Volume 4 of 7: Waukivory Pilot Project

4

Review of Environmental Factors

October 2013

REF Appendix A

AGL Energy in action.

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Appendix A

Agricultural impact statement

Waukivory Pilot Testing

Agricultural Impact Statement

Prepared for AGL Upstream Gas Investments | 27 September 2013

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Waukivory Pilot Testing

Final

Report J13005RP1 | Prepared for AGL Upstream Gas Investments | 27 September 2013

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1 Introduction

1.1 Purpose of the AIS

The NSW Government's Strategic Regional Land Use Policy (SRLUP) requires consideration and assessment of agricultural resources with potential to be impacted by coal seam gas (CSG) activities, including exploration activities. A key regional challenge is to maintain and grow agricultural productivity whilst also supporting the development of coal seam gas and achieving co-existence. The NSW Government is in the process of mapping strategic agricultural land (SAL), in the form of either biophysical SAL (BSAL) or critical industry clusters (CICs), across the state to ensure that important land and water resources are properly protected. This mapping will then be incorporated into Strategic Regional Land Use Plans. It is important to note that the area of the Waukivory Pilot near Forbesdale has not yet been mapped as part of this process.

During the exploration phase, the Policy outlines a requirement for a specific assessment of agricultural impacts through the preparation of an Agricultural Impact Statement (AIS). This AIS identifies and assesses impacts on agricultural resources or industries resulting from AGL's proposed gas exploration using four existing drilled wells near Forbesdale, south-east of Gloucester in the geological basin. These exploration wells will be used to investigate the potential for CSG resources in accordance with the requirements of Petroleum Exploration Licence No. 285 (PEL 285). PEL 285 is shown in Figure 1.1.

This AIS forms part of the Review of Environmental Factors (REF), for the approval sought under Part 5 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). Agricultural resources or industries describe land on which agriculture is dependent and the associated water resources (quality and quantity) that are linked to that land (DRE, 2012).

The NSW Department of Trade and Investment, Regional Infrastructure and Services - Division of Resources and Energy (DRE) issued AIS guidelines in November 2012 (refer to Appendix A).

The guidelines state that the level of detail in the AIS must be consistent with the likely level of impact. For example, the AIS needs to provide enough information to establish the level of risk. Further, the guidelines require the proponent to provide baseline information on the project and perform a risk assessment of the proposed exploration activity in accordance with Section A of the AIS Guidelines (Chapter 2).

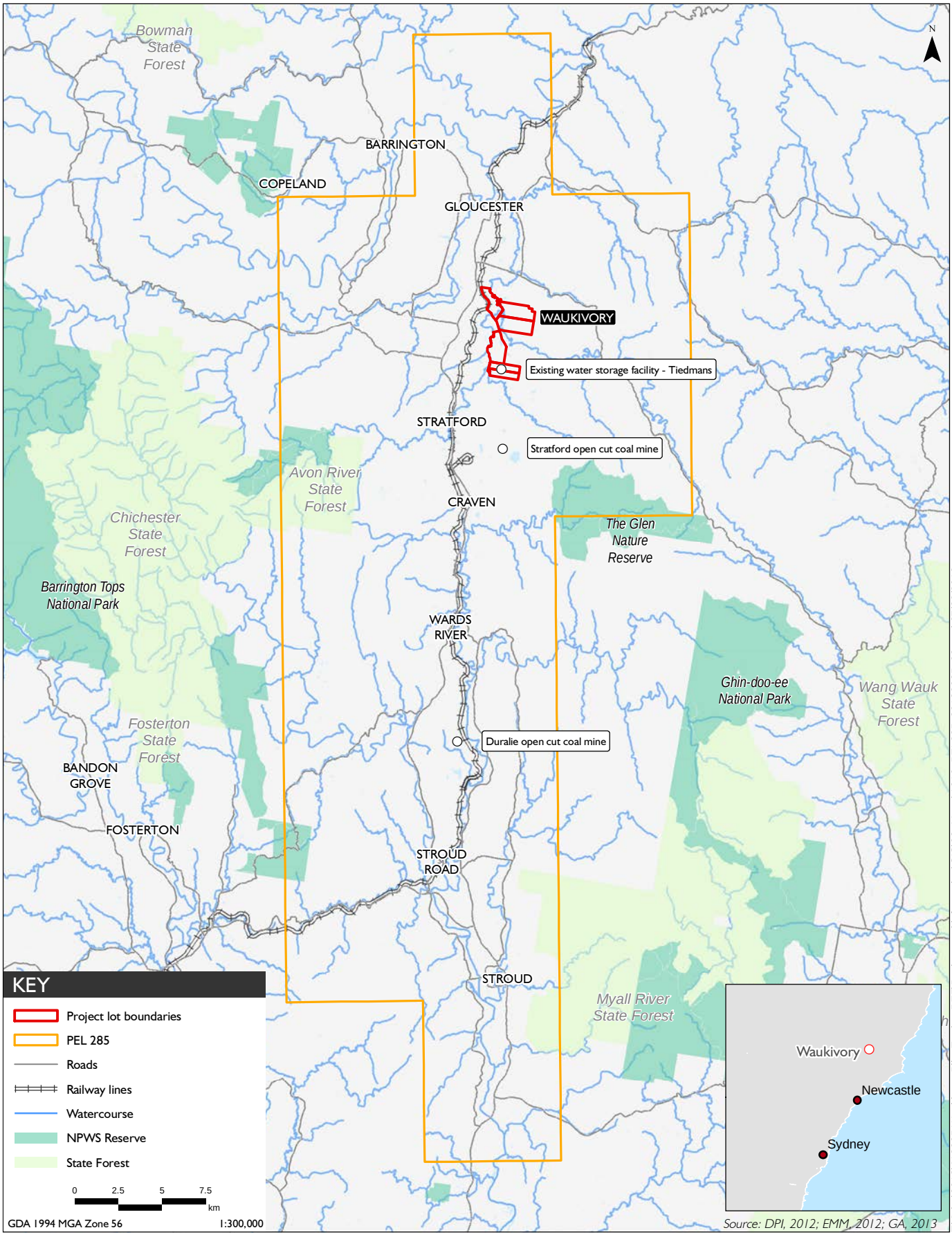
Should the initial risk assessment identify a medium risk to agricultural resources or industries, the proponent is required to provide an assessment of the activities on these matters and prescribe additional mitigation where required in accordance with Section B of the AIS Guidelines (Chapter 3).

1.2 Background of proposed exploration activities

AGL has undertaken previous exploration activities with the drilling of four exploration wells and one groundwater monitoring piezometer (WKmb04) at the 'Waukivory Pilot' (the site) to identify gas resources. The site is 6 kilometres (km) south-east of Gloucester in the Gloucester Basin and is currently used for light cattle grazing and light crop cultivation.

The site is zoned E3 Environmental Management under the Gloucester Local Environmental Plan 2010 (LEP), which is the typical zoning in the immediate area. Approximately 600 m to the northwest, land is zoned R5 - Large Lot Residential. Approximately 500 m to the south and 3.5 km to the east land is zoned as RU1 Primary Production.

The four existing exploration wells proposed for pilot testing are known as WK11, WK12, WK13 and WK14. In addition to the pilot testing of these four wells, another monitoring piezometer will be drilled – WKmb05 but is not part of the proposed activity (rather it has been assessed as a separate Category 1 activity with the NSW Office of Water). The purpose of the proposed activity is to identify the quantity, quality and depth of coal in the region, as well as its gas content and permeability.



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PEL 285
Agricultural Impact Statement
Waukivory Pilot Project
Figure 1.1

2 Section A - Initial assessment

2.1 Location, intensity and duration of the proposed exploration activity

2.1.1 Property and locality description

The site is south of Gloucester in the Avon River Valley (Figure 1.1) and is currently used for light cattle grazing and the growth of pasture and cultivation of fodder crops. The existing exploration well sites of the Waukivory Pilot are in the locality of Forbesdale. The four exploration well sites, existing and proposed monitoring bores/piezometers (WKmb04 and WKmb05, respectively) are on three privately-owned (freehold) blocks. The existing exploration well sites are identified as:

- Waukivory 11 (WK11);
- Waukivory 12 (WK12);
- Waukivory 13 (WK13); and
- Waukivory 14 (WK14).

WK11, WK13 and WKmb04 are on Lot 11 DP 841445, 20 Grantham Road, Forbesdale, while WK 12 and WK14 are on Lot 251 DP 785579, 197 Fairbairns Road, Forbesdale (Table 2.1). Both of these properties are owned by Gloucester Resources (Agriculture) Pty Limited (Gloucester Resources), and the proponent has an existing access arrangement with the landholders. The proposed geophone/water monitoring bore (WKmb05) has been assessed separately as a Category 1 activity in accordance with the conditions of PEL 285. WKmb05 will be on Lot 26 DP1112877, Forbesdale (Table 2.1). The locations are shown in Figure 2.1.

These wells and monitoring bores/piezometers are connected by access tracks and will also have a small pipeline network installed. As part of the activity application, AGL may construct a buried water pipeline between WK13 and Tiedmans dam, which is located on a nearby property owned by AGL (Tiedmans). The pipeline will traverse the subject site and properties owned by AGL with an underbore of Fairbairns Road.

The proposed activity and the geophone/water monitoring bore are on privately-owned (freehold) land in cleared grazing paddocks and light cropping fields.

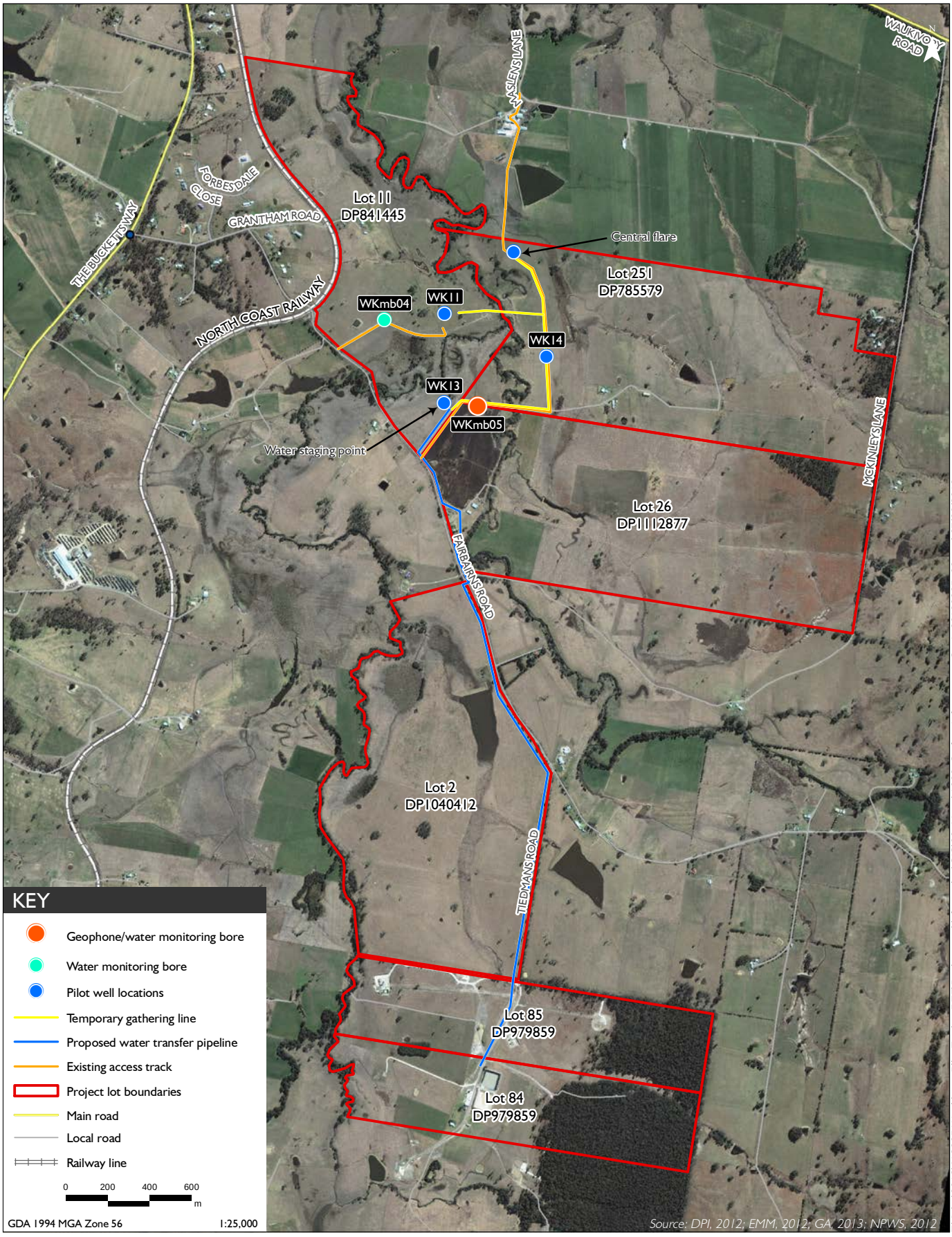
Figure 2.1 shows the location of the proposed activity. Figure 2.2 shows the alignment of the proposed water transport pipeline between WK13 and Tiedmans dam. The coordinates of the existing wells are presented in Table 2.1. The area required for the proposed activity (4 ha) has been previously cleared and had gravel pads constructed to enable the drilling of the four exploration wells in 2010. Each well has a total construction footprint of 100 m x 100 m, inclusive of water storage, which was previously assessed and approved in 2010.

The drilling of WKmb05 requires a pad of approximately 60 m x 70 m, however WKmb05 is not part of the application having been assessed as a Category 1 activity.

The water and gas reticulation network between the wells requires a temporary corridor of 10 m wide. The water pipeline between WK13 and Tiedmans dam is approximately 3.5 Km long and requires a temporary corridor of 6 m wide. The pipeline will be laid to a depth of between 450 mm and 1,000 mm.

Table 2.1 Location of wells, monitoring piezometer and water pipeline

Site	Address	Lot	DP	Coordinates
WK 11	20 Grantham Road, Forbesdale	11	841445	402748, 6452884
WK 12	197 Fairbairns Road	251	785579	402416, 6452164
WK 13	20 Grantham Road, Forbesdale	11	841445	402906, 6452384
WK 14	197 Fairbairns Road	251	785579	402419, 6452590
Wkmb04	20 Grantham Road, Forbesdale	11	841445	402132, 6452558 (approx.)
WKmb05	Fairbairns Road	26	1112877	402576, 64521488
Water pipeline	Fairbairns Road	2	1040412	Linear
Water pipeline	Fairbairns Road	1	196054	Linear
Water pipeline	Fairbairns Road	26	1112877	Linear



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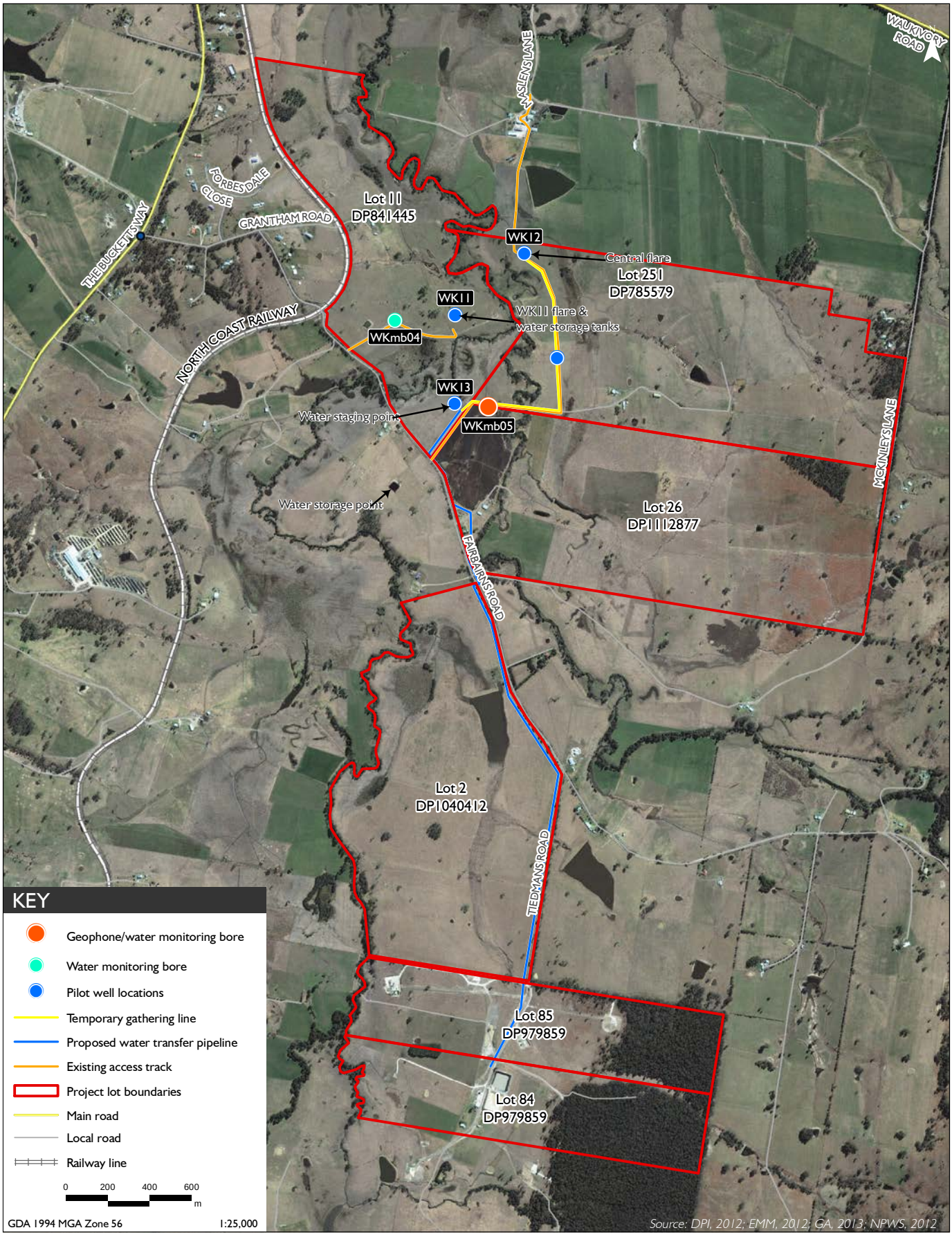
Proposed layout for Option 1
Agricultural Impact Statement
Waukivory Pilot Project
Figure 2.1



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Proposed layout for Option 2

Agricultural Impact Statement
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Figure 2.2

2.1.2 Zoning

The site is zoned E3 Environmental Management in the Gloucester Local Environmental Plan 2010 (LEP).

The objectives of the E3 zone are:

- to protect, manage and restore areas with special ecological, scientific, cultural or aesthetic values;
- to provide for a limited range of development that does not have an adverse effect on those values; and
- to conserve biological diversity and native vegetation corridors, and their scenic qualities, in a rural setting.

An assessment of the ecological and biodiversity impacts of the establishment of the four exploration wells was undertaken in 2010 (EMM 2010). Further ecological assessment was undertaken by EMM to identify biodiversity features in the proposed pipeline option route and its surrounds, with the results included in Appendix H of the REF. The REF identified that the exploration wells and the water transport pipeline would not have a long term significant impact on the environment.

It is considered that the subject site is zoned E3 Environmental Management due to the environmental as well as the scenic qualities of the location. There is a significant ridgeline to the east of the subject lots. The activity will not have a significant impact upon the scenic or aesthetic qualities of the area. All works are for exploration purposes and are short term in nature.

State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (Mining SEPP) prevail over LEPs in the event of an inconsistency. Under the Mining SEPP the proposed exploration activities are permitted without development consent and approval for the activity is required by a determining authority. Therefore, the assessment is subject to an assessment under Part 5 of the EP&A Act. The Minister for Mineral Resources and Energy (or delegate) will be the determining authority.

Notwithstanding the above, the proposed activities will adhere to the principles and objectives of the LEP zones. Pilot testing of the potential gas resource is the last part of the exploration process and determines the flow characteristics and quantities of the gas resource. The activity is temporary and will implement measures to protect and conserve agricultural land, co-exist with existing agricultural practices, avoid impacts on natural ecological systems and processes and will only have a transient effect on aesthetic values.

2.1.3 Ownership

Lot 251 DP 785579 and Lot 11 DP 841445 are currently owned by Gloucester Resources. AGL has an existing access arrangement in place with the landholder. The pipeline will traverse the subject site and properties owned by AGL with an underbore of Fairbairns Road.

2.1.4 Nature of activities

The proposed activities will convert four existing exploration wells (WK11, WK12, WK13 and WK14) to pilot wells for pilot testing in accordance with the requirements of PEL 285.

The four existing wells on the site, (WK11, WK12, WK13 and WK14), were approved by DRE and established in 2011. Gas flow from the four pilot wells will be tested in a central enclosed flare/s at WK12 (and possibly WK11 under Option 2 described in the REF).

An additional monitoring bore/piezometer (WKmb05) will be installed near WK13 and is shown in Figure 2.1. It should be noted that WKmb05 has been assessed as a Category 1 activity in accordance with the conditions of PEL 285 and is subject of a separate application with the NSW Office of Water. The installed logger in the monitoring bore/piezometer will constantly measure groundwater pressure and groundwater level. Groundwater will be sampled regularly throughout the project. The monitoring piezometer will provide data on the proposed activity as well as be incorporated into the ongoing monitoring network for the approved Gloucester Gas Project.

The proposed activity is expected to employ up to 20 people (principally contractors and suppliers) over the 12 to 18 month period. A summary of the overall construction requirements and operational activities are shown in Table 2.2.

Table 2.2 Activity summary

Activity	Description
Authorisation/title number	PEL 285
Titleholder and operator	AGL
Activity type	Pilot testing
Activity scope	• conversion of four exploration wells to pilot wells using perforating and fracture stimulation techniques; • pilot testing of four wells; • construction of a water storage area at either WK13 or at WK13 and WK11; with the storage being either a turkeys nest dam or a temporary above-ground facility; • construction of associated infrastructure including water and gas gathering lines, including a potential underbore of the Avon River as outlined in the REF; • construction of a potential water transport pipeline between WK13 and Tiedmans dam as outlined in the REF; • enclosed central gas flare/s at WK12 or at WK12 and WK11; • delivery of equipment (and water) to undertake the activity; • lawful disposal of flowback water to an appropriate facility; • disposal of produced water to Tiedmans for reuse in accordance with Tiedmans approval or lawful disposal offsite at an appropriate facility; and • site rehabilitation where agreed with the landowner.

2.1.5 Activity duration

The proposed activity is expected to occur over a 12 to 18 month period. However, the REF seeks approval for a 36 month duration to allow for unforeseen delays. The agricultural activities at the site will continue during the proposed activities, therefore existing agricultural land will not be reduced.

An outline of the expected duration for each phase of operation is shown in Table 2.3.

Table 2.3 Timetable

Activity	Approximate duration
Construction	
Ancillary works, including holding dam construction	8 – 12 weeks
Operation	
Perforation	7 days
Hydraulic fracture stimulation	5 – 7 days per well
Installation of wellhead surface equipment	7 days per well
Flowback	4 – 16 weeks
Pilot testing	6 – 18 months
Decommissioning	
Suspension and rehabilitation	2 – 6 weeks

Pilot testing and flowback will occur 24 hours a day, seven days a week. Standard work hours for all other noise generating activities will be Monday to Friday, 7:00 am to 6:00 pm and Saturday 8:00 am to 1:00 pm, with no work on Sundays or public holidays in accordance with the *Interim Construction Noise Guideline* (DECC 2009) and the licence conditions of PEL 285.

2.2 Nearby agricultural resources and industries

2.2.1 Regional context

The main land uses in the Gloucester/Dungog/Great Lakes area are agriculture; mining; conservation areas and forestry; and residential development. The main agricultural activity in the region is grazing with a small amount of horticulture, intensive animal production and dairying (ABARE, 2004). Approximately 36% of the Gloucester and Great Lakes region is agricultural land and the total value of agricultural production in 2006 was approximately $63.7 million (ABS 2007). Total employment in the agricultural industry in the Gloucester and Great Lakes LGAs is 829, with the main agricultural employment being in specialised beef cattle farming (ABS 2007).

2.2.2 Local context

i Overview

The site is transected by the Avon River and Waukivory Creek. The main land use near the site is beef and dry dairy cattle grazing on improved and semi improved pastures. Other land uses in the wider area include residential development and coal mining, with the Stratford and Duralie coal mines approximately 5 km and 24 km south, respectively.

The nearest conservation areas are The Glen Nature Reserve and Avon River State Forest, which are approximately 9 km south east and 10 km south west, respectively.

The nearest locality is Forbesdale, which is approximately 1 km west.

ii Biophysical SAL or critical industry clusters

The site area and the potential water transport pipeline route have not been mapped as part of the SRLUP. Therefore it is not mapped as either BSAL or as a CIC. This AIS will consider the land around the site with respect to the relevant site verification criteria. Based on publicly available information, an assessment against the criteria was done and is presented in Table 2.4.

BSAL must have access to a 'reliable water supply'. All of the area in the Manning Valley, including the Gloucester Valley has access to a reliable water supply. Ten site verification criteria have been identified (Table 2.4). For soil to be classified as BSAL it must meet all of the criteria outlined in Table 2.4.

Table 2.4 Assessment against criteria used to determine Biophysical SAL

Criteria	Description	Assessment	Justification
1	Is slope less than or equal to 10%?	Yes	Undulating low hills. Slopes<10% (Henderson 2000).
2	Is there <30% rock outcrop?	Yes	Rock outcrop is generally absent (Henderson 2000).
3	Does <20% of area have unattached rock fragments >60mm diameter?	Yes	The area has been used for cropping as evidenced by a review of aerial photography. Based on this review it has been assumed that this criterion has been satisfied.
4	Does 50% of the area have gilgais >500mm deep?	No	Gilgais are unlikely in the soils identified during desktop review.
5	Is slope <5%? **Or** Does soil have moderately high or high fertility?	Yes	Slopes would be generally <5% (Henderson 2000).
6	Are there nil rock outcrops **or** Does soil have moderately high or high fertility?	Yes	Outcrops are generally absent.
7	Does soil have moderate fertility **or** Does soil have moderately high or high fertility?	No	Potential soil fertility is low (Henderson 2000).
8	Is effective rooting depth to a physical barrier >750mm?	Yes	Root depth >1,500 mm (Henderson 2000).
9	Is soil drainage better than poor?	Yes	Moderately well drained brown sodosol (50% of soil landscape), Moderately well drained Grey kurosol (40% of soil landscape and moderately well drained brown Tenesol (10% of soil landscape).
10	Does the pH range from 5 – 8.9 if measured in water or 4.5 – 8.1 if measured in calcium chloride, within the uppermost 600 mm of the soil profile?	Yes	Soil landscape pH ranges from pH 5.5 - pH 6.5.
11	Is salinity (EC) .4dS/m **or** are chlorides <800 mg/kg when gypsum is present, within the uppermost 600 mm of the soil profile?	Yes	Area is not at risk of becoming dryland salinity. Based on this it is likely that these criteria will be met.
12	Is effective rooting depth to a chemical barrier >75mm?	Yes	Root depth >1,500 mm (Henderson 2000).

Based on publicly available information, the area of the proposed activity is unlikely to be classified as BSAL under the SRLUP and the area is unlikely to be mapped as a CIC.

iii Water

There are two watercourses in the vicinity of the proposed activity (Figure 2.1). The Avon River dissects the study area, with WK 11 on its western banks while WK12, WK13 and WK14 are to the east. Waukivory Creek is a tributary of the Avon River which dissects WK13 and WK14. The intersection of Waukivory Creek and Avon River is south of WK11 and WK12.

Likely volumes for fracture stimulation are between 1 ML and 2.5 ML per well and approximately 6 ML in total for the four wells. As part of the proposed activity, a double-lined dual compartment turkeys nest dam (or temporary above-ground water storage) will be constructed to store water at WK13 or at WK13 and WK11 (under Option 2). Following hydraulic fracture stimulation, flowback water will be contained in the smaller compartment of the turkeys nest dam (or in a secured water storage tank) at WK13 or WK13 and WK11. This water will then be transported and lawfully disposed of at an offsite facility.

Produced water is not considered a wastewater stream but rather natural groundwater suitable for reuse (once salinity aspects are addressed through blending). Produced water will be pumped to the secured water storage area/s and then transported by trucks or via the proposed water transport pipeline to AGL's Tiedmans property, blended and reused for irrigation in accordance with the previously approved reuse proposals (see the Water Management Plan for the Tiedmans irrigation trial).

In accordance with the Tiedmans irrigation approval (DRE, 2011) the produced water from the proposed activity will be blended (ie mixed) with fresh water at the Tiedmans property to achieve water quality parameters (ANZECC 2000) suitable for application (ie irrigation) to land for agricultural purposes. The application to land of produced water following blending is in accordance with ANZECC guidelines (ANZECC 2000) and the *Draft Code of Practice for Coal Seam Gas Extraction* (NSW Government 2012). As such, the proposed activity will not have a long-term impact and is not expected to cause significant impacts to water quality, or cause economic, heath, ecosystem or amenity impacts.

2.3 Rehabilitation

Rehabilitation of pilot test wells is generally undertaken in two stages; initial site rehabilitation of disturbed land (including construction laydown areas, access track and gas gathering pipeline verges) following the completion of site establishment and to cap and suspend the test wells at the completion of gas flow testing. On completion of activities construction laydown areas, access track and gas gathering pipeline verges will be rehabilitated and returned to its pre-existing use and condition, or better. Gas and water gathering lines will be rehabilitated as will access tracks that are no longer required by the landholder. As the proposed pilot testing will utilise existing wells, the initial rehabilitation stage was completed in 2012. The potential water transport pipeline between WK13 and Tiedmans dam will be removed and rehabilitated in consultation with the landholder.

Prior to suspending the pilot test wells AGL would seek approval through DTIRIS – DRE by providing information in accordance with section 521 of the Schedule of Onshore Petroleum Exploration and Production Safety Requirements.

2.4 Impacts on agricultural resources and industries

2.4.1 Land capability

Draft Inherent Soil Fertility and Draft Land and Soil Capability (LSC) mapping prepared by the Office of Environment and Heritage (OEH) for the Upper Hunter Strategic Regional Land Use Plan area was reviewed (Appendix B). The site was characterised as LSC Class 4 which is defined as:

> 'moderate to severe limitations. Land generally not capable of sustaining high impact land uses unless using specialised management practices with high level of knowledge, expertise, inputs, investment and technology. Limitations are more easily managed for lower impact land uses (eg grazing) (Riddler 1987).'

The proposed activity will temporarily disturb approximately 4 ha, which has been previously cleared and had gravel pads constructed to enable the drilling of the four exploration wells in 2010. Existing, adjacent and on-site agricultural activities (grazing and fodder crop production) will continue unaffected during the activity. Upon completion of the proposed activity, the disturbed land will be rehabilitated to a pre-activity condition. No long term impacts to the agricultural land at the site or along the potential water transport route are anticipated to result from the activity.

2.4.2 Biophysical SAL or critical industry clusters

Based on publicly available information, the project area is unlikely to be classified as BSAL under the SRLUP.

2.4.3 Water

Water will be sourced from licensed water supply works from either the nearby Pontilands Dam or Tiedmans property off Fairbairns Road. The use of water for the proposed activity will not reduce the water available for agricultural industries as AGL is not seeking any additional water licence requirements as part of the application.

Within the Gloucester Basin, three types of aquifers have been identified during previous investigations (SRK Consulting, 2010). In order of depth this includes:

- shallow alluvial aquifer;
- shallow bedrock aquifer; and
- coal seam water bearing zones.

Prior to the SRK Consulting investigations, an investigation undertaken by AECOM stated that the depth to water in the shallow alluvial aquifer in the Gloucester Basin ranges from 2 m to 20 m, while in the shallow bedrock aquifer depth to water is generally 20 m to 40 m. In addition, the groundwater within coal seams is considered a very poor aquifer, and is generally confined and sub-artesian with most water being produced from higher in the stratigraphic sequence (AECOM 2009).

These results were confirmed by SRK Consulting (2010)[1] who reviewed the data available for registered groundwater bores in the Gloucester Basin. From a total of 128 registered bores/wells identified in the Gloucester Basin, the depth of the bores/wells varied from between 6 m to 66 m below ground level (mbgl). Of these, four were on an alluvial aquifer (6 m to 9 mbgl) while the rest were all deeper, at up to 66 mbgl, and sited in the shallow fracture (bedrock) aquifer (Permian rocks). The majority of the bores and wells in the shallow bedrock aquifer had groundwater levels ranging from 1.5 m to 33.7 mbgl.

Many bores have been established for monitoring purposes with the remainder of bores/wells mostly being used for stock and domestic purposes. The primary aquifers across the catchment are the shallow alluvium associated with the major rivers and creek systems, and the shallow fractured bedrock to around 75 mbgl.

Due to the steel and concrete casing production hole design and the extraction depth of coal seams (between 300 m and 1,000 m) it is highly unlikely that any impacts will incur to beneficial aquifers in the area. A Surface Water and Groundwater Management Plan will be implemented during the activity which include continual monitoring of any changes to water quality within shallow aquifers and the associated proceedings.

2.4.4 Transport

Access to the site will be via council maintained roads and existing private access tracks within the subject properties as identified in Figure 2.3. The proposed activity will involve the delivery of plant and equipment required for the hydraulic fracture stimulation and flow testing of the pilot wells. Delivery of these items to and from the site may cause minor interruptions to traffic flow on local roads.

During the operational phase, a water transport pipeline between WK13 and Tiedmans dam may be constructed. Alternatively, a number of tankers may visit the site to deliver water used for hydraulic fracture stimulation. A hierarchy of sources have been included and assessed within the REF. The preferred option is to pipe water from Tiedmans dam on Fairbairns Road, with the secondary option of trucking water from either Tiedmans dam or AGL's Pontilands property also on Fairbairns Road. The least preferred option is to purchase water on the open market.

Access and egress of the tankers delivering source water from Pontilands Dam and Tiedmans will cause very minor interruptions to traffic flow on local roads as the distance is very short. Additional roads and greater travelling distances may be required should AGL source water from the open market. The construction of the water transport pipeline will minimise truck movements. A drill rig and a crane will also be delivered to the site for workover (maintenance). However, this will be on an infrequent basis and is not expected to result in interruptions to traffic flow on local roads.

Limited plant will be delivered to site during the decommissioning stage and is not expected to result in interruptions to local traffic flow.

An analysis of traffic volumes within the local road network (EMM 2011) found that there is sufficient capacity to accommodate the additional traffic movements. However, traffic resulting from the establishment and operation phases may cause some minor interruptions to traffic flow on local roads.

[1] SRK Consulting (2010) *Gloucester Basin Stage 1 Gas Field Development Project Preliminary Groundwater Assessment and Initial Conceptual Hydrogeological Model*.

2.4.5 Employment and economic development

It is considered that a detailed assessment of agricultural production levels is not required due to the temporary nature of the proposed activity. Pilot well testing is a temporary land use, and one that will co-exist simultaneously with agricultural land uses. The original approval granted in 2010 allowed the drilling of the exploration wells WK11 – WK14. These were drilled whilst simultaneously sharing the site with grazing cattle.

2.5 Agricultural impact risk ranking

The AIS guidelines prepared by DRE provide a risk ranking of exploration activities with the following examples of low risk exploration activities:

- The proposed exploration activity is located on agricultural land or on rural land with low potential for commercial agricultural land use.
- No intensive agricultural activities are being undertaken in the immediate vicinity of the proposed exploration activity.
- The duration of the exploration activity is short (e.g. less than one month at a particular location).
- The proposal is not part of a larger project so there are unlikely to be cumulative impacts.
- The proposed exploration activity will not result in permanent impacts on water or land resources.
- All surface disturbances will be fully rehabilitated to the pre-existing land condition or better.

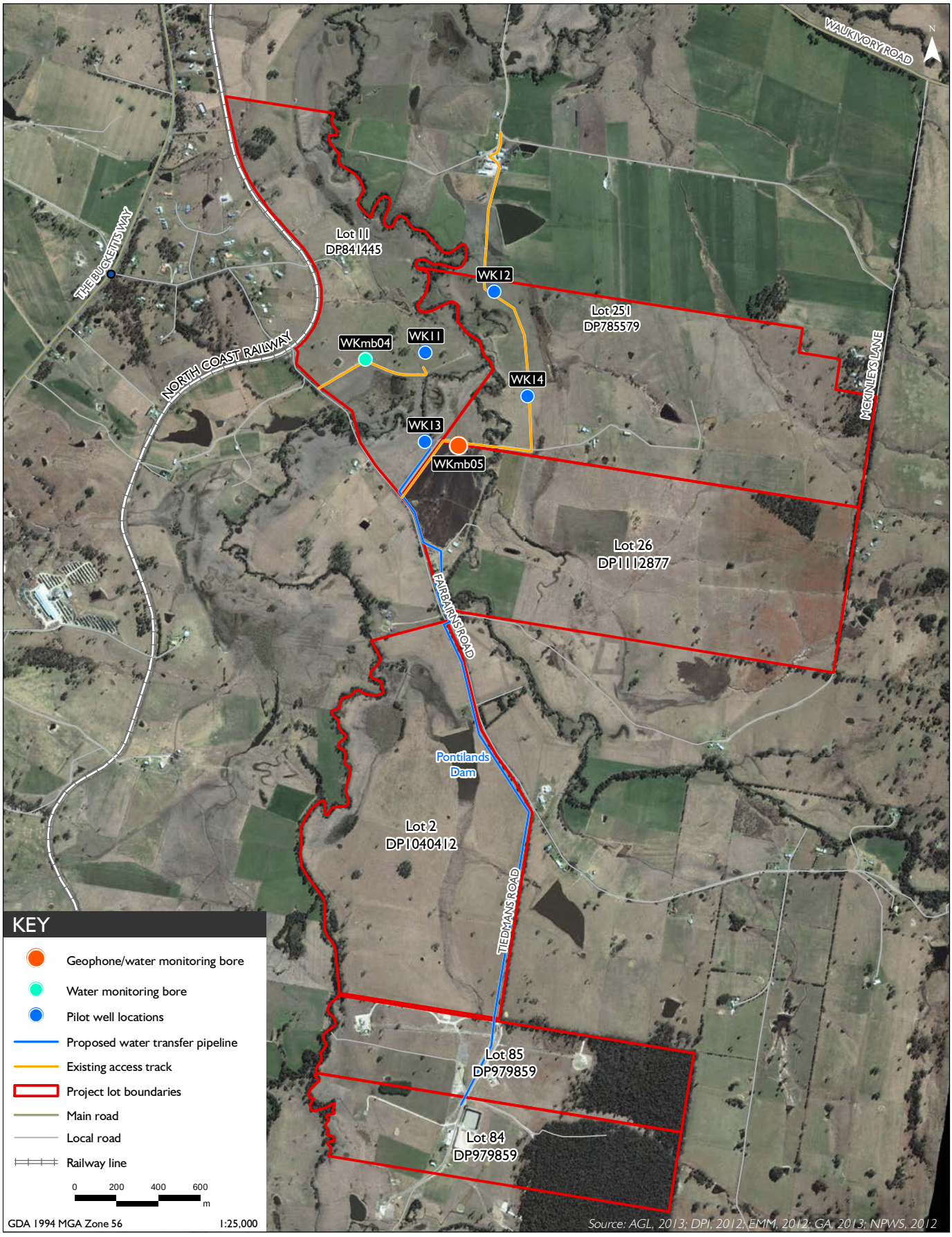
Examples of the characteristics of moderate to high risk exploration activity are:

- the proposal is located on or near Biophysical Strategic Agricultural Land (BSAL) or Critical Industry Cluster (CIC); or
- there are significant concerns about the project in the agricultural community.

Whilst the site has not yet been mapped in accordance with the Strategic Regional Land Use Policy, the site is not near land likely to be characterised as a CIC or as SAL.

Using the agricultural impact risk ranking matrix provided in the AIS guidelines (see Appendix A), and based on the assessment in pages 8 - 13 of this AIS, a preliminary agricultural **risk ranking of D4 (ie low)** was determined as being “minor damage and/or short term impact to agricultural resources or industries” and “can be managed as part of routine operations”. This ranking was assigned because of the ‘unlikely’ nature (Table 2 of the AIS Guidelines) of ‘Level 4’ consequences (Table 3 of the AIS Guidelines). The AIS Guidelines state that where the exploration activity is demonstrated to result in a low risk of agricultural impacts, no further information is required to be submitted as part of the AIS.

However, because the AIS Guidelines states that “large-scale exploration activities, such as coal seam gas pilot testing would need to fully consider impacts on agricultural resources and industries” and because of the community interest over CSG projects in general, further assessment in accordance with Section B of the Guidelines has been provided as a precautionary measure. This assessment is provided in Chapters 3, 4 and 5 of this AIS.



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Site access plan
Agricultural Impact Statement
Waukivory Pilot Project
Figure 2.3

3 Section B – Assessment

This assessment has been carried out in response to community interest in coal seam gas proposals, despite a **risk ranking of D4 (Low)**.

3.1 Assessment of resources

3.1.1 Agricultural resources and production

i Strategic agricultural land

The proposed activity is on land that has not yet been mapped in accordance with SRLUP. Based on publicly available information the project area is unlikely to be classified as BSAL under the SRLUP (Table 2.4).

ii Soil characteristics

As the wells are already drilled, the proposed activity is not expected to impact on soil type or depth characteristics at the well locations. The excavation of the water and gas gathering lines, the proposed water transport pipeline and turkeys nest dams will result in the removal of soil material, with the top soils stockpiled on site to be used for the rehabilitation following completion of the flow testing activities. Following rehabilitation of these areas, no effects on the soil type of depth characteristics are expected.

The site is on land with 'no known occurrence' of acid sulphate soils (ASS).

iii Topography and slope

Local topography at the site is relatively flat. The water staging point/s will be at WK13 or at WK13 and WK11. The site/s are generally flat and at approximately 130 m AHD (WK11) and 100 m AHD (WK13). The site has not been mapped within the "flood planning area" as identified in Gloucester LEP. A flood planning area is the area of land below the flood planning level (1 in 100 year flood plus a 0.5 m freeboard) and thus subject to flood related development controls. However, it is recognised that the site is subject to periodic localised flooding and design and operational controls, which meet industry standards, are in place to address potential impacts from flooding.

The water pipeline (from WK13) is mainly in a creek-flat open cattle paddock. The proposed alignment is within 50 m of Waukivory Creek at its nearest point. At this point, Waukivory Creek is part of a gentle open depression. The proposed alignment also crosses two ephemeral drainage lines that are tributaries to the Avon River.

iv Land capability characteristics

Draft Inherent Soil Fertility and Draft Land and Soil Capability (LSC) OEH for the Upper Hunter Strategic Regional Land Use Plan area was reviewed.

The system outlines eight classes of agricultural land:

- Class 1: Very slight to negligible limitations – no special land management practices required.
- Class 2: Slight but significant limitations – can be managed by readily available, easily implemented management practices.

- Class 3: Moderate limitations – can be managed by more intensive readily available and accepted management practices.
- Class 4: Moderate to severe limitations – can only be managed by specialised management practices with high level of knowledge, expertise, inputs, investment and technology.
- Class 5: Severe limitations – there are few methods available to overcome limitations.
- Class 6: Very severe limitations – land incapable of sustaining many land use practices. Land often used for low intensity land uses (low intensity grazing).
- Class 7: Extremely severe limitations – land incapable of sustaining most land uses. Limitations cannot be overcome.
- Class 8: Extreme limitations – land incapable of sustaining any land use and best left undisturbed and managed for conservation.

As discussed in section 2.4.1 the site was determined to be LSC Class 4 based on the above definitions.

The existing adjacent grazing activities will continue during the proposed activity which is temporary. Through management of excavated top soil and its use in the rehabilitation of the site following completion of the temporary activities, the proposed activity is not expected to affect the LSC of the site or surrounding areas.

v Water users

a. Water sources

The preferred water supply source is the Pontilands Dam. An application is currently with NOW for 20 ML/year for irrigation, industrial and stock purposes. Alternatively water can be sourced from the Tiedmans property or purchased from the open market.

Irrespective of the source of water a water staging point will be required in the vicinity of the Waukivory pilot wells. This will minimise truck movements on site. The water staging point will either be a double-lined dual compartment turkeys nest dam, or a temporary above-ground water storage tank. Water will be piped from the staging point to/from each of the individual well sites as required during fracture stimulation activities.

There are two options for supplying source water for hydraulic fracturing at exploration wells. Both options require a water staging area at WK13 and both options involve supplying source water to WK14 and WK12 by buried gathering lines from the water staging area at WK13. The two options relate to the supply of source water for hydraulic fracturing at WK11 and are described below.

b. Option 1

Source water for hydraulic fracturing will be delivered from the water staging area to WK11 by buried gathering lines from the water staging area at WK13.

c. Option 2

Source water for hydraulic fracturing will be supplied to temporary above-ground storage tanks at WK11 by truck.

d. Water users and licences

There are several fresh water options for sourcing water for hydraulic fracture stimulation including:

- water from the Tiedmans property
- water from the Pontilands Dam; and
- town water or water purchased on the market (ie potentially from Yancoal, a nearby mine operator).

AGL (in advance of the REF evaluation and approval process) has submitted an application to NOW to licence Pontilands Dam and to take water for 'stock, irrigation and industrial' purposes.

Water from the Tiedmans property has mostly been derived from previous pilot testing on the Stratford wells that are licensed for industrial and irrigation purposes. Being licensed for industrial purposes, this produced water is able to be reused for fracture stimulation purposes.

There are no groundwater dependent ecosystems or local groundwater users within the immediate vicinity of the Waukivory pilot wells that could be affected.

vi Water quality and yields

a. Surface water

Water quality was monitored in the Avon River between 1994 and 2011 for the Stratford Coal Mine Extension Project (see Table 3.1).

Table 3.1 Avon River water quality

Site W1	pH	EC (µS/cm)	Alkalinity (mg/L)	Turbidity (NTU)	Total nitrogen (mg/L)	Total phosphorus (mg/L)
Average	7	332	67.3	64.9	1.71	0.15
% exceedance	9	0	-	37	74	49

Notes: exceedance is the amount of samples (%) that exceed the Australian and New Zealand Environment and Conservation Council's (ANZECC) aquatic ecosystem guideline for slightly disturbed lowland rivers in south east Australia.

Source: Gilbert and Associates (2012).

b. Groundwater

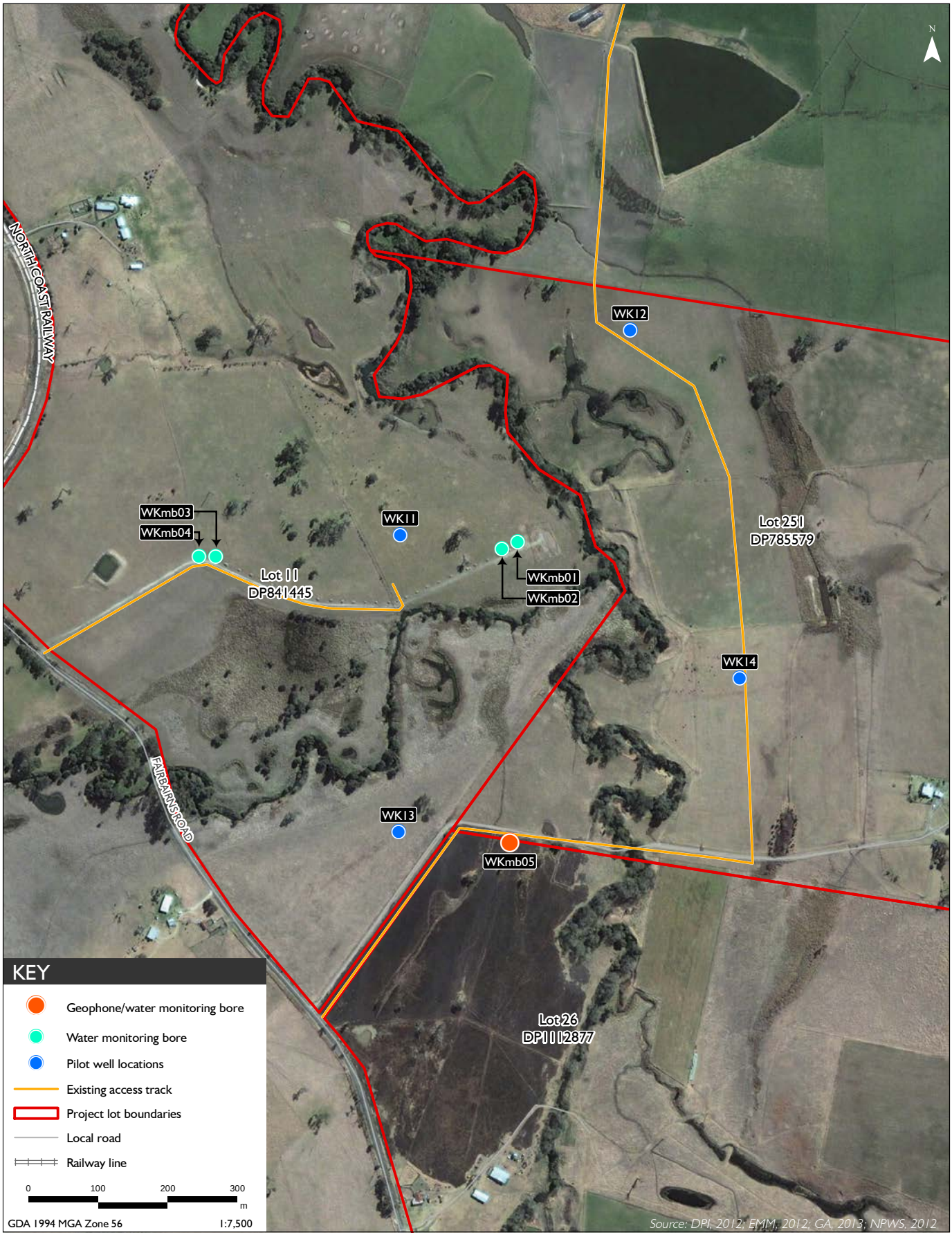
The main groundwater monitoring network will be one cluster of monitoring bores within the central area of influence of the flow testing program, one cluster immediately to the west of the westernmost pilot wells and a single monitoring bore to the east of the southernmost pilot well (WK13) is proposed (WKmb05). The central monitoring bores will monitor the upper fractured rock and thrust fault aquifer zones, while the western site will monitor the upper fractured rock aquifer and deeper Roseville coal seam water bearing zone. The monitoring bore locations are shown on Figure 3.1.

The two westernmost monitoring bores were completed late January 2012 with the eastern sites completed in June 2012. The intention is to monitor shallow beneficial aquifers and potential fault pathways though which shallow groundwater may drain.

There are additional (existing) monitoring bores on adjacent lands that will be used in the interpretation of results from this pilot testing program. Summary details of all bores within 3 km are provided in Table 3.2.

Table 3.2 Summary of monitoring bores – Waukivory Pilot and surrounds

Sub – area and purpose	Monitoring bores
Adjacent to pilot testing program area (new sites for this program)	WKmb02 – Shallow fractured rock depth – 62 m screened interval – 52 to 61 m
	WKmb03 – Thrust fault depth – 210 m Screened Interval – 200 to 209 m
West of field adjacent to pilot testing program area (new sites for this program)	WKmb01 – Shallow fractured rock depth – 54 m screened interval – 47 to 53 m
	WKmb04 – Deep coal seam (Roseville CS) Depth – 360 m screened interval – 335 to 347 m
Deep water monitoring bore with VWPs	WKmb05 – depth of borehole approximately 1,000 m
Adjacent land (owned by Gloucester Resources)	GR-P1 – Shallow alluvium depth – 10.2 m screened interval – 5.5 to 8.5 m
	GR-P2 – Shallow alluvium depth – 11 m screened interval – 4 to 9 m
	GR-P3 – Shallow alluvium depth – 11.2 m screened interval – 5 to 9 m
Remote (AGL sites) located approximately 3 km to the north east of the pilot test area	Continue to monitor the water levels in AGL dedicated monitoring bores:
	WMB01 - Shallow alluvium depth – 8.5 m screened interval – 5 to 8 m
	WMB02 - Shallow sandstone depth – 23.0 m screened interval – 15 to 21 m
	WMB03 – Shallow coal seam (Bowens Rd CS) Depth – 36 m screened interval – 32 to 34 m
	WMB04 – Deep sandstone depth – 80.5 m screened interval – 67 to 79 m



Location of groundwater monitoring bores

Agricultual Impact Statement
Waukivory Pilot Project

Figure 3.1

vii Current land use and relevant history

The site is currently a mix of gas exploration and agricultural practices including cattle grazing and light cropping.

viii Key agricultural support infrastructure (eg roads, railways, processing facilities)

The key aspects of agricultural infrastructure in the area relate to transportation with the main routes proximal to the site being Bucketts Way, which connect Gloucester to the Pacific Highway in the south and to the east. The North Coast railway line runs from north to south through the area which transports passengers and freight between Brisbane and Sydney and coal from Stratford Mine site to the Port of Newcastle for export.

As stated in Section 2.4.4, the site is accessed from local council roads. The proposed activity will involve the delivery of water and plant and equipment required for the hydraulic fracture stimulation and flow testing of the pilot wells. Delivery of these items to and from the site is unlikely to cause interruptions to traffic flow on local roads as the preferred options of source water and disposal are in close proximity to site and off Fairbairns Road.

During the operational phase, some tankers will visit the site to collect flowback water for disposal. It is considered that vehicle access and egress from the site will not result in disruptions based on the current levels of traffic on local council roads. A drill rig and a crane will also be delivered to the site for workover (maintenance); however this will be on an infrequent basis and is not expected to result in interruptions to traffic flow on local roads.

Limited plant will be delivered to site during the decommissioning stage and is not expected to result in interruptions to local traffic flow.

ix Location and type of agricultural industries

The main agricultural activity in the region is grazing with a small amount of horticulture, intensive animal production and dairying (ABARE, 2004). Approximately 36% of the Gloucester and Great Lakes region is agricultural land and the total value of agricultural production in 2006 was approximately $63.7 million (ABS, 2007). Total employment in the agricultural industry in the Gloucester and Great Lakes LGAs is 829, with the main agricultural employment being in specialised beef cattle farming (ABS, 2007).

The main land use near the site is beef and dry dairy cattle grazing on improved and semi improved pastures (Henderson, 2000). Other land uses in the wider area include residential development and coal mining, with the Stratford and Duralie coal mines located approximately 5 km and 24 km south, respectively.

The Upper Hunter Strategic Regional Land Use Plan has not mapped the site as BSAL or as being within a CIC. Based on publicly available information the site is unlikely to be classified as BSAL under the SRLUP (Table 2.4).

x Climate conditions

Monthly average temperatures in nearby Taree (50 km from the site) (BoM, station 060141) reach an average high of 28.7°C in January and drop to a maximum of 18.4°C in July. The mean maximum temperature is 24°C (BOM 2012). The region typically receives a peak in rainfall of 142 millimetres (mm) in February, and its lowest rainfall (mean of 53.5 mm) in August before steadily rising again through to December.

3.1.2 Current agricultural enterprises

The site comprises of cattle grazing and light fodder cropping.

i Location and area of land to be temporarily removed from agriculture

The land has already been used by AGL for the purposes of CSG exploration with four established wells, co-existing with agricultural land use of light cattle grazing. The area to be used for the proposed activity is not currently used for agricultural purposes.

An activity footprint of 100 x 100 m is allowed for manoeuvring and placement of construction plant around each of the existing wells. The central flare has a small additional footprint of 10 x 10 m. The proposed water transport pipeline would require a construction corridor 6m wide. Some minor levelling activities will occur in the vicinity of the drilled wells to ensure stability of equipment and plant for the proposed activity. Only areas that are involved with construction and equipment used for the extraction process will be temporarily unavailable for agricultural practices.

The construction of the dual compartment holding dam will also exclude this area temporarily from agricultural activities. Flowback water will be transported to an appropriate facility for lawful disposal. Produced water will be transported to the Tiedmans property either via truck or water pipeline where the water will be blended and used for irrigation subject to achieving acceptable water quality criteria for these purposes. Therefore, it is considered that the addition of the holding dam has potential to increase the area used for agricultural purposes.

ii Location and area of land to be returned to agricultural use post-exploration

The activity footprint of 100 m x 100 m used for pilot testing, gas gathering lines and flare/s location will be rehabilitated to pre-activity condition (LSC Class 4) or better, which will enable future suitable agricultural practices to be undertaken, should future gas exploration or production activities not be undertaken. The land used for the water pipeline will be rehabilitated to pre-activity condition at the request of the landowners.

If further investigation or production of the wells is not required, the wells would be plugged in accordance with the Borehole Sealing Requirements (Department of Primary Industries, now DII), and the site rehabilitated.

iii Location and area of land that will not be returned to agriculture

No current areas of agricultural activities will be required for the proposed activity.

The broader Gloucester Gas Project has received approval for the construction and operation of a gas producing development by the NSW Government under Part 3A of the EP&A Act.

If the results of the proposed exploration activities prove a viable resource, the wells will be capped and suspended pending the commencement of the Gloucester Gas Project Part 3A production approval. Alternatively, the wells will be plugged and abandoned in accordance with the *EDG01: Borehole Sealing Requirements on Land: Coal Exploration* (Department of Trade & Investments Resources and Energy, April 2012), and the site rehabilitated.

3.2 Assessment of impacts

3.2.1 Agricultural resources

The proposed activity can be viewed as a co-existing land use with surrounding grazing, and light cropping. The use of this land for pilot testing is considered to be of a temporary nature, and would not impact future agricultural potential of the land.

The impact on soil function and capability from the project is expected to be of low adverse impact as the pre-existing soil classes are low in fertility and agricultural capability. Post development rehabilitation practices and produced water management will ensure soil productivity is returned to the same or improved state.

Existing water licences (WAL 181545 and WA 20CA208664) will be used for the proposed activity. Potential impacts to groundwater are considered to be low adverse following mitigation measures and addition safeguards outlined in the Surface and Groundwater Management Plan (refer to Appendix D of the REF) and Tiedmans Produced Water Management Plan. It is considered that the proposed activities will not impact agricultural resources on site or nearby surrounding agricultural enterprises.

i Agricultural productivity

The Manning Valley has some history in extractive industries including open cut coal mining and gold mining as well as dairy farming, beef cattle grazing and tourism. The proposed activity has been designed and planned to ensure it is sympathetic to existing land uses, both on the site and in the surrounding landscape. AGL has an extensive and ongoing community consultation program consisting of a consultative committee, readily available project information, and regular consultation with landowners.

The site has already been used by AGL for the purposes of CSG exploration with four already established exploration wells which co-exist simultaneously with cattle grazing activities. However, pilot well testing is a temporary land use, and is not expected to affect the land being used for agricultural land uses now or in the future.

The implementation of appropriate management, mitigation and safety procedures and utilisation of existing water licences will minimise any off-site impacts from the proposed activity (refer to the REF for detailed information regarding the mitigation strategy). Given this, the proposed activity is unlikely to adversely affect agricultural productivity on the site or on nearby surrounding land uses.

ii Monitoring

To confirm the integrity of well construction and potential impacts associated with targeted fracture stimulation, groundwater monitoring networks (mostly in shallow aquifers) will be installed in reasonable proximity to selected gas wells to assess whether there are water level drawdown or water quality changes that would indicate connectivity. In addition to the established shallow monitoring network, AGL will utilise the existing piezometers in the area. These piezometers will provide information on the deeper non-beneficial aquifers associated with the pilot testing.

iii Risk assessment

Other additional risks to agriculture that may affect access to markets and supplies are shown in Table 3.3.

Table 3.3 Risk-based agricultural assessment for the proposed activity

Potential hazard	Initial risk rating	Mitigation	Final risk rating
weed invasion	Moderate	Control of noxious weeds prior to commencement of works. Vehicle washdown procedures (where appropriate).	Low
bushfire	Moderate	Designation of asset protection zones (APZs). Vehicles and plant can only drive on designated tracks and not in tall grasses. Fire fighting equipment will be maintained on site.	Low
soil erosion	Moderate	Use of appropriate sediment and erosion controls during the proposed activity. Prompt rehabilitation of disturbed areas.	Low
animal disease outbreak	Low	Fenced compounds will be installed around the wells and central flare.	Low
interruption to water supply (for stock and irrigation)	Moderate (temporary)	No interruption expected as water sources are controlled by AGL.	Low
increased dust	Moderate (temporary)	Dust monitoring. Use of water carts for dust suppression. Prompt rehabilitation of disturbed areas.	Low
increased noise	Moderate (temporary)	Employee and contractor induction. Restriction on work hours for noise generating activities. Positioning of noisy equipment away from sensitive receivers. Consultation with sensitive receivers. Use of temporary noise barriers.	Low
increased traffic	Low (temporary)	Staggering of water truck movements removing any water/ waste from site to minimise impacts to local roads.	Low

3.2.2 Water

i Water usage

The proposed activity constitutes a temporary re-allocation of local water resources from an existing licensed allocation. AGL proposes to convert the current surface water licence water use at the Tiedmans property from 'irrigation' to 'irrigation and industrial purposes' to enable a small proportion of this allocation to be used for the proposed activity. The remainder of the allocation will continue to be used for the fodder and lucerne crop and also for light cattle grazing at the Tiedmans property.

A water reuse strategy is proposed to capture produced water and blend it with fresher water obtained from existing licensed allocations. The blended water will then be sampled and tested to determine if the water quality achieves the desired criteria (in accordance with the existing approval granted by DRE in 2012) for irrigation of the fodder and lucerne crops. The criteria have been set in accordance with relevant ANZECC Guidelines. It is expected that the blended water will achieve the irrigation criteria and increase the volumes of water available for agricultural purposes on site.

ii NSW Aquifer Interference Policy

An assessment of the proposed activity against the NSW Aquifer Interference Policy was prepared. Following analysis of the groundwater data sampled on site from monitoring bores for the relevant alluvial, fracture rock and porous rock aquifers, the assessment characterised these aquifers as 'less productive' (refer to Section 4.2.4 of the REF) as they have low yields and high total dissolved solids compared to the criteria for highly productive groundwater sources.

3.2.3 Socio-economic impacts

Operational impacts are not expected to affect agricultural support services due to the temporary nature and small scale of the proposed activity. The properties will continue to operate as agricultural businesses during the proposed exploration activity. There may be a temporary minor increase in regional employment during the proposed activity through the use of local contractors and suppliers, however it is not expected to reduce the labour pool used by existing agricultural practices and enterprises in the area. Furthermore, the proposed activity is not expected to impact agricultural processing and value-adding industries.

The potential for visual impact and visual sensitivity as a result of the enclosed flare facility is considered to be negligible as direct views of the flame itself would be enclosed. Furthermore the proposed flare/s facility and infrastructure is not considered to be out of context for the rural setting of each location due to the size and colour of the proposed structure.

Visual amenity has also been considered as part of the equipment selection. The fencing type and materials have been chosen based on the fencing used in the area and on neighbouring properties.

3.2.4 Strategic agricultural land

The site has not yet been mapped in accordance with the SRLUP, however the site has been considered in terms of SAL (Section 2.4.2).

4 Section B - Mitigation measures

4.1 Overview

The proposed activity will not disturb land currently used for agricultural practices. Elsewhere on the properties, land is used for light cattle grazing, which will continue to operate during the proposed activity. The land disturbed for the proposed activity will be rehabilitated to pre-activity condition or better following completion of the proposed activity for potential future agricultural activities.

4.1.1 Project design review/alternatives

The 'do nothing' alternative has been considered in comparison with conducting the proposed activity. Doing nothing carries consequences for energy supply in the Hunter region and in NSW. The main existing gas supply for NSW comes from South Australia's Cooper Basin. This resource is predicted to decline in a few years time which could lead to a reduction in energy supply to NSW (Australian Energy Regulator 2012).

The proposed pilot test well locations have been selected as the site has previously been used for gas exploration with the drilling of wells in 2011. This minimises the ground disturbance required for the proposed activity. Alternative locations within the targeted section of the PEL would require drilling of wells and therefore, greater land disturbance than the proposed activity at the site. With its existing infrastructure, the site was considered the most appropriate site to capitalise resources whilst incurring minimal environmental impacts.

4.1.2 Environmental management and monitoring programs

AGL has prepared an EMP for exploration activities within PEL 285, which will be implemented for the proposed activity at the site. The EMP outlines specific environmental management programs monitoring procedures, complaint mechanisms, consultation requirements and strategies to achieve acceptable environmental impact and minimal degrading incidents. These strategies include:

- baseline groundwater monitoring networks have been installed and will monitor groundwater levels and quality during and after pilot testing. Details of the existing monitoring bores and the monitoring programs are provided in the AGL Surface Water and Groundwater Management Plan (SWGMP) (Appendix D in the REF);
- monitoring water storage levels to ensure over flows are not experienced; and
- sampling and testing salinity level of blended water in the holding dam/ temporary water storage to ensure adequate ANZECC guidelines levels are achieved enabling irrigation of land.

Further details on the environmental management and monitoring programs are provided in the EMP.

The fracture stimulation management plan contains mitigation and contingency measures relevant to fracture stimulation activities.

4.1.3 Contingency planning

AGL has an emergency response plan in place. The emergency response plan covers injury, safety and environmental procedures and protocols. In addition to this plan, the EMP contains several specific plans which include contingency measures for environmental aspects of the proposed activity. However, given the nature of the proposed activity, the focus of contingency planning relates to the management of water. The management of both surface water and groundwater are outlined in the SGWP (Appendix D in the REF).

Table 4.1 outlines potential situations that may be encountered which will require immediate response action. The implementation of AGL's code of conduct and continual onsite management should always avoid these situations from occurring however as a precautionary measure the following trigger response plan has been developed. These responses are outlined in the approved Tiedmans irrigation documentation for the approved activities.

Table 4.1 Contingency plan for water

Indicator	Action	Response
Irrigation water electrical conductivity (EC) (in blended water dam compartment) accepted criteria	Stop pumping to dam compartment 1	Dilute with fresh water from the available licences and store in blended water dam compartment
	Investigate	Monitor EC levels in dam
Visible overland flow or breakout areas while irrigating	Stop irrigating	Reduce irrigation application rate
	Investigate	
Seepage water around the produced water dams that indicate leakage	Inspect dam to identify leak	Reduce dam levels to repair liner/banks as necessary
Development of elevated water table in natural soils adjacent to irrigation area	Stop irrigating	Reduce irrigation application rate
	Investigate	Determine need for additional irrigation areas
Rising shallow (regional) groundwater level trend outside of natural range, and more than 0.5m per annum	Stop irrigating	Reduce irrigation application rate
	Investigate	Stop altogether if levels reach surface
		Store produced water
Surface water salinity exceeds baseline levels by 20%*	Stop irrigating	Reduce irrigation application rate
	Investigate	Store produced water
		If none of these options are available, store water until production phase of project for future water treatment by reverse osmosis or other appropriate technologies.

Given the nature of hydraulic fracture stimulation and flow testing where additional data on water levels, water quality and water production trends is gathered to enhance scientific understanding of the geological and hydrogeological conditions, there are no defined triggers for actions in the SGWMP arising from these activities (Table 4.2). However, actions would be undertaken to identify significant changes in conditions during these activities. For example, a significant response in alluvial or shallowest fractured rock monitoring bores would generate an investigation and remedial response. Significant changes in deeper monitoring bore trends would also be investigated but remedial action is considered unlikely.

Table 4.2 Key water quality indicators for irrigation water supply

Indicator	Numerical criteria (trigger values)
Salinity (EC)	The EC limits for growing pasture and fodder on sand and loam soils are 4,700, and 2,700 µS/cm respectively (ANZECC and ARMCANZ 2000).
Heavy metals and metalloids	Long and short-term trigger values for heavy metals and metalloids in irrigation water are presented in Table 4.2.10 of the ANZECC Guidelines (ANZECC and ARMCANZ 2000) except where there are natural exceedances evident in the shallow groundwater and surface water data.

4.1.4 Remedial actions

The SWGMP contains monitoring and review protocols, which have been agreed with the GGP Community Consultative Committee's (GCCC) Peer Reviewer as an appropriate adaptive management approach to assess data and trends during pilot testing programs. The protocol focuses on water level and water quality baseline monitoring, and changes that may occur outside of expected seasonal changes.

4.1.5 Rehabilitation

As noted in Section 2.3, following completion of proposed activity, the pilot wells will be suspended, capped, plugged and abandoned in accordance with *EDG01: Borehole Sealing Requirements on Land: Coal Exploration* (Department of Trade & Investments Resources and Energy, April 2012) unless further testing or production is required.

Rehabilitation of pilot test wells is generally undertaken in two stages; initial rehabilitation of surplus construction area following the completion of site establishment and to cap and suspend the test wells at the completion of gas flow testing. On completion of activities, all areas including the water pipeline will be rehabilitated to return the land to its pre-existing use and condition, or better at the request of the landowner.

i Initial rehabilitation

This stage of the works generally involves the following activities:

- emptying pit(s), tanks or pipelines of water and backfill;
- reshape the land if required (cut and fill works);
- spread topsoil;
- re-vegetation by spreading seed; and
- relocation of compound fence and sediment controls.

Variations to the above activities may be required subject to site constraints, new technical information or to fit with future land uses. Screening may be provided where appropriate using vegetation sourced from the local area including drought tolerant species endemic to the local area.

The wells will be secured, capped and suspended in line with accepted industry standards, to await any further testing or production (as part of the Gloucester Gas Project).

ii Final rehabilitation and suspension

The final rehabilitation works will typically involve the following activities:

- suspension of test wells in accordance with DTIRIS-DRE Guidelines and the PEL conditions;
- removing plant and equipment and relocation of fenced compounds; and
- rehabilitation, contouring, and re-vegetation.

5 Section B - Consultation

AGL has consulted with various state and local government agencies, industry, local Indigenous groups, the general community, the GCCC and the site owner. Table 5.1 details the stakeholder consulted, details of the consultation, and issues raised and the proposed resolution measures.

Feedback from stakeholder consultation has informed the project design process, with AGL having regard for community concerns on some aspects of the proposed activities. Design measures taken in response include enclosure of the central flare, reuse of water onsite and the construction of a water pipeline to the Tiedmans property to minimise the number of truck movements to and from site. These will be implemented during the proposed activity ensuring that the activities co-exist with agriculture.

Ongoing consultation with immediate landowners will be targeted to ensure that affected parties have a clear understanding of the activities associated with pilot well testing exploration. Information provided to these landowners will clearly define the details of the pilot well testing, including location, duration, hours of operation and any other relevant information related to the activity.

In addition to targeted community stakeholder consultation, AGL has demonstrated a commitment to informing the wider regional community about the exploration activities associated with the GGP. AGL has provided a range of communication media with which it is able to disseminate information about current and upcoming activities and receive feedback and input from any member of the community.

AGL has implemented a wide reaching, inclusive approach to consultation which seeks to inform all aspects of the local and wider community as to current and future exploration activities associated with the GGP. The approach to communication through a range of options is detailed in Table 5.1.

Table 5.1 Consultation activities undertaken

Item	Summary
Project website www.agk.com.au/gloucester	Website includes regular project updates to keep all member of the community informed of current and planned future activities.
Project telephone line and email address 1300 886 170 gloucester@agl.com.au	The project telephone and answering is staffed 24 hours per day to respond to community enquiries. A dedicated email address has also been established to respond to community concerns or queries.
Gloucester office 22 Tate Street Gloucester 02 6558 1166	AGL's Gloucester office is in Gloucester and is staffed by AGL personnel who are available to discuss and answer enquiries about the GGP.
Community information sessions	Community information sessions have been undertaken by AGL and will continue as requested by local community groups.
Stakeholder meeting	Meetings with stakeholders include government agencies, indigenous groups, local community groups and surrounding landowners.

Table 5.1 Consultation activities undertaken

Item	Summary
Communication materials	Community updates –Information placed in local newspapers. Surrounding landowners will be provided with written information which details the location, duration and hours of operation of the pilot well testing activities. Contact details will also be provided to surrounding landowners to provide a direct form of contact to AGL in the event of a concern/impact during pilot well testing activities.
Landholders (Gloucester Resources)	There has been ongoing communication since late 2010 between AGL and Gloucester Resources (GRL). Meetings have been held in the AGL office to discuss access options, water bore licence applications and to develop access and compensation agreements. During site construction and drilling of wells, AGL consulted with GRL and kept them up to date on all activities on site via phone calls and emails at management level and during site discussions at the field level; Meetings are ongoing as required to discuss the logistics for the next phase of the process (ie flow testing program and in particular the vehicle movements and water management on site for each).
Gloucester Community Consultation Committee (GCCC)	The GCCC provides a direct line of communication to a number of community representatives and allows direct feedback to AGL as to community issues related to the GGP. This direct line of communication allows AGL to make informed decisions for their exploration activities that has regard for, and mitigates wherever possible, community concerns around the activity. GCCC members include local government, MidCoast Water, local business, agriculture, Industry, landowners, community groups and AGL. The GCCC meets every two months and minutes of these meetings are posted on AGLs website.

6 Conclusion

This AIS has been prepared in accordance with the AIS Guidelines (DRE, 2012) and SRLUP (DP&I, 2012) for the fracture stimulation and pilot testing of four existing vertical exploration wells on two properties in PEL 285; 20 Grantham Road (Lot 11 DP 841445) and 197 Fairbairns Road (Lot 251 DP 785579), Forbesdale and a water pipeline through Lot 2, DP 1040412, Lot 1, DP 196054 and Lot 26, DP 1112877.

The purpose of fracture stimulation and pilot testing is to identify potential CSG resources by testing the composition, flow rate and volume of gas in target coal seams. The fracture stimulation and pilot testing program is also important to assess water production volumes and whether there is any connectivity between shallow aquifers and deep coal seam water bearing zones. The activity will be temporary with the wells suspended and the surplus land rehabilitated to its pre-existing state at completion of the activity. The purpose of this AIS is to identify and asses any potential agricultural impacts caused by the proposed activity.

A risk assessment under Section A of the AIS Guideline indicated that the proposed activity represented a **low risk to agriculture (D4)**. However, due to community interest, further assessment in accordance with Section B of the AIS Guidelines was undertaken. This assessment (presented in Chapters 3, 4 and 5 of this AIS) has demonstrated the proposed activity poses a low risk and therefore will not result in significant impacts to:

- BSAL or CICs;
- agricultural resources or production of the site and surrounding area; and
- agricultural enterprises in the surrounding area.

The land that is disturbed from the proposed activity will be rehabilitated to pre-activity or better following completion of the activities. Subject to the results of the flow testing, this land will be available for agricultural activities.

Appendix A

AIS guidelines

Fact Sheet

November 2012

STRATEGIC REGIONAL LAND USE POLICY

Guideline for Agricultural Impact Statements at the Exploration Stage

This guideline describes the requirements for an Agricultural Impact Statement (AIS) for mineral and petroleum (including coal seam gas) exploration activities. This guideline should be read in conjunction with the Division of Resources & Energy *Environmental Impact Assessment (REF) Guidelines*.

INTRODUCTION

Some areas of regional NSW are experiencing significant growth in mining and petroleum (including coal seam gas) projects, leading to increasing land use conflicts, particularly with agricultural industries.

In response, the NSW Government has delivered its Strategic Regional Land Use Policy, which sets out a range of initiatives to better balance growth in the mining and coal seam gas industries with the need to protect important agricultural land and water resources.

One of these initiatives is the new requirement for an AIS for mineral and petroleum (including coal seam gas) exploration activities.

WHEN IS AN AIS REQUIRED?

An AIS is required for exploration activities subject to further approval under the *Mining Act 1992* or *Petroleum (Onshore) Act 1991* and submission of a Review of Environmental Factors (REF) for assessment under Part 5 of the *Environmental Planning and Assessment Act 1979*. These activities are defined in the conditions of exploration licences.

The requirements described in this interim guideline will be replaced by (and included in) an updated version of the Division of Resources & Energy *Environmental Impact Assessment (REF) Guidelines*.

The requirements for an AIS for State Significant Development applications for mining and petroleum (including coal seam gas) are listed in the Department of Planning and Infrastructure's *Guideline for Agricultural Impact Statements*.

THE PURPOSE OF AN AIS

The purpose of an AIS is to ensure a focused assessment of the potential impacts of exploration activities on agricultural resources or industries.

The term 'agricultural resources or industries' is used to describe the land on which agriculture is dependent and the associated water resources (quality and quantity) that are linked to that land.

The information provided in the AIS will form a key component of the assessment process in terms of evaluating and avoiding impacts on and loss of agricultural lands.

The Division of Energy and Resources (DRE) within NSW Trade & Investment will consult with the Office of Agricultural Sustainability & Food Security in determining the exploration activity application.

WHAT SHOULD BE INCLUDED IN AN AIS

The level of detail in the exploration AIS must be consistent with the likely level of impact. The level of detail required in an AIS for exploration activities will reflect the risk associated with that activity.

For example, where the exploration activity is constrained to a small area over a short timeframe and has no permanent impacts, the explorer will be expected to provide enough information to establish that the activity is low risk. However, larger scale exploration activities, such as coal seam gas pilot testing would need to fully consider impacts on agricultural resources and industries.

SECTION A

The following information must be provided as part of the AIS for all exploration activities:

- Briefly describe the nature, location, intensity and duration of the proposed exploration activity;
- Briefly describe the nature and location of agricultural resources and industries with the potential to be impacted by the proposed exploration activity;
- Briefly describe how and when any disturbance resulting from the exploration activity will be rehabilitated;
- Identify and describe the nature, duration and consequence of any impacts on agricultural resources and industries; and,
- With reference to Tables 1-3 (*Agricultural Impact Risk Ranking*), identify the risk of the proposed exploration activity impacting on agricultural resources or industries.

Where the exploration activity is demonstrated to result in a low risk of agricultural impacts, no further information is required to be submitted as part of the AIS.

Examples of low risk exploration activity are:

- *The proposed exploration activity is located on agricultural land or on rural land with low potential for commercial agricultural land use*
- *No intensive agricultural activities are being undertaken in the immediate vicinity of the proposed exploration activity*
- *The duration of the exploration activity is short (e.g. less than one month at a particular location)*
- *The proposal is not part of a larger project so there are unlikely to be cumulative impacts;*
- *All surface disturbance will be fully rehabilitated to the pre-existing land condition or better*
- *The proposed exploration activity will not result in permanent impacts on water or land resources.*

Examples of the characteristics of moderate to high risk exploration activity are:

- *The proposal is located on or near Biophysical Strategic Agricultural Land (BSAL) or Critical Industry Cluster (CIC)*
- *There are significant concerns about the project in the agricultural community.*

Table 1 Agricultural Impact Risk Ranking - matrix

PROBABILITY / CONSEQUENCE	A Almost Certain	B Likely	C Possible	D Unlikely	E Rare
1. Severe and/or permanent damage. Irreversible impacts.	A1	B1	C1	D1	E1
2. Significant and /or long term damage. Long term management implications. Impacts difficult or impractical to reverse.	A2	B2	C2	D2	E2
3. Moderate damage and/or medium-term impact to agricultural resources or industries. Some ongoing management implications which may be expensive to implement. Minor damage or impacts over the long term.	A3	B3	C3	D3	E3
4. Minor damage and/or short-term impact to agricultural resources or industries. Can be managed as part of routine operations.	A4	B4	C4	D4	E4
5. Very minor damage and minor impact to agricultural resources or industries. Can be effectively managed as part of normal operations.	A5	B5	C5	D5	E5

where:

	= low risk
	= medium risk
	= high risk

Table 2 Agricultural Impact Risk Ranking - probability descriptors

Level	Descriptor	Description
A	Almost certain	Common or repeating occurrence
B	Likely	Known to occur or it has happened
C	Possible	Could occur or I've heard of it happening
D	Unlikely	Could occur in some circumstances but not likely to occur
E	Rare	Practically impossible or I've never heard of it happening

Table 3 Agricultural Impact Risk Ranking - consequence descriptors

Level: 1	**Severe Consequences**	**Example of Implications**
Description	• Severe and/or permanent damage to agricultural resources, or industries • Irreversible • Severe impact on the community	• Long term (eg 20 years) damage to soil or water resources • Long term impacts (eg 20 years) on a cluster of agricultural industries or Important agricultural lands
Level: 2	**Major Consequences**	**Example of Implications**
Description	• Significant and/or long-term impact to agricultural resources, or industries • Long-term management implications • Serious detrimental impact on the community	• Water or soil impacted, possibly in the long term (eg 20 years) • Long term (eg 20 years) displacement / serious impacts on agricultural industries
Level:3	**Moderate Consequences**	**Example of Implications**
Description	• Moderate and/or medium-term impact to agricultural resources, or industries • Some ongoing management implications • Minor damage or impacts but over the long term.	• Water or soil known to be affected, probably in the short – medium term (eg 1-5 years) • Management could include significant change of management needed to agricultural enterprises to continue.
Level: 4	**Minor Consequences**	**Example of Implications**
Description	• Minor damage and/or short-term impact to agricultural resources, or industries • Can be effectively managed as part of normal operations	• Theoretically could affect the agricultural resource or industry in short term, but no impacts demonstrated • Minor erosion, compaction or water quality impacts that can be mitigated. • For example, dust and noise impacts in a 12 month period on extensive grazing enterprises.
Level: 5	**Negligible Consequences**	**Example of Implications**
Description	• Very minor damage or impact to agricultural resources, or industries • Can be effectively managed as part of normal operations	• No measurable or identifiable impact on the agricultural resource or industry

November 2012

SECTION B

If the proposed exploration activity is identified as a **medium or high risk exploration activity**, the following information must be submitted as part of the AIS.

Note. Exploration activities falling into the red or orange areas of the Agricultural Impact Risk Ranking Matrix (Table 1) are medium or high risk exploration activities. These include the following risk rankings:

- *A1-A3*
- *B1-B2*
- *C1-C2*
- *D1*

Assessment of resources

Agricultural resources and production

Note. The following information will help in determining the direct impacts of the exploration activity on agricultural resources and production. This information will also help in understanding the significance of agricultural production and assist in identifying stakeholders who may potentially be impacted by the exploration activity.

The AIS should include information (as text and/or maps), where relevant on the following:

- any land identified as Strategic Agricultural Land (SAL) on or within two kilometres of the exploration activity;
- soil characteristics, including types and depth;
- topography and slope;
- land capability characteristics;
- potentially affected water sources and other water users' water licence volumes and extraction locations;
- water quality and typical bore yield rates in these potentially affected water sources;
- current land use and relevant history of the agricultural enterprises for areas potentially impacted by the exploration activity;
- key agricultural support infrastructure (e.g. roads, railways, processing facilities);
- location and type of agricultural industries; and,
- climate conditions, including rainfall.

Current agricultural enterprises

The AIS should describe the location and production levels of commodities produced by agricultural enterprises which may potentially be impacted by the exploration activity. This should include:

- the location and area of land to be temporarily removed from agriculture;
- the location and area of land to be returned to agricultural use post-exploration, and its productive potential relative to pre-exploration; and,
- the location and area of land that will not be returned to agriculture.

Only information that is publicly available is required to be provided in the AIS.

Assessment of impacts

Identification and assessment of the impacts of the project on agricultural resources or enterprises

The AIS should identify any adverse impacts (including cumulative impacts) on agricultural resources and industries in the area which may potentially be impacted by the exploration activity.

The AIS should include a risk-based assessment of:

- the effects of the project on agricultural resources;
- consequential productivity effects of this on agricultural enterprises;
- uncertainty associated with the predicted impacts and mitigation measures and the consequences of and likelihood that these uncertainties will be realised; and,
- additional risks to agriculture such as weed management, biosecurity, subsidence, dust, noise, vibration, fire and traffic conditions that may affect access to markets and supplies.

The impact assessment relating to agricultural enterprises should extend to farm productivity, land values and flow-on impacts to regional communities.

Account for any physical movement of water away from agriculture

Any water that might be transferred or will no longer be available for agricultural use as a result of the exploration activity should be identified in the AIS.

The potential impacts of the exploration activity on water resources should be identified, quantified and compared with the minimal impact considerations, consistent with the requirements of the Aquifer Interference Policy.

Assessment of socio-economic impacts

If the duration of the project is greater than 6 months then the AIS should include a risk based assessment of the likely impacts directly on agricultural production or marketing (e.g. farm labour availability) and any possible impacts on agricultural support services, processing, value adding industries and regional employment.

If it is likely that there will be impacts beyond the local area of the project, the socio-economic assessment must consider the impacts on agricultural support services and value adding industries relevant to affected agricultural enterprises including potential impacts on local and regional employment.

The socio-economic impact assessment must also address any potential impact on visual amenity, landscape values and tourism infrastructure relied upon by local and regional agricultural enterprises.

Additional requirements for activities on or near Strategic Agricultural Land

If the exploration activity is located on or within two kilometres of SAL, the AIS must specifically address the potential impacts of the activity on SAL.

Mitigation Measures

Identification of options for minimising adverse impacts on agricultural resources

The AIS should document feasible options to avoid, minimise or mitigate potential significant impacts on agricultural resources, including agricultural lands, enterprises and infrastructure at the local and regional level including:

- project design review/alternatives;
- proposed monitoring programs to assess predicted versus actual impacts as the exploration activity progresses;
- trigger response plans and trigger points at which exploration activities will cease or be modified or remedial actions will occur to address impacts including a process to respond to unforeseen impacts;
- the proposed remedial action to be taken in response to a trigger event;
- the basis for assumptions made about the extent to which remedial actions will address and respond to impacts;
- demonstrated capacity for the rehabilitation of disturbed lands to restore agricultural resources; and
- demonstrated planning for rehabilitation that minimises the extent of disturbances.

Consultation

Community consultation requirements will be imposed as a condition of all exploration licences.

DRE Community Consultation Guidelines outline the minimum requirements licence holders must comply with regarding community consultation.

FOR FURTHER INFORMATION

If you would like further information relating to the preparation of Agricultural Impact Statements, or the Strategic Regional Land Use Policy, please visit:

Department of Planning & Infrastructure website:
www.planning.nsw.gov.au

Division of Resources & Energy website:
www.resources.nsw.gov.au

Department of Primary Industries website:
www.dpi.nsw.gov.au

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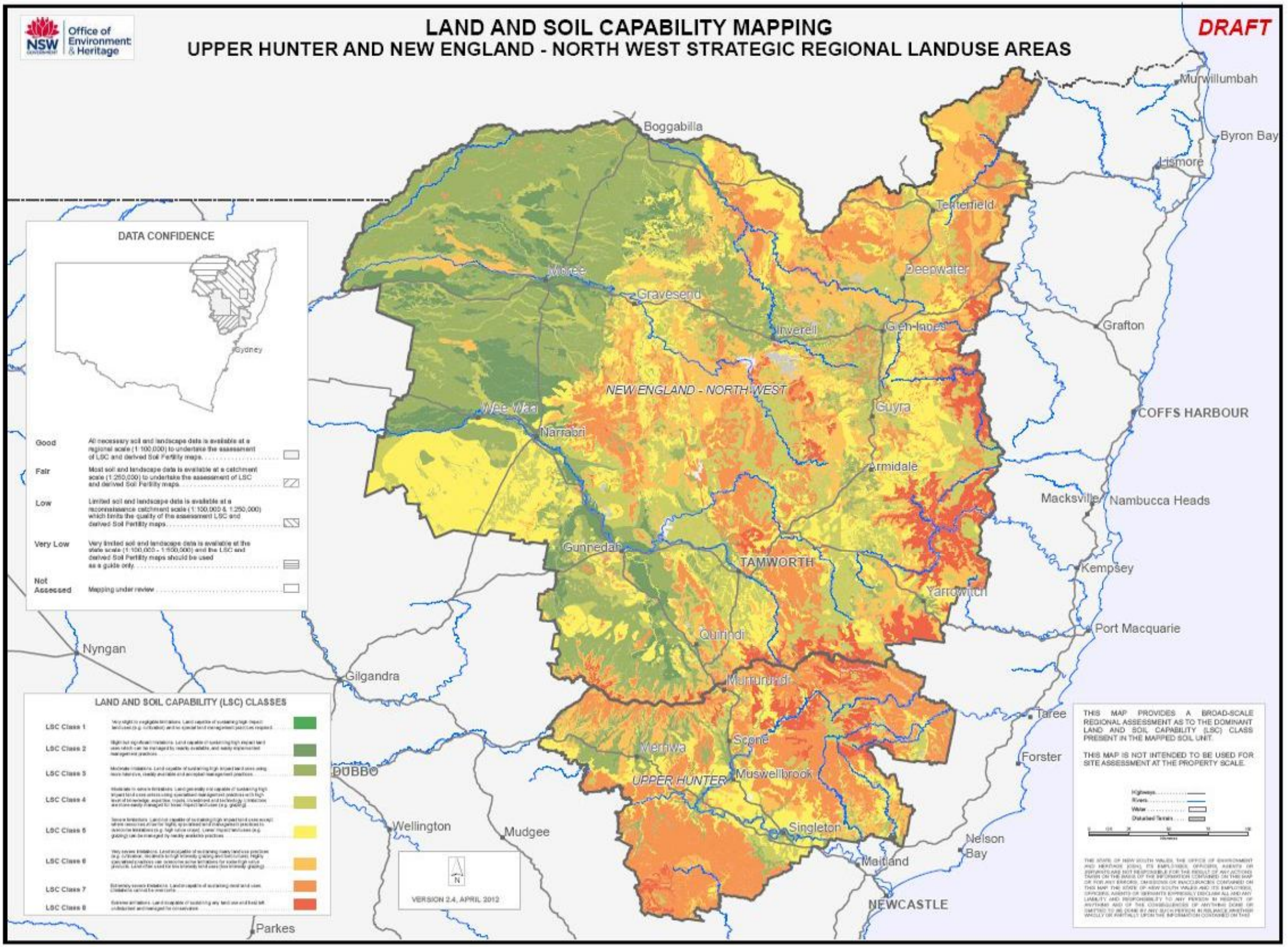
Appendix B

Draft Inherent Soil Fertility and Draft Land and Soil Capability (LSC) mapping

LAND AND SOIL CAPABILITY MAPPING
UPPER HUNTER AND NEW ENGLAND - NORTH WEST STRATEGIC REGIONAL LANDUSE AREAS

DRAFT

Office of Environment & Heritage



DATA CONFIDENCE

Good	All necessary soil and landscape data is available at a regional scale (1:100,000) to undertake the assessment of LSC and derived Soil Fertility maps.
Fair	Most soil and landscape data is available at a catchment scale (1:250,000) to undertake the assessment of LSC and derived Soil Fertility maps.
Low	Limited soil and landscape data is available at a reconnaissance catchment scale (1:100,000 & 1:250,000) which limits the quality of the assessment LSC and derived Soil Fertility maps.
Very Low	Very limited soil and landscape data is available at the state scale (1:100,000 - 1:1,500,000) and the LSC and derived Soil Fertility maps should be used as a guide only.
Not Assessed	Mapping under review

LAND AND SOIL CAPABILITY (LSC) CLASSES

LSC Class 1	Very slight to negligible limitations. Land capable of sustaining high impact land uses (e.g. cultivation) and the special land management practices required.
LSC Class 2	Slight but significant limitations. Land capable of sustaining high impact land uses which can be managed by readily available, and easily implemented management practices.
LSC Class 3	Moderate limitations. Land capable of sustaining high impact land uses using more intensive, readily available and accepted management practices.
LSC Class 4	Moderate to severe limitations. Land generally not capable of sustaining high impact land uses unless using specialised management practices with high level of knowledge, expertise, inputs, investment and technology. Limitations are more easily managed for lower impact land uses (e.g. grazing).
LSC Class 5	Severe limitations. Land not capable of sustaining high impact land uses except where resources allow for highly specialised land management practices to overcome limitations (e.g. high value crops). Lower impact land uses (e.g. grazing) can be managed by readily available practices.
LSC Class 6	Very severe limitations. Land incapable of sustaining many land use practices (e.g. cultivation). Moderate to high intensity grazing land but not all. Highly specialised practices can overcome some limitations for suited high value products. Land often used for less intensely land uses (low intensity grazing).
LSC Class 7	Extremely severe limitations. Land incapable of sustaining most land uses. Considered suitable for a few land uses.
LSC Class 8	Extreme limitations. Land incapable of sustaining any land use and should be undisturbed and managed for conservation.

VERSION 2.4, APRIL 2012

THIS MAP PROVIDES A BROAD-SCALE REGIONAL ASSESSMENT AS TO THE DOMINANT LAND AND SOIL CAPABILITY (LSC) CLASS PRESENT IN THE MAPPED SOIL UNIT.

THIS MAP IS NOT INTENDED TO BE USED FOR SITE ASSESSMENT AT THE PROPERTY SCALE.

Highways
Rivers
Water
Disturbed Terrain

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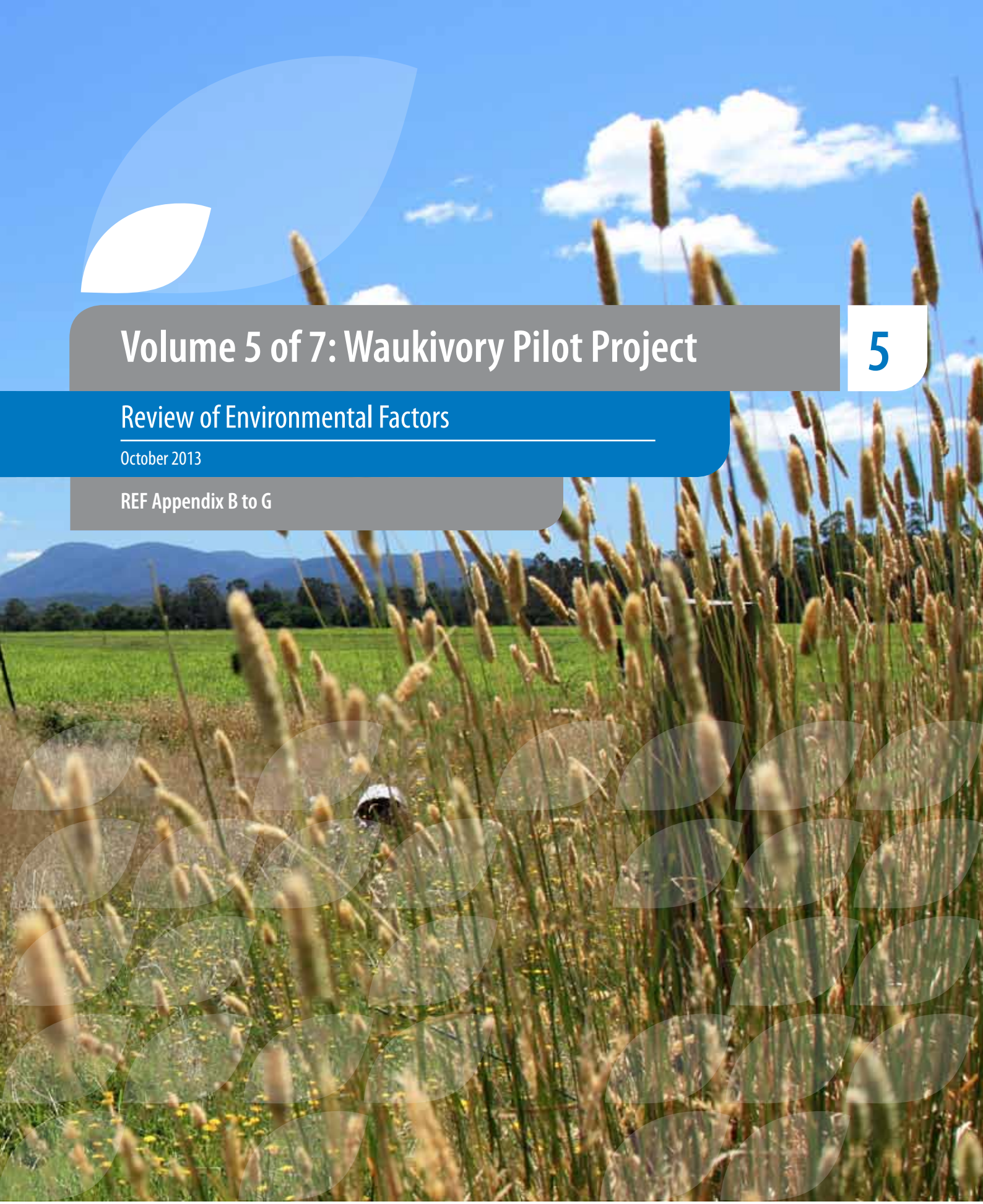
Volume 5 of 7: Waukivory Pilot Project

5

Review of Environmental Factors

October 2013

REF Appendix B to G



AGL Energy in action.

EMM
EMGA Mitchell McLennan

Appendix B

Fracture stimulation management plan

Fracture Stimulation Management Plan Waukivory Pilot, Gloucester NSW

AGL Upstream Investments Pty Limited

Date: September 2013

Table of Contents

Document Revision History

Date	Version	Author	Reviewers	Comment
15/09/2013	5	R Braikenridge	M Moraza	Prior to REF submission
23/08/2013	4	R Braikenridge	M Roy, S Westgate, R Walker	
26/06/2013	3	R Braikenridge	R Walker	
02/04/2013	2	R Braikenridge	S Westgate	
22/03/2013	1	M Roy & J Czapla	R Braikenridge, A Parker, G Comber, J Ross, T Laurie, T Ryan	

1 Introduction

What is a Fracture Stimulation Management Plan?

[Code of Practice, Sections 1.1, 1.2 and Section 1.3 *Leading Practice*]

This Fracture Stimulation Management Plan (**FSMP**) identifies and explains hydraulic fracture stimulation activities carried out in the Gloucester Gas Project (GGP), in compliance with the *Code of Practice for Coal Seam Gas – Fracture Stimulation Activities* (**Code of Practice**).

This FSMP identifies risks (health, safety and environmental) and risk mitigation methods to facilitate safe execution of fracture stimulation activities. It also describes fracture diagnostic tools that are used to understand fracture growth (geometry) in the selected coal seams being stimulated. All fracture treatments are to be conducted in accordance with the FSMP.

The Code of Practice sets out the principles, mandatory requirements and leading practice targets to be adopted in FSMPs. Overarching mandatory requirements of the FSMP are:

a) fracture stimulation activities will not be conducted except in accordance with the approved FSMP;
b) the FSMP describes the nature, location, scale, timing, duration hours of operation and other relevant features of the fracture stimulation;
c) the FSMP demonstrates that all risks to the environment, existing land uses, the community and workforce, as a result of the fracture stimulation activity, are managed through an effective risk management process that includes identification of hazards, assessment of risks, implementation of control measures and monitoring of the integrity and effectiveness of the control measures;
d) the FSMP identifies how AGL will address and comply with each requirement of the Code of Practice;
e) compliance - the FSMP will be reviewed and as necessary revised by AGL in certain circumstances (see Section 3);
f) the detail provided in the FSMP is appropriate to the nature, scale, intensity and potential impacts of the proposed fracture stimulation activities; and
g) commercially sensitive and personal information is not included in the FSMP, unless specifically required by the Code of Practice.

A number of the requirements in the Code of Practice duplicate other regulatory document requirements or systems adopted by AGL. To avoid duplication and ensure that the FSMP is properly integrated into AGL's environmental management system, the FSMP will form part of the Gloucester Gas Project Environmental Management System.

Where relevant this FSMP also makes reference to other key documents including Management Plans and Codes of Practice (section 1.3 of the Code of Practice).

1.1 Operations

This FSMP covers fracture stimulation activities at the Waukivory Pilot project, Gloucester, NSW. The Review of Environmental Factors (REF) that this FSMP relates to describes the Waukivory Pilot project as:

- the conversion of four existing exploration wells to pilot wells using perforating and fracture stimulation techniques;
- pilot testing four wells;
- construction of water storages for flowback and produced water;
- construction of associated infrastructure including water pipelines and gas gathering lines;
- enclosed central gas flare/s;
- delivery of equipment and water;
- lawful disposal of flowback water to an appropriate facility;
- transport of produced water;
- suspension of exploration wells; and
- site rehabilitation of surplus land.

The general operation details of the fracture stimulation activity are set out in the following table.

Type of Fracture Stimulation Activities	Water/Linear Gel Based Fluids
Exploration Area	Gloucester Basin, NSW
Petroleum Exploration Licence (PEL)	PEL 285
Well Names and Numbers	Waukivory 11, 12, 13 and 14
Anticipated Execution Date	Q4 2013
Duration	60 days*

*The REF describes 7 days for perforating, and 5-7 days for fracture stimulation per well. However when completing these items in conjunction with each other, including securing the well and mobilising equipment between each wellsite, and the delivery of materials and water for each wellsite, the perforating and fracture stimulation of the four pilot wells are estimated to take approximately 60 days.

1.2 Objectives of Fracture Stimulation

AGL employs multiple techniques to enhance gas production from its natural coal seam gas (CSG) activities; horizontal drilling, under-reaming, and hydraulic fracture stimulation. The stimulation or production enhancement technique used depends on the properties of the coal formation, and the number of targeted coal seams in a well.

Within AGL's New South Wales CSG activities, 123 wells from a total of 160 wells drilled (as at August 2012) have been hydraulically fracture stimulated.

Hydraulic fracturing creates a more efficient flow path for the CSG thereby increasing its production. By increasing the CSG produced by each well, AGL can:

- Reduce the number of wells required for drilling and production
- Minimise the surface or visual impact of the project
- Increase the reservoirs economic lifetime
- Increase recoverable reserve

Understanding fracture design and geometry enables AGL to optimise well spacing and number of wells, and risks associated with hydraulic fracture stimulation.

This FSMP outlines the methodology to be used in hydraulic fracture stimulations in AGL's CSG development from planning design phase, job execution phase and post-job monitoring including flowback of fracture stimulation fluids. The objective is to facilitate best practice and minimise health, safety and environmental risks associated with hydraulic fracture stimulation.

[Code of Practice, Sections 16.1, 16.2 and Section 16.3 *Leading Practice*]

Other CSG specific industry Code of Practices or guidelines applicable to this document are:

- NSW *Code of Practice* for Coal Seam Gas Well Integrity 2012
- American Petroleum Institute (API) Guidance Document HF 1 *Hydraulic Fracturing Operations* – Well Construction and Integrity Guidelines October 2009
- API Guidance Document HF 2 *Water Management Associated with Hydraulic Fracturing June 2010*
- API Guidance Document HF 3 *Practices of Mitigating Surface Impacts Associated with Hydraulic Fracturing January 2011*
- API RP 51R *Environmental Protection for Onshore Oil and Gas Production Operations and Leases July 2009*
- API std 65-2 *Isolating Potential Flow Zones During Well Construction December 2010*
- AS/NZS ISO 31000:2009 Risk management – Principles and guidelines

These are available at http://www.api.org/policy/exploration/hydraulicfracturing/

What is Hydraulic Fracture Stimulation?

During a hydraulic fracture stimulation treatment, fluid (typically over 99% water) is pumped down the wellbore into the selected coal seam (also called a formation). The fluid is pumped at a pressure high enough to widen existing natural fractures (cleats) in the coal seam. When fracturing a coal seam, the fracture follows an existing cleat or pathway along the coal seam.

As pumping continues, the fracture extends from the wellbore and grows. Once the desired geometry of the fracture is created, proppant (sand) is added to the fluid and pumping continues until the proppant is placed into the fracture. When all the proppant is in the fracture, pumping is stopped. The pressure inside the fracture drops and the stress in the formation reduces such that the fracture closes. The closing fracture traps the proppant inside the formation and helps to maintain a permeable and conductive path through the coal seam to the wellbore.

The permeable path left in the formation is the main objective of the fracture stimulation. This proppant flow path enhances production by allowing groundwater from the coal seam (produced water) and gas to flow from the coal seam to the wellbore with minimised resistance.

Typical hydraulic fracture stimulations performed for AGL create fractures that are estimated to be 5 - 20 millimetres wide and extend laterally (fracture stimulation length) for 20 to 60 metres within the coal seam. The height of the fracture may vary from field to field. Fractures are typically contained within the coal seam. This is because the sealing rocks above and below the coal seam, which are significantly harder than a coal, limit the vertical height growth of the fracture.

In certain formations a fracture may grow vertically beyond the coal seam as the fracture extends laterally away from the wellbore. This would be very rare and the extent of this vertical height growth would be minimal due to the relatively small (in terms of fluid injected and pressures applied) fracture treatments conducted on CSG wells. The intention is to optimise the fracture in the coal seam and not the bounding layers. Fracture geometry is monitored during fracture stimulation and adjustments will be made if necessary to minimise the risk of vertical growth. These measures are discussed further in section 2.6 and section 8 of this FSMP.

Why Use Hydraulic Fracture Stimulation?

Hydraulic Fracture Stimulation has been used in the oil and gas industry since the 1950s as a technique for enhancing production. The basic premise behind hydraulic fracture stimulation is that it creates a higher permeability pathway within the coal seam connected back to the cased wellbore. It is particularly effective in low-permeability formations.

Hydraulic fracture stimulation has evolved into a suitable technique to stimulate most wells under extremely varying circumstances. Originally developed for conventional low-permeability oil and gas wells around 60 years ago, it still plays a crucial role in developing low-permeability conventional reservoirs and is increasingly used to produce higher levels of gas from unconventional low-permeability carbonates, shales and coal seam reservoirs.

1.3 Responsibilities

AGL Upstream Investments Pty Ltd (AGL) is responsible for compliance with this FSMP. The fracture treatment is designed based on coal reservoir properties, fracture-engineering guidelines, previous experience, fracture stimulation modelling and post job analysis. The fracture design is done in close consultation with the geological and reservoir department and the selected fracturing service provider (also the principal contractor).

The gas production well monitoring (water quality sampling and tracking of pumped volumes) is undertaken by the AGL Operations and consultants specifically engaged to monitor water levels and water quality (see separate Groundwater Management Sub-Plans).

2 Background

The Gloucester Gas Project is located within the Gloucester Geological Basin. The Gloucester Basin is sedimentary in origin with the deposition of sediments occurring from the early Carboniferous (290 million years ago) to likely the latter part of the Triassic (200 million years ago) though Permian sediments currently remain in the Basin. The Gloucester Basin is small in size and has undergone a significant amount of deformation associated with the New England Fold Belt.

2.1 Geology

[Code of Practice, Section 3.2(a)]

The Gloucester Basin is divided up into three major stratigraphic units: the Alum Mountain Volcanics, the Dewrang Group and the Gloucester Coal Measures. The Dewrang Group and the Gloucester Coal Measures contain 15 laterally extensive coal units and represent the main coal seam gas targets.

Exploration activities in the study area will target the Gloucester Coal Measures (which are located at depths from surface to over 1000m). Gas content of the coal is commonly of the order of 1-20m^3/tonne with gas content increasing with depth. The stratigraphy of the Gloucester Basin is presented in Figure 1 *(adapted from* Lennox, M., 1991).

The Gloucester Basin is a north south trending synclinal shaped trough containing Permian volcanics and sediments. Basement comprises Carboniferous sedimentary rocks and volcanic units. The basin sequence is capped by Late Permian fluvial-deltaic sediments of the Dewrang Group and Gloucester Coal Measures. The top of the Permian section has been exposed to erosion.

Throughout the evolution of the Gloucester Basin, sandstones, mudstones, conglomerates and coals were deposited in fault-controlled troughs. The preserved basin stratigraphy is up to 4000m thick. Widespread Early Permian volcanic activity may be related to thermal upwelling beneath the base of the continental lithosphere in a retroarc basin setting. Due to the Late Permian fall in relative sea level, shallow water and fluvial conditions prevailed. The complex interplay of tectonics extensional faulting, high rates of sediment supply produced significant lateral stratigraphic variability throughout the Gloucester Basin.

The Gloucester Basin exhibits a complex structural history. Early normal and syn-depositional faults occur and in many cases have been reactivated by the later Hunter-Bowen orogenic events. The Gloucester Basin displays steep dips of up to 80° on its flanks, dipping towards the north-south trending basin axis and relatively flattening towards the centre of the basin. The basin is dissected by several major thrust structures.

Stratigraphy of the Gloucester Basin

			Formation		Seam	Depositional Environment
UPPER PERMIAN	GLOUCESTER COAL MEASURES	CRAVEN SUBGROUP	Crowthers Rd Conglomerate		Conglomerate, minor sandstone	Distal Alluvial Fan
			Leloma Formation		Sandstone, minor siltstone and coal	Alluvial Plain
					Linden Coals	
					Marker/JD Coals	
					Jo Doth Tuff	
					Bindaboo Coals	
					Deards Coal	
					Sandstone, minor siltstone and coal	
			Jilleon Formation		Cloverdale Coal	Hiatus Coal
					Conglomerate, sandstone and siltstone	Alluvial Plain
					Roseville Coal	
					Tereel Coals/Fairbairns Lane	
			Wards River Conglomerate		Conglomerate and sandstone	Distal Alluvial Fan
			Wenhams Formation		Bowens Rd Coal	Hiatus Coal
					Siltstone	Marsh
					Bowens Rd Lower Coal	Back Barrier Coal
			Speldon Formation		Marine influenced sandstone	Marginal Marine, prodelta, beach
		AVON SUB GROUP	Dogtrap Creek Formation		Glenview Coal	Back Barrier Coal
					Sandstone, siltstone	Lower Delta Plain
			Waukivory Creek Formation		Avon Coals	Hiatus Coal
					Triple, Rombo, Glen Rd	Upper Delta Plain
					Sandstone and siltstone	Upper Delta Plain
					Parkers Rd and Valley View Coals	Hiatus Coal
					Siltstone and mudstone	Transitional
	DEWRANG GROUP		Mammy Johnsons Formation		Sandstone and siltstone	Marginal Marine, Barrier, Wave Dominated Delta
					Intra Mammy Johnsons Coal	Back Barrier Coal
					Bioturbated sandstone	Marginal Marine, Barrier, Wave Dominated Delta
			Weismantels Formation		Siltstone and mudstone	Back Barrier Lagoon
					Weismantels Coal	Back Barrier Coal
			Duralie Road Formation		Marine Sandstone, conglomerate	Marginal Marine, Fan Delta
LWR PERM			Alum Mountain Volcanics		Clareval Coal	Hiatus Coal
					Conglomerate and coal	Distal Alluvial Fan
					Rhyolite, basalt, welded tuff	Bimodal Terrestrial Volcanics
					Basal Coal	

Figure 1: Stratigraphy of the Gloucester Basin

2.2 Hydrology and Hydrogeology

[Code of Practice, Section 3.2(b), 7.2(a)]

Surface water

The Waukivory site is within the Manning River Catchment (approximately 8,200 km^2 in size) and the Avon River Sub Catchment. The Avon River originates to the south west of Gloucester and joins the Gloucester River to the north of the township of Gloucester. Waukivory Creek, Dog Trap Creek and Avondale Creek are also located within the Sub Catchment.

The Avon River is a gaining stream in this area i.e. there are groundwater seepage discharges to the river. Baseflow accessions from the shallow alluvium are expected in this area based on data from the nearby Waukivory gauging station (PB, 2012b). The Avon River is mostly a permanent stream although during low rainfall periods there is negligible flow and the river can be reduced to a succession of waterholes.

Water quality is highly variable ranging from fresh (after periods of rain) to brackish (after extended dry periods).

Groundwater

The broader (ridgeline) areas of the Gloucester Basin south of Gloucester are underlain by Carboniferous volcanics, the hillsides by a variety of Permian sedimentary rocks while the valley floors are underlain by Quaternary alluvium associated with the Avon River and other minor tributaries.

Groundwater in the Permian rocks is a low value water resource and is rarely used for agricultural and other consumptive uses. Rock permeabilities are generally low, aquifers are mostly bedding and fracture zones, bore yields in rocks and fracture zones are very low and water quality is generally brackish to slightly saline.

Based on the latest water level, water quality and isotope data from the Phase 2 studies (PB, 2012a), there is a good appreciation of groundwater recharge, discharge and flow processes through the different hydrogeological units of the Gloucester Basin. These units (based on SRK Consulting, 2010) are confirmed as:

- Alluvial aquifers;
- Fractured bedrock aquifers;
- Coal seam water bearing zones;
- Confining units.

Only the first two units are aquifers. The deeper rock types being either very poor aquifers/aquitards (coal seams, siltstones and sandstones) or confining aquitard/aquiclude layers (claystones or indurated sandstones).

The **alluvium** is relatively shallow (maximum 15m thickness) and in some areas contains an unconfined (sand and gravel) aquifer. Water tables are generally less than 5m below surface. Groundwater flow processes are relatively simple with rainfall being the predominant recharge source on the floodplain. Flooding occasionally adds additional recharge water to the alluvial water table. Groundwater discharge from the alluvium is to the rivers as baseflow and shallow groundwater is also expected to be transpired by riparian vegetation.

The **bedrock** contains mostly tight siltstone and indurated sandstone rock types with occasional thin semi-confined sedimentary/fractured aquifers (typically to around 75m depth). Water tables are

generally greater than 10m below surface with deepest levels at elevated sites and in areas of active coal mining. Rainfall is the only recharge source to the bedrock aquifers and recharge does not occur everywhere in the landscape. Recharge mostly occurs in areas of rock outcrop. In areas where there is a weathered (clayey) profile, brackish to saline water quality suggests there is negligible (vertical) rainfall recharge. Groundwater flow in bedrock aquifers is lateral, either within local fracture zones or individual strata if there are no interconnecting and open fracture zones. Groundwater discharge is via seepage to springs and to the alluvium (and indirectly to creeks and rivers) along the floor of the valley.

The groundwater in the deeper bedrock units is moving very slowly with lateral movement within each rock unit predominating. Confining rock permeabilities are very low; coal seam permeabilities are slightly higher (but are still not high enough to be considered aquifers).

Therefore, the only beneficial aquifers in the region are the shallow alluvial groundwater source and shallow semi-confined sedimentary/fractured aquifers to around 75m depth. Deeper zones are water bearing zones but rarely aquifers.

There are no known groundwater dependent ecosystems (GDEs) (apart from stream baseflow accessions) in the vicinity of the Waukivory Pilot Project , although there may be some uptake of shallow groundwater (from the alluvium) by native terrestrial vegetation on the floodplain. Diffuse discharge of saline groundwater from bedrock seeps is thought to occur into the alluvium as the stream salinity increases during dry periods. Groundwater discharge is diffuse and discharge does not occur at any one point in the landscape.

2.3 Target Formations (Coal Seams)

[Code of Practice, Section 3.2(b), 3.2(c)]

Definition of the distances between targeted formations and aquifers

As outlined in Section 2.2, the beneficial aquifers at the area subject of the Waukivory Pilot are all shallow aquifers that occur either in the very shallow alluvial sediments or the shallow fractured bedrock. The bedrock contains mostly tight siltstone and indurated sandstone rock types with occasional thin semi-confined sedimentary/fractured aquifers (typically to around 75m depth). The deepest water supply bore known in the Waukivory Pilot area has a depth of 66m.

The target coal measures for CSG development for the Waukivory Pilot sites are within the Late Permian Gloucester Coal Measures at depths ranging from approximately 300 to 1000m from the surface. This variation of depth will not be fully covered by fracture stimulation treatment(s). Instead, multiple small fracture stimulation treatments will be performed, each one initiated at a coal seam target depth.The formations to be targeted are the Leloma, Jilleon, Wenhams, Dogtrap Creek and Waukivory Creek Formations. These formations contain cemented sandstones, siltstones and claystones interbedded with the coal seams. These low permeability formations, together with effective separation intervals of over 200m between the target CSG coal measures and the shallow beneficial aquifers, means there is negligible risk of fractures propagating from the targeted coal seams to these shallow beneficial aquifer zones.

2.4 Rock Mechanics

Rock Characteristics

The targeted coal seams are interbedded with sandstones, siltstones and mudstones with similar lithologys above and below the target coal seams. These intervening strata are expected to be considerably tighter and harder than the target reservoir and should limit vertical fracture growth into these zones. Modelling of this is discussed further in section 2.6 of this FSMP.

To identify faulted areas prior to drilling AGL conducted a 3D seismic survey to assist in well placement. This allowed AGL to place wells away from high angle vertical faults and only intersect low angle faults.

The several large fault zones intersected by the Waukivory pilot wells have been confirmed by image logs acquired as part of the logging of the wells. These image logs allow accurate identification of the location of faults and their dip. Zones were the selected for the fracture stimulation located away from these faults.

As a further mitigation for fracture stimulation treatments to migrate up faults, real-time pressure monitoring will occur throughout the program. This allows AGL and Principal Contractor engineers to monitor fracture geometry as it propagates in real-time through the use of geophones in a nearby monitoring well. This can also be confirmed by concurrent monitoring of treating pressure throughout the fracture stimulation to assess whether the hydraulic fracture treatment is migrating up faults, which would be indicated by reduced treating pressure.

Stress generally increases with depth, leading to a preference for the vertical component of the fracture to propagate upwards rather than downwards. The fracture geometry will be monitored in real time and adjustments made to the treatment to reduce vertical growth, and achieve a longer fracture within the target coal seam.

Stress Fields

[Code of Practice, Section 3.2(d) and Section 3.3 *Leading Practice*]

Direction of minimum and maximum stresses is used to determine the likely direction of the hydraulic fracture propagation. The fracture will propagate along the direction of maximum horizontal stress (opening against the minimum stress direction). Interpretation of image logs by AGL show the principal horizontal stresses in the Waukivory Pilot, allowing geologists and engineers to predict the orientation that the fracture will propagate.

In May 2013, AGL carried out additional stress testing on coal (target seam) and sandstone (natural barrier to fracture growth) intervals to complete the data package required to build a mechanical earth model. This model will be used as the basis for simulating predicted fracture propagation, geometry and containment within the target zone (see section 2.6).

The use of geophone monitoring during the hydraulic fracture stimulation operation will allow further information to be gathered about fracture geometry, and whether a T-shaped fracture may be created if the overburden stress should be less than the minimum horizontal stress. A T-shaped fracture has

both a vertical and a horizontal component, as opposed to a more simple hydraulic fracture, which has a vertical component only. A T-shaped fracture exhibits less vertical growth.

2.5 Pressures for Fracture Stimulation

[Code of Practice, Section 3.2(e) and Section 10.3 *Leading Practice*]

The maximum pressure required to initiate and propagate a fracture varies with the depth of the target zone, rock mechanics, and geological stress profiles. AGL is carrying out additional stress testing on zones of interest and bounding layers to build a mechanical earth model to complement geophysical logging and laboratory rock mechanics to then use this information for fracture stimulation modelling. Fracture stimulation modelling is used as a predictive tool for well design purposes and fracture geometry (see section 2.6). The pumping pressure of the fracture stimulation treatment will be monitored in real time in conjunction with other diagnostic tools to ascertain fracture geometry to optimise the well design.

AGL has gained knowledge of the rock mechanics of the zones of interest through previous exploration and fracturing activities (see section 2.7). Based on previous experience in this geological region, average treating pressures are expected to range from 2400 to 4300 psi. The wellbore and surface treating equipment is designed, with safety factors built-in, to withstand pressures higher than the maximum operating surface treating pressures of up to 4680 psi.

2.6 Modelling

[Code of Practice, Sections 3.2(f), 3.2(g) and Section 3.3 *Leading Practice*]

The ability to model the fracture propagation including extent and orientation in an exploration area in complex rock such as coal requires various techniques to better understand the behaviour of the fracture within the coal seam. AGL proposes to use geophone monitoring technology in each of the fields proposed for fracture stimulation. This will provide real time data including the fracture geometry (extent and orientation), and can then be used and incorporated to refine future fracture modelling. As more information is obtained from the various diagnostic techniques deployed (refer to diagnostic tools, section 8.1) the ability to accurately model fracture propagation including extent and orientation using a numerical simulator will provide a higher level of accuracy. This will strengthen the reliability of the model and minimise potential for the actual fracture propagation field to exceed that modelled.

In May 2013, AGL obtained cores from both formations of interest and bounding layers for testing mechanical rock properties, as well as in-situ stress testing of different depth intervals at a nearby well. This completed the data package required to build a mechanical earth model, which in turn will be incorporated into fracture stimulation modelling.

A mechanical earth model will model stress contrast between different rock layers, providing key data used in fracture stimulation modelling to ascertain how different fracture program designs will affect fracture growth and geometry during pumping of the fracture stimulation.

The goal is to design a hydraulically induced fracture that effectively stimulates whilst being contained within the treatment zone, and will not grow vertically toward the beneficial aquifers. Similar stress models can then be built for subsequent fracture stimulation target wells in the region. A model can

be built for each well by using the same correlation algorithms obtained at AGL's core test well to correlate the dipole sonic logs run on individual target wells.

2.7 Exploration Activities and Fracturing

The exploration target wells selected in the Gloucester Basin have undergone significant review. An offset core hole has been drilled retrieving core samples of the coal and strata. Geophysical logging and permeability testing have also been conducted. The data set of information obtained from the offset core hole provides essential information to assist with the fracture design.

Hydraulic fracture stimulation has previously been utilized by AGL and previous explorers within the basin on 8 Stratford Pilot wells, located to the south of the Waukivory Pilot and on Waukivory 3 and Faulkland 3 located to the north and west of the pilot respectively. Two other wells in the basin, Craven 6 and Weismantel 3, have also been fracture stimulated.

Since AGL became operator of this PEL, four wells were fracture stimulated in May and June 2009 as part of the ongoing Gloucester exploration program. These were: Stratford 7, Craven 6, Stratford 10, and Waukivory 3. The Gloucester fracture stimulation fluid consisted of about 99.4% water and sand. The remaining 0.6% was made up of additives to increase the fluid's viscosity. In total for the four wells, 4.4 ML of water, 533 tonnes of sand, and 25,280 litres of additives were used. There have been no identified impacts of groundwater or surface water resources from these activities. The target coal seams for the Waukivory program are the same as for these previous pilot test wells.

Fracturing targets the coal seams, more than 200 metres below the shallow aquifers. Shallow aquifers are protected by four barriers within the well construction: two steel and two cement barriers. The well construction design incorporates numerous contingencies to ensure zonal isolation between coal seams and other formations including aquifers. Aside from the important environmental consideration, zonal isolation is important for gas production, as water migration from any other source will hinder gas production, so all precautions are taken to ensure no connection between other formations can exist.

To check the integrity of well construction and any potential impacts associated with targeted fracture stimulation, groundwater monitoring networks (mostly in shallow aquifers) have been installed in reasonable proximity to selected gas wells to assess whether there are water level drawdown or water quality changes that would indicate connectivity. In addition to the established shallow monitoring network, AGL has obtained separate approval to establish a geophone (deep water monitoring) borehole to assess the impacts of the fracture stimulation program. The borehole will be converted to a water monitoring bore using a number of vibrating wire piezometers (VWPs) immediately after the fracture stimulation programs and prior to the flow testing programs.

The fluid used during fracture stimulation is recovered from the well through the 'flowback' and dewatering processes. This is done by using a "breaker" to react with the gel, breaking down its viscosity back to that of plain water so that the fluid's ability to flow is increased, allowing it to be produced back to surface.

The flowback water is then captured into open-top tanks. The fluid may then be held at a temporary storage facility prior to being lawfully disposed of to an appropriate facility in accordance with the requirements set out in AGL's Waukivory pilot testing REF.

Although critical geological and reservoir information are gathered during the exploration core hole drilling and stratigraphic wells, the flow characteristics of the reservoir are not fully understood. This is why the stimulation process is conducted, testing the well production potential to compliment the data set and have a better understanding of the economics and potential reserves of the area. This information assists AGL in determining whether a field has the potential to be commercially developed.

3 Compliance

[Code of Practice, Section 1.2(e)]

This FSMP is to be updated, reviewed and revised by AGL as necessary. The following are examples in which the FSMP would need to be reviewed and revised:

- Prior to making significant changes to an approved fracture stimulation design and operating procedure.
- If the level of risk to health, environment, land, and/or community from fracturing activities significantly increases.
- If control measures are not adequately mitigating the consequences of identified risks.

4 Planning and Risk Assessment

4.1 Notification

[Code of Practice, Sections 12.1, 12.2]

At least 10 days before starting hydraulic fracture stimulation activities AGL is to lodge a Notice of Intent to Carry out Fracture Stimulation with the Department of Trade and Investment Regional Infrastructure and Services (DTIRIS).

In the event of an unforeseen significant technical deviation from the work program, which may be the result of well integrity issues, significant incident on location, or abnormal fracture treating pressure response, the AGL Head of Field Development or designated engineer will notify the Office of Coal Seam Gas (OCSG) as soon as is practicable, and within the same day this event has occurred.

4.2 Stakeholder Consultation

[Code of Practice, Sections 2.1, 2.2, and Section 2.3 *Leading Practice*]

AGL has conducted appropriate consultation with stakeholders to ensure that potentially affected stakeholders are fully informed about fracture stimulation activities, and to inform stakeholders of the risk assessment and development of management plans.

AGL has discussed the Waukivory Pilot project, including the proposed fracture stimulation activity, with the Gloucester Shire Council. Landholders directly affected by the proposal have been consulted, and access arrangements with relevant landholders have been agreed. The Aboriginal cultural heritage

assessment also involved the Forster and Karuah Local Aboriginal Land Councils (LALC). Additional consultation with adjacent landholders would also be undertaken prior to the commencement of any works.

AGL continues to maintain an open and ongoing communication with the local community about its present and future activities. There have been ongoing general information mail-outs regarding the exploration activities of the GGP (Gloucester Gas Project) within this area. Regular community updates are also published in both the Gloucester Advocate and Dungog Chronicle and posted on AGL's Gloucester project website. Communications with the public are also maintained via the GGP Community Consultative Committee (GCCC).

The overall objective of community consultation for the GGP is to ensure clear, effective, open, two-way communication at all times by listening, recording and responding to issues. The approach includes distributing information to and interacting with the local community and landowners affected by the proposed development and to obtain community feedback.

Information sessions are held in Gloucester and surrounding villages to provide project updates and information about specific project activities. Project newsletters are published and distributed to all of the 2422 postcode area and to the north of Stroud Road, along with being published to AGL's Gloucester project website.

- Letterbox drops and door knocking of neighbours to project activities is undertaken.
- A project information line has been established to provide 24 hours point of contact for the community (1300 886 170).
- Site visits to other AGL projects and to local project work activities are made available to the GCCC, neighbours and other interested members of the community.
- Stakeholder engagement and contact with the community will be recorded in the Consultation Manager database and responses times and actions will be tracked via Consultation Manager to ensure issues, responses and outstanding actions can be tracked.
- Project briefings are undertaken with key stakeholders including Gloucester Shire Council and MidCoast Water.
- Fact sheets are produced and provided to the community via letterbox drops, and on the project website outlining the nature of activities, scale, timing duration and hours of operation for local work activities.

AGL has considered community concerns in the design of the activity. Measures including the enclosure of the central flare, reuse of water onsite to minimise the number of truck movements to and from site will be implemented during the proposed activity. To date, activities have co-existed with agriculture, and this is intended to continue.

As part of the wider GGP a CCC was formed in September 2008 to provide a forum for discussion and exchange of information between the community, Government agencies and AGL. The GCCC assists AGL in identifying project related local issues for consideration during the development, environmental, construction and operational phases of the project. It also acts as a communication link between AGL, the community and other stakeholders. The CCC includes representatives from the community, local Landcare Group, Gloucester, Great Lakes and Dungog Council, MidCoast Water as well as representatives from AGL. The GCCC meets at least six times a year and representatives are

provided with project updates/briefings from key project staff and minutes from the GCCC meetings are also available to individuals on the GGP web site (www.agl.com.au/gloucester).

In terms of ongoing consultation to be undertaken prior to and during the fracture stimulation activities:

- AGL has an office in Gloucester. Members of the community are able to directly speak with AGL project officers at the office, and view the information display and fact sheets.
- A Community Relations Manager has been engaged for the GGP, and will continue to communicate and engage relevant stakeholders throughout the project. AGL has taken a proactive approach to dispute resolution, in assigning key team members to liaise directly with landholders and adjacent residents. These team members will work proactively with stakeholders to identify issues early, address issues in an appropriate and timely manner, and to keep the affected stakeholder informed throughout the resolution process.

A full description of consultation undertaken and proposed to be undertaken is provided in section 2.5 of the REF.

4.3 Risk Assessments

[Code of Practice, Sections 4.1, 4.2, 8.1, 8.2, 16.1, 16.2 and Section 8.3 *Leading Practice*]

AGL conducted risks assessments in accordance with AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines. This assessment is documented in the Risk Assessment Report for AGL Energy's Fracture Stimulation Activities in Gloucester (AGL Energy, March 2013) (**Risk Assessment Report**) which is enclosed as **Appendix A** of this FSMP.

The Risk Assessment Report was broken up into thirteen categories;

a) workplace health and safety;
b) public safety;
c) chemical risk assessment;
d) land contamination;
e) air pollution;
f) localised temporary noise and vibration;
g) induced seismicity;
h) induced subsidence and other induced ground movements;
i) impacts on water resources;
j) conflicts with existing land uses;
k) flowback and waste management;
l) loss of well integrity; and
m) other risks.

The framework of the risk management principles as defined by the ISO 31000:2009 is illustrated in **Figure 2** and the process is illustrated in **Figure 3**.

One of the categories in the Risk Assessment Report is chemical risk assessment. This assessment is documented in the Human Health and Ecological Risk Assessment: Hydraulic Stimulation Activities, Gloucester Gas Project (EnRisks, April 2013) (**HHERA**) which is **Appendix M** of the REF.

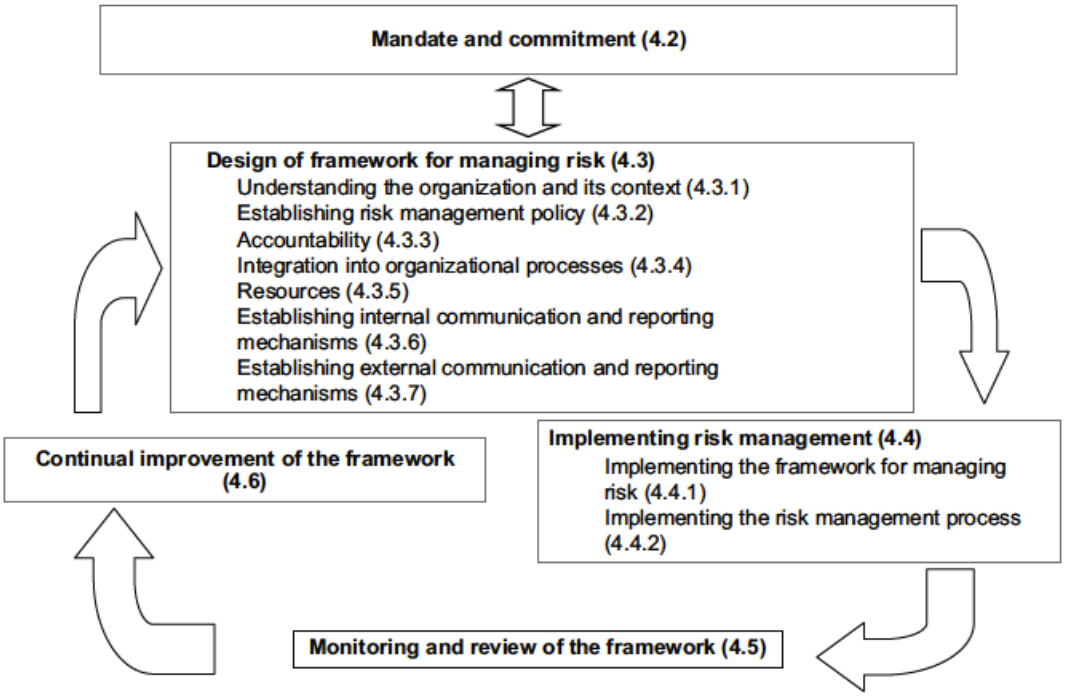


Figure 2. Relationship between the components of the framework for managing risk (ISO, 2009)

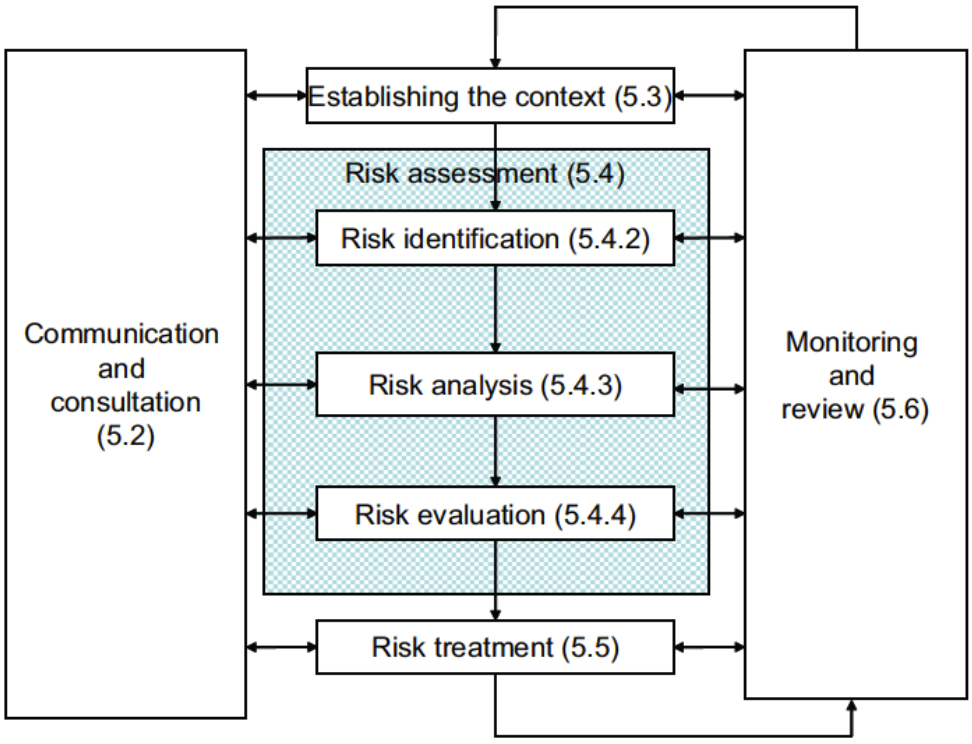


Figure 3. Risk management process (ISO, 2009)

The table below identifies the risks which have been assessed, and for which mitigation measures have been proposed, in the REF, Risk Assessment Report, HHERA and other documents (e.g., Environmental Management Plan, Surface Water and Groundwater Management Sub-plan).

Risks which have been assessed in accordance with section 4.2 of the Code of Practice	Document which assessed the risk and summary
Workplace health and safety assessment	REF: includes section 8.5 Risk Assessment Report: item i in table under section 4.1. This report concluded that the risks relating to workplace health and safety are: - heavy vehicle movements through local townships and access roads to sites raising a risk of vehicle related accidents: moderate; - incorrectly secured loads raising risk of accidents for other road users: moderate; - equipment damage during rig up: low; - injury to onsite personnel due to rig up: moderate; - excessive occupational noise to onsite personnel during job execution: low; - failed or uncontrolled pressure release to onsite personnel causing injury during job execution: moderate; - failed or uncontrolled pressure of the flowback line causing injury to personnel: moderate; - well control failure causing injury: low; - fire due to machinery causing injury: low; - chemical mishandling or inadvertent contact with chemicals which may cause injury: moderate; and - site and equipment may be sabotaged by unauthorised or illegal entrants resulting in injury: low. HHERA: see section 3.4.2, Table 6
Community impacts assessment	REF: includes sections 6.8, 8 and 9 Environmental Management Plan (**EMP**): European Heritage Management Sub-Plan (section 3), Fire Management Sub-Plan (section 3 – bushfire relates to community), and Traffic Management Sub-Plan (section 3) Risk Assessment Report: items ii, vii, and xii, in table under section 4.1. The risks identified in this report are: - public safety: moderate; - conflict with existing land uses (risk of air pollutants damaging neighbouring occupied properties): low; - conflict with existing land uses (risk of localised temporary visual and noise impacts to neighbouring properties): high;

Risks which have been assessed in accordance with section 4.2 of the Code of Practice	Document which assessed the risk and summary
	and - localised temporary noise and vibration due to heavy vehicles, operational equipment and flow back operations: moderate.
Fracture stimulation fluid assessment	REF: includes sections 2.8.7 and 6.5 This FSMP: The list of approved fluids for use can be found in section 7.5 of this FSMP and in the HHERA (section 3.3 and Appendix M to the REF). The FSMP addresses the issue of using chemical additives in fracture stimulation fluids. Fracture stimulation fluids are screened for all the chemical additives that are proposed to be used. EMP: Dangerous Goods and Hazard Material Management Sub Plan (Section 3 and Table 4-1). HHERA: section 4. The HHERA concluded as follows: - risks to human health and the environment are considered to be negligible or low; - the highest identified risk level is low which is considered to be a level of risk that can be adequately managed through the implementation of existing operational management measures; - no significant risk issues have been identified that require detailed quantification of risks; - based on the available information there are no pathways by which hydraulic fracture stimulation fluids injected into the CSG well can migrate to any freshwater body that may be of importance with respect to future beneficial uses of these freshwater aquifers or the discharge of water into aquatic environments.
Environmental assessment	REF: includes sections 6.7 and 8 EMP: Air Quality Management Plan (section 3), Soil and Water Management Plan (sections 2 and 3), and Flora and Fauna

Risks which have been assessed in accordance with section 4.2 of the Code of Practice	Document which assessed the risk and summary
	Management Plan (section 3). Risk Assessment Report: items iv, v and vi in table under section 4.1. The risks identified in this report are: - land contamination (spills and leaks of materials): moderate; - land contamination (noxious weeds from offsite may be transported by vehicles and contaminate the local area): moderate; - air pollution (excessive exhaust emissions and surface dust generated from road movements): moderate; - air pollution (fines and fluids mists may blow into the atmosphere during operations): low; and - source water spill during transport to site: low; - flow back water incorrectly transported, captured or removed which may result in a spill: low. HHERA: Table 6
Geological assessment	REF: includes sections 4.1.4, EMP: section 3.1 Risk Assessment Report: items iv, x and xi in table under section 4.1. The risks identified in this report are: - induced seismicity (risk of inducing seismicity that could, for example, disrupt a nearby fault): low risk; - induced subsidence and other induced ground movements (risk that there may be surface ground movement): low; and - fracture growth containment - fracture diagnostics (risk of connectivity and cross contamination between coal seams and beneficial aquifers, and risk of surface water/groundwater connectivity): low.
Groundwater and surface	REF: includes sections 4.2, 6.2, and 6.5.2

Risks which have been assessed in accordance with section 4.2 of the Code of Practice	Document which assessed the risk and summary
water assessment **[Code of Practice, Section 7.1 and 7.2]**	This FSMP: section 2.2. The major focus is the beneficial aquifers which mainly occur in the shallow sandy alluvium which is less than 15m depth, although other minor aquifers also occur in the shallow bedrock to depths of around 75m. EMP: Dangerous Goods and Hazard Material Management Plan, section 3 Surface Water and Groundwater Management Sub-Plan for the Waukivory Pilot Testing Program: Gloucester Gas Project Risk Assessment Report: item iv in table under section 4.1. Four primary risks were identified in this report: - source water spill: low risk - flow back water may be incorrectly transported, captured or removed which may result in a spill: low risk - causing connectivity and cross-contamination between coal seams and beneficial aquifers: low - induce changes to groundwater pressure and levels, and changes to surface water levels and flow: low. **Note** The assessments in the documents listed above address: - spills of raw (source) water for the fracture stimulation programs and flow back water; - beneficial aquifers versus deeper coal seam water bearing zones; - groundwater contamination from either chemicals used in fracture stimulation fluids or from cross-contamination of water sources from separate water bearing formations; - changes to groundwater levels and pressures; - changes to surface water levels; and - changes to groundwater quality. Further to section 7.2(f) of the Code of Practice, the consultations undertaken with the NSW Office of Water (**NOW**) included several meetings with NOW staff, in Newcastle in 2012, from their Major Projects and Licensing Units. Discussions have revolved around the nature of the exploration (appraisal) programs, the local hydrogeological environment and associated risks, monitoring and

Risks which have been assessed in accordance with section 4.2 of the Code of Practice	Document which assessed the risk and summary
	reporting requirements, and the necessary licensing requirements to complement the approvals under Part 5 of the *Environmental Planning and Assessment Act 1979* (NSW) from DTIRIS for this program.
Flowback and Waste Management **[Code of Practice, Sections 8.1, 8.2 and Section 8.3 *Leading Practice*]**	REF: includes sections 2.7.7(iv) and (vi) and 6.6 This FSMP: sections 10 and 11 EMP: Waste Management Plan (section 3) Surface Water and Groundwater Management Sub-Plan for the Waukivory Pilot Testing Program: Gloucester Gas Project Risk Assessment Report: item viii in table under section 4.1. The risk that waste from operations may enter the surrounding environment was assessed as low. HHERA: Table 6 **Note** The flowback water will be captured into open tanks at each well and then piped via gathering lines to the double-lined dual compartment turkeys nest dam or into temporary above ground water storage (and into tanks, depending on which option is chosen as appropriate). Flowback water will be characterised before being lawfully disposed of to an appropriate facility. Produced water is natural groundwater suitable for re-use (once salinity aspects are addressed through blending). Produced water will be taken to Tiedman's provided the irrigation water achieves prescribed water quality criteria as outlined in the existing approval for the trial irrigation.
Well Control and Integrity Assessment	REF: includes section 2.8.7 EMP: section 3.6 Safety Management Plan Risk Assessment Report: item ix in table under section 4.1. This

Risks which have been assessed in accordance with section 4.2 of the Code of Practice	Document which assessed the risk and summary
	report concluded that the risk to well integrity due to issues such as failure of pressure containment devices, casing, master valve or lubricator is low.

4.4 Safety Management Plan

[Code of Practice, Sections 5.1, 5.2]

The Gloucester Gas Project Health and Safety Management Plan, which is part of AGL's Health Safety and Environment Management System, complies with the mandatory requirements of the Code of Practice [section 5.2 of the Code of Practice].

Prior to commencing any activities relating to the Waukivory Pilot project, AGL will ensure that operators and contractors prepare, implement and review a Safety Management Plan to address any safety risks that may arise from the fracture stimulation activity, and to ensure that the design and operation of the site and its equipment are safe.

A copy of the Safety Management Plan is attached as Appendix F to the REF.

5 Emergency Response Plan

[Code of Practice, Sections 11.1, 11.2]

Incidents and emergencies will be prepared for and managed appropriately to ensure that risks to health, safety and the environment are minimised.

The Gloucester Gas Project Emergency Response Plan, which has been prepared in accordance with cl 43 of the *Work Health and Safety Regulation 2011,* complies with the mandatory requirements of the Code of Practice [section 11.2], as well as the *NSW Code of Practice for Coal Seam Gas Well Integrity.*

A copy of the Emergency Response Plan is attached to the REF as Appendix G.

6 Environmental Incident Response Plan

[Code of Practice, Section 11.3]

An Environmental Incident Response Plan has been prepared for the GGP, which sets out procedure to be followed and actions to be taken in the event of:

a) Well blow out or loss of integrity;
b) Chemical spill or other pollution incident;

c) Damage to an overlying water source;
d) Breach of regulatory requirements, including significant non-compliance with the FSMP;
e) Any other significant environmental incident associated with the fracture stimulation activity.

A copy of the Environmental Incident Response Plan is Appendix N to the REF.

7 Design

[Code of Practice, Sections 3.1, 3.2 and Section 3.3 *Leading Practice*]

The fracture stimulation activity will be designed to:

- avoid impacts on water resources;
- contain fractures within the targeted area; and
- minimise chemical use.

Successful hydraulic fracture stimulations require comprehensive planning and design phases. The fundamental principles of the fracture stimulation design will be to ensure:

- Safe pressure and pump rates;
- the fracture is contained within the target formation;
- Well integrity is maintained at all times;
- the minimal use of water;
- the minimal use of chemical additives; and
- the safe handling of fracture stimulation fluid flowback and disposal.

The table below indicates the relevant sections of this FSMP which discusses the description of the design of the fracture stimulation activity required under section 3.2 of the Code of Practice.

Information required to be incorporated under section 3.2 of the Code of Practice	**FSMP**
1) a) characteristics of geological formations, including the identification of rock types and conditions, aquifers and hydrocarbon-bearing zones	2) sections 2.1 and 2.2
3) b) definition of distances to these aquifers from the target coal beds	4) section 2.3
5) c) identification of the characteristics of intervening strata, including porosity/permeability and the extent of natural fracturing	6) section 2.4
7) d) determination of geological stress fields and areas of faulting	8) section 2.4
9) e) determination of maximum pressures to be used for fracture stimulation, based on the characteristics of surrounding geology	10) section 2.5

11) f) modelling of the likely fracture propagation field, including extent and orientation	12) section 2.6
13) g) discussion of any potential for the fracture propagation field to exceed that modelled in (f)	14) sections 2.6 and 2.7

7.1 Well Construction

The construction of a well is often influenced by whether or not hydraulic fracture stimulation is going to be performed. If a well is to be fracture stimulated then it needs to be designed and completed to accommodate for the requirements of the fracture. Treatment pressures, zonal isolation, flow rates, monitoring and flowback requirements can greatly influence a well's construction.

The *Code of Practice for Coal Seam Gas: Well Integrity* has been adopted and complies with the API standards and best practice for wells that will be fracture stimulated. All gas production wells have been or will be completed with multiple casings (and pressure cemented in place) to ensure that aquifers remain isolated. Cement Bond Logs (CBLs) are conducted on wells proposed for fracture stimulation to confirm that cement quality and bond are acceptable for the fracture stimulation of these wells.

7.2 Historical Review of Activities

A valuable tool in the design process is reviewing past activities in the area and other areas of a similar nature. Reviewing past activities promotes a culture of continuous improvement and optimises future activities. As designs are optimised and tailored to an area the amount of materials (water, proppant and chemicals) used in a treatment can be minimised reducing the impact of the fracture stimulation activity.

Numerous technical reports have been reviewed and investigations conducted to better understand key parameters that influence the impacts of fracturing to ensure the designs are fit for purpose.

7.3 Core Analysis

[Code of Practice, Section 3.3 *Leading Practice*]

By analysing cores prior to treatment many key characteristics can be identified about the formation. These characteristics include:

- Mineralogy – Evaluate the mineral content of the rock to help determine fluid sensitivity, anisotropy and potential for clay swelling/migration.
- Water Saturation – To determine potential for water production and fluid cleanup issues.
- Permeability – Both vertical and horizontal
- Porosity
- Presence of Natural Fractures
- Rock Mechanics – Determine elastic properties, embedment potential, and the stress contrast for zonal isolation.

When working in a new formation, it is important to conduct core analyses to gather information required for building accurate models and selecting the correct additives and proppants.

To date, AGL has cored and analysed 25 coreholes in Gloucester which includes Pontilands 03 (cored in April - May 2013) from which core analyses are being used to build a mechanical earth model which can be calibrated for each pilot well in the region.

7.4 Fluid Selection

[Code of Practice, Sections 6.1, 6.2]

Fracture stimulation fluids were designed with guiding principles to:

- minimise volumes of water and chemical additives;
- minimise potential impact to the environment and human health;
- ensure that all additives are certified as BTEX free;
- ability to transport proppant into the fracture;
- act as friction reducer to pressure, thus requiring less horsepower on site;
- induce a fracture geometry suitable to reservoir characteristics; and
- the fluid breaks back to water in a predetermined time and leaves minimal formation damage to the coal seam.

There are three main fluid types that are most commonly used.

- Treated Water – A treated water fluid recipe is a basic fluid for performing hydraulic fracture stimulations. The fluid is usually treated with a bactericide to minimise the risk of introducing foreign bacteria into the formation.
- Linear Gel – Linear gel fluid is a viscosified treated water. Linear gels are able to carry higher concentrations of proppant (sand) than water, thereby reducing the required volumes of water. They also reduce pumping friction and can reduce the required hydraulic horsepower required.
- Cross-linked Gel – Cross-linked gel is based on a linear gel. The cross-linked fluid has additional additives that crosslink the gel which further increases the viscosity of the gel. Cross-linked gels are used when high proppant (sand) concentrations are required or when low viscosity fluids are unable to maintain the desired fracture geometry.

The fluid's main purpose is to create the fracture geometry and to transport the natural fracture sand (proppant). After fracture treatment, the fluids viscosity breaks or reduces (with the aid of a "breaker") back to water so that it can easily flow back to the wellbore and hence to surface.

Water-based linear gel is proposed to be used for the Wauikivory Pilot, with a cross-linked gel to be used as an alternative.

This FSMP identifies:

Mandatory requirements for use of chemicals in fracture stimulation (section 6.2 of the Code of Practice)	**Document**
All chemicals to be injected as part of the fracture stimulation process	Section 7.5; and HHERA (Appendix M to the REF)

The Chemical Abstract Service (CAS) registry number for those chemicals	HHERA Appendix MC to the REF
The volumes and concentrations of those chemicals	Section 7.5; and HHERA (Appendix M to the REF)
Potential risks to human health arising from exposure to those chemicals	HHERA section 3.4, section 4 (Appendix M to the REF)
The risk, likelihood and consequences of surface spills of these chemicals	HHERA section 3.4.3 and Table 9
Whether chemical concentrations at the point of injection will exceed: ANZECC 2000 guidelines for overlying groundwater and surface water uses that may be affected; ADWG 2004 if a drinking water supply may be affected natural background concentrations if the water source is not effectively described by ANZECC or ADWG guidelines; or if the chemical is not specified in ANZECC or ADWG guidelines and may have a toxic effect, then assess whether the toxic[1] effect is likely to exceed a trigger toxicity level determined in accordance with a suitable methodology such as those described in section 2: OECD Guidelines for the Testing of Chemicals	HHERA section 3.4.3 and Table 8 and HHERA appendices
The risk, likelihood and consequence of the injected chemicals affecting the beneficial use class of the target aquifer or any other aquifer	Risk Assessment Report (Appendix A), including Groundwater risk assessment
Storage and management of chemicals	REF EMP EIRP Risk Assessment Report (Appendix A)

[1] As defined in Approved Criteria for Classifying Hazardous Substances (National Occupational Health and Safety Commission 2004).

7.5 Fracture Stimulation Chemicals

[Code of Practice, Sections 6.1, 6.2]

A list of chemicals (concentrations and volumes) that may be used in fracture stimulation of these pilot wells is provided in the table below. While linear gel has been selected for the Waukivory Pilot project, all chemicals that may be needed have been listed for completeness, and risk assessed in the HHERA. The number of chemicals has been minimised as far as possible.

The recipe used fur hydraulic fracturing fluid were selected to represent the most basic, low risk recipe with the least number of chemical additives, to ensure potential impacts to subsurface coal seams are negligible to minor, while at the same time providing adequate physical properties to achieve the hydraulic fracturing design objectives.

Volumes and Constituents in Proposed Fracture Stimulation Fluid for Waukivory Pilot

(Based on information provided by AGL's service provider)

Compound Present	Product	Purpose	Well Pre-Treatment[1]	Treated Water	Linear Gel	Cross-Linked Gel	Indicative Quantity[2]
			% volume of compound in fluid				(litres)
Water	H_2O	Main Fracture Fluid	88.12%	99.81%	99.65%	99.53%	5,988,194
Hydrochloric Acid	HCl	Clean Perforations and Casing	10.88%	-	-	-	870
Citric Acid	FE-2	Iron Sequesterant	0.36%	-	-	-	29
Ground Coffee Beans	HAI-150E	Corrosion Inhibitor	0.04%	-	-	-	3
Acetic Acid	Acetic Acid	pH Adjusting Agent	0.60%	0.03%	0.03%	0.03%	1,848
THPS Tetrakis(hydroxymethyl) Phosphonium Sulfate[3]	Tolcide PS75	Bactericide	-	0.01%	0.01%	0.01%	450
Guar Gum	WG-36	Gelling Agent	-	-	0.16%	0.16%	7,513
Hemicellulase Enzyme 15%, Carbohydrate 85%	GBW-30	Gel Breaker	-	-	<0.01%	<0.01%	92
Choline Chloride	Choline Chloride	Clay Stabiliser	-	0.15%	0.15%	0.15%	9,000
Monoethanolamine borate	BC-140C	Cross-Linker	-	-	-	0.11%	-
Sodium Hydroxide	Caustic Soda	pH Buffer	-	-	-	0.01%	-
Total			100.00%	100.00%	100.00%	100.00%	6,008,000

Indicative Volume of Fluid[2]	Well Pre-Treatment[1]	Treated Water	Linear Gel	Total Treatment
Average per well (L)	2,000	350,000	1,150,000	1,502,000
Total for all 4 wells (L)	8,000	1,400,000	4,600,000	6,008,000

Quantity of Proppant - quartz silica sand	Total Treatment
Average per well (kg)	206,750
Total for all 4 wells (kg)	827,000

Notes:

[1]Well pre-treatment is conducted to clean casing and perforations prior to fracture stimulation.

[2]The volumes of each fluid are indicative only and actual volumes cannot be determined until fracture stimulation treatment occurs. This is because during the fracture stimulation treatment AGL monitors the fracture growth using a variety of diagnostic tools. This allows AGL to analyse the fracture geometry and fine-tune the final volumes. In addition, information gained from the initial treatments will enhance design of subsequent treatments.

[3]As an alternative to using THPS as a bactericide, AGL may use product BE-7 (a mixture of sodium hypochlorite and sodium hydroxide) in treated water, that will be used in the linear gel and cross-linked gel recipes at a concentration by volume of 0.015% sodium hypochlorite and 0.001% sodium hydroxide, which will represent a total volume of 900 litres sodium hypochlorite and 60 litres of sodium hydroxide. The HHERA Table 8 has also assessed these compounds in the alternative bactericide.

7.6 Water Usage and Resources

[Code of Practice, Section 7.1, 7.2]

Water for the activities covered in this FSMP will be sourced from licensed water supply works located on either of AGL's Pontilands and Tiedman's properties off Fairbairns Road. AGL (in advance of the REF evaluation and approval process) has submitted an application to NOW to licence a large dam on the Pontilands property and to take water for 'stock, irrigation and industrial' purposes.

The estimated volume of water to be used in these fracture stimulation activities is approximately 6 ML for the Waukivory Pilot site (equivalent to the volume of approximately 2.4 Olympic sized swimming pools). The expected licence allocation for industrial/stock/irrigation purposes for the Pontilands Dam is 20 ML per annum (from the total volume available in dam of approximately 50ML) so there will be sufficient water available to take this source water for industrial purposes. For further information see the Surface water and Groundwater Management Plan, which is Appendix D to the REF.

7.7 Hydraulic Fracture Stimulation Fluid Pump Schedules

[Code of Practice, Sections 3.1, 3.2, 10.2]

Pumping schedules will depend primarily on three factors; propant (sand) mass,, proppant concentration, and fracture extension pressure. The fluid selected for the pumping schedule will be decided either from fluid compatibility tests or through historical information.

Proppant mass required for a hydraulic fracture stimulation is based on a factor of mass of proppant per net height of coal to be stimulated. A typical range for this factor is 3700 to 8200 kg of proppant /net metres of coal height.

Depending on the fluid selected, the proppant concentration will vary. Typical values for the maximum sand concentration able to be supported for the three main types of fluids are:

- Treated water: up to 200kg proppant /m3 of fluid
- Linear Gel: up to 500kg proppant/m3 of fluid
- Crosslinked Gel: up to 1000kg proppant /m3 of fluid

Maximum proppant concentrations are generally only a guideline for planning material quantities (water, proppant and chemicals) required to execute stimulation. Often the maximum proppant concentration is decided during the treatment by observing the treating pressures. The onsite engineer will often make changes to the pumping schedule during the operation based on observed treating pressures and rates and other diagnostic data that is able to be analysed in real time.

7.8 Fracture Geometry Modelling

[Code of Practice, Sections 3.1, 3.2, 10.2 and Sections 3.3, 10.3 *Leading Practice*]

Several simulators are available for modelling the idealised geometry of hydraulic fractures. To ensure that these models are reliable, they will be calibrated using direct diagnostic tools to accurately predict fracture geometry. AGL is currently building a mechanical earth model to incorporate measured stress (both core and *in-situ*) in target zones and bounding layers into the fracture stimulation model (see section 2.6).

Numerical simulators require a great deal of input data in order to accurately represent the rock mechanics, fluids, pressures, and temperatures. Modelling is strengthened by performing diagnostic injection tests prior to the main fracture stimulation. The diagnostic injection test includes pumping a predetermined volume of the selected fracture fluid into the coal seam without any proppant. The pressure decline post injection is monitored and the information obtained by this test can be entered into the fracture simulator and a higher degree of confidence is then obtained. During the fracture stimulation, real time monitoring will occur using geophones in a nearby monitoring well. This will enable the fracture geometry to be monitored whilst the fracture propagates, and afterwards fracture stimulation model will be further refined with this measured data.

7.9 Equipment Selection

[Code of Practice, Sections 5.2, 10.2, 14.2]

The equipment that comprises a hydraulic fracture stimulation fleet generally consists of High Pressure Pumps, Treating Iron, Blending Equipment, Dry Gel Blender, Well Head equipment Monitoring Instrumentations and a Data Monitoring Van. Other pieces of equipment may include mobile fluids laboratories, chemical additive trailers, and additive pumps.

High Pressure Pumps

High pressure pumps should be evaluated for both their hydraulic horsepower (hhp) and their maximum working pressure. It is general practice to have at least 50% more hhp on location than the job design specifies to compensate for unforeseen equipment failures and/or treating conditions. Pump combinations should be able to deliver both high and low flow rates to allow sensitive adjustment of flow rate as required for hydraulic fracture stimulation in exploration wells.

The pumping equipment will be rated high enough to carry out the required pressure test. The pressure test will be at least 10% higher than maximum allowable treating pressure during the job. Therefore the pumping equipment will be pressure rated to greater than the pressure required for the pressure test.

Treating Iron

The treating iron is the high pressure steel pipe which carries fluids from the pump to the wellhead.

The treating iron on location will have annual inspections. Inspection of treating iron will include hydrostatic pressure testing and wall thickness measurements. The pressure rating of the treating iron will be at least, if not greater than, the required test pressure.

The treating iron will be arranged so that maximum fluid flow rates are not exceeded in any of the treating iron components. Tables of maximum flow rates will be kept, and made available by the service company for their respective equipment.

Blending Equipment

The blending equipment on location should be able to add the required number and quantities of additives. The chemical additive rates required is cross checked against the additive rates available from the blending equipment.

Dry Gel Blending Equipment

AGL will use a dry gel blender, allowing an environmentally sensitive option compared to batch mixing of fracture fluid. When using a dry gel blender, additives are mixed with water as it is pumped to create the fracture stimulation fluid. The advantages of this technology are significantly less volume of leftover fluids which would then have to be disposed of, less chemical usage and better environmental control. Less handling and mixing of chemicals will result in a lower exposure to safety risks and greatly reduced risk of spillage of made-up fracture stimulation fluid.

Data Monitoring Van

The data monitoring van is generally the central point of communications during a treatment. It is important that the supervisors in the Data Monitoring Van have a clear line of site of the well site, and that all data acquisition equipment is properly recording. Prior to a treatment, all data equipment and sensors are calibrated and tested to ensure proper operation and reliable recordings.

8 Fracture Geometry Diagnostics

[Code of Practice, Sections 3.1, 3.2, 10.2, 13.2, 14.2 and Section 10.3 *Leading Practice*]

Fracture geometry is complex and can take many shapes and orientations. Over 6,000 mapped fractures have shown fracture geometries with multiple parallel planes, geometries in multiple directions, and "T-Shaped" fracture geometries having both a vertical and a horizontal component (Barree, 2002).

However by implementing proper diagnostics, fracture geometry can be properly characterised. Table 1 lists the various diagnostic tools available for monitoring fracture geometry along with their associated limitations and degrees of certainty.

Table 1. Fracture Geometry Diagnostic Tools, Limitations, and Degree of Certainty

Will Determine	Y
May Determine	M
Can Not Determine	N

Group	Diagnostic	Main Limitation	Length	Height	Width	Azimuth	Dip	Volume	Conductivity
Indirect, Direct, Near Wellbore	Net Pressure Analysis	Modelling assumptions from reservoir description	M	M	M	N	N	M	M
	Well Testing	Need accurate permeability and pressure	M	N	M	N	N	N	M
	Production Analysis	Need accurate permeability and pressure	M	N	M	N	N	N	M
	Radioactive Tracers	Depth of Investigation	N	M	M	M	M	N	N
	Temperature Logging	Thermal conductivity of rock layers skews results	N	M	N	N	N	N	N
	Production Logging	Only determines which zones contribute to	N	M	N	N	N	N	N

		production							
	Borehole Imaging Tool	Run only in open hole and only provides near wellbore information	N	N	N	M	M	N	N
Direct **Far Field**	Surface Tilt Mapping	Resolution decreases with depth	M	M	N	Y	Y	Y	N
	Downhole Offset Tilt Mapping	Resolution decreases with offset well distance	Y	Y	M	M	M	M	M
	Geophone Mapping	May not work in all formations	Y	Y	N	Y	M	N	N
	Treatment Well Tiltmeters	Fracture length must be calculated from height and width	M	Y	Y	N	N	N	N

To determine fracture geometry with a high degree of confidence the methods that must be employed are a Surface Tilt Mapping, Downhole Offset Tilt Mapping, and/or Geophone Mapping. These diagnostic tools directly measure the geometry of the fracture. The results from using this new technology will assist in understanding the response of fracturing in a known geographical area.

8.1 Diagnostic Tools

There are many diagnostic tools used in the oil and gas industry in conjunction with hydraulic fracture stimulation. For diagnosing fracture geometry the suite of diagnostic tools that can be used together to give a comprehensive view of fracture geometry are Geophone Monitoring, Surface Tilt Meters, Nolte-Smith Plot, Radioactive Tracers and Gamma Ray Logs and Dipole Sonic Logs, Pressure Confirmation Test and Temperature Logs. These diagnostic tools can accurately depict fracture geometry.

The proposed diagnostic tools for the Waukivory Pilot project will be Temperature Logging, Geophone monitoring, Nolte-Smith plots (Diagnostic Plots), and Pressure Confirmation Test.

Geophone Monitoring Technology

Geophone monitoring is based on detecting the small reservoir movements that take place as a result of the fracture stimulation process. These movements are caused by changes in stress (fracture opening) and fluid pressure (leakoff), and they occur along natural fractures, bedding planes, and other weakness zones in the rocks with which the fracture makes contact. Therefore, it is an acceptable and widely used technology for monitoring fracture growth by tracking the distribution of the microseismic events. Geophone fracture mapping services enable real-time monitoring of key fracture parameters, fracture height and length, fracture azimuth, fracture asymmetry, fracture growth versus time and formation containment.

Geophone monitoring is usually performed by placing long arrays of sensitive receivers in offset wells at a depth that is close to the zone to be fractured. The microseisms are characterized by the emission of both compression (P) waves and shear (S) waves, and these are detected by the receivers in the monitoring well. Robust grid-search and migration methods are used to determine where the events originated based on wave arrival times and polarizations. It is important to have an accurate velocity model, therefore significant effort is placed on characterizing and calibrating the model.

The distance that microseisms can be observed depends primarily on the size of the microseism and noise levels. In shale reservoirs, microseisms can often be detected at distances up to 1,500 m, whereas many other reservoirs such as coal have much shorter observation distances. In shale and tight gas sand formations, the large detection distance allows vertical height to be monitored even if there is significant height growth. Although the microseisms in coal are less pronounced, they can be accurately measured by having the geophone monitoring well closer to the offset well being fracture stimulated. Depending on the coal, the distance may be between 60 to 250 metres.

For the Wauikivory Pilot project, the geophone monitoring well will be 160 metres from the selected well to be fractured.

Geophone monitoring technology is typically deployed in the exploration phase to better understand fracture geometry, optimize the fracture treatment, provide information on geometry which will compliment groundwater testing and optimize well spacing and density.

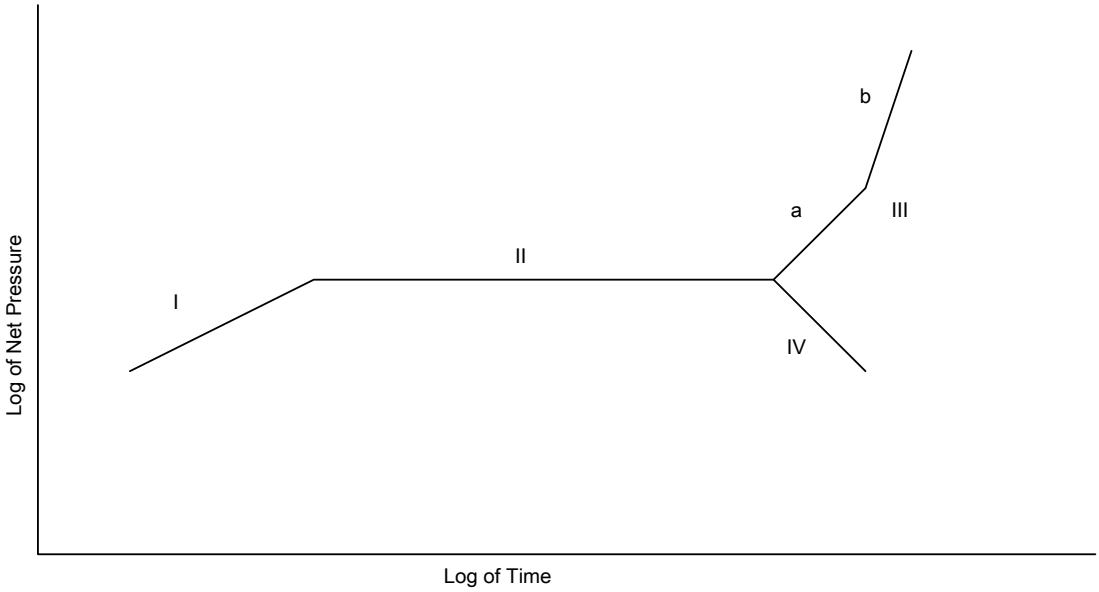
Surface Tiltmeters

Surface tiltmeter fracture monitoring is the measurement of small displacements at the surface of the earth using sensitive tiltmeters. Surface tiltmeters are used to measure minute deformation induced by the fracture. A tiltmeter works on the same principle as a carpenter's level, but the sensitivities are orders of magnitude greater (in the order of nanoradians). When a fracture is created, it deforms the rock surrounding it and this deformation radiates outward. An array of tiltmeters on the surface can be used to measure the deformation pattern and determine some details of the fracture orientation. Dipping and horizontal fractures induce distinct patterns, which are easy to separate from vertical fractures, and it is straightforward to resolve the azimuth and dip of the fractures with a surface array. The amplitude of the tilt signal and the width of the deformed zone can be used to determine the depth to the fracture's center and the fracture volume. If significant height growth were to occur, it would be observable in the surface tiltmeter data.

By combining both geophone monitoring and tiltmeters during the exploration phase of CSG development, the information obtained would be able to be used to compliment ground water hydrogeology information and potential impacts from fracture stimulations while providing important fracture geometry that will assist with fracture modeling and fracture designs in a given field. This technology is typically deployed once in a new exploration area to gather critical information. Other diagnostic tools are then used incorporating key data from Geophone Monitoring and Surface Tiltmeters.

Diagnostic Plots (Nolte Smith Plot)

A Nolte-Smith Plot can be used to analyse net pressure real-time responses during a fracture treatment to interpret the fracture geometry being created (Economides, 2007).



- Mode I: Propagation of fracture geometry.
- Mode II: Represents height growth in addition to length growth, or increased fluid loss, or both.
- Mode IIIa: Indicates that there is width growth. Good indication that a tip screenout is occurring.
- Mode IIIb: Indicates that a screenout is occurring
- Mode IV: This behaviour is indicative of uncontrolled height growth.

By using a Nolte-Smith plot during activities it is possible to predict when a fracture is starting to grow out of the targeted formation. If this behaviour is observed the treatment can be stopped prematurely or slowed to avoid excessive height growth. In this way, AGL and its contractor will carefully control the extent of fracture propagation during the hydraulic fracturing activity.

Logs (Dipole Sonic)

Image logs and Dipole Sonic measurements will determine apertures and the presence of fractures, their orientation as well as the state of stress and rock mechanics information. Note that Dipole Shear and Cross Dipole measurements are needed due to coal slowness and to establish local stress direction and cleating in coal (Manrique, 2001).

By running dipole sonic logs before and after a hydraulic fracture stimulation, changes in the anisotropy can be evaluated to give an indication of the presence of new near wellbore fractures that are created from a hydraulic fracture stimulation (Tellez, 2007). New fractures observed from dipole sonic logs can give a good indication of fracture height.

Pressure Confirmation Test

Fracture treatments commence from the deepest target seam, progressing up the well targeting the next upper interval. When a zone has been fracture stimulated, the zone is isolated by deploying a wireline set bridge plug. This plug provides a pressure seal and isolates the fractured zone which still contains pressure from the treatment. When the next upper zone is perforated, the pressure in the well is monitored. If there is an increase in pressure or the well starts to flows then it can be determined that the pervious fracture has grown and intersected the coal above. If no change in pressure is measured, then it can be determined that the lower fracture did not intersect the zone above. This test is repeated as the intervals are treated in the well.

Temperature Logs

A geophysical logging unit is used to lower temperature instruments into a well after the fracture execution. The temperature profile when compared to the base temperature gradient provides information such as fracture height growth. Although the well is cased and cemented, the temperature probes used can measure the influence of temperature behind pipe.

9 Execution

[Code of Practice, Sections 5.1, 5.2, 13.1, 13.2, 14.2]

The execution of a hydraulic fracture stimulation usually involves several parties (i.e., AGL personnel, hydraulic fracture stimulation company operators, perforation company operators and crane company operators). It is important when conducting fracture stimulation activities that a clear line of communication and reporting is established between all parties.

Each service company will have their own safety standards and standard operating procedures to abide by. However, outlined below are the guidelines for the practices adopted to execute a safe and successful hydraulic fracture stimulation activity.

[see also Risk Assessment, HHERA and Gloucester Gas Project Emergency Management Plan.]

The Principal Contractor (Fracturing Services Company) is an integral participant in the safety management plan and emergency response plan as regards fracturing stimulation activities. These plans are conducted to minimise risk to health and safety of employees of AGL, principal contractor,

and other contractors, official visitors to the fracture stimulation operation site, and general public that may be affected by the activities.

The safety management plans and standard operating procedures of contractors and AGL are assessed to ensure that interaction between parties is managed safely and safety responsibilities are identified for each party.

9.1 Pre Job Planning

[Code of Practice, Section 5.2]

The service company will ensure the following before mobilising to location::

- Review loadout sheet and verify all equipment and chemicals required for the operation are loaded.
- Ensure that all MSDS sheets are available for the chemicals to be used.
- Ensure that adequate pressure and rate monitoring equipment is loaded with the data monitoring van.
- Supervisor reviews the projects pumping requirements and ensure that sufficient treating iron and pumps are available.

9.2 Location Preparation

[Code of Practice, Sections 5.2, 13.1, 13.2]

The following should be read in conjunction with the Health and Safety Management Plan and Environmental Management Plan location preparation requirements:

- Conduct Operator specific site induction for the area.
- Conduct a safety meeting upon arriving at location.
- Assign roles and responsibilities to all crew members involved on location.
- Review the location and assess for safety hazards.
- Designate a muster area in case of emergency.
- Spot the equipment on location. A guide should be used when spotting equipment. The guide should be wearing high visibility vest.
- Verify that all tanks on location are equipped with sites so that fluid volumes can be gauged and recorded.
- Verify proppant quantities on location.
- Verify wellhead for connection and pressure rating.
- Check there is adequate communication equipment on location so that all personnel operating critical machinery are in direct communication with the site supervisor.
- Prime pumps and treating lines.
- Follow the service company's standard operating procedures to conduct pressure tests.
- Set and test pressure relief valves according to the service company's standards.

- Set and test the overpressure shutdown system according to the service company's standards.

9.3 Fluids Quality Assurance

[Code of Practice, Section 10.2(e)]

Prior to execution of the operation, the fluids are tested for quality assurance. Upon arrival at the location the service company will:

- Treat water with bactericide.
- If using a gelled system, perform a gel test with water on location and the gelled system to be used. The water and gel additives should yield the desired viscosity. If the system does not gel, then remediation should be undertaken until desired gel system is obtained.
- Once a good gel is obtained, a gel breaker test is performed. The breaker is tailored to give the desired break time.

9.4 Mitigating Health, Safety and Environment Risks

[Code of Practice, Sections 4.2, 5.2, 13.1, 13.2]

A number of documents are relevant to mitigating health, safety and environmental risks.

The Risk Assessment Report (Appendix A) identifies how activities will be conducted in a manner that mitigates health, safety and environment risks (including chemical use, impact on water resources, land contamination, air pollution, noise and vibration, induced seismicity, induced subsidence or other induced ground movements, and waste management).

The Gloucester Gas Project Emergency Response Plan (Appendix G to the REF) identifies how activities will be conducted in a manner that mitigates risk due to loss of well integrity, workplace health and safety and public safety.

The Gloucester Gas Project Environmental Management Plan (see Appendix E in the REF) forms the basis of the environmental management for the GGP's exploration activities. The Environmental Management Plan:

- provides that all activities will be undertake in accordance with the AGL Energy HSE Policy, which outlines AGL's commitment to ongoing sound management of environmental aspects and performance;
- sets out AGL's Environmental Principles, which include a commitment to minimise our impact on the environment;
- describes AGL's Environmental System Management Framework for the GGP;
- sets out key legislative and regulatory requirements;
- describes GGP activities;
- sets out processes for implementation, monitoring and review; and
- incorporates the environmental management requirements of Life Guard, the AGL Health, Safety and Environment (HSE) Management System which is based on the requirements of ISO: 14001:2004. The Life Guard system is implemented across all AGL Energy operated businesses.

The Gloucester Gas Project Environmental Incident Response Plan (see section 6 above and REF) sets out procedures to be followed and actions to be taken in the event of environmental incidents.

The Gloucester Gas Project Health and Safety Management Plan (as referenced in section 4.4 above and see Appendix F to the REF) addresses the specific safety risks that might arise from a fracture stimulation activity, including ensuring that the design and operation of the site and equipment are safe, and including mitigating risks due to noise and spills.

For mitigating conflicts with existing land uses see section 4.2 (Stakeholder Consultation) and Section 13 (Coal Mining).

For further information on potential for impact on water resources see section 2.3, as well as the Surface Water and Groundwater Management Plan.

AGL has carried out a comprehensive assessment of all risks associated with the activity and how each of the identified risks will be avoided, managed or mitigated by adopting best practice safety and environmental risk management practices.

Given AGL's controls, the risk of a "worst case" operational scenario, being a loss of well integrity or if natural gas is found to be leaking out of the ground from unidentified well bores, is low.

However in the unlikely event that AGL experiences one of these events, then AGL would immediately take steps to contain the situation by shutting down hydraulic fracturing activities or flow testing operations to identify the cause of the incident, and rectify the issue. This would be considered a reportable incident to the OCSG and the EPA.

In the highly unlikely event that the cause of the incident cannot be immediately identified or the steps taken to rectify the situation are unsuccessful, then a management plan would be initiated to identify and rectify the issue. This would be done in consultation with relevant regulators.

As a last resort, then a protective measure can be taken to stop any and all leakage by injecting cement into the entire well and plugging the well and sealing all perforations (plugging and abandoning). This means that the well bore is sealed and isolated from the surrounding rock and coal layers.

The process of plugging and abandoning a well is a common practice that is carried out at the end of life of a natural gas well but it is also a practice that can be applied at any time when there is a risk that well control or well integrity has been compromised. Once a well has been plugged and abandoned, the well is completely inert and isolated from the external environment.

The small and highly diluted concentration and choice of chemical additives being used in the hydraulic fracture stimulation activity when compared to the gross rock and water volume of the earth stratum located in the area of the pilot well project, means that there is likely to be negligible long term impact on the natural environment in the highly unlikely event of a worst case operational scenario.

9.5 Job Execution

[Code of Practice, Sections 5.2, 10.2(e), 13.1, 13.2]

Following the completion of rig up all personnel involved in the operation will conduct a safety meeting. This meeting will be lead by the supervisor of the service company.

- Discuss the details of the operation from start to finish.
- Assign roles and responsibilities and line of communication.
- Review expected treating pressures and maximum allowable pressures.
- Point out the location of the muster area.
- Designate emergency response and first aid personnel and an emergency vehicle.
- Ensure that the pump operator, supervisor, and blender operator have Operating Procedures for the pump and additives schedule.
- Outside supervisor should walk the treating lines and ensure that valves are in the correct configuration.
- Conduct a final pressure test before starting the job.
- Acquire approval from AGL representative before beginning the treatment.
- Open the wellhead.
- Begin the treatment as per designed pump schedule.
- If changes are made to the schedule they should be communicated through the service company supervisor.
- The engineer should monitor and record the pressure and rate data.
- Nolte-Smith plot should be used to interpret net pressure and make informed decisions about fracture geometry.
- Following the treatment, the well should be shut-in and wellhead pressure is to continue being monitored.
- Monitor the pressure until fracture closure is determined to have occurred.
- Once closure is determined, begin flowing back the well and recovering fracture stimulation fluid as per AGL's standards (See section 10 of this FSMP for details).
- While the well is flowing back, the service company can begin rigging down equipment.
- The principal fracture stimulation contractor is responsible for removal and disposal of any garbage, waste and chemicals on site at the completion of the fracture stimulation activity, in accordance with fracture stimulation contractor's environmental management procedures.

Flowback, Dewatering and Disposal

[Code of Practice Sections 8.1, 8.2 and Section 8.3 *Leading Practice*]

AGL will manage flowback water in a way that ensures risks to health, safety and the environment are appropriately managed.

It is a commonly accepted practice in hydraulic fracture stimulation to flow back a well as soon as possible following a treatment. However in coal seams it is recommended to allow the reservoir to fully close before flowing back the well to minimise the amount of proppant that flows back. Closure of the fracture can be determined using diagnostic techniques such as Nolte-G Plot or Square Root of Time plot.

Specific flowback procedures will be followed to mitigate safety and environmental risks. [Gloucester AGL Risk Assessments, Appendix A].

The fracture stimulation fluid will be flowed back to an open – top tank fitted with a diffuser to diffuse the energy of the flowback stream directly from each individual well. A spare tank will be available to

take on flowback water from the flowback tank to ensure sufficient holding capacity is available on site. Water quality sampling will be undertaken in accordance with the Surface Water and Groundwater Management Plan. Flowback water will then be lawfully disposed of to an appropriate facility.

Flowback water will be monitored until it has the same composition as natural formation (coal seam) groundwater. Both detailed water quality analyses and salinity readings will be used to assess the recovery of flow back water. Pumped volumes will also be tracked and recorded. At this stage the fracture stimulation fluid flowback will be deemed complete, and subsequent water flow is known as produced water. Reuse of produced water (such as mixing with fresh water to a suitable quality for crop irrigation) is described in the REF (i.e., reuse for purposes of irrigation is subject of a separate approval).

For the fracture stimulation program, tracking water quality and any changes is important. The following water quality sampling program is proposed for all locations:

- raw (source) waters to be used for fracture stimulation;
- fracture stimulation fluid mixture (i.e. the raw waters plus the sand and any chemical additives) to be injected into each gas well (if there are multiple fracture stimulation zones per well and all are the same recipe then just one event will be sampled);
- flowback water (i.e., return water still exhibiting chemical composition of fracture stimulation fluid); and
- produced water (natural groundwater from the coal seam/s) when sufficient fracture stimulation fluid volume is pumped back to surface so that the water exhibits the same composition as natural formation water. This is different for every fracture stimulation activity, but is expected to be after around 8 - 12 weeks of flowback.

Further details of this water monitoring program (including analytical suites) are provided in the Surface Water and Groundwater Management Sub-plan (see REF).

This FSMP is being submitted as part of an overlying REF, and as such any consent conditions will be incorporated into the storage requirements, methods for disposal and other surface water management methods in addition to those described in this FMSP.

10 Monitoring

[Code of Practice, Sections 10.1, 10.2 and Section 8.3 *Leading Practice*]

Fracture stimulation activities will be effectively monitored to allow the prompt identification and mitigation of any health, safety or environmental risks.

The FSMP describes the monitoring program to ensure that any risks have been identified, quantified and avoided or appropriately managed so that residual risks are within acceptable limits before, during and after the fracture stimulation activity.

10.1 Pre-Job Water Monitoring

Prior to fracture stimulation activities, overlying beneficial aquifers and coal seams are monitored to assess water level/pressure trends and to characterise the water quality. Details are provided in the Surface Water and Groundwater Management Sub-plan for this program.

As well as the four dedicated monitoring bores (plus the deeper vibrating wire piezometers) close to the pilot testing sites, property surveys to assess baseline water levels and water quality in private bores will be conducted on neighbouring properties within a 2km radius (if access is allowed). Two kilometres is more than sufficient to encompass the predicted fracture length plus a very large margin to provide for any uncertainty.

10.2 Job Monitoring

During a fracture treatment the following will be monitored and recorded:

- Raw water quality of the source to be used for fracture stimulation
- Bottom hole pressure
- Surface injection pressure
- Fracture fluid mixture water quality
- Fracture fluid injection rates and volumes (including viscosity and pumping rate)
- Chemical additive rates and volumes
- Proppant rates and volumes

10.3 Post-Job Monitoring

Flowback fluids can be monitored so as to determine when all the flowing fluid has transitioned from injected fracture stimulation fluid to formation water. Monitoring will:

a) Determine the volume and quality of flowback and produced water;
b) Quantify any change in surrounding water sources;
c) Pressure test casing to verify that the integrity of the well and well equipment has been maintained.

AGL will monitor salinity and chemical composition of the flowback fluid, along with flowback water volumes to identify transition from flowback water to produced water. Details are provided in the Surface Water and Groundwater Management Sub-Plan.

11 Post Job Analysis

An integral part of the continuous improvement process in the hydraulic fracture stimulation process is post job analysis and reporting. The service company will provide AGL with a detailed analysis of treatment including:

- Designed Pump Schedule
- Actual Pump Schedule
- Summary of all chemicals used and their quantities
- Plot of the treatment pressures, rates, and proppant concentrations over time

- Plot of the chemical additive rates over time
- Pressure decline analysis selecting closure:
- Nolte G Plot
- Square Root of Time Plot
- History Pressure Match
- Fracture geometry prediction
- A table summarising the following details;
    - Average Treating Pump Rate
    - Average Treating Pump Pressure
    - Formation Breakdown Pressure
    - Instantaneous Shut In Pressure (ISIP)
    - Fracturing Gradient
    - Closure Pressure
    - Closure Gradient
    - Tubular Friction (@ISIP)
    - Perforation Friction Pressure (@ISIP)
    - Total Near Wellbore Friction
    - Treatment Pad Fluid and Volume
    - Treatment Main Fluid and Volume
    - Treatment Flush Fluid and Volume
    - Treatment Total Water Volume
    - Proppant Type and Mass
    - Maximum Proppant Concentration Placed
    - Total Proppant Placed In Formation
    - Total Proppant Pumped

12 Coal Mining

[Code of Practice, Sections 9.1, 9.2]

The FSMP aims to ensure that fracture stimulation activities do not adversely impact on current and future (approved) coal mining activities.

The Waukivory Pilot project is located to the north of the Stratford Coal mine owned by Yancoal Australia Ltd. The mine currently conducts open cut mining across several small pits covering the stratigraphic interval from the Avon up to the Roseville coals.

The Waukivory Pilot is located within EL 6523 operated by Gloucester Resources Ltd which currently proposes to conduct open cut mining adjacent to the Waukivory Pilot project. Gloucester Resources was consulted during the planning of the Waukivory Pilot project to ensure the placement of wells would not impact on their proposal.

AGL is currently in discussions with both Yancoal Australia Ltd and Gloucester Resources Ltd regarding cooperation agreements.

13 Notification and Reporting

[Code of Practice, Sections 14.1, 14.2]

In addition to notification requirements under the Environment Incident Response Plan, Safety Management Plan, EPL and PEL 285, AGL will notify the OCSG within 24 hours in the event of:

- an incident resulting in threatened or actual loss of well integrity;
- a fracture stimulation being prematurely terminated in the event of a sudden and apparent loss of pressure (indicating possible uncontrolled vertical growth out of the target coal seam) where diagnostic monitoring indicates unusual vertical height growth, or an abnormal fracture treating pressure response which cannot be rectified by changes to the pumping schedule;
- in the event that gas is found to be leaking out of the ground from an unidentified bore.

A completed Fracture Stimulation Completion Report will be submitted to the Department's Mine Safety Operations and Environmental Sustainability Unit in the approved form within 30 days of completing hydraulic fracture stimulation activities on a well.

The Fracture Stimulation Completion Report will comply with the requirements of section 14.2 of the Code of Practice.

[Code of Practice Section 15.2(d)]

Following plug and abandonment of a well, AGL will provide the department with a copy of the records referred to in section 15 below.

14 Record Keeping

[Code of Practice, Section 15.1, 15.2]

Records of fracture stimulation activities must be kept in accordance with the Code of Practice. Records are to be made available to the Department for inspection on request.

The following records will be kept for each fracture stimulation:

- The FSMP
- Fracture stimulation design inclusive of fluids, treating rates and pressures, and designed pressure test requirements
- Laboratory tests conducted on fluids used in the fracture treatment
- Pressure tests
- Any leak off tests and/or formation integrity test report
- Chemicals used in the fracture stimulation fluid (name, type and volumes)
- Site specific risk assessments
- Source of water used in the fracture stimulation
- Service company operation reports
- Environmental monitoring results
- Completion report

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Glossary

Aquiclude	An impermeable body of rock or stratum of sediment that acts as a barrier to the flow of groundwater (also aquitard)
Aquifer	Rock or sediment in a formation, group of formations, or part of a formation that is saturated and sufficiently permeable to transmit economic quantities of water.
Aquifer Connectivity	Exchange of flow of water from one aquifer to another
Aquifer Properties	The characteristics of an aquifer that determine its hydraulic behaviour and its response to abstraction.
Aquifer, Confined	An aquifer that is overlain by low permeability strata. The hydraulic conductivity of the confining bed is significantly lower than that of the aquifer.
Aquifer, Semi-Confined	An aquifer overlain by a low-permeability layer that permits water to slowly flow through it. During pumping, recharge to the aquifer can occur across the confining layer – also known as a leaky artesian or leaky confined aquifer.
Aquifer, Unconfined	Also known as a water table aquifer. An aquifer in which there are no confining beds between the zone of saturation and the surface. The water table is the upper boundary of an unconfined aquifer.
Aquitard	A low-permeability unit that can store groundwater and also transmit it slowly from one aquifer to another. Aquitards retard but do not prevent the movement of water to or from an adjacent aquifer.
Australian Height Datum (AHD)	The reference point (very close to mean sea level) for all elevation measurements, and used for correlating depths of aquifers and water levels in bores.

Barrier	Any means of preventing an uncontrolled release or flow of well bore fluids to surface.
BOP	Blowout Preventer: one of several valves installed in a wellhead to prevent the escape of pressure either in the annular space between the casing and the drill pipe or in the open hole during drilling, completion and workover activities
Bore	A structure drilled below the surface to obtain water from an aquifer or series of aquifers.
Breaker	A chemical that reduces the viscosity of a fluid by breaking long-chain molecules into shorter segments.
Casing	A pipe placed in a well to prevent the wall of the hole from caving in and to prevent movement of fluids from one formation to another
Casing Head	A heavy flanged steel fitting connected to the first string of casing. It provides a housing for slips and pack-off assemblies that surface seal additional casing/tubing strings
Cement	Powder consisting of alumina, silica, lime and other substances that hardens when mixed with water. Extensively used to bond casing to the walls of the wellbore
Centipoise (CP)	The symbol for centipoise is cP or cps, depending on the source. It is a unit of measurement for the viscosity of a fluid. The viscosity of a fluid is described as the measure of a fluid's resistance to flow e.g. water flows easier than honey, therefore honey has the higher viscosity.
Claystone	A non-fissile rock of sedimentary origin composed primarily of clay-sized particles (less than 0.004 mm).
Coal	A sedimentary rock derived from the compaction and consolidation of vegetation or swamp deposits to form a fossilised carbonaceous rock.
Coal Seam	A layer of coal within a sedimentary rock sequence.
Coal Seam Gas (CSG)	Coal seam gas is a form of natural gas (predominantly methane) that is extracted from coal seams.
Completion (Or Workover) Program	A document that describes the detailed well procedures and risk mitigation for activities including completions, testing, intervention, well repair and/or abandonment
Contractors	Third parties contracted by AGL to provide well engineering equipment including drilling rigs, materials, equipment and

	services
Coring	Process of cutting a vertical, cylindrical sample of the formations.
Crosslink Gel	A fluid that has a very high viscosity typically in the range of 200-1000 cP
Dewatering	The process of removing formation water from a targeted coal seam. Dewatering is required to reduce pressure in the coal so gas can desorb and produce.
Discharge	The volume of water flowing in a stream or through an aquifer past a specific point in a given period of time.
Drawdown	A lowering of the water table in an unconfined aquifer or the pressure surface of a confined aquifer caused by pumping of groundwater from bores and wells.
Drilling Fluid/Mud	Circulating fluid that can lift cuttings from the wellbore to the surface and cool the drill bit.
Drilling Program	A document that describes the detailed well procedures and risk mitigation for activities including drilling, testing and/or well suspension
Electrical Conductivity (EC)	A measure of a fluid's ability to conduct an electrical current and is an estimation of the total ions dissolved in water. It is often used as a measure of water salinity.
Evaluation	Includes mud logging, wire line logging, formation evaluation while drilling, coring and well testing
Flowback	The process of allowing fluids to flow from the well following a treatment, either in preparation for a subsequent phase of treatment or in preparation for cleanup and returning the well to production.
Flowback Water	In relation to this document, flowback water is the return to surface of fracture stimulation fluids before transition to natural formation water, after which fluid flowing from the well is termed produced water.
Fracture Pad	The initial part of the fracture fluid that creates the fracture width and controls the initial fluid loss but contains no proppant.
Groundwater	The water contained in interconnected pores or fractures located below the water table in an unconfined aquifer or located at depth in a confined aquifer.

Hydraulic Conductivity	The rate at which water of a specified density and kinematic viscosity can move through a permeable medium (notionally equivalent to the permeability of an aquifer to fresh water).
Injection Well	Well through which fluids are injected into an underground stratum which may increase reservoir pressure.
Leak Off Test	Progressive wellbore formation pressure test: fluid is pumped fluid is pumped into the wellbore to gradually increase the pressure that the formation experiences. At some pressure, fluid will enter the formation (or leaks off) to provide well integrity information
LFL	Lower Flammable Limit: lowest concentration (percentage) of a gas or vapour in air capable of producing a flash of fire in presence of an ignition source (arc, flame, heat). Concentrations lower than LFL are 'too lean' to burn. Also called lower explosive limit (LEL). CSG is flammable at a concentration of between 5% and 15% of gas in air.
Linear Gel	A fluid that has a higher viscosity than water but a lower viscosity than crosslink gel. Typically they have a viscosity between 12 – 20 cP.

Microsiemens/Centimetre (µs/Cm)	A measure of water salinity commonly referred to as EC (see also Electrical Conductivity). Most commonly measured in the field with calibrated field meters.
Monitoring Bore	A non-pumping bore, is generally of small diameter that is used to measure the elevation of the water table and/or water quality. Bores generally have a short well screen against a single aquifer through which water can enter.
Operations / Activities	Any work conducted including rig moves, drilling, running and cementing casing, evaluation, completion, workover and abandonment
Perforations	The communication tunnel created from the casing or liner into the reservoir formation, through which oil or gas is produced. The most common method uses jet perforating guns equipped with shaped explosive charges. However, other perforating methods include bullet perforating, abrasive jetting or high-pressure fluid jetting
Permeability	The ability, or measurement of a rock's ability, to transmit fluids, typically measured in darcies or millidarcies. The term was basically defined by Henry Darcy, who showed that the common mathematics of heat transfer could be modified to adequately describe fluid flow in porous media.
pH	potential of Hydrogen; the logarithm of the reciprocal of hydrogen-ion concentration in gram atoms per litre; provides a measure on a scale from 0 to 14 of the acidity or alkalinity of a solution (where 7 is neutral, greater than 7 is alkaline and less than 7 is acidic).
Porosity	The percentage of pore volume or void space, or that volume within rock that can contain fluids. Porosity can be a relic of deposition (primary porosity, such as space between grains that were not compacted together completely) or can develop through alteration of the rock (secondary porosity, such as when feldspar grains or fossils are preferentially dissolved from sandstones).
Primary Well Control	Precautions taken to avoid an influx of formation fluid to the wellbore, including monitoring for increases in pore pressure, maintaining sufficient hydrostatic head and avoiding swabbing and surging
Produced Water	Natural groundwater generated from coal seams during flow testing and production dewatering. It does not include the other water streams (drill, fracture

	stimulation/flowback/workover water and brine water) that require separate water management.
Production Casing	A casing string that is set across the reservoir interval and within which the primary completion components are installed
Production Zone	Hydrocarbon producing zone of the formation
Proppant	Natural sand or synthetic high strength particles used with fracturing to fill the fracture space and hold the fracture open during the production life of a well.
Reservoir	A subsurface body of rock having sufficient porosity and permeability to store and transmit fluids. Sedimentary rocks are the most common reservoir rocks because they have more porosity than most igneous and metamorphic rocks and form under temperature conditions at which hydrocarbons can be preserved. A reservoir is a critical component of a complete petroleum system.
Sandstone	Sandstone is a sedimentary rock composed mainly of sand-sized minerals or rock grains (predominantly quartz).
Sandstone Aquifer	Permeable sandstone that allows percolation of water and other fluids, and is porous enough to store large quantities.
Screenout	Occurs during a hydraulic fracture stimulation treatment when the maximum allowable treating pressure is reached before all the planned proppant is placed in the formation.
Secondary Well Control	Secondary Well Control is implemented when Primary Well Control has failed to prevent the influx of formation fluid or pressure into the wellbore. This involves the controlled circulation or the influx out of the well bore and, if necessary, increasing the mud gradient
Shale	A laminated sediment in which the constituent particles are predominantly of clay size.
Siltstone	A fine-grained rock of sedimentary origin composed mainly of silt-sized particles (0.004 to 0.06 mm).
Slickwater	A fluid with a very low viscosity (slightly higher viscosity than water) or water.
Slurry	A mixture of suspended solids and liquids. Muds in general are slurries, but are seldom called that. Cement is a slurry and

	is often referred to as such.
Stratigraphy	The depositional order of sedimentary rocks in layers.
Surface Casing	A drilled and cemented pipe used to provide blow-out protection, to seal off water/hydrocarbon sands, and prevent loss of circulation. Often used to seal off water sands, weak formations and/or lost circulation zones. In some cases surface and intermediate casing requirements are provided by the same string
Surfactant	A chemical that preferentially adsorbs at an interface, lowering the surface tension or interfacial tension between fluids or between a fluid and a solid. This term encompasses a multitude of materials that function as emulsifiers, dispersants, oil-wetters, water-wetters, foamers and defoamers. The type of surfactant behavior depends on the structural groups on the molecule (or mixture of molecules). Hydrophile-lipophile balance (HLB) number helps define the function that a molecular group will perform.
Unconventional Resource	An umbrella term for oil and natural gas that is produced by means that do not meet the criteria for conventional production. What has qualified as unconventional at any particular time is a complex function of resource characteristics, the available exploration and production technologies, the economic environment, and the scale, frequency and duration of production from the resource. Perceptions of these factors inevitably change over time and often differ among users of the term. At present, the term is used in reference to oil and gas resources whose porosity, permeability fluid trapping mechanism, or other characteristics differ from conventional sandstone and carbonate reservoirs. Coalbed methane or CSG, gas hydrates, shale gas, fractured reservoirs, and tight gas sands are considered unconventional resources.
Water Quality	Term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.
Water Table	The top of an unconfined aquifer. It is at atmospheric pressure and indicates the level below which soil and rock are saturated with water.
Well	Pertaining to a gas exploration well or gas production well
	Includes the BOP stack, BOP control system, full open safety valves, circulating hose (and circulating head), drill string

Well Control Equipment	safety valves (inside BOPs), mud and cement pumps, the choke and kill lines and manifold, and all associated pipe work and valves.
Well Head Reportable Leak	An emission due to an unplanned release from a well site facility that, at a measurement distance of 150mm immediately above (and downwind) and surrounding the leak source in an open air environment above ground position; gives a sustained LFL reading greater than 10% of LFL for a 15 second duration.
Well Heads	The system of spools, valves and assorted adapters that provide pressure control of a production well.
Well Intervention	An operation carried out by re-entering an existing well
Well Program	A CSG Operator document that describes the detailed well procedures and risk mitigation for activities including Drilling, Completions, Testing, Intervention / Workover and/or Abandonment
Wellbore	A wellbore is a hole that is drilled to aid in the exploration and recovery of natural resources including oil, gas or water. A wellbore is the actual hole that forms the well. A wellbore can be encased by materials such as steel and cement, or it may be uncased.
Workover	Well procedure to perform one or more remedial activities on a producing well to attempt production increase. Examples of workover activities are pump repairs, well deepening, plugging back, pulling and resetting liners, squeeze cementing, re-perforating, etc
Zonal	An interval or unit of rock differentiated from surrounding rocks on the basis of its fossil content or other features, such as faults or fractures. For example, a fracture zone contains numerous fractures.

Appendix A – Risk Assessment Report for AGL's Fracture Stimulation Activities in the Gloucester Basin (AGL Energy, March 2013)

RISK ASSESSMENT REPORT FOR AGL ENERGY'S FRACTURE STIMULATION ACTIVITIES IN GLOUCESTER

A risk assessment has been conducted on the proposed Fracture Stimulation Activities in Gloucester. The report is based on the NSW Department of Trade & Investment (Resources & Energy) Code of Practice for Coal Seam Gas (Fracture Stimulation Activities) (September 2012) **("The Code").** The report of this risk assessment ("**Risk Assessment Report**") is set out below.

1. BACKGROUND TO RISK ASSESSMENT AND SCOPE

1.1 Background

AGL holds petroleum exploration licence ("**PEL**") 285, which is located in the Gloucester Geological Basin north of Newcastle NSW. AGL carries out petroleum exploration activities within PEL 285. As part of its exploration program, AGL proposes to undertake Hydraulic Fracture Stimulation Activities ("**HFSA**").

This report forms part of the HFSA application and management process, and should be read in conjunction with AGL's Fracture Stimulation Management Plan – Gloucester NSW ("**FSMP**").

2. RISK MANAGEMENT REQUIREMENTS

The Code requires that a FSMP be in place prior to the commencement of a fracture stimulation activity. The Code states that the FSMP should incorporate a risk assessment that meets the following requirements:

a) The FSMP must include a risk assessment complying with AS/NZS ISO 31000:2009 Risk management - Principles and Guidelines.

b) The risk assessment must identify risks associated with the fracture stimulation activity, the likelihood of each risk and the consequence of each risk.

c) The risk assessment must define appropriate management controls to ensure identified risks are constrained to acceptable levels.

d) At a minimum, the risk assessment must address risks associated with:

i. workplace health and safety (see heading 5 of the Code)

ii. public safety (see heading 5 of the Code)

iii. chemical use (see heading 6 of the Code)

iv. impacts on water resources (see headings 7 and 8 of the Code)

v. land contamination

vi. air pollution

vii. noise & vibration

viii. waste management (e.g. flowback water as per heading 8 of the Code)

ix. loss of well integrity

x. induced seismicity

xi. induced subsidence or other induced ground movements

xii. conflicts with existing land uses

There are specific mandatory requirements in the Code to be assessed for each of these issues.

3. RISK ASSESSMENT PROCESS

3.1 AGL's Approach to Risk

AGL is committed to ensuring that risk management practices are entrenched into all business processes and operations to drive consistent, effective and accountable action, decision making and management practice. AGL's fundamental, underlying risk principles are consistent with ISO 31000 (Risk Management – Principles & Guidelines); and, the COSO standard for Enterprise Risk Management.

AGL recognises that risk is dynamic and is inherent in all external and internal operating environments and is committed to managing all risks effectively. Effective risk management is a means for achieving competitive advantage and is pivotal to enabling the ongoing growth and success of our business.

AGL's Risk Management Policy ("**Policy**") is approved by the AGL Board and publically available on www.agl.com.au The Policy sets out the objectives and accountabilities for the management of risk within AGL such that it is structured, consistent and effective. The Policy and AGL Risk Management & Assessment Framework are the two key documents that together formalise AGL's Risk Framework.

Effective risk management within AGL has a number of objectives:

› Promote an enterprise wide approach by integrating risk management processes with:

  » business strategy; project management; process and decision making;

  » audit, insurance and specialist risk functions; and

  » compliance and general governance functions.

› Promote consistency and transparency in methodology, assessment and management processes.

› Promote proactive recognition of external factors and anticipate uncertainties that may affect the achievement of strategy.

› Sponsor confidence in operations, management decisions and certainty regarding expected outcomes.

› Protect the interests of AGL shareholders.

› Provide assurance to counterparts, customers, employees and the community.

› Sponsor innovation and maximise value from assets, ventures and opportunities.

› Recognise that risk is embedded in all our activities and that the underlying risk appetite is key to effective decision making.

› Provide appropriate, consistent and transparent ownership and accountability around risk mitigation.

› Enable the design and implementation of controls that:

  » are structured to promote effective realisation of objectives;

» provide appropriate assurance; and

» are cost effective.

› Recognise that timely and accurate monitoring, review, communication and reporting of risk is critical to:

» providing early warning mechanisms for the effective management of risk occurrences and consequences;

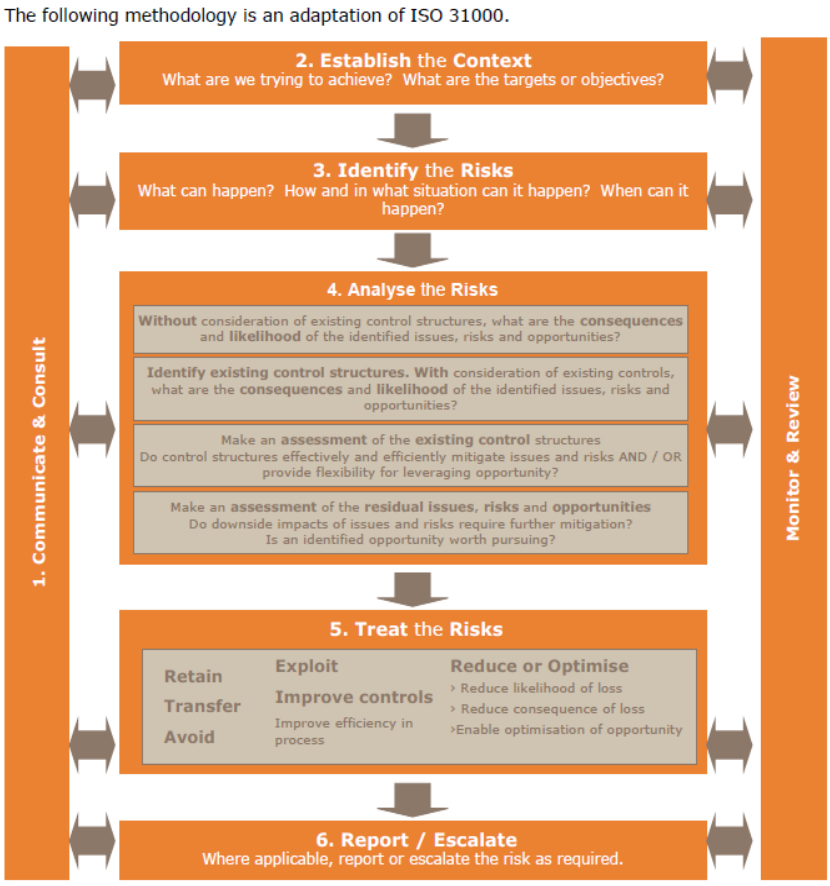
» providing assurance to management, the Board and shareholders;

» providing a solid platform for growth; and

» generating and maintaining a sound corporate history.

Just as risk is inherent in our operations, risk management is also inherent in all decision making and management processes. Risk management is essential to good corporate governance and is a fundamental component of good management practice.

The following methodology has been used to identify the risks included in this Risk Assessment and is an adaption of ISO 31000.



Source: AGL Risk Management Policy

3.2 AGL's Consequence & Likelihood Risk Evaluation Matrix

Table 1: Likelihood Rating Guide

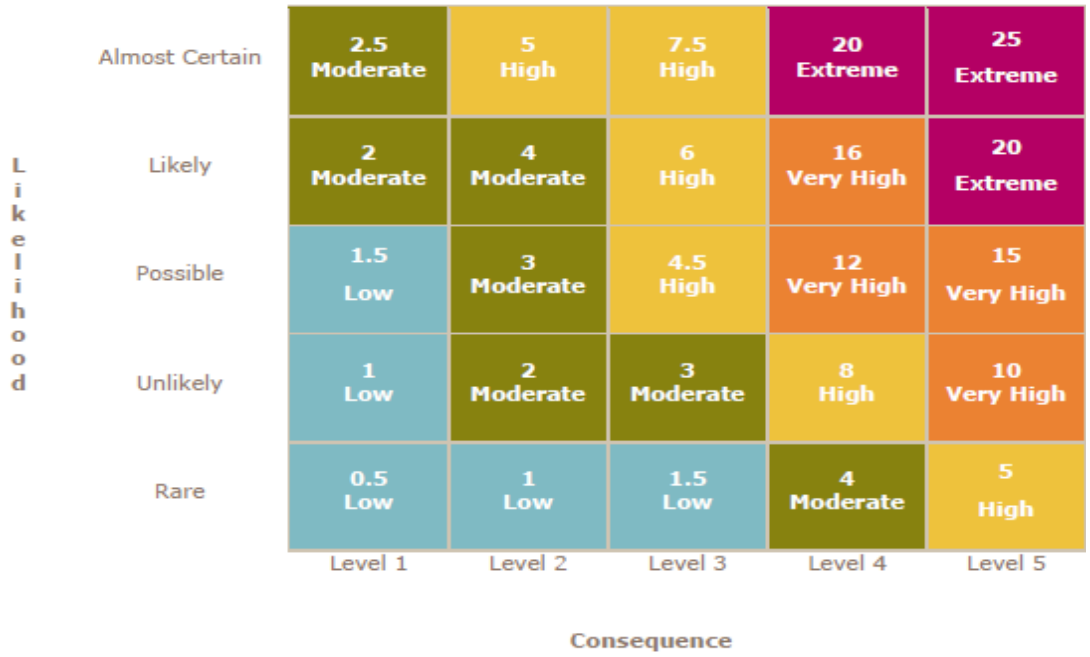
		Likelihood Description		
Score	Descriptor	Complexity	Susceptibility/ Exposure	Probability
5	Almost Certain	Can only be performed after specialist training and education, years of knowledge required, very advanced technology, extreme inter dependencies between tasks	Extremely susceptible – large numbers of new people and/or new to AGL, attractive to most people with ready access, newly implemented, a lot of changes, new system, untried processes	Knowledge/evidence either within AGL or externally suggests this event/risk occurs almost all of the time. The occurrence of this risk is common and expected - greater than 1 in 2 chance (greater than 50%)
4	Likely	Advanced training, education and specialist knowledge, a significant number of variables and interrelated tasks and dependencies	Highly susceptible - many new people, item is attractive, a lot of changes to the systems and procedures, the item is aging or otherwise becoming susceptible, the event is likely to occur sooner rather than later.	Knowledge/evidence either within AGL or externally suggests this event/risk occurs at regular intervals - between 1 in 10 and 1 in 2 chance (10% to 50%)
3	Possible	High level skill required, usually secondary studies necessary, detailed knowledge needed, advanced technology, a number variable tasks or steps	Quite a few people involved, audit trail difficult to follow, requires 'specialist' knowledge and skills, newly introduced staff and/or procedures, one would expect the event to occur at intervals	Occurs either within AGL or known environment on an irregular basis but frequently enough to be more than a remote possibility - between 1 in 100 and 1 in 10 chance (1% to 10%)
2	Unlikely	Requires basic training but can be quickly mastered by most people, few variations or steps involved	Recent changes, attractive but difficult to obtain, new people, some new processes or procedures, quite a few people involved, one would expect the risk to occur occasionally.	Aware that the event has occurred occasionally either within AGL or externally. However, it is not something that would be classed as a common occurrence and would only occur in certain remote circumstances - between 1 in 10000 and 1 in 100 (0.01% to 1%)
1	Rare	Straight forward singular tasks requiring little or no training	Has a minimum degree of susceptibility, been around for years, tried and true, well known and understood, can't conceive the risk occurring.	Either is not known to have occurred or has not occurred in many 'exposures' to the potential risk - greater than 1 in 10000 (less than 0.01%)

Table 2: Consequence Rating Guide

Consequence Rating Guide

		Consequence Definitions						
Score	**Descriptor**	**Commercial / Profitability / Assets**	**Business Continuity**	**Customer**	**Regulatory / Legal**	**Reputation**	**Environment & Community**	**People & Safety**
0.5	Level 1	Maximum risk less than $100k.	Minor business interruption. Temporary delay in operations with little effect, business would return to normal immediately.	May impact or lose a small number of domestic or small commercial customers.	Once off minor breach. Notification of relevant authority may be required, but negligible possibility of prosecution or breach of license.	Issue resolved in day to day management. Small local publicity.	Negligible and short term environmental impact to localised area of negligible environmental value. No impact beyond AGL's operational area. No interest by local community.	Injury or illness that may require medical treatment or first aid resulting in no lost time.
1.0	Level 2	Maximum risk between $100k and $1M.	Business interruption causes problems to either internal or external customers however business as usual achieved after several hours; AND / OR Growth options put off for up to 3 months.	Some loss of third party confidence AND impact to or loss of small number of Industrial & Commercial OR Major customers OR hundreds of domestics.	Multiple minor breaches. Regulator may express concern. Possible breach of licence or regulation requires notification to relevant authority / regulator, but unlikely to be associated with financial penalty.	Managed locally, some publicity in local and state press.	Small scale and short term environmental impact to localised area of low environmental value. No impact beyond AGL's operational area. No/minor interest by local community.	Injury or illness that temporarily impairs a person's life. Return to work with rehabilitation to same role.
1.5	Level 3	Maximum risk between $1M and $25M.	Business interruption causes impact to internal or external customers that last up to 5 business days; AND / OR Growth options are delayed for between 3 and 6 months.	Impact to or loss of several Industrial & Commercial OR Major Customers OR thousands of domestics.	Systemic breaches small to medium breaches or 1 large breach. Breach of regulatory / license requirements with likely action by regulatory authorities, resulting in tightening of licence and permit conditions and financial penalties or fines. Enforceable undertakings possible. Unfavourable policy outcomes.	Sustained regional/State coverage.	Moderate, short to medium term environmental impact that may extend beyond AGL's operational area and/or may result in local community complaint(s).	Injury or illness that permanently impairs a person's life. Return to work with rehabilitation and alternate role.
4	Level 4	Maximum risk between $25M to $100M.	Business interruption causes impact to internal or external customers that last for between 1 and 2 weeks; AND / OR Growth options are delayed for between 6 months and 12 months.	Impact to or loss of a large number of Industrial & Commercial OR Major Customers OR tens of thousands of domestics	Civil prosecution Unfavourable tariff outcomes. Unfavourable policy outcomes impact commercial position. Unable to secure necessary permits for growth / developments. Incident could result in revocation of licence/permits, large fines and prosecutions.	Sustained national press coverage.	Significant medium term impact on important environment/habitat and/or widespread local community complaints.	Injury or illness that results in a fatality or permanently impairs a person's life. No return to work.
5	Level 5	Risk may exceed $100M.	Business interruption causes impact to internal or external customers that last for more than 2 weeks; AND / OR Growth options are delayed for more than 1 year.	Impact to, or long term loss of many Industrial & Commercial OR Major Customers OR hundreds of thousands of domestics.	Civil / criminal prosecution Unfavourable tariff outcomes put commercial Loss of operating licences. Loss of licenses and possible closure of facility, significant fines and/or jail penalties could result.	Continuous national and/or international coverage.	Severe long term damage to the environment and/or sustained widespread local community complaints over time. Any loss or damage to listed or protected environment/habitat.	Injury or illness that results in more than 1 fatality or permanently impairs more than 1 person's life. No return to work.

Table 3 Consequence and Likelihood Risk Evaluation Matrix



The following Risk Assessment has been conducted using the tables included in section 3.2.

3.3 Risk Assessment Workshop

The principal mechanism for identifying, analysing and evaluating GSFA risks for the purposes of the Risk Assessment Report was a series of workshops attended by representatives of AGL and its contractors ("**Risk Assessment Workshop**").

This Risk Assessment Report contains the output of these workshops. The Risk Assessment Report follows the guidance as mandated in the Code, and indentifies risks, proposed mitigation strategies if required and risk ratings after controls and mitigation strategies are applied. It should be noted that risk is dynamic and additional workshops will be conducted to further develop the risks identified, ensure that risk treatments have due by dates and accountability assigned.

The following table outlines the details of the Risk Assessment Workshops.

Date of Workshop and Facilitation	**Scope of Workshop**
14 December 2012 Facilitated by AGL Energy Head of Group Risk and Compliance	• impacts on water resources • land contamination • air pollution • noise & vibration • waste management (e.g. flowback water) • induced seismicity • induced subsidence or other induced ground movements
17 December 2012 Facilitated by AGL Energy Head of Group Risk and Compliance	• public health and safety • conflicts with existing land users
23 January 2013 Facilitated by AGL Energy Head of Group Risk and Compliance	• workplace health & safety • chemical use • loss of well integrity • overview of findings to date

Table 4: Details of Risk Assessment Workshops

3.4 Selection of Risk Assessment Workshop attendees and other interviewees

The Risk Assessment Workshop participants were key stakeholders from the project team, principal contractor representatives and other experts deemed appropriate for the activity. The roles of Risk Assessment Workshop participants is listed below:

Role	Company
Head of Group Risk & Compliance	AGL Energy
Risk Manager	AGL Energy
Head of Gas Operations	AGL Energy
Manager Hydrogeology	AGL Energy
Manager Geoscience	AGL Energy
Community Relations Manager	AGL Energy
Land and Approvals Manager	AGL Energy
Health & Safety Business Partner	AGL Energy
Environmental Manager	AGL Energy
Senior Geologist	AGL Energy
Senior Petroleum Engineer	AGL Energy
Project Coordinator	AGL Energy
Health Safety & Environment Coordinator	Halliburton
Fracturing Service Manager	Halliburton
Senior Technical Advisor	Halliburton

Table 5: List of Risk Workshop Participants and Company

Preparation for Risk Assessment Workshops and interviews

Prior to the Risk Assessment Workshop, materials which were included as part of the deliberations included;

- The Code
- NSW Department of Trade and Investment (Resources and Energy) Code of Practice for Coal Seam Gas (Well Integrity) (September 2012)

3.5 Comment on the Risk Assessment Workshop process

- Whilst controls have been identified to mitigate the identified risks, the responsibility and dates for completion of these is ongoing: and
- as a general observation, the participants in the Risk Assessment Workshops were well engaged and provided constructive and open input and comments.

4. KEY POINTS AND RECOMMENDATIONS FROM RISK ASSESSMENT

4.1 Key Risks Identified and the Controls to Treat the Risk

Set out below is a table summarising:

- key risks as required by the Code and addressed in the Risk Assessment (including risk ratings based on implementation of controls to mitigate the risk); and
- recommendations to assist in addressing these matters.

Risks	Controls to Mitigate
i Workplace Health & Safety a. Heavy vehicle movements through local townships and through access roads to sites, raising a risk of vehicle related accidents Consequence: Level 4 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Moderate	1. Drivers are appropriately licensed and competency assessed 2. Vehicles have maintenance records and routine checks 3. Journey management plans are completed, which include identification of the travel route 4. The selected travel route is assessed prior to mobilisation of heavy vehicles movements 5. Vehicle management systems, including live tracking of service provider performing fracture stimulation services 6. Use of escort vehicle ahead of convoy 7. Vehicles generally travel in convoys 8. Communications plans will include traffic arrangements 9. No night time travel of heavy vehicles unless a separate Journey Management and Risk Assessment is conducted 10. Policy of mandatory rest breaks for long journeys
b. Due to the movement of equipment to and from the site, incorrectly secured loads may raise a risk of accidents for other road users Consequence: Level 3 (Consequence driver: Safety) Likelihood: Unlikely Current Risk Rating: Moderate	1. Drivers are appropriately licensed and competency assessed 2. All loads are prepared by skilled personnel and fixed according to Australian standards 3. Pre and post check list for each vehicle, incorporates walk around, debrief and pre brief with drivers
c. Equipment damage during setup (known as 'Rig Up') Consequence: Level 3 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Low	1. Drivers are appropriately licensed and competency assessed 2. Personnel to be wear appropriate safety and protective gear at all times 3. Site is controlled by a Site Safety Manager 4. Site is managed by Project Schedule to ensure orderly movements on site 5. Safety management plan prepared for the site 6. Safe work plans are prepared for the site

Risks	Controls to Mitigate
	7. Authorised personal only are allowed on site 8. Reversing any of equipment requires land guide 9. Wellhead is to be barricaded to prevent reversing into same
d. Injury to onsite personnel due to equipment set up – (known as 'Rig Up') Consequence: Level 3 (Consequence driver: Safety) Likelihood: Unlikely Current Risk Rating: Moderate	1. Contractors will conduct site visit and planning workshop prior to establishment 2. Personnel to be wear appropriate safety and protective gear at all times 3. Perimeter fencing will be establishment 4. Site management will be established which includes but not limited to, land guides, site directions, access limitations, signage, permit to work system 5. Pre Rig Up meeting prior to commencement of work 6. Authorised personnel only on site 7. Controlled equipment movement allowed on site during Rig Up
e. During job execution, there may be a risk of excessive occupational noise to onsite personnel Consequence: Level 2 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Low	1. Noise impact assessment conducted 2. All personnel on site will be required to wear hearing protection during fracturing operations 3. Exclusion zones known as Red Zones will be established 4. Frac Master - designated Site Safety Manager will control the site at all times or their delegate the Ground supervisor
f. There may be a risk of failed or uncontrolled pressure release to onsite personnel causing injury during job execution Consequence: Level 4 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Moderate	1. Specification of well design to deal to risk 2. Controlled primary pressure safety control – electronic pump cut outs in equipment 3. Annual third party certification of all pressure equipment 4. Signage and exclusion zones 5. Remote and local equipment kill switches 6. Secondary pressure relief valve to enable pressure release 7. Continuous pressure monitoring

Risks	Controls to Mitigate
g. There may be a risk of failed or uncontrolled pressure of the flowback line causing injury to personnel Consequence: Level 4 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Moderate	1. Flow back lines are pressure rated 2. Fixed bean choke to control flowback 3. Contractors operating standards 4. Open top flow back tank located 25 metres away from well with diffuser to further control fluid flowback 5. Exclusion zones are maintained 6. Flowback lines will be secured 7. Flowback operating procedures to be implemented
h. There may be a risk of well control failure causing injury Consequence: Level 3 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Low	1. Policy and procedures for handling of well head valves using designated trained person 2. Continuous monitoring of well pressures 3. Manufacturer rated and certified to API certified valves specified 4. API pressure rated casing installed 5. Check valves installed in main treating lines
i. There may be a risk of fire due to machinery failure causing injury Consequence: Level 3 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Low	1. Preventative maintenance program 2. Pre job inspections 3. Fire extinguishing equipment on site and regularly serviced and on the ground ready for use 4. Personnel trained in fire fighting techniques 5. Emergency Fire drills conducted 6. Rural/Local Fire Service contact details on site and debriefed prior to activities 7. Emergency Response Plan well understood and reviewed in Site Induction and Pre Job Meeting 8. Fracturing equipment equipped with Rig savers/ mechanical or electrical emergency shutdown controls

Risks	Controls to Mitigate
j. There is a risk that chemical mishandling or inadvertent contact with chemicals may cause injury Consequence: Level 3 (Consequence driver: Safety) Likelihood: Unlikely Current Risk Rating: Moderate	1. Chemicals are segregated by class and a load sheets are generated identifying specification and locations 2. Adhere to Dangerous Goods Code 3. Heavy vehicles designated for chemical movements are Dangerous Goods rated 4. Visual inspections are conducted for stored chemicals 5. Personnel have chemical handling training 6. Exclusion zones around chemical areas 7. Emergency Response Plan 8. Safety showers, first aid kits and eye wash bays on site 9. Dry gel eliminates need to batch mix chemicals in water holding tanks 10. Equipment allows continuous monitoring of chemical injection into fluid 11. Chemicals only stored in Australian Standard approved containers 12. All chemicals to be stored in bunded areas 13. All Material Safety Data Sheets (MSDS) are available on site 14. Human Health and Ecological Risk Assessment (HHRA) completed for all chemicals 15. Appropriate personal protective equipment for the chemicals being handled
k. There is a risk that the site and equipment may be sabotaged by unauthorised and illegal entrants resulting in injury Consequence: Level 3 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Low	1. Inform and work with the local Police services 2. Use of appropriate Security firms and fencing 3. Use of signage to inform general public that the site is “restricted” 4. Security and site workforce to walk the site every morning and night 5. Secure site each night

Risks	Controls to Mitigate
ii Public Safety a. There is a risk of an illegal protest leading to harm to protestors and the work force Consequence: Level 2 (Consequence driver: Safety) Likelihood: Likely Current Risk Rating: Moderate	1. Follow AGL Protest Response Plan 2. Inform and work with the local Police services 3. Use of appropriate security firms and fencing 4. Use of signage to inform general public that the site is “restricted” 5. Security and site workforce to walk the site every morning and night 6. Proactive consultation with the community prior to works commencing
iii Chemical Risk Assessment **(Separate Report annexed– Human Health and Ecological Risk Assessment, February 2013)**	Human Health and Ecological Risk Assessment completed for all chemicals

Risks	Controls to Mitigate
iv Impacts on Water Resources a. There is a risk of source water spill during transport to site. Consequence: Level 1 (Consequence driver: Environment) Likelihood: Unlikely Current Risk Rating: Low	1. The preferred source water is fresh water from the Pontilands Dam and spills would have little to no impact on the environment 2. If an alternative source is used, the water quality may be brackish water. The fill and unloading areas are contained. Spills of brackish water would have minimal impact on soils and surface water. 3. Vacuum truck is available on site
b. There is a risk that the flow back water may be incorrectly transported, captured and/or removed which may result in a spill. Consequence: Level 1 (Consequence driver: Environment) Likelihood: Unlikely Current Risk Rating: Low	1. Flow back water will be stored in designed tanks or other above ground holding tanks, which are fully contained 2. Pipes used to transport flow back water to above ground holding tanks will be visually inspected 3. Visual inspections are conducted on all tanks prior to the storage of any liquids. Visual inspections are also conducted several times a day during fracture stimulation operations to ensure no overflow or leaks 4. Water tanks are bunded so that if a leak occurs the liquid is contained 5. Vacuum truck is available on site 6. Sealed transport tankers are used to remove flowback water from site or holding dams to an approved facility 7. Surplus water tanks are kept on site so that if a leak was to occur in a tank the contents of the tank could be pumped into the spare tank 8. Pipes are pressure tested during commissioning before use 9. Wells are supervised during flow back operations 10. Environmental Incident Response Plan covers this possibility
c. The Code requires a qualitative assessment of risk that GFSA may cause connectivity and cross contamination between coal seams and beneficial aquifers. (i.e. exchange of poor water quality between these two sources that may	Low permeability aquitard layers exist between shallow beneficial aquifers and target coal seams. AGL have developed strategies including: 1. A Surface Water & Groundwater Management Plan has been written to protect surface water and beneficial aquifers. Baseline assessments

Risks	Controls to Mitigate
impact water quality characteristics). [Code 7.2(c)(i) and (iv)] Consequence: Level 3 (Consequence driver: Environment) Likelihood: Rare Current Risk Rating: Low	suggest that groundwater moves laterally within layers and vertical connectivity is low. A Groundwater Monitoring program has been implemented (since early 2012) and will be used to monitor water levels, pressures and water quality during the fracture stimulation program. 2. Pressure monitoring (at individual gas wells) during fracture stimulation. 3. Geophone monitoring, measuring direction and height of the fracture in real time on selected wells. 4. Temperature log, confirms fracture height after the fracture stimulation of each zone. 5. Fracturing execution commences from the deepest zone and progress up the well. This means more information is gathered before approaching the beneficial aquifers. 6. Monitoring changes in the flowback chemistry 7. Groundwater monitoring programs provide baseline data prior to fracture stimulation programs thereby allowing trends or changes in shallow water chemistry to be identified 8. Faulting is mapped through 3D seismic and zones selected for stimulation are away from faults
d. The Code requires an assessment of the risk that GFSA may induce: • changes to groundwater pressure and levels; • changes to surface water levels and flow. This is generally referred to as surface water/groundwater connectivity [Code 7.2(ii) and (iii)] Consequence: Level 3 (Consequence driver: Environment) Likelihood: Rare Current Risk Rating: Low	AGL and the principal contractor have developed strategies including; 1. A Surface Water & Groundwater Management Plan that protects surface water and beneficial aquifers. A Groundwater Monitoring program has been implemented 2. Pressure monitoring during fracture stimulation. 3. Geophone monitoring, measuring direction and height of the fracture in real time on selected wells 4. Temperature log, confirms fracture height after the operation 5. Fracturing execution commences from the deepest zone and progress up the well. This means more information is gathered before approaching the beneficial aquifers 6. Monitoring changes in the flowback chemistry 7. Groundwater monitoring programs provide baseline data prior to fracture stimulation programs thereby allowing trends or changes in shallow water chemistry to be identified

Risks	Controls to Mitigate
v Land Contamination a. There is a risk that there may be spills and leakages of materials such as oils, lubricants, on site fuels, chemicals, additives, water, sand and packaging. Consequence: Level 2 (Consequence driver: Environment) Likelihood: Unlikely Current Risk Rating: Moderate	1. All contractors on site are subject to pre qualification and selection process 2. Environmental Management Plan, Environment Response Plan, handling and storage procedures, audit procedures, site inspections, spill kits, onsite waste storage facility, training and supervision 3. Handling of chemicals and fluids is subject to the Contractor's and AGL's handling procedures 4. On site supervision of activities 5. Daily toolbox talks that emphasise the importance of following AGL and Contractor procedures 6. Human Health and Ecological Risk Assessment completed for fracture stimulation fluids
b. There is a risk that noxious weeds from outside of the project area maybe transported by vehicles and contaminate the local area. Consequence: Level 3 (Consequence driver: Environment) Likelihood: Unlikely Current Risk Rating: Moderate	1. Truck wash downs, prior to entering project area 2. Drivers trained to inspect trucks prior to journey commencement 3. Documented evidence is provided for each washed truck 4. Journey management plan 5. AGL to inspect vehicles prior to entering site

Risks	Controls to Mitigate
vi Air Pollution a. Due to trucks, vehicles, operational equipment operating during activities, there is a risk of excessive exhaust emissions and surface dust being generated from road movements. Consequence: Level 2 (Consequence driver: Environment) Likelihood: Unlikely Current Risk Rating: Moderate	1. All contractors on site are subject to AGL pre qualification and selection process which includes a preventative maintenance system and adherence to Australian Standard vehicle emissions 2. Routine dust suppression where generation has been observed on roads and appropriate gravel will be used to surface roads where required to minimise from road movements 3. Signposted travelling speeds on lease roads to reduce dust generation from traffic movements 4. Environment Management Plan
b. There is a risk that during operations fines and fluid mists may blow into the atmosphere. Consequence: Level 1 (Consequence driver: Environment) Likelihood: Unlikely Current Risk Rating: Low	1. Fluids are captured and contained via flowback tanks 2. Flowback water is diffused to minimise the chance of any fluid being blown into the atmosphere 3. All fracture stimulation activities are greater than 200 metres from residences
vii Localised, Temporary Noise and Vibration a. Due to heavy vehicles, operational equipment and flow back operations there will be a risk of exceeding the constructions noise goal Consequence: Level 2 (Consequence driver: Environment) Likelihood: Possible Current Risk Rating: Moderate	1. AGL will establish and maintain sound walls between activities and receptors as required 2. AGL will conduct a noise impact assessment 3. Fracture stimulation pumping, workover rig operations and heavy vehicle movements will be restricted to 7am to 6pm Monday to Friday and 8:00 am – 1:00 pm Saturday. Outside of these hours activity will be limited to light vehicle access, rigging up, rigging down, equipment maintenance and pilot testing. 4. Community consultation will occur with neighbours prior to commencement of activities 5. AGL will assess orientation of equipment on a well by well basis to minimise any noise impact. 6. Noise logging onsite and at nearby receivers to identify any problematic areas

Risks	Controls to Mitigate
viii Waste Management (flowback) a. There is a risk that waste from operations may enter the surrounding environment. Consequence: Level 1 (Consequence driver: Environment) Likelihood: Unlikely Current Risk Rating: Low	1. All contractors on site are subject to AGL pre qualification and selection process 2. The chemical waste contents are dealt comprehensibly in the chemical risk assessment report. 3. Flowback water will be contained within bunded tanks, with vacuum truck available on location. 4. Water will be chemically analysed to determine the appropriate transport and disposal method
ix Loss of well integrity a. There is a risk to the well integrity due to issues such as failure of pressure containment devices, casing, master valve and/or lubricator Consequence: Level 3 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Low	1. Appropriate well design 2. Safety margins incorporated into Fracture Stimulation design 3. Conformity with Code of practice for Well Integrity 4. API certified casing and wellhead 5. Bridge Plugs to isolate each treated zone 6. Perforation of selected zones only 7. Cement Bond Logs to be run on all wells to be fracture stimulated 8. Casing is pressure tested prior to perforating
x Induced seismicity a. Risk identified in Code– Induced Seismicity. AGL understands "induced seismicity" to require an assessment of any risk that fracture stimulation activities will induce seismicity that could, for example, disrupt a nearby fault. Consequence: Level 3 (Consequence driver: Environment) Likelihood: Rare Current Risk Rating: Low	1. Drilling and logging records have been performed to identify faults. 2. Seismic mapping to identify faults, and avoid activity near significant faults 3. Magnitude of events are below the threshold where damage can occur to beneficial aquifers and surface infrastructure
xi Induced subsidence and other induced ground movements a. Risk identified in Code – Induced	1. Consolidated rock is not supported by pore

Risks	Controls to Mitigate
Subsidence. The Code requires an assessment of risks associated with "induced subsidence or other induced ground movements,", which AGL understands to mean the risk there may be surface ground movement Consequence: Level 1 (Consequence driver: Environment) Likelihood: Rare Current Risk Rating: Low	pressure thus change of pressure in the coal seam will not result in subsidence in ground about this zone
xii Conflicts with existing land users a. The Code requires an assessment of the risk of air pollution, which AGL understands to mean the risk of air pollutants damaging neighbouring occupied properties e.g. dairy farms Consequence: Level 1 (Consequence driver: Community) Probability: Unlikely Current Risk Rating: Low	1. Machinery and vehicles are maintained and inspected prior to use 2. Fluids are captured and contained via flowback tanks 3. Flowback water is diffused to minimise the chance of any fluid being blown into the atmosphere 4. All fracturing activities are greater than 200 metres from residences
b. There is a risk of localised, temporary visual and noise impacts to neighbouring properties. Consequence: Level 3 (Consequence driver: Community) Probability: Possible Current Risk Rating: High	1. Establish and maintain sound walls between activities and receptors as required 2. Fracture stimulation pumping, workover rig operations and heavy vehicle movements will be restricted to 7am to 6pm Monday to Friday and 8:00 am – 1:00 pm Saturday. Outside of these hours activity will be limited to light vehicle access, rigging up, rigging down, equipment maintenance and pilot testing. 3. Proactive consultation with the community prior to works commencing 4. Assess orientation of equipment on a well by well basis to minimise any noise impact 5. Noise logging onsite and at nearby receivers to identify any problematic areas
xiii Other Risks a. GFSA will include perforation activities and low emitting enclosed radioactive density measurement	1. Follow dangerous goods code 2. Radioactive sources and perforating guns will be handled by appropriately trained and

Risks	Controls to Mitigate
tool that may cause harm to onsite contractors and employees if incorrectly handled Consequence: Level 3 (Consequence driver: Health) Probability: Rare Current Risk Rating: Low	competent personnel 3. Emergency response plan 4. Equipment is marked and secured 5. Equipment is maintained and systematically certified 6. Security at well sites during inactive periods to deter theft and vandalism
b. Due to extreme weather (e.g. floods, lightning, high winds, bushfire) there is a risk to damage and disturbance of equipment resulting in injury or environmental damage Consequence: Level 2 (Consequence driver: Health) Probability: Unlikely Current Risk Rating: Moderate	1. Flood Management Plan 2. Bushfire Management Plan 3. Preference to locate above ground open top water storage at areas above flood zones 4. Appropriately licences for crane usage 5. Trained and competent crane operators 6. Operations procedure include weather stop protocols
c. Risk that fracture stimulation activity may intersect with unrecorded wells, previously drilled by other operators, that have not been properly plugged and abandoned, causing connection with other subsurface layers or surface. Consequence: Level 3 (Consequence driver: Environment and Community) Probability: Possible Current Risk Rating: High	1. Location of historical exploration wells is know from mine records. Wells within 600m of a Pilot test well and with any common coal seams intersected in them will be properly plugged and abandoned prior to stimulation activities

5. CONCLUSION

The risk assessment conducted outlines the key risks associated with GFSA and the controls in place to constrain these risks to acceptable levels. The above analysis has identified no very high or extreme risks.

Appendix B – Code of Practice Table of Compliance

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
1 Fracture Stimulation Management Plan		
A Fracture Stimulation Management Plan (FSMP) must be in place prior to the commencement of a fracture stimulation activity.	✓	Section 1 - Introduction Section 1.1 - Operations
· The FSMP is a non-technical document which is designed to demonstrate to the NSW Government and other stakeholders that the titleholder will appropriately manage the risks associated with the fracture stimulation activity and comply with the mandatory requirements of this Code.	✓	"
· The FSMP may summarise relevant information from other regulatory documentation requirements and the titleholder's management systems, provided that the source of this information is identified.	✓	"
· For most exploration activities, the FSMP would normally be submitted with a Review of Environmental Factors (REF) as part of an activity approval application to the department. The FSMP may partially fulfil the content requirements for a REF as set out in ESG2: Environmental Impact Assessment Guidelines (NSW Trade & Investment - Mineral Resources Branch, 2012).	✓	"
1.1 Principles	✓	Section 1 - Introduction
· All fracture stimulation activities should be subject to a Fracture Stimulation Management Plan	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
(FSMP) approved by the NSW Government.		
· The FSMP should identify all relevant issues associated with the fracture stimulation activity and demonstrate how these will be managed to ensure that residual risks to the environment, community and workforce are reduced to acceptable levels.	✓	"
· The form of the FSMP should be flexible enough to accommodate and avoid duplication of existing titleholder management systems and regulatory requirements.	✓	"
· The detail provided in the FSMP should be appropriate to the nature, scale, intensity and potential impacts of the proposed fracture stimulation activity.	✓	"
· The FSMP should be freely available to the public.	✓	"
1.2 Mandatory requirements	✓	Section 1 - Introduction Section 1.1 - Operations
a) Fracture stimulation activities must not be conducted except in accordance with a FSMP approved by the department.	✓	"
b) The FSMP must describe the nature, location, scale, timing, duration, hours of operation and	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
other relevant features of the fracture stimulation activity.		
c) The FSMP must demonstrate that all risks to the environment, existing land uses, the community and workforce, as a result of the fracture stimulation activity, are managed through an effective risk management process that includes identification of hazards, assessment of risks, implementation of control measures and monitoring of the integrity and effectiveness of the control measures.	✓	"
d) The FSMP must identify how the titleholder will address and comply with the requirements of this Code.	✓	"
e) The FSMP must be reviewed and as necessary revised by the titleholder:	✓	Section 3 - Compliance
i. before making a significant change to the design or operation of the fracture stimulation activity	✓	"
ii. if the sensitivity of potentially affected environmental, land use or community features significantly increases	✓	"
iii. in the event that monitoring indicates that the consequences of the fracture stimulation activity exceed those identified in the FSMP, or that a risk control measure does not adequately control the risk	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
f) The detail provided in the FSMP must be appropriate to the nature, scale, intensity and potential impacts of the proposed fracture stimulation activity.	✓	Section 1 - Introduction
g) The FSMP is a public document and may be published by the department on its website or by other means. Commercially sensitive or personal information should not be included within a FSMP unless specifically required by this Code.	✓	"
1.3 Leading practice	✓	Section 1 - Introduction
a) The FSMP may summarise relevant information from other regulatory documentation requirements and the titleholder's management systems, provided that the source of this information is identified and made available to the department.	✓	"
b) Examples of source documents referred to in (a) may include:	✓	"
· consultation plans	✓	Section 4.2 - Stakeholder Consultation
· risk assessments	✓	FSMP Appendix A REF Appendix L

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
· well design	✓	Submitted to regulator (DTIRIS)
· fracture stimulation design	✓	To be issued in Fracture Stimulation Program
· environmental impact assessments	✓	REF
· operational plans	✓	To be issued in Fracture Stimulation Program
· environmental management plans	✓	REF Appendix B
· waste management plans	✓	REF Appendix E sub-plan
· safety management plans	✓	REF Appendix F
· monitoring plans	✓	REF SWGMP
· incident response plans	✓	REF Appendix N
· emergency response plans	✓	REF Appendix G

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
· completion/workover programs	✓	Submitted to regulator (DTIRIS)
· notifications	✓	Section 4.1 - Notification
· fracture stimulation completion reports	✓	to be issued upon completion
2 Stakeholder consultation		
2.1 Principles	✓	Section 4.2 - Stakeholder Consultation
Titleholders should undertake appropriate consultation with stakeholders to:	✓	"
· ensure that affected stakeholders are fully informed about fracture stimulation activities	✓	"
· inform the risk assessment and development of management plans	✓	"
2.2 Mandatory requirements	✓	Section 4.2 - Stakeholder Consultation
a) Titleholders must consult with affected stakeholders prior to undertaking a fracture stimulation activity.	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
b) The FSMP must summarise any stakeholder consultation undertaken, or proposed to be undertaken, prior to, during and after the fracture stimulation activity.	✓	"
2.3 Leading practice	✓	Section 4.2 - Stakeholder Consultation
Titleholders should engage in full and open communication with stakeholders, including providing stakeholders with an explanation of:	✓	"
a) the nature, location, scale, timing, duration, hours of operation and other relevant features of the fracture stimulation activity	✓	"
b) the risks associated with the fracture stimulation activity	✓	"
c) how these risks are being managed	✓	"
3 Fracture stimulation design		
3.1 Principles	✓	Section 7 - Design Section 7.7 - Hydraulic Fracture Stimulation Fluid Pump Schedules

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
		Section 7.8 - Fracture Geometry Modelling Section 8 - Fracture Geometry Diagnostics
The fracture stimulation activity should be designed to:	✓	"
· avoid impacts on water resources	✓	"
· contain fractures within the targeted area	✓	"
· minimise chemical use	✓	"
3.2 Mandatory requirements	✓	Section 7 - Design Section 7.7 - Hydraulic Fracture Stimulation Fluid Pump Schedules Section 7.8 - Fracture Geometry Modelling Section 8 - Fracture Geometry Diagnostics

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
The design of the fracture stimulation activity must be described in the FSMP. This description must incorporate the following:	✓	“
a) characterisation of geological formations, including the identification of rock types and conditions, aquifers and hydrocarbon-bearing zones	✓	Section 2.1 - Geology
b) definition of distances to these aquifers from the target coal beds	✓	Section 2.2 - Hydrology and Hydrogeology Section 2.3 - Target Formations
c) identification of the characteristics of intervening strata, including porosity/permeability and the extent of natural fracturing	✓	Section 2.3 - Target Formations
d) determination of geological stress fields and areas of faulting	✓	Section 2.4 - Rock Mechanics: Stress Fields
e) determination of maximum pressures to be used for fracture stimulation, based on the characteristics of the surrounding geology	✓	Section 2.5 - Pressures of Fracture Stimulation
f) modelling of the likely fracture propagation field, including extent and orientation	✓	Section 2.6 - Modelling

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
g) discussion of any potential for the fracture propagation field to exceed that modelled in (vi).	✓	Section 2.6 - Modelling
3.3 Leading practice	✓	Section 2.4 - Rock Mechanics: Stress Field Section 2.6 - Modelling Section 7 - Design Section 7.3 - Core Analysis Section 7.8 - Fracture Geometry Modelling
· Fracture stimulation modelling software can be used to assist in better understanding and controlling fracture growth.	✓	"
· Cores from formations of interest and bounding layers should be tested for rock mechanical properties and used in fracture stimulation simulations.	✓	"
4 Risk assessment		

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
4.1 Principles	✓	Section 4.3 - Risk Assessments
The FSMP should incorporate a risk assessment conducted in accordance with relevant Australian or international standards to identify the risks posed by the fracture stimulation activity and to ensure that the likelihood and consequence of these risks is properly understood.	✓	"
4.2 Mandatory requirements	✓	Section 4.3 - Risk Assessments Section 9.4 - Mitigating Health, Safety and Environment Risks
a) The FSMP must include a risk assessment complying with AS/NZS ISO 31000:2009 Risk management - Principles and Guidelines.	✓	"
b) The risk assessment must identify risks associated with the fracture stimulation activity, the likelihood of each risk and the consequence of each risk.	✓	"
c) The risk assessment must define appropriate management controls to ensure identified risks are constrained to acceptable levels.	✓	"
d) At a minimum, the risk assessment must address risks associated with:	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
i. workplace health and safety (see heading 5 of this Code)	✓	"
ii. public safety (see heading 5 of this Code)	✓	"
iii. chemical use (see heading 6 of this Code)	✓	"
iv. impacts on water resources (see headings 7 and 8 of this Code)	✓	"
v. land contamination	✓	"
vi. air pollution	✓	"
vii. noise & vibration	✓	"
viii. waste management	✓	"
ix. loss of well integrity	✓	"
x. induced seismicity	✓	"
xi. induced subsidence or other induced ground movements	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
xii. conflicts with existing land uses	✓	"
5 Safety		
5.1 Principles	✓	Section 4.4 - Safety Management Plan Section 9 - Execution
Fracture stimulation activities should be carried out safely and with minimal risks to the health of employees, visitors and members of the public:	✓	"
· The titleholder is responsible for the safety of not only workers and visitors to the site of a fracture stimulation activity, but also members of the general public who might be affected by the activity.	✓	"
· A rigorous, risk-based approach should be applied to managing the safety risks associated with a fracture stimulation activity.	✓	"
5.2 Mandatory requirements	✓	Section 4.4 - Safety Management Plan Section 7.9 - Equipment Selection

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
		Section 9 - Execution Section 9.1 - Pre Job Planning Section 9.2 - Location Preparation Section 9.4 - Mitigating Health, Safety and Environment Risks Section 9.5 - Job Execution
a) Prior to commencing a fracture stimulation activity, titleholders must ensure that operators and contractors prepare, implement and review as necessary, a Safety Management Plan2 to address the specific safety risks that might arise from a fracture stimulation activity, and to ensure that the design and operation of the site and its equipment are safe.	✓	"
b) The Safety Management Plan must provide the basis for:	✓	"
i. the identification of hazards	✓	"
ii. the assessment of risks arising from those hazards	✓	"
iii. the development of controls for those risks	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
iv. the reliable implementation of those controls through a formal safety assessment process.	✓	"
c) The Safety Management Plan must include:	✓	"
i. a short description of the activity and site location	✓	"
ii. the management structure of the major contractor for the activity	✓	"
iii. any systems, policies, programs, plans and procedures in place relating to the work undertaken at the site	✓	"
iv. the Emergency Plan (see heading 11)	✓	"
v. communication systems (such as emergency communication systems)	✓	"
vi. a work health and safety policy that includes the work health and safety objectives for the activity	✓	"
vii. the arrangements for appropriate instruction, training, including certification requirements, and provision of information for workers	✓	"
viii. the arrangements for the safe use of plant as per the Work Health and Safety Act 2011,	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
including the acquisition of fit-for-purpose plant and its commissioning, operation and maintenance		
ix. appropriate control systems such as:	✓	"
· alarm systems, pressure and flow detection system as part of well control, pressure control systems, emergency shutdown systems, a fluid monitoring system, a fire fighting system, a gas monitoring system	✓	"
· a process for managing change including a process for managing any changes to plant, operating procedures, organisational structure, workers and the Safety Management Plan	✓	"
· the mechanisms for implementing, monitoring and reviewing and auditing safety policies and the Safety Management Plan – for example, the plans must be reviewed if a relevant safety code, safety requirement or standard is introduced or amended, or in the event of a reasonably foreseeable incident	✓	"
· key performance indicators to be used to monitor compliance with the plan	✓	"
· mechanisms for recording, investigating and reviewing incidents at the fracture stimulation site and implementing recommendations from an investigation or review of an incident	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
· any site safety rules, with the detail of arrangements for ensuring that all persons at the site, whether workers, contractors, suppliers or visitors, are informed of the rules	✓	"
· the arrangements for document control and record keeping.	✓	"
d) Titleholders are responsible for ensuring that if a contractor is commissioned to undertake well operations, the contractor has a Safety Management Plan encompassing the scope of their work, which includes the following matters to ensure Safety Management Plans are consistent:	✓	"
ii. an identification of the specific risks that may arise as a result of the proposed or likely interactions between safety management systems, and how the risks will be controlled	✓	"
iii. an identification of the safety responsibilities of each party.	✓	"
6 Use of chemicals in fracture stimulation		
6.1 Principles	✓	Section 7.4 - Fluid Selection Section 7.5 - Fracture Stimulation Chemicals
The use of chemical additives in fracture stimulation activities should be minimised as far as	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
reasonably practicable		
Chemical additives should be selected and managed to minimise potential impacts on the environment	✓	"
The use of additives containing BTEX compounds (benzene, toluene, ethyl benzene and xylenes) is banned in NSW	✓	"
6.2 Mandatory requirements	✓	Section 7.4 - Fluid Selection Section 7.5 - Fracture Stimulation Chemicals REF Appendix B
The FSMP must identify:		
a) All chemicals to be injected as part of the fracture stimulation process	✓	"
b) The Chemical Abstract Service (CAS) registry number for those chemicals	✓	"
c) The volumes and concentrations of those chemicals	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
d) Potential risks to human health arising from exposure to those chemicals	✓	"
e) The risk, likelihood and consequence of surface spills of these chemicals	✓	"
f) Whether chemical concentrations at the point of injection will exceed:	✓	"
i. ANZECC 2000 guidelines4 for overlying groundwater and surface water uses that may be affected	✓	"
ii. ADWG 20045 if a drinking water supply may be affected	✓	"
iii. natural background concentrations if the water source is not effectively described by ANZECC or ADWG guidelines; or	✓	"
iv. if the chemical is not specified in ANZECC or ADWG guidelines and may have a toxic6 effect, then assess whether the toxic effect is likely to exceed a trigger toxicity level determined in accordance with a suitable methodology such as those described in Section 2: OECD Guidelines for the Testing of Chemicals7.	✓	"
g) The risk, likelihood and consequence of the injected chemicals affecting the beneficial use class of the target aquifer or any other aquifer	✓	"
h) How those chemicals will be stored and managed.	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
7 Water resources		
7.1 Principles	✓	Section 4.3 - Risk Assessments: Groundwater and Surface Water Assessment
Protection of water resources should be a primary consideration in both the design and execution of a fracture stimulation activity.	✓	"
7.2 Mandatory requirements	✓	Section 4.3 - Risk Assessments: Groundwater and Surface Water Assessment
The FSMP must, at a minimum:	✓	"
a) Identify the location, extent, pre-existing water quality and use of water sources which have the potential to be impacted by the fracture stimulation activity.	✓	"
b) Identify sources of fracture stimulation injection water, the estimated quality and volume to be injected and any licensing/approval requirements under the Water Management Act 2000 or Water Act 1912.	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
c) Include a qualitative risk assessment for risks associated with the fracture stimulation activity, including:	✓	"
i. cross-contamination between coal bed waters and shallower water sources	✓	"
ii. changes to groundwater pressure and levels	✓	"
iii. changes to surface water levels	✓	"
iv. changes to water quality characteristics.	✓	"
d) If the risk of establishing a connection between the target coal bed and other water sources as a result of the fracture stimulation activity is assessed to be moderate or higher, then a fate and transport model study must be undertaken to quantify the impacts on water sources and the likelihood of any changes to the beneficial use8 category applicable to any affected aquifer.	✓	"
e) If there is a moderate or greater risk of significant changes to pressure or levels as referred to in c) (ii) or (iii), the impacts on all affected aquifers must be quantitatively assessed.	✓	"
f) Describe consultation undertaken with the NSW Office of Water in developing the water resources component of the risk assessment.	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
8 Management of flowback water		
8.1 Principles	✓	Section 4.3 - Risk Assessments Section 4.3 - Risk Assessment: Flowback and Waste Management Section 10 - Flowback, Dewatering and Disposal
That flowback water is managed in a way that ensures that risks to health, safety and the environment are appropriately managed.	✓	"
8.2 Mandatory requirements	✓	Section 4.3 - Risk Assessments Section 4.3 - Risk Assessment: Flowback and Waste Management Section 10 - Flowback, Dewatering and Disposal
The FSMP must:	✓	"
a) Identify how flowback water is to be managed to ensure that risks to health, safety and the	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
environment are maintained at acceptable levels		
b) Reflect consent conditions regarding storage requirements, methods for disposal and other surface water management methods	✓	"
c) Describe the reuse, recycling or disposal methods for the flowback water	✓	"
d) Describe if and how flowback water will be stored and treated on site	✓	"
e) Describe if and how flowback water will be characterised and disposed of in accordance with the relevant OEH waste classification guidelines9.	✓	"
8.3 Leading practice	✓	Section 4.3 - Risk Assessments Section 4.3 - Risk Assessment: Flowback and Waste Management Section 10 - Flowback, Dewatering and Disposal Section 11 - Monitoring

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
· Flowback water should be promptly pumped from the well to maximise the recovery of fluids injected as part of the fracture stimulation activity. This pumping should be continued until background water quality parameters for the target formation are reached.	✓	"
· The volume and quality of the flowback water with time should be recorded in order to establish the fate of any additives injected as part of the fracture stimulation fluid.	✓	"
· Tracer elements may be used to assist in identifying the fate of the fracture stimulation fluid.		
9 Impacts on coal mining		
9.1 Principles	✓	Section 13 - Coal Mining
To ensure that fracture stimulation activities do not adversely impact on current and future coal mining activities.	✓	"
9.2 Mandatory requirements	✓	Section 13 - Coal Mining
a) The FSMP must identify whether the fracture stimulation activity is adjacent to a mining lease, and if so, whether a cooperation agreement has been entered into with the adjacent authorisation holder regarding the potential impacts of their activities on, or arising from, the proposed fracture stimulation activity.	✓	"

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Code of Practice Clause	Comply	FSMP Reference
b) Titleholders must refer to conditions of title for additional requirements.	✓	"
10 Monitoring		
10.1 Principles	✓	Section 11 - Monitoring
That fracture stimulation activities are effectively monitored to allow the prompt identification and mitigation of any health, safety or environmental risks.	✓	"
10.2 Mandatory requirements	✓	Section 7.7 - Hydraulic Fracture Stimulation Fluid Pump Schedules Section 7.8 - Fracture Geometry Modelling Section 7.9 - Equipment Selection Section 8 - Fracture Geometry Diagnostics Section 11 - Monitoring
a) The FSMP must describe any monitoring arrangements, including monitoring before, during and after the fracture stimulation activity.	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
b) The titleholder must carry out sufficient monitoring to establish that significant risks have been:	✓	"
i. identified	✓	"
ii. quantified	✓	"
iii. avoided, or appropriately managed so that residual risks are within acceptable limits before, during and after the fracture stimulation activity.	✓	"
c) Monitoring of overlying water sources must be undertaken over an area sufficient to encompass the predicted fracture length plus a sufficient margin to provide for any uncertainty.	✓	"
d) Prior to fracture stimulation, monitoring must be undertaken to characterise water source level, pressure and quality. This monitoring should include existing wells and water bores at a minimum.	✓	"
e) During fracture stimulation, monitoring must be undertaken to:	✓	Section 9.3 - Fluids Quality Assurance Section 9.5 - Job Execution
i. record key parameters such as bottom hole pressure and surface injection pressure	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
ii. establish the volume, composition, viscosity and pumping rate of fracture fluids and proppants	✓	"
f) Post-stimulation monitoring must be undertaken to ensure that induced inter-aquifer connectivity has been prevented by:	✓	"
i. determining the volume and quality of flowback and produced water	✓	"
ii. quantifying any changes in surrounding water sources	✓	"
iii. pressure testing of casing to verify that the integrity of the well and well equipment has been maintained.	✓	"
10.3 Leading practice	✓	Section 2.5 - Pressures for Fracture Stimulation Section 7.8 - Fracture Geometry Modelling Section 8 - Fracture Geometry Diagnostics
Fracture stimulation simulations should be validated by monitoring fracture growth in real time to determine actual fracture geometry and extent.	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
11 Incident and emergency response		
11.1 Principles	✓	Section 5 - Emergency Response Plan
Incidents and emergencies must be prepared for and managed appropriately to ensure that risks to health, safety and the environment are minimised.		"
11.2 Mandatory requirements – general emergencies	✓	Section 5 - Emergency Response Plan
a) The titleholder must prepare an Emergency Plan10 for the fracture stimulation activity addressing emergency procedures, including:	✓	"
i. evacuation procedures	✓	"
ii. medical treatment and assistance	✓	"
iii. notifying emergency service organisations at the earliest opportunity	✓	"
iv. effective communication to coordinate the emergency response and all persons at the workplace	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
v. testing of the emergency procedures, including the frequency of testing	✓	‘
vi. regular mandatory information, training and instruction to workers	✓	“
b) The Emergency Plan must include:	✓	“
i. the name of the project	✓	“
ii. the title ID	✓	“
iii. GPS coordinates and location on a roadmap indicating directions to the nearest hospital or emergency air evacuation site	✓	“
iv. contact details for the operating company and contractors at the site.	✓	“
c) The Emergency Plan must specify actions to be taken and identify persons responsible in the event of an emergency arising as a result of:	✓	“
i. serious injury or fatality to a person at the site	✓	“
ii. well blow-out or loss of well integrity causing an uncontrolled release of fluid	✓	“

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
iii. unplanned ignition of methane	✓	"
iv. chemical spill or other pollution incident	✓	"
v. any other serious event associated with the operations	✓	"
d) Workers must be trained in emergency response procedures.	✓	"
e) The Emergency Plan must in place and adequately resourced during the conduct of the fracture stimulation activity.	✓	"
f) Serious workplace incidents including injuries and fatalities must be reported to the department (Mine Safety) as required under Part 3 of the Work Health and Safety Act 2011.	✓	"
g) The Emergency Plan must be reviewed and tested as soon as reasonably practicable after any emergency has occurred at the site and whenever the Safety Management Plan is reviewed.	✓	"
11.3 Mandatory requirements – environmental incidents	✓	Section 6 - Environmental Incident Response Plan
a) The titleholder must prepare and maintain an Environmental Incident Response Plan11,12 setting out in detail the procedures to be followed and actions to be taken in the event of:	✓	"

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
i. well blowout or loss of integrity	✓	"
ii. chemical spill or other pollution incident	✓	"
iii. damage to an overlying water source	✓	"
iv. breach of regulatory requirements, including significant non-compliance with the FSMP	✓	"
v. any other significant environmental incident associated with the fracture stimulation activity.	✓	"
b) The matters required to be included in an Environmental Incident Response Plan are:	✓	"
i. a description of the hazards to human health or the environment associated with the fracture stimulation activity	✓	"
ii. the likelihood of any such hazards occurring, including details of any conditions or events that could, or would, increase that likelihood,	✓	"
iii. details of the pre-emptive action to be taken to minimise or prevent any risk of harm to human health or the environment arising out of the activity	✓	"
iv. an inventory of potential pollutants on the premises or used in carrying out the activity, 11 Part	✓	"

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Code of Practice Clause	Comply	FSMP Reference
5.7A of the Protection of the Environment Operations Act 1997 (POEO Act) requires environment protection licensees to		
v. the maximum quantity of any pollutant that is likely to be stored or held at the location of the fracture stimulation activity	✓	"
vi. a description of the safety equipment or other devices that are used to minimise the risks to human health or the environment and to contain or control a pollution incident	✓	"
vii. the names, positions and 24-hour contact details of those key individuals who:	✓	"
· are responsible for activating the plan, and	✓	"
· are authorised to notify relevant authorities under paragraph (e) and (f), and	✓	"
· are responsible for managing the response to a pollution incident	✓	"
viii. the contact details of each relevant authority referred to in paragraph (e) and (f)	✓	"
ix. details of the mechanisms for providing early warnings and regular updates to the owners and occupiers of premises in the vicinity of the fracture stimulation activity	✓	"

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Code of Practice Clause	Comply	FSMP Reference
x. the arrangements for minimising the risk of harm to any persons who are present where the fracture stimulation activity is being carried out	✓	"
xi. a detailed map (or set of maps) showing the location of the fracture stimulation activity, the surrounding area that is likely to be affected by a pollution incident, the location of potential pollutants on the activity site and the location of any stormwater drains on the activity site	✓	"
xii. a detailed description of how any identified risk of harm to human health will be reduced, including (as a minimum) by means of early warnings, updates and the action to be taken during or immediately after a pollution incident to reduce that risk	✓	"
xiii. the nature and objectives of any staff training program in relation to the plan	✓	"
xiv. the dates on which the plan has been tested and the name of the person who carried out the test,	✓	"
xv. the dates on which the plan is updated,	✓	"
xvi. the manner in which the plan is to be tested and maintained.	✓	"
c) The Environmental Incident Response Plan must be made readily available:	✓	"

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Code of Practice Clause	Comply	FSMP Reference
i. to an authorised officer representing an authority listed in paragraph (e) and (f) on request	✓	"
ii. at the site of the fracture stimulation activity, to any person who is responsible for implementing the plan.	✓	"
d) The Environmental Incident Response Plan must be tested prior to the commencement of the fracture stimulation activity to ensure that the information included in the plan is accurate and up to date and the plan is capable of being implemented in a workable and effective manner.	✓	"
e) Pollution incidents that cause or threaten material harm to the environment must be immediately notified to each of the following authorities in the following order:	✓	"
i. the appropriate regulatory authority (ARA)	✓	"
ii. the Environment Protection Authority (EPA) if they are not the ARA	✓	"
iii. the Ministry of Health	✓	"
iv. the department (Mine Safety – as the WorkCover Authority)	✓	"
v. the local authority, e.g. the local council, if this is not the ARA	✓	"

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Code of Practice Clause	Comply	FSMP Reference
vi. Fire and Rescue NSW	✓	“
vii. the department (Environmental Sustainability Unit)	✓	“
f) The titleholder must also immediately notify the NSW Office of Water (NOW) if a water source is harmed.	✓	“
12 Notification requirements		
12.1 Principles	✓	Section 4.1 - Notification
That the department is made aware that a fracture stimulation activity is to be undertaken and has the opportunity to observe the activity.	✓	”
12.2 Mandatory requirements	✓	Section 4.1 - Notification
At least 10 business days before starting hydraulic fracturing activities, the titleholder must complete and lodge a Notice of Intention to Carry out Fracture Stimulation on the department’s approved form.	✓	”

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
13 Undertaking the fracture stimulation activity		
13.1 Principles	✓	Section 9 - Execution Section 9.2 - Location Preparation Section 9.4 - Mitigating Health, Safety and Environment Risks Section 9.5 - Job Execution
Fracture stimulation activities must be undertaken in accordance with all relevant approvals. The activity should be undertaken in a manner that ensures that risks to health, safety and the environment are appropriately managed.	✓	”
13.2 Mandatory requirements	✓	Section 8 - Fracture Geometry Diagnostics Section 9 - Execution Section 9.2 - Location Preparation Section 9.4 - Mitigating Health, Safety and Environment Risks

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
		Section 9.5 - Job Execution
a) The titleholder must ensure that well construction, cement and casing integrity meet the standards set out in the NSW Code of Practice for Coal Seam Gas Well Integrity before fracture stimulation operations commence to ensure that cement and casing integrity is sufficient for the planned activity.	✓	”
b) The titleholder must ensure that fracture stimulation activities are conducted in a manner which:	✓	”
i. complies with this Code, relevant Government policies, approval conditions, title conditions and legislative requirements	✓	”
ii. manages all health, safety and environmental risks associated with the fracture stimulation process	✓	”
iii. uses all reasonable endeavours to ensure the fracture stimulation is contained within the targeted area	✓	”
iv. uses all reasonable endeavours to ensure that fractures do not induce connections with water sources	✓	”
v. uses all reasonable endeavours to avoid pollution of water sources	✓	”

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
vi. puts in place appropriate monitoring, response plans and reporting regimes to ensure that any risk to health, safety or the environment can be promptly addressed or mitigated	✓	”
14 Completion report		
14.1 Principles	✓	Section 14 - Reporting
Key parameters of the conduct and impacts of fracture stimulation operations must be reported to the department to ensure that health safety and environmental risks have been appropriately managed and that regulatory requirements have been met.	✓	”
14.2 Mandatory requirements	✓	Section 8 - Fracture Geometry Diagnostics Section 9 - Execution Section 14 - Reporting Section 7.9 - Equipment Selection
a) A completed Fracture Stimulation Completion Report must be submitted to the department (Mine Safety Operations + Environmental Sustainability Unit) in the approved form within 30 days of the cessation of the fracture stimulation activity.	✓	”

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
b) The report must include:	✓	”
i. identifying information concerning the title, the contractor, and the location of the well	✓	”
ii. commencement and completion dates of fracturing for each well	✓	”
iii. details of each interval fractured	✓	”
iv. summary of operations (including volume and type of chemicals used in each stage)	✓	”
v. assessment of the fracture stimulation including:	✓	”
· casing and bottom hole pressure with time	✓	”
· bottom hole calculated proppant concentration	✓	”
· rate that fracturing fluid was pumped over time and the total volume pumped at each stage	✓	”
· composition of the fracturing fluid and any other chemicals introduced into the well (quantity of each component; concentration of each component; name of chemical compounds contained in fluid)	✓	”

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
· concentration of proppant over time	✓	”
· maximum surface pressure at each stage	✓	”
· estimated frac gradient for the target interval	✓	”
· details of equipment and diagnostic techniques used	✓	”
· if fracturing has been undertaken on a coal seam – any other details to assist future assessment of the impact on the seam, and any increased risk to safe and efficient mining of coal	✓	”
· if a known event related to the fracturing activities has caused material environmental harm, details of each step taken to mitigate the harm.	✓	”
vi. a hydraulic fluid fracturing statement	✓	”
The department may publish the completion report on its website.	✓	”
Fracture Stimulation Activities 15	✓	”
15 Record keeping		

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
15.1 Principles	✓	Section 15 - Record Keeping
That appropriate records are kept of fracture stimulation activities to facilitate resolution of any future issues.	✓	”
15.2 Mandatory requirements	✓	Section 15 - Record Keeping
a) The titleholder must maintain a record of all fracture stimulation activities (refer also to the NSW Code of Practice for Coal Seam Gas Well Integrity).	✓	”
b) The records referred to in (a) must be made available to the department for inspection on request.	✓	”
c) The titleholder must maintain the following records of all fracture stimulation activities (as per (a)):	✓	”
i. the FSMP	✓	”
ii. engineering design (including design safety factors used for casing and estimated load calculations)	✓	”
iii. laboratory results for any tests conducted in conjunction with the activity	✓	”

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
iv. pressure tests	✓	”
v. leak off test and/or formation integrity test reports	✓	”
vi. details of all chemicals used (name, type and volume of each chemical)	✓	”
vii. risk assessments	✓	”
viii. sources of water used for fracture stimulation operations	✓	”
ix. service company reports	✓	”
x. environmental monitoring results	✓	”
xi. completion report	✓	”
d) Following plug and abandonment of a well, the titleholder must provide the department with a copy of the records referred to in (a).	✓	”
16 Application of Australian and international standards		
16.1 Principles	✓	Section 1 - CSG Specific Industry

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
		CoP or Guidelines Section 4.3 - Risk Assessments
Relevant Australian and international standards should be complied with where these are of an equal or higher standard than those set out in this Code and do not conflict with the NSW regulatory framework.	✓	”
16.2 Mandatory requirements	✓	Section 1 - CSG Specific Industry CoP or Guidelines Section 4.3 - Risk Assessments
Titleholders must comply with the following standards in so far as these standards are of an equal or higher standard than those identified elsewhere in this Code and do not conflict with the NSW regulatory framework:	✓	”
a) AS/NZS ISO 31000:2009 Risk management - Principles and guidelines	✓	”
b) NSW Code of Practice for Coal Seam Gas Well Integrity 2012	✓	”
16.3 Leading practice	✓	Section 1 - CSG Specific Industry CoP or Guidelines

Table of Compliance

Code of Practice Clause	Comply	FSMP Reference
a) Titleholders should comply with the following guidelines in so far as these guidelines set an equal or higher standard than those identified elsewhere in this Code and do not conflict with the NSW regulatory framework:	✓	”
i. American Petroleum Institute Guidance Document HF 1 Hydraulic Fracturing Operations - Well Construction and Integrity Guidelines October 2009	✓	”
ii. American Petroleum Institute Guidance Document HF 2 Water Management Associated with Hydraulic Fracturing June 2010	✓	”
iii. American Petroleum Institute Guidance Document HF 3 Practices for Mitigating Surface Impacts Associated with Hydraulic Fracturing January 2011	✓	”
iv. American Petroleum Institute Recommended Practice 51R Environmental Protection for Onshore Oil and Gas Production Operations and Leases July 2009	✓	”
and Gas Production Operations and Leases July 2009 b) Relevant Australian and international standards and guidelines not identified in this Code should be complied	✓	”
b) Relevant Australian and international standards and guidelines not identified in this Code should be complied with in so far as they set requirements of an equal or higher standard than those	✓	”

Table of Compliance		
Code of Practice Clause	**Comply**	**FSMP Reference**
identified elsewhere in this		

Appendix C

Air quality impact assessment

Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology

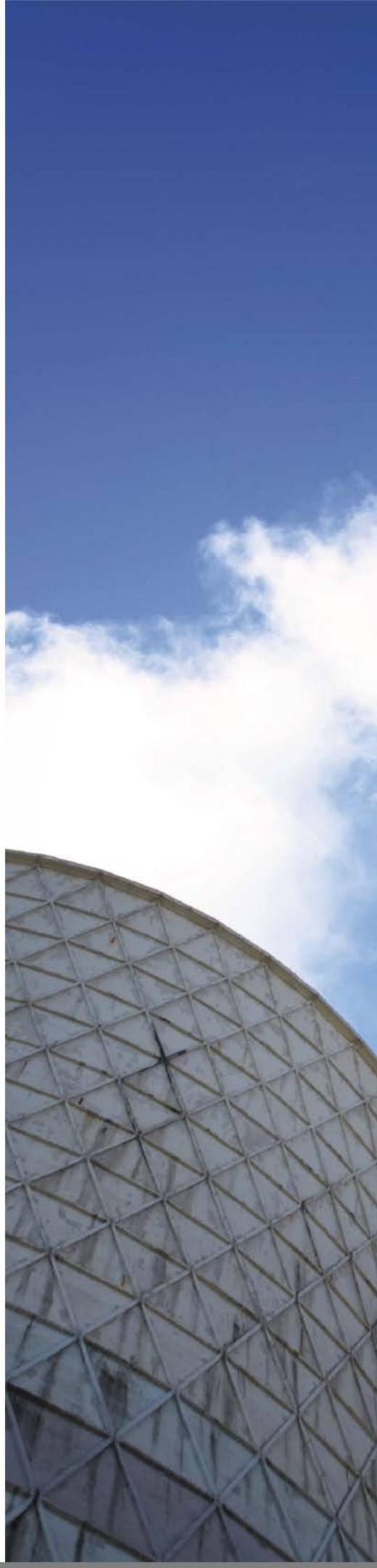
REVISED REPORT

QUALITATIVE AIR QUALITY AND GREENHOUSE GAS ASSESSMENT – AGL GLOUCESTER PILOT PROJECT

AGL Upstream Investments Pty Ltd

Job No: **7909**

25 July 2013



PROJECT TITLE:	Qualitative Air Quality and Greenhouse Gas Assessment – AGL Gloucester Pilot Project
JOB NUMBER:	7909
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DOCUMENT CONTROL

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EXECUTIVE SUMMARY

AGL Upstream Investments Pty Ltd (AGL) seeks approval for the pilot testing of four existing vertical exploration wells at Gloucester, NSW.

The pilot testing activity involves pump testing, flaring and the use of gas gathering lines. The gas from the four exploration wells is directed to an enclosed central flare at the Waukivory 12 location (Scenario 1) or flares at both Waukivory 11 and Waukivory 12 locations (Scenario 2) for flaring prior to discharge. The venting of gas will be minimised where possible.

Previous air quality assessments that determined ground level concentrations of pollutants resulting from emissions from flares have been carried out using air dispersion modelling. These assessments have determined that the emissions from flares lead to low ground level concentrations of NO_2, CO and VOCs. Therefore, it is feasible to address the air quality risks qualitatively (i.e. without the use of dispersion modelling).

The qualitative assessment indicates that the likely concentrations for all air quality parameters would not approach NSW EPA air quality criteria as a result of the Project operating alone or when considered with other sources (i.e. existing background sources).

Impacts of fugitive emissions have been evaluated and it is concluded that, due to well design and construction procedures, any fugitive gas emissions are likely to be minimal, of short duration and localised. To monitor and manage fugitive emissions, AGL have committed to the use of mobile monitoring to evaluate methane concentrations in the Gloucester Valley both prior to and during the pre-production process.

Greenhouse gas (GHG) emissions from flaring at the flare were calculated to represent 0.011% of Australia's national GHG emissions for the baseline year 2012. Accordingly, emissions are minor when compared to national and NSW annual GHG emissions. The act of flaring emissions as opposed to venting them directly is highlighted as good practice in terms of carbon management. This is due to the relative potency of methane as a greenhouse gas.

CONTENTS

1 INTRODUCTION

AGL Upstream Investments Pty Ltd (AGL) is the holder and operator of Petroleum Exploration Licence (PEL) 285 near Gloucester, NSW. AGL seeks approval for pilot testing of four existing exploration wells (the Project) identified as:

- Waukivory 11 (WK 11)
- Waukivory 12 (WK 12)
- Waukivory 13 (WK 13)
- Waukivory 14 (WK 14).

There are currently two possible scenarios for the pilot testing operation, with the final option being dependent upon AGL's desire to construct an underbore. Both scenarios have been evaluated within this assessment.

In the first scenario, gas from pilots wells WK11, 12, 13 and 14 will be directed to a flare at Waukivory 12 . A contingency flare is also proposed for Scenario 1 to be located at Waukivory 12 to deal with potential high gas flows. The second scenario will involve operating two flares, one each at Waukivory 12 (central flare) and Waukivory 11 (secondary flare). The activity will be temporary in duration.

In accordance with the *Additional Part 5 REF requirements for petroleum prospecting: A supplement to ESG2: Environmental Impact Assessment Guidelines 2011* (NSW TIRE, 2012)**,** dispersion modelling is not required as the proposed Waukivory pilot wells are not deemed to pose a risk of adverse air quality impacts. In this assessment we compare the estimated gas flow rates, and consequent emission profiles from flaring gas from the Waukivory pilot wells with AGL's previous impact assessment at their Windermere pilot well project in Bulga, NSW. The results of dispersion modelling undertaken at Windermere are referenced to understand the magnitude of the likely ground level concentrations at Waukivory.Pacific Environment has been engaged to prepare a qualitative air quality and greenhouse gas (GHG) assessment as part of the Review of Environmental Factors (REF).

1.1 Background

The Gloucester Gas Project (GGP) is located near Stratford, approximately 100 kilometres north of Newcastle within PEL 285, issued under the Petroleum (Onshore) Act, 1991. The project is wholly owned and operated by AGL.

AGL will continue to explore within PEL 285 as a part of its exploration licence, including drilling additional exploration wells, core holes, undertaking further seismic studies and an aeromagnetic survey of the Gloucester Basin.

All exploration activities are regulated by the NSW Government under the Petroleum (Onshore) Act. Most activities require the submission and approval of a Review of Environmental Factors (REF) prior to commencement.

1.2 Objectives of the study

The objectives of the study are as follows:

- To assess qualitatively the potential air quality impacts from the gas extraction and flaring associated with the pilot testing of the four exploration wells.
- To assess the GHG emissions from the pilot testing of the four exploration wells, and to put them into their context in terms of National and NSW emissions.

1.3 Scope of Work

The scope of work involves the following tasks:

- Provision of an overview of the Project and the associated potential impacts on local air quality.
- Provision of estimates of emissions to air associated with the Project, including flaring of coal seam methane.
- Provision of an overview of existing ambient air quality.
- Description of local climatic conditions and prevailing meteorology referencing a local meteorological monitoring station.
- Comparison of estimates of emissions with previous air dispersion modelling outputs to determine likely air quality impacts.
- Estimation of the projects contribution to GHG emissions using estimation methods in accordance with the relevant guidelines.
- Assessment of the residual greenhouse gas emissions in the context of total Australian and NSW emissions.

2 PROJECT DESCRIPTION

The Gloucester Gas Project (GGP) is a coal seam gas (CSG) exploration project which comprises PEL 285 in the Hunter Region. AGL is the holder and operator of this PEL and is part way through its CSG exploration program.

Exploration is expected to continue for the terms of the PEL to appraise and evaluate the quantity and quality of the natural gas resource. There are several components of exploration, one of which is pilot testing of gas wells. AGL proposes pilot testing of four Waukivory wells in the Gloucester Gas Project within PEL 285. The pilot wells will identify potential CSG resources by testing the composition, flow rate and volume of gas in target coal seams.

The pilot testing activity involves pump testing, flaring and the use of gas gathering lines. During pump testing, a hydraulic or electric surface dewatering pump is mounted on the wellhead to drive the downhole pump.

At the surface the pumped water is directed to a gas/water separator where any remaining entrained gas is removed from the pumped water. The gas separating chamber has inlets for both the water and the gas streams coming from the gas well. Similarly it has outlets for both the water and the gas streams, with the produced formation water going (in some cases via water lines) to the tanks and the gas via gas gathering lines to the enclosed central flare.

Ideally a 1:1 gas to water ratio is maintained in the chamber that allows most of the remaining gas dissolved in the pumped water to be released. The water is forced out from the base of the chamber by the gas pressure and directed through water lines to storage tanks on site.

The gas is forced through the top of the separating chamber through an electrical instrument flow meter (FloBoss) and directed to the enclosed central flare. A telemetry system is connected to the FloBoss to send data to its server so that the well performance can be monitored remotely. The gas line from the separator is fitted with an adjustable choke that allows the flow of gas to be regulated or stopped. An automatic shut-down valve (SDV) is installed to respond to abnormal well behaviours or an emergency situation. The SDV can be controlled remotely via the telemetry system thus providing protection to the surface equipment in case of high pressure gas spike events.

During flaring, a steel gas line is installed from each well to the inlet of the horizontal enclosed flare to ensure that gas can be safely flared with minimal visual impact. Enclosing the flare is an important measure, particularly if sufficient quantities of gas are produced during flow testing. The venting of gas will be minimised where possible.

2.1 Local Setting

The local setting is dominated by dairy and beef cattle farming and some coal mining, with a few private residences and other sensitive receptors in the area. The township of Gloucester is located in Gloucester Shire located approximately 4 km north of the Project site, within the Manning district on the Mid North Coast of NSW.

Approximately 15 km south of Gloucester, just outside of Stratford, Yancoal operates the Stratford coal mine, under Stratford Coal Limited (SCL). SCL have applied for an extension to their mining operations. The expansion would allow an additional 11 years of mining at up to 2.6 million tonnes per annum. Mining would be extended into three new open cut mining areas:

- Roseville West Pit Extension;
- Avon North Open Cut; and
- Stratford East Open Cut.

Gloucester Resources Limited (GRL) has proposed the establishment of a new open-cut coal mine on land covered by their Exploration Licence 6523. Council has resolved unanimously to oppose the GRL coal mining application as the proposed site:

- is substantially within an area zoned for Environmental and Scenic Protection
- is within 850 metres of residential housing in the Forbedale Estate
- adds to the cumulative impact of (all) mining activity surrounding Gloucester

The GRL proposed coal mine would border AGL's Waukivory gas wells at its site near Gloucester, which is within 500m of the Forbedale Estate.

There are approximately 12 residences within a distance of approximately 1 km of the central flare (Scenario 1). The location of the closest private receptors in relation to the pilot wells and the central flare are shown in **Figure 2.1** (supplied by AGL). There are additional residences within a distance of approximately 1 km of the flare at Waukivory 11 (Scenario 2).

For the purposes of assessing air quality impacts from the Project, the closest residences are selected and presented in **Table 2.1**.

Figure 2.1: Closest Residences to the Pilot Well Flare Site

Table 2.1: Closest Private Resident Locations

ID	Easting (m)	Northing (m)
R1	401819	6452633
R2	402100	6452087
R3	401662	6452802
R4	403183	6452252
R5	402680	6453546
R6	402474	6451595
R7	401587	6452969
R8	402034	6453085
R9	401672	6453064
R10	401738	6452970
R11	401644	6452884
R12	401693	6452733

3 AIR QUALITY CRITERIA

The Project will result in emissions associated with the CSG management, including venting and flaring. Venting is associated with emissions of GHG, principally methane (CH_4). Flaring will emit quantities of criteria air pollutants, principally nitrogen oxides (NO_x), carbon monoxide (CO) and volatile organic compounds (VOCs).

3.1 Oxides of Nitrogen

Oxides of nitrogen are produced when fossil fuels are combusted in the presence of air. NO_x emitted by fossil fuel combustion are comprised mainly of nitric oxide (NO) and nitrogen dioxide (NO_2). NO is much less harmful to humans than NO_2 and is not generally considered a pollutant at the concentrations normally found in ambient air.

NO_2 is the regulated oxide of nitrogen in NSW and effects of exposure to NO_2 include irritation of the lungs and lower resistance to respiratory infections such as influenza. The effects of short-term exposure are still unclear, but continued or frequent exposure to concentrations that are typically much higher than those normally found in the ambient air may cause increased incidence of acute respiratory illness in children. Concern with NO is related to its transformation to NO_2 once released to atmosphere and its role in the formation of photochemical smog.

Typically, close to the combustion sources, NO_2 makes up 5 to 20 per cent by weight of the total oxides of nitrogen. At the point of emission, NO_x would consist of approximately 90-95% of NO and 5-10% of NO_2, the regulated oxide. The dominant short term conversion is NO to NO_2 through oxidation with atmospheric ozone (O_3) as the plume travels from source.

$$NO + O_3 \equiv NO_2 + O_2$$

Therefore, to determine the ground level concentration of NO_2 it is necessary to account for the transformation of NO_x to NO_2.

3.2 Volatile Organic Compounds (VOCs)

Organic hydrocarbons are comprised of a collection of various VOCs, and several of these compounds may be toxic, including benzene, ethylbenzene, 1,3-butadiene, toluene and xylenes. Methane itself is a common VOC but is often distinguished from other VOCs using the term non-methane VOCs or NMVOCs.

Air toxics are present in the air in low concentrations, however characteristics such as toxicity or persistence means they can be hazardous to human, plant or animal life. Organic hydrocarbons also include reactive organic compounds, which play a role in the formation of photochemical smog. There are no impact assessment criteria specified for total VOCs, however predictions can be compared to the impact assessment criteria for individual organic pollutants that may be present in the flared gas.

3.3 Methane

Coal seam gas (CSG) constitutes approximately 97% methane (with the remainder being ~2% carbon dioxide, ~1% ethane). It is therefore important to discuss air quality criteria relevant to this compound, particularly when discussing the potential for fugitive gas impacts.

There are no health criteria for methane commonly used in NSW or Internationally that are relevant to concentrations that might be expected locally associated with a fugitive release of CSG.

A methane concentration of 1,000ppm is referenced as a health criterion based on asphyxiation. Additionally, criteria is available related to explosivity, where a Lower Explosive Limit (LEL) value of 50,000ppm is referenced.

The global background concentration of methane is currently 1.8ppm, with local/regional fluctuations expected due to both natural and man-made sources.

Examples of naturally occurring methane sources include coal seams, wetlands, permafrost and termite activity.

Man-made methane sources include rice paddies, livestock, landfill, biomass burning, waste water treatment, natural gas distribution and coal mining.

Any of these sources may be expected to yield ambient methane concentrations of >10ppm, however with no implications for health.

Rather, methane is an effective greenhouse gas, with a global warming potential 21 times greater compared to carbon dioxide.

3.4 Carbon Monoxide

CO is a colourless, odourless gas, formed from the incomplete or inefficient combustion of fuels containing carbon and may be emitted from the flaring of gas.

Exposure to CO can cause a reduction in the oxygen-carrying capacity of the red blood cells, resulting in decreased oxygen supply to vital organs such as the heart and brain.

3.5 Summary of Air Quality Goals

The NSW EPA prescribes ambient impact assessment criteria which are outlined in their "*Approved Methods for Modelling and Assessment of Air Pollutants in NSW*" (**NSW DEC, 2005**). The impact assessment criteria refer to the total pollutant load in the environment and impacts from new sources of these pollutants must be added to existing background levels for compliance assessment. **Table 3.1** summarises the air quality goals that are relevant to this study.

Table 3.1: NSW EPA Impact Assessment Criteria

Pollutant	Assessment Criteria	Averaging Period
Nitrogen Dioxide	246 µg/m^3	1-Hour
	62 µg/m^3	Annual
Carbon Monoxide	30 mg/m^3	1-Hour
	10 mg/m^3	8-Hour
VOCs	N/A[1]	N/A

Note: [1] Compound Specific

3.6 Standards of Concentration for Flares

The NSW Government's *Protection of the Environment Operations (Clean Air) Regulation 2010* ("the Clean Air Regulation") details appropriate stack emission limits for both scheduled and unscheduled activities, including the use of flares.

The Clean Air Regulation specifies that no visible emission other than for a total period of no more than 5 minutes in any 2 hours should occur from new flare sources.

4 EXISTING AMBIENT AIR QUALITY

Air quality standards and goals are used to assess the total pollutant level in the environment, including the contributions from new projects and existing sources. To fully assess impacts against all the relevant air quality standards and goals it is necessary to have information on the background concentrations to which the project is likely to contribute.

The NSW EPA collects concentration data for air quality parameters of relevance to this study at several monitoring sites around the Hunter Valley and Newcastle area. The closest EPA monitoring sites to the Project are Wallsend, Newcastle, Beresfield, Muswellbrook and Singleton. NO_2 and CO data have been collated from the EPA's database to determine current ambient concentrations of these parameters.

The EPA sites are located in different land use areas than that of the Project (i.e. the Newcastle air shed is likely impacted by vehicle emissions, whereas mining will be a significant source in the Gloucester Valley). However, analysing this data is still useful to gain a conservative estimation of expected background levels at the Project Area. Due to the difference in land use types, concentrations at these EPA sites are likely to be similar to the Project Area and considered appropriate in any background analysis. All data presented in the sections below are from the 2009 to 2012.

4.1 NO_2 concentrations

Figure 4.1 presents the maximum hourly NO_2 concentration data collected at the EPA monitoring stations near the Project area. All five monitoring stations are well below the EPA 1-hour impact assessment criterion of 246 µg/m³. The maximum hourly concentration recorded at the Muswellbrook site is 94 µg/m³. It is noted that the Muswellbrook site is located within a high population density area and also within proximity to various Hunter Valley mines such as Bengalla and Mount Arthur. The maximum value of 94 µg/m³ recorded at the Muswellbrook site represents approximately 38% of the assessment criterion.

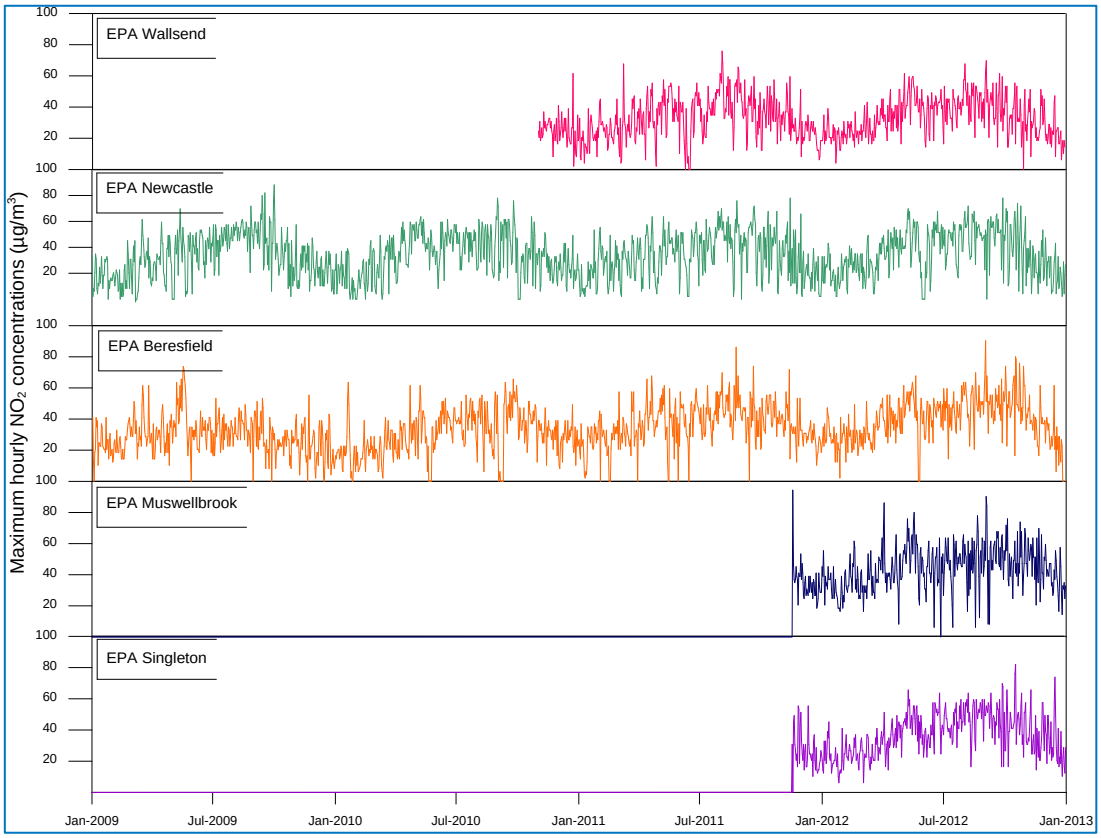

Figure 4.1: NO_2 concentrations measured at EPA monitoring stations (2009 to 2012)

4.2 CO concentrations

Figure 4.2 presents the maximum 8-hour rolling CO concentration data collected at the EPA Newcastle site. Out of the five stations discussed above, this was the only one that had available CO data. **Figure** 4.2 shows that CO concentrations measured at the Newcastle site are well below the impact assessment criterion of 10 mg/m³. The maximum value recorded was 2.4 mg/m³ which occurred in August 2009.

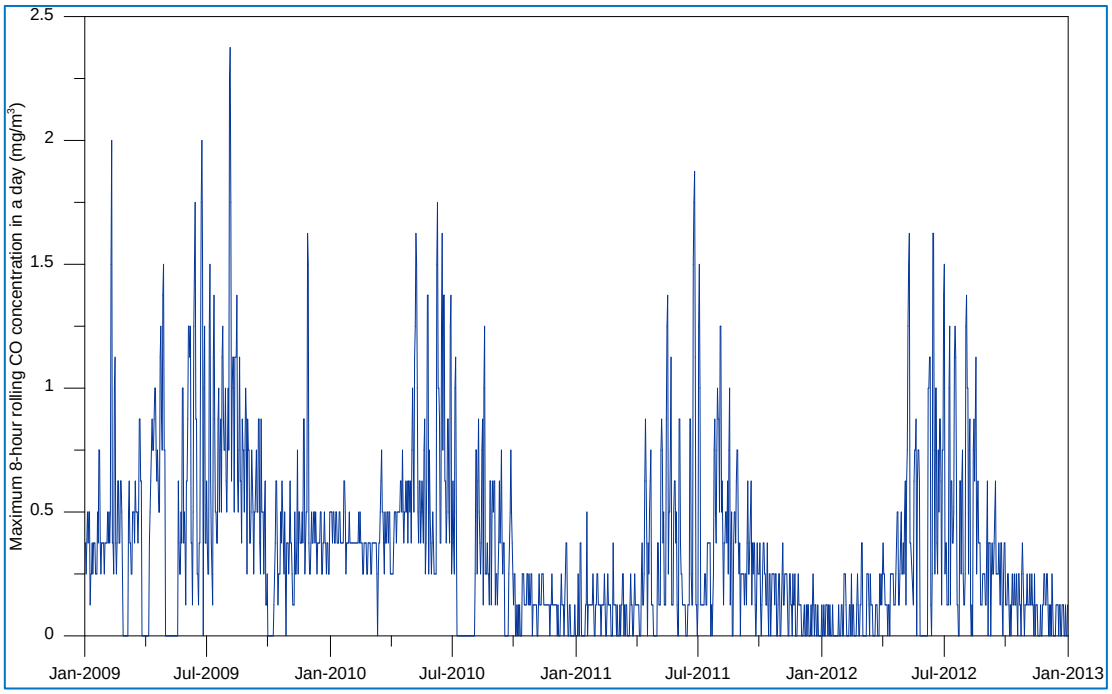

Figure 4.2: CO concentrations measured at EPA Newcastle monitoring station (2009 to 2012)

5 PREVAILING METEOROLOGY

5.1 Local Climatic Conditions

The Bureau of Meteorology (BoM) collects climatic information in the vicinity of the study area. A range of climatic information collected from Chichester Dam Automatic Weather Station (AWS) (located approximately 38 km from the Project site) and Taree Airport AWS (located approximately 52.3 km from the Project site) are presented in **Table 5.1** and **Table 5.2,** respectively(**BoM, 2013**).

Temperature and humidity data at Taree Airport AWS consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean monthly rainfall and the average number of rain days per month.

The annual average maximum and minimum temperatures experienced at Chichester Dam are 20.6°C and 12.2°C, respectively. On average December is the hottest month at Chichester Dam, with an average maximum temperature of 26.6°C. July is the coldest month, with average minimum temperature of 6.2°C.

Rainfall data collected at Chichester Dam shows that February is the wettest month, with an average rainfall of 185.6 mm over 13.1 rain days. The average annual rainfall is 1319.3 mm with an average of 130.6 rain days.

Table 5.1: Climate Information for Chichester Dam

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean Maximum Temperature (ºC)[1]													
Mean	26.2	24.9	23.3	20.2	17.4	14.2	13.7	15.5	19.1	21.4	24.1	26.6	20.6
Mean Minimum Temperature (ºC)[1]													
Mean	16.7	16.7	16.2	12.7	9.7	7	6.2	6.9	9.8	12.1	14.9	17.2	12.2
Rainfall (mm)[2]													
Mean	164	185.6	169.6	99.9	95.6	104	54.4	59.9	62.5	92.1	105.1	125.6	1319.3
Raindays (Number)													
Mean	12.5	13.1	13.3	10.3	10.6	11.2	9.6	8.5	8.4	10.3	11.1	11.7	130.6

Source: ***BOM (2013)***
[1] *ºC = degrees Celsius*
[2] *mm = millimetres*
Climate averages for Station: 061151; Commenced: 1938, Last record: 2013; Latitude: 32.24 °S; Longitude: 151.68 °E.

The annual average maximum and minimum temperatures experienced at Taree Airport are 24°C and 12.5°C, respectively. On average January is the hottest month at Taree Airport, with an average maximum temperature of 28.8°C. August is the coldest month, with average minimum temperature of 6.7°C.

The annual average relative humidity reading collected at 9 am from the Taree Airport is 75% and at 3 pm the annual average is 58%. The month with the highest relative humidity on average is March with 9 am averages of 86%. The month with the lowest relative humidity is August with a 3 pm average of 50%.

Rainfall data collected at Taree Airport shows that February is also the wettest month, with an average rainfall of 151.5 mm over 14.1 rain days. The average annual rainfall is 1145.5 mm with an average of 154.7 rain days.

Table 5.2: Climate Information for Taree Airport AWS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 am Mean Dry-bulb and Wet-bulb Temperatures (ºC)[1] and Relative Humidity (%)													
Dry-bulb	23.3	22.5	20.4	18.9	15.3	12.6	11.8	13.3	17.3	19.8	20.5	22.6	18.2
Wet-bulb	20.2	20.3	18.8	16.7	13.2	10.9	9.9	10.6	13.6	15.6	17.4	19.1	15.5
Humidity	74	81	86	79	78	80	77	70	65	63	73	71	75
3 pm Mean Dry-bulb and Wet-bulb Temperatures (ºC)[1] and Relative Humidity (%)													
Dry-bulb	27.1	26.7	25.2	22.6	20	17.8	17.2	18.6	20.9	22.3	23.5	25.7	22.3
Wet-bulb	21.5	21.5	20.2	17.9	15.1	13.4	12.5	12.9	15.1	16.6	18.6	20.1	17.1
Humidity	60	63	62	62	58	59	56	50	53	55	62	60	58
Mean Maximum Temperature (ºC)[1]													
Mean	28.8	28.4	26.8	24.2	21.3	18.9	18.4	20	23	24.5	25.7	27.6	24
Mean Minimum Temperature (ºC)[1]													
Mean	18.2	18.2	16.4	13.6	10	7.8	6.8	6.7	9.3	11.7	15.1	16.6	12.5
Rainfall (mm)[2]													
Mean	99.1	151.5	140.3	116.5	96.2	105.2	65.6	52.2	51.7	78.9	120.6	77.7	1145.5
Raindays (Number)													
Mean	13.1	14.1	14.5	13.9	12.8	13.9	12.9	10.8	9.6	11.4	14.3	13.4	154.7

Source: ***BOM (2013)***
[1] *ºC = degrees Celsius*
[2] *mm = millimetres*
Climate averages for Station: 060141; Commenced: 1997, Last record: 2013; Latitude: 31.89 °S; Longitude: 152.51 °E.

6 EMISSIONS TO AIR

Dust emissions generated during construction phases are generally able to be adequately controlled and have not been evaluated further. The primary emissions of concern during the operation phase will be emissions from the flaring at the central flare at Waukivory 12 and the contingency flare at Waukivory 12 (Scenario 1) or the flares at Waukivory 12 (central flare) and 11 (secondary flare) (Scenario 2). Minor fugitive emissions may also occur during the rehabilitation phase of the Project.

Previous air quality assessments that determined ground level concentrations of pollutants resulting from emissions from flares have been carried out using air dispersion modelling. These assessments have determined that the emissions from flares lead to low ground level concentrations of NO_2, CO and VOCs. In accordance with the *Additional Part 5 REF requirements for petroleum prospecting: A supplement to ESG2: Environmental Impact Assessment Guidelines 2011*, dispersion modelling is not required as the proposed Waukivory pilot wells are not deemed to pose a risk of adverse air quality impacts. Based upon previous studies, there is sufficient certainty that the air quality impacts associated with operation of the flares will not be significant.

The ground level concentrations of pollutants from the Gloucester flares can be determined by the rate of emission of pollutants and the characteristics of the flares. The emission rates are calculated from the total gas flow rate through the flares. Therefore, the gas flow rate at a given site will determine the overall emissions of the air quality indicators. The flare exit characteristics impact the efficiency of the dispersion of emissions from the source.

6.1 Emissions Estimation

Emissions from the flares have been derived based on Chapter 13.5 (Industrial Flares) of the US EPA AP-42 emission factors (**US EPA, 1995**), based on operating enclosed flares.

For the flare at Gloucester, a gas flow rate of 655 L/s at the central flare at Waukivory 12 and 328 L/s at the contingency flare was assumed (based on 3.0 Mscf/day as provided by AGL for flare capacity) (Scenario 1). For Scenario 2, the gas flow rate was split between the central flare at Waukivory 12 (655 L/s) and the secondary flare at Waukivory 11 (328 L/s).

The total gas flow rates through the Gloucester flares have been used, along with the US EPA AP-42 emission factors, to calculate the overall emissions of each of the key pollutants. **Table 6.1** presents the emission rates calculated for the Windermere central flare and Gloucester's central, secondary and contingency flares.

Table 6.1: Emission Rates per Flare Source

Pollutant	Emission Rate (g/s)[1]		
	Gloucester		Windermere
	Central Flare	Secondary Flare / Contingency Flare	Central Flare
Oxides of nitrogen (NO_x)	0.24	0.12	0.18
Carbon monoxide (CO)	1.29	0.65	0.97
Volatile Organic Compounds (VOCs)	0.49	0.24	0.37

Note: [1] Emission rate based on the total divided by three for each stack source as each flare would be modelled as three sources.

The combined emission rates from the operation of both flares at Waukivory are predicted to be double the emission rates predicted for the central flare at Windermere in the Hunter Valley. The increase in emission rates is due to an increase in the maximum expected gas flow rate from the four wells at Waukivory of 3.0 Mscf/day (which is based on the total flare capacity) compared to Windermere's expected gas flow rate of 1.5 Mscf/day from three wells.

6.2 Source Characteristics

The source characteristics (source height, source diameter, release height, exit velocity etc.) will impact on the nature of dispersion close to the emission source and alter the ground level concentrations.

The effective source height and effective source diameter was taken as the actual source height and diameter for the flare. This is due to the fact that the flare was enclosed and horizontal in configuration, and the assumption was made that the flare source dimensions will reflect, on a reasonable basis, the effective release height and plume diameter. Adjustments are typically required to determine the effective release height and effective source diameter of the flame.

The exit velocity, release height and equivalent diameter were based on data provided by AGL for horizontal enclosed flares. The rectangular shape of the enclosed flare can be simulated as three adjacent stack sources. The parameters for each of these sources are presented in **Table 6.2**.

Table 6.2: Source Characteristics

Parameter	Flare Characteristics		
	Gloucester		Windermere
	Central Flare	Secondary Flare / Contingency Flare	Central Flare
Flare type (foot)	40	20	20
Height (m)	6.0	3.0	3.0
Diameter (m)	3.50	2.47	2.47
Temperature (K)	456	456	456
Exit Velocity (m/s)	4.6	4.6	4.6

Note: [1] Equivalent diameter based on the area of the flare divided by three for each stack source

Both Scenarios at Gloucester involve the operation of two flares, either the central flare and the contingency flare (Scenario 1) or the central flare and the secondary flare (Scenario 2). Both scenarios involve one 40 foot flare and one 20 foot flare. The gas rates fed into the 40 foot flare is double that fed to the 20 foot flare, and overall total gas flow rates for either Scenario are double those anticipated for the Windermere central flare.

However, the central flare proposed in either Scenario at Gloucester has a release height that is double that of the flare at Windermere. This will allow for greater dispersion of air quality parameters, which will ultimately assist in reducing ground level concentrations close to the source. Thus, while the central flare has an emission rate greater than that assessed within the Windermere assessment, this is anticipated to be largely off-set by the increased release height compared with Windermere.

The secondary flare at Waukivory 11 for Scenario 2 is located at a distance from the central flare at Waukivory 12. This will lead to greater dispersion of emissions (i.e. less opportunity for cumulative effects associated with operation of both flares) than Scenario 1, where the central flare and the contingency flare are located close to the Waukivory 12 pilot well. Therefore, the Scenario 1 provides the worst case emission profile.

6.3 Local Terrain and Meteorology

Local terrain and meteorology can influence how well atmospheric emissions disperse once they are emitted from the flares. The following sections compare the local meteorology and terrain at both Gloucester and Windermere to enable a qualitative assessment of the dispersion of emissions from the CSG flares at both sites.

6.3.1 Meteorology

The immediate area surrounding Gloucester does not service a local Bureau of Meteorology (BoM) automatic weather station (AWS). The closest AWS reporting wind conditions is located at Taree Airport.

Taree is an open flat, coastal area approximately 52.3 km north-east of Gloucester. At Taree Airport, the annual average 9am wind direction is predominantly westerly shifting to south-easterly in the afternoon, reflecting the coastal wind flow pattern of afternoon sea breezes. The afternoon sea breezes are unlikely to impact local meteorology at Gloucester. This is also reflected in the strengthening of wind speeds in the afternoon in Taree (**Table 6.3**).

Wind flows close to the Windermere site at the Bulga AWS indicate the annual average 9 am wind direction is predominantly a northerly, southerly or north-westerly. The annual average 3pm wind direction is predominantly north-westerly, easterly or south-easterly in nature. Effectively the mountain range to the south west blocks any westerly or south-westerly wind flows from affecting the site. The afternoon wind speeds are slightly elevated compared with the morning wind speeds.

Table 6.3: Wind Speed and Direction

AWS Location	Wind Speed (km/h)		Wind Direction	
	Annual Average 9am	Annual Average 3 pm	Annual Average 9am	Annual Average 3pm
Taree Airport	10.6	17.9	W	SE
Bulga	11.2	15.7	N, S, NW	NW, E, SE

6.3.2 Terrain

The Project site at Gloucester is located in the centre of an 8 km wide valley, which is likely to be influenced by synoptic scale and local wind conditions. While synoptic conditions are strong, these are likely to overwhelm the local wind flow patterns. If synoptic wind conditions are predominantly in the north-south direction, channelling of winds down the valley will result. If synoptic wind conditions in the east-west direction dominate, eddies will be created in the valley. If synoptic conditions are generating light winds, then local conditions will dominate.

Mountain-valley flows are light winds caused by greater solar radiation reaching the mountain tops than the valley floors. The warm air at the mountain tops rises creating an area of low pressure, which causes the air from the valley to flow up the slopes. Therefore, as the day warms the winds flow from the valley floor up the side of the mountains. However, at night mountain air cools quickly and flows down into valleys. This mountain-valley flow during the night may lead to the formation of a temperature inversion.

Temperature inversions occur most often when a warm, less dense air mass moves over a dense, cold air mass (e.g. when the air near the ground rapidly loses its heat on a clear night). Topography can play a role in creating a temperature inversion by causing cold air to flow from mountain peaks down into valleys. This cold air then pushes under the warmer air rising from the valley, creating the inversion.

Inversion layers can trap pollution close to the ground and thus lead to elevated ground level concentrations. Other meteorological conditions that lead to poor dispersion of pollutants include calm conditions, usually occurring overnight.

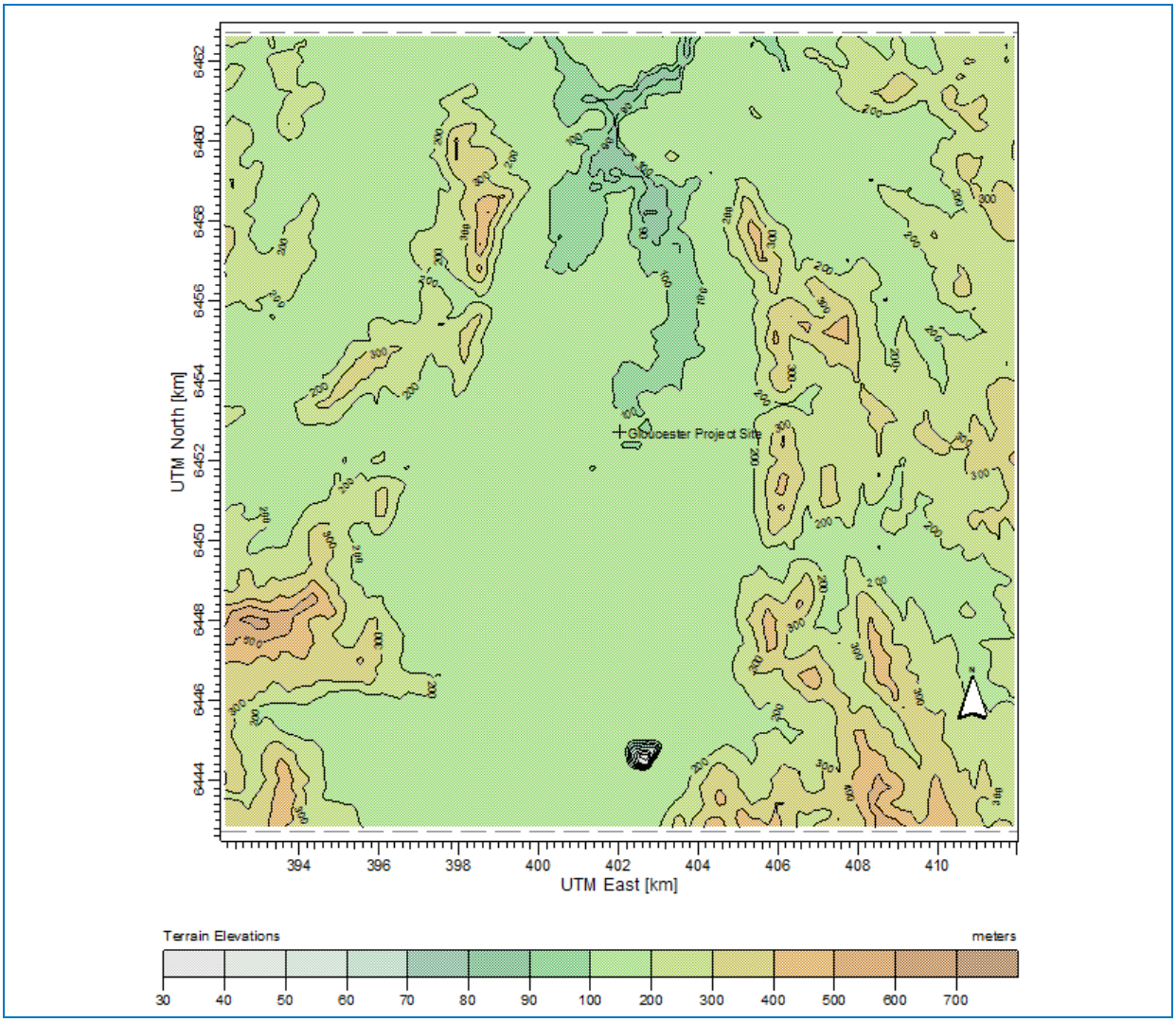

Figure 6.1: Local Terrain – Gloucester

The Windermere project site is located 2 km north east of a mountain range in an otherwise flat area, close to Bulga in NSW. In a similar topographical situation to Gloucester, wind flows in Windermere would be influenced by synoptic flows and occasionally by local flows. Predominant wind flows in the morning are from the north, north-west and southerly directions and shift in the afternoon to a north-westerly, easterly or south-easterly direction. This indicates that the predominant wind conditions are typified by synoptic flows being channelled through the valley system. On occasion, local wind flows such as mountain-valley flows and inversion layers may also form.

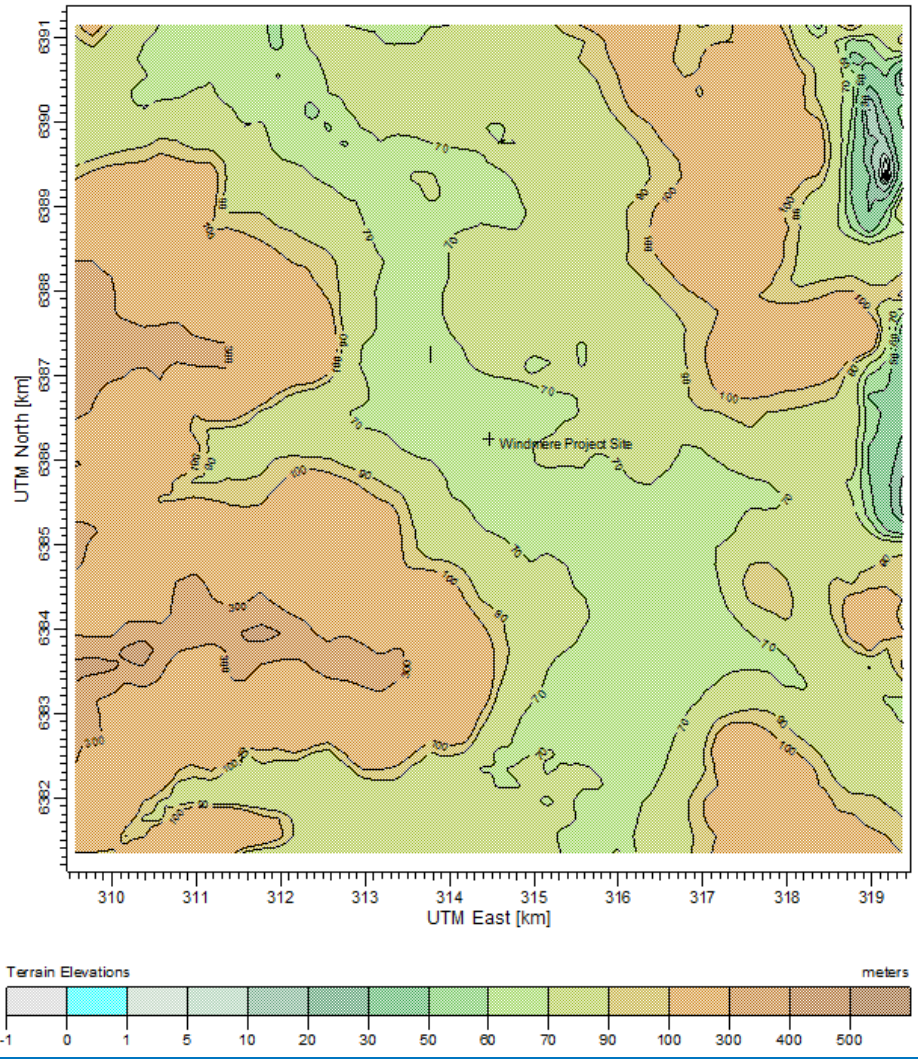

Figure 6.2: Local Terrain – Windermere

Overall, the meteorology of the Gloucester site is dominated by synoptic scale flows which should lead to good dispersion except under calm conditions or during inversion events. Windermere displays similar local terrain and is likely to be influenced by comparable synoptic and local wind conditions. This indicates that the role of terrain and meteorology in the dispersion of emissions at Windermere is likely to be similar to dispersion at Gloucester and, other factors being equal, lead to similar predictions of air quality impact.

6.4 Summary of Factors affecting Dispersion

Table 6.4 summarises the comparisons between the Gloucester and Windermere sites for the factors that affect dispersion.

Table 6.4: Factors affecting Dispersion

Factor	Comparison of Gloucester and Windermere
Emission Rates	The emission rates from the flares at Waukivory are predicted to be double the emission rates used for the flares at Windermere, due to the doubling of the maximum expected gas flow rate.
Source Characteristics	Both Scenarios at Gloucester involve two flares compared with Windermere's one. This is to accommodate the increased gas flow rate. The central flare proposed in either Scenario at Gloucester has a proposed exit height that is double that of the flare at Windermere. This additional height will enable greater and will assist in reducing ground level concentrations close to the source. The secondary flare at Waukivory 11 for Scenario 2 is located at a distance from the central flare at Waukivory 12. This will lead to greater dispersion of emissions (i.e. less plume merging) than Scenario 1, where the central flare and the contingency flare are located close to the Waukivory 12 pilot well. Therefore, Scenario 1 provides the worst case emission profile.
Local Terrain and Meteorology	The Gloucester site is dominated by synoptic scale flows which should lead to good dispersion except under calm conditions or during inversion events. Windermere displays similar local terrain and is likely to be influenced by comparable synoptic and local wind conditions. This indicates that the role of terrain and meteorology in the dispersion of emissions at Windermere is likely to be similar to dispersion at Gloucester and, other factors being equal, will lead to similar predicted ground level concentrations.

7 QUALITATIVE IMPACT ASSESSMENT

Based on a comparison of the local terrain, meteorology and emission rates/characteristics from Gloucester and Windermere, it has been determined that the modelling predictions generated within the AGL Windermere can be used to provide a conservative assessment of the operation of flares servicing the four Gloucester CSG pilot wells.

The following sections outline the ground level concentrations predicted for Windermere and the likely ground level concentrations at Gloucester.

7.1 Dispersion Modelling Results

Dispersion modelling for the operation of the central flare evaluated within the AGL Windermere assessment was conducted using the CALPUFF atmospheric dispersion model. CALPUFF is endorsed by the US and NSW EPA, and has been extensively used in Australia.As noted above, the central flare options proposed for Waukivory have superior dispersion characteristics (double the exit height), but one third greater emissions compared with the Windermere site. It is anticipated that these two opposing factors will largely cancel out, such that the central flares and the Windermere flare impacts may be regarded as comparable. Conversely, Waukivory's secondary / contingency flare options are anticipated to have emission rates that are one third less than those adopted for the Windermere assessment.

Notwithstanding that the two flares will be geographically separated (thus aiding dispersion), given the discussions above, it is concluded that by doubling the maximum ground level predictions made at Windermere, this will provide a conservative assessment of potential impacts at nearby receptors to the Waukivory flares.

The maximum (reasonable worst case) ground level concentrations at receptors at Gloucester are presented in **Table 7.1**, adopting for Scenario 1, a 2:1 ratio of the results predicted for Windermere.

Table 7.1: Likely Maximum Ground Level Concentrations at Gloucester

	Maximum Concentration at Receptors (Windermere)	Likely Maximum Concentration at Receptors (Gloucester Scenario 1 - Worst case)	1-hr Impact Assessment Criterion	Annual Impact Assessment Criterion (µg/m³)	8-hr Impact Assessment Criterion (mg/m³)
NO_2 1-hr Average (µg/m³)	4.5	9	246	-	-
NO_2 1-hr Average + Background (µg/m³)	98.5	103	246	-	-
NO_2 Annual Average (µg/m³)	0.2	0.4	-	62	-
CO 1-hr Average (mg/m³)	0.12	0.24	30	-	-
CO 8-hr Average (mg/m³)	0.09	0.18	-	-	10
CO 8-hr Average + Background (mg/m³)	2.49	2.58	-	-	10
VOC 1-hr Average (mg/m³)	0.046	0.092	-	-	

Table 7.2 shows the percentage of the assessment criteria of that these predicted maximum ground level concentrations comprise, including background ambient air quality concentrations. It is highlighted that all predictions represent less than 50% of the relevant air quality criteria. Further, where predictions comprise more than 5% of criteria, the majority of the contribution is associated with background air quality, rather than any incremental increase associated with the project.

Table 7.2: Percentage of the Assessment Criteria

Assessment Criteria	Percentage of the Assessment Criteria (%)	
	Windermere	Gloucester
NO_2 1-hr Average (µg/m³)	2	4
NO_2 1-hr Average + Background (µg/m³)	40	42
NO_2 Annual Average (µg/m³)	0.3	0.6
CO 1-hr Average (mg/m³)	0.4	0.8
CO 8-hr Average (mg/m³)	0.9	1.8
CO 8-hr Average + Background (mg/m³)	25	26
VOC 1-hr Average (mg/m³)	NA	NA

On the basis of the dispersion modelling carried out for the pilot testing of three exploration wells at Windermere site, it can be inferred that the ground level concentrations for all air quality parameters expected as a result of emissions from the four exploration wells at Gloucester would also not approach the relevant NSW EPA air quality criteria. This is either as a result of the Project operating alone or when considered with other sources (i.e. existing background sources). Therefore, the impact on air quality in the local air shed is considered to be low as a result of the Project.

8 FUGITIVE EMISSIONS

8.1 Emissions during Construction and Operation

The Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIICCSRTE), has recently released a Technical Discussion Paper titled *Coal Seam Gas: Enhanced Estimation and Reporting of Fugitive Greenhouse Gas Emissions under the National Greenhouse and Energy Reporting (Measurement) Determination* (hereafter, the CSG Technical Discussion Paper). The CSG Technical Discussion Paperoutlines potential methods to estimate various individual sub-sources of fugitive greenhouse gas emissions from associated with the various stages of CSG production. The principle types of fugitive emissions relate to vented emissions, gas leakages and flaring of gas.

In the pre-production phase, venting and flaring are outlined as the activities resulting in the release of fugitive emissions. The fugitive emissions generated once flaring commences have been accounted for in Section 9 of this document. The methods documented within the CSG Technical Discussion Paper for calculating fugitive emissions from venting involve either direct measurement or sampling throughout the process of well drilling, testing and completion.

AGL's pre-production process is summarised as follows: during well production, casing and perforation, no gas is anticipated to be flowing, with water management being the main issue. A period of two to four weeks (depending on the well) is then required for pumping water to tanks. The pump generator requires bottle gas during this stage as there is not enough gas pressure contained in the well. Once there is enough gas pressure (from de-watering) to flare and run the pump generator in its own right, the generator no longer requires bottled gas, and uses the gas produced from the well. During each component of the above stages, the well is controlled to contain gas. For example, there will be blow off protection to flare in the event of hitting a gas pocket (i.e. emissions are flared and not vented).

Following fracture stimulation of the wells, the flow from the wells will be directed to an open top tank or pit. During this stage, the flowback line will be transporting water (initially fracture flowback water, then produced water) and venting a mixture of gas/ air. Once the fracture stimulation pressure is depleted and flowback stops, workover will complete the well. Upon completion of workover, the Waukivory pilot wells will have the well separators and instrumentation installed, and the well would be soap tested for leaks by AGL Production Operators during initial commissioning. At this point, any venting would cease and flaring of gas would commence.

In view of the above discussion, it is concluded that, due to well design and construction procedures, any fugitive gas emissions are likely to be minimal, of short duration and localised.

In view that any fugitive emission of CSG is essentially methane, as discussed in **Section 3.3**, there are no significant health implications associated with concentrations that are anticipated in the ambient environment. A high level of understanding is in place regarding the potential to generate fugitive emissions based on AGL's experience with CSG projects, including the existing Camden Gas Project.

During operation of the pilot well AGL intends to ensure fugitive emissions remain at a minimum through implementing a Gas Leak Detection and Response procedure. Once the wells are in this pilot testing phase, the Production Operators will routinely undertake leak testing using hand-held gas detectors, and soap testing surface piping and facilities on a monthly basis. Subject to the duration of the pilot test, the Waukivory wells may also be included in the 2014 annual leak detection survey, completed by a third party consultant. AGL additional intend to use a high-resolution Picarro CH_4 gas analyser for fugitive emissions monitoring (refer **Section 8.3**).

8.2 Suspension of Wells

If the results of the proposed activity prove a viable resource, AGL may seek to convert the proposed pilot wells to production wells. If necessary, the pilot wells would be capped and suspended until the Stage 1 production project commences. If further investigation is not required, the well would be

plugged in accordance with the Borehole Sealing Requirements and the Code of Practice for Coal Seam Gas - Well Integrity, and the site rehabilitated.

Should further testing be required, the wells will typically be secured, capped and suspended in line with industry best practice and the NSW Code of Practice for Coal Seam Gas – Well Integrity, to await any further testing, subject to relevant approvals. Well suspension is undertaken in such a way to ensure that the well is sealed to prevent leakage. The site will also be made secure.

Provided the wells are suspended in an appropriate manner in accordance with the relevant guidelines, fugitive air emissions from the suspended wells are expected to be negligible.

8.3 Fugitive Emission Monitoring

AGL intend to monitor and manage their potential to generate fugitive emissions through a fugitive methane monitoring campaign both prior to and during the pre-production process.

The fugitive monitoring is to be completed using a Picarro G-2031-i Cavity Ring Down Spectrometer (Picarro) to measure ambient methane concentrations across the Gloucester Valley. This instrument additionally measures the isotopic signature of the methane (referred to as the $\delta^{13}C\text{-}CH_4$). This allows different methane sources to be identified, for example livestock (biogenic) generated methane versus CSG (thermogenic) methane. The Picarro instrument is vehicle-mounted, allowing for survey of the whole Gloucester Valley in a relatively short amount of time.

The fugitive methane monitoring system was initially designed for evaluation of fugitive methane within AGL's Camden Gas Project. It has been evaluated by the NSW EPA, the NSW Office of the Chief Scientist and Engineer, and NSW Department of Planning and Infrastructure. Results of the fugitive monitoring campaign are currently proposed to be peer reviewed by the CSIRO.

9 GREENHOUSE GAS ASSESSMENT

An estimate has been made of the GHG emissions associated with the operation of either the flare at Waukivory 11 (Scenario 1) (i.e. using an enclosed flare) or the two flares at Waukivory 11 and 12 (Scenario 2). It is noted that the GHG estimates will be the same regardless of the option that is selected. Estimates have been compared with the estimated GHG emissions if this gas were to be vented direct to atmosphere. GHG emissions have been estimated based upon the methods outlined in The Commonwealth Department of Climate Change and Energy Efficiency (DCCEE) *National Greenhouse Accounts* (NGA) *Factors 2012* (**DCCEE, 2012b**).

The gas flow rate at Gloucester is expected to be 983 L/s for the operation of four wells. The gas content is assumed to be approximately 98% methane and 2% CO_2 based on test well measurements, which is considered conservative.

The estimated GHG emissions (t CO_2-e / annum) are presented in **Table 9.1**. The flaring of extraction gas compared to direct gas venting is estimated to result in a reduction of approximately 1307.1 kt CO_2-e/annum. The GHG emissions from gas flaring for the life of the project (estimated to be approximately 18 months) are estimated to be 93.5 kt CO_2-e.

Table 9.1: Calculated Estimation of GHG emissions

	t CO_2-e / annum - Gas Venting	t CO_2-e / annum - Flare
Central Flare	1,369,432	62,304
GHG Reduction	1,307,128	

Based on the above estimates, the annual GHG emissions associated with flaring at the Waukivory wells would represent an increase of 0.011% on Australia's national GHG emissions in 2012 of 546.1 Mt CO_2-e (**DCCEE, 2013**).

The annual greenhouse emissions for NSW in 2009/10 were 157.4 Mt (**DCCEE, 2012a**). The additional Scope 1 emissions from the Project represent an approximate increase of 0.040% of the NSW 2009/10 total.

10 CONCLUSIONS

This study has assessed air quality impacts due to the flaring of CSG from pilot test wells in Gloucester, NSW.

The qualitative assessment indicates that the likely concentrations for all air quality parameters would not approach NSW EPA air quality criteria as a result of the Project operating alone or when considered with other sources (i.e. existing background sources).

Impacts of fugitive emissions have been evaluated and it is concluded that, due to well design and construction procedures, any fugitive gas emissions are likely to be minimal, of short duration and localised. To monitor and manage fugitive emissions, AGL have committed to the use of mobile monitoring to evaluate methane concentrations in the Gloucester Valley both prior to and during the pre-production process.GHG emissions are expected from the Project and emissions are minor when compared to national and NSW annual GHG emissions.

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Appendix D

Surface water and groundwater management plan

Surface Water and Groundwater Management Plan for the Waukivory Pilot Testing Program – Gloucester Gas Project

Date: 23 September 2013

Table of Contents

Document Revision History

Date	Version	Author	Comment
6 December 2011	V1-1	John Ross	Initial Draft for Internal Review
16 December 2011	V1-2	John Ross	Second Draft for Internal Review
8 March 2012	V1-3	John Ross	Final Draft for Internal Review
31 August 2012	V1-4	John Ross	Revised Final Draft for Internal Use
28 September 2012	V1-5	John Ross	Revised Final Draft for Internal Use at start of the drilling program
20 December 2012	V2-1	John Ross	Final Draft for Waukivory Pilot REF for the fracture stimulation and flow testing program for internal review
12 April 2013	V2-2	John Ross	Final for Waukivory Pilot REF for the fracture stimulation and flow testing program
23 September 2013	V2-3	John Ross	Revised Final for Waukivory Pilot REF for the fracture stimulation and flow testing program

Glossary

Alluvium	Unconsolidated sediments (clays, sands, gravels and other materials) deposited by flowing water. Deposits can be made by streams on river beds, floodplains, and alluvial fans.
Alluvial aquifer	Permeable zones that store and produce groundwater from unconsolidated alluvial sediments. Shallow alluvial aquifers are generally unconfined aquifers.
Aquifer	Rock or sediment in a formation, group of formations, or part of a formation that is saturated and sufficiently permeable to transmit economic quantities of water.
Aquifer properties	The characteristics of an aquifer that determine its hydraulic behaviour and its response to abstraction.
Aquifer, confined	An aquifer that is overlain by low permeability strata. The hydraulic conductivity of the confining bed is significantly lower than that of the aquifer.
Aquifer, semi-confined	An aquifer overlain by a low-permeability layer that permits water to slowly flow through it. During pumping, recharge to the aquifer can occur across the confining layer – also known as a leaky artesian or leaky confined aquifer.
Aquifer, unconfined	Also known as a water table aquifer. An aquifer in which there are no confining beds between the zone of saturation and the surface. The water table is the upper boundary of an unconfined aquifer.
Aquitard	A low-permeability unit that can store groundwater and also transmit it slowly from one aquifer to another. Aquitards retard but do not prevent the movement of water to or from an adjacent aquifer.
Australian Height Datum (AHD)	The reference point (very close to mean sea level) for all elevation measurements, and used for correlating depths of aquifers and water levels in bores.
Bore	A structure drilled below the surface to obtain water from an aquifer or series of aquifers.

Breaker	A chemical that reduces the viscosity of a fluid by breaking long-chain molecules into shorter segments.
Claystone	A non-fissile rock of sedimentary origin composed primarily of clay-sized particles (less than 0.004 mm).
Coal	A sedimentary rock derived from the compaction and consolidation of vegetation or swamp deposits to form a fossilised carbonaceous rock.
Coal seam	A layer of coal within a sedimentary rock sequence.
Coal seam gas (CSG)	Coal seam gas is a form of natural gas (predominantly methane) that is extracted from coal seams.
Conceptual model	A simplified and idealised representation (usually graphical) of the physical hydrogeologic setting and the hydrogeological understanding of the essential flow processes of the system. This includes the identification and description of the geologic and hydrologic framework, media type, hydraulic properties, sources and sinks, and important aquifer flow and surface-groundwater interaction processes.
Contamination	Contamination is the presence of a non natural compound in soil or water, or unwanted compound in chemicals or other mixtures.
Crosslink gel	A fluid that has a very high viscosity typically in the range of 200-1000 cP.
Depressurisation	The process of reducing the hydrostatic pressure and removing formation water from a targeted coal seam. Depressurisation is required to reduce pressure in the coal so gas can desorb and produce.
Dewatering	The process of removing formation water from a targeted coal seam and drawing the water level down within the perforated coal seam horizon so that unconfined conditions prevail.
Discharge	The volume of water flowing in a stream or through an aquifer past a specific point in a given period of time.

Drawdown	A lowering of the water table in an unconfined aquifer or the pressure surface of a confined aquifer caused by pumping of groundwater from bores and wells.
Electrical Conductivity (EC)	A measure of a fluid's ability to conduct an electrical current and is an estimation of the total ions dissolved. It is often used as a measure of water salinity.
Fracture stimulation	See hydraulic fracturing.
Flowback	The process of allowing fluids to flow from a gas well following a treatment, either in preparation for a subsequent phase of treatment or in preparation for cleanup and returning the well to production.
Flowback water	Flowback water is fracture stimulation fluids and deep groundwater pumped to surface after a fracture stimulation program before water transitions to natural formation water (groundwater), after which fluid flowing from the well is termed produced water.
Fractured rock aquifer	Aquifers that occur in sedimentary, igneous and metamorphosed rocks which have been subjected to disturbance, deformation, or weathering, and which allow water to move through joints, bedding planes, fractures and faults. Although fractured rock aquifers are found over a wide area, they generally contain much less groundwater than alluvial and porous sedimentary aquifers.
Groundwater	The water contained in interconnected pores or fractures located below the water table in an unconfined aquifer or located at depth in a confined aquifer or water bearing zone.
Groundwater system	A system that is hydrogeologically more similar than different in regard to geological province, hydraulic characteristics and water quality, and may consist of one or more geological formations.
Hydraulic conductivity	The rate at which water of a specified density and kinematic viscosity can move through a permeable medium (notionally equivalent to the permeability of an aquifer to fresh water).

Hydraulic fracturing	A fracture stimulation technique that increases a gas well's productivity by creating a pathway into the targeted coal seam by injecting sand and fluids through the perforated interval directly into the coal seam under high pressure.
Linear gel	A fluid that has a higher viscosity than water but a lower viscosity than crosslink gel. Typically they have a viscosity between 12 – 20 cP.
microSiemens per centimetre (µS/cm)	A measure of water salinity commonly referred to as EC (see also Electrical Conductivity). Most commonly measured in the field with calibrated field meters.
Monitoring bore	A non-pumping bore, is generally of small diameter that is used to measure the elevation of the water table and/or water quality. Bores generally have a short well screen against a single aquifer through which water can enter.
Numerical model	A model of groundwater flow in which the aquifer is described by numerical equations, with specified values for boundary conditions, that are usually solved on a digital computer. In this approach, the continuous differential terms in the governing hydraulic flow equation are replaced by finite quantities. The computational power of the computer is used to solve the resulting algebraic equations by matrix arithmetic. In this way, problems with complex geometry, dynamic response effects and spatial and temporal variability may be solved accurately. This approach must be used in cases where the essential aquifer features form a complex system (ie. High complexity models).
pH	potential of Hydrogen; the logarithm of the reciprocal of hydrogen-ion concentration in gram atoms per litre; provides a measure on a scale from 0 to 14 of the acidity or alkalinity of a solution (where 7 is neutral, greater than 7 is alkaline and less than 7 is acidic).
Piezometer	See monitoring bore
Piezometric surface	The potential level to which water will rise above the water level in an aquifer in a bore that penetrates a

	confined aquifer; if the potential level is higher than the land surface, the bore will overflow and is referred to as artesian.
Produced water	Natural groundwater generated from coal seams during flow testing and production dewatering.
Proppant	Sand or synthetic high strength particles used with fracturing to fill the fracture space and hold the fracture open during the production life of a well.
Recharge	The process which replenishes groundwater, usually by rainfall infiltrating from the ground surface to the water table and by river water reaching the water table or exposed aquifers. The addition of water to an aquifer.
Sandstone	Sandstone is a sedimentary rock composed mainly of sand-sized minerals or rock grains (predominantly quartz).
Sandstone aquifer	Permeable sandstone that allows percolation of water and other fluids, and is porous enough to store large quantities.
Screen	A type of bore lining or casing of special construction, with apertures designed to permit the flow of water into a bore while preventing the entry of aquifer or filter pack material.
Sedimentary rock aquifer	These occur in consolidated sediments such as porous sandstones and conglomerates, in which water is stored in the intergranular pores, and limestone, in which water is stored in solution cavities and joints. These aquifers are generally located in sedimentary basins that are continuous over large areas and may be tens or hundreds of metres thick. In terms of quantity, they contain the largest volumes of groundwater.
Shale	A laminated sediment in which the constituent particles are predominantly of clay size.
Siltstone	A fine-grained rock of sedimentary origin composed mainly of silt-sized particles (0.004 to 0.06 mm).
Standing water level (SWL)	The height to which groundwater rises in a bore after it

	is drilled and completed, and after a period of pumping when levels return to natural atmospheric or confined pressure levels.
Stratigraphy	The depositional order of sedimentary rocks in layers.
Water bearing zone	Geological strata that are saturated with groundwater but not of sufficient permeability to be called an aquifer.
Water quality	Term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.
Water table	The top of an unconfined aquifer. It is at atmospheric pressure and indicates the level below which soil and rock are saturated with water.
Well	Pertaining to a gas exploration well or gas production well.
Zonal isolation	Isolating an interval or unit of rock from surrounding rock types on the basis of its lithology or other features, such as faults or fractures.

1. Introduction

Version 1 of this Groundwater Management Plan (GMP) was prepared in 2011/12 as a condition of the REF approval for the Waukivory exploration drilling program at Gloucester issued by the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) – Resources and Energy (Environmental Sustainability Unit). The initial approval for the drilling program was dated 12 October 2011.

Version 2 of this GMP has been expanded in 2012/13 into a Surface Water and Groundwater Management Plan (SGMP) and includes more information for the proposed fracture stimulation and pilot testing Review of Environmental Factors (REF) for the Waukiviory pilot testing program.

It focuses on the Waukivory local area and not the wider area that is the Stage 1 Gas Field Development Area (GFDA) of the Gloucester Gas Project (GGP) that is approved under Part 3A of the *EP&A Act*.

The exploration area, and the pilot wells and groundwater monitoring bores are shown on Figure 1. This SGMP should be read in combination with the Proposed Exploration Wells - Waukivory REF (EMGA/Mitchell McLennan, 2011) and Proposed Fracture Stimulation and Flow Testing REF (EMGA/Mitchell McLennan, 2013).

This new SGMP includes substantially more information that is required under the new Code of Practice for Coal Seam Gas – Fracture stimulation activities (DRE, 2012) and new Aquifer Interference Policy requirements (NSWT&I, 2012b)

1.1. Objectives

The purpose of this SGMP is to provide a framework which describes how AGL will assess any changes in the different groundwater systems in the local area, particularly within the shallow aquifers and thrust faulting in the area, due to fracture stimulation and dewatering of the deep coal seams. The primary risks to be assessed are:

- The connectivity of shallow aquifers and the deep water bearing zones, and
- The contamination of shallow aquifers.

The objectives of this SGMP and associated reporting are therefore to:

- Describe the water level and water quality monitoring network across the different groundwater systems located beneath the Waukivory pilot testing area;
- Build a database of baseline information (permeability, water levels and water quality for shallow beneficial use aquifers) located beneath the local area;
- Identify water level and water quality trends that may suggest connectivity or contamination of aquifers due to fracture stimulation and/or dewatering activities;
- Highlight the results of a risk assessment and adopted controls/mitigation measures;
- Provide a monitoring framework for the community and regulators on the groundwater monitoring program to be adopted for the pilot testing program;
- Address the future data requirements for the larger Stage 1 GFDA; and
- Outline the reporting requirements for the monitoring program.

1.2. Responsibilities

AGL Upstream Investments Pty Ltd (AGL) is responsible for compliance with this SGMP. The fracture stimulation and pilot well monitoring (tracking of injected and pumped volumes) will be undertaken by AGL Operations staff based at Gloucester. Periodic monitoring of the water quality from the pilot wells being depressurised/dewatered, together with water levels from the nested monitoring bore network will mostly be carried out by technical specialists appointed by AGL.

1.3. Approval Conditions

The groundwater conditions attaching to the initial REF approval for the construction of the gas wells were:

4. A NSW Office of Water hydrogeologist should be notified 28 days prior to the commencement of drilling.

7. A groundwater monitoring program must be developed for the proponent's exploration activities. The monitoring program should lead to the development of a conceptual model of the local groundwater behaviour, both in the target seams and other key aquifers. Prior to moving to production stage, it is expected a numerical hydrogeological model utilising the information gained from this monitoring program, and other available sources will be prepared. This model should quantify predicted impacts on the target aquifers, any other affected aquifers or surface water sources, and any users, including the environment.

The original GMP relates to the first part of Condition 7 being the monitoring program and the development of a conceptual model.

AGL sought clarification of the remainder of Condition 7 and has been advised that the 'exploration' program includes the drilling, fracture stimulation, and flow testing of the gas wells, and the preparation of a conceptual model for the local groundwater behaviour at the end of the exploration program. The numerical model is required before moving to a production program (i.e. after the exploration program), and is therefore not part of the proposed Waukivory pilot testing program activities.

This new SGMP is submitted with the REF for fracture stimulation and flow testing of four wells at the Waukivory site. Further updates to this SGMP may be required depending on the new REF approval conditions and any Environment Protection Licence (EPL) and bore licence (aquifer interference) requirements for this exploration appraisal activity.

2. Background

This chapter mostly provides summary information relating to the landform, surface water, geology and hydrogeology for the Waukivory area. More details are provided in the Phase 1 groundwater investigation report for the Stage 1 GFDA (SRK Consulting, 2010), the Phase 2 groundwater investigation report (PB, 2012a), the revised conceptual model for the Gloucester Basin (PB, 2013a), and the water balance for the same area (PB, 2013b).

2.1. Landform

The Gloucester geological basin straddles the Manning River Catchment to the north and the Karuah River Catchment to the south.

The landforms of the locality are guided by the geology of the Stroud Gloucester Syncline and comprise ridges to the east and west, undulating low hills and flat land in the centre where the Avon River flows to the north. The lowest points in the area are on the Avon River floodplain at an elevation of approximately 100 mAHD.

2.2. Hydrological Setting

The Waukivory site is within the Manning River Catchment (approximately 8,200 km^2 in size) and the Avon River Sub Catchment. The Avon River originates to the south west of Gloucester and joins the Gloucester River to the north of the township of Gloucester. Waukivory Creek, Dog Trap Creek and Avondale Creek are also located within the Sub Catchment.

The Avon River is a gaining stream in this area i.e. there are diffuse groundwater seepages and discharges to the river. Baseflow accessions from the shallow alluvium are expected in this area based on data from the nearby Waukivory gauging station (PB, 2012b). The Avon River is mostly a permanent stream although during low rainfall periods there is negligible flow and the river can be reduced to a succession of waterholes.

2.3. Geological and Hydrogeological Setting

2.3.1. Geology

The Gloucester Basin is a synclinal structure formed by Permian consolidated sediments. The Permian Rocks display steep dips of up to 90° on the edge of the basin, dipping towards the north south axis, and flattening towards the basin centre. They lay on a basement composed of Early and Late Carboniferous sedimentary and volcanic units that are part of the New England Fold Belt. The geology of the region comprises Quaternary sediments along the valley floor and Permian rocks along the flanks and over most of the catchment. Carboniferous volcanics form the major east and west ridgelines.

The geological strata of the Gloucester Basin (from youngest to oldest) on a local scale can be summarised as:

- Unconsolidated alluvial deposits along the Avon River (Quaternary in age).

- Sedimentary rocks (including substantial coal measures at depth) of the Gloucester Coal Measures (Permian in age)
- Fractured basement rocks of the New England Fold Belt below the sedimentary rocks (Palaeozoic age)

At a local scale, the geology and geological structure at this Waukivory exploration site is complex. The pilot is situated close to the centre of the basin and the strata are shallowly dipping at ~20° towards the west. A major north-south trending low angle thrust fault (dipping from east to west) with a vertical throw of more than two hundred metres occurs in this area (see Figure 2). The eastern gas wells are located in the stable (footwall) block of this major thrust fault, while the western locations go through the fault but are located in the upthrusted block (hanging wall). Subcrop for the thrust fault is expected to be beneath the Avon River and the shallow alluvium in this area.

2.3.2. Hydrogeology

The broader (ridgeline) areas of the Gloucester Basin are underlain by Carboniferous volcanics, the hillsides by a variety of Permian sedimentary rocks while the valley floors are underlain by Quaternary alluvium associated with the Avon River and other minor tributaries.

Groundwater in the Permian rocks is a low value water resource and is rarely used for agricultural and other consumptive uses. Rock permeabilities are generally low, aquifers are mostly bedding and fracture zones, bore yields in rocks and fracture zones are very low and water quality is generally brackish to slightly saline.

Based on the latest water level, water quality and isotope data from the Phase 2 studies (PB, 2012a and PB, 2012c), there is a good appreciation of groundwater recharge, discharge and flow processes through the different hydrogeological units of the Gloucester Basin. These units (based on SRK Consulting, 2010) are confirmed as:

- Alluvial aquifers;
- Fractured bedrock aquifers;
- Coal seam water bearing zones;
- Confining units.

Only the first two units are aquifers. The deeper rock types being either very poor aquifers/aquitards (coal seams, siltstones and sandstones) or confining aquitard/aquiclude layers (claystones or indurated sandstones).

The **alluvium** is relatively shallow (maximum 15m thickness) and in some areas contains an unconfined (sand and gravel) aquifer. Water tables are generally less than 5m below surface. Groundwater flow processes are relatively simple with rainfall being the predominant recharge source on the floodplain. Flooding occasionally adds additional recharge water to the alluvial water table. Groundwater discharge from the alluvium is to the rivers as baseflow and shallow groundwater is also expected to be transpired by riparian vegetation.

The **bedrock** contains mostly tight siltstone and indurated sandstone rock types with occasional thin semi-confined sedimentary/fractured aquifers (typically to around 75m depth). Water tables are generally greater than 10m below surface with deepest levels at elevated sites and in areas of active coal mining. Rainfall is the only recharge source to the bedrock aquifers and recharge does not occur everywhere in the landscape. Recharge mostly occurs in areas of rock outcrop. In areas where there is a weathered (clayey) profile, brackish to saline water quality suggests there is negligible (vertical) rainfall recharge. Groundwater flow in bedrock aquifers is lateral, either within local fracture zones

or individual strata if there are no interconnecting and open fracture zones. Groundwater discharge is via seepage to springs and to the alluvium (and indirectly to creeks and rivers) along the floor of the valley.

The groundwater in the deeper bedrock units is moving very slowly with lateral movement within each rock unit predominating. Confining rock permeabilities are very low, deep coal seam permeabilities are slightly higher (but are still not high enough to be considered aquifers).

Therefore, the only beneficial aquifers in the region are the shallow alluvial groundwater source and shallow semi-confined sedimentary/fractured aquifers to around 75m depth. Deeper zones are water bearing zones but rarely aquifers.

There are no known groundwater dependent ecosystems (GDEs) (apart from stream baseflow accessions) although there may be some uptake of shallow groundwater (from the alluvium) by native terrestrial vegetation on the floodplain. Diffuse discharge of saline groundwater from bedrock seeps is thought to occur into the alluvium as the stream salinity increases during dry periods. Groundwater discharge is diffuse and discharge does not occur at any one point in the landscape.

2.4. Fracture Stimulation

Hydraulic fracturing has been used on older gas production wells at Gloucester, and the intention is to continue to use this technology at all of the Waukivory pilot well sites.

Hydraulic fracturing consists of pumping a fluid into a steel cased and cemented wellbore to create enough pressure to crack, or fracture, the target rock layer. The fluid contains a "proppant" like sand carried by a viscous guar gel that helps prop the fractures open to allow gas to be produced to surface.

The likely constituents of the well pre-treatment[1] after perforating each well and the linear gel fluid mix used for all fracture stimulations are described in Table 2.1.

[1] Well pre-treatment is conducted to clean casing and perforations prior to fracture stimulation

Table 2.1: Components of Well Pre-Treatment and Fracture Stimulation Fluids

Volumes and Constituents in Proposed Fracture Stimulation Fluid for Waukivory Pilot

(Based on information provided by AGL's service provider)

Compound Present	Product	Purpose	Well Pre-Treatment[1]	Treated Water	Linear Gel	Cross-Linked Gel	Indicative Quantity[2]
			% volume of compound in fluid				(litres)
Water	H_2O	Main Fracture Fluid	88.12%	99.81%	99.65%	99.53%	5,988,194
Hydrochloric Acid	HCl	Clean Perforations and Casing	10.88%	-	-	-	870
Citric Acid	FE-2	Iron Sequesterant	0.36%	-	-	-	29
Ground Coffee Beans	HAI-150E	Corrosion Inhibitor	0.04%	-	-	-	3
Acetic Acid	Acetic Acid	pH Adjusting Agent	0.60%	0.03%	0.03%	0.03%	1,848
THPS Tetrakis(hydroxymethyl) Phosphonium Sulfate[3]	Tolcide PS75	Bactericide	-	0.01%	0.01%	0.01%	450
Guar Gum	WG-36	Gelling Agent	-	-	0.16%	0.16%	7,513
Hemicellulase Enzyme 15%, Carbohydrate 85%	GBW-30	Gel Breaker	-	-	<0.01%	<0.01%	92
Choline Chloride	Choline Chloride	Clay Stabiliser	-	0.15%	0.15%	0.15%	9,000
Monoethanolamine borate	BC-140C	Cross-Linker	-	-	-	0.11%	-
Sodium Hydroxide	Caustic Soda	pH Buffer	-	-	-	0.01%	-
Total			100.00%	100.00%	100.00%	100.00%	6,008,000

Indicative Volume of Fluid[2]	Well Pre-Treatment[1]	Treated Water	Linear Gel	Total Treatment
Average per well (L)	2,000	350,000	1,150,000	1,502,000
Total for all 4 wells (L)	8,000	1,400,000	4,600,000	6,008,000

Quantity of Proppant - quartz silica sand	Total Treatment
Average per well (kg)	206,750
Total for all 4 wells (kg)	827,000

Notes:

[1] Well pre-treatment is conducted to clean casing and perforations prior to fracture stimulation.

[2] The volumes of each fluid are indicative only and actual volumes cannot be determined until fracture stimulation treatment occurs. This is because during the fracture stimulation treatment AGL monitors the fracture growth using a variety of diagnostic tools. This allows AGL to analyse the fracture geometry and fine-tune the final volumes. In addition, information gained from the initial treatments will enhance design of subsequent treatments.

[3] As an alternative to using THPS as a bactericide, AGL may use product BE-7 (a mixture of sodium hypochlorite and sodium hydroxide) in treated water, that will be used in the linear gel and cross-linked gel recipes at a concentration by volume of 0.015% sodium hypochlorite and 0.001% sodium hydroxide, which will represent a total volume of 900 litres sodium hypochlorite and 60 litres of sodium hydroxide. The HHERA Table 8 has also assessed these compounds in the alternative bactericide.

Fracturing occurs at the coal seam (and only targets the coal seam), hundreds of metres below the surface and shallow aquifers. Shallow aquifers are protected by four barriers within the well construction: two steel and two cement barriers. The well construction design incorporates numerous contingencies to ensure zonal isolation between coal seams and other formations including aquifers. Aside from the important environmental consideration, zonal isolation is important for gas production, as water migration from any other source will hinder gas production, so all precautions are taken to ensure no connection between other formations can exist.

To check the integrity of well construction and any potential impacts associated with targeted fracture stimulation, AGL undertakes geophysical surveys and groundwater monitoring. Groundwater monitoring networks (mostly in shallow aquifers) can be installed in reasonable proximity to selected gas wells to assess whether there are water level drawdowns or water quality changes that would indicate connectivity (this is the strategy that is being applied in the Waukivory area).

The fluid used during fracture stimulation is recovered from the well through the 'flowback' and dewatering processes. Essentially, what goes down the well comes back up. This is done by using a "breaker" to react with the gel, breaking down its viscosity back to water so that the fluid's ability to flow is increased and it can be produced back to surface.

The fluid is then captured in a double-lined dual compartment turkeys nest dam or temporary above-ground water storage. AGL is planning to lawfully dispose of flowback water to an appropriate facility.

At Waukivory it is planned to fracture stimulate multiple zones in all four gas wells WK11, WK12, WK13 and WK14. Further details are provided in EMGA/Mitchell McLennan, 2013 and the fracture stimulation management plan (AGL, 2013).

3. Water Management Framework

In NSW, drilling activities that intersect groundwater systems and groundwater abstractions from different groundwater sources are managed by the NSW Office of Water (NOW). There are numerous groundwater policies and licensing systems that apply to different areas and different projects. Only those policies and plans that are relevant to the Gloucester Gas Project (GGP) area are discussed in this Surface Water and Groundwater Management Plan (SGMP).

The access, taking and use of groundwater in NSW is currently managed and implemented by the NOW under two primary legal instruments — the *Water Management Act 2000* (WMA) and the *Water Act 1912* (WA).

All groundwater in the GGP area is located within two groundwater systems – the alluvial sediments associated with the unregulated streams, and the sedimentary/fractured bedrock aquifers. The alluvial sediments are managed under the Lower North Coast Unregulated and Alluvial Water Sources Water Sharing Plan (WSP) and the WMA, while the deeper sedimentary/fractured rock groundwater is currently managed under the WA.

3.1. Groundwater Policies

There are several overarching policies that apply to the development and management of groundwater systems across NSW. These include:

- The **NSW State Groundwater Policy Framework** (Department of Land and Water Conservation (DLWC) 1997). The NSW State Groundwater Policy Framework introduces three policy documents:
    - NSW Groundwater Quality Protection Policy (DLWC, 1998)
    - NSW Groundwater Quantity Management Policy (draft) (DLWC, 2001)
    - NSW Groundwater Dependent Ecosystem Policy (DLWC, 2002).

The NSW State Groundwater Policy Framework aims to slow, halt or reverse degradation in groundwater resources, ensure long-term sustainability of the biophysical characteristics of the groundwater system, maintain the full range of beneficial uses of these resources and maximise the economic benefit to the region and state.

Other policies of interest include:

- Buried Groundwater Sources Policy (NOW, 2011)
- Aquifer Interference Policy (NOW, 2012)

The **Buried Groundwater Sources Policy** has been developed to set out a framework for how access to water will be managed in groundwater sources that are fully buried or partly buried (such as deep sedimentary basins).

Water sharing plans made under the WMA set limits on the availability of water by specifying a limit on the annual total volume of water available for extraction from water sources within the plan area. This limit is termed the long-term average annual extraction limit (LTAAEL) and is based on the annual volume of recharge to the water source. In buried groundwater sources the policy proposes to allow access to 0.002% of the storage as a one off use licence. The current proposal provides access to storage only once the water available under the LTAAEL (annual volume) is fully allocated within the WSP.

Fully buried or partly buried groundwater sources have little or no surface expression (outcrop), and therefore have very little or no water available for extraction based on the LTAAEL (rainfall recharge).

This policy has no application in the Gloucester Basin at this time, and will only be available once the WSP for the Northern Fractured and Porous Rock Groundwater Sources commences and any unassigned water is allocated.

The **Aquifer Interference Policy** defines aquifer interference activities and describes how these will be managed under the licensing and approvals regime in the WMA. Under this policy, a water access licence is required to be held by anyone taking water from an aquifer and adjacent water sources that may be impacted by the aquifer interference activity. The policy focuses on high risk activities such as mining, CSG, sand and gravel extraction, construction dewatering, aquifer injection activities, and other activities that have the potential to contaminate groundwater or result in unacceptable loss of storage or other structural damage to an aquifer.

Coal seam gas activities have been determined as aquifer interference activities and some extra approval conditions for this Waukivory pilot testing program may be imposed for the fracture stimulation and pilot testing components of the exploration program.

The format of these approvals is yet to be clarified by NOW, however they are expected to apply to the new Waukivory REF approvals and/or the associated production bore licences.

3.2. Legislation

3.2.1. Water Act (1912)

The WA has been in place since 1912. Since 2003 the WA has been progressively phased out (repealed) and replaced by the WMA.

All of AGL's bore licences for the GGP have been issued under the WA as this is the appropriate water regulation for CSG exploration activity at this time for this water source. New bore licences required for the construction of the pilot wells and monitoring bores have been issued under the WA.

AGL holds three bore licences for this exploration program as of September 2013. Two relate to the construction of the gas (test) wells and one licence applies to the new monitoring bores within the flow testing area. AGL has applied for new bore licences for the construction of the proposed geophone/vibrating wire water monitoring location east of WK13, and for each of the four gas wells to be perforated, fracture stimulated and flow tested. Details are provided in Table 3.1.

Table 3.1: Bore Licences for the Waukivory Flow Testing Program

Licence No.	Local Well or Bore No.	Lot and DP	Purpose
20BL172854	WK12 and WK14	251/785579	Gas (test) wells
20BL173094	WK11 and WK13	11/841445	Gas (test) wells
20BL173038	WKMB01, WKMB02, WKMB03 and WKMB04	11/841445	Water monitoring bores
New bore licence currently pending with NOW	WKMB05	26/1112877	Construction of geophone borehole and then conversion to vibrating wire piezometers (VWPs)
New bore licence currently pending with NOW (two required)	WK12 and WK14	251/785579	Conversion to gas production wells for flow testing program
New bore licence currently pending with NOW (two required)	WK11 and WK13	11/841445	Conversion to gas production wells for flow testing program

This SGMP and these bore licences only relate to the Waukivory exploration program and associated drilling, fracturing, dewatering, groundwater monitoring and associated compliance activities.

3.2.2. Water Management Act (2000)

There is no Water Sharing Plan for the sedimentary (porous) rocks of the Gloucester Basin at this time and therefore the WMA currently does not apply to these groundwater sources. The WMA will come into force for the Gloucester CSG project once the Water Sharing Plan for this water source commences, and the WA is repealed. The timeframe for this to occur is likely to be within the next 12 to 18 months.

3.3. Aquifer Interference Approvals

The Aquifer Interference Policy (NOW, 2012) defines exemptions based on the level of risk. The exempt activities are those considered to pose a minimal risk to water sources, their dependent ecosystems and other water users. As all four pilot wells are to be hydraulic fracture stimulated, an aquifer interference approval (in the form of explicit conditions on the new REF approval or new bore licences for the pilot testing) is anticipated.

The policy also requires those new CSG exploration activities where groundwater is taken (irrespective of volume) to have a water access licence or a volumetric bore licence approval.

The pilot testing proposed at Waukivory will involve dewatering, and therefore under the policy, new production bore licences are required for this pilot testing program. AGL has lodged four licence applications for industrial and irrigation purposes for each of the four pilot wells (and each for an allocation of 5 ML per annum). The amount of 5 ML for each pilot well is based on the maximum likely extraction from each well during an extended pilot testing program, and includes flowback water recovered immediately after the fracture stimulation program.

Volumes recovered during the pilot testing program may be less that this total volume of 20 ML per annum, but based on the early pilot testing programs at Stratford, these volumes are considered to be reasonable upper limits. It is not possible to better estimate the water production profiles at this time without completing the pilot testing program.

3.3.1. Characterisation of the local groundwater systems

'Highly productive groundwater sources' are defined in the *NSW Aquifer Interference Policy* (NOW, 2012) as having the following properties:

- total dissolved solids of less than 1,500 mg/L, and
- water supply works that can yield water at a rate greater than 5 L/sec.

Table 3.2 provides information on the groundwater productivity of aquifers based on water bore and monitoring bore data in the vicinity of the Waukivory site.

Table 3.2: Local characteristics for the Waukivory Pilot Testing Program

Aquifer	Yield (L/s)	Electrical Conductivity (EC) (µS/cm)	(approx) Total Dissolved Solids (mg/L)
Alluvium	<2	2,000 – 7,500 #	1,500 – 6,000
Fractured rock	<0.5	3,500 – 5,000 #	3,000 – 4,250

Key # values based on nearby monitoring bore data

Both the yields from the alluvial aquifer and the fractured rock aquifer are too low, and the total dissolved solids (TDS) of the groundwater too high to classify local groundwater systems as a highly productive groundwater source. Therefore, all aquifer systems at Waukivory are classified as 'less productive groundwater sources', as defined by the *NSW Aquifer Interference Policy* (NOW, 2012).

3.3.2. Minimum impact considerations

A qualitative aquifer impact assessment was undertaken against the minimal impact considerations for aquifer interference activities, in line with Table 1 of the *NSW Aquifer Interference Policy* (NOW, 2012).

Alluvial, fractured and porous rock aquifers at Waukivory were assessed. Predicted effects are less than the Level 1 minimal impact considerations for all beneficial aquifers, and across all categories (ie water table, water pressure and water quality). The full assessment is provided at Appendix A1.

The assessed impact to surface water and groundwater resources is assessed to be low. More formal risk assessments are provided in Chapter 5.

4. Drilling and fracture stimulation program

To comply with Condition 4 of the original REF approval, NOW was notified that drilling was to commence within 28 days on:

- 7 November 2011 (for the monitoring bore and pilot well drilling programs)
- 31 August 2012 (for the rescheduled pilot well drilling program)

This chapter is in two parts – Section 4.1 describes the drilling methods used for the pilot well drilling program (and the protection of groundwater), and Sections 4.1 and 4.2 describe the methods proposed for the fracture stimulation program (and associated groundwater monitoring).

4.1. Drilling completions and pilot well integrity

The drilling and fracture stimulation program is to complete the four pilot wells as follows:

- Drill, case and suspend each of the wells (completed); and
- Perforate and fracture stimulate coal seams in all four wells (planned).

The four gas wells were drilled and completed between 2nd October and 24th November 2012. The drilling stages consisted of the following:

- **Conductor Casing Section** – The conductor section was drilled through the immediate surface to a typical depth of 6m or until drill resistance was encountered (usually at the base of any alluvium/colluvium but in this case was at the base of weathered rock). The conductor casing was steel and was cemented in place to provide a seal and prevent washouts of the unconsolidated earth. The conductor casing also provides a seal to prevent washouts during the drilling of the next hole section, the surface hole.
- **Surface Casing Section** - Steel surface casing was inserted to 10-15% of the target depth and was pressure cemented back to surface, which is considered good drilling practice. The purpose of this casing is to isolate shallow formations and provide structural support for the pilot well during drilling.
- **Production Casing Section** - Beyond the steel surface casing the rest of the borehole was drilled to the target depth and then fully cased and cemented. The steel casing and cement again isolate shallow aquifers and other water bearing formations that may be encountered during the drilling process. This ensures that there is no interaction between aquifers or strata and the targeted coal seams, and ensures no cross-contamination between aquifers.

Once the wells are completed and cased/suspended, the perforation and fracture stimulation programs involve:

Perforation

The perforation technique involves correlation of cased hole logs with open hole logs and the detonation of shaped explosive charges that penetrate the steel casing, cement and formation establishing the interconnection. Perforation is required to allow communication between the production casing and the target zones. In cased hole completions, the pilot well is drilled down past the formations desired for production and has a casing or a liner run in, isolating the formation from the wellbore. Perforating usually involves lowering in

perforating guns, which is a string of shaped charges, down to the desired depth and firing them to perforate the casing at the target depth.

Hydraulic fracture stimulation

Perforations are required to gain access between the production casing and the selected formation. When access to the formation has been established, the formation needs to be stimulated to enhance formation water and gas flow. Hydraulic fracture stimulation involves the injection of a slurry of sand and water at high pressure. This process stimulates the reservoir by providing a highly conductive flow path for gas and water that extends away from the wellbore and into the seam.

The sand is locked in place by the pressure of the coal formation and the injected water and formation water is allowed to flowback out to the well for pumping to the surface. This technique widens cleats and fractures in the coal seams to provide a conductive path for gas to flow freely to the well. As the water is removed, the resulting drop in reservoir pressure enables the gas to begin to desorb from the coal and flow to the wellbore. The wellbore then requires cleaning and maintenance. The tubing, rods and pump required for gas flow testing are then placed within this casing once each gas test well is completed and the surface wellhead equipment is installed.

In addition, new codes of practice have been released for CSG drilling activities in NSW. These two new codes apply to well integrity (NSWT&I, 2012a) and fracture stimulation (NSWT&I, 2012b). This drilling and testing program complies with these codes of practice. More details are provided in AGL's fracture stimulation plan (AGL, 2013).

The drilling must also comply with the 'Minimum Construction Requirements for Water Bores in Australia' (NUDLC, 2012). This document outlines consistent and standard information and technical standards for the water bore drilling industry and regulators for constructing, maintaining, rehabilitating and decommissioning water bores in Australia. The document was prepared by the National Uniform Drillers Licensing Committee (NUDLC), which consists of representatives from the drilling industry and each state and territory of Australia.

4.2. Monitoring fracture stimulations

A new monitoring borehole (Waukivory 05) will be drilled to monitor the fracture completion of the Waukivory 13 pilot well. It will initially be installed with geophones but will then be converted to a water monitoring location with VWPs cemented in place. It is expected to be completed to a depth of approximately 1000m and will be installed a few months in advance of the fracture stimulation program to obtain natural seismicity data. The geophone monitoring work will give the reservoir engineers a fracture map of the completion. The Waukivory 05 well will be located at a distance of approximately 100 to 120 m and east from Waukivory 13. This location has been chosen to obtain the best quality fracture monitoring data by avoiding the Sigma 1 stress angles encountered in the current well data in the area.

Upon completion of the fracture stimulation program the fully cased and cemented well will be perforated and completed with a series of vibrating wire piezometers so that it can be used as another groundwater monitoring location for intervals below 350 mbgl during the pilot testing program. Monitoring depths have not been confirmed at this time.

5. Risk Assessment

An impact assessment for the drilling program that was completed in November 2012 was included in the previous GMP and for this SGMP has been moved to Appendix A1.

A risk assessment workshop was held in December 2012 to identify all risks, assess those risks, and determine appropriate risk mitigation measures associated with the fracture stimulation and flowback program for the Waukivory pilot test. Full details are provided in the Risk Assessment Report that attaches to the Fracture Stimulation Management Plan (AGL, 2013).

Included in this chapter are those risks that may impact on water resources, are associated with the management of fracture stimulation, flowback water activities, and are potentially a direct result of depressurisation associated with the pilot testing program.

Risks associated with the blending and reuse of produced water are not covered in this SGMP as these risks have been previously assessed in the Tiedmans Irrigation trial REF (PB, 2010). The associated irrigation REF approval conditions and the Water Management Plan (AGL, 2012) developed for the irrigation trial are outside of the scope and approval requirements of this REF.

The risk to water resources (particularly groundwater) potentially increases when each of the wells is fracture stimulated, and the pilot testing program commences. The key (water related) risks, the assessed risk rankings and the controls to mitigate those risks are presented in Table 5.1.

Table 5.1: Detailed Impact Assessment – Water related risks and controls

Fracture Stimulation Impacts on Water Resources	
Risk 1 There is a risk of source water spill during transport to site. Consequence: Level 1 (Consequence driver: Environment) Likelihood: Unlikely Current Risk Rating: Low	1. The preferred source water is fresh water from the Pontilands Dam and spills would have little to no impact on the environment 2. If an alternative source is used, the water quality may be brackish water. The fill and unloading areas are contained. Spills of brackish water would have minimal impact on soils and surface water. 3. Vacuum truck is available.
Risk 2 There is a risk that the flow back water may be incorrectly transported, captured and/or removed which may result in a spill. Consequence: Level 1 (Consequence driver: Environment)	1. Flow back water will be stored in double lined above ground dams or other above ground temporary storage tanks. 2. Pipes used to transport flow back water to above ground holding facility will be visually inspected 3. Visual inspections are conducted on all storage options prior to the transfer of any liquids. Visual inspections are also conducted several times a day during fracture stimulation

Likelihood: Unlikely Current Risk Rating: Low	operations to ensure no overflow or leaks 4. Vacuum truck is available. 5. Sealed transport tankers are used to remove flowback water from site or holding dams to an approved facility 6. Surplus water tanks are available so that if a leak was to occur in a tank the contents of the tank could be pumped into the spare tanks 7. Pipes between the individual wells and holding dam are pressure tested during commissioning before use, and will have a flowmeter at either end to ensure all fluid is accounted for 8. Wells are monitored during flow back operations 9. Environmental Incident Response Plan covers this possibility
Risk 3 The Code requires a qualitative assessment of risk that GFSA may cause connectivity and cross contamination between coal seams and beneficial aquifers. (i.e. exchange of poor water quality between these two sources that may impact water quality characteristics). [Code 7.2(c)(i) and (iv)] Consequence: Level 3 (Consequence driver: Environment) Likelihood: Rare Current Risk Rating: Low	Low permeability aquitard layers exist between shallow beneficial aquifers and target coal seams. AGL have developed strategies including: 1. A Surface Water & Groundwater Management Plan has been written to protect surface water and beneficial aquifers. Baseline assessments suggest that groundwater moves laterally within layers and vertical connectivity is low. A Groundwater Monitoring program has been implemented (since early 2012) and will be used to monitor water levels, pressures and water quality during the fracture stimulation program. 2. Pressure monitoring (at individual gas wells) during fracture stimulation. 3. Geophone monitoring, measuring direction and height of the fracture in real time on selected wells. 4. Temperature log, confirms fracture height after the fracture stimulation of each zone. 5. Fracturing execution commences from the deepest zone and progress up the well. This means more information is gathered before approaching the beneficial aquifers. 6. Monitoring changes in the flowback chemistry 7. Groundwater monitoring programs provide baseline data prior to fracture stimulation programs thereby allowing trends or changes in shallow water chemistry to be identified

Risk 4 The Code requires an assessment of the risk that GFSA may induce: • changes to groundwater pressure and levels; • changes to surface water levels and flow. This is generally referred to as surface water/groundwater connectivity [Code 7.2(ii) and (iii)] Consequence: Level 3 (Consequence driver: Environment) Likelihood: Rare Current Risk Rating: Low	8. Faulting is mapped through 3D seismic and zones selected for stimulation are away from faults AGL and the principal contractor have developed strategies including; 1. A Surface Water & Groundwater Management Plan that protects surface water and beneficial aquifers. A Groundwater Monitoring program has been implemented 2. Pressure monitoring during fracture stimulation. 3. Geophone monitoring, measuring direction and height of the fracture in real time on selected wells 4. Temperature log, confirms fracture height after the operation 5. Fracturing execution commences from the deepest zone and progress up the well. This means more information is gathered before approaching the beneficial aquifers 6. Monitoring changes in the flowback chemistry 7. Groundwater monitoring programs provide baseline data prior to fracture stimulation programs thereby allowing trends or changes in shallow water chemistry to be identified
Management of Flowback Water	
There is a risk that waste from operations may enter the surrounding environment. Consequence: Level 1 (Consequence driver: Environment) Probability: Possible Current Risk Rating: Low	1. All contractors on site are subject to AGL pre qualification and selection process 2. The chemical waste contents are dealt comprehensibly in the chemical risk assessment report. 3. Flowback water will be contained within purpose-designed tanks, or lined above ground water storage facility, with vacuum truck available. 4. Water will be chemically analysed and lawfully disposed of to an appropriate facility.
Depressurisation associated with the Flow Testing Program	
Risk 1 There is a risk that dewatering associated with the flow test may induce changes to local groundwater pressure and levels or induce changes to surface water levels and flow. This	AGL have developed strategies including: 1. Intensive groundwater monitoring of shallow groundwater monitoring bores (both AGL and GRL locations) to detect water level or pressure

is generally referred to as enhanced natural leakage and is an important risk to be assessed. Consequence: Level 2 (Consequence driver: Environment) Probability: Unlikely Current Risk Rating: Low **Risk 2** There is a risk that dewatering associated with the flow test may reduce water levels in nearby private water bores and at pumps on the Avon River. Consequence: Level 3 (Consequence driver: Community) Probability: Rare Current Risk Rating: Low	changes 2. Using the deeper VWPs (formally the micro seismic monitoring location), to assess deeper water pressure changes in the target coal seams being depressurised. 3. Monitoring changes in the produced water chemistry. Groundwater monitoring throughout the flow testing program provides new data to compare against the (natural) baseline data that was collected prior to fracture stimulation and flow testing programs thereby allowing trends or changes in shallow water levels to be identified. AGL have developed strategies including: 1. Intensive groundwater monitoring of shallow groundwater monitoring bores (both AGL and GRL locations) to detect water level or pressure changes close to the flow testing program 2. The closest water supply work is an excavation located 600m away which would not be a risk of water level decline because of low natural connectivity and the dominance of surface water accessions. The closest bore into rock is around 1.5 km distance and would not be within the area of influence of depressurisation 3. Property surveys of water supply works on private properties within 2kms of the pilot are proposed for late 2013.

There are also more general impact assessment matters of concern to communities and regulators that are summarised in Table 5.2.

Table 5.2: Commentary on General Impact Assessment Issues

General Impact Assessment for Groundwater Systems	
Level of confidence in predicting the impacts	AGL has undertaken fracture stimulation and flow testing activities as part of the on-going exploration works associated within all of their upstream gas projects, particularly the nearby Stratford pilot testing program. The resulting significant level of experience gained from previous projects has resulted in a high level of confidence in accurately predicting any potential associated impacts to groundwater systems from the testing program.
Reversibility of Impacts	The potential for shallow (beneficial) aquifer impacts is considered low. Fracture stimulation will only be within the targeted coal seams and similarly the dewatered groundwater will be only derived from the coal seam water bearing zone targets. Drawdown impacts in shallow aquifers are expected to be negligible and no shallow water quality impacts are anticipated given the number of confining layers in the geological sequence. No impacts to surface water resources are expected. Baseline accessions are a small component of surface water flows in this catchment (PB, 2013b) so there would need to be sharp declines in shallow groundwater levels over an extended period for surface water

General Impact Assessment for Groundwater Systems	
	resources to be impacted. Given the very small volumes of groundwater likely to be pumped as produced water (ie less than 20 ML), the overall risks are assessed to be low and the reversibility of any impacts is not an issue.
Effectiveness of the proposed methods to manage or mitigate the impacts	The proposed methods to manage or mitigate impacts to groundwater have been derived from past project experience. This water management plan and the dedicated monitoring proposed is considered to be sufficient to identify any potential impacts. Management and mitigation measures are not proposed as part of this pilot testing program unless shallow aquifers less than 75m are definitely impacted by the pilot testing program.
Level of public interest	The IPR report by Dr Rick Evans (SKM, 2012) emphasised the importance of this pilot testing program to confirm water production rates and the possibility of any impacts to shallow aquifers. At this stage it is considered that the general public will maintain a higher level of interest in ensuring all works are undertaken with minimal impacts to shallow groundwater systems. The level of impact to groundwater systems from the proposal is considered low however the pilot testing program is necessary to confirm any drawdown or water quality impacts.

6. Monitoring Plan and Reporting

Government (through the NSW Office of Water (NOW)) requires a higher level of groundwater monitoring associated with all CSG programs. These requirements generally relate to:

- a formal groundwater monitoring and modelling plan;
- installation of dedicated monitoring bores;
- collection of periodic water level, water quality and volumetric data;
- reporting of data and trends; and
- numerical modelling.

Specific details are listed in the new aquifer interference policy and PEL conditions, and involve:

- establishing baseline groundwater conditions;
- complying with water access rules;
- assessing the potential for water level, water quality or pressure drawdown impacts on nearby water users and GDEs;
- assessing the potential for increased saline or contaminated water inflows to aquifers and rivers;
- assessing the potential for enhanced hydraulic connection;
- assessing the potential for river bank stability or high wall instability; and
- proposing the method for disposing of extracted water.

This SGMP covers most of these elements. Disposal and reuse of extracted (produced) water is dealt with under the Tiedman Irrigation Program water management plan (AGL, 2012).

The objective of a dedicated groundwater network and associated monitoring program is to protect the shallowest beneficial aquifers used for water supply across the area. These are the Quaternary alluvial aquifers (to maximum 15m depth) and the uppermost Permian sedimentary/fractured rock aquifers (to around 75m depth).

With the Waukivory pilot there is an opportunity to collect important groundwater data associated with a pilot testing trial where the deep coal seams will be fracture stimulated and depressurised. This additional groundwater monitoring will provide:

- a better understanding of groundwater flow paths and the connectivity of aquifers and deeper water bearing zones (under actual flow testing conditions);
- an improved conceptual model of groundwater flow (in an area of substantial thrust faulting); and
- more definitive proof of connectivity (or the lack of connectivity) of coal seam zones with shallow aquifers to better inform the community and regulators (pre GGP Stage 1 development).

For the purposes of this SGMP:

- The period of flow where the return water is defined as flowback water is deemed to be finalised when 90% of the volume of fracture stimulation fluids used at each

well is recovered OR a salinity trigger of 5000 µS/cm is reached (and maintained) for the return waters;

- Produced water is deemed to be all deep groundwater that is pumped to surface after the flowback water trigger is achieved.

From a water resource and environmental protection perspective, these thresholds are considered more than adequate to protect all local consumptive uses of surface water and groundwater, and the local riverine environment.

6.1. Private Water Bores

There are only four registered water bores (one of which is a shallow excavation) located within 5 kms of the proposed exploration program, and there is one water bore (the excavation) within 1 km of the western gas well sites. The two private bores within 2kms of the western gas wells will be surveyed in advance of any fracture stimulation and flow testing program to assess baseline conditions. Details are summarised in Table 6.1.

Table 6.1: Summary of Private Water Bores – Waukivory Area

Bore No.	Type and Date	Depth (m)	Aquifer Zone (m)	Water Level (m bgl)	Geology	Distance to closest gas well
GW054940	Excavation (1981)	4.0	2.5 to 4.0	Not known	Alluvium	~ 600m to WK13
GW080357 *	Bore (2002)	40.5	22 to 22.2 29 to 29.3 37 to 37.2	14.0	Sandstone	~ 2.6km to WK11
GW080487 *	Bore (2004)	60.0	17.0 to 18.0	17.0	Shale	~ 1.5km to WK11
GW200330	Bore (2006)	50.0	Unknown	Not known	Shale	~ 1.8km to WK13

Note *: these two bores were water sampled as part of the Phase 1 SRK study in May 2010
shaded bores are to be property surveyed for this pilot testing program

None of the water bores into rock are of use for monitoring purposes during the pilot testing program because of their distance from the exploration program sites. The nearest licensed bore (the excavation which is GW054940) is excavated into alluvium, and is the least likely water source to be affected by depressurising/dewatering. No ongoing monitoring of water levels or water quality (after the property surveys are completed) is considered necessary at any of these private water bore sites for the Waukivory flow testing program.

6.2. Monitoring Network and Frequency

Pilot Wells

The pilot wells that are completed as test production wells will also be available for monitoring during the fracture stimulation and pilot testing programs. It is proposed to fracture stimulate all wells.

Fracture stimulation fluid flowback quantities and quality will to be monitored and tested. AGL will lawfully dispose of flowback water to an appropriate facility. For the fracture

stimulation program, it is proposed to take water samples of the fracture stimulation fluids (as injected and as pumped out as flowback water) and then to take a final water sample once the fracture stimulation fluids have been removed.

Once the water quality is representative of the natural formation water (deep groundwater) the flowback of fracture stimulation water is deemed to have ceased, and subsequent water recovery (referred to as produced water) will be transported to AGL's Tiedman property, blended and reused for irrigation, in accordance with the previously approved reuse proposals (see the Water Management Plan for the Tiedman irrigation trial).

For the pilot testing program, it is proposed to install pressure transducers in each well so as to continuously monitor the drop in hydrostatic head as each of the coal seams is depressurised/dewatered. In addition it is planned to obtain weekly water samples from each gas well so as to track salinity (EC) and to submit regular water samples for laboratory analysis.

Monitoring Bores

The main groundwater monitoring network will be one cluster of monitoring bores within the central area of influence of the flow testing program, and one cluster immediately to the west of the westernmost pilot wells. The central monitoring bores will monitor the upper fractured rock and thrust fault aquifer zones, while the western site will monitor the upper fractured rock aquifer, aquitards and deeper Roseville coal seam water bearing zone. The monitoring bore locations are shown on Figure 2.

The two westernmost monitoring bores were completed late January 2012 (although WKmb04 is not operational at this time) with the eastern sites completed in June 2012. The intention is to monitor shallow beneficial aquifers and potential fault pathways though which shallow groundwater may drain.

There are additional (existing) monitoring bores on Gloucester Resources Ltd (GRL) lands that will be used in the interpretation of results from this pilot testing program. The adjacent sites are GRL monitoring bores and the remote sites are AGL monitoring bores. Those monitoring bores within 500m of any of the pilot wells (with the exception of the proposed deep monitoring bore with the VWP installations) are shown on Figure 1. Summary details of all bores within 3kms are provided in Table 6.2.

Table 6.2: Summary of Monitoring Bores – Waukivory Area

Area	Sub – area and Purpose	Monitoring Bores
Waukivory	Within field Immediate pilot testing program area (new sites for this program)	WKMB02 – Shallow fractured rock Depth – 62 m Screened Interval – 52 to 61m WKMB03 – Thrust fault Depth – 210 m Screened Interval – 200 to 209m
Waukivory	West of field Adjacent to pilot testing program area (new sites for this program)	WKMB01 – Shallow fractured rock Depth – 54 m Screened Interval – 47 to 53m WKMB04 – Deep coal seam (Roseville CS) Depth – 360 m Screened Interval – 335 to 347m (Note – this site is to be converted to several VWPs before it is fully functional)

Waukivory	Deep water monitoring bore with VWPs	WKMB05 – depth of borehole approximately 1000 m and location of VWPs is still to be confirmed
Waukivory	Adjacent (GRL sites)	GR-P1 – Shallow alluvium Depth – 10.2 m Screened Interval – 5.5 to 8.5 m GR-P2 – Shallow alluvium Depth – 11 m Screened Interval – 4 to 9m GR-P3 – Shallow alluvium Depth – 11.2m Screened Interval – 5 to 9m
Waukivory	Remote (AGL sites) located ~3kms to the north east of the pilot test area.	Continue to monitor the water levels in AGL dedicated monitoring bores: WMB01 - Shallow alluvium Depth – 8.5 m Screened Interval – 5 to 8 m WMB02 - Shallow sandstone Depth – 23.0 m Screened Interval – 15 to 21 m WMB03 – Shallow coal seam (Bowens Rd CS) Depth – 36 m Screened Interval – 32 to 34 m WMB04 – Deep sandstone Depth – 80.5 m Screened Interval – 67 to 79 m

6.2.1. Water Levels

Pilot Wells

Static water levels are unlikely to be obtained in each gas well after perforating and prior to the fracture stimulation program due to wellhead safety requirements and the immediate recovery of fracture stimulation fluids. For the pilot testing program, it is proposed to install pressure transducers in each well so as to monitor the drop in hydrostatic head as each of the coal seams is depressurised. These are sensitive instruments that sometimes fail under the changeable pressure conditions that occur within the inner production casing and pump tubing. If the pressure transducers fail during the pilot test, the test will continue without this data. It is expected that the water levels within the targeted coals seams will be close to or within the uppermost perforated intervals.

Monitoring Bores

Three of the four nested monitoring bores that are located within the area of influence of the pilot testing program have been equipped with dataloggers to collect baseline information in front of any fracture stimulation and pilot testing programs. This monitoring program commenced in February 2012 and will continue for the life of the Waukivory flow testing program (including a minimum 8 week recovery period after the flow test). Vibrating wire piezometers (VWPs) will be installed in the remaining water monitoring bore prior to the commencement of the fracture stimulation program. Dataloggers will continue indefinitely in these bores depending on the status and requirements of the broader GGP.

In addition the deep well (WKmb05) will be converted and completed with VWPs after the fracture stimulation program and is expected to be operational for the full period of the pilot testing program.

Existing monitoring sites in the broader area have dataloggers installed and these will continue indefinitely at the current data collection rate (one reading every 6 hours).

6.2.2. Water Quality

AGL has three primary tiers of water quality monitoring, sampling and reporting. The **Comprehensive suite** is used for important sampling events. The **Basic suite** is for all other sampling events and is mainly used for tracking major salinity / chemistry changes in the CSG produced water (wells and ponds). The **Intermediate suite** is unlikely to be used for this flow testing program. The analytical suites listed in Table 6.3 have been adopted for all AGL's CSG water sampling programs since August 2010.

The basic suite is just the check on field parameters, major ions and dissolved metals, the intermediate suite is the same plus total suspended solids and nutrients, while the comprehensive suite is everything in this listing.

Major changes from a saline water quality signature would trigger investigations and repeat sampling to identify the source. Any significant changes in the basic suite would trigger either repeat sampling or an intermediate or comprehensive sampling event.

Pilot Wells

For the fracture stimulation program, the following water quality sampling program is proposed for all locations (WK11, WK12, WK13 and WK14):

- raw (source) waters to be used for fracture stimulation;
- fracture stimulation fluid mixture (ie. the raw waters plus the sand and any chemical additives) to be injected into each gas well (if there are multiple fraccs per well and all are the same recipe then just one event will be sampled per well);
- flowback water (ie. return water immediately after the fracture stimulation fluid water volume is pumped back to surface); and
- produced water (natural groundwater from the coal seam/s after the fracture stimulation fluid water volume is pumped back to surface).

Field parameters will be taken for all water samples taken during fracture stimulation together with enough water sample for the comprehensive suite of analytes as listed in Table 6.3.

Table 6.3: Laboratory analytical suites

Category	Suites			Parameters	
Check on Field Parameters	Basic	Intermediate	Comprehensive	Electrical conductivity and TDS	
Major ions				*Cations*	*Anions*
				calcium	chloride
				magnesium	carbonate
				sodium	bicarbonate
				potassium	sulphate

Category	Suites			Parameters	
Dissolved metals and minor / trace elements				aluminium arsenic barium beryllium boron bromine cadmium chromium cobalt copper iron	lead manganese mercury molybdenum nickel selenium strontium uranium vanadium zinc
Other analytes				Fluoride Total organic carbon	Silica
Total Suspended Solids				TSS	
Nutrients				Nitrate Nitrite Ammonia	Reactive phosphorus Total phosphorus
Dissolved gases				Methane	
Hydrocarbons #				Phenol compounds Polycyclic aromatic hydrocarbons (PAH)	Total petroleum hydrocarbons (TPH)/ benzene, toluene, ethyl benzene and xylenes (BTEX)

Key: Additional analytes may be analysed for flow back waters.

Once the pilot testing program is under way, weekly water samples from each gas well will be taken to track field parameters (mainly salinity (EC) and pH). At the beginning of the pilot testing program, and then at periods of two months, regular water samples (basic suite) will be taken for laboratory analysis to check that there are no apparent changes in the produced water chemistry. A sample for comprehensive analysis will be taken from each well at the end of the pilot testing program. Details of the proposed water quality sampling program are shown in Table 6.4.

Table 6.4: Groundwater monitoring sites, suites and frequencies

Fracced Wells	Baseline	Fracture Stimulation				Pilot Testing			
(WK11, WK12, WK13 and WK14)		Raw	Mix	Flowback	Nat	Start	Mth 2	Mth 4	Mth 6
Basic						X	X	X	
Comprehensive	X	X	X	X	X				X

Monitoring Bores

Baseline water quality monitoring data was collected at three of the four new nested monitoring bore sites in the immediate vicinity of Waukivory pilot test area in 2012. Further water sampling is proposed immediately before the fracture stimulation program.

Bores have been purged and sampled for water quality and isotopes. The initial baseline event in 2012 was a comprehensive event plus isotopes. The second baseline event (immediately pre fracture stimulation) will be a comprehensive event.

Environmental isotopes (oxygen-18 and deuterium), methane isotopes and radio isotopes (carbon 13 and carbon 14) were analysed from the nested monitoring bores as part of the baseline sampling event.

No sampling during the pilot testing program is proposed because it is important to maintain the most accurate data set from the water level monitoring. However all monitoring bores will be purged and sampled for water quality and isotopes after the pilot testing program. One post pilot testing sampling event is proposed being a comprehensive event plus isotopes within 4 weeks of the cessation of the test.

6.3. Monitoring water volumes

Approximate water volumes of between 1 and 2.5ML per well and around 6ML for the whole fracture stimulation program are expected to be required for this Waukivory pilot. The quality of the water does not necessarily have to be fresh but it needs to be consistent in water quality and low in bacterial contaminants or load.

Water for Fracture Stimulation

Water will be sourced from licensed water supply works located on either of AGL's Pontilands and Tiedmans properties off Fairbairns Lane. Town water is the third water supply option. AGL (in advance of the REF evaluation and approval process) has submitted an application to NOW to licence a large dam on the Pontilands property and to take water for 'stock, irrigation and industrial' purposes.

The estimated volume of water to be used in these fracture stimulation activities is approximately:

- Waukivory #11 – 0.9 ML;
- Waukivory #12 – 1.4 ML;
- Waukivory #13 – 1.5 ML; and
- Waukivory #14 – 2.4 ML.

This equates to around 6 ML for the whole of the program for the Waukivory site. The expected allocation for the Pontilands Dam is 20 ML per annum (and there is about 50 ML in storage) so there will be sufficient water available to take this source water for industrial purposes. All the water in the Pontilands Dam is fresh water derived from local catchment runoff.

Water in the Tiedman dams has mostly been derived from previous pilot testing on the Stratford wells that are licensed for industrial and irrigation purposes. Being licensed for industrial purposes, this produced water is able to be reused for fracture stimulation purposes (if required).

Pilot Wells

During the pilot testing program (which is expected to last for at least six months), produced water volumes will be metered at each of the pilot well sites and checked against the water volumes that are delivered via the internal water gathering lines and/or road tankers to the Tiedman produced water dams.

Pumping rates for each well are unlikely to exceed 0.3 L/s at the start of the test and are likely to diminish after 6 months if the water production profiles observed for the pilot wells at Stratford are repeated here. It is not expected that produced water volumes will exceed 5 ML for each well and 20 ML in total for the whole pilot testing program.

6.4. Reporting

All data from the baseline investigation and pilot testing program will be collated and analysed and the results assessed and written up into a detailed technical report within 6 months of completion of the pilot test. The investigation results will focus on permeability, water levels, water quality, and environmental/radioisotope data and trends. There will be a discussion of the water data obtained from all pilot wells and all monitoring bores monitored for this flow testing program.

The conceptual model that is developed in the latest site investigation and water balance studies (PB, 2013a and PB, 2013b) will be reviewed and improved (if required) based on the results from this pilot testing program.

It is not expected that a numerical model will be prepared specifically for the pilot testing program (although numerical modelling of this local area is currently underway as part of the GGP Stage 1 approval). After the pilot testing program, the numerical groundwater model may be updated to replicate the results of the pilot testing program. The local model is focused on fault structures and is being developed to help design and calibrate the regional numerical model required for the Stage 1 development. The numerical model development and results will not be part of the Waukivory technical report.

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Figures

Energy in action.™

AGL

Author: Upstream Gas

Date: 28/03/2013

Ref: 2575R5

Gas Wells and Water Monitoring Locations - Waukivory

Metres

0 125 250

Scale 1:5,000 @A3

Geocentric Datum of Australia 1994

Sources: AGL Energy Limited, MapData Sciences, SKM

Legend

Geophone/VWP location

WKMB05

Water Monitoring Bore

AGL Wells

Roads

Railways

Canal

Cadastre

N

Figure 1

DRAFT SECTION and LOCATIONS

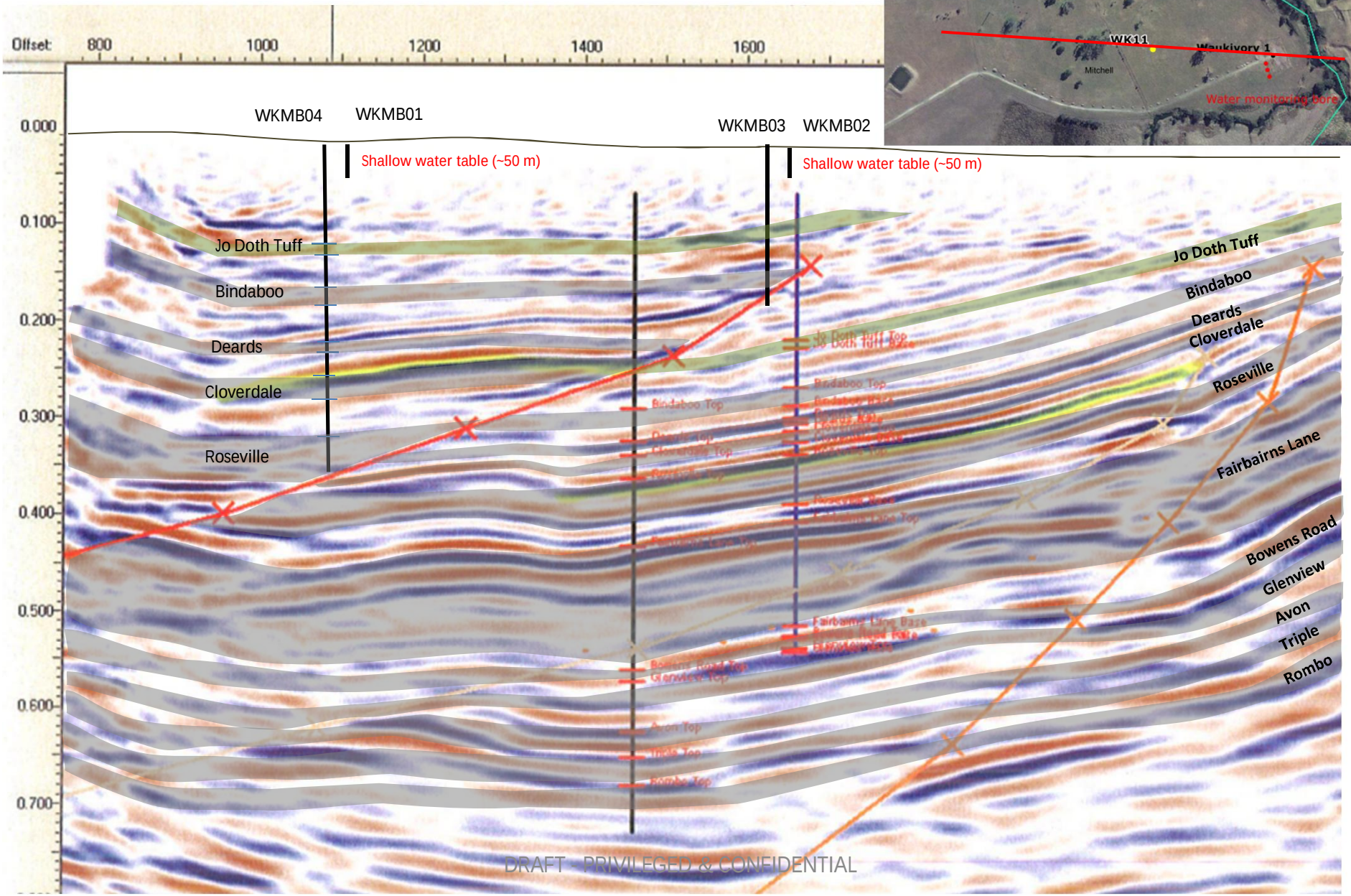

Figure 2

Appendices

Appendix A1: Minimum impact considerations for less productive aquifers

Appendix A2: Groundwater impact assessment for gas well drilling program

A1 Minimum impact considerations for less productive aquifers

Table A1.1 Minimum impact considerations for the less productive alluvial aquifers

Water component	Minimum impact considerations	Assessment
Water table	1. Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan"(2) variations, 40m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan; or A maximum of a 2m decline cumulatively at any water supply work unless make good provisions should apply. 2. If more than 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; Listed in the schedule of the relevant water sharing plan then appropriate studies will need to demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than 2m decline cumulatively at any water supply work then make good provisions should apply.	The Avon River alluvium has a maximum thickness of 15 m and contains a shallow unconfined (water table) aquifer. There are no known groundwater dependent ecosystems (GDEs) except for minor baseflow accessions to the Avon River. There are relatively few water supply works nearby. The closest water supply bore is located about 600m across gradient on the neighbouring property (GW054940) and is completed as an excavation in the shallow alluvial aquifer. *Fracture Stimulation* Fracture stimulation at depth in the coal seams will not propagate to the near surface alluvial aquifers. *Dewatering* There is no potential for the water table in the alluvium to decline during coal seam dewatering due to environmental safeguards including casing and cementing of the gas wells. Therefore, a decline in the water table level is also unlikely. Water levels will be monitored in the pilot test wells and monitoring bores. Four monitoring bores at the site have collected over 12 months of seasonal data on baseline water levels to inform the design of the proposed activity. These bores will be monitored during

		and after hydraulic fracture stimulation, and during the pilot testing program. In summary, predicted effects are **less than the Level 1 minimal impact considerations**.
Water pressure	Level 1. A cumulative pressure head decline of not more than 40% of the "post-water sharing plan"(2) pressure head above the base of the water source to a maximum of a 2m decline, at any water supply work. Level 2. If the predicted pressure head decline is greater than requirement 1. above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.	There is only a 'water table' aquifer in the alluvial aquifers so the Water Pressure criterion has no relevance.
Water quality	Level 1. (a) Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity; and (b) No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity. Redesign of a highly connected(3) surface water source that is defined as a "reliable water supply"(4) is not an appropriate mitigation measure to meet considerations 1.(a) and 1.(b) above. (c) No mining activity to be below the natural ground surface within 200 m laterally from the top of high bank or 100 m vertically beneath (or the three dimensional extent of the alluvial water source - whichever is the lesser distance) of a highly connected surface water source that is defined as a "reliable water supply". (d) Not more than 10% cumulatively of the three dimensional extent of the alluvial material in this water source to be excavated by mining activities beyond 200 m laterally from the top of high bank and 100 m	The beneficial aquifers at Waukivory and its surrounds are all shallow aquifers that occur in very shallow alluvial sediments or shallow fractured bedrock. The alluvium has a maximum thickness of 15m and contains variable quality water from fresh to moderately saline. As a result no single beneficial use category can be assigned. The alluvial aquifer is expected to be connected to surface water near the Avon River but is known to be poorly connected at the edges of the floodplain. As all gas wells are cased and cemented to full depth, changes in the water quality of beneficial aquifers are unlikely. Activities with potential to contaminate groundwater in beneficial aquifers include the use of chemical additives in fracturing fluids, the storage of produced and flowback water in the holding dam, and reuse of water for irrigation. Fracture stimulation of coal seams at

	vertically beneath a highly connected surface water source that is defined as a “reliable water supply” Level 2. If condition 1.(a) is not met then appropriate studies will need to demonstrate to the Minister’s satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works. If condition 1.(b) or 1.(d) are not met then appropriate studies are required to demonstrate to the Minister’s satisfaction that the River Condition Index category of the highly connected surface water source will not be reduced at the nearest point to the activity. If condition 1.(c) or (d) are not met, then appropriate studies are required to demonstrate to the Minister’s satisfaction that: - there will be negligible river bank or high wall instability risks; - during the activity’s operation and post-closure, levee banks and landform design should prevent the Probable Maximum Flood from entering the activity’s site; and - low-permeability barriers between the site and the highly connected surface water source will be appropriately designed, installed and maintained to ensure their long-term effectiveness at minimising interaction between saline groundwater and the highly connected surface water supply.	depth in the gas wells will not impact the shallow alluvial aquifers. Substantial mitigation measures are in place to monitor fracture stimulation and fracture fluids (see Chapter 5). In summary, predicted effects are expected to be **less than the Level 1 minimal impact considerations**.
OVERALL ASSESSMENT		The assessed impact on the (less productive) shallow alluvial aquifers along the floodplain of Avon River as a result of the proposed fracture stimulation and flow testing programs are assessed to be minimal to negligible based on the baseline water level and water quality monitoring that has been completed to date, and the known conceptual flow model for shallow aquifers, deep aquifers and deeper water bearing zones.

Table A1.2 Minimum impact considerations for less productive porous and fractured rock aquifers

Water component	Minimum impact considerations	Assessment
Water table	Level 1. Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan. A maximum of a 2m decline cumulatively at any water supply work. Level 2. If more than 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" variations, 40 m from any: (a) high priority groundwater dependent ecosystem; or (b) high priority culturally significant site; listed in the schedule of the relevant water sharing plan if appropriate studies demonstrate to the Minister's satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than a 2 m decline cumulatively at any water supply work then make good provisions should apply.	There may be a 'water table' in the shallow fractured rock but it is difficult to identify. The aquifers in the rock underlying the site are considered to be semi-confined to confined and are therefore assessed under the 'water pressure' criterion below.
Water pressure	Level 1. A cumulative pressure head decline of not more than a 2 m decline, at any water supply work. Level 2. If the predicted pressure head decline is greater than requirement 1. above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.	The porous and fractured rocks beneath the alluvium and beneath the Waukivory area contain a few semi-confined aquifers in the uppermost 75m from surface. These are semi-confined to confined aquifers that have low permeability confining layers throughout the sedimentary sequence. Yields to bores are typically low and the water quality is slightly to moderately saline. The deeper bores in rock in the local area are around 60m deep. There are limited beneficial uses for this groundwater (limited to some stock and industrial applications such as dust suppression). The deeper coal seams are confined water bearing zones with more low permeability layers

		separating the shallow fractured rock aquifer from these zones which mostly occur below 150m depth. *Fracture Stimulation* There are inherent difficulties in predicting pressure head decline during hydraulic fracture stimulation. Prior to hydraulic fracture stimulation, a simulator will be run to provide a preliminary model of rock mechanics, fluids, pressures and temperatures. Due to the difficulty in predicting changes to the fracture geometry from simulation, a mini fracture will be performed prior to the main fracture. A pre-determined volume of the hydraulic fracture stimulation fluid will be pumped into the coal seam without proppant. The pressure decline will be monitored, and these data will be used to inform the main hydraulic fracture stimulation. The mini fracture will give a higher degree of confidence that the Level 1 minimum impact threshold for water pressure is not exceeded. In addition, a microseismic monitoring bore will be in place near WK13 to assess the extent and orientation of fractures in the targeted coal seams. *Dewatering* There is limited potential for the water levels in the shallow fractured rock aquifers to decline during coal seam dewatering due to environmental safeguards including casing and cementing of the gas wells. Additionally, groundwater monitoring data indicates that a vertical connection between the deeper fractured rock aquifers and the deeper coal seams is unlikely (PB 2012a and PB 2012c). Proving this lack of connectivity is one of the

		primary reasons for the flow testing program. Water levels will be monitored in the pilot test wells and monitoring bores. Seven monitoring bores at the site have collected over 15 months of seasonal data on baseline water levels to inform the design of the proposed activity. Four of these bores are in the fractured rock and thrust fault zone and three are in the alluvium. These bores will be monitored during and after hydraulic fracture stimulation, and during the flow testing program. Water supply bores are very unlikely to be affected given their distance from the gas wells and pilot test program. In summary, predicted effects are **less than the Level 1 minimal impact considerations**.
Water quality	Level 1. Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity. Level 2. If condition 1 is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.	The shallow fractured rock aquifer is not considered a beneficial aquifer, or a 'reliable water supply' as it has a low yield (generally less than 1 L/s), and has slight salinity (generally above 3000 mg/L TDS). There are very few bores constructed into the rock. The deepest water supply bore known in the local area is 60 m. As all gas wells are cased and cemented to full depth, changes in the water quality of all the shallow beneficial aquifers are unlikely. The only activity with potential to contaminate groundwater in beneficial aquifers is the storage of flowback water. Fracture stimulation of coal seams at depth in the gas wells will not impact the shallow porous and fractured rock aquifers. In summary, predicted effects are **less than the Level 1 minimal impact considerations**.

OVERALL ASSESSMENT		The assessed impact on the (less productive) porous and fractured rock aquifers beneath the Waukivory area as a result of the proposed fracture stimulation and pilot testing programs are assessed to be minimal based on the baseline water level and water quality monitoring that has been completed to date, and the known conceptual flow model for shallow aquifers, deep aquifers and deeper water bearing zones.

A2 Groundwater impact assessment (drilling program)

It is considered that, by drilling the pilot wells in accordance with the requirements outlined in Chapter 4, the potential to impact on groundwater systems and local groundwater users is low adverse to negligible. There are no groundwater dependent ecosystems or local groundwater users within the immediate vicinity of the Waukivory pilot wells that could be affected. Impacts are assessed in Table A.1.

Table A2.1: Impact Assessment – Waukivory Drilling Program

Impact Assessment for Groundwater Systems	
Size, scope and intensity of impacts	The potential impacts on groundwater systems is considered low as the drilling works are for a short duration and undertaken in accordance with the new Well Integrity Code of Practice and national standards. Following the completion of drilling, the exploration hole will be capped and suspended in accordance with the *Petroleum and Gas (Production & Safety) Regulation 2004 – Schedule 3*.
Level of confidence in predicting the impacts	AGL has undertaken core hole and stratigraphic hole drilling activities as part of the on-going exploration works associated within all of their upstream gas projects. The resulting significant level of experience gained from previous projects has resulted in a high level of confidence in accurately predicting any potential associated impacts to groundwater systems from the exploration drilling works.
Reversibility of Impacts	As the anticipated potential for groundwater impacts is considered low and only water based drilling fluids are used, the reversibility of any impacts is considered to be high.
Mitigation Management Measures	Mitigation management measures would be pre-emptive and also adaptive to ameliorate any potential for impact. Measures would include: ▪ The well will be cased at the surface plus there will be an internal surface casing to ~100m to protect shallow aquifers; ▪ Any drilling fluids/mud will be contained in appropriately sized surface tanks or lined sumps (within the drill compound area); ▪ All sumps will be HDPE lined and bunded and have a sufficient capacity in case of heavy rain or additional flow from the holes; ▪ A periodic "pump-out" of the sumps will occur as required to prevent any discharge during wet weather events; ▪ All land disturbed during drilling activities will be restored to pre-operational quality as soon as practical; ▪ Drilling activities will be undertaken in accordance with Australian Government standards, DTIRIS - Minerals Guidelines, Industry best practice and NSW Government standards for well construction. Any additional draft or final Government Codes of Practice. These mitigation measures are considered to effectively ameliorate all impacts to groundwater and protect its quality.
Effectiveness of the proposed methods to manage or mitigate the impacts	The proposed methods to manage or mitigate impacts to groundwater have been derived from past project experience. The drilling process is governed by national standards and industry guidelines. The standards and guidelines outline methods to mitigate potential impacts. Accordingly, the proposed management/mitigation measures proposed are considered to be effective measures as they are enforced through national standards.
Compliance with any relevant policies or plans	The drilling methods comply with the national standards, *The minimum construction requirements for water bores in Australia* (NUDLC, 2012) and industry best practice.
Level of public interest	The drilling requires a licence pursuant to the *Water Act 1912* which does not include any allocation to extract groundwater. At the drilling stage it is considered that the general public will maintain an interest in ensuring all works are undertaken with no impacts to groundwater systems. The level of impact to groundwater systems from the proposal is low and predictable with a high level of certainty.

Impact Assessment for Groundwater Systems	
Is further information required to confidently determine the impact of the activity?	No additional information is required to confirm the predicted level of impact risk to a groundwater system evaluated for the exploration drilling activities.
Categorisation of the extent of impact	Based on the impact assessment matters listed above the potential for drilling impacts to a groundwater system is determined to be **low adverse to negligible**.

Appendix E

Environmental management plan

GLOUCESTER GAS PROJECT

Exploration
ENVIRONMENTAL MANAGEMENT PLAN

AGL Upstream Investments Pty Limited
April 2013

Revision Due: April 2014

Document Control
Environmental Management Plan

Approval:

Authorising Officer	Mike Roy
Title	Head of Gas Operations
Signature	
Date	April 2013

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1. Introduction

1.1. Scope of Environmental Management Plan (EMP)

This document is the AGL Upstream Investment Pty Limited (AGL) Environmental Management Plan (EMP) for exploration activities associated with Petroleum Exploration Licence 285 (PEL 285) and describes AGL's system to manage potential environmental issues associated with these activities.

Exploration and testing activities are undertaken to evaluate the natural gas resource potential of the Coal Measures within the area covered by PEL 285 primarily located within the local government areas (LGAs) of Great Lakes, Dungog and Gloucester in NSW (see Appendix C).

In accordance with the conditions of recently renewed PEL 285, Groundwater Monitoring and Modelling Plans are prepared for pilot testing activities. Further, an overarching Fracture Stimulation Management Plan has been prepared for exploration activities.

This EMP is applicable to all exploration activities and will be updated on annual basis as required to incorporate future exploration activities.

In 2011, approval for the Gloucester Gas Project (GGP) was granted by the Planning and Assessment Commission. In 2012, the validity of this approval was upheld by the Land and Environment Court. The GGP comprises a gas production field, central processing facility and a pipeline to Hexham. This EMP does not include activities associated with the GGP. A separate EMP is required under the conditions of approval.

1.2. Background to EMP

An EMP was prepared during the preliminary and formative stages of exploration activities in the PEL. Since the preparation of the EMP, there have been changes to legislative requirements, industry codes and practices. Community expectations of the level of information provided in EMPs have also increased. In addition, exploration activities have continued in the PEL area and submitted several environmental assessment documents under the provisions of Part 5 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) to conduct these exploration activities. The EMP has been updated accordingly to accommodate these changes.

1.3. Objectives and targets of EMP

The objective of this EMP is to describe the environmental management framework of exploration activities for PEL 285. This framework sets out environmental requirements and establishes the processes for implementation, monitoring and review. These processes are designed to ensure compliance, continuous improvement and to minimise the potential environmental impacts of our proposed activities.

Exploration activities are ongoing within the PEL to collect exploration data to determine potential natural gas resources in accordance with AGLs obligations under the conditions of the PEL. The various exploration activities are now assessed and approved by NSW Department of Trade and

Investment, Regional Infrastructure and Services (Division of Resources and Energy) or DTIRIS-DRE, under section 111 of the EP&A Act. Prior to 2011, applications for exploration activities were submitted and approved by the former Department of Industry and Investment (DII) under Part 5 of the EP&A Act. Exploration activities are likely to be approved under the EP&A Act and require an Environment Protection License (EPL).

1.4. Environmental management framework

The EMP will form the basis of the environmental management for the exploration activities within PEL 285 subject to the relevant approval and assessment.

The following sections of the EMP identify the legislative and regulatory requirements for the exploration activities. It describes the activities, contains specific environmental management plans (Sub Plans) for key aspects and sets out processes for implementation, monitoring and review. The EMP is a key operational document for exploration activities and will be included in the induction program for each exploration site, together with detailed relevant site specific information.

The EMP also incorporates the environmental management requirements of Life Guard, the AGL Health Safety and Environment (HSE) Management System which is based on the requirements of ISO 14001: 2004. The Life Guard system is implemented across all AGL Energy operated businesses.

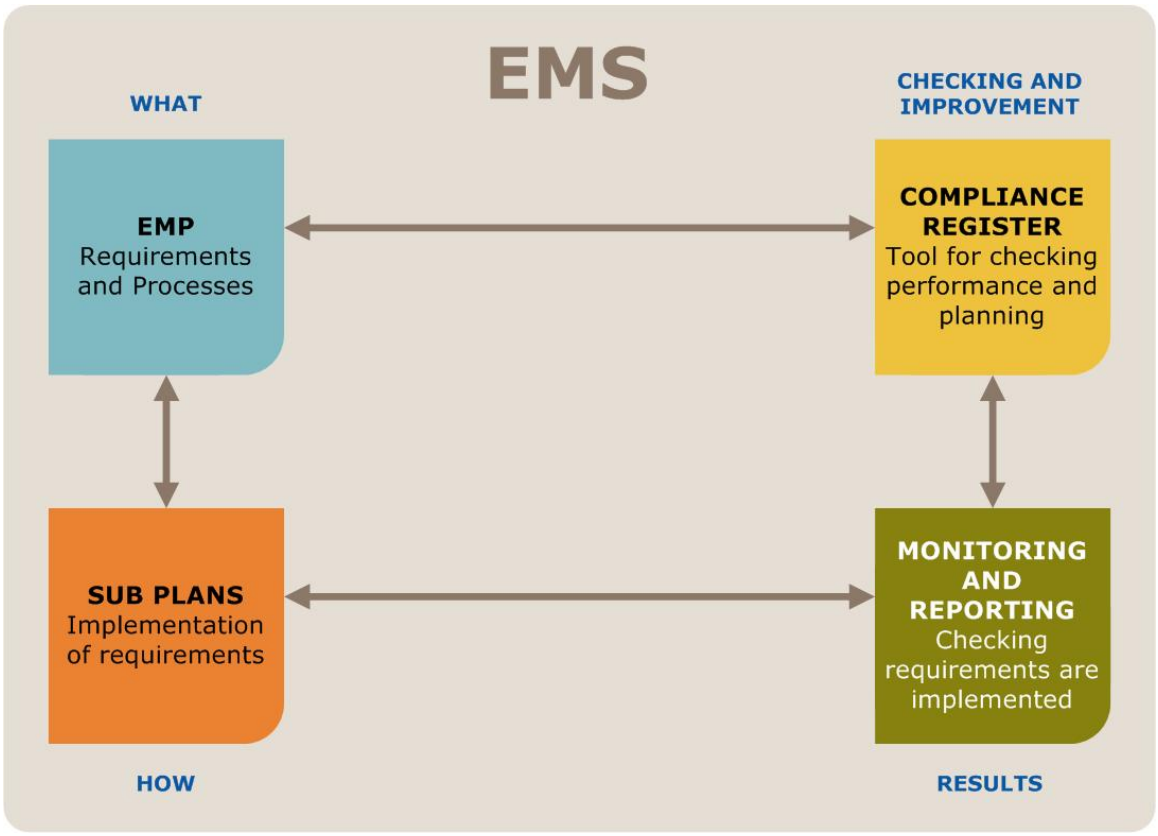
At AGL, we believe that providing a safe and healthy workplace for all people, and protecting the environment is a vital part of the way we do business. That's why our Life Guard program exists - to display and implement AGL's commitment to health and safety, to the environment and to provide practical tools to manage HSE. Additionally, being Safe and Sustainable in all our business operations is one of our key Company Values.

1.5. Environmental policy

All activities will be undertaken in accordance with the AGL Energy HSE Policy (refer Appendix B) that outlines our commitment to ongoing sound management of environmental aspects and performance.

In addition AGL has a set of environmental principles, which include a commitment to minimise our impact on the environment (refer to Appendix B). Figure 1 illustrates AGLs Environmental System Management Framework.

Figure 1 PEL 285 Environmental Management System Framework



1.6. Layout of EMP

This EMP comprises the following key elements (generally in accordance with our target to build towards compliance with the requirements of the Environmental Management System ISO14001:2004):

- Environmental Policy (Section 1.5);
- Summary of Legislative Requirements (Section 2);
- Description of Activities and Potential Environmental Impacts (Section 3);
- Risk Management, Objectives and Targets (Section 4);
- Implementation and Operation (Section 5);
- Monitoring and Checking (Section 6);
- Management Review (Section 7);
- Environmental Management Sub Plans (Appendix A);
- AGL HSE Policy;
- PELs; and

- Emergency Response Plan.

Figure 1 assists in describing the context of this EMP.

1.7. Table of abbreviations

Table 1-1: Table of Abbreviations

Acronym	Definition
ACHMSP	Aboriginal Cultural Heritage Management Sub Plan
AGL	AGL Upstream Investments Pty Limited
AHIP	Aboriginal Heritage Impact Permit
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
CAA	Controlled Activity Approval
CCC	Community Consultation Committee
CO_2	Carbon Dioxide
DII	NSW Department of Industry and Investment
DP&I	NSW Department of Planning and Infrastructure
DSEWPaC	Commonwealth Department of Sustainability, Environment, Water, Populations and Communities
DTIRIS-DRE	NSW Department of Trade and Investment, Regional Infrastructure and Services NSW
ECR	Environmental Compliance Register
EP&A Act	NSW Environmental Planning and Assessment Act 1979
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
EMP	Environmental Management Plan
EPA	NSW Environment Protection Authority
FFMSP	Flora and Fauna Management Sub Plan
ft	Foot
GGP	Gloucester Gas Project
HCCC	Hunter Community Consultative Committee
HSE	Health Safety and Environment System

Acronym	Definition
JSEA	Job Safety and Environmental Analysis
KPI	Key Performance Indicator
LGA	Local Government Area
mm	Millimetre
NES	National Environmental Significance
NPW Act	NSW National Parks and Wildlife Act 1974
NOW	NSW Office of Water
NV Act	NSW Native Vegetation Act 2003
OEH	NSW Office of Environment and Heritage
PAH	Polycyclic aromatic hydrocarbons
PEL	Petroleum Exploration Lease
PO Act	NSW Petroleum (Onshore) Act 1991
POEO Act	NSW Protection of the Environment Operations Act 1997
REF	Review of Environmental Factors
RFS	NSW Rural Fire Service
RMS	NSW Roads and Maritime Services
SDV	Shut-down valve
SIS	Surface to in-seam
TJ	Terajoules
TPH	Total petroleum hydrocarbons
TSC Act	NSW Threatened Species Conservation Act 1995
WM Act	NSW Water Management Act 2000

2. Legislative requirements

2.1. Environmental legislative reporting requirements

Table 2-1 provides a summary of the primary environmental legislative reporting requirements, its requirements and how it may apply to the exploration activities within PEL 285.

Table 2-1: Summary of environmental legislative reporting requirements

Legislation and regulatory body	Approval / Licence requirements	Summary of key aspects
Pre-2011 Approvals		
EP&A Act NSW Department of Industry and Investment (DII)	Part 5, section 111 – Review of Environmental Factors (REF) to obtain approval from Minister for Mineral Resources for certain activities within a PEL.	Part 5 approvals have been issued for drilling and testing at Weismantel, Faulkland, Craven, Waukivory and Stratford. Other previously completed exploration activities were also approved under Part 5.
Post-2011 Approvals		
EP&A Act DTIRIS-DRE under Section 111	Part 5, section 111 – REF to obtain approval from Minister for Mineral Resources for certain activities within a PEL.	Applications for scheduled exploration activities have been submitted to DTIRIS-DRE under section 111 of the EP&A Act and are awaiting approval. This EMP has been prepared on the assumption that these activities will proceed as proposed in the REFs.
Other Approvals		
Petroleum (Onshore) Act 1991 (PO Act) DTIRIS-DRE	Requires consideration to be given to protection of the environment before a petroleum title is granted.	AGL holds a petroleum exploration licence (PEL 285). Natural gas exploration activities can only be carried out under the authority of a petroleum title.
Protection of the Environment Operations Act 1997 (POEO Act) EPA	The POEO Act regulates the key pollution aspects being air, water, noise and land.	AGL, its employees and agents have an obligation to conform to the requirements of the Act and any associated licences issued under the Act.
Heritage Act 1977 OEH	Approval is required to disturb/destroy relics or do certain things that will affect an object subject to an Interim Heritage Order or listed on the State Heritage Register. An excavation permit under section 139 is required under certain circumstances.	Approval may be required if works will disturb a relic or an object subject to an Interim Heritage Order or listed on the State Heritage Register. The Heritage Council has standard exemptions for specific works requiring approvals.

Legislation and regulatory body	Approval / Licence requirements	Summary of key aspects
National Parks and Wildlife Act 1974 (NPW Act) OEH	An Aboriginal Heritage Impact Permit (AHIP) permit is required to harm an Aboriginal object or Aboriginal place under section 90 of the Act (unless consent is provided under Part 4, Division 4.1 State Significant Development of the EP&A Act).	The NPW Act is relevant if Aboriginal objects are discovered during the course of the works.
Native Vegetation Act 2003 (NV Act) OEH	Clearing of native vegetation (outside urban zoning) must be carried out in accordance with a development consent or a property vegetation plan (section 12(1)), unless it is permitted clearing or activities listed as excluded clearing.	If clearing is approved to be undertaken under Part 5 of the EP&A Act, approval under the NV Act is not required. However, where clearing of native vegetation in non-urban or residential areas and zones is required for exempt development or a Part 4 development (excluding Division 4.1 State Significant Development), clearing must be carried out in accordance with a property vegetation plan, or obtain development consent from the Minister for Planning or delegate (CMAs).
Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Department of Sustainability, Environment, Water, Populations and Communities (DSEWPaC)	All activities must consider matters of National Environmental Significance (NES) as well as any Commonwealth land. If a significant impact is proposed, the approval of the Commonwealth Minister for DSEWPaC is required.	The EPBC Act applies if any action that has, will have or is likely to have a significant impact: - on a matter of NES; or - on Commonwealth land (whether action takes place inside or outside Commonwealth land. Refer to Appendix A (Flora and Fauna Management Sub Plan) for specific measures relating to MNES.
Work Health and Safety Regulation 2011 NSW WorkCover Authority	Part 7.1 deals with Dangerous Goods. Dangerous goods are required to be placarded and quantities notified to WorkCover NSW when stored above certain levels.	Exploration activities do not require a Dangerous Goods Notification.

Legislation and regulatory body	Approval / Licence requirements	Summary of key aspects
Threatened Species Conservation Act 1995 (TSC Act) OEH	The Act provides for the protection of threatened flora and fauna (other than fish and marine vegetation) native to NSW and threatened populations, communities and critical habitat.	The Act applies if any threatened species, populations, communities and/or critical habitat listed under the Act is potentially affected by the activity or impacted on or off the work site, as a consequence of the activity. A section 91 licence or section 95 certificate is required under the TSC Act if threatened species, populations or communities are harmed or picked, or their habitat is damaged. Unless the harm was carried out under an approval obtained under Part 4 or Part 5 of the EP&A Act. Refer to Appendix A (Flora and Fauna Management Sub Plan) for specific measures relating to threatened species, populations and communities.
Water Management Act 2000 (WM Act) NSW Office of Water (NOW)	A Controlled Activity Approval (CAA) required under section 91(2) for controlled activities when working in, on or under 'waterfront land' (ie land within 40 m of a watercourse). A water use approval is required under section 89 to use water for a particular purpose at a particular location. Water management works approvals may be required under section 90 for water supply works, drainage works or flood works.	The Act applies if working on or under 'waterfront land' (ie within 40 m of a watercourse), where water extraction (ie water supply works) is required, or where interference activities are required. Approvals are required for these activities.
Water Act 1912 and WM Act NOW	Water licences are required for drilling activities under both the *Water Act 1912*, which applies in areas where no Water Sharing Plan is in place and the WMA which applies where there is a Water Sharing Plan. There are several Water Sharing Plans within the areas of the PELs.	Water licences are required under Part 5 of the Act for all gas exploration and water monitoring holes. For pilot testing, a production bore licence is required for each gas well site for industrial and irrigation purposes.
Roads Act 1993 NSW Roads and Maritime Services (RMS)	Section 138 of the *Roads Act 1993* requires authority consent for any activities likely to impact on the operational efficiency of the road network.	A Road Occupancy Licence must be obtained if activities are deemed likely to impact on traffic, such as undertaking seismic activities within road reserves.
Contaminated Land Management Act 1997 OEH	Must report to EPA if land contamination presents "a significant risk of harm."	The Act is relevant if contaminated land is found or suspected. No contaminated land is suspected to occur in areas of exploration activities within PEL 285. Any contamination found during works will be reported.

Legislation and regulatory body	Approval / Licence requirements	Summary of key aspects
Rural Fires Act 1997 NSW Rural Fire Services (RFS)	The district fire control office in charge of the local fire station must be informed before the lighting of any fires. No open flame on total fire ban days. Duty to take steps to prevent bushfires.	The Act is relevant if fires are to be lit or if undertaking activities with fire risk. Gas flaring activities will be undertaken in accordance with approval and licence requirements.
Noxious Weeds Act 1993 Department of Primary Industries (Agriculture)	The relevant control authority must be notified within three days of becoming aware that a notifiable weed is on AGL land. The spread of noxious weeds must be controlled so that they do not impact adjoining land.	The Act is relevant if listed weeds area found or imported on site.
Commonwealth *National Greenhouse and Energy Reporting Act 2007* Commonwealth Department of Climate Change and Energy Efficiency	Must report greenhouse gas emissions, energy consumption and production if the corporate group emits 125 kilotonnes or more greenhouse gases (CO2 equivalent), or produces or consume 500 terajoules (TJ) or more of energy for the 2008-2009 reporting year. Note these reporting thresholds decrease for the 2009-2010 and 2010-2011 reporting years.	The Act is relevant to the AGL Energy group of companies, including exploration activities. AGL is required to report all greenhouse gas emissions, energy consumption and production on a financial year basis.
Policy		
Strategic Regional Land Use Plan Upper Hunter	An agricultural impact statement is a new statewide requirement for all mining, CSG exploration and production proposals.	An agricultural impact statement must be included in all REFs submitted after December 2012.
NSW Aquifer Interference Policy	Aquifer interference approvals are required for mining activities where water is extracted (including CSG), extractive industries, dewatering, injection works and activities that may contaminate an aquifer.	This policy is relevant to CSG exploration projects where water will be extracted from an aquifer. Minimal impact considerations within the policy need to be assessed with respect to the proposed exploration activities.
Codes of Practice		
Draft Code of Practice for Coal Seam Gas Exploration	The explorer must maintain a record of community engagement. Where no exploration activity is occurring, an annual report must be submitted by the end of January. Where exploration activity is occurring, a quarterly report must be lodged within one month of the end of each quarter.	All CSG explorers will be required to abide by this Code of Practice. Compliance with this Code of Practice will be included as a condition of all new licences and will be added as a condition of licences where those licences are renewed.

Legislation and regulatory body	Approval/ Licence requirements	Summary of key aspects
Code of Practice for Coal Seam Gas Well Integrity	The titleholder must record accurate information on drilling, completion, workover and well abandonment. These records must be maintained in an accessible way for the five years following abandonment of a well. The Title holder is required to nominate a competent operator in charge of daily well operations who will ensure compliance of the tiles and provisions of the PO Act and Regulations. The titleholder must submit the following reports and notifications to DTIRIS-DRE: » location surveys of well co-ordinates; » annual reporting of operations; » annual safety report; » reports for seismic program, drilling of an exploration well, drilling of a production well, or a “significant” component of a work program within six months of completion of each; » notifications to drill; » well completion reports; and » incident reporting.	CSG titleholders are required to comply with this code to ensure that any activities relating to CSG well integrity are compliant with conditions of title pursuant to the PO Act. The Code of Practice requires that the following management plans are developed: » Safety Management Plan; » EMP; » Pollution Incident Response Management Plan; and » Emergency Response Plan. The Code of Practice sets mandatory and good industry design practices for: » well design; » casing; » cementing; » wellheads; » drilling fluids; » evaluation, logging, testing, coring; » well monitoring/ maintenance; » well suspension; and » well abandonment. CSG exploration wells must be plugged and abandoned and the department notified on the approval form within 3 months of the last drilling or testing activity. The mandatory requirements of this phase are outlined in section 4.9.2.

Legislation and regulatory body	Approval / Licence requirements	Summary of key aspects
Code of Practice for Coal Seam Gas Fracture Stimulation Activities	The Code of Practice requires that a Fracture Stimulation Management Plan (FSMP) is in place prior to works commencing. The management plan must be developed in accordance with the Code of Practice and submitted with an REF as part of an activity approval. The FSMP must be prepared having regard for the mandatory and leading practice requirements outlined in the Code of Practices, which relate to: » stakeholder consultation; » fracture stimulation design; » risk assessment; » safety (including a Safety Management Plan); » use of chemicals in fracture stimulation; » water resources; » management of flowback water; » impacts on coal mining; » monitoring; » incident and emergency response; » notification requirements; » undertaking the fracture stimulation activity; » completion report; » record keeping; » application of Australian and international standards; and » definitions. A completed fracture stimulation completion report must be submitted to DTIRIS (Mine Safety Operations and Environment Sustainability Unit) in the approved form within 30 days of the cessation of the fracture stimulation activity. Mandatory reporting requirements are detailed in Section 14.2 of the code of practice.	The fracture stimulation completion report must ensure that health safety and environmental risks have been appropriately managed and that regulatory requirements have been met. The code of practice ensures the incorporation of management plan development, stakeholder consultation and a focus relating to safety plans and operations to reduce any potential impacts to employees or the environment. Operation management aspects of the Code included successive monitoring of environmental factors, especially water use and flowback control, record keeping and notification requirements. Relevant Australian standards for the construction and operation of fracture stimulation activities are outlined by the Code with leading practices included to help guide the attainment of these respective standards.

2.2. Licences and approvals

The standards, performance measures and statutory requirements with which AGL is required to comply with are outlined in the licences and approvals listed in Table 2-2.

General conditions of approval for different activities are summarised in Table 2-3, while specific conditions are summarised in the Environmental Management Sub Plans.

Table 2-2: Summary of licences and approvals

Name / No.	Issued by	Description	Date of issue	Date of expiry / renewal
PEL				
PEL 285	DII Minerals (now DTIRIS-DRE)	Licence granted under Part 3 of the PO Act to undertake exploration activities.	15 September 2008	15 April 2012. AGL is currently renewing their PEL.
Part 5 Approvals				
PEL 285 Approval to conduct Seismic Exploration Activities on PEL285	DII Minerals (now DTIRIS-DRE)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to conduct a seismic survey in PEL 285.	14 November 2011	On completion of activity.
PEL 285 Approval to undertake drilling of the Waukivory exploration wells and piezometer	DII Minerals (now DTIRIS-DRE)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to conduct drilling of exploration wells and installation of piezometer	6 October 2011	On completion of activity.
PEL 285 Approval to conduct Gloucester Seismic Survey	DII Minerals (now DTIRIS-DRE)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to conduct Gloucester Seismic Survey.	13 October 2009	On completion of activity.
PEL 285 Approval to Drill Coal Seam Methane Exploration Boreholes	DII Minerals (now DTIRIS-DRE)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to drill boreholes at Gloucester 1 and 2, Craven 7 and Wards River 1, 2, 3, 4 and 5.	17 July 2009	On completion of activity.
PEL 285 Approval to drill, test and fracture stimulate coal seam gas exploration wells Waukivory 3, Waukivory 4, Stratford 7, Stratford 10 and Faulkland 2	DII Minerals (now DTIRIS-DRE)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to drill, test and fracture stimulate five wells	9 December 2008	On completion of activity.

Name / No.	Issued by	Description	Date of issue	Date of expiry / renewal
PEL 285 Approval to fracture stimulate coal seam methane exploration wells Weismantel 3, Faulkland 3 and Craven 6	DII Minerals (now DTIRIS-DRE)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to fracture stimulate three test wells	30 October 2008	On completion of activity.
PEL 285 Approval to relocate, drill and flow test coal seam methane exploration core hole Faulkland 3	DII Minerals (now DTIRIS-DRE)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to relocate, drill and flow test the Faulkland 3 corehole	2 April 2008	On completion of activity.
PEL 285 Approval to drill, fracture stimulate, dewater and flow test coal seam methane exploration core holes LMG03, LMG04, LMG05, LMG06, LMG08 and Optional Well	DII Minerals (now DTIRIS-DRE)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to drill, fracture stimulate, dewater and flow test six wells	31 July 2007	On completion of activity.
PEL 285 Approval to drill and test coalbed methane exploration wells LMG09, LMG10, LMG12, LMGC04, LMGC10, LMGC11, LMGW02, LMGW03, LMGWL01, LMGWL02 and LMGWL03	DII Minerals (now DTIRIS-DRE)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to drill and test 11 wells	27 March 2007	On completion of activity.
Bore licences				
20BL168850 and 20BL168851	DII (now NSW Office of Water)	Approval granted to construct and test two coal seam gas wells (Stratford 1 and 3)	16 October 2008	16 October 2013
20BL172554, 20BL172555 and 20BL172556	DII (now NSW Office of Water)	Approval granted to construct and test two coal seam gas wells (Stratford 2, 7 and 10)	11 August 2010	11 August 2015

Name / No.	Issued by	Description	Date of issue	Date of expiry / renewal
20BL172557, 20BL172558, 20BL172559, 20BL172560 and 20BL172561	DII (now NSW Office of Water)	Approval granted to construct and test five coal seam gas wells (Stratford 4, 5, 6, 8 and 9)	8 October 2010	8 October 2015
20BL172619 and 20BL172626	DII (now NSW Office of Water)	Approval granted to install 18 groundwater monitoring bores (S4MB01, S4MB02, S4MB03, TMB01, TTPB, TTMB01, TTMB02, TTMB03, TMB02, TMB03, TMB04, TMB05, TGMB01, TGMB02,TCMB01, TCMB02, TCMB03 and TCMB04)	1 November 2010	In perpetuity.
Works approval - 20CA204347 WAL 19521 (20AL204346)	DII (now NSW Office of Water)	Approval for an irrigation pump on an unregulated river. This approval will be converted from 20SL021595 under new water sharing plan for the site	In progress	-
20BL172631 and 20BL172632	DII (now NSW Office of Water)	Approval granted to install two groundwater monitoring bores (AMB01 and AMB02)	22 November 2010	In perpetuity.
20BL173274	DII (now NSW Office of Water)	Approval granted to install a groundwater monitoring bore at PL03	5 September 2012	In perpetuity, but must be constructed within 12 months.
20BL172682	DII (now NSW Office of Water)	Approval granted to install, test and monitor two groundwater monitoring bores (RMB01 & RMB02)	24 January 2011	In perpetuity.
20BL172667	DII (now NSW Office of Water)	Approval granted to test and monitor two groundwater bores (BMB01 and BMB02)	23 December 2010	In perpetuity.
20BL172670	DII (now NSW Office of Water)	Approval granted to test and monitor four groundwater bores (WMB01, WMB02 ,WMB03 and WMB04)	13 January 2011	In perpetuity.

Name / No.	Issued by	Description	Date of issue	Date of expiry / renewal
20BL172550, 20BL172551, 20BL172552 and 20BL172553	DII (now NSW Office of Water)	Approval granted to test four pilot wells (Craven 6, Waukivory 3, Faulkland 3 and Weismantel 3)	11 August 2010	In perpetuity.
20BL172223, 20BL172224, 20BL172225, 20BL172226, 20BL172227, 20BL172228 and 20BL172229	DII (now NSW Office of Water)	Approval granted to test seven wells (Gloucester 1, Gloucester 2, Craven 7, Wards River 1, Wards River 2, , Wards River 4 and Wards River 5	2 July 2009	In perpetuity.
20BL172258	DII (now NSW Office of Water)	Approval granted to test Wards River 3 well	9 July 2009	In perpetuity.
20BL173094	DII (now NSW Office of Water)	Approval granted to test two wells (Waukivory 11 and Waukivory 13)	1 December 2011	In perpetuity.
20BL173038	DII (now NSW Office of Water)	Approval granted to test four wells (WKMB01, WKMB02, WKMB03 and WKMB04)	15 November 2011	In perpetuity.
20BL172854	DII (now NSW Office of Water)	Approval granted to test two wells (Waukivory 12 and Waukivory 14)	9 June 2011	In perpetuity.
20BL173094	DII (now NSW Office of Water)	Approval granted to install and test a microseismic bore (WK05)	No issue date. The work is being completed under existing test licence	In perpetuity.

Table 2-3: Summary of approval, licence, permit and lease requirements

Consent / Title	Requirement
PEL 285 Approval to drill and test coalbed methane exploration wells LMG09, LMG10, LGM11, LMG12, LMGC04, LMGC10, LMGC11, LMGW02, LMGW03, LMGWL01, LMGWL02 and LMGWL03	» The works must be carried out at the location(s) and in accordance with the methods contained in REF for Exploration Boreholes for project 31004 dated March 2007. » The location and height (AHD) of each well collar must be determined to an accuracy of 1 m and the position of the hole within all potentially mineable coal seams must also be determined to an accuracy of 1 m. This information must be supplied to the satisfaction of the Department. » At the completion of well testing, and prior to abandonment of the well, any steel casing must be removed from the vertical interval(s) encompassing all potentially mineable coal seams. Alternatively, glass-reinforced epoxy casing may be used across mineable coal seams subject to separate written approval of the Department. » Downhole logging and/or imaging of a quality acceptable to the Department must be used to confirm the removal or absence of steel casing through potentially mineable coal seams. All logs and information pertinent to this condition must be provided to the Department. Abandonment of the well must not proceed until written confirmation is received from the Department confirming that this condition has been satisfied.
PEL285: Approval to fracture stimulate coal seam methane exploration wells Weismantel 3, Faulkland 3 and Craven 6	» The works must be carried out at the location(s) and in accordance with the methods contained in: o REF of Exploration Boreholes - Lucas Molopo Gloucester Waukivory 02 to 04 and Lucas Molopo Gloucester Craven 02 to 04 as AMENDED and prepared by Lucas Energy Pty Ltd (including all appendices) dated July 2008; o REF for Exploration Boreholes - Doc no. G-H-PEL285-RP-0-070319 - Re-issued for DPI-MR Assessment dated July 2008; and o REF - Addendum for Boreholes Weismantel 3, Faulkland 3 and Craven 6 prepared by Lucas Energy Pty Ltd (including all appendices) dated August 2008. » Prior to the commencement of activities on each site, the title holder must make reasonable efforts to provide notice of disturbing activities, in particular any drilling or fraccing operations, to immediate neighbours of the land on which the activities are to take place. The titleholder must accommodation reasonable requests by landholders for limited rescheduling of activities. » The site must be securely fenced with a lockable gate and adequate signs warning of potential dangers. » The location and height (AHD) of each well collar must be determined to an accuracy of 1 m and the position of the hole within all potentially mineable coal seams must also be determined to an accuracy of 1 m. This information must be supplied to the satisfaction of the department. » Reasonable access must be provided to the Departmental staff to carry out additional surveys or inspections as necessary. » Except in emergencies, or with the written consent of all affected landholders and the Department (Manager Petroleum Operations), no activities which are likely to disturb landholders or other affected parties (with the exception of dewatering, venting or flaring) are permitted at well sites or associated areas outside the following times

Consent / Title	Requirement
	o 7:00am to 6:00pm on weekdays. o 8:00am to 1:00pm on Saturdays. o No activities (other than dewatering, venting or flaring) will be permitted on Sundays or public holidays. This condition may be amended or waived at the discretion of the Manager Petroleum Operations if the well site is located more than 1km from the nearest residence.
PEL285: Approval to drill, test and fracture stimulate coal seam gas exploration wells Waukivory 3, Waukivory 4, Stratford 7, Stratford 10 and Faulkland 2	» The works must be carried out at the location(s) and in accordance with the methods contained in: o REF for Exploration Boreholes and Production Evaluation Testing (Doc. No. G-STP-L-AP-A-080818) - PEL 285 - Gloucester Basin amended and re-submitted by Lucas Energy Pty Ltd in August 2008; and o REF Addendum for Boreholes Stratford 7, Stratford 10, Waukivory 3, Waukivory 4 and Faulkland 2 prepared by Lucas Energy Pty Ltd dated December 2008. » The titleholder must maintain access roads to any sites subject to this approval in a condition satisfactory to the Department and landholder requirements. » The location and height (AHD) of each well collar must be determined to an accuracy of 1 m and the position of the hole within all potentially mineable coal seams must also be determined to an accuracy of 1 m. This information must be supplied to the Department. » Reasonable access must be provided to the Departmental staff to carry out additional surveys or inspections as necessary.
PEL285: Approval to relocate, drill and flow test coal seam methane exploration core hole Faulkland 3	» The works must be carried out at the location(s) and in accordance with the methods contained in: o Letter from Paul Bilston (General Manager - Lucas Energy) entitled RE: Proposed Well Location Change - Faulkland 3; and o REF for Exploration Boreholes (Document No. G-H-PEL285-RP-0-070319) by Lucas Coal Seam Gas Pty Ltd dated March 2007. » The location and height (AHD) of each well collar must be determined to an accuracy of 1 m and the position of the hole within all potentially mineable coal seams must also be determined to an accuracy of 1 m. This information must be supplied to the satisfaction of the Department. » At the completion of well testing, and prior to abandonment of the well, any steel casing must be removed from the vertical interval (s) encompassing all potentially mineable coal seams. Alternatively, glass-reinforced expoxy casing may be used across may be used across mineable coal seams subject to separate written approval of the Department. » Downhole logging and/or imaging of a quality acceptable to the Department must be used to confirm the removal or absence of steel casing through potentially mineable coal seams. All logs and information pertinent to this condition must be provided to the Department. Abandonment of the well must not proceed until written confirmation is received from the Department confirming that this condition has been satisfied.
PEL285: Approval to	» The works must be carried out at the location(s) and in accordance with

Consent / Title	Requirement
drill, fracture stimulate, dewater and flow test coal seam methane exploration core holes LMG03, LMG04, LMG05, LMG06, LMG08 and Optional Well	the methods contained in REF for Stratford Pilot Project (Document No. G-H-PEL285-REF-A-0705) submitted by Lucas Coal Seam Gas Pty Ltd on 12 June 2007 » The location and height (AHD) of each well collar must be determined to an accuracy of 1 m and the position of the hole within all potentially mineable coal seams must also be determined to an accuracy of 1 m. This information must be supplied to the satisfaction of the Department » At the completion of well testing, and prior to abandonment of the well, any steel casing must be removed from the vertical interval(s) encompassing all potentially mineable coal seams. Alternatively, glass-reinforced epoxy casing may be used across may be used across mineable coal seams subject to separate written approval of the Department. » Downhole logging and/or imaging of a quality acceptable to the Department must be used to confirm the removal or absence of steel casing through potentially mineable coal seams. All logs and information pertinent to this condition must be provided to the Department. Abandonment of the well must not proceed until written confirmation is received from the Department confirming that this condition has been satisfied.

3. PEL 285 overview

Coal seam gas exploration activities are undertaken in the Gloucester area which comprises PEL 285 issued under the PO Act (refer to Appendix C for figures).

AGL is the 100% owner and operator of this licence following its acquisition from the joint venture of Lucas Energy and Molopo Australia in December 2008. PEL 285 covers all of the Gloucester Geological Basin, spanning over 1,300 square kilometres (km^2) and centred around the town of Stratford, approximately 70 km north of Newcastle in New South Wales (NSW).

AGL is only part way through its gas exploration under PEL 285. 2D seismic data surveying approximately 77.5 km over 13 seismic lines have been completed. Four exploration test wells in the Waukivory pilot program have been drilled but not tested and aeromagnetic surveys are currently being undertaken. Exploration is expected to continue for the term of PEL 285. AGL is exploring the Gloucester region to appraise and evaluate the quantity and quality of the natural gas resource in accordance with its obligations as stated within the conditions of this PEL.

3.1. Gas exploration process

3.1.1. Overview

The gas exploration process is designed to identify, evaluate and potentially prove that natural gas resources exist and can be commercialised for delivery to gas markets. The process can be defined by four main stages:

1) identifying prospects and leads through geological and geophysical desktop studies;

2) identifying hydrocarbon accumulations through the drilling of core and stratigraphic holes;

3) evaluating the potential size of the discovery through geophysical surveys such as seismic, magnetics, gravity and further core and stratigraphic drilling where necessary; and

4) evaluating the deliverability and commerciality of the discovery by gas flow testing to enable reserves certification and ultimately commercial project development investment decisions.

Core holes are drilled to identify and test gas saturation, composition and content, then seismic lines are shot (usually two-dimensional) to gather more regional information about the size, structure and geology of an area. The last stage is drilling and gas flow testing of wells to determine the deliverability of the gas.

Once the preferred geological target areas have been identified, the site selection process then considers the environmental and social constraints of the area. These include land use (existing and future), topography, subsurface geology, flora and fauna, archaeology and noise. This detailed design information becomes part of the environmental assessment and approvals process for the proposed activities.

There are a variety of exploration activities to generate the required exploration data outlined in Section 3.1. The activities likely to be undertaken in the exploration phase include:

- Groundwater monitoring;
- Seismic survey;

- Core hole drilling;
- Stratigraphic exploration drilling; and
- Gas exploration testing.

Groundwater monitoring

Groundwater studies have occurred since 2007 and are well advanced. Since January 2012, phases 1 (desktop study) and 2 (detailed groundwater investigations) have been completed, while phases 3 (numerical model) and 5 (project updates) have commenced. Phase 4 (monitoring program) is still ongoing. Phase 1 and 2 groundwater appraisal reports are available on AGLs website. Groundwater studies thus far show no evidence of a natural connection between shallow and deep groundwater systems.

Groundwater monitoring is undertaken by installing monitoring bores in advance of proposed flow testing programs, however is not warranted when undertaking corehole programs. The primary aim of installing the bores is to gather further aquifer and coal seam characteristics to confirm the different groundwater systems and the conceptual groundwater flow model. These networks will then assist in the establishment of a baseline dataset and the degree of connectivity (if any) between shallow aquifers and deep coal seam water bearing formations.

Water levels are monitored continuously to identify regional and seasonal trends. Water quality is also monitored biannually with the comprehensive suite including parameters such as salinity, pH, cation/anion ratio, heavy metals, nutrients, dissolved gases, polycyclic aromatic hydrocarbons (PAHs), phenols, total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene and xylene (BTEX), as well as environmental and radioisotopes.

Seismic survey

There are a variety of seismic acquisition methods which may be potentially used as part of the exploration process including Mini-Sosie, Envirovibe and Vibroseis surveys. Each method typically involves a vehicle driving over a pre-determined surveyed path, mapping underground geological features through the use of sound waves.

Seismic exploration is a geophysical method that creates images of the sub-surface using artificially generated sound waves. The source of the soundwaves is from a vibrating plate which is lowered to the ground. The sound waves travel down into the earth and get reflected back to the surface at geological boundaries. The reflected soundwaves are detected by surface receivers, or geophones.

The seismic process is usually non-intrusive and nothing remains on the property once the work has been completed. The work is generally undertaken in cleared areas and road verges to ensure there is as little disruption as possible to the primary land use.

Mini-Sosie is a seismic method which uses a converted construction compactor operated by hand. The Envirovibe seismic unit is mounted on an articulated buggy, providing excellent manoeuvrability while the Vibroseis units are truck mounted.

Choice of the correct seismic source for a particular application involves consideration of a range of factors including the required target resolution, economics, environmental issues, health and safety issues and access constraints.

Core hole drilling

Core hole drilling is designed to remove subsurface rock core samples for testing and analysis. It requires the construction of a fenced drilling compound with a level drill pad and drill pit(s) and further details are provided in Section 3.3. The timeframe for corehole drilling depends on the length of the cored interval, the testing to be performed, hours of operation and the total drilling depth.

Following initial site construction and establishment (detailed below), core drilling operations would be sequenced as follows:

- collection of rock chips at the surface until coring begins;
- collection of drill cores at 6 metre intervals;
- logging of “non coal” cores by a geologist and storage in core boxes;
- taking photographs of coal cores and immediate placement into sealed canisters for subsequent gas testing;
- continuation of the above drilling and testing until the total depth is reached;
- geophysical logging and other ’downhole‘ testing; and
- installation of a pressure monitor into the hole for on-going (long term) data collection.

Testing of coal core samples requires simulation of the reservoir pressure and temperature conditions for accuracy. The gas core testing work is carried out by geologists in a demountable site office, and may be required 24 hours a day.

The core holes are generally cemented, plugged and abandoned in accordance with DTIRIS-DRE requirements. Rehabilitation occurs immediately after drilling and testing has been completed, unless the holes are needed for further exploration testing. A piezometer may be installed into the hole for on-going data collection and the hole may be cased, capped and suspended in line with industry best practice for future testing work.

Stratigraphic exploration drilling

This exploration method involves the drilling of exploration holes to retrieve and test drill cuttings and complete subsequent downhole logging and analysis. The holes are typically designed to provide geological, permeability and gas composition data. It requires the construction of a fenced drilling compound with a level drill pad and tanks or drill pit(s) as outlined in Section 3.3. The timeframe to complete stratigraphic drilling depends on the testing to be performed, hours of operation, the total drilling depth and weather conditions.

Stratigraphic exploration holes are rehabilitated in the same manner as core holes. Rehabilitation would occur immediately following the completion of works. However, the hole may be cased, capped and suspended in line with industry best practice for future gas monitoring or testing work.

Gas exploration testing

Gas exploration test or pilot wells are used to establish and test whether the identified gas resource in a particular area will flow from the target coal seams, and the rate at which it flows. It is the last stage in the gas exploration process, designed to establish the recovery and deliverability of the gas to the surface.

The exploration test wells or pilot wells are generally drilled vertically, but can also be drilled deviated or horizontally, to evaluate specific coal intervals in clusters of two to five wells, depending on the number of coal seams being targeted. Gas flow from test wells would generally be tested to an enclosed flare or gathered to a central enclosed flare, depending on the approval.

Following drilling, the casing is perforated to establish a connection with the target coal seam. It is then stimulated, generally either by hydraulic fracture stimulation or under-reaming. The completion is installed by inserting the tubing and wellhead.

3.2. Site construction

3.2.1. Site construction activities

The site construction phase involves the following activities:

- Pre-construction induction of construction crews ;
- site preparation;
- construction of access roads;
- drilling and associated activities.

Pre-construction induction of construction crews

Environmental constraint overview

The primary environmental constraints in relation to exploration activities include, but are not limited to:

- ecological;
- Aboriginal heritage; and
- European heritage.

Where required, environmental constraints and pre-clearance activities (if any) will be communicated to construction crews during the induction process prior to work commencing. Specific commitments, requirements or activities to be undertaken prior to works commencing will be undertaken in accordance with the relevant approvals.

Further information is contained within the Flora and Fauna Management Sub Plan (FFMSP) and the ACHMSP.

Site preparation

The preparation of the compound and construction works generally involves the following activities:

- installation of silt fences and other environmental controls as required;
- upgrading or installation of private access roads;
- fencing the site compounds to restrict access to people and stock;
- removal of topsoil over access ways and storage for rehabilitation;
- installation of drain culverts, cattle grids, fencing, gates, bed level crossing and other road works as necessary;

- earthworks as required on a site-specific basis;
- construction of drilling compound and fencing of the perimeter;
- stripping and stockpiling of topsoil and, then cut and fill to achieve a level drill pad area and lined drill pit if required. This construction generally includes an up-slope diversion drain around the site to manage excessive surface flow. (The profile is returned as near as possible to the original profile during initial rehabilitation);
- trucking in a hard surface (typically shale or aggregate) for drill pad; and
- rehabilitation of disturbed areas outside of the drill pad.

Construction of access roads

Access to well surface locations is typically along existing public roads and private access roads within the relevant property boundary. Earthworks may be required to construct or upgrade private access roads to new well surface locations to enable the drilling rig and support equipment access to the sites. Where practicable, existing private road access is used to minimise construction activity and environmental disturbance.

All private access roads used during operations are returned to their pre-operations state, or to a condition agreed by the landholder.

Drilling and associated activities

A variety of current technologies are available for the drilling of wells. Typical technologies currently used are detailed below. New technologies would be reviewed and implemented as developed and commercially available.

1) Under-balanced vertical drilling: This method of drilling is typically used where pressure of the overlying strata exceeds the pressure of the drilling fluid. Drilling penetration rates are maximised through the shallow, abrasive, medium hardness sands. Equipment required involves a drilling rig equipped with air compressors and booster packages that provide the energy for the percussion air hammer to drive the drill bit and for fluid circulation. The drilling action employed uses a percussion air hammer, button bit and drill collars to provide the impact to break up formations. Under-balanced drilling also requires a drill pit or pits to capture the drill cuttings and produced water from the drilled formations.

2) Overbalanced vertical drilling: This method of drilling is typically used where the pressure of drilling fluid exceeds the pressure of the overlying strata. Future use allows the drilling of wells where land access constraints or environmental features limit the use of drill pits. Apart from the drill rig, equipment focus is on drill fluid circulation and solid control systems. The drilling relies on applied weight on bit and rotation to penetrate and remove the formations. Weight is provided by running drill collars (heavy joints of pipe) behind the bit with rotation and torque provided by the rig's top drive or a downhole motor.

3) Core drilling: Core hole drilling is designed to collect a cylindrical sample of rock or 'core' and it requires a specialised core diamond drill bit. A core drill bit is unusual in that it has a hole in its centre which allows the bit to drill around a central cylinder of rock, which is taken in through the bit and into the core barrel. The core barrel itself may be thought of as a special storage chamber for holding the rock core. The core catcher serves to grip the bottom of the core and, as tension is applied to the drill string, the rock under the core breaks away from

the undrilled formation below it. The core catcher also retains the core so that it does not fall out the bottom of the drill string, which is open in the middle at that point.

4) Directional drilling: Direction drilling requires similar surface equipment to overbalanced drilling, but has the advantage that bottom hole locations can be typically located up to some 400 m away from the surface location (depending on the vertical depth of the coal seam). Therefore, wells can be drilled into areas that are constrained for vertical well construction. In addition, multiple wells can be drilled from a single location and gas reserves that are potentially sterilised by surface developments can be accessed from outside of the developed areas. The drilling of these wells requires similar surface equipment to the overbalanced drilling technique. Directional equipment and a steerable mud motor are added to the downhole equipment to allow control of the drilling angle and direction.

5) Horizontal drilling / surface to in-seam (SIS) drilling: Horizontal drilling is used to increase the drainage area of a reservoir and provide a means of stimulating the reservoir through the drilling process. The well is drilled vertically from the surface and gradually builds angle so as to intersect the seam near parallel with the seam dip angle. Once intersected, this portion of the well bore is cased, cemented and a smaller hole is subsequently drilled through the seam anywhere from about 1,300 m to 2,500 m. It allows a significant reduction in the number of well surface locations along with the ability to access previously sterilised gas reserves. This technique requires continuous drilling, and the drilling operation must therefore be conducted 24 hours a day, 7 days a week. This is a technique not typically used in exploration.

6) Perforation: The perforation technique involves correlation of cased hole logs with open hole logs and the detonation of shaped explosive charges that penetrate the steel casing, cement and formation establishing the interconnection. Perforation is required to allow communication between the production casing and the target zones. In cased hole completions, the pilot well is drilled down past the formations desired for production and has a casing or a liner run in, isolating the formation from the wellbore. Perforating usually involves lowering in perforating guns, which is a string of shaped charges, down to the desired depth and firing them to perforate the casing at the target depth.

7) Testing: Once downhole wireline geophysical logging has been completed a program of coal seam permeability and other testing may be conducted on selected exploration holes. The testing generally involves the lowering of special purpose packers on slim rods into the boreholes. The packer would isolate specific target coal seams for small scale downhole water production and injection tests to determine permeability characteristics. Only experienced contractors/operators would be considered for this testing. The drilling rig would remain in standby during this time.

Drill cuttings management

Drill cuttings are collected and stored in the lined drill pit or holding tanks. The drill cuttings normally contain sandstone and coal so there is very little sulphidic mineralisation to cause acid rock drainage.

Once the drilling operations are completed, the following options are available to manage the drill cuttings:

1) Burying of drill cuttings approximately two metres below ground level, covering cuttings with excavated soils and subsequent rehabilitation. Drill cuttings are buried below the root zone of crops or revegetation areas to minimise potential impacts.

2) Storage of drill cuttings in tanks at the wellhead (usually used when drilling overbalanced). These tanks are used for recycling management and surge capacity. Drill cuttings are buried and disposed of as per option one above.

3) Reuse on roads if material is suitable or in accordance with the activity approval.

Drilling water management

Drilling water is typically delivered and recycled from previous drilling campaigns, from licenced stand-pipes or from other approved sources in the local area. For over-balanced test wells, water and drilling mud is used in the construction of the exploration hole. The volume of water required for the drilling process varies depending on the type of drilling. Drilling mud and water is pumped from the hole following construction and stored in tanks or drill pits for re-use, disposal to a licenced facility or other approved disposal.

The tank or drill pit fluid levels are managed to allow free space for rainfall events. Drill pits are constructed with an upslope diversion drain around the site to divert rainwater surface runoff around the pit. This ensures that only direct rainfall enters the pit. All pits are lined with polyethylene and designed with adequate capacity to accommodate the water associated with construction and natural rainfall events.

3.3. Casing and cementing

3.3.1. Overview

The drilling of well typically occurs in two sections, surface hole and production hole. The surface hole which is a larger diameter hole is cased off with steel casing and pressure cemented back to surface. After drilling the well to the desired total depth, the drill pipe is removed and production casing is run until it reaches the bottom of the well. The production casing is cemented by first pumping a spacer to remove clean and displace the mud from the well and this is followed by a cement slurry. The cement slurry is displaced under pressure filling the annular gap between the centralised casing and the open hole. Again the cement is brought back to surface. The cement slurry formulations for both the surface hole and production hole are laboratory tested to ensure the desired properties such as thickening time, rheology, compressive strength and fluid loss are obtained for the well conditions.

The major objective of cementing is to isolate hydrocarbon bearing fluids, gas, and water formations. For example, this is undertaken to exclude fluids such as water in one aquifer (or layer) from gas in another. To achieve this objective, a hydraulic seal must be obtained between the casing and the cement, and between the cement and the ground layer formations for the life of the exploration hole. This requirement makes primary cementing a very important operation performed during the construction of each test well.

Cement is pumped into the casing (as one specific cementing event) to fill the annular column from the bottom up which is displaced under pressure using specialised equipment. Cement is typically brought much higher in the wellbore (even to the surface) to exclude other undesirable fluids from the wellbore, to protect freshwater zones, and to protect the casing from corrosion. The well is left shut in for a time to allow the cement to harden before beginning completion work or drilling out to a deeper horizon.

All casings are cemented in place to ensure the coal seam zones are isolated from the other strata and casing integrity exceeds the life of the well.

3.3.2. Pilot well casing installation

A typical vertical gas pilot well design would include the following steps:

1) Drilling and installation of **conductor casing** from the surface to the base of the alluvial sediments where bedrock is encountered. The depth of this casing may range from less than 1 m to approximately 50 m in depth depending on the depth of the bedrock. The annulus of the casing would then be filled with cement and left to set.

2) Drilling and installation of a **surface casing** within approximately the first 10% of the proposed total vertical depth of the test well or across deeper beneficial aquifers. The annulus of this casing would then be filled with a cement and left to set. The purpose of this casing is to isolate shallow formations, protect beneficial aquifers and provide structural support for the remaining surface and subsurface equipment to be installed in a test well.

3) Installation of a **production casing** (post borehole geophysical logging) within the surface casings to the total depth of the pilot well which is pressure cemented to seal the well. The steel casing and cement would isolate aquifers and other formations that may be encountered during the drilling process. This would ensure that there would be no interaction between aquifers or strata and the targeted coal seams by providing a positive hydraulic seal, and would ensure no cross-contamination between aquifers before perforation.

3.3.3. Cement bond logs

The production casing is pressure cemented in place against the different geological strata and the integrity checked using cement bond geophysical logs. Cement bond geophysical logs are used to confirm that all casings are properly set against the adjacent formations. This evaluation tool provides confirmation of the quality of the cement job and that the cement job is to provide zonal isolation.

Upon completion of the test well, the target coal seam for gas testing is identified and the production casing is perforated to provide connection with the target coal seam zone or zones.

3.4. Exploration (flow) testing

3.4.1. Overview

There are a number of technologies currently available for well stimulation to encourage gas to flow such as under-reaming and horizontal drilling, but principally hydraulic fracture stimulation is expected to be used during exploration.

3.4.2. Exploration testing activities

Under-reaming

For the under-reaming technique, wells are drilled in the same way as an overbalanced vertical well, with casing installed across the coal seams of interest. The under-reaming tool is run in the hole on conventional drill pipe and hinged cutting arms are opened through rotation. Current tools are able to under-ream a 178 millimetre (mm) cased hole out to approximately 450 mm. This stimulation technique is best suited to high permeability coals where the reservoir connectivity to the wellbore is high prior to under-reaming and is aimed at maximising the well's contact area with the gas reservoir.

Horizontal drilling

Horizontal wells are drilled to maximise the surface area available in the targeted coal seams to maximise gas flow, recover gas from reservoirs unable to be accessed by vertical wells and also reduce surface footprint. After surface casing is installed and cemented, the drill bit is steered to the top of the target coal seam in a near horizontal orientation. The well is then cased and cemented with the production casing string. The production hole is drilled through the coal seam and maintains its trajectory in coal using logging while drilling and geosteering tools. A poly-liner or fibreglass liner may be run to increase the stability and longevity of the production hole or the horizontal may be left in an open hole state.

Hydraulic fracture stimulation

Perforations are required to gain access between the production casing and the selected formation. When access to the formation has been established, the formation needs to be stimulated to enhance formation water and gas flow. Hydraulic fracture stimulation involves the injection of a slurry of sand and water at high pressure. This process stimulates the reservoir by providing a highly conductive flow path for gas and water that extends away from the wellbore and into the seam.

The sand is locked in place by the pressure of the coal formation and the injected water and formation water is allowed to flow back out to the well for pumping to the surface. This technique widens cleats and fractures in the coal seams to provide a conductive path for gas to flow freely to the well. As the water is removed, the resulting drop in reservoir pressure enables the gas to begin to desorb from the coal and flow to the wellbore. The wellbore then requires cleaning and maintenance. The tubing, rods and pump required for gas flow testing are then placed within this casing once each gas test well is completed and the surface wellhead equipment is installed.

3.4.3. Hydraulic fracture stimulation water management

The volume of water required for hydraulic fracture stimulation of a test well depends on the design of the hydraulic fracture stimulation, the number of coal seams to be stimulated and geological parameters.

Following hydraulic fracture stimulation (where required), water is removed from the coal seam and transported to a licensed disposal facility.

Dewatering pumps and associated equipment may be used to remove the injected hydraulic fracture stimulation water and the formation water, which reduces reservoir pressure and allows gas desorption to occur. Pilot wells not requiring a dewatering pump are referred to as free flowing. This means that the reservoir pressure within the coal seam combined with a velocity string installed in the well, produce the frac and formation water without the assistance of a downhole pump.

3.5. Gas flow testing

3.5.1. Overview

Flow testing of the potential gas resource is undertaken as the last part of the exploration process to establish the flow characteristics and quantities for the identified gas resource. The gas flow testing of pilot wells is ongoing until the well has reached steady state flow, at which time the well is suspended.

Activities at each test well site during flow testing typically include:

- routine daily/weekly operator inspections of gas flow rates and equipment;
- formation water disposal; and
- workover maintenance.
- During the gas flow testing phase, gas is generally diverted to an enclosed horizontal flare to be burnt safely.
- Operator involvement at the exploration hole surface location is minimised by the installation of various automated and remotely operated functions.
- Telemetry is connected to all exploration holes undergoing gas flow testing so the production test data can be accessed and reviewed. In this case, the exploration holes have numerous alarms and automatic shutdown functions which are based on a 'cause and design'. Any exploration hole under gas flow testing can be shut-in or opened remotely from the gas plant control room once the communication equipment has been installed at the site.

3.5.2. Test wellhead design

There are two types of test wellhead design used throughout the construction of wells during exploration, traditional or enclosed, and these may include pumps if required.

Traditional well surface facilities comprise of a secure chain mesh fenced compound with metering, telemetry, separator, compressor and tank (if required) and is generally used in open paddocks. Enclosed well surface facilities involves a secure fenced compound with part or all of the above listed surface facility covered within a secure enclosure similar to a prefabricated pad mounted electricity substation. The use of enclosed well heads is dependent on the need for acoustic attenuation, the surrounding land uses and other operational issues.

The equipment for gas flow testing of pilot wells consists of the wellhead, variable choke, water/gas separator and the flow measuring instrumentation. The wellhead configuration is fully enclosed and pressure sealed.

3.5.3. Gas flow testing activities

Pump testing

The hydraulic or electric surface dewatering pump is mounted on the wellhead to drive the downhole pump. A hydraulic skid is connected to the hydraulic pump which provides the hydraulic power to the pump. A silenced electrical generator or mains supply is connected to the hydraulic skid to provide power (electrical over hydraulic) to operate the hydraulic skid. Electricity from the mains supply is supplied through above or below ground connections.

At the surface the pumped water is directed to a gas/water separator where any remaining entrained gas is removed from the pumped water.

The gas separating chamber has inlets for both the water and the gas streams coming from the gas well. Similarly it has outlets for both the water and the gas streams, with the produced formation water going (in some cases via water lines) to the tanks and the gas to the enclosed flare (at times through gas gathering lines to a central flare).

Ideally a 1:1 gas/water ratio is maintained in the chamber that allows most the remaining gas dissolved in the pumped water to be released. The water is forced out from the base of the chamber by the gas pressure and directed through water lines to storage tanks on site.

The gas is forced through the top of the separating chamber through an electrical instrument flow meter (FloBoss) and directed to the enclosed flare. A telemetry system is connected to the FloBoss to send data to its server so that the well performance can be monitored remotely. The gas line from the separator is fitted with an adjustable choke that allowed the flow of gas to be regulated or stopped. An automatic shut-down valve (SDV) is installed to respond to abnormal well behaviours or emergency situation. The SDV can be controlled remotely via the telemetry system thus providing protection to the surface equipment in case of high pressure gas spike events.

Gas flare

A steel gas line is installed to the inlet of the horizontal enclosed flare to ensure that gas can be safely flared with minimal visual impact. Enclosing the flare is an important measure, particularly if sufficient quantities of gas are produced during flow testing.

The flare consists of a walled 20 foot (ft) container, manufactured and treated with fire retardant material, placed a safe distance from the gas pilot well. The gas generated during the flow test can then be ignited safely or vented to the atmosphere if there is not enough gas flow to ignite the flare. The gas flare unit incorporates flow detection equipment, which detects the flow of gas and an auto ignite system to automatically flare the detected gas flows. As a safety precaution the unit is fitted with safety shut off valves that operate to cease gas flow when gas flow is detected in the absence of the flare. This prevents gas from being emitted to the atmosphere. The gas flare unit will be design and constructed to meet the Australian standards for gas appliances.

Gas gathering lines

Gas gathering lines may be used during flow testing of the exploration test wells. The gas gathering lines are designed, constructed and operated in accordance with the requirements of Australian Standard AS 4645.3 – 2008 Gas Distribution Networks Part 3: Plastics Pipe Systems. Gas gathering lines are typically buried to a minimum depth of 750 mm and up to 1,200 mm in some areas, including unsealed and sealed road crossings and creek and drainage line crossings. The gas gathering lines are buried with marker tape and tracer cable. The routes of the gas gathering system are generally selected to utilise disturbed areas. The route of the gas gathering system is registered with Dial Before You Dig and is clearly signposted.

3.5.4. Maintenance of well sites

During flow testing or long term data collection from exploration holes, an occasional ‘work over’ or other maintenance may be required. The work over typically involves a rig to run or remove a pipe for clearing the hole of fill, obstructions, pumps or other issues. Work over and maintenance activities are undertaken on a case by case basis as needed at individual holes, typically when an issue has been identified.

3.6. Closure and rehabilitation

3.6.1. Overview

Rehabilitation is generally undertaken in two stages; initial rehabilitation of surplus construction area following the completion of drilling and at closure and plug and abandonment of the exploration hole. On completion of activities, all disturbed areas will be rehabilitated, as agreed with the landholder.

Prior to suspending or abandoning exploration holes AGL would seek approval through DTIRIS-DRE by providing information in accordance with section 521 of the Schedule of Onshore Petroleum Exploration and Production Safety Requirements.

3.6.2. Initial rehabilitation

Initial rehabilitation work involves:

- emptying water and backfill from the pit;
- reshaping the land if required (cut and fill works);
- spreading topsoil;
- revegetation by spreading seed, or planting native trees or allowing natural regeneration; and
- removal of the compound fence and sediment controls.

Variations to this rehabilitation process may be required subject to site constraints, new technical information or to fit with future land uses. Screening is generally provided where appropriate using vegetation sourced from the local area including drought tolerant species endemic to the local area.

The holes are generally cemented, plugged and abandoned in accordance with DTIRIS-DRE Guidelines for Borehole Sealing Requirements on Land" (EDG No.01) and rehabilitated after drilling and testing has been completed, unless needed for further exploration testing. In this case the holes will typically be secured, capped and suspended in line with industry best practice, to await any further testing.

3.6.3. Final rehabilitation

Final rehabilitation work involves:

- sealing/ plugging and abandonment of wells in accordance with DTIRIS-DRE "Guidelines for Borehole Sealing Requirements on Land" (EDG No.01) and the PEL conditions;
- removing plant and equipment from wellheads and removal of fenced compounds;
- filling in excavation; and
- rehabilitation, contouring and revegetation.

4. Risk management and objectives and targets

4.1. Environmental risk management

Environmental risks are typically identified and mitigated at the following stages:

- prior to approval: an environmental impact assessment is completed;
- prior to commencement of works: an Environmental Aspects and Impacts Register is prepared and works are undertaken in compliance with regulatory approvals during the site planning process;
- during works: inspections and monitoring are carried out; and
- during works: Job Safety and Environmental Analysis (JSEA), site inductions and toolbox meetings.

An environmental impact assessment of proposed exploration works is conducted for new activities prior to their approval in accordance with section 111 of the EP&A Act. An environmental impact assessment typically assesses each identified potential environmental effect or issue, indicating the level of likely impacts and recommends mitigation measures to reduce the extent of impacts.

The recommended mitigation measures from each environmental assessment or REF for exploration activities are required to be implemented as part of the environmental management under the approval.

The site planning process brings together all relevant AGL team members and contractors to plan and implement the work once it is approved to ensure it is carried out in line with AGL, regulatory and approval requirements.

At the job or site level, risks are identified and managed using JSEAs. JSEA's are used to identify potential accidents, hazards and potentially environmentally harmful conditions and the means for their control.

Site inductions incorporate the relevant management measures from the regulatory and safety approval, REF, site planning, JSEA's and the landowner. This is done to ensure that each person entering the exploration site follows these measures.

The internal monitoring process minimises and manages the environmental risks of exploration activities by ensuring that recommended mitigation and management measures have been implemented. Further details on this process are available in Section 4.4.

4.2. Key environmental management activities

Environmental management of exploration activities is governed by:

- approval conditions;
- environmental impact and risk assessment (Section 4.1);

- PEL requirements; and
- AGL objectives, targets and key performance indicators that are applied to every AGL Upstream Gas Project.

The Environmental Sub Plans presented in Appendix A provide the required actions necessary to manage and reduce specific environmental impacts.

AGL endeavours to minimise the environmental impact of its activities. The following general operating principles are implemented:

- placement of exploration holes, associated infrastructure and access roads within cleared areas, where practicable;
- preference to use existing tracks and road verges;
- management of operations through ongoing consultation with the landowner; and
- minimisation of the activity footprint of where possible.

4.3. Environmental Management Sub Plans

Specific Environmental Management Sub Plans have been developed to manage the issues summarised in Table 4-1. These Environmental Management Sub Plans are designed to satisfy approval conditions for exploration activities. The plans provide implementation and reporting mechanisms required to satisfy approval conditions and enable focussed management of identified issues (refer to Section 6 of this EMP).

Each Environmental Management Sub Plan includes the following information:

- objectives and targets (Table 4-1) for each specific aspect;
- identification of key personnel responsible for major tasks;
- a summary of relevant statutory obligations including conditions and other requirements;
- a description of the mitigation measures to be implemented, including site specific details;
- an outline of monitoring requirements; and
- reference to specific records that will be maintained.

The Environmental Management Sub Plans are designed to be applied across the exploration activities. They include general management measures for each issue, and the relevant site specific information and data for use in different well fields so that the requirements of all relevant consents are satisfied.

The issues listed in Table 4-1 are those generally associated with the activity. Issues specific to certain sites or activities will be captured and covered in the site design planning and assessment process and the site specific induction.

Table 4-1: Summary of Activities and Relevant Environmental Management Sub Plans

Relevant Sub Plans → / Activity↓	Air quality	Dangerous goods and hazardous substances	Noise	Soil and water	Groundwater	Produced Water	Flora and fauna	Community (see Section 5.3)	Landscape and rehabilitation	Traffic and access	Aboriginal and European heritage	Waste	Emergency (including Fire and Flood)
Drilling and construction works													
Installation / upgrade of access roads	X			X			X	X	X	X	X		X
Construction of drill compound	X			X			X	X	X		X	X	X
Drilling / testing activities	X	X	X	X	X			X				X	X
Hydraulic fracture stimulation	X	X	X	X	X			X		X		X	X
Gas flow testing and maintenance													
Water Storage						X							
Water disposal/reuse				X		X						X	X
Work over			X		X			X				X	X
Pump operation	X		X		X			X				X	X
Plug and abandonment, closure and rehabilitation													
Empty pit/ tank water				X								X	X
Filling in excavation	X			X					X				X
Rehabilitation, contouring and revegetation	X			X					X				X

Relevant Sub Plans → / Activity↓	Air quality	Dangerous goods and hazardous substances	Noise	Soil and water	Groundwater	Produced Water	Flora and fauna	Community (see Section 5.3)	Landscape and rehabilitation	Traffic and access	Aboriginal and European heritage	Waste	Emergency (including Fire and Flood)
Seal/ plug and abandonment of holes			X		X			X				X	X

4.4. Activity or site-specific management measures

Environmental assessments supporting applications for exploration activities may identify activity or site-specific management measures for implementation to minimise predicted impacts. These commitments will be implemented in accordance with the relevant supporting documentation and/or conditions of the activity approval and be the responsibility of the Environment Manager, unless otherwise stated.

Activity or site-specific management measures will be communicated to on-site personnel (including contractors, as required) prior to commencement of works by the Environment Manager (or nominated delegate) and form part of the site induction process.

4.5. Objectives, targets and key performance indicators

The environmental objectives and targets developed for exploration activities are summarised in Table 4-2. Environmental key performance indicators (KPIs) have been set by AGL to provide information to assess environmental performance. Aspects, objectives, targets and KPIs are detailed in Table 4-2.

4.5.1. Monitoring of environmental key performance indicators

The targets and KPIs listed in Table 4-2 will be monitored and reported against in the Rehabilitation and Relinquishment Report which will be produced for each exploration hole (refer Table 5-3) and submitted to DTIRIS-DRE.

Table 4-2: Objectives, targets and key performance indicators

Aspect	Objective	Targets and KPIs
Land use	**1 To avoid significant disturbance to land use or damage to infrastructure.** 1.1 To adequately protect rural productivity. 1.2 To prevent significant adverse affects on stock. 1.3 To avoid unauthorised disturbances or damage to landowner assets and infrastructure. 1.4 To notify the landowner at least five days prior to construction commencing. 1.5 To ensure that all construction activity is constrained to the exploration site and access roads. 1.6 To ensure that no landholder issues are outstanding or remain unresolved as a result of activities.	Target = zero complaints received from landowners. Target = zero missed adjoining landowner notifications prior to construction.
Soils and terrain	**2 To minimise soil disturbance where possible, prevent contamination and promote soil stability.** 2.1 To prevent soil contamination. 2.2 To appropriately control soil erosion and compaction. 2.3 To appropriately manage activities in waterlogged and inundated soils. 2.4 To prevent mixing of topsoil and subsoil. 2.5 To ensure that soil exposure times between clearing and restoration are kept to a minimum. 2.6 To continue to monitor and manage soil erosion consistent with the surrounding land and until the site has stabilised in consultation with the landowner.	Target = zero incidents relating to soil disturbance or contamination. Target = no long-term erosion.
Construction noise	**3 To comply with the construction standards for noise control.** 3.1 To minimise noise during the construction phase. 3.2 To implement best practice noise management measures for Construction works	Target = zero exceedances of noise goals. Target = zero complaints received from nearby receivers.

Aspect	Objective	Targets and KPIs
Air emissions	**4 To adequately protect air quality.** 4.1 To control the quality and quantity of vehicle exhaust emissions. 4.2 To minimise dust generation during activities. 4.3 To control the emission of greenhouse gases.	Target = zero incidents or complaints received regarding uncontrolled air emissions.
Surface water and groundwater resources	**5 To minimise the potential impacts of activities on water resources.** 5.1 To maintain water quality and flow 5.2 To ensure that windrows and soil stockpiles have been broken at appropriate places to allow natural surface water flow.	Target = zero incidents relating to water contamination or aquifer connectivity from activities.
Noxious weeds, pathogens and pest species	**6 To prevent the introduction and dispersal of noxious weeds, pathogens and pest species.** 6.1 To appropriately control the introduction and spread of weeds, pathogens and pest species. 6.2 To ensure that all interstate vehicles are appropriately checked and cleaned prior to site access.	Target = zero complaints from landowners relating to noxious weeds.
Flora	**7 To minimise the loss of remnant native vegetation.** 7.1 To avoid areas of remnant vegetation where practicable. 7.2 To minimise disturbance to native vegetation (including grasses and herbs). 7.3 To promptly carry out rehabilitation activities to promote vegetation re-growth in all disturbed work areas to a standard consistent with the surrounding area. 7.4 To establish a photographic record of the site prior to any clearing activities.	Target = zero complaints from landowners relating to native vegetation disturbance.
Fauna	**8 To minimise adverse impacts on fauna.** 8.1 To clear vegetation that has been assessed and approved for removal. 8.2 To adequately protect fauna from physical harm. 8.3 To ensure that the drill sumps and pits are checked daily for trapped fauna. 8.4 To ensure fauna escape methods are provided where necessary.	Target = no injured fauna.

Aspect	Objective	Targets and KPIs
Waste	**9 To minimise waste creation and disposal, and maximise reuse or recycling.** 9.1 To minimise waste creation by identifying and eliminating, or minimising the waste generation at its source. 9.2 To maximise all opportunities for reuse or recycling in an environmentally appropriate manner, where possible. 9.3 To avoid land or water contamination, minimise health risks and avoid disturbance to visual amenity by prompt clean up and removal of waste from site. 9.4 To ensure that any environmental impacts relating to waste management are reported and acted upon immediately.	Target = waste disposal and recycling records are accurately maintained for the AGL Environmental Footprint Report. Target = zero non conformances relating to waste management practices.
Aboriginal heritage	**10 To minimise impacts to Aboriginal heritage.** 10.1 To minimise disturbance to Aboriginal objects. 10.2 To implement an effective consultation program with traditional landowners, community groups, regulatory authorities, and other relevant stakeholders.	Target = no unauthorised damage to heritage sites as a result of activities.
Public risk	**11 To minimise the risks to public health and safety.** 11.1 To adequately protect public safety. 11.2 To adequately reduce the likelihood of fire.	Target = zero complaints or incidents recorded relating to public safety. Target = zero fires as a result of activities.
Visual amenity	**12 To minimise impacts to the visual characteristics of the area.** 12.1 To minimise visual impacts from activities in consultation with the landowner. 12.2 To maintain visual impacts at an acceptable level.	Target = zero complaints received from local residents relating to visual impacts.
Rehabilitation	**13 To promote and maintain regrowth of vegetation.** 13.1 To monitor and maintain vegetation cover to ensure that it is consistent with surroundings. 13.2 To ensure that a photographic record is maintained at all sites. 13.3 To ensure that the site remains free of weeds and pathogens. 13.4 To engage in consultation with the landowner and gain agreement on the scope of rehabilitation.	Target = no new weeds established at exploration sites.

Aspect	Objective	Targets and KPIs
Operational noise	**14 To minimise noise due to operations.** 14.1 To comply with the operations standards for noise control for flow testing of exploration pilot wells. 14.2 To ensure that there are no unresolved noise-related complaints from the public. 14.3 To implement best practice noise management measures for flow testing of exploration pilot wells.	Target = zero unresolved complaints from local residents relating to noise.
Emergency response	**15 To quickly and effectively minimise adverse impacts associated with an emergency situation.** 15.1 To prepare and implement an emergency response plan. 15.2 To review of emergency response plans and procedures.	Target = minimal impacts from emergency events.
Resource use	**16 To ensure efficient use of resources.** 16.1 To manage the efficient consumption of water, electricity, fuel and gas.	Target = Resource usage records are accurately maintained for AGL Environmental Footprint Report.
Dangerous goods and hazardous materials	**17. To manage the purchasing, storage, transport, handling and disposal of dangerous goods and hazardous materials (including waste dangerous goods and hazardous materials) during exploration activities.** 17.1 To prevent pollution of the environment (soil, surface water, groundwater, atmosphere).	Target = zero incidents resulting in dangerous goods or hazardous materials entering the environment or causing harm or injury to personnel.
Traffic	**18. To minimise the potential traffic impacts on public roads during activities.**	Target = zero incidents or complaints received regarding traffic disruption.
Fire	**19. To prevent fires and mitigate potential impacts of bushfire.** 19.1 To mitigate potential impacts of bushfires. 19.2 To prevent fire generation from activities. 19.3 To control the emission of greenhouse gases.	Target = zero indents of fire throughout all activities.

Aspect	Objective	Targets and KPIs
Flood	**20. To adequately manage flood and other high water events.** 20.1 To control the potential risks of floods while on site. 20.2 To adequately store fluids and materials on site as securely as practicable to minimise risk of escape during a flood as a result of our activities. 20.3 To prevent the transport of materials or anything else off site due to flood water.	Target = zero incidents or complaints received regarding flooding and AGL activities.

5. Implementation and Operation

5.1. Structure and Responsibility

AGL is responsible for overall environmental management of the exploration activities through the implementation of this EMP and the leadership of the Head of Gas Operations, Head of Exploration and the Head of Land and Approvals.

All personnel and contractors are accountable through conditions of employment or contracts and each individual is responsible for ensuring that their work complies with all regulatory requirements, AGL commitments and the appropriate procedures.

All staff and contractors are responsible for undertaking activities in a way that minimises environmental impact with the aim of improving the company's environmental performance.

Key organisational roles and responsibilities are shown in Table 5-1.

Table 5-1: Key Organisational Roles and Responsibilities

Role	Accountabilities
Head of Gas Operations	Overall responsibility for endorsement of the EMP. Directly responsible for the reporting requirements contained in this EMP. Reports to the Group General Manager Upstream Gas.
Land and Approvals Manager	Responsible for development, implementation, monitoring and reporting in compliance with the operation components of the EMP. Administers the complaints register in consultation with the team. The role includes a focus on the continual improvement of environmental performance of people and equipment. Reports to the Head of Land and Approvals.
Environment Manager	Responsible for development, implementation, monitoring and reporting in compliance with the operation components of the EMP. Responsible for informing staff of environmental issues. Also responsible for implementing site-based environmental management measures as prescribed by the Environmental Management Sub Plans. Reports to the Head of Gas Operations.
Drilling Completions Manager	Directly responsible for the overseeing and fulfilment of commitments contained in this EMP.
Drilling Specialist	Directly responsible for the fulfilment of commitments contained in this EMP. Reports to the Completion/ Drilling Manager regarding the drilling operations environmental performance and due diligence.
Community Relations Manager	Responsible for external communications, particularly in landholder negotiation. Reports to the Project Coordinator.

Role	Accountabilities
Production Operations Manager	Directly responsible for the fulfilment of commitments contained in this EMP and for ensuring Construction and Rehabilitation contractors comply with the environmental objectives and the EMP. Reports to the Head of Gas Operations.
Construction Contractors	Responsible for ensuring that works are in compliance with the EMP, meeting regulatory requirements, and ensuring that all environmental objectives contained in the contracts are attained. Report to Production Operations Manager.
Drilling Contractors	Responsible for ensuring that works are in compliance with the EMP, meeting regulatory requirements, and ensuring that all environmental objectives contained in the contracts are attained. Report to the Drilling Specialist and the Completion/ Drilling Engineer.
Supervisors and Field Engineers	Field based personnel responsible for ensuring compliance with the environmental objectives and the EMP.

5.2. Training and competence

All employees including contractors are required to attend an induction prior to commencing work at each site to ensure that all personnel are aware of their HSE responsibilities and have the necessary knowledge and skills to fulfil them.

Site specific inductions cover the requirements of the EMP and the relevant approval as they relate to the site, including:

- drilling hazards, controls and residual risk;
- management of sensitive areas, where applicable;
- erosion control;
- surface water and groundwater quality;
- air quality;
- cultural heritage management;
- weed, pathogen and pest species control;
- fauna and flora preservation;
- bushfire management;
- traffic and access;
- noise;
- chemical storage and handling;
- emergency and Spill response;
- waste management; and

- protecting the amenity of landowners and neighbours.

In addition, job specific training is conducted prior to the commencement of the work activities where required.

It is the responsibility of the contractors to consult with AGL to prepare and implement an induction and job specific training program applicable to their work scope. Approval from AGL shall be obtained prior to implementation.

All training records are maintained at the AGL Camden Office and all employees are also issued with a training and operations passport which records all training courses completed.

All specialist environmental consultants working on exploration activities have been selected based on their experience, industry certification/ accreditation, skills base, and knowledge of AGL business requirements; ensuring professional quality service is continually provided.

5.3. Communication

AGL has communication requirements that are critical to delivery with several internal and external stakeholders that must be consulted. Sections 5.3.1 to 5.3.3 detail these requirements, while Section 5.3.4 provides detail on the procedures for complaint management.

5.3.1. Key communication requirements

The key communication requirements are summarised in Table 5-2.

Table 5-2: Key communication requirements

Condition / Licence No.	Key communication requirement
PEL285: Approval to Drill Coal Seam Methane Exploration Boreholes	A community contact telephone number is to be available for the receiving of complaints during drilling operations. Any complaints must be reported to DPI within 24 hours of the complaint being received. For each complaint, a report on consultations and investigations undertaken with the complainant and proposed mitigation measures must be provided to DPI for approval within 48 hours of the complain being received.

5.3.2. Internal communication

AGL communicates internally through the following forums:

- Toolbox meetings;
- Team meetings where personnel from all the different teams working on the PEL 285 exploration activities meet to discuss project and site level issues including environmental issues; and
- Monthly Project Report. This report is an important form of communication within AGL and provides management with an overview of performance for the month. It also includes discussion of any safety, environmental incidents and training.

5.3.3. External communication

AGL has an extensive external engagement program to proactively communicate with the community, local councils and regulatory authorities. The following sections detail consultation with the community, councils and regulatory authorities.

Community

AGL pro-actively engages the community, in order to keep landowners, neighbours, residents, local councils and relevant government agencies informed of exploration activities, and ensure that the interests of the community are addressed. AGL has raised awareness of its activities and created a strong relationship with the community through a range of community engagement initiatives which include:

- regular and ongoing consultation with landholders and neighbours;
- distribution of updates and other community consultation material on exploration proposals;
- operation of a project websitehttp://agk.com.au/gloucester/;
- erection of signage on exploration sites;
- placement of information on local notice boards and copies provided at two local shops; and
- Ongoing operation of the Gloucester Community Consultation Committee.

Significant consultation takes place in person directly with each landowner. This ensures that their interests can be quickly understood and specifically addressed.

Telephone contact details are provided to surrounding neighbours and residences during work and displayed at each exploration site in the event that members of the public have further questions or issues regarding the activities.

The Gloucester Community Consultative Committee (CCC) has been formed for the GGP. The purpose of the committee is to provide a forum for open discussion and to act as a conduit between AGL and the community. It is aimed at facilitating good working relationships amongst committee members and to act as a channel to assist AGL in improving communication, education and notification within the general community and community groups.

The Gloucester CCC includes:

- community representatives, to provide a cross section of community interests;
- representatives from specialist interest groups, at the discretion of the independent Chairperson;
- elected and or staff representatives from local Councils; and
- representatives of AGL Energy (with input from other specialist company representatives or consultants as required).

Meeting minutes are circulated to the Gloucester CCC participants, which includes the local Council. Copies of the minutes and items presented at the meetings are available for download from the AGL GGP website at http://agk.com.au/gloucester/index.php/community-matters/.

Councils

PEL 285 is located entirely within the Gloucester Geological Basin and the Hunter Region. The Project spans across six LGAs, including Maitland, Port Stephens and Newcastle in the Lower Hunter and Gloucester, Dungog and Great Lakes in the Upper Hunter region. AGL communicates with Council representatives through the Gloucester CCC (refer above); through consultation with the relevant Councils on new exploration proposals in their LGA and by providing update briefings to senior Council staff. There is also communication with Council staff in relation to ongoing operations with appropriate staff members within relevant Council areas on specific issues.

Regulatory authorities

AGL reports to the various regulatory authorities as prescribed by its statutory and regulatory requirements. In addition, AGL communicates with staff of the Department of Planning and Infrastructure (DP&I), DTIRIS-DRE, OEH through regular update meetings and informal discussions on an ongoing basis throughout the year as required.

5.3.4. Complaints management

Complaints can be received through the following channels:

- by telephone to the Gloucester general office number (02 6558 1166), to the Land and Approvals Manager's number, on the contact numbers provided in newsletters and upcoming work notifications, or via the community hotline number (1300 886 170);
- through the GGP website http://agk.com.au/gloucester/;
- via email gloucestergasproject@agl.com.au; and
- directly to personnel on site.

Complaints are recorded and may also be listed on the incident management database (refer Table 5-3) if it relates to an incident.

5.4. Reporting

AGL has a number of environmental reporting requirements specified by its approval conditions and internal practices. A summary of AGL's ongoing reporting requirements for exploration activities is provided in Table 5-3.

Table 5-3: Key environmental reporting requirements

Key reporting requirement	To who	Condition / Licence No.
» The licence holder must lodge reports as required by section 131 and of the PO Act and Part 3, clause 14 of the PO Regulation to the satisfaction of the Minister detailing the operations conducted and the expenditures incurred. » The reports must include all maps, plans and data necessary to satisfactorily interpret and evaluate the reports. » All reports submitted should be in accordance with the Department's Digital Reporting Guidelines. » The format necessary for reports is outlined in condition 22 of PEL 285.	DTIRIS-DRE	PEL 285

Key reporting requirement	To who	Condition / Licence No.
» An Environmental and Rehabilitation Report must be submitted to the Department as follows: i) The reports must be prepared according to Departmental requirements for environmental and rehabilitation reporting on exploration licences ii) The reports must be lodged within one month of expiry or earlier termination of the licence or whenever part of the licence ceases to have effect. iii) The reports must be prepared to the satisfaction of the Department and include information on all surface disturbing prospecting operations and rehabilitation carried out in the licence area or in part of the licence that has ceased to have effect.	DTIRIS-DRE	PEL 285
» An Incident and Complaints Report must be submitted to the Department as follows: i) The report is to be submitted within 24 hours of any serious environmental incident, breach of Conditions 1 to 27 or breach of other environmental regulations, or a serious complaint from landholders or the public. ii) The report must include the details of the exploration licence, contact details for the exploration manager, complainant and landholder, a map showing the area of concern, the nature of the incident or complain, likely causes and consequences, and a timetable showing actions taken or planned to fix the problem. iii) Details of all incidents or complaints occurring whilst the licence is in force must be included in reports prepared in accordance with Condition 23 (c). » Additional environmental reports may be required on specific surface disturbing operations or environmental incidents from time to time as directed in writing by the Department and must be lodged as instructed.	DTIRIS-DRE	PEL 285
» The location and height (AHD) of each borehole collar must be determined to an accuracy of 1 m and the position of the hole within all potentially mineable coal seams must also be determined, using a gyroscopic downhole tool, to an accuracy of 1 m. This information must be supplied to the Department of Primary Industries (DPI). The definition of potentially mineable coal seams will be determined by the Director Coal and Petroleum Development. Reasonable access must be provided to DPI staff to carry out additional surveys as necessary.	DTIRIS-DRE	PEL 285
» At the completion of production testing and prior to plug and abandonment of the hole, steel casing must be removed from the vertical interval(s) encompassing all potentially mineable coal seam(s). Alternatively, glass reinforced epoxy casing meeting good oilfield design criteria may be used across mineable coal seams, subject to separate approval of the Inspector of Coal Mines. Downhole geophysical tools and/or cameras must be used to confirm the removal or absence of steel casing throughout the prescribed interval. All logs and information pertinent to the steel casing must be provided to the Department.	DTIRIS-DRE	PEL 285

Key reporting requirement	To who	Condition / Licence No.
» The work program will be reviewed at the end of year two and continuation/renewal of the title beyond that period will be dependent upon the submission of a satisfactory report of work carried out over the previous two years. A status report of work undertaken and expenditure incurred shall be submitted annually.	DTIRIS-DRE	PEL 285
» The location and height (AHD) of each well collar must be determined to an accuracy of 1 m and the position of the hole within all potentially mineable coal seams must also be determined to an accuracy of 1 m. This information must be supplied to the satisfaction of the Department. » Downhole logging and/or imaging of a quality acceptable to the Department must be used to confirm the removal or absence of steel casing through potentially mineable coal seams. All logs and information pertinent to this condition must be provided to the Department. Abandonment of the well must not proceed until written confirmation is received from the Department confirming that this condition has been satisfied.	DTIRIS-DRE	PEL285: Approval to drill and test coalbed methane exploration wells LMG09, LMG10, LGM11, LMG12, LMGC04, LMGC10, LMGC11, LMGW02, LMGW03, LMGWL01, LMGWL02 and LMGWL03
» The location and height (AHD) of each well collar must be determined to an accuracy of 1 m and the position of the hole within all potentially mineable coal seams must also be determined to an accuracy of 1 m. This information must be supplied to the satisfaction of the Department.	DTIRIS-DRE	PEL285: Approval to fracture stimulate coal seam methane exploration wells Weismantel 3, Faulkland 3 and Craven 6
» The location and height (AHD) of each well collar must be determined to an accuracy of 1 m and the position of the hole within all potentially mineable coal seams must also be determined to an accuracy of 1 m. This information must be supplied to the satisfaction of the Department.	DTIRIS-DRE	PEL285: Approval to drill, test and fracture stimulate coal seam gas exploration wells Waukivory 3, Waukivory 4, Stratford 7, Stratford 10 and Faulkland 2
» The location and height (AHD) of each well collar must be determined to an accuracy of 1 m and the position of the hole within all potentially mineable coal seams must also be determined to an accuracy of 1 m. This information must be supplied to the satisfaction of the Department.	DTIRIS-DRE	PEL285: Approval to relocate, drill and flow test coal seam methane exploration core hole Faulkland 3

Key reporting requirement	To who	Condition / Licence No.
» Report any incidents that cause or have the potential to cause material harm to the environment.	DTIRIS-DRE, EPA, Ministry for Health, WorkCover, local Council, and Fire and Rescue NSW	Part 5.7 of the POEO Act
» Annual AGL Sustainability Report which includes sections on environmental management, greenhouse footprint and community performance (includes the AGL Environmental Footprint Report).	Publicly available	Internal requirement

5.5. Document Control

Quality control of documents and data is managed in accordance with AGL's Document and Data Control Procedure AGL-DCP-HSE-006-001.

The procedure was developed to ensure that only current, relevant documents are available. Under this procedure, documents must be authorised and include the correct issue number, revision of work instructions, specifications, procedures and other key documents and data.

6. Monitoring and checking

6.1. Environmental monitoring and measurement

AGL uses various task specific checklists and the daily drilling report from drilling contractor (records any environmental incidents) to monitor and measure environmental performance and compliance with this EMP.

Other informal checks of environmental performance include:

- daily / weekly inspections during construction;
- storm damage monitoring after major storm events; and
- lighting checks, where relevant.

Completed forms are maintained and non-compliance issues which cannot be closed out immediately are dealt with via the non-conformance procedure as appropriate (outlined in Section 6.4).

Issue-specific monitoring is conducted on a site specific basis as required through AGL's site planning process which is used to ensure that this EMP, operational and safety requirements are implemented and applicable to each exploration site.

6.2. Environmental Compliance Register

AGL has implemented Mipela, an Environmental Compliance Register (ECR) for the GGP, which will also be used for exploration activities. Mipela is both a planning tool and compliance checking tool. It provides a summary of all of the approval, statutory requirements and licence conditions.

Mipela is an important tool for managing and tracking compliance with all of the environmental commitments.

Mipela is an automated and controlled electronic system which sends a reminder email to the responsible personnel, reminding them of commitments requiring action. It is updated when a new approval, licence or lease is granted or modified by the Land and Approvals team.

6.3. Audit requirements

Life Guard is AGL's overarching health, safety and environmental management system. The system was established to document a framework of requirements, policies, standards, compliance guides and management practices for AGL Energy as a whole.

Audits may cover health, safety and environmental performance. The Life Guard system also provides the procedures and checklist to enable teams to undertake internal self audits.

The following audits are undertaken as means of further assessing the environmental performance of the GGP:

- internal audits in response to incidents, changes, events or non conformances, if applicable;

- potential internal operations audits;
- potential independent Life Guard HSE audits; and
- potential regulatory authority audits.

6.4. Incident management, non-conformance, and corrective / preventative action

All incidents including environmental incidents, near misses and complaints are recorded electronically on the Life Guard site through ConnectFirst (AGL's Incident Reporting and Information System).

These on-line reports can be entered by any employee who has witnessed or been part of an incident. A notification is sent to the relevant team leader. The team leader is responsible for carrying out the investigation of the incident and ensuring the corrective actions are completed.

All incidents related to the GGP are discussed at the GGP team meetings. The findings of incident investigations and corrective actions are communicated and tracked until the incident investigation is closed.

6.5. Change management

Change is an integral part of AGL's business. However change can introduce new hazards into the workplace if not managed correctly or can even invalidate previous risk assessments and control strategies. Changes must be managed to ensure that environmental risks arising from such changes remain at acceptable levels.

Company personnel, contractors, management or external sources may identify the need to implement a change. As such, all contractors and external sources should raise any proposed or suggested changes with an appropriate person and the proposed change should be entered into a Change Request Form.

A Management of Change procedure has been developed titled 'Plant Modification and Design Change Request'. This procedure ensures:

- all modifications to equipment, systems and procedures are carried out in a manner so as not to produce a hazard to safety, environment, production or plant operability; and
- all modifications to equipment, systems and procedures are reviewed by authorised personnel and approved prior to implementation.

7. Management review

7.1. Management review and continual improvement

AGL recognises that continuous improvement is a cornerstone of the management system, providing an opportunity to review operation of management systems and their continuing suitability. Management review also provides an opportunity to make adjustments to management systems and improve their effectiveness.

This EMP will be reviewed and if necessary amended and updated:

- following any major incident (review may be restricted to applicable sections);
- upon receipt of new approval conditions, licences and permits;
- when directed by the Director-General of the DTIRIS-DRE; and
- annually, as a minimum.

The review is undertaken by the Land and Approvals team and Environment Manager. The scope of the review is comprehensive and includes:

- findings of audits, where applicable;
- performance against KPI's;
- major non-conformances or incidents recorded; and
- issues raised by government authorities (if any).

Reviews are documented and approved by Management along with any subsequent changes or modifications.

The reviews are part of the continuous improvement cycle of:

- setting performance standards;
- measurement of performance;
- comparison against standards; and
- corrective or remedial actions.

Appendix A: Environmental Management Sub Plans

A.1: Air Quality Sub Plan

GLOUCESTER GAS PROJECT

Exploration

AIR QUALITY MANAGEMENT SUB PLAN

AGL Upstream Investments Pty Limited
April 2013

Document Control

Air Quality Management Sub Plan

Approval:

Authorising Officer	Mike Roy
Title	Head of Gas Operations
Signature	
Date	April 2013

Revision Status:

Revision	Date	Prepared By	Checked By	Approved By	Comments
1	April 2013	EMGA Mitchell McLennan			

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8	Environment Manager	Aaron Clifton
9	Environmental Adviser	Brett Hayward
10	Health and Safety Manager	Alex Secerbegovic
11	AGL website	-
12	DTIRIS-DRE	Michael McFadyen

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1. Introduction

This Air Quality Management Sub Plan (AQMSP) has been prepared to supplement the Environmental Management Plan (EMP) for exploration activities within Petroleum Exploration Lease 285 (PEL 285).

The Sub Plan has been developed to specifically address and manage potential air quality issues for all the operations of the GGP and is based on the previously prepared and approved Environment, Health and Safety Management Plans and the AGL Energy Life Guard System. More information is available in the EMP.

1.1. Objective

The overall objective of the AQMSP is to adequately protect air quality by:

- controlling the quality and quantity of vehicle exhaust emissions;
- minimise dust generation during activities; and
- controlling the emission of greenhouse gases.

1.2. Target

The target for PEL 285 exploration activities is zero incidents or complaints received regarding uncontrolled air emissions.

1.3. Responsibilities

Personnel responsible for implementing this AQMSP include the following:

- the Environment Manager is responsible for notifying the Environmental Protection Authority (EPA) and all other necessary government agencies (in accordance with Part 5.7 of the NSW *Protection of the Environment Operations Act 1997* (POEO Act)) in the event of a pollution event;
- the Environment Manager (or delegate) is responsible for informing site personnel of the required procedures for the protection of air quality via an induction program;
- the Environment Manager, Project Coordinator and Land and Approvals Manager are responsible for checking adherence to operating procedures and delegation of maintenance works on control measures;
- the Environment Manager and Project Coordinator are responsible for monitoring air emissions and dust generation;
- the Project Coordinator is responsible for ensuring reasonable and feasible air emissions source controls investigated and installed;

- the Project Coordinator is responsible for ensuring all AGL vehicles are properly maintained and serviced;
- the Land and Approvals Manager is responsible for landowner consultation with assistance from the Community Relations Manager in addressing and managing complaints in relation to air emissions; and
- all employees and contractors are responsible for managing air emissions, particularly dust, from their work activities and working in a manner so as to minimise dust and other air emissions.

1.4. Table of abbreviations

Table 1-1: Table of Abbreviations

Acronym	Definition
AGL	AGL Upstream Investments Pty Limited
AQMSP	Air Quality Management Sub Plan
DTIRIS-DRE	NSW Department of Trade and Investment, Regional Infrastructure and Services (Division of Resources and Energy)
EMP	Environmental Management Plan
EPA	NSW Environment Protection Authority
PEL	Petroleum Exploration Lease
POEO Act	NSW Protection of the Environment Operations Act 1997

2. Requirements

2.1. Key licence requirements

The key licence requirements relating to air quality management are included in Table 2-1.

Table 2-1: Key licence requirements

Reference	Requirement
Petroleum Exploration Lease 285 (PEL 285)	» Operations must be carried out in a manner that does not cause or aggravate air pollution, water pollution, soil contamination or erosion. The licence holder must observe and perform any instructions given by the Director-General.
PEL 285 Waukivory Pilot Testing	» The works must be carried out at the location(s) and in accordance with the methods contained in: ▪ Review of Environmental Factors Proposed Exploration Wells, Waukivory dated March 2011 by AGL Upstream Investments. ▪ Letter from Toni Laurie, AGL Land and Approvals Manager, dated 1 August 2011 requesting that fracture stimulation not be considered at this time. ▪ Letter from David Kelly, AGL Head of Land and Approvals, dated 28 September 2011 concluding that the risk of adverse impacts to surface water, groundwater and soil will be minimal.
PEL 285 Gloucester 2013 Seismic Survey Program	» The activity must be carried out generally in accordance with the: ▪ Review of Environmental Factors for Gloucester Seismic Survey – PEL 285 – AGL Gloucester L E Pty Ltd submitted in September 2009; and, ▪ Condition of this approval.
PEL 285: Approval to fracture stimulate coal seam methane exploration wells Weismantel 3, Faulkland 3 and Craven 6	» The titleholder must undertake a dust minimisation program to the satisfaction of the Manager Petroleum Operations
PEL 285: Approval to drill, test and fracture stimulate coal seam gas exploration wells Waukivory 3, Waukivory 4, Stratford 7, Stratford 10 and Faulkland 2	» The titleholder must undertake a dust minimisation program to the satisfaction of the Manager Petroleum Operations

2.2. Key legislative and regulatory requirements

The key regulatory requirements relating to air emissions include those listed in Table 2-2.

Table 2-2: Key regulatory requirements

Legislation / Policy	Relevance
Protection of the Environment Operations Act 1997 (POEO Act)	It is an offence to wilfully or negligently cause any substance to leak, spill or otherwise escape (whether or not from a container) in a manner that harms or is likely to harm the environment. Pollution incidents causing or threatening material harm are to be notified to the EPA and all other necessary government agencies in accordance with Part 5.7 of the POEO Act.

3. Management measures

3.1. Potential air emission sources

Potential air emissions from field development and maintenance activities include the following:

- dust during activities associated with construction, gas flow / production testing rehabilitation and associated activities;
- vehicle emissions during construction, gas flow / production testing and rehabilitation; and
- fugitive emissions from pilot wells during maintenance and gas flow / production testing.

3.2. Air quality control measures

Air quality control measures for the GGP are shown in Table 3-1.

Table 3-1: Air quality control measures

Activity	Action	Responsibility
General	» The hierarchy of control for air quality management (i.e. avoid, recycle, minimise and manage) should be fully applied during procurement. » The workforce induction program shall inform site personnel of required procedures for the protection of air quality.	Environment Manager (or delegate)
Greenhouse gas	» Greenhouse gas emissions associated with gas flow / production testing shall be minimised by adopting strict operating procedures. » Plant and equipment shall be regularly maintained and serviced to limit emissions. » The flaring of gas from pilot wells shall be limited to that necessary as part of the production evaluation process, following which flaring will be halted. » Flaring is recognised as preferable to venting of coal seam methane gas. » Leak detection surveys shall be periodically performed at well sites and along any pipeline once installed as per Australian Standard (AS2885.3) requirements.	Environment Manager/ Project Coordinator
Dust emissions	» If excessive dust generation is observed, dust control measures such as the use of water carts shall be implemented. » Designated internal access roads will be utilised and vehicles to adhere to sign-posted vehicle speed limits. » Vehicles that carry a potentially dust generating load will be covered at all times, except during loading and unloading. » Disturbed areas shall be revegetated with existing species and access restricted until the vegetation is established.	Environment Manager/ Project Coordinator

3.3. Activity or site-specific requirements

Exploration activities are required to undertake an environmental impact assessment (EIA) as part of the approval process. The EIA will contain site-specific management measures or commitments to minimise impacts on various environmental aspects. These commitments need to be implemented, in addition to any requirement in this EMP, in accordance with the relevant supporting documentation and/or conditions of the activity approval and be the responsibility of the Environment Manager, unless otherwise stated.

The EIA and approval documentation will be provided to any contractor and activity or site-specific management measures will be communicated to on-site personnel (including contractors, as required) prior to commencement of works by the Environment Manager (or nominated delegate) and may form part of the site induction process.

4. Monitoring and reporting

4.1. Monitoring requirements

Monitoring will be undertaken on a regular basis during operations, in accordance with Section 6.1 of the EMP.

4.2. Reporting requirements

At this stage, the GGP does not have any reporting requirements relating to air quality. This AQMSP will be updated as approvals are gained and reporting is required.

4.3. Records

Records related to this Sub Plan include:

- complaints related to air pollution;
- inspection checklists; and
- reports to authorities relating to incidents causing or threatening to harm the environment as a result of air emissions.

All records required to be kept for the GGP will be in a legible form, kept for at least four years and be available to any authorised officer of the EPA if requested.

5. Administrative

5.1. Site specific plans

Currently not applicable

5.2. Attachments

Currently not applicable

5.3. Definitions

Currently not applicable

5.4. Life Guard references

HSE Corporate Policy

LG-HSE-CG-070: Air Pollution and Odours

A.2: European Cultural Heritage Sub Plan

GLOUCESTER GAS PROJECT

Exploration

EUROPEAN HERITAGE MANAGEMENT SUB PLAN

AGL Upstream Investments Pty Limited
April 2013

Document Control

European Heritage Management Sub Plan

Approval:

Authorising Officer	Mike Roy
Title	Head of Gas Operations
Signature	
Date	April 2013

Revision Status:

Revision	Date	Prepared By	Checked By	Approved By	Comments
1	April 2013	EMGA Mitchell McLennan			

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1. Introduction

This European Heritage Management Sub Plan (EHMSP) has been prepared to supplement the Environmental Management Plan (EMP) for exploration activities within Petroleum Exploration Lease (PEL 285).

The EHMSP has been developed to specifically address and manage potential European Heritage issues for exploration activities and is based on the previously prepared and approved Environment, Health and Safety Management Plans and the AGL Energy Life Guard system. More information is available in the EMP.

1.1. Objective

The objective of the EHMSP is to minimise impacts to European cultural heritage. This will be achieved by following recommendations relating to the protection of European heritage sites and values.

1.2. Target

No unauthorised damage to European Heritage sites as a result of exploration activities within PEL 285.

1.3. Responsibilities

Personnel responsible for implementing the requirements of the EHMSP are described below:

- the Environment Manager is responsible for notifying the NSW Heritage Branch within the Office of Environment and Heritage, Department of Premier and Cabinet, in the event that an unrecorded relic is uncovered;
- the Environment Manager (or delegate) is responsible for informing site personnel of the heritage management procedures through the site specific induction program;
- the Environment Manager and Land and Approvals Manager are responsible for implementing site specific heritage recommendations as required;
- the Environment Manager, Land and Approvals Manager and Project Coordinator are responsible for monitoring procedures and reporting as required;
- the Land and Approvals Manager is responsible for landowner consultation with assistance from the Community Relations Manager in addressing and managing incidents and complaints in relation to heritage management; and
- all employees/ contractors are responsible for following the induction requirements that arise from their work activities onsite, so as to minimise the environmental impact.

1.4. Table of abbreviations

Table 1-1: Table of Abbreviations

Acronym	Definition
AGL	AGL Upstream Investments Pty Limited
DTIRIS-DRE	NSW Department of Trade and Investment, Regional Infrastructure and Services (Division of Resources and Energy)
EHMSP	European Heritage Management Sub Plan
EP&A Act	NSW Environmental Planning and Assessment Act 1979
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
EMP	Environmental Management Plan
LEP	Local Environmental Plan
NES	National Environmental Significance
NHL	National Heritage List
OEH	NSW Office of Environment and Heritage
PEL	Petroleum Exploration Lease
SHR	State Heritage Register

2. Requirements

2.1. Key approval requirements

There are currently no specific approval requirements for European Heritage. This section will be updated as approvals are gained.

2.2. Key legislative and regulatory requirements

Table 2-1 lists the key NSW and Commonwealth legislation and policies that relate to heritage. The State Heritage Register (SHR) lists items of national and state heritage significance and items of local significance are listed in local environmental plans (LEPs). The following LEPs are applicable to the GGP:

- Great Lakes LEP 1996,
- Dungog LEP 2006;
- Gloucester LEP 2010.

The LEPs listed above contain items in the project area and within the Petroleum Exploration Leases (PELs) which have been identified as being of local heritage significance. Development of, or in proximity to, these items may be required to address specific requirements to achieve compliance.

Table 2-1: Legislation and policies - European Heritage

Legislation / Policy	Relevance
NSW *Environmental Planning and Assessment Act* (EP&A Act)1979	The EP&A Act and the EP&A Regulation include provisions to ensure that proposals which have the potential to impact the environment are subject to detailed assessment, and provide opportunity for public involvement. Environmental impact assessments under Part 4 and Part 5 are required to consider potential impacts on heritage items.
NSW Heritage Act 1977	The purpose of the NSW Heritage Act 1977 is to ensure that the non-Aboriginal heritage of NSW is adequately identified and conserved. The Act is concerned with all aspects of conservation ranging from the most basic protection against damage and demolition, to restoration and enhancement. Under the NSW Heritage Act, a relic means any deposit, object or material evidence that: relates to the settlement of the area that comprises NSW, not being Aboriginal settlement; and is of State or local heritage significance. Section 57 of the Act lists the activities that require approval from the Heritage Branch if an item is subject to an Interim Heritage Order or is on the State Heritage Register. Certain activities may not require approval under standard exemptions under S57(2). Section 139 prohibits disturbance of a relic unless it is conducted in accordance

Legislation / Policy	Relevance
	with an “excavation permit from the Heritage Council”. Section 146 requires that the discovery of a previously unknown relic be reported to the Heritage Council within a reasonable time of its discovery.
Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	The EPBC Act requires the approval of the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities for actions that may have a significant impact on matters of National Environmental Significance (NES). Approval from the Commonwealth is in addition to approvals required under NSW legislation. Matters of NES applicable to heritage under the EPBC Act include World and National heritage properties. There are currently no World or National heritage properties or places identified within PEL 285.

3. Management measures

3.1. Existing heritage items

There are currently no known items of European heritage within the PEL 285 district. This list will be updated as exploration activities progress.

3.2. General control measures

Table 3-2 describes control measures to be implemented both generally and specific to project activities to minimise impacts to items of European heritage.

Table 3-1: Control measures - European heritage

Activity	Action	Responsibility
Pre-activity	Locations of wells, access roads and gas gathering lines have been selected to avoid items of heritage significance.	Environment Manager/ Project Coordinator/ Land and Approvals Manager
Construction, operation, and rehabilitation	Brief personnel/ contractors prior to excavation during the site specific induction on heritage issues and on appropriate course of action if any heritage relics are discovered.	Environment Manager (or delegate)
	All works will be confined to the exploration compound and designated access routes.	Environment Manager/ Project Coordinator
	Maintain existing vegetation which provides screening or works and minimise removal of vegetation where possible.	Environment Manager / Land and Approvals Manager
	Implement the recommendations of heritage assessments, where relevant.	Environment Manager / Land and Approvals Manager
	If any historic relics, as defined by the *Heritage Act 1977* are identified in the course of activities, then works in the vicinity of the finds are to cease immediately, and an archaeologist from the NSW Heritage Branch is to be contacted, and an appropriate course of action implemented.	Environment Manager / Land and Approvals Manager
	If required for the above, a suitably qualified archaeologist will assess the item/s or site and provide a report to the Project Manager with recommendations. The report will be submitted to OEH for assessment. No work will recommence without approval from OEH and the Project Manager.	Environment Manager / Land and Approvals Manager

3.3. Activity or site-specific requirements

Exploration activities are required to undertake an environmental impact assessment (EIA) as part of the approval process. The EIA will contain site-specific management measures or commitments to minimise impacts on various environmental aspects. These commitments need to be implemented, in addition to any requirement in this EMP, in accordance with the relevant supporting documentation and/or conditions of the activity approval and be the responsibility of the Environment Manager, unless otherwise stated.

The EIA and approval documentation will be provided to any contractor and activity or site-specific management measures will be communicated to on-site personnel (including contractors, as required) prior to commencement of works by the Environment Manager (or nominated delegate) and may form part of the site induction process.

4. Monitoring and reporting

Personnel responsible for various monitoring and reporting are indicated in Section 1.3. Complaints and incidents related to heritage management will be recorded, addressed and reported in accordance with Sections 5.3.4 and 6.4 of the EMP and with this Sub Plan.

Monitoring to ensure works are being carried out in compliance with this Sub Plan will be done by:

- site specific inductions;
- toolbox meetings;
- spot checks;
- regular site inspections; and
- review of records including minutes of site specific inductions and toolbox meetings, the complaints register and incident reports.

Reporting will be undertaken where required and will be made available to the appropriate personnel. Reporting is the responsibility of the Environment Manager.

4.1. Records

Where European Heritage management and monitoring measures are required, the following list outlines the records that should be kept (in addition to any site-specific record requirements noted within the relevant assessment for the activity being undertaken):

- records of complaints and incidents related to European heritage;
- records of Site Specific Inductions meetings; and
- inspection checklists, where applicable.

5. Administrative

5.1. Site-specific plans

Currently not applicable.

5.2. Attachments

Currently not applicable.

5.3. Definitions

Under the NSW *Heritage Act 1977*, a 'relic' is defined as:

relic means any deposit, object or material evidence:

(a) which relates to the settlement of the area that comprises New South Wales, not being Aboriginal settlement, and

(b) is of State or local heritage significance.

5.4. Life Guard references

HSE Corporate Policy

Heritage Conservation – LG-HSE-CG-076

A.3: Dangerous Goods and Hazardous Materials Sub Plan

GLOUCESTER GAS PROJECT

Exploration

DANGEROUS GOODS AND HAZARDOUS MATERIALS SUB PLAN

AGL Upstream Investments Pty Limited
April 2013

Document Control

Dangerous Goods and Hazardous Materials Sub Plan

Approval:

Authorising Officer	Mike Roy
Title	Head of Gas Operations
Signature	
Date	April 2013

Revision Status:

Revision	Date	Prepared By	Checked By	Approved By	Comments
1	April 2013	EMGA Mitchell McLennan			

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9	Environmental Adviser	Brett Hayward
10	Health and Safety Manager	Alex Secerbegovic
11	AGL website	-
12	DTIRIS-DRE	Michael McFadyen

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List of Tables

1. Introduction

This Dangerous Goods and Hazardous Materials Sub Plan (DGHMSP) has been prepared to supplement the Environmental Management Plan (EMP) for exploration activities within Petroleum Exploration Lease 285 (PEL 285).

The DGHMSP is based on the previously prepared and approved Environment, Health and Safety Management Plans and the current AGL Energy Life Guard System. More information is available in the EMP.

1.1. Objective

To manage the purchasing, storage, transport, handling and disposal of dangerous goods and hazardous materials (including waste) during construction, operation and maintenance activities so as not to cause pollution of the environment (ie soil, surface water, groundwater, or atmosphere).

1.2. Target

The target for the DGHMSP is zero incidents resulting in dangerous goods or hazardous materials entering the environment or causing harm or injury to personnel.

1.3. Responsibilities

Personnel responsible for implementing this environmental sub plan include the following:

- the Environment Manager in accordance with Part 5.7 of the *Protection of the Environment Operations Act 1997* (POEO Act), is responsible for notifying the Environmental Protection Authority (EPA), Ministry of Health, WorkCover, local Council, and Fire and Rescue NSW in the event of a pollution event;
- all Field Team Leaders are responsible for regular inspections;
- all field personnel are responsible for handling dangerous goods and hazardous materials in accordance with this sub plan; and
- all employees and contractors are responsible for the storage and handling of the dangerous goods and hazardous materials used in exploration activities.

1.4. Table of abbreviations

Table 1-1: Table of Abbreviations

Acronym	Definition
AGL	AGL Upstream Investments Pty Limited
DGHMSP	Dangerous Goods and Hazardous Materials Sub Plan
DTIRIS-DRE	NSW Department of Trade and Investment, Regional Infrastructure and Services (Division of Resources and Energy)
EMP	Environmental Management Plan
EPA	NSW Environment Protection Authority
JSEA	Job Safety and Environmental Analysis
kg	Kilograms
L	Litre
MSDS	Material Safety Data Sheets
OHS	Occupational Health and Safety
PEL	Petroleum Exploration Lease
POEO Act	NSW Protection of the Environment Operations Act 1997

2. Requirements

2.1. Key licence requirements

The key licence and development consent requirements relating to dangerous goods and hazardous materials are included in Table 2-1. Approval conditions from other activities are not listed here as they did not contain conditions specific to dangerous goods and hazardous materials.

Table 2-1: Key licence requirements

Reference	Requirement
Petroleum Exploration Lease 285 (PEL 285)	» Operations must be carried out in a manner that does not cause or aggravate air pollution, water pollution, soil contamination or erosion. The licence holder must observe and perform any instructions given by the Director General.
PEL 285 Waukivory Pilot Testing	» The works must be carried out at the location(s) and in accordance with the methods contained in: ▪ Review of Environmental Factors Proposed Exploration Wells, Waukivory dated March 2011 by AGL Upstream Investments. ▪ Letter from Toni Laurie, AGL Land and Approvals Manager, dated 1 August 2011 requesting that fracture stimulation not be considered at this time. ▪ Letter from David Kelly, AGL Head of Land and Approvals, dated 28 September 2011 concluding that the risk of adverse impacts to surface water, groundwater and soil will be minimal.
PEL 285 Gloucester 2013 Seismic Survey Program	» The activity must be carried out generally in accordance with the: ▪ Review of Environmental Factors for Gloucester Seismic Survey – PEL 285 – AGL Gloucester L E Pty Ltd submitted in September 2009; and, ▪ Condition of this approval.

2.1.1. Key regulatory requirements

The key regulatory requirements relating to dangerous goods and hazardous materials include those listed in Table 2-2.

Table 2-2: Key regulatory requirements

Legislation / Policy	Relevance
Protection of the Environment Operations Act 1997	It is an offence to wilfully or negligently cause any substance to leak, spill or otherwise escape (whether or not from a container) in a manner that harms or is likely to harm the environment. It is an offence to pollute waters. Pollution incidents causing or threatening material harm to be notified to the EPA, Ministry of Health, WorkCover, local Council, and Fire and Rescue NSW in accordance with Part 5.7 of the POEO Act. Waste must be stored in an environmentally safe manner.

Legislation / Policy	Relevance
Contaminated Land Management Act 1997	Clause 60 Duty to Report Contamination - A person who becomes aware that the person's activities in, on or under land have contaminated the land in such a way as to present a significant risk of harm must, as soon as practicable after becoming so aware, notify the EPA in writing that the land has been so contaminated.
Work Health and Safety Act 2011 and *Work Health and Safety Regulation 2011*	A person conducting business or undertaking must consider how to control a risk associated with the storage and handling of dangerous goods where it is not reasonably practicable to eliminate risk. In each area where dangerous goods are stored or handled, provision must be made for containment of spills. A person conducting business or undertaking must ensure packaged dangerous goods are labelled in accordance with the Australian Dangerous Goods code. A person conducting business or undertaking must ensure that a register of all dangerous good is kept and maintained (including Material Safety Data Sheets and risk assessments) and is readily accessible to all employees. A person conducting or undertaking business must ensure, so far as reasonably practicable, that dangerous goods at the premises do not inadvertently become unstable, decompose or change to create a different hazard or increase the risk associated with the dangerous goods. Dangerous goods are required to be placarded when stored above 'Placarding' quantities, and quantities notified to WorkCover NSW when stored above 'Manifest' levels (refer to Table 2-3 below). Exploration activities do not require storage of dangerous goods above Manifest levels and therefore, does not require a Notification.
Key Australian Standards / Codes	The Australian Dangerous Goods Code. AS1216: Class Labels for Dangerous Goods. AS1940: The Storage and Handling of Flammable and Combustible Liquids. AS2507: The Storage and Handling of Agricultural and Veterinary Chemicals. AS3780: The Storage and Handling of Corrosive Substances. AS3833: The Storage and Handling of Mixed Classes of Dangerous Goods in Packages and Intermediate Bulk Containers. AS4326: The Storage and Handling of Oxidizing Agents.

Table 2-3 lists the placarding quantities for dangerous goods. Definitions of dangerous goods classes and packing groups are provided in the *Work Health and Safety Regulation 2011.*

Table 2-3: Dangerous goods placarding quantities

Description of dangerous goods	Placarding quantity	Manifest quantity
Group 1: Class 2.1	500 L	5,000 L
Group 1: Class 2.2 Subsidiary Risk 5.1	2,000 L	10,000 L
Group 1: Other Class 2.2	5,000 L	10,000 L
Group 1: Class 2.3	50 L	500 L
Group 1: Aerosols	5,000 L	10,000 L
Group 1: Cryogenic Fluids	1,000 L	10,000 L
Group 2: Class 3, 4.1, 4.2, 4.3, 5.1, 5.2, 6.1 or 8 – Packing Group I	50 kg or L	500 kg or L
Group 2: Class 3, 4.1, 4.2, 4.3, 5.1, 5.2, 6.1 or 8 – Packing Group II	250 kg or L	2,500 kg or L
Group 2: Class 3, 4.1, 4.2, 4.3, 5.1, 5.2, 6.1 or 8 – Packing Group III	1,000 kg or L	10,000 kg or L
Group 2: Class 3, 4.1, 4.2, 4.3, 5.1, 5.2, 6.1 or 8 – Mixed Packing Group in a single Class with the quantity of each Packing Group below the specified quantity for the Packing Group.	1,000 kg or L	10,000 kg or L
Group 3: Class 9 packing Group II	1,000 kg or L	10,000 kg or L
Group 3: Class 9 Packing Group III	5,000 kg or L	10,000 kg or L
Group 3: Class 9 Mixed packing group (with the quantity of each Packing Group below the specified quantity for the Packing Group.)	5,000 kg or L	10,000 kg or L
Group 4: Mixed Classes of dangerous goods where none of the Classes, types or Packing Groups (if any) present exceeds the quantities specified for the relevant quantity in Item 1, 2 or 3 of this Table.	5,000 kg or L--The quantity applies only if the placarding quantity for an individual Class that is present is 5,000 kg or L.	10,000 kg or L
	2,000 kg or L--The quantity applies only if the placarding quantity for all of the Classes present is 2,000 kg or L or less.	
Group 5: C1 combustible liquids stored and handled with fire risk dangerous goods where none of the Classes, types or Packing Groups (if any) present exceeds the relevant quantities in Item 1, 2 or 3 of this Table.	1,000 kg or L	10,000 kg or L
Group 6: Goods too dangerous to be transported that are not kept in a laboratory.	Any quantity	Any quantity
Group 7: C1 combustible liquids in bulk stored and handled separately from other dangerous goods.	10,000 L	100,000 L
Group 7: C1 combustible liquids stored and handled in packages separately from other dangerous goods.	50,000 L	100,000 L
Group 7: C1 combustible liquids in bulk and in packages stored and handled separately from other dangerous goods provided the quantity in bulk is 10,000 L or less.	50,000 L	100,000 L

3. Storage of dangerous goods and hazardous materials

Dangerous goods and hazardous materials are stored and/ or handled in the following areas:

- fuels are stored during drilling and hydraulic fracture stimulation at well sites.
- drilling and hydraulic fracture stimulation additives are stored at well sites or designated AGL storage areas off site.

4. Control measures

The control measures for dangerous goods and hazardous materials are detailed in Table 4-1.

Table 4-1: Control measures for dangerous goods and hazardous materials

Activity	Action	Responsibility
General	The contractor will maintain a MSDS register for all chemicals used on site.	Contractor/Environment Manager
	This DGHMSP will be used in conjunction with the Emergency Response Plan for exploration activities within PEL 285.	Contractor/Environment Manager
Purchasing	All dangerous goods and hazardous materials stored on site shall be entered on the GGP Chemical Manifest (including a register, risk assessments and material safety data sheets - MSDS).	Environment Manager/ Health and Safety Manager
	New dangerous goods and hazardous materials shall be purchased in accordance with the AGL Purchasing Procedure, a risk assessment undertaken and MSDS obtained.	Project Coordinator
Storage, use and transport	All dangerous goods and hazardous materials shall be stored and where practicable handled within containment facilities (for example, bunded areas, leak proof trays) designed to prevent the release of spilt materials to the environment.	Environment Manager/ Health and Safety Manager
	The storage, handling and transport of dangerous goods and hazardous materials shall comply with legislation and Australian Standards, including but not limited to containment, placarding and segregation from incompatible materials.	Environment Manager/ Health and Safety Manager
	All vehicles and equipment shall be adequately maintained so as to minimise drips or leaks of dangerous goods and Hazardous Materials.	Environment Manager / Health and Safety Manager / contractor
	All storage and handling equipment (including transfer hoses) shall be kept in a well maintained condition.	Environment Manager / Health and Safety Manager / contractor
	Where it is necessary to refuel heavy equipment onsite, adequate spill prevention and containment measures (for example, drip trays) will be implemented.	Environment Manager / contractor
	Equipment will not be refuelled within 50 m of any body, water course or drainage line.	Environment Manager / contractor
	Transport of dangerous goods to be undertaken under appropriate licence.	Environment Manager / Health and Safety Manager / contractor

Activity	Action	Responsibility
Risk Assessment	Job Safety and Environment Analysis (JSEAs) shall incorporate storage and handling of dangerous goods and hazardous materials and reference the relevant MSDS.	Environment Manager / Health and Safety Manager / all employees and contractors
	Prior to commencing construction, operations or maintenance, the planned arrangement of all dangerous goods and hazardous materials storage areas should be reviewed to eliminate potentially hazardous conditions.	Environment Manager/ Health and Safety Manager / all employees and contractors
	Prior to commencing fracture stimulation activities, a human health and ecological risk assessment in accordance with the code of practice will be undertaken.	Project Coordinator/ Land and Approvals Manager
Labelling	All dangerous goods and hazardous materials should be stored in approved containers and properly labelled.	Environment Manager/ Health and Safety Manager / all employees and contractors
	All packaged dangerous goods must be labelled in accordance with the Australian Dangerous Goods code.	Environment Manager/ Health and Safety Manager / all employees and contractors
	If unmarked drums arrive on location or if in doubt as to the constituents of a chemical substance, treat as a hazardous, toxic substance until found otherwise.	Environment Manager / Land and Approvals Manager / Health and Safety Manager / all employees and contractors
Training	The workforce induction program shall inform site personnel of the required chemical storage and handling procedures and the required spill prevention and response procedures.	Environment Manager/ Health and Safety Manager (or delegate) / all employees and contractors
	The MSDS must be read prior to using any substance and available during storage and use of dangerous goods and hazardous materials.	Environment Manager/ Health and Safety Manager / all employees and contractors
	Training records are to be maintained by AGL.	Environment Manager/ Health and Safety Manager / all employees and contractors

Activity	Action	Responsibility
Decanting	Any dangerous goods or hazardous materials decanted into a second container must be clearly labelled with name and safety risk phrases (for example flammable or toxic). The second container must be of good integrity, thoroughly cleaned, and compatible with the intended product to be stored.	Environment Manager / all employees and contractors
Disposal	Waste dangerous goods and hazardous materials, including empty drums and containers, must be stored in assigned storage areas until they are disposed of in accordance with the MSDS.	Environment Manager / all employees and contractors
	Waste dangerous goods and hazardous materials shall be managed and disposed in accordance with the requirements of relevant legislation and industry standards.	Environment Manager / all employees and contractors
Spill Response	In the event of a spill or leak of dangerous goods and hazardous materials the safety of personnel and third parties shall be protected as the first priority.	Environment Manager/ Health and Safety Manager / all employees and contractors
	All spills of dangerous goods and hazardous materials shall be addressed promptly and stopped at source as soon as practicable and contained to the smallest possible area.	Environment Manager/ Health and Safety Manager / all employees and contractors
	During activities, appropriate strategies and equipment shall be in place to deal with a spill of all types and volumes of dangerous goods and hazardous materials to be used on-site.	Environment Manager / all employees and contractors
	Containment and recovery equipment shall include, but not be limited to absorbent materials (for example, pads and straw bales), shovels and sand bag sacks and protective clothing (for example, gloves, overalls, and boots).	Environment Manager / all employees and contractors
	Pollution incidents causing or threatening material harm to be notified to the Environmental Manager, EPA, and other necessary government agencies as per Table 2-2 immediately.	Environment Manager / all employees and contractors
	Spilt material shall be recovered as soon as possible, using appropriate equipment.	Environment Manager / contractors
	Contaminated soil, or spill recovery materials (such as sawdust and absorbent pads) shall be disposed of to appropriately licensed facilities.	Environment Manager / all employees and contractors
	Spill response equipment shall be maintained onsite and replaced as required.	Environment Manager / Health and Safety Manager / all employees and contractors

Activity	Action	Responsibility
	All spillages involving dangerous goods and hazardous materials from any part of the activities are to be treated as toxic materials.	Environment Manager / all employees and contractors

4.1. Activity or site-specific requirements

Exploration activities are required to undertake an environmental impact assessment (EIA) as part of the approval process. The EIA will contain site-specific management measures or commitments to minimise impacts on various environmental aspects. These commitments need to be implemented, in addition to any requirement in this EMP, in accordance with the relevant supporting documentation and/or conditions of the activity approval and be the responsibility of the Environment Manager, unless otherwise stated.

The EIA and approval documentation will be provided to any contractor and activity or site-specific management measures will be communicated to on-site personnel (including contractors, as required) prior to commencement of works by the Environment Manager (or nominated delegate) and may form part of the site induction process.

5. Monitoring and reporting

5.1. Monitoring requirements

Monitoring requirements for the DGHMSP will consist of regular inspections of dangerous goods and hazardous materials. Inspections will be conducted to review compliance with the DGHMSP, with implementation of recommendations and corrective actions.

5.2. Reporting requirements

Reporting requirements for the DGHMSP include:

- dangerous goods are required to be notified to WorkCover NSW when stored above 'Manifest' quantities (refer to Table 2-3 above). Exploration activities within PEL 285 do not require storage of dangerous goods above Manifest levels and is therefore not currently required to notify WorkCover.
- pollution incidents causing or threatening material harm to be notified to the EPA and other necessary government agencies as per Table 2-2 immediately.
- a person who becomes aware that the person's activities in, on or under land have contaminated the land in such a way as to present a significant risk of harm must notify the EPA and other necessary government agencies as per Table 2-2 immediately.

5.3. Records

Records related to the DGHMSP include:

- Records of incidents and near misses.
- Records of Site Specific Inductions and toolbox meetings.
- Inspection checklists, where applicable.

6. Administrative

6.1. Site-specific plans

Emergency Response Plan

6.2. Attachments/References

Refer to:
Emergency Response Plan
MSDS Register

6.3. Definitions

Dangerous goods - "Dangerous goods is defined in the NSW OHS Act 2000 as: "(a) substances or articles subject to a national standard declared by the National Occupational Health and Safety Commission under section 38 of the *National Occupational Health and Safety Commission Act 1985* of the Commonwealth; and (b) any other substances or articles of risk to public safety." It is noted that the *National Occupational Health and Safety Commission Act 1985* has been superseded by the *Safe Work Australia Act 2008* and that the relevant functions of the National Occupational Health and Safety Commission have been assumed by Safe Work Australia.

Hazardous materials - Hazardous materials are defined as 'anything that, when produced, stored, moved, used or otherwise dealt with without adequate safeguards to prevent it from escaping, may cause injury or death or damage to life, property or the environment' (NSW Fire Brigades Act 1989).

6.4. Life Guard references

HSE Corporate Policy

LG-HSE-016: Hazardous Materials Management

LG-HSE-CG-023: Material Safety Data Sheets

LG-HSE-CG-024: Hazardous Substances and Dangerous Goods

LG-HSE-CG-054: Storage and Warehousing

LG-HSE-CG-055: Transport of Materials and Goods

A.4: Fire Management Sub Plan

GLOUCESTER GAS PROJECT

Exploration

FIRE MANAGEMENT SUB PLAN

AGL Upstream Investments Pty Limited
April 2013

Document Control

Fire Management Sub Plan

Approval:

Authorising Officer	Mike Roy
Title	Head of Gas Operations
Signature	
Date	April 2013

Revision Status:

Revision	Date	Prepared By	Checked By	Approved By	Comments
1	April 2013	EMGA Mitchell McLennan			

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9	Environmental Adviser	Brett Hayward
10	Health and Safety Manager	Alex Secerbegovic
11	AGL website	-
12	DTIRIS-DRE	Michael McFadyen

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1. Introduction

This Fire Management Sub Plan (FIMSP) has been prepared to supplement the Environmental Management Plan (EMP) for exploration activities within Petroleum Exploration Lease 285 (PEL 285).

The FIMSP has been developed to specifically address and manage potential fire issues for exploration activities and associated construction.

The FIMSP is based on the previously prepared and approved Environment Health and Safety Management Plans and the current AGL Energy Life Guard system. More information is available in the EMP.

1.1. Objectives

The overall objectives of the FIMSP are to:

- mitigate potential impacts of bushfire; and
- prevent fire generation from activities.

1.2. Target

The target of the FIMSP is to have zero incidents of fire caused by exploration activities.

1.3. Responsibilities

Personnel responsible for implementing the requirements of this FIMSP are described below:

- the AGL Environment Manager (or delegate) is responsible for informing site personnel of the fire management procedures through the induction program;
- the AGL Environment Manager and Land and Approvals Manager are responsible for ensuring that the bushfire risk is assessed at all sites related to the GGP, and assets have the appropriate asset protection zones (APZ's);
- the AGL Environment Manager and Land and Approvals Manager (or delegate) are responsible for implementing site specific fire measures as required;
- the AGL Environmental Advisor, Land and Approvals Manager and Project Coordinator are responsible for monitoring procedures and reporting as required;
- the Land and Approvals Manager is responsible for landowner consultation with assistance from the Community Relations Manager in addressing and managing incidents and complaints in relation to fire; and
- all employees/ contractors are responsible for following the induction requirements that arise from their work activities onsite, so as to minimise the environmental impact.

1.4. Table of abbreviations

Table 1-1: Table of Abbreviations

Acronym	Definition
AGL	AGL Upstream Investments Pty Limited
APZ	Asset Protection Zones
DTIRIS-DRE	NSW Department of Trade and Investment, Regional Infrastructure and Services (Division of Resources and Energy)
EP&A Act	NSW Environmental Planning and Assessment Act 1979
EMP	Environmental Management Plan
ERP	Emergency Response Plan
FIMSP	Fire Management Sub Plan
HSE	Health Safety and Environment System
PEL	Petroleum Exploration Lease
RF Act	NSW Rural Fires Act 1997

2. Requirements

2.1. Key approval requirements

All activities carried out on-site shall comply with all relevant legislation, regulations and guidelines. These include but are not limited to the legislation described in Table 2-1. Approval conditions from other activities are not listed below as they did not contain conditions specific to flora and fauna.

Table 2-1: Key approval requirements

Licence	Requirement
Petroleum Exploration Lease 285 (PEL 285)	» Operations must be carried out in a manner that does not cause or aggravate air pollution, water pollution, soil contamination or erosion. The licence holder must observe and perform any instructions given by the Director General. » The licence holder must take all precautions against causing an outbreak of fire and must comply with the provisions of and regulations under the Rural Fires Act 1997 and must not burn off any grass, foliage or herbage without the consent of the owner or occupier and the local fire authority.
PEL 285 Waukivory Pilot Approval	» The works must be carried out at the location(s) and in accordance with the methods contained in: ▪ Review of Environmental Factors Proposed Exploration Wells, Waukivory dated March 2011 by AGL Upstream Investments. ▪ Letter from Toni Laurie, AGL Land and Approvals Manager, dated 1 August 2011 requesting that fracture stimulation not be considered at this time. ▪ Letter from David Kelly, AGL Head of Land and Approvals, dated 28 September 2011 concluding that the risk of adverse impacts to surface water, groundwater and soil will be minimal.
PEL 285 Gloucester 2D Seismic Survey Program	» The activity must be carried out generally in accordance with the: ▪ Review of Environmental Factors for Gloucester 2D Seismic Survey – PEL 285 – AGL Gloucester L E Pty Ltd submitted in September 2009; and, ▪ Condition of this approval.

2.2. Key legislative and regulatory requirements

Table 2-2: Key legislative and regulatory requirements

Legislation / Policy	Relevance
NSW *Environmental Planning and Assessment Act 1979* (EP&A Act)	The EP&A Act and Regulation include provisions to ensure that proposals which have the potential to impact the environment are subject to detailed assessment.
NSW *Rural Fires Act 1997* (RF Act)	The RF Act includes provisions for the prevention, mitigation and suppression of rural fires. Under Part 4 of the RF Act, public authorities, owners and occupiers of land have a duty to prevent bushfires.

3. Management measures

3.1. Potential fire emission sources

Potential fire emission sources for exploration activities include:

- natural bushfire;
- personnel lit fires; and
- fire as a result of a failure of exploration equipment and operations.

3.2. General management measures

Table 3-1 summarises the general measures to be implemented to manage potential fire emission sources and outlines responsibilities for their implementation.

Table 3-1: Fire Management Measures

Activity	Action	Responsibility
General	» The AGL Employee and Contractor Induction shall inform all site personnel of required procedures to prevent fire. » The AGL Employee and Contractor Induction shall inform all site personnel of and emergency procedures in the event of a fire or bushfire.	AGL Environment Manager
Risk management	» Implement measures from the AGL Health and Safety Management Plan for the Gloucester Region. » Implement measures from the Emergency Response Plan. » No smoking on site, except in prescribed areas. » Construction equipment to carry emergency communications equipment and a minimum of one fire extinguisher. » All mobile plant is to have a minimum of one fire extinguisher. » The site safety and hazard assessment process will guide how activities are managed during extreme or catastrophic fire danger events.	AGL Environment Manager / Project Coordinator
Bushfire	» The pre-construction site hazard assessment for new sites will be competed to determine risks associated with bushfire. » Formed access roads will be provided for exploration activities, where practicable. Where provided, vehicles will remain on designated roads and access tracks and adhere to signposted vehicle speed limits. This will prevent accidental fire ignition in tall grasses. » AGL will make available fire fighting equipment and capabilities such as (but not limited to) fire	AGL Environment Advisor / Land and Approvals Manager / Project Coordinator

Activity	Action	Responsibility
	extinguishers, fire blankets and small petrol-powered fire fighting pumps if the need is identified during the site hazard assessment.	

3.3. Activity or site-specific requirements

Exploration activities are required to undertake an environmental impact assessment (EIA) as part of the approval process. The EIA will contain site-specific management measures or commitments to minimise impacts on various environmental aspects. These commitments need to be implemented, in addition to any requirement in this EMP, in accordance with the relevant supporting documentation and/or conditions of the activity approval and be the responsibility of the Environment Manager, unless otherwise stated.

The EIA and approval documentation will be provided to any contractor and activity or site-specific management measures will be communicated to on-site personnel (including contractors, as required) prior to commencement of works by the Environment Manager (or nominated delegate) and may form part of the site induction process.

4. Monitoring and reporting

4.1. Monitoring requirements

Fire monitoring requirements include the following:

- The AGL Land and Approvals Manager (or delegate) will monitor weather conditions and local fire warnings through the following sources:
  - NSW Rural Fire Service website http://www.rfs.nsw.gov.au; and/or
  - NSW Rural Fire Service Information Line 1800 NSW RFS (1800 679 737).

4.2. Reporting requirements

An Incident and Complaints Report must be submitted to DTIRIS-DRE within 24 hours of any serious environmental incident, or breach of the PEL approval requirements regarding fire.

4.3. Records

The following records are to be kept in relation to fire for exploration activities:

- records of complaints related to fire; and
- records of any reports to authorities relating to fire incidents causing or threatening harm to the environment.

5. Administrative

5.1. Site specific plans

Currently not applicable.

5.2. Attachments/References

Refer to:

Emergency Response Plan

Health and Safety Management Plan – Gloucester Operations

5.3. Definitions

Currently not applicable.

5.4. Life Guard References

HSE Corporate Policy

AGL Life Guard Standard 19 – Environmental Aspects and Impacts

AGL Life Guard Compliance Guide 71 – Ecosystem Protection

A.5: Flood Management Sub Plan

GLOUCESTER GAS PROJECT

Exploration

FLOOD MANAGEMENT SUB PLAN

AGL Upstream Investments Pty Limited
April 2013

Document Control

Flood Management Sub Plan

Approval:

Authorising Officer	Mike Roy
Title	Head of Gas Operations
Signature	
Date	April 2013

Revision Status:

Revision	Date	Prepared By	Checked By	Approved By	Comments
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2	Head of Land and Approvals, Upstream Gas	Suzanne Westgate
3	Head of Exploration	Andrew Falkner
4	Project Coordinator	Chris Holmes
5	Acting Drilling Completions Manager	James Ashton
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8	Environment Manager	Aaron Clifton
9	Environmental Adviser	Brett Hayward
10	Health and Safety Manager	Alex Secerbegovic
11	AGL website	-
12	DTIRIS - DRE	Michael McFadyen

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List of Tables

1. Introduction

This Flood Management Sub Plan (FLMSP) has been prepared to supplement the Environmental Management Plan (EMP) for exploration activities within Petroleum Exploration Lease 285 (PEL 285).

The FLMSP has been developed to specifically address and manage potential flooding issues for exploration activities and associated construction. The FLMSP is designed to be read in conjunction with the Emergency Response Plan, which provides general measures in the event of a flooding emergency.

The FLMSP is based on the previously prepared and approved Environment, Health and Safety Management Plans and the current AGL Energy Life Guard System. More information is available in the EMP.

1.1. Objectives

The objectives of the FLMSP are to:

- control potential risks of floods while on site;
- prevent the escape of equipment, fluids and materials during a flood as a result of AGL's activities;
- prevent the transport of materials off site due to flood water; and
- protection of assets.

1.2. Targets

The target of the FLMSP is to have zero incidents or complaints received regarding flooding and AGL activities.

1.3. Responsibilities

Personnel responsible for implementing the requirements of this FLMSP are described below:

- the AGL Environment Manager (or delegate) is responsible for informing site personnel of the flood management procedures through the induction program;
- the AGL Environment Manager and Land and Approvals Manager are responsible for implementing site specific recommendations for flooding as required;
- the AGL Environment Manager, Land and Approvals Manager and Project Coordinator responsible for monitoring procedures and reporting as required;
- the Land and Approvals Manager is responsible for landowner consultation with assistance from the Community Relations Manager in addressing and managing incidents and complaints in relation to flooding; and
- All employees/ contractors are responsible for following the induction requirements that arise from their work activities onsite, so as to minimise the environmental impact.

1.4. Table of abbreviations

Table 1-1: Table of Abbreviations

Acronym	Definition
AGL	AGL Upstream Investments Pty Limited
EMP	Environmental Management Plan
EPA	NSW Environment Protection Authority
FLMSP	Flood Management Sub Plan
HSE	Health Safety and Environment System
PEL	Petroleum Exploration Lease
POEO Act	NSW Protection of the Environment Operations Act 1997
REF	Review of Environmental Factors

2. Requirements

2.1. Key licence conditions

Table 2-1 lists the key licence conditions in relation to flooding. Approval conditions from other activities are not listed here as they did not contain conditions specific to flooding.

Table 2-1: Key license conditions

Licence	Requirement
Petroleum Exploration Lease 285 (PEL 285)	» Operations must be carried out in a manner that does not cause or aggravate air pollution, water pollution, soil contamination or erosion. The licence holder must observe and perform any instructions given by the Director-General. » The licence holder must reinstate, as soon as practicable, any artificial or natural watercourse disrupted during seismic operations.
PEL 285 Waukivory Pilot Approval	» The works must be carried out at the location(s) and in accordance with the methods contained in: ▪ Review of Environmental Factors Proposed Exploration Wells, Waukivory dated March 2011 by AGL Upstream Investments. ▪ Letter from Toni Laurie, AGL Land and Approvals Manager, dated 1 August 2011 requesting that fracture stimulation not be considered at this time. ▪ Letter from David Kelly, AGL Head of Land and Approvals, dated 28 September 2011 concluding that the risk of adverse impacts to surface water, groundwater and soil will be minimal. » Any in-ground water storage facilities must be designed and managed to maintain sufficient freeboard to contain runoff and precipitation from a 1 in 20 year storm. » A NSW Office of Water hydrogeologist should be notified 28 days prior to commencement of drilling.
PEL 285 Gloucester 2013 Seismic Survey Program	» The activity must be carried out generally in accordance with the: ▪ Review of Environmental Factors for Gloucester Seismic Survey – PEL 285 – AGL Gloucester L E Pty Ltd submitted in September 2009; and, ▪ Condition of this approval.

2.2. Key legislative and regulatory requirements

Table 2-2 lists the applicable NSW and Commonwealth legislation and policies for the GGP in relation to flooding.

Table 2-2: Key legislative and regulatory requirements

Legislation / Policy	Relevance
NSW Protection of the Environment Operations Act 1997 (POEO Act)	» Under the POEO Act, it is an offence to wilfully or negligently cause any substance to leak, spill or otherwise escape (whether or not from a container) in a manner that harms or is likely to harm the environment. » The Environment Protection Authority (EPA) must be notified of pollution incidents causing or threatening material harm.

3. Management measures

3.1. Potential impacts

The activities with the potential to impact on flooding occur primarily during construction of well drilling compounds and access roads. The EMP contains further details of these activities. Potential flood sources are shown in Table 3-1.

Table 3-1: Flood sources

Flood Source	Cause
Rivers and streams	Excessive rainfall and stormwater events including snow and hail
Groundwater	Release of groundwater from artesian bores or pressurised aquifer systems.
Overland flow	Heavy rainfall
Blocked or overloaded drainage systems	Under capacity drainage during heavy rainfall or backing up of water from a blocked drainage point
Broken water mains	Breach of high pressure and/or high volume mains

3.2. General management measures

Table 3-2 summarises the measures to be implemented to manage potential flooding issues and outlines responsibilities for their implementation.

Table 3-2: Flood Management Measures

Action	Responsibility
A flooding risk assessment should be undertaken at all sites prior to work. Site specific management measures for high flooding risk sites will be reviewed by appropriately qualified professionals during the site planning process. Weather will be monitored and reasonable precautions are to be taken when flooding is predicted – see Table 4-1 for flooding monitoring information.	AGL Environmental Manager/ Land and Approvals Manager
A flood management procedure will be prepared, where required, as part of the development of an emergency response plan.	Project Coordinator
Safety standards will be maintained to reduce the risk of potential flooding events.	Project Coordinator / Land and Approvals Manager

3.3. Activity or site-specific requirements

Exploration activities are required to undertake an environmental impact assessment (EIA) as part of the approval process. The EIA will contain site-specific management measures or commitments to minimise impacts on various environmental aspects. These commitments need to be implemented, in addition to any requirement in this EMP, in accordance with the relevant supporting documentation and/or conditions of the activity approval and be the responsibility of the Environment Manager, unless otherwise stated.

The EIA and approval documentation will be provided to any contractor and activity or site-specific management measures will be communicated to on-site personnel (including contractors, as required) prior to commencement of works by the Environment Manager (or nominated delegate) and may form part of the site induction process.

4. Monitoring and reporting

4.1. Monitoring requirements

The AGL Land and Approvals Manager (or delegate) is responsible for monitoring flood risk and alerting site staff in the event of a flood. Flood risk can be monitored through the information sources provided in Table 4-1.

Table 4-1: Sources of flooding information

Flooding information	Source
Regional flood warnings	http://www.bom.gov.au/nsw/warnings
NSW daily river reports (Hunter region)	http://waterinfo.nsw.gov.au/hunter.shtml
Local weather	SMS alerts from Waukivory weather station

4.2. Reporting requirements

There are no reporting requirements for the FLMSP.

4.3. Records

Records to be kept for the FLMSP include:

- hazard assessment for new sites; and
- records of any reports to authorities relating to incidents causing or threatening to harm the environment as a result of flooding.

5. Administrative

5.1. Site-specific plans

Site specific management measures for high flooding risk sites will be prepared by appropriately qualified professionals during the site planning process.

5.2. Attachments/references

Refer to Emergency Response Plan

5.3. Definitions

Currently not applicable.

5.4. Life Guard References

HSE Corporate Policy

AGL Life Guard Standard 19 – Environmental Aspects and Impacts

AGL Life Guard Compliance Guide 71 – Ecosystem Protection

A.6: Flora and Fauna Management Sub Plan

GLOUCESTER GAS PROJECT

Exploration

FLORA AND FAUNA MANAGEMENT SUB PLAN

AGL Upstream Investments Pty Limited
April 2013

Document Control

Flora and Fauna Management Sub Plan

Approval:

Authorising Officer	Mike Roy
Title	Head of Gas Operations
Signature	
Date	April 2013

Revision Status:

Revision	Date	Prepared By	Checked By	Approved By	Comments
1	April 2013	EMGA Mitchell McLennan			

Controlled Document Distribution List:

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1. Introduction

This Flora and Fauna Management Sub Plan (FFMSP) has been prepared to supplement the Environmental Management Plan (EMP) for exploration activities within Petroleum Exploration Lease 285 (PEL 285).

The FFMSP has been developed to specifically address and manage potential flora and fauna issues for GGP exploration activities and associated construction.

The FFMSP is based on the previously prepared and approved Environment, Health and Safety Management Plans and the current AGL Energy Life Guard System. More information is available in the EMP.

1.1. Objectives

The objectives of the FFMSP are to:

- minimise the loss of remnant native vegetation; and
- minimise adverse impacts on fauna.

1.2. Targets

Targets have been set for the GGP, for both flora (Section 1.2.1) and fauna (Section 1.2.2). Key performance indicators (KPIs) have also been set for the GGP against which the targets will be measured (Section 1.2.3).

1.2.1. Flora targets

Flora targets for the GGP are to:

- avoid areas of remnant vegetation outside of the assessed construction footprint;
- establish a photographic record of the site prior to any clearing activities;
- minimise disturbance to native vegetation (including grasses and herbs); and
- reinstate disturbed work areas in a timely manner to a standard consistent with the surrounding area and/or as agreed with the landowner.

1.2.2. Fauna targets

Fauna targets for the GGP are to:

- minimise habitat disturbance;
- minimise physical harm to fauna; and
- monitor open trenches and drill pits on a daily basis for trapped fauna and that fauna escape methods are provided.

1.2.3. Key performance indicators (KPIs)

Flora and fauna KPIs for the GGP include:

- close-out of flora issues within two weeks;

- zero complaints from landowners relating to native vegetation disturbance; and
- no injured fauna.

1.3. Responsibilities

Personnel responsible for implementing the requirements of this FFMSP are described below:

- the Environment Manager (or delegate) is responsible for informing site personnel of the flora and fauna management procedures through the induction program;
- the Environment Manager is responsible for implementing site specific recommendations such as fencing off sensitive areas of vegetation as required;
- the Environment Manager, Land and Approvals Manager and Project Coordinator are responsible for monitoring procedures and reporting as required;
- the Land and Approvals Manager is responsible for landowner consultation with assistance from the Community Relations Manager in addressing and managing incidents and complaints in relation to flora and fauna; and
- all employees/ contractors are responsible for following the induction requirements that arise from their work activities onsite, so as to minimise the environmental impact.

1.4. Table of abbreviations

Table 1-1: Table of Abbreviations

Acronym	Definition
AGL	AGL Upstream Investments Pty Limited
DBH	Diameter at Breast Height
DSEWPaC	Commonwealth Department of Sustainability, Environment, Water, Populations and Communities
DTIRIS-DRE	NSW Department of Trade and Investment, Regional Infrastructure and Services NSW (Division of Resources and Energy)
EEC	Endangered Ecological Community
EP&A Act	NSW Environmental Planning and Assessment Act 1979
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
EMM	EMGA Mitchell McLennan
EMP	Environmental Management Plan
FFMSP	Flora and Fauna Management Sub Plan
KPI	Key Performance Indicator
LCA	Local Control Authorities
NES	National Environmental Significance
NV Act	NSW Native Vegetation Act 2003

Acronym	Definition
PEL	Petroleum Exploration Lease
REF	Review of Environmental Factors
TSC Act	NSW Threatened Species Conservation Act 1995

2. Requirements

2.1. Key licence conditions

Table 2-1 summarises the key licence conditions in relation to flora and fauna management.

Table 2-1: Key licence conditions

Licence	Requirement
PEL 285	» The licence holder must not cut, destroy, ringbark or remove any timber or other vegetative cover on any land subject of this licence except such as directly obstructs or prevents the carrying on of operations. Any clearing not authorised under the *Petroleum (Onshore) Act 1991*, must comply with the provisions of the *Native Vegetation Act 2003*. The licence holder must have any necessary licence from the Department before using timber from any Crown land within the licence area. » The licence holder must cause as little disturbance as possible of the vegetation and topsoil in carrying out seismic surveys. In particular when a seismic line is prepared, disturbance of the vegetation and the topsoil along the seismic line should not exceed four and a half metres in width without the prior approval of the Director General and subject to any conditions he may stipulate.
PEL285 Gloucester 2D Seismic Survey	» Activities must be carried out generally in accordance with the Review of Environmental Factors for the Gloucester 2D Seismic Survey submitted by the licence holder on the 15th September 2009.

Approval conditions from other activities are not listed above as they did not contain conditions specific to flora and fauna.

2.2. Key legislative and regulatory requirements

Table 2-2 lists the applicable NSW and Commonwealth legislation and policies.

Table 2-2: Key legislative and regulatory requirements

Legislation / Policy	Relevance
NSW Environmental Planning and Assessment Act 1979 (EP&A Act)	The EP&A Act and Regulation include provisions to ensure that proposals which have the potential to impact the environment are subject to detailed assessment. Section 5A of the EP&A Act provides specific provisions for determining whether proposed developments and activities will have a significant impact on threatened species, populations or ecological communities, or their habitats.

Legislation / Policy	Relevance
NSW *Threatened Species Conservation Act 1995* (TSC Act)	The objectives of the TSC Act are to prevent the extinction and promote the recovery of threatened species, populations, ecological communities and critical habitat in NSW. The schedules of the TSC Act provide lists of species, populations and ecological communities that are endangered, vulnerable or extinct. Actions that may impact on threatened species, populations and ecological communities must be properly assessed. TSC Act threatened species, populations and communities with potential to occur within the PEL 285 area include, but are not limited to: » Grey-crowned Babbler (*Pomatostomus temporalis temporalis*); » Barred Cuckoo-shrike (*Coracina lineata*) » Turquoise Parrot (*Neophema pulchella*) » Scarlet Robin (*Petroica boodang*) » Varied Sitella (*Daphoenositta chrysoptera*) » Speckled Warbler (*Chthonicola saggitata*); » Eastern Bentwing Bat (*Miniopterus schreibersii oceanensis*); » Eastern False Pipistrelle (*Falsistrellus tasmaniensis*); and » Eastern Freetail Bat (*Mormopterus norfolkensis*).
NSW *Noxious Weeds Act 1993* (NW Act) ***Note - Weed Management is addressed in the Rehabilitation and Landscape Management Plan***	In NSW, the NW Act is applicable to the notification and classification of noxious weeds. While the act is administered by the NSW Department of Primary Industries as divisions of the Department of Trade and Investment, Regional Infrastructure and Services, Local Control Authorities (LCA) are responsible for implementing the act on private land, usually the local council. The following species are present on the site and are listed under the NW Act: » Lantana (*Lantana camara)* » Camphor Laurel (*Cinnamomum camphora*); » Small-leaved Privet (*Ligustrum sinense)*; and » Large-leaved Privet *(Ligustrum lucidum)*
NSW *Native Vegetation Act 2003* (NV Act)	In NSW, the NV Act states that clearing of native vegetation (outside urban zonings) must be carried out in accordance with a development consent or a property vegetation plan (section 12(1)), unless it is permitted clearing or activities listed as excluded clearing. The Act does not apply in a number of circumstances related exploration activities within PEL 285; including, for example, if the clearing is carried out in accordance with a determination under Part 5 of the EP&A Act, or is carried out on Excluded Land.
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	The EPBC Act sets out the requirements for the approval of the Commonwealth Minister for the Department of Sustainability, Environment, Water, Populations and Communities (DSEWPaC) for actions that may have a significant impact on matters of National Environmental Significance (NES). Matters of NES include wetlands of national importance; Commonwealth listed threatened species, threatened ecological communities and migratory species.

3. Management measures

3.1. Potential impacts

The activities with the potential to impact on flora and fauna occur primarily during construction of well drilling compounds and access roads. Refer to the EMP for further details of these activities.

Where possible, construction activities are located in previously cleared or disturbed areas. Ecological assessments have been undertaken in these areas (Section 4.3) to determine the likely level of impact.

Potential environmental impacts can include:

- direct disturbance or removal of native flora, fauna and EECs; and
- direct disturbance to habitat including clearing of native vegetation, particularly hollow bearing trees, removal of logs and leaf litter and allowing contaminated runoff to enter water bodies; and
- indirect disturbance to native flora and fauna habitats through weed invasion and degradation of waterways.

Areas not assessed and approved for disturbance will not be disturbed during exploration activities. Where specific requirements are outlined in an approval regarding flora and fauna management prior to and/or during activities, the FFMSP will be updated accordingly.

3.2. General management measures

The flora and fauna management strategies in Table 3-1 generally apply to the construction activities. As stated in the EMP, issues during the remainder of the life of exploration activities including weeds and rehabilitation are addressed in the Landscape and Rehabilitation Management Sub Plan.

Table 3-1 summarises the general measures to be implemented to manage potential flora and fauna issues and outlines responsibilities for their implementation.

Table 3-1: Flora and fauna management measures

Activity	Action	Responsibility
General	» The AGL Employee and Contractor Induction shall inform all site personnel about flora and fauna management measures and the designated work areas and access routes.	Environment Manager (or delegate)
	» Potential impacts of vegetation clearing will be considered in the siting and placement of exploration activity infrastructure.	Environment Manager/ Land and Approvals Manager/ Project Coordinator
	» Preference will be given to disturbed areas in determining routes for gas gathering lines. The AGL Biodiversity Register should be used for guidance during site planning and site selection.	Environment Manager / Project Coordinator/ Land and Approvals Manager

Activity	Action	Responsibility
Access	» All construction and maintenance activities shall be restricted to the well compound area and designated access routes. » All vehicles shall obey speed limits and remain on designated vehicle tracks and in designated work areas.	Environment Manager / Project Coordinator
Construction	» The site design and layout process will determine which trees / vegetation to clear to minimise disturbance. » Where required, site specific management activities may be required as part of the approval conditions for some exploration activities. These site specific management activities may include pre-clearance surveys, demarcation of sensitive vegetation not to be disturbed etc. In these instances, the construction crews will be informed of the requirements of the approval during the induction process. » Significant habitat areas will be designated as 'no-go' areas to construction staff and vehicles. » Works shall not be undertaken within 2 m of the drip line of native trees to be retained. » The Environment Manager and Land and Approvals Manager will be notified in the event that damage occurs to vegetation outside of the designated work area. » All open trenches shall be checked daily for trapped animals, and those found shall be removed, recorded and relocated to appropriate areas away from construction activities by appropriately experienced and/or qualified personnel. » Trenches shall generally not be left open overnight on public land. Where this is necessary, fauna escape methods, such as ramps at either end of a trench will be provided; and » Any noxious weed material cleared shall be disposed of at a facility licensed to receive green waste.	Environment Manager / Project Coordinator/ Land and Approvals Manager
Stockpiles	» Cleared vegetation shall be either spread on adjacent vegetated areas or stockpiled so as not to impede vehicles, stock or wildlife, surface drainage or water flows and to avoid damage to adjacent live vegetation. » Cleared vegetation shall be stockpiled separately for subsequent re-spreading within the compound during site rehabilitation.	Environment Manager / Project Coordinator

3.3. Activity or site-specific requirements

Exploration activities are required to undertake an environmental impact assessment (EIA) as part of the approval process. The EIA will contain site-specific management measures or commitments to minimise impacts on various environmental aspects. These commitments need to be implemented, in addition to any requirement in this EMP, in accordance with the relevant supporting documentation and/or conditions of the activity approval and be the responsibility of the Environment Manager, unless otherwise stated.

The EIA and approval documentation will be provided to any contractor and activity or site-specific management measures will be communicated to on-site personnel (including contractors, as required) prior to commencement of works by the Environment Manager (or nominated delegate) and may form part of the site induction process.

4. Monitoring and reporting

4.1. Monitoring requirements

Flora and fauna monitoring requirements for GGP include the following:

- the Environment Manager (or delegate) will establish a photographic record of work areas prior to any clearing activities;
- the Environment Manager will ensure any vegetation clearance is carried out in accordance with the environmental impact assessment and relevant approval conditions; and
- the Environment Manager, Project Coordinator and contractors will check open trenches and drill pits daily for trapped fauna and provide fauna escape methods (ie plank of wood installed from open pit floor up to normal ground level).

4.2. Reporting requirements

Flora and fauna reporting requirements include the following:

- inspection checklists completed by the Environment Manager, Project Coordinator, or Land and Approvals Manager; and
- records of complaints and incidents relating to flora and fauna. OEH must be notified in the event of an incident relating to flora and fauna.

5. Administrative

5.1. Site specific plans

Site specific flora and fauna information will be provided as part of the induction program.

5.2. Attachments

Currently not applicable.

5.3. Definitions

Currently not applicable.

5.4. Life Guard references

HSE Corporate Policy

AGL Life Guard Standard 19 – Environmental Aspects and Impacts

AGL Life Guard Compliance Guide 71 – Ecosystem Protection

A.7: Landscape and Rehabilitation Management Sub Plan

GLOUCESTER GAS PROJECT

Exploration

REHABILITATION & LANDSCAPE MANAGEMENT SUB PLAN

AGL Upstream Gas Investments Pty Limited
April 2013

Document Control

Rehabilitation & Landscape Management Sub Plan

Approval:

Authorising Officer	Mike Roy
Title	Head of Gas Operations
Signature	
Date	April 2013

Revision Status:

Revision	Date	Prepared By	Checked By	Approved By	Comments
1	April 2013	EMGA Mitchell McLennan			

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1. Introduction

This Rehabilitation and Landscape Management Sub Plan (RLMSP) has been prepared to supplement the Environmental Management Plan (EMP) for exploration activities within Petroleum Exploration Lease 285 (PEL 285).

The RLMSP has been developed to specifically address and manage potential environmental issues during rehabilitation in the short and long term up to final closure.

This Sub Plan has also been designed to meet the requirements for the preparation of a Weed Management Plan and management of visual issues and landscaping.

It is based on the previously prepared and approved Environment Health and Safety Management Plans and the AGL Energy Life Guard System. More information is available in the EMP.

1.1. Objectives

The overall objectives of the RLMSP are to:

- minimise and manage potential rehabilitation and landscape issues; and
- return the land to a pre-operations state (or better) in line with the relevant consent conditions and in consultation with the relevant landowner.

Specific objectives of the RLMSP are shown in Table 1-1.

Table 1-1: Specific objectives of the RLMSP

Category	Objectives
General	» Carry out rehabilitation activities promptly to promote vegetation regrowth in all disturbed work areas to a standard consistent with the surrounding area; and » ensure that the compound area remains free of weeds.
Flora	» To monitor and maintain vegetation cover to ensure that it is consistent with the surrounding environment in consultation with the landowner.
Noxious weeds, pathogens and pest species	» Prevent the introduction and dispersal of noxious weeds, pathogens and pest species; » appropriately control the introduction and spread of weeds, pathogens and pest species; and » ensure that all interstate vehicles are appropriately checked and cleaned prior to site access.
Visual amenity	» Minimise visual impacts from operations activities in consultation with the relevant landowner; and » maintain visual impacts at an acceptable level.

1.2. Key performance indicators and targets

Key performance indicators in relation to rehabilitation and landscape include:

- close out of issues within two weeks;
- zero complaints from landowners relating to vegetation cover or weed growth; and
- zero complaints received from local residents relating to visual impacts.

1.3. Responsibilities

Personnel responsible for implementing the requirements of this Sub Plan are described below:

- the AGL Environment Manager (or delegate) is responsible for informing site personnel of the rehabilitation management procedures through the induction program;
- the AGL Environment Manager, Project Coordinator and Land and Approvals Manager are responsible for implementing site specific recommendations as required;
- the AGL Environment Manager, Project Coordinator and Land and Approvals Manager are responsible for monitoring procedures and reporting as required;
- the Land and Approvals Manager is responsible for landowner consultation with assistance from the Community Relations Manager in addressing and managing incidents and complaints; and
- all employees/ contractors are responsible for following the induction requirements that arise from their work activities onsite, so as to minimise the environmental impact.

1.4. Table of abbreviations

Table 1-2: Table of Abbreviations

Acronym	Definition
AGL	AGL Upstream Investments Pty Limited
DTIRIS-DRE	NSW Department of Trade and Investment, Regional Infrastructure and Services (Division of Resources and Energy)
EP&A Act	NSW Environmental Planning and Assessment Act 1979
EMP	Environmental Management Plan
KPI	Key Performance Indicator
NW Act	NSW Noxious Weeds Act 1993
OEH	NSW Office of Environment and Heritage
PEL	Petroleum Exploration Lease
REF	Review of Environmental Factors
RLMSP	Rehabilitation and Landscape Management Sub Plan

2. Approval requirements

2.1. Key licence requirements / conditions of approval

Table 2-1 provides the key licence requirements and conditions of approval in relation to rehabilitation and landscape management. Approval conditions from other activities are not listed above as they did not contain conditions specific to rehabilitation and landscaping.

Table 2-1: Key licence requirements / conditions of approval

Reference	Requirement/Condition
Petroleum Exploration Lease 285 (PEL 285)	» Land disturbed must be rehabilitated to a stable and permanent form suitable for a subsequent land use acceptable to the Director-General so that: ▪ There is no adverse environmental effect outside the disturbed area and that the land is properly drained and protected from soil erosion. ▪ The state of the land is compatible with the surrounding land and land use requirements. ▪ The landforms, soils, hydrology and flora require no greater maintenance in the longer term than that in the surrounding land. ▪ If vegetation is to be re-established the vegetation must be appropriate to the area and at an acceptable density. If the vegetation is to include native vegetation, local indigenous species must be used in revegetation programs, unless otherwise directed. ▪ The land does not pose a threat to public safety. » Any topsoil that is removed must be stored and maintained in a manner acceptable to the Director-General. » An Environmental and Rehabilitation Report must be submitted to the department as follows: ▪ The reports must be prepared according to Departmental requirements for environmental and rehabilitation reporting on exploration licences. ▪ The reports must be lodged within one month of expiry or earlier termination of the licence or whenever part of the licence ceases to have effect. ▪ The reports must be prepared to the satisfaction of the Department and include information on all surface disturbing prospecting operations and rehabilitation carried out in the licence area or in the part of the licence that has ceased to have effect. » An Incident and Complaints Report must be submitted to the Department as follows: ▪ The report is to be submitted within 24 hours of any serious environmental incident, breach of Conditions 1 to 27 or breach of other environmental regulations, or a serious complaint from landholders or the public. ▪ The report must include the details of the exploration licence, contact details of the exploration manager, complainant and landholder, a map showing the area of concern, the nature of the incident or complaint, likely causes and consequences, and a timetable showing actions taken or planned to fix the problem. ▪ Details of all incidents or complaints occurring whilst the licence is in force must be included in reports prepared in accordance with Condition 23.

Reference	Requirement / Condition
PEL 285 Waukivory Pilot Approval	» The works must be carried out at the location(s) and in accordance with the methods contained in: ▪ Review of Environmental Factors Proposed Exploration Wells, Waukivory dated March 2011 by AGL Upstream Investments. ▪ Letter from Toni Laurie, AGL Land and Approvals Manager, dated 1 August 2011 requesting that fracture stimulation not be considered at this time. ▪ Letter from David Kelly, AGL Head of Land and Approvals, dated 28 September 2011 concluding that the risk of adverse impacts to surface water, groundwater and soil will be minimal. » All pits and sumps constructed for the containment of fluids and cuttings are to be lined with an impermeable liner to prevent leakage and contamination to soil, surface water or groundwater. At the completion of drilling operations, all liners, drill cuttings and waste are to be removed to a licensed facility.
PEL 285 Gloucester 2013 Seismic Survey Program	» The activity must be carried out generally in accordance with the: ▪ Review of Environmental Factors for Gloucester Seismic Survey – PEL 285 – AGL Gloucester L E Pty Ltd submitted in September 2009; and, ▪ Condition of this approval.
PEL 285 Approval to fracture stimulate coal seam methane exploration wells Weismantel 3, Faulkland 3 and Craven 6	» Within 3 years from the date of this approval, the well (s) subject to this approval must either: » a) be completed and fully rehabilitated; or » b) a Development Application for consent under the EP&A Act must be lodged for conversion of the exploration well(s) to production well(s). » At the completion of well testing, and prior to abandonment of the well, any steel casing must be removed from the vertical interval (s) encompassing all potentially mineable coal seams. Alternatively, glass-reinforced expoxy casing may be used across mineable coal seams subject to separate written approval of the Department. » Downhole logging and/or imaging of a quality acceptable to the Department must be used to confirm the removal or absence of steel casing through potentially mineable coal seams. All logs and information pertinent to this condition must be provided to the Department. Abandonment of the well must not proceed until written confirmation is received from the Department confirming that this condition has not been satisfied. » A rehabilitation report must be provided to the Department within two months of well abandonment for all surface and underground disturbance arising from activities subject to this approval.
PEL285: Approval to drill, test and fracture stimulate coal seam gas exploration wells Waukivory 3, Waukivory 4, Stratford 7, Stratford 10 and Faulkland 2	» The titleholder must maintain access roads to any sites subject to this approval in a condition satisfactory to the Department and landholder requirements » Within 3 years from the date of this approval, the well (s) subject to this approval must either: » a) be completed and fully rehabilitated; or » b) a Development Application for consent under the EP&A Act must be lodged for conversion of the exploration well(s) to production well(s). » At the completion of well testing, and prior to abandonment of the well, any steel casing must be removed from the vertical interval (s) encompassing all potentially mineable coal seams. Alternatively, glass-reinforced expoxy casing may be used across mineable coal seams subject to separate written approval of the Department. » Downhole logging and/or imaging of a quality acceptable to the Department must be used to confirm the removal or absence of steel casing through potentially mineable coal seams. All logs and information pertinent to this condition must be provided to the Department. Abandonment of the well must not proceed until written confirmation is received from the Department confirming that this condition has not been satisfied. »

Reference	Requirement / Condition
PEL285: Approval to drill, fracture stimulate, dewater and flow test coal seam methane exploration core holes LMG03, LMG04, LMG05, LMG06, LMG08 and Optional Well	» At the completion of well testing, and prior to abandonment of the well, any steel casing must be removed from the vertical interval (s) encompassing all potentially mineable coal seams. Alternatively, glass-reinforced expoxy casing may be used across may be used across mineable coal seams subject to separate written approval of the Department. » Downhole logging and/or imaging of a quality acceptable to the Department must be used to confirm the removal or absence of steel casing through potentially mineable coal seams. All logs and information pertinent to this condition must be provided to the Department. Abandonment of the well must not proceed until written confirmation is received from the Department confirming that this condition has been satisfied.

2.2. Key legislative and regulatory requirements

Table 2-2 lists the applicable NSW and Commonwealth legislation and policies for the GGP.

Table 2-2: Key legislative requirements

Legislation / Policy	Relevance
NSW *Environmental Planning and Assessment Act 1979* (EP&A Act)	The EP&A Act and its Regulation include provisions to ensure that proposals which have the potential to impact the environment are subject to detailed assessment.
NSW *Noxious Weeds Act 1993* (NW Act)	In NSW, the NW Act is applicable to the notification and classification of noxious weeds. While the act is administered by Primary Industries (Agriculture), local control authorities are responsible for implementing the NW Act on private land, which are usually the local council. The following species are present on the site and are listed under the NW Act: » Lantana (Lantana camara)

3. Management

3.1. Rehabilitation overview

Rehabilitation will be undertaken on land disturbed by AGL activities (ie wells, gas gathering lines, drill sites and pits). The overall objective of undertaking rehabilitation at each disturbed location is to return the land to pre-operational land use and condition or better.

Rehabilitation is generally undertaken in two stages:

- initial rehabilitation:
  - rehabilitation of the surplus construction area following the completion of drilling; and
  - upon completion of gas gathering line construction activities.
- final rehabilitation:
  - at the plug and abandonment of the exploration hole, all disturbed areas will be rehabilitated to pre-existing use and condition, or better, as agreed with the landholder.

The rehabilitation requirements for each location will be determined in accordance with the landowner, the agreement between the landowner, AGL and conditions of approval for the activity. The surrounding land uses and options to minimise environmental impact would also be taken into consideration.

Prior to suspending or abandoning exploration holes AGL would seek approval through DTIRIS-DRE by providing information in accordance with section 521 of the Schedule of Onshore Petroleum Exploration Safety Requirements.

3.1.1. Initial rehabilitation

Wells

Exploration holes have the option at completion of drilling activities to be cement, plugged and abandoned or capped and suspended for future works, pending drilling results, in accordance with DTIRIS-DRE requirements and the Onshore Petroleum Exploration and Production Safety Requirements.

For in initial rehabilitation, exploration holes are capped and suspended in line with industry requirements. Once the drilling and testing activities are complete, the surplus compound areas will be partly rehabilitated, by emptying and backfilling pits (if any) and rehabilitating any disturbed areas outside compound areas. The upgraded access tracks will be maintained for access throughout the property and appropriate erosion and sedimentation control measures will be maintained.

All rehabilitation works would be undertaken with maximum regard to environmental protection and rehabilitation, vegetation, subsoil and topsoil management, weed control, erosion and sedimentation management and revegetated.

Variations to this rehabilitation process may be required subject to site constraints, new technical information or to fit with future land uses. Screening is generally provided where appropriate using vegetation sourced from the local area including drought tolerant species endemic to the local area.

Gas gathering lines

Excavation of a trench will be required in the event that gas gathering lines are used for the GGP. Trenches will generally be backfilled and compacted on the day of the excavation.

3.1.2. Closure and final rehabilitation

Upon completion of gas flow testing operations, closure of the wells, and rehabilitation of the well sites will be undertaken. The wellhead will either be plugged and abandoned or capped and suspended, pending approvals for future production.

The final rehabilitation works would typically include:

- sealing/ plugging and abandonment of wells in accordance with DRE Borehole Sealing guidelines and the PEL conditions;
- removing plant and equipment from wellheads and removal of fenced compounds;
- filling in excavation; and
- rehabilitation, contouring, and revegetation of all disturbed areas.

3.2. Management measures

The rehabilitation and landscape management strategies in Table 3-2 generally apply after the exploration activities are finished. They are designed to meet and fit in with site specific recommendations from the various environmental impact assessment documentation and consents/approvals for exploration activities.

It should be noted that the measures outlined in Table 3-2 relating to weed management have been included in this RLMSP to guide the preparation of a Weed Management Plan for the GGP.

Table 3-2 summarises the measures to be implemented to manage potential rehabilitation and landscape issues and outlines responsibilities for their implementation.

Table 3-2: Rehabilitation and landscape management measures

Activity	Action	Responsibility
General	» The rehabilitation requirements for each exploration site will be in accordance with the terms of access agreement between the landowner and the company and the approval conditions. » The site specific Induction shall inform all employees and contractors about rehabilitation management measures, control procedures for weeds, pathogens and pest species and the designated work areas and access routes and procedures.	Environment Manager / Land & Approvals Manager
Access roads	» All activities will be restricted to the compound area and designated access routes (where possible).	Environment Manager / Land & Approvals Manager
Visibility (construction)	» For exploration sites where residents may be exposed to extended periods of uninterrupted views during work, the installation of green mesh or other appropriate fencing around the construction compound should be considered.	Environment Manager / Project Coordinator

Activity	Action	Responsibility
Initial rehabilitation	» All waste materials and equipment shall be removed from the area once backfilling and tie-ins are completed. » Topsoil and vegetation material shall be re-spread in the immediate vicinity of the area of origin to limit the potential spread of weeds and pathogens. » Waste management shall be implemented to avoid attracting vertebrate pests (see Waste Management Sub Plan). » Sediment control measures shall be implemented where necessary to prevent erosion manage sedimentation. (See Soil and Water Management Sub Plan). » Disturbed areas will be graded to reinstate pre-existing surface contours and natural drainage patterns. » All fences which were cut and replaced by gates during activities shall be repaired to at least the equivalent pre-operations condition, unless permanent gates or other arrangements are agreed with the landholder. » Initial rehabilitation of the exploration compound is to be consistent with the established character of surrounding land. » All flagging and bunding installed for environmental or safety reasons shall be removed.	Environment Manager / Project Coordinator
Stockpiles	» Cleared vegetation shall be stockpiled separately for subsequent re-spreading within the compound during site rehabilitation. » Disturbed areas shall be reinstated as soon as practicable.	Environment Manager / Project Coordinator
Weeds and pathogens	» All vehicles and portable infrastructure from interstate will be in a clean state free from soil and vegetation prior to entering the site » Exploration drilling sites, restored access tracks and water and gas gathering line routes shall be inspected following the completion of rehabilitation, for evidence of soil settlement, weeds and pest animals. » Active weed control and monitoring shall be required at sites identified as infested. » Herbicides are to be used to kill noxious weeds. Drift, drip or run-off to surface waters or non-target species is to be avoided. Personnel using herbicides are to be appropriately trained and qualified.	Environment Manager / Project Coordinator

Activity	Action	Responsibility
Final rehabilitation	» Earthworks, vegetation clearing and soil disturbance would be limited to the construction and operational footprint as appropriate. » Upgraded access tracks and their associated erosion and sediment controls will be maintained during exploration activities. » Exploration holes will be capped and suspended in line with DTIRIS-DRE requirements if not intended for future use. » Surplus compound areas will be partly rehabilitated at the completion of drilling and testing activities. This includes emptying and backfilling pits (if any) and rehabilitating any disturbed areas outside the compound. » All plant and equipment (e.g. portable toilets), tanks and fenced compounds will be removed. » Silt fences and other environmental controls will be removed. » Excavated areas will be filled in, including diversion drains. » Displaced soil would be contained in a designated bunded area for use as backfill. » Soil that has become contaminated through contact with fuels or lubricants will be removed from site and disposed of at a licensed facility. » Rehabilitation, contouring and revegetation will be undertaken (if required) as soon as practicable after completion. » Revegetation will include species agreed to by the landowner. » In the case of capped and suspended works, the area will be revegetated as soon as practicable to avoid potential environmental issues.	Environment Manager / Land and Approvals Manager / Project Coordinator

3.3. Activity or site-specific requirements

Exploration activities are required to undertake an environmental impact assessment (EIA) as part of the approval process. The EIA will contain site-specific management measures or commitments to minimise impacts on various environmental aspects. These commitments need to be implemented, in addition to any requirement in this EMP, in accordance with the relevant supporting documentation and/or conditions of the activity approval and be the responsibility of the Environment Manager, unless otherwise stated.

The EIA and approval documentation will be provided to any contractor and activity or site-specific management measures will be communicated to on-site personnel (including contractors, as required) prior to commencement of works by the Environment Manager (or nominated delegate) and may form part of the site induction process.

4. Monitoring and reporting

4.1. Monitoring requirements

Rehabilitation and landscape monitoring requirements for GGP include the following:

- Photographic records of disturbed areas during the rehabilitation period as appropriate.
- Completion of a rehabilitation and relinquishment report for each exploration site.

4.2. Reporting requirements

A rehabilitation and relinquishment report (including a plug and abandonment report) and statutory declaration will be prepared and submitted to the DTIRIS-DRE after completion of well plug, abandonment and surface rehabilitation of the well sites and containment dam.

4.3. Records

Landscape and rehabilitation records to be maintained by AGL include:

- Records of incidents relating to landscaping and rehabilitation.
- Photographic records of disturbed areas during the rehabilitation period as appropriate; and
- Completion of a rehabilitation and relinquishment report for each exploration site.

5. Administrative

5.1. Site specific plans

Site-specific information will be provided as part of the Site Specific Induction.

5.2. Attachments

Rehabilitation plans will be attached as they are developed.

5.3. Definitions

Currently not applicable

5.4. Life Guard references

HSE Corporate Policy

AGL Life Guard Standard 19 – Environmental Aspects and Impacts

A.8: Traffic and Access Management Sub Plan

GLOUCESTER GAS PROJECT

Exploration

TRAFFIC AND ACCESS MANAGEMENT SUB PLAN

AGL Upstream Gas Investments Pty Ltd

April 2013

Document Control

Traffic and Access Management Sub Plan

Approval:

Authorising Officer	Mike Roy
Title	Head of Gas Operations
Signature	
Date	April 2013

Revision Status:

Revision	Date	Prepared By	Checked By	Approved By	Comments
1	April 2013	EMGA Mitchell McLennan			

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1. Introduction

This Traffic and Access Management Sub Plan (TMSP) has been prepared to supplement the Environmental Management Plan (EMP) for exploration activities within Petroleum Exploration Lease 285 (PEL 285).

The TMSP has been developed to specifically address and manage potential traffic issues within the road reserve and on public roads for exploration activities, in line with the requirements of relevant leases and approvals. This TMSP outlines protocols, procedures and management measures for implementation to mitigate and minimise potential traffic impacts on the community and environment during activities.

It is based on the current AGL Energy Life Guard System and more information is available in the EMP.

1.1. Objective

To outline traffic and access management measures for site-establishment and exploration activities and to minimise potential traffic impacts on public roads.

1.2. Target

Zero incidents or complaints received regarding traffic disruption or environmental impact.

1.3. Responsibilities

Personnel responsible for implementing this TMSP include the following:

- the Land and Approvals Manager and Project Coordinator (or delegate) are responsible for liaising with Roads and Maritime Services (RMS) and/ or Council regarding works with the potential to impact upon traffic flows on a public road;
- the AGL Environment Manager (or delegate) is responsible for informing site personnel of the required procedures and protocols for traffic and access management via an induction program;
- the AGL Environment Manager, Project Coordinator and Land and Approvals Manager are responsible for monitoring compliance with this TMSP and site-specific requirements;
- the Land and Approvals Manager is responsible for landowner consultation with assistance from the Community Relations Manager in addressing and managing public enquiries in relation to traffic movements and access arrangements; and
- all employees and contractors are responsible for working in a manner which minimises potential traffic impacts on community safety and the environment.

1.4. Abbreviations

Table 1-1: Table of Abbreviations

Acronym	Definition
AGL	AGL Upstream Investments Pty Limited
DPI	NSW Department of Primary Industries
DTIRIS-DRE	NSW Department of Trade and Investment, Regional Infrastructure and Services (Division of Resources and Energy)
EMP	Environmental Management Plan
EP&A Act	Environmental Planning and Assessment Act 1979
HSE	Health Safety and Environment System
OEH	NSW Office of Environment and Heritage
PEL	Petroleum Exploration Lease
POEO Act	NSW Protection of the Environment Operations Act 1997
REF	Review of Environmental Factors
RMS	NSW Roads and Maritime Services
Roads Act	Roads Act 1993
TMSP	Traffic and Access Management Sub Plan

2. Requirements

Table 2-1 lists the key licence and approval requirements for exploration activities in relation to traffic. Approval conditions from other activities are not listed below as they did not contain conditions specific to traffic management.

2.1. Key licence / approval requirements

Table 2-1: Summary of key licence / approval requirements

Reference	Requirement
Petroleum Exploration Lease 285 (PEL 285)	» Operations must not affect any road or track unless with the prior written approval of the Director-General and subject to any conditions stipulated. » The licence holder must pay the local council, the Crown Land Division of the Department of Primary Industries (DPI) (formerly part of the Department of Lands) or RMS the costs incurred in fixing any damage to roads caused by the operations carried out under the licence. » Access tracks must be kept to a minimum and positioned so that they do not cause any unnecessary damage to the land. Temporary access tracks must be ripped, topsoiled and revegetated as soon as possible after they are no longer required for prospecting operations. The design and construction of access tracks must be in accordance with specifications of the Department of Climate Change and Environment (now Office of Environment and Heritage (OEH)). If imported topsoil is to be used on access tracks the source of the topsoil must be approved by an environmental officer. » The use of any road or track must be restricted during wet weather to prevent damage to such road or track.
PEL 285 Waukivory Pilot Approval	» The works must be carried out at the location(s) and in accordance with the methods contained in: ▪ Review of Environmental Factors Proposed Exploration Wells, Waukivory dated March 2011 by AGL Upstream Investments. ▪ Letter from Toni Laurie, AGL Land and Approvals Manager, dated 1 August 2011 requesting that fracture stimulation not be considered at this time. ▪ Letter from David Kelly, AGL Head of Land and Approvals, dated 28 September 2011 concluding that the risk of adverse impacts to surface water, groundwater and soil will be minimal.

Reference	Requirement
PEL 285 Gloucester 2D Seismic Survey Program	» The activity must be carried out generally in accordance with the: ▪ Review of Environmental Factors for Gloucester 2D Seismic Survey – PEL 285 – AGL Gloucester L E Pty Ltd submitted in September 2009; and, ▪ Conditions of this approval.
PEL285: Approval to fracture stimulate coal seam methane exploration wells Weismantel 3, Faulkland 3 and Craven 6	» The titleholder must maintain access roads to any sites subject to this approval in a condition satisfactory to the Department and landholder requirements

2.2. Key legislative and regulatory requirements

All activities carried out on-site shall comply with all relevant legislation, regulations and guidelines. These include but are not limited to the legislation described in Table 2-2.

Table 2-2: Key statutory requirements for the GGP

Act	Statutory requirements
Environmental Planning and Assessment Act 1979 (EP&A Act)	» Requires consideration of the environmental impacts of a proposed development, including those related to traffic and access.
Roads Act 1993 (Roads Act)	» Section 138 requires that any works on or over a public road or connection to a public road require consent from the appropriate roads authority. » Other requirements include Australian Standard AS 1742.3 and the RMS' "Traffic Control at Work Sites" manual.
Road Transport (Vehicle Registration) Regulation 2007	» Limits the overall size (width, height and length) and some internal dimensions of vehicles to ensure that they have adequate manoeuvrability and that they are compatible with road systems and other traffic. A permit is required from the RMS to exceed dimensions if the length, rear overhang, forward projection, width or height of a vehicle exceeds the limits allowed by the Regulation.
RTA Vehicle Standards Information Sheet No. 5 – Vehicle Dimension Limits	» Sets out the limits for vehicle length, height and width, ground clearance, projecting loads and equipment, loading space, rear overhang, turning circle and axle groups and suspension systems.

3. Management measures

3.1. Overview

The activities of the project involve the use of public roads for delivery and disposal of equipment and materials (inclusive of water) to and from the site. Activities also utilise the road reserve for seismic surveys during the exploration phase and also for the construction of gas gathering lines and provision of access to well surface locations during exploration activities. Gas gathering line construction activities may involve trenching, and/or underboring of public roads.

These activities also require vehicles to use the public roads, including heavy vehicles, to transport machinery and personnel to and from well surface locations and gas gathering lines in the field. A significant number of vehicle movements could occur during construction works with intermittent vehicle activity during the production (or operational) and rehabilitation phases of the project. Similarly, the transportation of water (either delivery of source water or disposal of flowback and produced water) has the ability to generate a significant number of vehicle movements depending on the type and location of the exploration activity being undertaken.

Contractors will be responsible for oversized vehicles as AGL does not own any oversized vehicles. Contractors will be required to adhere to relevant legislation regarding oversized vehicles.

3.2. Potential traffic impacts

3.2.1. Seismic surveys

The vehicles utilised to undertake the seismic surveys will be required to stop for a short period at any one point to allow recording of the seismic information collected from the vibroseis truck. This will result in infrequent delays and temporary road occupancies by the surveying trucks during surveying and when utilising public roads for access/transport to the survey areas. Further, some delays to traffic on public roads may occur as a consequence of seismic vehicles travelling to the surveying locations.

Surveying will not be conducted in mainstream traffic flows on high trafficked roadways except under circumstances where it is required for manoeuvring around permanent obstacles such as signage, infrastructure, bridge crossings or natural obstacles or where road verges are non-existent or of an inadequate width or condition for surveying.

The scope of the impact is localised to the immediate seismic route and survey vehicle work area. The impact of the seismic activities to traffic is considered low for the majority of the seismic works and will be for a short duration.

3.2.2. Access requirements

Activities associated with the GGP will require the use of some existing access points, both public and private. The construction works may impact on roadways and access ways in the following ways:

- an increase in the volume of vehicles;
- the need to create additional access ways; and

- manoeuvring within the proposed work areas.

This is not expected to significantly impact on the locality given the temporary nature of the activities.

3.3. Control measures – traffic and access management

The following control measures would be implemented for exploration activities as specified (Table 3-3).

Table 3-1: Traffic control measures

Activity	Action	Responsibility
Exploration	Access tracks must be kept to a minimum and be positioned so that they do not cause any unnecessary damage to the land.	Land and Approvals Manager/ Environment Manager/ Project Coordinator
Exploration	The design and construction of access tracks must be in accordance with the specifications of OEH and DTIRIS-DRE.	Project Coordinator
Exploration	The use of any road or track will be restricted during wet weather to prevent damage to such road or track.	Project Coordinator/ Environment Manager
Exploration	Transportation of equipment and machinery likely to cause delays to traffic flows would be timed to avoid peak traffic flows, wherever possible.	Project Coordinator/ Environment Manager
Exploration	Vehicle operators would be advised of designated access routes and roadways during the site specific induction. These specific routes would be used to access sites to minimise potential impacts on larger areas of the locality.	Project Coordinator/ Environment Manager
Exploration	A baseline assessment of specific routes may be undertaken in consultation with the RMS and/ or Council to assess and document the condition of the road prior to AGL using the road.	Land and Approvals Manager / Environment Manager/ Project Coordinator
Exploration	All personnel shall adhere to site vehicle speed limits and take extra precaution when driving near stock.	Land and Approvals Manager / Environment Manager/ Project Coordinator
Exploration	All works undertaken in roadways or road verges would be conducted under controlled conditions, (including as described in traffic control plans where relevant), which would be prepared for works potentially impacting traffic. The plans will be prepared by specialist contractors prior to the commencement of works in consultation with the RMS and/or local government authorities and AGL, to address the specific measures stipulated within this TMSP, and will comply with the requirements of Australian Standard AS 1742.3 and the RTA's 'Traffic Control at Works Sites' manual.	Environment Manager/ Project Coordinator
Exploration	Community members potentially affected by works adjacent to roads would be notified and provided with details of the works including expected duration, hours of work and contact details. A community phone hotline will be maintained for residents to register any concerns may have about the works.	Community Relations Manager/ Land and Approvals Manager
Exploration	Appropriate signage of works would be displayed in	Project Coordinator/

Activity	Action	Responsibility
	accordance with Road Occupancy Permit, where required.	Environmental Manager
Exploration	The use of oversized vehicles would be in accordance with relevant regulations and RMS guidelines.	Project Coordinator/
Exploration	Where relevant, the contractor would also apply for permits and approvals required for road occupancy and other road corridor works.	Project Coordinator/ Environment Manager
Exploration	All vehicles should be maintained according to manufacturer's specifications.	All
Exploration	A journey management plan will be prepared for exploration activities that require significant traffic movement e.g. fracture stimulation of wells. The journey management plan should outline routes, number of vehicles, management of vehicles and use of ancillary support vehicles (of applicable).	Contractor

3.4. Activity or site-specific management measures

Exploration activities are required to undertake an environmental impact assessment (EIA) as part of the approval process. The EIA will contain site specific management measures or commitments to minimise impacts on various environmental aspects. These commitments need to be implemented, in addition to any requirement in this EMP, in accordance with the relevant supporting documentation and/or conditions of the activity approval and be the responsibility of the Environment Manager, unless otherwise stated.

The EIA and approval documentation will be provided to any contractor and activity or site-specific management measures will be communicated to on-site personnel (including contractors, as required) prior to commencement of works by the Environment Manager (or nominated delegate) and may form part of the site induction process.

4. Monitoring and reporting

Monitoring to ensure works are being carried out in compliance with this TMSP will be done by:

- site-specific inductions;
- spot checks;
- regular site inspections; and
- review of records including minutes of site-specific inductions and toolbox meetings, the complaints register and incident reports.

Complaints and incidents related to traffic and access management will be recorded, addressed and reported in accordance with sections 5.3.4 and 6.4 of the EMP and with this TMSP.

5. Administrative

5.1. Site-specific plans

Site specific plans will be prepared as required, and developed in consultation with RMS and/ or Council. Copies of these plans will be kept on file at site.

5.2. Definitions

Currently not applicable.

5.3. Life Guard references

HSE Corporate Policy.

AGL Energy Safe Driving Policy.

LG-HSE-CG-049 Road-Vehicles Safety.

6. References

- Australian Standard AS 1742.3.
- RMS “Traffic Control at Work Sites” manual.

A.9: Soil and Water Management Sub Plan

GLOUCESTER GAS PROJECT

Exploration

SOIL AND WATER MANAGEMENT SUB PLAN

AGL Upstream Investments Pty Limited
April 2013

Document Control

Soil and Water Management Sub Plan

Approval:

Authorising Officer	Mike Roy
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Date	April 2013

Revision Status:

Revision	Date	Prepared By	Checked By	Approved By	Comments
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Table 3-1 Summary of control measures for soil and water

1 Introduction

1.1. Introduction

This Soil and Water Management Sub Plan (SWMSP) has been prepared to supplement the Environmental Management Plan (EMP) for exploration activities within Petroleum Exploration Lease 285 (PEL 285).

This SWMSP describes AGL's management of surface water during exploration activities, and excludes management of groundwater for these activities which are subject to a separate management plan (refer to the Groundwater Management Sub Plan).

1.2. Objectives

Objectives relating to the SWMSP are described below:

1.2.1. Construction Objectives

- To minimise and where possible, prevent soil disturbance and contamination and associated impacts on riparian corridors and native vegetation caused by construction.
  - To prevent soil erosion.
  - To prevent soil contamination.
  - To appropriately control soil compaction.
  - To appropriately manage construction activities in waterlogged and inundated soils.
  - To prevent mixing of topsoil and subsoil.
  - To ensure that soil exposure times between clearing and restoration are minimised.
- Minimise the negative impacts of the construction on surface water resources.
  - To maintain surface water quality.
  - To ensure that windrows and soil stockpiles have been broken at appropriate places to allow natural surface water flow.

1.2.2. Operation Objectives

- To promote and maintain soil stability.
- To ensure there is no long-term erosion on compound areas.
- To continue to monitor and manage soil erosion on the leased areas consistent with surrounding land and until the area has stabilised.

1.3. Targets

Targets relating to this SWMSP are outlined below:

- Zero incidents relating to soil disturbance or contamination.
- Zero incidents relating to water contamination from construction works or exploration activities.
- Close out of issues within two weeks.

1.4. Legal and regulatory framework

1.4.1. Key statutory requirements

All activities carried out on-site shall comply with all relevant legislation, regulations and guidelines. These include but are not limited to the legislation described in Table 1-1.

Table 1-1: Key statutory requirements for the GGP

Act	Statutory requirements
Protection of the Environment Operations Act 1997 (POEO Act)	» It is an offence to wilfully or negligently cause any substance to leak, spill or otherwise escape in a manner that harms or is likely to harm the environment.
	» It is an offence to pollute waters under the Act.
	» Pollution incidents causing or threatening material harm are to be reported to the Environment Protection Authority (EPA).
Environmental Planning and Assessment Act 1979 (EP&A Act)	» Water impacts must be assessed under section 111 and clause 228 of regulations.
Water Management Act 2000 (WM Act)	» Water access licences and various other approvals are required for the extraction and use of water under section 56 of the WM Act. » Controlled activity approval is required under development consents under Part 4 or approvals under Part 5 of the EP&A Act for controlled activities when working on 'waterfront land' (within 40 m of a watercourse) » A water use approval is required under section 89 to use water for a particular purpose at a particular location. » Water management works approvals may be required under section 90 for water supply works, drainage works or flood works.

The regulatory approvals, licences and leases held by AGL for exploration activities within PEL 285 are listed in the EMP in Table 1-2.

1.4.2. Regulatory approvals, licences and leases

The soil and water management standards, performance measures and statutory requirements exploration activities are required to comply with are outlined in the conditions of the consents, leases and licences listed in Table 1-2 below.

Table 1-2: Summary of approval, licence, permit and lease requirements

Consent / Title	Requirement
Petroleum Exploration Lease 285 (PEL 285)	» Operations must be carried out in a manner that does not cause or aggregate air pollution, water pollution, soil contamination or erosion. The licence holder must observe and perform any instructions given by the Director-General. » Operations must be carried out in a manner which avoids pollution of any catchment area. » If the licence holder is using or about to use any process which the Director-General believes is likely to pollute the waters of any catchment area the licence holder must refrain from using or cease using such process within twenty-four hours of the receipt by the licence holder of a notice in writing requiring the licence holder so to do. » The licence holder must comply with any regulations in force for the protection from pollution of any catchment area. » The licence holder must cause as little disturbance as possible of the vegetation and the topsoil in carrying out activities. In particular when a seismic line is being prepared, disturbance of the vegetation and the topsoil along the seismic line should not exceed four and a half metres in width without the prior approval of the Director-General and subject to any further conditions stipulated. » If the slope of a seismic line exceeds two degrees, spoon drains and/pr cross banks to disperse water and prevent erosion must be made at regular intervals using sand bags or other suitable fill material. Advice from the NSW Office of Water (NOW) should be sought in areas of steep terrain. » The licence holder must reinstate, as soon as practicable, any artificial or natural watercourse disrupted during activities. » Land disturbed must be rehabilitated to a stable and permanent form suitable for a subsequent land use acceptable to the Director-General so that: ▪ there is no adverse environmental effect outside the disturbed area and that the land is properly drained and protected from soil erosion; ▪ the state of the land is compatible with the surrounding land and land use requirements; ▪ the landforms, soils, hydrology and flora require no greater maintenance than that in the surrounding land; ▪ if vegetation is to be re-established the vegetation must be appropriate to the area and at an acceptable density. If the vegetation is to include native vegetation, local indigenous species must be used in revegetation programs, unless otherwise directed; and ▪ the land does not pose a threat to public safety. » Any topsoil that is removed must be stored and maintained in a manner acceptable to the Director-General. » Access tracks must be kept to a minimum and be positioned so that they do not cause any unnecessary damage to the land. Temporary access tracks must be ripped, topsoiled and revegetated as soon as possible after they are no longer required for prospecting operations. The design and construction of access tracks must be in accordance with the specifications

Consent / Title	Requirement
	of the relevant government departments. If imported topsoil is used on access tracks the source of the topsoil must be approved by AGL's Environmental Adviser.
PEL 285 Waukivory Pilot Approval	» The works must be carried out at the location(s) and in accordance with the methods contained in: ▪ Review of Environmental Factors Proposed Exploration Wells, Waukivory dated March 2011 by AGL Upstream Investments. ▪ Letter from Toni Laurie, AGL Land and Approvals Manager, dated 1 August 2011 requesting that fracture stimulation not be considered at this time. ▪ Letter from David Kelly, AGL Head of Land and Approvals, dated 28 September 2011 concluding that the risk of adverse impacts to surface water, groundwater and soil will be minimal. » All pits and sumps constructed for the containment of fluids and cuttings are to be lined with an impermeable liner to prevent leakage and contamination to soil, surface water or groundwater. At the completion of drilling operations, all liners, drill cuttings and waste are to be removed to a licensed facility. » A NSW Office of Water hydrogeologist should be notified 28 days prior to the commencement of drilling. » Any in-ground water storage facilities must be designed and managed to maintain sufficient freeboard to contain runoff and precipitation from a 1 in 20 year storm. » Documentation covering the chain of custody for any off-site disposal of water must be maintained and made available for inspection by the Department on request.
PEL 285 Gloucester 2013 Seismic Survey Program	» The activity must be carried out generally in accordance with the: ▪ Review of Environmental Factors for Gloucester 2D Seismic Survey – PEL 285 – AGL Gloucester L E Pty Ltd submitted in September 2009; and, ▪ Conditions of this approval.
REF for exploration boreholes GL_PEL285_REF_EB09	» Sediment and erosion control structures would be left in place until the potential for erosion and sedimentation is sufficiently reduced by site restoration, which will include the sowing of suitable pasture species.

1.5. Responsibilities

Personnel responsible for implementing this SWSMP include the following:

1. The AGL Environment Manager is responsible for informing site personnel of the required procedures for the protection of soil to prevent erosion, and water quality via an induction program.
2. The AGL Environment Manager, Project Coordinator and Land and Approvals Manager (or delegates) responsible for checking adherence to operating procedures and delegation of maintenance works on control measures.

3. The AGL Environment Manager and Land and Approvals Manager are responsible for notifying appropriate regulatory agencies of soil or water related incidents where necessary.

4. The AGL Environment Manager is responsible for ensuring reasonable and feasible erosion controls installed and maintained.

5. The Land and Approvals Manager responsible for landowner consultation with assistance from the Community Relations Manager in addressing and managing complaints in relation to soil erosion and water management.

6. All employees are responsible for protection soil and water, from their work activities and working in a manner to minimise erosion and pollution.

1.6. Table of abbreviations

Table 1-3: Table of Abbreviations

Acronym	Definition
AGL	AGL Upstream Investments Pty Limited
DP&I	NSW Department of Planning and Infrastructure
DTIRIS-DRE	NSW Department of Trade and Investment, Regional Infrastructure and Services (Division of Resources and Energy)
EP&A Act	NSW Environmental Planning and Assessment Act 1979
EMP	Environmental Management Plan
EPA	NSW Environment Protection Authority
HSE	Health Safety and Environment System
NOW	NSW Office of Water
PEL	Petroleum Exploration Lease
POEO Act	NSW Protection of the Environment Operations Act 1997
SWMSP	Soil and Water Management Sub Plan
WM Act	NSW Water Management Act 2000

2 Description of Activities and Impacts

The activities are described in detail in the main body of the EMP. The following activities in Table 2-1 have been assessed as having the potential to impact on local soil and water resources.

Table 2-1: Summary of potential impacts on local soil and water resources

Activity	Potential impacts
Exploration	
Seismic surveys	Track erosion
	Damage undisturbed areas
Core hole and stratigraphic exploration drilling	Discharge sediment-laden return water
	Erosion of drill pad
Gas exploration testing	Surface water becomes sediment laden
	Discharge sediment laden runoff
Construction	
Installation/upgrade of access roads	Erosion of stockpiled topsoil
	Discharge sediment-laden runoff
Construction of drill pad	Erosion of stockpiled spoil
	Discharge sediment-laden runoff
Vehicle access	Track erosion
	Damage undisturbed areas
Drilling	Discharge sediment-laden return water
	Erosion of drill pad
	Surface water becomes sediment laden
	Discharge sediment-laden runoff
Construction of Gas Gathering Lines	Erosion of stockpiled spoil
	Damage undisturbed areas, including riparian corridors and native vegetation
	Discharge sediment laden runoff
Exploration well testing	
Hydraulic fracture stimulation and under-reaming	Discharge sediment-laden return water
	Erosion of drill pad
	Surface water becomes sediment-laden
	Discharge sediment-laden runoff
Gas flow testing	
Pump testing	Surface water becomes sediment-laden
	Discharge of produced water

Activity	Potential impacts
Initial rehabilitation	
Initial well rehabilitation	Erosion of backfilled and rehabilitated excavation
	Compaction of soil
	Discharge sediment-laden runoff
	Damage undisturbed areas
Final rehabilitation	
Final well rehabilitation	Erosion of backfilled and rehabilitated excavation

3 Management and mitigation measures

A range of soil and water control measures have been developed to be undertaken as part of the exploration activities. This section describes the management and mitigation measures which will be put into place during various exploration activities.

3.1. General operating principles

Operations, maintenance and construction employees including contractors are required to attend an induction prior to commencing work at each site to ensure that all personnel are aware of their Health, Safety and Environment (HSE) responsibilities and have the necessary knowledge and skills to fulfil them. It is the responsibility of the contractors to consult with AGL to prepare and implement an induction and job specific training program applicable to their work scope. Approval from AGL shall be obtained prior to implementation.

3.2. Control measures

Control measures are proposed for the following categories in relation to soil and water management:

- diversion drains;
- silt fences and hay bales;
- water crossings;
- soil stockpiles;
- batters;
- construction pads;
- chemicals and fuels;
- drilling;
- groundwater;
- access roads / tracks; and
- rehabilitation.

These measures are summarised in Table 3-1.

Table 3-1: Summary of control measures for soil and water

Category	Measure
General	» Vehicle access to and within the site will be clearly defined and communicated to all personnel. » Employees and contractors are required to attend a site specific induction prior to commencing work at each site to ensure that all personnel are aware of their HSE responsibilities and have the necessary knowledge and skills to fulfil them. » It is the responsibility of the contractors to consult with AGL to prepare and implement an induction and job specific training program applicable to their work scope. Approval from AGL shall be obtained prior to implementation. » The exploration site and access routes shall avoid, where practicable, low-lying areas that are subject to water inundation and flooding. » Vehicle and equipment movement in water inundated areas shall be prohibited. » Sweeping of public roads will be undertaken if necessary.
Diversion drains	» Diversion drains shall be constructed as necessary to divert surface water drainage away from soil stockpiles, construction pads, lined drill pits and other disturbed areas in accordance with this plan. No area requiring diversion drains shall be left overnight without diversion drains unless approved. » Diversion drains and other constructed waterways shall consider the design guidelines provided in Section 5.4.4 of Managing Urban Stormwater – Soils and Construction (Landcom, 2004).
Silt fences and hay bales	» Silt fences and/or hay bale filters as appropriate shall be installed prior to the commencement of works, in order to minimise sediment movement. They shall be installed parallel with the contours, on the immediate downslope perimeter of disturbed areas where potential for significant sediment migration is identified by the site planning process and in accordance with Chapter 6.3.7 of Managing Urban Stormwater – Soils and Construction (Landcom, 2004). » Additional control devices will be installed upslope of areas of disturbance where there is a probability of clean surface water flows flowing across the surface and exacerbating surface erosion. » Silt fences will be used for low energy flows when filtering is the main aim. » Hay bale filters where a degree of ponding or energy loss is required. » Silt fences shall: ▪ be of Siltfence2000 or equivalent; ▪ be no more than 0.6 m high; ▪ Be securely attached (for example by staples or plastic or wire ties) to support stakes (for example wooden stakes or star pickets) placed no more than three metres apart, driven into the ground or until firmly embedded; ▪ Extend 0.15 m below ground surface via excavation of a narrow trench which is backfilled after placement of the filter fabric. ▪ Comprise a continuous roll where practicable. When joints are necessary, the filter fabric shall be spliced, or connected with plastic or wire ties or clips, with a minimum 0.15 m overlap and securely fastened at both ends to posts. ▪ Be removed when no longer required.
Water crossings	Crossings of drainage channels/ water courses including access tracks shall address: » Installation of filter fence either side of the area of works, providing sufficient space between the filter fences for the works to be undertaken. » Temporary waterway crossings shall be constructed where roads traverse natural drainage lines in accordance with Chapter 5.3.4 of

Category	Measure
	Managing Urban Stormwater – Soils and Construction (Landcom, 2004). » Where appropriate, barrier mesh (upslope) and sediment fencing (downslope) or similar materials shall be installed in accordance with details in Chapter 5.4.4 of Managing Urban Stormwater – Soils and Construction (Landcom, 2004). » Unrestricted vehicular plant access to undisturbed areas shall not be permitted.
Soil stockpiles	» Soil stockpiles – Soil stockpiles shall be constructed in accordance with details in Chapter 4.3 of Managing Urban Stormwater – Soils and Construction (Landcom, 2004). » Stockpiles will not exceed a height of three metres. » Soil stockpiles will be placed away from kerbs and drainage lines. » Soil stockpiles will be used as backfill at the conclusion of drilling operations. » Soil contaminated through contact with drilling fluids, fuels or lubricants will be removed from site and disposed of at a licensed facility.
Batters	» The batters of completed embankments shall be less than 3(H):1(V). » Immediately following completion of earthworks, batters shall be stabilised and disturbed areas shall be revegetated in accordance with Chapter 7 of Managing Urban Stormwater – Soils and Construction (Landcom, 2004).
Construction pads	Where temporary and or permanent construction pads are proposed, the following steps should be undertaken: » Construct a diversion drain upslope from any cut batters to intercept any surface run-off and direct it to safe disposal points; » Install a silt fence on the downslope side of the work area and at least 50% of the sides adjacent to the downslope edge of the work area. » Form cut and fill batters with a grade no steeper than 3(H):1(V); and » Re-instate excavated material once activities associated with the pad have been completed. Where permanent construction pads are proposed, the following additional steps should be undertaken: » Berms or benches are recommended on batters with a vertical height greater than 5 metres.
Chemicals and fuels	» On site refuelling to be minimised, where it is to occur spill trays will be used and a spill kit to be located nearby. » Spill kits will be available at all times. » All plant will be maintained in good working conditions to avoid oil, fuel and chemical discharge into soils and waterways. » Temporary bunding will be installed around work areas to prevent potential chemical and drilling fluid spills and runoff. » All chemicals and fuels will be stored in bunded areas away from drainage lines. » The capacity of the bunded area will be at least 110% of the largest chemical container stored within the bunded areas.
Drilling	» Drilling activities will be undertaken in accordance with Australian Government Standards, DTIRIS – DRE guidelines, industry best practice and the NSW Government standards for well construction. » All produced formation water must be collected and stored in a secure manner which prevents leakage and contamination of soil, surface water and groundwater. » Construction of drill pads will consider upslope diversion drains to divert clean water around the site. Where required, the drilling compound may need integrated drainage to a lined retention pit for all general surface water flows. » Prior to drilling, a polyethylene membrane lined drill pit or tanks shall be provided to retain drilling debris and associated water for the drilling

Category	Measure
	process. » Tanks must be maintained regularly, and have overflow capacity in case of heavy rain. » The pit(s) shall be bunded on the upslope side, the downslope side, and at least one other side. The fourth side may be left open for access provided that by doing so any overflow would not escape the bunded area. The bund on the accessible side may need to be constructed with much gentler slopes (in the order of 1V:10H) to allow plant movement over the bund. » All drilling debris and associated water from the drilling process shall be captured by the pit(s) or tanks. Where consented/approved to do so, drill cuttings are to be buried approximately 2 m below ground level. » A periodic 'pump out' of the sumps will occur as required to prevent any surcharge during wet weather events. » Produced water will be collected in secure storage and either diluted for irrigation or disposed of at a licensed facility. » A minimum freeboard of 300 mm shall be maintained in the drill pit at all times.
Access roads / tracks	» Access shall be restricted to formed tracks, either via existing tracks where possible, or new tracks to be constructed. » A speed limit will be set on access tracks to prevent excess dust. » The design and construction of access tracks must be in accordance with the specifications of the Department of Planning and Infrastructure (DP&I). » Any sections of track should be constructed, wherever possible by stripping the surface vegetation and topsoil. To limit erosion, track grades should be generally less than 10°. However, short lengths of steeper grades may occur on existing tracks or may be needed to negotiate difficult sections where unavoidable. Such sections would need to be shaled to allow free surface drainage and to avoid excessive ponding in wheel tracks. » Where run-off cannot be controlled by crossfall drainage, cross drains or cross-banks may need to be used. » All formed batters should have a grade no steeper than 1(V): 3(H). » Access roads shall be constructed at an appropriate slope along contours where practicable. » Spoon drains and diversion drains shall be used to control surface runoff from roads as appropriate. » Sediment filters (silt fences or hay bale filters, as appropriate) shall be installed downslope of disturbance associated with construction of the internal main access road where the potential for significant sediment migration is identified. » Temporary diversion drains will be designed and constructed upslope of disturbed areas where the potential for significant runoff from the upslope undisturbed areas to the disturbed area is identified. » Access road batters shall be stabilised through revegetation.
Seismic lines	» When carrying out seismic surveys disturbance to vegetation and topsoil will be minimised. Disturbance will not exceed 4.5 m in width without the prior approval of the Director-General. » If the slope of a seismic line exceeds two degrees, spoon drains and/or cross banks to disperse water and prevent erosion will be made at regular intervals using sand bags or other suitable fill material. » Any artificial or natural watercourse disrupted during seismic operations will be reinstated as soon as practical. » A recovery plan should be developed for the seismic surveys to recover bogged vehicles.
Construction of Gas Gathering	» Spoil from trenching shall be temporarily stockpiled adjacent to the trench on the upslope side of the trench where possible. Where a chain

Category	Measure
Lines	trencher is used, spoil may be stockpiled on both sides of the trench. » Topsoil should be stockpiled separately to the underlying soils. This means that there will be two windrows of material adjacent to the trench. » Silt fencing around the trench will only be required in areas within 50 m of watercourses or other sensitive areas, e.g near riparian corridors, as identified by AGL or their contractor. » The trench should be backfilled as soon as practical using the excavated spoil. If the trench is not backfilled on the day of excavation, consideration should be given to upslope protection of the stockpiled spoil. » Stormwater caught in the trench may be used for dust suppression on adjacent areas. Stormwater shall not be discharged to existing waterways. Stormwater may be discharged across adjacent vegetated areas.
Rehabilitation	» Land disturbed during activities will be restored to pre-operational quality, as soon as practical. » Wherever possible, sediment accumulated in erosion and sediment control structures will be reused for restoration or spread on well vegetated areas at least 50 metres from waterways. » Rehabilitate impacted areas immediately. Land disturbed will be rehabilitated to a stable and permanent form suitable for a subsequent land use acceptable to the Director-General so that: » There is no adverse environmental effect outside the disturbed area and that the land is properly drained and protected from soil erosion. » The state of the land is compatible with the surrounding land and land use requirements. » The landforms, soils, hydrology and flora require no greater maintenance than that in the surrounding land. If vegetation is to be re-established the vegetation must be appropriate to the area and at an acceptable density. If the vegetation is to include native vegetation, local indigenous species must be used in revegetation programs, unless otherwise directed.

3.3. Activity or site-specific management measures

Exploration activities are required to undertake an environmental impact assessment (EIA) as part of the approval process. The EIA will contain site specific management measures or commitments to minimise impacts on various environmental aspects. These commitments need to be implemented, in addition to any requirement in this EMP, in accordance with the relevant supporting documentation and/or conditions of the activity approval and be the responsibility of the Environment Manager, unless otherwise stated.

The EIA and approval documentation will be provided to any contractor and activity or site-specific management measures will be communicated to on-site personnel (including contractors, as required) prior to commencement of works by the Environment Manager (or nominated delegate) and may form part of the site induction process.

4 Monitoring and maintenance

4.1. Monitoring and maintenance requirements

The following monitoring is required for exploration activities:

- All sediment control devices shall be inspected prior to commencement of earth works.
- The sediment control structures shall be periodically inspected for capacity (ie sediment build-up), structural integrity (ie stability) and effectiveness (ie sediment containment) and maintained accordingly.

Monitoring will be during inspections conducted in accordance with this Plan, with implementation of recommendations and corrective actions.

4.2. Records

The following records, where relevant, relating to monitoring and maintenance are to be maintained:

- Drilling Operations Compliance Checklist;
- Gas Gathering System Construction Checklist;
- Well Checklist;
- Rehabilitation Checklist;
- Civil Construction Checklist;
- Dam Inspection Form;
- Sediment Control Removal Form;
- Daily drilling report by drilling engineer (records any spills or other incidents); and
- Records of daily / weekly inspections during construction.

5 Unplanned events

5.1. Unplanned discharges

In the event of an unplanned discharge, an inspection of the site shall be undertaken to make an assessment on which of the control measures described in the SWMSP for the site are required to be implemented.

In the event of a serious unplanned discharge, and where further discharge is imminently likely, works are to cease until the imminent risk is removed. This may be by installation of additional control measures, repair of existing controls, or by increasing the capacity of existing detention basins or drill pits.

An assessment of whether any nearby watercourses have been impacted by the discharge, and whether any rehabilitation work, such as de-silting, is required.

Unplanned discharges shall be recorded on the Life Guard site through ConnectFirst (AGL's Incident Reporting and Information System) as an Incident or Non-Conformance, with corrective and preventative actions to be determined and managed in accordance with existing Incident or Non-Conformance reporting procedures.

EPA and all other necessary government agencies will be notified of any unplanned discharges which may cause or threaten material harm to the environment as soon as practicable after AGL becomes aware of the incident, in accordance with the requirements of Part 5.7 of the POEO Act.

6 Administrative

6.1. Site specific plans

› Site specific information will be provided as part of the Induction Program.
› A documented layout of the erosion and sediment controls are prepared for each well surface location and kept on file at site.

6.2. Attachments

› Currently not applicable

6.3. Definitions

› Currently not applicable

6.4. Life Guard references

HSE Corporate Policy

AGL Life Guard Standard 19 – Environmental Aspects and Impacts

A.10: Waste Management Sub Plan

GLOUCESTER GAS PROJECT

Exploration

WASTE MANAGEMENT SUB PLAN

AGL Upstream Gas Investments Pty Limited
April 2013

Document Control

Waste Management Sub Plan

Approval:

Authorising Officer	Mike Roy
Title	Head of Gas Operations
Signature	
Date	April 2013

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1. Introduction

This Waste Management Sub Plan (WMSP) has been prepared to supplement the Environmental Management Plan (EMP) for exploration activities within Petroleum Exploration Lease 285 (PEL 285).

The WMSP has been developed to specifically address and manage waste management issues for exploration activities and associated construction, in line with the requirements of relevant licences and approvals. Types of wastes within this WMSP include solid, liquid and gaseous.

1.1. Objectives

To minimise waste creation and disposal, and maximise reuse or recycling by:

- minimising waste creation by identifying and eliminating, or minimising the waste generation at its source;
- avoiding land or water contamination and minimise health risks by prompt clean up and removal of waste from site;
- maximising opportunities for reuse or recycling in an environmentally appropriate manner where possible; and
- ensuring that any environmental impacts relating to waste management are reported and acted upon immediately.

1.2. Target

The target of the WMSP is to accurately maintain waste disposal and recycling records for AGL's Environmental Footprint Report, and zero non-conformances relating to waste management practices. The Environmental Footprint Report is part of AGL's Annual Sustainability Report.

1.3. Responsibilities

AGL personnel responsible for implementing this WMSP include the following:

- the AGL Environment Manager is responsible for notifying the Environment Protection Authority (EPA) and other relevant government agencies in the event of a waste related pollution event;
- the AGL Environment Manager (or delegate) is responsible for informing site personnel of the correct procedures required for effective waste management, through the induction program;
- the AGL Environment Manager (or delegate) is responsible for the monitoring of waste disposal, and reporting as required;
- the Project Coordinator is responsible for any further improvements or controls of the waste management process;

- the Land and Approvals Manager is responsible for landowner consultation with assistance from the Community Relations Manager in addressing and managing incidents and complaints in relation to wastes; and
- all employees and contractors are responsible for correctly managing wastes that arise from their work activities on-site, so as to minimise the environmental impact.

1.4. Abbreviations

Table 1-1: Table of Abbreviations

Abbreviation	Definition
AGL	AGL Upstream Investments Pty Limited
DTIRIS-DRE	NSW Department of Trade and Investment, Regional Infrastructure and Services (Division of Resources and Energy)
EMP	Environmental Management Plan
EPA	NSW Environment Protection Authority
HSE	Health Safety and Environment System
LG	Life Guard
PEL	Petroleum Exploration Lease
POEO Act	NSW Protection of the Environment Operations Act 1997
REF	Review of Environmental Factors
WMSP	Waste Management Sub Plan

2. Requirements

2.1. Key licence requirements

Key licence requirements for exploration activities within PEL 285 are summarised in Table 2-1. Approval conditions from other activities are not listed below as they did not contain conditions specific to traffic management.

Table 2-1: Summary of key licence requirements

Reference	Requirement
Petroleum Exploration Lease 285 (PEL (285)	» Operations must be carried out in a manner that does not cause or aggravate air pollution, water pollution, soil contamination or erosion. The licence holder must observe and perform any instructions given by the Director-General. » All refuse must be deposited in properly constructed containers. The licence holder must maintain the area in a clean and tidy condition at all times. » Machinery and buildings must be removed from the area on the expiry or earlier termination of the licence and the area left in a clean, tidy and stable condition to the satisfaction of the Director-General. » Operations must be carried out in a manner which avoids pollution of any catchment area.
PEL 285 Waukivory Pilot Approval	» At the completion of drilling operations, all liners, drill cuttings and waste are to be removed to a licensed facility.
PEL 285 Gloucester 2013 Seismic Survey Program	» The works must be carried out at the location(s) and in accordance with the methods contained in: ▪ Review of Environmental Factors Proposed Exploration Wells, Waukivory dated March 2011 by AGL Upstream Investments. ▪ Letter from Toni Laurie, AGL Land and Approvals Manager, dated 1 August 2011 requesting that fracture stimulation not be considered at this time. ▪ Letter from David Kelly, AGL Head of Land and Approvals, dated 28 September 2011 concluding that the risk of adverse impacts to surface water, groundwater and soil will be minimal.
PEL285: Approval to drill, test and fracture stimulate coal seam gas exploration wells Waukivory 3, Waukivory 4, Stratford 7, Stratford 10 and Faulkland 2	» The titleholder must maintain access roads to any sites subject to this approval in a condition satisfactory to the Department and landholder requirements

It is a general requirement of all licences and approvals that work be carried out in accordance with the relevant supporting environmental impact assessment documentation, which incorporates any site-specific recommendations or commitments related to waste.

2.2. Key legislative and regulatory requirements

All activities carried out on-site shall comply with all relevant legislation, regulations and guidelines. These include but are not limited to the legislation described in Table 2-2.

Table 2-2: Key statutory requirements for the GGP

Act	Statutory requirements
Protection of the Environment Operations Act 1997 (POEO Act)	» It is an offence for the following to occur. - Wilfully or negligently cause any substance to leak, spill or otherwise escape (whether or not from a container) in a manner that harms or is likely to harm the environment. - If a person transports waste to a place that cannot lawfully be used as a waste facility for that waste, or causes or permits waste to be transported. - If the owner/occupier of any land uses the land as a waste facility without lawful authority. - To supply information that is false or misleading in a material respect about waste relating to transport, storage, handling and disposal.

3. Management measures

3.1. Potential waste sources

Potential sources of waste from exploration activities include the following:

- general waste (including office related refuse);
- used oil, air and fuel filters;
- paper and cardboard;
- pallets and packaging material;
- scrap metal and welding wastes;
- garden-related green waste; and
- drill waste (from drill mud and cuttings).

Field activities may result in the following types of waste:

- poly-pipe gathering line offcuts;
- batteries;
- produced water from well sites; and
- general refuse material from construction, drilling and other contractor activities.

Materials recycled from exploration activities include:

- used oil filters;
- paper and cardboard;
- scrap metal;
- garden-related green waste;
- poly-pipe;
- batteries; and
- produced water.

3.2. Control measures – waste management

Table 3-1: Waste control measures

Activity	Action	Responsibility
General	During any pre purchase risk assessment, and prior to the commencement of any waste producing activities, specific waste management strategies shall be developed for each waste stream based on the principles of avoidance, resource recovery and appropriate disposal.	Project Coordinator
	The employee and contractor induction shall inform all site personnel about correct waste management procedures based on the principles of avoidance, resource recovery and appropriate disposal.	Project Coordinator/ Environment Manager
	Waste containers shall be provided at all work sites.	Project Coordinator
	All work areas shall be maintained in a neat and tidy condition, litter bins will be used at all times and regular emptying shall prevent the accumulation of litter on-site.	All
	Waste identified for recycling shall be stored separately from other waste.	Project Coordinator
	Temporary portable sanitation or ablution facilities shall be provided where existing facilities are not present. A licensed contractor is to empty such facilities and the waste is to be disposed of at a licensed facility.	Project Coordinator
	Activities will be carried out to minimise waste where possible, and any waste generated is disposed in a correct manner.	Project Coordinator/ Environment Manager
Spills	Spills of waste materials shall be dealt with in a prompt and thorough manner, and reported to the AGL Environmental Manager.	Environment Manager/ Land and Approvals Manager
	Contaminated soil, or spill recovery materials (such as sawdust and absorbent pads) shall be disposed of at appropriately licensed facilities.	Project Coordinator/ Environment Manager
Disposal	Any waste generated is to be disposed of in an appropriate manner in accordance with relevant standards and guidelines.	All
	General refuse shall be collected and transported to EPA approved recycling or disposal sites.	Project Coordinator/ Environment Manager
	Hazardous waste shall be managed in accordance with existing guidelines and standards.	Project Coordinator
	Waste oil, solvents and other toxic material, shall be collected for safe storage and transport offsite for reuse, recycling, treatment or disposal.	Project Coordinator/ Environment Manager
	On-site waste disposal is prohibited.	All

Activity	Action	Responsibility
	Sewerage disposal shall be via an approved septic system or mobile chemical treatment system.	Project Coordinator/ Environment Manager

3.3. Activity or site-specific management measures

Exploration activities are required to undertake an environmental impact assessment (EIA) as part of the approval process. The EIA will contain site specific management measures or commitments to minimise impacts on various environmental aspects. These commitments need to be implemented, in addition to any requirement in this EMP, in accordance with the relevant supporting documentation and/or conditions of the activity approval and be the responsibility of the Environment Manager, unless otherwise stated.

The EIA and approval documentation will be provided to any contractor and activity or site-specific management measures will be communicated to on-site personnel (including contractors, as required) prior to commencement of works by the Environment Manager (or nominated delegate) and may form part of the site induction process.

4. Monitoring Report

Waste monitoring and reporting will be undertaken in accordance with the requirements and frequency stated within the relevant approvals for PEL 285 exploration activities. These activities will include the following:

- inspection checklists completed by the AGL Environment Manager, Project Coordinator, Land and Approvals Manager, or their delegate;
- tracking of waste in accordance with EPA waste tracking requirements;
- records of complaints and incidents relating to waste; and
- reporting of waste generated for the annual AGL Energy Environment Footprint Report.

5. Administrative

5.1. Site-specific plans

Currently not applicable.

5.2. Definitions

Waste

(a) any substance (whether solid, liquid or gaseous) that is discharged, emitted or deposited in the environment in such volume, constituency or manner as to cause an alteration in the environment, or

(b) any discarded, rejected, unwanted, surplus or abandoned substance, or

(c) any otherwise discarded, rejected, unwanted, surplus or abandoned substance intended for sale or for recycling, processing, recovery or purification by a separate operation from that which produced the substance, or

(d) any processed, recycled, re-used or recovered substance produced wholly or partly from waste that is applied to land, or used as fuel, but only in the circumstances prescribed by the regulations, or

(e) any substance prescribed by the regulations to be waste.

Source: NSW *Protection of the Environment Operations Act 1997*

5.3. Life Guard references

HSE Corporate Policy.

LG-HSE-020: Waste Management and Resource Conservation.

LG-HSE-CG-063: Waste Management and Minimisation.

A.11: Aboriginal Cultural Heritage Management Sub Plan

GLOUCESTER GAS PROJECT

Exploration

ABORIGINAL CULTURAL HERITAGE MANAGEMENT SUB PLAN

AGL Upstream Gas Investments Pty Limited
April 2013

Document Control

Aboriginal Cultural Heritage Management Sub Plan

Approval:

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Date	April 2013

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1. Introduction

AGL Upstream Investments Pty Ltd (AGL) is undertaking exploration in Petroleum Exploration Licence 285 (PEL 285) for the purpose of identifying and extracting coal seam gas within the Gloucester region of New South Wales (NSW). The exploration activities under PEL 285 generally comprise drilling of exploration core holes and test wells and undertaking seismic surveys and pilot testing wells.

This Aboriginal Cultural Heritage Management Plan (ACHMP) covers all exploration activities in PEL 285 issued under the *Petroleum (Onshore) Act 1991* in the local government area (LGA) boundaries of Great Lakes, Dungog and Gloucester in NSW. This ACHMP has been prepared to supplement the Environmental Management Plan (EMP) for exploration activities in PEL 285.

In 2011, the Planning and Assessment Commission approved the Gloucester Gas Project (GGP). The validity of the approval was upheld in 2012 by the Land and Environment Court in 2012. The GGP comprises a gas production field, central processing facility and a pipeline to Hexham. This ACHMP does not include activities identified in the GGP environmental assessment (EA) and applies only to exploration activities.

This ACHMP provides guidance for the care of Aboriginal objects and sites which may be encountered during Project activities. A summary of this ACHMP is included in Appendix C.

1.1. Exploration activities in PEL 285

1.1.1. Exploration process

Exploration is designed to identify, evaluate and potentially prove that natural gas resources exist and can be commercialised for delivery to gas markets. The process can be defined by four main stages:

- identifying prospects and leads through geological and geophysical desktop studies;
- identifying hydrocarbon accumulations through the drilling of core and stratigraphic holes;
- evaluating the potential size of the discovery through geophysical surveys such as seismic, magnetic, gravity and further core and stratigraphic drilling; and
- evaluating the deliverability and commerciality of the discovery by gas flow testing to enable reserves certification and ultimately project development investment decisions.

Seismic lines are initially shot (usually two-dimensional) to gather more regional information about the size, structure and geology of an area, then core holes are drilled to identify and test gas saturation, composition and content. The last stage is drilling and production testing of gas test wells to determine the deliverability of the gas.

More information is given in Section 3.1 of the EMP.

1.1.2. Areas covered by this ACHMP

Exploration activities occur within PEL 285 which covers all of the Gloucester Basin, Spanning over 1,300 square kilometres (km^2). PEL 285 is generally in the vicinity of Stroud, Wards River, Craven, Stratford, Gloucester and Barrington (see **Error! Reference source not found.**).

1.1.3. Activities covered by this ACHMP

Exploration activities covered by the ACHMP include:

- construction of drilling pads involving ground disturbance (cut and fill) or covering with gravel;
- excavation of ground by drill holes, pilot well or core holes;
- installation of associated local infrastructure required for testing and gas extraction; and
- land management activities associated with land rehabilitation after completion of the above activities.

1.2. Planning Context

Coal seam gas exploration activities are assessed under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). Construction of core holes, test wells, associated infrastructure and access tracks have the potential to harm Aboriginal objects.

Aboriginal cultural heritage due diligence studies are conducted as part of Review of Environmental Factors (REFs) for Project activities where required. Test excavation, under the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (the Code – DECCW 2010b) is a management measure that can be implemented based on the results of these studies.

1.3. Relevant legislation

1.3.1. Petroleum (Onshore) Act 1991

The *NSW Petroleum (Onshore) Act 1991* (PO Act) regulates the prospecting of petroleum primarily through the issue of certain licences and/or leases such as PELs.

A PEL allows the holder exclusive rights to prospect for petroleum on the land covered by the license.

Exploration activities are subject to the area bound by PEL 285 issued under the PO Act.

1.3.2. Environmental Planning and Assessment Act 1979

The EP&A Act regulates development in NSW. Aboriginal heritage is a mandatory consideration in the preparation of an environmental impact assessment under the EP& A Act.

When required under section 111 of the EP&A Act, REFs under Part 5 of the EP&A Act have been prepared for activity applications for exploration. Aboriginal heritage due diligence assessments are conducted as components of these REFs.

1.3.3. National Parks and Wildlife Act 1974

The NPW Act protects Aboriginal objects and Aboriginal places in NSW. Under the NPW Act, it is an offence to do any of the following things without an exemption or defence provided for under the NPW Act (penalties apply):

- a person must not knowingly harm or desecrate an Aboriginal object; and
- a person must not harm or desecrate an Aboriginal object or Aboriginal place (strict liability).

Harm includes destroy, deface or damage of an Aboriginal object or Aboriginal Place, and in relation to an object, movement of the object from the land on which it has been situated.

An Aboriginal object is defined in section 5 of the NPW Act as:

> ...any deposit, object or material evidence (not being a handicraft made for sale) relating to the Aboriginal habitation of the area that comprises New South Wales, being habitation before or concurrent with (or both) the occupation of that area by persons of non-Aboriginal extraction, and includes Aboriginal remains.

Anyone who exercises due diligence in determining that their actions will not harm Aboriginal objects or carried out a low impact activity as defined by the NPW Regulations has a defence against prosecution for the strict liability offence if they later harm an object.

An Aboriginal Heritage Impact Permit (AHIP) under section 90 of the NPW Act must be obtained prior to harming an Aboriginal object or Aboriginal place.

1.4. Scope and objectives of this ACHMP

This ACHMP has been developed to manage all previously recorded Aboriginal objects within PEL 285 that are associated with Project activities. It also provides procedures to manage Aboriginal objects should they be discovered during exploration activities. The ACHMP establishes:

- procedures for recording and assessing Aboriginal objects and sites encountered during Project activities;
- procedures for managing Aboriginal objects impacted by any Project activities where there is no feasible alternative to harm under an AHIP;
- a protocol for consulting Registered Aboriginal Parties (RAPs), where required;
- a process for curating Aboriginal objects which may be collected under an AHIP in the course of exploration activities; and
- procedures for managing unanticipated Aboriginal objects found during exploration activities.

1.5. Review of this plan

AGL is currently renewing their PEL. It is intended that this plan will guide Aboriginal heritage actions for the proposed duration of PEL 285. This document will be reviewed every three years.

1.6. Key approval requirements

PEL 285 requires that AGL comply with the following requirement:

> ...The licence holder must not knowingly harm any Aboriginal object or Aboriginal place within the licence area except in accordance with an AHIP issued under the NPW Act and must take every precaution in drilling, excavating, or disturbing the land against any such destruction, defacement or damage

1.7. Change management

The AGL Environment Manager is responsible for the plan, which will be stored in AGL's document control system. Amendments will be made according to AGL's document control procedure. Printed versions will not be considered 'controlled documents' as they may not show recent amendments. Changes to the plan may be made in the following circumstances:

- where an AHIP application is required;

- where new Aboriginal objects are discovered which require specific management approaches proportionate to their cultural significance that are not covered by this plan;
- where new activity impacts are outside the scope of the plan and further Aboriginal consultation is required; and
- where approved modifications to activities introduce new impacts on Aboriginal heritage not generally covered by the plan.

1.8. Abbreviations

Table 1-1: Table of Abbreviations

Abbreviation	Definition
ACHMP	Aboriginal Cultural Heritage Management Plan
AGL	AGL Upstream Investments Pty Limited
AHIP	Aboriginal Heritage Impact Permit
AHIMS	Aboriginal Heritage Information Management System
DTIRIS-DRE	NSW Department of Trade and Investment, Regional Infrastructure and Services (Division of Resources and Energy)
EMP	Environmental Management Plan
GGP	Gloucester Gas Project
NPW Act	National Parks and Wildlife Act 1974
OEH	Office of Environment and Heritage
PAD	Potential archaeological deposit
PEL	Petroleum Exploration Lease
RAP	Registered Aboriginal Parties
REF	Review of Environmental Factors

2. Aboriginal heritage values

2.1. The people

The land covered by the ACHMP has been identified primarily with the Birpai Aboriginal people in the north of PEL 285 and Worimi Aboriginal people in the south. The Birpai and Worimi people are of the Kattang Aboriginal language group. The Birpai Aboriginal people were identified as having a territory that covered an area of approximately 7,300 km^2, extending from the mouth of Manning River at Taree, south to Cape Hawke (near Forster) on the coast, and inland to the dividing range around Gloucester in the south-west and the head of the Hastings River in the north-west (Tindale 1974). The Worimi territory covered an area of approximately 3,900 km^2, extending from the Hunter River to Forester near Cape Hawke along the coast and inland to about Glendon Brook, Dungog, the head of Myall Creek and south to Maitland (Tindale 1974).

2.2. Gloucester region Aboriginal sites

Aboriginal sites in the Gloucester region have largely been recorded through environmental impact assessments related to coal mining activities dating from the 1980s onwards. Archaeological investigations in the Gloucester area have been fairly limited in comparison to the plethora of archaeological assessments and recorded Aboriginal sites throughout the Hunter Valley Central Lowlands (see ERM 2004). Archaeological surveys in the Gloucester region have provided the only records of Aboriginal sites in the region, with the majority of these comprising of open camp sites characterised by low density artefact scatters and isolated finds. Open camp sites are most commonly identified in proximity to ephemeral or permanent water courses. Sites related to bora initiation ceremonies are rare but have been identified close to the townships of Stroud and Craven. Scarred trees are also rare and this can be partly attributed to the extensive post-European clearance of mature trees that may have retained markings. Potential archaeological deposits (PADs) have been identified in conjunction with permanent watercourses and are often situated on gently-sloped landform rises that provide good outlook over the surrounding landscape.

Many Aboriginal sites have been recorded within the nearby Barrington Tops National Park. Sites in the park include open campsites with stone artefacts, scarred trees, ceremonial places and mythological sites recorded in dreaming stories.

The Hunter Valley Central Lowlands, including many areas within a 100 km radius of PEL 285, have been extensively investigated and have had thousands of Aboriginal sites recorded over the past three decades. The sites recorded in the Hunter Valley indicate the site types potentially occurring on similar landform units in the Gloucester region. Open camp sites, as similarly found within the Gloucester region, are the most commonly occurring site type. Other types such as axe grinding grooves occur with some regularity on sandstone outcrops within watercourses. Scarred trees are less common and ceremonial sites relating to old bora initiation ceremonies are rare. Rockshelters with art or artefact deposits occur in the sandstone fringes of the Central Lowlands.

While Aboriginal people are likely to have lived in the Gloucester region from the earliest time of Aboriginal settlement, there has been no comprehensive dating of open Aboriginal archaeological sites. Recent optically stimulated luminescence dates from the Hunter Valley (a site within the Warkworth mine lease) indicate evidence younger than 10,000 years. This agrees with the predominance backed artefacts and associated technology (dating to within the last 10,000 years and mostly last 5,000 years) within sites throughout the Hunter Valley and Gloucester region.

2.3. Previous Aboriginal heritage studies for exploration activities

Five Aboriginal heritage studies have been conducted in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (DECCW 2010c - due diligence guidelines 2010) at a series of exploration activity areas as a supporting document to five separate REFs. Another six Aboriginal heritage impact assessments were conducted as supporting documents to REFs prior to the implementation of due diligence guidelines in 2010.

All previous investigations have included searches of the Aboriginal Heritage Management System (AHIMS) database and some have included physical site inspections, where necessary. These studies were undertaken to identify Aboriginal heritage constraints to the proposed exploration activities.

In early 2013, a series of potential archaeological deposits (PADs) within the proposed exploration drilling area at Wards River has required further assessment including Aboriginal community consultation (see **Error! Reference source not found.**).

The previous Aboriginal heritage studies are summarised in **Error! Reference source not found.** and discussed further below.

Table 2-1: Aboriginal heritage assessments completed for exploration activities

Report reference	Findings
Lucas Coal Seam Gas Pty Limited March 2007, *Gloucester Joint Venture: Review of Environmental Factors For Drilling - PEL 285*.Report prepared for Gloucester Joint Venture	No Aboriginal site issues
Lucas Coal Seam Gas Pty Limited June 2007, *Gloucester Joint Venture: Review of Environmental Factors - For Drilling Stratford Pilot*. Report prepared for Gloucester Joint Venture	Three Aboriginal sites found — impacts avoided
Lucas Energy Pty Limited July 2008, *Gloucester Joint Venture: Review of Environmental Factors For Drilling - PEL 285*. Amended report for Gloucester Joint Venture	No Aboriginal site issues
Lucas Energy Pty Limited August 2008, *Review of Environmental Factors For Exploration Boreholes and Production Evaluation Testing.* Report prepared for Gloucester Joint Venture	No Aboriginal site issues
AGL Pty Limited April 2009, *Review of Environmental Factors For Exploration Boreholes.* Report prepared for AGL Gloucester L E Pty Limited	One Aboriginal site (an isolated find) and one PAD identified: • Isolated find (AHIMS site #31-1-0036) was collected under AHIP #1105164-3172. No further Aboriginal objects or constraints identified PAD 1 (AHIMS site #38-1-0036) underwent test excavation under AHIP# 1104789-3171. No Aboriginal objects identified. Site is no longer a PAD, no Aboriginal site issue
AECOM September 2009, *AGL Gloucester Seismic Survey, Gloucester NSW*. Report prepared for AGL Gloucester L E Pty Limited	No Aboriginal site issues
Parsons Brickenhoff Australia Pty Limited June 2011, *Gloucester Exploration Program – Irrigation Proposal Review of Environmental Factors*.	Two Aboriginal sites identified — impacts avoided

Report prepared from AGL Energy Limited	
EMGA Mitchell McLennan (EMM) 2011a, *Review of Environmental Factors: Proposed Exploration Wells, Waukivory*. Report prepared for AGL Upstream Investments Pty Limited	One Aboriginal site found — impacts avoided
EMM 2011b, *PEL 285 Seismic Survey: Review of Environmental Factors, Gloucester Shire Council*. Report prepared for AGL Upstream Investments Pty Limited	Eight sites located within 300 m of seismic lines — impacts avoided
EMM 2011c, *PEL 285 – Proposed Reservoir Coreholes: Review of Environmental Factors.* Prepared for AGL Upstream Investments Pty Limited	Two Aboriginal sites identified over 500 m from activity area – impacts avoided
EMM 2013, *Proposed Exploration Drilling – Wards River: Review of Environmental Factors.* Draft report prepared for AGL Upstream Investments Pty Limited	Six PADs identified — undergoing Aboriginal consultation and test excavation to determine if AHIP is required

3. Aboriginal community consultation

3.1. Consultation process

3.1.1. Consultation process for Aboriginal heritage assessments

Aboriginal community consultation is a statutory requirement as part of the AHIP process to determine potential impacts of proposed activities on Aboriginal objects and places. Consultation is also required for archaeological test excavation under the Code - where the proponent may be uncertain about whether or not their activity may have potential to harm Aboriginal objects or places. Aboriginal consultation is achieved through consultation with RAPs who hold cultural knowledge relevant to the lands on which Project activities occur.

Aboriginal consultation (for AHIP applications and potential AHIP applications) is required to be undertaken in accordance with the *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (DECCW 2010). The consultation process follows three main stages that involve:

- Stage 1: Notification — through placement of a public notice in a locally circulating newspapers and contact with agencies nominated in the guidelines for lists of Aboriginal parties who are to be invited to register interest;
- Stage 2: Presentation and methodology — through correspondence, a meeting and/or site inspection of the project area to discuss the proposed activity and seek RAP views on the appropriate method of assessment, and views on any AHIP application; and
- Stage 3: Review of draft reports —draft versions of the Aboriginal cultural heritage assessment report and AHIP application issued to RAPs for review, input and comment with a review period of four weeks. This may involve a meeting held within the review period to provide the opportunity for direct feedback, questions and input to a draft Aboriginal cultural heritage management plan. Written responses are requested by four weeks after a draft report of any type is issued for review.

The details of Aboriginal consultation will be provided in any Aboriginal cultural heritage assessment report where consultation is required. The report will include:

- a list of all RAPs;
- a detailed description of the consultation process followed;
- the outcomes of consultation, including recommendations and information from RAPs; and
- details of how any issue raised by RAPs has been addressed and considered in Aboriginal heritage management.

3.1.2. Consultation process for developing an ACHMP

The development of activity or site-specific ACHMPs may be required as a condition of AHIP approval. In this instance, the ACHMP may require Aboriginal consultation with RAPs to develop management strategies for known or potential Aboriginal objects. Aboriginal consultation with RAPs for an AHIP specific ACHMP should follow the same general procedures outlined above in Stages 1 to 3 of the consultation process for Aboriginal heritage assessments. This should include:

- notifying RAPs that a ACHMP is being developed for particular activities;
- meetings and correspondence specifically for the ACHMP; and
- review of draft ACHMP and input by RAPs.

3.2. Registered Aboriginal Parties

Formal Aboriginal consultation has been undertaken for two Project activities within PEL 285. The details of consultation are provided in their respective assessment reports. Table 3.1 provides a summary of Aboriginal consultation conducted within PEL 285 for exploration activities.

Table 3-1: Formal Aboriginal consultation undertaken for exploration activities within PEL 285

Report reference	Consultation summary
AGL Pty Limited April 2009, *Review of Environmental Factors For Exploration Boreholes.* Report prepared for AGL Gloucester L E Pty Limited	RAPs identified through the notification stage of consultation: • Indigenous Cultural Resources Management Services • Forster LALC • Booken Booken Elders Group • Nora Fisher (Elder) • Garigal Aboriginal Community Inc (Glen Jonas) • The Minimbah & District Aboriginal Elders Inc. (Eva Leon) Stage 3 of consultation has been completed – AHIP undertaken
EMM 2013, *Proposed Exploration Drilling – Wards River: Review of Environmental Factors.* Draft report prepared for AGL Upstream Investments Pty Limited	RAPs identified through the notification stage of consultation: • Forster LALC; • Mick Leon trading as Doo-Wa-Kee; • Taree Indigenous Development & Employment Limited; • Vernap Aboriginal Corporation; • Gloucester Worimi First Peoples Aboriginal Corporation; and • Guiwan Cultural Elders Aboriginal Association Incorporated. Stage 2 of consultation completed prior to test excavation in accordance with the Code

3.3. Consultation for future exploration activities

The process outlined in Section 3.1 will be followed where Aboriginal consultation is required for particular exploration activities. Consultation activities undertaken and its outcomes will be presented in an assessment report supporting the AHIP application under the NPW Act.

4. Management

4.1. Objective

The objective of this ACHMP is to provide guidelines for the protection and preservation of Aboriginal cultural heritage values, including Aboriginal sites and objects. The information below provides procedures to manage Aboriginal cultural heritage issues related to exploration activities.

4.2. Impact management hierarchy

The key processes for Aboriginal heritage management are, in priority order:

1. assessment of exploration activity areas through pre-activity due diligence assessment consistent with established OEH guidelines;
2. avoidance of impact to known Aboriginal objects by moving exploration activities where possible;
3. investigation of archaeologically sensitive areas on non-disturbed land which cannot be avoided by Project activities;
4. consultation with Aboriginal stakeholders where an AHIP is required;
5. AHIP approval for unavoidable Aboriginal site impacts; and
6. mitigation, under AHIP approval, of impacts on Aboriginal sites which cannot be avoided by exploration activities.

The manner in which these objectives are addressed is described below.

4.3. Approach

4.3.1. Consultation

Aboriginal consultation in accordance with OEH guidelines must be undertaken for any test excavation conducted under the Code and by all AHIP applicants. The process of consultation is outlined in Section 3 (stages 1 to 2 for investigations, stages 1 to 3 for AHIP applications) and be followed and documented on a site-specific basis in respective reporting required.

Where consultation has been undertaken for particular activities such as those outlined in Section 3, each RAP will be kept informed regarding Aboriginal heritage management, including future revisions of any AHIP related ACHMP, future AHIP, and modifications to approved exploration activities that relate to the AHIP.

4.3.2. Assessment

4.3.2.1. Context

Land on which exploration activities, with the exception of low impact activities, are undertaken is subject to assessment in accordance with the OEH guidelines: *Due Diligence Guidelines for Protection of Aboriginal Objects in NSW* (due diligence - DECCW 2010). Due diligence assessments will be conducted for the purpose of identifying the presence of Aboriginal objects and archaeologically sensitive areas (DECCW 2010). The OEH model of archaeological sensitivity applies to the following landform features:

- within 200 m of waters , or
- located within a sand dune system, or
- located on a ridge top, ridge line or headland, or
- located within 200 m below or above a cliff face, or
- within 20 m of or in a cave, rock shelter, or a cave mouth;
- and is on land that is not disturbed land (definitions of disturbance are provided in the due diligence guidelines).

Please refer to the due diligence guidelines for the complete process for identifying archaeological sensitivity.

4.3.2.2. Procedures

The following procedures will be followed for any future Aboriginal archaeology assessments:

- a due diligence desktop assessment will be carried out as per the relevant OEH guidelines;
- where Aboriginal heritage issues are identified in the due diligence assessment, avoidance of the area will be considered when practicable; and
- if the exploration activity is within an area associated with a previous AHIP application, all RAPs will be provided with due diligence reports. This will provide RAPs with the opportunity to comment on the assessment and management recommendations in line with consultation requirements.

4.3.3. Avoidance

4.3.3.1. Context

Aboriginal sites and archaeologically sensitive areas (on non-disturbed land) identified in due diligence studies will be avoided where possible.

Avoidance may not be possible if there are property constraints (eg if all of the subject area is within an archaeologically sensitive area close to a major watercourse) or where there are built or environmental matters constraining the placement of exploration activities (eg where an access track with artefacts cannot be moved due to the presence of threatened plants, property boundary or built features).

4.3.3.2. Procedures

The following procedures will be implemented to avoid harm to Aboriginal sites and archaeologically sensitive areas:

- newly identified Aboriginal sites within 50 m of exploration activities on AGL properties will be fenced or identified within a reasonable time of discovery;
- exploration activities will be moved where possible to avoid Aboriginal sites by at least 50 m;
- fencing will be temporary, comprising star pickets and temporary high visibility tape or comparable material with signage to the effect of 'Environmentally sensitive area. Keep out' (ie not drawing unauthorised attention to the nature of the Aboriginal site); and
- temporary fencing will be removed on completion of the associated exploration activity; and
- Aboriginal sites identified on private property close to exploration activities will be fenced or identified in a similar way to AGL-owned sites.

4.3.4. Investigation

4.3.4.1. Context

Should the due diligence desktop assessment identify sensitive landscapes that are likely to contain Aboriginal heritage, further investigation will be undertaken. Clarification of presence or absence of Aboriginal objects within non-disturbed areas deemed sensitive is required through test excavation. Test excavation may proceed without an AHIP under the Code (OEH 2012) and must be of sufficient scope to identify the significance of any Aboriginal objects present. The guidelines do not specify how this is determined; therefore it will be determined by a qualified archaeologist.

The standardised test excavation methodology in this ACHMP for all future exploration activities is provided below and is in accordance with the Code.

4.3.4.2. Procedures

The following procedures will be followed during test excavations:

- RAPs will be notified in writing two weeks prior to test excavation;
- AGL's archaeologist will notify OEH two weeks prior to test excavation, in accordance with the Code;
- Field representatives from the RAP list will be sought to assist AGL's archaeologist for the duration of test excavation. The amount of work required will determine the number of RAPs involved;
- the area of proposed exploration activity impact will be identified within the defined archaeologically sensitive area (eg access track extent, area of cut and fill or drilling area);
- test pit methodology will be determined in consideration of the nature of impact being proposed and the extent of sensitive area and undertaken in accordance with the Code, in areas potentially impacted by the activity; and
- reporting will be completed as required by the Code and an AHIP application prepared if required.

4.3.5. Applying for an AHIP

If Aboriginal sites are identified during the investigation described in Section 2.4 and harm cannot be avoided by exploration activities, then AGL will apply for an AHIP. Any future AHIP will be subject to the management approach set out in the AHIP application and associated ACHMP which has been developed in consultation with RAPs.

4.3.6. Mitigation

4.3.6.1. Context

The salvage of Aboriginal objects provides a means of caring for Aboriginal heritage so that future generations may have the opportunity to benefit from the Aboriginal heritage material. The most likely form of Aboriginal objects within the PEL activity areas is stone artefacts. Where possible, stone artefacts will be recorded, moved and retained in the Project activity area without removal.

Mitigation measures include collection (which includes moving the artefacts out of harm's way), or salvage excavation where Aboriginal objects have high scientific or educational values on the basis of rarity or research value. Salvage excavation may be warranted if the dense knapping floor assemblage, rare implements or a hearth feature is present.

In each instance all Aboriginal objects will be recorded and a report produced.

No land disturbance activities will be monitored. If an area is deemed to likely contain material additional investigations will be carried out to clear the area prior to construction.

4.3.6.2. Procedures

The procedures for artefact collections comprise:

- prior to collection, the location of identified artefacts or artefact cluster will be marked and the site photographed;
- the MGA coordinates of each artefact or artefact cluster will be recorded by GPS receiver;
- identified artefacts will be collected and placed in a labelled bag;
- the artefacts will be temporarily moved to the offices of AGL's archaeologist for the purpose of recording and reporting;
- the artefacts will be returned to the site and placed in the ground in a secure location close to the original site location;
- if artefacts cannot be returned to the site, they will be stored in a secure keeping place as deemed in the AHIP application. The long term curation of the artefacts will be determined in consultation with RAPs, or, if RAPs are out of contact in the long term, OEH;
- given the small-scale nature of any such collection and the small areas of land subject to project activities, collection will be undertaken by the project archaeologist and at least one competent and experienced field representative drawn from the RAP body; and
- the above actions will be notified to the OEH AHIMS on the appropriate OEH form.

4.3.7. Discovery of previously unknown Aboriginal objects during development

4.3.7.1. Context

Although Aboriginal objects (typically stone artefacts) are commonly clustered close to environmental features such as water bodies and major watercourses, they may occur in unpredictable isolated instances anywhere on the landscape. Aboriginal objects cannot be harmed without an AHIP (see Section 1.4.3). Discovery of an unanticipated Aboriginal object will result in cessation of exploration activities which would harm the object until an AHIP is obtained permitting harm.

4.3.7.2. Procedures

The procedure for unexpected finds is as follows:

- all works within the immediate vicinity will cease until the potential Aboriginal object(s) can be assessed and recorded by a qualified archaeologist;
- the extent and significance of the Aboriginal object(s) will be determined.
- if the exploration activities cannot avoid the Aboriginal object(s), an application will be made for an AHIP to cover the newly discovered object(s); and
- subject to obtaining approval, the Aboriginal object(s) will be managed in accordance with the AHIP approval.

4.3.8. Discovery of Aboriginal ancestral remains

In the event that known or suspected Aboriginal skeletal remains are encountered during the exploration activity, the following procedure will be followed:

- all work close to the find will cease in the immediate vicinity;
- the find will be immediately reported to the work supervisor who will immediately advise the Environment Manager or other nominated senior staff member;

- AGL will promptly notify the police (as required for all human remains discoveries);
- AGL will contact OEH for advice on identification of the skeletal material as Aboriginal and management of the material; and
- if the remains are Aboriginal ancestral remains, the RAPs will be contacted and consultative arrangements will be made to discuss ongoing care of the remains.

4.4. Operational and training protocols

4.4.1. Obligation to avoid harm

All employees, contractors, sub-contractors and visitors to any AGL activity area have an obligation to avoid harm to Aboriginal heritage, unless engaged in an Aboriginal heritage management activity described in this plan.

The definition of harm used in this plan stems from the definition in Section 5 of the NPW Act. The examples used below are for illustrative purposes and are not exhaustive.

Harm an object or place includes any act or omission that:

- destroys, defaces or damages the object or place; or
- in relation to an object—moves the object from the land on which it had been situated; or
- is specified by the regulations; or
- causes or permits the object or place to be harmed in a manner referred to above, but does not include any act or omission that:
- desecrates the object or place; or
- is trivial or negligible; or
- is excluded from this definition by the regulations.

Harm does not include something that is trivial or negligible. Examples of what might be a trivial or negligible act are picking up and replacing a small stone artefact, or crushing a small Aboriginal object when walking on track.

4.4.2. Obligation to protect

AGL personnel, contractors and subcontractors having responsibility for land management or construction have an obligation to protect Aboriginal heritage within their area of work responsibility.

Protection means active recognition of known Aboriginal heritage and active measures to avoid Aboriginal heritage. This may include fencing, mitigation of erosion effects or modification of work plans to avoid Aboriginal heritage, eg changing vehicular access routes.

4.4.3. Induction of workers

The following procedures/restrictions will be communicated to all workers during inductions:

- Aboriginal objects are protected by law with significant penalties for any form of disturbance, including movement of artefacts;
- the potential for Aboriginal objects impacts has been assessed and any nearby Aboriginal objects have been fenced or identified;
- fenced Aboriginal sites are not to be entered; and
- if suspected Aboriginal objects are found, which are likely to be flaked stone artefacts with distinctive angular margins (see Appendix B), the works supervisor should be informed

immediately and relevant AGL personnel contacted as soon as possible. The procedure in Section 4.3.7 of this ACHMP should be followed.

4.5. Implementation of this plan

The responsibilities for implementing this ACHMP are provided in Table 5.1.

Table 5-1: Roles and responsibilities for Aboriginal heritage management

Role	Responsibilities
Project Coordinator	• Ensure that adequate financial and personnel resources are made available for the implementation of the plan
Head of Gas Operations	• Manage the implementation of the plan across PEL 285 activity areas
Land and Approvals Manager Environment Manager	• Manage the overall implementation of the plan • Oversee signage and fencing of areas in accordance with the plan and ensure it is maintained • The person responsible for managing the overall implementation of the plan • Coordinate relevant specialist personnel to conduct test excavation, collection and/or salvage excavation depending on heritage assessment or AHIP approval specifications • Ensure inclusion of Aboriginal heritage in worker inductions through delivery or input to induction documents • Distribute copies of this plan as required • Arrange for review of the plan within three years

As the document owner, the Environment Manager is the contact point for any person that does not understand this plan or its requirements, and will provide guidance and training to any person that requires additional training regarding this plan.

5. Reporting

5.1. Statutory reporting requirements

Notifications to OEH are required in relation to discovery, impact and care of Aboriginal objects under the NPW Act. This will be the responsibility of the Environment Manager.

5.2. Discovery of Aboriginal objects

Under s89A of the NPW Act, it is a requirement that OEH is notified of Aboriginal objects as soon as practicable after they are first identified. This is usually done through the completion of an OEH Aboriginal Site Card which is submitted to the Aboriginal Heritage Information Management System (AHIMS). Information regarding AHIMS and site recording forms can be downloaded from the OEH website located at:

http://www.environment.nsw.gov.au/licences/DECCAHIMSSiteRecordingForm.htm

5.3. Discovery of Aboriginal objects

The reporting of authorised impacts to Aboriginal sites and objects may be required as a condition of an AHIP issued under the NPW Act. In this case, reporting must be provided to OEH on the specified form which can be downloaded from the OEH website at:

http://www.environment.nsw.gov.au/resources/cultureheritage/120558asirf.pdf

References

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AGL Pty Limited April 2009, *Review of Environmental Factors For Exploration Boreholes.* Report prepared for AGL Gloucester L E Pty Limited.

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2010b Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales.

2010c Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales.

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2011c, *PEL 285 – Proposed Reservoir Coreholes: Review of Environmental Factors.* Prepared for AGL Upstream Investments Pty Limited.

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2013, *Proposed Exploration Drilling – Wards River: Review of Environmental Factors.* Draft report prepared for AGL Upstream Investments Pty Limited.

Environmental Resources Management Australia (ERM) 2004, *Upper Hunter Valley Aboriginal Heritage Baseline Study.* Report to the Upper Hunter Aboriginal Heritage Trust.

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Lucas Energy Pty Limited July 2008, *Gloucester Joint Venture: Review of Environmental Factors For Drilling - PEL 285*. Amended report for Gloucester Joint Venture.

August 2008, *Review of Environmental Factors For Exploration Boreholes and Production Evaluation Testing.* Report prepared for Gloucester Joint Venture.

Parsons Brickenhoff Australia Pty Limited June 2011, *Gloucester Exploration Program – Irrigation Proposal Review of Environmental Factors*. Report prepared from AGL Energy Limited.

Tindale, N 1974, *Aboriginal Tribes of Australia* Berkeley, University of California Press.

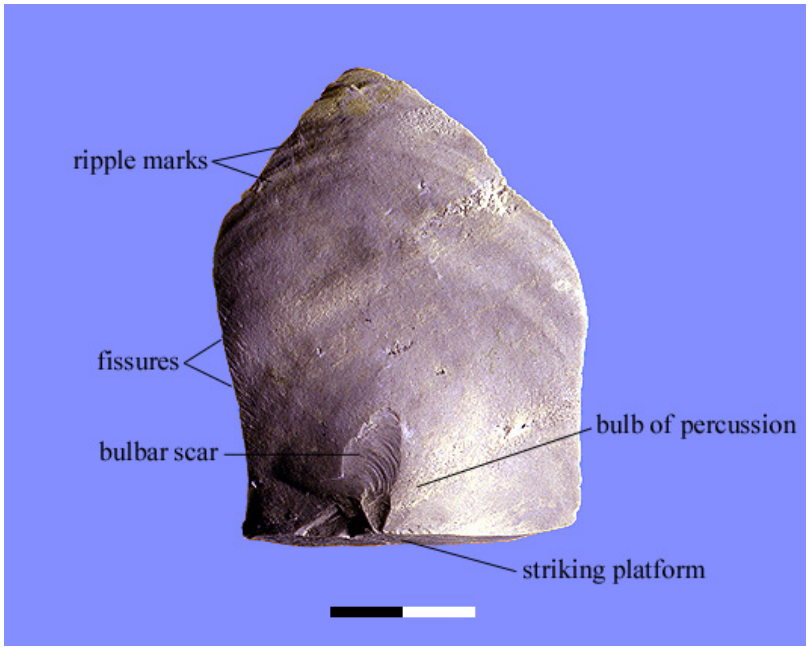
Appendix A – Aboriginal consultation documents

All aboriginal consultation documents will be compiled, inserted and issued to OEH if an AHIP application is made. This will include the following information:

- consultation log spreadsheet;
- example letter of notification to agencies;
- example letter of invitation to identified aboriginal parties;
- written responses from RAPs;
- letter of presentation and draft methodology issued to raps;
- site visit handouts given to RAPs 7 Feb 2013;
- letter accompanying draft ACHMP and draft AHIP application distributed to raps; and
- written responses to draft ACHMP.

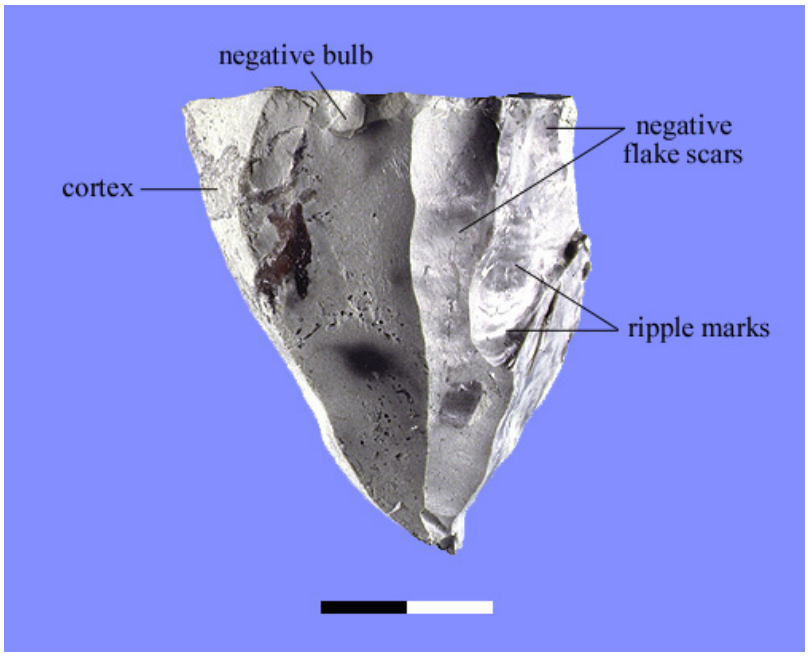
Appendix B – Aboriginal stone artefact images

Aboriginal flaked stone artefact: 'Flake'



Source: Holdaway & Stern 2004, *A Record In Stone: The Study of Australia's Flaked Stone Artefacts*, Museum Victoria and Aboriginal Studies Press. *Fig.1.3.1*

Aboriginal stone artefact: 'Core'

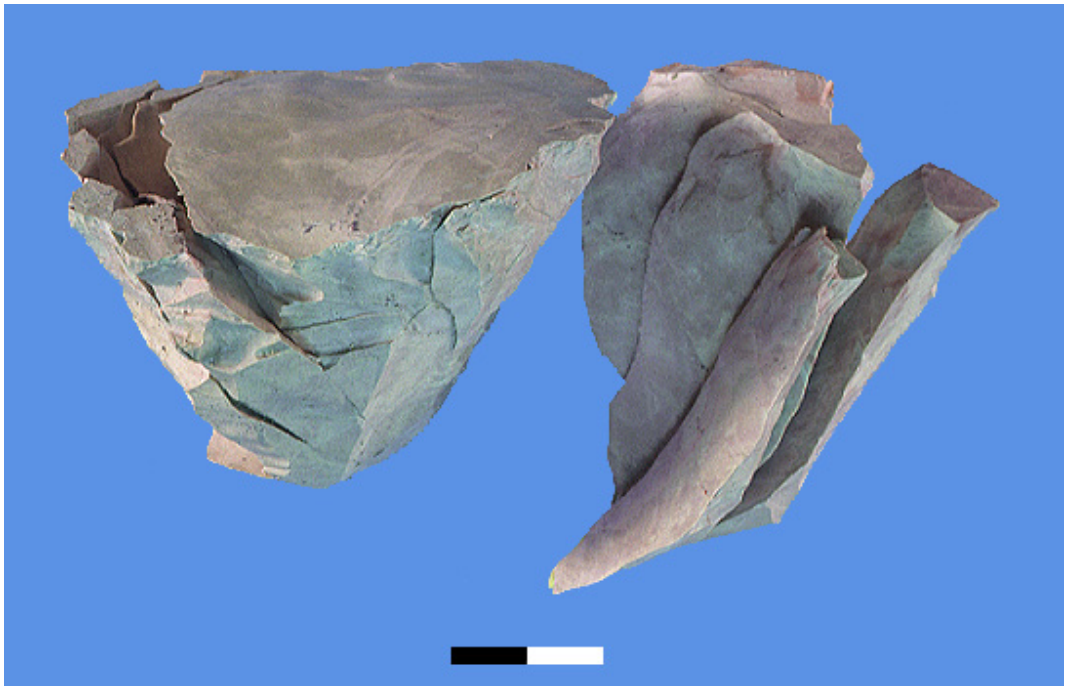


Source: Holdaway & Stern (2004) *Fig.1.5.1*

Aboriginal stone artefact: 'Hammerstone'

Source: Holdaway & Stern (2004) *Fig.1.6.1*

Aboriginal flaked stone artefacts 'Core and flakes joined back together'



Source: Holdaway & Stern (2004) *Fig.1.14.16*

Appendix C – ACHMP summary

This ACHMP summary is provided for inclusion in Environmental Planning documents.

Aboriginal Cultural Heritage Management Plan

Objective	To protect and preserve Aboriginal cultural heritage.
Target	• To adequately protect Aboriginal cultural heritage sites and values. • To implement an effective consultation program with traditional landowners, community groups, regulatory authorities, and other relevant stakeholders.
KPI	Target = no unauthorised damage to heritage sites as a result of activities.
Responsibilities	Land and Approvals Manager, or delegate Head of Gas Operations, or delegate
Key Approval Requirements	PEL 285 The licence holder must not knowingly harm any Aboriginal object or Aboriginal place within the licence area except in accordance with an Aboriginal Heritage Impact Permit (AHIP) issued under the *National Parks and Wildlife Act 1974*, and must take every precaution in drilling, excavating, or disturbing the land against any such destruction, defacement or damage.
Key Legislative and Regulatory Requirements	National Parks and Wildlife Act 1974 • An Aboriginal Heritage Impact Permit is required to harm Aboriginal objects. Section 90 (unless under former Part 3A or Part 4, Division 4.1 of the EP&A Act 1979)
Mitigation Measures	There are three basic levels of management options available for the Aboriginal archaeological sites and in order of preference these are: • Conservation through avoidance; • Preservation through ongoing management; and • Salvage and interpretation. Avoidance Avoidance is the main management and mitigation measure used by AGL for exploration activities. We avoid potential impacts through the following measures. • Aboriginal cultural heritage will be considered during the project design phase of proposed works (before the proposal is submitted for approval) to ensure that exploration activities are sited to: o avoid significant heritage sites where possible, and o remain within existing and/ or previously disturbed areas where possible. • Where possible, activities or infrastructure will be relocated, replaced or redesigned if it has the potential to impact Aboriginal heritage site before the proposal is submitted for approval. • Aboriginal cultural heritage will be considered during the site planning phase of approved works. • Where AGL activities are located near existing pre-recorded artefact areas, the areas will be clearly sign posted or noted in the Site Specific Induction to avoid any inadvertent entry or impact as appropriate. • All vehicles are to travel along AGL designated access roads only and keep to the designated fenced compound areas.

- The Site Specific Induction will consider the inclusion of these and any additional measures to protect Aboriginal heritage.
- Drilling supervisors and other key individuals may be required to undertake Aboriginal artefact identification training.

An exploration site compound, tracks or other work areas could contain previously unidentified or unrecorded Aboriginal heritage artefacts, despite known sites having been avoided.

- Due diligence investigations must be made prior to Project activities.
- If an unrecorded heritage artefact item is found, work must stop immediately and must be reported promptly to the AGL Site Supervisor.
- Work must not continue until approval is given by the AGL Site supervisor.

Procedure for previously undiscovered Aboriginal Objects

If in the course of construction an Aboriginal Object is discovered, the following will procedures should be followed:

- All works within the immediate vicinity should cease until the potential Aboriginal Object(s) can be assessed and recorded by a qualified archaeologist.
- The extent and significance of the Aboriginal Object(s) will be determined.
- Appropriate approvals will be sought.
- Subject to obtaining AHIP approval, the Aboriginal Object(s) will be recorded and collected, and later relocated to an appropriate location at the completion of works (refer to Collection and Relocation of identified Aboriginal Object above). Immediately after collection, construction may then continue.
- Should any of these Aboriginal Object(s) be deemed culturally significant, then further investigation with a qualified archaeologist should be undertaken to determine the need for further archaeological investigation. If the Aboriginal Object(s) are not regarded to be significant, these will be collected for analysis, and relocation.

Discovery of Human Remains

If during the course of construction works Human Remains are uncovered, the following procedure should be followed:

- Inform AGL of the find and cease all works within the vicinity of the remains. Do not further disturb or remove any of the remains.
- Inform the Local Police and the Office of Environment and Heritage.
- If the remains are determined to be Aboriginal then the Aboriginal stakeholders, following OEH advice should be informed of their discovery. The handling of the remains will be dealt with following the development of a management strategy in which the Aboriginal stakeholder groups will be involved.
- Depending on the nature of the remains, the area may require total conservation, altering the proposed works or the Aboriginal stakeholders may deem it necessary to remove the burial from this site and repatriate the remains.

The measures outlined below would be adopted once appropriate consultation has been undertaken through the approvals process in accordance with the relevant statutory requirements and permits (where required).

Collection and Relocation

The Aboriginal Objects shall be collected using the following typical methodology:

- Each site will be photographed, its location recorded using GPS and additional information recorded as appropriate.
- The Archaeologist and relevant Aboriginal stakeholders will collect and bag the surface Aboriginal Objects from each site to be impacted.
- Upon completion of archaeological works, the Archaeologist will analyse the Aboriginal Objects.
- Following completion of the reporting requirements, collected Aboriginal Objects

	will be relocated adjacent to their former location on-site. If this cannot be achieved, an alternative for all collected cultural material must be agreed upon by the identified Aboriginal Stakeholder Groups, such as a common 'keeping place'. Excavation of Sites and Potential Archaeological Deposits The objective of archaeological excavation is to accurately determine site contents and values prior to impact and mitigate impact through the retrieval, salvage and recording of artefacts. • Archaeological test excavation must be conducted in accordance with the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (DECCW 2010) • Archaeological testing through the excavation of archaeological sites and areas of Potential Archaeological Deposit (PAD) should be limited to the areas that will experience sub-surface impacts associated with construction works in line with archaeological conservation principles and where appropriate. • Site specific conditions will be considered and changes to standard methodology should be agreed between the local Aboriginal groups and AGL where possible. On-site Monitoring at the commencement of ground disturbance works Monitoring of ground disturbance cannot be legally conducted except under an AHIP. Although monitoring has been a strategy for investigating whether Aboriginal objects exist within the soil, changes to legislation and guidelines require investigation to be via test excavation under the Code. If Aboriginal objects are discovered through monitoring without an AHIP, the act of disturbance leading to discovery through monitoring would be grounds for strict liability prosecution. Analysis of Aboriginal Objects • Any artefacts recovered from the procedures described above will be collected and analysed. The analysis will include details of stone type, manufacturing techniques and varieties of tool types. • Consultation with Aboriginal groups will be undertaken to determine an appropriate Care Agreement for relocation or storage of any artefacts recovered after the completion of the works. Interpretive Signage • Where appropriate, interpretative signage may be placed at some locations to identify and acknowledge the significance and cultural values of a site to the local Aboriginal people. • All interpretive signage would be developed in consultation with Aboriginal stakeholder groups. Any information used on the interpretative signage must have prior permission from the relevant Aboriginal stakeholders.
Review	• Review will be undertaken on a regular basis during inspections. • Inspections will be conducted to monitor compliance with this Environmental Management Plan, with implementation of recommendations and corrective actions.
Reporting	Statutory requirements Notifications to OEH are required in relation to discovery, impact and care of Aboriginal objects under the NPW Act. This will be the responsibility of the Environment Manager. Discovery of Aboriginal objects Under s91 of the NPW Act, it is a requirement that OEH is notified of Aboriginal objects as soon as practicable after they are first identified. This is usually done through the completion of an OEH Aboriginal Site Card which is submitted to the Registrar of the Aboriginal Heritage Information Management System (AHIMS) for inclusion on the Aboriginal sites database. Information regarding AHIMS and site recording forms can be downloaded from the OEH website located at: <http://www.environment.nsw.gov.au/licences/DECCAHIMSSiteRecordingForm.htm>

	Reporting impact to Aboriginal sites Although not strictly required by the NPW Act, OEH expects that information on authorised impacts to Aboriginal sites is reported to them on the specified form which can be downloaded from the OEH website at: <http://www.environment.nsw.gov.au/resources/cultureheritage/120558asirf.pdf.>
Records	• Records of complaints and incidents related to Aboriginal heritage. • Records of Site Specific Inductions and Toolbox meetings. • Inspection checklists, where applicable.
Associated Documents	• Site Specific Aboriginal Heritage information will be provided as part of the Site Specific Induction.

A. 12 Noise Management Sub Plan

GLOUCESTER GAS PROJECT

Exploration

NOISE MANAGEMENT SUB PLAN

AGL Upstream Investments Pty Limited
April 2013

Document Control

Noise Management Sub Plan

Approval:

Authorising Officer	Mike Roy
Title	Head of Gas Operations
Signature	
Date	April 2013

Revision Status:

Revision	Date	Prepared By	Checked By	Approved By	Comments
1	April 2013	EMGA Mitchell McLennan			

Controlled Document Distribution List:

Copy No	Position	Name
1	Head of Gas Operations	Mike Roy
2	Head of Land and Approvals, Upstream Gas	Suzanne Westgate
3	Head of Exploration	Andrew Falkner
4	Project Coordinator	Chris Holmes
5	Acting Drilling Completions Manager	James Ashton
6	Production Operations Manager	Adam Stepanoff
7	Land & Approvals Manager	Toni Laurie
8	Environment Manager	Aaron Clifton
9	Environmental Adviser	Brett Hayward
10	Health and Safety Manager	Alex Secerbegovic
11	AGL website	-
12	DTIRIS-DRE	Michael McFadyen

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List of Tables

1. Introduction

This Noise Management Sub Plan (NMSP) has been prepared to supplement the Environmental Management Plan (EMP) for exploration activities within Petroleum Exploration Lease 285 (PEL 285).

The Sub Plan has been developed to specifically address and manage potential noise issues for exploration in PEL 285 related to the Gloucester Gas Project (GGP) and is based on previously prepared and approved Environment, Health and Safety Management Plans and the AGL Energy Life Guard System. More information is available in the EMP.

1.1. Objective

The overall objective of the NMSP is to:

- comply with relevant noise standards;
- minimise / control noise activities; and
- limit noise generating activities, at the nearest sensitive receiver, to Monday to Friday 7:00 am to 6:00 pm and Saturday 8:00 am to 1:00 pm.

1.2. Target

The target for PEL 285 exploration activities is zero incidents or complaints received regarding uncontrolled noise emissions.

1.3. Responsibilities

Personnel responsible for implementing this NMSP include the following:

- the Environment Manager is responsible for notifying the Environmental Protection Authority (EPA) and all other necessary government agencies (in accordance with Part 5.7 of the NSW *Protection of the Environment Operations Act 1997* (POEO Act)) in the event of excessive noise events;
- the Environment Manager (or delegate) is responsible for informing site personnel of the required procedures for the noise protection via an induction program;
- the Environment Manager, Project Coordinator and Land and Approvals Manager are responsible for checking adherence to operating procedures and delegation of maintenance works on control measures;
- the Environment Manager and Project Coordinator are responsible for monitoring noise emissions;
- the Project Coordinator is responsible for ensuring reasonable and feasible noise emission controls are investigated and installed;
- AGL employees and contractors are responsible for ensuring all AGL vehicles are properly maintained and serviced;
- the Land and Approvals Manager is responsible for landowner consultation with assistance from the Community Relations Manager in addressing and managing complaints in relation to noise emissions; and

- all employees and contractors are responsible for managing noise emissions from their work activities and working in a manner so as to minimise noise emissions.

1.4. Table of abbreviations

Table 1-1: Table of abbreviations

Acronym	Definition
AGL	AGL Upstream Investments Pty Limited
ICNG	Interim Construction Noise Guideline
NMSP	Noise Management Sub Plan
DTIRIS-DRE	NSW Department of Trade and Investment, Regional Infrastructure and Services (Division of Resources and Energy)
EMP	Environmental Management Plan
EPA	NSW Environment Protection Authority
PEL	Petroleum Exploration Lease
POEO Act	NSW Protection of the Environment Operations Act 1997

2. Requirements

2.1. Key licence requirements

The key licence requirements relating to noise management are included in Table 2-1.

Table 2-1: Key licence requirements

Reference	Requirement
PEL 285	» Operations must be carried out in a manner as to minimise noise disturbance and the licence holder must observe and perform any instructions given by the Director-General.
PEL 285 – Approval to fracture stimulate coal seam methane exploration wells Weismantel 3, Faulkland 3 and Craven 6	» The titleholder must implement management practices as necessary to minimise potential noise and vibration impacts resulting from activities subject to this approval. These management practices are to include, but are not limited to: ▪ Identifying all potentially affected noise and / or vibration sensitive receivers (including residences, schools, commercial premises and noise sensitive equipment) that may be affected by the approved activities; ▪ Predicting potential noise and vibration levels from the proposed operations where appropriate; ▪ Identifying and implementing all reasonable and feasible mitigation methods to reduce any noise and vibration impacts; ▪ Documenting and implementing any specific work practices the titleholder will employ to limit noise and vibration; ▪ Conducting noise and vibration monitoring where appropriate; ▪ Appropriate informing affected residences and other relevant parties in advance of any activities and updating information as required. » If so directed in writing by the Manager Petroleum Operations, additional noise and vibration management practices may be required. Any written instructions given by the Manager Petroleum Operations with regard to noise and vibration management are to be implemented by the operator. » The operator must ensure that a suitably qualified person is available at all times during fraccing and production testing operations to undertake noise measurements as required. A calibrated noise monitoring device should be made available for this purpose.
PEL 285 – Approval to drill, test and fracture stimulate coal seam gas exploration wells Waukivory 3, Waukivory 4, Stratford 7 and Stratford 10 and Faulkland 2	
PEL 285 – Approval to relocate, drill and flow test coal seam methane exploration core hole Faulkland 3	

2.2. Key legislative and regulatory requirements

The key regulatory requirements relating to noise emissions include those listed in Table 2-2.

Table 2-2: Key regulatory requirements

Legislation / Policy	Relevance
Protection of the Environment Operations Act 1997 (POEO Act)	The Environment Protection Authority (EPA) is the appropriate regulatory authority responsible for regulating noise from activities scheduled under and activities carried out under the POEO Act. It is an offence under the POEO Act if noise is emitted to a premises because of the occupier's failure to maintain or operate plant or to deal with materials in a proper and efficient manner.
Interim Construction Noise Guideline (ICNG)	The Interim Construction Noise Guideline deals with the assessment of noise from construction activities and advises on best practice approaches to minimise noise impacts. It is specifically aimed at managing noise from construction works regulated by the EPA and is used to assist in setting statutory conditions in licences or other regulatory instruments.

3. Management measures

3.1. Potential noise emission sources

Potential noise emitting exploration and maintenance activities include, but not limited to:

- core hole drilling;
- exploration well drilling;
- construction of dam and irrigation areas, including earthwork equipments, construction vehicles, hand tools and construction personnel; and
- 2D and 3D seismic survey, including movement of heavy vehicles.

3.2. Noise control measures

Noise control measures for the GGP exploration are shown in Table 3-1.

Table 3-1: Noise control measures

Activity	Action	Responsibility
Core hole drilling	The strategies to minimise noise include: » consult with the local community by providing with written notice well in advance of proposed activities; » where possible, obtain a drill rig with lower noise emission levels; and » employ reasonable work practices to minimise noise impacts. During drilling operations at PL03 and PL05, the mitigation strategies to manage noise include: » undertake regular maintenance of drilling machinery to minimise noise emissions. Confine maintenance to standard daytime construction hours and where possible, away from noise sensitive receivers; » select the quietest suitable machinery available for each work activity; » maximise the offset distance between noisy items of plant / machinery and nearby sensitive receivers; » where practicable, ensure noisy plant / machinery are not working simultaneously in close proximity to sensitive receivers; and » adopt the use of mobile screens or barriers for drilling during out of hours periods.	Environment Manager/ Project Coordinator
Pilot well drilling	The strategies to minimise noise include: » provide the local community with written notice well in advance of proposed activities; » where possible obtain a drill rig with lower noise emission levels; » use temporary noise barriers; and » employ all reasonable work practices to minimise any impacts.	Environment Manager/ Project Coordinator

Activity	Action	Responsibility
Construction of dam and irrigation areas	The strategies to minimise noise include: » notify local residents of the nature and duration of work prior to construction activities commencing; » post a sign displaying a contact name and number of the construction contractor at the front entrance of the site; » keep a register of complaints on site; » handle any received complaints in a prompt and responsive manner including investigating the source of noise and reasonable and feasible measures which could be implemented to reduce noise; » restrict construction activities that are audible at the nearest sensitive receivers to the standard working hours outlined in the DECCW Interim Construction Noise Guideline (2009) (i.e. Monday to Friday 7am to 6pm, Saturday 8am to 1pm, no work on Sunday and public holidays); » turn off equipment and machinery when not in use; and » repair or replace equipment and machinery if it becomes excessively noisy. To reduce potential noise impacts from operational truck movements, and preserve acoustic amenity at the nearest receiver: » observe signposted speed limits; and » avoid unnecessary revving of engines and manage site egress / ingress to reduce requirements for reversing.	Environment Manager/ Project Coordinator
Seismic surveys	The strategies to minimise noise and vibration include: » prevent machinery from 'warming-up' before the nominated working hours, where they are audible to residences; » undertake regular maintenance of machinery to minimise noise and vibration emissions; » confine maintenance to standard daytime construction hours and where possible, away from sensitive receivers; » select the quietest suitable machinery available for each work activity; » maximise the offset distance between items of plant / machinery and nearby sensitive receivers; and » where practicable, queuing of vehicles will not occur adjacent to any residential receiver.	Environment Manager/ Project Coordinator

3.3. Activity or site-specific requirements

Exploration activities are required to undertake an environmental impact assessment (EIA) as part of the approval process. The EIA will contain site-specific management measures or commitments to minimise impacts on various environmental aspects. These commitments need to be implemented, in addition to any requirement in this EMP, in accordance with the relevant supporting documentation and/or conditions of the activity approval and be the responsibility of the Environment Manager, unless otherwise stated.

The EIA and approval documentation will be provided to any contractor and activity or site-specific management measures will be communicated to on-site personnel (including contractors, as required) prior to commencement of works by the Environment Manager (or nominated delegate) and may form part of the site induction process.

4. Monitoring and reporting

4.1. Monitoring requirements

Monitoring will be undertaken on a regular basis during operations, in accordance with Section 6.1 of the EMP.

4.2. Reporting requirements

At this stage, the GGP exploration does not have any reporting requirements relating to noise. This NMSP will be updated as approvals are gained and reporting is required.

4.3. Records

Records related to this NMSP include:

- complaints related to noise levels;
- inspection checklists; and
- reports to authorities relating to incidents causing or threatening to harm the environment as a result of noise emissions.

All records required to be kept for the GGP exploration will be in a legible form, kept for at least four years and be available to any authorised officer of the EPA if requested.

5. Administrative

5.1. Site specific plans

Currently not applicable

5.2. Attachments

Currently not applicable

5.3. Definitions

Currently not applicable

5.4. Life Guard references

HSE Corporate Policy

Appendix B: AGL Health, Safety and Environment Policy

Objectives
AGL's aspiration for Health, Safety and Environment is Zero Harm to our people and to the environment we operate in. Our Health, Safety and Environmental (HSE) Management System, Life Guard, assists us to achieve this.

Our HSE policy objectives are to:

- provide a safe and healthy workplace and eliminate work related injuries and illnesses, and
- actively demonstrate a commitment to sustainable growth, including the protection of the environment.

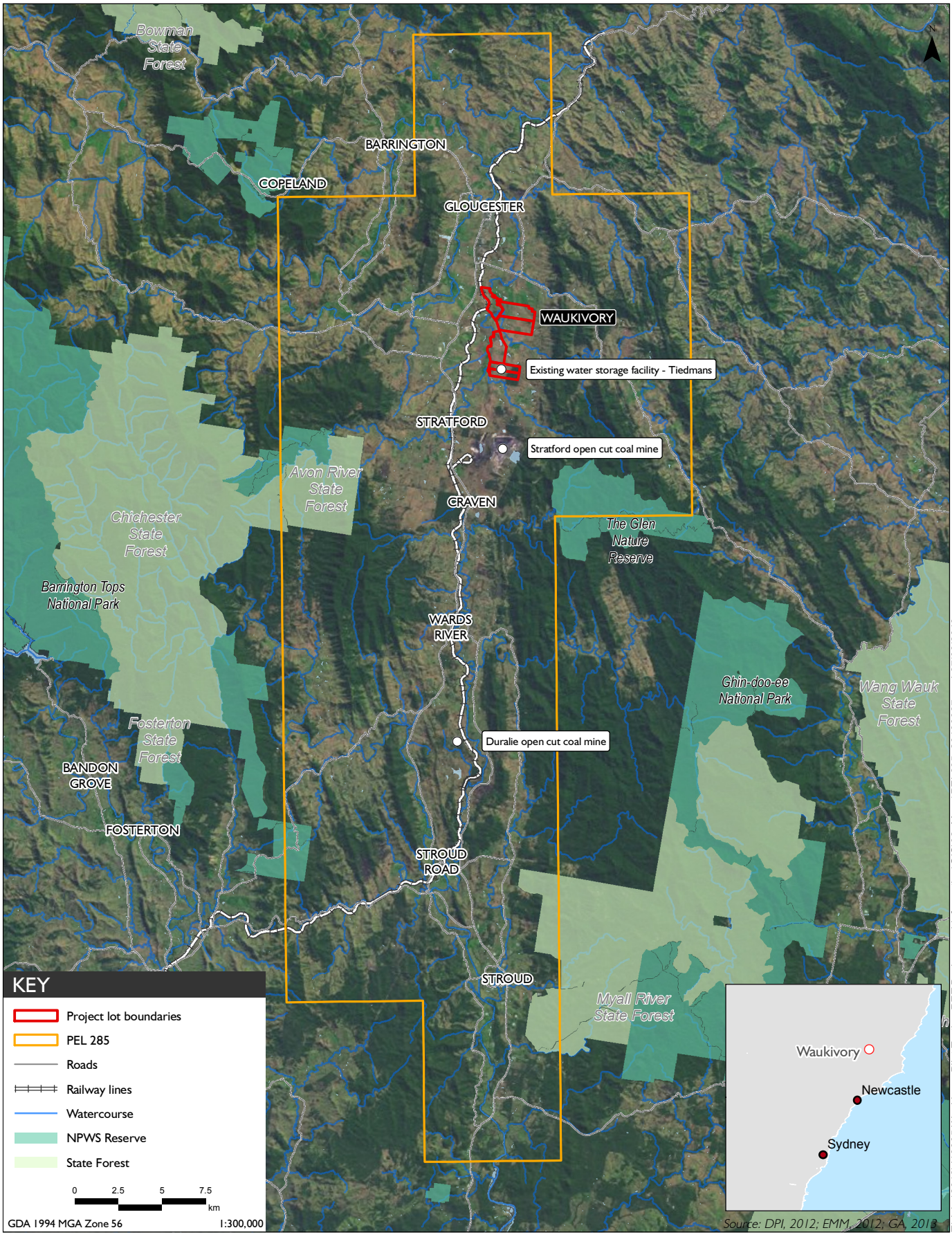
Strategy
We will achieve these objectives by:

- Giving safety, health and environmental considerations equal priority with other business objectives.
- Meeting or exceeding the requirements of legislation.
- Performing our work safely and with proper regard for the environment.
- Ensuring that our people have sufficient resources for the management of HSE activities, and that these activities are managed consistently and constantly.
- Leading, training and motivating our people and our contractors to work in a safe and responsible manner.
- Managing non-conformance to HSE rules and procedures in a fair and consistent way, in order to prevent injuries or environmental harm.
- Improving our HSE performance by establishing HSE goals at all levels within the company.
- Consulting with our people and the community on health, safety and environmental issues.
- Using resources and energy efficiently, and minimising waste, emissions and pollution from our activities.
- Actively participating in the policy debate on energy and related environmental matters, through engaging with Government, the energy sector, the community, employees and other stakeholders.

This policy applies to all employees, contractors, products and services, and joint ventures under AGL's operational control.

Michael Fraser
Managing Director
September 2012

Appendix C: Petroleum Exploration Licence and Petroleum Production Lease Figures


Bowman State Forest
BARRINGTON
COPELAND
GLOUCESTER
WAUKIVORY
Existing water storage facility - Tiedmans
STRATFORD
Stratford open cut coal mine
Avon River State Forest
CRAVEN
Chichester State Forest
The Glen Nature Reserve
Barrington Tops National Park
WARDS RIVER
Ghin-doo-ee National Park
Wang Wauk State Forest
Fosterton State Forest
Duralie open cut coal mine
BANDON GROVE
FOSTERTON
STROUD ROAD
STROUD
Myall River State Forest
N
KEY
Project lot boundaries
PEL 285
Roads
Railway lines
Watercourse
NPWS Reserve
State Forest
0 2.5 5 7.5
km
GDA 1994 MGA Zone 56
1:300,000
Waukivory
Newcastle
Sydney
Source: DPI, 2012; EMM, 2012; GA, 2013
T:\Jobs\2013\J13005 Waukivory Pilot Testing REF\Background information\GIS\02_Maps\PEL285_20130927.mxd 27/09/2013

Appendix D: Emergency Response Plan

Please refer to Appendix G of the Waukivory Pilot REF

Appendix F

Health and safety management plan

Energy in action.™

AGL

HEALTH AND SAFETY MANAGEMENT PLAN

AGL UPSTREAM GAS GLOUCESTER GAS PROJECT

Prepared by: Alexandra Secerbegovic
AGL Health and Safety Manager, Upstream Gas

Authorised by: Mike Roy
Head of Gas Operations, Upstream Gas

Revision Status:

Revision	Date	Prepared By	Checked By	Approved By	Comments
V1.0	September 2012	JDS	ET	MM	
V2.0	March 2013	AWS	AS	MR	Update to address Code of Practice for Fracture Stimulation Activities.
V3.0	April 2013	Alex Secerbegovic	Mike Roy	Mike Roy	Review of V2.0. Minor formatting changes made to the document.

Authorised by the
Head of Gas Operations

Mike Roy

Date:

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Appendices

Definitions

SMP	Safety Management Plan
OHSMS	Occupational Health and Safety Management Plan
PEL	Petroleum Exploration Licence
IADC	International Association of Drilling Contractors
Contractor	A company or individual who provides services to AGL
Principal Contractor	A contractor appointed by AGL who manages contractors on the site

Document History and Status

1.1 Revision

The AGL Gloucester Project Manager (Project Manager) is responsible for the revision and update of this Safety Management Plan (Plan). A new revision date is required with any updates or revisions, and will be circulated to those on the distribution list once the revision has been formally reviewed by the AGL Project Manager.

This Plan is a controlled document and is not to be revised without the prior approval of the AGL Project Manager.

This Plan will be reviewed and revised as required:

- following any major incident, reasonably foreseeable incident or other relevant event;
- following the making or amendment of an applicable safety code, safety requirement, standard or legislation;
- following changes or proposed changes to the Gloucester Project (Project) that has potential impacts on health and safety;
- when directed by the Director-General of the Department responsible for administration of the NSW Petroleum (Onshore) Act;
- At least annually

1.2 Distribution

All requests for changes to the Distribution of the document are to be addressed to the AGL Project Manager. The document will be available electronically – no numbered copes will be issued. A hard copy will be available at each well site where work is occurring. This Plan shall be distributed to:

	Position	Name	Location
1	Project Manager	Alex Kennedy-Clark	Sydney
2	AGL Head of Gas Operations	Mike Roy	Camden
3	AGL Operations Manager	Adam Stepanoff	Hexham
4	On each work site	Contractor / Company Man	Various

This Plan shall be:

- clearly displayed and provided to all Major and Minor Works Contractors who have responsibilities under this Plan;
- available for inspection at the relevant site (or another place if not practical to do so), at the Gloucester Site and accessible from the relevant AGL Site Safety Manager;
- provided or made accessible to each AGL person who has a responsibility under this Plan.

Similarly, a copy of Major and Minor Works Contractors' Safety Management Plans shall also be available for inspection at relevant sites.

1.3 Major Works Contractors and Minor Works Contractors

- Major Works Contractors are subcontractors engaged by AGL which operate under their own Safety Management Plan. Such safety management plans should be consistent with this Plan; and
- Minor Works Contractors are subcontractors engaged by AGL which operate under the requirements of this Plan but use their own activity specific Safety Management Plan to supplement this plan where necessary as determined and established with the Minor Works Contractor at the time of engagement.

It is anticipated that most contractors working on the Project will be Major Works Contractors.

A reference to Contractors within this Plan and the attachments is a reference to both Major Work and Minor work Contractors and their subcontractors.

Introduction and Purpose

It is AGL's intention to provide the guidance necessary to facilitate coal seam methane exploration operations in the Gloucester Region, NSW in respect of the activities conducted by AGL, and to ensure that employees, contractors, consultants and the general public are provided (to the extent AGL is obligated) with a safe working environment that is, as far as reasonably practicable, free from the risk of injury and illness.

This Plan provides health & safety guidelines in respect of activities conducted by AGL to the AGL Project Team (Gloucester), employees, service providers, Contractors and representatives.

The separate Environmental Management Plan for the Project provides guidelines as to environmental requirements for the Project. The Environmental Management Plan is administered by the AGL UG Environment Team.

2.1 Objective

The objective of this Plan is to ensure that all Project activities conducted by, for and on behalf of AGL are conducted safely, efficiently and in accordance with this Plan and relevant legislation.

This Plan comprises the following elements:

- A corporate commitment stating AGL's commitment to conduct activities in an environmentally responsible and safe manner with due consideration to all occupational health and safety issues; the AGL HSE Policy addresses this aspect and is set out in Appendix A;
- Description of specific roles for management, employees and Contractors;
- Appropriate induction and training of relevant personnel;
- Monitoring and (where applicable) reviewing programs to assess compliance with procedures and the achievement of objectives;
- Ongoing consultation to seek input from and inform all parties of relevant issues;
- A system of reporting for recording of data ;
- Emergency response procedures, to be displayed and readily accessible and all on site to be familiar with its contents;
- Establishment of the level of training and experience of employees and (where relevant) Contractors and ensure that they are adequate and maintained.

To achieve the health and safety objectives, AGL requires Contractors to carry out the following:

- Conduct activities in a manner consistent with environmental, and health and safety requirements, including this Plan and the AGL HSE Policy and Golden Rules;
- Comply with applicable health and safety laws and regulations;
- Identify potential hazards of an operation and implement the appropriate controls or procedures prior to undertaking such operations;
- Ensure as far as practicable, and within appropriate standards, that design and operation of equipment and site facilities are safe and are maintained in a safe condition;
- Deal promptly and effectively with any incidents by such means as to give priority to the safety of employees, Contractors and the public;
- Conduct activities in a manner which has due and proper regard for the safety and welfare of employees, Contractors, visitors on site and members of the general public who might be affected by AGL operations; and
- Monitor and report health and safety performance.

2.2 References

The following legislation, standards, codes of practice and guides are relevant to AGL UG activities in NSW

- NSW Petroleum (Onshore) Act 1991
- NSW Petroleum (Onshore) Regulation 2007
- NSW Work Health and Safety Act 2011
- NSW Work Health and Safety Regulation 2011
- AS/NZS ISO 31000: Risk management – Principles and guidelines;
- AS/NZS 4801- Occupational Health & Safety Management Systems;
- NSW Schedule of Onshore Petroleum Exploration and Production Safety Requirements August 1992 (Legislative Guideline)
- NSW Code of Practice for Coal Seam Gas (Fracture Simulation)-2012
- NSW Code of Practice for Coal Seam Gas Well Integrity-2012

2.3 Project Overview

AGL is exploring the coal seam methane resources from the sub-surface coals of the Gloucester Basin within Petroleum Exploration Licence (PEL) 285. This work shall be conducted in compliance with the licence issued by NSW Department of Trade & Investment, Regional Infrastructure & Services.

The Gloucester Gas Project is located approximately 200 km to the north-north-east of Sydney. The concept area is situated within the Gloucester and Great Lakes Local Government Areas approximately 100km north of Newcastle and comprises approximately 210 square kilometres.

The current stage of the Project involves the construction, drilling, operation, maintenance and rehabilitation of well sites, access roads, a gas gathering system and water management and disposal facilities. This plan covers a number of subprojects, namely, work-over, core hole drilling, pilot production testing (including fracture stimulation) and environmental rehabilitation and monitoring of seismic survey lines.

These activities fall primarily under the regulation of the NSW Petroleum (Onshore) Act 1991 and the Petroleum (Onshore) Regulation 2007 and are administered by the Department of Trade & Investment, Regional Infrastructure and Services, although some activities, including clearing, grading and the construction of roads and pads are administered by the NSW Work Health and Safety Act 2011 and NSW Work Health and Safety Regulation 2011.

AGL is the "Operator" for the purposes of the NSW Petroleum (Onshore) Act 1991, in respect of the activities conducted by AGL in the Gloucester Region.

The drilling of core holes is to be undertaken by a competent and experienced contractor under contract from AGL. The drilling contractor may subcontract some works including, in particular, provision of a camp. The seismic acquisition will also be undertaken by a specialist contractor, under contract from AGL.

As part of the water monitoring activities, drilling and monitoring of such water bores will be undertaken by specialist contractors.

A range of other activities which are ancillary to the drilling, including provision of a camp, survey, cultural heritage monitoring, clearing, grading, fencing, supply of materials, and disposal of waste, will be performed by contractors to AGL.

2.4 Contractor OHS Management

AGL's Contractor HSE Management Procedure manages all contract work where Contractors are engaged to work at any AGL owned or operated location. The level of health and safety compliance required of Contractors is based on the assessed level of risk exposure to that risk identified in the ISN Contractor HSE Pre-Qualification System. All contractors must undertake an AGL pre-qualification process in order to work on behalf of AGL. This is undertaken through ISN, the external provider for this service, or internally through AGL health and safety team.

As the project is covered by the NSW Petroleum (Onshore) Act 1991, NSW Petroleum (Onshore) Regulation 2007, NSW Work Health and Safety Act 2011 & Work Health and Safety Regulation 2011, Contractors must comply with these legislative requirements as well as the requirements under the

Code of Practice for Coal Seam Gas (Fracture Simulation)-2012 and the Code of Practice for Coal Seam Gas (Fracture Simulation)-2012.

Contractors must also comply with their own safety management plan requirements and the requirements of this Plan.

All Contractors carrying out works for the Project must have a current Occupational Health & Safety Management System and associated Safety Management Plan (SMP) relevant to the work being carried out. Contractors' Safety Management Plans must be applicable to the specific undertaking of the contracted activities and where appropriate for the activities, must include:

- a description of the Contractor's plant, its location and operations;
- each site under the Contractor's control for which a Site Safety Manager is required;
- details of the Contractor's:
    - organisational structure, safety responsibilities and safety policies;
    - communications and control systems, temperature and pressure controls, emergency systems and equipment;
    - process for managing change;
    - record management; and
- key performance indicators to monitor compliance with its plan and the NSW Petroleum (Onshore) Act 1991, NSW Petroleum (Onshore) Regulation 2007, the NSW Work Health & Safety Act 2011 and the Work Health and Safety Regulations 2011;
- how any interactions with other operators or Contractors (and their safety management systems) will be identified and managed;
- how likely risks will be controlled;
- a skills assessment of the minimum requirements for each person to carry out specific work and an accompanying training and supervision program for improving and monitoring skills and competencies;
- mechanisms for recording, investigating and reviewing incidents (including implementing recommendations);
- safety standards, safe operating and maintenance procedures and management controls which will be implemented, monitored, and reviewed during all stages of the Project AGL will act as contract manager to monitor and manage Contractors' ongoing compliance;
- details of machinery and equipment which may affect the safety of the plant;
- a description of activities proposed or carried out at a plant which may adversely affect the safe and efficient mining or future mining of coal;
- proposed measure(s) to mitigate risks and assessment of the potential risks that activity may cause to the safe and efficient extraction of gas.

Contractors' Safety Management Plans must be accompanied by a project specific safety assessment comprising a risk assessment identifying and addressing any project specific risks and hazards, as well as management controls to be implemented and monitored in respect of those risks.

Contractor's Safety Management Plans and risk assessments must be issued to the AGL Health & Safety Manager, or relevant AGL Health & Safety Business Partner as nominated by the Health and Safety Manager, for review prior to any mobilisation activities.

Commitment, Policy & Targets

3.1 AGL Policies

AGL is committed to the health and safety of everyone who may be affected by its business or undertaking and to the protection of the environment. AGL expects that all Contractors, service providers and consultants that are involved with the Project have adequate policies to match this commitment and demonstrate this commitment through leadership. A copy of the following AGL Policies are provided in Appendix A, and will be available at induction and displayed on sites where practical:

- Health Safety and Environment Policy
- Upstream Gas Step Back Policy
- Safety Golden Rules

Safe Driving Policy

AGL is committed to promoting and encouraging a safe driving culture and eliminating behaviour and practices which could injure people or damage vehicles, property or the environment. In relation to the activities AGL conducts, AGL requires all drivers and their managers to plan realistic driving schedules, allow sufficient time, take rest breaks during journeys, drive to conditions, and not drive when fatigued. Provisional and Learner licence holders shall not drive except in the case of emergencies. AGL expects all Contractors to have similar systems in place.

Drug and Alcohol Policy- Upstream Gas

To the extent that it relates to AGL's undertaking, AGL is committed to provide a healthy, safe and productive workplace. Substance abuse jeopardises this commitment and will be dealt with effectively and appropriately. AGL will not accept any increase in risk to an employee, or any other party, as a result of substance abuse. Random Drug and Alcohol Testing will be implemented on site. Upstream Gas has developed a Drug and Alcohol Testing Policy which sets out the processes to follow for drug and alcohol testing. All employees and contractors are made aware of the key policy requirements during the relevant AGL HSE induction.

Rehabilitation Policy

It is AGL's policy to ensure an early and safe return to work, through consultation, participation and the provision of an injury management plan for an injured or ill employee.

Smoke Free Workplace Policy

AGL maintains a strictly no smoking policy at any AGL site and under no circumstances will smoking be tolerated. This policy applies to all AGL employees, contractors, suppliers and visitors. No smoking signs are displayed at prominent locations at all Upstream Gas workplaces. Smoking will only be permitted in designated non-hazardous areas.

3.2 AGL Golden Safety Rules

AGL has four Golden Safety Rules that apply to every person affected by its business or undertaking, including Contractors and visitors to all AGL owned and operated premises.

Employees, Contractors and visitors must:

1. report all injuries;
2. report all significant incidents, hazards or near misses that have an actual or potential risk rating of high or above on AGL's FIRM risk matrix – see Appendix E;
3. only use plant and equipment in a manner which will not compromise its safe operation or protection; and
4. only operate plant and equipment with the required licence and authority, and in accordance with operating procedures.

These Golden Safety Rules are incorporated within this Plan. In addition, AGL Upstream Gas has seven additional Golden Rules relating to work that apply to every person affected by its business or undertaking, including Contractors and visitors to all AGL owned and operated premises.

1. Permits to Work
2. Energy Isolation
3. Ground Disturbance
4. Confined Space Entry
5. Working at Heights
6. Lifting Operations
7. Driving Safety

These Golden Safety Rules are addressed in more detail in section 15 of this Plan.

3.3 Key Performance Indicators

The AGL Project team has established and implemented Health and Safety goals and targets consistent with the AGL HSE Policy including the commitment to measuring and improving OHS performance. The AGL Project team has specifically developed these goals and targets, in relation to AGL's undertakings, for the duration of the Project.

The AGL H&S Business Partner will ensure these goals and targets are communicated to all Contractors prior to commencement of their work.

The tables below identify the targets set and how each target is calculated.

Lagging Indicators	Target
Lost Time Injury Frequency Rate: (Number LTI X 1,000,000 / Man Hours)	4
Medical Treatment Frequency Rate: (Number MTI X 1,000,000 / Man Hour)	<5
Total Injury Frequency Rate: (Number TRIFR X 1,000,000 / Man Hours)	<5

Leading Indicators	Target
Percentage of Audits Performed Against Schedule (No of Audits Undertaken / Number of Audits Due X 100)	90%
Percentage of Workplace Inspections Performed (No of Inspections Undertaken / No of Inspections Due X 100)	90%
Percentage of Actions Closed Out on Time (Number of Actions Closed / Number of Actions Due X 100)	95%
Number of emergency exercise tests conducted and recorded (e.g. Desktop tests of communications and procedures for emergencies)	At least two / month per contractor work package

3.4 Measurement & Evaluation of Health and Safety Performance

To the extent that they relate to AGL's undertakings, planned reviews, audits and inspections will be undertaken by AGL throughout the duration of the Project to ensure the effective monitoring of this Plan, operational hazards, aspects and impacts, and Health and Safety performance compliance. AGL will also ensure the application of corrective action to all identified deficiencies and non-compliances for its operations. AGL, along with the management team of each Contractor, will act as supervisor for any Contractors on AGL sites to monitor and manage Contractors' ongoing compliance with their own Work Health and Safety obligations, both under applicable legislation, and under their contract with AGL.

3.5 Reporting - Workplace Health and Safety (WHS) Performance

AGL shall maintain an appropriate record system for its own operations and health and safety reporting shall be conducted in accordance with this Plan, licence conditions and regulatory requirements, and will include:

- health and safety incidents and non-compliance reports;
- outcome analysis;
- induction attendance;
- audit reports and monitoring results.

Contractors shall ensure that a daily or weekly overview of their health and safety performance is provided to AGL to ensure compliance by Contractors with their contracts with AGL. This overview should include the following as a minimum:

- hours worked for the period;
- lost time injuries;
- medical treatment injuries;
- first aid injuries; and
- near miss incidents.

Accountabilities & Responsibilities

The AGL Group General Manager Upstream Gas is ultimately responsible for the management and safe operation of AGL's undertakings during the Project. All AGL personnel and Contractors have separate responsibilities and obligations to minimise impacts on the environment, work safely and maintain a healthy working environment for themselves, their fellow workmates and the public.

AGL Leaders are responsible for:

- ensuring that sufficient human, material and financial resources, including technical resources and support, are provided in their area of responsibility;
- the effective management of OHS-related aspects of the operations for which they are responsible and exercise relevant control, including the achievement of goals; and
- ensuring that actions have been completed to introduce, manage and operate systems to meet the organisation's corporate requirements for OHS management.

The responsibilities of key project personnel are as follows:

4.1 Group GM Upstream Gas

AGL's Group General Manager Upstream Gas is accountable and responsible for the OHS performance of AGL for the Project.

4.2 Head of Exploration

AGL's Upstream Gas Head of Exploration is accountable to the Group General Manager Upstream Gas.
It is the responsibility of the Head of Exploration to ensure that sufficient resources are available to implement, develop and maintain a health and safety management plan throughout the life of the Project. The Head of Exploration will ensure actions and delegations have been completed to introduce and manage systems to meet AGL's corporate requirements.

In particular the Head of Exploration is to:

- provide leadership and support for the Project team in order to ensure deliverables are met;
- assist in setting, defining and communicating AGL's Workplace Health and Safety (WHS) goals and targets for its activities;
- ensure that WHS matters relating to the Project are reported to relevant personnel and are included in the agenda of management meetings;
- ensure the resources needed to ensure that WHS objectives are met are provided and that this Safety Management Plan is implemented, maintained and improved;

- put in place systems so that AGL Contract Supervisors fulfil their obligations and responsibilities required by this Plan;
- review significant incident/hazard reports, minutes of meetings and AGL audit reports as they relate to exploration activities; and
- participate in significant incident/hazard investigations as appropriate.

4.3 Head of Gas Operations

The AGL Upstream Gas Head of Operations is accountable to the Group General Manager Upstream Gas.

The Head of Gas Operations is to:

- ensure the resources needed to ensure WHS objectives are met in respect of the Gas Operations area (to the extent of AGL's undertaking) are provided;
- review significant incident/hazard reports, minutes of meetings and AGL audit reports as they relate to gas operations activities;
- put in place systems so that AGL Contract Supervisors fulfil the obligations and responsibilities required by this plan;
- participate in AGL incident/hazard investigations where appropriate;
- ensure employees for which he/she is responsible in a Project activity are trained in the assessment of risk and job safety analysis for carrying out the activity; and
- when necessary, participate in risk assessments such as design reviews, risk assessment workshops, hazard and operability studies. etc.

4.4 Manager Operations

The Upstream Gas Manager Operations is accountable to the Head of Gas Operations. The Manager Operations is responsible for liaising with relevant Major and/or Minor Works Contractors undertaking production and operations activities on the Project and accordingly is the AGL Contract Supervisor for production and operations works. The Manager Operations is to:

- ensure this Plan is communicated to all relevant personnel involved in the Project to ensure awareness and understanding of the key aspects for which they are responsible;
- assist in setting, defining and communicating the Project's OHS goals and targets;
- take steps, with the Head of Gas Operations, to provide the resources needed to ensure OHS objectives are met in respect of production and operations (to the extent of AGL's undertaking) are provided and that this Safety Management Plan is implemented, maintained and reviewed;
- review incident/hazard reports, minutes of meetings and AGL audit reports as they relate to production and operations activities;

- has the responsibilities in respect of production and operations contracts as set out in section 4.9;
- participate in incident/hazard investigations where appropriate;
- ensure employees for which they are responsible in a Project activity are trained in the assessment of risk and job safety analysis for carrying out the activity; and
- when necessary, participate in risk assessments such as design reviews, risk assessment workshops, hazard and operability studies.

4.5 Drilling and Completions Manager

The Upstream Gas Drilling and Completions Manager is accountable to the Head of Gas Operations. The Drilling and Completions Manager is responsible for liaising with relevant Major Works Contractors' undertaking drilling activities on the Project and accordingly is the AGL Contract Supervisor for drilling works. The Drilling and Completions Manager is to:

- assist in setting, defining and communicating the Project's WHS goals and targets;
- take steps, with the Head of Gas Operations, to provide the resources needed to ensure OHS objectives are met in respect of drilling (to the extent of AGL's undertaking) are provided and that this Plan is implemented, maintained and reviewed;
- review incident/hazard reports, minutes of meetings and AGL audit reports as they relate to drilling activities;
- have responsibilities in respect of drilling contracts;
- ensure employees for which they are responsible in a Project activity are trained in the assessment of risk and job safety analysis for carrying out the activity; and
- when necessary, participate in risk assessments such as design reviews, risk assessment workshops, hazard and operability studies.

4.6 AGL Health & Safety Manager (H&S Manager)

The AGL H&S Manager is accountable to the Head of HSE. The H&S Manager is to:

- manage the development, implementation, review and update of this Plan;
- oversee the implementation of AGL's Contractor Management Program in respect of this Project, including ensuring the integrity of the Major Works Contractors' safety management plans are managed and that their plans and H&S systems achieve parity with AGL's Life Guard system & requirements;
- ensure currency of knowledge of NSW safety regulatory environment and communicate changes or alerts to the Project team;
- ensure employees supervising a Project activity are trained in the assessment of risk and job safety analysis for carrying out the activity;
- support the Project team and provide specialist OHS advice;

- ensure the WHS risk management requirements within this Plan are met;
- attend or lead the investigation of any incident or near miss (to the extent that the incident or near miss relates to AGL's WHS duties and obligations;
- stop work in emergencies or when unsafe or environmentally harmful working conditions are identified until such conditions are sufficiently corrected;
- conduct regular Project OHS workplace inspections, AGL audits and provide feedback and recommendations;
- in conjunction with the relevant AGL Contract Manager and/or H&S Business Partner, conduct compliance checks of the Contractors' WHS;
- monitor safety performance of the Project personnel in compliance with this Plan;
- when necessary, participate in risk assessments such as design reviews, risk assessment workshops, hazard and operability studies;
- report all accidents, injuries and near misses to the Upstream Gas Leadership Team;
- communicate and consult with the Project team through project Team meetings and other forums as required; and
- issue stop work orders when site conditions are considered to be potentially unsafe and hazardous to personnel or the public or where there is a significant risk of harm to the environment.

4.7 AGL Project Manager

The AGL Project Manager is accountable to the Upstream Gas Leadership Team.

The AGL Project Manager is responsible for implementation of this Plan and will ensure all representatives of the AGL Project team understand the requirements of this Plan. In addition the Project Manager will:

- Assist the AGL H&S Manager to manage the development, implementation and review of this Plan;
- define, document and communicate roles, responsibilities and authorities of all in the Project in order to facilitate effective WHS management;
- ensure that safety matters relating to the Project are included in the agenda of Project team meetings;
- review AGL incident/hazard reports, and AGL audit reports relevant to the Project; and
- foster a continuous improvement approach to all safety matters.

4.8 AGL Health and Safety Business Partner

The AGL H&S Business Partner is accountable to the AGL H&S Manager. The AGL H&S Business Partner is responsible to assist the AGL H&S Manager in implementation of this Plan through the implementation and administration of the AGL Contractor Management System:

- implement AGL's Contractor Management System in respect of the Project, including ensuring the integrity of the Major Works Contractors' Safety Management Plan and that their plans and Health and Safety systems achieve parity with AGL's Life Guard system & requirements and this Plan;
- ensure Contractors involved in a Project activity have appropriate systems in place for training in the assessment of risk and job safety analysis for carrying out the activity;
- review AGL incident/hazard reports, minutes of meetings and AGL audit reports where relevant;
- participate in incident/hazard investigations (to the extent that the workplace health and safety incident/hazard pertains to AGL's Work Health and Safety duties and operations) as required;
- in conjunction with the relevant AGL Contract Manager and/or H&S Manager, conduct compliance checks and audits of the Contractors' OHS; and
- issue stop work orders when site conditions are considered to be potentially unsafe and hazardous to personnel or the public or where there is a significant risk of harm to the environment.

4.9 AGL Contract Supervisor

Each contract for works covered by this Plan shall have an AGL Contract Supervisor, to be the Project team member from the area within AGL which was responsible for engaging that contractor.

The AGL Contract Manager is responsible for the following:

- managing Contractors to fulfil their obligations and responsibilities required by this Plan, the contract which is in place and their safety management systems;
- review AGL incident/hazard reports and minutes of meetings for Contractors for which they are AGL Contract Supervisors;
- foster a continuous improvement approach to all WHS matters;
- assist the H&S Business Partner to conduct compliance checks of the Contractors' safety management systems under the requirements of this Plan;
- liaise closely (where necessary) with Contractors on WHS matters;
- when necessary, participate in risk assessments such as design reviews, risk assessment workshops, hazard and operability studies;

- report all accidents, injuries and near misses to the H&S Manager and Head of Gas Operations or Exploration as appropriate, with copies of reports to the Project Manager and H&S Business Partner; and
- issue stop work notices in respect of the contracts for which they are responsible when site conditions are considered to be potentially unsafe and hazardous to personnel or the public, or where there is a significant risk of harm to the environment.

4.10 AGL Site Safety Managers (including Company Men)

AGL Site Safety Managers are responsible for ensuring all Workplace Health and Safety obligations in relation to works for which AGL is Operator are adhered to and met throughout the duration of the works. Duties include:

- ensuring site inductions are given to all people entering the site;
- ensuring each person at the site complies with standard operating and emergency procedures and other safety measures;
- ensuring appropriate first aid and safety equipment is available and maintained at the site;
- ensuring relevant staff at the site are trained in first aid, emergency and other safety procedures; and
- ensuring processes are in place to make sure the above obligations are met.

When appropriate, the Company Men and supervisors of remote work crews are responsible for daily location monitoring of personnel in remote areas (see Communications section).

Site Safety Manager:

AGL will appoint a 'Site Safety Manager" as appropriate for each project or sub activity that forms part of the Project who shall be responsible for executing the duties as listed above.

- The Manager Operations is the Site Safety Manager in respect of all Gloucester Gas Project exploration activities.
- In certain circumstances if a Contractor is appointed to carry out 'workover' operations, the Contractor must appoint a Site Safety Manager responsible for the operation of the workover rig.
- In remote operations sites, the senior supervisor may be appointed to the position;
- Where drilling operations are being conducted the drilling Contractor must appoint a Site Safety Manager for operation of the drill rig, and the Contractor's surface facilities. The AGL Company Man will be the Site Safety Manager for sub-surface operations.

Site Safety Managers are to issue stop work orders in respect of works at their site when site conditions are considered to be potentially unsafe and hazardous to personnel or the public, or where there is significant risk of harm to the environment.

4.11 Contractors - Project Manager

The Project Manager of each Contractor is responsible for:

- undertaking a project specific risk assessment and determining the controls and procedures to be implemented and monitored to control the identified risks;
- ensuring Major and, where applicable, Minor Works Contractors' safety management plans and OHS systems meet or exceed for its own operations the requirements of AGL's Plan and that Contractors' plans are appropriate for the contracted scope of work;
- overall management of the Contractor's Project Team and subcontractors to achieve project WHS milestones and objectives;
- in accordance with any contractual requirements, reporting to AGL any proposed material changes to scope of work, personnel or job procedures, in accordance with Management of Change procedures, before proceeding with the work. This includes material changes that are required due to field conditions being different from those anticipated;
- assigning responsibilities to the Contractor's Project Team and defining them in the Contractors' project specific safety management plan; and
- ensuring that all subcontractors have developed and implemented WHS management systems that comply as a minimum guide to AGL and Project requirements and standards.

4.12 All Personnel

Project personnel at all levels are responsible for their health and safety and that of their co-workers and the general public. Each individual is responsible for ensuring their work complies with regulatory requirements.

All persons are required to report any deviation from the conditions anticipated in this Plan and report accidents or unsafe conditions to the Site Safety Manager.

The Work Health and Safety Act 2011 (NSW) Part 3, (sections 35 – 39) outlines the requirements for the notification of incidents 4.13

Stop Work Procedures

Under the Stop Work Procedures, AGL may direct a Contractor to suspend works if the works are not being performed in compliance with the Contractor's own WHS obligation on site or if the works are being conducted in such a manner as to endanger the health and safety of any person on site.

Risk Assessment and Management

AGL has developed a fully integrated risk management (FIRM) framework guided by the risk management standards and methodologies recommended by the Australian and New Zealand Risk management – Principles and guidelines AS/NZS ISO 31000:2009. The AGL FIRM framework provides a process for the identification of hazards, assessment of the risk level, implementation of appropriate mitigation strategies and monitoring and review.

The AGL Project Manager, or nominee, and AGL H&S Manager, or nominee, will participate in risk workshops in relation to the activities which AGL conducts. The Gloucester Project Manager is be responsible for identifying any AGL owned risk and the appropriate management level of sign-off.

AGL will advise contractors of any identified Project work activities or conditions that have significant potential hazards associated with them through access to this SMP and the risk register, kick off meetings and inductions.

5.1 Risk Management Process

A Risk Management process and Project HSE Risk Register shall be implemented by AGL which:

- provides a list of all identified hazards associated with AGL's project work activities, and the control measures required to minimise the risk of harm to persons on site or the environment;
- ensures the risk assessment takes into consideration both the likelihood of a hazard, aspect or impact becoming an event or incident and the consequence and severity of such an incident or event; and
- ensures that prior to the implementation of control measures, the proposed measures are reviewed to ensure they do not create a new hazard or risk.

The hierarchy of controls must be applied so that risks associated with identified hazards are eliminated or controlled to as low as is reasonably practicable.

The following sections outline the minimum Risk Management Process required.

5.2 Risk Register

A Project Risk Register has been developed and is being maintained for the duration of the Project. The Project HSE Risk Register will be reviewed on a periodic basis to ensure that all risk management controls are current and effective. Records of these evaluations will be maintained.

5.3 Project Risk Workshop & Hazard Study

A Project Risk Workshop and Hazard Study has been conducted on the Project and will be conducted on individual work packages (as required), prior to commencement. This shall be organised by AGL. This study details the specific work activities and identifies potential hazards associated with proposed methods of mobilisation, travel, construction, plant equipment, and interface with contractors and operations.

Having identified a particular risk to the Project, it is the nominated "Risk Owner's" responsibility to assess that risk and where necessary take appropriate action to eliminate, reduce or transfer that risk to the extent possible, while taking into account the costs of doing so. While in many instances, appropriate action may enable the risk to be eliminated or reduced immediately, there will be other instances where the risk or its management is complex, crosses divisional boundaries, is potentially re-occurring or requires attention from people with appropriate specialist knowledge.

The purpose of the study is to identify high risk activities that will require further detailed analysis and the completion of a Safe Work Method Statement.

In addition AGL's Contract Supervisor and the Contractor Project Manager MUST undertake a Site Specific Hazard Identification Risk Assessment process and ensure that all identified risks are mitigated to a level that is 'reasonably practical' (See items 5.4 to 5.9 below)

5.4 Safe Work Method Statements (SWMS)

AGL as the Operator will ensure its employees and Contractors supervising or involved in activities conducted by AGL are aware of the assessment of risk and job safety analysis for carrying out the activity.

The Contractor must ensure all personnel involved in the activity that are supervised by, or working under the direction of the Contractor, are trained in risk assessment and job safety analysis for carrying out the activity.

It is the responsibility of each Contractor to ensure that all work activities carried out during the Project that have the potential to affect the health and safety of people, or the environment, or to cause damage to equipment, are carried out in a safe and environmentally sound manner and that all Contractor personnel and subcontractors comply with their required safe work procedures.

It is a requirement that all high risk activities are identified and that Safe Work Method Statements are completed for these activities.

High risk activities include (but are not limited to) work associated with:

- potential for a person to fall from one level to another that is reasonably likely to cause injury to that person;
- structural alterations that require temporary support to prevent collapse;
- a confined space;
- excavation to a depth greater than 1.5 metres;
- the use of explosives;
- energised electrical installations and services (on or near);
- an area that may have a contaminated or flammable atmosphere;
- active roadways or railways (on or near) and
- other as identified in WHS / Petroleum legislation

A permit to work may also be required prior to high risk activities being carried out (see section 15.1 of this Plan).

If there is no standard operating procedure for an activity at the drilling operating plant or a change of circumstances happens that means a standard operating procedure for carrying out an activity at the operating plant is no longer sufficient, a Job Safety Analysis / SWMS must be carried out for the activity to assess the potential risks for the activity or any additional risks that may result.

Contractors are to review and authorise all SWMS and ensure that a register of the statements is kept.

AGL will conduct safety reviews to ensure such work is carried out in compliance with each Contractor's SWMS and that they are consistent, or exceed AGL Life Guard requirements, AGL Golden Rules for Upstream Gas and this Safety Management Plan.

5.5 Pre Start Task Risk Assessments

Prior to conducting each work activity it is necessary that all personnel think through the task that they are about to undertake and conduct a review of the activity, associated risks and controls.

5.6 Look Think Act

Look Think Act is a simple method of keeping aware of the hazards in the workplace and is a prompt to think and act in a way that makes workplaces safe.

It is a simple 3 step risk assessment tool that helps everyone to take a proactive approach to identifying hazards in the workplace, assessing the risk of injury or incident, and most importantly, taking action to make it safe for ourselves and those around us.

The three words, Look Think Act, equate to the key words in any risk assessment process; identify the hazards, assess the risks and control the risks.

- Look tells us to spot the hazards or potential hazards that exist in the work we do;
- Think tells us to assess the risk to the health and safety of ourselves and others, and to the environment; and
- Act tells us that we must make it safe. That is, make sure we do something to minimise or better still, eliminate the risk.

The AGL Employee and Contractor induction process provides awareness training on Look Think Act.

5.7 Hazards

Throughout the duration of the Project it is the responsibility of all personnel to be alert to and report to their immediate leader or supervisor any risk identified which may impact upon the health, safety and working environment of themselves, other personnel or the general public.

Each Contractor is to implement a system for the reporting, correction and monitoring of all Project safety hazards. A register of all reported hazards and the actions must be maintained by the Contractor. AGL will maintain a register of all hazards and actions reported by Minor Works Contractors. The total number and the potential risk ranking of each hazard is to be reported to AGL from Contractors on a monthly basis.

5.8 Standard Operating Procedures

Contractors shall ensure that their Standard Operating Procedures (**SOPs**):

- cover critical operating parameters and safe operating limits (both abnormal and normal operation);
- cover details of the consequences of exceeding the limits;
- cover actions to be taken should limits be exceeded;
- meet applicable standards; and
- ensure deviations from preferred standards are justified by risk assessments.

There shall be a process for ensuring SOPs are checked, reviewed and updated. This process is to involve operating staff. SOPs are required for all routine work activities and must be accompanied by a JSA/SWMS.

5.9 Change Management

Any material change to the scope of work, key personnel or organisation structure, work methodology, equipment, operating procedures, other resources, or contractors, will require the relevant Contract Supervisor to formally evaluate (to the extent that it impacts upon AGL's undertaking on site) the impact of the changes, including conducting a risk assessment and evaluation of the impacts to the overall Project, personnel safety, environment, and resources.

Relevant documents include;

- Procedure- Management of Change- DCS_GN_MOC_PR_001
- Procedure-Management of Change, Drilling and Completions Operation-- DCS_GN_MOC_PR_003

Any identified changes to risks shall be notified to Project personnel via toolbox talks, changes to SOPs, pre-start talks, notices and Project updates.

5.10 Pre-Purchase Risk Assessment

A Pre-Purchase Assessment Form must be completed for all assets requiring registration and all new chemicals to identify all of the requirements for purchase, but most specifically that the item meets all specifications for the purpose it is being purchased for. It also ensures that equipment that is fit for purpose is being purchased. For the purpose of this procedure the term “item” will be used throughout this document to inclusively mean both equipment assets and new chemicals.

Relevant documents include:

- AGL UG Pre-Purchase Risk Assessment DCS_GN_AD_PR_006

Training and Competency

6.1 AGL Induction & Training

All Project personnel shall be required to undertake an induction in accordance with AGL's Health, Safety and Environment Induction and refresher Induction requirements. This shall be conducted prior to travel to site where possible, and in any case, prior to commencing work to ensure that all personnel are aware of their health and safety obligations and have the necessary knowledge and skills to fulfil them.

Contract Supervisors MUST ensure that any persons intending to work on the site completes AGL UG Module 1 and Module 2 (Project Specific) which is part of AGL's On-Line Induction. They must also ensure that Contractors are informed of site specific hazards and information. This may take the form of a 'site hazard inspection' or site specific induction.

It is the responsibility of each Contractor to prepare and implement such further induction and job specific training program appropriate to their scope and methods of work.

AGL will maintain records of all inducted Project persons.

AGL ensures appropriate OHS training is given to all employees and leaders, appropriate to their role, other roles and responsibilities, the work activity and level of risk. Inductions are conducted at the commencement of employment, for job transfer, contractors and visitors, upon entry to all sites.

6.2 AGL Induction – Pre Mobilisation

Prior to any site mobilisation or Project activities there may be a requirement for site visits for pre mobilisation activities such as inspections, testing and other activities. It is a requirement that the relevant AGL Contract Supervisor ensures appropriate processes are in place for all AGL personnel or Contractors to be advised of information including:

- site location and safe travel to and from;
- requirements for site entry and specific site hazards;
- site clothing requirements;
- personal protective equipment;
- required training (e.g. 4WD certification); and
- specific medical conditions of personnel allergies etc.

Undertaking AGL UG Module 2 Induction will satisfy these requirements.

6.3 Site Specific Training

Each Contractor is to conduct a training needs analysis to identify the induction and safe work related activity training requirements for their Project personnel and subcontractors. They are responsible for providing instruction and training and keeping appropriate records of certification and training attendance. An appropriate level of supervision shall be determined by Contractors in respect of personnel and subcontractors for which they are responsible.

6.3.1 Visitor Inductions

The Site Safety Manager for a site or their delegate is to ensure that all visitors and persons delivering plant, or providing services, to that site have completed a site specific induction, or are accompanied by a person who has completed a site specific induction, and have completed a visitor's induction. The visitor's induction will cover the specific hazards on site, PPE requirements, site rules and emergency response procedures.

All visitors must register their arrival and departure from site with the Site Safety Manager. The Site Safety Manager is to ensure records of visitors' attendance on site are kept.

The Site Safety Manager will ensure that visitors have the appropriate PPE, which is to be worn at all times whilst on site.

6.3.2 Site Specific Induction

Each Site Safety Manager will ensure that a site specific induction be conducted for all personnel employed on their site and will maintain records of all inducted persons. Before operations commence, inductions shall be conducted covering general environmental and health and safety management issues, including:

- site specific rules and procedures;
- project responsibilities and accountabilities;
- emergency management & response including first aid;
- reporting requirements and methods;
- all relevant Project activities, associated risks and controls;
- regulatory requirements relevant to the work;
- consultation arrangements;
- plant and equipment hazards, controls and residual risk;
- drilling health and safety hazards, controls and residual risk;
- bushfire management; and
- travel, traffic and access.

6.4 Prescribed Occupations

All personnel performing work including subcontractors must be suitably qualified to carry out the specific work activities.

Records of competency will be viewed at induction and the information maintained on the relevant Contractor Induction Register.

AGL requires that Drilling Contractors ensure that workers meet minimum certification and competency requirements as identified below. Drilling Contractors shall demonstrate each person working on a drilling rig, meets the required competencies identified for their position under the drilling competency standard, or that if they do not hold the competencies, they are undergoing training for the required competencies and are acting under the direct supervision of a competent person for the drilling rig.

For the mineral exploration industry sector, which includes coal seam gas drilling, the required title/competencies are:

- Drillers Assistant – Certificate II;
- Driller – Certificate III;
- Senior Driller – Certificate IV; and
- Driller Supervisor – Certificate V.

Other prescribed occupation qualifications that may apply to some Project activities include:

- Rigger;
- Dogger;
- Forklift; and
- Heavy vehicle drivers.

6.5 Competency to Operate

Each Contractor must ensure that there is a system in place to make certain that operators of plant are competent to operate and are familiar with the plant that they are required to operate, or the activity that they are required to conduct. This system must ensure initial and ongoing validation of competence.

Each Contractor must complete a skills assessment identifying the minimum skills, knowledge, competencies and experience requirements for each person to carry out specific work. There must also be a training and supervision program in place that contains the mechanism for imparting skills,

knowledge, competencies and experience required. This program shall include the assessment of new skills, the monitoring of performance and ensuring the ongoing retention of skill levels.

Types of training that may be required include, but are not limited to, well control, IADC Rig Pass Training, Coal Bed Methane Drilling, Air Drilling Induction, and High Pressure High Temperature Well Control.

For well completion activities, the relevant Contractor shall ensure that persons are trained in the standard operating procedure which applies to the activities the person carries out; and are made aware of the risks arising from failing to ensure the production tubing hanger is landed and secured correctly.

Minor Works Contractors directly contracted to AGL, will be required to produce evidence of the competency and qualifications of their personnel to the AGL representative, who will maintain these records.

A practical education and awareness program shall be in place to ensure employees and contractors understand the nature of the hazards and risks associated with the equipment not operating correctly. The equipment and machinery, which are clearly identified as critical, shall be included in relevant training and maintenance programs and procedures.

Consultation

AGL is committed to ensuring all necessary OHS information is regularly communicated to all Project personnel as required and that personnel are appropriately consulted, to the extent that it relates to AGL's undertaking.

During the Project, consultation with relevant landholders and regulatory authorities shall continue. Consultation shall ensure that stakeholders are kept informed, and that local knowledge and expertise are utilised appropriately.

The Project Co-ordinator shall ensure continued close liaison with the landholders as the Project activities occur on their property. This shall ensure that the landholders are kept informed of land access requirements, the schedule of tasks and rehabilitation activities.

7.1 Progress Updates

Project progress shall be monitored by the AGL Project Manager through various means of communication at project team meetings.

7.2 Kick-off Meeting

AGL will hold a kick-off meeting with relevant Contractors shortly after the relevant contract has been issued. This meeting will ensure that the Project OHS responsibilities and requirements are clearly understood by all the relevant parties. This Plan will be issued to the Contractors at or ahead of the Kick-off Meeting for discussion.

Contractors will be encouraged to hold kick-off meetings with their subcontractors and suppliers prior to the commencement of works on site.

7.3 Weekly Safety Meetings

All Contractors will ensure that weekly safety meetings are held to share and discuss WHS information with personnel including the following:

- review of incidents;
- review of information relating to site procedures and expectations;
- review of task assessments;
- review of employee suggestions (HAZOB);
- review of area inspections;
- presentation of safety statistics;
- opportunity for input and suggestions for safety and environmental improvements;
- discussion on Industry and Project OHS alerts;

- notification of changes to procedures or the project; and
- general site related issues.

These toolbox meetings will be documented.

7.4 Pre-Start Meetings

Contractors and their employees will be required to attend and participate in pre-start meetings in their work groups prior to the commencement of each shift. Agenda items for these meetings will be workplace safety and health issues, environmental impact and management, specific safety requirements for current and future work, development of SWMS and work permits.

Each work group supervisor will encourage discussion about the work to be performed during the shift. The Pre-Start Meeting will provide an opportunity to review SWMS.

Feedback will also be provided on previously raised issues. Where tasks continue from the previous days, the Contractor shall advise personnel accordingly and highlight any issues raised from meetings with the Project Site Supervisor. Pre-start meetings will be documented.

7.5 Shift Change Meetings

Contractors and their employees will be required to attend and participate in shift change meetings in their work groups prior to the hand over to a new shift. Agenda items for these meetings will be the current state of the operation, plant and equipment, safety information and work permits.

Where tasks continue from the previous shift, the Contractor shall advise personnel accordingly and highlight any issues raised from meetings with the Project Site Supervisor and issues raised at the previous Pp-start meeting. These discussions will be documented.

Communications

This Plan will be communicated to all Project personnel who have an obligation under this Plan through a number of means including inductions, inspections, training, project meetings, noticeboards, safety messages, weekly safety talks, pre-start meetings and alerts as needed. Changes to this Plan will be promptly notified to Project personnel who have an obligation under this Plan.

8.1 Project Notice Board

Contractors will be responsible for establishing a Project notice board at a prominent location to maintain the following:

- Contractors' OHS policy;
- safety alerts and industry incidents;
- safety statistics;
- significant weather forecasts;
- site OHS committee minutes (if a committee is formed) and OHS promotional material;
- persons in charge;
- first aid personnel;
- emergency telephone numbers and radio procedures;
- hazardous area diagrams; and
- Project OHS performance including positive performance indicators.

8.2 Emergency Communications

Contact numbers and street addresses for all local emergency services will be prominently displayed on a Project notice board in the site office and provided to each work crew on the Project. Where necessary, maps will be included showing the most direct routes for access to these emergency facilities. The site copy of the Emergency Response Plan must be readily available and should be kept in the site office within easy access to work crews (the Emergency Response Plan contains detailed maps showing locations of hospitals and other medical facilities), Prohibited or restricted areas will also be clearly signposted. Such signs should conform to AS 1319 "Rules for the Design and Use of Safety Signs in the Occupational Environment".

Contractors will implement a site radio communications protocol and include it in their site induction process.

It is desirable that Contractors, including cultural heritage monitors, always work in groups of no less than two persons at all times (and see section 10.7 Remote Area Safety)

If necessary AGL will maintain an appropriate number of satellite phones for emergency communications in work they control.

8.3 Journey Management and Check-in (if applicable)

AGL Site Safety Managers are responsible for monitoring the daily movements and activities of their Project personnel in remote areas.

This will be a process of checking each work group at the end of each day, to ensure they have safely finished work, and to establish the work plans for the following day.

Incident Reporting, Recording and Investigation

AGL & Contractors will develop and implement a system of incident reporting, recording and investigation of all incidents and potential incidents that occur on site in relation to their own undertakings.

AGL employees will refer to “HSE Incident Management Procedure LG-HSE-CP-006”.

9.1 Classification of Incidents

To the extent that the incident relates to AGL’s activities, classifications are to be initially determined by the AGL Head of Exploration or Manager Gas Operations (as appropriate having regard to the nature of the incident) and the AGL H&S Manager after consideration of information obtained through initial incident report or from information received from the treating medical practitioner.

The AGL H&S Manager has responsibility for the final classification of all near misses, incidents, injuries and illnesses for AGL corporate reporting purposes. The AGL H&S Manager is to ensure that all incidents are classified correctly for internal and external purposes.

The AGL Fully Integrated Risk Management Assessment matrix (in appendix E) shall be used in the classification of incidents, defined as:

- Low– potential / actual ranking of Low on the risk matrix;
- Moderate – potential / actual ranking of Moderate; and
- Significant – potential / actual ranking of High, Very High or Extreme.

9.2 Notification

Each Contractor must notify AGL of any notifiable incident, actual or potential injury or incident to property. All incidents are to be verbally and formally reported by the Contractor to the relevant AGL Contract Manager within the timeframes designated in Appendix C.

The AGL H&S Manager will initially make verbal notification followed by a brief written outline of known facts of any Contractor significant incident to the AGL Group General Manager Upstream Gas within the defined timeframes. The AGL H&S Manager and responsible Leaders are responsible for reporting significant incidents within AGL in accordance with prescribed standards.

The AGL incident reporting system, Connect First, will be used for AGL internal notification and investigation of all AGL workplace incidents. AGL workplace incidents will be reviewed internally, with

information communicated to the wider business through team meetings and other forms of notification.

ConnectFirst incident notifications are also generated to a wider company distribution list within a short period of the initial entry. In the event of a serious incident, first notification to key personnel will be by phone or personal contact.

9.3 Notification to External Bodies

As per the requirements of the NSW Petroleum (Onshore) Act 1991 & Regulation 2007, and the NSW Work Health and Safety Act 2011 and Work Health and Safety Regulation 2011, incidents will be notified as per Appendix D.

All notifiable safety incidents shall be notified to the relevant regulatory authorities by, in the case of incidents requiring verbal notification, the Head of Exploration, Manager Operations or the Project Manager, and in the case of other incidents, the Project Manager or AGL H&S Manager.

Major works Contractors which are the operator of plant are responsible for notifying regulatory authorities of incidents in respect of their plant.

9.4 Investigating and Reporting

All HSE incidents including an emergency involving a fatality, serious injury or significant damage to property or the environment, shall be immediately reported to the appropriate personnel. Where the incident relates to an undertaking of AGL, the AGL H&S Manager or delegate is to co-ordinate the recording of all factual details of the incident as soon as possible after the event and recorded into AGL's online incident management system when practical to do so. Requirements of the AGL Incident Management Procedure must be implemented immediately following any HSE incident.
Subject to any advice AGL takes, any report may be the subject of legal professional privilege.

The AGL Incident Management Procedure can be found on AGL's intranet health and safety page. The Incident Management Procedure also includes reporting requirements to external regulatory authorities. Government agency representatives may also carry out investigations.

Set out below are the requirements applying to investigations of incidents which relate to AGL's activities. Contractors **must**:

- have in place a root cause investigating methodology with adequate numbers of trained Lead Investigators;
- permit the AGL HS Manager, H&S Business Partner or Contract Manager (at AGL's choice) to be involved in the investigation as an observer for Significant incidents, and where required for Low and Moderate incidents;

- Keep AGL fully informed of all investigations, including by responding promptly and comprehensively to all requests for information; and
- AGL may also conduct its own investigation into the incident, the Contractor's compliance with its contractual obligations and the steps it has or proposes taking to remedy any failed defences or systems to ensure it is achieving compliance.

9.5 Corrective and Preventative Actions

Each Contractor's Project Manager is to review incident outcome actions and monitor their effectiveness. Contractors are responsible for the implementation of any corrective actions and controls necessary to prevent recurrence in their areas of responsibility.

Contractors are to maintain a log of corrective and preventative actions for all incidents. Incident logs are to be tabled at weekly progress meetings and monitored to ensure their effectiveness and timely close out.

Incident logs are to contain the following minimum information:

- date of incident;
- name of injured person where applicable;
- incident classification;
- actual and maximum reasonable consequence classes;
- brief description of incident;
- brief description of injury, damage or loss;
- description of system reinforcement and any timetables for preventative actions; and
- names of team members responsible for implementation of any necessary corrective action.

9.6 Lessons Learnt

Where incident investigations identify lessons learnt that may apply to other contractors or personnel, a report may be forwarded to the relevant parties by the AGL H&S Manager subject to the status of that investigation. Lessons learnt are to be shared with other AGL projects performing similar tasks.

9.7 Records

An electronic database is maintained by AGL to record all incidents which relate to the activities conducted by AGL. A report will be forwarded to the AGL H&S Manager on a monthly basis for all incidents recorded during the period.

The AGL H&S Manager is to maintain copies of all Significant incident reports and investigations on behalf of the Project on the AGL network drives.

Management of Major and Minor Works Contractors

AGL has adopted an OHS Contractor Management Procedure. This procedure involves:

- identification and assessment of hazards and level of risk associated with the proposed works in accordance with guidelines;
- determination of OHS requirements for the works and development of relevant documentation (including the OHS provisions in the contract);
- Contractor selection having regard to those OHS requirements. If the contract is to be tendered, weightings to be accorded to Health & Safety are to be within specified ranges depending on assessed risk level;
- execution of the contract and development by the Contractors of OHS documents and systems as required;
- monitoring of Contractors' OHS performance; and
- review and close out.

10.1 Contractor Pre-qualification

The Contractor management system provides for the pre-qualification of Contractors. AGL employees the services of an external company, ISNetworld (ISN) that specialises in Contractor HSE pre-qualification. All contractors are required to be pre-qualified and subscribed to the ISN system. Pre-qualification assessment addresses business licence requirements, insurances, and OHS performance as measured by Lost Time Injury Frequency Rate and Total Injury Frequency Rate over the previous 2 years.

To be eligible to conduct high risk work, Contractors must have an Safety Management System that has been reviewed and accepted by AGL. Prequalification is valid for 1 year, however currency of insurances and licences for the period of a proposed contract must be checked prior to entry into the contract.

10.2 Subcontractors

Contractors are to implement a system for the pre-qualification and selection of their sub-contractors. Contractors must inform the AGL Project Manager if they will be using any sub-contractors or if their sub-contractors will use sub-contractors for the works being carried out on behalf of AGL. The main objective of a Contractors' system is to assess their WHS capability and that of their subcontractors to ensure that all work carried out by third parties is controlled so as to prevent harm to their own personnel and others.

A Contractor's subcontractors and any contractors directly contracted for Project work activities in respect of a site must ensure that they are complying with the Contractor's site specific Safety Management Plan. Contractors will have a subcontractor management system in place and review and approve all subcontractor health and safety plans prior to commencement of site work.

10.3 Insurance Requirements

Contractors shall maintain adequate levels of insurance to cover incidents that involve injury to persons or damage to equipment under their control. Contractors are required to provide the relevant AGL Contract Manager with valid certificates of currency for the insurance requirements specified in their contract prior to commencing work. Such insurance requirements include as a minimum:

- public liability insurance;
- workers compensation insurance;
- equipment damage insurance; and
- motor vehicle insurance.

AGL Company Men shall also be required to hold professional indemnity insurance.

The insurance policies must be current for the period of the work and no work is to commence until written evidence is supplied to AGL confirming the currency of insurances.

Contractors must ensure that AGL is specified or referred to in the contract for public liability insurance as being a person to whom the insurance cover provided by that contract extends for the purpose of enabling AGL to recover the amount of its loss from the Contractor's insurer in accordance with the contract of public liability insurance.

10.4 Management of Multiple Subcontractors

Major contractors who employ subcontractors are responsible for their management and their safety performance.

10.5 Emergency Preparedness and Response Management

An Emergency Response Plan shall be prepared by Contractors prior to the commencement of activities.

AGL and Contractors will have in place an Emergency Response Plan (ERP) in accordance with their OHS responsibilities. The ERP is to effectively respond to any foreseeable emergency and that in the event of an emergency, plans and capabilities are in place for dealing with such situations so as to preserve the health and safety of all personnel at the Project, protect the environment and preserve company capability and reputation. A separate Emergency Response Plan has been developed by AGL to address any foreseeable emergency events. (Ref: Emergency Response Plan Gloucester Project).

As a minimum the ERP shall include:

- phone numbers and street addresses for all local emergency services. Contact phone numbers for all relevant AGL Contractor personnel - including after hours numbers, mobile phone numbers, etc;
- procedures to be taken by the responsible persons in the event of an emergency;
- specific controls and means of dealing with emergencies arising from specific activities within the scope of their work;
- specified means of communication for emergencies;
- first aid procedures;
- basic fire fighting procedures; and
- the other mandatory requirements for an Emergency Response Plan as set out in the Code of Practice for Coal Seam Gas Fracture Stimulation Activities 2012.

Contractors will have in place emergency response procedures that identify their respective muster points, details on the communication processes, schedules for exercises and adequate provision of resources including people and equipment.

AGL and Contractors are to establish communication with the emergency services and ensure that they are aware of the site.

All personnel and visitors to site will be made aware of the site emergency procedures during the site specific induction. Evacuation procedures, emergency contact numbers and emergency equipment diagrams will be posted in key locations on site.

10.6 First Aid Facilities and Services

Contractors will be equipped on-site with appropriate First Aid equipment that shall be adequate for the needs of the site, and risk assessed for remote area operations. As a minimum there must, for Contractors, be at least two first aid trained crew with current certificates on each crew. The training standard should be to St. Johns Level 2 or higher. Contractors are to ensure sufficient communication protocols are established should a first aider be required to attend a particular area on the Project site.

10.6.1 First Aid Kit

A comprehensive first aid kit sufficient to deal with all minor injuries and for emergency first aid for major injuries should be available on site provided by all Contractors. Included in the kit should be a first aid manual and a chart showing resuscitation procedures. This first aid kit should be in a secure container (but not locked) and kept in a designated and signposted location. It is the responsibility of the Contractor to ensure that the kit is restocked. Kits shall include a snake bite kit.

10.6.2 Flushing Water

A suitable quantity of potable water is to be available at drilling workplaces at all times. A ready supply of fresh water should be available on site to permit rapid flushing of eyes and skin, in the event of burns or chemical spill.

10.7 Remote Area Safety (If applicable)

Where applicable all personnel travelling in remote areas shall ensure they carry sufficient drinking water (the Royal Flying Doctor Service recommends 10 litres per person per day in hot conditions).

Each work crew shall carry a first aid kit suitable for the work being undertaken and for remote areas and must have at least two people qualified in first aid.

If the anticipated planned journey will change significantly, the work crew supervisor and the AGL supervisor shall be notified as soon as possible.

Working alone should be avoided where possible and it is AGL's preference that two people work together or in close proximity at all times in remote areas. If working alone is unavoidable, controls must be put in place to ensure that a person has adequate communications, equipment, and check-in processes to minimise the risks. A 'man down' unit, to trigger communication if the wearer is in circumstances likely to indicate difficulties, is desirable for personnel regularly working alone.

Security

11.1 Site Security

Contractors are responsible for site security at sites for which they are responsible.

AGL Project team members and management representatives must ensure they escort their employees and visitors during their initial visit to the Project site and ensure persons are aware of the site rules and hazards so to prepare for their visit, including but not limited to the nature of the terrain, hazards associated with country / long distance driving, personal protective equipment, and WHS induction requirements.

11.2 Public Safety

AGL Contract Supervisors will work with Contractors to make sure appropriate measures are in place for the protection of third parties in the proximity of the site. These may include warning and restricted entry notices prominently displayed, exclusion controls – fenced off areas, locked and secure premises, fire management systems installed, grass / scrub areas around perimeter fencing maintained at low levels, site practice to control or remove slip / trip hazards in and around the compounds, installations located well inside fenced areas. AGL shall implement site security arrangements when deemed required.

Monitoring & Inspection

Inspection, monitoring and reviewing of AGL activities shall be undertaken to assess and record whether activities are in compliance with regulatory requirements and the objectives outlined in this Plan. These processes shall also ensure construction and operation activities are resulting in an acceptable level of impact with minimum potential harm to personnel.

The Contractor's Site Safety Manager, or their delegate, shall inspect all activities on a daily basis. They shall carry out remedial actions initiated to rectify any faults detected.

The Contractor's Site Safety Manager shall monitor activities to assess compliance with the Contractor's Safety Management Plan.

12.1 Corporate AGL HSE Review

To the extent that it relates to AGL's undertaking, AGL Corporate HSE will conduct project audits of activities relevant to AGL's undertaking to ensure the implementation of this Plan and compliance with the Life Guard system.

12.2 AGL Project Team Reviews

To the extent that they relate to AGL's undertaking, regular planned site inspections will be conducted during the life-cycle of the Project to ensure all WHS requirements are maintained and contract obligations are being met.

AGL-specific audits and Contractor reviews relating to systems, processes and procedures, plant and equipment will also be scheduled, particularly during times of high site activity levels.

The review program shall include a compliance component to be conducted during the project to assess compliance with this Plan, any relevant Contractors' Safety Management Plan, licence conditions and regulatory requirements.

The findings of AGL audits shall be submitted to the AGL Health & Safety Business Partner and AGL H&S Manager. Rectification plans or corrective actions shall then be developed and implemented as required.

12.3 Corrective and preventative actions

The results of all AGL activity audits and inspections will be recorded on checklists and / or reports which, on completion, will be forwarded to the AGL H&S Manager for review, and for co-ordinating follow-up actions if necessary.

Corrective Action Requests (and/or Non-Conformance Reports raised from planned AGL-specific audits and contract reviews will be discussed directly with relevant AGL personnel and the relevant Contractor respectively for timely action.

In addition, AGL Project team members will conduct informal site checks when attending the site and immediately address any hazards (if possible) and raise issues with the relevant managers.

AGL and Contractors are to capture all actions from inspections, audits or hazard reports in a Corrective Action Register. Open corrective actions are to be reviewed on a regular basis to ensure that they are properly closed.

12.4 Review Schedule

Review Activity	By Whom	By When	Date Completed
Project progress review	Project Team	Two-weekly	Recorded 2-weekly
Initial Corporate HS review-	H&S Manager or Delegate	TBA	Completed by end TBA
Drilling Rig review	External	Optional	As required
Corehole Rig review	AGL H&S Manager and/or Drilling & Completions Engineer	To be conducted for each corehole	Recorded as they occur
Project Compliance	Project team members	as project team members are attending sites	Recorded as they occur

The above schedule will be included in the overall project plan and reviewed as appropriate.

Registers and Records

AGL and Contractors will maintain the following registers (as they apply to the activity):

13.1 Registers

- electrical inspection register;
- lifting equipment register;
- Safety Data Sheet register;
- rig audit register;
- incident register;
- outstanding hazards register;
- induction register; and
- training register.

13.2 Records

- SWMS;
- SOPs;
- calibration certificates;
- plant inspections;
- project meetings;
- weekly safety and pre-start meetings;
- records of training and qualifications;
- records of insurances;
- risk assessments;
- maintenance records;
- compliance certificates;
- other as required by legislation.

Guidelines –Drilling Operations

14.1 Pre Construction Activities

All pre-construction activities shall comply with all relevant sections of this Plan.

The objectives of pre-construction management are to:

- appropriately consult with all relevant stakeholders to prevent conflicts during activities; and
- prepare appropriate management strategies to minimise potential impacts and hazards.

The Drilling and Completions Manager and AGL Company Men are to ensure that all Contractors are made aware of their responsibilities as outlined in the Plan and also to ensure that they hold appropriate public liability and workers compensation insurance.

The Drilling Contractor is responsible for all drilling and well control procedures and it is that Contractor's responsibility to ensure that:

- all its equipment and procedures conform to the requirements of this Plan;
- all workers at or near a well site are familiar with their areas of responsibility;
- all training, experience and certification levels in well control procedures are maintained; and
- all well control equipment is maintained and tested prior to drilling out cement and to accord with any additional AGL requirements.

Other contract services, including down-hole logging, fracture stimulation and other well testing procedures, are to be carried out by suitably qualified personnel. It is the responsibility of the senior representative on site for each service Contractor to ensure that all personnel, equipment and procedures under its control meet the requirements of this Plan.

14.2 Fire Prevention

Fire constitutes a major risk on all drill sites, particularly on those where gas is intersected during drilling. Consequently, the recognition and minimisation of fire hazards, sources of ignition and fuel, is essential for the safe operation of the site.

Sources of fuel on site are: formation gas that has reached the surface, petroleum products used as fuel and lubricants (diesel, petrol, grease and oils), compressed gas, rags, bags, rope, timber, combustible waste, etc.

Sources of ignition include: explosion, naked flame, sparks, spontaneous combustion, smoking, welding, cutting, grinding, electrical faults, and lightning. Sparks may be generated mechanically from

friction (striking of metal), electricity (loose or faulty connections, overloading, improper grounding, short circuits, incorrect fuses, etc.) and from engine exhausts.

14.2.1 General Precautions

- All Site personnel and visitors are to be conversant with the safety regulations governing fire prevention;
- All internal combustion engines used for the powering of a drill rig and its ancillary equipment are to be, as far as practical, diesel engines fitted with efficient flame and/or spark arresters;
- If a "Hot Work Permit" is required, naked flames, smoking or motor vehicles without efficient flame and/or spark arresters will NOT be permitted within fenced / controlled work places except where necessary for the purposes of cutting, welding or other essential requirements and only then with appropriate additional safeguards;
- Appropriate refuelling procedures will be documented and followed to ensure that any spills or loss of containment of hydrocarbons is avoided.
- The fenced / controlled work place around the drill rig and support equipment must be kept clear of dry brush and grass;
- Notices prohibiting naked flames and smoking will be prominently displayed;
- Smoking will not be permitted within the fenced / controlled work place. Employees must not bring lighters, matches or (if required by the relevant site rules) mobile phones into controlled work places;
- Electrical work will only be carried out by certified electricians;
- Compressed gas cylinders must not be used without a pressure recording regulator;
- Spilled hydrocarbons will be cleaned up immediately, even if it is necessary to curtail operations;
- Engine oil will be drained into containers for removal from site and will not be allowed to drain loose under engines, mountings, etc;
- Flammable waste including oily rags, sacks, rope, etc., will be collected and stored safely prior to removal from site; and
- Where flammable formation gas from the well cannot be contained, it shall be conveyed away via the BOP and flare line and safely ignited and allowed to flare within the confines of the flare pit.

14.2.2 Special Precautions for Cutting and Welding

Cutting and welding are prime sources of fire ignition and require special consideration. Cutting and welding are permitted by a qualified operator, provided authorisation has been granted by the person in charge.

All cutting and welding operations must be properly supervised by the Drilling Contractor under the conditions of their hot work permit system. The requirements include:

- preparing the appropriate Hot Work Permit;
- inspecting the area in which the work is to be done;
- determining if the work is necessary and safe;
- ensuring that the welder has a thorough understanding of the job;
- ensuring that the welder is qualified for the job;
- ensuring that the equipment to be used is in first class condition; and
- ensuring that an alert assistant is standing by with a fire extinguisher at hand.

The following checks should be carried out before welding or cutting:

- ensure that no sparks, flame or hot slag is likely to fall upon combustible material or equipment which can be set alight or damaged in any way;
- if cutting or welding must be carried out around timber decks or timber supports, continuously wet the timbers or cover with non flammable insulating sheets;
- ensure that adequate ventilation is provided while work is in progress; and
- the Drilling Supervisor must be satisfied that cutting on structural members does not endanger the strength and safety of the structure and that the structures will still conform to DCDMA and/or API standard. If he/she is not qualified to decide, the matter must be referred to a person who is qualified.

Cutting or welding is not to be performed by a person working alone. One person will be delegated to observe flying sparks and falling slag in order to prevent a fire, and a pre-arranged signal will be established whereby cutting and welding will cease immediately a hazardous situation arises.

Additional requirements for electric welding are:

- all ground connections will be securely made to eliminate sparking; and
- connection of the ground return to a common conductor, or to the unit upon which the welding machine and the work are situated, is permitted provided returns are not made through conductors such as pipe containing gases or liquids, other cables, conduits, chains, wire rope, etc.

14.2.3 Fire Fighting Equipment

Each drilling site shall have readily accessible and in good operating condition, not less than four (4) 9kg capacity fire extinguishers. It shall be the responsibility of the Contractor to supply the fire extinguishers:

- fire extinguishers and other fire fighting equipment will comply with the appropriate Australian standard(s) and are to be used for fire fighting and training purposes only;
- fire protection equipment shall be periodically inspected, documented and maintained;

- fire fighting equipment shall be readily available near welding operations; and
- crew members should be familiarised with the location of fire control equipment and trained in the use of such equipment.

The Emergency Response Plan includes the contact number for fire emergency services.

14.3 Access

Access to the well sites will be required on a regular basis during drilling and testing operations. Access to the properties will be via public roads and internal property roads as agreed with the landholder. Wherever practicable, existing roads and tracks shall be used and the location and creation of new tracks (if needed) shall be constructed in consultation (led by the Project Manager) with the landholder.

Signage shall be erected at each drill site to display warnings and contact details.

14.4 Bushfire Risk Management

Drilling and completion activities have the potential to ignite bushfires through the operation of flammable fuel powered equipment and vehicles.

In regard to bushfire risk, the management objective is to reduce the threat of bushfires to construction personnel, third parties, property and the environment.

The AGL site Safety Managers must advise personnel at their site of any relevant alerts and fire bans. All personnel must comply with fire bans. The AGL Emergency Response Plan provides more detail on the process to be followed in the event of a bushfire.

14.5 Risk Management

The construction and operation of the well site brings with it risks to personnel and the general public in the area. However, these risks have been minimised through the design, construction and operation management. The Drilling Contractor's Safety Management Plan shall identify risks to the operation and ensure risks are mitigated so far as reasonably practicable with the objective of minimising risks to personnel and the public.

14.6 Well Completion Requirements

Well completion and workover activities will be required on all production wells. Activities that will be performed included:

- drill stem test;
- running and cementing casing;
- perforating well bore;

- fracture stimulating coal seams;
- running and retrieving tubing; and
- running and retrieving rods and downhole pumps.

The Drilling Contractor shall ensure they comply with well completion safety requirements as per:

- Section 522 (5) of the Schedule of Onshore Petroleum Exploration and Production Safety Requirements August 1992;
- Code of Practice for Coal Seam Gas (Fracture Simulation)-2012; and
- Code of Practice for Coal Seam Gas Well Integrity-2012.

All well head equipment must comply with requirements of relevant standards as per Section 703(7) of the Schedule of Onshore Petroleum Exploration and Production Safety Requirements August 1992. (e.g. ISO 10423 based on API 6A specification). Any open ended valves or fittings must be fitted with an appropriate sealing and other potential plug. All pressurised wells must be leak tested after installation at all joints, valves, threads and other potential leak points using a portable calibrated ppm detector to detect any leak.

All well sites will be fenced to a level to be determined by AGL (according to a risk assessment of the potential hazard) so as to limit access to the well and well head. Signage shall be attached to the fencing to display warnings and contact details.

If a person involved in landing the production tubing hanger or securing the tie down bolts for the production tubing hanger is not appropriately qualified for the activity, the operator of the plant must ensure a job safety analysis for the activity is carried out and the activity is directly supervised by an appropriately qualified person for installing well completion equipment.

AGL will carry out a risk assessment of emissions from potential leakage sources at well sites and establish a program for regular inspections of well head equipment in accordance with that assessment. Inspections will review and assess wellhead equipment to ensure long term integrity is being maintained, including leak testing of all joints, valves, threads and other potential leak points using a portable calibrated ppm detector to detect any leaks.

14.7 Pre-Production Testing

A range of tasks are required in readiness for production testing of the coal seam methane resource. Pre-production testing management objectives are to reduce public risk by protecting well site integrity.

14.8 Production Testing

In regard to well production testing procedures, the management objectives are to reduce the impact of the testing process on air, soil and water quality as well as flora and fauna and the general public.

The production wellhead will be often unmanned and the prime safety consideration will be preventing unauthorised access to the site. The well and equipment around the well would be fully enclosed with a fence with locked gate, preventing casual entry to the well by animals and unauthorised people. The following signs will be clearly displayed:

- WELL NAME AND NUMBER;
- PRIVATE PROPERTY - NO UNAUTHORISED ENTRY;
- NO SMOKING;
- HARD HAT AREA;
- ELECTRICAL WARNING; and
- MACHINE ON TIMER – MAY START AT ANY TIME (if applicable).

14.9 Plugging and Abandonment of Wells

During plug and abandonment activities, the well should remain monitored. The plug and abandonment procedure in the work program should be followed and cement calculations done on actual well volumes with excess.

The Contractor's Rig Manager is responsible for ensuring cement calculations are done on actual well volumes and depths drilled and these are to be checked by an AGL Drilling Engineer. All plug and abandonment operations should be undertaken as per Section 521 (7) of the NSW Onshore Petroleum Exploration and Production Safety requirements August 1992.

14.10 Control Systems and Emergency Controls

The Contractor shall ensure that appropriate control systems including, for example, alarm systems, pressure and flow detection systems as part of well control temperature and pressure control systems and emergency shutdown systems, fluid monitoring systems, and gas detection systems are in place and are clearly identified. The Contractor will also ensure that training and education programs in these systems are in place and used, and that calibration, maintenance and testing processes are in place and documented. The emergency shutdown activation must be suitably located so that access to it is not impeded in the event of an incident.

Guidelines – All Operations

15.1 Permit to Work System (AGL Upstream Gas Golden Rule)

AGL and Contractors must implement a 'permit to work' system to manage high risk operations and activities at site. Permits must be obtained before conducting work that involves:

- confined space entry;
- work on energy systems;
- ground disturbance in locations where buried hazards may exist; or
- hot work in potentially explosive environments.

The 'permit to work' system must be documented to ensure that:

- authorised persons are trained in issuing permits;
- hazards are identified;
- precautions are taken;
- a register of issued permits is kept; and
- at the completion of work the permit is returned to the issuer and closed.

Permits must:

- define the scope of work;
- include a validity period;
- identify all hazards and assess risk;
- establish control measures to eliminate or mitigate hazards;
- link the work to other associated work permits or simultaneous operations;
- be authorised by the Permit Authority;
- communicate the above information to all involved in the work; and
- ensure adequate control over the return to normal operations.

The isolation of equipment and services will require the preparation, review and approval of appropriate isolation procedures prior to issuing the permit to work. Isolation, making safe and restoration of equipment and services must only be carried out by qualified personnel.

AGL may request a review a Contractor's isolation procedures for high risk activities that could involve AGL HSE and/or AGL Operations.

15.2 Energy Isolation (AGL Upstream Gas Golden Rule)

Any isolation of energy systems; mechanical, electrical, process, hydraulic and others, cannot proceed unless a permit to work has been issued, and the following isolation procedures are followed:

- the method of isolation and discharge of stored energy are agreed and executed by a competent person(s);
- any stored energy is discharged;
- a system of locks and tags is utilised at isolation points;
- a test is conducted to ensure the isolation is effective;
- isolation effectiveness is periodically monitored; and
- at least two people are to be in attendance when working on or close to exposed live conductors in situations where isolations are not possible or practicable.

15.3 Ground Disturbance (AGL Upstream Gas Golden Rule)

Work that involves a man-made cut, cavity, trench or depression in the earth's surface formed by earth removal cannot proceed unless ground disturbance procedures are followed:

- a hazard assessment of the work site is completed by the competent person(s);
- all underground hazards, i.e., pipelines, electric cables, etc., have been identified, located and if necessary, isolated;
- Where persons are to enter an excavation:
    - a confined space entry permit must be issued if the entry meets the confined space definition;
    - ground movement must be controlled and collapse prevented by systematically shoring, sloping, benching, etc., as appropriate; and
    - ground and environmental conditions must be continuously monitored for change.

15.4 Confined Space Entry (AGL Upstream Gas Golden Rule)

A confined space is defined as: an enclosed or partially enclosed space which:

(a) is not intended to be used as a regular workplace;

(b) has restricted means of entry or exit;

(c) is at atmospheric pressure during occupancy; and

(d) may:

(i) have atmospheric contaminants or an unsafe oxygen level, or both; or

(ii) cause entrapment or engulfment.

Work that involves 'Confined Space Entry' cannot proceed unless the following confined space entry procedures are followed:

- all other options have been ruled out;
- a permit is issued with authorisation by the Permit Authority;
- the permit is communicated to all affected personnel and posted, as required;

- all persons involved are competent to do the work;
- all sources of energy affecting the space have been isolated;
- testing of atmospheres is conducted, verified and repeated as often as defined by the risk assessment;
- a stand-by person is stationed; and
- unauthorised entry is prevented.

15.5 Working at Heights (AGL Upstream Gas Golden Rule)

Working at heights of 2 metres (6 feet) or higher above the ground cannot proceed unless procedures for working at heights are followed:

- a fixed platform is used with guard or hand rails, verified by a competent person(s); or
- fall arrest equipment is used that has:
    - a proper anchor - mounted, preferably overhead;
    - full body harness using double latch self locking snap hooks at each connection;
    - synthetic fibre lanyards; and
    - shock absorber,

  and which limits free fall to 2 metres (6 feet) or less; and
- all work at heights equipment must be fit for purpose, inspected prior to use, and maintained by a competent person;
- equipment found to be damaged or defective must be taken out of service;
- all items, including tools and equipment, are secured; and
- person(s) are competent to perform the work, including use of the prevention and protection equipment.

15.6 Cranes, Lifting Equipment and Transport of Loads (AGL Upstream Gas Golden Rule)

Contractors must ensure compliance to the AS1418 series of standards for cranes and relevant legislation in respect to plant that is designed to lift or move.

Lifts utilising cranes, hoists, drill and workover rigs or other mechanical lifting devices are not to commence unless procedures for lifting operations are followed:

- an assessment of the lift has been completed and the lift method and equipment has been determined by a competent person(s);
- operators of powered lifting devices are trained and certified for that equipment;
- rigging of the load is carried out by a competent person(s);
- lifting devices and equipment has been certified for use within the last 12 months (at a minimum);
- load does not exceed dynamic and/or static capacities of the lifting equipment;
- any safety devices installed on lifting equipment are operational;

- all lifting devices, equipment, and the secured load have been visually examined before each lift by a competent person(s);
- clear communication is to be established and maintained between all persons involved in the lift; and
- under no circumstances is anybody to work under a suspended load exclusion zone.

Restraints on loads must be appropriate for the transport. Loading and unloading operations are to be assessed and the risks identified and managed.

Mitigations include:

- restraint bollards are used wherever practical for transport of pipe racks and other long loads;
- appropriate exclusion zones to be put in place when loading and unloading;
- loading and unloading procedures to include requirements for correct sequence of events and/or use of primary and secondary restraints;
- safe work method statements to be used where no procedure exists; and
- refer to Australian load restraint guide for transport.

15.7 Driving Safety (AGL Upstream Gas Golden Rule)

All categories of vehicles, including powered mobile plant, must not be operated unless driving procedures are followed:

- the vehicle is regularly inspected and maintained by a competent person;
- the vehicle is suitable for the local driving conditions;
- drivers must assess the suitability and safety of the vehicle prior to any journey being undertaken;
- the vehicle is used in a way that prevents or minimises risks to health and safety of the driver;
- the passenger number does not exceed the manufacturer's design specification for the vehicle;
- loads are secure and do not exceed the manufacturer's design specifications or legal limits for the vehicle;
- the driver operates the vehicle at a speed consistent with site speed restrictions and the existing conditions;
- seat belts are installed and worn by all occupants; and
- safety helmets are worn by riders and passengers of motorcycles, bicycles, quads, snow-mobiles and similar types of vehicle.

Drivers must only be authorised to operate the vehicle if:

- they are trained, certified and medically fit to operate the class of vehicle; and
- they are not under the influence of alcohol or drugs or suffering from fatigue.

The hazards associated with remote driving include poor and variable conditions, vehicle breakdown, injury or collisions with livestock or fauna and exacerbation of incidents as a result of isolation and poor communications.

Work hours will consider time required for driving to and from sites.

Driving at dawn and dusk will be minimised to reduce the potential for accidents due to collisions with animals, and impaired visibility as a result of driving into the sun. Drivers should drive to conditions at all times and take into account hazards such as sun, dust, road conditions, etc.

15.7.1 Communications

Contractors will ensure that communication systems are established so that to the extent reasonably practicable, a person working in isolation can be contacted and can make contact with required personnel.

15.7.2 Vehicle Standards

Flags are typically used during construction of the access roads. Vehicles must not drive in excess of the sign posted speed limit. State speed limits and road rules apply on public roads.

A daily inspection of the vehicle should be made each morning to check the condition of spare tyre(s), sufficient water in the vehicle for each person, general vehicle condition including oil level, location of first aid kit, etc.

15.7.3 Driver Competency

The site specific induction shall include awareness of safe 4WD vehicle operation and assessment of capability (e.g. 4WD training course), in particular prior to construction of access roads. As required, AGL supervisors/managers and Contractors will nominate designated competent drivers. Provisional licence holders shall not drive except in case of emergencies.

The use of designated drivers shall be considered for transporting work crews to site.

15.8 Electrical

Hazards from portable power supplies can lead to electrocution. Contractors will ensure that any electrical work performed on any electrical installation or electrical plant, will be carried out in accordance with AS3012 Electrical Installations, AS3000 Wiring Rules, and by a competent person.

Contractors will ensure a risk assessment is carried out on all foreseeable electrical hazards to ensure that all electrical plant is safe to carry out the work it is designed for and that any risks to health and safety of personnel are eliminated or mitigated.

All electrical equipment brought onto site will be inspected, tested and tagged in accordance with the requirements of AS3760 by the Major or Minor Works Contractors which provides guidance on the frequency of inspection and frequency under various environments. Use, inspection and maintenance of RCD's will be in accordance with legislative requirements.

15.9 High Voltage Electricity & Overhead Powerlines

In areas designated "high voltage", all personnel will work strictly in accordance with approved operating procedures developed in accordance with statutory requirements, ESAA Guidelines and only under the direction of a suitably trained and competent person.

Contractors will ensure all personnel are aware of high voltage hazards present at any site for which they are responsible and that prior to delivery of all plant and equipment to the site, an appropriate assessment shall be carried out to determine the need, and to what extent, safety control measures are required. The Contractor is responsible to ensure this assessment is carried out and that all determined control measures are implemented.

In the event that any site is located at or near overhead powerlines, or any access to a site passes below an overhead powerline, the relevant site Safety Manager will be responsible for ensuring the requirements of the Electrical Safety Office Code of Practice 2010 – Working Exposed Live Parts will be followed.

Relevant Documents:

- Procedure- Work Near Overhead Power lines-DCS_GN_HSE_PR_002
- Overhead Power Lines Risk Assessment Checklist- DCS_GN_HSE_FM_002

The site specific induction will, if relevant, include this hazard and discuss controls.

15.10 Extreme Weather Conditions

Where it relates to AGL's undertaking, AGL supervisors of Contractors shall ensure the risks of adverse weather or working conditions are evaluated and managed appropriately. This includes, but is not limited to, controls and conditions of work with regard to personnel exposure to environmental conditions, such as heat, cold, rain and wind.

15.11 Housekeeping

Housekeeping at all Project sites shall be maintained to the highest of practicable standards. Site inspections will include housekeeping. Work areas should be maintained reasonably clean and free of debris to remove slip and trip hazards.

15.12 Hazardous substances

All Contractors and subcontractors will advise a Contractor's representative, in advance, of all hazardous substances they intend to bring onto a site for which that Contractor is responsible and provide copies of Safety Data Sheets (SDS).

A SDS file will be maintained by the Contractor's representative for all hazardous chemicals stored on-site.

Contractors and subcontractors will make provision for the safe transport, receiving, storage, handling, use and disposal of hazardous materials and substances and maintain appropriate MSDS.

Contractors and subcontractors will ensure that all personnel are adequately trained in correct use and the necessary precautions of the hazardous material/substance prior to use and maintain records of this training.

SDS must be accessible to those personnel working with the hazardous substance and may require the development of safe work procedures on the use of the substance or chemical.

Oil spill kits are to be kept on each plant where oil or hydrocarbons are stored or handled in the event of a spill.

Means should be provided to convey any hazardous substance away from the rig floor while pulling wet strings of pipe.

Hazardous leaks or spills should be promptly cleaned up to reduce the risk of falls, contamination of surface water and fire hazards.

Further requirements are contained in the Environmental Authority and the EMP.

15.13 Manual Handling

Contractors are to ensure that any manual handling that is likely to be a risk to health is identified and assessed in accordance with the relevant health and safety legislation. Lifting equipment will be used to carry all heavy loads. Contractors will ensure that site personnel are aware of all manual handling risks as part of the OHS site induction and ensure that lifting equipment is made available for use.

15.14 Noise

Contractors will ensure that personnel are not unduly exposed to unsafe levels of noise and that unsafe levels of noise are minimised and that exposure standards set out in legislation are adhered to. Personal hearing protectors are to be properly used and maintained where noise levels are likely to be high, such as in the vicinity of heavy machinery. The site specific induction for all personnel shall include information and training on the hazards of noise and the control measures implemented. Any noise complaints by land-owners or the general public are to be immediately reported to the representative of any Contractor and the relevant AGL Contract Manager. The Environmental Authority and EMP set out additional requirements for acceptable Noise levels and the associated management of environmental noise which must be adhered to.

15.15 Plant and Equipment

Only suitably qualified and competent personnel will operate heavy machinery. Contractors are required to ensure personnel licences and / or certificates are sighted before any work can commence. Personnel working in proximity to heavy machinery are required to wear high visibility vests, to keep a safe distance from vehicles and to use radio communication wherever possible.

Contractors will only use equipment that is fit –for –purpose and maintain a Plant and Equipment Register for all plant and equipment on site.

All plant shall be inspected and assessed for suitability, condition and risks, prior to commencing work on the Project. Daily pre-use inspections shall be conducted on all plant.

All safety critical machinery and equipment shall be identified and documented to allow for traceability and maintenance. Commissioning, testing & maintenance procedures for this machinery and equipment which adhere to the Work Health and Safety Act 2011 shall be in place and used.

15.16 Personal Protective Equipment

Contractors are responsible for ensuring that all personnel use the appropriate Personal Protective Equipment (PPE) whenever it is required and to ensure that the equipment is of the appropriate type.

The equipment issued should conform to legislative requirements and the relevant Australian Standard(s), be stored correctly, worn correctly, be in good working order and within any specified inspection date or manufacture expiry date. The site specific inductions will include the general site PPE requirements.

AGL employees, Contractors, subcontractors and visitors to a Project site are all required to wear the appropriate items of PPE and clothing for the site area or the work being performed. All personnel PPE identified as required in each JSEA shall be provided by the Contractor or subcontractor and its use

enforced. Where PPE is required it is the responsibility of the Contractor and subcontractor to ensure that individuals have been adequately instructed in the application of that PPE.

All AGL employees and Contractors' employees are to be supplied with personal protective equipment and are expected to use it. This equipment will include but is not necessarily limited to:

- full length clothing;
- high visibility shirt or vest;
- safety helmet with sun cover;
- safety glasses and face shield appropriate to the job;
- hearing protection;
- steel capped safety boots;
- gloves; and
- respiratory protection (as required).
-

The equipment that is worn by each employee or Contractor at any time will depend on the job at hand. AGL employees shall wear protective clothing and protective equipment when working under conditions where there is reasonable potential for injury or illness that can be prevented by use of such equipment.

It shall be the responsibility of the Contractor to supply PPE to its employees to meet this standard.

Guidelines for appropriate use of safety equipment are outlined below:

- safety hat, full length clothing, safety boots, high visibility shirt or vest and safety glasses should be should be worn by anybody, including visitors, within 30 metres of the well, well equipment and the drill site;
- hearing protection should be worn by all crew and company personnel working on the drill platform or near the compressors when drilling is under way;
- safety glasses, face shield, or other eye protection equipment appropriate for the work being done should be worn by employees engaged in any work where there is a reasonable probability of injury to eyes from flying objects, chemicals or injurious light or heat rays;
- when handling chemicals that may irritate or be injurious to skin, employees should wear rubber gloves, protective apron, or other protective equipment as appropriate with reference to MSDS prior to handling;
- loose or poorly fitted clothing should not be worn;
- employees should not work in clothing which is saturated with any flammable, hazardous or irritating substances;
- employees with hair of such length as to be a hazard in a work area should keep it contained in a suitable manner while performing their duties; and

- all site personnel are to wear safety glasses as part of the standard PPE requirements. Contractors are to ensure that appropriate eye protection (safety goggles, face shield) is used during certain work activities including cutting, grinding, welding, etc.

15.17 Camps - (where applicable)

Health and safety at the accommodation camps shall be managed by the camp contractor and monitored by the relevant Contractor or, where applicable, AGL. Camp Contractors shall establish camp rules to address behaviour and safety matters. Camp inspections shall be conducted to ensure safety, health and hygiene is managed for persons staying at the camp.

Inspections shall include, but not be limited to:

- electrical safety;
- fire safety;
- emergency arrangements;
- food audits;
- water quality;
- sewerage management;
- cleanliness;
- housekeeping; and
- waste disposal.

15.18 Working Hours and Fatigue

The Project has a variety of working hours, shifts and days worked, depending on the nature of the work, location and accommodation arrangements. To the extent that it relates to AGL's activities, AGL requires that arrangements should be in place to identify the hazards associated with working hours. Aspects to be considered should include:

- working hours arrangements;
- driving times between work;
- demands of the work tasks;
- fatigue critical tasks;
- extended exposure to hazards;
- information and training;
- adequacy of supervision; and
- individual and lifestyle factors.

The arrangements associated with monitoring, assessing and applying control measures to hazards associated with long working hours should cover not only actual work, but also personnel who are on call or on stand-by for extended periods.

When extended work periods are required any work deemed to present an unacceptable risk due to personnel being tired or not sufficiently alert, should be immediately stopped.

The monitoring of fatigue experienced by personnel working extended hours, should rely not only on reporting by personnel but also on observation and assessment by Project supervisors and Contractor supervisors.

Special care should be taken during the first and end shift in any sequence. Particular attention should be paid to the risk to personnel who are required to drive vehicles, for all or part of their work period.

Document Control

16.1 Review and Update Procedures

This plan is a controlled document and is not to be revised without the prior approval of the AGL Project Manager. The plan will be reviewed formally annually by the AGL Project Manager in consultation with the, AGL H&S Manager, AGL H&S Business Partner, Contractors (to the extent relevant) and immediately after any significant incident or change to the activities of the Project.

16.2 Distribution of copies

This Health and Safety Plan will be issued to Contractors to assist in alignment of the Project Specific Safety Management Plan with the AGL Life Guard system.

All requests for changes to the distribution list are to be addressed to the AGL Project Manager.

16.3 Documentation and Data Control

AGL will ensure that the current and up-to-date version of OHS related documents is available to Contractors and consultants and that all the relevant records are kept for the required duration, including records required by legislation. This includes but is not limited to:

- OHS policies;
- OHS goals, targets and objectives;
- description of the scope of the OHS system;
- description of the main elements of the OHS management system, their interaction and reference to related documents;
- documents, including records, required by this Plan; and
- documents, including records, determined by the organisation to be necessary to ensure the effective planning, operation and control of processes that relate to its significant OHS issues.

AGL will ensure that all required OHS documentation and records are clearly written and presented so that it is easy to understand for those who need to use it.

The documentation will be periodically reviewed, revised and authorised as necessary by competent and responsible personnel, communicated and be readily accessible to all appropriate or affected personnel. The documentation will be in a suitable format to describe the core elements of the OHS management system and their interaction; and provide direction to related documentation.

Contractors are required to ensure all OHS-related documents, including external documents, are controlled by a document control system. A procedure outlining responsibility shall be established, implemented and maintained regarding the document control system, which will address creation and

modification of the various types of documents and data. The document control system shall include the control of both hard-copy and electronic documents, formal review and authorisation by competent and responsible personnel, and identification, registration and revision control including dates of revision.

List of Abbreviations

Abbreviation	Explanation
WHS	Work Health and Safety
EMP	Environmental Management Plan
OHS	Occupational Health and Safety
JSEA	Job Safety and Environment Analysis (also JSA)
Management Team	AGL Project Team
PPE	Personal Protective Equipment
SMP	Safety Management Plan
SWMS	Safe Work Method Statement
Project	The gas exploration program of which AGL is operator, (PEL285)

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Appendices

Appendix A - AGL HSE Policy

Objectives
AGL's aspiration for Health, Safety and Environment is Zero Harm to our people and to the environment we operate in. Our Health, Safety and Environmental (HSE) Management System, Life Guard, assists us to achieve this.

Our HSE policy objectives are to:

- provide a safe and healthy workplace and eliminate work related injuries and illnesses, and
- actively demonstrate a commitment to sustainable growth, including the protection of the environment.

Strategy
We will achieve these objectives by:

- Giving safety, health and environmental considerations equal priority with other business objectives.
- Meeting or exceeding the requirements of legislation.
- Performing our work safely and with proper regard for the environment.
- Ensuring that our people have sufficient resources for the management of HSE activities, and that these activities are managed consistently and constantly.
- Leading, training and motivating our people and our contractors to work in a safe and responsible manner.
- Managing non-conformance to HSE rules and procedures in a fair and consistent way, in order to prevent injuries or environmental harm.
- Improving our HSE performance by establishing HSE goals at all levels within the company.
- Consulting with our people and the community on health, safety and environmental issues.
- Using resources and energy efficiently, and minimising waste, emissions and pollution from our activities.
- Actively participating in the policy debate on energy and related environmental matters, through engaging with Government, the energy sector, the community, employees and other stakeholders.

This policy applies to all employees, contractors, products and services, and joint ventures under AGL's operational control.

Michael Fraser
Managing Director
September 2012

Our Values
One team
Delivery
Authentic
Safe and Sustainable
Vitality

AGL Actions, not words.

Upstream Gas
Health, Safety and Environment

Step Back Policy

Upstream Gas is committed to the health and safety of its people and to the protection of the environment. It is not acceptable for any employee or contractor to leave work injured or for the environment to be harmed by our work activities.

This guideline applies to all Upstream Gas employees and contractors. Personnel, who identify a potentially uncontrolled hazardous HSE work situation, have the right and the responsibility to cease work immediately. Only when the situation has been resolved to an acceptable level shall work recommence.

INDIVIDUAL'S RESPONSIBILITIES

- Immediately make the work area safe, only if competent to do so;
- Report all unsatisfactory work conditions immediately to their leader or persons in charge;
- Ensure AGL Safety Golden Rules for reporting incidents is followed.

LEADER RESPONSIBILITIES

The relevant leader or person in charge shall (as appropriate):

- Take all reports of unsatisfactory HSE conditions seriously; and
- Evaluate any further immediate or temporary make-safe measures put into place; and
- Consult with all personnel and all relevant parties about the situation and determine the appropriate remedial actions necessary; and
- Resolve the matter to an acceptable level; and
- Ensure the identified hazard is recorded in the relevant AGL incident management system.

Mike Moraza
Group General Manager Upstream Gas
August 2010

Page 1 of 1

AGL ENERGY
Safety Golden Rules

AGL is committed to providing a safe workplace for all employees, contractors and visitors. We strive to ensure that every person goes home from work at least as healthy as when they came. We recognise that some aspects of our work involve hazards that, if not properly controlled, may result in a harmful, and at times life-threatening, situation.

As part of our Safety First strategic initiative and our Safe and Sustainable value, AGL has developed safety golden rules (Golden Rules) as fundamental expectations of safe behaviour. They are designed to protect employees, contractors and visitors from unsafe behaviour that has the potential to create a life-threatening situation.

Failure to adhere to Golden Rules jeopardises AGL's ability to provide a safe workplace for all employees. This behaviour is taken very seriously by AGL. Therefore, a breach of the Golden Rules by anyone in the employ of AGL may result in disciplinary action being taken, which may lead to termination of employment.

AGL's Golden Rules

There are four Golden Rules that are applicable AGL-wide. As our people's safety and wellbeing is important to us, employees must:

1. **Report all injuries.**
2. **Report all significant incidents, hazards or near misses.***
3. **Only use plant and equipment in a manner which will not compromise its safe operation or protection.**
4. **Only operate plant and equipment with the required licence and authority, and in accordance with operating procedures.**

*Incidents, hazards or near misses that have an actual or potential risk rating of high or above on AGL's FIRM risk matrix

In addition to these four core Golden Rules, some AGL business units have their own Golden Rules specific to the nature of work undertaken in that business. These business unit-specific Golden Rules apply to employees, contractors and visitors within those business units as well as the four core AGL Golden Rules. The same importance is attached to a failure to adhere to a business unit-specific Golden Rule as to an AGL-wide Golden Rule.

Who do Golden Rules apply to?

- Golden Rules apply to all employees of AGL.
- Contractors are expected to follow all Golden Rules whilst on AGL premises. Failure to do so may result in a contractor being asked to leave the site or may affect the continuation of the contract.
- Visitors are expected to follow all Golden Rules whilst on AGL premises. Failure to do so may result in a visitor being asked to leave the site.

Application of Golden Rules:

- The application of Golden Rules should always be in accordance with the purpose and intent of the Rules, i.e. preventing AGL employees placing themselves or others in unacceptably dangerous situations.
- When considering the disciplinary action to be taken in response to a breach of Golden Rules, leaders should consider all circumstances directly or indirectly relating to the incident. This may include:
    - whether the person was aware of the Golden Rule;
    - whether the person wilfully and knowingly failed to adhere to the Golden Rule; and
    - any other relevant or extenuating circumstances in the incident.

Responsibilities
All leaders are responsible for:

- Ensuring all employees are aware of the Golden Rules applicable to the workplace.
- Ensuring any visitors or contractors at the site are informed about Golden Rules applicable to the workplace.
- Implementing Golden Rules consistently and fairly.
- Responding to any breaches of Golden Rules in accordance with AGL's "Counselling for Improved Performance Policy". Any leader who does not address a breach will be considered to have committed a breach themselves.
- Involving and consulting their People & Culture Business Partner in any formal investigation and/or performance improvement process.
- Making every effort to ensure that employees are reminded of the content and importance of Golden Rules at regular intervals. For example, this may be through toolbox talks, team meetings or workplace inspections.

All employees are responsible for:

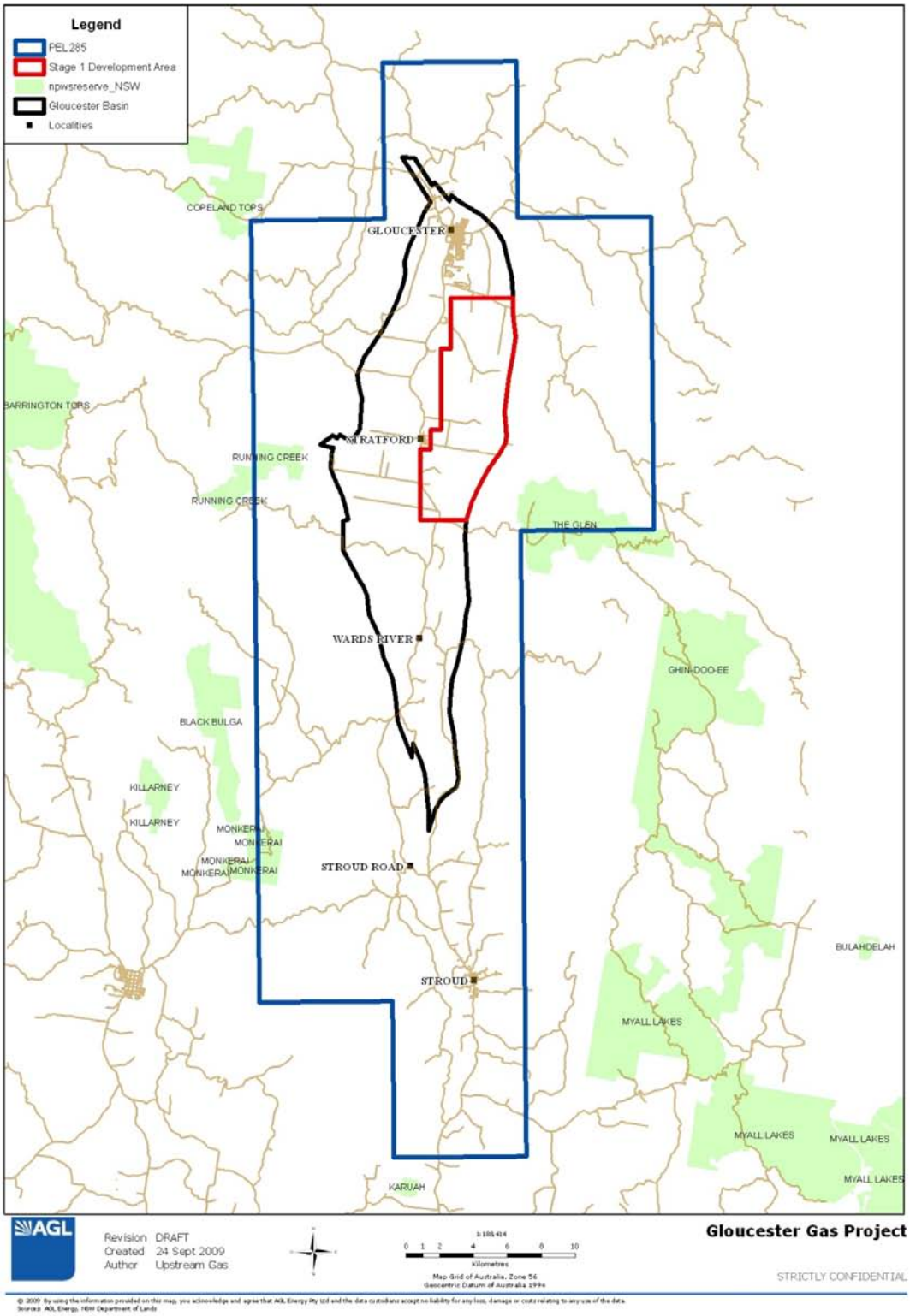
- Ensuring they are aware of all Golden Rules applicable to their workplace.
- Ensuring they are aware of all Golden Rules applicable to any temporary workplace within AGL, for example whilst visiting another site
- Adhering to all Golden Rules.
- Encouraging other employees to adhere to all Golden Rules.
- Ensuring any visitors or contractors they are responsible for at the site are informed about Golden Rules applicable to the workplace.
- Reporting any breaches of these rules to their leader. Any employee who knowingly ignores a breach of Golden Rules, including as a result of failing to report the incident, will be regarded as having committed a breach themselves.

People & Culture are responsible for:

- Providing guidance on the interpretation of Golden Rules.
- Providing guidance on the use of disciplinary processes to address breaches of Golden Rules, in accordance with the "Counselling for Improved Performance" policy.

Michael Fraser
MD and CEO
AGL Energy

Appendix B –PEL285



Appendix C Incident Management Process

STEPS	WHO/ WHAT	PROCESS
1. Incident occurs or hazard identified	**Anyone**	
2. Make safe and verbally advise the relevant direct leader immediately	**Anyone**	With the exemption of the following circumstances, do not disturb an incident site that has the potential for investigation by an external authority; Making the site safe for the intent of protecting the environment, health or safety of a person; aiding an injured person involved in an incident; or to prevent a further occurrence of an incident.
3. Assess incident for 'Notifiable Incident' requirements	**Direct Leader**	If there has been a fatality, follow the requirements of the Life Guard *Workplace Fatality procedure*. Refer to Appendix A: Obligations to Notify to External Authorities – Health, Safety and Environmental Incidents If possible Notifiable Incident - notify AGL Group Legal and HSE before contacting the relevant authority. If Significant Notifiable Incident - refer to Appendix B: Legal Professional Privilege. AGL Legal with Executive Team (ET) member will determine if legal professional privilege will be invoked. AGL Legal will engage legal and other specialists as required and appoint an "Instructing Lawyer" to advise and assist HSE and the business to manage the overall investigation.
4. Assess potential for LTI and risk level – Follow verbal notification process	**Direct Leader / Responsible Leader***	Where an injured worker is not able to attend work due to a work related injury/disease or the incident has a potential risk level of High or above – Direct leader to initiate the chain of command notification to the relevant ET member, with verbal notification to the CEO by the *responsible leader** within 24 hours of the incident. For all HSE matters, use the Consequence and Likelihood Rating Matrices in the AGL Risk Assessment Framework to assess the potential risk level. That is, based on the same conditions of the event, what is the most feasible event that could have occurred? * *Responsible leader* is the leader of the group where the incident occurred and who reports to a level 3 leader. A level 3 leader reports to an ET member.
5. Record in incident management system	**Anyone**	As soon as practicable, but no later than 24 hours after an incident or hazard identification.
6. System generated notification and workflow emails	**System**	A system generated notification of all work related records will be emailed to the HSE team and Head of Group Risk and a workflow email to the direct leader of the colleague/s involved in the incident to **record** the potential risk level into the system. A system generated email will be emailed to the direct leader and HSE Advisor for all first aid and non work related records.
7. Record potential risk level in incident management system	**Direct Leader**	Record potential risk level within 24 hours of incident being entered into the system.

<table>
<tr><th colspan="7">POTENTIAL RISK LEVEL</th></tr>
<tr><th></th><th></th><th>LOW</th><th>MODERATE</th><th>HIGH</th><th>VERY HIGH</th><th>EXTREME</th></tr>
<tr><td rowspan="2">8. Notification based on potential for LTI and risk level

(a) Verbal notification</td><td rowspan="2">Direct Leader/ Responsible Leader*</td><td>Direct Leader to notify their leader within 24 hours of incident (Only required where injury resulted in an MTI).</td><td>Direct Leader to initiate the "chain of command" notification to the relevant level 3 leader within 24 hours of incident. A level 3 leader reports to an ET member.</td><td colspan="3">Direct leader to initiate the chain of command notification to the relevant ET member, with verbal notification to the CEO by the responsible leader* within 24 hours of the incident.
(Also required if an injured worker is not able to attend work due to a work related injury/disease)

* Responsible leader is the leader of the group where the incident occurred and who reports to a level 3 leader. A level 3 leader reports to an ET member.</td></tr>
<tr><td colspan="5">Note: Relevant verbal notification process is followed if the incident potential risk level or injury status escalates after the initial incident notification. Process commences from time the revised incident risk level or injury status is confirmed.</td></tr>
<tr><td>(b) Notification to Executive Team</td><td>Head of HSE</td><td colspan="2">Not required.</td><td colspan="3">As required by the ET HSE Notification Procedure.</td></tr>
<tr><td>(c) Notify incident to external authorities if required & Nominate an AGL contact representative</td><td>Direct Leader</td><td colspan="2">Not required.</td><td colspan="3">The most relevant senior leader / employee for the business, or nominee, shall contact and remain the contact representative for the relevant authority.

Use the External Incident Notification Guidelines to assist.

A system generated information email has been sent to the AGL Legal Team.</td></tr>
</table>

Appendix C Incident Management Process

POTENTIAL RISK LEVEL						
		LOW	MODERATE	HIGH	VERY HIGH	EXTREME
(d) System generated email	**System**	Relevant HSE Advisor / Manager		HSE Team, Head of Group Risk and Head of Legal. (P&C Business Partners and some ET. Personal information withheld).		
(e) Significant Incident Report	**Executive Team member's nominee**	Not required.			***Executive Team Incident Information Form*** to Head of HSE within 24 hours.	
9. Send Hazard Alert	**HSE Team**	Not required.	Not required.	Yes.	Yes.	
10. Assign investigation team (minimum requirements)	**Most Snr Mgr in chain Of Command**	Individual trained in the relevant investigation methodology.	Individual trained in the relevant investigation methodology and / or Business HSE Advisor.		Individual trained in the relevant investigation methodology, Business HSE Advisor and Business HSE Manager.	AGL-Appointed External Investigator
11. Investigate the incident	**Investigation team**	5 Why's or ICAM Lite.	5 Why's / ICAM Lite.	ICAM.		Method determined suitable by AGL-Appointed External Investigator
12. Record the investigation	**Investigation Leader or Nominee**	Record investigation directly in the incident management system.	Record investigation in the incident management system and attach investigation report.			Record investigation in the incident management system. Report prepared by AGL-Appointed External Investigator to be held in a secure file accessible to HSE and/or AGL Legal

Appendix C Incident Management Process

		POTENTIAL RISK LEVEL				
		LOW	MODERATE	HIGH	VERY HIGH	EXTREME
13. Create action plans and record actions in incident management system	**Direct Leader**	Direct Leader's leader to verify plan.		Relevant ET member to verify plan.		CEO or ET to verify plan.
14. Management review and approval of investigation and corrective actions	**As per Risk Level**	Leader's leader to approve.	Leader's leader to approve in consultation with HSE Advisor if required.	Head of Business Unit in consultation with HSE Advisor / HSE Manager if required.	Head of Business Group in consultation with HSE Manager if required. Head of Business Group to notify Head of Group Risk of investigation approval.	CEO or ET / in consultation with Head of HSE if required. Head of Business Group to notify Head of Group Risk of investigation approval.
15. Communication Lesson(s) Learnt	**HSE Team**	Not required.	Not required unless incident involved actual LTI.	Yes		
16. HSE review of incident classification in system	**HSE Advisor**	Yes. Near miss incidents or hazards with a Low Potential Risk Level do not require classification review.	Yes			
17. Conduct actions	**As Assigned**	Depending on investigation outcomes and actions.				
18. Verify actions	**Direct Leader**	Direct Leader.				
19. Close incident	**Direct Leader**	Direct Leader.				

POTENTIAL RISK LEVEL						
		LOW	MODERATE	HIGH	VERY HIGH	EXTREME
20. Close incident notification to person involved	**System**	Email notification of closed incident to colleague/s involved, direct leader, direct leader's leader and relevant HSE Advisor / Manager.				

Appendix D- Incident Notification Table

NOTES

A. Applies to any incident which occurs as a result of the conduct of petroleum activities in relation to operating plant.
- NSW Petroleum (Onshore) Act 1991
- NSW Petroleum (Onshore) Regulation 2007

B. Applies to any incident which occurs anywhere else, for instance en route to operating plant, and/or other AGL Sites.
- Workplace Health and Safety Act 2011
- Workplace Health and Safety Regulation 2011

- A:- NSW Petroleum (Onshore) Regulation 1992		
Incident	**Way report must be given**	**When report must be given**
an incident involving death or serious injury of a person	by telephone	immediately
	in writing	as soon as practicable (within 5 days)
an incident involving injury to a person requiring attention by a medical practitioner	by telephone	immediately
	in writing	as soon as practicable
where serious damage to property occurs	by telephone	immediately
	in writing	as soon as practicable
escape or ignition of Petroleum or other material; a) Spillage of hydrocarbons which in areas of inland waters is in excess of 80 litres and in other areas in excess of 500 litres b) An escape of Petroleum in a gaseous form in excess of 500 cubic meter c) Any uncontrolled escape or ignition of Petroleum or any flammable or combustible material or toxic chemicals causing a potentially hazardous situation	by telephone	immediately
	in writing	as soon as practicable
an incident involving damage to property that may result in a significant loss of structural integrity or load bearing capacity in the property damaged or results in some other significant unsafe condition.	by telephone	immediately
	in writing	as soon as practicable
any emergency	by telephone	immediately
Workplace Health and Safety Act 2011		
Serious incidents involving a fatality or a serious injury or illness	by telephone (13 10 50)	immediately

Appendix E - Fully Integrated Risk Management (FIRM) Assessment Matrix

Consequence Rating Guide

		Consequence Definitions							
Score	**Descriptor**	**Commercial / Profitability / Assets**	**Business Continuity**	**Customer**	**Regulatory / Legal**	**Reputation**	**Environment & Community**	**People & Safety**
0.5	Level 1	Maximum risk less than $100k.	Minor business interruption. Temporary delay in operations with little effect, business would return to normal immediately.	May lose a small number of domestic or small commercial customers.	Once off minor breach. Notification of relevant authority may be required, but negligible possibility of prosecution or breach of license.	Issue resolved in day to day management. Small local publicity.	Negligible and short term environmental impact to localised area of negligible environmental value. No impact beyond AGL's operational area. No interest by local community	Injury or illness requiring medical treatment or first aid resulting in no lost time
1	Level 2	Maximum risk between $100k and $1M.	Business interruption causes problems to either internal or external customers however business as usual achieved after several hours; AND / OR Growth options put off for up to 3 months.	Some loss of third party confidence AND loss of small number of Industrial & Commercial OR Major customers OR hundreds of domestics.	Multiple minor breaches. Regulator may express concern. Possible breach of licence or regulation requires notification to relevant authority / regulator, but unlikely to be associated with financial penalty.	Managed locally, some publicity in local and state press.	Small scale and short term environmental impact to localised area of low environmental value. No impact beyond AGL's operational area. No/minor interest by local community.	Injury or illness that temporarily impairs a person's life. Return to work with rehabilitation to same role.
1.5	Level 3	Maximum risk between $1M and $25M.	Business interruption causes impact to internal or external customers that last up to 5 business days; AND / OR Growth options are delayed for between 3 and 6 months.	Impact to or loss of several Industrial & Commercial OR Major Customers OR thousands of domestics.	Systemic breaches small to medium breaches or 1 large breach. Breach of regulatory / license requirements with likely action by regulatory authorities, resulting in tightening of licence and permit conditions and financial penalties or fines. Enforceable undertakings possible. Unfavourable policy outcomes.	Sustained regional/State coverage.	Moderate, short to medium term environmental impact that may extend beyond AGL's operational area and/or may result in local community complaint(s)..	Injury or illness that permanently impairs a person's life. Return to work with rehabilitation and alternate role.
4	Level 4	Maximum risk between $25M to $100M.	Business interruption causes impact to internal or external customers that last for between 1 and 2 weeks; AND / OR Growth options are delayed for between 6 months and 12 months.	Impact to or loss of a large number of Industrial & Commercial OR Major Customers OR tens of thousands of domestics	Civil prosecution Unfavourable tariff outcomes. Unfavourable policy outcomes impact commercial position. Unable to secure necessary permits for growth / developments. Incident could result in revocation of licence/permits, large fines and prosecutions.	Sustained national press coverage.	Significant medium term impact on important environmental/habitat and/or widespread local community complaints.	Injury or illness that results in a fatality or permanently impairs a person's life. No return to work..

Appendix E - Fully Integrated Risk Management (FIRM) Assessment Matrix

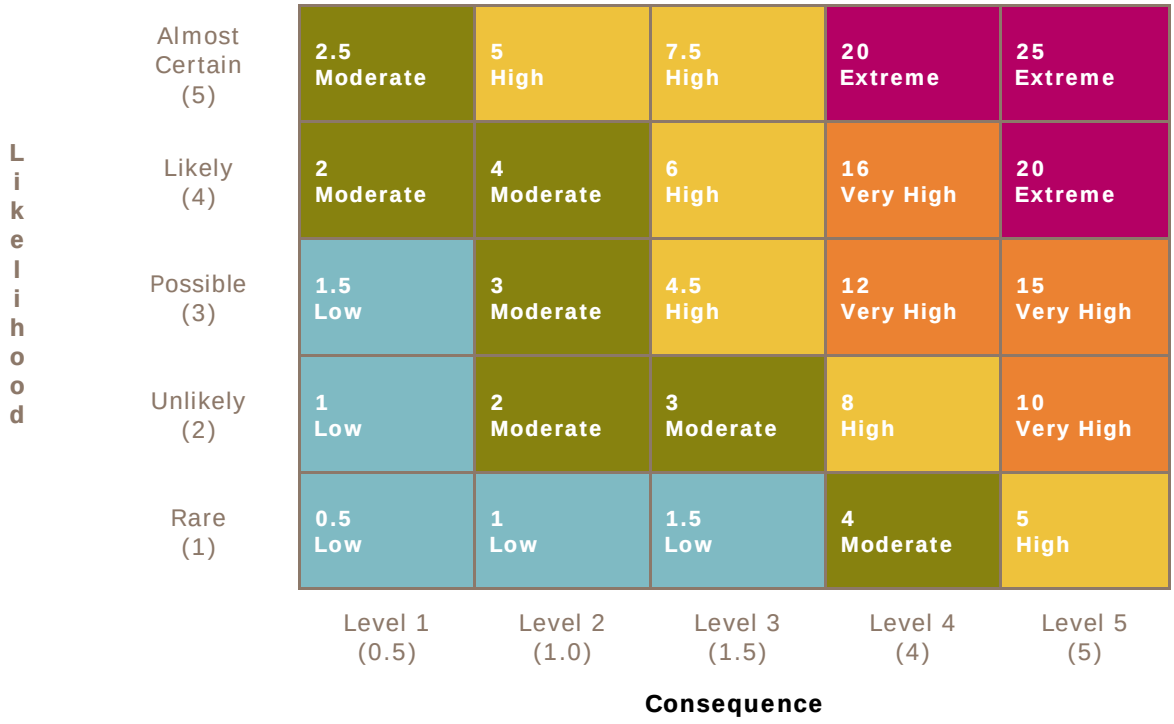
Consequence Rating Guide

	Consequence Definitions							
Score	**Descriptor**	**Commercial / Profitability / Assets**	**Business Continuity**	**Customer**	**Regulatory / Legal**	**Reputation**	**Environment & Community**	**People & Safety**
5	**Level 5**	Risk may exceed $100M.	Business interruption causes impact to internal or external customers that last for more than 2 weeks; AND / OR Growth options are delayed for more than 1 year.	Long term loss of many Industrial & Commercial OR Major Customers OR hundreds of thousands of domestics.	Civil / criminal prosecution Unfavourable tariff outcomes put commercial Loss of operating licences. Loss of licenses and possible closure of facility, significant fines and/or jail penalties could result.	Continuous national and/or international coverage.	Severe long term damage to the environment and/or sustained widespread local community complaints over time. Any loss or damage to listed or protected environment/habitat.	Injury or illness that results in more than 1 fatality or permanently impairs more that 1 person's life. No return to work..

Likelihood Rating Guide

		Likelihood Description		
Level	**Descriptor**	**Complexity**	**Susceptibility / Exposure**	**Probability**
5	Almost Certain	Can only be performed after specialist training and education, years of knowledge required, very advanced technology, extreme inter dependencies between tasks	Extremely susceptible – large numbers of new people and/or new to AGL, attractive to most people with ready access, newly implemented, a lot of changes, new system, untried processes	Knowledge/evidence either within AGL or externally suggests this event/risk occurs almost all of the time. The occurrence of this risk is common and expected - greater than 1 in 2 chance (greater than 50%)
4	Likely	Advanced training, education and specialist knowledge, a significant number of variables and interrelated tasks and dependencies	Highly susceptible - many new people, item is attractive, a lot of changes to the systems and procedures, the item is aging or otherwise becoming susceptible, the event is likely to occur sooner rather than later.	Knowledge/evidence either within AGL or externally suggests this event/risk occurs at regular intervals - between 1 in 10 and 1 in 2 chance (10% to 50%)
3	Possible	High level skill required, usually secondary studies necessary, detailed knowledge needed, advanced technology, a number variable tasks or steps	Quite a few people involved, audit trail difficult to follow, requires 'specialist' knowledge and skills, newly introduced staff and/or procedures, one would expect the event to occur at intervals	Occurs either within AGL or known environment on an irregular basis but frequently enough to be more than a remote possibility - between 1 in 100 and 1 in 10 chance (1% to 10%)
2	Unlikely	Requires basic training but can be quickly mastered by most people, few variations or steps involved	4.3.1. Recent changes, attractive but difficult to obtain, new people, some new processes or procedures, quite a few people involved, one would expect the risk to occur occasionally.	Aware that the event has occurred occasionally either within AGL or externally. However, it is not something that would be classed as a common occurrence and would only occur in certain remote circumstances - between 1 in 10000 and 1 in 100 (0.01% to 1%)
1	Rare	Straight forward singular tasks requiring little or no training	Has a minimum degree of susceptibility, been around for years, tried and true, well known and understood, can't conceive the risk occurring.	Either is not known to have occurred or has not occurred in many 'exposures' to the potential risk - greater than 1 in 10000 (less than 0.01%)

Consequence & Likelihood Risk Evaluation Matrix



Appendix G

Emergency response plan

EMERGENCY RESPONSE PLAN FOR AGL UPSTREAM GAS GLOUCESTER GAS PROJECT Petroleum Exploration Licence 285

Prepared by: Alexandra Secerbegovic
AGL Health and Safety Manager, Upstream Gas

Authorised by: Mike Roy
Head of Gas Operations, Upstream Gas

Section 1 Emergency Plan

Section 2 Emergency Response Procedures

FOR ALL EMERGENCIES

AMBULANCE
FIRE
POLICE

DIAL **000 or**
112 FROM A MOBILE PHONE

PROVIDE THE FOLLOWING:

1. Name and location of the Facility
2. Number of injured persons and the nature of injury
3. The type and scale of emergency including a brief description
4. Hazards involved (e.g. substances)
5. Telephone contact number (for any return calls)

   Usually a mobile number for the person making the call

IF SOMEBODY IS INJURED:

Where competent to do so, implement the following first aid DRSABCD Action Plan.

DRSABCD Action Plan

D

Check for **DANGER** — ensure scene is safe

R

Check for **RESPONSE**

Response	**No response**
• Make comfortable • Monitor response	

S

SEND for help

Call 000 for an ambulance,
or ask bystander to make the call

A

Open **AIRWAY**
Open mouth — look for foreign material

No foreign material	**Foreign material**
• Leave on back • Open airway	• Place in recovery position • Open and clear airway

B

Check for **BREATHING**

Normal breathing	**Not normal breathing**
• Place in recovery position • Ensure ambulance has been called (000) • Monitor breathing and response	• Ensure ambulance has been called (000) • Commence CPR

C

Start CPR

30 compressions : 2 breaths

If unwilling or unable to perform breaths, perform chest compressions only (100/min.).

D

DEFIBRILLATION

- Apply defibrillator (AED) as soon as available
- Follow the voice prompts

Continue CPR until — • the patient shows responsiveness and normal breathing • more qualified help arrives • you are physically unable to continue.

	FOR URGENT REFERENCE
Appendix 1	Stratford Pilot
Appendix 2	Gloucester Emergency Services Map
Appendix 3	Waukivory Pilot – Emergency Services Map
Appendix 4	Craven, Wards River & Weismantel Well Map
Appendix 5	Gloucester, Waukivory & Faulkland Well Map
Appendix 6	Site Emergency Contacts Card

DISTRICT CONTACT DETAILS

24 Hr Community Line:	1300 858 987
AGL North Sydney Office:	(02) 9921 2999
AGL Gloucester Office:	(02) 6558 1166
Ambulance:	000 (Mobile 112)
Dept of Primary Industry, Mineral Resources & Energy:	(02) 4931 6666 0418 699 284 (Glyn Macdonald - Inspector)
DECCW:	131555
Fire: Gloucester Fire Station:	000 or 112 (02) 6558 9222
Gloucester Hospital:	(02) 6538 5000
Land Owners:	On file at office
Operator Next of Kin:	On file at office
Police:	000 or 112 (02) 6558 1204
Gloucester Shire Council:	(02) 6538 5250
State Emergency Services:	132500 (02) 6558 1788 (Gloucester)
WorkCover:	131050 (business hours) (02) 9214 9220 (after hours)

Please Note:

Individual AGL employee and contractor contact details will be recorded on Site Emergency Cards (Appendix 6). This will be available at each well site.

175 YEARS SUPPORTING THE COMMUNITY

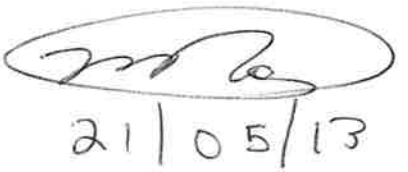
AGL

Section 1 - Emergency Plan

TABLE OF CONTENTS

Document Control

Approval:

Emergency Plan Authoriser	Mike Roy
Title	Head of Gas Operations
Signature	
Date	21/05/13

Revision:

Reviewed by	Signature	Date
AGL Upstream Gas Health & Safety Manager		
AGL Project Manager		

Revision Status:

Revision	Date	Prepared By	Checked By	Approved By	Comments
0	November 2011	JDeS	ET	MR	New format based on Hunter ERP which was updated following comments from DII Minerals in 2010.
1	March 2013	AWS	AS	MR	Update to address Code of Practice for Fracture Stimulation Activities.
2	April 2013	Alex Secerbegovic	Mike Roy	Mike Roy	Minor formatting changes made to Revision 1. Addition of protocols for response.

All updates of this Emergency Plan must be prepared by the AGL Upstream Gas Health and Safety Business Partner and authorised by the AGL Upstream Gas Health and Safety Manager before inclusion.

Distribution

All requests for changes to the Distribution of the document are to be addressed to the AGL Gloucester Project Manager.

	Position	Name	Location
1	Project Manager	Alex Kennedy-Clark	Sydney
2	AGL Head of Gas Operations	Mike Roy	Camden
3	AGL Operations Manager	Adam Stepanoff	Hexham
4	On each work site	Contractor / Company Man	Various

This Plan shall be:

- clearly displayed and provided to all Contractors;
- available for inspection at the relevant site (or another place if not practical to do so), at the Gloucester Site and accessible from the relevant AGL Site Safety Manager;
- provided or made accessible to each AGL person who has a responsibility under this Plan.

A controlled copy of this document will be stored electronically on the AGL network for access by AGL staff.

1. Definitions & Abbreviations

APPEA	Australian Petroleum & Production Exploration Association
Assembly Area(s)	The designated place or places where people assemble during the course of an evacuation
AS	Australian Standard
Bomb	A device of any shape, which can look obvious or be camouflaged, may vary in its sophistication, and may not necessarily "explode".
Bomb Threat	A threat, written or verbal, delivered by electronic, oral, or other medium, threatening to place or use an explosive, chemical, biological, or radiological device at a time, date, place or against a specific person or organization.
Code Red Management Plan	The AGL Code Red Management Plan provides leadership to support teams when a situation escalates beyond local site emergency response plans.
Competent Person	A person who has acquired through training, education, qualification, experience or a combination of these, the knowledge and skill enabling him/her to correctly perform the required task.
DECCW	Department of Environment, Climate Change and Water
DTIRIS	Department of Trade and Investment, Regional Infrastructure and Services
Emergency	An event that arises internally, or from external sources, which may adversely affect the occupants or visitors in a Facility, and which requires an immediate response.
EPA	Environmental Protection Authority (part of the DECCW)
Evacuation	The orderly movement of people from a place of danger.
Facility	A building, structure, or workplace that is, or may be, occupied by people (occupants).
Jemena	Gas Network Authority. The new company name for the previously known Alinta
Person-in-Charge	The designated Field Supervisor approved by AGL to provide onsite supervision and control of operations at any particular time.
Titleholder	AGL Gas Upstream Gas
WHS Act	The Work Health and Safety Act 2011
WorkCover	Occupational Health and Safety Authority for NSW under the Work Health and Safety Act 2011 NSW

2. Purpose

To ensure that arrangements are in place to effectively respond to any foreseeable emergency and that in the event of an emergency, plans and capabilities are in place for dealing with such situations so as to preserve the health and safety of people, protect the environment and preserve the organisation's capability and reputation.

3. Objectives

The objectives of this Emergency Response Plan are as follows:

- To maintain a sufficient level of preparedness
- To respond efficiently to limit the impacts of an emergency
- To manage an emergency until the emergency service personnel arrive and take control where is deemed necessary based on the emergency level
- To support emergency services with information, knowledge, skills and equipment where feasible
- To protect people, emergency responders, personnel and the community from harm
- Comply with government licence requirements

4. Scope

This Plan was developed based on the requirements of AS3745 *Planning for Emergencies in Facilities*, which outlines the minimum requirements for the establishment, validation and implementation of an emergency plan for a Facility to provide for the safety of occupants of that Facility and its visitors leading up to and during an Evacuation. This Emergency Plan applies only to the human / life safety aspects of emergencies within the Project. This emergency plan does not cover operational incidents, community disaster management, business continuity, security or environmental impacts beyond the Project area.

5. Relationship with Other Plans

In the event that the emergency escalates and cannot be contained by the local AGL Gloucester team of employees, the AGL Code Red Management Plan shall be activated. The goal of the Code Red Management Plan is to support this Emergency Response Plan, through providing a consistent communications framework that supports the operational response to a crisis and will enable AGL to provide timely, accurate information to all of our stakeholders.

The AGL Code Red process is designed to minimise the impact of the incident or event on the AGL Group. The goal of the Code Red Management Plan is to support existing operational incident management plans, disaster recovery plans and business continuity plans. The Code Red Management Plan provides a consistent Code Red communications framework that supports our operational response to a crisis and will enable AGL to provide timely, accurate information to all of our stakeholders. All matters relating to AGL Code Red Management Plan are to be directed to the AGL Group General Manager for Upstream Gas and the AGL Head of Corp Support Service & Company Secretary.

In the event of a community protest, the response will be managed in accordance with the AGL Protest Response Plan. The plan states “the first person aware of an incident is responsible for reporting the incident to his or her AGL Supervisor, who, in turn, should report the incident to the Group General Manager Upstream Gas. The Group General Manager Upstream Gas is responsible for convening the Protest Management Group and acting as its leader.

For the AGL Gloucester Gas Project, when a serious emergency occurs (as defined in section 13.2) the list below is to be worked through until contact is made with an AGL employee. It is not sufficient to leave a message.

The Health and Safety Business Partner will prepare a specific Site Emergency Card for each well site (see appendix 6).

The AGL representative will then determine the need to contact the Group General Manager for consideration of the AGL Code Red Management Plan.

AGL Operations Manager	0477 762 057
AGL Head of Gas Operations	0408 027 910
AGL Land & Approvals Manager	0448 259 563
AGL Health & Safety Business Partner	0477 707 511
AGL Community Relations Manager	0428 027 714

AGL Project Manager	0434 078 210
AGL North Sydney Office	02 9921 2999
AGL Media Liaison	0408 465 479
AGL Head of Legal Dept	0439 214 020

6. References

This Emergency Plan has been developed in accordance with the requirements of AS3745 Planning for Emergencies in Facilities and AGL Health Safety and Environment Standard for Emergency Preparedness and Response and the Code of Practice for Coal Seam Gas – fracture stimulation activities (Trade & Investment Resources & Energy).

The following documents were also considered in the development of this Emergency Plan:

- On-Site Emergency Planning A Guide to Help Organisations Develop On-Site Emergency Plans in a heightened security environment – New South Wales State Emergency Management Committee
- Guidelines for Emergency Plans at facilities having notifiable quantities of dangerous goods: Policy 1 Version 2.0 – Fire and Rescue NSW
- NSW Department of Planning Hazardous Industry Planning Advisory Paper No. 1
- AGL HSE Management System Standard: *Emergency Preparedness and Response*

7. Emergency Plan Consultation

The Plan shall be reviewed upon development and for all subsequent updates by the Upstream Gas Health & Safety Business Partner in consultation with internal and any relevant external stakeholders. Input to the consultation process shall be provided through safety meetings, project meetings, email etc.

An Emergency Planning Committee (EPC) may be formed consisting of the Health and Safety Business Partner, Environmental Officer, Land and Approvals Manager and Project Manager. Reasonable time shall be provided for the consultative review period to ensure adequate assessment of information and provision of relevant feedback to the Upstream Gas Health and Safety team.

The feedback provided will be reviewed by the AGL Health and Safety team. This Emergency Plan cannot be approved by the Head of Gas Operations without prior consultation with the relevant parties mentioned above.

8. Key Stakeholders

The key stakeholders identified which have the potential to be involved in various ways either directly or indirectly include:

- AGL Employees
- AGL Contractors
- Visitors to AGL's Gloucester Gas Project
- AGL Board of Directors
- AGL Executive Team'
- AGL Upstream Gas Leadership Team
- Fire and Rescue NSW and NSW Rural Fire Service
- NSW Ambulance and Police services
- Relevant government regulatory authorities
- Business employees, visitors and owners in the vicinity of the Gloucester Gas Project
- Members of the public in the vicinity of the Gloucester Gas Project
- AGL Shareholders
- Local Council

Consultation will take place with the above as is necessary and information will be provided upon request to the above stakeholders or when communication of certain applicable aspects of the Plan are required such as during contractor / visitor inductions to site or for regulatory reporting requirements.

9. Responsibilities, Training and Drills

The AGL Head of Gas Operations is responsible for the implementation of this Emergency Response Plan. Resources shall be obtained and maintained to provide the level of protection required by this plan. As a minimum:

- All AGL Gloucester based employees must understand the requirements of this plan
- All supervisory personnel must understand the detail of all emergency response procedures
- The Person-In-Charge of any works shall be competent in all of the above requirements as they apply to the works

The Head of Gas Operations shall ensure all personnel are appropriately trained and that drills of the emergency response procedures are performed on a regular basis and at least annually.

Regular drills will be carried out to refresh knowledge of workers in emergency equipment and procedures and to assess the effectiveness of this Plan. Records of drills will be maintained and kept on the AGL shared network drive.

The outcomes including any necessary training and instruction will be provided to workers.

10. Review and re-testing

The AGL Head of Gas Operations and the AGL Health and Safety Business Partner shall ensure that this Emergency Response Plan is reviewed at least upon the following situations:

- Legislation change or new legislation is introduced
- Key staff changes
- Changes in emergency contacts and numbers
- Plant and equipment modification
- Outcomes from incidents/hazards on site, within AGL or the industry
- Changes in circumstances in any adjacent properties
- Changes in plant operating and safety procedures
- When AGL's Safety Management Plan is reviewed
- At least annually

All changes should be made as and when they occur and the AGL Health and Safety Business Partner is responsible for ensuring the relevant revisions issued to each person nominated on the Distribution List. Any feedback or recommendations from those on the distribution list such as Fire and Rescue NSW, will be seriously considered by AGL. In the event of any changes which effects or has an impact on the adjacent premises, a consultation process will be undertaken.

The Emergency Response Plan will be re-tested as soon as reasonably practicable after any emergency has occurred at the site and whenever AGL's Safety Management Plan is reviewed.

11. Introduction

11.1. Site Location and Surrounds

The AGL Gloucester Gas Project is centred on Gloucester NSW with activities performed under land access agreements and at AGL owned properties.

11.2. Key Activities Performed

Activities performed are related to coal seam gas exploration under PEL 285.

11.3. Operating Hours

Hours of operation are specific to site activities and are noted in the Review of Environmental Factors (REF) associated with the activity.
Specific work activity hours will be communicated through the induction process for each stage of work.

12. Responsibilities

12.1. Introduction to AGL Upstream Gas – Gloucester Gas Project

The Gloucester Gas Project forms part of the wider Upstream Gas business unit which forms part of AGL Energy Ltd. Specific responsibilities for key positions on site are listed below.

This Emergency Response Plan will be in place and adequately resourced during the conduct of any well activities (including, for the avoidance of doubt, fracture stimulation activity).

12.2. Head of Gas Operations

The Head of Gas Operations reports to the Group General Manager Upstream Gas and holds overall responsibility to ensure effective implementation of emergency preparedness and response activities. This includes:

- Ensuring all hazards relating to foreseeable emergency situations are identified for each work activity or project and effective controls are in place to mitigate the risk
- Ensuring a risk register has been established that formally documents the hazards, impacts and controls relating to foreseeable emergency situations on site

- Ensuring an Emergency Response Plan is established in accordance with relevant legislative and good industry requirements and is reviewed and approved by appropriate personnel;
- Ensuring the Emergency Response Plan remains effective and is reviewed and updated and tested on a regular basis;
- Ensuring all employees are aware of the requirements under this Emergency Response Plan;
- Ensuring that resources are provided to enable the development and implementation of the Emergency Response Plan
- Identifying and rectifying deficiencies and opportunities for improvement in the emergency plan and emergency response procedures

12.3. Managers / Supervisors

- Ensuring all hazards relating to foreseeable emergency situations are identified for each work activity or project under their control, and that effective controls in place to mitigate the risk;
- Ensuring a risk register has been established that formally documents the hazards, impacts and controls relating to emergency situations;
- Ensuring this Emergency Response Plan is effectively communicated to employees under their control;
- Ensuring relevant training of emergency procedures is undertaken by their employees under their direct control and that no employees undertake emergency response activities without sufficient training;
- Ensure that any contractors under their supervision have emergency preparedness and response procedures in place that comply with relevant legislative and good industry practice;
- Immediately report any incidents, hazards or near misses to their leader, the HSE team and in the AGL incident management system.
- Identifying and rectifying deficiencies and opportunities for improvement in the emergency plan and emergency response procedures.

12.4. Health and Safety Personnel

- Developing an Emergency Response Plan in compliance with legislative and good industry requirements and in consultation and communication with relevant leaders and employees;
- Ensuring document control requirements are adhered to while developing, communicating and maintaining this Plan;
- Assisting leaders and employees in understanding and applying the requirements of this Emergency Response Plan;
- Ensuring all those listed on Distribution List receive a controlled copy of this Procedure;
- Report any incidents, hazards or near misses to their leader, the HSE team as per the AGL incident management system;

- Ensuring that the Emergency Response Plan is readily identifiable and available to the appropriate persons;
- Assisting leaders and supervisors in ensuring employees receive relevant emergency preparedness and response training;
- Establishing strategies to ensure visitors and contractors are made aware of emergency response procedures as required;
- Ensuring that the emergency response procedures remain viable and effective by reviewing, and testing the emergency response procedures on a regular basis;
- Ensuring that the Emergency Response Plan is reviewed at the end of the validity period, after an emergency, an exercise, or any changes that affect the Emergency Response Plan;
- Ensuring that a permanent record of events for each emergency is compiled and retained;
- Identifying and rectifying deficiencies and opportunities for improvement in the emergency plan and emergency response procedures.

12.5. Everyone

Everyone, including employees, visitors, contractors, other third party etc is responsible for their own health and safety and to others that could be adversely affected by their acts or omissions. They must carry out their activities in a manner consistent with the AGL HSE policies and this procedure.

Everyone is responsible for the health and safety implications of their own actions and have a duty to carry out their work in a manner which does not present a risk to themselves or others. All persons are required to report accidents or unsafe conditions to their AGL leader or approved delegate. Everyone is responsible for identifying and rectifying deficiencies and opportunities for improvement in the emergency plan and emergency response procedures.

All persons must ensure that they implement any part of this Emergency Response Plan as required under the Plan or requested by an AGL manager in the event of an emergency situation. Everyone is responsible for ensuring they understand this Emergency Response Plan and where they do not, to seek clarification where required. All occupants and visitors regardless of their abilities have some obligation to take responsibility for their own safety and prepare a plan for Evacuation in an emergency.

13. Classification / Levels of Emergencies

In the event of an emergency, the Person In Charge will classify the situation under the category of Minor, Serious or Major.

13.1. Minor Emergency

A minor emergency is one that can be satisfactorily handled by AGL personnel and does not affect or threaten parties beyond the scope of the direct operations.

13.2. Serious Emergency

A serious emergency is one that has implications beyond the control of local personnel. It would generally involve parties outside the direct scope of the operations including Government Agencies and outside contractors.

Where assistance from emergency services organisations is required, they are to be notified at the earliest opportunity.

13.3. Major Emergency

A major emergency is an incident having major safety, environmental, Governmental, economic or public welfare implications.

Where assistance from emergency services organisations is required, they are to be notified at the earliest opportunity.

13.4. Injury to Personnel

In the event of a serious injury it is crucial to notify medical authorities (Ambulance, Hospital and contact Doctor) as quickly as possible. It is also important that the next of kin of the injured are promptly notified, as detailed below.

NEXT OF KIN NOTIFICATION SHALL ONLY BE MADE BY A PERSON DESIGNATED BY AGL's UPSTREAM GAS GROUP GENERAL MANAGER OR BY A MEMBER OF THE POLICE FORCE.

Under no circumstances are names to be released to anyone before the next of kin have been notified except in the case where the emergency response personnel request it.

14. Investigating and reporting

All HSE incidents including an emergency involving a fatality, serious injury or significant damage to property or the environment, shall be immediately reported to the appropriate personnel including Gloucester Gas Project leaders, regulatory authorities, and recorded into AGL's online incident management system when practical to do so. Requirements of the AGL Incident Management Procedure must be implemented immediately following any HSE incident or emergency.

The AGL Incident Management Procedure (LG-HSE-CP-006) can be found on AGL's intranet health and safety page. The Incident Management Procedure also includes reporting requirements to external regulatory authorities. Government agency representatives may also carry out investigations.

DO NOT DISTURB AN INCIDENT SITE FOR AT LEAST 48 HOURS OR MORE AS SPECIFIED BY A REGULATORY AUTHORITY UNLESS ABSOLUTELY NECESSARY FOR DIRECT SAFETY OR ENVIRONMENTAL REASONS.

Reports required by government regulations shall be promptly prepared and submitted as specified in relevant legislation.

15. General Safety

In general, appropriate clothing must be worn at all times including a minimum of long trousers and covered foot wear. Observe all safety signs such as "No Smoking" and "No Unauthorised Entry". These are placed for the safety of all personnel. All visitors are to be made aware of safety requirements.

16. The Press and News Media

At the site the senior AGL person shall have the responsibility to control news media personnel and in general they are to be denied access to all sites.

NO STATEMENTS WILL BE ISSUED ON SITE UNLESS AUTHORISED BY AGL'S GROUP GENERAL MANAGER OR HIS DEPUTY.

DO NOT SPECULATE ON WHAT HAPPENED OR THE EXTENT OF DAMAGE.
Redirect any queries from the media to AGL's Media Liaison and Legal Department. The phone numbers for both are:

AGL Media Liaison	0408 465 479 or 0400 488 836
AGL Head of Legal Dept	0439 214 020

Answer Press and Media queries with:
"A statement will be issued by the Company as soon as we have determined the facts. Until then there is no information available".
Provide AGL contact details of AGL's Media Liaison to the Press if necessary.

17. Termination of an Emergency

17.1. General

When the emergency services, in consultation with the Person-in-Charge, has specified that the emergency has been controlled, the Person in Charge shall again assume full control and will ensure the following procedures are observed:

- The site shall be made safe. This must be done with the Head of Gas Operations (or delegate) and will include removal of burnt equipment and the safe disposal or drainage of hydrocarbon liquids and vapours.
- All emergency alarms and fire fighting equipment and general safety equipment must be returned to full active status as defined in this Plan. This will include recharging fire extinguishers used and replacing any damaged fire fighting equipment and alarms.
- Assessment and repair, replacement or disposal of all damaged plant equipment must be made in conjunction with the AGL Head of Gas Operations
- The requirements for proper public relations and debriefing, and any necessary Statutory Investigations are to be fully observed.

17.2. Statutory Investigation

In the event of a fatality or serious / significant incident, the Police and relevant government authorities will be involved and there may be a Coronial Inquiry.
In the event of any incident involving emergency service personnel, the appropriate site manager shall contact the NSW Department of Trade and Investment and the NSW WorkCover Authority to notify of the incident.
The most senior AGL Manager on site is responsible for ensuring that there is no interference with evidence and that any cleaning up, repairs etc, apart from that necessary to bring the emergency under control, does not occur without approval of investigating officers from the authorities above.

17.3. Report & Review of Emergency

After an emergency has occurred, it is the responsibility of the AGL Head of Gas Operations to ensure the requirements of AGL's HSE Incident Management Procedure are implemented and that the relevant investigation is carried out by Competent Persons to ensure that findings are recorded and corrective actions put in place to eliminate and / or mitigate the risk of an incident reoccurring.

17.4. Review of Emergency Plan after an Emergency

The AGL Head of Gas Operations together with the AGL Health and Safety Business Partner shall review the effectiveness of this Emergency Response Plan as stipulated in this Plan.

The AGL Head of Gas Operations must immediately update this Emergency Response Plan with relation to any improvement highlighted by the site emergency or whenever the Safety Management Plan is reviewed.

17.5. Person in Charge and Emergency Services

The Person in Charge is responsible for the control of the site and emergency situation until the emergency services arrive on site. Duties include those as stipulated in Section 2 of this document for each type of specific emergency and the following:

- Cooperating with and assisting the emergency services response team senior member
- Appointing a suitable liaison that can liaise with the emergency services personnel. This must be the most suitable person that has knowledge about controlling the emergency situation at hand and / or is the most senior AGL person on site
- Provide access to the site and direct response personnel to area where assistance is required

- Direct medical staff to the position of any injured personnel
- Ensure that Police keep external roadways clear for emergency vehicles
- Ensure that all internal roadways are clear for emergency vehicles
- Ensure that there is an AGL representative at any access points to direct emergency services personnel to the incident scene and redirect any media.

Leave it to the emergency services to evacuate the site and any surrounding buildings, businesses and / or residences if this has not been done so already. Evacuation will be done under their instructions.

Section 2 - Emergency Response Procedures

18. Emergency Procedures

18.1. General

As part of AGL's Health, Safety and Environment Policy, AGL is committed to the health and safety of its people by providing a safe and healthy work place.

AGL Managers and Supervisors are responsible for:

› Informing all personnel entering AGL owned or operated sites of safety requirements and the need for enforcing safety standards.
› Ensuring that operations are carried out in a safe working environment and in accordance with good practice as well as any applicable specific regulations.
› Improving competence and efficiency through training and emergency drills.

Following are procedures for all foreseeable emergency situations specific for the work being undertaken by AGL in Gloucester including:

- Casualty Evacuation
- General Evacuation
- Well Blow Out, Fire, unplanned ignition of methane or Explosion Emergency at a Well Site
- Bush Fire
- Flooding (Emergency)
- Oil or Chemical Spill
- Security Breach
- Bomb Threat
- Administration Building Fire

It is not feasible to cover every detail for every situation; however, the guidelines should be followed where feasible. The main theme running through the procedures is life safety, communication and reporting. As soon as possible after an emergency situation develops, contact the next person in the chain of command.

Emergency Response Protocols

AGL UG has developed three Emergency Response Protocols to be used at all operational sites that fall under this Emergency Response Plan. These are:

1. Electric Shock
2. Heat Stress
3. Fluid Injection

The purpose of these protocol is to provide guidance for people to follow in the event that a person(s) is suspected to any of these incidents. The protocols identify the minimum level of treatment and medical diagnosis. The protocol applies to any person impacted by these incidents, regardless of how minor the contact may appear.

Relevant documentation:

- Electric Shock Protocol DCS_GN_HSE_PL_002
- Heat Illness Protocol DCS_GN_HSE_PL_003
- Fluid Injection Protocol DCS_GN_HSE_PL_001

Protocols must be printed out and accessible on each notice board or other appropriate place at each work site. Protocols are available in the appendix of this document.

18.2. Reports

18.2.1. Reporting of Death and Serious Injury

Death, Serious injury or Dangerous Occurrence (as defined under Part 3 of the NSW WHS Act 2011) shall be immediately or as soon as is reasonably practicable, notified to an Inspector from the NSW Trade and Investment or WorkCover NSW in accordance with the requirements of Part 3 of the WHS Act 2011.

Where a person dies or suffers a serious injury a report of the death or injury shall be made immediately to an:

› Inspector of DTIRIS if associated with exploration and establishment
› Inspector of WorkCover of any accident or other occurrence at a place of work notifiable under WHS Act 2011 NSW
› a report in writing giving full particulars of the death or injury and all related circumstances are to be transmitted to the appropriate regulator within the required period after the occurrence of the death or injury.

18.2.2. Written Records of Death and Injury

A record is to be kept of each injury, whether or not a serious injury is suffered. These records shall include:

› particulars of the injury;
› the circumstances leading to the occurrence of the injury; and
› the treatment (if any) given to the injured person and the name of each medical practitioner (if any) consulted in relation to the injury.

18.2.3. Reporting Serious Damage

Serious damage to property means:

› the loss or destruction of property with a value exceeding $50,000;
› damage to property, the repair of which would cost an amount exceeding $50,000; or

› the loss or destruction of any property, or any damage to property, by reason of which any person dies or suffers serious injury.

Where a serious damage to property occurs:

› a report of each occurrence is immediately to be made to the appropriate regulatory Inspector; and

› a report in writing of such occurrence is to be submitted to the regulator within 5 days of the incident occurring, specifying:

i. the date, time and place of such occurrence;

ii. particulars of the damage;

iii. the events so far as they are known or suspected that caused or contributed to the occurrence;

iv. particulars of repairs carried out or proposed to be carried out to damaged property; and

v. measures taken, or to be taken, to prevent a possible re-occurrence.

18.2.4. Reporting Potentially Hazardous Event

Where an event occurs which is not in the normal or ordinary course of a particular operation and which is professionally considered to be likely to cause injury to a person or serious damage to property, but such event does not cause injury or serious damage, a report of the event is immediately to be made to the appropriate regulatory Inspector.

18.2.5. Reporting Damage Less than $50,000

Where damage to property occurs which is not serious damage to property but which results in a significant loss of structural integrity or load bearing capacity in the property damaged or results in some other significant unsafe condition a report of the damage is immediately to be made to the appropriate regulatory Inspector.

18.2.6. Reporting Escape or Ignition of Petroleum and Other Material

A report is immediately to be made to the appropriate regulatory Inspector upon the occurrence of:

› a spillage of hydrocarbons which in areas of inland waters is in excess of 80 litres and in other areas in excess of 500 litres;

› an uncontrolled escape of Petroleum in a gaseous form in excess of 500 cubic metres; or

› any uncontrolled escape or ignition of Petroleum, any other flammable or combustible material or toxic chemicals causing a potentially hazardous situation.

18.2.7. Reporting incidents with significant visual impacts

Where an event occurs which poses an actual visual impact to the community, a report of the event is to be immediately made to the appropriate regulatory authority.

18.2.8. Public Reporting

All significant incidents shall be made public through the Community Consultative Committee. Information shall be provided on the incident, the cause and corrective and preventive actions taken to prevent recurrence. Status on the implementation of the corrective and preventive actions shall be detailed and updated.

19. Casualty Evacuation

Decisions regarding casualty Evacuation can be made by anyone. If it is assessed that the casualty is stable, then the Person-in-Charge will make the decision regarding casualty Evacuation. This might be the casualty being driven to the nearest hospital / medical centre, or might be made in consultation with ambulance personnel or local doctors.

After evacuation to local facilities, decisions on patient care and/or transfer will be made by Ambulance and/ or hospital personnel. The method of evacuation will depend on incident location and the extent and type of injuries. Evacuation would normally be by road.

Job Title	Duties	
All Personnel 1. First person to identify emergency situation if alone Or 2. Most Senior or Knowledgeable person on immediate site to effectively respond	1)	Ensure first aid is immediately administered.
	2)	Assess need for medical assistance, on or off site, and/or Evacuation. If the casualty has a potential concussion, potential fracture or break to any part of the body, if they have fallen from heights or have an impact injury then an ambulance must be called. IF IN DOUBT EVACUATE.
	3)	Call 000 (Triple Zero) or 112 if calling from a mobile phone and liaise with ambulance personnel, local doctors if required and Police if criminal act or in the case of death.
	4)	Advise and liaise with your leader or the next in line in your Chain of Command until you verbally notify a Leader who can contact the Person-in-Charge (if not already on site).
	5)	Prepare patient for medical Evacuation.
	6)	Ensure patient is accompanied to hospital
Person-in-Charge (the most Senior or Knowledgeable person to effectively respond)	1)	Ensure duties of All Personnel have been fulfilled.
	2)	Ensure any necessary personal effects accompany patient(s), e.g. medications and ID. (Call Administration team for information if required).
	3)	Assess need for additional items For emergency handling such as: • Two way communication system and mobile phone • Gas detector • Barricades, signage, lightings • Additional radio communication, fire extinguisher, transport vehicles • Supplies for supporting the crews and other people engaged with the emergency etc.

Job Title	Duties	
	4)	Advise and liaise with your leader or the next in line in your chain of command until you verbally notify a Leader.
	5)	Secure site and ensure the site is not disturbed for 48 hours or unless otherwise advise by government authority.
Other Personnel	1)	Follow all reasonable instructions from the Person-In-Charge of the situation or emergency response personnel and report to designated Assembly Area immediately or other safe area as agreed.
	2)	Unless directed otherwise or if part of the fire control crew, stay away from the immediate emergency affected area.
Head of Gas Operations (or their nominated delegate)	1)	Ensure the duties of Person-in-Charge are fulfilled.
	2)	Advise and liaise with your leader or the next in line in your chain of command until you verbally notify a Leader.
	3)	Advise AGL Head of Legal where required.
	4)	Verbally advise all required Authorities of the situation as soon as practical as per “Reports” section of this Emergency Response Plan
	5)	If necessary, arrange for next of kin to be notified.
	6)	Undertake formal report to Authorities where required and implement corrective measures where applicable to prevent repeat of accident.
AGL Group General Manager (or their nominated delegate)	1)	Ensure the duties of Head of Gas Operations are fulfilled.
	2)	Assess if situation requires escalation to an AGL Code Red (Initiate the steps of Code Red if required).
	3)	Liaise with Government Departments as appropriate.
	4)	Notify other AGL personnel as appropriate.
	5)	Ensure formal report to Authorities where required has been undertaken and ensure implementation of corrective measures where applicable to prevent repeat of accident has been completed.

20. General Evacuation

A condition may arise requiring a general Evacuation of all or non-essential personnel. The reasons for such an evacuation are varied but may be due to fire, explosion or well blow out. The duties relating to Casualty Evacuation (see section 19 of this Plan) should be read and followed in conjunction with these notes. The situations are very similar but with an increase in magnitude of potential consequences.

Job Title	Duties	
All Personnel 1. First person to identify emergency situation if alone Or 2. Most Senior person on immediate site to effectively respond	1)	Life Safety: Ensure immediate safety of yourself and anyone within the Facility or immediate area. Take necessary steps to make the situation safe and minimise further injuries or damage prior to Evacuation if safe to do so.
	2)	Assess need for total or partial evacuation. IF IN DOUBT EVACUATE.
	3)	Assess whether Evacuation is within capability of existing transport facilities.
	4)	Assess number of injured personnel and extent of injuries. (Follow the Duties set out in the Casualty section of this document).
	5)	Advise and liaise with your leader or the next in line in your chain of command until you verbally notify a Leader to contact the PersonIn-Charge (if not already on site).
Person-in-Charge (the most Senior or Knowledgeable person to effectively respond)	1)	Ensure duties of All Personnel have been fulfilled
	2)	Ensure that all on site have evacuated to the Assembly Area or other safe area.
	3)	Assess need for additional items For emergency handling such as: • Two way communication system and mobile phone • Gas detector • Barricades, signage, lightings • Additional radio communication, fire extinguisher, transport vehicles • Supplies for supporting the crews and other people engaged with emergency etc.
	4)	Advise and liaise with your leader or the next in line in your chain of command until you verbally notify a Leader.
	5)	Inform adjoining land owner/ occupiers if necessary. If Officer cannot be contacted you must contact your Leader or chain- of command until you reach and verbally notify a

Job Title	Duties	
		Leader.
Other Personnel	1)	Follow all reasonable instructions from the Person-In-Charge of the situation or emergency Response personnel and report to designated Assembly Area immediately or other safe area as agreed.
	2)	Unless directed otherwise or if part of the fire control crew, stay away from the immediate emergency affected area.
Head of Gas Operations (or their nominated delegate)	1)	Ensure the duties of Person In-Charge are fulfilled.
	2)	Advise and liaise with your leader or the next in line in your chain of command until you verbally notify a Leader.
	3)	Advise AGL Head of Legal where required.
	4)	Verbally advise all required Authorities of the situation as soon as practical as per “Reports” section of this document.
	5)	Undertake formal report to Authorities where required and implement corrective measures where applicable to prevent repeat of accident.
AGL Group General Manager (or their nominated delegate)	1)	Ensure the duties of Head of Gas Operations are fulfilled.
	2)	Assess if situation requires escalation to an AGL Code Red (Initiate the steps of Code Red if required).
	3)	Liaise with Government Departments as appropriate.
	4)	Notify other AGL personnel as appropriate.
	5)	Ensure formal report to Authorities where required has been undertaken and ensure implementation of corrective measures where applicable to prevent repeat of accident has been completed.

21. Well Blowout, Fire or Explosion Emergency at a Well Site

An uncontrolled loss of containment of hydrocarbons (includes methane), fire or PUVCE (percussive unconfined vapour cloud explosion) is a serious situation that requires immediate corrective action.

With appropriate wind conditions, a fire can spread rapidly and present a threat to life and property not only on the well site, but also in the nearby areas.

The key to containing a Wellsite fire is to isolate the problem area and then de-pressure that section of plant and equipment at risk to a safe area, if possible.

The Person-in-Charge should ensure that NSW Fire & Rescue are contacted and that personnel know and understand their duties. Drills should be conducted as appropriate.

Job Title	Duties	
All Personnel 1. First person to identify emergency situation if alone Or 2. Most Senior person on immediate site to effectively respond	1)	Life Safety: Ensure immediate safety of yourself and anyone within the Facility or immediate area.
	2)	Control Fire: attempt to control or extinguish any fire with appropriate fire equipment only if **trained and safe** to do so.
	3)	Call emergency services dial 000 (Triple Zero) or 112 if calling from a mobile phone. To advise of any uncontrolled loss that has potential to cause significant harm and cannot be isolated or sufficiently controlled.
	4)	Evacuation: Assess all Evacuation routes for safety hazards and advise occupants and visitors of an emergency and to evacuate to designated Assembly Area or other safe place.
	5)	Advise and liaise with your leader or the next in line in your Chain of Command until you verbally notify a Leader to contact the Person-In-Charge (if not already on site).
Person-In-Charge	1)	Ensure steps of All Personnel are fulfilled.

Job Title	Duties	
	2)	If there is an ignition of gas, assess the type, location and extent of fire and secure site and any adjoining sites that may be at risk and inlet to the associated gathering line if possible. Shut off or remove source of fuel if possible to do so safely. Control Fire: attempt to control or extinguish the fire with appropriate fire equipment only if trained and safe to do so. If safe to do so, ensure to de-pressure any gas containing equipment located close to the fire by venting/flaring to minimise collateral damage. DO NOT vent if a fire is close
	3)	Assess need for additional items for emergency handling such as: • Two way communication system and mobile phone • Gas detector • Barricades, signage, lightings • Additional radio communication, fire extinguisher, transport vehicles • Supplies for supporting the crews and other people engaged with emergency etc.
	4)	Advise and liaise with your leader or the next in line in your Chain of Command until you verbally notify a Leader.
	5)	Coordinate with the AGL Land and Compliance Officer / Approvals Manager for the land owner and adjoining land owner/ occupiers to be informed. If Officer cannot be contacted you must contact your Leader or Chain-in-Command until you can verbally notify a Leader.
	6)	Advise and liaise with your leader or the next in line in your Chain of Command until you verbally notify someone
Other Personnel	1)	Follow all reasonable instructions from the Person-In-Charge of the situation or Emergency Response personnel and report to designated Assembly Area immediately or other safe area as agreed.
	2)	Unless directed otherwise or if part of the fire control crew, stay away from the immediate emergency affected area.
Head of Gas Operations	1)	Ensure the duties of Person-in-Charge are fulfilled.

Job Title	Duties	
(or their nominated delegate)	2)	Advise and liaise with your leader or the next in line in your Chain of Command until you verbally notify a Leader.
	3)	Advise AGL Head of Legal where required.
	4)	Verbally advise all required Authorities of the situation as soon as practical as per Reports section of this document.
	5)	Undertake formal report to Authorities where required and implement corrective measures where applicable to prevent repeat of accident.
AGL Group General Manager (or their nominated delegate)	1)	Ensure the duties of Head of Gas Operations are fulfilled.
	2)	Assess if situation requires escalation to an AGL Code Red (Initiate the steps of Code Red if required).
	3)	Liaise with Government Departments as appropriate.
	4)	Notify other AGL personnel as appropriate.
	5)	Ensure formal report to Authorities where required has been undertaken and ensure implementation of corrective measures where applicable to prevent repeat of accident has been completed.

22. Bush fire at, or Near a Well Site

Any fire is a serious situation that requires immediate corrective action.

With appropriate wind conditions, a bush fire close to a well site can spread rapidly and present a threat to life and property not only at its location, but also in the nearby areas.

The key to containing a bush fire, near or at, a well site fire is to isolate the problem area in the form of long grass and scrub and then shut in the affected well(s) at risk, so as to minimise damage from the fire.

If any person on site is in any doubt as to their safety or the safety of others, then leave the site immediately.

Job Title	Duties	
All Personnel 1. First person to identify emergency situation if alone Or 2. Most Senior person on immediate site to effectively respond	1)	Life Safety: ensure immediate safety of yourself and anyone within the Facility or immediate area.
	2)	Control Fire: attempt to control or extinguish the fire with appropriate fire equipment only if trained and safe to do so.
	3)	Call emergency services dial 000 (Triple Zero) or 112 if calling from a mobile phone. To advise of any fire.
	4)	Evacuation: Assess all Evacuation routes for safety hazards and advise occupants and visitors of an emergency and to evacuate to Assembly Area or other safe place including leaving the site. (Follow instructions for General Evacuation)
	5)	Advise and liaise with your leader or the next in line in your Chain of Command until you verbally notify a Leader to contact the Person-in-Charge (if not already on site).
Person-In-Charge (the most Senior person within Operations / Project Area to effectively respond)	1)	Ensure duties of All Personnel have been fulfilled
	2)	Secure well by closing master valve.
	3)	Assess type, location and extent of fire. Do not close off any pipes or vessels that are subject to heat as they may become over pressured and fail.

Job Title	Duties	
	4)	If bush fire is likely to be fuelled by gas and or hydrocarbon liquids from the surface flow line, either: Close gathering line inlet valve and bleed off well head facilities, and consider de-pressuring the gathering line at gas plant end, or isolating and depressurising section of line (See Note 2 below).
	5)	If safe to do so, de-pressure any gas containing equipment located close to the fire by venting/flaring to minimise collateral damage. DO Not vent if fire is close.
	6)	If safe to do so, relocate fire trailer to wellhead in preparation for fire control activities.
	7)	Use fire trailer and/or knapsack if safe to do so. Note it may be appropriate to allow fire to diminish prior to using the correct type of extinguisher. If in doubt leave the site
	8)	Assess need for additional items for emergency handling such as: • Two way communication system and mobile phone • Gas detector • Barricades, signage, lightings • Additional radio communication, fire extinguisher, transport vehicles • Supplies for supporting the crews and other people engaged with emergency etc.
	9)	Advise and liaise with your leader or the next in line in your chain of command until you verbally notify a Leader.
	10)	Coordinate with the AGL Land and Compliance Officer / Approvals Manager for the land owner and adjoining land owner/ occupiers to be informed. If Officer/Approvals Manager cannot be contacted you must contact your Leader or chain of command until you can verbally notify a Leader.
	11)	Advise potentially affected third parties (as appropriate).
	12)	If time permits clear away any long grass or scrub that may act as a fire source.

[2] While natural gas will normally disperse quickly and in an upward direction, gas vented from high pressures can be very cold and hence heavier than air, until it warms up, and can contain heavier hydrocarbon that will not disperse so easily.

Job Title	Duties	
Other Personnel	1)	Follow all reasonable instructions from the Person-In-Charge of the situation or emergency response personnel and report to designated Assembly Area immediately or other safe area as agreed.
	2)	Unless directed otherwise or if part of the fire control crew, stay away from the immediate emergency affected area.
Head of Gas Operations (or their nominated delegate)	1)	Ensure the duties of Person-in-Charge are fulfilled.
	2)	Assess need for additional items For emergency handling such as: • Two way communication system and mobile phone • Gas detector • Barricades, signage, lightings • Additional radio communication, fire extinguisher, transport vehicles • Supplies for supporting the crews and other people engaged with emergency etc.
	3)	Advise and liaise with your leader or the next in line in your chain of command until you verbally notify a Leader.
	4)	Advise AGL Head of Legal where required.
	5)	Verbally advise all required Authorities of the situation as soon as practical as per Reports section of this document.
	6)	Undertake formal report to Authorities where required and implement corrective measures where applicable to prevent repeat of accident.
AGL Group General Manager (or their nominated delegate)	1)	Ensure the duties of Head of Gas Operations are fulfilled.
	2)	Assess if situation requires escalation to an AGL Code Red (Initiate the steps of Code Red if required).
	3)	Liaise with Government Departments as appropriate.
	4)	Notify other AGL personnel as appropriate.
	5)	Ensure formal report to Authorities where required has been undertaken and ensure implementation of corrective measures where applicable to prevent repeat of accident has been completed.

In regard to bushfire risk, the management objective is to reduce the threat of bushfires to personnel, third parties, property and the environment.

Management Strategies	Responsibility
› The induction program shall inform personnel of the required bushfire management procedures as described above. › AGL shall maintain regular liaison with local emergency services organisations. › Regular liaison with landholder shall be conducted regarding the nature and schedule of operations activities.	› Field Environment & Safety Officer › Land and Compliance Officer
› All operations and project/construction activities shall be restricted to the well site area and designated access routes. › All vehicles shall carry fire extinguishers. › A mobile safety trailer, fire extinguishers and general safety gear is used for site operational work. › All machinery shall be maintained and operated to comply with relevant fire safety standards. › The event of a fire shall be limited through the employment of fire prevention mechanisms.	› Field Environment & Safety Officer › All personnel

23. Flooding

All AGL personnel, each contractor and person in charge on behalf of AGL is responsible for the safety of their unit and personnel, and must have procedures in place to ensure that each person under their authority is fully acquainted with their duties in the event of a flood. For non-emergency flooding refer to these procedures.

Job Title	Duties	
All Personnel 1. First person to identify emergency situation if alone Or 2. Most Senior person on immediate site to effectively respond	1)	On advice from the SES or AGL or discovery of a flood that threatens a site, raise the alarm by calling your Leader or the next in line in your Chain of Command until you verbally notify a Leader to contact the Person-in-Charge (if not already on site).
	2)	Life Safety: ensure immediate safety of yourself and anyone within the Facility or immediate area.
Person-in-Charge	1)	Ensure the duties of All Personnel have been fulfilled
	2)	Monitor the situation and assess need for additional items For emergency handling such as: • Two way communication system and mobile phone • Gas detector • Barricades, signage, lightings • Additional radio communication, fire extinguisher, transport vehicles • Supplies for supporting the crews and other people engaged with emergency etc.
	3)	Advise and liaise with your leader or the next in line in your chain of command until you verbally notify a Leader.
	4)	Assess need for additional services or Evacuation.
Other Personnel	1)	Follow all reasonable instructions from the Person-In-Charge of the situation or emergency response personnel and report to designated Assembly Area immediately or other safe area as agreed.
	2)	Unless directed otherwise or if part of the flood control crew, stay away from the immediate emergency affected area.
Head of Gas Operations	1)	Ensure the duties of Person-in-Charge are fulfilled.

Job Title	Duties	
(or nominated delegate)	2)	Advise and liaise with your leader or the next in line in your chain of command until you verbally notify a Leader.
	3)	Verbally advise all required Authorities of the situation as soon as practical.
AGL Group General Manager (or nominated delegate)	1)	Ensure the duties of Head of Gas Operations are fulfilled.
	2)	Assess if situation requires escalation to an AGL Code Red (Initiate the steps of Code Red if required).
	3)	Liaise with Government Departments as appropriate.
	4)	Notify other AGL personnel as appropriate.
	5)	Ensure formal report to Authorities where required has been undertaken and ensure implementation of corrective measures where applicable to prevent repeat of accident has been completed.

24. Oil or Chemical Spill

Pollution as a result of an oil or chemical spill can have a significant impact on the environment. All spills will be handled in accordance with the APPEA Code of Environmental Practice.

Job Title		Duties
All Personnel 1. First person to identify emergency situation if alone Or 2. Most Senior or Knowledgeable person on immediate site to effectively respond	1)	Life Safety: ensure immediate safety of yourself and anyone within the Facility or immediate area.
	2)	For uncontained oil or chemical spills call the emergency services on 000 (triple zero) or 112 from a mobile.
	3)	Evacuation: assess all Evacuation routes for safety hazards and advise occupants and visitors of an emergency and to evacuate to Assembly Area or other safe place.
	4)	Contain spill: attempt to contain spill from leaving immediate area only if trained and safe to do so.
	5)	Advise and liaise with your leader or the next in line in your chain of command until you verbally notify a Leader to contact the Person-In-Charge (if not already on site).
Person-In-Charge	1)	Ensure duties of All Personnel have been fulfilled.
	2)	Arrest the spill and take steps to prevent repeat.
	3)	Arrest the spread of fluid. Mobilise equipment to build pits and/or bunds if required.
	4)	Begin clean up operations. Mobilise equipment and personnel to collect and place spillage in suitable containers or pits.
	5)	Assess need for additional items for emergency handling such as: • Two way communication system and mobile phone • Gas detector • Barricades, signage, lightings • Additional radio communication, fire extinguisher, transport vehicles • Supplies for supporting the crews and other people engaged with emergency etc.
	6)	Advise and liaise with your leader or the next in line in your chain of command until you verbally notify a Leader.
Other Personnel	1)	Follow all reasonable instructions from the Person-In-Charge of the situation or emergency response personnel and report to designated Assembly Area immediately or other safe area as agreed.
	2)	Unless directed otherwise or if part of the fire control crew, stay away from the immediate emergency affected area.

Job Title		Duties
Head of Gas Operations (or nominated delegate)	1)	Ensure the duties of Person-In-Charge are fulfilled.
	2)	Advise and liaise with your leader or the next in line in your chain of command until you verbally notify a Leader.
	3)	Verbally advise all required Authorities of the situation as soon as practical as per “Reports” section of this Plan.
	4)	Undertake formal report to Authorities where required and implement corrective measures where applicable to prevent repeat of accident.
AGL Group General Manager (or nominated delegate)	1)	Ensure the duties of Head of Gas Operations are fulfilled.
	2)	Assess if situation requires escalation to an AGL Code Red (Initiate the steps of Code Red if required).
	3)	Liaise with Government Departments as appropriate.
	4)	Notify other AGL personnel as appropriate.
	5)	Ensure formal report to Authorities where required has been undertaken and ensure implementation of corrective measures where applicable to prevent repeat of accident has been completed.

25. Security Breach

The presence on site of any individuals who have not made themselves known to the operations personnel is to be treated as a security breach.

Job Title	Duties	
All Personnel	1)	On discovery of unauthorised personnel on site, question them on who they are and why they are on site.
	2)	Inform the Person-in-Charge and if necessary, and safe to do so, escort individuals from the site.
Person-in-Charge	1)	Ensure duties of All Personnel have been fulfilled.
	2)	If an intruder is acting in a dangerous fashion advise local police by dialling 000 (triple zero) or 112 from a mobile, requesting assistance,
	3)	If intruder is threatening plant in a manner that may lead to a process incident, address the situation appropriately to minimise risk of injury to personnel and damage to equipment.
	4)	Ensure safety of all personnel within immediate area
Other Personnel	1)	Assist Person-In-Charge in controlling incident if necessary.
	2)	Assist or vacate the site as instructed.
Head of Gas Operations (or nominated delegate)	1)	Ensure the duties of Person-In-Charge are fulfilled.
	2)	Advise and liaise with your leader or the next in line in your chain of command until you verbally notify a Leader.
	3)	Liaise with emergency services personnel
	4)	Verbally advise all required Authorities of the situation as soon as practical as per Reports section of this Plan.
	5)	Undertake formal report to Authorities where required and implement corrective measures where applicable to prevent repeat of accident.
AGL Group General Manager (or nominated delegate)	1)	Ensure the duties of Head of Gas Operations are fulfilled.
	2)	Liaise with Government Departments as appropriate.
	3)	Notify other AGL personnel as appropriate.
	4)	Ensure formal report to Authorities where required has been provided and ensure implementation of corrective measures where applicable to prevent repeat of incident has been completed.

26. Bomb Threat

Do not ignore any Bomb Threat, you must treat them all as genuine.

Job Title	Duties	
All Personnel	1)	Written Threat: if a Bomb Threat is received in writing it should be kept, including any envelope or container. Avoid unnecessary handling. Place evidence in plastic envelope or sleeve as quickly as possible to maintain integrity.
	2)	Telephone Threat: complete the Upstream Gas Bomb Threat Procedure checklist (DCS_GN_HSE_FM_005).
	3)	Suspect Object: Do not touch any suspect object.
	4)	Police: Notify the police dial 000 (triple zero) or 112 from mobile and inform your leader or the next in line in your chain of command until you verbally notify a Leader to contact the Person-In-Charge (if not already on site).
Person-In-Charge	1)	Ensure duties of All Personnel have been fulfilled.
	2)	Assess a safe Assembly Area, preferably an open area, by assessing the information provided by the Bomb Threat.
	3)	Commence evacuation of all persons on site to an appropriate Assembly Area.
	4)	Coordinate with the AGL Land and Compliance Officer / Approvals Manager for the land owner and adjoining land owner/ occupiers to be informed. If Officer cannot be contacted you must contact your Leader or chain of command until you can verbally notify a Leader.
	5)	Advise and liaise with your leader or the next in line in your Chain of Command until you verbally notify someone.
	6)	Advise Jemena and other potentially affected third parties (as appropriate).
	7)	Provide assistance to police if required and a search of the Facility.
Other Personnel	1)	Assist Person in Charge in controlling incident if necessary.
	2)	Assist or vacate the site as instructed.
Head of Gas Operations (or nominated delegate)	1)	Ensure the duties of Person-in-Charge are fulfilled.
	2)	Advise and liaise with your leader or the next in line in your chain of command until you verbally notify a Leader.

Job Title	Duties	
	3)	Verbally advise all required Authorities of the situation as soon as practical as per Reports section of this document.
	4)	Undertake formal report to Authorities where required and implement corrective measures where applicable to prevent repeat of accident.
AGL Group General Manager (or nominated delegate)	1)	Ensure the duties of Head of Gas Operations are fulfilled.
	2)	Assess if situation requires escalation to an AGL Code Red (Initiate the steps of Code Red if required).
	3)	Liaise with Government Departments as appropriate.
	4)	Notify other AGL personnel as appropriate.
	5)	Ensure formal report to Authorities where required has been provided and ensure implementation of corrective measures where applicable to prevent repeat of incident has been completed.

If you receive a Bomb Threat it is important to keep the person talking. To do this, ask the questions on the Upstream Gas Bomb Threat Procedure (DCS_GN_HSE_FM_005) as follows.

Questions to ask	Answers given
When is the Bomb going to explode?	
Where is it right now?	
Why are you doing this to us?	
What will cause it to explode?	
What does it look like?	
What kind of Bomb is it?	
What is your address?	
What is your name?	
Where are you?	
Exact wording of the threat.	

The Police or Emergency Services will want to interview you about the caller. Try to be able to provide the following details.

Caller's Voice	
Accent (Specify)	
Any impediment (Specify)	
Voice (Loud, Soft, etc.)	
Speech (Flat, Slow, etc.)	
Diction (Clear, Muffled)	
Manner (Calm, Emotional, etc.)	
Did you recognise the voice?	
If so, who do you think it was?	
Was the caller familiar with the area?	

Language	
Well Spoken	
Incoherent	
Irrational	
Taped	
Message read by caller	
Abusive	
Other	

Background Noises	
Street Noises	
House Noises	
Aircraft	
Ships / Boats	
Traffic / Trains	
Machinery / Music	
Voices	
Public Phone / STD	
Other Noises	

Other Details	
Sex of Caller	
Estimated Age	
Date / Time	
Duration of Call	
Number Called	
Your details	

27. Administration Building Fire

If you see fire or smoke, do not panic or shout.

Remain calm - remember ***RACE***

1. RESCUE

Rescue any people in immediate danger (only if it safe to do so).

2. ALARM

Raise the alarm:

1. ring the Fire Brigades on 000
2. press the Evacuation Alarm button
3. notify the most senior manager on site

3. CONTAIN

If practicable, close all doors and windows behind you to contain the fire (only if it safe to do so).

4. EXTINGUISH

Try to extinguish the fire using appropriate fire-fighting equipment only if you are trained and it is safe to do so.

After carrying out RACE:

1. Follow the instructions of your Fire Wardens
2. Fire Wardens follow the steps under General Evacuation

28. Emergency Response Maps

1 Stratford Pilot

2 Gloucester Emergency Services Map

3 Waukivory Pilot – Emergency Services Map

4 Craven, Wards River & Weismantel Well Map

5 Gloucester, Waukivory & Faulkland Well Map

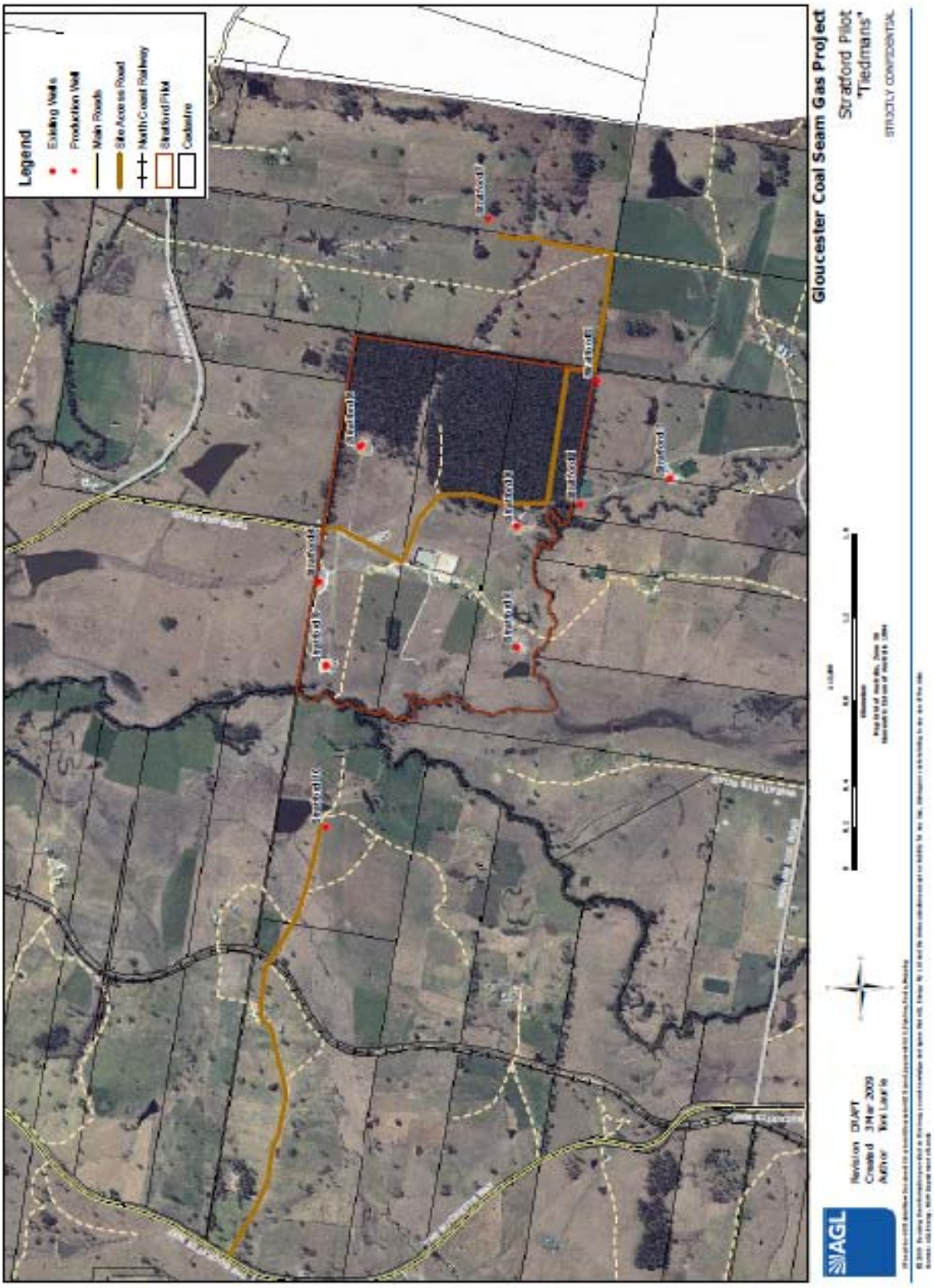
6 Site Emergency Cards

7 Electric Shock Protocol

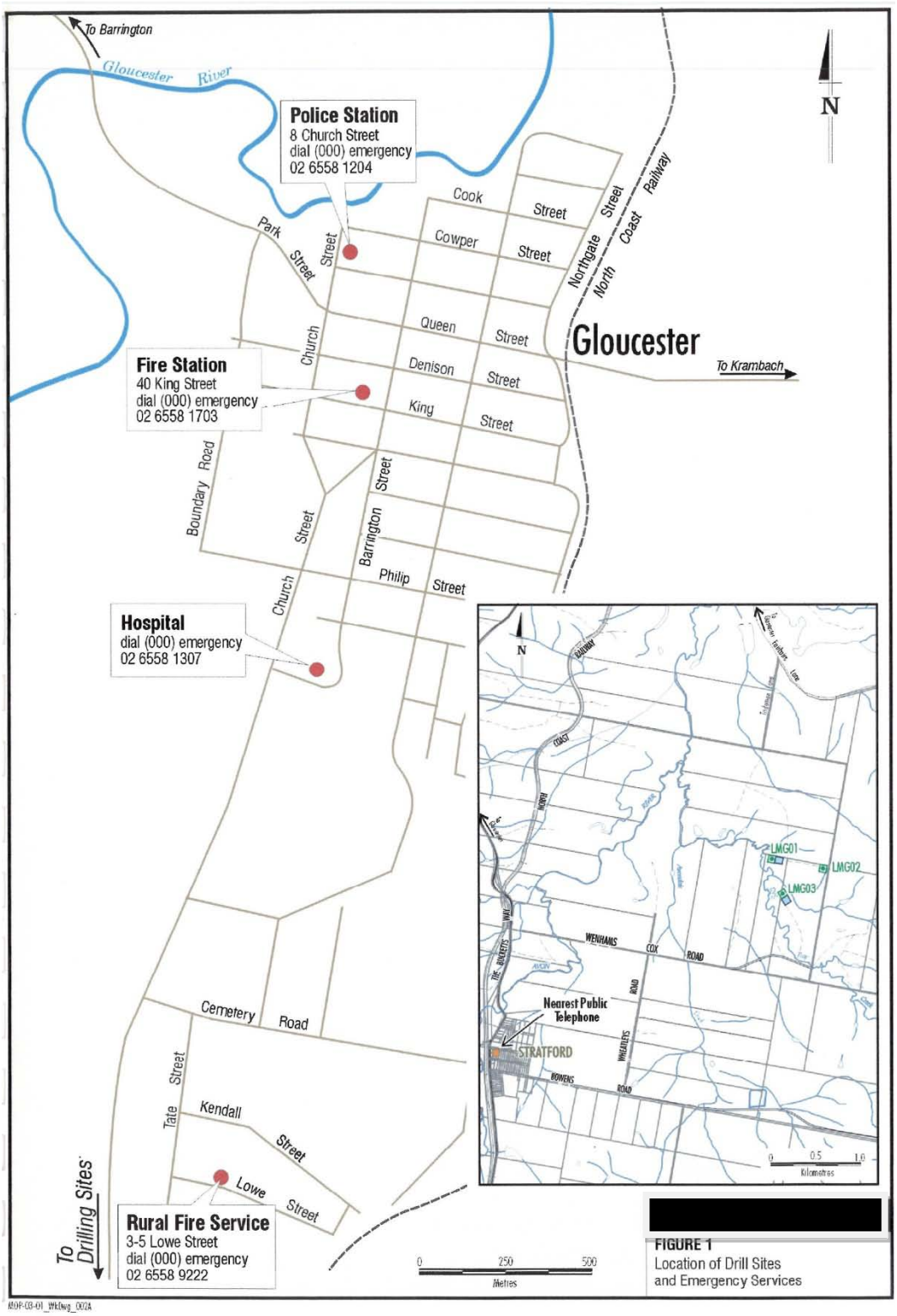
8 Heat Stress Protocol

9 Fluid Injection Protocol

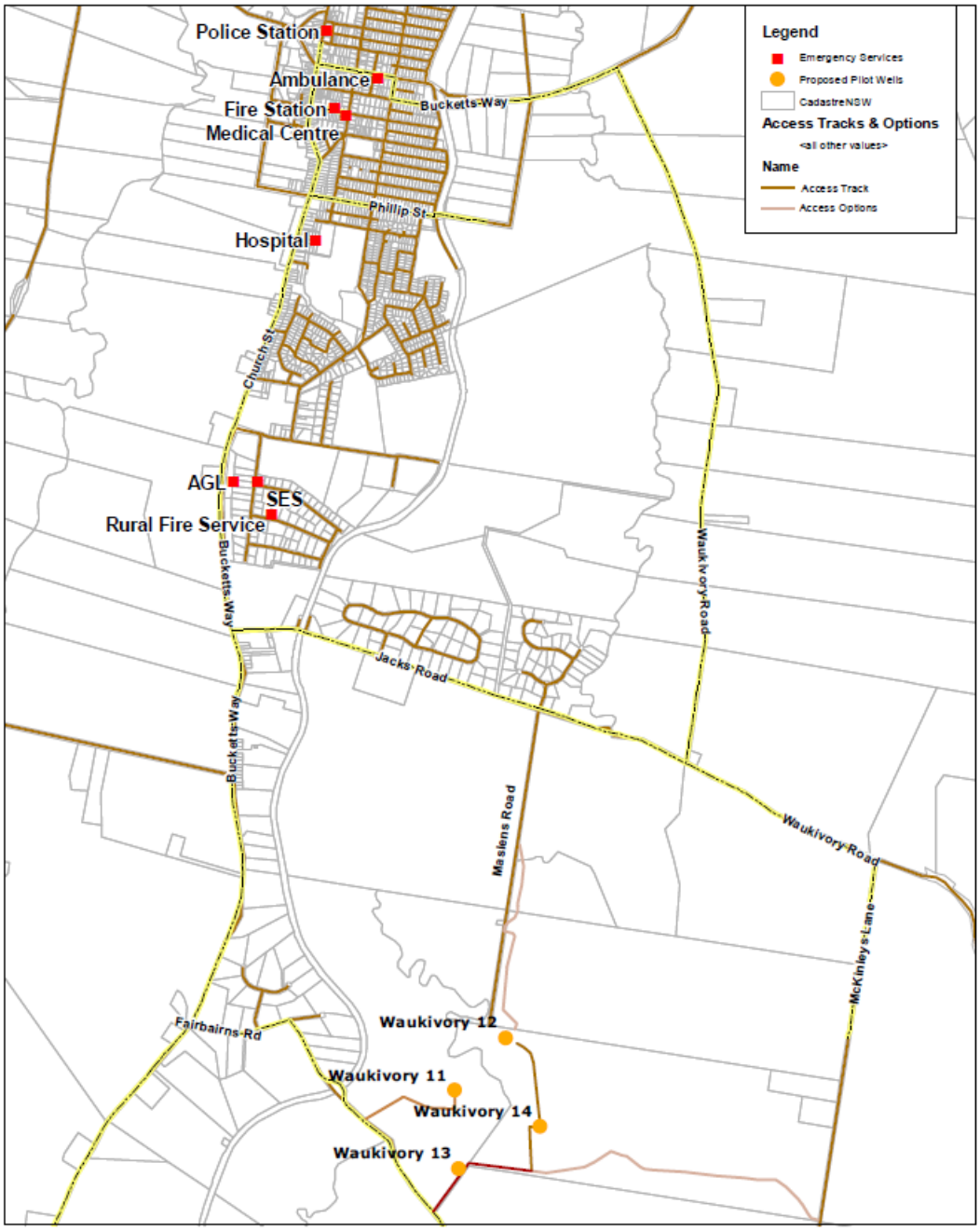
Appendix 1 - Stratford Pilot



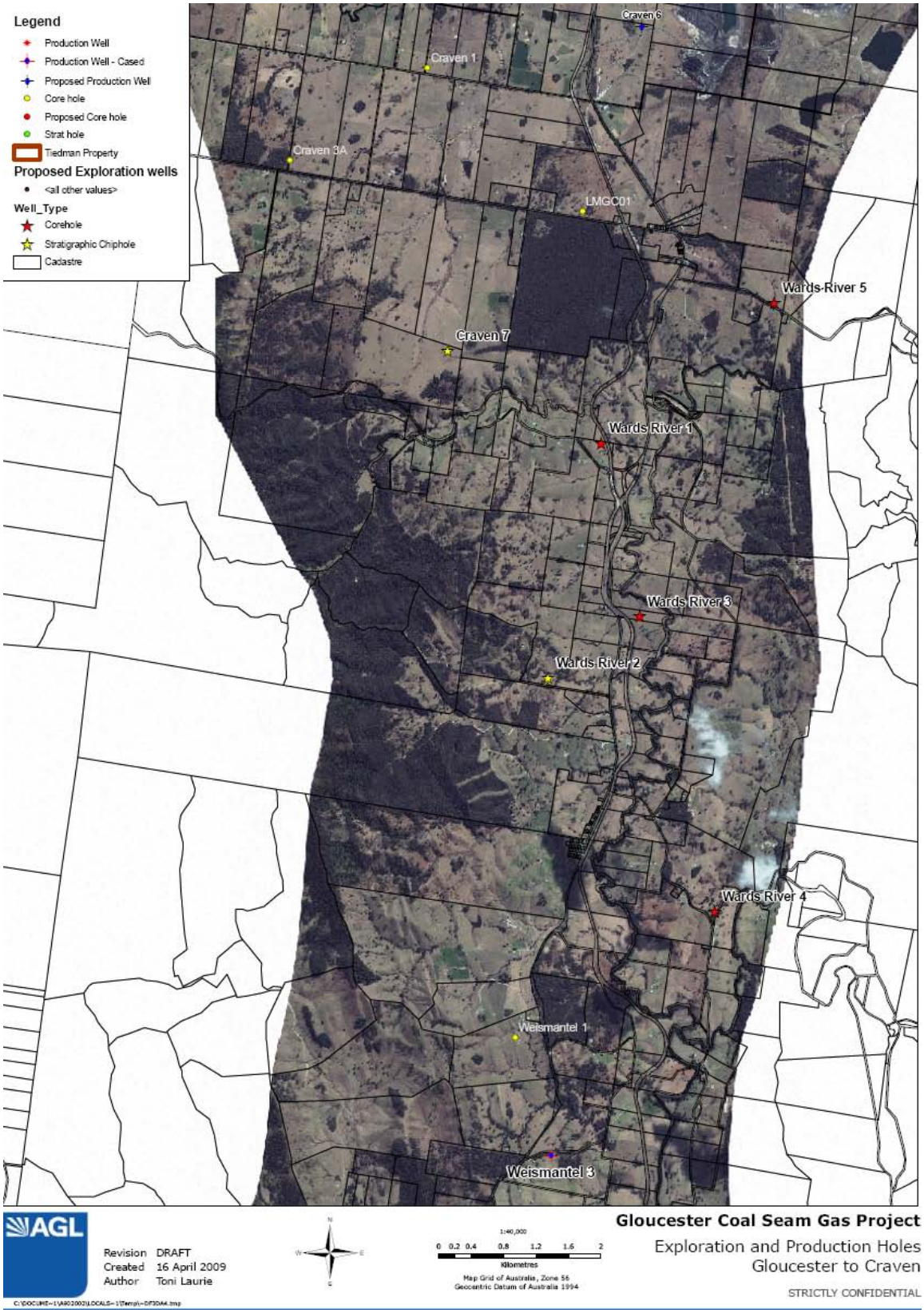
Appendix 2 – Gloucester Emergency Services Map



Appendix 3 – Waukivory Pilot – Emergency Services Map



Appendix 4 – Craven, Wards River & Weismantel Well Map



Appendix 5 – Gloucester, Waukivory & Faulkland Well Map

Project Name: Gloucester Gas Project

IN THE EVENT OF AN EMERGENCY RING 000 IMMEDIATELY OR 112 IF CALLING FROM A MOBILE PHONE

Please State:

1. **Nature of the Incident**
2. **Number of Casualties and an Indication of their condition.**
3. **Exact location (with directions) as follows:**

Well Name:

Co-ordinates: **E** **N**

Gate Access:

Closest Main Road:

Gate Key Requirement:

If possible, meet emergency crew at the gate

AGL Energy Pty Ltd	
Drilling & Completions Manager	(Name / contact)
Drilling & Completions Engineer	(Name / contact)
Land & Approvals Manager	(Name / contact)
Head of Explorations	(Name / contact)
Health & Safety Business Partner	(Name / contact)
Head of Gas Operations	(Name / contact)
Contractors	
Contractor 1	(Name / contact)
Contractor 2	(Name / contact)
Contractor 3	(Name / contact)

IT IS NOT SUFFICIENT TO LEAVE A MESSAGE

Where a significant event / emergency occurs you must call the numbers above in the order listed as soon as possible. If the first number is not answered you must continue to call down the list until you make personal contact.

OTHER EMERGENCY SERVICES CONTACTS	
Dial Before You Dig	1100
Telstra – Report Cable Damage	132 203
State Emergency Services	132 500
Poisons Information Centre	131 126
Environment Protection Authority	131 555
Roads & Maritime Services	131 700
Gloucester Hospital	02 6538 5000
Police – Gloucester Police Station	02 6558 1204
Gloucester Council	02 6538 5250

DCS-GLO-HSE-FM-xxx

Rev 1 17/12/12

Appendix 7 – Electric Shock Protocol

AGL Upstream Gas - Protocol

ELECTRIC SHOCK PROTOCOL

Document Ref Number:	**DCS_GN_HSE_PL_002**
Revision Number:	1
Issue Date:	23 November 2012
Revision Due By:	23 November 2012
Prepared By:	Alexandra Secerbegovic
Checked By:	Alexandra Secerbegovic
Approved By:	Alexandra Secerbegovic
Team:	AGL Upstream Gas Health and Safety

This protocol applies to any person receiving an electric shock, regardless of how minor the contact may appear. This protocol and CPR instructions must be available on the site noticeboard at all times.

Purpose

To provide guidance for people to follow in the event that a person(s) is suspected of receiving an electric shock.

This procedure complies with the *"Electric Shock Protocol" of the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS).* ***The DTIRIS protocol and appendices must be understood by all workers on site and shall be readily available for use in the event of an injury.***

Response

Step 1
a) Make area safe and secure to prevent further injury
b) Isolated power source before attempting to attend the victim

Step 2
a) Assess condition and stabilise victim
b) Provide necessary first aid treatment

Danger
Responsive
Send for help
Airway
Breathing
CPR
Defibrillator

Continue CPR until qualified personnel arrive or signs of life return

Step 3
a) Call an ambulance or arrange transport to nearest medical facility
b) The patient must not be left alone or allowed to drive

Step 4
a) Record relevant details of the incident on the "Electric Shock Protocol Form"

Step 5
a) Send form with patient to medical facility

Step 6
a) Contact the medical facility and advise of the incident and transport arrangements

Step 7
a) Provide incident information and "Electric Shock Protocol Form" to the medical facility reception

Note: At this time, a 12 lead ECG is to be requested for the victim

Step 8
a) Upon being released the patient shall be driven back to work or elsewhere as appropriate
b) Upon arrival back at work, the patient should report the results to their Supervisor

In an Emergency Dial 000 or 112 from a mobile phone.

Work site name:

Nearest hospital:
Address:
Phone:

Appendix 8 – Heat Stress Protocol

AGL Upstream Gas - Protocol

HEAT STRESS PROTOCOL

Document Ref Number:	**DCS_GN_HSE_PL_003**
Revision Number:	1
Issue Date:	07 January 2013
Revision Due By:	07 January 2015
Prepared By:	UG H&S Manager
Checked By:	UG H&S Business Partners
Approved By:	UG H&S Manager
Team:	Health and Safety

Treatment varies according to the type of heat illness. Apply first aid, seek medical assistance immediately if you, or someone you're with, shows signs of heat exhaustion or heat stroke. This protocol must be available on site at all times.

Purpose

To provide guidance for people to follow in the event that a person(s) is suspected of sustaining a heat illness.

Symptoms

Some heat-related illness and common symptoms include:

a. **Deterioration** in existing medical conditions.
b. **Heat rash** Looks like a red cluster of pimples or small blisters.
c. **Heat cramps** including muscle pains or spasms, usually in the abdomen, arms or legs.
d. **Dizziness and fainting** Can be a feeling of light-headedness before fainting occurs.
e. **Heat exhaustion** including paleness and sweating, rapid heart rate, muscle cramp, headache, nausea and vomiting, dizziness or fainting.
f. **Heat stroke** Person may stagger, appear confused, have a fit or collapse and become unconscious. The skin may be dry with no sweating and the person's mental condition worsens.

Response

Heat rash

1. Move the person to a cooler, less humid environment and keep the affected area dry.
2. Try using unperfumed talcum powder to increase comfort.
3. Avoid ointments or creams.

Heat cramps

1. Stop activity and sit quietly in a cool place and increase fluid intake.
2. Rest few hours before returning to work.
3. Seek medical help if no improvement.

Dizziness and fainting

1. Get the person to a cool area and lay them down.
2. If fully conscious, increase fluid intake.

Heat exhaustion

1. Get the person to a cool area and lay them down and remove outer clothing.
2. Wet skin with cool water or wet cloths.
3. Increase fluid intake if they are fully conscious.
4. Seek medical advice.

Heat stroke

Heat stroke is a medical emergency and requires urgent attention:

1. Call triple zero (000) for an ambulance.
2. Get the person to a cool, shady area and lay them down while you're waiting.
3. Remove outer clothing and wet their skin with water, fanning continuously.
4. Do not give the person fluids to drink.
5. Position an unconscious person on their side and clear their airway.
6. If medical attention is delayed, seek further instructions from ambulance or hospital emergency staff.

In an Emergency Dial 000 or 112 from a mobile phone.

Work site name:

Nearest hospital:
Address:
Phone:

Appendix 9 – Fluid Injection Protocol

AGL Upstream Gas - Protocol

FLUID INJECTION PROTOCOL

Document Ref Number:	DCS_GN_HSE_PL_001
Revision Number:	1
Issue Date:	23 November 2012
Revision Due By:	23 November 2014
Prepared By:	Alexandra Secerbegovic
Checked By:	Alexandra Secerbegovic
Approved By:	Alexandra Secerbegovic
Team:	AGL Upstream Gas Health and Safety

WARNING: Failure to act appropriately may result in death of patient, or the need to amputate the affected limb. This protocol must be available on the site noticeboard at all times.

1. Purpose

To ensure adequate and efficient emergency response to anyone on site that sustains a fluid injection injury.

This procedure complies with the "Fluid Injection Protocol" of the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS). The DTIRIS protocol and appendices must be understood by all workers on site and shall be readily available for use in the event of an injury.

2. Response

Step 1:

a) Make area safe to prevent further injury
b) Call an ambulance as appropriate to emergency response protocols on site.
c) Provide First Aid:

- Gentle cleaning of the injured part
- Immobilise and elevate the affected limb to a comfortable position
- Rest the patient to avoid anxiety
- Do NOT give food or fluids

Step 2:

a) Take patient to the first aid room
b) Attach an "Information Kit" which includes the following documents to the patient

- Dear Doctor Letter
- Information from Sydney Hospital, "High Pressure Injection Injury of a Hand"
- Injuries involving High Pressure Injection
- Material Safety Data Sheet of the fluid involved

Step 3

a) The patient must not be left alone or allowed to drive
b) Repeat "baseline observation" every 20-30 minutes. Make notes

Step 4

a) At the hospital, hand over the "Dear Doctor Letter" immediately

Step 5

a) When the doctor arrives, hand over the "Information Kit" documents
b) A medical check will be performed
c) The doctor may require the person to be admitted for observation or surgery
d) The family of the patient should then be advised if not already done so

Step 6

a) If following examination the patient is not admitted they shall be driven back to work.

Step 7

a) Upon arrival back at work, the patient should report the results to their Supervisor.

In an Emergency Dial 000 or 112 from a mobile phone.

Nearest hospital equipped to deal with fluid injection injuries is:

Work site name:

Hospital:
Address:
Phone:

EMM
EMGA Mitchell McLennan

www.emgamm.com

SYDNEY
Ground Floor, Suite 1, 20 Chandos Street
St Leonards NSW 2065
T 02 9493 9500 F 02 9493 9599

NEWCASTLE
Level 1, 6 Bolton Street
Newcastle NSW 2300
T 02 4927 0506 F 02 4926 1312

BRISBANE
Suite 1, Level 4, 87 Wickham Terrace
Spring Hill Queensland 4000
T 07 3839 1800 F 07 3839 1866

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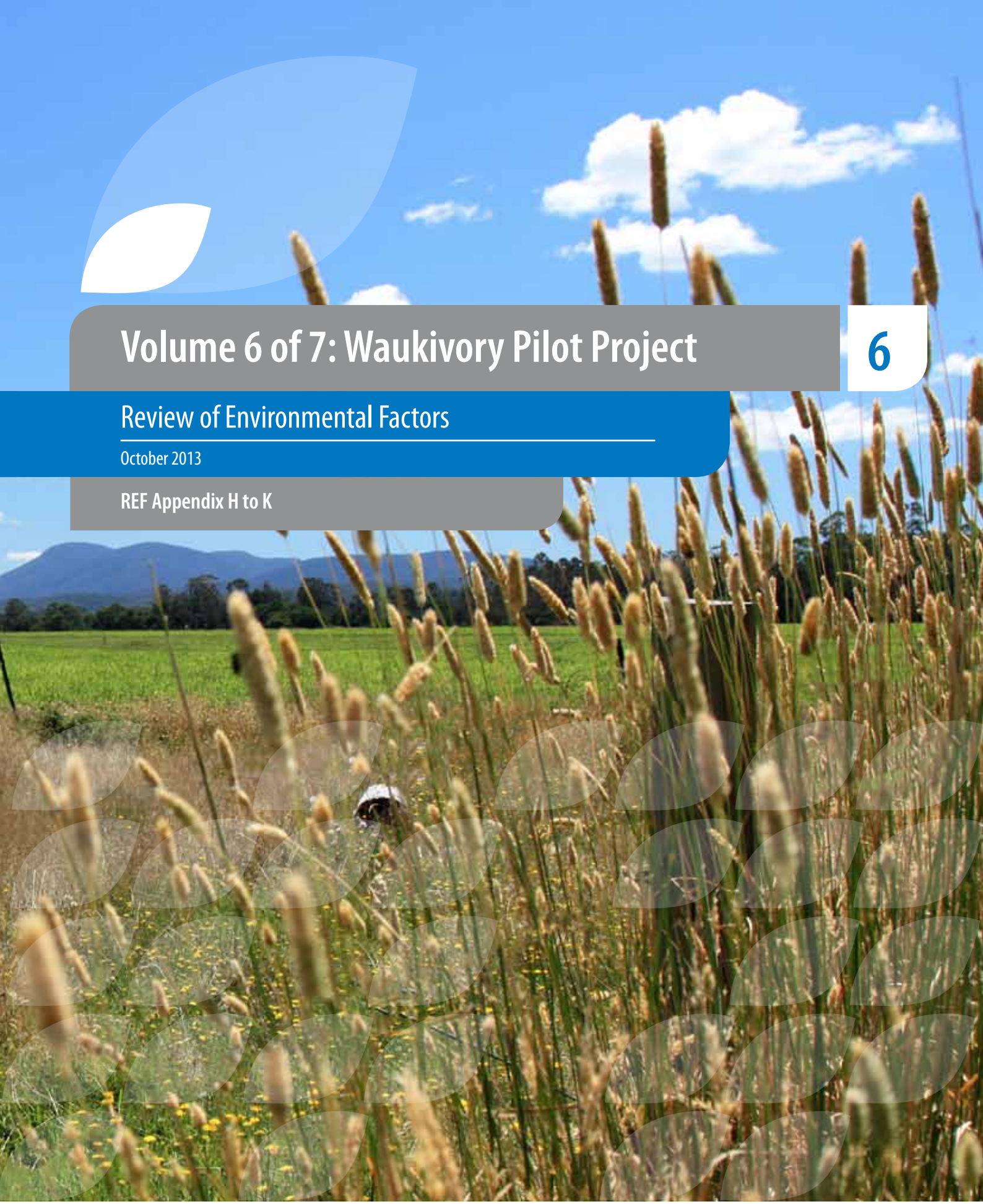
6

Review of Environmental Factors

October 2013

REF Appendix H to K



AGL Energy in action.

EMM
EMGA Mitchell McLennan

Appendix H

Minimum impact considerations for less productive aquifers

A2 Groundwater impact assessment (drilling program)

It is considered that, by drilling the pilot wells in accordance with the requirements outlined in Chapter 4, the potential to impact on groundwater systems and local groundwater users is low adverse to negligible. There are no groundwater dependent ecosystems or local groundwater users within the immediate vicinity of the Waukivory pilot wells that could be affected. Impacts are assessed in Table A.1.

Table A2.1: Impact Assessment – Waukivory Drilling Program

Impact Assessment for Groundwater Systems	
Size, scope and intensity of impacts	The potential impacts on groundwater systems is considered low as the drilling works are for a short duration and undertaken in accordance with the new Well Integrity Code of Practice and national standards. Following the completion of drilling, the exploration hole will be capped and suspended in accordance with the *Petroleum and Gas (Production & Safety) Regulation 2004 – Schedule 3*.
Level of confidence in predicting the impacts	AGL has undertaken core hole and stratigraphic hole drilling activities as part of the on-going exploration works associated within all of their upstream gas projects. The resulting significant level of experience gained from previous projects has resulted in a high level of confidence in accurately predicting any potential associated impacts to groundwater systems from the exploration drilling works.
Reversibility of Impacts	As the anticipated potential for groundwater impacts is considered low and only water based drilling fluids are used, the reversibility of any impacts is considered to be high.
Mitigation Management Measures	Mitigation management measures would be pre-emptive and also adaptive to ameliorate any potential for impact. Measures would include: ▪ The well will be cased at the surface plus there will be an internal surface casing to ~100m to protect shallow aquifers; ▪ Any drilling fluids/mud will be contained in appropriately sized surface tanks or lined sumps (within the drill compound area); ▪ All sumps will be HDPE lined and bunded and have a sufficient capacity in case of heavy rain or additional flow from the holes; ▪ A periodic "pump-out" of the sumps will occur as required to prevent any discharge during wet weather events; ▪ All land disturbed during drilling activities will be restored to pre-operational quality as soon as practical; ▪ Drilling activities will be undertaken in accordance with Australian Government standards, DTIRIS - Minerals Guidelines, Industry best practice and NSW Government standards for well construction. Any additional draft or final Government Codes of Practice. These mitigation measures are considered to effectively ameliorate all impacts to groundwater and protect its quality.
Effectiveness of the proposed methods to manage or mitigate the impacts	The proposed methods to manage or mitigate impacts to groundwater have been derived from past project experience. The drilling process is governed by national standards and industry guidelines. The standards and guidelines outline methods to mitigate potential impacts. Accordingly, the proposed management/mitigation measures proposed are considered to be effective measures as they are enforced through national standards.
Compliance with any relevant policies or plans	The drilling methods comply with the national standards, *The minimum construction requirements for water bores in Australia* (NUDLC, 2012) and industry best practice.
Level of public interest	The drilling requires a licence pursuant to the *Water Act 1912* which does not include any allocation to extract groundwater. At the drilling stage it is considered that the general public will maintain an interest in ensuring all works are undertaken with no impacts to groundwater systems. The level of impact to groundwater systems from the proposal is low and predictable with a high level of certainty.

Impact Assessment for Groundwater Systems	
Is further information required to confidently determine the impact of the activity?	No additional information is required to confirm the predicted level of impact risk to a groundwater system evaluated for the exploration drilling activities.
Categorisation of the extent of impact	Based on the impact assessment matters listed above the potential for drilling impacts to a groundwater system is determined to be **low adverse to negligible**.

Appendix I

Ecological assessment of wells

AGL Upstream Investments Pty Ltd

Gloucester Coal Seam Gas Project
Waukivory
Pilot Well Sites & Water Monitoring Site

Final

Ecological Assessment

March 2011

Alison Hunt and Associates Pty Ltd

TERRESTRIAL | MARINE | AQUATIC

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APPENDICES

1 INTRODUCTION

1.1 Background

Alison Hunt & Associates Pty Ltd was commissioned by AGL Upstream Investments Pty Ltd (AGL) to undertake an ecological assessment of its proposal to construct four coal seam methane gas exploration wells known as Waukivory 11, 12, 13, 14 and a water monitoring bore all of which are located 5 km south of Gloucester, NSW (Figure 1).

The purpose of the study was to assess the potential direct and indirect impacts of the proposal on biodiversity particularly in relation to threatened species and endangered ecological communities. AGL is preparing a Review of Environment Factors (REF) in accordance with requirements of *Condition No. 1 (Environmental Assessment) of Petroleum Exploration Licence (PEL) No. 285*. This ecological assessment meets the requirements under Part 5A of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act), *Threatened Species Conservation Act 1995* (NSW) (TSC Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act).

Key ecological issues that required clarification include:

- The potential for endangered ecological communities, threatened species and / or their habitat listed under the TSC Act to occur within the study area;
- The potential presence of any matters of National Environmental Significance (NES) listed under the EPBC Act; and
- Any avoidance, management or mitigation options.

1.2 Proposal

The proposal includes the drilling of the four new coal seam methane pilot production boreholes shown in Figure 2 followed by downhole logging, running and cementing production casings in place,. Three of the four wells will be completed by either hydraulic fracturing or under reamed. One of the wells, either Waukivory 12 or 14, would be 'twinned' and both hydraulic fracturing and under reaming would take place at the one well site resulting in two boreholes drilled within the same pad area. The wells will have dewatering pumps connected to surface facilities. The work is expected to be completed over a period of approximately 6 weeks. Final stages of the work will involve production testing of the wells for approximately 12 - 15 months.

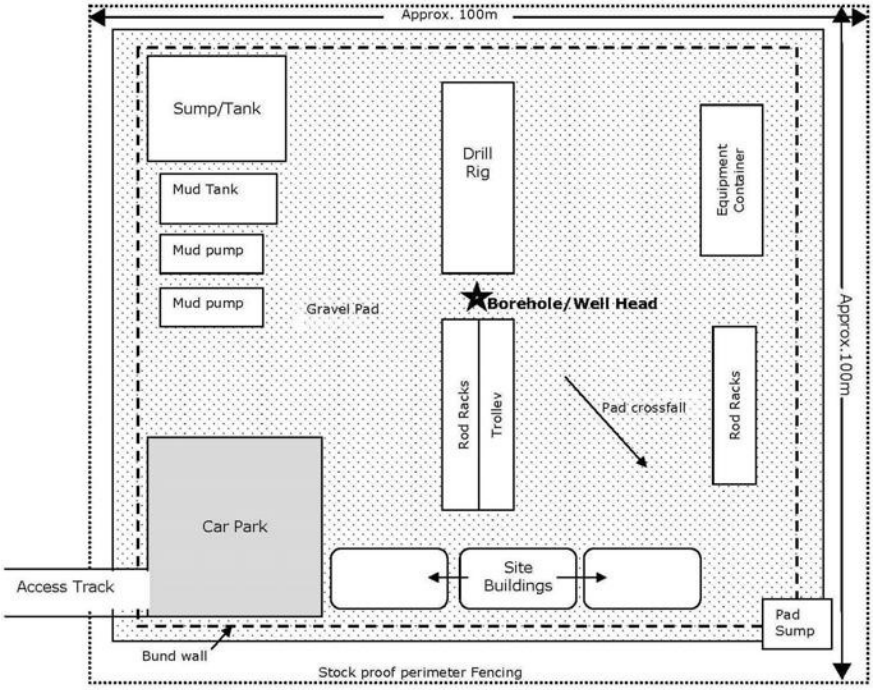
The drilling activities on each borehole site will involve temporary ground surface disturbance of an area approximately 70 m x 60 m. Water storage (turkeys nest) and flaring equipment during production testing will require a potential site disturbance of an additional area of up to 100 m x 100 m. All activities, including the construction of access roads, would be undertaken within existing cleared agricultural paddocks.

Diagram 1 shows the layout of a typical borehole pad. Access to most of the work area is available from existing farm tracks although at some sites new tracks would need to be constructed across cleared paddocks. In some instances upgrading of the existing tracks would be required in order to ensure safe heavy vehicular passage to the work sites. No major creek crossings would be altered.

Provision would be made for storage of drilling fluid for recirculation within the work area. Water would be stored in lined pits and / or tanks on site. Stock proof site fencing would be erected to delineate the work zone and to limit the extent of disturbance. A transportable laboratory / office (2.4 m x 3.6 m) would be installed on-site during the drilling, wireline logging, perforation and stimulation operations. Access to drilling sites and heavy vehicle movements would be minimised during periods of heavy rain. New access tracks will be graded and vehicle speeds restricted in dry conditions to minimise dust generation.

At the completion of the exploration test program, AGL will suspend each well, remove surface equipment and other surface facilities, reduce the access area to a 10 m x 10 m area and restore the disturbed area as agreed with the Landholder. In the event that the well site(s) are no longer required or approved, for future production, AGL will plug and abandon the well, and restore the area to its original condition including respreading all topsoil and removing all roads as agreed with the Landholder.

Diagram 1 Typical borehole pad layout



A water monitoring bore would also be drilled and a logger installed to constantly measure water pressures and levels approximately 250 m west of Waukivory 11 (refer Figure 2) A pad size of approximately 50 x 30 m would be required for installation although this area would be rehabilitated at completion of installation with only the bore remaining on site. The final installation is shown in

Plate 1 Example of an installed water monitoring bore

1.3 Legislative Framework

A number of legislative requirements need to be met in relation to biodiversity issues for the proposed works and these may include but not necessarily be limited to:

1.3.1 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

The EPBC Act requires assessment of proposed actions that are likely to cause significant impacts on matters of NES listed under the Act. The EPBC Act identifies seven matters of NES and these include:

- World Heritage properties;
- National Heritage places;
- Wetlands of international importance (Ramsar Wetlands);
- Threatened species and ecological communities;
- Migratory species;
- Commonwealth marine areas; and
- Nuclear actions (including uranium mining).

Those matters of NES relevant to this proposal may include threatened species, ecological communities and migratory species. If, after addressing the criteria set out in the Administrative Guidelines for the EPBC Act, it is concluded that a significant impact on matters of NES is likely then a referral to the Department of Sustainability, Environment, Water, Population and Communities (SEWPAC) may be required.

1.3.2 NSW *Environmental Planning and Assessment Act 1979*

Pursuant to the EP&A Act an assessment of the impacts of the proposed works on land that is critical habitat or on threatened species, populations or ecological communities, or their habitats listed under the TSC Act, must be undertaken in the form of an Assessment of Significance. This involves assessing potential impacts of the proposal based on seven criteria that aid in assessing if the proposal is likely to have a significant impact on threatened species or their habitat or endangered ecological communities at the site or that have the potential to occur. If the Assessment of Significance concludes that a significant impact is likely then a Development Application must be accompanied by a Species Impact Statement (SIS).

1.3.3 NSW *Threatened Species Conservation Act 1993*

The TSC Act applies to terrestrial and aquatic flora and fauna. This Act is administered by the NSW Department of Environment, Climate Change and Water (DECCW). Pursuant to the EP&A Act an assessment of the impacts of the proposed works in areas of critical habitat or is likely to affect threatened species, populations or ecological communities, or their habitats listed under the NSW *Fisheries Management Act 1994* (FM Act), must be undertaken in the form of an Assessment of Significance. This involves assessing potential impacts of the proposal based on seven criteria that aid in assessing if the proposal is likely to have a significant impact on threatened species or their

habitat or endangered ecological communities at the site or that have the potential to occur. If the Assessment of Significance concludes that a significant impact is likely then a Development Application must be accompanied by a Species Impact Statement (SIS).

1.3.4 State Environmental Planning Policy 44 - Koala Habitat Protection

State Environmental Planning Policy No. 44 Koala Habitat (SEPP 44) aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas to ensure a permanent free-living population over their present range and reverse the current trend of koala population decline by:

- Requiring the preparation of plans of management before development consent can be granted in relation to areas of core koala habitat;
- Encouraging the identification of areas of core koala habitat; and
- Encouraging the inclusion of areas of core koala habitat in environment protection zones.

The policy applies to 107 local government areas including Gloucester LGA and therefore this policy is considered in assessing this proposal.

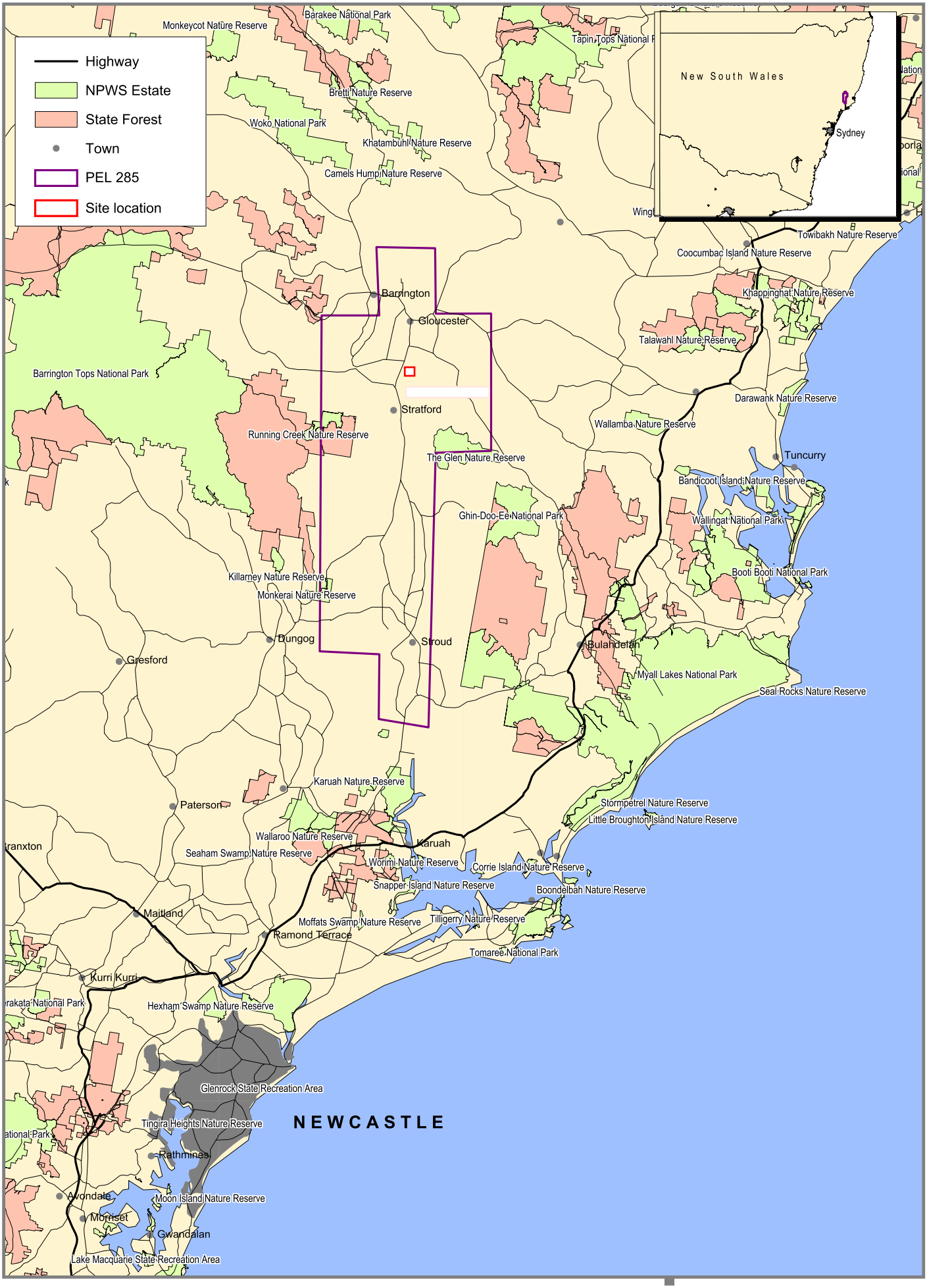


Figure 1 Location of Waukivory well sites

AH Ecology

Proposed Pilot Well Locations

Figure 2 Proposed Waukivory pilot well sites and monitoring bore site

Energy in action.™

AGL

Author:	Upstream Gas
Date:	26/10/2010
Ref:	2575r1

Meters
0 100 200
Scale 1:5,000

N

Geocentric Datum of Australia 1994

Legend
- Proposed Pilot Wells
- Cored Well
- Railway
- Road
- Property Boundaries

Sources: AGL Energy Limited, MapData Sciences, SKM

2 METHODS

This assessment was designed to meet the requirements of the EP&A Act, TSC Act and EPBC Act. Several tasks were addressed including:

- A review of available literature and databases to assist with the identification of site values, especially in relation to threatened species, populations and endangered ecological communities;
- A field investigation to ascertain the site condition and the presence or likely presence of threatened or protected species;
- An impact assessment to determine the likely effects of the proposal on the ecology of the site and locality; and
- Preparation of preliminary recommendations to ameliorate and mitigate impacts.

2.1 Literature Review

Available literature and database records pertaining to the site and locality (i.e. within a 10 km radius) were reviewed. The full list of reference materials is provided in Section 7 and those of particular relevance are listed below:

- DECCW – Threatened species database records (DECCW 2010);
- SEWPAC – Online protected matters search tool for Matters of National Environmental Significance (NES) (SEWPAC 2010);
- AECOM 2009 Gloucester Coal Seam Gas Project. Ecological Assessment. Gloucester to Hexham. Report prepared for Lucas Energy, Gloucester NSW;
- Alison Hunt & Associates Pty Ltd 2009 Addendum. Gloucester Coal Seam Gas Project. Ecological Assessment. Gloucester to Hexham: Amended Sections. Report prepared for AECOM, Gordon NSW; and
- Alison Hunt & Associates Pty Ltd 2011 Gloucester Coal Seam Gas Project. Targeted Surveys. Draft. Report prepared for AGL.

2.2 Site Assessment

An assessment of the proposed Waukivory sites was undertaken on 17 November 2010. The locations of the proposed wells and associated infrastructure are all within highly modified environments that have been cleared of native vegetation, largely revegetated with introduced pasture species and used for grazing of stock over a considerable number of years. Consequently, the disturbed nature of the proposed sites indicated that detailed surveys would not be required to characterise the ecology of the sites, their conservation value and the potential impacts of the proposal.

During the site assessment the dominant plant species were recorded and the likelihood of threatened fauna and flora assessed through determining if suitable habitat was present. For plants this included several factors including the vegetation types present, drainage patterns, weed invasion and present land use activities. A general fauna habitat assessment included an assessment of the nature and condition of habitats, specific resources and features of relevance for native fauna. In addition, indirect evidence of fauna (e.g. scats, feathers, fur, tracks, dens, nests, scratches, chew marks and owl wash) was recorded.

2.3 Limitations

This assessment was aimed at providing an overall assessment of the ecological values of the sites with particular emphasis on the likely presence of threatened species. This was undertaken through integration of data from a number of sources to allow an assessment of the impacts of the proposal. This study was not designed so that all species, whether resident or transitory to the site, would be recorded. It is therefore likely that a number of species not mentioned within this report would also utilise the resources of the site from time to time.

3 RESULTS

3.1 Environmental Setting

Gloucester and the proposed Waukivory pilot well sites are situated in the Gloucester Valley, NSW. The landforms of the Gloucester Valley are characterised by north-south oriented linear ridges with intervening undulating lowlands and floodplains. The topography consists of grassy flats and gentle rises. The PEL area contains the geological domain known as the Gloucester Basin or Stroud-Gloucester Syncline. This is a canoe shaped trough containing some 4,000 m of Permian volcanics and sedimentary rocks. Soils comprise moderate to deep, moderately well-drained Brown Sodosols (Yellow Soloths) and moderately well-drained Grey Kurosols (Yellow Soloths) on imperfectly to moderately well drained sideslopes and crests shallow to deep (Lucas 2007).

The broader area contains significant biodiversity values including the world heritage listed Central Eastern Rainforest Reserves (Barrington Tops Area) NSW (Barrington Tops National Park) as well as the Woko National Park, six nature reserves and four state conservation areas. In all, 51,090 ha (approximately 17% of the entire LGA) are dedicated to species and ecosystem conservation, (Gloucester Shire Council 2005). Nonetheless, the LGA continues to lose biodiversity through:

- Land clearing;
- Habitat alteration through weed invasion;
- Domestic and feral animal activity; and
- Poor land management techniques.

With such significant conservation areas the LGA provides habitat for a number of species and endangered ecological communities listed on the schedules of the NSW TSC Act and Commonwealth EPBC Act and these are listed in Gloucester Shire Council's *Supplementary State of the Environment Report 2005*. A review of these lists indicated that the majority of species and ecological communities would be confined to the vegetated areas within conservation areas, within remnant vegetation in private ownership, and in riparian areas and along coastal waterways.

3.2 Gloucester Valley Vegetation

Native vegetation of the Gloucester Valley falls within the *Hunter-Macleay Dry Sclerophyll Forests* vegetation class which are transitional between the *Dry Coastal Valley Grassy Woodlands and Northern Hinterland Wet Sclerophyll Forests* of the steeper and wetter slopes (Keith 2004). Woodlands in the locality have previously been mapped by NPWS (1999) as *Ecosystem (ES) 145 Sydney Peppermint – Stringybark*, *ES 71 Ironbark*, *ES 47 Escarpment Redgum* and *ES 33 Dry Foothills Spotted Gum*. The canopy of vegetated areas is largely dominated by Spotted Gum (*Corymbia maculata*), Narrow-leaved Ironbark (*Eucalyptus crebra*), Grey Box (*E. moluccana*), Grey Gum (*E. punctata*), Small-fruited Grey Gum (*E. propinqua*), Grey Ironbark (*E. siderophloia*) and Forest Red Gum (*E. tereticornis*). The occurrence and dominance of these species is largely dependent on soils, drainage and proximity to drainage lines. Shrubs are characterised by Silver-stemmed Wattle (*Acacia parvipinnula*), Forest Oak (*Allocasuarina torulosa*), Coffee Bush (*Breynia oblongifolia*), Gorse Bitter Pea (*Daviesia ulicifolia*), Peach Heath (*Lissanthe strigosa*). White Root (*Pratia purpurascens*),

Mulga Fern (*Cheilanthes sieberi* subsp. *sieberi*), Barbed Wire Grass (*Cymbopogon refractus*), Kangaroo Grass (*Themeda australis*) and Wiry Panic (*Entolasia stricta*) dominate the understorey. These areas grade into the cleared, lower elevation, fertile soils used for agriculture.

3.3 Climate

Gloucester and surrounding areas experience their highest mean rainfall and highest mean temperatures between December and March with the highest rainfall occurring in March at 127 mm and the highest temperatures in January and February at 29 ^{o}C. During winter, rainfall drops to 47 mm during August with mean maximum temperatures of 19 ^{o}C during June and July, and mean minimum temperatures to 6 ^{o}C during July and August (Table 1).

Table 1 Mean rainfall recorded at Gloucester Post Office and mean temperature at Taree

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Mean rainfall (mm)	115	122	127	77	68	67	51	47	52	68	82	104	982
Mean maximum temperature (^{o}C)	29	29	27	25	22	19	19	20	23	25	27	28	24
Mean minimum Temperature (^{o}C)	18	18	16	13	10	7	6	6	9	12	14	16	12
Source: Bureau of Meteorology http://www.bom.gov.au/jsp/ncc/cdio/weatherData accessed 21 April 2009.													

3.4 Proposed Waukivory Pilot Well Sites and Monitoring Bore Site

The location of the proposed activities are all within highly modified environments that have been cleared of native vegetation, revegetated with introduced pasture species and used for grazing over a considerable number of years (Figure 2). None of the proposed sites contain remnant native shrubs or trees and none would be located in riparian areas or within seepage zones although some access roads would cross minor drainage lines. The lack of structural diversity of the sites means that fauna habitat resources, such as trees, shrubs, rocky areas and fallen timber, are extremely limited and in general, habitat suitable for fauna would generally be limited to those common species of native and introduced fauna regularly found in disturbed areas.

AGL

Revision DRAFT

Created 27 Jan 2011

Author Upstream Gas

N W E S

1:7,000

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Meters

Map Grid of Australia, Zone 56
Geocentric Datum of Australia 1994

Gloucester Gas Project

Figure 3 Proposed Waukivory pilot well sites and Option 1 access tracks

STRICTLY CONFIDENTIAL

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Revision DRAFT

Created 27 Jan 2011

Author Upstream Gas

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Meters

Map Grid of Australia, Zone 56
Geocentric Datum of Australia 1994

Gloucester Gas Project

Figure 4 Proposed Waukivory pilot well sites and Option 2 access tracks

STRICTLY CONFIDENTIAL

Sources: AGL Energy, NSW Department of Lands, Geoscience Australia

3.4.1 Waukivory 11

Waukivory 11 would be located in a paddock on a slight rise approximately 100 m up slope from the Avon River (Figure 3) (Plate 2). The paddock is currently being grazed and is dominated by pasture species, such as White Clover (Trifolium repens), Couch (*Cynodon dactylon*), Wimmera Ryegrass (*Lolium rigidum*) and *Carex* sp.

Access to Waukivory 11 would be via a track from Fairbairns Lane which would be constructed along a fenceline through agricultural paddocks. Near to the Avon River the track would head north for 100 m through a paddock to access the well site. Construction of this track would not require the removal of any shrubs or trees (Figure 2)

Plate 2 Proposed location of Waukivory 11

3.4.2 Waukivory 12

Waukivory 12 would be located within a relatively flat paddock approximately 60 m from a backwater of the Avon River (Plate 3). This backwater is completely cleared of native vegetation although several Red Gum trees were evident along the banks. The paddock is vegetated with species typical of grazing land in the Gloucester valley and these included Paspalum (*Paspalum dilatatum*), Perennial Ryegrass (*Lolium perenne*), *Carex* sp. and Kikuyu Grass (*Pennisetum clandestinum*) with scattered occurrences of Purpletop (*Verbena bonariensis*) and Fireweed (*Senecio madagascariensis*).

There are currently two options for access to Waukivory 12 (Figure 3 and Figure 4). Option 1 would be from the south via Waukivory 14 which would be accessed from an existing farm track upgraded to meet the requirements for transporting machinery. From Waukivory 14, a 500 m access track would be constructed through a paddock to reach Waukivory 12. Option 2 would be from the north along an existing farm access track to a dam and then through a paddock to the well site. This option would require the crossing of a shallow drainage line. No removal of native trees or shrubs would be required for either option.

Plate 3 Proposed location of Waukivory 12

3.4.3 Waukivory 13

Waukivory 13 would be located within a flat paddock 250 m west of the Gloucester River and 100 m south of the Avon River (Figure 3) (Plate 4). The location of Waukivory 13 is within a paddock dominated by Kikuyu and White Clover.

Access to the site would be from a gravel road which runs off Fairbairns Lane. The well site is located approximately 20 m inside the fenceline. There would be no trees or shrubs removed for construction of the access track.

Plate 4 Proposed location of Waukivory 13

3.4.4 Waukivory 14

Waukivory 14 would be located on a slight rise approximately 100 m upslope of the Gloucester River within a grazing paddock which is dominated by agricultural species typical of this setting (Plate 5). Access to this site would be along gravel road off Fairbairns Lane.

There are currently two options for access to Waukivory 14 (Figure 3 and Figure 4). Option 1 would be from the south along an existing farm track which would be upgraded to meet the requirements for transporting machinery. Option 2 would be from the north via Waukivory 12 along a 500 m track constructed within a paddock. No removal of native trees or shrubs would be required for either option.

Plate 5 Proposed location of Waukivory 14

3.4.5 Water Monitoring Bore Site

The water monitoring bore site would be located approximately 250 m west of Waukivory 11 in an agricultural paddock most recently used for grazing (Figure 2). The area is dominated by pasture species. The site would be located along the track proposed for access to Waukivory 11 (Figure 3). Construction of the track and bore installation would not require the removal of any trees or shrubs.

3.4.6 Fauna Habitat

The lack of structural diversity across the Waukivory pilot well sites means that fauna habitat resources, such as trees, shrubs, rocky areas and fallen timber, are extremely limited and in general, habitat suitable for fauna would be limited to those common species of native and introduced fauna regularly found in disturbed areas, such as the Eastern Grey Kangaroo (*Macropus giganteus*), European Red Fox (*Vulpes vulpes)*, Black Rat (*Rattus rattus*), House Mouse (*Mus musculus*), and domestic cats and dogs.

3.5 Conservation Significance

3.5.1 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

Although remote to the study area, Myall Lakes which is listed as a Wetland of International Significance (Ramsar Sites) is listed under the EPBC Act as being within the same catchment as the study area.

Predictive modelling indicates that 14 fauna, 13 flora and 12 migratory species listed under the EPBC Act have the potential to occur within the locality of the site (i.e. 10 km) and these are listed at Appendix A along with their likelihood of occurrence. There are no EPBC Act listed species with real potential to occur across the Waukivory sites or directly adjacent.

3.5.2 NSW *Threatened Species Conservation Act 1995*

Endangered Ecological Communities

A number of Endangered Ecological Communities (EEC) are listed as occurring within the Karuah Manning CMA and these are:

- Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South East Corner Bioregions;
- Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions;
- Hunter Lowland Redgum Forest in the Sydney Basin and NSW North Coast Bioregions;
- Lowland Rainforest on Floodplain in the New South Wales North Coast Bioregion;
- Littoral Rainforest in the NSW North Coast, Sydney Basin and South East Corner Bioregions;
- Lower Hunter Spotted Gum - Ironbark Forest in the Sydney Basin Bioregion;
- Lowland Rainforest on Floodplain in the New South Wales North Coast Bioregion;
- River-Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions;
- Sub-tropical Coastal Floodplain Forest of the NSW North Coast bioregion;
- Swamp oak floodplain forest of the NSW North Coast, Sydney Basin and South East Corner bioregions;
- Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions; and
- Sydney Freshwater Wetlands in the Sydney Basin bioregion.

The proposed Waukivory pilot well sites are highly modified with the majority of the area comprising paddocks and consequently none of the EECs listed above occur across the survey area.

Species

A total of 63 threatened species listed under the TSC Act have been recorded within the locality consisting of ten species of plant, one reptile, four amphibians, 25 birds and 23 mammals and these are listed at Appendix A. The survey area lacks the complexity required to provide habitat for a range of threatened species as pasturelands generally have few refuge areas or foraging resources, especially for mammals and reptiles. The Gloucester and Avon Rivers may provide refuge and some foraging habitat for some species (e.g. Glossy Black-cockatoo). However, these areas would not be altered as a consequence of this proposal. Road reserves along access roads may provide nesting and foraging habitat for the Grey-crowned Babbler (*Pomatostomus temporalis temporalis*) which is listed as vulnerable under the TSC Act. Similarly, the Grass Owl (*Tyto capensis*) may occasionally forage across the study area as its favoured habitat is tall grass, including grass tussocks in swampy areas, grassy plains, swampy heath, and cane grass, or sedges on flood plains.

Table 2 Threatened species for which habitat occurs locally

Species	Conservation Status	Habitat	Likelihood of occurrence on site
Grey-crowned Babbler *Pomatostomus temporalis temporalis*	V-TSC	Open woodland, particularly those with intact understorey.	Known to occur at the northern end of the Tiedmans block and is likely to occur in other nearby woodland areas.
Grass Owl *Tyto capensis*	V-TSC	Tall grass, including grass tussocks in swampy areas, grassy plains, swampy heath, and cane grass, or sedges on flood plains.	Cleared paddocks. Unlikely-but may occasionally forage across wetter paddock areas.
Note: TSC = NSW *Threatened Species Conservation Act 1995*. EPBC = Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. V = Vulnerable, E = Endangered.			

3.6 Corridors and Connectivity

The proposed pilot wells are situated in an agricultural landscape and most of the adjacent lands have been cleared with only isolated pockets of remnant bushland remaining within the broad valley area around Gloucester. The Gloucester River and Avon River and unnamed tributaries would provide the strongest linkages along the valley floor. This project is unlikely to affect movement corridors and connectivity for any species of plant or fauna within the locality as impacts are confined to small areas within agricultural paddocks.

3.7 SEPP 44 - Koala Habitat Protection

An assessment under *State Environment Planning Policy No. 44 – Koala Habitat Protection* (SEPP 44) is required as the Gloucester LGA is listed under Schedule 1 of SEPP 44. This SEPP requires the identification and protection of core koala habitat within the LGA. Core koala habitat means an area of land with a resident population of koalas, evidenced by attributes such as breeding females (i.e. females with young) and recent sightings of and historical records of a population. Potential koala habitat means areas of native vegetation where the trees of the types listed in Schedule 2 of the Act, constitute at least 15% of the total number of trees in the upper or lower strata of the tree component. The proposed pilot well sites could not be considered core koala habitat or potential koala habitat as the proposed route lacks trees and in particular those species listed under Schedule 2 of this SEPP. Consequently no further provisions of SEPP 44 need apply to this application.

4 IMPACT ASSESSMENT

There are a number of disturbances that would be associated with the proposed works and these are listed in Table 3.

Table 3 Disturbances associated with the proposal

Proposal Stage	Disturbance
Site preparation	Clearance of existing groundcover and topsoil (to be stored for site rehabilitation).
	Import of gravel and erection of site fence around an area of up to 100 m x 100 m for the proposed well sites.
	Import of gravel and erection of site fence around an area of up to 50 m x 30 m for the water monitoring bore site.
Preparation of access tracks	Grading and improvement of access tracks for heavy vehicle access maximum 4m disturbance width. Existing bridge crossings of the Gloucester and Avon Rivers would not be altered.
Borehole drilling	Movement of vehicles to and from the established drill pad.
	Operational noise of drill rig and associated activities.

As a consequence, a number of direct and indirect impacts associated with construction and operation of the proposal have the potential to occur and these are discussed below.

4.1 Direct Impacts

4.1.1 Vegetation Clearance

The site is characterised by cleared land which has been used for grazing of stock over a number of years. A key aim of the proposal has been to locate the pilot wells and associated infrastructure in such a way as to avoid the removal of any trees and shrubs and this has been achieved. As the works are situated within paddocks, the majority of vegetation cleared would be agricultural pasture species and pasture weeds.

4.1.2 Loss of Fauna Habitat

Some habitat for grazing species, such as the Eastern Grey Kangaroo, would be temporarily lost from the site. These areas will be reinstated to their current condition through reseeding of pasture grasses and hence impacts would be temporary and minor. The proposal has been designed to avoid the removal of trees and there are not expected to be any additional direct losses of fauna habitat.

4.2 Indirect Impacts

4.2.1 Disturbance of fauna

Disturbance of fauna during construction could occur through an increase in noise and activity levels across the site, including an increase in traffic. Disturbance of fauna can result in changes to the behaviour and patterns of usage of resources by certain fauna species and / or increases in roadkill. As the majority of construction activities would be within the highly modified paddock areas of the site it is anticipated that this proposal would provide few risks to fauna.

4.2.2 Runoff and Sedimentation

There is the potential for impacts on drainage lines, down slope areas and the Gloucester and Avon Rivers during and following construction from run-off and sedimentation through earthworks and the removal of pasture. Provided stringent stormwater and sediment trapping systems are implemented and that revegetation of the area is undertaken as soon as is practical after construction, then indirect impacts are not anticipated. It is recommended that works not be undertaken during times of high rainfall and preferably during the drier months of the year, i.e. June to September (refer to Table 1).

4.3 Threatening Processes

It is unlikely that any key threatening processes listed under the TSC Act or EPBC Act would be exacerbated by this proposal as the pilot well sites and access ways have been located to avoid areas of native vegetation and riparian or seepage areas and no native vegetation would be cleared or important natural drainage patterns altered.

4.4 Priority Actions for Gloucester Shire Council LGA

There are 90 priority actions identified as being 'High priority' in the Gloucester Shire Council LGA and these include actions which apply to 31 threatened species, populations and communities, and one key threatening process. None of the actions of this proposal are inconsistent with any of the strategies or actions identified for this area.

4.5 NSW *Environmental Planning and Assessment Act 1979*

Two threatened species may potentially be impacted by this proposal and therefore Assessments of Significance as required under Part 5 of the EP&A Act, have been undertaken as a precautionary measure. These species are:

- Grey-crowned Babbler (*Pomatostomus temporalis temporalis*);and
- Grass Owl (*Tyto capensis*).

The Assessments of Significance for these species are provided at Appendix B.

It was concluded that this proposal would not impact on any known breeding habitat for these species and it is unlikely to have a significant impact on foraging resources and that with the implementation of stringent management measures it is unlikely that any of these species would be significantly impacted by this proposal and therefore a Species Impact Statement is not necessary.

4.6 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

The Waukivory sites and access tracks support very limited habitat for native fauna and flora as it is highly modified through clearing and agricultural land uses and it is unlikely that that any matters of NES would be significantly impacted by this proposal. It is considered that this proposal is unlikely to be considered a controlled action under the EPBC Act.

4.7 Cumulative Impacts

Cumulative impacts are those that add to the deterioration of the ecological values of a site or locality and generally occur when remaining native vegetation is removed or altered, fauna habitat is removed or altered and / or the natural hydrology of the area is altered. There are unlikely to be cumulative impacts associated with this proposal as native vegetation would not be removed, fauna habitat would not be altered and with stringent management measures the hydrology of the site would not be changed and any impacts would be minor and temporary.

5 RECOMMENDATIONS

A number of recommendations and management measures are available and should be implemented to mitigate and ameliorate potential impacts within the locality. Central to these measures should be the preparation and implementation of a Construction Environmental Management Plan and Sediment and Erosion Control Plan.

5.1 Mitigation Measures

A number of mitigation measures are recommended to protect adjacent biodiversity.

5.1.1 Performance Objectives

- To minimise impacts on remaining biodiversity values of the well sites; and
- Protect biodiversity values across the locality.

5.1.2 Goals

Goals for the proposed works should be to:

- Minimise the amount of vegetation to be removed;
- Protect the remaining vegetation and fauna habitat;
- Ensure that erosion of the works areas does not occur and that sedimentation of adjacent areas is avoided; and
- Ensure that impacted areas are protected from erosion and weed invasion and restored to their current levels at the completion of the drilling operations.

5.1.3 Recommendations

Mitigation measures should include:

- Construction works be undertaken during drier periods;
- Preparation and implementation of a Construction Environmental Management Plan for the work on site which includes:
    - On site environmental management to advise machinery operators and other on-site personal on ways of minimising ecological impacts;
    - Fencing of the areas where work is being carried out to ensure that machinery remains in the designated works zone and to contain the area of disturbance;
    - Measures to control the number of vehicles entering the site(s)
    - Measures to control and strictly limit the speed of vehicles on the site to reduce the risk of fauna injuries;
    - Fencing the drilling sites with temporary stock-proof fencing and bunded where appropriate;

- Measures and requirements to ensure all drilling fluid is contained on site. No discharge of drilling fluid to waterways, aquatic and riparian environments would be permitted without suitable licences or approvals;
- Measures to control weeds across all sites would be implemented;
- Ongoing monitoring and, if necessary, restoration maintenance would be undertaken until grass cover has re-established;
- Rubbish should be collected and removed off site to prevent it attracting pests, entering waterways and causing harm to fauna;
- No chemicals, fuels and / or wastes should be stored within or near any natural or stormwater drainage lines. All such substances are to be contained in sealed vessels of appropriate volumes and, where necessary, stored within bunded areas;

- Preparation and implementation of an Erosion and Sediment Control Management Plan prepared for the proposed redevelopment which includes:
  - Installation of sediment fences to prevent stormwater runoff and sediment entering the adjacent drainage lines and rivers;
  - Stockpiling of soil that may contain seeds of exotic species away from the creeks, drainage lines and other areas of native vegetation to prevent transportation to adjacent areas during rainfall or wind events; and
  - Measures to ensure that erosion and movement of sediments down slope do not occur during construction and these should include protection of bare ground with the use of jute mats or similar, weed control and revegetation of disturbed areas with pasture species.

6 CONCLUSIONS

The proposal would avoid the removal of native vegetation communities, and trees and shrubs, as the proposed well sites and access tracks would be constructed in agricultural paddocks which have been cleared and used for cropping and grazing over many years. It is considered that the minor and temporary nature of disturbance at the proposed well sites and along access tracks means that any impacts on flora and fauna are likely to be temporary and minor and could be managed to protect current values.

Assessments under the NSW EP&A Act, including those species, populations and communities listed under the TSC Act concluded that significant impacts are unlikely and that a Species Impact Statement is not required. Similarly, it was concluded that matters of NES listed under the Commonwealth EPBC Act would not be significantly impacted and consequently is unlikely to be considered a controlled action under the EPBC Act.

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APPENDIX A

THREATENED SPECIES RECORDED WITHIN THE LOCALITY OF PEL 285

Threatened Species recorded within the locality of PEL 285

Species / Community	Conservation Status	Habitat	Likelihood of occurrence on site
FLORA			
Asperula asthenes	V-TSC V-EPBC	Damp sites along river beds.	Mostly cleared paddocks. Unlikely-no habitat.
Angophora inopina Charmhaven Apple	V-TSC V-EPBC	Occurs must frequently in woodland / forest, wet heath, sedge woodland.	Mostly cleared paddocks. Unlikely-no habitat.
Callistemon linearifolius	V-TSC	Grows in dry sclerophyll forest on the coast and adjacent ranges.	Mostly cleared paddocks. Unlikely-no habitat.
Cynanchum elegans	E-TSC E-EPBC	Most frequently on the edge of dry rainforest vegetation.	Mostly cleared paddocks. Unlikely-no habitat.
Slaty Red Gum *Eucalyptus glaucina*	V-TSC V-EPBC	Grows in grassy woodland and dry eucalypt forest	Mostly cleared paddocks. Unlikely-no habitat.
Grevillea guthrieana	E-TSC E-EPBC	Grows along creeks and cliff lines in eucalypt forest, on granitic or sedimentary soil.	Mostly cleared paddocks. Unlikely-no habitat.
Small-flower Grevillea *Grevillea parviflora* ssp. *parviflora*	V-TSC V-EPBC	Occurs in a range of vegetation types from heath and shrubby woodland to open forest.	Mostly cleared paddocks. Unlikely.
Melaleuca groveana	V-TSC	Grows in woodland, heath and shrubland, often in exposed sites, at high elevations.	Mostly cleared paddocks. Unlikely-no habitat.
Brush Cherry *Syzygium paniculatum*	V-TSC V-EPBC	Occurs on gravels, sands, silts and clays in rainforests.	Mostly cleared paddocks. Unlikely-no habitat.
Tetratheca juncea	V-TSC V-EPBC	Mainly in low open forest / woodland with a mixed shrub understorey and grassy groundcover.	Mostly cleared paddocks. Unlikely-no habitat.

Species / Community	Conservation Status	Habitat	Likelihood of occurrence on site
FAUNA			
Stephens' Banded Snake *Hoplocephalus stephensi*	V - TSC	Rainforest and eucalypt forests and rocky areas.	Mostly cleared paddocks. Unlikely-no habitat.
Wallum Froglet *Crinia tinnula*	V - TSC	Paperbark swamps and sedge swamps of the coastal 'wallum' country.	Mostly cleared paddocks. Unlikely-no habitat.
Green & Golden Bell Frog *Litoria aurea*	E-TSC V-EPBC	Marshes, dams & stream-sides particularly those containing *Typha* or *Eleocharis*.	Cleared paddocks. Unlikely-no habitat..
Booroolong Frog *Litoria booroolongensis*	E-EPBC	Along the western-flowing streams of the Great Dividing Range.	Mostly cleared paddocks. Unlikely-no habitat.
Davies' Tree Frog *Litoria daviesae*	V - TSC	Permanently flowing streams above 400 m elevation.	Mostly cleared paddocks. Unlikely-no habitat.
Black-necked Stork *Ephippiorhynchus asiaticus*	E - TSC	Permanent freshwater wetlands. Feeds on fish, frogs, eels, turtles, crabs and snakes.	Mostly cleared paddocks. Unlikely-no habitat.
Powerful Owl *Ninox strenua*	V - TSC	Large tracts of forest from, from woodland and open sclerophyll forest to tall open wet forest and rainforest.	Mostly cleared paddocks. Unlikely-no habitat.
Grey-crowned Babbler *Pomatostomus temporalis temporalis*	V - TSC	Open woodlands.	May occur along vegetation bordering access tracks or along Gloucester and Avon Rivers.
Speckled Warbler *Pyrrholaemus sagittatus*	V - TSC	Eucalypt communities with grassy understorey.	Mostly cleared paddocks. Unlikely-no habitat.
Sooty Owl *Tyto tenebricosa*	V - TSC	Rainforest and moist Eucalypt forests.	Mostly cleared paddocks. Unlikely-no habitat.
Masked Owl *Tyto novaehollandiae*	V - TSC	Lives in dry eucalypt forests and woodlands.	Mostly cleared paddocks. Unlikely-no habitat.
Glossy Black-Cockatoo *Calyptorhynchus lathami*	V-TSC E-EPBC	Open woodlands with stands of She-oak.	Mostly cleared paddocks. Some foraging habitat along creeklines.

Species / Community	Conservation Status	Habitat	Likelihood of occurrence on site
Magpie Goose *Anseranas semipalmata*	V - TSC	Mainly found in shallow wetlands with dense growth of rushes or sedges.	Mostly cleared paddocks. Unlikely-no habitat.
Australasian Bittern *Botaurus poiciloptilus*	V-TSC	Emergent vegetation in freshwater & brackish wetlands.	Cleared paddocks. Unlikely-no emergent vegetation.
Bush Stone-curlew *Burhinus grallarius*	E-TSC	Open forests & woodlands with sparse grassy ground layer & fallen timber.	Mostly cleared paddocks. Unlikely-no habitat.
Brown Treecreeper *Climacteris picumnus*	V-TSC	Eucalypt forests & woodlands of inland plains and slopes of the Great Dividing Range. Less commonly found on coastal plains and ranges.	Mostly cleared paddocks. Unlikely-too coastal.
Barred Cuckoo-shrike *Coracina lineata*	V-TSC	Rainforest, eucalypt forests and woodlands, clearings in secondary growth, swamp woodlands and timber along watercourses.	Mostly cleared paddocks. Unlikely-no habitat.
Emu *Dromaius novaehollandiae*	EP-TSC	Open forest, woodland, coastal heath, coastal dunes, wetland areas, tea tree plantations and open farmland, and occasionally in littoral rainforest between Evans Head and Red Rock.	Unlikely-not known from area.
Comb-crested Jacana *Irediparra gallinacea*	V-TSC	Inhabits permanent wetlands with a good surface cover of floating vegetation, especially water-lilies.	Mostly cleared paddocks. Unlikely-no habitat.
Black Bittern *Ixobrychus flavicollis*	V-TSC	Forested, freshwater & saline wetlands. Breeding along watercourses.	Mostly cleared paddocks. Unlikely-no habitat.
Hooded Robin *Melanodryas cucullata*	V-TSC	Structurally diverse lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee.	Unlikely-no habitat.
Black-chinned Honeyeater *Melithreptus gularis gularis*	V-TSC	Upper levels of drier open forests or woodlands dominated by box and ironbark eucalypts.	Unlikely-no habitat.
Swift Parrot *Lathamus discolor*	E-TSC E-EPBC	Occur in areas where eucalypts are flowering profusely or where there are abundant lerp infestations.	Cleared paddocks. Unlikely-no habitat.
Turquoise Parrot *Neophema pulchella*	V-TSC	Lives on edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland.	Cleared paddocks. Unlikely-no habitat.
Barking Owl *Ninox connivens*	V-TSC	Breeding HBT >20 cm diam. Forage woodlands, grassy woodlands, forests & into grasslands 250 m.	Unlikely – no substantial woodland areas within 250 m of sites.

Species / Community	Conservation Status	Habitat	Likelihood of occurrence on site
Powerful Owl *Ninox strenua*	V-TSC	Inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest.	Cleared paddocks. Unlikely-no habitat.
Regent Honeyeater *Xanthomyza phrygia*	E-TSC E-EPBC	Inhabits dry open forest and woodland, particularly Box-Ironbark woodland, and riparian forests of River Sheoak.	Cleared paddocks. Unlikely-no habitat.
Wompoo Fruit-Dove *Ptilinopus magnificus*	V-TSC	Occurs in, or near rainforest, low elevation moist eucalypt forest and brush box forests.	Cleared paddocks. Unlikely-no habitat.
Rose-crowned Fruit-Dove *Ptilinopus regina*	V-TSC	Sub-tropical and dry rainforest.	Cleared paddocks. Unlikely-no habitat.
Superb Fruit-Dove *Ptilinopus superbus*	V-TSC	Rainforest and similar closed forests.	Cleared paddocks. Unlikely-no habitat.
Grass Owl *Tyto capensis*	V-TSC	Tall grass, including grass tussocks in swampy areas, grassy plains, swampy heath, and cane grass, or sedges on flood plains.	Cleared paddocks. Unlikely-but may occasionally forage across wetter paddock areas.
Eastern Cave Bat *Vespadelus troughtoni*	V - TSC	Cave-roosting species found in dry open forest and woodland, near cliffs or rocky overhangs.	Cleared paddocks. Unlikely-no habitat.
Eastern False Pipistrelle *Falsistrellus tasmaniensis*	V - TSC	Prefers moist habitats with trees >20 m. Roosts in HBT or under bark or in buildings.	Cleared paddocks. Unlikely-no habitat.
Golden-tipped Bat *Kerivoula papuensis*	V - TSC	Rainforest and adjacent sclerophylla forest.	Cleared paddocks. Unlikely-no habitat.
Large-eared Pied Bat *Chalinolobus dwyeri*	V-TSC V-EPBC	Roosts in caves, derelict mines frequenting low to mid elevation dry open forest and woodland close to these features.	Cleared paddocks. Unlikely-no habitat.
Little Bentwing-bat *Miniopterus australis*	V - TSC	Moist Eucalypt forests whilst roosting in caves and man-made structures	Cleared paddocks. Unlikely-no habitat.
Eastern Bent-wing Bat *Miniopterus schreibersii oceanensis*	V - TSC	Roosting – caves, derelict mines, storm-water tunnels, buildings. Foraging - forested areas.	Cleared paddocks. Unlikely-no habitat.
Eastern Freetail-bat *Mormopterus norfolkensis*	V - TSC	Dry sclerophylla forest & woodland. Roosts - hollows & under bark or man-made structures.	Cleared paddocks. Unlikely-no habitat.

Species / Community	Conservation Status	Habitat	Likelihood of occurrence on site
Large-footed Myotis *Myotis adversus*	V - TSC	Forages over streams and pools catching insects and small fish by raking their feet across the water surface	Cleared paddocks. Unlikely-no habitat. May forage along creeklines.
Greater Broad-nosed Bat *Scoteanax rueppellii*	V - TSC	Woodland, moist and dry eucalypt forest, and rainforest but prefers tall wet forest.	Cleared paddocks. Unlikely-no habitat.
Grey-headed Flying-fox *Pteropus poliocephalus*	V-TSC V-EPBC	Subtropical & temperate rainforests, tall sclerophylla forests & woodlands, heaths & swamps.	Mostly cleared paddocks. Unlikely-no habitat.
Spotted-tailed Quoll *Dasyurus maculatus*	V - TSC	Forests and heathlands.	Mostly cleared paddocks. Unlikely-no habitat.
Koala *Phascolarctos cinereus*	V - TSC	Eucalypt forests and woodlands.	Cleared paddocks. No habitat would be altered.
Squirrel Glider *Petaurus norfolcensis*	V - TSC	Eucalypt forests and woodlands.	Mostly cleared paddocks. Unlikely-no habitat.
Rufous Bettong *Aepyprymnus rufescens*	V - TSC	Tall, moist eucalypt forest to open woodland, with a tussock grass understorey.	Mostly cleared paddocks. Unlikely-no habitat.
Eastern Pygmy-possum *Cercartetus nanus*	V - TSC	Rainforest, sclerophylla forest & woodland to heath – but heath & woodland preferred. .	Mostly cleared paddocks. Unlikely-no habitat. Known from Tiedman block 3 km south of the sites.
Parma Wallaby *Macropus parma*	V - TSC	Moist eucalypt forest with thick, shrubby understorey.	Mostly cleared paddocks. Unlikely-no habitat.
Yellow-bellied Glider *Petaurus australis*	V - TSC	Occur in tall mature eucalypt forest generally in areas with high rainfall.	Mostly cleared paddocks. Unlikely-no habitat.
Squirrel Glider *Petaurus norfolcensis*	V - TSC	Inhabits mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest with heath understorey in coastal areas.	Mostly cleared paddocks. Unlikely-no habitat.
Brush-tailed Rock-wallaby *Petrogale penicillata*	E-TSC V-EPBC	Rocky escarpments, outcrops, steep slopes or cliffs – especially those with caves, ledges or overhangs & shrub cover.	Mostly cleared paddocks. Unlikely-no habitat.
Brush-tailed Phascogale *Phascogale tapoatafa*	V - TSC	Dry sclerophylla open forest with sparse groundcover. Also heath, swamps, rainforest & wet sclerophylla forest.	Mostly cleared paddocks. Unlikely-no habitat. Known from Tiedman block 3 km south of the sites.

Species / Community	Conservation Status	Habitat	Likelihood of occurrence on site
Common Planigale *Planigale maculata*	V - TSC	Rainforest, eucalypt forest, heathland, marshland, grassland and rocky areas.	Mostly cleared paddocks. Unlikely-no habitat.
Long-nosed Potoroo *Potorous tridactylus*	V-TSC V-EPBC	Inhabits coastal heaths and dry and wet sclerophyll forests.	Mostly cleared paddocks. Unlikely-no habitat.
Red-legged Pademelon *Thylogale stigmatica*	V - TSC	Forest with dense understorey and ground cover.	Mostly cleared paddocks. Unlikely-no habitat.
Note: TSC = NSW *Threatened Species Conservation Act 1995*. EPBC = Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. V = Vulnerable, E = Endangered, Mig = Migratory, EEC = Endangered Ecological Community, EP = Endangered Population.			

APPENDIX B

ASSESSMENT OF SIGNIFICANCE UNDER THE EP&A ACT

APPENDIX B

Assessment of Significance

Background

As required under the Section 5 of the *Environmental Planning & Assessment Act 1979* (EP&A Act), Assessments of Significance were undertaken to determine the significance of impacts of the proposal on threatened species listed on Schedules of the NSW *Threatened Species Conservation Act 1995* (TSC Act). A number of threatened species were listed as occurring within the locality but habitat for only a very small percentage of these occur at the site due to the highly modified nature of the proposal area. Therefore, Assessments of Significance have been undertaken only for those species for which potential habitat occurs either across the study area or within the near locality. Those species addressed are:

- Grey-crowned Babbler (*Pomatostomus temporalis temporalis*); and
- Grass Owl (*Tyto capensis*).

Grey-crowned Babbler

Grey-crowned Babbler (GCB) (*Pomatostomus temporalis temporalis*) (eastern subspecies) is listed as Vulnerable under the TSC Act. This species is found throughout large parts of northern Australia and in south-eastern Australia. In NSW, the eastern subspecies occurs on the western slopes of the Great Dividing Range, and on the western plains reaching as far as Louth and Hay. It also occurs in woodlands in the Hunter Valley and in several locations on the north coast of NSW. It may be extinct in the southern, central and New England tablelands. This species is a laborious flyer so birds prefer to hop to the top of a tree and glide down to the next one. Birds are generally unable to cross large open areas. GCB feed on invertebrates, either by foraging on the trunks and branches of eucalypts and other woodland trees or on the ground, digging and probing amongst litter and tussock grasses. Across their range, breeding can occur throughout the year. However, within NSW, almost all observations of breeding activity have been from July to December (Higgins & Peters 2002).

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

The proposal would not directly impact on any known breeding or foraging areas of this species as all works would be undertaken outside of woodland areas. However, the GCB is known extensively from the Gloucester Shire Council LGA and it is possible that this species would occur in nearby woodland or trees. No potential habitat would be removed or altered for this proposal. The Grey-crowned Babbler appears to be relatively disturbance tolerant as this bird has been observed foraging and nesting in gardens, parks and small remnants, along fence boundaries and man-made structures near major roads (Parsons Brinckerhoff 2005). However,

this species is a laborious flyer and is known to feed on the ground placing it at risk of being struck by construction traffic which would increase temporarily during drilling operations. To avoid bird strike stringent traffic management should be implemented and traffic flow, vehicle speed and vehicle numbers entering and leaving the sites should be controlled.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Not an endangered population.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

I. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

II. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not an endangered ecological community.

d) in relation to the habitat of a threatened species, population or ecological community:

I. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

II. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

III. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The proposed action would not result in habitat being removed or altered and habitat would not become fragmented or isolated from other areas. All proposed works are to be undertaken within pasture improved paddocks.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared for this species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

Although the Grey-crowned Babbler Retention Plan – Gloucester Shire Council (Parsons Brinckerhoff 2005) deals with potential family groups outside of the study area, several of the management measures are applicable to management of the GCB within the study area and these are:

- Habitat protection and maintenance: to maintain and protect woodland remnants that form part of a corridor network and other habitats that have potential for regeneration for the longer term benefit of the species; and
- Road and traffic management: prevent / reduce the incidence of collision of GCB with motor vehicles through the implementation of go slow areas and increasing public awareness through signage.

This proposal would not remove or modify current habitat for this species and a Construction Environment Management Plan would ensure that vegetated areas are protected, through fencing where appropriate and education of personnel to raise awareness of the importance of this species. Stringent traffic management would also be implemented to ensure that the incidence of collision does not increase due to the increase of traffic and it will address such matters as traffic numbers, traffic speed and traffic flow.

DEC have also identified five strategies to help recover the species (DEC 2005d) and these include community and land-holder awareness, development and implementation of protocols and guidelines, habitat rehabilitation / restoration, research and survey / mapping and habitat assessment. None of the actions of this proposal are inconsistent with any of the strategies or actions outlined in the PAS.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

It is unlikely that any key threatening processes listed under the TSC Act would be exacerbated by this proposal as the proposed work sites have been located to avoid areas of native vegetation and consequently no native vegetation would be cleared as a consequence of this proposal. Threats identified by DEC (2005) include clearing of woodland remnants, heavy grazing and removal of woody debris and nest predation by bird species. None of these threats would be increased as a consequence of this proposal.

Conclusion

No changes to GCB habitat would occur through removal or modification as all proposed works are outside of woodland and remnant vegetation and potential disturbance through an increase in traffic movement would be managed through stringent traffic controls. Therefore, it is considered unlikely that this proposal would have significant impacts on this species.

Grass Owl

The Grass Owl (*Tyto capensis*) is listed as Vulnerable under the TSC Act. Grass Owls have been recorded occasionally in all mainland states of Australia but appear to be more commonly recorded in northern and north-eastern Australia. In NSW they are more likely to be found in the north-east. Grass Owl numbers often increase when rodent numbers increase. They are found in areas of tall grass, including grass tussocks in swampy areas, grassy plains, swampy heath, and cane grass, or sedges on flood plains. They rest by day in a 'form' - a trampled platform in a large tussock or other heavy growth. They also nest in trodden-down grass (DECC 2005).

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

Disturbance to grassed and tussocky areas within paddocks would be minimal and temporary. Substantial areas of foraging and nesting habitat would remain within the locality and consequently it is unlikely that this species would be adversely affected or placed at the risk of extinction as a consequence of this proposal.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

Not an endangered population.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

I. Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

II. Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

Not an endangered ecological community.

d) in relation to the habitat of a threatened species, population or ecological community:

I. The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

II. Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

III. The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

The proposal would only temporarily disrupt potential habitat for this species. Disturbance would be minimal and the borehole sites would be revegetated with pasture species as soon as practicable after completion of the drilling operations.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

Critical habitat has not been declared for this species.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There has not been a recovery plan or threat abatement plan prepared for the Grass Owl. Five PAS have been prepared for the Grass Owl and this proposal would not be inconsistent with any of the objectives of these PAS (DEC 2005a).

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

It is unlikely that any key threatening processes listed under the TSC Act would be exacerbated by this proposal as the proposed work sites have been located to avoid areas of native vegetation and consequently no native vegetation would be cleared as a consequence of this proposal. However, threatening processes listed by DECC (2005) for the Grass Owl include, loss of suitable habitat due to grazing, agriculture and development and disturbance and habitat degradation by stock. Disturbance to any potential habitat for this species would be minimal and temporary as the sites would be returned to their current condition at the completion of testing.

Conclusion

It is considered unlikely that this proposal would result in significant impacts on this species as disturbance to any potential habitat would be minimal and temporary as the sites would be returned to their current condition at the completion of testing.

Appendix J

Ecological assessment of water pipeline

Addendum

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14 August 2013

To Toni Laurie
From Cassandra Thompson

Subject Ecological assessment of water pipeline option for the Waukivory pilot testing project

Dear Toni,

1 Introduction

1.1 Background

The Gloucester Gas Project (GGP) Petroleum Exploration Licence (PEL) 285 is a coal seam gas (CSG) exploration project 100 km north of Newcastle. AGL Upstream Investments Pty Ltd (AGL), as the sole owner and operator of this PEL, is obliged to appraise and evaluate the quantity and quality of the natural gas resource. As part of the exploration, AGL proposes pilot testing of four wells on two properties in PEL 267; 20 Grantham Road (Lot 11 DP 841445) and 197 Fairbairns Road (Lot 251 DP 785579), Forbesdale (AGL refers to the project as 'Waukivory'). The pilot wells will identify potential CSG resources by testing the composition, flow rate and volume of gas in target coal seams.

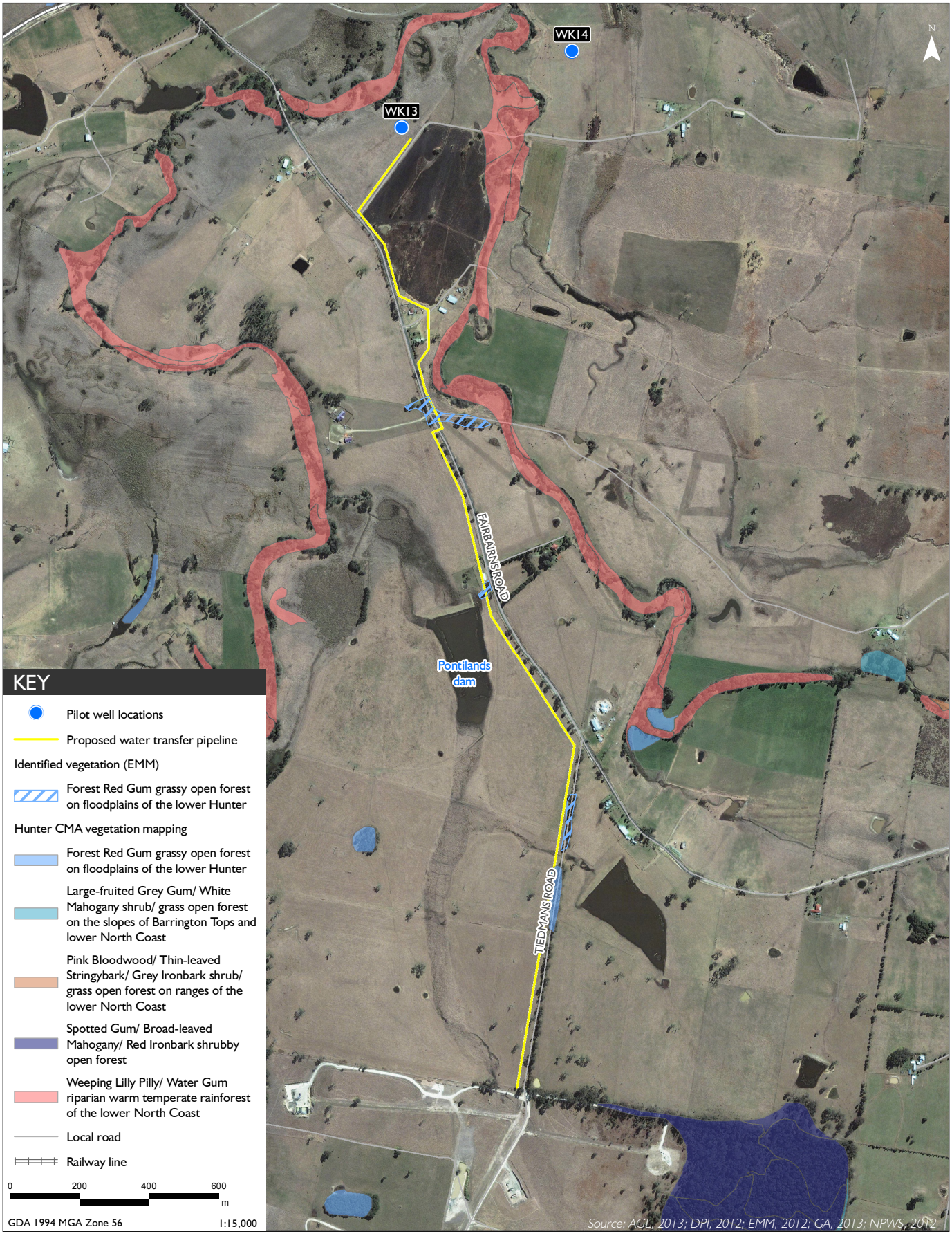
EMGA Mitchell McLennan Pty Ltd (EMM) was engaged by the proponent, AGL, to prepare this review of environmental factors (REF) for pilot testing. It will be lodged with the Department of Trade and Investment, Regional Infrastructure and Services – Division of Resources and Energy (DTIRIS-DRE) for assessment and approval under Part 5 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). An ecological assessment of the proposed exploration wells and supporting infrastructure (ie access tracks) was conducted by Alison Hunt and Associates in 2010 to support the REF.

As part of the project, AGL are considering two options for water transfer for the Waukivory pilot testing project. The first option was assessed as part of the REF. However, the second has not been assessed for ecological values. This addendum assesses the ecological impacts of the second option, which would involve installation of an underground water pipeline between WK 13 and the AGL water management facility on the Tiedman property (Figure 1). The proposed pipeline would traverse the properties presented in Table 1. These properties are near Forbesdale in the Gloucester LGA.

Table 1 Location of site

Site	Address	Lot	DP	Coordinates
Pipeline	237 Fairbairns Road, Forbesdale.	26	1112877	Linear
Pipeline	306 Fairbairns Road, Forbesdale.	2	1040412	Linear
Pipeline	100 Tiedmans Road Forbesdale	85	979859	Linear
Pipeline	100 Tiedmans Road, Forbesdale	84	979859	Linear
Pipeline	Road reserve	1	196054	Linear

The ecological assessment by Alison Hunt and Associates has considered the potential impacts of the project on ecological values and commits to measures to minimise these. This addendum aims to provide the results of the additional assessment of the water pipeline between the Tiedman property and WK13 done by EMM.



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Mapped and identified vegetation types
Waukivory pilot testing
Proposed water transfer pipeline
Figure 1

2 Method

Updated searches of the OEH *Atlas of NSW Wildlife* and SPRAT database were undertaken for the Waukivory drilling application area, to determine if additional species had been listed or recorded in the region that required targeted survey and assessment.

A site survey was conducted on 9 August 2013. The entire route of the water pipeline was traversed on foot and ecological features including fauna habitat, vegetation boundaries and any areas of ecological sensitivity were mapped using a hand-held GPS. A corridor 200 m wide was surveyed to allow flexibility to move the alignment to avoid any identified sensitive features.

The potential impacts of the water pipeline route were assessed and added to the REF. This included an assessment of the likelihood for threatened species to occur in the alignment and consideration of the ecological matters required under the EP&A Act. Where the pipeline was considered likely to impact on threatened biodiversity (threatened species, populations or communities listed under the TSC Act or EPBC Act), an assessment was undertaken to determine the significance of any potential impacts and if additional surveys or assessment was required, included as an appendix to the REF.

3 Results

3.1 Vegetation

Remnant vegetation comprises large paddock trees (predominantly Forest Red Gum (*Eucalyptus tereticornis*), Narrow-leaf Ironbark (*E. crebra*), Rough-barked Apple (*Angophora floribunda*) and Grey Box (*E. moluccana*), which are scattered across the landscape, particularly along the road reserves and associated with the Avon River and Waukivory Creek.

The vegetation in the locality of the pipeline option has been mapped as part of the Greater Hunter Native Vegetation Mapping Project. The mapping indicates that the study area contains patches of Weeping Lilly Pilly/Water Gum riparian warm temperate rainforest of the lower North Coast along the Avon River and Waukivory Creek with smaller remnants of Forest Red Gum grassy open forest on floodplains of the lower Hunter adjacent to these areas and in isolated stands surrounded by agriculture.

The proposed water pipeline route only traverses a small area of Forest Red Gum grassy open forest which is associated with the vegetation along the road reserve of Tiedman's Lane, however other woodland remnants in the area which have not been mapped, are considered likely to be characteristic of this community also (Figure 1). The vegetation in these patches is dominated by Forest Red Gum with occasional interspersed Grey Box and Rough-barked Apple.

Some areas also contain Narrow-leaf Ironbark, particularly along Tiedman's Lane. The trees often occur above a disturbed understorey which has been ploughed and is dominated by weeds including Purpletop (*Verbena bonariensis*), Fireweed (*Senecio madagascariensis)*, Scotch Thistle (*Onopordum acanthium*) and Whisky Grass (*Andropogon virginicus*). Disturbance tolerant and pasture species include Kikuyu (*Kikuyu spp*.), White Clover (*Trifolium repens*), Couch (*Cynodon dactylon*) and Paspalum (*Paspalum dilantum*).

Pontilands Dam, adjacent to the proposed water pipeline, contains a significant resource for waterfowl in the locality. The threatened Black-necked Stork (*Ephippiorhynchus asiaticus*) has been recorded previously in this area. The dam contain sedges and reeds, providing sheltering and nesting habitat for common waterbirds including the Purple Swamphen (*Porphyrio porphyrio*), Eurasian Coot (*Fulica atra*) and Grey Teal (*Anas gracilis*), which were recorded in the dam during the site visit. Swampy, low-lying areas containing sedges and the occasional White Feather Honeymyrtle (*Melaleuca decora*) adjacent to the proposed water pipeline also contain significant habitat for waterbirds with the Pacific Heron (*Ardea pacifica*) observed foraging in the swampy area to the south of well 13.

All other parts of the water pipeline route contain disturbed agricultural land which is dominated by gazing tolerant grasses, pasture species and weeds. These areas do not align with any mapped vegetation types.

3.2 Threatened species

There has been 63 TSC Act listed threatened species have been recorded within 10 km of the proposed activity. These comprise ten plant, one reptile, four amphibian 25 bird and 23 mammal species. The water pipeline route will not impact any areas identified as containing important habitat, such as breeding resources, for threatened species.

A habitat assessment table was completed for all species which have the potential to occur in the proposed water pipeline area and its surrounds (see Table 2). The trench will occur adjacent to areas that contain potential habitat for a number of species including the road reserves which provide foraging habitat for the Grey-crowned Babbler (*Pomatostomus temporalis temporalis*), the open paddocks which provide potential foraging habitat for the Grass Owl (*Tyto capensis*) and the dam which provides potential habitat for migratory waterbirds and the Black-necked Stork which has been recorded here previously.

3.3 Threatened ecological communities

One threatened ecological community listed as occurring in the Karuah Manning CMA subregion, was considered to occur in the vicinity of the proposed water pipeline. Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions endangered ecological community (Hunter Lowland Redgum Forest EEC) occurs in the drainage flats and lower slopes of the locality. It corresponds to the areas mapped and identified onsite as remnants of the Forest Red Gum grassy open forest vegetation community (Figure 1). Stands are highly degraded from historical agricultural practices, with few characteristic understorey species remaining including Tall sedge (*Carex apressa*) and Blady Grass (*Imperata cylindrica*) in areas.

3.4 Migratory species

Twelve migratory bird species and their habitats are predicted to occur within 10 km of the site (DSEWPaC, 2012). However, it is unlikely that any migratory bird species will occur at the site due to the lack of suitable habitat. However, the dam adjacent to the proposed water pipeline and other low-lying swampy areas provide potentially suitable habitat for such species. A habitat assessment table was completed for all species which have the potential to occur in the proposed water pipeline area and its surrounds (see Table 2). It was considered that potential habitat for the Cattle Egret, Great Egret and Rainbow Bee-eater occurred.

Table 2 Threatened species recorded within the locality of PEL 285

Species/community	Conservation status		Habitat	Likelihood of occurrence and potential for impacts from the proposed activity
	TSC Act	EPBC Act		
Flora				
Asperula asthenes	V	V	Damp sites along river beds.	Unlikely-no suitable habitat in the proposed pipeline route. None identified during the survey.
Charmhaven Apple *Angophora inopina*	V	V	Occurs most frequently in woodland/forest, wet heath, sedge woodland.	Unlikely-no suitable habitat in the proposed pipeline route. None identified during the survey.
Callistemon linearifolius	V		Grows in dry sclerophyll forest on the coast and adjacent ranges.	Unlikely-no suitable habitat in the proposed pipeline route. None identified during the survey.
Cynanchum elegans	E-TSC E-EPBC		Most frequently on the edge of dry rainforest vegetation.	Unlikely-no suitable habitat in the proposed pipeline route. None identified during the survey.
Slaty Red Gum *Eucalyptus galucina*	V	V	Grows in grassy woodland and dry eucalypt forest.	Unlikely-no suitable habitat in the proposed pipeline route. None identified during the survey.
Grevillea guthrieana	E-TSC E-EPBC		Grows along creeks and cliff lines in eucalypt forest, on granitic or sediment soil.	Unlikely-no suitable habitat in the proposed pipeline route. None identified during the survey.
Small-flower Grevillea *Grevillea parviflora ssp. parvifora*	V	V	Occurs in a range of vegetation types form health and shrubby woodland to open forest.	Unlikely-no suitable habitat in the proposed pipeline route. None identified during the survey.
Melaleuca groveana	V		Grows in woodland, health and shrubland, often in exposed sites, at high elevations.	Unlikely-no suitable habitat in the proposed pipeline route. None identified during the survey.
Brush Cherry *Syzygium paniculatum*	V	V	Occurs on gravels, sands, silts and clays in rainforests.	Unlikely-no suitable habitat in the proposed pipeline route. None identified during the survey.
Tetratheca juncea	V	V	Mainly in low open forest/woodland with a mixed shrub understory and grassy groundcover.	Unlikely-no suitable habitat in the proposed pipeline route. None identified during the survey.
Fauna				

Table 2 Threatened species recorded within the locality of PEL 285

Species/community	Conservation status		Habitat	Likelihood of occurrence and potential for impacts from the proposed activity
	TSC Act	EPBC Act		
Stephen' Banded Snake *Hoplocephalus stephensi*	V		Rainforest and eucalypt forests and rocky areas.	Unlikely-no suitable habitat in the proposed pipeline route.
Wallum Froglet *Crinia tinnula*	V		Paperback swamps and sedge swamps of the coastal 'wallum' country.	Unlikely-no suitable habitat in the proposed pipeline route.
Green & Golden Bell Frog *Litoria aurea*	E	V	Marshes, dams & stream-sides particularly those containing *Typha* or *Eleochairs*.	Unlikely-no suitable habitat in the proposed pipeline route. Potential habitat in the dam nearby, though this will not be impacted.
Booroolong Frog *Litoria booroolongensis*	E		Along the western-flowing streams of the Great Dividing Range.	Unlikely-no suitable habitat in the proposed pipeline route.
Davies' Tree Frog *Litoria daviesae*	V		Permanently flowing streams above 400 m elevation.	Unlikely-no suitable habitat in the proposed pipeline route.
Black-necked Stork *Ephippiorhynchus asiaticus*	E		Permanent freshwater wetlands, Feeds on fish, frogs, eels, turtles, crabs and snakes	Previous record in the dam adjacent to the proposed pipeline route. This species may be indirectly impacted by the project. **Further assessment required[1].**
Powerful Owl *Ninox strenua*	V		Large tracts of forest from, from woodland and open sclerophyll forest to tall open wet forest and rainforest.	Potential habitat in the dam nearby, though this will not be impacted.
Grey-crowned Babbler *Pomatostomus temporalis temporalis*	V		Open woodlands.	Known to occur in roadside vegetation along Tiedman's Lane. This species may be indirectly impacted by the project. **Further assessment required[1].**
Speckled Warbler *Pyrrholaemus sagittatus*	V		Eucalypt communities with grassy understorey.	Unlikely-no suitable habitat in the proposed pipeline route.
Sooty Owl *Tyto tenebricosa*	V		Rainforest and moist Eucalypt forests.	Unlikely-no suitable habitat in the proposed pipeline route.

Table 2 Threatened species recorded within the locality of PEL 285

Species/community	Conservation status		Habitat	Likelihood of occurrence and potential for impacts from the proposed activity
	TSC Act	EPBC Act		
Masked Owl *Tyto novaehollandiae*	V		Lives in dry eucalypt forests and woodlands.	Unlikely-no suitable habitat in the proposed pipeline route.
Glossy Black-Cockatoo *Calyptorhynchus lathami*	V		Open woodlands with stands of She-oak.	Unlikely-no suitable habitat in the proposed pipeline route.
Magpie Goose *Anseranas semipalmata*	V		Mainly found in shallow wetlands with dense growth of rashes or sedges.	Unlikely-no suitable habitat in the proposed pipeline route. Potential habitat in the dam nearby, though this will not be impacted.
Australasian Bittern *Botaurus poiciloptilus*	V		Emergent vegetation in freshwater & brackish wetlands.	Unlikely-no suitable habitat in the proposed pipeline route. Potential habitat in the dam nearby, though this will not be impacted.
Bush Stone-curlew *Burhinis grallarius*	E		Open forests & woodlands with sparse grassy ground layer & fallen timber.	Unlikely-no suitable habitat in the proposed pipeline route.
Brown Treecreeper *Climacteris picumnus*	V		Eucalypt forests & woodlands of inland plains and slopes of the Great Dividing Range. Less commonly found on coastal plains and ranges.	Unlikely-no suitable habitat in the proposed pipeline route.
Barred Cuckoo-shrike *Coracina lineate*	V		Rainforest, eucalypt forests and woodlands, clearings in secondary growth, swamp woodlands and timber along watercourses.	Unlikely-no suitable habitat in the proposed pipeline route.
Emu *Dromaius novaehollandiae*	E (pop)		Open forest, woodland, coastal heath, coastal dunes, wetland areas, tea tree plantations and open farmland, and occasionally in littoral rainforest between Evans Head and Red Rock.	Unlikely-not known from area.
Comb-crested Jacana *Irediparra gallinacean*	V		Inhabits permanent wetlands with a good surface cover of floating vegetation, especially water-lilies.	Unlikely-no suitable habitat in the proposed pipeline route. Potential habitat in the dam nearby, though this will not be impacted.
Black Bittern *Ixobrychus flavicollis*	V		Forested, freshwater & saline wetlands, Breeding along watercourses.	Unlikely-no suitable habitat in the proposed pipeline route. Potential habitat in the dam nearby, though this will not be impacted.
Hooded Robin	V		Structurally diverse lightly wooded country, usually open eucalypt woodland,	Unlikely-no suitable habitat in the proposed pipeline route.

Table 2 Threatened species recorded within the locality of PEL 285

Species/community	Conservation status		Habitat	Likelihood of occurrence and potential for impacts from the proposed activity
	TSC Act	EPBC Act		
Melanodryas cucullata			acacia scrub and mallee.	
Black-chinned Honeyeater *Melithreptus gularis gularis*	V		Upper levels of drier open forests or woodlands dominated by box and ironbark eucalypts.	Unlikely-no suitable habitat in the proposed pipeline route.
Swift Parrot *Lathamus discolour*	E	E	Occur in areas where eucalypts are flowering profusely or where there are abundant lerp infestations.	Unlikely-no suitable habitat in the proposed pipeline route.
Turquoise Parrot *Neophema Pulchella*	V		Lives on edges of eucalypt woodland adjoining clearings, timbered ridges and creeks in farmland.	Unlikely-no suitable habitat in the proposed pipeline route.
Barking Owl *Ninox connivens*	V		Breeding HBT>20 cm diam. Forage woodlands, grassy woodlands, forests & into grasslands 250m.	Unlikely-no suitable habitat in the proposed pipeline route.
Powerful Owl *Nonox strenua*	V		Inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest.	Unlikely-no suitable habitat in the proposed pipeline route.
Regent Honeyeater *Xanthomyza Phrygia*	E	E	Inhabits dry open forest and woodland, particularly Box-Ironbark woodland, and riparian forests of River Sheoak.	Unlikely-no suitable habitat in the proposed pipeline route.
Wompoo Fruit-Dove *Ptilinopus magnificus*	V		Occurs in, or near rainforest, low elevation moist eucalypt forest and brush box forests.	Unlikely-no suitable habitat in the proposed pipeline route.
Rose-crowned Fruit-Dove *Ptilinopus regina*	V		Sub-tropical and dry rainforest.	Unlikely-no suitable habitat in the proposed pipeline route.
Superb Fruit-Dove *Ptilinopus superbus*	V		Rainforest and similar closed forests.	Unlikely-no suitable habitat in the proposed pipeline route.
Grass Owl *Tyto capensis*	V		Tall grass, including grass tussocks in swampy areas, grassy plains, swampy heath, and cane grass, or sedges on flood plains.	Unlikely-but may occasionally forage across wetter paddock areas. This species may be indirectly impacted by the project. **Further assessment required[1].**

Table 2 Threatened species recorded within the locality of PEL 285

Species/community	Conservation status		Habitat	Likelihood of occurrence and potential for impacts from the proposed activity
	TSC Act	EPBC Act		
Eastern Cave Bat *Vespadelus troughtoni*	V		Cave-roosting species found in dry open forest and woodland near cliffs or rocky over hangs.	Unlikely-no suitable habitat in the proposed pipeline route.
Eastern False Pipistrelle *Falsistrellus tasmaniensis*	V		Prefers moist habitats ith trees >20 m. Roosts in HBT ir under bark or in buildings.	Unlikely-no suitable habitat in the proposed pipeline route.
Golden-tipped Bat *Kerivoula papuensus*	V		Rainforest and adjacent sclerophylla forest.	Unlikely-no suitable habitat in the proposed pipeline route.
Large-eared Pied Bat *Chalinolobus dwyeri*	V	V	Roosts in caves, derelict mines frequenting low to mid elevation dry open forests and woodland close to these features.	Unlikely-no suitable habitat in the proposed pipeline route.
Little Bentwing-bat *Minioterus australis*	V		Moist Eucalypt forests whilst roosting in caves and man-made structures.	Unlikely-no suitable habitat in the proposed pipeline route.
Eastern Bent-wing Bat	V		Roosting – caves, derelict mines, storm-water tunnels, buildings. Foraging – forested areas.	Unlikely-no suitable habitat in the proposed pipeline route.
Eastern Freetail-bat *Mormopterus norfolkensis*	V		Dry sclerophylla forest & woodland. Roosts – hollows & under bark or man-made structures.	Unlikely-no suitable habitat in the proposed pipeline route.
Large-footed Myotis *Myotis adversus*	V		Forages over streams and pools catching insects and small fish by raking their feet across the water surface.	Unlikely-no suitable habitat in the proposed pipeline route.
Greater Broad-nosed Bat *Scoteanax rueppellii*	V		Woodland, moist and dry eucalypt forest, and rainforest but prefers tall wet forest.	Unlikely-no suitable habitat in the proposed pipeline route.
Grey-headed Flying-fox *Pteropus poliocephalus*	V	V	Subtropical & temperate rainforests, tall sclerophylla forests & woodlands, heaths & swamps.	Unlikely-no suitable habitat in the proposed pipeline route.
Spotted-tailed Quoll *Dasyurus maclatus*	V		Forests and heathlands.	Unlikely-no suitable habitat in the proposed pipeline route.
Koala *Phascolarctos cinereus*	V		Eucalypt forests and woodlands.	Unlikely-no suitable habitat will be impacted.

Table 2 Threatened species recorded within the locality of PEL 285

Species/community	Conservation status		Habitat	Likelihood of occurrence and potential for impacts from the proposed activity
	TSC Act	EPBC Act		
Squirrel Glider *Petaurus norfolcensis*	V		Eucalypt forests and woodlands/	Unlikely-no suitable habitat in the proposed pipeline route.
Rufous Bettong *Aepyprymnus rufescens*	V		Tall, moist eucalypt forest to open woodland, with a tussock grass understorey.	Unlikely-no suitable habitat in the proposed pipeline route.
Eastern Pygmy-possum *Cercartetus nanus*	V		Rainforest, sclerophylla forest &woodland to heath – but heath & woodland preferred.	Unlikely-no suitable habitat in the proposed pipeline route.
Parma Wallaby *Macropus australis*	V		Moist eucalypt forest with thick, shrubbery understorey.	Unlikely-no suitable habitat in the proposed pipeline route.
Yellow-bellied Glider *Petaurus australis*	V		Occur in tall mature eucalypt forest generally in areas with high rainfall/	Unlikely-no suitable habitat in the proposed pipeline route.
Squirrel Glider *Petaurus norfolcensis*	V		Inhabits mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest with heath understorey in coastal areas.	Unlikely-no suitable habitat in the proposed pipeline route.
Brush-tailed Rock-wallaby *Petrogale penicillata*	E	V	Rocky escarpments, outcrops, steep slopes or cliffs – especially those with caves, ledges or overhangs & shrub cover.	Unlikely-no suitable habitat in the proposed pipeline route.
Brush-tailed Phascogale *Phascogale tapoatafa*	V		Dry sclerophylla open forest with sparse groundcover. Also health, swamps, rainforest & wet sclerophylla forest.	Unlikely-no suitable habitat will be impacted.
Common Plaingale *Planigale maculate*	V		Rainforest, eucalypt forest, healtland, marshland, grassland and rocky areas.	Unlikely-no suitable habitat in the proposed pipeline route.
Long-nosed Potoroo *Potorous tridactylus*	V	V	Inhabits coastal heaths and dry and wet sclerophyll forests.	Unlikely-no suitable habitat in the proposed pipeline route.
Red-legged Pademelon *Thylogale stigmatica*	V		Forest with dense understorey and ground cover.	Unlikely-no suitable habitat in the proposed pipeline route.

1 – Further assessment was undertaken (Assessment of significance) and is provided at Appendix J of the Waukivory Pilot Testing REF (2013).

Note: TSC Act – Threatened Species Conservation Act 1995; EPBC Act – Environmental Protection and Biodiversity Conservation Act 1999; V – vulnerable; E – endangered; pop – population.

Appendix K

Assessment of significance for migratory species

Assessment of significance for migratory species

1 Introduction

Twelve migratory bird species and their habitats are predicted to occur within 10 km of the Waukivory Pilot Project area (DSEWPaC, 2012). Habitat assessments were undertaken for the Well sites (Appendix H of the REF) and for the pipeline corridor (Appendix I of the REF). It was considered that potential habitat for the Cattle Egret, Great Egret and Rainbow Bee-eater occurred in the vicinity of the pipeline corridor (Appendix I of the REF). This document provides an assessment of significance for these migratory species.

2 Significant impact criteria in accordance with the EPBC Act

The following section provides the criteria that must be considered in the assessment of migratory species listed under the EPBC Act. There are separate criteria for each listing category under the EPBC Act, in accordance with *'EPBC Act Policy Statement 1.1 Significant Impact Guidelines: Matters of National Environmental Significance'* (DEH, 2006).

2.1 Significant impact criteria for listed migratory species

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

- substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species;
- result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or
- seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

2.1.1 Migratory birds: Rainbow Bee-eater (*Merops ornatus*), Cattle Egret (*Ardea ibis*) and Great Egret (*A. modesta*)

Potential foraging habitat is present for the **Rainbow Bee-eater** along the Avon River and Waukivory Creek. This species breeds outside the study area on Rottnest Island (Western Australia) and islands in the south west Torres Strait (SEWPaC 2012).

The Avon River and Waukivory Creek floodplain contains potential habitat for the **Cattle Egret** and **Great Egret.** These species breed outside the study area from the central east coast to Bundaberg, and in inland wetlands including the Macquarie Marshes (SEWPaC 2012).

An assessment of significance has been completed to assess potential impacts on these migratory birds (Table M.1).

Table M.1 Assessment of significance for migratory birds

Assessment part	Discussion
1: substantially modify important habitat	The study area does not constitute an area of important habitat for these species, as an ecologically significant proportion (as defined under the guidelines (DEH, 2006)) of their populations do not reside in the study area, no breeding occurs in the area, it is not at the limit of their range and they are not known to be declining.
2 : result in invasive species	Soil disturbance during the proposed activity has the potential to introduce new weeds to the area. Environmental safeguards will be followed (Table 3.1) to minimise the introduction and spread of weeds into these species potential habitat.
3: disrupt lifecycle of ecologically significant proportion of population	An ecologically significant proportion of these species do not reside in the study area. In addition, they do not breed in the study area, foraging habitat is sub-optimal and the Project is unlikely to disrupt their migration patterns.
Conclusion	The proposed activity is not expected to result in significant impacts to the migratory bird species as: • an ecologically significant proportion of the species is not known to reside in the study area; and • the study area does not contain important habitat for the species.

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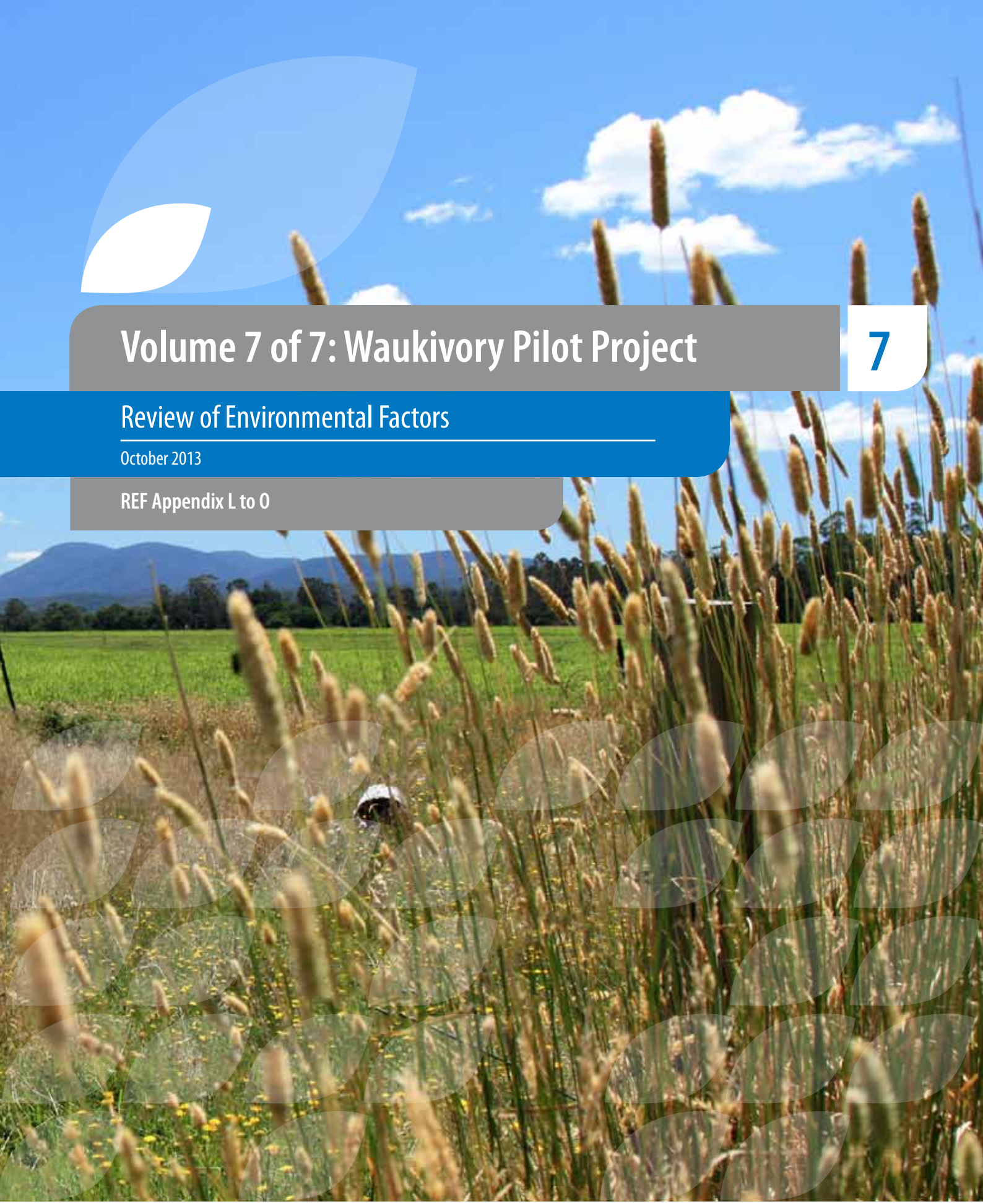
Volume 7 of 7: Waukivory Pilot Project

7

Review of Environmental Factors

October 2013

REF Appendix L to O



AGL Energy in action.

EMM
EMGA Mitchell McLennan

Appendix L

Risk assessment

RISK ASSESSMENT REPORT FOR AGL ENERGY'S FRACTURE STIMULATION ACTIVITIES IN GLOUCESTER

A risk assessment has been conducted on the proposed Fracture Stimulation Activities in Gloucester. The report is based on the NSW Department of Trade & Investment (Resources & Energy) Code of Practice for Coal Seam Gas (Fracture Stimulation Activities) (September 2012) **("The Code").** The report of this risk assessment ("**Risk Assessment Report**") is set out below.

1. BACKGROUND TO RISK ASSESSMENT AND SCOPE

1.1 Background

AGL holds petroleum exploration licence ("**PEL**") 285, which is located in the Gloucester Geological Basin north of Newcastle NSW. AGL carries out petroleum exploration activities within PEL 285. As part of its exploration program, AGL proposes to undertake Hydraulic Fracture Stimulation Activities ("**HFSA**").

This report forms part of the HFSA application and management process, and should be read in conjunction with AGL's Fracture Stimulation Management Plan – Gloucester NSW ("**FSMP**").

2. RISK MANAGEMENT REQUIREMENTS

The Code requires that a FSMP be in place prior to the commencement of a fracture stimulation activity. The Code states that the FSMP should incorporate a risk assessment that meets the following requirements:

a) The FSMP must include a risk assessment complying with AS/NZS ISO 31000:2009 Risk management - Principles and Guidelines.

b) The risk assessment must identify risks associated with the fracture stimulation activity, the likelihood of each risk and the consequence of each risk.

c) The risk assessment must define appropriate management controls to ensure identified risks are constrained to acceptable levels.

d) At a minimum, the risk assessment must address risks associated with:

i. workplace health and safety (see heading 5 of the Code)

ii. public safety (see heading 5 of the Code)

iii. chemical use (see heading 6 of the Code)

iv. impacts on water resources (see headings 7 and 8 of the Code)

v. land contamination

vi. air pollution

vii. noise & vibration

viii. waste management (e.g. flowback water as per heading 8 of the Code)

ix. loss of well integrity

x. induced seismicity

xi. induced subsidence or other induced ground movements

xii. conflicts with existing land uses

There are specific mandatory requirements in the Code to be assessed for each of these issues.

3. RISK ASSESSMENT PROCESS

3.1 AGL's Approach to Risk

AGL is committed to ensuring that risk management practices are entrenched into all business processes and operations to drive consistent, effective and accountable action, decision making and management practice. AGL's fundamental, underlying risk principles are consistent with ISO 31000 (Risk Management – Principles & Guidelines); and, the COSO standard for Enterprise Risk Management.

AGL recognises that risk is dynamic and is inherent in all external and internal operating environments and is committed to managing all risks effectively. Effective risk management is a means for achieving competitive advantage and is pivotal to enabling the ongoing growth and success of our business.

AGL's Risk Management Policy ("**Policy**") is approved by the AGL Board and publically available on www.agl.com.au The Policy sets out the objectives and accountabilities for the management of risk within AGL such that it is structured, consistent and effective. The Policy and AGL Risk Management & Assessment Framework are the two key documents that together formalise AGL's Risk Framework.

Effective risk management within AGL has a number of objectives:

› Promote an enterprise wide approach by integrating risk management processes with:

  » business strategy; project management; process and decision making;

  » audit, insurance and specialist risk functions; and

  » compliance and general governance functions.

› Promote consistency and transparency in methodology, assessment and management processes.

› Promote proactive recognition of external factors and anticipate uncertainties that may affect the achievement of strategy.

› Sponsor confidence in operations, management decisions and certainty regarding expected outcomes.

› Protect the interests of AGL shareholders.

› Provide assurance to counterparts, customers, employees and the community.

› Sponsor innovation and maximise value from assets, ventures and opportunities.

› Recognise that risk is embedded in all our activities and that the underlying risk appetite is key to effective decision making.

› Provide appropriate, consistent and transparent ownership and accountability around risk mitigation.

› Enable the design and implementation of controls that:

  » are structured to promote effective realisation of objectives;

» provide appropriate assurance; and

» are cost effective.

› Recognise that timely and accurate monitoring, review, communication and reporting of risk is critical to:

» providing early warning mechanisms for the effective management of risk occurrences and consequences;

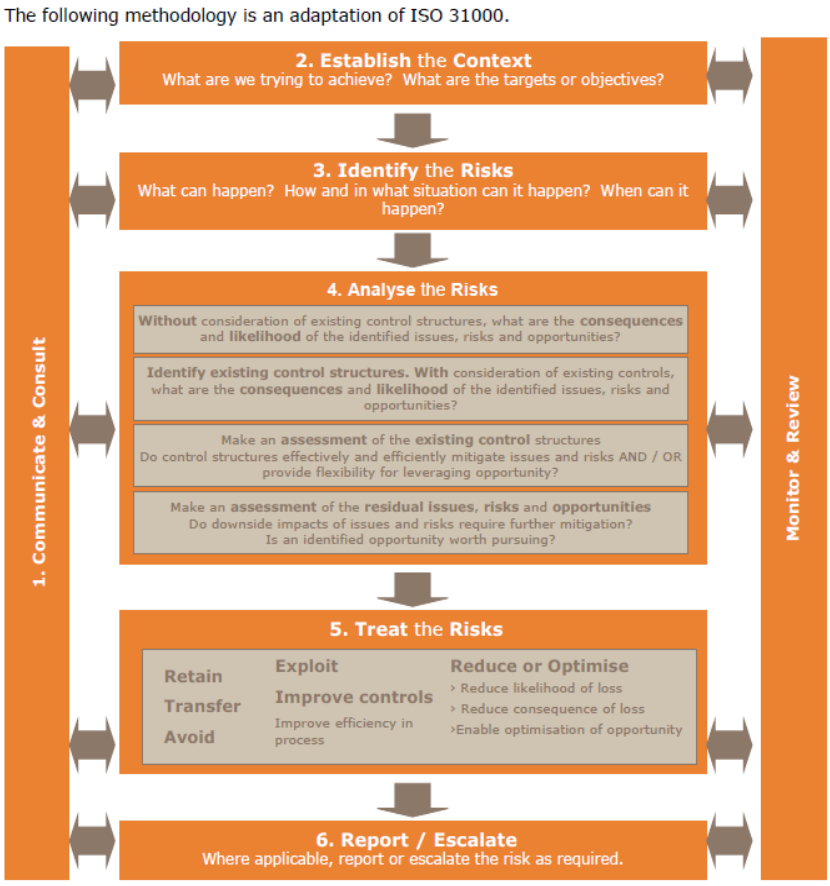
» providing assurance to management, the Board and shareholders;

» providing a solid platform for growth; and

» generating and maintaining a sound corporate history.

Just as risk is inherent in our operations, risk management is also inherent in all decision making and management processes. Risk management is essential to good corporate governance and is a fundamental component of good management practice.

The following methodology has been used to identify the risks included in this Risk Assessment and is an adaption of ISO 31000.



Source: AGL Risk Management Policy

3.2 AGL's Consequence & Likelihood Risk Evaluation Matrix

Table 1: Likelihood Rating Guide

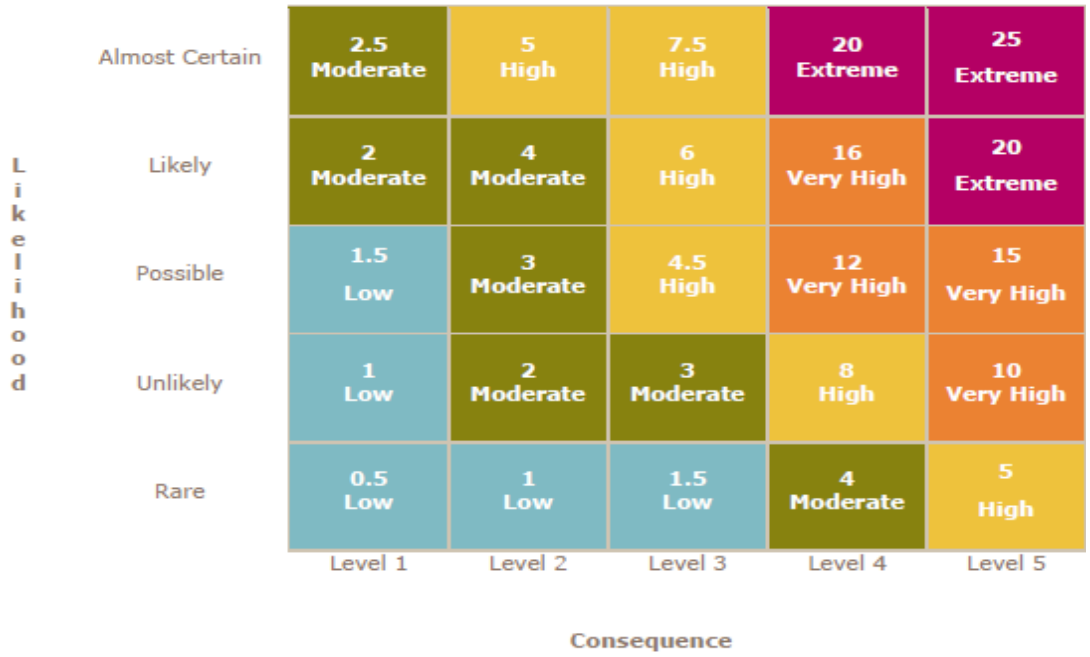
		Likelihood Description		
Score	Descriptor	Complexity	Susceptibility/ Exposure	Probability
5	Almost Certain	Can only be performed after specialist training and education, years of knowledge required, very advanced technology, extreme inter dependencies between tasks	Extremely susceptible – large numbers of new people and/or new to AGL, attractive to most people with ready access, newly implemented, a lot of changes, new system, untried processes	Knowledge/evidence either within AGL or externally suggests this event/risk occurs almost all of the time. The occurrence of this risk is common and expected - greater than 1 in 2 chance (greater than 50%)
4	Likely	Advanced training, education and specialist knowledge, a significant number of variables and interrelated tasks and dependencies	Highly susceptible - many new people, item is attractive, a lot of changes to the systems and procedures, the item is aging or otherwise becoming susceptible, the event is likely to occur sooner rather than later.	Knowledge/evidence either within AGL or externally suggests this event/risk occurs at regular intervals - between 1 in 10 and 1 in 2 chance (10% to 50%)
3	Possible	High level skill required, usually secondary studies necessary, detailed knowledge needed, advanced technology, a number variable tasks or steps	Quite a few people involved, audit trail difficult to follow, requires 'specialist' knowledge and skills, newly introduced staff and/or procedures, one would expect the event to occur at intervals	Occurs either within AGL or known environment on an irregular basis but frequently enough to be more than a remote possibility - between 1 in 100 and 1 in 10 chance (1% to 10%)
2	Unlikely	Requires basic training but can be quickly mastered by most people, few variations or steps involved	Recent changes, attractive but difficult to obtain, new people, some new processes or procedures, quite a few people involved, one would expect the risk to occur occasionally.	Aware that the event has occurred occasionally either within AGL or externally. However, it is not something that would be classed as a common occurrence and would only occur in certain remote circumstances - between 1 in 10000 and 1 in 100 (0.01% to 1%)
1	Rare	Straight forward singular tasks requiring little or no training	Has a minimum degree of susceptibility, been around for years, tried and true, well known and understood, can't conceive the risk occurring.	Either is not known to have occurred or has not occurred in many 'exposures' to the potential risk - greater than 1 in 10000 (less than 0.01%)

Table 2: Consequence Rating Guide

Consequence Rating Guide

		Consequence Definitions						
Score	**Descriptor**	**Commercial / Profitability / Assets**	**Business Continuity**	**Customer**	**Regulatory / Legal**	**Reputation**	**Environment & Community**	**People & Safety**
0.5	Level 1	Maximum risk less than $100k.	Minor business interruption. Temporary delay in operations with little effect, business would return to normal immediately.	May impact or lose a small number of domestic or small commercial customers.	Once off minor breach. Notification of relevant authority may be required, but negligible possibility of prosecution or breach of license.	Issue resolved in day to day management. Small local publicity.	Negligible and short term environmental impact to localised area of negligible environmental value. No impact beyond AGL's operational area. No interest by local community.	Injury or illness that may require medical treatment or first aid resulting in no lost time.
1.0	Level 2	Maximum risk between $100k and $1M.	Business interruption causes problems to either internal or external customers however business as usual achieved after several hours; AND / OR Growth options put off for up to 3 months.	Some loss of third party confidence AND impact to or loss of small number of Industrial & Commercial OR Major customers OR hundreds of domestics.	Multiple minor breaches. Regulator may express concern. Possible breach of licence or regulation requires notification to relevant authority / regulator, but unlikely to be associated with financial penalty.	Managed locally, some publicity in local and state press.	Small scale and short term environmental impact to localised area of low environmental value. No impact beyond AGL's operational area. No/minor interest by local community.	Injury or illness that temporarily impairs a person's life. Return to work with rehabilitation to same role.
1.5	Level 3	Maximum risk between $1M and $25M.	Business interruption causes impact to internal or external customers that last up to 5 business days; AND / OR Growth options are delayed for between 3 and 6 months.	Impact to or loss of several Industrial & Commercial OR Major Customers OR thousands of domestics.	Systemic breaches small to medium breaches or 1 large breach. Breach of regulatory / license requirements with likely action by regulatory authorities, resulting in tightening of licence and permit conditions and financial penalties or fines. Enforceable undertakings possible. Unfavourable policy outcomes.	Sustained regional/State coverage.	Moderate, short to medium term environmental impact that may extend beyond AGL's operational area and/or may result in local community complaint(s).	Injury or illness that permanently impairs a person's life. Return to work with rehabilitation and alternate role.
4	Level 4	Maximum risk between $25M to $100M.	Business interruption causes impact to internal or external customers that last for between 1 and 2 weeks; AND / OR Growth options are delayed for between 6 months and 12 months.	Impact to or loss of a large number of Industrial & Commercial OR Major Customers OR tens of thousands of domestics	Civil prosecution Unfavourable tariff outcomes. Unfavourable policy outcomes impact commercial position. Unable to secure necessary permits for growth / developments. Incident could result in revocation of licence/permits, large fines and prosecutions.	Sustained national press coverage.	Significant medium term impact on important environment/habitat and/or widespread local community complaints.	Injury or illness that results in a fatality or permanently impairs a person's life. No return to work.
5	Level 5	Risk may exceed $100M.	Business interruption causes impact to internal or external customers that last for more than 2 weeks; AND / OR Growth options are delayed for more than 1 year.	Impact to, or long term loss of many Industrial & Commercial OR Major Customers OR hundreds of thousands of domestics.	Civil / criminal prosecution Unfavourable tariff outcomes put commercial Loss of operating licences. Loss of licenses and possible closure of facility, significant fines and/or jail penalties could result.	Continuous national and/or international coverage.	Severe long term damage to the environment and/or sustained widespread local community complaints over time. Any loss or damage to listed or protected environment/habitat.	Injury or illness that results in more than 1 fatality or permanently impairs more than 1 person's life. No return to work.

Table 3 Consequence and Likelihood Risk Evaluation Matrix



The following Risk Assessment has been conducted using the tables included in section 3.2.

3.3 Risk Assessment Workshop

The principal mechanism for identifying, analysing and evaluating GSFA risks for the purposes of the Risk Assessment Report was a series of workshops attended by representatives of AGL and its contractors ("**Risk Assessment Workshop**").

This Risk Assessment Report contains the output of these workshops. The Risk Assessment Report follows the guidance as mandated in the Code, and indentifies risks, proposed mitigation strategies if required and risk ratings after controls and mitigation strategies are applied. It should be noted that risk is dynamic and additional workshops will be conducted to further develop the risks identified, ensure that risk treatments have due by dates and accountability assigned.

The following table outlines the details of the Risk Assessment Workshops.

Date of Workshop and Facilitation	**Scope of Workshop**
14 December 2012 Facilitated by AGL Energy Head of Group Risk and Compliance	• impacts on water resources • land contamination • air pollution • noise & vibration • waste management (e.g. flowback water) • induced seismicity • induced subsidence or other induced ground movements
17 December 2012 Facilitated by AGL Energy Head of Group Risk and Compliance	• public health and safety • conflicts with existing land users
23 January 2013 Facilitated by AGL Energy Head of Group Risk and Compliance	• workplace health & safety • chemical use • loss of well integrity • overview of findings to date

Table 4: Details of Risk Assessment Workshops

3.4 Selection of Risk Assessment Workshop attendees and other interviewees

The Risk Assessment Workshop participants were key stakeholders from the project team, principal contractor representatives and other experts deemed appropriate for the activity. The roles of Risk Assessment Workshop participants is listed below:

Role	Company
Head of Group Risk & Compliance	AGL Energy
Risk Manager	AGL Energy
Head of Gas Operations	AGL Energy
Manager Hydrogeology	AGL Energy
Manager Geoscience	AGL Energy
Community Relations Manager	AGL Energy
Land and Approvals Manager	AGL Energy
Health & Safety Business Partner	AGL Energy
Environmental Manager	AGL Energy
Senior Geologist	AGL Energy
Senior Petroleum Engineer	AGL Energy
Project Coordinator	AGL Energy
Health Safety & Environment Coordinator	Halliburton
Fracturing Service Manager	Halliburton
Senior Technical Advisor	Halliburton

Table 5: List of Risk Workshop Participants and Company

Preparation for Risk Assessment Workshops and interviews

Prior to the Risk Assessment Workshop, materials which were included as part of the deliberations included;

- The Code
- NSW Department of Trade and Investment (Resources and Energy) Code of Practice for Coal Seam Gas (Well Integrity) (September 2012)

3.5 Comment on the Risk Assessment Workshop process

- Whilst controls have been identified to mitigate the identified risks, the responsibility and dates for completion of these is ongoing: and
- as a general observation, the participants in the Risk Assessment Workshops were well engaged and provided constructive and open input and comments.

4. KEY POINTS AND RECOMMENDATIONS FROM RISK ASSESSMENT

4.1 Key Risks Identified and the Controls to Treat the Risk

Set out below is a table summarising:

- key risks as required by the Code and addressed in the Risk Assessment (including risk ratings based on implementation of controls to mitigate the risk); and
- recommendations to assist in addressing these matters.

Risks	Controls to Mitigate
i Workplace Health & Safety a. Heavy vehicle movements through local townships and through access roads to sites, raising a risk of vehicle related accidents Consequence: Level 4 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Moderate	1. Drivers are appropriately licensed and competency assessed 2. Vehicles have maintenance records and routine checks 3. Journey management plans are completed, which include identification of the travel route 4. The selected travel route is assessed prior to mobilisation of heavy vehicles movements 5. Vehicle management systems, including live tracking of service provider performing fracture stimulation services 6. Use of escort vehicle ahead of convoy 7. Vehicles generally travel in convoys 8. Communications plans will include traffic arrangements 9. No night time travel of heavy vehicles unless a separate Journey Management and Risk Assessment is conducted 10. Policy of mandatory rest breaks for long journeys
b. Due to the movement of equipment to and from the site, incorrectly secured loads may raise a risk of accidents for other road users Consequence: Level 3 (Consequence driver: Safety) Likelihood: Unlikely Current Risk Rating: Moderate	1. Drivers are appropriately licensed and competency assessed 2. All loads are prepared by skilled personnel and fixed according to Australian standards 3. Pre and post check list for each vehicle, incorporates walk around, debrief and pre brief with drivers
c. Equipment damage during setup (known as 'Rig Up') Consequence: Level 3 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Low	1. Drivers are appropriately licensed and competency assessed 2. Personnel to be wear appropriate safety and protective gear at all times 3. Site is controlled by a Site Safety Manager 4. Site is managed by Project Schedule to ensure orderly movements on site 5. Safety management plan prepared for the site 6. Safe work plans are prepared for the site

Risks	Controls to Mitigate
	7. Authorised personal only are allowed on site 8. Reversing any of equipment requires land guide 9. Wellhead is to be barricaded to prevent reversing into same
d. Injury to onsite personnel due to equipment set up – (known as 'Rig Up') Consequence: Level 3 (Consequence driver: Safety) Likelihood: Unlikely Current Risk Rating: Moderate	1. Contractors will conduct site visit and planning workshop prior to establishment 2. Personnel to be wear appropriate safety and protective gear at all times 3. Perimeter fencing will be establishment 4. Site management will be established which includes but not limited to, land guides, site directions, access limitations, signage, permit to work system 5. Pre Rig Up meeting prior to commencement of work 6. Authorised personnel only on site 7. Controlled equipment movement allowed on site during Rig Up
e. During job execution, there may be a risk of excessive occupational noise to onsite personnel Consequence: Level 2 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Low	1. Noise impact assessment conducted 2. All personnel on site will be required to wear hearing protection during fracturing operations 3. Exclusion zones known as Red Zones will be established 4. Frac Master - designated Site Safety Manager will control the site at all times or their delegate the Ground supervisor
f. There may be a risk of failed or uncontrolled pressure release to onsite personnel causing injury during job execution Consequence: Level 4 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Moderate	1. Specification of well design to deal to risk 2. Controlled primary pressure safety control – electronic pump cut outs in equipment 3. Annual third party certification of all pressure equipment 4. Signage and exclusion zones 5. Remote and local equipment kill switches 6. Secondary pressure relief valve to enable pressure release 7. Continuous pressure monitoring

Risks	Controls to Mitigate
g. There may be a risk of failed or uncontrolled pressure of the flowback line causing injury to personnel Consequence: Level 4 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Moderate	1. Flow back lines are pressure rated 2. Fixed bean choke to control flowback 3. Contractors operating standards 4. Open top flow back tank located 25 metres away from well with diffuser to further control fluid flowback 5. Exclusion zones are maintained 6. Flowback lines will be secured 7. Flowback operating procedures to be implemented
h. There may be a risk of well control failure causing injury Consequence: Level 3 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Low	1. Policy and procedures for handling of well head valves using designated trained person 2. Continuous monitoring of well pressures 3. Manufacturer rated and certified to API certified valves specified 4. API pressure rated casing installed 5. Check valves installed in main treating lines
i. There may be a risk of fire due to machinery failure causing injury Consequence: Level 3 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Low	1. Preventative maintenance program 2. Pre job inspections 3. Fire extinguishing equipment on site and regularly serviced and on the ground ready for use 4. Personnel trained in fire fighting techniques 5. Emergency Fire drills conducted 6. Rural/Local Fire Service contact details on site and debriefed prior to activities 7. Emergency Response Plan well understood and reviewed in Site Induction and Pre Job Meeting 8. Fracturing equipment equipped with Rig savers/ mechanical or electrical emergency shutdown controls

Risks	Controls to Mitigate
j. There is a risk that chemical mishandling or inadvertent contact with chemicals may cause injury Consequence: Level 3 (Consequence driver: Safety) Likelihood: Unlikely Current Risk Rating: Moderate	1. Chemicals are segregated by class and a load sheets are generated identifying specification and locations 2. Adhere to Dangerous Goods Code 3. Heavy vehicles designated for chemical movements are Dangerous Goods rated 4. Visual inspections are conducted for stored chemicals 5. Personnel have chemical handling training 6. Exclusion zones around chemical areas 7. Emergency Response Plan 8. Safety showers, first aid kits and eye wash bays on site 9. Dry gel eliminates need to batch mix chemicals in water holding tanks 10. Equipment allows continuous monitoring of chemical injection into fluid 11. Chemicals only stored in Australian Standard approved containers 12. All chemicals to be stored in bunded areas 13. All Material Safety Data Sheets (MSDS) are available on site 14. Human Health and Ecological Risk Assessment (HHRA) completed for all chemicals 15. Appropriate personal protective equipment for the chemicals being handled
k. There is a risk that the site and equipment may be sabotaged by unauthorised and illegal entrants resulting in injury Consequence: Level 3 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Low	1. Inform and work with the local Police services 2. Use of appropriate Security firms and fencing 3. Use of signage to inform general public that the site is “restricted” 4. Security and site workforce to walk the site every morning and night 5. Secure site each night

Risks	Controls to Mitigate
ii Public Safety a. There is a risk of an illegal protest leading to harm to protestors and the work force Consequence: Level 2 (Consequence driver: Safety) Likelihood: Likely Current Risk Rating: Moderate	1. Follow AGL Protest Response Plan 2. Inform and work with the local Police services 3. Use of appropriate security firms and fencing 4. Use of signage to inform general public that the site is “restricted” 5. Security and site workforce to walk the site every morning and night 6. Proactive consultation with the community prior to works commencing
iii Chemical Risk Assessment **(Separate Report annexed– Human Health and Ecological Risk Assessment, February 2013)**	Human Health and Ecological Risk Assessment completed for all chemicals

Risks	Controls to Mitigate
iv Impacts on Water Resources a. There is a risk of source water spill during transport to site. Consequence: Level 1 (Consequence driver: Environment) Likelihood: Unlikely Current Risk Rating: Low	1. The preferred source water is fresh water from the Pontilands Dam and spills would have little to no impact on the environment 2. If an alternative source is used, the water quality may be brackish water. The fill and unloading areas are contained. Spills of brackish water would have minimal impact on soils and surface water. 3. Vacuum truck is available on site
b. There is a risk that the flow back water may be incorrectly transported, captured and/or removed which may result in a spill. Consequence: Level 1 (Consequence driver: Environment) Likelihood: Unlikely Current Risk Rating: Low	1. Flow back water will be stored in designed tanks or other above ground holding tanks, which are fully contained 2. Pipes used to transport flow back water to above ground holding tanks will be visually inspected 3. Visual inspections are conducted on all tanks prior to the storage of any liquids. Visual inspections are also conducted several times a day during fracture stimulation operations to ensure no overflow or leaks 4. Water tanks are bunded so that if a leak occurs the liquid is contained 5. Vacuum truck is available on site 6. Sealed transport tankers are used to remove flowback water from site or holding dams to an approved facility 7. Surplus water tanks are kept on site so that if a leak was to occur in a tank the contents of the tank could be pumped into the spare tank 8. Pipes are pressure tested during commissioning before use 9. Wells are supervised during flow back operations 10. Environmental Incident Response Plan covers this possibility
c. The Code requires a qualitative assessment of risk that GFSA may cause connectivity and cross contamination between coal seams and beneficial aquifers. (i.e. exchange of poor water quality between these two sources that may	Low permeability aquitard layers exist between shallow beneficial aquifers and target coal seams. AGL have developed strategies including: 1. A Surface Water & Groundwater Management Plan has been written to protect surface water and beneficial aquifers. Baseline assessments

Risks	Controls to Mitigate
impact water quality characteristics). [Code 7.2(c)(i) and (iv)] Consequence: Level 3 (Consequence driver: Environment) Likelihood: Rare Current Risk Rating: Low	suggest that groundwater moves laterally within layers and vertical connectivity is low. A Groundwater Monitoring program has been implemented (since early 2012) and will be used to monitor water levels, pressures and water quality during the fracture stimulation program. 2. Pressure monitoring (at individual gas wells) during fracture stimulation. 3. Geophone monitoring, measuring direction and height of the fracture in real time on selected wells. 4. Temperature log, confirms fracture height after the fracture stimulation of each zone. 5. Fracturing execution commences from the deepest zone and progress up the well. This means more information is gathered before approaching the beneficial aquifers. 6. Monitoring changes in the flowback chemistry 7. Groundwater monitoring programs provide baseline data prior to fracture stimulation programs thereby allowing trends or changes in shallow water chemistry to be identified 8. Faulting is mapped through 3D seismic and zones selected for stimulation are away from faults
d. The Code requires an assessment of the risk that GFSA may induce: • changes to groundwater pressure and levels; • changes to surface water levels and flow. This is generally referred to as surface water/groundwater connectivity [Code 7.2(ii) and (iii)] Consequence: Level 3 (Consequence driver: Environment) Likelihood: Rare Current Risk Rating: Low	AGL and the principal contractor have developed strategies including; 1. A Surface Water & Groundwater Management Plan that protects surface water and beneficial aquifers. A Groundwater Monitoring program has been implemented 2. Pressure monitoring during fracture stimulation. 3. Geophone monitoring, measuring direction and height of the fracture in real time on selected wells 4. Temperature log, confirms fracture height after the operation 5. Fracturing execution commences from the deepest zone and progress up the well. This means more information is gathered before approaching the beneficial aquifers 6. Monitoring changes in the flowback chemistry 7. Groundwater monitoring programs provide baseline data prior to fracture stimulation programs thereby allowing trends or changes in shallow water chemistry to be identified

Risks	Controls to Mitigate
v Land Contamination a. There is a risk that there may be spills and leakages of materials such as oils, lubricants, on site fuels, chemicals, additives, water, sand and packaging. Consequence: Level 2 (Consequence driver: Environment) Likelihood: Unlikely Current Risk Rating: Moderate	1. All contractors on site are subject to pre qualification and selection process 2. Environmental Management Plan, Environment Response Plan, handling and storage procedures, audit procedures, site inspections, spill kits, onsite waste storage facility, training and supervision 3. Handling of chemicals and fluids is subject to the Contractor's and AGL's handling procedures 4. On site supervision of activities 5. Daily toolbox talks that emphasise the importance of following AGL and Contractor procedures 6. Human Health and Ecological Risk Assessment completed for fracture stimulation fluids
b. There is a risk that noxious weeds from outside of the project area maybe transported by vehicles and contaminate the local area. Consequence: Level 3 (Consequence driver: Environment) Likelihood: Unlikely Current Risk Rating: Moderate	1. Truck wash downs, prior to entering project area 2. Drivers trained to inspect trucks prior to journey commencement 3. Documented evidence is provided for each washed truck 4. Journey management plan 5. AGL to inspect vehicles prior to entering site

Risks	Controls to Mitigate
vi Air Pollution a. Due to trucks, vehicles, operational equipment operating during activities, there is a risk of excessive exhaust emissions and surface dust being generated from road movements. Consequence: Level 2 (Consequence driver: Environment) Likelihood: Unlikely Current Risk Rating: Moderate	1. All contractors on site are subject to AGL pre qualification and selection process which includes a preventative maintenance system and adherence to Australian Standard vehicle emissions 2. Routine dust suppression where generation has been observed on roads and appropriate gravel will be used to surface roads where required to minimise from road movements 3. Signposted travelling speeds on lease roads to reduce dust generation from traffic movements 4. Environment Management Plan
b. There is a risk that during operations fines and fluid mists may blow into the atmosphere. Consequence: Level 1 (Consequence driver: Environment) Likelihood: Unlikely Current Risk Rating: Low	1. Fluids are captured and contained via flowback tanks 2. Flowback water is diffused to minimise the chance of any fluid being blown into the atmosphere 3. All fracture stimulation activities are greater than 200 metres from residences
vii Localised, Temporary Noise and Vibration a. Due to heavy vehicles, operational equipment and flow back operations there will be a risk of exceeding the constructions noise goal Consequence: Level 2 (Consequence driver: Environment) Likelihood: Possible Current Risk Rating: Moderate	1. AGL will establish and maintain sound walls between activities and receptors as required 2. AGL will conduct a noise impact assessment 3. Fracture stimulation pumping, workover rig operations and heavy vehicle movements will be restricted to 7am to 6pm Monday to Friday and 8:00 am – 1:00 pm Saturday. Outside of these hours activity will be limited to light vehicle access, rigging up, rigging down, equipment maintenance and pilot testing. 4. Community consultation will occur with neighbours prior to commencement of activities 5. AGL will assess orientation of equipment on a well by well basis to minimise any noise impact. 6. Noise logging onsite and at nearby receivers to identify any problematic areas

Risks	Controls to Mitigate
viii Waste Management (flowback) a. There is a risk that waste from operations may enter the surrounding environment. Consequence: Level 1 (Consequence driver: Environment) Likelihood: Unlikely Current Risk Rating: Low	1. All contractors on site are subject to AGL pre qualification and selection process 2. The chemical waste contents are dealt comprehensibly in the chemical risk assessment report. 3. Flowback water will be contained within bunded tanks, with vacuum truck available on location. 4. Water will be chemically analysed to determine the appropriate transport and disposal method
ix Loss of well integrity a. There is a risk to the well integrity due to issues such as failure of pressure containment devices, casing, master valve and/or lubricator Consequence: Level 3 (Consequence driver: Safety) Likelihood: Rare Current Risk Rating: Low	1. Appropriate well design 2. Safety margins incorporated into Fracture Stimulation design 3. Conformity with Code of practice for Well Integrity 4. API certified casing and wellhead 5. Bridge Plugs to isolate each treated zone 6. Perforation of selected zones only 7. Cement Bond Logs to be run on all wells to be fracture stimulated 8. Casing is pressure tested prior to perforating
x Induced seismicity a. Risk identified in Code– Induced Seismicity. AGL understands "induced seismicity" to require an assessment of any risk that fracture stimulation activities will induce seismicity that could, for example, disrupt a nearby fault. Consequence: Level 3 (Consequence driver: Environment) Likelihood: Rare Current Risk Rating: Low	1. Drilling and logging records have been performed to identify faults. 2. Seismic mapping to identify faults, and avoid activity near significant faults 3. Magnitude of events are below the threshold where damage can occur to beneficial aquifers and surface infrastructure
xi Induced subsidence and other induced ground movements a. Risk identified in Code – Induced	1. Consolidated rock is not supported by pore

Risks	Controls to Mitigate
Subsidence. The Code requires an assessment of risks associated with "induced subsidence or other induced ground movements,", which AGL understands to mean the risk there may be surface ground movement Consequence: Level 1 (Consequence driver: Environment) Likelihood: Rare Current Risk Rating: Low	pressure thus change of pressure in the coal seam will not result in subsidence in ground about this zone
xii Conflicts with existing land users a. The Code requires an assessment of the risk of air pollution, which AGL understands to mean the risk of air pollutants damaging neighbouring occupied properties e.g. dairy farms Consequence: Level 1 (Consequence driver: Community) Probability: Unlikely Current Risk Rating: Low	1. Machinery and vehicles are maintained and inspected prior to use 2. Fluids are captured and contained via flowback tanks 3. Flowback water is diffused to minimise the chance of any fluid being blown into the atmosphere 4. All fracturing activities are greater than 200 metres from residences
b. There is a risk of localised, temporary visual and noise impacts to neighbouring properties. Consequence: Level 3 (Consequence driver: Community) Probability: Possible Current Risk Rating: High	1. Establish and maintain sound walls between activities and receptors as required 2. Fracture stimulation pumping, workover rig operations and heavy vehicle movements will be restricted to 7am to 6pm Monday to Friday and 8:00 am – 1:00 pm Saturday. Outside of these hours activity will be limited to light vehicle access, rigging up, rigging down, equipment maintenance and pilot testing. 3. Proactive consultation with the community prior to works commencing 4. Assess orientation of equipment on a well by well basis to minimise any noise impact 5. Noise logging onsite and at nearby receivers to identify any problematic areas
xiii Other Risks a. GFSA will include perforation activities and low emitting enclosed radioactive density measurement	1. Follow dangerous goods code 2. Radioactive sources and perforating guns will be handled by appropriately trained and

Risks	Controls to Mitigate
tool that may cause harm to onsite contractors and employees if incorrectly handled Consequence: Level 3 (Consequence driver: Health) Probability: Rare Current Risk Rating: Low	competent personnel 3. Emergency response plan 4. Equipment is marked and secured 5. Equipment is maintained and systematically certified 6. Security at well sites during inactive periods to deter theft and vandalism
b. Due to extreme weather (e.g. floods, lightning, high winds, bushfire) there is a risk to damage and disturbance of equipment resulting in injury or environmental damage Consequence: Level 2 (Consequence driver: Health) Probability: Unlikely Current Risk Rating: Moderate	1. Flood Management Plan 2. Bushfire Management Plan 3. Preference to locate above ground open top water storage at areas above flood zones 4. Appropriately licences for crane usage 5. Trained and competent crane operators 6. Operations procedure include weather stop protocols
c. Risk that fracture stimulation activity may intersect with unrecorded wells, previously drilled by other operators, that have not been properly plugged and abandoned, causing connection with other subsurface layers or surface. Consequence: Level 3 (Consequence driver: Environment and Community) Probability: Possible Current Risk Rating: High	1. Location of historical exploration wells is know from mine records. Wells within 600m of a Pilot test well and with any common coal seams intersected in them will be properly plugged and abandoned prior to stimulation activities

5. CONCLUSION

The risk assessment conducted outlines the key risks associated with GFSA and the controls in place to constrain these risks to acceptable levels. The above analysis has identified no very high or extreme risks.

Appendix M

Human health and ecological risk assessment

Human Health and Ecological Risk Assessment – Hydraulic Stimulation Activities, Gloucester Gas Project

Prepared for : AGL Upstream Investments Pty Ltd

19 September 2013

EnRiskS

Document History and Status

Report Reference	AGL/12/HGR001
Revision	C – Final
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Previous Revisions	B – Draft issued to AGL on 11 February 2013

Limitations

Environmental Risk Sciences has prepared this report for the use of AGL Upstream Investments Pty Ltd (AGL) in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report.

It is prepared in accordance with the scope of work and for the purpose outlined in the Section 1 of this report.

The methodology adopted and sources of information used are outlined in this report. Environmental Risk Sciences has made no independent verification of this information beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions. No indications were found that information contained in the report provided by AGL was false.

This report was prepared from October 2012 to September 2013 and is based on the information provided and reviewed at that time. Environmental Risk Sciences disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

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Section 1 Introduction

1.1 General

Environmental Risk Sciences Pty Ltd (enRiskS) has been commissioned by AGL Upstream Investments Pty Ltd (AGL) to undertake a human health and ecological risk assessment (HHERA) for its hydraulic fracture stimulation activities to be undertaken within the Gloucester basin of New South Wales (NSW).

The study area comprises PEL 285 located within the Gloucester basin, NSW. The specific project to which this HHERA relates are the Waukivory pilot test wells. The existing wells are located 5 km south of Gloucester township. Activities expected to be conducted in the study area include exploration to evaluate potential gas reserves (and potential to be commercialised for delivery to gas markets) and provide more detailed geological information of the region.

The proposed activity includes the following:

- Perforating the wells at the target coal seams;
- Hydraulic fracture stimulation of the target coal seams; and
- Flowback of hydraulic fracture stimulation fluid (flowback water/fluid).

The NSW Trade & Investment Resources & Energy Code of Practice for Coal Seam Gas, Fracture stimulation activities (September 2012) requires that a Fracture Stimulation Management Plan (FSMP) be in place prior to the commencement of a fracture stimulation activity. The Code of Practice states that the FSMP should incorporate a risk assessment that meets the following requirements:

a) The FSMP must include a risk assessment complying with AS/NZS ISO 31000:2009 Risk management - Principles and Guidelines.
b) The risk assessment must identify risks associated with the fracture stimulation activity, the likelihood of each risk and the consequence of each risk.
c) The risk assessment must define appropriate management controls to ensure identified risks are constrained to acceptable levels.
d) At a minimum, the risk assessment must address risks associated with:
   i. workplace health and safety
   ii. public safety
   iii. chemical use
   iv. impacts on water resources
   v. land contamination
   vi. air pollution
   vii. noise & vibration
   viii. waste management (e.g. flowback water)
   ix. loss of well integrity
   x. induced seismicity
   xi. induced subsidence or other induced ground movements
   xii. conflicts with existing land uses

The HHERA presented in this report addresses requirements d(iii), the use of chemicals in fracture stimulation. The Code of Practice states that chemical additives used in fracture stimulation activities should be minimised as far as reasonably practicable, and should be selected and managed to minimise potential impacts on the environment. The use of additives containing BTEX (benzene, toluene, ethylbenzene and xylenes) compounds is banned in NSW. More specifically, in relation to the completion of the HHERA in relation to chemicals used in fracture stimulation activities the Code of Practice requires the identification of the following:

a) All chemicals to be injected as part of the fracture stimulation process
b) The Chemical Abstract Service (CAS) registry number for those chemicals
c) The volumes and concentrations of those chemicals
d) Potential risks to human health arising from exposure to those chemicals
e) The risk, likelihood and consequence of surface spills of these chemicals
f) Whether chemical concentrations at the point of injection will exceed:
   i. ANZECC 2000 guidelines for overlying groundwater and surface water uses that may be affected
   ii. ADWG 2004 if a drinking water supply may be affected
   iii. natural background concentrations if the water source is not effectively described by ANZECC or ADWG guidelines; or
   iv. if the chemical is not specified in ANZECC or ADWG guidelines and may have a toxic[6] effect, then assess whether the toxic effect is likely to exceed a trigger toxicity level determined in accordance with a suitable methodology such as those described in Section 2: OECD Guidelines for the Testing of Chemicals.
   v. The risk, likelihood and consequence of the injected chemicals affecting the beneficial use class of the target aquifer or any other aquifer
   vi. How those chemicals will be stored and managed

The HHERA presented in this report addresses the above requirements in relation to the fracture stimulation chemicals that may be used within the Gloucester Gas Project.

In addition to the above requirements the draft EPBC Act conditions in relation to the Stage 1 Gloucester Project requires the following:

1. Prior to commencement of the action, the person taking the action must provide the minister with the following details on any hydraulic fracturing agents or other reinjected fluids likely to be used:
   a) estimated number and location (mapped, and expressed in latitude, longitude and depth) of wells where the agent or fluid may be used;
   b) Chemical Abstracts Service Number;
   c) typical load;
   d) typical concentration; and
   e) toxicity as total effluent toxicity and ecotoxicity, based on methods outlined in the National Water Quality Management Strategy.

While the Waukivory Pilot test wells are not part of the Stage 1 Gloucester Gas Project and is the subject of a separate referral, this assessment will also address the requirements of the above condition above.

The assessment presented in this report only addresses chemicals associated with fracture stimulation activities. No other activities that may be undertaken in the Gloucester Gas Project have been evaluated or considered in this assessment.

1.2 HHERA Methodology

1.2.1 General Approach

The methodology adopted for the conduct of the HHERA is in accordance with the protocols/ guidelines recommended by enHealth ("*Health Impact Assessment Guidelines*" (2001) and "*Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards*", 2012) and NEPM (Schedule B(4), "*Guideline on Health Risk Assessment Methodology*", 1999).

The framework for an ecological risk assessment is similar to the one adopted for the human health risk assessment and is consistent with guidance provided in NEPM ("*Guideline on Ecological Risk Assessment*", Schedule B(5)) and in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000).

In addition to the above the assessment has also considered the following:

- Methods for the calculation of drinking water guidelines as outlined in the National health and Medical Research Council, Australian Drinking Water Guidelines (NHMRC 2011).
- Methods for the assessment of toxicity in as outlined in the National Water Quality Management Strategy, as outlined in Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000).

These guidance documents have been endorsed by the NSW EPA for the conduct of HHERA's in NSW.

The HHERA presented in this report is primarily a qualitative assessment. The above guidance provides the basis for conducting both qualitative and quantitative assessments, however the guidance is more focused on quantitative evaluations. To assist in the qualitative evaluation of risk, a risk matrix approach has been adopted to assist in the ranking of key risk issues that need to be considered in evaluating the hydraulic fracture stimulation chemicals and activities.

The approach adopted is generally consistent with the requirements presented in Australian Standard/New Zealand Standard (AS/NZS) 4360:2004: Risk Management and AS/NZS ISO 31000:2009 Risk management - Principles and Guidelines, with some modification of the qualitative definitions to ensure they are relevant to the HHERA proposed.

This HHERA has considered the key aspects set out in Sections 1.2.2 to 1.2.5 in relation to the use of chemicals in hydraulic fracture stimulation activities.

1.2.2 Risk Issues

This general review is aimed at providing a general evaluation of the key aspects, relevant to the chemicals assessed, that affect the potential for exposures by humans or ecological receptors to occur. In relation to hydraulic fracture stimulation activities the risk issues that warrant consideration relate to:

- operational risks associated with the storage, handling and use of the chemicals; and
- human health and environmental risks associated with the potential for the surrounding environment, including humans, to be exposed to chemicals used during hydraulic fracture stimulation activities.

1.2.3 Consequence or Hazard

On the basis of the available information on the chemicals evaluated in this assessment, hazards associated with the chemicals have been evaluated with the potential for consequences to be of significance identified. The following aspects have been considered in this evaluation:

- Concentrations at the point of injection;
- Chemical and physical properties – evaluated in conjunction with other aspects below;
- Fate and transport in groundwater – presents consideration of the potential for the chemicals to have negligible, low, medium, high or very high potential to migrate to and move with groundwater, be persistent in the environment, bioaccumulate in aquatic species and/or the food chain;
- Human Toxicity – presents consideration of the potential for the chemicals to result in negligible, low, medium, high or severe acute and chronic human health effects that are relevant to operational exposures (in particular occupational) and offsite environmental environmental exposures;
- Ecological Toxicity – presents consideration of the potential for the chemicals to result in negligible, low, medium, high or severe toxicity to aquatic species.

On the basis of these properties, the following presents a summary of the categories and ranking system identified for the purpose of conducting a qualitative evaluation of potential consequences of exposure, both operational and environmental exposures.

Table 1 Summary of Consequence Categories and Ranking System

Rank	Consequence Descriptor	Occupational Exposures	Environmental Exposures		
			Potential for Off-Site Impacts – Fate and Transport	Off-Site Impacts to Human Health	Off-Site Impacts to the Ecosystem
1	**Negligible**	Generally low potential for adverse health effects during storage and handling	Chemical degrades rapidly under all conditions, is not bioaccumulative or taken up into the food chain	No adverse long-term health effects associated with low level environmental exposures	Negligible potential for adverse effects on aquatic ecosystem
2	**Low**	Minor nuisance effects such as odours, transient irritation effects, requires low level PPE	Chemical is somewhat mobile, degrades slowly (or only under some conditions), is not bioaccumulative or taken up into the food chain	Minor transient health effects or odour	Low potential for adverse effects on aquatic ecosystem
3	**Moderate**	Transient effects that may require medical treatment such as respiratory effects, more significant irritation effects that need to be managed with moderate level PPE	Chemical is mobile, degrades slowly, is not bioaccumulative or taken up into the food chain	Transient effects that may require medical treatment such as respiratory effects, more significant irritation	Moderate potential for adverse effects on aquatic ecosystem
4	**High**	Permanent health effects that require extended medical treatment and/or permanent disability and require a high level of PPE, monitoring and management	Chemical is mobile, persistent, has the potential for low to moderate bioaccumulation in aquatic species or food chain	Permanent health effects that require extended medical treatment and/or permanent disability	High potential for adverse effects on aquatic ecosystem
5	**Severe**	Death or significant injury likely to result in death - not to be used	Chemical is mobile, persistent, has the potential for high to very high bioaccumulation in aquatic species or food chain	Death or significant injury likely to result in death	Very high potential for significant adverse effects (including death of significant proportion of receptors) in ecosystem

1.2.4 Likelihood

The next step is to determine the likelihood of the hazard (i.e. exposure occurring at the receptor that may include human or ecological receptors) occurring. While the assessment of likelihood also needs to consider more site-specific aspects, more general information on hydraulic fracture stimulation activities is considered sufficient to provide a general measure of likelihood. The likelihood measure is only considered in the evaluation of environmental exposures as these exposures are dependent on the fate and transport of chemicals in the environment. The likelihood of occupational exposures (by workers involved in hydraulic fracture stimulation activities) are directly managed through the implementation of appropriate workplace health and safety policies and plans. These policies and plans are implemented and monitored by AGL and the principal contractor which results in the likelihood of occupation exposures occurring being managed at a level where such exposures are always considered to be highly unlikely. The assessment presented

here has been used to identify those chemicals used in hydraulic fracturing activities that require more significant levels of protection under the occupational health and safety plan.

The measure is split into five descriptors ranging from hazards that are considered 'Very Likely' to hazards that would be considered 'Highly Unlikely' as outlined in **Table 2**.

Table 2 Summary of Likelihood Categories and Ranking System

Rank	Descriptor	Likelihood of Exposure
1	Highly unlikely	No connection between coal seam and receiving environment and management measures in place to prevent surface spills – i.e. there is no pathway of exposure
2	Unlikely	Unlikely connection between coal seam and receiving environment, no extraction and use of aquifers for any purpose. Unlikely for any surface spills to reach receiving environment.
3	Possible	Possible connection between coal seam and receiving environment, possible extraction and use of aquifer. Possible that surface spills to reach receiving environment.
4	Likely	Likely connection between coal seam and receiving environment, potential use of aquifer or discharge to ecosystem. Likely that surface spills to reach receiving environment.
5	Very likely	Confirmed connection between coal seam and receiving environment, confirmed use of aquifer or discharge to ecosystem. Very likely (confirmed) that surface spills to reach receiving environment.

1.2.5 Qualitative Characterisation of Risk

The final step in assessing hazard and risk is to combine the potential likelihood (of exposure occurring for a receptor) and consequences determined using the above ranking system and descriptors to evaluate the level of overall risk. The approach adopted in this HHERA is based on a qualitative risk matric approach generally consistent with AS 4360:2004 and AS/NZS ISO 31000:2009, where the following risk matrices have been considered for occupational and environmental risk issues.

Table 3 Matrix Adopted to Characterise Occupational Risk Issues

	Consequence →				
	Negligible	Low	Moderate	High	Severe
Acute Hazards Associated with Storage and Use of Chemical	Generally low potential for adverse health effects during storage and handling	Minor nuisance effects such as odours, transient irritation effects, requires low level PPE	Transient effects that may require medical treatment such as respiratory effects, more significant irritation effects that need to be managed with moderate level PPE	Permanent health effects that require extended medical treatment and/or permanent disability and require a high level of PPE, monitoring and management	Death or significant injury likely to result in death - not to be used
	1	2	3	4	5

Table 4 Matrix Adopted to Characterise Environmental Risk Issues

				Consequence →			
				Negligible	Low	Moderate	High	Severe
			Potential for Off-Site Impacts - Fate and Transport	Chemical degrades rapidly under all conditions, is not bioaccumulative or taken up into the food chain	Chemical is somew hat mobile, degrades slow ly (or only under some conditions), is not bioaccumulative or taken up into the food chain	Chemical is mobile, degrades slow ly, is not bioaccumulative or taken up into the food chain	Chemical is mobile, persistent, has the potential for low to moderate bioaccumulation in aquatic species or food chain	Chemical is mobile, persistent, has the potential for high to very high bioaccumulation in aquatic species or food chain
				1	2	3	4	5
			Off-Site Human Health Issues (chronic)	No adverse long-term health effects associated w ith low level environmental exposures	Minor transient health effects or odour	Transient effects that may require medical treatment such as respiratory effects, more significant irritation	Permanent health effects that require extended medical treatment and/or permanent disability	Death or significant injury likely to result in death
				1	2	3	4	5
			Off-Site Impacts to Aquatic Ecosystem	Very low potential for adverse effects on aquatic ecosystem	Low potential for adverse effects on aquatic ecosystem	Moderate potential for adverse effects on aquatic ecosystem	High potential for adverse effects on aquatic ecosystem	Very high potential for significant adverse effects on aquatic ecosystem
				1	2	3	4	5
				Negligible	Low	Moderate	High	Severe
Likelihood of Exposure at Receptor ↑	Confirmed connection betw een coal seam and receiving environment, confirmed use of aquifer or direct discharge to environment/ecosystem	very likely	5	N	L	M	H	E
	Likely connection betw een coal seam and receiving environment, potential use of aquifer or discharge to local environment/ecosystem	likely	4	N	L	M	H	E
	Possible connection betw een coal seam and receiving environment, possible use of aquifer, limited management measures in place to prevent surface spillage (hence possible for surface spills to reach environment)	possible	3	N	L	M	M	H
	Unlikely connection betw een coal seam and a receiving environment, no use of aquifers for any purpose, management measures in place that make spills at ground surface unlikely	unlikely	2	N	L	L	L	L
	No connection betw een coal seam and receiving environment and management measures in place to prevent surface spills	highly unlikely	1	N	N	N	N	N

Table 5 Risk Outcomes

Rank	Description
N	Negligible risk - no adverse impacts
L	Low risk - potential for impacts is very low and potential for impacts to result in adverse effects is low. Risk issues identified can be effectively managed through implementation of appropriate management measures.
M	Medium risk - risk considered to be higher than identified in low risk category, risks should be quantified and management may be required
H	High risk - potential for significant exposures that have the potential to exceed acceptable risk levels for human health or ecological environments
E	Extreme risk - significant heath and/or ecological effects may occur

1.3 Study Area

The study area is located within PEL 285 located within the Gloucester basin, NSW (refer to **Figure 1**). Activities expected to be conducted in the study area include exploration to evaluate potential gas reserves (and potential to be commercialised for delivery to gas markets) and provide more detailed geological information of the region.

- The exploration process is defined by AGL in four main stages:
- Identifying prospects and leads through geological & geophysical desktop studies;
- Identifying hydrocarbon accumulations through the drilling of core and stratigraphic holes;
- Evaluating the potential size of the discovery through geophysical surveys such as seismic, magnetics, gravity and further core and stratigraphic drilling where necessary; and
- Evaluating the deliverability and commerciality of the discovery by gas flow testing to enable reserves certification and ultimately commercial project development investment decisions.

Core holes are drilled to identify and test gas saturation, composition and content. Seismic surveys are carried out to gather more regional information about the size, structure and geology of an area. Pilot wells and production testing determine the deliverability and flow rates of the gas reserves.

Once the preferred geological target areas have been identified, the site selection process then considers the environmental and social constraints of the area. These include community impacts, land use (existing and future), topography, subsurface geology, groundwater, water management, flora and fauna, archaeology, noise and traffic. This detailed design information becomes part of the environmental assessment and approvals process for the proposed exploration drilling activities.

The proposed fracture stimulation and pilot testing sites are located greater than 40m from any major watercourse or 20m from minor watercourse or drainage lines.

The current and proposed operations are in semi-rural or rural areas (also used for open cut coal mining operations) within the PEL, with most of the work proposed to be conducted on existing agricultural lands, predominantly used for beef cattle grazing.

The exploration holes proposed in this area are targeting the Gloucester Coal Measures.

Legend

PEL285

Local Government Areas

Towns

Kilometres

0 5 10

Scale 1:500,000

Geocentric Datum of Australia 1994

Sources: AGL Energy Limited, MapData Sciences

DATE PRODUCED: DECEMBER 2012

Figure 1

Location of Study Area (PEL 285)

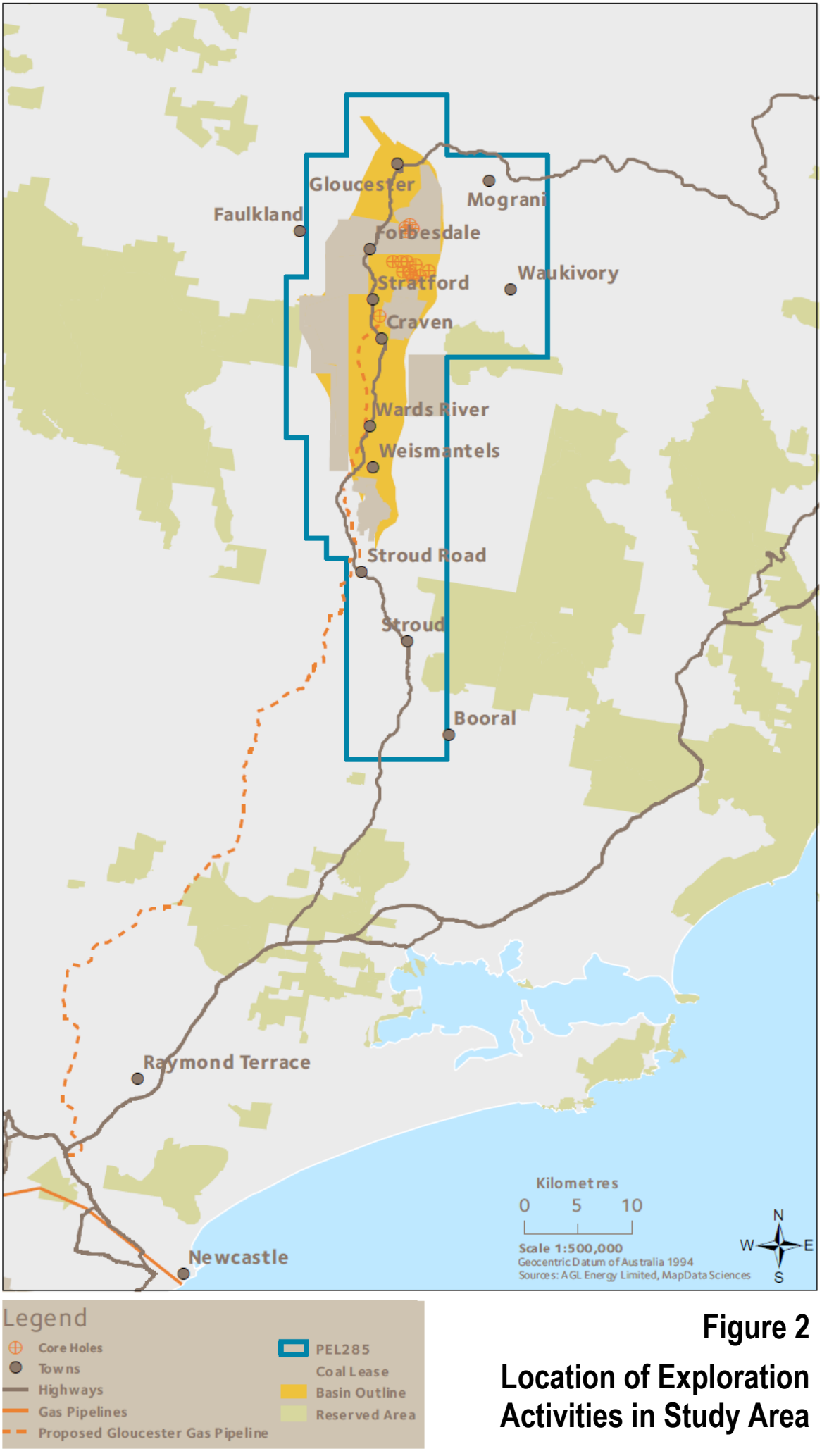

Figure 2

Location of Exploration Activities in Study Area

1.4 Geology

The coal seam methane resources in the study area are contained within rocks of Permian age.

The Gloucester Basin is divided up into three major stratigraphic units: the Alum Mountain Volcanics, the Dewrang Group and the Gloucester Coal Measures. The Dewrang Group and the Gloucester Coal Measures contain 15 laterally extensive coal units and represent the main coal seam gas targets.

Exploration activities in the study area are expected to target the Gloucester Coal Measures, which are located at depths from surface to over 1000m. Gas content of the coal is commonly of the order of 1-20m^3/tonne with gas content increasing with depth. However not all the coal seams may be suitable for gas production due to low permeability, but the location and distribution of relatively high and low permeability zones is poorly known at present. The presence of large basin wide thrust faulting may be a contributing factor.

The stratigraphy of the Gloucester basin is presented in **Figure 3** *(from* Lennox, M., 1991[1]*).*

The Gloucester Basin is a north south trending synclinal shaped trough containing Permian volcanics and sediments. Basement comprises Carboniferous sedimentary rocks and volcanic units. The basin sequence is capped by Late Permian fluvial-deltaic sediments of the Dewrang Group and Gloucester Coal Measures. The top of the Permian section has been exposed to erosion.

Throughout the evolution of the Gloucester Basin, sandstones, mudstones, conglomerates and coals were deposited in fault-controlled troughs. The preserved basin stratigraphy is up to 4000m thick. Widespread Early Permian volcanic activity may be related to thermal upwelling beneath the base of the continental lithosphere in a retroarc basin setting. Due to the Late Permian fall in relative sea level, shallow water and fluvial conditions prevailed. The complex interplay of tectonics extensional faulting, high rates of sediment supply produced significant lateral stratigraphic variability throughout the Gloucester Basin.

The Gloucester Basin exhibits a complex structural history. Early normal and syn-depositional faults occur and in many cases have been reactivated by the later Hunter-Bowen orogenic events. The Gloucester Basin displays steep dips of up to 80° on its flanks, dipping towards the north-south trending basin axis and relatively flattening towards the centre of the basin. The basin is dissected by several major thrust structures.

[1] Unpublished reference.

Stratigraphy of the Gloucester Basin

			Formation		Seam	Depositional Environment
UPPER PERMIAN	GLOUCESTER COAL MEASURES	CRAVEN SUBGROUP	Crowthers Rd Conglomerate	oO Oo	Conglomerate, minor sandstone	Distal Alluvial Fan
			Leloma Formation		Sandstone, minor siltstone and coal	Alluvial Plain
					Linden Coals	
					Marker/JD Coals	
					Jo Doth Tuff	
					Bindaboo Coals	
					Deards Coal	
					Sandstone, minor siltstone and coal	
			Jilleon Formation		Cloverdale Coal	Hiatus Coal
					Conglomerate, sandstone and siltstone	Alluvial Plain
					Roseville Coal	
					Tereel Coals/Fairbairns Lane	
			Wards River Conglomerate	oO Oo oO Oo	Conglomerate and sandstone	Distal Alluvial Fan
			Wenhams Formation		Bowens Rd Coal	Hiatus Coal
					Siltstone	Marsh
					Bowens Rd Lower Coal	Back Barrier Coal
			Speldon Formation		Marine influenced sandstone	Marginal Marine, prodelta, beach
		AVON SUB GROUP	Dogtrap Creek Formation		Glenview Coal	Back Barrier Coal
					Sandstone, siltstone	Lower Delta Plain
			Waukivory Creek Formation		Avon Coals	Hiatus Coal
					Triple, Rombo, Glen Rd	Upper Delta Plain
					Sandstone and siltstone	Upper Delta Plain
					Parkers Rd and Valley View Coals	Hiatus Coal
					Siltstone and mudstone	Transitional
	DEWRANG GROUP		Mammy Johnsons Formation		Sandstone and siltstone	Marginal Marine, Barrier, Wave Dominated Delta
					Intra Mammy Johnsons Coal	Back Barrier Coal
					Bioturbated sandstone	Marginal Marine, Barrier, Wave Dominated Delta
			Weismantels Formation		Siltstone and mudstone	Back Barrier Lagoon
					Weismantels Coal	Back Barrier Coal
			Duralie Road Formation		Marine Sandstone, conglomerate	Marginal Marine, Fan Delta
LWR PERM			Alum Mountain Volcanics		Clareval Coal	Hiatus Coal
				oO Oo	Conglomerate and coal	Distal Alluvial Fan
					Rhyolite, basalt, welded tuff	Bimodal Terrestrial Volcanics
					Basal Coal	

Figure 3 Stratigraphy of Gloucester Basin

1.5 Surface Water and Groundwater

The study area is located within the Hunter-Central Rivers Catchment Management Area (CMA) which covers an area of approximately 22000 square kilometres. It is the Manning River Catchment that is the main coastal catchment within which the project activities will be undertaken. The main sub-catchment is the Avon River catchment immediately to the south of Gloucester. The Gloucester River and the Barrington River join with the Avon River just downstream of Gloucester. Pumps on the Barrington River are the water supply source for Gloucester. The catchment receives the majority of its rainfall in December and January with areas subject to localised intermittent flooding and drought periods throughout the year.

The Manning River catchment is regulated by the Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources authorised under the *Water Management Act 2000.* This plan is the relevant water sharing plan for all unregulated water sources in the Karuah and Manning River catchments. The Plan includes the unregulated rivers and creeks, alluvial groundwater (which are above the tidal limit), and the tidal pool areas (which have not be previously covered by the *Water Act 1912*).

Groundwater resources within NSW are governed by Water Sharing Plans (WSPs) as administered under the *Water Management Act 2000* or where no Water Sharing Plans are established, by the *Water Act 1912*. The Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources (noted above) is the relevant plan that covers alluvial water sources within the region. There is no WSP for the underlying porous rock groundwater systems at this time.

The level of connectivity, the relative level of impact and the timing of connection have been considered in developing both the unregulated river and the associated groundwater sharing plans for the area. For the purposes of water sharing, aquifer types have been grouped into four basic categories:

- Porous rock aquifers found in rock formations such as sandstone or limestone (soft sedimentary rocks). Groundwater occurs within the pore space within the rock matrix;
- Fractured rock aquifers found in rock formations such as granite or basalt (igneous or metamorphic rocks). Groundwater in these rocks occurs mainly within the fractures and joints;
- Coastal sand aquifers, where groundwater is contained in the pore spaces in the unconsolidated sand sediments; and
- Alluvial aquifers, where groundwater is contained in the pore spaces in the unconsolidated floodplain material.

Alluvial aquifers and coastal sand aquifers are generally of high value water resource that occurs in most areas of Australia and are predominantly used for irrigation, town, stock and domestic uses. Alluvial aquifers are generally shallower than sedimentary and fractured rock aquifers and water levels often fluctuate due to varying recharge and pumping rates. Being near surface with shallow water tables, there is a higher potential for alluvial and coastal sand aquifers to be susceptible to surface contamination and pollution.

The project area where exploration is proposed is mostly underlain by Gloucester Coal Measures. There are thin alluvial sediments along the Avon River and major tributaries such as Waukivory Creek. The alluvial sediments are shallow (less than 12m depth) and thin (compared to downstream alluvium along the Manning River alluvium) and have low yields and variable water quality. This aquifer is rarely used by local farmers because of reliable surface water sources. Recharge of the alluvial aquifer is predominantly from direct surface infiltration from rainfall, flood recharge, runoff from catchment areas with only a small contribution from bedrock aquifers. Groundwater quality in the alluvial aquifers ranges from fresh-brackish (typically at the top of the aquifer where recharge is from rainfall and flood recharge) to salty (typically from the underlying Permian strata).

Groundwater in the Permian sedimentary (porous) rocks across the Gloucester basin is a low value water resource and is rarely used for agricultural and other consumptive uses. If used it is mostly for limited stock and industrial water use. Rock permeabilities are generally low, aquifers are mostly bedding and fracture zones within the uppermost 75m, bore yields in rocks and fracture zones are very low and water quality is generally brackish to slightly saline.

On a more local scale, maximum drilling depth for water bores is typically up to 75 metres, however the depth of target coal seams to be fracture stimulated are approximately 300 - 1000 metres. Therefore this risk assessment focuses on the beneficial groundwater resources that are drilled through and isolated by these wells within the porous bedrock formations that underlie the project area.

In addition, early testing programs at Stratford suggested there was negligible connectivity between shallow aquifer zones and water bearing zones as a result of these extensive flow testing programs of the deep CSG coal seam targets.

Hence limited connectivity is expected between the more shallow groundwater (alluvial groundwater) and groundwater in the target Gloucester Coal Measures at the Waukivory pilot sites.

The local hydrogeology (including depth and quality of aquifers) are assessed as part of the environmental assessment and permitting process for each pilot test well.

1.6 Receiving Environment

The Gloucester Gas Project covers a large area that is utilised for a range of land uses. This includes rural and semi-rural areas and some rural township areas. Hence there is the potential for the general public who live and/or work within and adjacent to the study area to be exposed to chemicals used in CSG operations should they be present in surface water (creeks, local rivers and local dams), soil and groundwater. Groundwater resources in the study area comprise fresh to brackish water aquifers in the upper alluvial formations. These aquifers have the potential to be used for a range of limited beneficial uses that are likely to include stock watering, and some domestic purposes with some baseflow returns to the Avon River. The aquifers are not suitable for drinking water. There is the expectation in the local community that these shallow beneficial aquifers remain suitable for all these uses. The deeper water bearing zones in the coal measure rocks contain slightly saline water with very limited beneficial uses (being some stock and industrial applications). There is much less reliance on this water source.

The pilot test area comprises a wide range of terrestrial environments and aquatic environments (that are evaluated by AGL during the Environmental Assessment stage for the exploration

activities). If chemicals used in the CSG operations have the potential to discharge into these environments then there may be the requirement to conduct more detailed evaluation of potential impacts. However this would only be relevant if there was a sufficiently elevated level of risk identified for these receptors.

Section 2 Hydraulic Fracturing Operations

2.1 General Description of Hydraulic Fracturing

CSG occurs in pore spaces/voids (cleats) commonly found in coal that is present as a series of interbedded layers within a thicker more variable layer of rock types that include sandstones, siltstones, mudstones and shales. The pore spaces within the coal rock mass are made up of fracture, joint plane and micro-fracture voids that impart a generally low permeability characteristic to the coal; limiting coal formation water flow under natural conditions. The procedure of CSG extraction involves the drilling of a series of production wells into the targeted coal seams and pumping out the coal formation water within the coal layers. This lowers the hydraulic pressure in the coal layers and allows desorption (release) of methane from the coal matrix. This methane gas is then free to flow towards the production well.

Hydraulic fracture stimulation has been used in the oil and gas industry since the 1950's as a technique for enhancing production. The basic premise behind fracturing is that is places a region of artificially high permeability within the formation from which fluid and/or gas is to be produced. It is particularly effective in formations with low-permeability. Hydraulic fracturing has evolved into a technique suitable to stimulate most wells under extremely varying circumstances. (Economides 2007).

Fracture stimulation creates a more efficient flow path for the CSG thereby increasing its production. Increasing the CSG produced by each well facilitates:

- Reduction in the number of wells required for drilling and production
- Minimising the surface or visual impact of the project
- Increasing the reservoirs economic lifetime
- Increases in the recoverable reserve.

The methodologies adopted by AGL encompass the life cycle of a hydraulic fracture stimulation, from planning to post-job monitoring.

During a hydraulic fracturing stimulation treatment, fluid is pumped down the wellbore into individual or small groupings of coal seams which have been selected and isolated from all other formations. The fluid being forced into the formation increases in pressure as it encounters resistance to flow through the formation. When the fluid pressure building in the formation generates a stress that is greater than the stress required to fracture the formation, a fracture is created. Coal formations contain existing fractures referred to as cleats. When hydraulically fracture stimulating a coal seam, the fracture often follows an existing cleat or pathway into the coal reservoir.

As pumping continues, the fracture extends from the wellbore and grows. Once the desired geometry of the fracture is created, proppant (fine grained sand) is added to the fluid and pumped into the fracture. When all the proppant is placed in the fracture, pumping is stopped. The pressure inside the fracture drops and the stress in the formation reduces such that the fracture closes. The closing fracture traps the proppant inside the formation and helps to maintain a permeable and conductive path through the formation to the wellbore. The permeable path left in the formation is the main objective of the fracture stimulation treatment. This proppant filled flow path enhances

production by allowing CSG formation water and gas to flow from the formation to the wellbore with minimised resistance.

It is important to emphasise that the fracture stimulation initiates at the targeted coal seam/s and enhanced fractures do not migrate vertically to insect shallow aquifers or surface water resources, and fracture stimulation fluids are flowed back after the stimulation process. Consequently there are no exposure pathways for fracture stimulation fluids to enter groundwater systems particularly the shallow aquifers used for different consumptive uses. Typical hydraulic fracturing stimulations for AGL create fractures that are estimated to be 5-20 millimetres wide and extend laterally (fracture stimulation length) for 20 to 60 metres perpendicular to the minimum stress direction within the coal seam. The height of the fracture may vary but fractures are typically contained within the coal seam. The sealing rocks above and below the coal seam, which are significantly harder than the coal, limit the vertical height growth of the fracture

As discussed in **Sections 1.4 and 1.5** the Gloucester Gas Project operations primarily target the Gloucester Coal Measures that are at a depth that is below local and regional groundwater aquifers that may be used for a range of purposes that include irrigation and livestock. During the current exploration campaign, AGL will be using geophone monitoring data acquisition to monitor fracture growth geometry to confirm that it will not impact on these groundwater aquifers. In addition, the exploration well construction methodology (which must comply with DTIRIS – Minerals guidelines including Code of Practice for Coal Seam Gas – Well Integrity, industry best practice and the Water Act (1912) and the “Minimum Construction Requirements for Water Bores in Australia Ed 3” (NUDLC 2012)) adopted prevents the vertical interconnection of groundwater aquifers with deeper water bearing zones. The well construction does this by providing four barriers (two steel and two pressure-tested cement) between water from the CSG producing zones and groundwater aquifers.

It is an important aspect of the risk assessment that the aquifers of concern (that are relevant to the assessment of human health or environment risk issues) are identified and the potential for hydraulic connectivity between the target formation and the aquifers of concern is evaluated. The AGL Surface and Groundwater Management Sub Plan for the Waukivory pilot provides further detail on the groundwater monitoring program that has been implemented prior to fracture stimulation commencing, including establishment of a dedicated groundwater network and associated monitoring program to protect the shallowest aquifers used for water supply across the area.

2.2 Description of AGL Operations

2.2.1 Drilling Techniques

AGL employs multiple techniques to enhance gas production from its CSG operations; horizontal drilling, open-hole completions, under-reaming, cavitation and hydraulic fracture stimulation. The stimulation or production enhancement technique used depends on the properties of the coal reservoir, and the number of targeted coal seams in a well. Within AGL’s New South Wales CSG operations, 123 wells out of a total 160 wells drilled (as at September 2012) have been hydraulically fracture stimulated.

The pilot test wells are vertical wells. This means that the wells are drilled vertically to intercept the target coal seams. Wells have multiple casings with a conductor casing near surface, a surface

casing to around 120 metres to exclude shallow aquifers and a production casing to full depth. All casings are pressure cemented in place. Cement quality is checked by running a Cement Bond Log.

2.2.2 Well Construction

The NSW DRE Code of Practice for Well Integrity has been adopted by AGL and complies with the American Petroleum Institute (API) standards and best practice for wells that will be fracture stimulated. All gas exploration and production wells have been and will be completed with multiple casings (and pressure cemented in place) to ensure that aquifers remain isolated.

Figure 4 presents cross-sectional illustrations of the existing well construction demonstrating the level isolation that is achieved with the construction methodology.

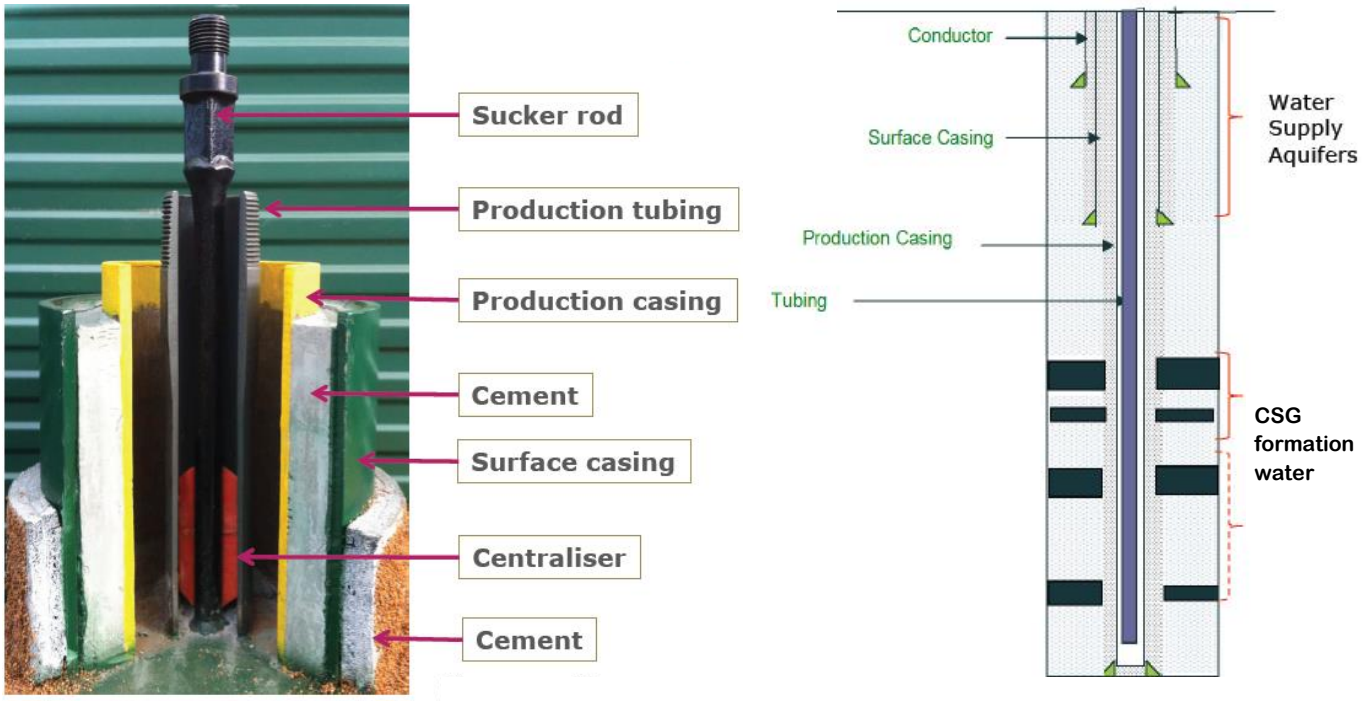

Figure 4 Typical Well Construction (from AGL)

2.2.3 Fracture Stimulation Fluids

The majority of the fracture stimulation fluid comprises water and sand (approximately 98 – 99.5%) however a small percentage of other chemicals are also used.

The additive options for hydraulic fracture stimulation process include:

- Treated water: A treated water fluid formation is a basic fluid for performing hydraulic fracture stimulations. The fluid is treated with a bactericide to minimise the risk of introducing foreign bacteria into the formation which can lead to the development of hydrogen sulphide (H_2S) in the well. H_2S often results from the bacterial breakdown of organic matter in the absence of oxygen and is a corrosive gas with potential to affect the steel casing of the well. The treated water fluid is aimed at minimising these risks. Clay stabiliser may be added to prevent swelling and migration of formation clays.
- Linear gel: This linear gel fluid formulation is a viscosified treated water. The viscosifying agent is a guar gum. Further additives include a breaker used to decrease the viscosity of the linear gel over time allowing more efficient flowback of the fracturing fluid following a hydraulic fracturing treatment. Linear gels are able to carry higher concentrations of proppant than water, thereby reducing the required volumes of water. They also reduce pumping friction and can reduce the required hydraulic pressure required.
- Cross-linked gel: This cross-linked gel fluid formulation is based on a linear gel. The cross-linked fluid has additional additives that cross-link the gel which further increases the viscosity of the gel. Cross-linked gels are used when high proppant concentrations are required or when low viscosity fluids are unable to maintain the desired fracture geometry.

It is expected that linear gel will be used for the pilot testing programs at Gloucester.

Fracture stimulations are specifically designed for each well and seek to avoid impacts on water resources, contain fractures within the targeted seam, and minimise additive or chemical use. Each design will be based on the requirements of the Code of Practice for Coal Seam Gas – Fracture Stimulation Activities, and incorporate the following:

- characteristics of geological formation, including the identification of rock types and conditions, aquifers and hydrocarbon-bearing zones;
- definition of distances to these aquifers from the target coal beds;
- identification of the characteristics of intervening strata, including porosity/ permeability and the extent of natural fracturing;
- determination of the geological stress fields and areas of faulting;
- determination of maximum pressures to be used for fracture stimulation, based on the characteristics of surrounding geology;
- modelling of the likely fracture propagation field, including extent and orientation; and
- discussion of any potential for the fracture propagation field to exceed the modelled field.

These fluids are derived from specific companies (as further evaluated in this report) and are based on knowledge of past operational successes and failures and results from fluid compatibility tests. The fluids main purpose is to create the fracture geometry and to transport proppant. Only the minimum volume of chemicals required to achieve this outcome is used during hydraulic fracture stimulation activities.

It is noted that BTEX (benzene, toluene, ethylbenzene and xylenes) products, and products that may contain BTEX, are not used in hydraulic fracture stimulation activities by AGL.

All fluids will be stored, transported and handled in accordance with legislative requirements, the manufacturer's specifications, contracting company's procedures and the AGL Dangerous Goods and Hazardous Materials Sub Plan.

Regulatory Requirements

Mandatory requirements of the Code of Practice require the identification CAS registry numbers, and volume and concentration of chemicals proposed to be used. It is noted that the chemicals proposed to be used in hydraulic fracture stimulation activities are all listed on the Australian Inventory of Chemical Substances (AICS). The AICS is maintained by the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) and is a list of industrial chemicals used in Australia. Chemicals on the AICS can be imported or manufactured in Australia without being first notified to NICNAS as a new chemical. A listing on the AICS does not mean that the chemical has been assessed in detail by NICNAS. Only a small number of the chemicals listed on the AICS have been assessed in detail by NICNAS (where issues such as hazards, public health, workplace health and environmental effects associated with its proposed industrial use are evaluated in more detail). For chemicals listed on the AICS there is no requirement to notify NICNAS of their use in hydraulic fracturing.

For chemicals that have been assessed in detail by NICNAS, the use of the chemical for hydraulic fracture stimulation constitutes a new use and hence it is recommended (by NICNAS) that the chemical suppliers of these compounds notify NICNAS of their use and a secondary notification assessment may be required. None of the proposed chemicals for use in hydraulic fracture stimulation have been assessed in detail by NICNAS, however some (citric acid and sodium hydroxide) have been determined to be Priority Existing Chemicals, hence they may be undergoing or proposed to be evaluated in detail by NICNAS. If these chemicals are flagged for evaluation by NICNAS, use in hydraulic fracture stimulation should be included in the evaluation.

The Agricultural and Veterinary Chemicals Code Regulations 1995 (amended 1 July 2013) made under the Agricultural and Veterinary Chemicals Act 1994 and administered by the Australian Pesticides and Veterinary Medicines Authority (APVMA) has declared (Schedule 3 Part 3) that "*biocides to control organisms in water, used for the purpose of maintaining equipment associated with the extraction of coal seam gas in serviceable condition*" are not agricultural chemical products and as such do not require registration by APVMA for use as outlined in this assessment.

2.2.4 Hydraulic Fracture Stimulation Injection and Recovery

Where hydraulic fracture stimulation is undertaken, pumping schedules and job design are based on specific reservoir properties. If a well has low permeability, then the fracture design will want to maximise fracture penetration or fracture half-length within the coal seam. If a well has good permeability, then a shorter fatter fracture will be designed connecting back to the wellbore. To achieve the fracture design, various key criteria can be incorporated to optimise the execution result. This includes fluid viscosity, pump rate, proppant mass and proppant concentration. The fluid selected for the pumping schedule will be decided either from fluid compatibility tests or through historical information.

Proppant mass required for a hydraulic fracture stimulation is based on a factor of mass of proppant per net height of coal to stimulated. A typical range for this factor is ~ 3700 to 8200 kg of proppant /net meters of coal.

Depending on the fluid selected, the proppant concentration will vary. Maximum proppant concentrations are generally only a guideline for planning material quantities (water, proppant and chemicals) required to execute a stimulation. Often the maximum proppant concentration is decided during the treatment by observing the treating pressures. If a well has good permeability then proppant concentration will be increased, forming a shorter fatter fracture and maximising the differential pressure between the formation and wellbore. The onsite engineer monitors treating pressures in real time and will adjust the pumping rates and proppant concentration accordingly. The total volume of fluids and proppant are measured and recorded for every job.

The fluids injected during fracture stimulation, with the exception of the sand proppant, are returned to the surface soon after completion of the hydraulic fracturing operation as flowback fluids. Flowback fluids comprise injected hydraulic fracturing fluids as well as formation water from the target coal seam. AGL operations manage the flowback fluids including capturing the fluid in above ground storage tanks or lined ponds. No flowback water is stored in any unlined dams or other reservoirs where there is a direct connection to the local environment. Flowback water is characterised and transported to licensed disposal facilities.

Flowback fluids can be monitored so as to determine when all the flowing fluid has transitioned from injected fracture stimulation fluid to formation water.

2.3 Fracture Issues

Reservoir stimulation is critically important for economically recovering coal seam gas in most operations. Hydraulic fracture stimulation technology is widely applicable to a range of coal seam conditions. Fracture geometry is important in determining the effectiveness of gas recovery. Coal contains natural fractures known as cleats, which extend vertically and horizontally in a coal seam, giving coal its “blocky” nature. However, these cleats do not individually extend vertically or laterally over large distances. Consequently it is essential to create and maintain open fractures which widely transect these natural cleats in the coal to promote the transport of fluids from the coal reservoir. The propagation and orientation of these fractures is controlled primarily by the orientation of the major fracture system in the coal, and the orientation of the horizontal stress field existing in the coal.

There is evidence that the confinement of hydraulically created fractures in the coal seam, and minimising penetration into the roof and floor of the seam depends very largely on the in-situ strength contrast (relative hardness) between the coal and the bounding rock layers.

The Gloucester Gas Project is in the exploration phase and activities proposed in the study area are expected to include geotechnical and seismic studies to identify the nature of fractures within the target coal seams and overlying materials. A geophone monitoring study will also be conducted in a nearby well during the fracture process to monitor the geometry of fracture growth in the first well to be fracture stimulated.

There is a risk that faults offer the potential for communication between rock strata. However, the pressure or force of overlaying geological layers, combined with overall regional compression of the Gloucester Basin, reduces that risk.

In addition, the geological structure of the Gloucester basin within the Stage 1 Development, where AGL activities are proposed, has been carefully examined to identify areas where faulting has occurred. Areas where high angle faults occur have been avoided as they compartmentalise the coal seams and restrict the drainage radius of any proposed wells. Low angle vertical faults, while also contributing to compartmentalisation, do not break up the reservoir to the same degree as high angle faults and can be safely accommodated during the drilling and hydraulic fracture stimulation of wells.

Notwithstanding the low risk that low angle faults pose, AGL has mapped the fault zones in the vicinity of the Waukivory pilot wells through the use of 3D seismic and wellbore imagers. This allows AGL to target coal seams for hydraulic fracture stimulation that are not located adjacent to these fault zones, thereby further reducing the risk.

Additional mitigation will include real time monitoring of the fracture movement captured by the use of a geophone network in a nearby monitoring wells for the first well that will be treated. This allows AGL to accurately tailor its fracture treatment program for the remaining three wells where the geophone network is unable to be used. Real-time monitoring will still be conducted utilising the methods described in the FSMP. The geophone network detects vibrations of the fracture pathway and relays this information back to the hydraulic fracture stimulation engineer to monitor the progress, including whether the fracture pathway is migrating into unscheduled locations. The hydraulic fracture stimulation engineer can adjust the way the fracture is progressing based on this real time information by changing the pump rate or, if necessary, shutting down the activity.

On the basis of the available information there is a very low probability that strata above and below the coal seams would be affected. AGL will carefully engineer and manage their hydraulic fracture stimulation activities to ensure that produced fractures would not significantly penetrate the strata both above and below the coal seams, and the possibility of them affecting fresh water alluvial aquifers, located more than 200m above the fracture stimulation interval, is negligible.

2.4 Potential Impact of Operations

The focus of this report is on the potential for chemicals used in hydraulic fracturing operations to be of concern to human health or the environment. Hence AGL hydraulic fracturing operation methods and procedures (outlined above and presented in the AGL Fracture Stimulation Management Plan) have been reviewed further in conjunction with the available information on the study area to identify and evaluate the potential for impacts to occur and be of potential significance. **Table 6** presents a summary of the potential Impacts identified.

Other impacts associated with CSG operations (associated with earthworks, traffic and construction) are separately evaluated and managed/addressed by AGL. While these activities have the potential to result in impacts to the environment, they are not related to the use of hydraulic fracturing chemicals and are not further evaluated in this assessment.

Table 6 Summary of Potential Risks and Likelihood - Hydraulic Fracture Stimulation Activities

Development Phase and Potential Impacts	Likelihood*	Comments and Management Measures
Well Construction/Hydraulic Fracture Stimulation/Production		
Risk that CSG operations result in contamination of upper aquifers that are relevant to regional beneficial uses (irrigation, stock water, baseflow returns to streams)	1	As outlined in **Section 1.4**, the underlying geology creates a hydraulic barrier between the target Coal Measures and the upper alluvial and naturally fractured rock aquifers. It is noted that gas production would be severely compromised if water inflow from other formations were to occur; hence best practice is to ensure no communication between the gas production zone and overlying or underlying water bearing zones.
Risk that hydraulic fracture stimulation of target coal seam results in vertical fractures that result in increased permeability or interconnectivity between target coal seam and upper aquifers resulting in contamination of these upper, more shallow aquifers where regional beneficial uses (irrigation, stock water, baseflow returns to streams) may be important	1	As outlined in **Section 2.2.2** the methodology for well construction makes it highly unlikely that any interconnection between aquifers will be created during well construction. The target coal seam is expected to be well isolated. Wells have been drilled and casing has been pressure cemented consistent with the current Code of Practice - Well Integrity standards. Cement Bond Logs are run to ensure coal seam is well isolated.
Risk that storage and handling of hydraulic fracture stimulation fluids may result in exposure by workers involved in fracture stimulation activities	1	AGL occupational health and safety protocols are employed to manage and mitigate workplace exposure risks.
Risk that accidental spillage of hydraulic fracturing fluids may result in exposures by workers and/or runoff to the adjacent environment (terrestrial or local aquatic environments where present)	2	AGL operational procedures are in place to minimise the potential for these impacts to occur. In accordance with the AGL Dangerous Goods and Hazardous Materials Sub Plan, fluids are stored in bunded areas with onsite spill kits, all onsite personnel wear necessary PPE, well siting requirements ensures that fracture stimulation wells are not located within 40 m of a creek, flowback water is stored within lined ponds or aboveground tanks that are not affected by rainfall (including flooding), a Soil and Surface Water Management Plan, Emergency Response Plan and Flood Management Plan has been developed and implemented by AGL for all operations to mitigate the potential for any runoff to adjacent environments.
Risk that accidental release of flowback water from CSG well or from storage tanks resulting in exposure to workers and/or runoff to the adjacent environment (terrestrial or local aquatic environments where present)	2	

* Refer to **Table 2** for description of these indicators

On the basis of the above, the pathways by which chemicals used in hydraulic fracturing activities may be released to the environment where exposures may occur by aquatics and terrestrial receptors, workers and other members of the public is via accidental spill and releases of fluids, products and flowback water. These accidental spills and releases occur as a result of aboveground operations and may result in direct exposures. No pathways of exposure have been identified by which subsurface operations associated with hydraulic fracturing can result in the discharge or release of chemicals to an overlying freshwater aquifer that may be used for any beneficial use or discharge to a receiving waterbody.

Based on the implementation of a range of risk management measures by AGL, accidental spills and releases of these chemicals/fluids is considered to be unlikely.

While unlikely, the potential for chemicals released to result in harm to human health or the environment has been evaluated further in the following section.

Section 3 Chemical Hazard Assessment

3.1 General

The review presented in this report has focused on chemicals proposed to be used in future hydraulic fracture stimulation activities in the study area.

3.2 Consideration of National Water Quality Management Strategy

The National Water Quality Management Strategy provides policies, processes and national guidelines for the purpose of managing water resources to meet current and future needs in Australia. The overall policy objective of the strategy is "*achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development*."

This strategy and associated guidelines, address a wide range of issues associated with water quality. More specifically guidelines have been established to assist in the assessment, protection and management of beneficial use and environmental water quality. The guidelines refer to effluent quality in the context of discharges from a water treatment plant, industry or a process. Effluent more broadly is considered to be any wastewater discharge. Hence in this context water that is used in the hydraulic fracturing process, in particular, the flowback water that is extracted from the well, can be considered to be effluent. The produced water that follows is considered more of a resource as it can be beneficially reused.

Effluent discharges from a process are required to be assessed and evaluated in accordance with the relevant guidelines within the National Water Quality Management Strategy. For most effluents, including those from hydraulic fracturing, the relevant guideline is the ANZECC & ARMCANZ Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000). These guidelines are relevant to the assessment of effluent discharges into an environment and include water quality criteria that are based on the protection of fresh or marine environments as well as a framework for the assessment of other stressors and toxicants where guidelines are not available.

The assessment of potential effects associated with effluent discharges incorporates evaluation of toxicity as well as the management of discharges. Regardless of toxicity if an effluent does not discharge to an aquatic environment through effective management of wastewater, then the objectives of the National Water Quality Management Strategy are effectively met. Similarly if the toxicity of the effluent discharge is sufficiently low to meet the desired level of protection for the environment then the objectives are effectively met. Both these aspects, potential for discharge to an environment and toxicity are evaluated in this assessment consistent with the requirements of the National Water Quality Management Strategy.

Within the ANZECC (2000) guidelines a tiered approach to the assessment of effluent toxicity is presented. This ranges from the default approach of comparing water quality with available water quality guidelines relevant to the level of environmental protection, derivation of water quality guidelines where published values are not available, evaluation of local reference data (i.e. background information on the local environment) and collecting local biological effects data (such as conducting more specific ecological tests including direct toxicity assessment). Where effluents being discharged to an environment are being evaluated it is important that more detailed local

biological effects testing be undertaken. However, where effluent is not discharged to the environment (or the potential for discharge is essentially low to negligible (associated with accidental spills only) as is the case in this assessment, refer to **Section 2.4**) it is appropriate that the potential toxicity of the effluent be evaluated just using the standard approach based on the water quality guidelines (published or derived from available studies). This approach has been adopted in this assessment, where the toxicity of the individual chemical and the chemicals as a mixture have been evaluated, as outlined in the following section. Further refinement of the risk assessment is not necessary given the low potential for this effluent to reach the environment (being either local surface water resources or the underlying shallow groundwater).

3.3 Chemical Information

The following chemicals are proposed to be used by AGL during the fracture stimulation activities.

Volumes and Constituents in Proposed Fracture Stimulation Fluid for Waukivory Pilot

(Based on information provided by AGL's service provider)

Compound Present	Product	Purpose	Well Pre-Treatment[1]	Treated Water	Linear Gel	Cross-Linked Gel	Indicative Quantity[2]
			% volume of compound in fluid				(litres)
Water	H_2O	Main Fracture Fluid	88.12%	99.81%	99.65%	99.53%	5,988,194
Hydrochloric Acid	HCl	Clean Perforations and Casing	10.88%	-	-	-	870
Citric Acid	FE-2	Iron Sequesterant	0.36%	-	-	-	29
Ground Coffee Beans	HAI-150E	Corrosion Inhibitor	0.04%	-	-	-	3
Acetic Acid	Acetic Acid	pH Adjusting Agent	0.60%	0.03%	0.03%	0.03%	1,848
THPS Tetrakis(hydroxymethyl) Phosphonium Sulfate[3]	Tolcide PS75	Bactericide	-	0.01%	0.01%	0.01%	450
Guar Gum	WG-36	Gelling Agent	-	-	0.16%	0.16%	7,513
Hemicellulase Enzyme 15%, Carbohydrate 85%	GBW-30	Gel Breaker	-	-	<0.01%	<0.01%	92
Choline Chloride	Choline Chloride	Clay Stabiliser	-	0.15%	0.15%	0.15%	9,000
Monoethanolamine borate	BC-140C	Cross-Linker	-	-	-	0.11%	-
Sodium Hydroxide	Caustic Soda	pH Buffer	-	-	-	0.01%	-
Total			100.00%	100.00%	100.00%	100.00%	6,008,000

Indicative Volume of Fluid[2]	Well Pre-Treatment[1]	Treated Water	Linear Gel	Total Treatment
Average per well (L)	2,000	350,000	1,150,000	1,502,000
Total for all 4 wells (L)	8,000	1,400,000	4,600,000	6,008,000

Quantity of Proppant - quartz silica sand	Total Treatment
Average per well (kg)	206,750
Total for all 4 wells (kg)	827,000

Notes:

[1]Well pre-treatment is conducted to clean casing and perforations prior to fracture stimulation.

[2]The volumes of each fluid are indicative only and actual volumes cannot be determined until fracture stimulation treatment occurs. This is because during the fracture stimulation treatment AGL monitors the fracture growth using a variety of diagnostic tools. This allows AGL to analyse the fracture geometry and fine-tune the final volumes. In addition, information gained from the initial treatments will enhance design of subsequent treatments.

[3]As an alternative to using THPS as a bactericide, AGL may use product BE-7 (a mixture of sodium hypochlorite and sodium hydroxide) in treated water, that will be used in the linear gel and cross-linked gel recipes at a concentration by volume of 0.015% sodium hypochlorite and 0.001% sodium hydroxide, which will represent a total volume of 900 litres sodium hypochlorite and 60 litres of sodium hydroxide. The HHERA Table 8 has also assessed these compounds in the alternative bactericide.

To assist in the evaluation of the potential for the chemicals used in hydraulic fracture stimulation operations to be of concern with respect to the human health or the environment, the following information has been compiled and reviewed:

Physical/Chemical Data

Physical and chemical information on the chemicals were obtained from the following sources:

- Material Safety Data Sheets (MSDS) provided by AGL's service provider for the products proposed to be used in hydraulic fracturing operations (included in **Appendix B**);
- Hazardous Substances Databank (HSDB), accessed from February 2012 to March 2013;
- Published chemical reviews or assessment reports (as referenced for each chemical);
- Modelled from the USEPA (2009) EPISUITE (Estimation Programs Interface Suite, Version 4.10, 2011). This program incorporates USEPA peer-reviewed modelling programs for the estimation of physical/chemical data, environmental fate and ecotoxicity data for organic chemicals.

Environmental Fate and Transport

Fate and Transport of the fracturing chemicals in the environment have been evaluated on the basis of the following:

- Volatility of the compound – potential for the chemical to partition to the vapour phase from water (based on Henry's Law constant) or soil (based on vapour pressure) and hence be present in air at any significant concentration;
- Mobility in the environment – potential to migrate to and discharge to a receiving environment has been evaluated on the basis of the solubility of the compound in water (more soluble compounds prefer to stay in solution and be more mobile) and Koc (the potential for the compound to adsorb to organic matter present in soil or sediments, limiting mobility);
- Potential to accumulate in the food chain or aquatic/terrestrial species – the potential for chemicals to bioaccumulate has been assessed on the basis of calculated bioconcentration

factors (BCF). Where these are not available the potential for chemicals to be considered bioaccumulative has been based on the nature of the chemical to be absorbed and eliminated;

- Potential for degradation in the environment – the potential for degradation to less toxic (or in some cases more toxic) species is of importance. Some chemicals rapidly degrade to non-toxic compounds that regardless of mobility in the environment, will never be of concern. However there are other compounds that degrade more slowly and hence will remain in the environment for longer (potentially resulting in exposure and harm) or they may degrade to more toxic compounds that are more persistent in the environment. The potential for degradation in surface soil and surface water is of most relevance for this assessment.

The overall ranking of potential fate in the environment has been conducted on a qualitative basis using the measures outlined in **Table 1.**

Human Toxicity

The assessment of potential risk issues for human receptors needs to consider:

- occupational risks by workers who may be exposed during use of the chemicals/fluids or managing spill/release incidents. These issues more specifically relate to acute exposures and hazards;
- chronic (long-term) health effects that may be relevant to exposures by all members of the public in the event that concentrations of chemicals are present in soil or groundwater in an area where exposure can occur on a regular basis.

These health effects have been evaluated on the basis of published information from peer-reviewed sources, as identified and selected using enHealth (2012) guidance. It is noted that a number of chemicals have very limited data available and hence the studies available have been further evaluated for the purpose of determining the potential for adverse health effects to be of significance.

Where available, published guidelines for soil and water quality (stock, limited domestic or irrigation water quality) have been identified. More specifically published drinking water guidelines (i.e. concentrations in water that are safe for all members of the population to consume every day for a lifetime) have been identified and considered in this assessment. Where these guidelines are not available and the available published reviews have identified a suitable Tolerable Daily Intake (TDI) or No Observed Adverse Effects Level (NOAEL) this value has been presented and used to derive a preliminary drinking water guideline following guidance provided by the National Health and Medical Research Council (NHMRC, 2011) for the derivation of the Australian Drinking Water Guidelines. This has been undertaken on the basis of the following:

$$Preliminary\ Guideline\ (DWGp) = \frac{TDI\ x\ Body\ Weight\ x\ \%intake}{Water\ Consumption}$$

$$TDI = \frac{NOAEL}{Safety\ Factor}$$

Based on guidance provided by NHMRC (2011), a provisional guideline has been derived on the basis of a body weight of 70 kg, water consumption rate of 2 L/day and a %intake of chemicals from drinking water of 10% (assuming most of the chemicals considered are not common chemicals in the diet). The safety factor adopted would typically depend on a wide range of factors, however for the purpose of this assessment a default factor of 1000 has been adopted (to address intraspecies and interspecies variability and limitations/uncertainties with the database).

All relevant published drinking water guidelines or calculated preliminary drinking water guidelines are presented in **Appendix A**.

The comparison with drinking water guidelines (assuming water consumption) is the most stringent evaluation that is relevant for human health. There is no intention that the water will be used for, or contaminate, drinking water. The only possible exposure pathway is via an accidental spill, as dealt with in the risk analysis table (see **Table 6**).

Where drinking water guideline is available or a preliminary drinking water guideline can be calculated (using the above approach), this has been compared with the potential for the contaminant concentration that is likely to be present in hydraulic fracture stimulation fluids (prior to any dilution). This comparison has then been used in the determination of the potential consequences of exposure (should it occur).

It is noted that there are a number of chemicals where no suitable human health guidelines are available or relevant, hence the evaluation of these chemicals has been undertaken on a qualitative basis only.

The overall ranking of potential acute (occupation) and chronic health effects has been conducted on a qualitative basis using the measures outlined in **Table 1.**

Environmental Toxicity

The potential for adverse effects to a receiving environment to occur has been evaluated on the basis of the available published information/studies in relation to acute and chronic toxicity to species in the environment. Most of the available data relates to aquatic toxicity and this has therefore been assumed to be protective of terrestrial effects.

Toxicity values for ecological receptors for fresh or marine water quality guidelines that are relevant to a 95% protection level have been adopted from Australian guidelines, specifically ANZECC (2000). Where these guidelines are not available, toxicity values derived from relevant ecological studies (referred to as Tox(eco) values) have been identified. These are threshold concentrations in water relevant for the assessment of potential adverse effects in a range of ecological species (refer to **Appendix A** for further detail on the range of Tox(eco) values available for each of the chemicals considered in this assessment).

Where available, and relevant, the identified water quality guideline or Tox(eco) has been compared with the potential concentration that is likely to be present in hydraulic fracture stimulation fluids (prior to dilution). This comparison has assisted in the determination of the potential consequences of exposure (should it occur).

It is noted that there are a number of chemicals where no suitable guidelines are available for evaluating ecotoxicity, hence the evaluation of these chemicals has been undertaken on a qualitative basis only.

The overall ranking of potential environmental effects has been conducted on a qualitative basis using the measures outlined in **Table 1.**

Characterisation of Potential Risk

The potential for risks to be of concern has been evaluated on the basis of the following:

- the handling of chemicals prior to use in hydraulic fracture stimulation activities has been assessed on the basis of potential workplace health and safety risks using the risk ranking as presented in **Table 1**. This evaluation identified chemicals that require additional personal protective equipment (PPE) and care to ensure workers who use the chemicals above-ground are adequately protected;
- in the event of a spill above-ground prior to injection of the fracturing fluid into the well, the potential for adverse human health and environmental risks has been assessed using a worst-case approach assuming that the maximum concentrations present in the fracturing fluid are present in an area where exposure by humans (in drinking water) or the environment may occur, and there is no dilution of the concentrations in any other water body or degradation of any chemicals. This worst-case assessment has been undertaken by calculating a Hazard Index (HI) using the following equations:

$$HI\,(human\ health) = \frac{concentration\ in\ fracturing\ fluid}{drinking\ water\ quality\ guideline}$$

$$HI\,(environmental) = \frac{concentration\ in\ fracturing\ fluid}{water\ quality\ guideline\ or\ Tox(eco)}$$

This calculation has been undertaken to enable a ranking of the potential worst-case consequences of effects should a spill occur (and there is no dilution or degradation).

The final ranking of a human health or environmental hazard has been undertaken on a qualitative basis and has considered the calculated HI as well all available information in relation to the nature of the adverse effects identified following exposure, and the potential for such exposures to occur over a long period of time (i.e. more than a year where the exposure is considered to be chronic) based on the behaviour of the chemical once it is in the environment. This is important as most of the human health and ecological guidelines adopted are based on chronic (long-term) exposures to these chemicals.

The final risk ranking has then been determined on the basis of the consequences as outlined in **Table 1**.

- evaluation of potential risks based on the consequences (as calculated above) and likelihood of the event (connection between groundwater aquifers or a spill) occurring (based on the likelihood descriptors as outlined in **Table 2**). This evaluation takes into account policies and procedures adopted by AGL in the conduct of all aspects of fracture stimulation activities and utilises the risk matrix as described in **Table 4**.

3.4 Summary of Chemical Reviews

3.4.1 General

Appendix A presents a summary of all the available information considered in relation to the parameters outlined in **Section 3.2** and the values relevant to the assessment of potential hazard as outlined in **Section 3.3**.

It is noted that there are a number of products used in hydraulic fracture stimulation activities that are insoluble solids where the only hazard relates to occupational exposures during use. For the products proposed to be used this includes quartz silica including crystobalite (sand) which is used to prop open fractures in the subsurface (not expected to be present in flowback water) and the inhibitor (ground coffee beans, refer to MSDS for the product FE-2).

Some of these products require specific use of personal protective equipment (PPE) to ensure worker health and safety. Use of such PPE is addressed at an operational level by AGL. If spilled, these solids do not leach or migrate and can be readily and easily cleaned up (as per AGL operational requirements). Hence no further detailed evaluation of impacts to human health or the environment has been presented for these products.

3.4.2 Occupational Assessment of Hazard

Based on the available data **Table 7** presents a summary of the hydraulic fracture stimulation chemicals that are ranked from 1 (negligible) to 4 (high) and require varying levels of PPE to ensure occupational exposures are appropriately addressed.

Table 7 Summary of Occupational Hazard Analysis of Chemicals used in Hydraulic Fracturing Activities

Compound	Occupational Hazard Ranking
Moderate to High Hazards – Transient to permanent health effects that may require medical treatment (or disability) and require moderate to high level of PPE, monitoring and management	
Hydrochloric acid	3-4
Sodium hypochlorite	3-4
THPS (Phosphonium, Tetrakis (Hydroxymethyl)-Sulfate)	3-4
Sodium hydroxide	3-4
Moderate Hazards – Transient effects that may require medical attention and include respiratory and more significant irritation effects that need to be managed with moderate level PPE.	
Citric acid	3
Acetic acid	3
Hemicellulase enzyme concentrate	3
Low to Moderate Hazards – minor nuisance effects including low level irritation that requires to low level PPE to more transient effects that may require medical attention and include respiratory and more significant irritation effects that need to be managed with moderate level PPE	
Monoethanolamine Borate	2-3
Negligible to Low Hazards – low to minor nuisance effects including low level irritation that may require low level PPE	
Guar gum	2
Choline chloride	1-2

* Refer to **Table 1** for descriptions of these ranking scores

3.4.3 Human Health and Environmental Hazard Assessment

In relation to hazards to human health and the environment in the event that hydraulic fracturing fluids containing the chemicals evaluated are spilled at the ground surface (prior to injection into the well), a worst-case assessment of potential hazards has been undertaken based on potential impacts to human health (non-occupational) and the environment. This has been undertaken following the approach outlined in **Section 3.3**.

The detailed information relevant to each chemical considered is summarised in **Appendix A**. **Table 8** presents a summary of key ranking and quantitative values presented in **Appendix A** as well as the calculated HI for human health and environmental hazards. It is noted that the HI calculated for human health and environmental hazards is a worst-case calculation relevant to potential exposure that may occur prior to any dilution, sorption to soil/sediments or degradation in the environment.

Table 8 Summary of Human Health and Environmental Hazard Analysis of Chemicals used in Hydraulic Fracturing Activities – Based on Chemicals at Point of Injection

Compound	Concentration in hydraulic fracture stimulation fluid before injection in well (mg/L)	Potential for Off-Site Migration (fate and transport in environment)	Human Health Evaluation – Worst-case			Ecological Health Evaluation – Worst-case		
			Drinking Water Guideline (mg/L)	HI	Hazard Ranking	Water Quality Guideline or Tox(eco) (mg/L)	HI	Hazard Ranking
Citric acid	5991	2	15	400	2	85 to1535[T]	70 to 4	2
Hydrochloric acid	128,205	2	Based on pH	NA	2-3	Based on pH	NA	3
Guar gum	2397	1	NA	NA	1	NA	NA	1
Hemicellulose enzyme concentrate	4.5	1	NA	NA	1	NA	NA	1
Acetic acid	314	2	NA	NA	1	32 to 300[T]	10 to 1	2
THPS (Phosphonium, Tetrakis (Hydroxymethyl)-Sulfate)	110	2	0.126	870	4	0.06 to 24[T]	>1500 to 4.5	4
Sodium hypochlorite	181	2	0.3 for chlorite	600	3	0.028 to 0.71[T]	>6000 to 250	4
Sodium hydroxide	12 to 103 (X-link gel)	1-2	Based on pH	NA	2-3	Based on pH	NA	3
Monoethanolamine borate	0 to 1250 (X-link gel)	2-3	4 (boron)	0 - 312	3	0.37 (boron) to 5000[T]	>3000 to 0.25	3
Choline chloride	1632	2	12250	0.1	1	3.5[T]	466	3

Notes:

Refer to **Appendix A** for more detail on each chemical and explanations on the basis for the risk ranking selected for fate and transport in the environment, human health and environmental hazards.

T = range of concentrations based on the range of data available from relevant ecotoxicological studies considered as Tox(eco) values (refer to **Appendix A** for further details on these values).

NA = not applicable on the basis of the following reasons:

- The only effects identified relate to the pH of the chemical (acid or alkali) and hence there are no quantitative human health or ecological values that are based on a concentration of the chemical in water. No HI can be calculated. The ranking of risk has therefore been undertaken on a qualitative basis as presented in **Appendix A**.

- The compound is not toxic to humans and/or the environment at any dose in all the studies undertaken. Hence there are no quantitative values that can be used to calculate a HI.

To further assist in understanding the approach outlined in **Table 8**, the following presents a worked example for citric acid:

- In relation to the behaviour of citric acid in the environment the following was concluded in **Appendix A**:

  *The compound does not sorb to soil or particles in the water column, is readily and rapidly degraded and does not bioaccumulate - potential for discharge to receiving environment is low – this is risk ranking 2 (as per **Table 1**)*

- In relation to evaluating human health hazards the following was undertaken:

  - The review conducted in **Appendix A** did not identify any published drinking water guidelines for citric acid, however a preliminary drinking water guideline of 15 mg/L could be derived (as outlined in **Section 3.3**)
  - The concentration of citric acid in hydraulic fracturing fluids was 5991 mg/L.
  - The calculated HI (using the equations in **Section 3.3**) is 5991/15 = 399.4, which can be rounded up to 400.
  - Based on this value and with consideration of the nature of the human health effects relevant for ingestion of citric acid the following was concluded, in **Appendix A**, in relation to ranking of the hazard:

    *While the concentration in hydraulic fracturing water may exceed the provisional guideline, citric acid is used in many food products with no upper limit set by the WHO or FSANZ,, hence the risks have been considered low – this is risk ranking 2 (as per **Table 1**)*

- In relation to evaluating environmental hazards the following was undertaken:

  - The review conducted in **Appendix A** did not identify any published water quality guidelines (for fresh or marine waters), however the available ecotoxicological studies identified a range of Tox(eco) values that ranged from 85-1535 mg/L.
  - The concentration of citric acid in hydraulic fracturing fluids was 5991 mg/L.
  - The calculated HI (using the equations in **Section 3.3**) ranges from 5991/85 = 70, to 5991/1535 = 3.9 which can be rounded up to 4.
  - Based on this value and with consideration of the nature of the ecological effects relevant for the presence of citric acid in the environment concluded, in **Appendix A**, in relation to ranking of the hazard:

    *As citric acid is readily degraded the potential for ecological impacts is considered to be low – this is risk ranking 2 (as per **Table 1**)*

On the basis of **Table 8**, in the event that hydraulic fracture stimulation fluid were spilled at the ground surface and were released into the environment the following presents a summary of the

chemicals that have been identified to pose a high to negligible risk to human health (non-occupational) or the environment.

Table 9 Summary of Human health and Environmental Hazard Rankings for Hydraulic Fracturing Chemicals (in the event of surface spill)

Consequence Descriptor	Off-Site Impacts to Human Health	Off-Site Impacts to the Ecosystem
Negligible (1)	No adverse long-term health effects associated with low level environmental exposures:	Negligible potential for adverse effects on aquatic ecosystem:
	Guar gum Hemicellulose enzyme concentrate Acetic acid Choline chloride	Guar gum Hemicellulose enzyme concentrate
Low (2)	Minor transient health effects or odour:	Low potential for adverse effects on aquatic ecosystem:
	Citric acid	Citric acid Acetic acid
Moderate (2-3 and 3)	Transient effects that may require medical treatment such as respiratory effects, more significant irritation:	Moderate potential for adverse effects on aquatic ecosystem:
	Hydrochloric acid Monoethanolamine borate Sodium hypochlorite Sodium hydroxide	Hydrochloric acid Monoethanolamine borate Sodium hydroxide Choline chloride
High (3-4 and 4)	Permanent health effects that require extended medical treatment and/or permanent disability:	High potential for adverse effects on aquatic ecosystem:
	THPS (Phosphonium, Tetrakis (Hydroxymethyl)-Sulfate)	Sodium hypochlorite THPS (Phosphonium, Tetrakis (Hydroxymethyl)-Sulfate)

Review of **Tables 8 and 9** indicates that most of the chemicals utilised in hydraulic fracturing operations are associated with negligible to low/moderate hazards to human health and/or the environment. There are some chemicals that are of greater concern (including sodium hypochlorite, THPS, sodium hydroxide, monoethanolamine borate, hydrochloric acid and choline chloride) should they be released directly to an environment (where they may be present in undiluted fracturing fluids) where exposure may occur. The overall risk of the use of these chemicals depends not only on theses hazards, but the likelihood that exposure may occur. This is further discussed in the following section.

Section 4 Risk Characterisation/Assessment

The evaluation of potential risks associated with the use of chemicals in proposed hydraulic fracture stimulation activities in the Gloucester Gas Project has been evaluated on the basis of the risk assessment matrix presented in **Section 1.2.5** and the following information:

- available information in relation to the study area;
- chemicals proposed to be used in hydraulic fracture stimulation activities;
- the likelihood that chemicals used in hydraulic fracture stimulation activities may be discharged to an environment where there is the potential for some level of exposure (human or ecological) (presented in **Table 6**); and
- the hazards (human health and ecological) identified for these chemicals (summarised in **Tables 7 to 9**).

While a range of hazards have been identified in relation to the behaviour of the evaluated chemicals in the environment, occupational/acute hazards, chronic health effects and ecological impacts, the likelihood that any of these chemicals may be discharged into an environment where any level of exposure may occur has been evaluated as highly unlikely (no exposure pathway is present) or unlikely (in relation to the potential for accidental spills or releases of chemicals in fluids or flowback water). These evaluations are summarised on the risk matrix presented in **Table 10** (refer to **Tables 3 and 5** for risk definitions).

Table 10 Summary of Overall Risk Ranking for Chemicals used in Hydraulic Fracture Stimulation Activities

				Consequence →				
				Negligible	Low	Moderate	High	Severe
				Potential for Off-Site Impacts - Fate and Transport	Chemical degrades rapidly under all conditions, is not bioaccumulative or taken up into the food chain	Chemical is somew hat mobile, degrades slow ly (or only under some conditions), is not bioaccumulative or taken up into the food chain	Chemical is mobile, degrades slow ly, is not bioaccumulative or taken up into the food chain	Chemical is mobile, persistent, has the potential for low to moderate bioaccumulation in aquatic species or food chain	Chemical is mobile, persistent, has the potential for high to very high bioaccumulation in aquatic species or food chain
					1	2	3	4	5
				Off-Site Human Health Issues (chronic)	No adverse long-term health effects associated w ith low level environmental exposures	Minor transient health effects or odour	Transient effects that may require medical treatment such as respiratory effects, more significant irritation	Permanent health effects that require extended medical treatment and/or permanent disability	Death or significant injury likely to result in death
					1	2	3	4	5
				Off-Site Impacts to Aquatic Ecosystem	Very low potential for adverse effects on aquatic ecosystem	Low potential for adverse effects on aquatic ecosystem	Moderate potential for adverse effects on aquatic ecosystem	High potential for adverse effects on aquatic ecosystem	Very high potential for significant adverse effects on aquatic ecosystem
					1	2	3	4	5
					Negligible	Low	Moderate	High	Severe
Likelihood of Exposure at Receptor ↑	Confirmed connection betw een coal seam and receiving environment, confirmed use of aquifer or direct discharge to environment/ecosystem	very likely	5	N	L	M	H	E
	Likely connection betw een coal seam and receiving environment, potential use of aquifer or discharge to local environment/ecosystem	likely	4	N	L	M	H	E
	Possible connection betw een coal seam and receiving environment, possible use of aquifer, limited management measures in place to prevent surface spillage (hence possible for surface spills to reach environment)	possible	3	N	L	M	M	H
	Unlikely connection betw een coal seam and a receiving environment, no use of aquifers for any purpose, management measures in place that make spills at ground surface unlikely	unlikely	2	N	L	L	L	L
	No connection betw een coal seam and receiving environment and management measures in place to prevent surface spills	highly unlikely	1	N	N	N	N	N

On the basis of the assessment presented, the following can be concluded in relation to risks associated with the proposed use of chemicals in hydraulic fracture stimulation activities:

- Risks to human health and the environment are considered to be negligible or low;
- The highest identified risk level is low which is considered to be a level of risk that can be adequately managed through the implementation of existing operational management measures. This is currently conducted as outlined in the Fracture Stimulation management Plan NSW (prepared by AGL 2013) and associated management plans. The identified level of risk is supported by reviews of former operations where controls have been implemented to ensure that should a spillage occur it would be minor in nature.
- No significant risk issues have been identified that require detailed quantification of risk.
- Based on the available information there are no pathways by which hydraulic fracture stimulation fluids injected into the CSG well can migrate to any freshwater body that may be of importance with respect to future beneficial uses of these freshwater aquifers or the discharge of water into aquatic environments. Hence there is no specific requirement identified for the detailed assessment of chemical recovery in flowback water. However, good environmental practice in CSG operations supports that AGL adopt a suitable approach to demonstrate chemical recovery in flowback water. AGL propose to monitor flowback water chemistry to determine when transition to produced water occurs. Flowback water will be chatacterised and lawfully disposed of to an appropriate facility.

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Appendix A Proposed Hydraulic fracturing Chemical Summaries

Volumes and Constituents in Proposed Fracture Stimulation Fluid for Waukivory Pilot

(Based on information provided by AGL's service provider)

Compound Present	Product	Purpose	Well Pre-Treatment[1]	Treated Water	Linear Gel	Cross-Linked Gel	Indicative Quantity[2]
			% volume of compound in fluid				(litres)
Water	H_2O	Main Fracture Fluid	88.12%	99.81%	99.65%	99.53%	5,988,194
Hydrochloric Acid	HCl	Clean Perforations and Casing	10.88%	-	-	-	870
Citric Acid	FE-2	Iron Sequesterant	0.36%	-	-	-	29
Ground Coffee Beans	HAI-150E	Corrosion Inhibitor	0.04%	-	-	-	3
Acetic Acid	Acetic Acid	pH Adjusting Agent	0.60%	0.03%	0.03%	0.03%	1,848
THPS Tetrakis(hydroxymethyl) Phosphonium Sulfate[3]	Tolcide PS75	Bactericide	-	0.01%	0.01%	0.01%	450
Guar Gum	WG-36	Gelling Agent	-	-	0.16%	0.16%	7,513
Hemicellulase Enzyme 15%, Carbohydrate 85%	GBW-30	Gel Breaker	-	-	<0.01%	<0.01%	92
Choline Chloride	Choline Chloride	Clay Stabiliser	-	0.15%	0.15%	0.15%	9,000
Monoethanolamine borate	BC-140C	Cross-Linker	-	-	-	0.11%	-
Sodium Hydroxide	Caustic Soda	pH Buffer	-	-	-	0.01%	-
Total			100.00%	100.00%	100.00%	100.00%	6,008,000

Indicative Volume of Fluid[2]	Well Pre-Treatment[1]	Treated Water	Linear Gel	Total Treatment
Average per well (L)	2,000	350,000	1,150,000	1,502,000
Total for all 4 wells (L)	8,000	1,400,000	4,600,000	6,008,000

Quantity of Proppant - quartz silica sand	Total Treatment
Average per well (kg)	206,750
Total for all 4 wells (kg)	827,000

Notes:

[1]Well pre-treatment is conducted to clean casing and perforations prior to fracture stimulation.

[2]The volumes of each fluid are indicative only and actual volumes cannot be determined until fracture stimulation treatment occurs. This is because during the fracture stimulation treatment AGL monitors the fracture growth using a variety of diagnostic tools. This allows AGL to analyse the fracture geometry and fine-tune the final volumes. In addition, information gained from the initial treatments will enhance design of subsequent treatments.

[3]As an alternative to using THPS as a bactericide, AGL may use product BE-7 (a mixture of sodium hypochlorite and sodium hydroxide) in treated water, that will be used in the linear gel and cross-linked gel recipes at a concentration by volume of 0.015% sodium hypochlorite and 0.001% sodium hydroxide, which will represent a total volume of 900 litres sodium hypochlorite and 60 litres of sodium hydroxide. The HHERA Table 8 has also assessed these compounds in the alternative bactericide.

Chemical summaries for compounds identified in hydraulic fracturing fluids

List of acronyms:

Utilised in evaluation of human health effects:

LD50	Lethal dose required to cause death in 50% of the (non-human) species evaluated (used to evaluate acute toxicity of chemicals)
TDI	Tolerable daily intake
NOAEL	No observed adverse effect level
DWG	Drinking water guideline
pDWG	Preliminary drinking water guideline (calculated where no published value is available)

Utilised in evaluation of environmental effects:

PNEC	Predicted no-effect concentration
EC	Effects concentration, typically expressed as the concentration that results in effects in a percentage of test organisms in a given population under a defined set of conditions. Hence there are the following levels of effects concentrations: EC50 = this is also known as the median effective concentration and is the statistically derived concentration of a substance in an environmental medium expected to produce a certain effect in 50% of test organisms
LC	Lethal concentration, typically expressed as the concentration that results in death of a percentage of test organisms in a given population under a defined set of conditions. LC50 = this is the statistically derived concentration of a substance in an environmental medium expected to produce death in 50% of test organisms

EC50/LC50 are often used in ecotoxicology as an indicator of the toxicity of a compound to the environment.

NOEC	No observed effect concentration (NOEC) – the highest concentration of a compound to which organisms are exposed in a full life-cycle or partial-cycle (short-term) test that causes no observable effects on the test organisms. This is often used to estimate chronic toxicity of chemicals.

In the main report the various ecotoxicological measures available have been more generally referred to as **Tox(eco)** values, which is an abbreviation for toxicity (ecological species) value.

Compound		Citric acid	
Proposed concentration in hydraulic fracturing fluid (mg/L)		5991 mg/L (approx.)	AGL
MSDS Available		Yes	
Listed on AICS		Yes	
NICNAS Evaluation		Not assessed but listed as Priority Existing Chemical	
CAS No.		77-92-9	M
Molecular Formula		C6-H8-O7	H
Colour/ Form		white powder or granules	M
Odour/ Taste		odourless, strong acidic taste	M
Odour Threshold		NA	
Corrosive		No	M
Explosive		No	M
Irritation		Mild irritant to skin and eyes	M
Stability		Stable	M
Incompatibility		organic acids, strong alkalis, strong oxidisers	M
Solubility		water, ethanol, ether, ethyl acetate	
Solubility (mg/L in water (20-25^{o}C)		3.83E+05	H
Molecular weight		192.12	H
pH		2 to 2.2	M
Vapour Pressure (mmHg at 20-25^{o}C)		1.70E-08	H
Vapour Density (air = 1)		NA	
Henry's Law (atm.m^{3}/mol at 20-25^{o}C)		4.30E-14	H
Volatility potential	Soil	Very low	
	Water	very low	
Log Kow		-1.64	H
Koc		3.1	H
Soil Adsorption/ Mobility		highly mobile	
Potential for bioaccumulation (BCF)		3.2 - low	H
Degradation potential	Soil	May be biodegraded with degradation observed in sludge over 1-42 days	H
	Water	Readily biodegradable in aquatic environments (within 5 days)	H
Comments			
Ranking - Fate and Transport		The compound does not sorb to soil or particles in the water column, is readily and rapidly degraded and does not bioaccumulate - potential for discharge to receiving environment is low	**2**

Compound		Citric acid	
Human Health			
General		Citric acid is a water soluble organic solid. It is a natural substance that appears as an intermediate in the basic physiological citric acid or Krebs cycle in every eukaryote cell. Citric acid has been produced for many years in high volumes. It has wide dispersive use, being added to processed food and beverages, used in pharmaceutical preparations and in household cleaners as well as in special technical applications.	OECD
Acute Effects		Based on many experimental data in animals and on human experience, citric acid is of low acute toxicity. The primary acute effects are related to irritation of the eyes, respiratory tract and skin. LD50 ranges from 2700 to 12000 mg/kg	H, M, OECD
Occupational Inhalation Guidelines (mg/m3)	**TWA**		
	STEL	NA	
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate where appropriate PPE is required for the use of this chemical	**3**
Chronic Effects		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as low where appropriate PPE is required for the use of this chemical	
		Citric acid is recognised by Food Standards Australia New Zealand (FSANZ) and the WHO JECFA as safe as a multipurpose food additive. No upper limit of concentrations has been established in food products.	
Classifications		Acetic acid has not been classified by International Agency for Research on Cancer (IARC) or the United States Environment Protection Agency (USEPA). The few studies that are available have not shown that acetic acid is carcinogenic, mutagenic or teratogenic in animal studies.	
Guidelines	**Soil**	NA	
	Drinking water	NA	
	NOAEL	4000 mg/kg/day based on repeated dose oral study	OECD
	NOAEL	425 to 7500 mg/kg/day based on reproductive effects	OECD
	DWGp	15 mg/L (calculated on the basis of the lowest NOAEL and equation in report, however note that the available studies in relation to effects are limited hence this calculation is conservative.	

Compound		Citric acid	
Ranking - Chronic Health Impacts		While the concentration in hydraulic fracturing water may exceed the provisional guideline, citric acid is used in many food products with no upper limit set by the WHO of FSANZ, hence the risks have been considered low.	**2**
Ecological			
General		A large number of studies are available in relation to the ecological toxicity of citric acid. Citric acid is extremely widespread in nature and widely distributed in plants and animal tissues and fluids. The following presenting a general summary	OECD
Aquatic toxicity data (mg/L)	**LC50 = 440-1516**	acute toxicity to fish species	OECD, M
	EC50 = 85-1535	acute toxicity to aquatic invertebrates	OECD
	EC = 1 -300	toxicity to aquatic plants	OECD
	NOEC = 80 - 625	chronic toxicity in aquatic invertebrates and fish	OECD
	Tox(eco)	85 to 1535 mg/L	
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	
Ranking - Ecological Impacts		As citric acid is readily degraded the potential for ecological impacts are considered to be low	**2**

OECD 2000, Citric Acid. SIDS Initial Assessment Report, UNEP November 2000.
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound	Hydrochloric acid	
Proposed concentration in hydraulic fracturing fluid (mg/L)	128205 mg/L (approx.)	AGL
Listed on AICS	yes	
NICNAS	Not assessment but is classified under NOHSC	
CAS No.	7647-01-0	M
Molecular Formula	Cl-H	H
Colour/ Form	clear, colourless to slightly yellow fuming liquid	M
Odour/ Taste	sharp pungent and irritating odour	M
Odour Threshold	7 mg/m^3	USEPA
Corrosive	Corrosive to metals	M
Explosive	Will react with most metals to evolve hydrogen gas which when mixed with air may result in fire or explosion if ignited	M
Irritation	Irritating to skin and eyes, respiratory system and mouth, oesophagus and stomach, with potential for severe burns	M
Stability	stable	M
Incompatibility	metals	M
Solubility (mg/L in water (20-25^oC)	82.3 g/100g	H
Molecular weight	36.46	H
pH	<1	M
Vapour Pressure (mmHg at 20-25^oC)	26	M
Vapour Density (air = 1)	1.3	M
Henry's Law (atm.m^3/mol at 20-25^oC)	4.90E-10	H
Volatility potential **Soil**	will evaporate	
Volatility potential **Water**	low	
Log Kow	NA	
Koc	NA	
Soil Adsorption/ Mobility	dissociates	
Potential for bioaccumulation (BCF)	negligible	H
Degradation potential **Soil**	rapidly dissociate to chloride and hydronium ions	
Degradation potential **Water**	rapidly dissociates to chloride and hydronium ions	
Ranking - Fate and Transport	The compound does not sorb to soil or particles in the water column, is readily and rapidly dissociated and does not bioaccumulate - potential for discharge to receiving body is low	**2**

Compound		Hydrochloric acid	
Human Health			
General		Health effects from exposure to hydrochloric acid are principally associated with acute exposures in occupational environments. In addition many of the effects reported are associated with the pH of the acid rather than the effects of the compounds themselves.	OECD
Acute Effects		There are few detailed studies reported for human exposure. The irritation of hydrogen chloride to mucous is so severe that workers evacuate from the work place shortly after detecting its odour. A relation between concentrations from accidental exposure and health effects have not been reported in detail. The acute oral lethal dose for 50% of the species (LD50) values were determined to be 238-700 mg/kg bw for rats, and the inhalation lethal concentration in air for 50 % of the species (LC50) values were determined to be 23.7-60.9 mg/L (5min), 5.7-7.0 mg/L (30min) and 4.2-4.7 mg/L (60min) for rats, 20.9 mg/L (5min), 3.9 mg/L (30min) and 1.7 mg/L (30min) for mice. Hydrogen chloride is corrosive to the skin and severe effects can be expected from exposure to the eyes. No skin sensitisation has been reported.	OECD, M
Occupational Inhalation Guidelines (mg/m^3)	**TWA**	NA	S
	Peak	7.5	S
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate to high where appropriate PPE is required for the use of this chemical	**3-4**
Chronic Effects		The available data suggests that effects associated with the low pH of the acid is of most significance in relation to long-term effects. Local irritation effects are most common in long term studies. No evidence of carcinogenic effects were reported during oral, dermal or inhalation studies. No reliable studies are available in relation to the assessment of reproductive or developmental toxicity. Protons and chloride ions are normal constituents in the body fluid of animal species, low concentrations of HCl gas/mist or acid solution do not seem to cause effects. In addition the gastric glands secrete HCl acid into the stomach.	OECD
Classifications		International Agency for Research on Cancer (IARC) has classified hydrochloric acid as a group 3 carcinogen - not classifiable	
Guidelines	**Soil**	NA	
	Drinking water	NA	
	pDWG	NA – not calculated as no health effects identified for the ingestion of this chemical other than those associated with pH.	
Ranking - Chronic Health Impacts		Chronic effects associated with ingestion and dermal contact with this chemical are considered to be low to moderate	**2-3**

Compound		Hydrochloric acid	
Ecological			
	General	The hazard of hydrochloric acid for the environment is caused by the proton (pH effect). For this reason the effect of hydrochloric acid on the organisms depends on the buffer capacity of the aquatic ecosystem. Also the variation in acute toxicity for aquatic organisms can be explained for a significant extent by the variation in buffer capacity of the test medium. For example, LC50 values of acute fish toxicity tests varied from 4.92 to 282 mg/L. It is not considered useful to calculate a guideline for hydrochloric acid because factors such as the buffer capacity, the natural pH and the fluctuation of the pH are very specific for a certain ecosystem. There is a possibility that the emission of hydrochloric acid could locally decrease the pH in the aquatic environment.	OECD, M
Aquatic toxicity data (mg/L)	**EC50**	Lowest values for pH 4.4 to 5.3 based on short-term studies with algae, invertebrates and fish	H
	Tox(eco)	NA – only effects are associated with pH	
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	
Ranking - Ecological Impacts		The potential for ecological effects is considered to be low, however the buffering capacity of the receiving environment may vary and hence the potential for adverse effects is considered to be moderate	**3**

OECD 2002, OECD SIDS Hydrogen Chloride, SIDS Initial Assessment Report, August 2002
USEPA IRIS evaluation of hydrogen chloride
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound	Guar gum	
Proposed concentration in hydraulic fracturing fluid (mg/L)	2397 mg/L (approx.)	AGL
MSDS Available	yes	
Listed on AICS	yes	
NICNAS	Not assessed	
CAS No.	9000-30-0	M
Molecular Formula	NA	
Colour/ Form	off-white solid	M
Odour/ Taste	bean odour	M
Odour Threshold	NA	
Corrosive	No	
Explosive	Airborne dust may be explosive	M
Irritation	May cause eye, skin and respiratory irritation. May cause allergic respiratory reaction	M
Stability	stable	M
Incompatibility	strong oxidisers	M
Solubility	forms gel in water	
Solubility (mg/L in water (20-25oC)	forms gel in water	M
Molecular weight	approx 220000	H
pH	6.5 to 7.5	M
Vapour Pressure (mmHg at 20-25oC)	NA	
Vapour Density (air = 1)	NA	
Henry's Law (atm.m3/mol at 20-25oC)	NA	
Volatility potential – Soil	no	
Volatility potential – Water	no	
Log Kow	NA	
Koc	NA	
Soil Adsorption/ Mobility	NA	
Potential for bioaccumulation (BCF)	NA	
Degradation potential – Soil	Readily degradable in the environment	
Degradation potential – Water		
Comments	Guar gum is a high molecular weight polysaccharide (sugar complex) extracted from the seeds of the guar plant. It is extensively used as a thickener, stabiliser, suspending agent and binder of free water in many food products including non-alcoholic beverages, frozen dairy desserts, baked goods, gelatine, puddings, meat and meat products, condiments a relishes, breakfast cereals, cheeses, milk products, soups, sweet sauces, gravies, snack foods and processed vegetables. It is also used ion medications, in the paper and textile industries and as a flocculant in mining (including hydraulic fracturing and gelling and waterproofing explosives). As a natural sugar complex, if released into the environment guar gum would be readily dispersed and rapidly biodegraded resulting in no impacts to the aquatic and terrestrial environments.	
Ranking - Fate and Transport	On the basis of the chemical properties of guar gum the potential for discharge to a receiving environment is consider to be negligible	1

Compound		Guar gum	
Human Health			
General		Guar gum is very poorly absorbed and digested in the human body, is considered non-toxic and hence is used extensively as filler in food products. No adverse effects associated with human exposures to this product have been identified.	
Acute Effects		Acute effects are primarily associated with eye, skin and respiratory irritation. LD50 (oral) identified to be 6770 mg/kg in rats.	H, M
Occupational Inhalation Guidelines (mg/m3)	**TWA**	NA	
	STEL	NA	
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as low where appropriate PPE is required for the use of this chemical	**2**
Chronic Effects		No adverse effects have been observed in chronic rat studies where guar gum was administered at a dietary concentration of 5% for 24 months. No carcinogenic effects have been observed in any of the available studies. As this compound is widely used in food products with no safety concern, no TDI is available.	
Classifications		NA	
Guidelines	**Soil**	NA	
	Drinking water	NA	
	pDWG	NA – not calculated as no adverse health effects identified	
Ranking - Chronic Health Impacts		The potential for long term human health impacts, should exposure occur, is considered to be negligible	**1**
Ecological			
General		No data is available in relation to ecological effects of guar gum, however as it is a natural sugar complex that is rapidly degraded in the environment, no adverse effects are relevant to terrestrial and aquatic environments.	
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	
Ranking - Ecological Impacts		On the basis of the available information on the nature of the compound, ecological effects have been determined to be negligible.	**1**

M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound		Acetic acid	
Proposed concentration in hydraulic fracturing fluid (mg/L)		314 (approx.)	AGL
Listed on AICS		yes	
NICNAS		No assessment by NICNAS but is classified under NOHSC	
CAS No.		64-19-7	M
Molecular Formula		C2-H4-O2	H
Colour/ Form		Colourless liquid in aqueous solution	M
Odour/ Taste		Pungent, sour, vinegar-like odour with burning taste	M
Odour Threshold		range from 0.21 to 1ppm, detection at 24.3ppm	H
Corrosive		Corrosive to eyes and skin	M
Explosive		NA	
Irritation		irritation occurs at 25 mg/m^3 in air	M
Stability		stable as an aqueous solution	M
Incompatibility		oxidising agents that include nitrates, carbonates, hydroxides, oxides, phosphates, metals. Amines and perchloric acid	M
Solubility (mg/L in water (20-25oC)		NA	H
Molecular weight		60.05	H
pH		1.38	M
Vapour Pressure (mmHg at 20-25oC)		11.7 to 15.7	M,H
Vapour Density (air = 1)		2.1	H
Henry's Law (atm.m3/mol at 20-25oC)		1.00E-07	H
Volatility potential	Soil	low	H
	Water	no	
Log Kow		-0.17	H
Koc		6.5 to 228	H
Soil Adsorption/ Mobility		Not expected to sorb to soil, suspended solids or sediment. Highly mobile in the environment where the compound is expected to remain present in the dissociated form.	H
Potential for bioaccumulation (BCF)		3.2 - low	H
Degradation potential	Soil	Rapidly biodegrades under aerobic and anaerobic conditions. A range of data are available that suggest: • in soil 75% degradation occurs in 14 days; • in sludge 90% degradation occurs in 3 days; • acetic acid degrades 12.3% per hour in estuarine waters, 1% per hour in coastal water and 0.06% in seawater; and • in a biofilm column study, 95% removal of acetic acid under aerobic conditions and 99% removal under methanogenic conditions was observed	H
	Water		
Ranking - Fate and Transport		The compound does not sorb to soil or particles in the water column, is readily and rapidly degraded and does not bioaccumulate - potential for offsite risk issues is low	2

Compound		Acetic acid	
Human Health			
General		Health effects from exposure to acetic acid are principally associated with acute exposures in occupational environments. Acetic acid is absorbed from the gastrointestinal tract and through the lungs. It is readily metabolised by most tissues and may give rise to the production of ketones as intermediates.	H
Acute Effects		Acetic acid is a strong eye, skin, and mucous membrane irritant. Prolonged skin contact with glacial acetic acid may result in tissue destruction (HSDB). Inhalation exposure (8 hours) to acetic acid vapours at 10 ppm could produce some irritation of eyes, nose, and throat; at 100 ppm marked lung irritation and possible damage to lungs, eyes, and skin might result. Immediately dangerous to life or health (IDLH) vapour concentrations of 1,000 ppm cause marked irritation of eyes, nose and upper respiratory tract and cannot be tolerated. These predictions were based on animal experiments and industrial exposure. Skin sensitisation to acetic acid is rare, but has occurred	H
Occupational Inhalation Guidelines (mg/m3)	**TWA**	25	S
	STEL	37	S
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate where appropriate PPE is required for the use of this chemical	**3**
Chronic Effects		There are no data that suggest that long-term exposures to low concentrations of acetic acid results in adverse health effects. There are no chronic toxicity reference values available for acetic acid.	
		Acetic acid is recognised by Food Standards Australia New Zealand (FSANZ) and the US Food and Drug Administration (FDA) as safe as a multipurpose food additive, as a substance migrating to food from cotton and cotton fabrics used in dry-food packaging, as a substance migrating to food from paper and paperboard products, and as a general purpose food additive for animal feed.	
Classifications		Acetic acid has not been classified by International Agency for Research on Cancer (IARC) or the United States Environment Protection Agency (USEPA). The few studies that are available have not shown that acetic acid is carcinogenic, mutagenic or teratogenic in animal studies.	
Guidelines	**Soil**	NA	
	Drinking water	NA	
	pDWG	NA – not calculated as no health effects identified other than those associated with pH	

Compound		Acetic acid	
Ranking - Chronic Health Impacts		Chronic effects considered to be negligible as pH will be rapidly neutralised once in the environment	**1**
Ecological			
General		Limited data is available in relation to ecotoxicological data for acetic acid. The MSDS available notes that acetic acid is on the "OSPAR List of Substances/Preparations Used and Discharged Offshore which are considered to pose little or no risk to the environment".	M,H
Aquatic toxicity data (mg/L)	**LC50**	=100 to 300, for shrimp over 48 hr exposure in aerated water	H
	LC50	= 32 for Artemia salina	M
	LC50	=75, Lepomis macrochirus (Bluegill sunfish), 96 hour static bioassay	H
	LC50	=251, Gambusia affinis (Mosquito fish), 96 hour static bioassay at pH 6.9-8.7 and 16-25^{o}C	H
	EC50	=6000, Daphnia magna, 24 hour endpoint: immobilisation (static bioassay neutralised to pH 8.0 and 20 ^{o}C)	H
	Tox(eco)	32 – 300 mg/L (based on LC50)	
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	
Ranking - Ecological Impacts		Potential concentrations in hydraulic fracturing fluid is similar to the Tox(eco) concentrations, however where diluted in the seam groundwater, concentrations are expected to be lower. Hence the potential for adverse effects to aquatic ecosystems is considered low	**2**

M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound		Hemicellulase Enzyme Concentrate	
Proposed concentration in hydraulic fracturing fluid (mg/L)		4.5 (approx.)	AGL
MSDS Available		yes	
Listed on AICS		yes	
NICNAS		Not assessed	
CAS No.		9025-56-3	M
Molecular Formula		NA	
Colour/ Form		brown liquid	M
Odour/ Taste		sweet organic odour	M
Odour Threshold		NA	
Corrosive		No	M
Explosive		NA	
Irritation		May cause allergy or asthma symptoms or breathing difficulties if inhaled	M
Stability		stable	M
Incompatibility		oxidizing materials and acids	M
Solubility		soluble in water	
Solubility (mg/L in water (20-25oC)		NA	
Molecular weight			
pH		3.5-5	M
Vapour Pressure (mmHg at 20-25oC)		NA	
Vapour Density (air = 1)		NA	
Henry's Law (atm.m3/mol at 20-25oC)		NA	
Volatility potential	Soil	no	
	Water	no	
Log Kow		NA	
Koc		NA	
Soil Adsorption/ Mobility		NA	
Potential for bioaccumulation (BCF)		Low	H
Degradation potential	Soil	All the enzymes rapidly degrade aerobically and it is highly likely that they will be anaerobically decomposed like biomass in general.	HERA
	Water		

Compound	Hemicellulase Enzyme Concentrate	
General	There are several different kinds of cellulases (produced by fungi, bacteria and protozoans) that differ structurally and mechanistically, that are enzymes that catalyse the hydrolysis of cellulose. Enzymes that hydrolyse hemicellulose are usually referred to as hemicellulase and are usually classified under cellulase in general. Hemicellulase is a type of enzyme that catalyse the hydrolysis of cellulose, or degrades the plant cell wall polymer hemicellulose. Hemicellulose is any of several heteropolymers (matrix polysaccharides), such as arabinoxylans, present along with cellulose in almost all plant cell walls. While cellulose is crystalline, strong, and resistant to hydrolysis, hemicellulose has a random, amorphous structure with little strength. It is easily hydrolysed by dilute acid or base as well as myriad hemicellulase enzymes.	HERA
	Hemicellulase is used commercially in baking products and in various other food preparation technologies. It is used in cake mixes, baked goods, and frozen dough. The enzyme enhances the quality of the dough and helps with storage life. This type of enzyme is also produced by microorganisms that live in the human digestive tract and degrade dietary hemicellulose, which humans are incapable of digesting. It is taken by some as a supplement to aid in digestion.	HERA
Ranking - Fate and Transport	On the basis that this compound readily and rapidly degrades in the environment and does no bioaccumulate - potential for offsite risk issues is negligible	**1**
Human Health		
General	Health effects from exposure to this compound are principally associated with acute exposures in occupational environments.	M
Acute Effects	On the basis of the information presented in the MSDS, the product has been shown to result in adverse effects where inadequate PPE is worn. Inhalation exposures may result in irritation effects of the mucous membranes of the nose and throat resulting in coughing, dizziness and headache. May cause respiratory sensitisation with asthma-like symptoms in susceptible individuals. Those individuals with pre-existing respiratory impairment or disease are advised to avoid exposure. Dermal exposures may result in irritation, skin rash and dermatitis. It is noted to be a potential skin sensitiser. Ingestion may result in headache, nausea, vomiting, gastrointestinal irritation and diarrhoea	M
Occupational Inhalation Guidelines (mg/m3) **TWA**	NA	
STEL	NA	
Ranking - Occupational Risk Issues	On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate where appropriate PPE is required for the use of this chemical	**3**

Compound		Hemicellulase Enzyme Concentrate	
Chronic Effects		Other than occupational risk issues, noted above, no chronic studies are available that specifically address exposures to hemicellulose. Given that the enzyme is rapidly and completely degraded it is considered unlikely that it would be present in any environment where long-term exposures by humans may occur. If it were present it is considered unlikely to be present at concentrations that were identified as of concern in occupational environments. It is noted that this type of enzyme is also produced by microorganisms that live in the human digestive tract and degrade dietary hemicellulose, which humans are incapable of digesting. As proteins, enzymes are readily biodegraded in the gastrointestinal tract resulting in negligible bioavailability. The enzyme is taken by some as a supplement to aid in digestion and hence at concentrations that may be present in an environment (such as surface water or irrigation water) the enzyme is not considered to be toxic. More general information from repeated toxicity studies on cellulose (HERA, 2005) did not identify any significant effects, including no evidence of mutagenic activity, associated with ingestion of the enzyme. No carcinogenic potential would be predicted for this class of substance on the basis that there are no data suggesting carcinogenic outcomes from public literature, it has been demonstrated that the systemic bioavailability of enzymes is expected to be low and toxicologically insignificant, and as proteins, enzymes are readily biodegraded in the gastrointestinal tract resulting in negligible bioavailability.	
Classifications		NA	
Guidelines	Soil	NA	
	Drinking water	NA	
	pDWG	NA – not calculated as no adverse health effects identified in relation to exposure to this compound	
Ranking - Chronic Health Impacts		Chronic effects considered to be negligible	1

Compound		Hemicellulase Enzyme Concentrate	
Ecological			
	General	No data is available specifically in relation to ecotoxicological data for Hemicellulase Enzyme Concentrate. More generally in relation to the aquatic toxicity of cellulases (HERA 2005), the limited studies available indicate a low toxicity to aquatic species. The LD50 was found to be greater than 100 mg/L with a number of studies showing no effects at the highest levels of exposure relevant to the bioassays conducted. Given that the enzyme is rapidly and completely degraded, and the protein is expected to be rapidly converted within any species in a receiving environment, it is considered unlikely that it would be present in any environment where environmental exposures may occur.	HERA
Aquatic toxicity data (mg/L)	**LC50**	NA	H
	LC50	NA	H
	LC50	NA	H
	LD50	>100mg/L	HERA
	EC50	NA	H
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	
Ranking - Ecological Impacts		Potential concentrations in hydraulic fracturing fluid are lower than available LD50 concentrations. Hence the potential for adverse effects to aquatic ecosystems is considered negligible.	**1**

HERA, 2005. α-Amylases, Cellulases and Lipases, Human & Environmental Risk Assessment on ingredients of household cleaning products, Edition 1.0, November 2005.
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound	Monoethanolamine Borate	
Proposed concentration in hydraulic fracturing fluid (mg/L)	0 to 1250 mg/L (approx.)for proposed products	AGL
Listed on AICS	yes	
NICNAS	Not assessed	
CAS No.	26038-87-9	M
Molecular Formula	C2-H8-B-N-O3	M
Colour/ Form	blue liquid	M
Odour/ Taste	amine odour	M
Odour Threshold	NA	
Corrosive	considered corrosive	M
Explosive	NA	
Irritation	may cause irritation to eye, skin and respiratory system	M
Stability	Stable	M
Incompatibility	Strong oxidizers, dehydrating agents	M
Solubility (mg/L in water (20-25^{o}C)	approx 1x10^{-6} (2-aminoethanol)	
Molecular weight	104.9	M
pH	7.9	M
Comments	Very little data is available for this compound. Compound also a synonym of boric acid (CAS 10377-81-8) with 2-aminoethanol ester. This compound is also referred to as a borate ester. In relation to this compound data available for boric acid, 2-aminoethanol and borate esters. While a summary of some of the information for boric acid is presented in the following a review of boric acid is presented in the following summary.	
Vapour Pressure (mmHg at 20-25^{o}C)	0.404 for 2-aminoethanol	H
Vapour Density (air = 1)	2.1 for 2-aminoethanol	H
Henry's Law (atm.m^{3}/mol at 20-25^{o}C)	3.25x10^{-8} for 2-aminoethanol	H
Volatility potential – **Soil**	low	H
Volatility potential – **Water**	negligible	H
Log Kow	-1.31 for 2-aminoethanol	H
Koc	5 for 2-aminoethanol	H
Soil Adsorption/ Mobility	Likely to sorb to soil and sediments, however the compound may be partially mobile in soil	H
Potential for bioaccumulation (BCF)	low for all component compounds considered	H
Degradation potential – **Soil**	NA	
Degradation potential – **Water**	NA	
Ranking - Fate and Transport	A large level of uncertainty applies to the evaluation presented here, however there is the potential for this compound to be at least partially mobile in the environment, however it is not expected to bioaccumulate.	**2-3**

Compound		Monoethanolamine Borate	
Human Health			
General		Refer to the boric acid chemical summary for general and acute toxicity information on that component compound	
Acute Effects		Potential for 2-aminoethanol or ethanolamine to be irritating to the skin, eyes and respiratory system. Acute exposures have been associated with central nervous system depression, increased blood pressure, salivation, pupillary dilation with large doses associated with sedation, coma and death.	H
Occupational Inhalation Guidelines (mg/m3)	**TWA**	10 for boric acid	S
	Peak	NA	
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as low to moderate where appropriate PPE is required for the use of this chemical	**2-3**
Chronic Effects		Refer to the boric acid chemical summary for chronic toxicity of that component. In relation to 2-aminoethanol, repeated inhalation studies have shown behavioural changes, reduced body weight and pathological lesions to the lung, liver, kidneys, spleen and testes in a number of species. Insufficient data is available to evaluate carcinogenicity and in the studies available, the compound has not been shown to be mutagenic.	EU, NSF
Guidelines	**Soil**	3000 to 15000 mg/kg for residential to industrial land use	NEPM
	Drinking water	4 mg/L for boron	NHMRC
		2.4 mg/L for boron	WHO
	Irrigation	0.5 mg/L for boron	ANZECC
	Oral TDI	0.16 mg/kg/day for boron	NHMRC
		0.17 mg/kg/day for boron	WHO
		0.2 mg/kg/day for boron	USEPA
		0.04 mg/kg/day for monoethanolamine	NSF
		0.05 mg/kg/day for monoethanolamine in food	EU
Ranking - Chronic Health Impacts		On the basis of the available information in relation to long-term health effects of boron, and consideration of 2-aminoethanol, the compound has been ranked as moderate risk	**3**

Compound		Monoethanolamine Borate	
Ecological			
General		Refer to the boric acid chemical summary for ecological toxicity of that component. In relation to 2-aminoethanol, few detailed reviews are available, however the following range of effects levels are available from the USEPA PAN Pesticides Database.	
Aquatic toxicity data (mg/L)	**LC50 and EC50**	31 mg/L to 5000 mg/L for 2-aminoethanol	US
Published Guidelines	**Fresh water**	0.37 mg/L for boron based on 95% protection, high reliability trigger level for slightly-moderately disturbed ecosystems.	ANZECC
	Marine water	NA	
Ranking - Ecological Impacts		Potential concentrations in hydraulic fracturing fluids are below the available LD50 and EC50 concentrations (up to 5000 mg/L) established for aquatic species for 2-aminoethanol. However the concentration exceeds the ANZECC fresh water guideline for boron. The contribution of boric acid to the overall toxicity is not known, hence the potential for adverse effects has been conservatively considered to be the same as determined for boric acid/boron.	**3**

NSF International. 2008. Ethanolamine. CAS # 141-43-5. Oral Risk Assessment Document. January.
EU 2000. Opinion of the Scientific Committee on Food on the 10th additional list of monomers and additives for food contact materials. European Commission, 11 July 2000
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound		Boric Acid	
Listed on AICS		yes	
NICNAS		Not assessed	
CAS No.		10043-35-3	M
Molecular Formula		B-H3-O3	H
Colour/ Form		white granules	M
Odour/ Taste		odourless	M
Odour Threshold		NA	
Corrosive		yes	M
Explosive		NA	
Irritation		mild irritant to eyes, dust may be mechanically irritating	M
Stability		stable under recommended conditions	M
Incompatibility		strong bases	M
Solubility (mg/L in water (20-25oC)		5.00E+04	H
Molecular weight		61.833	H
pH		5.1	M
Vapour Pressure (mmHg at 20-25oC)		5.24E-18	US
Vapour Density (air = 1)		NA	US
Henry's Law (atm.m3/mol at 20-25oC)		NA	
Volatility potential	Soil	no	
	Water	no	
Soil Adsorption/ Mobility		Boron compounds in water may be adsorbed by soils and sediments. The extent of boron adsorption depends on the pH of the water. The greatest adsorption is observed at pH 7.5-9.0. Since the adsorption of boron is expected to be most significant for soils that contain high concentrations of amorphous aluminium and iron oxides and hydroxides, sediments with these characteristics may also strongly adsorb boron compounds.	H
Potential for bioaccumulation (BCF)		Review of bioconcentration data for boron by ATSDR (2010) suggests that in marine and freshwater plants, fish and invertebrates boron is not significantly bioconcentated.	ATSDR
Degradation potential	Soil	NA	
	Water	NA	
Comments		In aqueous solution, boron is normally present as boric acid and borate ions, with the dominant form of inorganic boron as undissociated boric acid in natural aqueous systems. In aqueous solution, boric acid acts as an electron acceptor (Lewis acid), accepting hydroxide from water to form (B(OH)4)- ion. In concentrated solutions (>0.1 M boric acid) polymeric species are formed.	H
Ranking - Fate and Transport		Overall, the potential for off-site impacts is considered to be low to moderate depending on the pH of the groundwater, the potential for boric acid and boron ions to be discharge to an aquatic environment and the nature of the boron ions present.	**2-3**

Compound		Boric Acid	
Human Health			
General		Boron is a naturally-occurring element that is widespread in nature; the average concentration in the earth's crust has been estimated to be 10 ppm. Boron in the environment is always found chemically bound to oxygen, usually as alkali or alkaline earth borates, or as boric acid. Boron is not transformed or degraded in the environment, but depending on environmental conditions (e.g., pH, moisture level), changes in the specific form of boron and its transport can occur. Boron is regarded as an essential trace mineral that affects the absorption, excretion, and metabolism of calcium, magnesium, and phosphorus in the body. Consequently, boron plays an important role in keeping bones and joints healthy, and may be important in treating and/or preventing osteoporosis and arthritis. Hence adverse effects are associated with both deficiency and elevated exposures. Numerous studies have shown that boric acid and borax are absorbed from the gastrointestinal tract and from the respiratory tract, as indicated by increased levels of boron in the blood, tissues, or urine or by systemic toxic effects of exposed individuals or laboratory animals. Absorption is poor through intact skin.	ATSDR
Acute Effects		The primary health effects associated with inhalation exposure of humans to boron are acute respiratory irritation. Acute-duration exposures of mining and processing workers to 0.44–3.1 mg boron/m^3 (5.7–14.6 mg particulates/m^3) as sodium borate dusts has been associated with mild irritation of the eyes, throat, and nose, as well as cough and breathlessness. Human case reports have shown that boron can be lethal following short-term oral exposure at high doses, although the dose estimation can be quite imprecise and variability in human responses to acute exposure is quite large. The minimal lethal dose of ingested boron (as boric acid) was reported to be 2–3 g in infants, 5–6 g in children, and 15–20 g in adults (ATSDR 2010). Other effects associated with acute toxicity for both borax and boric acid in animals given single large doses orally include depression, ataxia, convulsions, and death; kidney degeneration and testicular atrophy are also observed (WHO 2009).	ATSDR, WHO
Occupational Inhalation Guidelines (mg/m3)	**TWA**	10	S
	STEL		

Compound		Boric Acid	
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate where appropriate PPE is required for the use of this chemical	**3**
Chronic Effects		Limited human studies have not identified significant adverse health effects associated with exposures to boron. Animal studies have identified the reproductive system and developing foetus are the most sensitive targets of boron toxicity. Adverse developmental effects have been identified for acute-and intermediate-duration exposures. Decreases in the number of live foetuses and litters, decreases in body weight, and increases in the occurrence of external, visceral, and cardiovascular malformations were observed. Other systemic effects have been observed in orally exposed animals. Consistently observed effects following intermediate and chronic exposure include haematological alterations (decreases in haemoglobin levels and splenic haematopoiesis), desquamated skin, chronic inflammation and coagulative necrosis of the liver have also been observed (ATSDR 2010).	A
		No epidemiology studies have identified an association between boron exposure and development of cancer. However, some investigators have suggested that boron exposure in drinking water may be associated with lower incidences of some types of cancer in humans. *In vitro* genotoxicity assays have given predominantly negative results.	
Classifications		The International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP), and EPA have not classified boron for human carcinogenicity.	
Guidelines	**Soil**	3000 to 15000 mg/kg for residential to industrial land use	NEPM
	Drinking water	4 mg/L for boron	NHMRC
		2.4 mg/L for boron	WHO
	Irrigation	0.5 mg/L for boron	ANZECC
	Oral TDI	0.16 mg/kg/day for boron	NHMRC
		0.17 mg/kg/day for boron	WHO
		0.2 mg/kg/day for boron	USEPA
Ranking - Chronic Health Impacts		On the basis of the available information in relation to long-term health effects of boron the compound has been ranked as moderate risk	**3**

Compound		Boric Acid	
Ecological			
	General	The main species present in freshwaters, depending on pH, are borates e.g. B(OH)4- and boric acid B(OH)3, a weak acid, and the main removal mechanism is adsorption onto suspended clays or sediments, particularly on contact with seawater. Boron is an essential element required by aquatic plants. Boron is an important buffer for maintaining the pH of seawater	ANZECC
Published Guidelines	**Fresh water**	0.37 mg/L for boron based on 95% protection, high reliability trigger level for slightly-moderately disturbed ecosystems.	ANZECC
	Marine water	NA	
Ranking - Ecological Impacts		In relation to boron, the available data suggest it is moderately toxic to freshwater aquatic species.	**3**

ATSDR, 2010. Toxicological Profile for Boron, Agency for Toxic Substances and Disease Registry, November 2010.
ANZECC, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. National Water Quality Management Strategy. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, 2000
NEPM 1999. Health Based Investigation Levels.
NHMRC, 2011. (National Health and Medical Research Council and the Agriculture and Resource Management Council of Australia and New Zealand). Australian Drinking Water Guidelines - 6. National Water Quality Management Strategy.
WHO, 2009. Boron in Drinking Water, Background document for development of WHO Guidelines for Drinking-water Quality, 2009
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound	Choline Chloride	
Proposed concentration in hydraulic fracturing fluid (mg/L)	1632 (approx.)	AGL
Listed on AICS	yes	
NICNAS	Not assessed	
CAS No.	67-48-1	M
Molecular Formula	$C_5H_{14}NO.Cl$	S
Colour/ Form	White crystalline solid or colourless liquid	S
Odour/ Taste	Amine-like odour	S
Odour Threshold	NA	
Corrosive	no	M
Explosive	no	M
Irritation	Not significantly irritating to skin	E
Stability	stable at room temperature	M
Incompatibility	reacts with strong oxidants	M
Solubility (mg/L in water (20-25oC)	1.0E+06	S
Molecular weight	139.63	H
pH	NA	
Vapour Pressure (mmHg at 25oC)	4.9E-10	S
Vapour Density (air = 1)	NA	
Henry's Law (atm.m3/mol at 20-25oC)	2.06E-11	EPI
Volatility potential **Soil**	no	
Volatility potential **Water**	no	
Log Kow	-5.16	H (EPI)
Koc	2.3	S
Soil Adsorption/ Mobility	Will not adsorb to soil or sediments and hence may be mobile based on Koc values. The compound will not readily volatilise from soil or water.	S
Potential for bioaccumulation (BCF)	<1 - low	S
Degradation potential **Soil**	Considered to be readily biodegradable with 93% biodegradation occurring within 14 days.	S
Degradation potential **Water**		
Ranking - Fate and Transport	Overall, if released into the environment, choline chloride is considered to be mobile, being readily soluble in water and will poorly adsorb to particulates. However the compound is readily biodegradable and is not bioaccumulative in aquatic species or the food chain.	**2**

Compound	Choline Chloride	
Human Health		
General	Choline is an endogenous compound within the body. In addition it is a dietary component and found in foods as free choline and as esterified forms such as phosphocholine, glycerophosphocholine, sphingomyeline, and phosphatidylcholine. It functions as a precursor for acetylcholine, phospholipids, and the methyl donor betaine and is important for the structural integrity of cell membranes, methyl metabolism, cholinergic neurotransmission, transmembrane signaling, and lipid and cholesterol transport and metabolism.	S
Acute Effects	The critical adverse effect from high intake of choline is hypotension, with corroborative evidence on cholinergic side effects (e.g., sweating and diarrhoea) and fishy body odour. After inadequate dietary intake decreased choline stores and liver damage (as assessed by elevated alanine aminotransferase) may develop. Animal studies with choline chloride show a low acute toxicity after oral uptake (with a range of LD50s of 3150 – ≥5000 mg/kg bw determined in different studies). No acute toxicity attributable to choline was observed in humans following oral doses of ≥3000 mg choline magnesium trisalicylate/day.	S
Occupational Inhalation Guidelines (mg/m^3) – **TWA**	NA	
STEL	NA	
Ranking - Occupational Risk Issues	On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as negligible to low.	**1-2**
Chronic Effects	Based on the available data the following is noted in relation to chronic/repeated exposures to choline chloride: • no adverse effects have been observed on chronic animal studies associated with intakes up to 500 mg/kg bw/day. • The compound does not show a mutagenic, clastogenic or DNA damaging potential. • No developmental effects have been observed. • Limited effects have been observed on fertility, but not at normal levels of exposure (from the diet and formed from natural metabolic processes). Choline chloride is considered to be of low toxicity. This is not unexpected in view of its presence in the diet and its production in metabolic processes in the body; it fulfils key roles in nerve transmission, cell membrane integrity, and lipid metabolism. It is noted that inadequate choline levels are also associated with chronic effects that include liver damage.	**S**

Compound		Choline Chloride	
Guidelines	Soil	NA	
	Drinking water	NA	
	TDI	Adequate daily intakes for choline is 8 mg/kg/day for infants, which is also relevant for adult males and lactating women. For choline chloride the TDI is 11.2 mg/kg/day (1.4 times higher)	EU
	Upper Limit	Tolerable upper limit established by the US for adults is 3500 mg/day or 58 mg/kg/day	S, EU
	DWGp	39 mg/L based on the TDI and equation in report, and 12250 mg/L based on the tolerable upper limit and equation in report	C
Ranking - Chronic Health Impacts		On the basis of the available information in relation to the chronic human toxicity of choline chloride is has been ranked as Category 1 (negligible)	**1**
Ecological			
General		The following aquatic acute and chronic effect concentrations for freshwater as well as for marine species are available: Fish *Oryzias latipes* LC50 (96h) > 100 mg/l (nominal and measured) *Limanda limanda* LC50 (96h) > 1,000 mg/l (nominal) Invertebrates *Daphnia magna* EC50 (48h) = 349 mg/l (nominal and measured) *Daphnia magna* NOEC (21d) 30.2 mg/L (nominal and measured) *Crangon crangon* EC50 (48h) > 1,000 mg/l (nominal) Algae *Pseudokirchneriella subcapitata* ErC50 (72h) > 1,000 mg/L (nominal and measured), 72h NOEC (growth rate) 32 mg/l. Based on these data choline chloride is considered unlikely to be harmful to aquatic organisms. Based on the available data, choline chloride is expected to exert toxicity by a non-specific mode of action. An acute **$PNEC_{aqua}$ of 3.5 mg/L** can be derived on the basis of the Technical Guidance Document for the EU risk assessment procedure. The chronic value is equivalent.	S
Published Guidelines	Fresh water	NA	
	Marine water	NA	

Compound	Choline Chloride	
Ranking - Ecological Impacts	On the basis of the available information, if choline chloride were released directly into the environment, it is considered to be of low toxicity to aquatic environments, however the concentration proposed in the fracturing fluids is higher than the PNEC. The compound readily degrades in the environment and hence unlikely to remain long enough to be of concern in relation to chronic effects. Based on the potential for concentrations to be higher than the PNEC the potential for ecological impacts have been evaluated to be low to moderate.	**2-3**

EU 2003. Opinion of the Scientific Committee on Cosmetic Products and Non-Food Products Intended for Consumers concerning Choline Chloride.
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in January 2013)
S = OECD SIDS evaluation for choline chloride (October 2004)
C = calculated

Compound	Sodium Hypochlorite	
Proposed concentration in hydraulic fracturing fluid (mg/L)	181	AGL
Listed on AICS	yes	
NICNAS	Not assessed but listed as Priority Existing Chemical	
CAS No.	7681-52-9	M
Molecular Formula	Na-O-Cl	H
Colour/ Form	greenish yellow liquid	M
Odour/ Taste	chlorine like sweetish disagreeable odour	M
Odour Threshold	NA	
Corrosive	Corrosive to most metals including aluminium, copper, brass, bronze, carbon steel, Hastelloy, Inconel, lead, Monel, nickel and stainless steel type 400 series. Not corrosive to tantalum, titanium and zirconium	M
Explosive	Anhydrous Sodium Hypochlorite is very explosive. Primary amines and calcium hypochlorite or sodium hypochlorite react to form normal chloramines, which are explosive. Interaction of ethyleneimine with sodium (or other) hypochlorite gives the explosive N-chloro-compound. Removal of formic acid from industrial waste streams with sodium hypochlorite solution becomes explosive at 55 deg C. Several explosions involving methanol and sodium hypochlorite were attributed to formation of methyl hypochlorite, especially in presence of acid or other esterification catalyst. Use of sodium hypochlorite solution to destroy acidified benzyl cyanide residues caused a violent explosion, thought to have been due to formation of nitrogen trichloride	M
Irritation	Can cause irritation of the eyes, skin, respiratory and gastrointestinal tract. Exposure to high levels can result in severe corrosive damage to the eyes, skin, respiratory and gastrointestinal tissues and can be fatal	M
Stability	Stable however stability decreases with concentration, heat, light exposure, pH level and contamination with heavy metals	M
Incompatibility	Ether, ammonia acids, reducing agents, oxidisable materials, combustible materials (wood, cloth, organic materials) heavy metals (iron, copper and their alloys), dirt, magnesium, aluminium, tin and manganese. Does not polymerize	M
Solubility (mg/L in water (20-25oC)	29.3 g/100 g	H
Molecular weight	74.44	H
pH	12 for 10% solution	M
Vapour Pressure (mmHg at 20-25oC)	12.1	M
Vapour Density (air = 1)	0.9	H
Henry's Law (atm.m3/mol at 20-25oC)	2.21E-05	H
Volatility potential – Soil	low	
Volatility potential – Water	low	
Soil Adsorption/ Mobility	highly mobile	

Compound		Sodium Hypochlorite	
Potential for bioaccumulation (BCF)		no issues identified	SDA
Degradation potential	**Soil**	Compound is rapidly consumed through oxidation reactions to form chlorides. Some chlorinated compounds may be formed of which the low MW compounds are rapidly degraded but high MW compounds may be more persistent. Breakdown is rapid in the presence of sunlight with half-life from seconds to hours.	SDA
	Water		
Ranking - Fate and Transport		Overall, of released into the environment, sodium hypochlorite does not sorb to solid particles in the water column, is rapidly converted to lighter, readily degradable chlorinated compounds. Studies on the chlorinated by-products of sodium hypochlorite did not identify any bioaccumulative compounds. Hence sodium hypochlorite and associated by-products are not considered to be bioaccumulative in aquatic species or the food chain. The potential for migration to a receiving environment is considered to be low.	**2**
Human Health			
General		Health effects from exposure to sodium hypochlorite are principally associated with acute exposures in occupational environments. Although sodium hypochlorite solution itself is only moderately toxic, it liberates chlorine gas when acidified e.g. if mixed with acidic cleaning agents. Mixing sodium hypochlorite with ammonia-based solutions gives rise to chloramine compounds. Both chlorine and chloramines are strong respiratory irritants hence contribute to the toxic effects.	H
Acute Effects		Ingestion of small volumes of sodium hypochlorite causes burns to the mouth and throat, gastrointestinal irritation, nausea and vomiting. Larger volumes (approximately 300 ml in adults; 100 ml in children) may also cause abdominal and retrosternal pain and diarrhoea. Inhalation of chlorine gas causes burning of the throat and lungs, eye and nose irritation, chest tightness and coughing. At higher levels of exposure, tachypnoea, cyanosis and swelling of the airway may occur. Pulmonary oedema and respiratory failure may arise in severe cases, the onset of which may take up to 36 hours. In most cases symptoms are usually resolved in 1 – 4 weeks. However, in some instances pulmonary damage may lead to long-term Reactive Airways Dysfunction Syndrome (RADS), a chemical irritant-induced type of asthma following an acute respiratory exposure to an irritant gas. In addition, Acute Respiratory Distress Syndrome (ARDS), as a result of pneumonitis, has been reported in patients following inhalation of chlorine following the mixing of sodium hypochlorite and other hydrochloric acid. Sodium hypochlorite is corrosive and may irritate the skin or cause burning pain, inflammation and blisters. Ocular exposure can cause irritation, pain, lacrimation and photophobia.	UK

Compound		Sodium Hypochlorite	
Occupational Inhalation Guidelines (mg/m3)	**TWA**	NA	
	Peak	3 for chlorine gas	S
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate to high where appropriate PPE is required for the use and this chemical	**3-4**
Chronic Effects		Limited data is available in relation to long-term exposures to low concentrations of Sodium Hypochlorite. There are no chronic toxicity reference values available for sodium hypochlorite. Chronic skin exposure may result in skin irritation, pain, inflammation and blisters. There are no data indicating that sodium hypochlorite, without severe maternal toxicity, is associated with adverse effects on reproductive function, pregnancy or lactation in humans (Bull, 2007).	H
Classifications		International Agency for Research on Cancer (IARC) has classified hypochlorite salts as Group 3: not classifiable as to human carcinogenicity.	
Guidelines	**Soil**	NA	
	Drinking water	0.3 mg/L for chlorite, 3 mg/L for monochloramine (and chloramines in general) and 250 mg/L aesthetic guideline for chloride.	NHMRC
Ranking - Chronic Health Impacts		The potential concentrations in hydraulic fluids are well in excess of the drinking water guidelines for chlorite and monochloramine. It is noted that from a chronic exposure perspective sodium hypochlorite will not remain in the environment for a long period of time reducing the potential for chronic exposures and risks.	**3**
Ecological			
General		Sodium hypochlorite is low in toxicity to avian wildlife but highly toxic to freshwater fish and invertebrates. A significant number of ecotoxicity studies (991 records) have been conducted on sodium hypochlorite have been conducted, that are summarised on the USEPA PAN Pesticide Database. These data support the high toxicity of sodium hypochlorite to aquatic species (which is consistent with its use as a microbiocide). Studies associated with chlorinated organic by-products did not identify measureable effects on aquatic species. In addition no bioaccumulative compounds were detected.	SDA
Aquatic toxicity data (mg/L)	**LC50**	33 freshwater species in 28 general have been exposed to sodium hypochlorite and the acute LC50 (as the sum of free and combined chlorine) range from 0.028 mg/L for Daphnia magna to 0.71 mg/L for three spine stickleback.	SDA, U
	Tox(eco)	0.028 – 0.71 mg/L	
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	
Ranking - Ecological Impacts		Potential concentrations in hydraulic fracturing fluid are significantly higher than the available LC50s, hence where present in hydraulic fracturing fluids the ecological risk is considered to be high. It is noted that these potential impacts are considered to be acute as sodium hypochlorite readily breaks down in the environment.	**4**

SDA, 1997. Sodium Hypochlorite. Prepared by the Soap and Detergent Association
UK, 2007. Sodium Hypochlorite Toxicological Review. UK Health Protection Agency 2007
Bull S., 2007. Sodium Hypochlorite, Toxicological Overview. Prepared for the UK Health Protection Agency, CHAPD, HPA 2007, Version 1.
U = USEPA PAN Pesticides Database, accessed in April 2011 at http://www.pesticideinfo.org/Detail_Chemical.jsp?Rec_Id=PC34390
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound	Tetrakis(hydroxymethyl)phosphonium sulfate [THPS]	
Proposed concentration in hydraulic fracturing fluid (mg/L)	110 (34pprox..)	AGL
MSDS Available	yes	
Listed on AICS	yes	
NICNAS	Not assessed	
CAS No.	55566-30-8	M
Molecular Formula	C8H24O12P2S	H
Colour/ Form	colourless or yellowish liquid	M
Odour/ Taste	extremely sharp, acrid pungent odour	M
Odour Threshold	0.98ppm	M
Corrosive	Considered corrosive	M
Irritation	Severe irritation to eyes and may cause skin irritation. May cause skin sensitisation (allergic reaction)	M
Stability	Stable under normal storage and handling conditions. Decomposes at temperatures above 160^{o}C	M
Incompatibility	Oxidizing agents, acids, bases and reducing agents	M
Solubility	Soluble in ethanol, ether, acetone; slightly soluble in chloroform, soluble in oxygenated solvents, miscible with lower alcohols, ketones, benzene, diethyl ether	
Solubility (mg/L in water (20-25^{o}C)	NA	
Molecular weight	406.28	H
pH	3-6	M
Vapour Pressure (mmHg at 20-25^{o}C)	26.7	C
Density	1.38 g/mL (75% product)	C
Vapour Density (air = 1)	1.94	H
Henry's Law (atm.m^{3}/mol at 20-25^{o}C)	1.76x10^{-14}	C
Volatility potential – Soil	very low	
Volatility potential – Water	very low	
Log Kow	<0	H
Koc	2.2	H
Soil Adsorption/ Mobility	Limited potential for sorbtion to soil, organic matter or sediments. If remaining in the environment this compound will be mobile	C
Potential for bioaccumulation (BCF)	No	M, C
Degradation potential – Soil	High	C
Degradation potential – Water	Data suggests the compound biodegrades under aerobic and anaerobic conditions. Rapidly mineralised to CO2 in aquatic environment. May produce low concentrations of degradation products	M, C
Ranking - Fate and Transport	Overall, of released into the environment, this compound does not sorb to solid particles in the water column and is mobile, is mineralised to carbon dioxide and is not bioaccumulative in aquatic species or the food chain, on this basis the potential for discharge of this compound to a receiving environment is considered to be low.	**2**

Compound		Tetrakis(hydroxymethyl)phosphonium sulfate [THPS]	
Human Health			
General		Health effects from exposure to this compound are principally associated with acute exposures in occupational environments.	H
Acute Effects		The product has been shown to be highly acutely toxic via the oral route, of low toxicity via the dermal route, and of moderate toxicity via the inhalation route. It is considered to be corrosive to the eye and has been shown to be a dermal sensitiser. The product was also considered to be irritating to the skin.	H
Occupational Inhalation Guidelines (mg/m3)	**TWA**	2	ACGIH
	STEL	3 times TWA for no more than 30 minutes and under no circumstances more than 5 times TWA	ACGIH
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate to high where appropriate PPE is required for the use of this chemical	**3-4**
Chronic Effects		In short- and long-term oral animal studies, the liver has been identified as the primary target organ of toxicity for exposure to tetrakis (hydroxymethyl) phosphonium sulphate. Other health effects associated with chronic exposures, derived from animal studies, include effects on the liver, lung, testes, uterus and bone marrow, as well as lymphoid depletion of spleen and thymus. Some animals died when high doses of tetrakis (hydroxymethyl) phosphonium sulphate were given, or when higher doses of tetrakis (hydroxymethyl) phosphonium sulphate was given for longer periods of time. There is no indication that tetrakis (hydroxymethyl) phosphonium sulphate caused damage to the nervous system. Developmental effects have been reported in animals, but only at doses that are also toxic to the mother, which suggests that the foetus is not more sensitive to tetrakis (hydroxymethyl) phosphonium sulphate than the adult animal.	W
		Review by Health Canada (2010) considered data from chronic rat and mouse sties that suggested that tetrakis (hydroxymethyl) phosphonium sulphate has carcinogenic potential. In relation to genotoxicity, the number and quality of the available studies is limited and provide mixed results. However the Health Canada (2010) review considered that there was sufficient weight of evidence to consider the product as potentially genotoxic	C
Classifications		IARC has classified tetrakis (hydroxymethyl) phosphonium sulphate as Group 3: not classifiable as to human carcinogenicity due to lack of epidemiological data and inadequate evidence in animals.	

Compound		Tetrakis(hydroxymethyl)phosphonium sulfate [THPS]	
Guidelines	Soil	NA	
	Drinking water	NA	
	NOAEL	3.6 mg/kg/day based on bone marrow hypoplasia from a long term study in mice	W,C
	NOAEL	15 to 18 mg/kg bw/day based on maternal toxicity derived from a developmental study on rats and rabbits	C, M
	DWGp	0.126 mg/L based on lowest NOAEL and equation in report	
Ranking - Chronic Health Impacts		The potential for long term human health impacts, should exposure occur, is considered to be high due to the potential for carcinogenic and genotoxic effects and the potential for concentrations in hydraulic fracturing fluids to be higher than the DWGp	**4**
Ecological			
General		Limited data is available in relation to ecotoxicological data for THPS. Given that tetrakis (hydroxymethyl) phosphonium sulphate is an algaecide and slimicide, it is expected to adversely affect algae. Tetrakis (hydroxymethyl) phosphonium sulphate negatively affects biomass of the freshwater green algae at concentrations of 0.063 mg/L. LC50 ranges from 93 to 119 mg/L, EC50 ranges from 0.06 to 24 mg/L. Toxicity considered to be high.	M,H,C
Aquatic toxicity data (mg/L)	NOEC	0.67 to 10.4 mg/L based on studies conducted on juvenile Eastern oysters and water fleas, following USEPA guidelines	W
	NOEC	18.1 to 41 mg/L for studies conducted in accordance with USEPA guidance on rainbow trout, bluegill sunfish and marine sheepshead minnow	W
	NOEC	0.72 to 67.4 mg/L	C
	Tox(eco)	0.06 – 24 mg/L (based on range of EC50 and LC50)	
Published Guidelines	Fresh water	NA	
	Marine water	NA	
Ranking - Ecological Impacts		The most sensitive adverse effect associated with the release of tetrakis (hydroxymethyl) phosphonium sulphate into an aquatic environment is on algae. Other species are less sensitive to exposures to this compound, however the presence of algae in the aquatic ecosystem can be an important source of food for other species. Hence the protection of algae is of importance. On the basis of the available information the potential for adverse effects to aquatic ecosystems has been ranked as high	**4**

C = Health Canada, 2010. Tetrakis (Hydroxymethyl) Phosphonium Sulfate, Evaluation Report ERC2010-02. Health Canada, 17 February 2010
WHO 2000. Environmental Health Criteria 218, Flame Retardants: Tris(2-Butoxyethyl)phosphate, Tris(2-ethylhexyl)phosphate and Tetrakis(hydroxymethyl)phosphonium salts
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Compound	Sodium Hydroxide	
Proposed concentration in hydraulic fracturing fluid (mg/L)	12 to 103 mg/L (approx.) for the proposed products	AGL
Listed on AICS	yes	
NICNAS	Not assessed however and Existing Chemical Information Sheet is available and the chemical has been assigned as a Priority Existing Chemical for assessment, classified by HOHSC	
CAS No.	1310-73-2	M
Molecular Formula	H-Na-O	H
Colour/ Form	clear liquid	M
Odour/ Taste	no distinct odour	M
Odour Threshold	NA	
Corrosive	Corrosive to tin, aluminium, zinc and alloys containing these metals.	M
Explosive	direct contact with water can cause violent exothermic reaction	M
Irritation	Can cause eye, skin and respiratory burns	M
Stability	Stable	M
Incompatibility	Avoid contact with water, leather, wood, acids, organic halogen compounds or organic nitro compounds. Carbon monoxide gas can form upon contact with reducing sugars, food and beverage products in enclosed spaces.	M
Solubility (mg/L in water (20-25oC)	1.11E+06	H
Molecular weight	40	H
pH	14	M
Vapour Pressure (mmHg at 20-25oC)	1	H
Vapour Density (air = 1)	NA	
Henry's Law (atm.m3/mol at 20-25oC)	NA	
Volatility potential – **Soil**	low	
Volatility potential – **Water**	low	
Soil Adsorption/ Mobility	highly mobile	OECD
Potential for bioaccumulation (BCF)	NA	
Degradation potential – **Soil**	Dissociates rapidly to sodium and hydroxyl ions.	OECD
Degradation potential – **Water**		
Comments	Dissociates rapidly to sodium and hydroxyl ions that do not sorb to particulates or accumulate in living tissues. Both sodium and hydroxyl ions have a wide natural occurrence.	OECD
Ranking - Fate and Transport	Overall, the potential for migration to a receiving environment is considered to be negligible to low.	**1-2**

Compound		Sodium Hydroxide	
Human Health			
General		Solid NaOH is corrosive and many of the adverse effects associated with exposure to this compound are associated with pH and irritation effects.	H
Acute Effects		Depending on the concentration, solutions of NaOH are non-irritating, irritating or corrosive and they cause direct local effects on the skin, eyes and gastrointestinal tracts. Based on human data concentrations of 0.5-4.0 % were irritating to the skin, while a concentration of 8.0 % was corrosive for the skin of animals. Eye irritation data are available for animals. The non-irritant level was 0.2-1.0 %, while the corrosive concentration was 1.2 % or higher. A study with human volunteers did not indicate a skin sensitisation potential of sodium hydroxide. The acute toxicity of sodium hydroxide depends on the physical form (solid or solution), the concentration and dose. Lethality has been reported for animals at oral doses of 240 and 400 mg/kg bw. Fatal ingestion and fatal dermal exposure has been reported for humans.	OECD
Occupational Inhalation Guidelines (mg/m3)	**TWA**	NA	
	Peak	2	S
Ranking - Occupational Risk Issues		On the basis of the chemical properties and acute toxicity of the compound - occupational hazard ranking determined as moderate to high where appropriate PPE is required for the use of this chemical	**3-4**
Chronic Effects		Limited data is available in relation to the repeated or long-term toxicity of sodium hydroxide. Under normal handling conditions (non-irritating) neither the concentration of sodium in the blood nor the pH of the blood will be increased and therefore NaOH is not expected to be systemically available in the body. There is no risk of developmental or reproductive toxicity. The compound has not demonstrated any evidence of genotoxicity. Effects associated with pH remain relevant for the assessment of human health effects and these may be of importance.	OECD
Guidelines	**Soil**	NA	
	Drinking water	NA	
	pDWG	NA – not calculated as there are no adverse effects identified other than those associated with pH	
Ranking - Chronic Health Impacts		Chronic effects considered to be low to moderate depending on the pH at the point of exposure, however it is noted that pH will be quickly neutralised once in the environment limiting the potential for effects	**2-3**

Compound		Sodium Hydroxide	
Ecological			
	General	The hazard of NaOH for the environment is caused by the hydroxyl ion (pH effect). For this reason the effect of NaOH on the organisms depends on the buffer capacity of the terrestrial or aquatic ecosystem. Also the variation in acute toxicity for aquatic organisms can be explained for a significant extent by the variation in buffer capacity of the test medium. For example, LC50 values of acute aquatic toxicity tests varied from 33 to 189 mg/L. It is not considered useful to calculate a guideline for NaOH because factors such as the buffer capacity, the natural pH and the fluctuation of the pH are very specific for a certain ecosystem. There is a possibility that the emission of NaOH product could locally increase the pH in the local aquatic environment.	OECD, M
	Tox(eco)	NA as effects relate to pH	
Published Guidelines	**Fresh water**	NA	
	Marine water	NA	
Ranking - Ecological Impacts			**3**

OECD 2002, OECD SIDS Sodium Hydroxide. UNEP Publications March 2002.
M = data available on MSDS (refer to Appendix B)
H = data available from HSDB (accessed in February 2012)
S = occupational guidelines available from Safework Australia (retrieved February 2012)

Appendix B MSDS for Proposed Hydraulic Fracturing Chemicals

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **ACETIC ACID**

Revision Date: 27-Aug-2013

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Hazardous according to the criteria of NOHSC, Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name:	ACETIC ACID
Synonyms:	None
Chemical Family:	Organic acid
UN Number:	, UN2790
Dangerous Goods Class:	8
Subsidiary Risk:	None
Hazchem Code:	2P
Poisons Schedule:	S6
Application:	Acid

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT (w/w)	Australia NOHSC	New Zealand WES	ACGIH TLV-TWA

Acetic acid	64-19-7	30 - 60%	TWA: 10 ppm TWA: 25 mg/m^3 STEL: 15 ppm STEL: 37 mg/m^3	STEL: 15 ppm STEL: 37 mg/m^3 TWA: 10 ppm TWA: 25 mg/m^3	TWA: 10 ppm STEL: 15 ppm

Non-Hazardous Substance to Total of 100%

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory burns. May be harmful if swallowed. Combustible.

Risk Phrases R10 Flammable.

R34 Causes burns.

HSNO Classification Not Determined

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons
None known.

Special Exposure Hazards Use water spray to cool fire exposed surfaces. Decomposition in fire may produce toxic gases. Do not allow runoff to enter waterways.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption	Isolate spill and stop leak where safe. Neutralize with lime slurry, limestone, or soda ash. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse.
Storage Information	Store away from alkalis. Store away from oxidizers. Store in a cool well ventilated area. Keep container closed when not in use.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.
Respiratory Protection	Organic vapor/acid gas respirator.
Hand Protection	Impervious rubber gloves. Neoprene gloves. Nitrile gloves. Butyl rubber gloves.
Skin Protection	Full protective chemical resistant clothing.
Eye Protection	Chemical goggles; also wear a face shield if splashing hazard exists.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Clear
Odor:	Acrid
pH:	2.9
Specific Gravity @ 20 C (Water=1):	1.05
Density @ 20 C (kg/l):	1.048
Bulk Density @ 20 C (kg/M3):	Not Determined
Boiling Point/Range (C):	117
Freezing Point/Range (C):	16
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	42
Flash Point Method:	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	5.4
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	16
Vapor Pressure @ 20 C (mmHg):	11.7
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	100
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	60.6
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data: Stable

Hazardous Polymerization: Will Not Occur

Conditions to Avoid Keep away from heat, sparks and flame.

Incompatibility (Materials to Avoid) Strong alkalis.

Hazardous Decomposition Products Toxic fumes. Carbon monoxide and carbon dioxide.

Additional Guidelines Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure

Acute Toxicity

Inhalation Causes severe respiratory irritation.

Eye Contact May cause eye burns.

Skin Contact Causes severe burns.

Ingestion Causes burns of the mouth, throat and stomach.

Chronic Effects/Carcinogenicity Prolonged, excessive exposure may cause erosion of the teeth.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Acetic acid	64-19-7	3310 mg/kg (Rat) 600 mg/kg (Rabbit)	1060 mg/kg (Rabbit)	11.4 mg/L (Rat) 4 h

12. ECOLOGICAL INFORMATION

Ecotoxicological Information

Ecotoxicity Product

Acute Fish Toxicity: Not determined

Acute Crustaceans Toxicity: Not determined

Acute Algae Toxicity: Not determined

Ecotoxicity Substance

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Acetic acid	64-19-7	EC50: 90 mg/L (Microcystis aeruginosa)	LC50: 79 mg/l (Pimephales promelas) LC50: 75 mg/l (Pimephales promelas)	No information available	EC50: 47 mg/l (Daphnia magna) LC50: 32 mg/L (Artemia salina)

Persistence and degradability

Readily biodegradable

Bioaccumulative potential

Does not bioaccumulate

Mobility in soil
No information available

Results of PBT and vPvB assessment
No information available.

Other adverse effects

13. DISPOSAL CONSIDERATIONS

Disposal Method Disposal should be made in accordance with federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

ADR

UN2790, Acetic Acid Solution , 8 , III

Air Transportation

ICAO/IATA

UN2790, Acetic Acid Solution , 8 , III
RQ (Acetic Acid - 5683 kg.)

Sea Transportation

IMDG

UN2790, Acetic Acid Solution , 8 , III
RQ (Acetic Acid - 5683 kg.)
EmS F-A, S-B

Other Transportation Information

Labels: Corrosive

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS

Classification C - Corrosive.

Risk Phrases

R10 Flammable.

R34 Causes burns.

Safety Phrases

S23 Do not breathe gas, fumes, vapour or spray.
S26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S45 In case of accident or if you feel unwell, seek medical advice immediately.
S1/2 Keep locked up and out of reach of children.

16. OTHER INFORMATION

The following sections have been revised since the last issue of this SDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BC-140C**

Revision Date: 27-Aug-2013

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Non-Hazardous according to the criteria of NOHSC, Non-Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name: BC-140C
Synonyms: None
Chemical Family: Blend
UN Number: None
Dangerous Goods Class: None
Subsidiary Risk: None
Hazchem Code: None Allocated
Poisons Schedule: None Allocated
Application: Crosslinker

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT (w/w)	Australia NOHSC	New Zealand WES	ACGIH TLV-TWA
Monoethanolamine borate	26038-87-9	30 - 60%	Not applicable	Not applicable	Not applicable

Non-Hazardous Substance to Total of 100%

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation. May be harmful if swallowed.

Risk Phrases None

HSNO Classification Not Determined

4. FIRST AID MEASURES

Inhalation If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Get medical attention.

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons
None known.

Special Exposure Hazards Decomposition in fire may produce toxic gases.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse.

Storage Information Store away from oxidizers. Store in a cool well ventilated area. Keep container closed when not in use. Product has a shelf life of 36 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.
Respiratory Protection	Not normally needed. But if significant exposures are possible then the following respirator is recommended: Organic vapor respirator.
Hand Protection	Impervious rubber gloves.
Skin Protection	Rubber apron.
Eye Protection	Safety glasses.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Blue
Odor:	Amine
pH:	7.9
Specific Gravity @ 20 C (Water=1):	1.16
Density @ 20 C (kg/l):	1.16
Bulk Density @ 20 C (kg/M3):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (C):	Not Determined
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated

Incompatibility (Materials to Avoid) Strong oxidizers. Dehydrating agents.

Hazardous Decomposition Products Toxic fumes. Carbon monoxide and carbon dioxide.

Additional Guidelines Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure

Acute Toxicity

Inhalation May cause respiratory irritation.

Eye Contact May cause eye irritation.

Skin Contact May cause skin irritation.

Ingestion May be harmful if swallowed.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 1% are chronic health hazards.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Monoethanolamine borate	26038-87-9	>2000 mg/kg (Rat)	>2000 mg/kg (Rat)	No data available

12. ECOLOGICAL INFORMATION

Ecotoxicological Information

Ecotoxicity Product

Acute Fish Toxicity: Not determined

Acute Crustaceans Toxicity: Not determined

Acute Algae Toxicity: Not determined

Ecotoxicity Substance

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Monoethanolamine borate	26038-87-9	No information available	No information available	No information available	No information available

Persistence and degradability

No information available

Bioaccumulative potential

No information available

Mobility in soil

No information available

Results of PBT and vPvB assessment

No information available.

Other adverse effects

13. DISPOSAL CONSIDERATIONS

Disposal Method Disposal should be made in accordance with federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Transportation Information

Labels: None

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS
Classification	Not Classified
Risk Phrases	None
Safety Phrases	None

16. OTHER INFORMATION

The following sections have been revised since the last issue of this SDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **BE-7™**

Revision Date: 04-Jan-2011

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Hazardous according to the criteria of NOHSC, Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
53-55 Bannister Road
Canning Vale
WA 6155
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name: BE-7™
Synonyms: None
Chemical Family: Inorganic
UN Number: , UN1791
Dangerous Goods Class: 8
Subsidiary Risk: None
Hazchem Code: 2X
Poisons Schedule: S5
Application: Biocide

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT	Australia NOHSC	ACGIH TLV-TWA
Sodium hypochlorite	7681-52-9	10 - 30%	Not applicable	Not applicable
Sodium hydroxide	1310-73-2	0 - 2%	2 mg/m^3	2 mg/m^3

Total to 100%

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and skin burns. May cause respiratory irritation. May be harmful if swallowed.

Hazard Ratings

Flammability:	0
Toxicty:	1
Body Contact:	3
Reactivity:	2
Chronic:	1

Scale: Min/Nil=0 Low=1 Moderate=2 High=3 Extreme=4

4. FIRST AID MEASURES

Inhalation If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Get medical attention.

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.

Eyes Immediately flush eyes with large amounts of water for at least 20 minutes. Seek prompt medical attention.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Treatment based on sound judgment of physician and individual reactions of patient.

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons None known.

Special Exposure Hazards Decomposition in fire may produce toxic gases. Reacts with metals to generate flammable hydrogen gas.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Isolate spill and stop leak where safe. Remove ignition sources and work with non-sparking tools. Contain spill with sand or other inert materials. Scoop up and remove. Hypochlorite can be broken down by covering it with a reducing agent such as sodium sulfite or sodium thiosulfate.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse.

Storage Information Store away from acids. Store away from reducing agents. Store in a cool well ventilated area. Store away from direct sunlight. Keep container closed when not in use. Store between 59 F (15 C) and 84 F (29 C). Keep from freezing. Product has a shelf life of up to 6 months at 60F or lower.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.

Respiratory Protection If engineering controls and work practices cannot keep exposure below occupational exposure limits or if exposure is unknown, wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Selection of and instruction on using all personal protective equipment, including respirators, should be performed by an Industrial Hygienist or other qualified professional.

Acid gas respirator with a dust/mist filter. In high concentrations, supplied air respirator or a self-contained breathing apparatus.

Hand Protection Impervious rubber gloves. Nitrile gloves. Neoprene gloves. Viton gloves Butyl rubber gloves.

Skin Protection Wear impervious protective clothing, including boots, gloves, lab coat, apron, rain jacket, pants or coverall, as appropriate, to prevent skin contact.

Eye Protection Splashproof chemical monogoggles or safety glasses with side shields in conjunction with a face shield.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Clear light yellow
Odor:	Pungent
pH:	11-13
Specific Gravity @ 20 C (Water=1):	1.21
Density @ 20 C (kg/l):	1.14
Bulk Density @ 20 C (kg/m^3):	Not Determined
Boiling Point/Range (C):	~110
Freezing Point/Range (C):	-13.6
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined
Vapor Pressure @ 20 C (mmHg):	12
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	85
Evaporation Rate (Butyl Acetate=1):	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	Avoid contact with hydrochloric acid. Can react to release chlorine gas. Contact with certain metals produces hydrogen gas. Hazards increase greatly if material is allowed to dry.
Incompatibility (Materials to Avoid)	Strong acids. Contact with metals. Ammonium compounds. Organic matter. Cyanides. Alcohols. Nitrogen compounds. Cellulose. Ethyleneimine.
Hazardous Decomposition Products	Hydrogen chloride. Chlorine. Hypochlorous acid. Flammable hydrogen gas. Sodium oxides. Oxygen. Chlorine dioxide. Sodium chlorate
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	Causes severe respiratory irritation.
Skin Contact	Causes severe skin irritation. May cause skin burns. May cause an allergic skin reaction.
Eye Contact	Causes severe eye irritation May cause eye burns.
Ingestion	Causes burns of the mouth, throat and stomach. May be fatal if swallowed.
Aggravated Medical Conditions	Skin disorders. Lung disorders.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	LD50: 8910 mg/kg (Rat)
Dermal Toxicity:	LD50: > 10000 mg/kg (Rabbit)
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Sodium hypochlorite caused mutations in several short-term studies using bacteria and cultured mammalian cells. The significance of these tests is unclear. It was not mutagenic in tests (chromosome aberration and micronucleus) on live animals.

Reproductive / Developmental Toxicity: Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not determined

Bio-accumulation Not determined

Ecotoxicological Information

Acute Fish Toxicity: TLM48: 0.07 mg/l (Oncorhynchus mykiss) TLM96: 5.9 mg/l (Pimephales promelas)
Acute Crustaceans Toxicity: Not determined
Acute Algae Toxicity: Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Disposal should be made in accordance with federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

ADR

UN1791,Hypochlorite Solution, 8, III

Air Transportation

ICAO/IATA

UN1791,Hypochlorite Solution, 8, IIIRQ (Sodium Hypochlorite - 454 kg.)

Sea Transportation

IMDG

UN1791,Hypochlorite Solution, 8, IIIRQ (Sodium Hypochlorite - 454 kg.)
EmS F-A, S-B

Other Shipping Information

Labels: Corrosive

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	All components listed.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS

Classification

C - Corrosive.
N - Dangerous For The Environment.

Risk Phrases

R31 Contact with acids liberates toxic gas.
R34 Causes burns.
R50 Very toxic to aquatic organisms.

Safety Phrases

S28 After contact with skin, wash immediately with plenty of water
S45 In case of accident or if you feel unwell, seek medical advice immediately.
S50 Do not mix with acids
S61 Avoid release to the environment. Refer to special instructions/Safety data sheets.

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **CAUSTIC SODA LIQUID - 50%**

Revision Date: 27-Aug-2013

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Hazardous according to the criteria of NOHSC, Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name: CAUSTIC SODA LIQUID - 50%
Synonyms: None
Chemical Family: Hydroxide
UN Number: , UN1824
Dangerous Goods Class: 8
Subsidiary Risk: None
Hazchem Code: 2R
Poisons Schedule: S6
Application: pH Control

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT (w/w)	Australia NOHSC	New Zealand WES	ACGIH TLV-TWA
Sodium hydroxide	1310-73-2	30 - 60%	2 mg/m^3	Not applicable	2 mg/m^3

Non-Hazardous Substance to Total of 100%

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory burns. May be harmful if swallowed.

Risk Phrases R35 Causes severe burns.

HSNO Classification Not Determined

4. FIRST AID MEASURES

Inhalation If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Get medical attention.

Skin In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse. Destroy or properly dispose of contaminated shoes.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media
All standard fire fighting media

Extinguishing media which must not be used for safety reasons
None known.

Special Exposure Hazards May form explosive mixtures with strong acids. Reaction with steel and certain other metals generates flammable hydrogen gas.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Neutralize to pH of 6-8. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse.

Storage Information Store away from acids. Store in a cool well ventilated area. Keep container closed when not in use. Product has a shelf life of 12 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.

Respiratory Protection Dust/mist respirator. (N95, P2/P3)

Hand Protection Impervious rubber gloves.

Skin Protection Full protective chemical resistant clothing.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Clear colorless
Odor:	Odorless
pH:	14
Specific Gravity @ 20 C (Water=1):	1.52
Density @ 20 C (kg/l):	1.52
Bulk Density @ 20 C (kg/M3):	Not Determined
Boiling Point/Range (C):	144
Freezing Point/Range (C):	12
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined
Vapor Pressure @ 20 C (mmHg):	13 @ 60C
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	< 50
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Miscible
Solubility in Solvents (g/100ml):	Soluble in alcohols
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	40
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data: Stable

Hazardous Polymerization: Will Not Occur

Conditions to Avoid None anticipated

Incompatibility (Materials to Avoid) Strong acids. Peroxides. Halogenated compounds. Amphoteric metals such as aluminum, magnesium, lead, tin, or zinc.

Hazardous Decomposition Products None known.

Additional Guidelines Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure

Acute Toxicity

Inhalation Causes severe respiratory burns.

Eye Contact Causes severe eye burns.

Skin Contact Causes severe burns.

Ingestion Causes burns of the mouth, throat and stomach.

Chronic Effects/Carcinogenicity Prolonged, excessive exposure may cause erosion of the teeth.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Sodium hydroxide	1310-73-2	No data available	1350 mg/kg (Rabbit)	No data available

12. ECOLOGICAL INFORMATION

Ecotoxicological Information

Ecotoxicity Product

Acute Fish Toxicity: Not determined

Acute Crustaceans Toxicity: Not determined

Acute Algae Toxicity: Not determined

Ecotoxicity Substance

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Sodium hydroxide	1310-73-2	No information available	LC50: 45.4 mg/l (Oncorhynchus mykiss)	No information available	No information available

Persistence and degradability

The methods for determining biodegradability are not applicable to inorganic substances.

Bioaccumulative potential

Does not bioaccumulate

Mobility in soil

No information available

Results of PBT and vPvB assessment

No information available.

Other adverse effects

13. DISPOSAL CONSIDERATIONS

Disposal Method Disposal should be made in accordance with federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

ADR

UN1824, Sodium Hydroxide Solution , 8 , II

Air Transportation

ICAO/IATA

UN1824, Sodium Hydroxide Solution , 8 , II
RQ (Sodium Hydroxide - 908 kg.)

Sea Transportation

IMDG

UN1824, Sodium Hydroxide Solution , 8 , II
RQ (Sodium Hydroxide - 908 kg.)
EmS F-A, S-B

Other Transportation Information

Labels: Corrosive

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS
Classification	C - Corrosive.
Risk Phrases	R35 Causes severe burns.
Safety Phrases	S26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S45 In case of accident or if you feel unwell, seek medical advice immediately. S1/2 Keep locked up and out of reach of children. S37/39 Wear suitable gloves and eye/face protection.

16. OTHER INFORMATION

The following sections have been revised since the last issue of this SDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

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*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **CHOLINE CHLORIDE**

Revision Date: 03-Jan-2013

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: CHOLINE CHLORIDE
Synonyms: None
Chemical Family: Salt
Application: Clay Stabilization Agent

Manufacturer/Supplier
Halliburton Energy Services, Inc.
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (281) 575-5000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Choline chloride	67-48-1	60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause mild eye, skin, and respiratory irritation. May be harmful if swallowed.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards Not applicable.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 2, Flammability 0, Reactivity 0
HMIS Ratings: Health 2, Flammability 0, Physical Hazard 0 , PPE: B

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing.

Storage Information Store in a cool, dry location. Keep container closed when not in use.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally necessary.

Hand Protection Impervious rubber gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	White
Odor:	Mild amine
pH:	7-9
Specific Gravity @ 20 C (Water=1):	1.07 - 1.091
Density @ 20 C (lbs./gallon):	Not Determined

9. PHYSICAL AND CHEMICAL PROPERTIES

Bulk Density @ 20 C (lbs/ft3):	Not Determined
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	Avoid contact with metals such as aluminum, tin, lead, brass, bronze, copper, and zinc.
Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Oxides of nitrogen. Hydrogen chloride. Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	None known
Inhalation	May cause mild respiratory irritation.
Skin Contact	May cause mild skin irritation.
Eye Contact	May cause mild eye irritation.
Ingestion	May be harmful if swallowed.
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined

Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Disposal should be made in accordance with federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Transportation Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory or are exempt.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Not determined
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory or are exempt.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **FE-2**

Revision Date: 27-Aug-2013

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Hazardous according to the criteria of NOHSC, Non-Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name: FE-2
Synonyms: None
Chemical Family: Organic acid
UN Number: None
Dangerous Goods Class: None
Subsidiary Risk: None
Hazchem Code: None Allocated
Poisons Schedule: None Allocated
Application: Iron Control Agent

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT (w/w)	Australia NOHSC	New Zealand WES	ACGIH TLV-TWA
Citric acid	77-92-9	60 - 100%	Not applicable	Not applicable	Not applicable

Non-Hazardous Substance to Total of 100%

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation. Airborne dust may be explosive.

Risk Phrases R36 Irritating to eyes.

HSNO Classification 6.1E (Inhalation) Acutely Toxic Substances
6.3B Mildly irritating to the skin
8.3A Corrosive to ocular tissue

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons
None known.

Special Exposure Hazards Decomposition in fire may produce toxic gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.

Storage Information Store away from alkalis. Store away from oxidizers. Store in a cool, dry location. Product has a shelf life of 60 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Dust/mist respirator. (N95, P2/P3)

Hand Protection Impervious rubber gloves. Nitrile gloves. Neoprene gloves. Polyvinyl alcohol gloves. Polyvinylchloride gloves.

Skin Protection Normal work coveralls.

Eye Protection Chemical goggles; also wear a face shield if splashing hazard exists.

Other Precautions Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White
Odor:	Odorless
pH:	2 - 2.2
Specific Gravity @ 20 C (Water=1):	1.665
Density @ 20 C (kg/l):	Not Determined
Bulk Density @ 20 C (kg/M3):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (C):	Not Determined
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (C):	1000
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	8
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	65
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	0
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	192.13
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data: Stable

Hazardous Polymerization: Will Not Occur

Conditions to Avoid None anticipated

Incompatibility (Materials to Avoid) Strong alkalis. Strong oxidizers.

Hazardous Decomposition Products Carbon monoxide and carbon dioxide.

Additional Guidelines Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure

Acute Toxicity

Inhalation May cause respiratory irritation.

Eye Contact May cause severe eye irritation.

Skin Contact May cause skin irritation.

Ingestion Irritation of the mouth, throat, and stomach. May cause abdominal pain, vomiting, nausea, and diarrhea.

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 1% are chronic health hazards.

LD50 Oral: 11700 mg/kg; (rat)

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Citric acid	77-92-9	3000 mg/kg (Rat)	No data available	No data available

Test species: Rat

12. ECOLOGICAL INFORMATION

Ecotoxicological Information

Ecotoxicity Product

Acute Fish Toxicity: Not determined

Acute Crustaceans Toxicity: TLM96: 100-330 ppm (Crangon crangon)

Acute Algae Toxicity: Not determined

Ecotoxicity Substance

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Citric acid	77-92-9	No information available	LC50: 1516 mg/L (Lepomis macrochirus)	No information available	TLM96: 100-330 ppm (Crangon crangon)

Persistence and degradability
Biodegradable.

Bioaccumulative potential
Does not bioaccumulate

Mobility in soil
No information available

Results of PBT and vPvB assessment
No information available.

Other adverse effects

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations. Contaminated packaging may be disposed of by: rendering packaging incapable of containing any substance, or treating packaging to remove residual contents, or treating packaging to make sure the residual contents are no longer hazardous, or by disposing of packaging into commercial waste collection.

14. TRANSPORT INFORMATION

Land Transportation

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Transportation Information

Labels: None

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS

Classification Xi - Irritant.

Risk Phrases R36 Irritating to eyes.

Safety Phrases

S24/25 Avoid contact with skin and eyes.

16. OTHER INFORMATION

The following sections have been revised since the last issue of this SDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **GBW-30 BREAKER**

Revision Date: 05-Jan-2009

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Hazardous according to criteria of WorkSafe

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
53-55 Bannister Road
Canning Vale
WA 6155
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name: GBW-30 BREAKER
Synonyms: None
Chemical Family: Polysaccharide
UN Number: None
Dangerous Goods Class: None
Subsidiary Risk: None
Hazchem Code: None
Poisons Schedule: None
Application: Breaker

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	Australia NOHSC	ACGIH TLV-TWA
Hemicellulase enzyme	9012-54-8	5-15	Not applicable	Not applicable
Carbohydrates		85-85	Not applicable	Not applicable

Total to 100%

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye and respiratory irritation. May cause allergic respiratory reaction. Airborne dust may be explosive.

Hazard Ratings

Flammability:	1
Toxicity:	0
Body Contact:	1
Reactivity:	0
Chronic:	0

Scale: Min/Nil=0 Low=1 Moderate=2 High=3 Extreme=4

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media All standard fire fighting media

Unsuitable Extinguishing Media None known.

Special Exposure Hazards Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures Prevent from entering sewers, waterways, or low areas.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust.

Storage Information Store away from oxidizers. Store in a cool, dry location. Product has a shelf life of 12 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls Use in a well ventilated area.

Respiratory Protection Not normally needed. But if significant exposures are possible then the following respirator is recommended:
Dust/mist respirator. (95%)

Hand Protection Normal work gloves.

Skin Protection Normal work coveralls.

Eye Protection Wear safety glasses or goggles to protect against exposure.

Other Precautions None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Powder
Color:	White
Odor:	Odorless
pH:	7
Specific Gravity @ 20 C (Water=1):	1.5
Density @ 20 C (kg/l):	Not Determined
Bulk Density @ 20 C (kg/m^3):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (C):	Not Determined
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined**Min:** > 93
Flash Point Method:	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data: Stable

Hazardous Polymerization: Will Not Occur

Conditions to Avoid None anticipated

Incompatibility (Materials to Avoid)	Strong oxidizers.
Hazardous Decomposition Products	Carbon monoxide and carbon dioxide.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause mild respiratory irritation. May cause allergic respiratory reaction.
Skin Contact	None known.
Eye Contact	May cause mild eye irritation.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	LD50: 29700 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Readily biodegradable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	TLM96: > 3300 ppm (Crangon crangon)
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

ADR Not restricted

Air Transportation

ICAO/IATA Not restricted

Sea Transportation

IMDG Not restricted

Other Shipping Information

EPG: None
IERG: None
Labels: None

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory Not Determined
US TSCA Inventory All components listed on inventory or are exempt.
EINECS Inventory This product, and all its components, complies with EINECS

Classification Xn - Harmful.

Risk Phrases R42 May cause sensitization by inhalation.

Safety Phrases S2 Keep out of reach of children.
S22 Do not breathe dust.
S24 Avoid contact with skin.
S36/37 Wear suitable protective clothing and gloves.

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand Poisons Information System
Deunedin: -(03) 479 1200 (Normal Hours)
-(03) 474 0999 (Emergency)

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **HAI-150E**

Revision Date: 27-Aug-2013

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Non-Hazardous according to the criteria of NOHSC, Non-Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name: HAI-150E
Synonyms: None
Chemical Family: Blend
UN Number: None
Dangerous Goods Class: None
Subsidiary Risk: None
Hazchem Code: None Allocated
Poisons Schedule: None Allocated
Application: Corrosion Inhibitor

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT (w/w)	Australia NOHSC	New Zealand WES	ACGIH TLV-TWA
Contains no hazardous substances	Mixture	60 - 100%	Not applicable	Not applicable	Not applicable

Non-Hazardous Substance to Total of 100%

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation.

Risk Phrases None

HSNO Classification Non-hazardous

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Get medical attention if irritation persists. Wash with soap and water.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Under normal conditions, first aid procedures are not required.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media
All standard fire fighting media

Extinguishing media which must not be used for safety reasons
None known.

Special Exposure Hazards Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures Use appropriate protective equipment.

Environmental Precautionary Measures None known.

Procedure for Cleaning / Absorption Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions Avoid creating or inhaling dust.

Storage Information Store away from oxidizers. Store in a dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	A well ventilated area to control dust levels.
Respiratory Protection	Not normally needed. But if significant exposures are possible then the following respirator is recommended: Dust/mist respirator. (N95, P2/P3)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Brown
Odor:	Coffee bean
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	Not Determined
Density @ 20 C (kg/l):	Not Determined
Bulk Density @ 20 C (kg/M3):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (C):	Not Determined
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Strong oxidizers.

Hazardous Decomposition Products Carbon monoxide and carbon dioxide.

Additional Guidelines Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure

Acute Toxicity

Inhalation May cause mild respiratory irritation.

Eye Contact May cause mild eye irritation.

Skin Contact May cause mild skin irritation.

Ingestion None known

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 1% are chronic health hazards. Generally Recognized As Safe (GRAS)

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Contains no hazardous substances	Mixture	No data available	No data available	No data available

12. ECOLOGICAL INFORMATION

Ecotoxicological Information

Ecotoxicity Product

Acute Fish Toxicity: Not determined

Acute Crustaceans Toxicity: Not determined

Acute Algae Toxicity: Not determined

Ecotoxicity Substance

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Contains no hazardous substances	Mixture	No information available	No information available	No information available	No information available

Persistence and degradability

Product is biodegradable

Bioaccumulative potential

Does not bioaccumulate

Mobility in soil

No information available

Results of PBT and vPvB assessment

No information available.

Other adverse effects

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Transportation Information

Labels: None

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS
Classification	Not Classified
Risk Phrases	None
Safety Phrases	None

16. OTHER INFORMATION

The following sections have been revised since the last issue of this SDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **HYDROCHLORIC ACID**

Revision Date: 27-Aug-2013

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Hazardous according to the criteria of NOHSC, Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name: HYDROCHLORIC ACID
Synonyms: None
Chemical Family: Inorganic acid
UN Number: , UN1789
Dangerous Goods Class: 8
Subsidiary Risk: None
Hazchem Code: 2R
Poisons Schedule: S6
Application: Solvent

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT (w/w)	Australia NOHSC	New Zealand WES	ACGIH TLV-TWA
Hydrochloric acid	7647-01-0	30 - 60%	5 ppm	Not applicable	2 ppm

Non-Hazardous Substance to Total of 100%

3. HAZARDS IDENTIFICATION

Hazard Overview

May cause eye, skin, and respiratory burns. May be harmful if swallowed.

Risk Phrases

R34 Causes burns.

R37 Irritating to respiratory system.

HSNO Classification

6.1B (Inhalation) Acutely Toxic Substances
6.1D (Oral) Acutely Toxic Substances
6.1D (Dermal) Acutely Toxic Substances
8.1A Corrosive to metals
8.2B Corrosive to dermal tissue if exposed for greater than 3 mins
8.3A Corrosive to ocular tissue
9.1D Slightly harmful in the aquatic environment
9.3C Harmful to terrestrial vertebrates

4. FIRST AID MEASURES

Inhalation

If inhaled, remove to fresh air. If not breathing give artificial respiration, preferably mouth-to-mouth. If breathing is difficult give oxygen. Get medical attention.

Skin

In case of contact, immediately flush skin with plenty of soap and water for at least 15 minutes. Get medical attention. Remove contaminated clothing and launder before reuse.

Eyes

In case of contact, or suspected contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention immediately after flushing.

Ingestion

Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician

Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons
None known.

Special Exposure Hazards

May form explosive mixtures with strong alkalis. Decomposition in fire may produce toxic gases. Reaction with steel and certain other metals generates flammable hydrogen gas. Do not allow runoff to enter waterways.

Special Protective Equipment for Fire-Fighters

Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures

Use appropriate protective equipment.

Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Isolate spill and stop leak where safe. Contain spill with sand or other inert materials. Neutralize to pH of 6-8. Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid breathing vapors. Wash hands after use. Launder contaminated clothing before reuse.
Storage Information	Store away from alkalis. Store in a cool well ventilated area. Keep container closed when not in use. Store locked up. Product has a shelf life of 24 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area. Local exhaust ventilation should be used in areas without good cross ventilation.
Respiratory Protection	Acid gas respirator.
Hand Protection	Impervious rubber gloves.
Skin Protection	Full protective chemical resistant clothing. Rubber boots.
Eye Protection	Chemical goggles; also wear a face shield if splashing hazard exists.
Other Precautions	Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Liquid
Color:	Clear colorless
Odor:	Pungent acrid
pH:	0.8
Specific Gravity @ 20 C (Water=1):	1.18
Density @ 20 C (kg/l):	1.16
Bulk Density @ 20 C (kg/M3):	Not Determined
Boiling Point/Range (C):	110
Freezing Point/Range (C):	-46
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined
Vapor Pressure @ 20 C (mmHg):	26
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	35
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined

Partition Coefficient/n-Octanol/Water: Not Determined
Molecular Weight (g/mole): 36.5
Decomposition Temperature (C): Not Determined

10. STABILITY AND REACTIVITY

Stability Data: Stable

Hazardous Polymerization: Will Not Occur

Conditions to Avoid None anticipated

Incompatibility (Materials to Avoid) Strong alkalis.

Hazardous Decomposition Products Flammable hydrogen gas. Chlorine. Hydrogen sulfide.

Additional Guidelines Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure

Acute Toxicity

Product Information Under certain conditions of use, some of the product ingredients may cause the following:
Inhalation Causes severe respiratory irritation.
Eye Contact May cause eye burns.
Skin Contact May cause skin burns.
Ingestion Causes burns of the mouth, throat and stomach.

Chronic Effects/Carcinogenicity Prolonged, excessive exposure may cause erosion of the teeth.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Hydrochloric acid	7647-01-0	700 mg/kg (Rat)	5010 mg/kg (Rabbit) 1449 mg/kg (Mouse)	3124 ppm (Rat) 1 h 3.2 mg/L (Mouse)

12. ECOLOGICAL INFORMATION

Ecotoxicological Information

Ecotoxicity Product

Acute Fish Toxicity: Not determined
Acute Crustaceans Toxicity: Not determined
Acute Algae Toxicity: Not determined

Ecotoxicity Substance

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Hydrochloric acid	7647-01-0	No information available	LC50: 282 mg/L (Gambusia affinis) LC50: 20.5 mg/L (Lepomis macrochirus)	No information available	No information available

Persistence and degradability

The methods for determining biodegradability are not applicable to inorganic substances.

Bioaccumulative potential
Does not bioaccumulate

Mobility in soil
No information available

Results of PBT and vPvB assessment
No information available.

Other adverse effects

13. DISPOSAL CONSIDERATIONS

Disposal Method Disposal should be made in accordance with federal, state, and local regulations. Substance should NOT be deposited into a sewage facility.

Contaminated Packaging Follow all applicable national or local regulations. Contaminated packaging may be disposed of by: rendering packaging incapable of containing any substance, or treating packaging to remove residual contents, or treating packaging to make sure the residual contents are no longer hazardous, or by disposing of packaging into commercial waste collection.

14. TRANSPORT INFORMATION

Land Transportation

ADR

UN1789, Hydrochloric Acid Solution , 8 , II

Air Transportation

ICAO/IATA

UN1789, Hydrochloric Acid Solution , 8 , II
RQ (Hydrochloric Acid - 2273 kg.)

Sea Transportation

IMDG

UN1789, Hydrochloric Acid Solution , 8 , II
RQ (Hydrochloric Acid - 2273 kg.)
EmS F-A, S-B

Other Transportation Information

Labels: Corrosive

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory All components listed on inventory or are exempt.

New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS
Classification	C - Corrosive.
Risk Phrases	R34 Causes burns. R37 Irritating to respiratory system.
Safety Phrases	S9 Keep container in a well ventilated place. S26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. S45 In case of accident or if you feel unwell, seek medical advice immediately. S1/2 Keep locked up and out of reach of children. S36/37/39 Wear suitable protective clothing, gloves and eye/face protection.

16. OTHER INFORMATION

The following sections have been revised since the last issue of this SDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

TOLCIDE® PS75

1. IDENTIFICATION OF THE MATERIAL AND SUPPLIER

Product Name: TOLCIDE® PS75

Other Names: None

Recommended Use: Biocides.

Intended for industrial use only.
For further information, refer to the product technical data sheet.

MANUFACTURER / SUPPLIER:
RHODIA CHEMICALS PTY. LTD.
ACN 004 449 870
ABN 80 004 449 870
44 Real Avenue,
Norman Park, QLD. 4170
PO Box 1452 Coorparoo QLD. 4151 Australia
TEL: +61 7 38752888 FAX: +61 7 38752156

RHODIA NEW ZEALAND LIMITED
1 Bush Street, Levin New Zealand
TEL: +64 6 368 9372 FAX: +64 6 368 2071

EMERGENCY CONTACT NUMBER:
FOR EMERGENCY INVOLVING A SPILL, LEAK, FIRE, EXPOSURE OR ACCIDENT, CONTACT:
TEL: 1 800 033 111 [Australia] / 0800 734 607 [New Zealand] / +61 3 9663 2130 [International Callers] / +65 3103 1074 [Singapore/Asia Pacific]

2. HAZARDS IDENTIFICATION

AUSTRALIAN CLASSIFICATION
Classified as hazardous according to the criteria of Safe Work Australia Council (SWAC).
Hazard Category: - TOXIC (T)
- DANGEROUS FOR THE ENVIRONMENT (N)

Hazard Classification: HAZARDOUS SUBSTANCE, DANGEROUS GOODS.

Risk Phrases:
R23 Toxic by inhalation
R22 Harmful if swallowed.
R41 Risk of serious damage to eyes.
R43 May cause sensitisation by skin contact.
R61 May cause harm to the unborn child.
R50 Very toxic to aquatic organisms.

Safety Phrases:
S24 Avoid contact with skin.
S26 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S36/37/39 Wear suitable protective clothing, gloves and eye/face protection.
S45 Avoid contact with skin.
S53 Avoid exposure - obtain special instructions before use.
S61 Avoid release to the environment. Refer to special instruction/Safety Data Sheet.

Poison Schedule (Australia): Not scheduled.
NOTE: The SUSDP No. 24 June 2009 Appendix A provides a General Exemption from scheduling for "ALGICIDES, BACTERIOCIDES OR SLIMICIDES for industrial use that do not fit the definition of an agvet chemical product."

Signal Word: None allocated.

Further data:
Possible damage to liver following repeated or prolonged exposure by ingestion. Very toxic to aquatic organisms. NO particular fire or explosion hazard.

Specific hazards:
According to EC regulations, this product is classified as:
- TOXIC.
- TOXIC TO REPRODUCTION, Category 2.
- SENSITIZING.
- IRRITANT.
- DANGEROUS FOR THE ENVIRONMENT.

NEW ZEALAND CLASSIFICATION
Classified as Dangerous Goods according to NZS 5433:2007 Transport of Dangerous Goods on Land.
Classified as hazardous according to criteria in the HS (Minimum Degrees of Hazard) Regulations 2001.

HSNO Classification:
6.1C(oral), 6.5B(contact), 8.2C, 8.3A, 9.1A(fish), 9.1A(crustacean), 9.1A(algal), 9.3B

Signal Word: DANGER

Hazard Statements:
H301 Toxic if swallowed.
H317 May cause an allergic skin reaction.
H314 Causes severe skin burns and eye damage.
H400 Very toxic to aquatic life.

Precautionary Statements:
Prevention:
P104 Read Safety Data Sheet before use.
P264 Wash hands thoroughly after handling.
P260 Do not breath vapours
P261 Avoid breathing dust/fume/gas/mist/vapours/spray.
P270 Do not eat, drink or smoke when using this product.
P272 Contaminated work clothing *should* not be allowed out of the workplace.
P280 Wear protective gloves/protective clothing/eye protection/face protection.
P273 Avoid release to the environment.

Response:
P301+P310 IF SWALLOWED immediately call a POISON CENTRE or doctor/physician.
P301+P330+P331 IF SWALLOWED, rinse mouth, do NOT induce vomiting
P303+P361+P353 IF ON SKIN (or hair) Remove/Take off immediately all contaminated clothing and rinse skin with water/shower
P302+P352 IF ON SKIN, wash with plenty of soap and water.
P333+P313 If skin irritation or rash occurs, get medical advice/attention.

P305+P351+P338 IF IN EYES, rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do so. Continue rinsing.
P304+P340 IF INHALED remove to fresh air and keep at rest in a position comfortable for breathing.
P310 Immediately call a POISON CENTRE or doctor/physician.
P363 Wash contaminated clothing before re-use.
P391 Collect spillage.

Storage:
P405 Store locked up.

Disposal:
P501 Dispose of waste material through a licensed contractor.

3. COMPOSITION / INFORMATION ON INGREDIENTS

SUBSTANCE NAME	Proportion	CAS Number
TETRAKIS(HYDROXYMETHYL)PHOSPHONIUM SULPHATE	> 60%	55566-30-8
WATER	10 - 30%	7732-18-5

4. FIRST AID MEASURES

Ingested:
NEVER attempt to induce vomiting. Do not give anything to drink. Always obtain medical attention immediately. Show this sheet to the doctor.

Eye:
If contact with the eye(s) occurs, flush the eye with copious amounts of water for at least 15 minutes holding eyelid(s) open. Take care not to rinse contaminated water into the non-affected eye. Remove contact lenses, if present and easy to do so. Continue rinsing. Always obtain medical advice immediately, even if there are no symptoms. Show this sheet to the doctor.

Skin:
Remove all contaminated clothing and footwear. Wash with soap and water. Wash immediately and thoroughly for a prolonged period (at least 15 minutes). In case of inflammation (redness, irritation, ...) obtain medical attention.

Inhaled: Move the person away from the contaminated area. Make the affected person rest. Obtain medical attention. Show this sheet to the doctor.

Aggravated Medical Conditions Caused by Exposure.
Skin contact may aggravate existing skin disease.

First Aid Facilities:
Emergency equipment and first-aid box with instructions should be readily available. Safety shower and eye fountain as collective emergency equipment.

Advice to Doctor:
Treat symptomatically. No specific antidote available.
All treatment should be based on observed signs and symptoms of distress in the patient. Consideration should be given to the possibility that overexposure to materials other than this product may have occurred.

Further information:
Establish a first aid action plan before using this product. Use appropriate protective equipment when treating a contaminated person. Use first aid techniques to restore vital functions. Place contaminated clothing in a sealed bag for disposal.

Poisons Information:
For advice, contact a Poisons Information Centre (e.g. phone Australia 13 1126; New Zealand 0800 764 766) or a doctor (at once).

5. FIRE-FIGHTING MEASURES

Extinguishing Media
- Suitable: All extinguishing agents can be used (water, foam, powders, carbon dioxide, sand ...).
- Not suitable: None. If there is a fire close by, use suitable extinguishing agents.

Hazards from Combustion Products:
Under fire conditions, toxic gases or vapours are released. Decomposes at temperatures above 160 ^{0}C. On combustion or on thermal decomposition (pyrolysis) releases toxic gases or vapours of (Sulphur oxides).(Phosphorus oxides).(Carbon oxides (CO + CO_2)).(Phosphine)(Hydrogen).

Precautions for Fire Fighters and Special Protective Equipment:
Toxic gases or vapours are released. Do not breathe fumes. If safe to do so, move undamaged containers from fire area. Stay upwind. Evacuate the personnel away from the fumes. If possible to do so safely, shut off fuel to fire. In case of fire close by, cool down the containers/equipment exposed to heat with a water spray.

Fire fighters to wear self-contained breathing apparatus (SCBA) and full protective clothing.

Hazchem Code: 2X

Flammability:
This product is not a flammable or combustible liquid. Decomposes at temperatures above 160 ^{0}C.

6. ACCIDENTAL RELEASE MEASURES

Emergency Procedures
Personal Precautions:
Do not breathe spray. Avoid contact with eyes, skin and respiratory system. If spillage occurs on the public highway, indicate the danger and notify the authorities (police, fire brigade). Use full protective clothing and equipment. For further information refer to section 8 "Exposure-controls/personal protection".

Environmental Precautions: Prevent the product from spreading into the environment. Contain the spilled material by bunding.

Methods and Materials for Containment and Clean Up Procedures:
- Recovery: Recover as much of the product as possible. Absorb the product onto porous material. Transfer the product into a spare container:
- suitably labelled. Then take the emergency containers to an area reserved for subsequent recycling or disposal.
- Neutralisation: Absorb spillage with diatomaceous earth, sand or inert absorbent.
- Cleaning/Decontamination: Wash non-recoverable remainder with large amounts of water. Recover the cleaning water for subsequent disposal.
- Disposal: Place in an appropriate container and dispose of the contaminated material at a licensed site. (Refer to Section 13 "Disposal Considerations").

Dangerous Goods - Initial Emergency Response Guide (IERG) (SAA/SNZ HB76)
Guide 36: TOXIC LIQUID, ORGANIC, N.O.S.

7. HANDLING AND STORAGE

Precautions for Safe Handling
Technical measures: Ventilation
Measures: This product must only be handled by skilled operators.
Avoid exposure: Work in a well-ventilated area. Avoid forming aerosols. Avoid the formation of mists in the atmosphere. Do NOT handle without gloves. For further information refer to section 8 "Exposure-controls/personal protection".

Safe handling advice: Obtain special instructions before use. Handle and use in accordance with good occupational hygiene and safety practice. Do not mix with incompatible materials (See list in Section 10). When mixed with additives (for example surfactants, dispersants, antifoams), the toxicity by inhalation may be increased. Please contact Rhodia Product Stewardship for advice.

Conditions for Safe Storage
Take all necessary measures to avoid accidental discharge of products into drains and waterways due to the rupture of containers or transfer systems.
Store in a cool, dry area away from incompatible products.
Incompatible products: Strong reducing agents. Strong oxidizing agents. Strong acids. Strong bases.
Packaging: Polyethylene or polypropylene drums. (high density)
Packaging materials: Recommended: Plastic materials (polyethylene, polypropylene). (high density)

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

National Exposure Standards:
No exposure standards assigned to this specific material by the Safe Work Australia Council (SWAC), or the New Zealand Occupational Safety & Health Service (OSH).

Biological Limit Values:
Not established.

Engineering Controls:
Avoid splashes (appropriate clothing, protective screens on machines etc.)
Ensure good ventilation of the work station. Reduce exposure time to the minimum necessary.

Personal Protection Equipment:

Eye/Face Protection:
Safety glasses with side shields, or splash-proof chemical goggles, and a full-face shield. Final choice of appropriate eye/face protection will vary according to individual circumstances i.e. methods of handling or engineering controls and according to risk assessments undertaken. Eye protection should conform with Australian/New Zealand Standard AS/NZS 1337 - Eye Protectors for Industrial Applications.

Hand Protection:
Wear chemical-resistant protective gloves of impervious material. Protective gloves must be chosen according to the function of the work station: other chemicals which may be handled, physical protection necessary (resistance to cutting, puncture, heat), dexterity required. The selection of gloves must take into account the extent and duration of use at the workstation.

Glove material : Protective gloves made of PVC.

Thickness : 1.23 mm
Breakthrough time : >480 minutes
Protection class : 6
Glove material: Nitrile protective gloves
Thickness: 1.23 mm
Breakthrough time: >480 minutes
Protection class: 6
(Unpublished internal reports)

Final choice of appropriate gloves will vary according to individual circumstances i.e. methods of handling or according to risk assessments undertaken. Reference should be made to AS/NZS 2161.1: Occupational protective gloves - Selection, use and maintenance.

Skin and Body Protection: Wear suitable protective clothing, gloves and eye/face protection.

Respiratory Protection: Avoid breathing of vapours/mists. If mist is formed: Respiratory protective device with a particle filter. If engineering controls are not effective in controlling airborne exposure then respiratory protective equipment should be used suitable for protecting against airborne contaminants. Correct fit is essential to obtain adequate protection. If entering spaces where the airborne concentration of a contaminant is unknown then the use of a self-contained breathing apparatus (SCBA) with positive pressure air supply complying with AS/NZS 1715 / 1716, or any other acceptable International Standard is recommended. Final choice of appropriate respiratory protection will vary according to individual circumstances i.e. methods of handling or engineering controls and according to risk assessments undertaken. Reference should be made to Australian/New Zealand Standards AS/NZS 1715, Selection, Use and maintenance of Respiratory Protective Devices; and AS/NZS 1716, Respiratory Protective Devices.

Selection Criteria: Protective equipment must be chosen according to current AS/NZS standards and in cooperation with the supplier of protective equipment. Personal protective equipment must be defined after risk assessment for the workstation.

Collective emergency equipment: Personal protective equipment available close by in case of emergency. Safety shower and eye fountain.

Workplace Hygiene Measures:
Use clean and correctly maintained personal protective equipment. Keep personal protective equipment in a clean place, away from the work area.
Personal hygiene is an important work practice exposure control measure and the following general measures should be taken when working with or handling this material:
Always wash your hands immediately after handling this product, and once again before leaving the workplace.
Do NOT eat or drink in the workplace.

Further information: The user is responsible for monitoring the working environment in accordance with local laws and regulations.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	Colourless to pale yellow liquid with characteristic odour.
pH:	3 - 6
Freezing Point:	< -20 ^{0}C
Boiling Point:	108.5 ^{0}C (Normal pressure: 1013 hPa).
Flash Point:	Not applicable.
Oxidizing properties:	Not applicable.

Vapour Pressure:	<0.0000026 hPa @ 25 ^{0}C (Dry product).
Specific Gravity:	1370 - 1410 kg/m³ @ 20 ^{0}C
Solubility in Water:	Miscible (in all proportions).
Solubility in organic solvents:	Soluble in: methanol, n-methyl pyrrolidone, ispropanol. Insoluble in: acteone, tetrahydrofuran.
Octanol/water partition coefficient:	- 9.8 (log POW) (evaluation by structure-activity relationship)

10. STABILITY AND REACTIVITY

Chemical Stability:
Stable under normal storage and handling conditions. Decomposes at temperatures above 160 ^{0}C.

Hazardous Decomposition Products:
Under fire conditions, toxic gases or vapours are released. Decomposes at temperatures above 160 ^{0}C. On combustion or on thermal decomposition (pyrolysis) releases toxic gases or vapours of (Sulphur oxides).(Phosphorus oxides).(Carbon oxides (CO + CO_2)).(Phosphine)(Hydrogen).

Hazardous Reactions:
Hazardous Polymerization will not occur.

Incompatible Materials:
Strong bases.
Strong reducing agents.
Strong acids.
Strong oxidising agents.

Conditions to Avoid:
Decomposes above 160 ^{0}C.

11. TOXICOLOGICAL INFORMATION

Acute Health Effects:
Ingested:
Harmful if swallowed. Swallowing can result in nausea and vomiting. May cause irritation to mouth, throat and stomach. Possible damage to liver following repeated or prolonged exposure by ingestion.

Eye:
Risk of serious damage to eyes. Will cause severe irritation to the eyes with effects including watering of the eyes (tearing), pain, corneal opacity and blurred vision. If prompt action is not taken permanent eye damage may occur. Risk of serious damage to eyes.

Skin:
May cause sensitisation by skin contact. May cause irritation to the skin, with effects including redness, itchiness and drying/defatting.

Inhaled:
Toxic by inhalation. NOT considered to be irritating to the respiratory system.

Main Symptoms: Lachrymatory effect (watering of the eyes).

Acute Toxicity:
LC 50 inhalation (Rat) / 4 h : 0.591 mg/l. for males and females
Toxic by inhalation. (Published data).

LD 50 skin (Rat) : > 2000 mg/kg. for males and females
Not classified as harmful by contact with skin
(Unpublished internal reports)

LD 50 oral (Rat): 575 mg/kg. for males and females
Harmful if swallowed.
(Unpublished internal reports)

Irritation - Skin:
According to OECD method 404:
Not irritating to rabbits on cutaneous application. (Unpublished internal reports)

Irritation - Eyes:
Acute Symptoms: Watering of the eyes.

According to OECD method 405 :
Extremely irritating to rabbits on ocular application.
Risk of serious damage to eyes. (Unpublished internal reports)

Sensitisation - Skin:
May cause sensitisation on contact with skin. (Unpublished internal reports)

Repeated Dose Toxicity:
on ingestion
Repeated dose toxicity (90 days)(Rat)
for males and females
Hepatotoxic effects.
No observed effect level (NOEL) : 1 mg/kg/day (Unpublished internal reports)

Carcinogenicity:
Oral toxicity tests on rats and mice did not reveal any carcinogenic potential. (Published data).

Mutagenicity:
Ames test.
(S. typhimurium) (with or without metabolic activation). Negative. (Unpublished internal reports)

Chromosomal aberrations :
Mammalian cells (CHO) In vitro (with or without metabolic activation). Positive. (Unpublished internal reports)

In vitro
UDS test (Rat) Negative. (Unpublished internal reports)

Mouse lymphoma test/TK. (with or without metabolic activation). Positive. (Unpublished internal reports)

Rodent dominant Lethal test (Rat) In vivo Negative. (Unpublished internal reports)
In vivo micronucleus test (Mouse) Negative. (Unpublished internal reports)

Product is not considered to be genotoxic.

Reproductive Toxicity:
Fertility study (2 generations)(Rat) no impairment of fertility has been observed on ingestion (Unpublished internal reports)
Developmental toxicity study: on ingestion (Rat) NOEL, maternal toxicity : 15 mg/kg/day NOEL, foetal Toxicity : 30 mg/kg/day (Unpublished internal reports)

Developmental toxicity study: on ingestion(Rabbit) NOEL, maternal toxicity : 18 mg/kg/day NOEL, foetal toxicity : 18 mg/kg/day Effects on development were observed
May cause harm to the unborn child. (Unpublished internal reports)

Neurotoxicity:
Screening biochemistry test kit for cholinesterase activity inhibition.
The product does not induce inhibition.

12. ECOLOGICAL INFORMATION

Ecotoxicity:
LC 50 (Fish: Oncorhynchus mykiss) / 96h: 119 mg/l.
LC 50 (Fish: Lepomis macrochirus) / 96h: 93 mg/l.
EC 50 (Daphnia: Daphnia magna)/48 h: 19.4 mg/l.
EC 50 (Fresh water algae: Pseudokirchneriella subcapitata) / 96h : 0.20 mg/l.
EC 50 (Bacteria : Activated sludge) / 3 hr(s) : 24 mg/l
Very toxic to aquatic organisms tested. (Unpublished internal reports)

Persistence / Degradability
Persistence
Product is not persistent.

Degradability:
Abiotic degradation
- Other physico-chemical reactions: Product is easily oxidisable in aqueous media in dilute solutions.

Biodegradability:
- Ultimate aerobic biodegradability: Simulation study:
70% biodegradation after 21days (US EPA FIFRA, Subdivision N, § 162-4)
Readily biodegradable.

- Anaerobic biodegradation. Simulation study: 60% biodegradation after 30 days (US EPA FIFRA, Subdivision N, § 162-3)

Mobility:
Adsorption/Desorption: Log Koc = 2.2
Moderately mobile in soils.
Ultimate destination of the product: WATER

Bio-accumulation:
Octanol/water partition coefficient: - 9.8 (log POW) (evaluation by structure-activity relationship). Not potentially bioaccumulable.

Further Information: M factor = 1 [according to the Globally Harmonized System (GHS) and the 2nd Adaptation to Technical Progress of Directive 1999/45/EC]

Avoid contaminating waterways, drains or sewers

13. DISPOSAL CONSIDERATIONS

RESIDUES FROM PRODUCT
Prohibition: Do NOT discharge waste into drains.
Destruction/Disposal: Dispose of in accordance with relevant local regulations. Dispose of this product as hazardous waste. Incinerate at a licensed installation.

CONTAMINATED PACKAGING
Decontamination/cleaning: Take preliminary precautions based on the dangerous properties of the product. Empty the packaging completely prior to disposal.

Destruction/Disposal: Depending on local facilities, recycle or incinerate the packaging at an authorised site.

NOTE: The user's attention is drawn to the possible existence of local regulations regarding disposal.

14. TRANSPORT INFORMATION

UN Number: 2810
Proper Shipping Name: TOXIC LIQUID, ORGANIC, N.O.S. (Aqueous Solution of Tetrakis(hydroxymethyl)phosphonium sulphate)
Dangerous Goods Class: 6.1
Subsidiary risk: None allocated
Packing Group: III
Hazchem Code: 2X

AUSTRALIA
Road and Rail Transport: (Australia)
Australian Code for the Transport of Dangerous Goods by Road and Rail. Dangerous Goods of Class 6 (Toxic and Infectious Substances) are incompatible in a placard load with any of the following:
- Class 1, Explosives
- Class 3, Flammable Liquids, if the Class 3 dangerous goods are nitromethane
- Class 8, Corrosives, if the Class 6 dangerous goods are cyanides and the Class 8 dangerous goods are acids

And are incompatible with food and food packaging in any quantity.

Class 6 materials that are fire-risk substances are incompatible with Class 5 materials.

NEW ZEALAND
Land Transport: (New Zealand)
Classified as Dangerous Goods Class 6.1 (Toxic and Infectious Substances) according to NZS 5433:2007 Transport of Dangerous Goods on Land.
Dangerous Goods of Class 6 must not be loaded in the same freight container or on the same vehicle with the following:
- Class 1, Explosives
- Foodstuffs or Food Containers

Dangerous Goods of Class 6 must not be loaded in the same freight container with the following; and on the same vehicle must be separated horizontally by at least 3 metres unless all but one are packed in separate freight containers:
- Class 5.1, Oxidising Substances
- Class 5.2, Organic Peroxides

Dangerous Goods of Class 6 must not be loaded in the same freight container or on the same vehicle with the following if transported in segregation devices:
- Class 5.1, Oxidising Substances
- Class 5.2, Organic Peroxides
- Foodstuffs or Food Containers

Note: Cyanides (Class 6.1) of Packing Group II or III may be loaded in the same freight container or on the same vehicle with acids (Class 8).

INTERNATIONAL REGULATIONS
Land
- Rail/road (RID/ADR)
UN number: 2810
Proper Shipping Name (Technical Name) : TOXIC LIQUID, ORGANIC, N.O.S. (Aqueous Solution of Tetrakis(hydroxymethyl)phosphonium sulphate)
Labelling: 6.1.
Packing group: III.
ADR tunnel category : (E)
Class/Division : 6.1
Environmentally hazardous mark : YES
Hazard identification number: 60

Sea (IMO/IMDG)
UN Number: 2810
Proper Shipping Name (Technical Name) : TOXIC LIQUID, ORGANIC, N.O.S. (Aqueous Solution of Tetrakis(hydroxymethyl)phosphonium sulphate)
Labelling: 6.1.
Packing group: III.
Class/Division : 6.1
Marine pollutant (environmentally hazardous mark) : YES
Emergency schedule (EmS): F-A, S-A.

Air (ICAO-IATA)
UN number: 2810
Proper Shipping Name (Technical Name) : TOXIC LIQUID, ORGANIC, N.O.S. (Aqueous Solution of Tetrakis(hydroxymethyl)phosphonium sulphate)
Labelling: 6.1.
Packing group: III.
Class/Division : 6.1
Environmentally hazardous mark : NO
Passenger aircraft : Packing instruction: 611 - Maximum net quantity per package: 60 L
Cargo aircraft : Packing instruction: 618 - Maximum net quantity per package: 220 L

Further information: Empty containers which have not been cleaned are subject to the same transport regulations as those which are full.

NOTE: The above regulatory prescriptions are those valid on the date of publication of this sheet. However, given the possible evolution of transport regulations for hazardous materials and in the event of the SDS in your possession dating back more than 12 months, it is advisable to check their validity with your sales office.

15. REGULATORY INFORMATION

Poison Schedule (Australia): Not scheduled.
NOTE: The SUSDP No. 24 June 2009 Appendix A provides a General Exemption from scheduling for "ALGICIDES, BACTERIOCIDES OR SLIMICIDES for industrial use that do not fit the definition of an agvet chemical product."

HSNO Group: This substance falls under the HSNO Additives, Process Chemicals and Raw Materials (Toxic [6.1], Corrosive) Group Standard 2006.

HSNO Approval Number: The HSNO Approval Number for this Group Standard is HSR002510.

Approved handler requirements
Substances covered under this Group Standard **will** require an approved handler.

INVENTORY STATUS:

Inventory	*Status*
Australia (AICS)	Y
United States (TSCA)	Y
Europe (EINECS/ELINCS)	Y

Y = all ingredients are on the inventory.
P = One or more ingredients fall under the polymer exemption or are on the no longer polymer list. All other ingredients are on the inventory or exempt from listing.
N = Not determined or one or more ingredients are not on the inventory and are not exempt from listing.

Market limitation: Restrict to professional users. Intended for industrial use only.

16. OTHER INFORMATION

Reason For Revision:
1) Review against current SWAC / NOHSC and ERMA / HSNO criteria and latest information from manufacturer.
2) Changes and / or additions made to all Sections.

TThe customer is advised to consult the product Technical Data Sheets for further information including advice on suitable equipment.

SDSs are updated frequently. Please ensure that you have a current copy.

Key Legend Information:
ACGIH - American Conference of Governmental Industrial Hygienists
AICS - Australian Inventory of Chemical Substances
ASCC - Australian Safety and Compensation Council
CAS - Chemical Abstracts Service
EPA - Environmental Protection Agency [Int]
ERMA - Environmental Risk Management Authority [NZ]
EU - European Union
GHS - United Nations - Globally Harmonized System of Classification and Labelling of Chemicals[Int]
HSNO - Hazardous Substances and New Organisms [NZ]
IACR - International Agency for Research on Cancer
IATA - International Aviation Transport Authority [Int]
ICAO - International Civil Aviation Organization [Int]

IMDG - International Maritime Dangerous Goods [Int]
IMO - International Maritime Organisation. [Int]
NTP - National Toxicology Program
NIOSH - National Institute for Occupational Safety and Health [US]
NOHSC - National Occupational Health & Safety Commission
NZIoC - New Zealand Inventory of Chemicals [NZ]
OSHA - Occupational Safety and Health Administration [US]
SUSDP - Standard for the Uniform Scheduling of Drugs and Poisons [Aust]
STEL - Short Term Exposure Limit [Int]
SWAC - Safe Work Australia Council [Formerly ASCC]
TWA - Time Weighted Average [Int]
WES - Workplace Exposure Standard [NZ]
[Aust/NZ] = Australia/New Zealand
[Int] = International
[US] = United States of America

Principal References: Safety Data Sheet (SDS) - TOLCIDE®PS75, Issued by Rhodia UK Limited, UK, Date Prepared: 07-04-2010 Version: 7.

Date Prepared:	**04 – 07 – 2010**	**Prepared By: Rhodia Chemicals Pty. Ltd.**
Date Superseded:	**22 – 07 – 2007**	**The information herein is given in good faith but no warranty is expressed nor implied.**

END OF SAFETY DATA SHEET

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **WG-36 GELLING AGENT**

Revision Date: 27-Aug-2013

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Statement of Hazardous Nature Non-Hazardous according to the criteria of NOHSC, Non-Dangerous Goods according to the criteria of ADG.

Manufacturer/Supplier

Halliburton Australia Pty. Ltd.
15 Marriott Road
Jandakot
WA 6164
Australia

ACN Number: 009 000 775
Telephone Number: 61 (08) 9455 8300
Fax Number: 61 (08) 9455 5300

Product Emergency Telephone
Australia: 08-64244950
Papua New Guinea: 05 1 281 575 5000
NewZealand: 06-7559274

Fire, Police & Ambulance - Emergency Telephone
Australia: 000
Papua New Guinea: 000
New Zealand: 111

Identification of Substances or Preparation

Product Trade Name: WG-36 GELLING AGENT
Synonyms: None
Chemical Family: Polysaccharide
UN Number: None
Dangerous Goods Class: None
Subsidiary Risk: None
Hazchem Code: None Allocated
Poisons Schedule: None Allocated
Application: Gelling Agent

Prepared By

Chemical Compliance
Telephone: 1-580-251-4335
e-mail: fdunexchem@halliburton.com

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substances	CAS Number	PERCENT (w/w)	Australia NOHSC	New Zealand WES	ACGIH TLV-TWA
Guar gum	9000-30-0	60 - 100%	Not applicable	Not applicable	10 mg/m^3

Non-Hazardous Substance to Total of 100%

3. HAZARDS IDENTIFICATION

Hazard Overview	May cause eye and respiratory irritation. May cause allergic respiratory reaction. Airborne dust may be explosive.
Risk Phrases	None
HSNO Classification	Not Determined

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Suitable Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.

Extinguishing media which must not be used for safety reasons
None known.

Special Exposure Hazards	Decomposition in fire may produce toxic gases. Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.
Special Protective Equipment for Fire-Fighters	Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning / Absorption	Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.
Storage Information	Store away from oxidizers. Store in a cool, dry location. Product has a shelf life of 24 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area.
Respiratory Protection	Not normally needed. But if significant exposures are possible then the following respirator is recommended: Dust/mist respirator. (N95, P2/P3)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Off white
Odor:	Bean
pH:	6.5-7.5
Specific Gravity @ 20 C (Water=1):	1.42 -1.47
Density @ 20 C (kg/l):	Not Determined
Bulk Density @ 20 C (kg/M3):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (C):	Not Determined
Pour Point/Range (C):	Not Determined
Flash Point/Range (C):	Not Determined **Min:** > 93
Flash Point Method:	COC
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (g/m^3):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (g/m^3):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (g/l):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined
Decomposition Temperature (C):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Strong oxidizers.

Hazardous Decomposition Products Carbon monoxide and carbon dioxide.

Additional Guidelines Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure Eye or skin contact, inhalation.

Sympotoms related to exposure

Acute Toxicity

Inhalation May cause respiratory irritation. May cause allergic respiratory reaction.

Eye Contact May cause eye irritation.

Skin Contact None known.

Ingestion None known

Chronic Effects/Carcinogenicity No data available to indicate product or components present at greater than 1% are chronic health hazards.

Toxicology data for the components

Substances	CAS Number	LD50 Oral	LD50 Dermal	LC50 Inhalation
Guar gum	9000-30-0	6770 mg/kg (Rat)	No data available	No data available

12. ECOLOGICAL INFORMATION

Ecotoxicological Information

Ecotoxicity Product

Acute Fish Toxicity: Not determined

Acute Crustaceans Toxicity: Not determined

Acute Algae Toxicity: Not determined

Ecotoxicity Substance

Substances	CAS Number	Toxicity to Algae	Toxicity to Fish	Toxicity to Microorganisms	Daphnia Magna (Water Flea)
Guar gum	9000-30-0	No information available	No information available	No information available	No information available

Persistence and degradability
Readily biodegradable

Bioaccumulative potential
Does not bioaccumulate

Mobility in soil
No information available

Results of PBT and vPvB assessment
No information available.

Other adverse effects

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

ADR
Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Transportation Information

Labels: None

15. REGULATORY INFORMATION

Chemical Inventories

Australian AICS Inventory	All components listed on inventory or are exempt.
New Zealand Inventory of Chemicals	All components listed on inventory or are exempt.
US TSCA Inventory	All components listed on inventory or are exempt.
EINECS Inventory	This product, and all its components, complies with EINECS
Classification	Not Classified
Risk Phrases	None
Safety Phrases	None

16. OTHER INFORMATION

The following sections have been revised since the last issue of this SDS
Not applicable

Contact

Australian Poisons Information Centre
24 Hour Service: - 13 11 26
Police or Fire Brigade: - 000 (exchange): - 1100

New Zealand National Poisons Centre
0800 764 766

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.

Disclaimer Statement

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*****END OF MSDS*****

Appendix N

Environmental incident response plan

Environmental Incident Response Plan (EIRP)

AGL Gloucester Gas Project

19 SEPTEMBER 2013

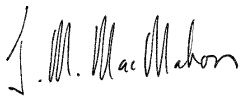
Prepared for

AGL Upstream Investments Pty Ltd

43177860

URS

Principal-In-Charge



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Katherine Dodd
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Date: **19 September** 2013
Reference: 43177860/EIRP_G/02
Status: FINAL

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Definitions and Abbreviations

Term	Definition
AGL	AGL Upstream Investments Pty Ltd
APPEA	Australian Petroleum Production and Exploration Association
Assembly Area	The designated place or places where people assemble during the course of an evacuation
CBL	Cement Bond Log
CCC	Community Consultative Committee
CSG	Coal Seam Gas
CSM	Coal Seam Methane
DA	Development Application
DBYD	Dial Before You Dig
EECs	Endangered Ecological Communities
EIA	Environmental Impact Assessment
EIRP	Environmental Incident Response Plan
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EPA	Environment Protection Authority
EPL	Environmental Protection Licence
ERP	Emergency Response Plan
FSMP	Fracture Stimulation Management Plan
FRNSW	Fire and Rescue NSW
HAZOP	Hazard and Operability Study
HHERA	Human Health and Ecological Risk Assessment
HDD	Horizontal Directional Drilling
IBC	Intermediate Bulk Container
Immediately	Promptly and without delay
LGA	Local Government Area
JSA	Job Safety Analysis
Material Harm	(a) harm to the environment is material if: (i) it involves actual or potential harm to the health or safety of human beings or to ecosystems that is not trivial, or (ii) it results in actual or potential loss or property damage of an amount, or amounts in aggregate, exceeding $10,000 (or such other amount as is prescribed by the regulations), and (b) loss includes the reasonable costs and expenses that would be incurred in taking all reasonable and practicable measures to prevent, mitigate or make good harm to the environment. It does not matter that harm to the environment is caused only in the premises where the pollution incident occurs. (*Protection of the Environment Operations Act 1997*)
MAOP	Maximum Allowable Operating Pressure

Definitions and Abbreviations

Term	Definition
Mercaptan(s)	A group of sulfur-containing organic chemical substances
MSDS	Material Safety Data Sheet
NSW	New South Wales
OEH	Office of Environment and Heritage
PA	Project Approval
PEL	Petroleum Exploration Lease
POP	Production Operations Plan
PPL	Petroleum Production Lease
PELA Act	*Protection of the Environment Legislation Amendment Act 2011*
PPE	Personnel Protective Equipment
Pollution Incident	An incident or set of circumstances during or as a consequence of which there is or is likely to be a leak, spill, or other escape or deposit of a substance, as a result of which pollution has occurred, is occurring or is likely to occur. It includes an incident or set of circumstances in which a substance has been placed or disposed of on premises, but does not include an incident or set of circumstances involving only the emission of any noise. (*Protection of the Environment Operations Act 1997*) The types of incidents that may occur include: • Minor – onsite pollution incident • Serious – intermediate pollution incident • Major – long term pollution incident Each type of incident requires a separate degree of response as described in Section 8 of this EIRP.
PIRMP	Pollution Incident Response Management Plan
Proppant	A proppant is a material that will keep an induced hydraulic fracture open, during or following a fracturing treatment.
POEO Act	*Protection of the Environment Operations Act 1997*
POEO(General) Regulation	*Protection of the Environment Operations (General) Regulation 2009*
PSV	Process Safety Valve
RAR	Gloucester Fracture Stimulation Management Plan Risk Assessment Report
RFS NSW	Rural Fire Service NSW
SIS	Surface to in seam
SCADA	Supervisory Control and Data Acquisition. An industrial measurement and control system consisting of a central host or master (usually called a master station, master terminal unit or MTU); one or more field data gathering and control units or remotes (usually called remote stations, remote terminal units, or RTUs); and a collection of standard and/or custom software used to monitor and control remotely located field data elements.
SF_6	Sulfur hexafluoride

Definitions and Abbreviations

Term	Definition
Secondary Treatment	Passive or active systems designed to treat contaminated discharge from Primary Containment and/or switchyard drainage systems. The principle of operation of these systems is to separate oil from any discharge. Examples of Secondary Treatment systems are retention dams with underflow discharge, or a coalescing plate oil/water separator tank.
SOP	Standard Operating Procedure
The Code	NSW Code of Practice for Coal Seam Gas: Fracture Stimulation Activities 2012
TVD	True Vertical Depth
WMP	Waste Management Plan

Document Control

Revision:

Reviewed by	Name / Signature	Date
Regina Walker		4 September 2013
Suzanne Westgate		9 September 2013

Revision Status:

Revision	Date	Prepared By	Checked By	Approved By	Comments
0	11 April 2013	URS Australia Pty Ltd			First version prepared to meet the requirements of the Code of Practice for Coal Seam Gas – Fracture Stimulation Activities, September 2012
1	29 August 2013	URS Australia Pty Ltd			Minor changes to section 3.3 and Appendix A
2	19 September 2013	URS Australia Pty Ltd			Acceptance of minor changes to Document Control page and Sections, 1, 3, 4, Table 4-1, 6 and 8

Controlled Document Distribution List:

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1

Introduction

1.1 Background

There is a duty to report and manage pollution incidents within the *Protection of the Environment Operations Act 1997* (POEO Act). Provisions of the POEO Act include a requirement for holders of an Environment Protection Licence (EPL) to prepare, keep, test and implement a Pollution Incident Response Management Plan (PIRMP).

The *NSW Code of Practice for Coal Seam Gas: Fracture Stimulation Activities* (the Code) developed for Coal Seam Gas (CSG) Titleholders identifies that for CSG fracture stimulation activities incidents and emergencies must be prepared for and managed appropriately to ensure that risks to health, safety and the environment are minimised. An Environmental Incident Response Plan (EIRP) must therefore be prepared by CSG Titleholders who undertake fracture stimulation activities.

The specific requirements for EIRPs are set out in Section 11.3 of the Code. In summary, this legislation requires the following:

- CSG Titleholders Holders must prepare a EIRP (Section 11.3);
- The EIRP must include the information detailed in the Code (Section 11.3)
- Titleholders must keep the plan at the site of any fracture stimulation activity;
- Titleholders must test the plan prior to the commencement of the fracture stimulation activity;
- Should a pollution incident occur in the course of a fracture stimulation activity so that material harm to the environment is caused or threatened within the meaning of Part 5.7 of the POEO Act, the Titleholder must immediately notify the relevant authorities (Section 11.3 (e)).

AGL Upstream Investments Pty Limited (AGL) carries out fracture stimulation activities at the Gloucester Gas Project, located in New South Wales near Stratford, approximately 100 kilometres (km) north of Newcastle.

This document has been developed to satisfy the EIRP requirements of Section 11.3 of the Code and details the procedures for notification of pollution incidents resulting in or having the potential to cause material harm to the environment. Notification of environmental incidents is required for those incidents causing or threatening to result in material environmental harm (a material harm incident) as defined in the POEO Act (see Section 5.1 of this report).

In accordance with Section 11.3 (a) of the Code a material harm incident shall include:

i. Well blowout or loss of well integrity;

ii. Chemical spill or other pollution incident;

iii. Damage to an overlying water source;

iv. Breach of regulatory requirements, including significant non-compliances with the Fracture Stimulation Management Plan (FSMP); and

v. Any other significant environmental incident associated with the fracture stimulation activity.

1.2 Objectives

The objectives of this EIRP are:

- To maintain a sufficient level of preparedness for a pollution incident.
- To respond efficiently to limit the impacts of a pollution incident.
- To manage a pollution incident until the emergency services and relevant authorities arrive and take control where it is deemed necessary.

- To support emergency services and relevant authorities with information, knowledge, skills and equipment where feasible.
- To protect the environment, human health and the community from harm.
- To outline how the risk of a pollution incident will be minimised and controlled and the development of planned actions to minimise and manage those risks.
- To document the notification protocol to ensure comprehensive and timely communication about a pollution incident is provided to relevant stakeholders.
- To comply with relevant government Acts and Regulations.

1.3 Scope

This EIRP has been prepared in accordance with the following Act and Code of Practice:

- Part 5.7A of the POEO Act 1997; and
- The *NSW Code of Practice for Coal Seam Gas: Fracture Stimulation Activities*.

The scope of this EIRP extends to the premises and plant to which Petroleum Exploration Licence (PEL) 285 applies, where AGL fracture stimulation activities are conducted.

This EIRP addresses environmental and human aspects of pollution incidents to which fracture stimulation activities apply. This EIRP does not address facility operational incidents, community disaster management, business continuity, security or environmental impacts beyond those defined in the Code.

The requirements and actions defined in this plan apply to AGL employees, contractors and visitors.

1.4 Relationship with Other Plans

In the event that a pollution incident escalates and cannot be controlled and/or managed by this EIRP, the AGL Gloucester Gas Project **Emergency Response Plan** and AGL **Code Red Management Plan** shall be implemented.

The purpose of the **Emergency Response Plan** is to support this EIRP in relation to environmental incidences. The purpose of the **Code Red Management Plan** is to support the **Emergency Response Plan** by providing a consistent communications framework that supports the operational response to a crisis. This will enable AGL to provide timely and accurate information to the relevant stakeholders.

The AGL Code Red process is designed to minimise the impact of an incident or event on the AGL Group. The goal of the **Code Red Management Plan** is to support existing operational incident management plans, disaster recovery plans and business continuity plans. The **Code Red Management Plan** provides a consistent communications framework that supports AGL's operational response to a crisis and will enable AGL to provide timely, accurate information to stakeholders. Matters relating to AGL **Code Red Management Plan** are to be directed to the AGL Group General Manager for Upstream Gas and the AGL Head of Corp Support Service & Company Secretary.

The **HSE Incident Management Procedure (LG-HSE-CP-006)** should also be implemented in conjunction with this EIRP and above referenced plans.

1.5 References

This EIRP has been developed in accordance with the requirements of the EPA's NSW Government Department of Trade and Investment, Resource and Energy *Code of Practice for Coal Seam Gas:*

1 Introduction

Fracture Stimulation Activities and the AGL Health Safety and Environment Standard for Emergency Preparedness and Response.

The following documents were also considered in the development of this EIRP:

- AGL HSE Incident Management Procedure (LG-HSE-CP-006).
- AGL Gloucester Gas Project Environmental Management Plan, March 2013.
- AGL Gloucester Gas Project Emergency Response Plan (PEL 285), Draft, 20 March 2013.
- AGL Code Red Management Plan.
- AGL Gloucester Gas Project Safety Management Plan, 20 March 2013.
- AGL Gloucester Gas Project Dangerous Goods and Hazardous Materials Sub Plan, March 2013.
- Human Health and Ecological Risk Assessment – Hydraulic Stimulation Activities – Gloucester Gas Project (Environmental Risk Sciences Pty Ltd, Draft, 11 February 2013).
- Code of Practice for Coal Seam Gas: Well Integrity, September 2012, DTIRIS, DRE.
- Gloucester Fracture Stimulation Management Plan Risk Assessment Report, Rev04.

2

Regulatory Requirements

Table 2-1 provides the information required under Section 11.3 of the Code and details where this is located in the EIRP.

Table 2-1 EIRP regulatory requirements

Section 153C	Detail required	Location in EIRP
(a)	The titleholder must prepare and maintain an Environmental Incident Response Plan setting out in detail the procedures to be followed and actions to be taken in the event of: i. Well blowout or loss of integrity ii. Chemical spill or other pollution incident iii. Damage to an overlying water source iv. Breach of regulatory requirements, including significant non-compliance with the FSMP v. Any other significant environmental incident associated with the fracture stimulation activity.	**Section 4**
(b)	The matters required to be included in an Environmental Incident Response Plan are: i. A description of the hazards to human health or the environment associated with the fracture stimulation activity	**Section** 4 **and Appendix A**
	ii. The likelihood of any such hazards occurring, including details of any conditions or events that could, or would, increase that likelihood	**Appendix A**
	iii. Details of the pre-emptive action to be taken to minimise or prevent any risk of harm to human health or the environment arising out of the activity	**Section 4.2**
	iv. An inventory of potential pollutants on the premises or used in carrying out the activity,	**Section 4.4**
	v. The maximum quantity of any pollutant that is likely to be stored or held at the location of the fracture stimulation activity	**Section 4.4**
	vi. A description of the safety equipment or other devices that are used to minimise the risks to human health or the environment and to contain or control a pollution incident	**Section 4.3**
	vii. The names, positions and 24-hour contact details of those key individuals who: • Are responsible for activating the plan, and • Are authorised to notify relevant authorities under paragraph (e) and (f), and • Are responsible for managing the response to a pollution incident	**Section 6.2**
	viii. The contact details of each relevant authority referred to in paragraph (e) and (f)	**Section 6.3**
	ix. Details of the mechanisms for providing early warnings and regular updates to the owners and occupiers of premises in the vicinity of the fracture stimulation activity	**Section** 8

2 Regulatory Requirements

Section 153C	Detail required	Location in EIRP
	x. The arrangements for minimising the risk of harm to any persons who are present where the fracture stimulation activity is being carried out	**Section 5.3**
	xi. A detailed map (or set of maps) showing the location of the fracture stimulation activity, the surrounding area that is likely to be affected by a pollution incident, the location of potential pollutants on the activity site and the location of any stormwater drains on the activity site	**Section 12**
	xii. A detailed description of how any identified risk of harm to human health will be reduced, including (as a minimum) by means of early warnings, updates and the action to be taken during or immediately after a pollution incident to reduce that risk	**Section** 7 **Section 5.3**
	xiii. The nature and objectives of any staff training program in relation to the plan	**Section** 9
	xiv. The dates on which the plan has been tested and the name of the person who carried out the test,	**Section 10**
	xv. The dates on which the plan is updated,	
	xvi. The manner in which the plan is to be tested and maintained.	
(c)	The Environmental Incident Response Plan must be made readily available:	
	i. To an authorised officer representing an authority listed in paragraph (e) and (f) on request	**Section 11**
	ii. At the site of the fracture stimulation activity, to any person who is responsible for implementing the plan.	
(d)	The Environmental Incident Response Plan must be tested prior to the commencement of the fracture stimulation activity to ensure that the information included in the plan is accurate and up to date and the plan is capable of being implemented in a workable and effective manner.	**Section 10**
(e)	Pollution incidents that cause or threaten material harm to the environment must be immediately notified to each of the following authorities in the following order: iii. The appropriate regulatory authority (ARA) iv. The Environment Protection Authority (EPA) if they are not the ARA v. The Ministry of Health vi. The department (Mine Safety – as the workcover Authority) vii. The local authority, e.g. The local council, if this is not the ARA viii. Fire and Rescue NSW ix. The department (Environmental Sustainability Unit)	**Section 6.3**
(f)	The titleholder must also immediately notify the NSW Office of Water (NOW) if a water source is harmed.	**Section 6.3**

3

Gloucester Gas Project

3.1 Location

The Gloucester Gas Project is located near Stratford, NSW, approximately 100 km north of Newcastle. The Gloucester Gas Project is a wholly owned and operated asset of AGL Upstream Investments Pty Limited.

The location of the proposed fracture stimulation activities and road access is shown in the attached map (**Appendix B**).

The Gloucester Gas Project employs 12 fulltime Gloucester based staff, 3 full time Hexham staff and one contractor based at Gloucester.

3.2 Surrounding Area

CSG exploration wells which are classified as fracture stimulation activity locations are located on private rural properties. This EIRP has been prepared for fracture stimulation activities to be undertaken in the Waukivory area (refer to **Appendix B**).

Locations which may potentially be impacted by a pollution incident occurring during a fracture stimulation activity may include:

- Adjacent landholders (refer to **Appendix B**); and
- Downstream water courses (including inundation areas and adjacent landholders).

3.3 Fracture Stimulation – Activity description

Fracture stimulation activities as defined by AGL are discussed in the following section as applicable to the Gloucester Gas Project.

Hydraulic fracturing consists of pumping a fluid into a steel cased and cemented wellbore to create sufficient pressure to fracture the target rock layer, to enhance water and gas flow.

The hydraulic fracture stimulation fluid will be 99.5% water and sand. The remaining additives will be determined once the testing and logging process has been completed. Options for hydraulic fracture stimulation additives include:

- Treated water: A treated water fluid formation is a basic fluid for performing hydraulic fracture stimulations. The fluid is treated with a bactericide to minimise the risk of introducing foreign bacteria into the formation which can lead to the development of hydrogen sulphide (H_2S) in the well. H_2S often results from the bacterial breakdown of organic matter in the absence of oxygen and is a corrosive gas with potential to affect the steel casing of the well. The treated water fluid is aimed at minimising these risks.
- Linear gel: This linear gel fluid formulation is a viscosified treated water. The viscosifying agent is a guar gum. Further additives include a breaker used to decrease the viscosity of the linear gel over time allowing more efficient flowback of the fracturing fluid following hydraulic fracturing treatment. Linear gels are able to carry higher concentrations of proppant than water, thereby reducing the required volumes of water. They also reduce pumping friction and can reduce the required hydraulic pressure required.
- Cross-linked gel: This cross-linked gel fluid formulation is based on a linear gel. The cross-linked fluid has additional additives that cross-link the gel which further increases the viscosity of the gel. Cross-linked gels are used when high proppant concentrations are required or when low viscosity fluids are unable to maintain the desired fracture geometry.

AGL will likely use dry gel blenders. When using a dry gel blender, chemicals are mixed with the fracture stimulation fluid as it is pumped rather than having to be pre-mixed in tanks prior to the fracture stimulation. This results in significantly less volume of leftover fluid and chemicals which would then have to be managed. Reduced handling and mixing of chemicals will result in a lower exposure to safety risks and lower chance of spillage of made-up fracture stimulation water.

Perforations are required to gain access between the well and the selected rock layer. The fluid contains a “proppant” like sand that helps prop the fractures open to allow gas to be produced to the surface. This process stimulates the reservoir by providing a highly conductive flow path for gas and water that extends away from the wellbore and into the seam.

The sand is locked in place by the pressure of the coal formation and the injected water and formation water is allowed to flow back out to the well for pumping to the surface. This technique widens cleats and natural fractures in the coal seams to provide a conductive path for gas to flow freely to the well. As the water is removed, the resulting drop in reservoir pressure enables the gas to begin to desorb from the coal and flow to the wellbore. The wellbore then requires cleaning and maintenance. The tubing, rods and pump required for gas flow testing are then placed within this casing once each gas test well is completed and the surface wellhead equipment is installed.

3.4 Contractors

Where required and as specified in work safety management plans contractors will be responsible for ensuring that appropriate pollution incident response procedures are implemented and are specific for the work they are carrying out on behalf of AGL.

These plans shall include the response procedures required to effectively respond to foreseeable pollution incidents and ensure that in the event of an incident, plans and resources are in place for managing these potential situations.

The incident response procedures for each fracture stimulation site shall identify the muster points, details of the communication processes and adequate provision of resources including trained people and pollution incident response equipment. Contractors shall ensure that evacuation procedures, emergency contact numbers and emergency equipment diagrams are made available to AGL. The incident response procedures will be consistent with this EIRP.

Contractors will also be required to comply with this EIRP.

3.5 Operating Hours

Normal Gas Project Operating Hours

Hours of operation for noise generating activities are as follows:

Monday to Friday 7:00am - 6:00pm

Saturday 8:00am -1:00pm

No work on Sundays or public holidays

Other activities (such as set up) may occur outside these hours.

Pilot testing and flowback operations will occur 24 hours a day, 7 days a week.

After Hours / 24 Hours Answering Services

The Gloucester Gas Project has in place a 24 Hour Community Hotline provided by an external call centre. The public can notify AGL of an incident by calling the answering service on **1300 886 170**.

The Community Hotline is provided to the community via AGL community updates and shall be provided to local residences where deemed necessary by the AGL Project Team. The call centre is required to pass on all messages and information to AGL.

4

Major Hazards

4.1 Likelihood of Potential Hazards

A description of potential hazards to the environment and human health associated with fracture stimulation activities is presented in the **Hazard Risk Register** (refer to **Appendix A**).

The **Hazard Risk Register** has been developed based on the **Gloucester Fracture Stimulation Management Plan Risk Assessment Report (RAR)**, carried out by AGL and **Draft Human Health and Ecological Risk Assessment – Hydraulic Stimulation Activities – Gloucester Gas Project (HHERA)** prepared by Environmental Risk Sciences Pty Ltd, August 2013.

The **Hazard Risk Register** describes the likelihood of the identified hazard occurring, the circumstances or events that could or may increase that likelihood and the mitigation measures that AGL has implemented to minimise the potential risk occurring.

The purpose of the **Hazard Risk Register** is to identify significant environment and community aspects and impacts associated with fracture stimulation activities, the potential impacts they pose to the environment and the controls necessary to effectively manage them. Management of impacts is prioritised according to the level of risk each aspect is assigned.

AGL conduct all CSG operations in accordance with the **Fracture Stimulation Management Plan (FSMP)** and *Code of Practice for Coal Seam Gas: Well Integrity* as identified in **Appendix A** to minimise the likelihood of incidents at sites where fracture stimulation activities are conducted.

Potential major hazards associated with fracture stimulation activities that have been identified for the Gloucester Gas Project are identified in the **Hazard Risk Register**. In addition the **Emergency Response Plan** identifies the emergency response actions for the following emergencies:

- Spills (e.g. hydrocarbon, hazardous chemicals, etc.) resulting in land contamination;
- Spills (e.g. hydrocarbon, hazardous chemicals, saline or sediment laden water, etc.) resulting in water contamination;
- Flooding (Emergency);
- Well blowout, fire or explosion emergency at a well site; and
- Bushfire at, near a well site.

4.2 Pre-emptive Actions

AGL have implemented a variety of pre-emptive and response mechanisms to help minimise or prevent risk of harm to the environment and human health from its activities associated with fracture stimulation activities.

The **Hazard Risk Register** (**Appendix A**) identifies mitigation measures for potential pollution incidents that may occur as a result of these activities. The pre-emptive and mitigation measures provided in the Hazard Risk Register are a combination of Engineering, Administrative and Personal Protective Equipment (PPE) control mechanisms as detailed in the hierarchy of control strategy.

AGL has developed and implemented the following procedures for foreseeable emergency and pollution incident situations specific to the work activities being undertaken across the Gloucester Gas Project within the **Emergency Response Plan**:

- Casualty Evacuation;
- General Evacuation;
- Well Blowout, Fire or Explosion Emergency at a Well Site;

- Bush Fire at, or Near, a Well Site;
- Flooding (Emergency);
- Oil or Chemical Spill;
- Security Breach;
- Bomb Threat; and
- Administration Building Fire.

Mitigation measures to minimise the occurrence of a breach of regulatory requirements including a significant non-compliance with the FSMP have been identified and are discussed within the Hazard Risk Register.

4.3 Safety Equipment

Arrangements including the description and location of safety equipment for minimising the risk of harm to the environment and people as a result of a pollution incident and for containing or controlling a pollution incident are included in the following AGL documentation:

- AGL Gloucester Gas Project Emergency Response Plan;
- AGL Gloucester Gas Project Environmental Management Plan;
- AGL Gloucester Gas Project Safety Management Plan;
- AGL Gloucester Gas Project Dangerous Goods and Hazardous Materials Sub Plan;
- AGL Code Red Management Plan; and
- AGL Incident Management Procedure.

Further details of safety equipment available for implementation during fracture stimulation activities are provided in **Appendix A** or addressed in the Site Plan (**Appendix C**).

4.4 Potential Pollutants

The majority of the fracturing fluid comprises water and sand (approximately 98% to 99.5%); however, a range of other chemicals may also be used:

- As a flocculant to treat source water;
- To form a gel to suspend and transport the sand through the small cracks and crevices created under hydraulic pressure in the coal seams;
- To maintain viscosity of the hydraulic fracturing fluid so that it can penetrate into the fractures while carrying the sand;
- To break down the viscosity of the gel once the hydraulic fracturing is complete;
- To stabilise the clays to prevent swelling and migration of formation clays that could block pore spaces and reduce permeability;
- To control the pH (buffer) to maintain the stability of the fluid and assist the hydration of the gel; and
- To eliminate bacteria (bactericide) ensuring bacteria is not introduced into the formation, and the gel viscosity is maintained and not degraded by bacteria.

Section 3.3 provides a description of fluid types most commonly used during AGL fracture stimulation activities.

BTEX (benzene, toluene, ethylbenzene and xylenes) products and products that may contain BTEX are not used in drilling or hydraulic fracturing activities by AGL.

4 Major Hazards

Fluids will be stored, transported and handled in accordance with legislative requirements, the manufacturer's specifications, contractors' procedures and the AGL **Dangerous Goods and Hazardous Materials Sub Plan**.

Hazardous materials are accompanied by the relevant Material Safety Data Sheets (MSDS) as required by Work Health and Safety Regulations 2011. AGL have developed and implemented a **Material Safety Data Sheet Register** for the Gloucester Gas Project.

Table 4-1 lists the potential pollutants stored and/or handled by contractors at an AGL site in the Gloucester Gas Project where fracture stimulation activities are carried out. The materials listed in **Table 4-1** may change depending on production operations. Potential pollution incidents associated with the materials identified in **Table 4-1** have been incorporated into the **Hazard Risk Register**.

Appendix C provides a Site Plan that displays the typical locations of potential pollutants at a fracture stimulation site at the Gloucester Gas Project. The plans provided in **Appendix C** show the 'typical' location of potential pollutants.

4.4.1 Fracture Stimulation Inventory of Typical Pollutants

Table 4-1 Potential pollutants handled/stored during fracture stimulation activities

Potential Pollutant	Product Name	Location	Maximum Quantity stored on well site
Diesel	-	Each well site during fracture stimulation activities only	10,000 L
Citric acid	FE-2	Secure Chemical Storage Area	18 kg
Hydrochloric acid	HCl	Secure Chemical Storage Area	933 L
Guar gum	WG-36	Secure Chemical Storage Area	1,258 kg
Acetic acid	Acetic acid	Secure Chemical Storage Area	372 L
Hemicellulase Enzyme Concentrate	GBW-30	Secure Chemical Storage Area	16 kg
Monoethanolamine Borate	BC-140C	Secure Chemical Storage Area	0 L
Choline Chloride	Choline Chloride	Secure Chemical Storage Area	1,368 L
THPS Tetrakis (hydroxymethyl) Phosphonium Sulfate[(1)]	Tolcide PS75	Secure Chemical Storage Area	450 L
Sodium Hydroxide	Caustic Soda	Secure Chemical Storage Area	0 L
Ground Coffee Beans	HAI-150E	Secure Chemical Storage Area	2 kg

Note: All chemicals when not in use will be stored in the storage container on site, except for diesel which is stored in a double skinned bulk fuel tank.
[(1)]Sodium Hypochlorite (product BE-7) may be used as an alternative bactericide to THPS. In that situation, a maximum of 342 litres of sodium hypochlorite would be stored on site in the Secure Chemical Storage Area instead of the THPS.

4.5 Site Maps

4.5.1 Fracture Stimulation Site Map

A general representation of the set-up and location of infrastructure and placement of potential pollutants on a fracture stimulation site is provided in **Appendix C.** Individual sites may vary depending on a number of factors, including but not limited to site topography and the presence of waterways.

5

Incident Management

5.1 Incident Classification

A pollution incident is defined in the POEO Act as an *'incident or set of circumstances during or as a consequence of which there is or is likely to be a leak, spill or other escape or deposit of a substance, as a result of which pollution has occurred, is occurring or is likely to occur'*. It includes an incident or set of circumstances in which a substance has been placed or disposed of on premises, but it does not include an incident or set of circumstances involving only the emission of any noise.

For an incident of potential material harm, as described above and/or an event as described in the Section 11.3 (a) of the Code, including:

I. Well blowout or loss of well integrity
Ii. Chemical spill or other pollution incident
Iii. Damage to an overlying water source
Iv. Breach of regulatory requirements, including significant non-compliances with the fsmp
V. Any other significant environmental incident associated with the fracture stimulation activity.

AGL shall classify a pollution incident as **Minor, Serious** or **Major** which will inform the required incident management response.

5.1.1 Minor (Onsite Pollution Incident)

A pollution incident occurs on site but has the potential to have short-term impacts on the environment. The incident is managed, contained onsite and notified to the relevant authorities as per the requirements stated in **Section** 6 of this EIRP.

5.1.2 Serious (Intermediate Pollution Incident)

A pollution incident occurs on site but has the potential to have short-term impacts on the environment outside the operation boundaries of the fracture stimulation activities (i.e. release of gas or spill into waterway). The incident is managed and notified to the relevant authorities as per the requirements stated in **Section 6** of this EIRP.

5.1.3 Major (Long-term Pollution Incident)

A pollution incident occurs on site but has the potential to have long-term impacts on the environment outside the operation boundaries of the fracture stimulation activities (i.e. groundwater impacts). The incident is managed, contained and notified to the relevant authorities as per the requirements stated in **Section 6** of this EIRP.

5.2 Emergency Response

Arrangements including the description and location of safety equipment, for minimising risk of harm to people and the environment as a result of a pollution incident, and for containing or controlling a pollution incident, are included in this EIRP as well as the AGL Gloucester Gas Project **Emergency Response Plan** and **Environmental Management Plan**.

The **Emergency Response Plan** documents the roles and accountabilities of key personnel at each operation in the event of an emergency and the contact details for appropriate emergency services. The plan also provides designated evacuation points and procedures in the event of an emergency. Any changes to emergency procedures are documented and communicated to all personnel.

5 Incident Management

The following emergency procedures have been developed for the specific major hazards identified in **Section 4.1** and are included in the **Emergency Response Plan**:

- Oil or Chemical Spill - resulting in land and or water contamination;
- Well Blowout, Fire or Explosion Emergency at a Well Site; and
- Flooding.

AGL employees and contractors receive emergency preparedness and response training during their site induction. AGL maintains a dedicated emergency response team that undergo regular training and operational drills. PPE and incident containment and control equipment are detailed in the **Hazard Register** (**Appendix A)** and **Section 4.3** and includes but is not limited to:

- Emergency spill kits;
- Static and portable pumping infrastructure;
- Earth moving plant;
- Sediment ponds; and
- Erosion and sediment control materials.

AGL has limited authority to undertake pollution management activities on private property or beyond the well compound boundaries and in such cases will liaise directly with and provide appropriate assistance to the relevant authority and emergency services. A pollution incident concerning field operations including well sites must be notified immediately in accordance with the POEO Act (s.148) to the relevant authorities specified in this EIRP (**Section 6**).

5.3 Minimising the Harm to Persons on the Premises

The **Emergency Response Plan** outlines the response procedures to be followed in the event of an emergency on site. In addition on site evacuation controls are implemented to minimise harm to persons on the premises in the event of a potentially life threatening incident occurring.

For individual fracture stimulation activity sites a site induction and tool box talks are given that address actions to be taken in the event that evacuation is required.

6

Notification

6.1 Determination of Material Harm

An environmental incident where there is a risk of 'material harm' (as defined by the POEO Act and reproduced in the Definitions section of this Plan) is required to be notified *immediately* to the:

- NSW EPA;
- NSW Ministry of Health;
- the Department Mine Safety (as the WorkCover Authority);
- Local council;
- Fire and Rescue NSW; and
- Environmental Sustainability Unit.
- The NSW Office of Water (NOW) must also be notified in the event a water source is harmed.

An **Incident Notification Protocol** (**Appendix D**) has been developed to summarise the process for notifying the relevant authorities of environmental incidents with a risk of material harm. For broader notification responsibilities (beyond the relevant authorities) refer to the **Emergency Response Plan**.

It is possible for a material harm incident to occur on land that is within the boundary of AGL operations.

The determination of a material harm incident will be made by the Gloucester **Environment Advisor** in consultation with the **Head of Gas Operations** and/or the AGL **Head of Legal**. If the **Environment Advisor** is not available immediately, the determination will be made by the **Head of Gas Operations**. If both the **Environment Advisor** and the **Head of Gas Operations** cannot be contacted the **Person-in-Charge** shall bypass this process and call the relevant authorities listed in **Table 6-2** providing only the required information (as detailed in **Section 6.3**).

6.2 AGL Internal Notification

Table 6-1 summarises the names, position titles and 24 hour contact details of the primary AGL individuals responsible for managing an environmental incident response and notifying the relevant authorities. Refer also to the **Incident Notification Protocol** (**Appendix D**) and AGL's **Emergency Response Plan**.

6 Notification

Table 6-1 AGL primary environmental incident contacts and responsibilities

AGL Personnel and Position	Contact Details	Responsibility
AGL PERSONNEL AND CONTRACTORS	-	• Responsible for undertaking notification as defined in this EIRP.
Brett Hayward Environment Advisor	Tel: (02) 9921 2079 Mob: 0477 360 288	• Responsible for authorising the EIRP and all subsequent updates. • Responsible for ensuring adequate resourcing for implementation of the EIRP. • Authorised to liaise with the relevant authority. • Responsible for undertaking notification as defined in this EIRP. • Responsible for managing the response to a pollution incident. • Responsible for arranging testing and updating of the EIRP. • Responsible for ensuring notification and training of EIRP. • Responsible for liaising with Head of Legal to determine material harm.
John Fitzgerald Head of Legal Department	Tel: (02) 9921 2754 Mob: 0439 214 020	• Responsible for determining if a pollution incident may result in material harm as defined in the EIRP. • Responsible for managing release of information to authorities. • Authorised to liaise with the relevant authority.
Mike Roy Head of Gas Operation**s**	Tel: (02) 4633 5200 Mob: 0408 027 910	• Responsible for undertaking notification as defined in this EIRP. • Responsible for ensuring adequate resourcing for implementation of the EIRP. • Authorised to liaise with the relevant authority. • Responsible for liaising with Head of Legal to determine material harm.
Toni Laurie Land and Approvals Manager	Tel: (02) 6558 1139 Mob: 0448 259 563	• Responsible for undertaking notification as defined in this EIRP. • Authorised to liaise with the relevant authority. • Responsible for coordinating communications with affected community members.
Ian Shaw Land Officer	Tel: (02) 6558 1162 Mob: 0428 364 298	• Responsible for coordinating communications with affected community members.
Therese Ryan Community Relations Manager	Tel: (02) 6558 2692 Mob: 0428 018 122	• Responsible for coordinating communications with affected community members.

For further AGL Emergency Contacts refer to the **Emergency Response Plan** (p.12).

6.3 External Notification

In the event of an environmental incident the **Person-In-Charge** will *immediately* contact the Gloucester **Environment Advisor.** If the **Environment Advisor** cannot be reached the **Person-In-Charge** will contact the **Head of Gas Operations**.

The **Environment Advisor** and/or the **Head of Gas Operations** will determine based on the information provided if the incident is likely to result in material harm.

Notification of an environmental incident is the responsibility of all site and contractor personnel. In the event of an incident, response and notification must be undertaken as per **Appendix D**, which contains the following information:

- The local government authority for the area in which the fracture stimulation activities are undertaken;
- The persons and authorities to be notified by Section 11.3 (d) of the Code; and
- The contact details of each relevant authority referred to in Section 11.3 (d) of the Code (**Table 6-2**).

The agencies listed in **Table 6-2** must be contacted in the order as listed.

Table 6-2 EIRP emergency services notification details

Contact	Contact Details
Fire Brigade	000 (mobile 112) ***(Only to be contacted first if fire services are required)***
EPA	131 555
NSW Ministry of Health – Newcastle (Hunter and New England)	(02) 4924 6477 fax: (02) 4924 6048
DTIRIS (DRE) – Mine Safety	(02) 4931 6656 0418 699 284 (Glyn Macdonald)
Gloucester Shire Council	(02) 6538 5250
Fire and Rescue NSW	1300 729 579
DTIRIS (DRE) - Environmental Sustainability Unit – Northern Region	(02) 4931 6605
NSW Office of Water*	(02) 4904 2500 1800 999 457

**in the event that a water source is harmed*

The following information must be communicated to each authority (in accordance with the POEO Act (C 150)) during pollution incidents causing or threatening material harm:

- **The time, date, nature, duration and location of the incident;**
- **The location of the place where pollution is occurring or is likely to occur;**
- **The nature, the estimated quantity or volume and the concentration of any pollutants involved, if known;**
- **The circumstances in which the incident occurred (including the cause of the incident, if known);**
- **The action taken or proposed to be taken to deal with the incident and any resulting pollution or threatened pollution, if known; and**

- **Other information prescribed by the Regulations.**

If the above information is not known during initial notification but becomes known afterwards, that information must be notified to the relevant authorities. The information required to be reported is only that information known to the person notifying the incident when the notification is given.

In addition to the above mandatory reporting requirements consideration may be given to notifying the following agencies/authorities.

Table 6-3 Other emergency services notification details

Contact	Contact Number	After Hours Contact Number
Gloucester Fire Station	000 (mobile 112) (02) 6558 9222	
Ambulance	000 (mobile 112)	-
Police	000 (mobile 112) (02) 6558 1204 (Gloucester) (02) 6555 1299 (Manning Great Lakes LAC)	-
State Emergency Service	(02) 6558 1788	132 500

A register of landholders within a 1 km radius of wells in the Waukivory Pilot (refer to **Appendix B**) area will be maintained by AGL to assist in appropriate notification of affected landholders in accordance with the Community Notification Protocol (**Appendix** E).

Once the above services and authorities have been notified the **Community Relations Manager** and **Land and Approvals Manager** will implement the Community Notification Protocol (**Section 8** and **Appendix E)**.

6.4 AGL's Emergency Response Plan

The **Emergency Response Plan** describes AGL's response to incidents of varying degrees of significance to the environment, workers and public safety.

The **Emergency Response Plan** classifies incidents as:

- Minor Emergency;
- Serious Emergency;
- Major Emergency; and
- Injury to Personnel.

The **Emergency Response Plan** does not specifically consider 'material harm' to the environment or events listed in Section 11.3(a) of the Code in its classification of incidents, however, based on the examples provided within the **Emergency Response Plan** incidents categorised as 'Serious Emergency' or greater are considered by AGL to present a risk of material harm to the environment.

7

Actions Following a Pollution Incident

7.1 General

When the Emergency Services, in consultation with the AGL **Person-In-Charge**, has specified that the emergency has been controlled, the AGL **Person-In-Charge** shall assume full control of the site and will ensure the following procedures are observed:

- The site shall be made safe. This must be done in association with the **Head of Gas Operations** (or delegate).
- Actions to minimise and control an environmental incident shall be implemented in accordance with the Environment Management Plan (EMP) and sub plans, including but not limited to, the use of secondary containment, spill kits, sediment control structures etc.
- Emergency equipment must be returned to full active status as defined in this Plan.
- Assessment and repair, replacement or disposal of damaged plant equipment must be made in conjunction with the AGL **Head of Gas Operations**.
- The requirements for Public Relations and debriefing, and necessary Statutory Investigations are to be fully observed.

7.2 Statutory Investigation

In the event of a pollution incident that involves a fatality or serious and/or significant incident the Police are likely to be involved. There may also be a Coronial Inquiry.

In the event of an incident involving emergency service personnel, the appropriate **Person-in-Charge** will implement and follow the **Incident Notification Procedure**.

The most senior AGL Manager on site is responsible for ensuring that there is no interference with evidence and that cleaning up and repairs apart from those necessary to bring the incident under control does not occur without approval of investigating officers from the authorities stated in the **Incident Notification Procedure**.

7.3 Report & Review of Emergency

After an incident has occurred it is the responsibility of the AGL **Head of Gas Operations** to ensure the requirements of AGL's **HSE Incident Management Procedure** are implemented and that the relevant investigation is carried out by competent persons to ensure that findings are recorded and corrective actions put in place to eliminate and / or mitigate the risk of an incident reoccurring.

Review of EIRP after an incident:

- The AGL **Head of Gas Operations** together with the AGL **Environment Advisor** shall review the effectiveness of this EIRP as described in **Section 10**.
- The AGL **Environment Advisor** must immediately update this EIRP with relation to improvements highlighted by the incident in accordance with the requirements stipulated in **Section 10**.

8

Communication

8.1 Communicating with Neighbours and the Local Community

In the event of an incident of actual and/or potential material harm and/or an event as listed in Section 11.3(a) of the Code the **Community Notification Protocol** (**Appendix E**) will be activated. Potentially affected adjacent neighbours / properties will be directly notified by the **Community Relations Manager** and/or **Land and Approvals Manager** after being briefed by the **Environment Advisor** based on the classification of the pollution incident as determined in **Section 5.1.** Regular updates will be provided by the Gloucester **Community Relations Manager** and/or **Land and Approvals Manager** with support from the Emergency Services as they become available.

Information provided to the community will be relevant to the incident and may include the following details:

- The type of incident that has occurred;
- Potential impacts to the landholder and the neighbours/ properties;
- Site contact details; and
- Advice or recommendations based on the incident type and scale.

Based on the classification of the environmental incident, the notification methodology may include:

Minor (Onsite Pollution Incident)

Reporting of the incident is communicated through the following media where appropriate or required:

- Same day verbal communication to the landholder(s) / sensitive receptor(s) nearest to the incident; and
- Written communication to the landholder(s) and sensitive receptor(s) nearest to the incident, including updates and actions taken.

Serious (Intermediate Pollution Incident)

Reporting of the incident is communicated through the following channels where appropriate or required:

- Same day verbal communication to the landholder(s) nearest to the incident;
- Same day verbal communication to neighbouring sensitive receptors;
- Written communication to the landholder(s) nearest to the incident within 24hrs, including updates and actions taken;
- Written communication to neighbouring sensitive receptors within 24hrs, including updates and actions taken;
- Written communication Community Consultative Committee (CCC), including updates and actions taken; and
- The AGL Gloucester Gas Project website.

Major (Long-term Pollution Incident)

In addition to the actions taken for a minor and serious incident reporting of the incident will be communicated through the following channels:

- Letterbox drop to landholders identified within the area impacted by the incident, including updates and actions taken;
- Letterbox drop to sensitive receptors, including updates and actions taken;

- Written communication CCC; and
- The AGL Gloucester Gas Project website.

8.2 Community Response Instructions

Response instruction to an incident will vary depending of the type and severity/classification of the incident. For example, in determining the extent of community notification for potential discharge of pollutants to land or a waterway, AGL will consider aspects such as the type of pollutant, location of nearby waterways and possible impacts on sensitive receptors.

Response instructions may include, but not be limited to, the following:

- To avoid the use of water in creeks or rivers and groundwater extraction bores affected or likely to be affected by a pollutant discharge.

9

Training

The AGL **Head of Gas Operations** is responsible for the implementation of this EIRP. Resources shall be obtained and maintained to provide the level of protection required by this Plan. As a minimum:

- Gloucester employees and contractors shall understand the requirements of this plan;
- Field personnel shall be trained in basic fire fighting techniques, use of pollution control equipment and first aid;
- Supervisory personnel shall understand the detail of this EIRP and all emergency response procedures; and
- The **Person-In-Charge** of individual fracture stimulation works shall be competent in all of the above requirements as they apply to the works.

The **Head of Gas Operations** shall ensure personnel are appropriately trained and that drills of the emergency response procedures are performed on a regular basis and at least annually.

10

Testing of the EIRP

The testing of the EIRP will be undertaken to check that the information is accurate and current and that the plan is capable of being implemented in a workable and effective manner. Testing shall be undertaken in the following ways:

- The EIRP will be tested by assessing and reviewing it and making any necessary changes as identified. Testing is taken to be either a desktop review or a practical environmental emergency drill procedure. Testing will include all components of the plan including training requirements;
- The EIRP will be tested prior to commencement of a fracture stimulation activity, where fracture stimulation has not already been undertaken prior to the commencement of the Code.
- A review of the EIRP will occur every 12 months commencing from the date of authorisation of the EIRP by the **Environment Advisor**. Contact details in this document must be kept current at all times.
- The EIRP will be reviewed within one month from the date of a pollution incident that occurs in the course of an activity to which fracture stimulation relates. This review will be undertaken to assess if the information included in the plan is accurate and up to date and that the plan is still capable of being implemented in a workable and effective manner.

Records will be kept in accordance with the AGL **Document Control Procedure AGL-DCP-HSE-006-001** and will be included in Document Control section of this plan and **Table 10-1**. Information to be retained concerning EIRP testing includes:

- The manner in which the test was undertaken;
- Dates when the plan has been tested;
- The person who carried out the testing; and
- The date and description of any update of or amendment to the plan.

Table 10-1 EIRP register of testing

Date of Test	Personnel Undertaking Test	Manner of Test	Summary of changes	Date of Update

In addition the AGL **Head of Gas Operations** and the AGL **Environment Advisor** shall ensure that this EIRP is reviewed at least upon the following situations:

- Prior to the commencement of the fracture stimulation activity;
- Legislation change or introduced;
- Staff changes;
- Changes in emergency contacts and numbers;
- Plant and equipment modification;
- Outcomes from incidents/hazards on site, within AGL or the industry;
- Changes in circumstances in any adjacent properties;
- Changes in plant operating and safety procedures; and
- At least annually.

Changes should be made as and when they occur and the AGL **Environment Advisor** is responsible for ensuring the relevant revisions issued to each person nominated on the Distribution List.

Availability of the EIRP

A copy of the EIRP will be located at the Gloucester Gas Project Administration Office and at a site where fracture stimulation activities are carried out so as to be easily accessible to those who are responsible for its implementation. The EIRP will also be readily available to an authorised officer representing an authority listed in **Section 6.3** on request.

Maps

A location map attached as **Appendix B** shows the locations of current exploration sites including fracture stimulation activities and the surrounding area that may be affected by a pollution incident. In addition the map shows sensitive receptors including the surrounding drainage lines (Avon River and Waukivory Creek).

12.1 Fracture stimulation activity site – (typical set-up)

The Site Plan (**Appendix C**) depicts the typical setup of a fracture stimulation activity site, showing the location of hazardous material storage, sediment controls, first aid, fire fighting and spill kits.

13

Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of AGL Upstream Investments Pty Ltd and only those third parties who have been authorised in writing by URS to rely on this Report.

It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report.

It is prepared in accordance with the scope of work and for the purpose outlined in the proposal dated 14 December 2012. Works were carried out in accordance with the terms and conditions agreed in the contract entitled Hunter Valley and Gloucester Gas Project EIRPs – ENV 968 / 3119721, dated 15 January 2013.

Where this Report indicates that information has been provided to URS by third parties, URS has made no independent verification of this information except as expressly stated in the Report. URS assumes no liability for any inaccuracies in or omissions to that information.

This Report was prepared between 7 January and 19 September 2013 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This Report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This Report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Except as required by law, no third party may use or rely on this Report unless otherwise agreed by URS in writing. Where such agreement is provided, URS will provide a letter of reliance to the agreed third party in the form required by URS.

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Except as specifically stated in this section, URS does not authorise the use of this Report by any third party.

It is the responsibility of third parties to independently make inquiries or seek advice in relation to their particular requirements and proposed use of the site.

Any estimates of potential costs which have been provided are presented as estimates only as at the date of the Report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.

A

Appendix A Hazard Risk Register

No.	Cause	Risk	Effect	Category	Controlled (Mitigated Risk)			Mitigations
	Due to….	**there is a possibility that…**	**which will have the result of…**		**Consequences**	**Likelihood**	**Risk Score**	**(What controls are in place to mitigate the risk?)**
1	Fracture Stimulation Activities	There is a risk of source water spill during transport to site.	The source water is fresh water and spills would have little to no impact on the environment	Water Resources	Level 1	Unlikely	Low	1.The preferred source water is fresh water from the Pontilands Dam and spills would have little to no impact on the environment 2. If an alternative source is used, the water quality may be brackish water. The fill and unloading areas are contained. Spills of brackish water would have minimal impact on soils and surface water. 3. Vacuum truck is available on site.
2	Fracture Stimulation Activities	There is a risk that the flowback water may be incorrectly transported, captured and/or removed which may result in a spill.	Potential pollution of water resources	Water Resources	Level 1	Unlikely	Low	1. Flow back water will be stored in designed tanks or other above ground holding tanks, which are fully contained. 2. Visual inspections are conducted on all tanks prior to the storage of any liquids. Visual inspections are also conducted several times a day during fracture stimulation operations to ensure no overflow or leaks. 3. Water tanks are bunded so that if a leak occurs the liquid is contained 4. Vacuum truck is available on site. 5. Sealed transport tankers are used to remove flowback water from site to holding dams or to an approved facility. 6. Surplus water tanks are kept on site so that if a leak was to occur in a tank the contents of the tank could be pumped into the spare tank. 7. Integrity testing of pipes are performed prior to commencement of the job. 8. Wells are supervised during flow back operations. 9. Environmental Response Plan covers this possibility.
3	Fracture Stimulation Activities	The Code requires a qualitative assessment of risk that fracture stimulation activities may cause connectivity and cross contamination between coal seams and beneficial aquifers.	Exchange of poor water quality between these two sources that may impact water quality characteristics	Water Resources	Level 3	Rare	Low	Low permeability aquitard layers exist between shallow beneficial aquifers and target coal seams. AGL have developed strategies including: 1. Groundwater Monitoring program implemented. 2. Pressure monitoring during fracture stimulation. 3. Micro seismic monitoring, measuring direction and height of the fracture in real time on selected wells. 4. Temperature log, confirms fracture height after the operation. 5. Fracturing execution commences from the deepest zone and progress up the well. This means more information is gathered before approaching the beneficial aquifers. 6. Monitoring changes in the flowback chemistry. 7. Groundwater monitoring programs provide baseline data prior to fracture stimulation programs thereby allowing trends or changes in shallow water chemistry to be identified. 8. Faulting is mapped through 3D seismic and zones selected for stimulation are away from faults.

No.	Cause	Risk	Effect	Category	Controlled (Mitigated Risk)			Mitigations
	Due to….	**there is a possibility that…**	**which will have the result of…**		**Consequences**	**Likelihood**	**Risk Score**	**(What controls are in place to mitigate the risk?)**
4	Fracture Stimulation Activities	The Code requires an assessment of the risk that fracture stimulation activities may induce: - changes to groundwater pressure and levels; or - changes to surface water levels and flow. This is generally referred to as surface water/groundwater connectivity [Code 7.2(ii) and (iii)].	Loss of volume and levels in shallower aquifers (i.e. water resource) and change water quality and increase in produced water volumes	Water Resources	Level 3	Rare	Low	AGL conducted a HHERA which identified that AGL shall construct all CSG wells in accordance with the Code of Practice Well Integrity and the American Petroleum Institute standards. AGL and the principal contractor have developed strategies that shall be implemented including: 1. Groundwater Monitoring program. 2. Pressure monitoring during fracture stimulation. 3. Micro seismic monitoring, measuring direction and height of the fracture in real time on selected wells. 4. Temperature log, confirms fracture height after the operation. 5. Fracturing execution commences from the deepest zone and progress up the well. This means more information is gathered before approaching the beneficial aquifers. 6. Monitoring changes in the flowback chemistry. 7. Groundwater monitoring programs provide baseline data prior to fracture stimulation programs thereby allowing trends or changes in shallow water chemistry to be identified.
5	Fracture Stimulation Activities	There is a risk that there may be spills and leakages of materials such as oils, lubricants, on site fuels, chemicals, additives, water, sand and packaging.	Potential contamination of soil and surface waters	Land Contamination	Level 2	Unlikely	Moderate	1. All contractors on site are subject to AGL pre-qualification and selection process which includes preparation of JSEAs and SOPs for the management of loss of containment. 2.AGL shall implement control measures for dangerous goods and hazardous materials as outlined in Table 4.1 of the Dangerous Goods and Hazardous Materials Sub Plan including, handling and storage procedures (for example bunded areas, leak proof trays), audit procedures, site inspections, spill kits, onsite waste storage facility, training and supervision requirements. 3. Handling of chemicals and fluids is subject to the Contractor's and AGL's handling procedures. 4. On site supervision of activities. 5. Daily toolbox talks that emphasise the importance of following AGL and Contractor procedures. 6. Human Health and Ecological Risk Assessment completed for fracture stimulation fluids.
6	Fracture Stimulation Activities	There is a risk that noxious weeds from outside of the project area maybe transported by vehicles and contaminate the local area.	Potential spread of noxious weeds	Land Contamination	Level 3	Unlikely	Moderate	1. Truck wash downs, prior to entering project area. 2. Drivers trained to inspect trucks prior to journey commencement. 3. Documented evidence is provided for each washed truck. 4. Journey management plan. 5. AGL to inspect vehicles prior to entering site.
7	Fracture Stimulation Activities	Due to trucks, vehicles, operational equipment operating during activities, there is a risk of excessive exhaust emissions and surface dust being generated from road movements.	On site and/or offsite dust impacts. Air quality impacted - greenhouse gas emissions	Air Pollution	Level 2	Unlikely	Moderate	1. All contractors on site are subject to AGL pre qualification and selection process which includes a preventative maintenance system and adherence to Australian Standard vehicle emissions. 2. Routine dust suppression where generation has been observed on roads and appropriate gravel will be used to surface roads where required to minimise from road movements. 3. Signposted travelling speeds on lease roads to reduce dust generation from traffic movements. 4. Environment Management Plan.

No.	Cause	Risk	Effect	Category	Controlled (Mitigated Risk)			Mitigations
	Due to….	**there is a possibility that…**	**which will have the result of…**		**Consequences**	**Likelihood**	**Risk Score**	**(What controls are in place to mitigate the risk?)**
8	Fracture Stimulation Activities	There is a risk that during operations fines and fluid mists may blow into the atmosphere.	On site and/or offsite dust impacts. Air quality impacted - greenhouse gas emissions	Air Pollution	Level 1	Unlikely	Low	1. Fluids are captured and contained via flowback tanks. 2. Flowback water is diffused to minimise the chance of any fluid being blown into the atmosphere. 3. All fracture stimulation activities are greater than 200 metres from residences.
9	Fracture Stimulation Activities	Due to heavy vehicles, operational equipment and flow back operations there will be a risk of exceeding the constructions noise goal	Off site noise impacts	Localised, temporary Noise and Vibration	Level 2	Possible	Moderate	1. AGL will establish and maintain sound walls between activities and receptors as required. 2. AGL will conduct a noise impact assessment. 3. AGL operating hours will be restricted to 7am to 6pm Monday to Friday and 8:00 am – 1:00 pm Saturday with no noise generating activities on Sundays and Public Holidays. 4. Community consultation will occur with neighbours prior to commencement of activities. 5. AGL will assess orientation of equipment on a well by well basis to minimise any noise impact. 6. Noise logging will be conducted onsite and at nearby receivers to identify any problematic areas.
10	Fracture Stimulation Activities	There is a risk that waste from operations may enter the surrounding environment	Potential contamination of soil and surface waters	Waste Management (flowback)	Level 1	Unlikely	Low	1. All contractors on site are subject to AGL pre qualification and selection process. 2. AGL operations shall be carried out in accordance with the recommendations made in the HHERA Report. 3. Flowback water will be contained within bunded tanks on location. 4. Flowback water will be characterised before being lawfully disposed of to an appropriate facility.
11	Fracture Stimulation Activities	There is a risk to the well integrity due to issues such as well blow out, failure of pressure containment devices, casing, master valve and/or lubricator	Safety	Loss of Well Integrity	Level 3	Rare	Low	AGL shall design and construct all wells in accordance with the Code of Practice for Well Integrity and ensure the following are undertaken: 1. Appropriate well design. 2. Safety margins incorporated into Fracture Stimulation design. 4. API certified casing and wellhead. 5. Bridge Plugs to isolate each treated zone. 6. Perforation of selected zones only. 7. Cement Bond Logs to be run on all wells to be fracture stimulated. 8. Casing is pressure tested prior to perforating.
12	Fracture Stimulation Activities	Risk identified in Code– Induced Seismicity. AGL understands "induced seismicity" to require an assessment of any risk that fracture stimulation activities will induce seismicity that could, for example, disrupt a nearby fault	Potential impact on local seismicity	Induced Seismicity	Level 3	Rare	Low	1. Drilling and logging records have been performed to identify faults. 2. Seismic mapping to identify faults, and avoid activity near significant faults. 3. Magnitude of events are below the threshold where damage can occur to beneficial aquifers and surface infrastructure.
13	Fracture Stimulation Activities	Risk identified in Code – Induced Subsidence. The Code requires an assessment of risks associated with "induced subsidence or other induced ground movements", which AGL understands to mean the risk there may be surface ground movement	Potential surface ground movements	Induced Subsidence and other induced ground movements	Level 1	Rare	Low	1. Consolidated rock is not supported by pore pressure thus change of pressure in the coal seam will not result in subsidence in ground about this zone.

No.	Cause	Risk	Effect	Category	Controlled (Mitigated Risk)			Mitigations
	Due to….	**there is a possibility that…**	**which will have the result of…**		**Consequences**	**Likelihood**	**Risk Score**	**(What controls are in place to mitigate the risk?)**
14	Fracture Stimulation Activities	The Code requires an assessment of the risk of air pollution, which AGL understands to mean the risk of air pollutants damaging neighbouring occupied properties e.g. vineyards, dairy farms	Offsite dust impacts	Conflicts with existing land users	Level 1	Unlikely	Low	1. Machinery and vehicles are maintained and inspected prior to use. 2. Fluids shall be captured and contained via flowback tanks. 3. Flowback water shall be diffused to minimise the chance of any fluid being blown into the atmosphere. 4. All fracturing activities shall be conducted greater than 200 metres from residences.
15	Fracture Stimulation Activities	There is a risk of localised, temporary visual and noise impacts to neighbouring properties	Potential offsite noise and visual amenity impacts	Conflicts with existing land users	Level 3	Possible	High	1. Establish and maintain sound walls between activities and receptors as required. 2. AGL operating hours will be restricted to 7am to 6pm Monday to Friday and 8:00 am – 1:00 pm Saturday with no noise generating activities on Sundays and Public Holidays. 3. Proactive consultation with the community prior to works commencing 4. Assess orientation of equipment on a well by well basis to minimise any noise impact. 5. Noise logging will be conducted onsite and at nearby receivers to identify any problematic areas.
16	Fracture Stimulation Activities	Fracture stimulation activities will include perforation activities and low emitting enclosed radioactive density measurement tool that may cause harm to onsite contractors and employees if incorrectly handled	Impacts on the health of AGL employees and contractors	Other Risks	Level 3	Rare	Low	1. Specialist contractor's will adhere to all relevant Codes on AGL sites. 2. Radioactive sources and perforating guns will be handled by. appropriately trained and competent personnel. 3. Emergency response plan. 4. Equipment is marked and secured. 5. Equipment is maintained and systematically certified. 6. Security at well sites during inactive periods to deter theft and vandalism.
17	Fracture Stimulation Activities	Damage of equipment due to extreme weather (e.g. floods, lightning, high winds, bushfire)	Damage and disturbance of equipment resulting in injury or environmental damage	Other Risks	Level 2	Unlikely	Moderate	1. A Flood Management Plan shall be implemented on site. 2. A Bushfire Management Plan shall be implemented on site. 3. Preference to locate above ground open top water storage at areas above flood zones. 4. Appropriately licences for crane usage. 5. Trained and competent crane operators. 6. Operations procedure include weather stop protocols.
18	Fracture Stimulation Activities	Risk that fracture stimulation activity may intersect with unrecorded wells, previously drilled by other operators, that have not been properly plugged and abandoned, causing connection with other subsurface layers or surface.	Connection with other subsurface layers or surface resulting in groundwater / surface water contamination	Other Risks	Level 3	Possible	High	1. Location of historical exploration wells is known from mine records. Wells within 600m of a Pilot test well and with any common coal seams intersected in them will be properly plugged and abandoned prior to stimulation activities.

B

Appendix B Location Map

Energy in action.™

AGL

Revision DRAFT
Created March 2013
Map Ref Gloucester

N
W E
S

1:10,000
0 0.05 0.1 0.2 0.3 0.4 0.5
Kilometres
Map Grid of Australia, Zone 56
Geocentric Datum of Australia 1994

Gloucester Gas Project

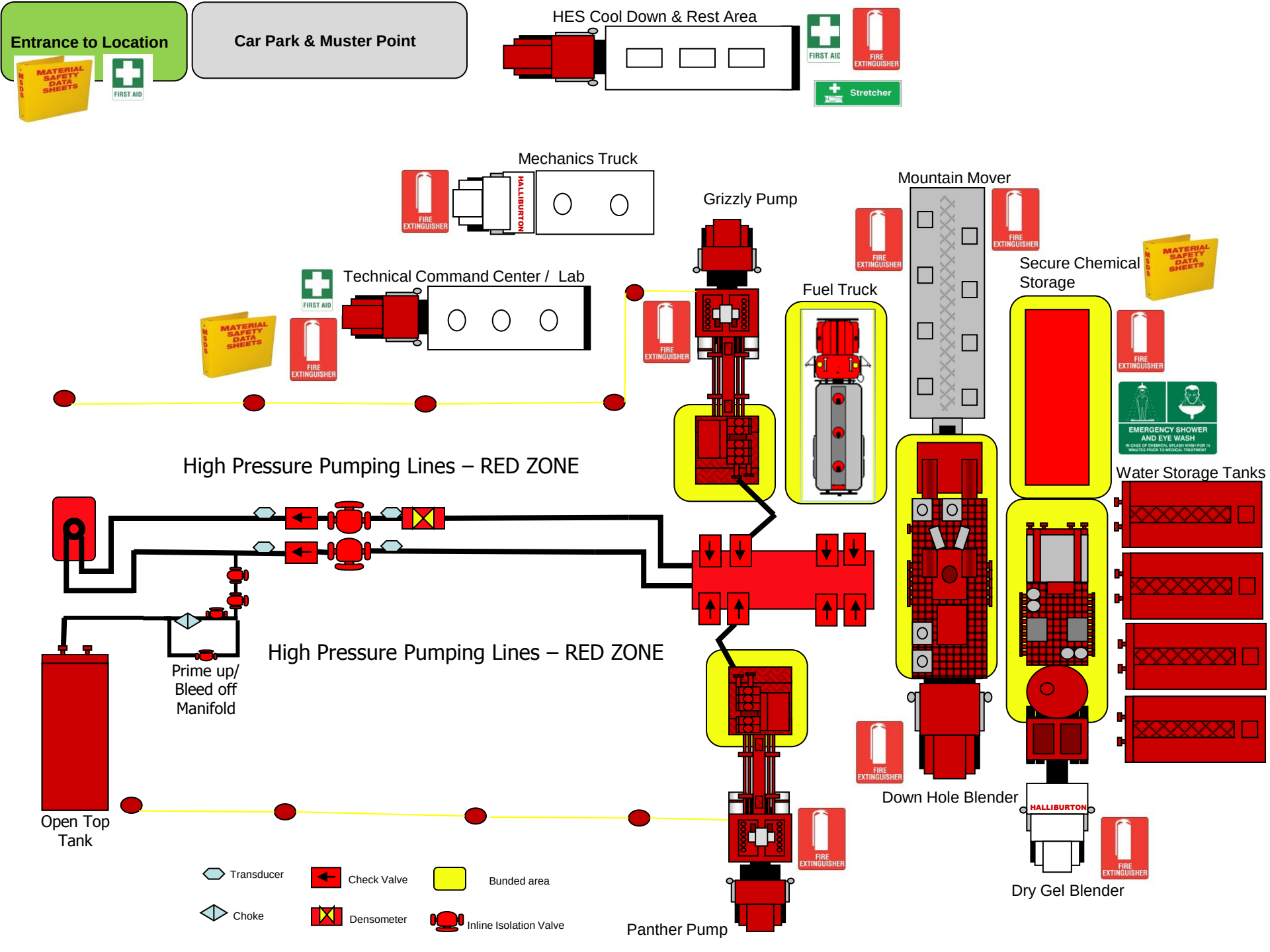
Waukivory Pilot
Sensitive Receivers

STRICTLY CONFIDENTIAL

Sources: AGL Energy, NSW Department of Lands

C

Appendix C Fracture Stimulation General Site Plan


Entrance to Location
Car Park & Muster Point
HES Cool Down & Rest Area
Stretcher
Mechanics Truck
Technical Command Center / Lab
Grizzly Pump
Fuel Truck
Mountain Mover
Secure Chemical Storage
Water Storage Tanks
High Pressure Pumping Lines – RED ZONE
High Pressure Pumping Lines – RED ZONE
Prime up/ Bleed off Manifold
Open Top Tank
Down Hole Blender
Dry Gel Blender
Panther Pump
Transducer
Check Valve
Bunded area
Choke
Densometer
Inline Isolation Valve

D

Appendix D Incident Notification Protocol

Appendix D - Incident Notification Protocol

Brett Hayward (BH)
Environmental Advisor
Tel: (02) 9921 2079
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John Fitzgerald
Head of Legal Department
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Land Officer
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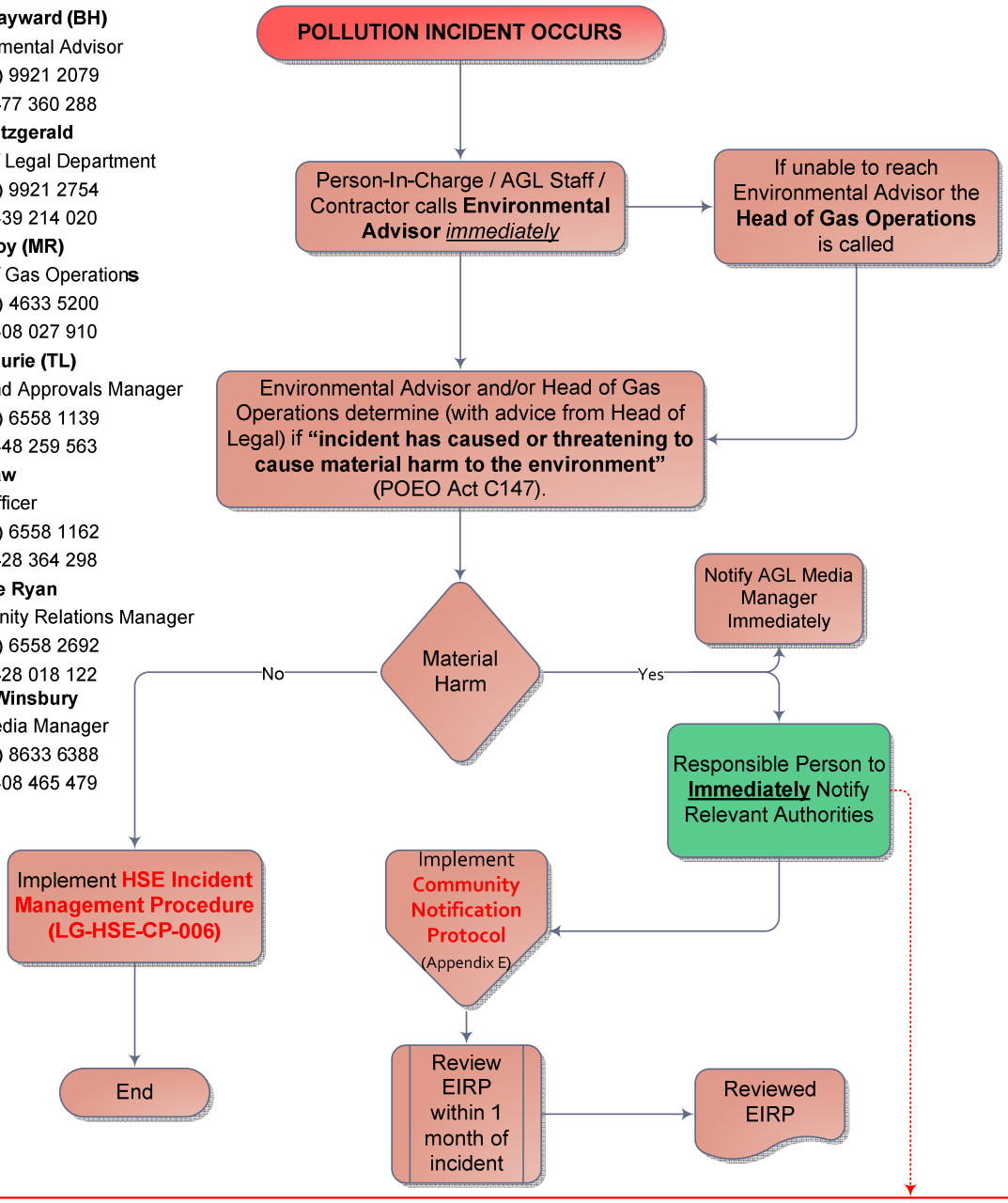
Therese Ryan
Community Relations Manager
Tel: (02) 6558 2692
Mob: 0428 018 122
Karen Winsbury
AGL Media Manager
Tel: (03) 8633 6388
Mob: 0408 465 479



AUTHORITIES TO CALL IN ORDER OF PRIORITY:

1. MR to Call: Fire Brigade: 000 (mobile 112)
   (To be contacted only if fire services are required)
2. BH to Call: EPA 131 555
3. BH to Call: Ministry of Health – Newcastle (Hunter & New England) (02) 4924 6477 / fax: (02) 4924 6048
4. MR to Call: DTIRIS (DRE) - Mine Safety (02) 4931 6656 / 0418 699 284 (Glyn Macdonald)
5. TL to Call: Council - Gloucester Shire Council (02) 6538 5250
6. MR to Call: Fire and Rescue NSW 1300 729 579
7. BH to Call: DTIRIS (DRE) - Environmental Sustainability Unit - Northern Region (02) 4931 6605
8. BH to Call: NSW Office of Water (only in the event of the pollution of water) (02) 4904 2500

'Immediately' means promptly and without delay.

E

Appendix E Community Notification Protocol

Appendix E - Community Notification Protocol

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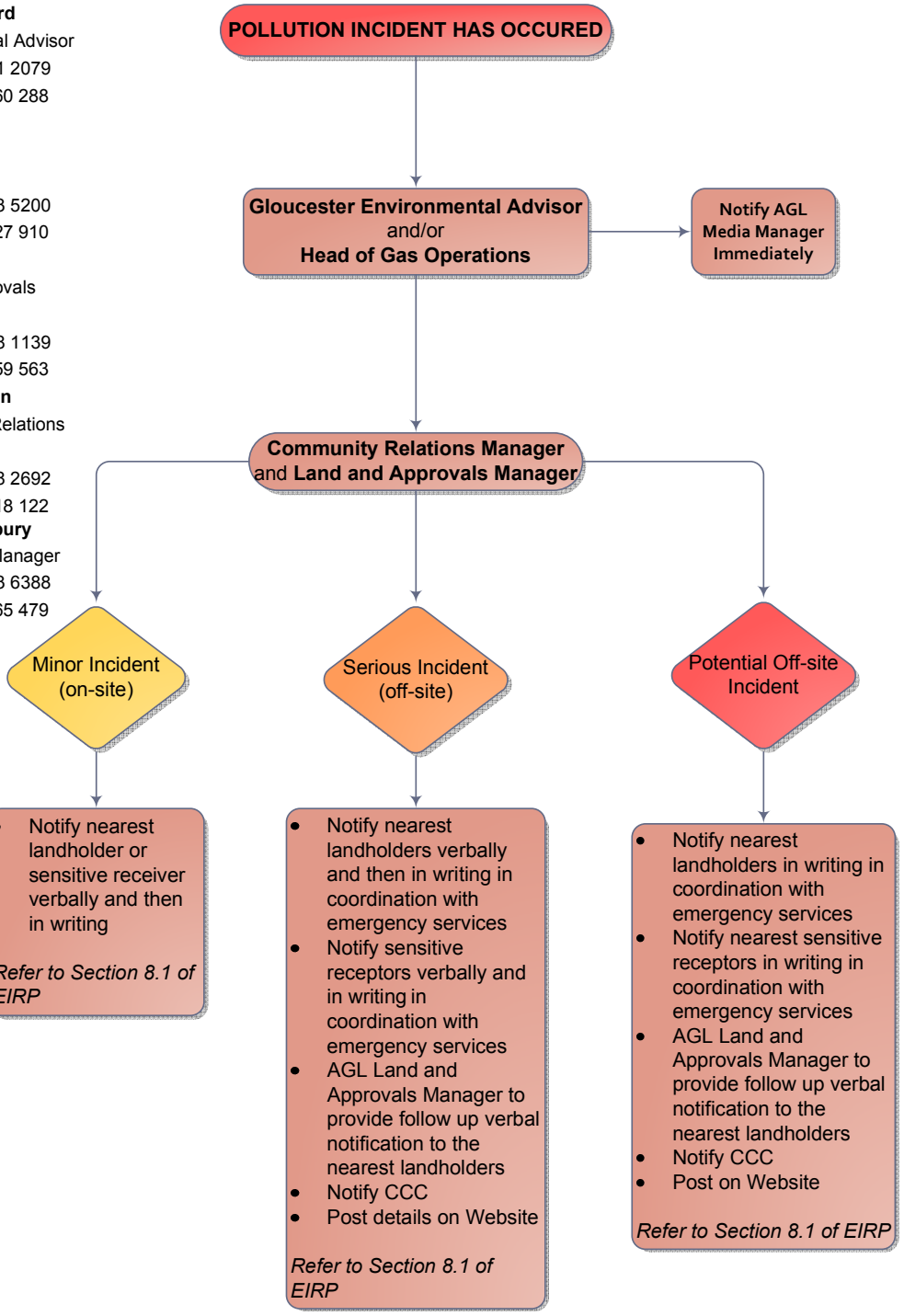

Information to Report to Community/Neighbours:

- **Refer to EIRP Section 8.1.**
- **When information is not available state that " Here is the information I am currently aware of, I will contact you as information becomes available".**
- **Provide 'actions to be taken' to landholders and/or sensitive receptors (Refer to Section 8.1 of EIRP).**

URS Australia Pty Ltd
Level 4, 407 Pacific Highway
Artarmon NSW 2064
Australia

T: 61 2 8925 5500
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Appendix O

Noise assessment

Memorandum

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25 September 2013

Subject Noise assessment report

The noise assessment report in this appendix was prepared to advise the Proposed Exploration Well: Waukivory Review of Environmental Factors by EMM (2011).

The noise assessment was considered adequate to use at this point in time, as it assessed the pilot program at the Waukivory wells. However, it does not assess potential noise impacts resulting from the construction of the proposed pipeline.

Noise impacts resulting from the construction of the proposed water pipeline were assessed by EMM in 2013 and are reported in the REF.

EMGA | MitchellMcLennan

29 March 2011

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Toni Laurie
Land and Approvals Manager
AGL
22 Tate Street
Gloucester, NSW 2422

Re: Gloucester Pilot Wells Waukivory 11 to 14 – Environmental Noise Assessment

Dear Toni,

1 Introduction

EMGA Mitchell McLennan Pty Ltd (EMM) has been engaged by AGL to conduct a preliminary noise assessment for the proposed pilot well exploration program in Gloucester, NSW. The subject of this study is pilot exploration wells identified as Waukivory (WK) 11 to 14.

This report assesses the potential environmental noise impact from the pilot project, including the noisiest construction related activities of drilling and fracture stimulation. It is understood that fracture stimulation is one of the well completion techniques available for exploration drilling, and dependent upon results of logging and testing, is likely to only be used for two of the four proposed exploration wells.

An alternate well completion method known as under-reaming is anticipated for two of the wells, and is similar to a standard drilling exercise which widens the hole beneath the cased and cemented section of the well. However, fracture stimulation noise predictions are presented in this noise report for all four exploration wells for reference in the event fracture stimulation is used for all wells. It is important to note that fracture stimulation will occur during the daytime shift only and for up to one hour at each of the four exploration wells.

In addition to the proposed exploration wells, a water monitoring piezometer will be established at a separate site west of WK 11. This will involve 24 hour drilling for up to four days to achieve a total depth of 300 m.

Also, the proposed WK 12 and WK 14 may undergo “twinning”. “Twinning” is a procedure in which two exploration wells are undertaken on the same drill pad site. The wells are within 6 m to 10 m apart at the surface therefore allowing both shallow and deeper coal seams to be pilot tested within the one pad in an efficient manner, should geological properties be suitable.

In comparison to the construction activities outlined above, operational activities will be relatively quiet and essentially relate to flaring of each proposed exploration well. Nonetheless, a noise impact assessment has also been undertaken of proposed operations. The potential increase in related road traffic noise has also been assessed.

2 Project description

The project description detail is provided in the Review of Environmental Factors (REF) report. From a noise perspective, the key elements include:

- Site establishment and preparation of well pad areas, as well as upgrading and preparation of established access tracks. Access to the constructed pads will be via council maintained roads and existing access tracks where possible. These activities will be confined to daytime only from Monday to Friday. Some new access tracks are likely to be required for WK 12, 13 and 14 to enable equipment to be moved across the existing grazing paddocks. An access track is required for WK 11 off the council maintained road (Fairbairns Road). A previous exploration well (Waukivory 1) was located to the immediate east of WK 11. The access track previously used for Waukivory 1 will be used to access WK 11. There is expected to be negligible impact from the construction of the access tracks.

- Drilling. Drilling of the exploration wells would be undertaken with a trailer or truck mounted drill rig. The type of drill rig to be used is typical of rigs used for coal seam gas drilling. This includes equipment to raise and lower rods in the well; drive gear for rotary drilling; wireline equipment for the recovery of core tubes; blow out prevention (BOP) equipment as a safety standard; and pumps for the circulation of drilling fluids. It is proposed that drilling will be conducted on a 24 hour basis for all four exploration wells. The drilling activity will be conducted on a constructed pad with an area of approximately 60 m by 40 m. With ancillary equipment, the pad maybe expanded to an area of 100 m by 100 m. The depth of the four exploration wells is expected to be approximately 1,000 m. Drilling of the water monitoring piezometer will likely be to a depth of 300 m. Should it be undertaken, the “twinned” wells at WK 12 and WK 14 will be shallower than the original well as it would target the shallower coal seams. All drilling is expected to be done using the same drill rig and there will not be any concurrent drilling at multiple sites.

- Fracture stimulation. Fracture stimulation is a common method used in coal seam gas operations to increase the permeability of the coal seam. This method uses the hydraulic pressure of fluid pumped into gas wells to open coal seams and help increase gas production. The fluid used in this process comprises approximately 99.5% water and sand, while 0.5% contains other additives. Fluids used during fracture stimulation are flushed from the coal seam and pumped to lined containment pits or tanks located on the surface and disposed of at appropriate off-site locations. Generally, only wells that intersect low permeability coal seams require fracture stimulation and these seams are usually very deep. Coal seam gas wells are fully lined with steel casing, which is securely cemented in place to isolate aquifers overlying the coal seam. The well must be fully cased and is perforated at specific intervals where the fracture stimulation is to be undertaken. Thus, fracture stimulation operations are controlled and designed so they are limited to coal seams and do not extend either above or below the targeted seam. It is proposed to utilise the fracture stimulation method for WK 11 and WK 13 but is not limited to these wells. Importantly, fracture stimulation will only occur for up to one hour per exploration well during the daytime period only (Monday to Friday 7am to 6pm and Saturday 8am to 1pm).

- Under-reaming. Under-reaming is a method that involves enlarging the size of a hole beneath the end of a casing. If suitable geological conditions exist an additional stage to open-hole completions can be added to widen the well where it intersects the target coal, which is located below the cased section of the well. After the well is cased a special reaming tool with rotating blades, jets or drill cones is used to ream out a cavity in the coal. Under-reaming is a useful process where there are

multiple seams and high permeability coal. Once the well has been widened at each seam, slotted casing is inserted across the coal interval and, where needed, gravel is packed between the walls of the cavity and casing to keep the cavity open. After under-reaming, the well is cleaned out with a fresh water flush. It is proposed to utilise the under-reaming method for WK 12 and WK 14 if the coal seam properties are found to be suited to this type of completion. Alternatively these wells may be fracture stimulated, should the under-reaming completion technique not produce sufficient flows for pilot testing purposes. Under-reaming will utilise the same drill rig as used in drilling and will be over a period of 24 hours per hole, with a 24 hour set-up phase.

- Flaring. A gas flare or flare stack is an elevated vertical stack or pipe for burning gas released during the production and processing of coal seam gas. Commonly referred to as "flaring", the flare burns gas that needs to be released for safety reasons. Flaring of gas burns off any combustible vapours produced from the gas well. The released gases and/or hydrocarbon vapour liquids are burned as they leave the flare stacks. Flaring is also considered the most environmentally friendly method to dispose of gas. The carbon dioxide (CO_2) produced from the burning process (i.e. the burning of methane gas) has less than one-twentieth the impact on the Earth's atmosphere than methane. As described later, the flare nozzle or the source of the noise in this process will be shielded by a solid structure (eg shipping containers). Once flaring begins, it will be continuous 24 hours per day and seven days per week.

All proposed activities are located on privately owned land in cleared grazing paddocks. Landholder consent has been obtained for the two lots identified for the four exploration wells. The work is expected to be completed over a period of approximately five to seven weeks. This includes testing, and as such drilling is not conducted over the entire period.

If the results of the drilling activities warrant further investigation, AGL may seek further approval from the Department of Industry and Investment (DII) to convert any of the exploration wells to production wells. In this situation the exploration well will be capped and suspended whilst the relevant approvals are sought. If further investigation of the exploration wells is not required the well will be plugged as per the Department of Primary Industries (DPI) Borehole Sealing Requirements, and the site rehabilitated.

3 Noise Goals

3.1 Construction noise

The construction component of the project will include site preparation and establishment, drilling and fracture stimulation (for some wells), before gas can be extracted and flared. Of these activities, the potentially highest noise emitting activities are drilling and fracture stimulation of the pilot wells. These exploration activities are temporary in nature therefore will be assessed according to construction noise guidelines.

3.1.1 Interim construction noise guideline

The NSW Department of Environment Climate Change and Water (DECCW) provides the Interim Construction Noise Guideline (ICNG) for the assessment and management of noise from construction works.

The ICNG provides two methodologies for the assessment of construction noise emissions:

- quantitative, which is suited to major construction projects with typical durations of more than three weeks; and
- qualitative, which is suited to short term infrastructure maintenance (less than three weeks).

The resultant methodology for a quantitative assessment requires a more complex approach, involving noise emission predictions from construction activities to the nearest sensitive receivers, whilst the qualitative assessment methodology is a more simplified approach that relies more on noise management strategies.

Given the predicted construction duration is greater than three weeks, the quantitative assessment methodology is the most suitable assessment methodology. Table 3.1 is an extract from the ICNG, providing guidance for residential receivers only.

In addition, the DECCW suggests the following time restriction for the construction activities where the noise is audible at residential premises:

- Monday to Friday 7.00 am - 6.00 pm;
- Saturday 8.00 am - 1.00 pm; and
- no construction work is to take place on Sundays or public holidays.

Table 3.1 ICNG residential criteria

Time of Day	Management Level $L_{Aeq\ (15\ min)}$*	How to Apply
Recommended standard hours: Monday to Friday 7:00 am to 6:00 pm Saturday 8:00 am to 1:00 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured LAeq (15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: i) times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences ii) if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times
Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2.

To establish appropriate construction noise criteria, the existing background noise levels need to be quantified for potentially affected residences. The DECCW provides the Industrial Noise Policy (INP) which includes guidelines for determining existing background noise levels. There is no existing background data for the surrounding sensitive receivers. In the absence of such background noise data for the potentially affected residences, the INP recommends adopting a conservative approach of setting a lower threshold background level typical of rural environments of 30dB(A). This is considered representative for the closest potentially affected residences to proposed well sites and was adopted for our assessment.

Based on the ICNG the noise criteria that will be adopted for residential receptors during construction activities are provided in Table 3.2.

Table 3.2 Residential construction noise criteria

Location	$L_{Aeq, 15min}$ Noise Criterion, dB(A)
Noise Assessment Locations (refer to Figure 1)	40, ie background plus 10dB (recommended hours) 35, ie background plus 5dB (Out of hours)

Notes: 1. The recommended construction hours are as described earlier.

As per the ICNG, out of hours construction works must be accompanied by a strong justification.

3.2 Industrial Noise Policy (INP)

Once the wells are established (drilled and, where required, fracture stimulated), they will extract gas and flare to the immediate environment. In noise assessment terms, it is this flaring (burning) of gas that will constitute the noisiest aspect of the operational phase of the project. The noise from flaring will be assessed against the NSW DECCW's Industrial Noise Policy (INP).

The DECCW, in its INP, provides guidelines for assessing industrial facilities. The INP states with respect to the criteria:

"*They are not mandatory, and an application for a noise producing development is not determined purely on the basis of compliance or otherwise with the noise criteria. Numerous other factors need to be taken into account in the determination. These factors include economic consequences, other environmental effects and the social worth of the development.*"

Assessment criteria depend on the existing amenity of areas potentially affected by a proposed development. Assessment criteria for sensitive receivers near industry are based on the following objectives:

- protection of the community from excessive intrusive noise; and
- preservation of amenity for specific land uses.

In order to ensure that these objectives are met, two separate criteria are prescribed by the DECCW, namely the intrusiveness criteria and the amenity criteria. A fundamental difference between the intrusiveness and the amenity criteria is that the former is applicable over 15 minutes in any period, while the latter covers the entire assessment period (i.e. day, evening and night).

3.2.1 Intrusiveness

The intrusiveness criterion requires that $L_{Aeq,15min}$ noise levels from a newly introduced source during the day, evening and night do not exceed the existing RBL by more than 5dB. This is expressed as:

$$L_{Aeq,15min} \leq RBL + 5 - K$$

where $L_{Aeq,15min}$ is the L_{eq} noise level from the source (i.e. site), measured over a 15 minute period and K is a series of adjustments for various noise characteristics. Where the RBL is less than 30dB(A), a value of 30 dB(A) is used.

As for construction noise criteria discussions above, the INP's minimum threshold background noise level of 30dB(A) will be adopted, resulting in an operational noise goal of **35dB(A)$L_{eq,15minute}$** for the day, evening and night time periods.

3.2.2 Amenity

The DECCW's amenity criterion requires industrial noise to be within an acceptable level for the particular locality and land use. Where ambient noise is already high, the acoustic environment should not be deteriorated significantly. The strategy behind the amenity criterion is a holistic approach to noise, where all industrial noise (i.e. existing and future) received at a given location does not exceed the recommended goals.

Private residences potentially affected by the project are covered by the DECCW's rural amenity category. The amenity criteria taken from Table 2.1 of the INP are given in Table 3.3.

Table 3.3 DECCW base amenity criteria

Location	Indicative area	Time period	Recommended $L_{eq,period}$ noise level, dB(A)	
			Acceptable	Maximum
Residential	Rural	Day	50	55
		Evening	45	50
		Night	40	45

Source: DECCW INP 2000

3.2.3 Project specific noise criteria

The INP requires that both the intrusiveness and amenity criteria are satisfied. However, the more limiting of the two becomes the project specific noise criteria (PSNC) or operational criteria for this exploration site alone. In this case and for all representative assessment locations, the intrusiveness criteria are the more limiting of the two and hence the PSNC are those presented earlier in Section 2.2.1 or **35dB(A)$L_{eq,15minute}$**.

3.3 DECCW road traffic noise criteria

For the assessment of potential road traffic noise impact from increases in road traffic due to the proposed pilot well project, we have adopted the DECCW Environmental Criteria for Road Traffic Noise (ECRTN, 1999), which provides external traffic noise criteria.

To determine suitable traffic noise criteria for a particular project, the road or roads must be categorised with respect to the ECRTN definitions. The current project will potentially create additional traffic on existing collector (The Bucketts Way) and local roads.

Hence, the most relevant ECRTN categories are:

- land use developments with potential to create additional traffic on collector roads; and
- land use developments with potential to create additional traffic on local roads.

Table 3.4 is an extract from the ECRTN and applies to the project.

Table 3.4 NSW DECCW Road Traffic Noise Criteria, 1999

Type of Development	**Criteria**		
	Day (7 am– 10 pm), dB(A)	**Night (10 pm– 7 am), dB(A)**	**Where criteria are already exceeded**
Land use developments with potential to create additional traffic on collector road	$60L_{eq,15hr}$	$55\ L_{eq,9hr}$	Where feasible, existing noise levels should be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access roads; regulating times of use; using clustering; using 'quiet' vehicles; and using barriers and acoustic treatments. In all cases, traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dB
Land use developments with potential to create additional traffic on local roads	$55\ L_{eq,1hr}$	$50\ L_{eq,1hr}$	

3.4 Sleep disturbance criteria

The aforementioned criteria, which consider the average noise emission of a source over a specified time, are appropriate for assessing noise from relatively steady-state sources, such as pump noise and other equipment. However, on-site sources such as truck reversing alarms and hand tool clangs are intermittent (rather than continuous) in nature, and as such, need to be assessed using the L_1 or L_{max} noise metrics.

The most important impact of such intermittent noises would be to disturb the sleep of nearby residents during the DECCW defined night period of 10pm to 7am.

The DECCW's ECRTN policy indicates that levels below 50 dB(A) to 55 dB(A) inside residences are unlikely to wake sleeping occupants. The likely number of noise events per night should also be considered. If bedroom windows are open, this corresponds to an external maximum noise level of approximately 60 dB(A) to 65dB(A) at a residence. However, this is considerably higher than the DECCW's current position on sleep disturbance which is that L_1 or L_{max} noise from a source should not exceed the existing background noise level by more than 15 dB. For the purpose of this assessment, the descriptors L_{max} and L_1 may be considered interchangeable.

The latter more conservative sleep disturbance approach was adopted for this study, and hence the proposed night time criterion for the adopted representative locations becomes:

- 45dB(A)Lmax, for intermittent type of events from the exploration site alone.

Integrated Design Solutions | 030464 F1 Rev D - 21 March 2011

EMGA | MitchellMcLennan

Proposed exploration wells and noise assessment locations

Proposed Exploration wells - Waukivory 11 to 14
Client: AGL Energy

Figure 1

4 Predicted Noise Levels and Impact Assessment

The prediction of noise from the construction and operations was undertaken using the Environmental Noise Model (ENM) prediction software. The ENM predicts total noise levels at receivers from the concurrent operation of multiple noise sources. The model included consideration of factors such as the lateral and vertical location of plant, source-to-receiver distances, ground effects, atmospheric absorption, and meteorological conditions.

4.1 Noise assessment locations

The closest and potentially the most exposed noise sensitive receivers to the proposed pilot well sites are residences as listed in Table 4.1. The proposed exploration wells and noise assessment locations are shown in Figure 1. Importantly, locations 4 and 5 are residential properties owned by a neighbouring mining company and are understood to be currently unoccupied.

Table 4.1 Noise assessment locations

Location	Address
1	20 Grantham Road, Forbesdale, NSW 2422
2	unknown
3	176 Farbains Road, Forbesdale, NSW 2422
4*	237 Farbairns Road, Forbesdale, NSW 2422
5*	197Farbairns Road, Forbesdale, NSW 2422
6	114 Maslens Lane, Gloucester, NSW 2422

*Notes: 1. *These properties are owned by a neighbouring mining company.*

4.2 Construction noise levels

The drill activity for WK 11 to WK 14 would occur over a period of about five to seven weeks. It is proposed to undertake 24 hour drilling at each of the exploration wells due to the local geology, well conditions and integrity, and for safe operations.

Once a well is drilled, completed and cemented, selected coal seams will be perforated, fracture stimulated and the dewatering pumps run in the exploration well to ready it for production testing.

It is proposed to utilise the fracture stimulation method for WK 11 and WK 13, however this may be extended to WK 12 and WK 14 and hence results of noise modelling is provided for all four exploration well locations. It is understood that fracture stimulation will only occur during the daytime shift and for a period of approximately one hour.

Whilst preparatory and other activities occur prior to and in between drilling and fracture stimulation, the noisiest construction activities are drilling and fracture stimulation. Hence these activities were assessed in detail.

4.2.1 Sound emission input data

For the assessment of noise from the proposed drilling and fracture stimulation operations, sound emission or power levels used to predict received noise levels are provided in Tables 4.2 and 4.3. The data were extracted from previous noise audits conducted by Atkins Acoustics, "*Construction Noise Assessment Exploration Drilling, May 2009*" and "*Operation and Construction Noise and Vibration Assessment, October 2009*".

Table 4.2 Drilling plant noise levels

Source	Octave Band Centre Frequency Noise Level, dB										Overall dB(A)
	31.5	63	125	250	500	1k	2k	4k	8k	16k	
Mud Pump	108.5	113.7	114.9	109.6	106.9	103.2	98.5	91.3	83.5	80.9	**108.5**
Atlas Copco Generator	105.2	105.4	102.9	101.7	97.6	91.2	89.0	84.3	74.9	65.5	**98.5**
Drilltec G55	108.7	111.3	112.0	108.4	104.5	102.9	97.4	91.5	81.5	76.5	**107.3**
Total (minus mud pump)	110.3	112.3	112.5	109.2	105.3	103.2	98.0	92.3	82.4	76.8	**108.1**
Total (with mud pump)	112.5	116.1	116.9	112.4	109.2	106.2	101.3	94.8	86.0	82.3	**111.5**

Table 4.3 describes the fracture stimulation plant sound power levels.

Table 4.3 Fracture stimulation plant sound power levels

Plant	Quantity	dB(A)
Generator (diesel)	1	103
Reticulating Pumps	4	124
Mountain Mover	1	123
V12 Pump	4	117
	Total	**127**

4.2.2 Mitigation measures

An existing drilling configuration currently used by the proponent at another location in NSW includes a quieter drill rig together with a purpose designed plant layout to ensure noise leaving the site is minimised. The proponent has had a detailed noise monitoring report prepared (by SLR Heggies – refer to Appendix A) for the mitigated drilling arrangement. The report shows that noise emanating from the drilling compound varies from one side to the other and the derived sound power levels range from 98dB(A) at one end to 106dB(A) at the opposite end of the compound. The SLR data is shown in Table 4.4 below.

Table 4.4 Mitigated drill and optimised plant layout sound power levels

Source	Octave Band Centre Frequency Noise Level, dB											Overall, dB(A)
	16	31.5	63	125	250	500	1k	2k	4k	8k	16k	
Monitoring Location												
Location 87 (NE)	99	110	108	110	106	99	101	99	96	88	79	**106**
Location 88 (SE)	104	112	111	114	104	101	101	99	96	90	83	**106**
Location 89 (SW)	97	120	106	104	98	93	94	91	88	84	73	**99**
Location 90 (NW)	100	117	105	110	98	92	90	87	84	78	68	**98**
Overall	**101**	**116**	**108**	**111**	**103**	**98**	**99**	**96**	**93**	**87**	**79**	**104**

Note 1: Drill orientation as measured at MP12 on 17 August 2010.
Source: SLR Heggies report

This directional noise characteristic was incorporated into the model to predict received noise levels for each of the receivers. In each case the arrangement was such that the quieter side of the compound faced the closest receiver to achieve maximum benefit for the potentially worst exposed location.

Another form of noise mitigation that has been considered is physical barriers which could include commercially available temporary walls or shipping containers. With careful design of the site layout, barriers could be expected to result in a 10dB reduction in received noise levels.

4.2.3 Predicted noise levels

A summary of predicted noise levels for drilling and fracture stimulation operations for the six identified residential assessment locations are presented in Table 4.5 and 4.6 respectively. These residences are representative of the potentially worst affected and are isolated properties in the vicinity of the proposed exploration well sites. The results are for calm weather conditions only since effects of adverse weather (e.g. temperature inversions at night or source to receiver winds) do not noticeably increase received noise levels where source to receiver distances are relatively short (i.e. less than 1 km). This is demonstrated in Appendix D of the INP where a 3 ^{0}C/100 m temperature inversion is quoted to result in a 1 dB to 1.5 dB enhancement for distances ranging from 100 m to 5 km. Similarly, adverse winds are unlikely to result in a more than marginal (i.e. 3 dB) enhancement of predicted noise levels. Also, a combined inversion and wind effect (i.e. drainage situation) is not considered relevant to this project as noise sources are not significantly elevated as compared to receiver locations.

Given the exceedances of conservative criteria, additional mitigation measures in the form of temporary portable barriers were considered. A nominal 10 dB reduction was adopted for the benefits of barriers as described earlier. The results that exceed the daytime or out of hours criteria are shown in bold text (where relevant). For the water monitoring piezometer drilling, a calculation including a barrier is not provided as this operation is limited to one day shift only and it is not considered reasonable or feasible to install a barrier for one day.

Table 4.5 Predicted Leq Noise Levels, dB(A) - Drilling

	Receiver						Leq Noise Level Criteria, dB(A)	
	1	**2**	**3**	**4***	**5***	**6**	**Day time**	**Out of Hours**
Drilling activities (Unmitigated)								
WK 11	**47**	**47**	**47**	**43**	**43**	37	40	35
WK 12	**45**	**42**	**42**	**41**	**46**	**48**	40	35
WK 13	**43**	**45**	**54**	**51**	**47**	**39**	40	35
WK 14	**41**	**41**	**44**	**45**	**53**	**42**	40	35
Piezometer	**50**	**54**	**50**	38	**41**	**41**	40	35
Drilling activities (Mitigated drill & layout)								
WK 11	33	33	33	25	21	19	40	35
WK12	31	28	28	24	25	33	40	35
WK 13	28	31	**42**	33	24	19	40	35
WK 14	23	20	22	23	**37**	27	40	35
Piezometer	35	**40**	33	17	18	23	40	35
Drilling activities (Mitigated drill & layout, plus Barrier)								
WK 11	33	33	33	25	21	19	40	35
WK12	31	28	28	24	25	33	40	35
WK 13	18	21	32	33	24	19	40	35
WK 14	23	20	22	23	**37**	27	40	35
Piezometer	25	30	23	17	18	23	40	35

Notes: *1. *These properties are owned by a neighbouring mining company.*

2. Barriers during drilling were only applied to WK13 and Piezometer locations and only in a direction towards affected properties (ie privately owned properties shown to exceed criteria without barriers, which are locations 1, 2 and 3).

Table 4.6 Predicted Leq Noise Levels, dB(A) – Fracture stimulation

	Receiver						Leq Noise Level Criteria, dB(A)	
	1	2	3	4*	5*	6	Day time	Out of Hours
Fracture stimulation activities (Unmitigated)								
WK 11	**62**	**62**	**62**	**58**	**58**	**52**	40	35
WK 12	**60**	**57**	**57**	**56**	**61**	**63**	40	35
WK 13	**58**	**60**	**69**	**66**	**62**	**54**	40	35
WK 14	**56**	**56**	**59**	**60**	**68**	**57**	40	35
Fracture stimulation activities (Mitigated - Barrier)								
WK 11	**52**	**52**	**52**	**48**	**48**	**42**	40	NA
WK 12	**50**	**47**	**47**	**46**	**51**	**53**	40	NA
WK 13	**48**	**50**	**59**	**56**	**52**	**44**	40	NA
WK 14	**46**	**46**	**49**	**50**	**58**	**47**	40	NA

*Notes: 1. *These properties are owned by a neighbouring mining company.*

4.2.4 Discussion of results

The proposed drilling noise levels are predicted to meet daytime criteria without mitigation or barriers at two of the 24 predictions presented. Of the 22 daytime exceedances shown, nine results are marginal (≤3 dB) and four are not significant (≤5 dB). All daytime noise levels are well below the ICNG's 75 dB(A) 'significantly affected' goal. Other points of discussion for drilling are:

- WK 11:
  - Daytime - The unmitigated daytime drilling noise predictions satisfy criteria at one of the six assessment locations. Deploying the quieter drill and optimised layout configuration, the criteria can be achieved at all locations.
  - Out of hours - The out of hours drilling noise is predicted to meet criteria at all assessment locations with the adoption of the quieter drill and optimised layout configuration.
- WK 12:
  - Daytime - The unmitigated daytime drilling noise is predicted to exceed criteria at all six assessment locations. Deploying the quieter drill and optimised layout configuration, the criteria can be achieved at all locations.
  - Out of hours – Similarly, out of hours drilling noise is predicted to satisfy criteria at all locations with the adoption of the quieter drill and optimised layout configuration.

- WK 13:
  - Daytime - The unmitigated daytime drilling noise predictions satisfy criteria at one of the six assessment locations. The exceedances are 3 dB, 5 dB, 14 dB, 11 dB and 7 dB for locations one to five respectively. With the adoption of the quieter drill and optimised layout configuration, five of the six assessment locations are predicted to satisfy daytime criteria. Introducing noise barriers to shield receivers to the west (ie location 3), shows that daytime drilling noise is predicted to meet criteria at all assessment locations.
  - Out of hours - Similarly, out of hours drilling is predicted to meet criteria at all six assessment locations with the adoption of the quieter drill and optimised layout configuration and noise barriers to protect assessment location 3.
- WK 14:
  - Daytime – The unmitigated daytime drilling noise is predicted to exceed criteria at all six assessment locations. The exceedances at are marginal at locations 1, 2 and 6 and not significant at location 3. With the adoption of the quieter drill and optimised layout configuration, daytime drilling noise is predicted to meet criteria at all locations.
  - Out of hours - Five out of the six assessment locations are predicted to satisfy the out of hours criteria. At location 5, the mitigated night time drilling noise is only marginally (2dB) above criteria. It is important to note that a difference in noise levels of 2dB is not perceptible in practice. In our experience, at this noise level internal noise impact is not likely. The exceedances for night time drilling (assessed externally as required by the DECCW guidelines) are not likely to impact occupants of dwellings, given they will be indoors during the more sensitive sleep times. Furthermore, location 5 is owned by a neighbouring mining proponent.
- Water monitoring piezometer
  - Daytime - The drilling noise satisfies the daytime criterion at location 4. The predicted exceedance for locations 5 and 6 is marginal (1 dB). The predicted exceedances at locations 1 to 3 are more significant. With the adoption of the quieter drill and optimised layout configuration, five of the six assessment locations are predicted to satisfy daytime criteria. Introducing noise barriers to shield receivers to the west (ie location 2), shows that daytime drilling noise is predicted to meet criteria at all assessment locations.
  - Out of hours – Similarly, out of hours drilling is predicted to meet criteria at all six assessment locations with the adoption of the quieter drill and optimised layout configuration and noise barriers to protect assessment location 2.

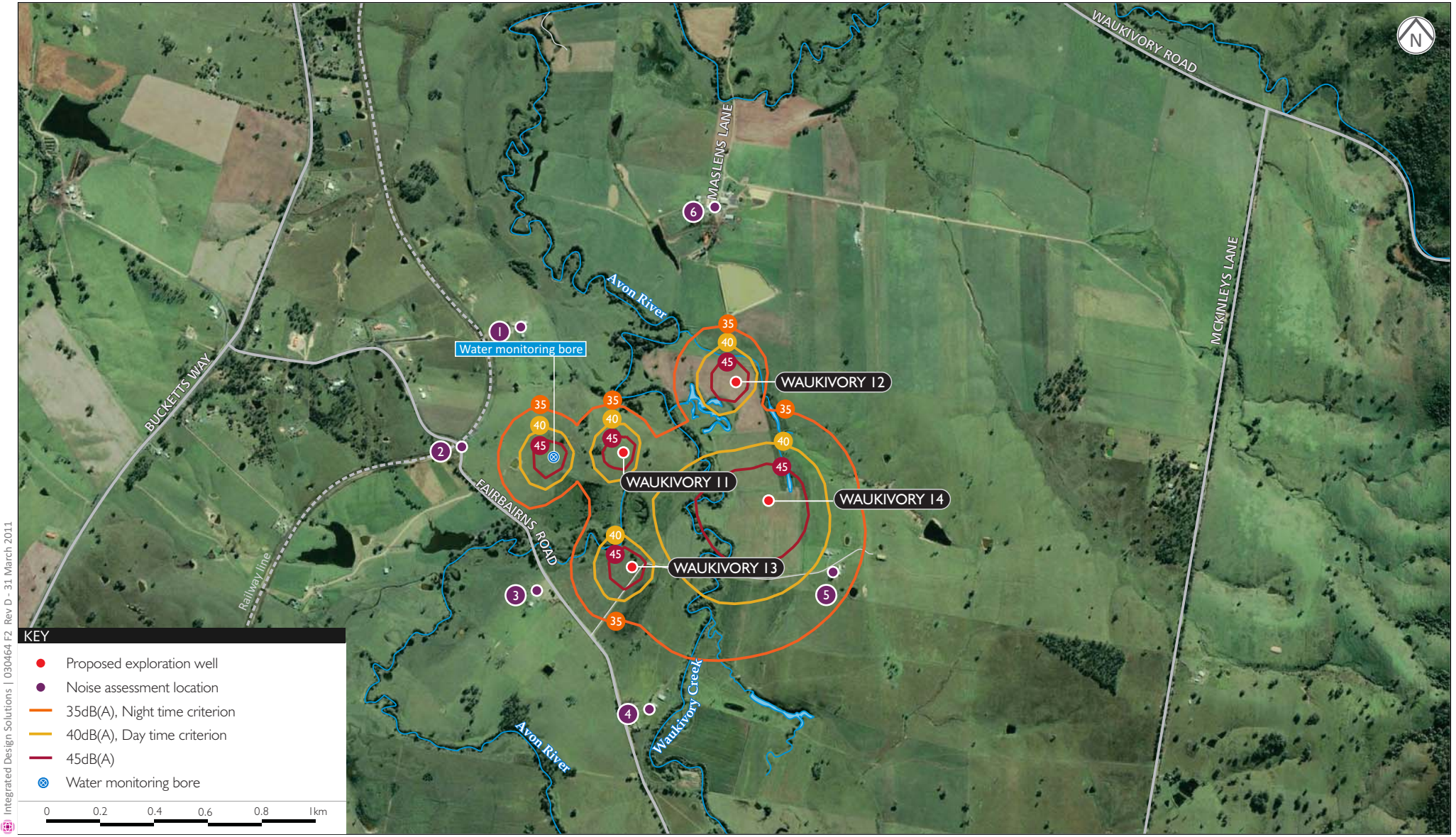
It should be re-iterated that the above results for the quieter drill and optimised layout configuration take advantage of the directional characteristics for the drilling orientation for the closest residence.

With respect to predicted fracture stimulation noise, all daytime noise levels are well below the ICNG's 75 dB(A) 'highly affected' level. Other findings include the following:

- Without mitigation, the results show that predicted daytime fracture stimulation noise will not meet criteria at all assessment locations for any wells. However, predicted noise levels are below the DECCW highly affected level of 75 dB(A).

- With noise barriers in place as for drilling, fracture stimulation noise levels as received at the assessment locations are significantly reduced. However, they remain above recommended daytime criteria. Given that this activity is limited to day shift only and to at most 1 hour at each exploration well, impacts are considered manageable through community consultation means.

The results of mitigated drilling activities are also presented graphically in Figure 2 as noise contours. The noise contours represent the outer envelope noise from drilling of one well at a time (i.e. not simultaneous drilling activities occurring at all four well locations).



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Predicted drilling outer envelope Leq noise levels - Mitigated drill and optimised layout dB(A)

Proposed Exploration wells - Waukivory 11 to 14

Client: AGL Energy

Figure 2

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4.3 Operational (flaring) noise levels

The noise emission from flaring will be controlled using two standard shipping containers that will shield the flare and provide at least 5dB of noise reduction. This is a practice common used by the proponent at similar operations, where noise predictions suggest flare sound power levels are in the order of 85 dB(A) to 90 dB(A) (inclusive of the 5 dB shielding offered by the shipping containers). This is a relatively quiet activity as compared to drilling or fracture stimulation and is reflected in the results shown in Table 4.5 and Figure 3 noise contours. The results are for the combined noise level of all four exploration wells flaring simultaneously, as the case may be once all exploration wells are completed. The results are for calm weather conditions, for reasons discussed previously, for the construction phase. As demonstrated, the predicted noise from flaring satisfies noise criteria at all receivers and hence noise impact is not likely from flaring.

Table 4.7 Operational (flaring) noise levels

Receiver	Predicted Leq Noise Levels for all four wells combined	Noise Criteria, dB(A)
		Day/evening/night
1	21	35
2	20	35
3	27	35
4	23	35
5	25	35
6	20	35

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Predicted operational (Flaring) Leq noise levels from all wells combined, dB(A)

Proposed exploration wells - Waukivory 11 to 14

Client: AGL Energy

Figure 3

4.4 Sleep disturbance noise predictions

Noise from possible intermittent activities include hammering using hand tools, metal to metal contact associated with out of hours drilling and similar activities. A typical source sound power (emission) level of 115 dB(A) was used to predict maximum (Lmax) noise at receivers. Table 4.6 presents the predicted Lmax noise levels assessed against the sleep disturbance criterion (45 dB(A)). Noise emitted from these activities should be controlled and managed by appropriate measures. The results do not include the benefits of barriers, which if designed appropriately would reduce levels to satisfy criteria at most locations. The only except may be location 2 during drilling of the water monitoring piezometer, where a marginal 2dB exceedance is predicted (ie 57dB(A) minus 10dB for barrier, results in a 47dB(A)Lmax level). This potential marginal exceedance is however limited to one or two nights. As discussed previously, a 2dB difference in noise level is not perceptible in practice.

Table 4.8 Predicted Lmax Noise levels, dB(A)

Well	Receiver						Sleep Disturbance Criteria, dB(A)
	1	2	3	4	5	6	
WK 11	47	47	47	41	43	41	45
WK 12	44	41	39	38	44	47	45
WK 13	41	44	54	50	46	36	45
WK 14	39	39	43	44	54	39	45
Piezometer	53	57	53	41	45	45	45

5 Road Traffic Noise Assessment

The calculation and prediction of road traffic noise adopts a standards-based approach to modelling, in that noise propagation calculations are carried out in accordance with accepted standards used in various countries. The adopted algorithm is the United Kingdom Calculation of Road Traffic Noise (CoRTN) method.

The project related traffic information used in our assessment was provided by the proponent. However, to assess potential impacts we must first establish the existing traffic noise levels at receivers. For Bucketts Way the traffic data used for calculating the existing noise was that obtained from actual counts in 2004, as provided by the NSW RTA on their website. More recent data was not available and growth patterns over the years (refer to Table 5.1) are not consistent and do not allow for a reasonable estimate of 2011 volumes. The existing traffic volumes on local roads near the well sites were assumed to be negligible, which means our assessment will be conservative with respect to changes in traffic noise for these roads.

Table 5.1 Buckets Way Annual Average Daily Traffic (AADT) by Year – RTA Station 09.332

1982	1984	1986	1988	1990	1992	1995	1998	2001	2004
3,010	-	3,117	-	3,806	1,468	4,609	4,262	3,282	4,095

Source: NSW RTA website.

Table 5.2 summaries expected traffic generated by the project. In addition, it was assumed that a nominal 5 small vehicle movements would be generated by the site during shift changes.

Table 5.2 Traffic volumes per well site

Truck Movements/day	Days of Operation per well	Time of truck movements	Truck movements per hour
60	180	2 x 12hr shifts/7 days	2 to 3 - on average 5 - typical maximum

5.1 Road traffic noise calculations

Based on the above truck and small vehicle movements, and an assumed average pass-by traffic speed of 50 km/hr, predicted noise levels for existing and future (including site related) traffic at nominal setback distances are summarised against criteria in Table 5.3.

For Bucketts Way, the 15 hour daytime volume was estimated as 85% of the AADT, and the night being 15% of AADT, which is typical breakdown adopted by road traffic engineers.

The predictions for Bucketts Way indicate no change to existing traffic noise and in all cases, including local roads, are expected to satisfy the daytime and out of hours criteria.

Table 5.3 Predicted Traffic Noise Levels

	Bucketts Way				Local Roads			
Set Back Distance (m)	**Day Leq,15hr, dB(A)**		**Night Leq,9hr, dB(A)**		**Day Leq,1hr, dB(A)**		**Night Leq,1hr, dB(A)**	
	Existing	**Inc. Project**	**Existing**	**Inc. Project**	**Existing (negligible)**	**Inc. Project**	**Existing (negligible)**	**Inc. Project**
20	59	59	54	54	39	52	36	50
40	56	56	51	51	36	48	33	47
60	54	54	49	49	33	46	30	45
80	52	52	47	47	32	45	29	43
100	51	51	46	46	31	44	28	42
150	49	49	44	44	29	41	26	40
Criteria	**60**	**60**	**55**	**55**	**55**	**55**	**50**	**50**

6 Conclusion and Recommendations

EMM has completed a construction, operation and road traffic noise impact assessment of the proposed pilot exploration wells WK 11 to 14 near Gloucester, NSW. This assessment recommends mitigation of noise by adoption of the proponent's quieter drill rig and optimised plant layout, as well as noise barriers during drilling at some sites, and for fracture stimulation to shield these noise sources and reduce impacts at residences. With these measures in place, drilling noise is shown to satisfy recommended criteria at all locations day and night, with the exception of a marginal 2dB exceedance at night at location 5 (a property owned by a neighbouring mining company). It should be noted that drilling noise levels inside this residence are not likely to be significant, and hence impact to occupants during the night period is not expected.

It is expected that whilst daytime noise criteria may be exceeded at residences by fracture stimulation activities, the predicted noise levels are well below the DECCW's highly noise affected levels. The exceedances are limited to at most 1 hour during the daytime at each of the four exploration wells. Hence, daytime construction noise levels are considered manageable.

The assessment also finds that sleep disturbance issues at night can be mitigated to satisfy DECCW criteria at most locations and that road traffic noise levels are predicted to satisfy relevant DECCW criteria. Similarly, noise from exploration well operations (i.e. flaring) is predicted to satisfy noise criteria at all residences and hence impact is not likely from flaring noise.

Other good practice noise management measures that should be considered include the following:

- use noise monitoring during initial drilling and fracture stimulation operations at the first exploration well site to be constructed to affirm and calibrate noise predictions;
- orientate the drill rig to take advantage of directional noise characteristics for the closest residence for the given well site as described in this report;
- ensure the community is consulted and provide them with written notice well in advance of proposed activities;
- ensure all landholders of each well are consulted and supportive of the project's intention for out of hours activities;
- where possible obtain a drill rig with lower noise emission levels;
- use temporary noise barriers as described in this report; and
- employ all reasonable and feasible work practices to minimise any impacts.

We trust that the above information satisfies your needs and if you have any further questions please contact the undersigned.

Yours sincerely

Najah Ishac (MEngSc, BE, MIEAust, MAAS)
Director
nishac@emgamm.com

Appendix A

SLR Heggies Mitigated Rig Report

27 September 2010

30-2131 Ensign Drill Rig 20100927

AGL Energy Limited
Lot 35 Medhurst Road
MENANGLE NSW 2568

Attention: Mr Aaron Clifton

Dear Aaron

Ensign Drill Rig
Sound Power Levels

1 INTRODUCTION

Heggies Pty Ltd (Heggies) was engaged by AGL Energy Limited to conducted operator-attended noise measurements of the current Ensign Drill Rig currently operating at MP12 drill site. The aim of the measurements was to determine sound power levels (SWLs) of the drill rig and its main components. This report presents the results of the noise investigation together with a discussion comparing the measured levels against the data provided by Canadian consultants Noise Control Systems.

2 PLANT NOISE AUDIT

In order to determine the major noise emission contributors, on-site sound pressure level measurements of the drill operation were conducted on 26 August and 27 August 2010.

The measurement locations are shown in **Figure 1** and the measured L_{Aeq} noise levels (and distance from the nearest equipment item) are listed in **Table 1**. It is noted that the background noise levels in the area (i.e. while plant was not operating) was measured to be approximately 40 dBA.

The main areas or equipment items and measurement locations are identified in **Figure 1.**

Heggies Pty Ltd 2 Lincoln Street Lane Cove NSW 2066 Australia
(PO Box 176 Lane Cove NSW 1595 Australia)
T: 61 2 9427 8100 F: 61 2 9427 8200 E: sydney@heggies.com www.heggies.com
ABN 29 001 584 612

Figure 1 Measurement Locations

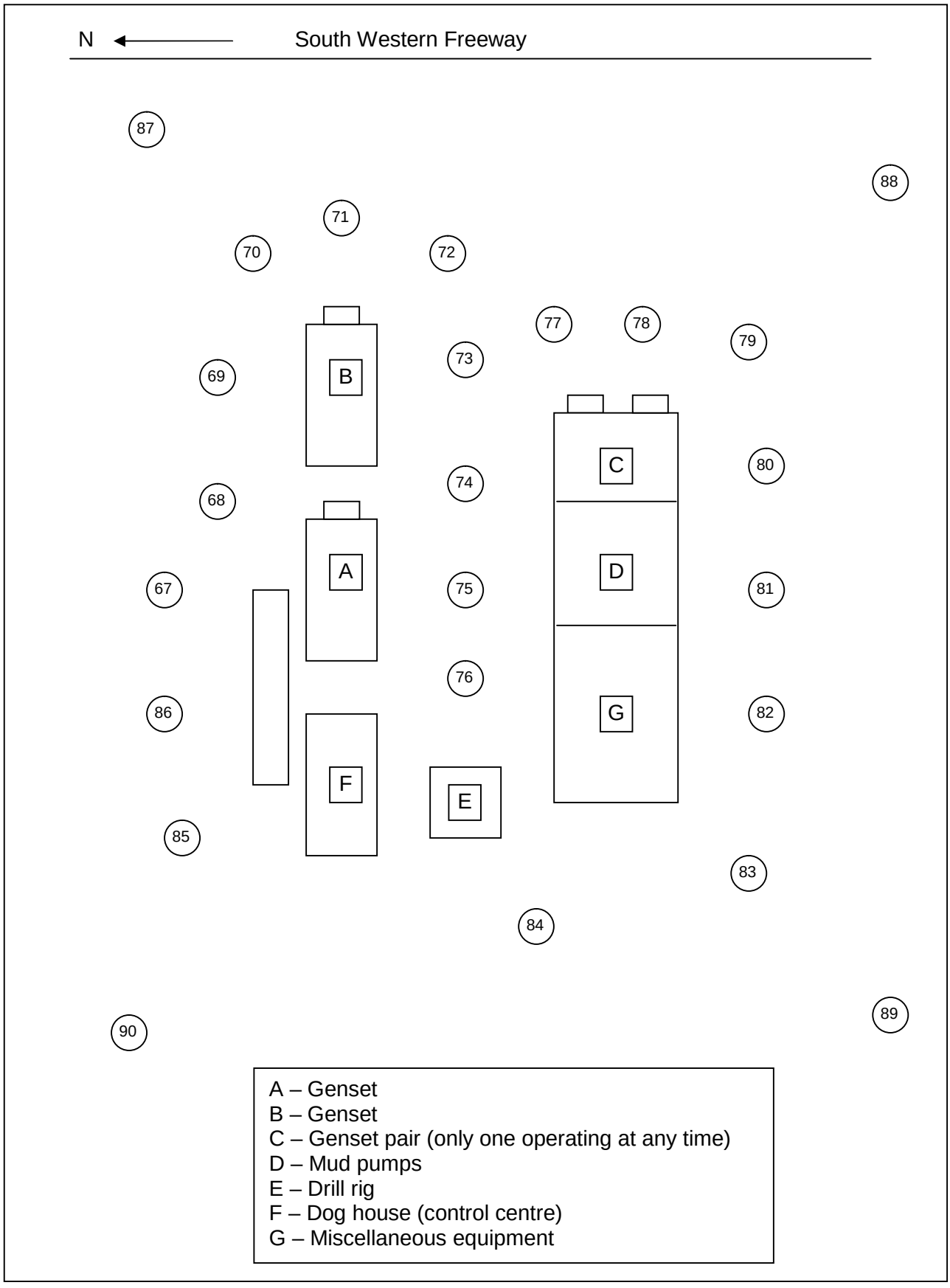

Table 1 Measured L_{Aeq} Noise Levels

Location Reference	Distance from Nearest Equipment (m)	L_{Aeq} Noise Levels
67	5	82 dBA
68	5	83 dBA
69	5	81 dBA
70	5	82 dBA
71	5	81 dBA
72	5	80 dBA
73	5	80 dBA
74	5	84 dBA
75	5	86 dBA
76	5	81 dBA
77	5	78 dBA
78	5	77 dBA
79	5	77 dBA
80	5	77 dBA
81	5	73 dBA
82	5	70 dBA
83	5	69 dBA
84	5	70 dBA
85	5	68 dBA
86	5	74 dBA
87	20	72 dBA
88	20	72 dBA
89	20	65 dBA
90	20	64 dBA

Table 2 presents the overall Sound Power Levels (SWL) for the main noise producing itmes and **Table 3** indicative SWLs different directions from the drill site. The noise from the site as a whole is directional and it is dominated by the Gensets (see **Figure 1**). The SWL results indicate that the Mud Pumps generate around 7 dBA less noise than the Gensets.

Table 2 Sound Power Levels for Main Noise Producing Items

Description	L_{Aeq}, SWL
A - Genset	106 dBA
B - Genset	107 dBA
C - Genset pair (one operating at any one time)	105 dBA
D - Mud pumps	99 dBA

It is noted that the noise emissions from the site is highly dependent on the orientation of the different items of equipment, and on shielding provided by less noisy items. The Sound Power Levels measured from the Dog house end of the site (Locations 89, 90) were around 7 dBA lower than SWLs at the opposite end of the site (Locations 87, 88) as shown in **Table 3**. The noise is predominately low frequency, with the most significant octave frequency bands being between 32 Hz to 125 Hz.

Table 3 Octave Band and Overall Sound Power Levels Measured at 20 m Locations

	Octave Band Sound Power Level											
Monitoring Location	**16 Hz**	**32 Hz**	**63 Hz**	**125 Hz**	**250 Hz**	**500 Hz**	**1 kHz**	**2 kHz**	**4 kHz**	**8 kHz**	**16 kHz**	**LAeq**
Location 87 (NE)	99	110	108	110	106	99	101	99	96	88	79	106
Location 88 (SE)	104	112	111	114	104	101	101	99	96	90	83	106
Location 89 (SW)	97	120	106	104	98	93	94	91	88	84	73	99
Location 90 (NW)	100	117	105	110	98	92	90	87	84	78	68	98
Overall	**101**	**116**	**108**	**111**	**103**	**98**	**99**	**96**	**93**	**87**	**79**	**104**

Note 1: Drill orientation as measured at MP12 on 17 August 2010.

3 COMPARISON AGAINTS NOISE CONTROL SYSTEMS SWL

The Noise Control Systems data consists of measurements of sound pressure level around the site, but none of these measurements has been taken at a distance of more than about 10 m from the plant. The noise levels predicted by Noise Control Systems at a distance of 200 m from the site range from 25 dBA up to 55 dBA. These levels correspond to estimated sound power levels (SWL) ranging from around 79 dBA up to 109 dBA for the different measurement locations.

Using the Noise Control Data (SWLs), Heggies previously estimated the overall sound power level of the drill rig as a whole to be approximately 109 dBA - 111 dBA (without and with the loader operating) and these values were used in the noise model for the MP23 site (see Heggies *letter 30-2131 20-300 Menangle Park 20100629*) i.e. 5 dBA higher than the overall SWL presented in **Table 3**.

4 CONCLUSIONS

The Sound Power Level survey of the Ensign drill operating at MP12 on 17 August 2010 found an overall operating SWL of 104 dBA for the drill.

I trust the above report meets your current requirements. Should you have any questions or require any additional information, please contact myself on 9427 8100.

Regards,

BRIONY CROFT
SENIOR CONSULTANT

Reviewed by: MB

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