REVIEW OF ENVIRONMENTAL FACTORS

PLAN: 13-V-PL-0005

REV: 1

STATUS: IFU

ENVIRONMENTAL DEPARTMENT

ARROW ENERGY LTD EXPLORATION

COAL SEAM GAS WELLS IN PEL445

BEX HILL 2
GENEVA 4
KEERRONG 1
PEACOCK 2
TUNGLEBUNG 1

Issued: November 2009
Amended: January 2010

This document is UNCONTROLLED when printed

CONTACT INFORMATION

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ADDRESS OF LAND

Bex Hill 2	Lot 1 Plan DP 1053808
Geneva 4	Lot 1 Plan DP 180223
Keerrong 1	Lot 74 Plan DP 755689
Peacock 2	Lot 271 Plan DP 703438
Tunglebung 1	Lot 99 Plan DP 751062

DECLARATION BY TITLEHOLDER

On behalf of Arrow Energy Ltd, I certify that the information contained within this Review of Environmental Factors, to the best of my knowledge, is neither false nor misleading.

Name: Bernadette Williams **Signature:** B Williams

Position: Environment Coordinator
Arrow Energy Ltd

Date: 29/01/15

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1. INTRODUCTION

1.1. Regional Locality

This document forms an integral part of the environment management planning for the exploration projects within the PEL 445 lease and relates specifically to the proposed drilling of five exploration coal seam gas (CSG) wells:

- Bex Hill 2
- Geneva 4
- Keerrong 1
- Peacock 2,
- Tunglebung 1

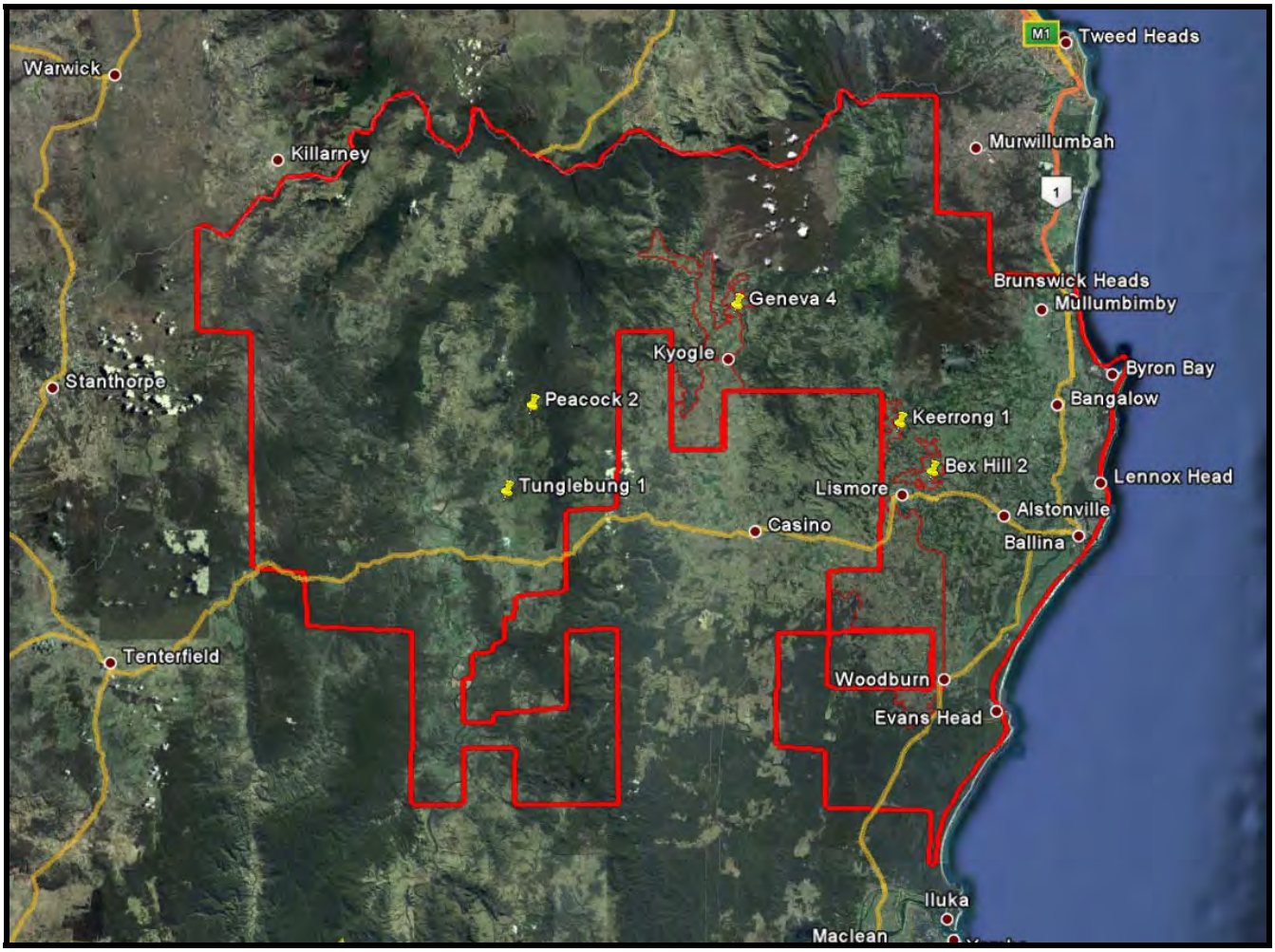
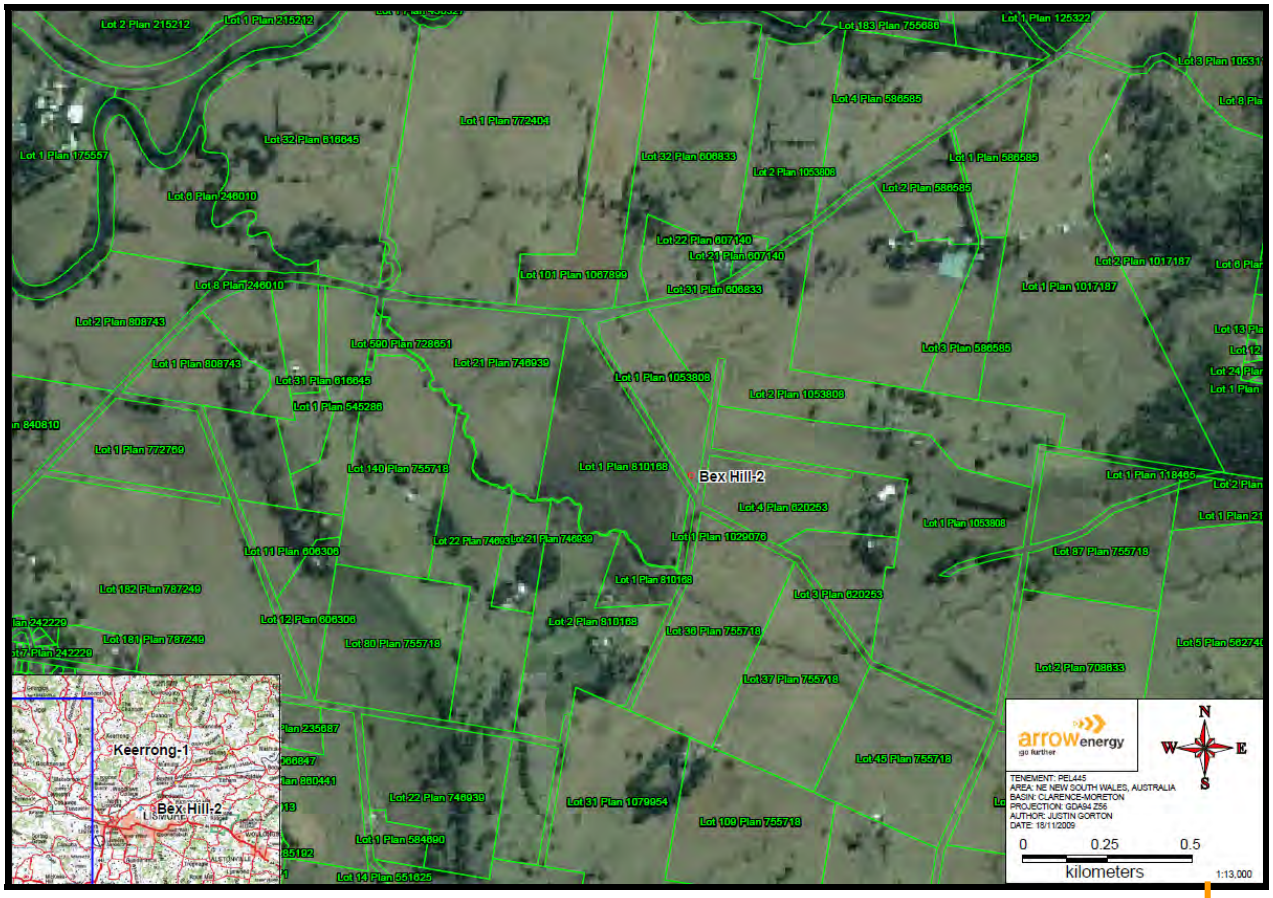


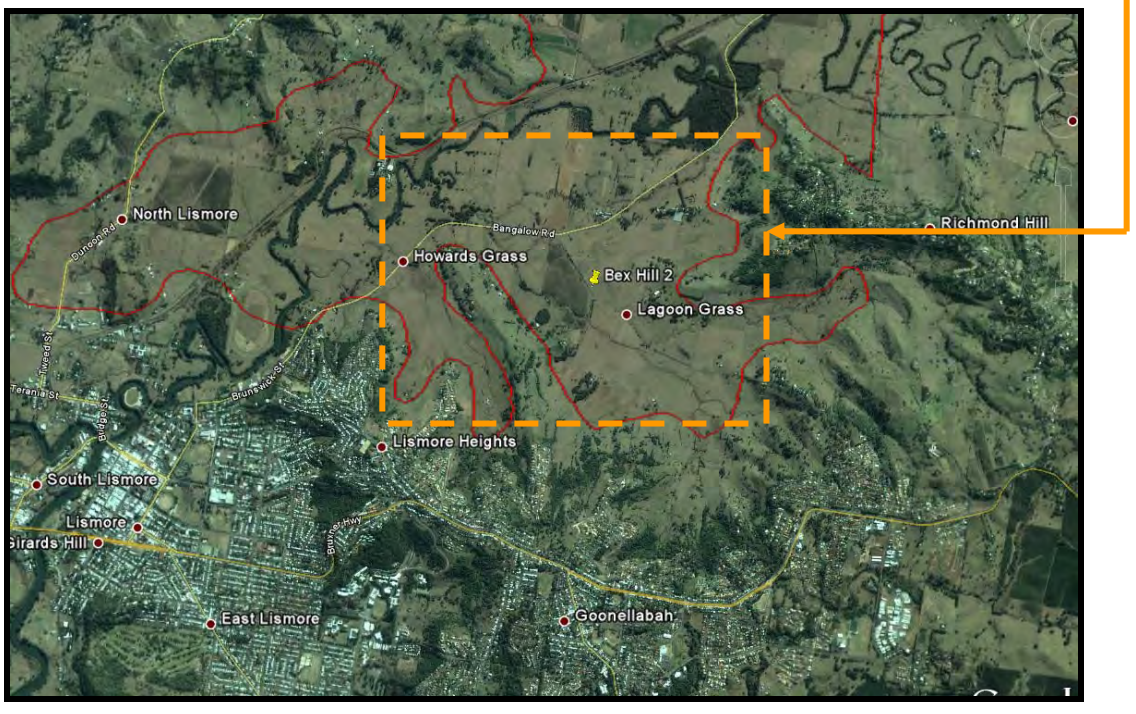
Figure 1: Location of the five exploration wells within PEL445

For each of the five wells, the final locations nominated are ideal based primarily on geological, landholder, environmental, and topographical constraints. In the case of extreme weather, the well locations may require shifted with agreement from all parties involved. The environmental study will encompass an area of contingency to allow for these circumstances.

1.2. Bex Hill 2

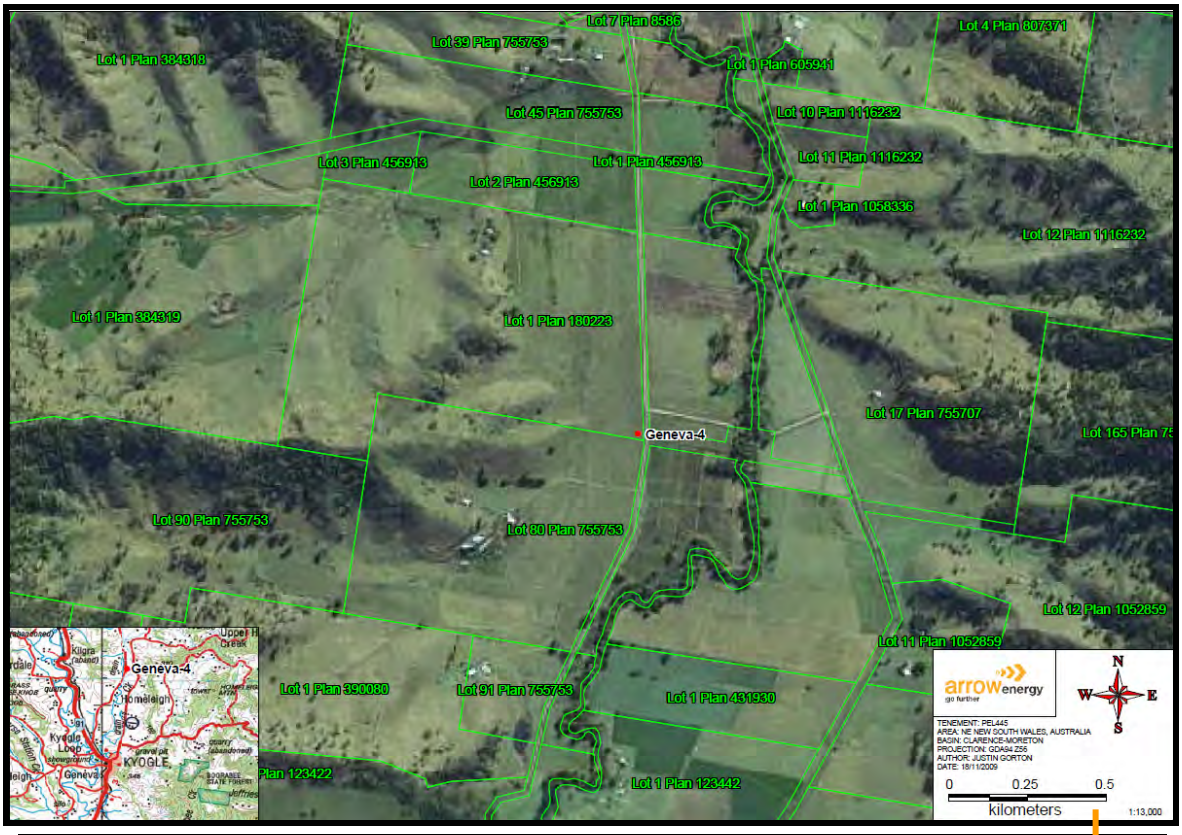
Local Government Area	Lismore
Lot numbers and Deposited Plans	Lot 1 Plan DP 1053808
Nearest Township	Lismore
Locality Map (Note: yellow pin – ideal drilling location of well; blue polygon – area in which the well location can be moved)	

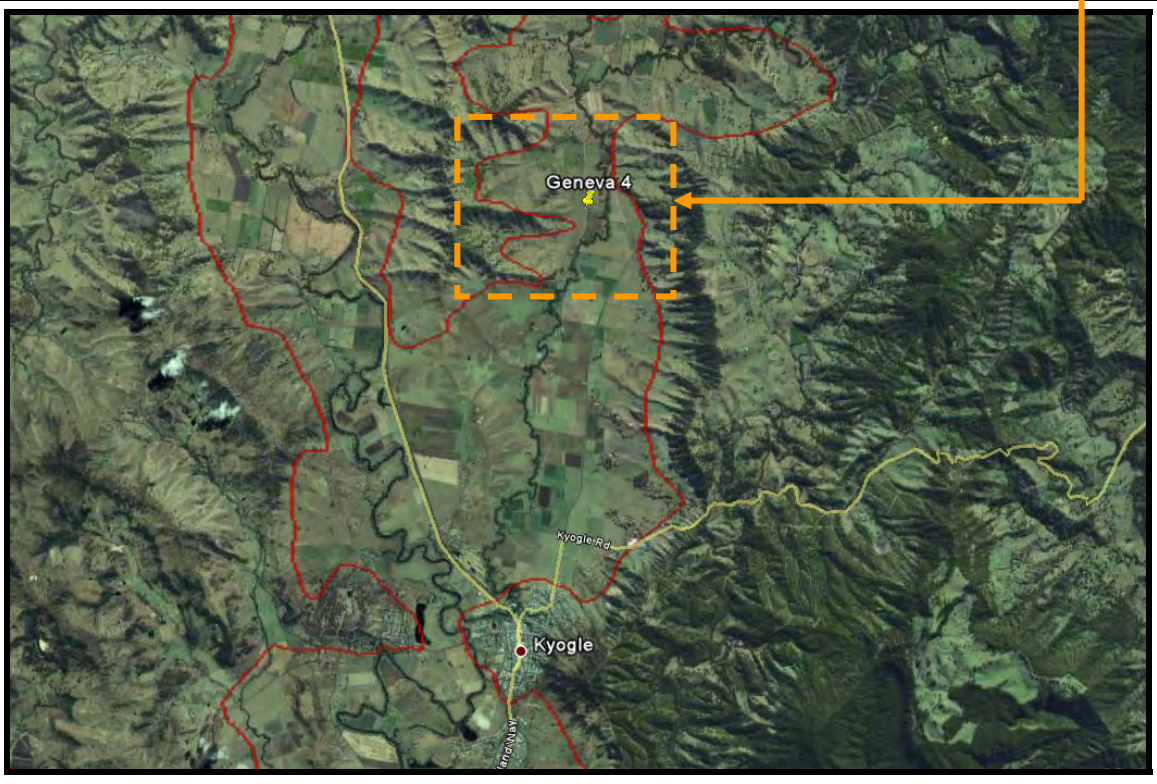




1.3. Geneva 4

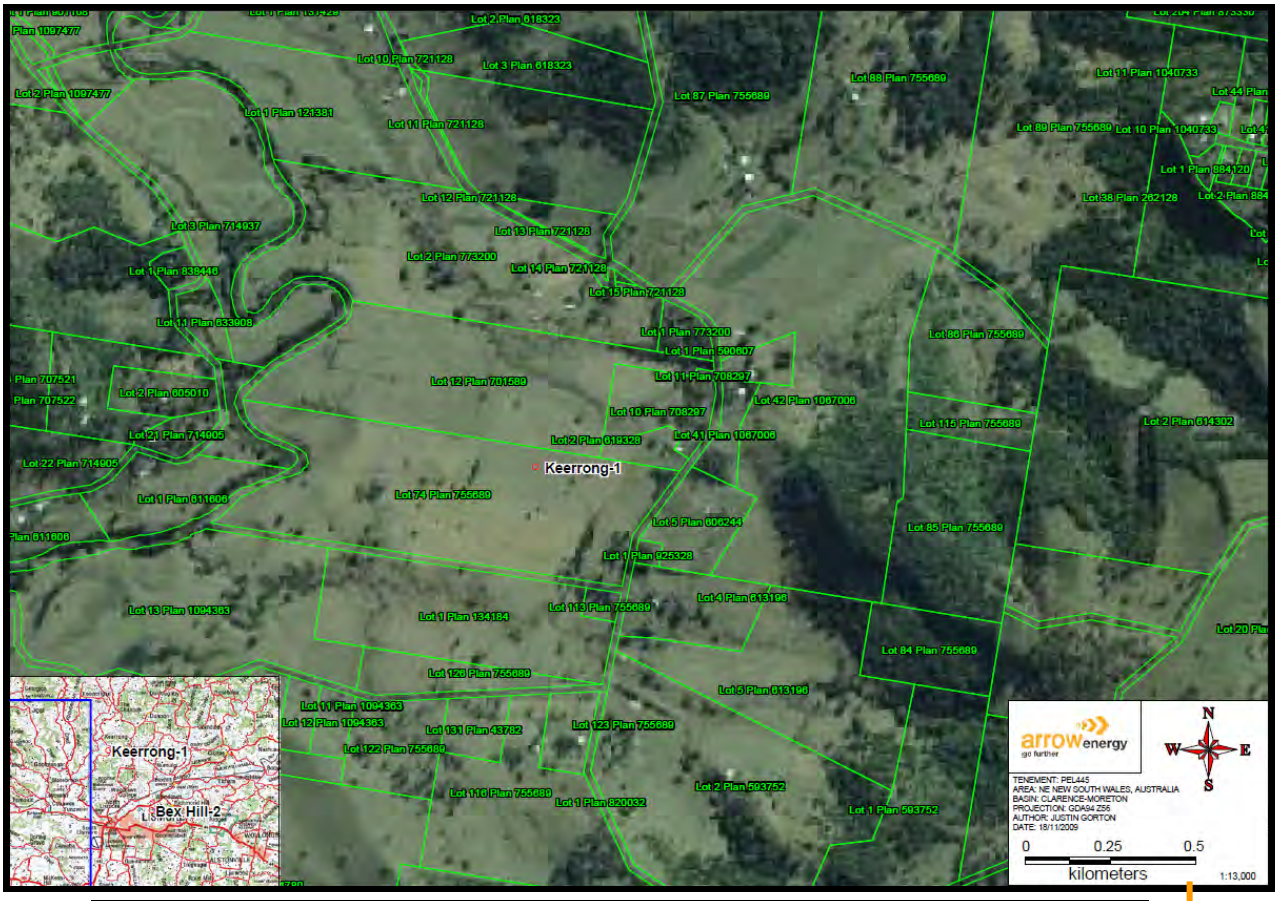
Local Government Area	Kyogle
Lot numbers and Deposited Plans	Lot 1 Plan DP 180223
Nearest Township	Kyogle
Locality Map (Note: yellow pin – ideal drilling location of well; blue polygon – area in which the well location can be moved)	





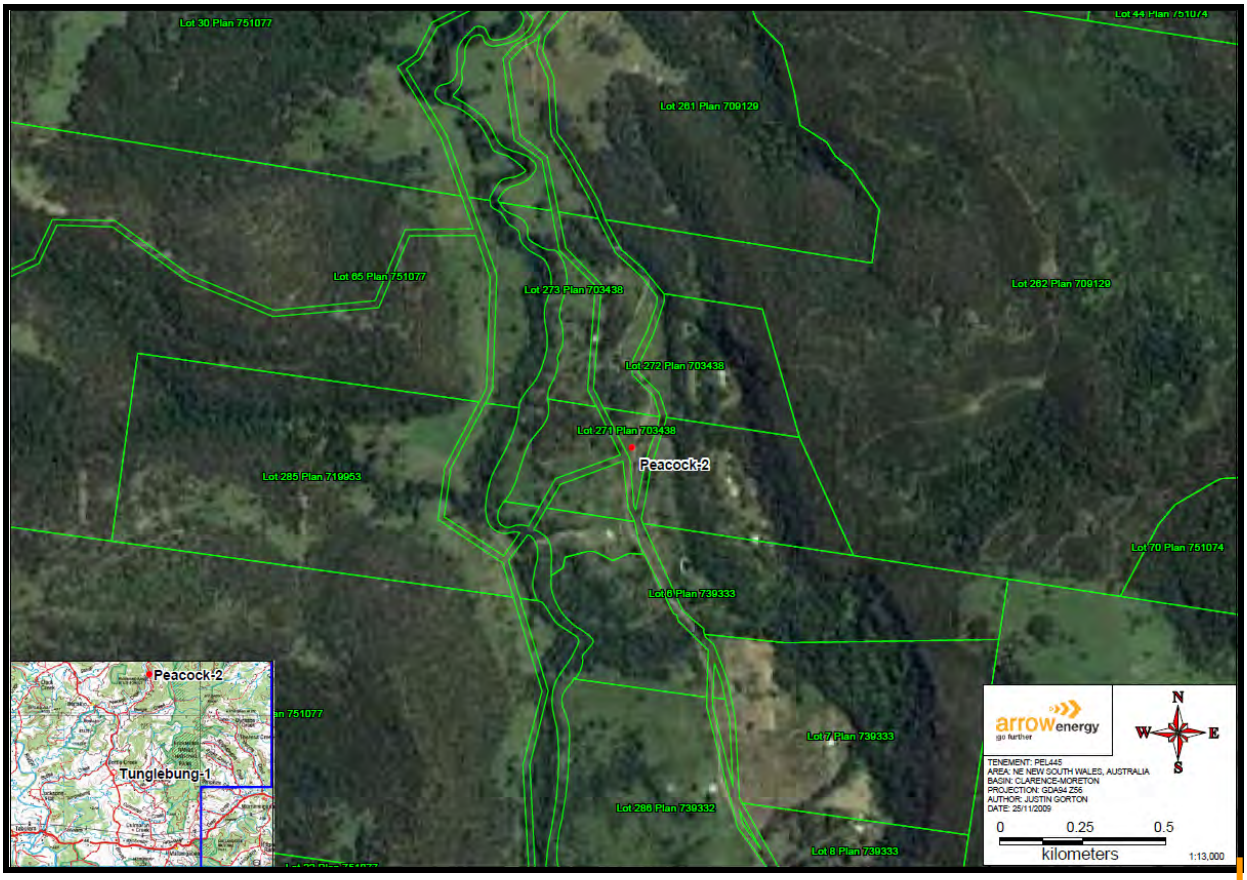
1.4. Keerrong 1

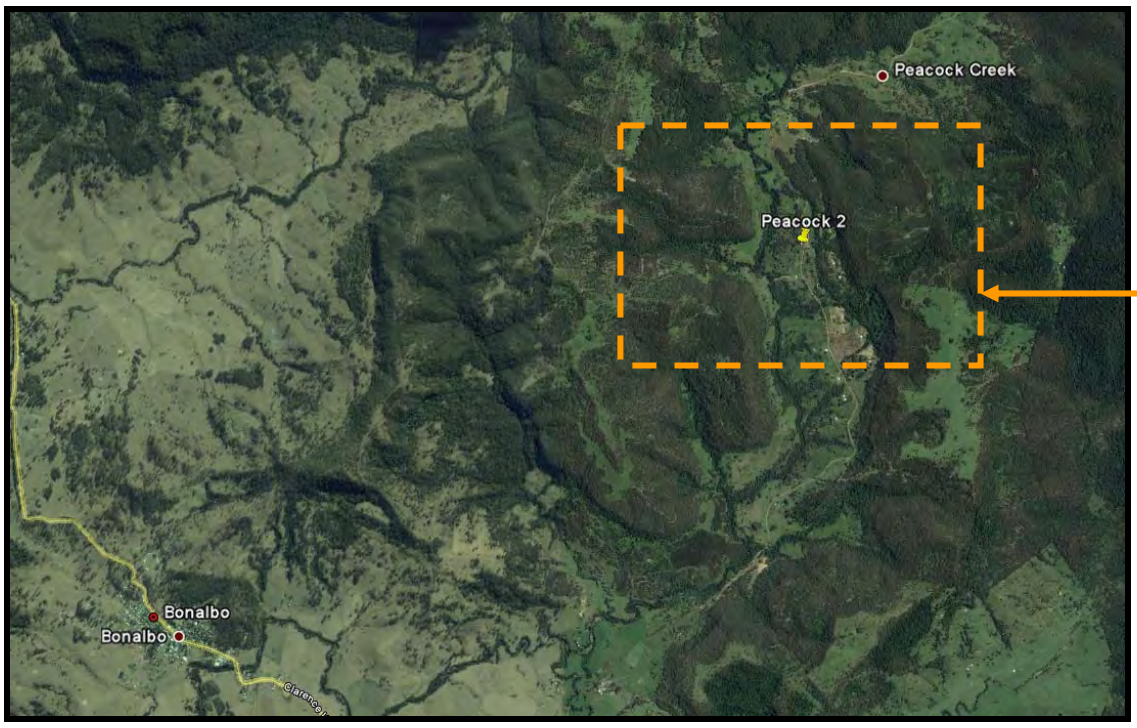
Local Government Area	Lismore
Lot numbers and Deposited Plans	Lot 74 Plan DP 755689
Nearest Township	Modenville
Locality Map (Note: yellow pin – ideal drilling location of well; blue polygon – area in which the well location can be moved)	



1.5. Peacock 2

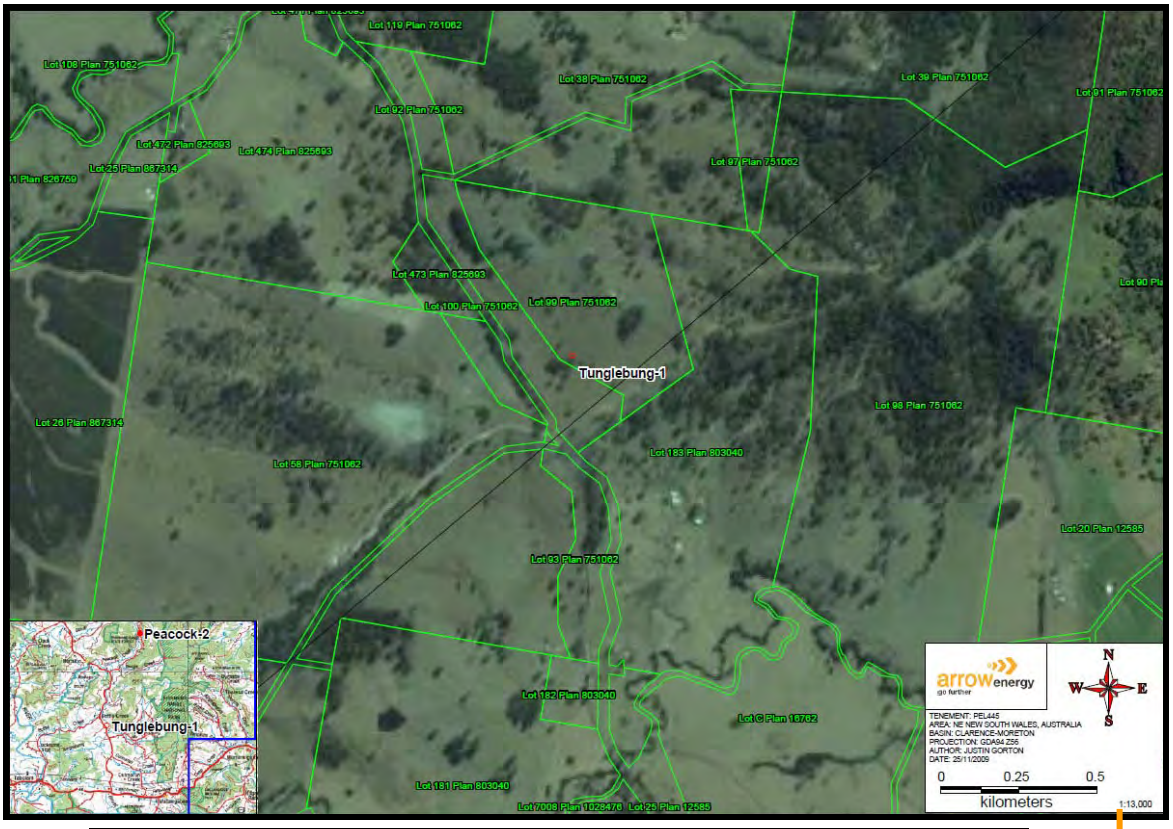
Local Government Area	Kyogle
Lot numbers and Deposited Plans	Lot 271 Plan DP 703438
Nearest Township	Bonalbo
Locality Map (Note: yellow pin – ideal drilling location of well; blue polygon – area in which the well location can be moved)	

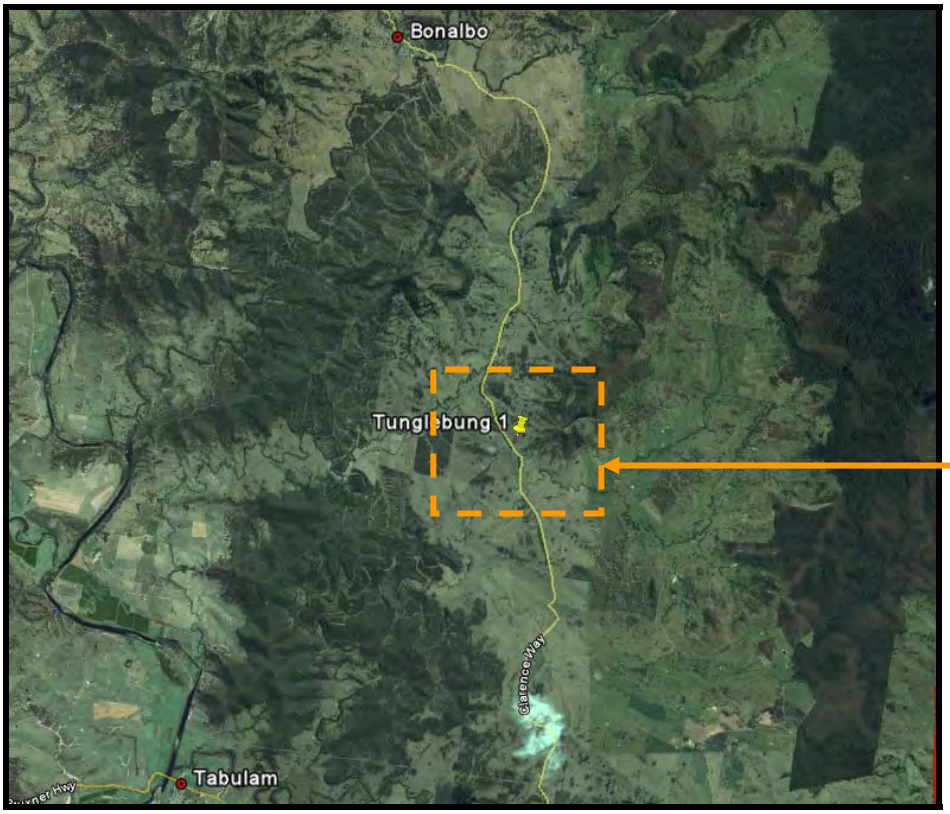




1.6. Tunglebung 1

Local Government Area	Kyogle
Lot numbers and Deposited Plans	Lot 99 Plan DP 751062
Nearest Township	Bonalbo and Tabulam
Locality Map (Note: yellow pin – ideal drilling location of well; blue polygon – area in which the well location can be moved)	





1.7. Review of protected areas

Presently available information confirms the subject land does not fall within any of the eleven categories of land that would reserve or protect the land for conservation purposes, although some of the wells are close to national parks and a area reserved by NSW Forestry.

Is the proposed activity located within an area that is:	Bex Hill 2	Geneva 4	Keerrong 1	Peacock 2	Tunglebung 1
Reserved or dedicated under the *National Parks and Wildlife Act 1974*?	No	No (~10km south-west Boarders Ranges NP)	No	No (~3km west Richmond Range NP)	No (~7km west Richmond Range NP)
Reserved or dedicated within the meaning of the *Crown Lands Act 1989* for preservation of other environmental protection purposes?	No	No	No	No	No
A World Heritage Area?	No	No (~10km south-west Boarders Ranges NP)	No	No (~3km west Richmond Range NP)	No (~7km west Richmond Range NP)
Land nominated as Environmental Protection Zones in environmental planning instruments?	No	No	No	No	No
Lands protected under SEPP 14 – Coastal Wetlands?	No	No	No	No	No
Lands protected under SEPP 26 – Littoral Rainforests?	No	No	No	No	No
Land identified as wilderness under the *Wilderness Act 1987* or declared as wilderness under the *National Parks and Wildlife Act 1974*?	No	No	No	No	No
Aquatic reserves dedicated under the *Fisheries Management Act 1994*?	No	No	No	No	No
Wetland areas dedicated under the *Ramsar Wetlands Convention*?	No	No	No	No	No
Land subject to a conservation agreement under the *National Parks and Wildlife Act 1974*?	No	No	No	No	No
Land identified as State Forest under the *Forestry Act 1916*?	No	No	No	No (~0.5km west NSW Forestry Zone 8 – Area s for further assessment)	No

1.8. Description of the Activity

The relevant works undertaken as part of the environmental study include well site access and pad construction, drilling, well analysis (including sampling, logging, and testing), well abandonment and rehabilitation.

Access Construction: Where possible, existing farm tracks will be used for access, in some cases they may have to be widened or touched up with a grader. If required, short temporary tracks will be created to link existing tracks to the well site. These tracks will be slashed in preference to grading (wherever possible) to prevent erosion. Gravel may be required on private roads for safe access to the site with landholder permission. This will be removed and private tracks restored to their original condition as part of rehabilitation; unless otherwise agreed by the landholder. Other works may include installation of gates and culverts with landholder permission.

Pad Construction: A pad will be constructed, keeping the footprint to a minimal size. This will involve slashing grass and possible grading in order to smooth the surface; providing a safe working environment. Gravel may be required where ground conditions are poor; which will be assessed at the time of construction. The total area of disturbance for the well site pad will encompass an area 70x70m, fenced, and lockable.

Three excavated pits (up to 4mx4mx2.5m) will be required for the drilling operation which contain approximately 30,000L of water. If the ground is permeable (i.e. very sandy), the pits will be lined with plastic to prevent leakage. Two pits will be installed adjacent to the drilling rig. One of these will be used to collect cuttings, sediment, and drilling fluids circulated from down hole. The other will contain a mix of fresh water, approved mud additives, and recycled mud to circulate down hole for bit lubrication, cuttings return, and hole stability. A third "flare" pit will be located 30m from the wellhead. This will be used primarily for emergency discharge of gas or in some circumstances; the emission of gas as part of flow testing activities.

Drilling: The exploration wells range from 350 – 700m in depth and will either be drilled on compressed air/mist or water (with a combination of approved, biodegradable mud additives), and either chip or core drilling.

- Bex Hill 2 Stratigraphic hole ~700m
- Geneva 4 Core hole ~700m
- Keerrong 1 Stratigraphic hole ~700m
- Peacock 2 Core hole ~350m
- Tunglebung 1 Stratigraphic hole ~400m

Drilling Fluids: Approved mud additives for the operation include KCL or Claymaster, FS2000 and occasionally Superfoam. These are either used as a mud for water-based drilling or in small concentrations with air/mist drilling are needed to control reactive clays, improve hole stability, and increasing viscosity for cuttings return. Water sourced for drilling will be from local supply (farmer's dam) or local town water.

Well Construction: The well construction will consist of a conductor, surface and target section. The 8" conductor section will be drilled to approximately 6m and cased with 6" PVC or steel casing and set with gypset. The 5½" surface section will be drilled to a minimum of 10% of the total proposed depth of the well and cased with API grade 4½" steel casing and set with cement grout at 1.68 S.G. In both circumstances, the cased sections may be increased to control poorly consolidated formation, groundwater aquifers, or to isolate the resource target in the surface section. The 4" surface section will be drilled to the base of the target resource and left open until logging and testing activities have been completed.

Operations: The drilling rig is staffed for 12 hour operation with designated hours of work from 6am – 6pm, 7 days per week. Combined staff consisting of 4 to 5 persons will be on-site under normal operating conditions. The rig will be onsite for approximately 5 to 10 days for a chip hole and 14 to 30 days for a core hole; operational delays may be caused by increment weather, mechanical issues, poor hole conditions, or other unforeseen affects.

Well Analysis:
Sampling - Continuous sampling will occur from surface to total depth (TD) by the Geologist onsite. 6m chip samples will be collected and logged until the cessation of the surface section in accordance with NSW DPI requirements. 3m chip or continuous core will be collected and logged to the base of the target section or TD.

Wireline Logging - At completion of the well, down hole wireline geophysical survey will be run through open and cased hole from total depth to surface. These include a minimum of gamma, density, calliper, and borehole deviation surveys. The drilling rig will be required to remain onsite to assist with conditioning the hole and in the case of the tools becoming stuck.

Drillstem - All economic coal seams will be drillstem tested as soon as feasibly possible after completion of the well. A second, smaller rig will be mobilised onsite to conduct this testing. A period of suspension may be required between demobilisation of the drilling rig and mobilisation of the testing rig. During this period, the well will be made safe by filling with water and installation of a 5000psi rated wellhead with 2" ball lockable release valve. The cellar will be infilled and tripod fencing will be installed around the wellhead with appropriate safety signage.

Rehabilitation - Once all drilling and testing activities have been completed, rehabilitation on the well site, pad and access will commence (refer to section 4.16 for further details)

Core Hole
- Small (4" – 96mm) hole drilled collecting continuous rock samples
- Testing measures how much gas might be in the ground
- Small rig onsite between 10 and 30 days
- Usually single well drilled in isolation

Stratigraphic Hole
- Small (4" – 96mm) hole drilled with only rock chips being bought to surface
- Testing measures depth and coal thickness
- Small rig onsite between 5 and 15 days
- Usually a small program of wells drilled ~5km apart

DST Testing
- Second rig arrives over previously drilled well to run Drill Stem Tests
- Tests measure how well the rocks are likely to flow
- Small test rig onsite for 5-10 days
- Small amounts of water are produced from the coals

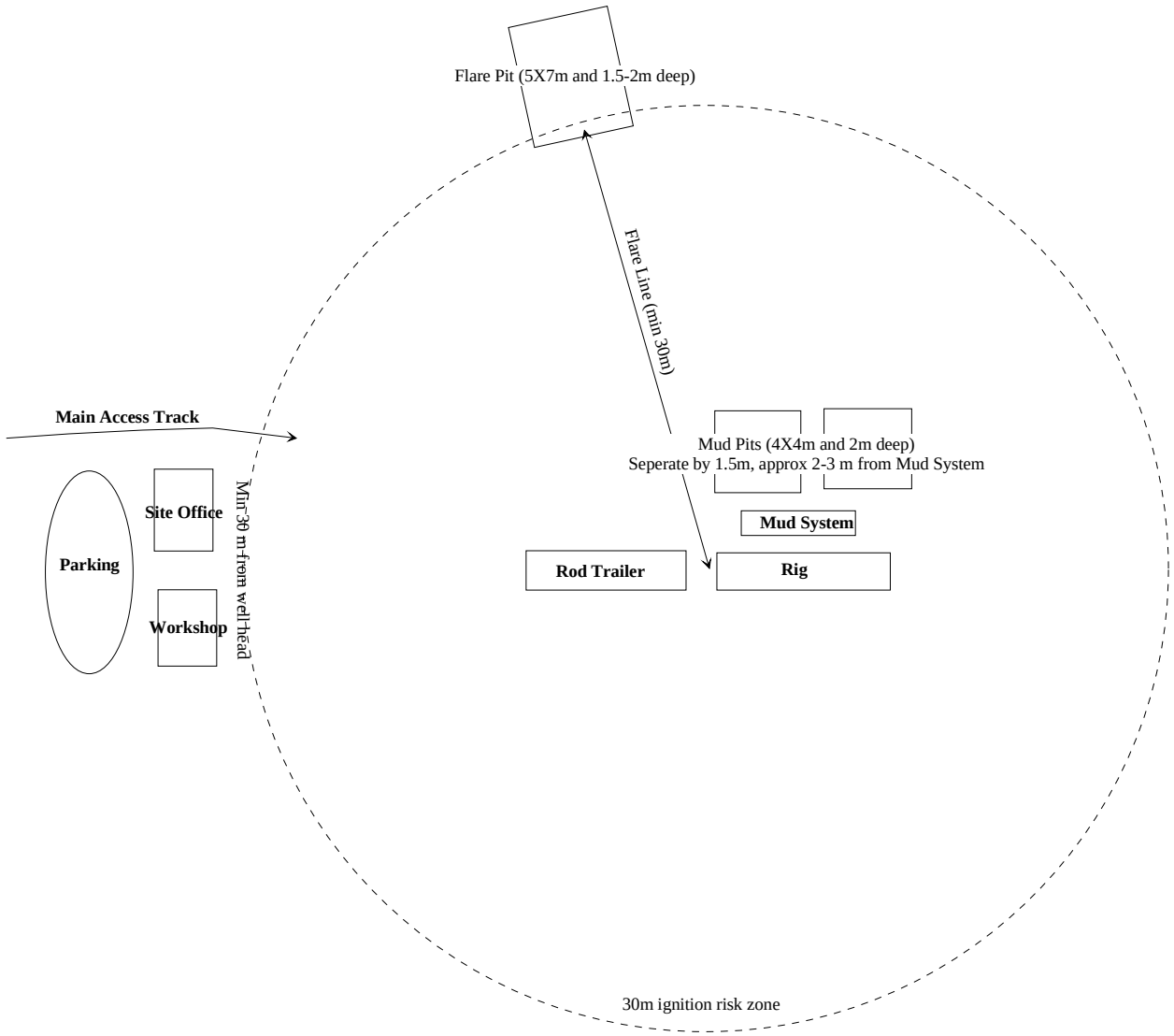


Figure 2: Plan of drill pad layout

Figure 3: Core or stratigraphic hole drilled with small truck-mounted rig.

Figure 4: Up to 3 small mud pits may be used.

Figures 5 & 6: Drill stem testing with small truck-mounted rig.

1.9. Justification of the Activity

The purpose of PEL 445, granted under the *Petroleum (Onshore) Act 1991*, is to permit the exploration for hydrocarbons. Thus the purpose of drilling the proposed five wells is to explore for potential coal seam gas reserves within the PEL445 lease. As such, the justification for these activities at the five proposed locations includes:

- To fullfill the tenure requirements of the approved work program
- The granting and the existence of the Permit;
- The sites suitability as exploration sites;
- The approved work plan for the permit;
- The intent of the permit holder;
- The consent of the landowner;
- Current and future demand profiles for gas as an alternative to less greenhouse friendly energy sources;
- Current and future demand for natural gas in the region.

1.10. Evaluation of Alternatives

As exploration for the region is in its early stages, currently there are no defined alternatives to establishing the presence of coal and the gas content of that coal, or the composition of that gas. Numerous other sites are available for exploration, but the site selected has been identified by preliminary inspections as being the most suitable site for the purpose of being on suitable ground and a satisfactory distance away from residences, to avoid causing disturbance to local residents. It seems inappropriate to further consider alternatives sites at this stage of exploration.

2. PLANNING

2.1. Licenses and Approvals Required

BNG is a subsidiary of Arrow Energy Group. BNG and is the registered holder for Petroleum Exploration Licence No 445, the current term of which expires on 18th April 2010. The NSW DPI grants this licence enabling BNG to undertake commercial viability assessments of the coal seam gas held within the coal seams that underlay the area.

PEL 445 is located in North-East NSW in a “horse shoe” shape around Casino. The northern boundary is defined by the QLD/NSW State border and extends east to the coast, west past Bonalbo following the edge of the Clarence-Moreton Basin, and south in a line with Casino. The central area immediately around Casino is excluded.

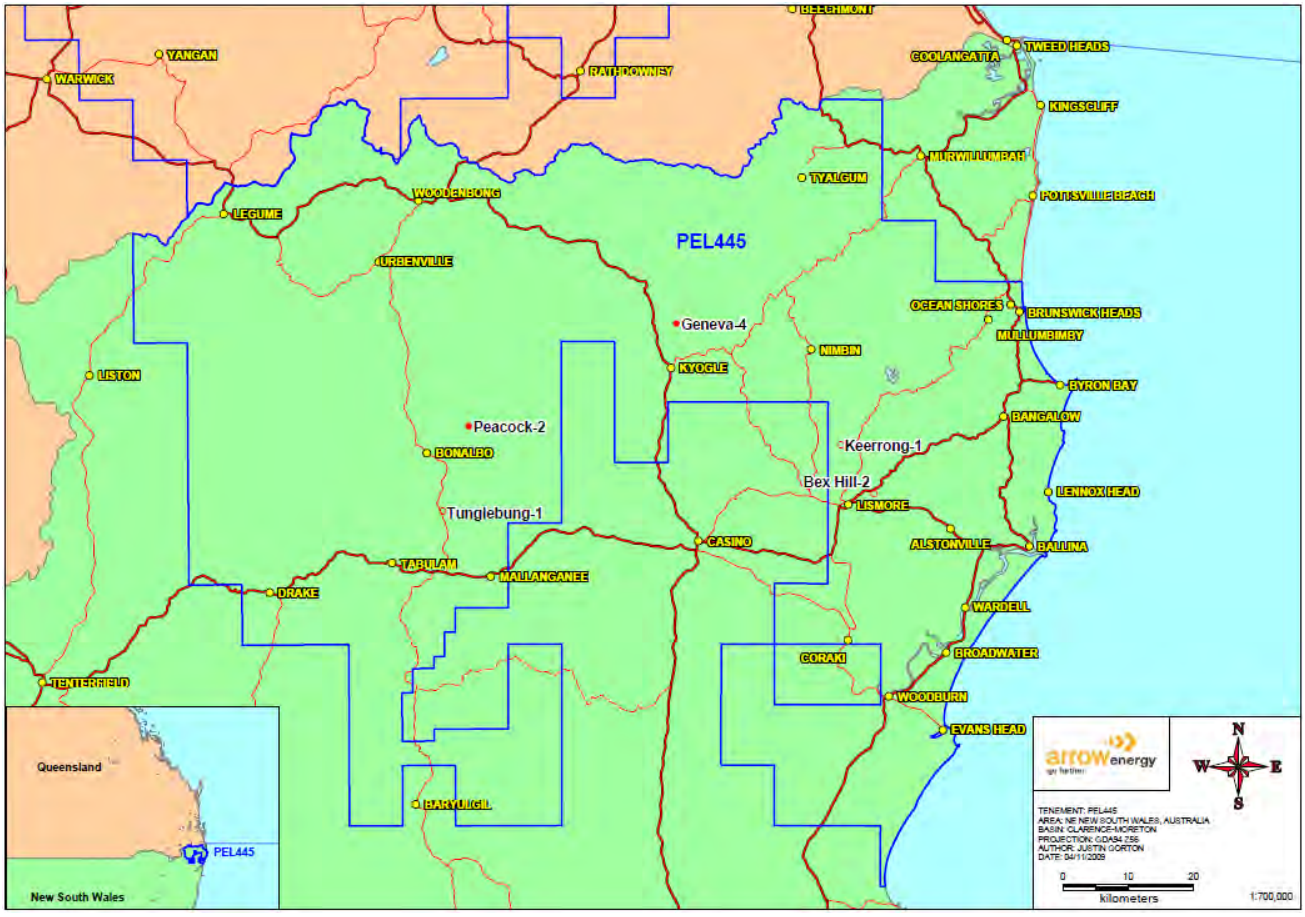


Figure 7: PEL445 Boundary

2.2. Zoning

The Local Environmental Plan (LEP) sets the framework for the management, development and conservation of land within the Council area. Land use zones within the LEP define activities which are permissible or restricted within that zone.

All five exploration holes are within rural zones (equivalent land use zone under the *Standard Instrument – Principal Local Environmental Plan*: **RU2 – Rural Landscape**)

Hole #	Local Government	Local Government Zoning Name / Comments
Bexhill 1	Lismore	Riverlands Zone 1(r) – Exempt development only with development consent – advertised development.
Geneva 4	Kyogle	Non-urban "A" Zone 1(a) – Exempt development only with development consent – advertised development.
Keerrong 1	Lismore	Riverlands Zone 1(r) – Exempt development only with development consent – advertised development
Peacock 2	Kyogle	Non-urban "A" Zone 1(a) – Exempt development only with development consent – advertised development.
Tunglebung 1	Kyogle	Non-urban "B" Zone 1(b) – Exempt development only with development consent – advertised development.

2.3. Stakeholder Consultation

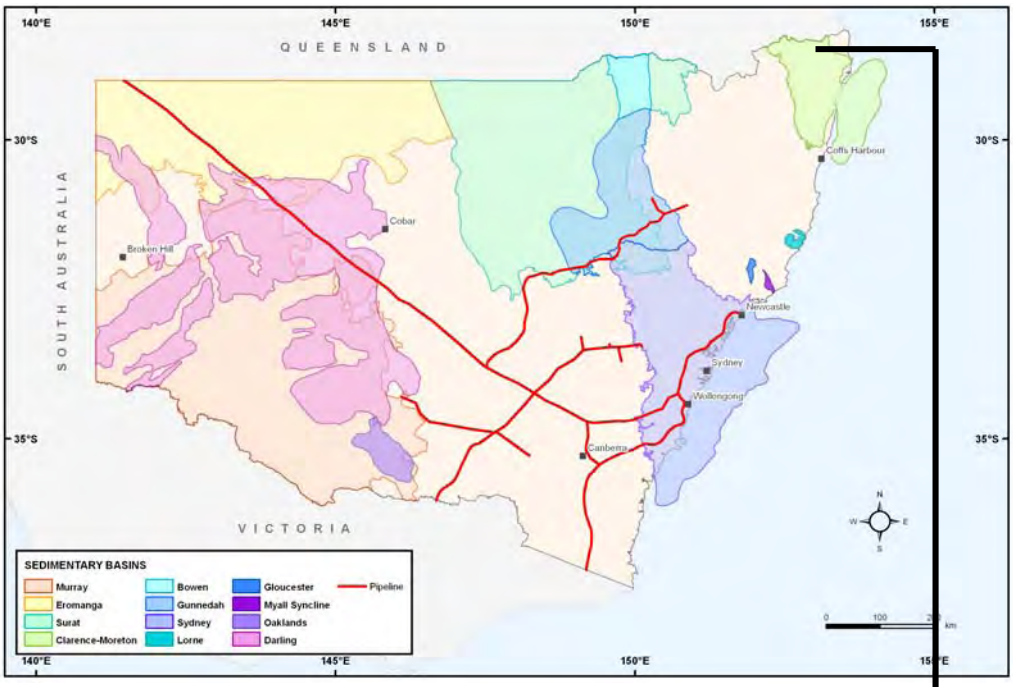
The following is a list of stakeholders relevant to the proposed activities. A confidential appendix of names and contact information has been provided separately to the administering authority (NSW Department of Industry and Investment, Minerals and Energy, Environmental Sustainability).

Stakeholder	Comments
NSW Department of Industry and Investment, Minerals and Energy, Environmental Sustainability	Correspondence DI&I (14 October 2009) in regards to notification of activities, REF approval process, and zoning requirements.
Local Governments: Kyogle Lismore	Local governments maybe contacted prior to and/or during operations esp in regards to waste disposal. Kyogle Council contacted (14 October 2009) in regards to zoning requirements in the Kyogle area.
Aboriginal cultural heritage	AHIMS search undertaken for each of the areas, with no concerns flagged. Further to one-on-one consultation is undertaken with the relevant Local Aboriginal Land Council and member of concerned relevant Aboriginal community to ensure artefacts and sites are not knowingly destroyed, defaced, or damaged.
Landowners	Each of the landowners has been contacted in regards to notification of entering their property and possible short-term impacts that may be experienced. Also discussions in regards to requirements of entering and working on the property, and compensation agreements.
Neighbours	Where activities could affect the nearby neighbours, contact is made to inform them of the activities and short-term impacts to expect.

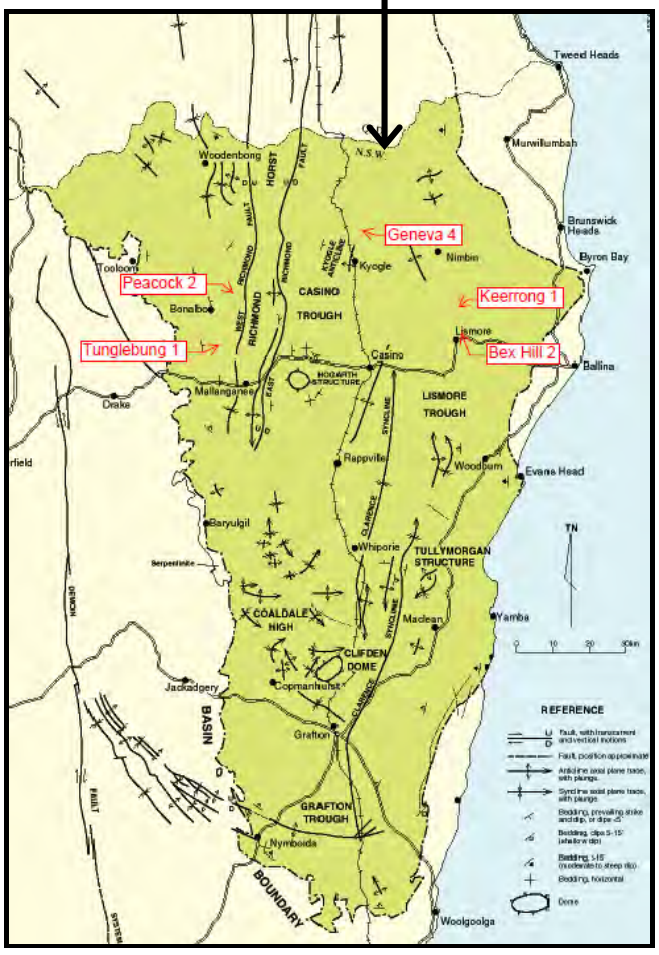
3. EXISTING ENVIRONMENT

3.1. Landforms and Geology

The five wells are located within the Clarence-Moreton Basin. This is an extensive intra-cratonic Mesozoic sedimentary basin located primarily onshore in north-eastern New South Wales and southern Queensland and possibly eastwards offshore across the adjacent continental shelf.



The Walloon Coal Measures represent a major episode of widespread fluvial and lacustrine to paludal deposition, which covers not only the Clarence-Moreton Basin, but also the Surat and Eromanga Basins. They consist of grey siltstone, thick-banded coal horizons and fine to medium grained lithic sandstone. The Walloon Coal Measures are overlain by the distinctive medium to coarse-grained Kangaroo Creek Sandstone. This is in turn overlain by the Grafton Formation, a fluvial to lacustrine claystone and sandstone unit. Tertiary intrusives and extrusives occur throughout the basin covering the sedimentary formations, however these are concentrated in the north of the basin associated with the Mount Warning Complex and the Main Range and Lamington Volcanics.

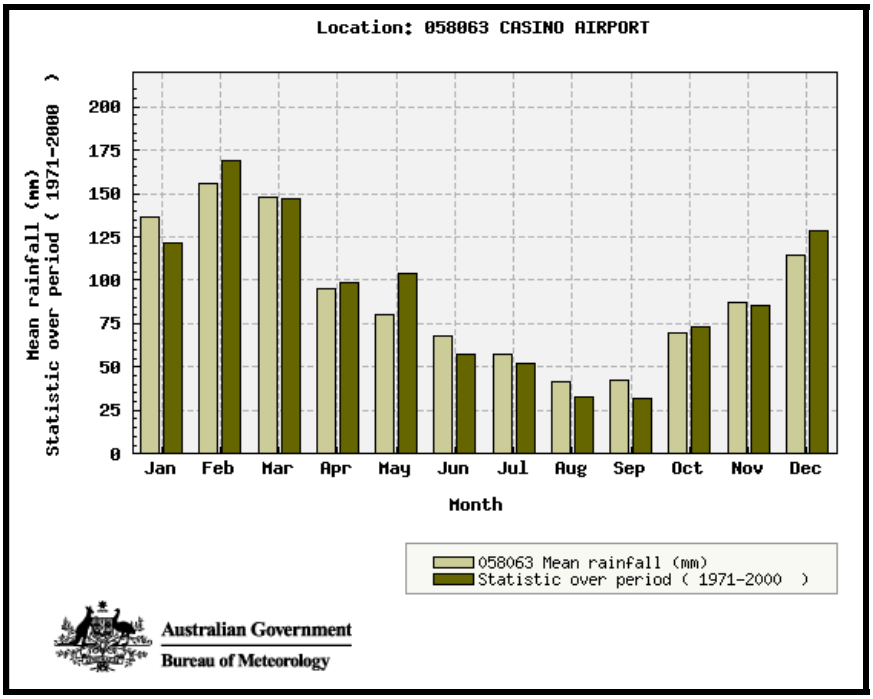


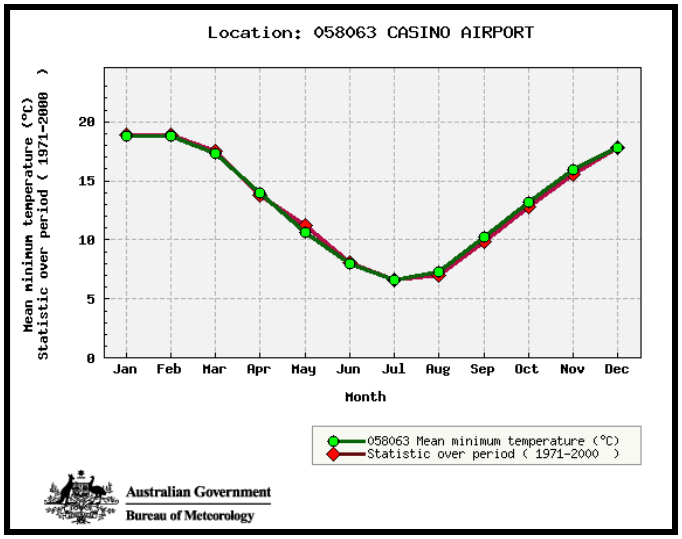
The Koukdandowie Formation underlying the Walloon Coal Measures is transitional with a significant decrease in coal and increase in grey siltstone and feldspatho-lithic sandstone. This is interfingered with the Heifer Creek Member downsequence consisting of clean, fine-medium grained, subangular to subrounded quartz sandstone which thickens toward the west of the basin.

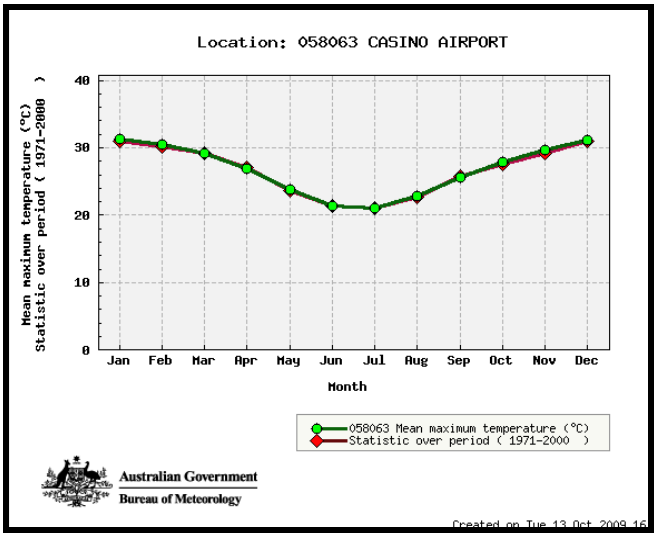
Hole #	Elevation Above Sea Level	Comments
Bexhill 1	~10m	In a small valley, surrounded by slightly elevated (~80 to 180m ASL) within 2-3km radius of the site
Geneva 4	~63m	In a small valley, surrounded by slightly elevated (~150 to 230m ASL) within 1-2km radius of the site
Keerrong 1	~18m	In a small valley, surrounded by slightly elevated (~80 to 180m ASL) within 1km radius of the site
Peacock 2	~285m	In a small valley, surrounded by slightly elevated (~400m ASL) within 0.5 to 1km radius of the site
Tunglebung 1	~211m	In a small valley, surrounded by relatively flat plains (~160 to 230m ASL) within 1km radius of the site.

3.2. Climate

Casino climate data is a fair representation of the climate at each of the five sites.







4. ENVIRONMENTAL IMPACTS AND MANAGEMENT

4.1. Air

Dust:
During construction of the well, problem road dust will be managed, especially in areas where dust from exploration activities are close to homes or other sensitive sites, by:

- covering main pad are with gravel to reduce disturbance of soil and creating dust;
- the application of water when necessary;
- the limiting of vehicle movement when necessary; and/or
- the monitoring of wind and climate conditions, when necessary, by the site supervisors.

Dust should be minimal from drilling, as:

- drilling with air requires the use of foam which will suppress the dust downhole; or
- drilling with water suppresses dust downhole.

Gas releases:
There will be no requirement to flare the gas as part of the routine drilling activity or post-drilling activity. However flaring of coal seam methane gas may be required in the case of emergency during drilling for safety reasons.

If the hole has been drilled with air, a gas flow test (venting and measuring of coal seam methane gas) may occur for a short time to provide an indication of gas flow. This may also be flared for a very short period of time to check that the gas is in fact methane and not carbon dioxide.

4.2. Water

Surface water:
Drilling activities will be managed to ensure that there is no significant disturbance to riverine areas (especially containing permanent water) or other surface waters.

Where there is a possibility of impact to any waters by surface waters from stormwater or other waters contaminated by petroleum activities, measures (e.g. bunding, directional sloping; diversions) shall be implemented and maintained to significantly reduce the risk of release to water bodies.

The proposed holes are located as follows in relation to nearby water bodies:

Hole #	Upslope or Downslope of water body	Distance to water body	Environmental Impact to Water Body – Risk Rating
Bexhill 1	Slightly downslope of a small creek	~0.3km	Very Low to Negligible
Geneva 4	Downslope of a medium-size creek	~0.35km	Very Low to Negligible
Keerrong 1	Downslope of a small creek Slightly upslope (~1V:163H or ~0.6% slope) of a second small creek	~0.2km ~0.5km	Very Low to Negligible Low to Very Low
Peacock 2	Upslope (~1V:20H or ~5% slope) of a medium size creek Upslope (~1V:13H or ~7.5% slope) of a small farm dam	~0.35 ~0.08km	Low Medium
Tunglebung 1	Slightly upslope (~1V:36H or ~3% slope) of a small farm dam	~0.36km	Low

Groundwater:
Drilling will be undertaken using water or air. Groundwater / drilling water derived from drilling operations will be continually reused during the drilling operation.

Identified aquifers will be cased and sealed as required to minimise the risk of cross-contamination. In the area of interest, the identified aquifers are Tertiary basalts and the Kangaroo Creek Formation (see Section 3.1). Tertiary basalts occur at or near surface to up to 50m depth where the Kangaroo Creek Sandstone may occur up to 100m in depth in the project areas.

Oil-based and synthetic-base drilling fluids will not be used. Where required for drilling performance or hole stability, some additives (e.g. bentonite, KCl or KCl replacements, biodegradable polymers) may be mixed with the water to increase hole stability, lubrication, and/or viscosity. Additives used are generally either natural (e.g. KCl, bentonite) or environmentally friendly / biodegradable and classified as low or medium hazard (MSDS classification) to ensure employee and environmental safety.

4.3. Soils

In a review of the NSW NR Atlas, the land capability is deemed of high to moderate agricultural value, suitable for native and/or improved pastures on low slopes containing alluvial or sedimentary-lithology derived soils.

Hole #	Soil Type	Potential Hazards (erosion, acidification, contamination, etc)	Soil Management / Hazard Mitigation Requirements	Land Capability
Bex Hill 2	Krasnozem (alluvial); well draining	Erosion hazard for the soil type is very high, however given the area is very flat there is less likelihood of a problem arising in the short period over which the drilling operations will occur. No salting is evident.	Erosion management techniques – reduce the areas cleared; slash rather than grade where possible; no off-track driving; create drainage diversion if required. (Refer to sections 4.6 & 4.7 for chemical hazards and contaminated land)	Native pasture; improved pasture; cropping
Geneva 4	Earthy Sand (alluvium lithology)		(Refer to sections 4.6 & 4.7 for chemical hazards and contaminated land)	Native pasture
Keerrong 1	Alluvial plain over alluvium lithology	Erosion hazard for the soil type is high, however given the area is very flat there is less likelihood of a problem arising in the short period over which the drilling operations will occur. No salting is evident.	Erosion management techniques – reduce the areas cleared; slash rather than grade where possible; no off-track driving; create drainage diversion if required. (Refer to sections 4.6 & 4.7 for chemical hazards and contaminated land)	Improved pasture
Peacock 2	Haplic Eutrophic Brown Dermosol / Grey-brown Podzolic Soil (sandstone lithology)	Erosion hazard is slight. No salting evident	(Refer to sections 4.6 & 4.7 for chemical hazards and contaminated land)	Native pasture, National/State Parks, logged native forest.

Hole #	Soil Type	Potential Hazards (erosion, acidification, contamination, etc)	Soil Management / Hazard Mitigation Requirements	Land Capability
Tunglebung 1	Brown Kurosol / Brown Podzolic Soil (sandstone lithology)	Erosion hazard is slight. No salting evident.	(Refer to sections 4.6 & 4.7 for chemical hazards and contaminated land)	Native pasture

Typically the only groundwork required will be grading of the drill pad area to protect the topsoil and digging of the mud pits (4*4m by 2m deep). This preparation will include:

- stockpiling of the topsoil for replacement during site rehabilitation (this could be for a period up to 5 months);
- stockpiling of the mud pit spoil separate to the topsoil for replacement back into the pit during the rehabilitation process;
- gravel may be required on the pad if ground conditions are poor; which will be assessed at the time of construction;
- established tracks will be used in preference to constructing tracks. In some circumstances, track construction may be required firstly be slashing but contingency for gravel if poor ground conditions exist; and
- fencing of the site where directed by the landholder during and/or after operational activities, esp. the mud pits prior to rehabilitation for landholder, stock, and fauna safety.

4.4. Noise and Vibration

It is anticipated that landholders and near-by neighbours that are residing close to the drilling operation may experience noise-levels above normal background levels (note: each of the five sites is within a 500m or less radius of the closest neighbour/s). As the drilling operation is a 12 hour operation, the probability the drilling operation being problematic should be appreciably reduced as the operations will not occur at night.

Arrow's Lands Department will undertake one-on-one consultation with the landholders prior to the operation commencing, advising them on possible impacts, answer any questions, and try to alleviate any concerns. Where appropriate to do so, consultation will also be undertaken with other nearby neighbouring stakeholders. Noise mitigation methods will be utilised wherever possible.

Complaints will be dealt with by the Lands and/or Environment Departments and/or Drilling Supervisors as they arise to determine the mitigation methods and/or best possible solution for both parties.

Vibration is not expected to be an issue at any of the sites.

4.5. Flora and Fauna

A search of the NSW Wildlife Atlas, indicates that:

- in the Lismore local government area, 63 threatened fauna species and 47 threatened flora species have been identified; and
- in the Kyogle local government area, 73 threatened fauna species and 31 threatened flora species have been identified.

Refer to Appendix 1, for maps of endangered fauna in close proximity to the drilling operations at Bex Hill 2 and Peacock 2.

All of the areas within and surrounding the proposed drilling locations are already highly disturbed cleared areas used for grazing and/or cropping, thus it is unlikely that the drilling operation will have any further impact on local flora or fauna species.

There should be no requirement to destroy vegetation other than possibly grading of native grasses / improved pastures for topsoil conservation and drilling safety reasons. Thus it is unlikely that fauna will be displaced by these minimal disturbances.

A review of protected areas in relation to the position of the five sites was undertaken, finding that none of the proposed areas are significant under any of the Australian or New South Wales environmental or conservation legislation. Furthermore nor are these areas close to any of the East-Asian Australasian Flyaway sites for migratory species.

Where landholders are concerned about spread of noxious weeds, equipment wash downs and weed declarations completed.

4.6. Chemical and Hazardous Substance Management

Minimal chemicals will be required for the drilling operations, most of which are classified as “Low Hazard” (MSDS classification) for on-shore drilling operations. Arrow is currently trialling new chemicals that are more environmentally friendly / biodegradable than current chemicals, replacing already low hazard chemicals with “greener” ones.
Drilling additives are only used when necessary to improve drilling and/or hole stability, and are not considered an aquifer pollutant (sealing rather than infiltrating). Where possible, the drilling liquids are separated from the chips / muds and recycled back down the hole, thus reducing the quantity of drilling chemicals used throughout the entire operation.

Chemicals are stored, managed and handled as per the material safety data sheets (MSDS). Chemicals and hydrocarbons will be stored in a designated laydown area with the MSDS readily available. The laydown should be sited more than 500m from a watercourse.

In the event of a spill incident, the spill will be contained and cleaned up as soon as possible. All environmental incidents are reported to the Arrow Environment Department in accordance with the Arrow incident guidelines.

4.7. Contaminated Land

It is envisaged that the proposed drilling operations will have a minimal impact in respect to land contamination. In the unlikely event that there is a major chemical or hydrocarbon incident, the spills will be cleaned up. The majority of the chemicals used are classed as non-hazardous or low hazard chemicals, thus it is unlikely that any incident will result in significant environmental harm.

The small mud pits will contain rock cuttings and associated drilling muds from the drilling operation. Recent analysis of materials in similar pits indicate that hydrocarbons and heavy metals are negligible (either undetectable or below NEPM guidelines for contaminated land) in these subsurface materials. Often the subsurface materials in the pits can be higher in salts than the surrounding natural materials, however amelioration of the pit materials can be achieved followed by site rehabilitation (refer to 4.16 for rehabilitation details).

4.8. Waste Minimisation and Management

Employees and contractors associated with the drilling activities will be accommodated in nearby towns, thus this will minimise the wastes generated on site that would normally be associated with a camp.

Wastes foreseen to be generated on site during the drilling operations may include:

Cleared vegetation / spoil	There should be no need to clear vegetation other than the surface vegetation (i.e. grasses) as the areas have all been highly disturbed. Surface vegetation will be cleared with the topsoil and stockpiled. This will then be spread back over the disturbed area once the drilling program is finished in this area. The vegetation and seed stock within the topsoil should enable regrowth once respread. Some of the spoil from the construction of the mud pits will be put back in the pit. The excess spoilt will be placed in an area determined by the landholder (e.g. resurfacing of access roads, etc).
General waste	These will be managed on a regular basis so to reduce the likelihood of the waste becoming a litter problem and to stop vermin. This will be disposed of to the local waste facility, in accordance with local government regulations.
Hazardous waste	There should be no significant quantities of hazardous substances required on site. Hydrocarbon wastes generated (eg oily rags; waste grease) will be separated from other waste streams and disposed of in accordance with local government regulations.
Sewage	Porta-loos are generally hired for use on the drill site. These will be managed by the company or as be contractual agreements. The waste will be disposed of in accordance with local government regulations.
Packaging	Where possible the packaging will be recycled; otherwise it will be disposed of in accordance with local government regulations at the local landfill facility.
Scrap metal / PVC	Off-cuts of pipe and other minimal amounts of scrap metals will be reused or recycled if possible to do so; otherwise it will be disposed of in the local landfill in accordance with local government regulations.
Downhole rock chips and muds	In consultation with the landholder, the preference is to bury this downhole waste on-site given it is relatively benign. These wastes will need to be mixed with some of the spoil that was derived from the pit or other materials to assist in the drying out of the pit contents. Some other ameliorants may be added to assist in the bio-rehabilitation of the wastes. If the chips and muds are required to be removed, due to wet-weather conditions and/or landholder request, it will be disposed of in an approved waste facility in accordance with local regulations.
Associated formation water.	All groundwater will be reused during the drilling operation or disposed of at an approved facility. If requested, the water may be tested for suitability for landholder use. At the completion of the site operations, the excess water will be either given to the landholder for use (if suitable) or disposed of at an approved facility in accordance with local regulation.

4.9. Natural Resource Use

The drilling activities will have a minimal impact on natural resources, including surface and groundwater and agricultural land.

There may be some need for water to use down hole if not using air for drilling. This will be sourced from local water sources (e.g. town water, landholder dam) and/or groundwater (e.g. landholder bore, produced during drilling). Where possible water will be reused repeatedly throughout the drilling program to minimise the need to draw from other fresh sources.

The holes will be located on agricultural land. Initially the drill pad will disturb ~0.2 hectares, however once rehabilitated, the area of disturbance should be reduced down to less than 20m^2.

4.10. Impact on the Community

The local community areas are extensively used for agricultural activities.

Local facilities (accommodation, recreation, shops) utilised for the short period over which the drilling employees will be residing in the local towns may benefit from a short-term increase in income.

The immediate landholders within the vicinity of the drilling operations may experience increased noise, traffic, and dust; however the implementation of site procedures and the consultation process prior the activities may help alleviated any major problems or complaints during the activity.

The development of positive stakeholder relationships throughout this program will assist with the advancement of future drilling programs in the area, in turn possibly resulting in the growth of a local CSG industry and a positive future impact on the communities.

4.11. Visual Assessment

The finial resulting bores will be plugged and abandoned and the sites rehabilitated. There may be occasional extended periods of suspension (up to ~5 months) between completing drilling and testing (drill stem) where the wellhead will be present on-site.

On some occasions there is a requirement for monitoring equipment to be installed after the drill stem testing, however for the five wells proposed there is no currently plan to undertake further monitoring past the drill stem testing. Thus all wells are likely to be plugged & abandoned and buried soon after the drill stem testing is complete.

Therefore, there should be only a short period (~1 to 5 months) where the wellhead will be visually noticeable. Once the area has been rehabilitated, there should be little indication of drilling works.

4.12. Heritage

Aboriginal heritage

A search has been made of the NSW Aboriginal Heritage Information Management System (AHIMS) database which determined that there are no recorded Aboriginal objects or declared Aboriginal places in or near the well site location(s). Searches have been attached in Appendix 2.

Additionally, consultation with the relevant Local Aboriginal Land Council and with the relevant member(s) of the Aboriginal community concerned has been undertaken to ensure that Arrow Energy Limited (including any of its subsidiaries) does not knowingly destroy, deface or damage any Aboriginal object or Aboriginal place within the licence area.

Arrow employees and contractors will be instructed in what to look out for during the excavating or other disturbance of the land, in an effort to take every precaution against any such destruction, defacement or damage. Cultural heritage monitors may be used to assist in clearing the site during land disturbance.

Other cultural heritage

As the propose project areas are already disturbed by agricultural activities, thus it is highly unlikely that the drilling operations will impact on other cultural heritage in the immediate area (if present).

4.13. Land use

The area that the drilling activity is relatively compact. The short term impact during operations should be minimal. There may be some small increases in noise and dust above what is currently experienced by the landholder or nearby neighbours.

Once all the activities have been completed and the area rehabilitated, there should be negligible long term impact on the current land use and the landholder.

4.14. Bushfire Prevention

With the exception of Peacock 2, the areas surrounding the four other drill sites has been significantly cleared of bush or forest vegetation. The area around Peacock 2 has been cleared, however there is still a higher risk then the other four sites.

Detailed and strict fire prevention measures are already in place on all drill sites as part of the site ***Safety Management Plan*** (SMP). These should be conveyed to all drilling personnel on site during initial site induction and adhered to strictly at all times whilst on site.

As a minimum (which may be similar to or in addition to these SMP requirements), the following mitigation measures have been recommended to reduce or minimise the risk of drilling activities causing a bush fire:

- Fire fighting equipment must be attached to all heavy plant, and additional extinguishers will be kept on site in a dedicated, marked area.
- In the unlikely event of a fire at the site, emergency procedures will be initiated as prescribed in the ***Emergency Management Plan*** (EMP) of the drilling contractor. This encompasses both site/equipment fires, as well as bush fire. The EMP will:
  - Identify the procedure for operating during the declared bushfire season;
  - Identify hot work controls to be implemented;
  - Identify the effect of any declared total fire ban days on which hot works should not be undertaken;
  - Identify how the drilling team is to identify the bushfires status on any given day and any changes that may occur during the day; and
  - Identify the utilisation of the EMP to identify evacuation, emergency contact, and emergency treatment facilities.

4.15. Cumulative Environmental Impacts

Cumulative environmental impacts are not expected during or after the drilling activity in any of the five areas. Each of the wells proposed are a sufficient distance apart (min 9km up to 66km max). Thus, the cumulative impacts of two or more wells should not cause cumulative environmental impacts.

4.16. Summary of Mitigation measures

Aspect	Impact	Mitigation Measures
Landholders	Landholders may be concerned / annoyed by any aspect/s associated with the drilling activities.	Landholder consultation will be undertaken prior to any activity starting on the site. This will include advising landholders of possible impacts, answering any queries they may have, and trying to organise activities in line with any requests. Where there are significant objections to drilling being undertaken on a property, Arrow will firstly look at arranging the drilling to occur on an alternative property above any formal action.
Cultural Heritage	Cultural heritage sites &/or artefacts can be destroyed	Cultural heritage search has been undertaken. As a rule, Arrow will always consult with the relevant Local Aboriginal Land Council, which may include visual monitoring during excavation or other site disturbances.
Air	Dust affecting landholders & neighbours. Greenhouse gas releases.	Arrow will minimise dust through management of the area and activities on a site-by-site basis. Venting during and post drilling will be limited wherever possible and dependent on testing requirements. There may be some fugitive emissions during the drilling program. Flaring will be necessary in an emergency for safety reasons.
Water	Surface water impact. Groundwater impact.	Where there is the possibility of impacting surface waters, mitigation measures will be implemented on a site by site basis. In particular, Peacock 2 will have to have measures in place to protect the nearby creek and dam. Drilling is undertaken using water or air. Where possible the associated groundwater is recycled during the drilling operation. The drilling additives hazard classifications (as per the MSDS sheets) are Low or Medium Hazard.
Soils	Erosion of disturbed areas.	Erosion management techniques will be implemented on a site-by-site basis to minimise erosion of the disturbed areas.
Noise & vibration	Excessive or continuous noise from drilling operation may cause annoyance to nearby residences.	Consultation with landholders prior to operations will help to manage any potential problems that may occur during operations.
Flora & fauna	Potential to cause harm to flora &/or fauna	A review of protected areas determined that the five proposed drill sites were not located within the vicinity of any conservation zones. As the proposed locations are within areas that have already been disturbed by the current or past land uses, the potential of the drilling operation to cause significant environmental harm to flora &/or fauna is deemed remote. Areas will rehabilitated to a condition similar to pre-disturbance.
Chemical & hazardous substances	Use or incidents relating to chemicals or hazardous substances could cause environmental harm.	Chemicals are stored, managed, and handled as per the MSDS. Environmental incidents are reported to the Environment Department in accordance with the Arrow incident guidelines.

Aspect	Impact	Mitigation Measures
Contaminated land	Contamination of the land	In the event that there is a spill or other land contamination, this will be cleaned up as soon as possible. Any remaining contaminated ground will be cleared prior to site remediation.
Waste	Contamination or degradation of the immediate land / water resources	All general, solid, sewage, and chemical wastes will be removed from site and disposed of as per local government regulations. Rock chips and muds produced during the drilling operation will be dried out in the pits and covered firstly with the spoil from the pit and then the top soil.
Natural resource use	Excess use to natural resources	There may be a limited requirement for water during the drilling operation, if the hole is not drilled using air.
Impact on Community	Negative impact on local community	The drilling operations should only be in one area for one to two weeks, thus the disruption to the local community should be minimal. The local landholders and their agricultural activities may experience some small inconveniences (eg noise, dust) however it is hoped that through the consultation process prior to the activities commencing, there should be relatively little disruption or complaint issues.
Land use	Short or long term impact on the current landuse	As the area required is relatively small, the short term impact on the current land use (nominally grazing / cropping) should insignificant. Once the area has been rehabilitated, there should be no long term impact
Bushfire Prevention	Extensive bush fire affecting both community and natural bushland ecosystem	As a minimum, sufficient fire fighting equipment must be located on site. Site personnel must be made aware of equipment and strict fire prevention rules, as detailed in the SMP. Site personnel must also be aware of the fire emergency plan in the EMP.
Cumulative environmental impacts	The cumulative effects of the operations may be significant	A cumulative impact is not expected as the distance between each of the five wells is greater than 9 km.

4.17. Rehabilitation Works

All disturbance caused by the operations will be rehabilitated to a pre-disturbance land use capability. Rehabilitation may be progressive and will be decommissioned at the cessation of the project. The disturbed land will be judged to be successfully rehabilitated when:

- The surface of the land is free from contamination;
- Grazing land has been returned to a state similar to pre disturbance conditions; and/or
- Cropping land has been returned to a state similar pre disturbance productivity.

The standard practice after testing is the following for the wellhead:

1. Install continuous cement plug from total depth (TD) to surface. Complete in stages of 200m with 8hr wait periods to tag and pressure test cement.
2. Survey wellhead
3. Dig out around casing and cut minimum 1.5m below ground level; install labelled cap with well name, casing depth, hole depth; backfill and bury.

The following rehabilitation cost estimate has been developed using the *DPI Schedule of Rehabilitation Costs Reference Data*.

Activity / Description	Quantity	Unit Amount	Total
Exploration holes	5	$275 / hole	$1,375
Maintenance of established rehabilitated areas	5	$715 / ha	$3,575
Contingency	-	10%	$495
Environmental monitoring	-	5%	$248
TOTAL			**$5,693**

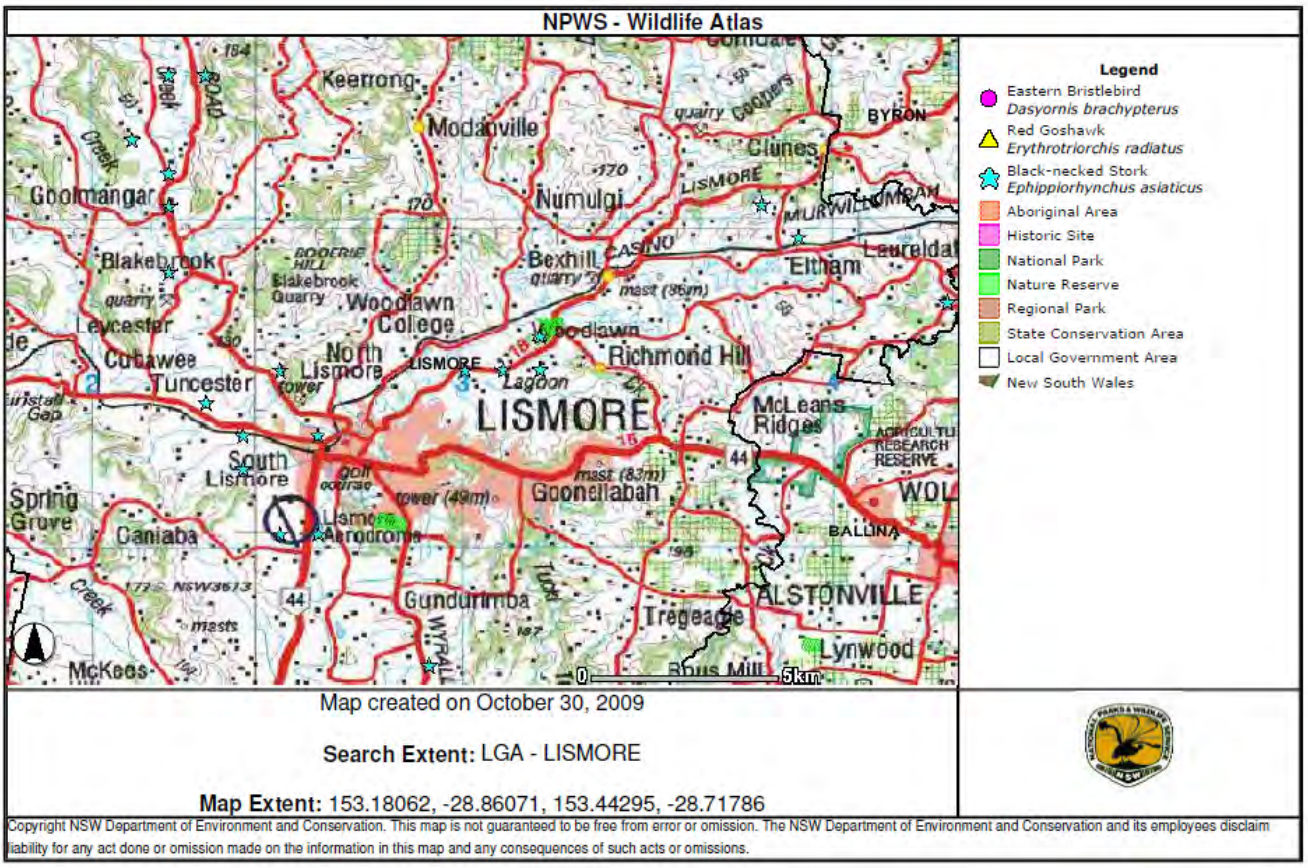
4.18. Summary of Impacts and Conclusions

The drilling program, consisting of five exploration holes, is a program that is vital to the pre-feasibility studies to determine the magnitude of CSG resources within PEL445. Each site will consist of a small drill pad and laydown area. As each of the five sites is located on previously disturbed land, used extensively for cropping and/or grazing, it is unlikely that the activities required to be undertaken (either prior, during, or after the drilling of the five holes) will have any significant environmental, economic, socially impacts, either singularly or cumulatively.

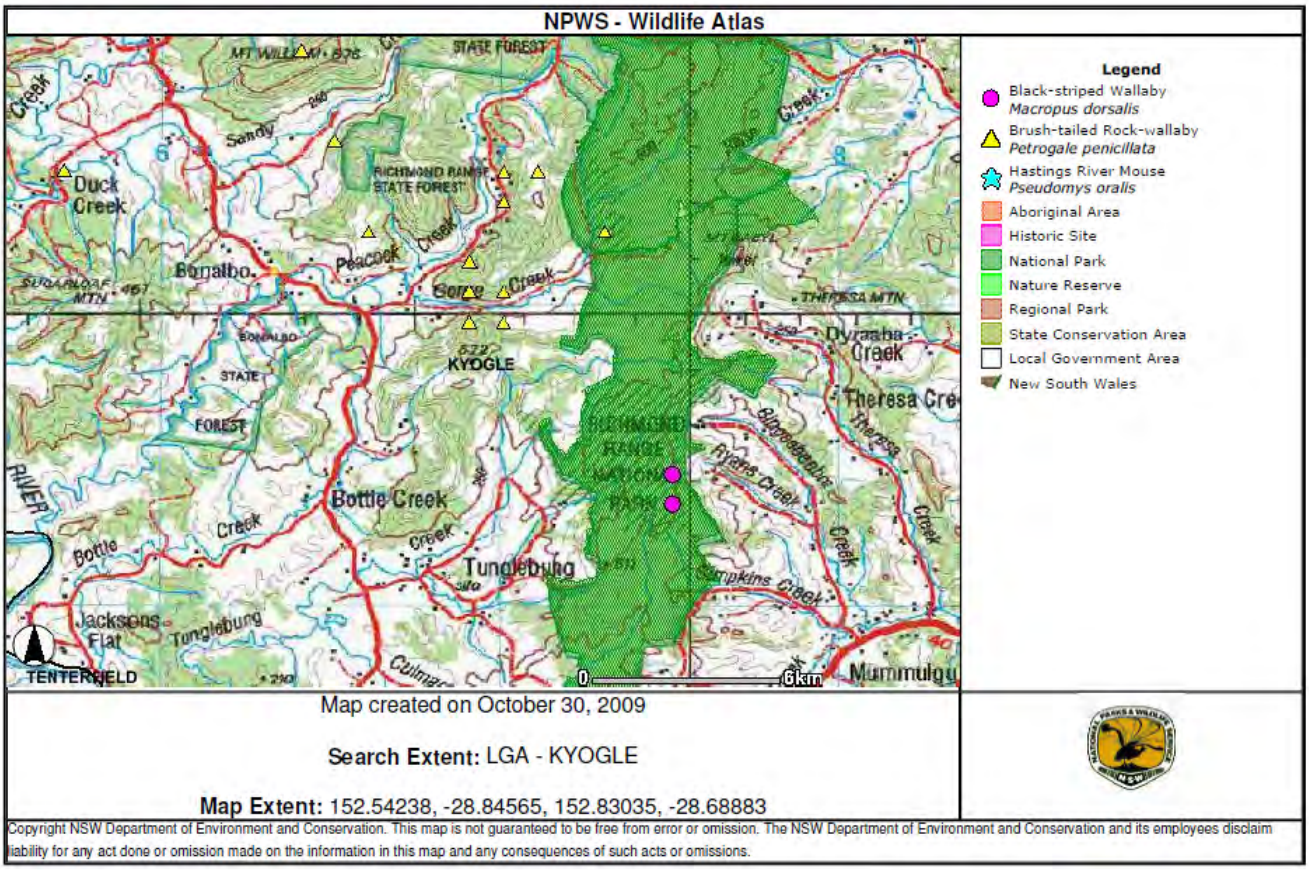
Individuals close to the activities may experience some nuisances (e.g. noise or dust). Landholder consultation is ongoing and mitigation measures will be implemented on a site-by-site basis.

This REF outlines the knowledge of the environment and the potential impacts as they are known at the present time. Arrow Energy Limited is confident that these proposed activities, in conjunction with the planned mitigation measures, will not create any long term, detrimental environmental impacts that are likely to change the local environment or the surrounding region.

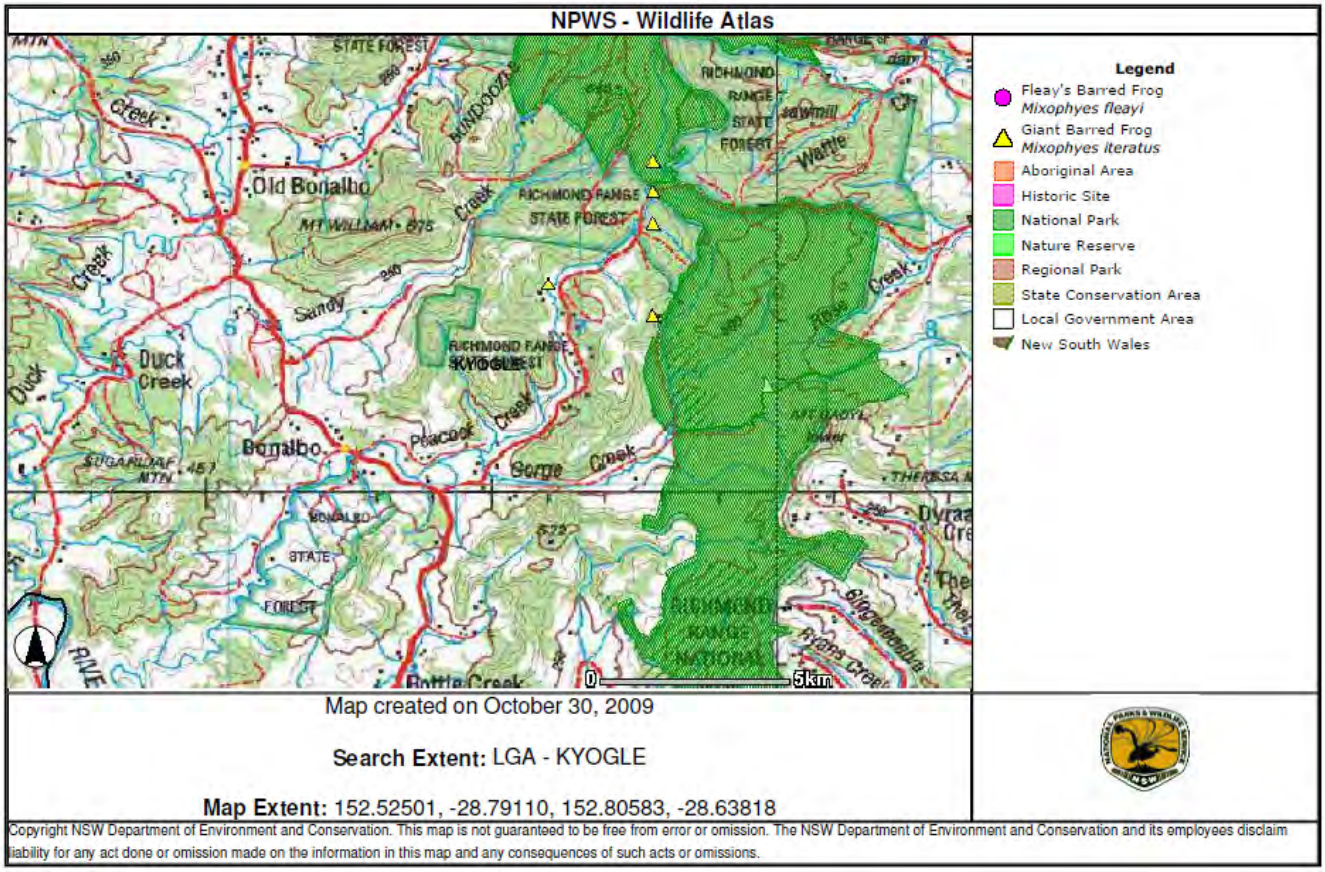
APPENDIX 1 – Endangered fauna in proximity to the drilling locations.



Endangered fauna in the vicinity of Bex Hill 2



Endangered fauna in the vicinity of Peacock 2



Endangered fauna in the vicinity of Peacock 2

Threatened Species & Seven Part Test of Significance

Under Section 5A of the EP&A Act, the DII is required to consider whether the activity is likely to have a significant effect on threatened species, populations or ecological communities, or their habitats. Section 5A lists seven factors to be considered, commonly referred to as the "sever part test of significance". Each of the factors are described below, and consideration of each factor subsequently noted (*italic*).

These include:

1. 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.

   No. Each of the five (5) proposed drill sites are located in highly modified and cleared areas. The operation is unlikely to affect the life cycle of any threatened species, which may occur within the adjacent environment and will not place any of these species in danger of extinction, due to the size, duration and localised nature of the works.

2. In the case of any 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.

   No. Due to the size, duration and localised nature of the proposed works it is expected that there will be no impact on the life cycle of these species, nor will they be in danger of extinction.

3. In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed –
    a. 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
    b. 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.

The two threatened species (the Brush-tailed Rock Wallaby and the Giant Barred-frog) were previously recorded in close proximity to the proposed Peacock 2 bore. The area around Peacock 2 is already disturbed and does not closely meet the habitat and ecology requirements for these two species. Thus it is unlikely that the ground disturbance or activities associated with the drilling the Peacock 2 bore will have any adverse effect on the extent of the ecological community, or is likely to substantially and adversely modify the composition of the ecological community, such that either the wallaby or the frog is placed at risk of extinction.

Notes on Habitat and Ecology:

- *Brush-tailed rock wallaby – occupy rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges facing north; and browse on vegetation in and adjacent to rocky areas eating grasses and forbs as well as the foliage and fruits of shrubs and trees.*
- *Giant Barred-frog – forage and live amongst deep, damp leaf litter in rainforests, moist eucalypt forest and nearby dry eucalypt forest, at elevations below 1000 m; and they breed around shallow, flowing rocky streams.*

4. In relation to the habitat of a threatened species, population or ecological community –
    a. the extent to which habitat is likely to be removed or modified as a result of the action proposed; and
    b. 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
    c. 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.

    No, to each of the above three factors. No critical habitat will be removed, modified, or isolated during the proposed works.

5. Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

    No critical habitat will be removed, modified or isolated during the proposed works.

6. Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

    Of the threatened species identified as potentially occurring within proposed drill sites, the Giant Barred-frog is listed under the EPBC Act as having a National Recovery Plan. Any future development of the site will be consistent with the recovery plan. No Threat Abatement Plans (where in place) will affect the proposed works.

7. 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.

    No. The proposed works are of a short duration and are not a key threatening process to identified potential threatened species in the area. Habitat loss / degradation and predation are considered some of the key threats to the two species listed as occurring in the immediate area. The proposed activities should not be responsible for any of the noted threats to the threatened species.

    Notes on Threats:

    Brush-tailed rock wallaby
    - Loss, degradation and fragmentation of habitat.
    - Predation by foxes and dogs.
    - Competition with feral goats.
    - Fire regimes that reduce the abundance and diversity of ground forage.

    Giant Barred-frog
    - Reduction in water quality, from sedimentation or pollution.
    - Changes in water flow patterns, either increased or decreased flows.
    - Reduction of leaf-litter and fallen log cover through burning.
    - Timber harvesting and other forestry practices.
    - Vegetation clearance.
    - Predation on eggs and tadpoles by introduced fish.
    - Weed spraying close to streams.
    - Chytrid fungal disease.

APPENDIX 2 – NSW Aboriginal Heritage Information Management System searches

- 091021_AHIMS Search_Bex Hill 2_Lot 1 CP DP1053808
- 091021_AHIMS Search_Geneva4_Lot 1 CP DP180223
- 091021_AHIMS Search_Keerrong1_Lot 74 CP DP755689
- 091021_AHIMS Search_Peacock2_Lot 271 CP DP703438
- 091021_AHIMS Search_Tunglebung1_Lot 99 CP DP751062