UNDERGROUND COAL GASIFICATION SYNGAS PRODUCTION AND POWER GENERATION

BLOODWOOD CREEK PROJECT MINING LEASE APPLICATION 50253

INITIAL ADVICE STATEMENT

Prepared for

CARBON ENERGY LIMITED

December 2009

CONTENTS

TABLES

FIGURES

1.0 EXECUTIVE SUMMARY

Carbon Energy Limited (CEL) and its wholly owned subsidiary Carbon Energy (Operations) Pty Ltd (CEOps) is seeking approval to develop a large-scale syngas production facility and an associated electrical power generation station at the Bloodwood Creek project site located approximately 40 kilometers west of Dalby.

CEOps has lodged an application for a mining lease (MLA 50253) along with an application for an environmental authority (EA). In order to progress and support the EA application CEOps has sought and been granted approval to prepare a Voluntary Environmental Impact Statement.

The Initial Advice Statement (IAS) provides an outline of the proposed project with general descriptions of the surrounding environments and includes the information required under Section 41(3) of the Environmental Protection Act.

The project the subject of the proposed EIS will utilise the proprietary technology owned by CEL to produce syngas by underground coal gasification (UCG). A proportion of the syngas will be used as a fuel source for the generation of up to 30MW of electricity by gas-powered engines and generators located on the mining lease.

The balance of the syngas produced will be provided as feedstock for a number of potential users depending upon various commercial and other considerations to be assessed at the time. The proposed EIS will not address the proposed uses or markets for syngas except for the 30MW power generation facility located on the mining lease. The additional potential uses for syngas may include large-scale power generation, ammonia, fertilizer and explosives production, methanol production and the supply of methane to an LNG facility.

The quantity of syngas produced at the Bloodwood Creek project will depend on the potential uses however, the proposed syngas production rate to be addressed in the proposed EIS will have an annual energy content of up to 40+ petajoules (PJ).

CEL is currently operating a UCG demonstration trial at Bloodwood Creek which is successfully producing syngas – a mixture of CO, H_2, CH_4 and C_2H_4. The trial has demonstrated the technology which allows control over the gasification process to vary the content of the gases within the syngas production stream depending upon the use for which the syngas is required.

Currently, the demonstration trial is producing syngas which is being used to generate approximately 5MW of electricity in alternators coupled to internal combustion gas engines.

2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE OF THE INITIAL ADVICE STATEMENT

The purpose of the IAS is:

- To provide information required under Section 71 and Section 41(3) of the Environmental Protection Act as part of an application for approval to voluntarily prepare an EIS for the Bloodwood Creek UCG project
- To provide information to stakeholders to assist them to determine the nature and level of their interest in the project; and
- To enable the preparation of Terms of Reference (ToR) for the EIS.

The IAS is intended to scope the potential impacts that will be investigated in detail prior to the assessment process which may lead to the grant of statutory approvals. The ToR will be developed based on the potential impacts and the requirements of relevant government agencies and other stakeholders through a public consultation process. An EIS and associated Environmental Management Plan will be prepared as part of the approvals process.

2.2 THE PROPONENT

CEL is an energy company created to make a significant reduction in the cost of production of clean power, liquid fuels and, potentially, other products from coal.

CEL was initially a 50/50 joint venture between the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Metex Resources Pty Ltd. Metex acquired the majority ownership from the CSIRO and has the operational and management responsibility for the Company. Metex recently changed its name to Carbon Energy Limited. It owns unique intellectual property in UCG and a range of associated technologies and has the full backing of CSIRO's capability in UCG.

CEL's business is to deliver a new generation of large scale energy projects based on the cleaner use of coal. The key to this is UCG which transfers the energy from coal into syngas (primarily, hydrogen and carbon monoxide), an extremely versatile and easily handled product. Syngas can be used in many existing proven industrial processes including directly as a low emission fuel gas for power generation and as feedstock for catalytic syntheses of liquid fuels, chemicals and fetilizers. It can be further transformed with steam into hydrogen and carbon dioxide. The carbon dioxide can be removed, effectively decarbonising the energy to zero emission hydrogen with potential uses in fuel cells, turbines and as a transport fuel.

The strategic advantage held by CEL is the proprietary UCG technology which can produce syngas from coal in large scale commercial volumes at lower cost than surface coal gasification methods. This significantly enhances the profitability of projects producing power, synfuel, and other syngas based products by reducing source fuel costs and upfront capital requirements. UCG has other important advantages in that it can use deep, high ash, conventionally unmineable coal and hence has an enormous primary resource base. It also avoids the expense and most of the environmental impact of coal mining, handling and the surface gasification plant. This results in a low cost, low impact, low emission route to clean coal utilisation for power and liquids.

2.3 PROJECT OVERVIEW

CEL is the holder of five granted Exploration Permits for Coal (EPC) in the Surat and Clarence Moreton Basins and a Mineral Development Licence. The EPCs and the MDL are listed in **Table 2.1** and indicated in **Figure 2.1, Figure 2.2, Figure 2.3** and **Figure 2.4**.

Table 2.1
Mining Tenements

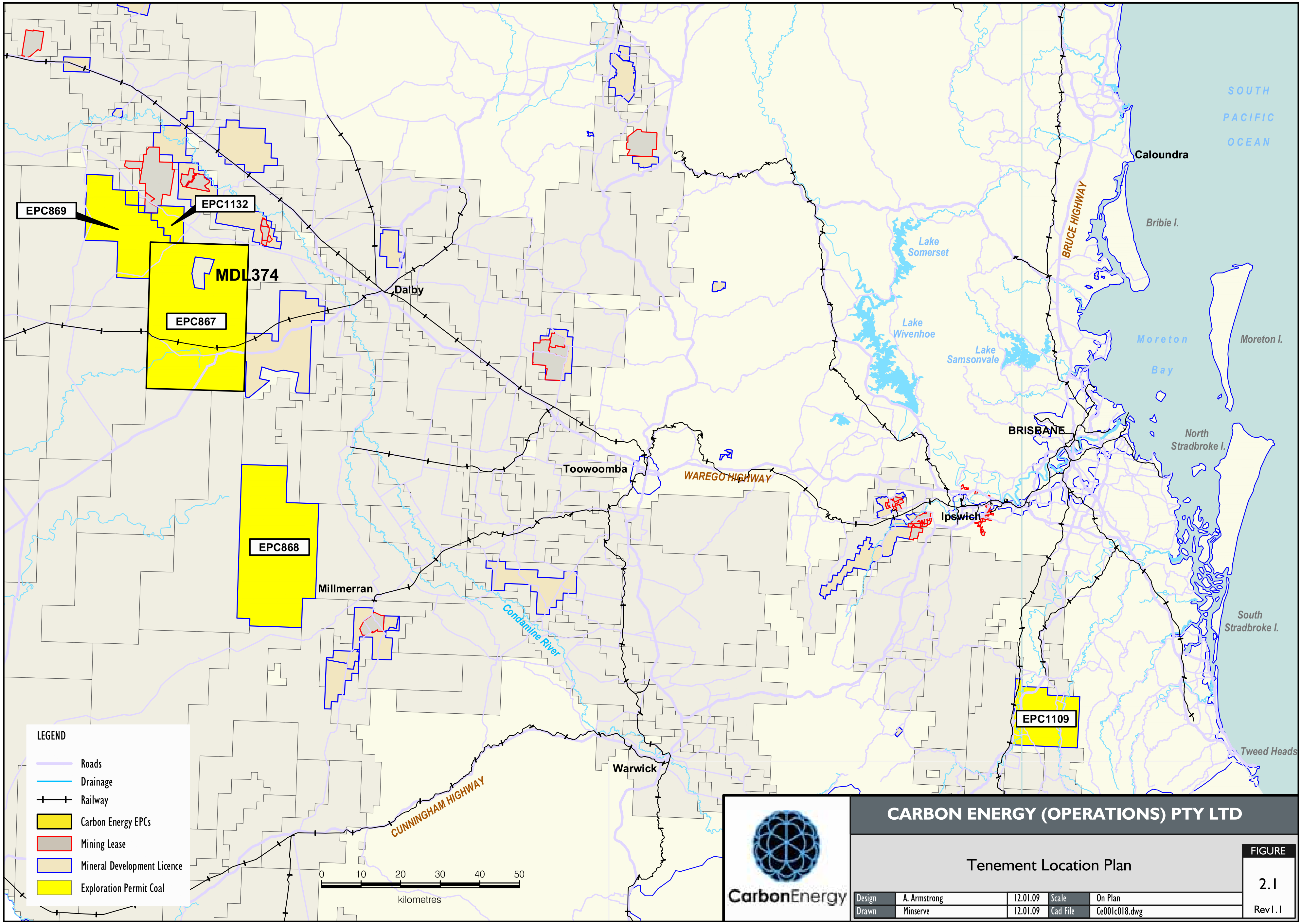
Tenement	Tenement Holders Name	Terms of the Tenement
EPC 867	Carbon Energy Pty Ltd	Five years from 18 February 2005
EPC 868	Carbon Energy Pty Ltd	Five years from 18 February 2005
EPC 869	Carbon Energy Pty Ltd	Five years from 14 October 2004
EPC 1109	Carbon Energy Pty Ltd	Five years from 14 February 2007
EPC 1132	Carbon Energy Pty Ltd	Five years from 21 June 2007
MDL 374	Carbon Energy Pty Ltd	Five years from 1 February 2009

CEL, through a wholly owned subsidiary Carbon Energy (Operations) Pty Ltd, recently submitted a mining lease application - MLA 50253 and will prepare an EIS to support the Environmental Authority application submitted with MLA 50253.

CEL has over 2,000 square kilometres of exploration permit covering billions of tonnes of potential coal deposits. A drilling program is currently focused on defining an area at Bloodwood Creek in the Surat Basin where oil and gas exploration wells have encountered a 10m thick coal seam. The target resource is likely to contain between 250 and 600 million tonnes of high ash coal suitable for UCG production. At a nominal yield of 2 barrels oil per tonne of coal this is equivalent to an oil reserve between 500 million and 1 billion barrels. Previous petroleum exploration wells suggest it is likely that a number of deposits of this scale occur on the EPCs held by CEL.

The deeper coals in the Surat Basin are high ash and not recoverable by conventional mining. This illustrates the ability of UCG technology to use otherwise non-recoverable resources. This applies universally and there will be many deposits world wide where UCG can unlock sterilised resources.

These coal deposits are located at the hub of energy infrastructure in SE Queensland. They straddle major natural gas and oil pipelines. Two power stations have recently been constructed and a third is under construction and the major state power connector and interstate power link crosses the leases.



CarbonEnergy

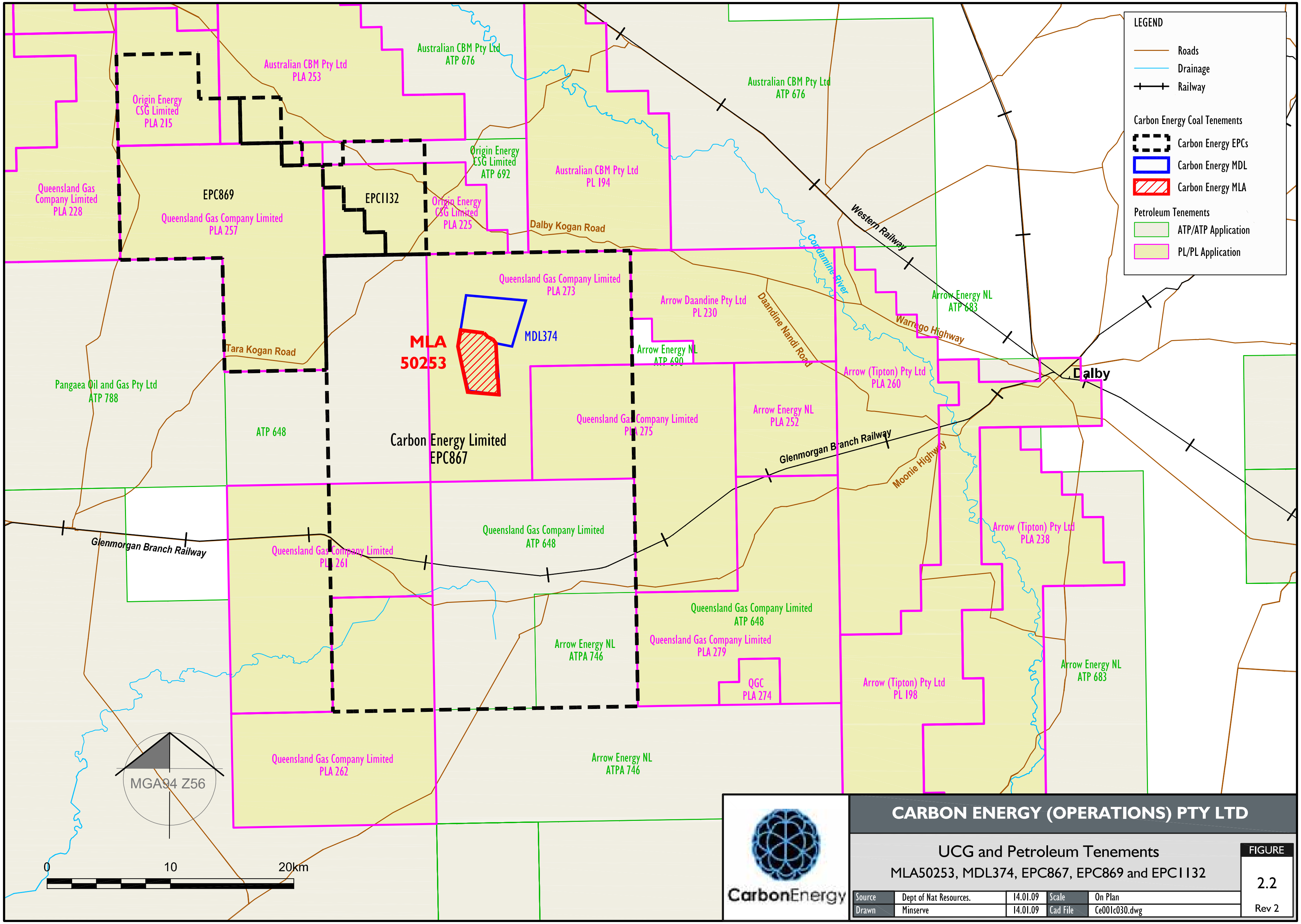
CARBON ENERGY (OPERATIONS) PTY LTD

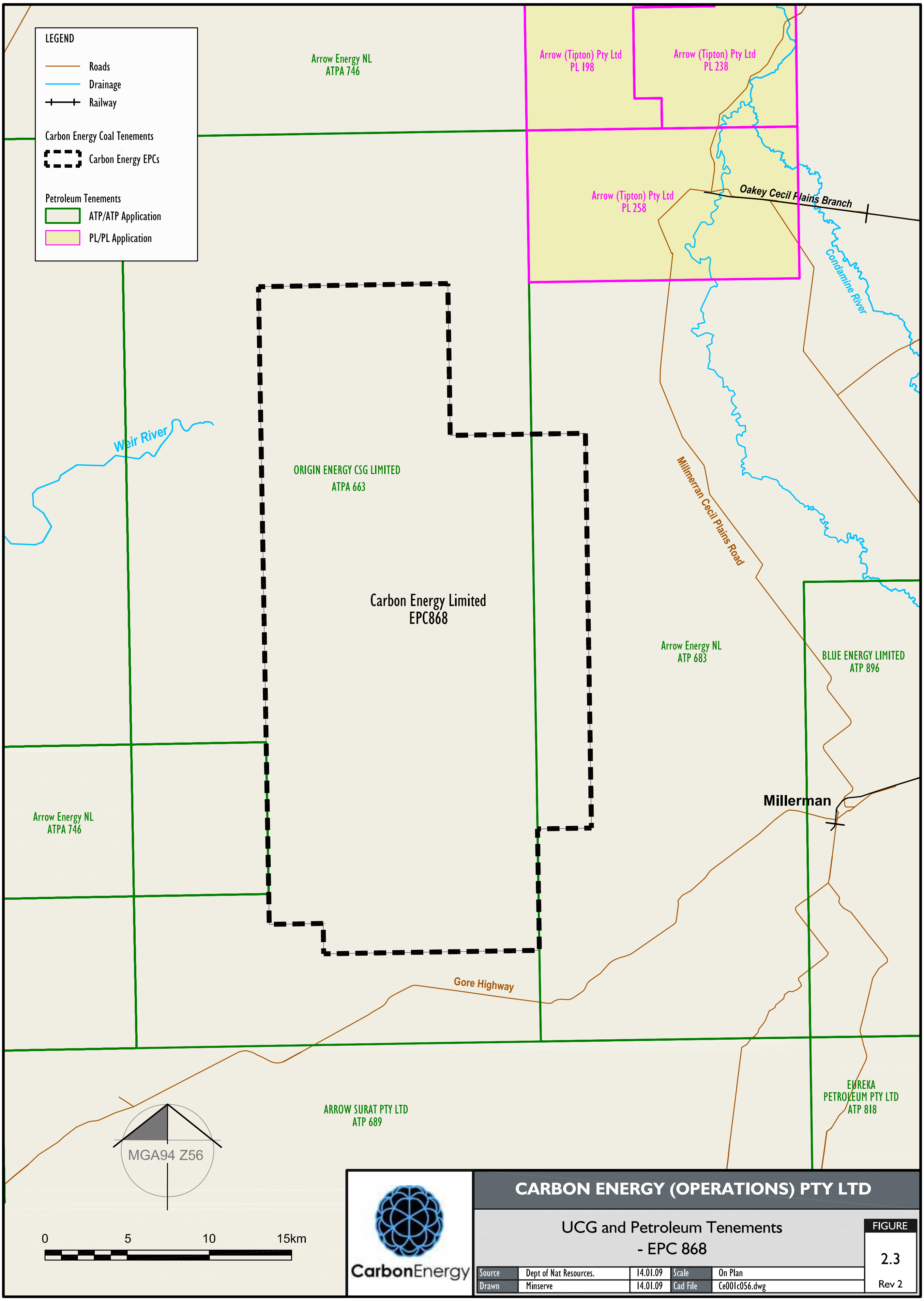
Tenement Location Plan

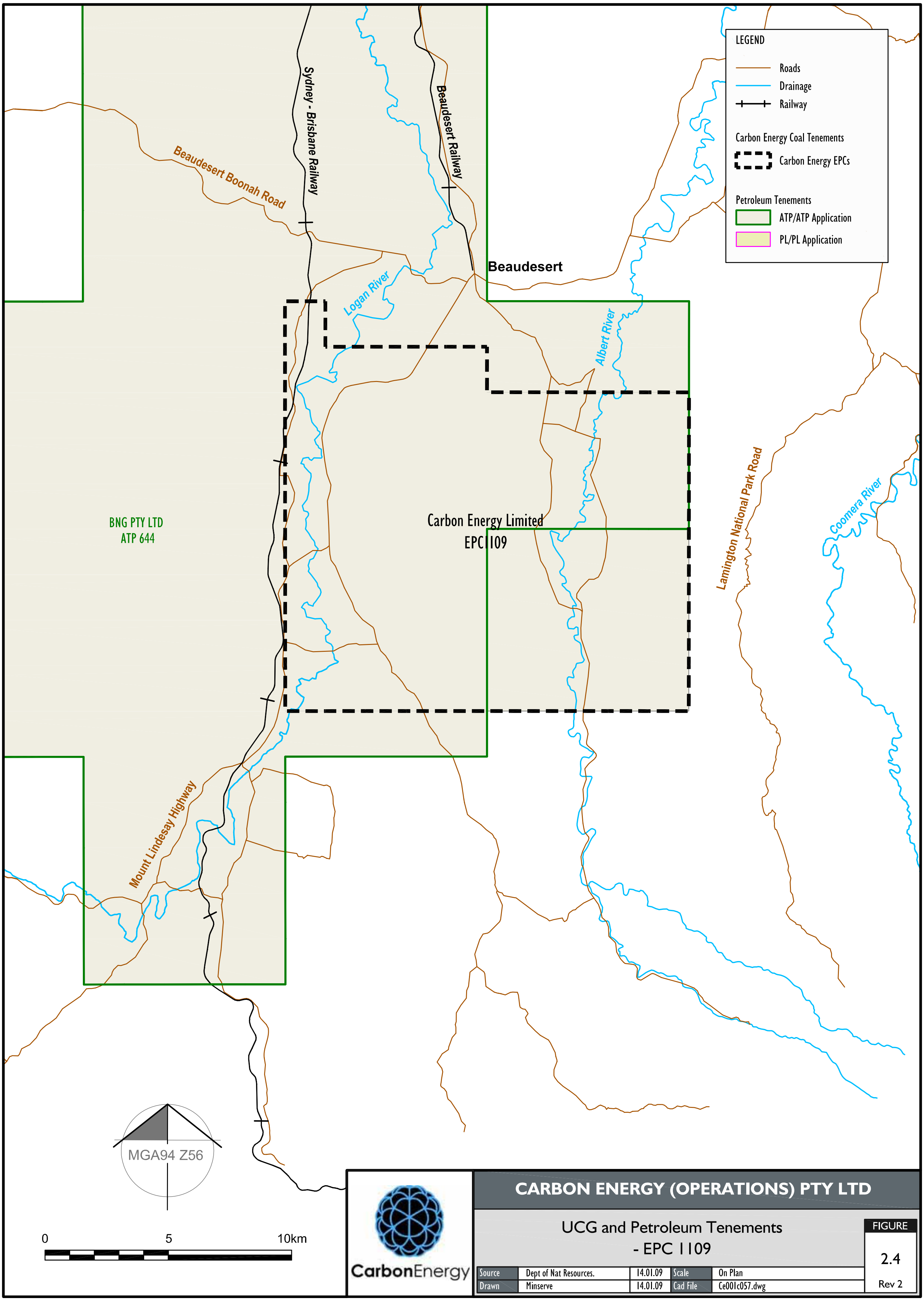
FIGURE 2.1

Rev1.1

Design	A. Armstrong	12.01.09	Scale	On Plan
Drawn	Minserve	12.01.09	Cad File	Ce001c018.dwg


LEGEND
Roads
Drainage
Railway
Carbon Energy Coal Tenements
Carbon Energy EPCs
Carbon Energy MDL
Carbon Energy MLA
Petroleum Tenements
ATP/ATP Application
PL/PL Application
MLA 50253
MDL374
Carbon Energy Limited EPC867
EPC869
EPC1132
Dalby
Western Railway
Glenmorgan Branch Railway
Condamine River
Warrego Highway
Moonie Highway
Daandine Nandi Road
Dalby Kogan Road
Tara Kogan Road
Australian CBM Pty Ltd ATP 676
Australian CBM Pty Ltd PLA 253
Australian CBM Pty Ltd PL 194
Origin Energy CSG Limited PLA 215
Origin Energy CSG Limited ATP 692
Origin Energy CSG Limited PLA 225
Queensland Gas Company Limited PLA 228
Queensland Gas Company Limited PLA 257
Queensland Gas Company Limited PLA 273
Queensland Gas Company Limited PLA 275
Queensland Gas Company Limited ATP 648
Queensland Gas Company Limited PL 261
Queensland Gas Company Limited PLA 262
Queensland Gas Company Limited PLA 279
QGC PLA 274
Arrow Daandine Pty Ltd PL 230
Arrow Energy NL ATP 690
Arrow Energy NL ATP 683
Arrow Energy NL PLA 252
Arrow Energy NL ATPA 746
Arrow (Tipton) Pty Ltd PLA 260
Arrow (Tipton) Pty Ltd PLA 238
Arrow (Tipton) Pty Ltd PL 198
Pangaea Oil and Gas Pty Ltd ATP 788
ATP 648
MGA94 Z56
0
10
20km
CarbonEnergy
CARBON ENERGY (OPERATIONS) PTY LTD
UCG and Petroleum Tenements
MLA50253, MDL374, EPC867, EPC869 and EPC1132
FIGURE
2.2
Rev 2
Source
Dept of Nat Resources.
14.01.09
Scale
On Plan
Drawn
Minserve
14.01.09
Cad File
Ce001c030.dwg


LEGEND
Roads
Drainage
Railway
Carbon Energy Coal Tenements
Carbon Energy EPCs
Petroleum Tenements
ATP/ATP Application
PL/PL Application
Arrow Energy NL
ATPA 746
Arrow (Tipton) Pty Ltd
PL 198
Arrow (Tipton) Pty Ltd
PL 238
Arrow (Tipton) Pty Ltd
PL 258
Oakey Cecil Plains Branch
Condamine River
Weir River
ORIGIN ENERGY CSG LIMITED
ATPA 663
Carbon Energy Limited
EPC868
Millmerran Cecil Plains Road
Arrow Energy NL
ATP 683
BLUE ENERGY LIMITED
ATP 896
Millerman
Arrow Energy NL
ATPA 746
Gore Highway
ARROW SURAT PTY LTD
ATP 689
EUREKA
PETROLEUM PTY LTD
ATP 818
MGA94 Z56
0
5
10
15km
CarbonEnergy
CARBON ENERGY (OPERATIONS) PTY LTD
UCG and Petroleum Tenements
- EPC 868
FIGURE
2.3
Rev 2
Source
Dept of Nat Resources.
14.01.09
Scale
On Plan
Drawn
Minserve
14.01.09
Cad File
Ce001c056.dwg


LEGEND
Roads
Drainage
Railway
Carbon Energy Coal Tenements
Carbon Energy EPCs
Petroleum Tenements
ATP/ATP Application
PL/PL Application
Sydney - Brisbane Railway
Beaudesert Railway
Beaudesert Boonah Road
Beaudesert
Logan River
Albert River
BNG PTY LTD
ATP 644
Carbon Energy Limited
EPC1109
Mount Lindesay Highway
Lamington National Park Road
Coomera River
MGA94 Z56
0
5
10km
CarbonEnergy
CARBON ENERGY (OPERATIONS) PTY LTD
UCG and Petroleum Tenements
- EPC 1109
FIGURE
2.4
Rev 2
Source
Dept of Nat Resources.
14.01.09
Scale
On Plan
Drawn
Minserve
14.01.09
Cad File
Ce001c057.dwg

2.4 BACKGROUND TO THE PROJECT

UCG produces syngas from coal by injecting oxygen directly into the coal seam through one set of boreholes and extracting the syngas through another set. CO_2 is then removed from the product gas. Gasification is carried out entirely underground and cavities are created in the coal seam. The process is contained within a "bubble" in the underground water table and will only continue while oxygen is being pumped underground. When this stops groundwater flows back and fills the underground voids. On shut down the cavity is steam flushed to ensure removal of any pollutants using proven processes designed and approved by the USA EPA.

CEL owns the entirety of CSIRO's UCG technology. This includes:

- Site selection and characterisation methodology
- UCG design tools and modelling packages
- Environmental control techniques, process design and control models.

CEL can evaluate the feasibility of UCG on a particular site, design the optimum UCG layout, model the gas composition that will be produced and determine the optimum configuration for the use of the gas e.g. power and liquid fuel options and hybrids that will produce the best outcome economically and environmentally. These tools provide the capability to do real time process analyses to identify the causes of variations in the underground gasifier performance and to make timely changes to operating conditions to continuously maintain gas product quality. The analyses and models are the innovative and leading-edge technologies inherent in the project.

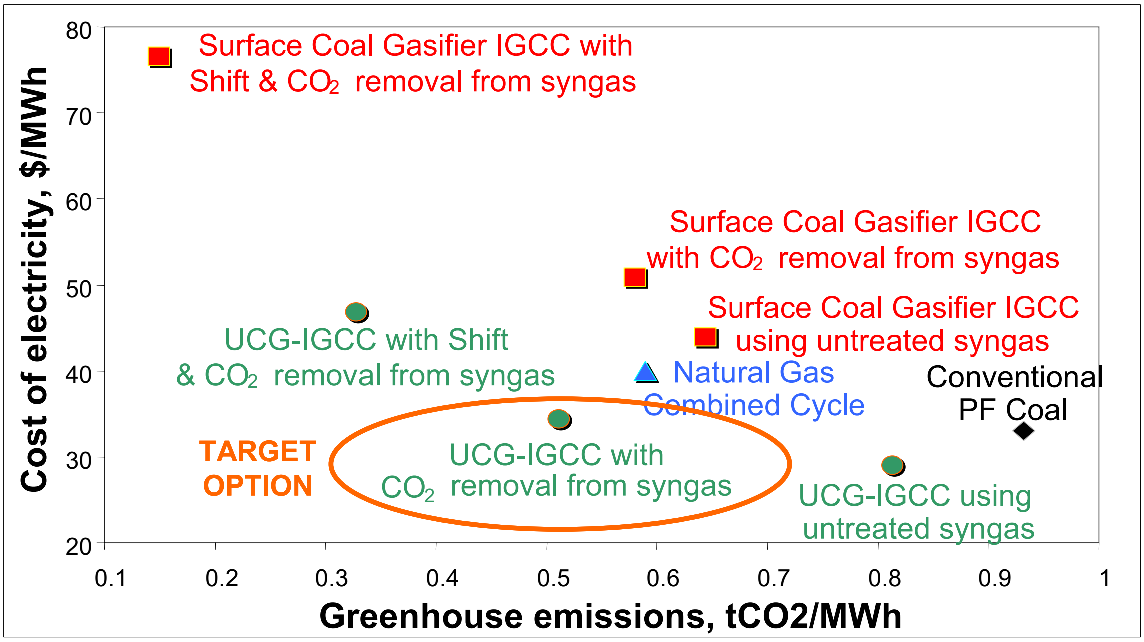
UCG has had many trials and demonstrations in western countries but no commercial scale operations have been carried out. CEL has unique predictive tools to identify the environmental impact of large scale coal removal and the effect it will have on overlying strata and aquifers. Operations can be modified to avoid or manage these impacts in sustainable ways.

Low Emission Electricity

By applying CEL technology to a suitable coal deposit electricity can be produced at a similar cost to conventional coal power stations with half the greenhouse emissions.

Figure 2.5 shows the Australian cost and greenhouse gas emissions for a range of new clean coal technologies compared to conventional pulverised fuel (PF) coal fired power stations and natural gas fueled generators. The upper square plots show the performance for surface coal gasification plants with three options, one using the gas directly from the gasifier, one removing CO_2 from the gas before combusting it, and the third, most expensive 'zero' emission option, converting the gas to hydrogen and CO_2 and removing the CO_2 before combustion. The lower circle plots show the same three options for UCG gas. There is a 'sweet spot' with the second option which provides 50% reduction in CO_2 emissions with no increase in cost over current coal fired power stations.

Figure 2.5
Greenhouse Emissions, tCO_2/MWh



Synfuels from Coal-to-Liquids

Liquid fuels can be produced from a medium thickness seam at approximately $A25 per barrel. There will be variations in cost based on local coal characteristics primarily the thickness of the coal seam being gasified with a thin 2m seam having costs about 25% higher than a thick 10m seam. In this application UCG based coal to liquids (CTL) has very significant advantages over other methods of synfuel production.

CEL Business Model

CEL has a number of business objectives. Primarily it aims to develop power, ammonia, fertilizer, explosives and synthetic diesel production plants on CEL's coal deposits and build the partnerships required to implement and fund such projects. It has commenced a staged development plan for the first of these on MDL 374 and MLA 50253.

In growing the business it is recognised that strategic alliances can provide significant opportunities. One is to partner with other coal owners in Australia and internationally to participate in the development of projects based on deep or low quality coals not conventionally mineable. An agreement with a major Indian coal mining company to jointly evaluate UCG potential in their leases has been signed and there are other opportunities in China and the USA. Another is to develop partnerships with companies that hold technology that can use syngas such as Gas to Liquids (GTL) and jointly identify suitable coal resources to base projects on with CEL providing the UCG components of these projects.

Since 1999 the CSIRO has been actively involved in research into UCG technologies and the issues involved in the use of this type of technology in Australia. Research has been conducted into the aspects of UCG technologies that have the potential to impact on the environment and therefore the suitability of the technologies for use in Australia on a large scale. The key areas of UCG that are considered include:

- Site selection
- Process design and operational behaviour
- Greenhouse gas emissions (incorporating economics)
- Groundwater and subsidence
- Social and legislative issues.

2.5 DRIVERS FOR UCG

Currently there is renewed interest worldwide in UCG technology with countries as diverse as the UK, India, China, and Australia having active research programs. The most obvious driver for UCG is energy security with the UK expecting depletion of North Sea natural gas stocks and both China and India having shortages of natural gas and electricity. In Australia although there are plentiful supplies of mined coal, analysis suggests that low cost fuel or syngas gas could be generated from the large resources of coal that are not economically viable to mine. Advances in drilling, remote sensing and control technologies are likely to improve economic, operating and environmental performance of UCG processes. The production of low cost fuel gas may provide a lower cost route to implementation of clean coal technologies for electricity generation compared to surface coal gasification. Low cost syngas could lead to the development of new chemical industries in particular one producing synthetic liquid fuels using the rapidly improving Fischer-Tropsch technology.

2.6 HINDRANCES TO UCG IMPLEMENTATION

One of the key hindrances to large scale UCG implementation is that it has not been done outside the former Soviet Union. This is perhaps the most significant threshold as the implementation in the Soviet Union was not in a transparently competitive environment and there is distrust in Western countries of the Soviet documentation especially regarding environmental issues. Regardless of this, if the drivers discussed above are strong enough, it would be expected that commercial interests would use published UCG technologies given that economic analyses indicates financial viability. The reason why this has not happened appear to be strongly based on the availability of cheap natural gas or mined coal in the regions with good coal deposits for UCG. There is little or no commercial advantage for UCG in these situations and the relative novelty of the UCG technology is detrimental to investment. This hindrance will disappear where natural gas or mined coal are in short supply or expensive which explains the renewed interest in UCG in the UK, China, India, and Japan.

The other significant hindrance is a lack of knowledge of the environmental impacts of large scale UCG implementation, specifically concerns about the potential for groundwater contamination. The concerns largely arise from specific trials of UCG in the 1970s in the USA where groundwater remediation was required due to organic contaminants from the UCG cavity migrating into the overlying aquifer. The requirement for remediation work was extensively published and despite this being due to specific faults in the UCG trials in question that were remedied in subsequent trials in the USA, it is necessary to explicitly address the likelihood of this type of problem in developing a UCG proposal for commercial implementation. Other potential environmental issues are less well published but the current procedures for gaining environmental approvals require that a full analysis of environmental performance is conducted.

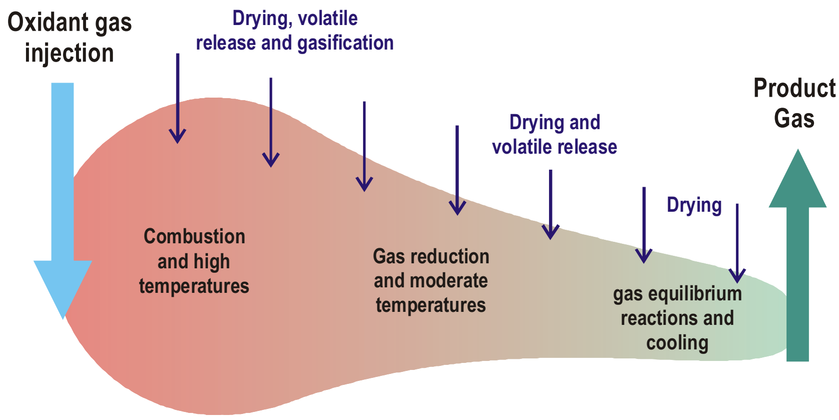
Previous trials of UCG have also suffered from poor selection of the site and inadequate analysis of the site characteristics. It should be noted that exploration for a UCG site should be performed to a similar degree of accuracy as for an underground mine. The coal seam has to be accurately modelled, overburden characteristics determined, and hydrogeological analysis completed prior to design and construction of the UCG reactors.

The research program conducted by the CSIRO focused on key issues critical to the success of UCG in the Surat Basin. The key issues are discussed and summarised below.

Fundamentals

UCG involves the same basic reactions as other types of coal gasification, namely coal devolatilisation, combustion, steam gasification, carbon dioxide gasification and hydrogen gasification. A schematic representation of the processes is given in **Figure 2.6**, showing a progression from high temperatures around the oxidant injection point at the left to low temperatures at the production well to the right. After oxygen has been depleted by the combustion processes the temperature of the gas decreases due to a combination of endothermic gasification reactions, evaporation of moisture and heat loss to the surrounding coal and rock. The temperature of the gas has an impact on the reactions that can occur at significant rates as gasification reactions will only occur rapidly at moderate to high temperatures. At lower temperatures devolatilisation will still occur but towards the production hole it is likely that only coal drying will occur. A process that is not shown but can be significant is the degassing of coal bed methane into the cavity and this may elevate the product gas methane content when gasifying gassy coal seams. At all stages the gas composition will change to approach the equilibrium composition, but at lower temperatures the rate of change of composition will be slow and the product gas may have 'frozen' at a composition resembling equilibrium at a higher temperature.

Figure 2.6
Schematic of the Processes Involved in UCG



The product gas is a mixture of the products from all of the reactions and includes methane, hydrogen, carbon monoxide, carbon dioxide, and various higher hydrocarbons. The exact composition will depend on a number of factors including the quantity of heat lost to the surrounding rock, the amount of water that flows into the reacting area, the amount of coal that participates in the reactions, the proportion of the coal that is left unreacted, the temperature at which the reactions occur, and the residence time of the gas at different temperatures in the cavity. An approximate indication of the gas composition can be obtained for a specific site by performing a mass and energy balance combined with a gas equilibrium calculation; however assumptions have to be made regarding heat losses, water flows, quantity of coal affected and the proportion of residual char. These can be based on past experimental experience or the results of more accurate modelling studies using the site characteristics. The product gas is generally described as either fuel gas or syngas depending on the intended end use. Changes in the operating parameters such as the oxygen feed rate and pressure can be used to modify the product gas composition to improve calorific value as a fuel or to adjust the hydrogen to carbon monoxide ratio as a synthesis gas.

Site Characteristics

A large range of sites with different characteristics have been used in past UCG trials and it has been determined that the operational performance is strongly dependent on the site. The key criteria for a successful UCG site can be summarised as:

- Thick coal seam with minimal discontinuities
- Structurally robust overburden with low permeability
- Hydraulically sealed coal seam
- Ash content less than 50% (approximately)
- No good quality groundwater near the coal seam.

The depth of the coal seam may also be important to the functionality of the process utilising the UCG product gas as the operating pressure of the gasifier is limited to the hydraulic head at the coal seam.

Techniques

A large number of gasification techniques have been used at UCG trials in the past denoting technology improvements with time. The general trend has been to reduce the use of mining in favour of the use of drilled wells with more recent techniques involving advanced directional drilling technology to reduce the total amount of drilling required. The techniques are a method of positioning injection and production wells in the coal however there are distinct differences in how gasification proceeds with some techniques. The techniques most likely to be applied in Australia are variants of the vertical wells technique used extensively in countries of the former Soviet Union and variants of the controlled retracting injection point (CRIP) technique involving parallel, directionally drilled wells. The vertical wells approach is more appropriate for relatively shallow (<300m) coal seams as the grid of regularly spaced wells requires excessive drilling at greater depth while the directionally drilled CRIP-type systems are suited to deeper seams, where the higher cost of the wells can be justified due to the reduction in the number of wells required. In both approaches it is desirable to delineate a block of coal and gasify it completely, leaving only small pillars of coal between blocks to isolate the different cavities during operation.

Operating Methods

The methods used to start and operate a UCG site have been shown to strongly influence not only the operational performance but also the environmental performance of the site. The feed rates and the substances fed to a gasifier will impact on the gas production rate, gas quality and the rate of coal consumption. However, the major operating issue that has arisen as a problem area in gasification operation has been the operating pressure. Excessive pressures have been linked to contamination of surrounding groundwater with organics and by-products of the gasification process and reduced process efficiencies due to high product gas losses. The current best practice operating parameters that have been adopted in both Soviet operations and the more recent trials in the USA include ensuring that the gasifier operating pressure does not exceed the hydrostatic head pressure at the coal seam thereby restricting the loss of product from the gasifier into the surrounding strata. Generally, this restriction has been found to improve both operating and environmental performance of the UCG sites. A procedure formally adopted in the USA is the Clean Cavern Concept which also includes operating practices to ensure cleaning of organics from the cavity during the shutdown phase. The last of the government funded trials in the USA, Rocky Mountain 1, validated the use of this procedure and similar techniques are believed to have been successfully demonstrated during the Chinchilla trial in Australia.

Oxidant Selection

UCG, like surface coal gasification, can use either oxygen or air as the feed gas. In surface gasifiers there has been a trend to use oxygen because the size of the gasifier can be reduced with considerable savings in capital expenditure despite the requirement for an air separation plant. With UCG the expenditure on gasifier construction is relatively minor so the use of oxygen will depend largely on the requirements for the product gas. Typically low nitrogen dilution is required in syngas so oxygen would generally be preferred. In electricity generation processes the presence of nitrogen is not important if the gas calorific value is sufficient for use in gas turbines. Good quality air-blown UCG product gas will typically be acceptable while oxygen-blown UCG product gas is likely to require dilution at the combustor in order to reduce the combustion temperature to the operating limit of the gas turbine. However if carbon dioxide is to be removed from the gas stream it is better to have a low nitrogen stream and therefore oxygen is the preferred oxidant. There will be some differences in the design and operation of air and oxygen UCG systems. The metal components of an oxygen system must be of higher grades but pipe diameters can be smaller and this reduces the cost of directionally drilled wells significantly. Operationally higher temperatures are expected in oxygen-blown systems so higher hydrocarbons are more likely to react to form simpler compounds and lower tar content in the product gas will result.

3.0 REGIONAL GEOLOGY

3.1 SURAT BASIN

The tenements held by CEL are located along the eastern margin of the intracratonic Surat Basin, which covers an area of approximately 300,000km^2 of southern Queensland and northern NSW as indicated in **Figure 3.1**. The basin hosts up to 2,500m of predominantly continental Jurassic sediments and Early Cretaceous marine beds, with coal seams largely confined to the Jurassic Walloon Coal Measures (WCM). The basin is bounded to the east by a combination of fault systems and onlap relationships with granites of the Auburn Arch in the north and metasediments of the New England Fold Belt in the south. Between these structural blocks, sediments of the Surat Basin are continuous across the Kumbarilla Ridge with those of the Clarence-Moreton Basin, while in the west the sequence interfingers with sediments of the Eromanga Basin across the Nebine and Cunnamulla Ridges. The northern part of the basin overlies the Permo-Triassic Bowen Basin, where its extent is limited by an erosional margin, while in the south the margin is defined by onlap relationships with metasediments of the Central West Fold Belt in NSW.

3.2 REGIONAL STRATIGRAPHY

Rock units of the Surat Basin can be divided into two main sequences, with the lower unit represented by non-marine sediments of Early Jurassic to earliest Cretaceous age, and an upper sequence of Early Cretaceous marine rocks. The basal unit of the Surat Basin is the Early Jurassic Precipice Sandstone, which is a transgressive fluviatile unit deposited unconformably on the eroded upper surface of the Middle Triassic Moolayember Formation as indicated in **Figure 3.2**. The Precipice Sandstone is overlain by interbedded quartzose to lithic sandstones and siltstones of the Early Jurassic Evergreen Formation, and thereafter by quartzose sandstones and minor carbonaceous shales of the Hutton Sandstone, a major aquifer horizon in the region. Deposition of the Hutton Sandstone commenced in the Early Jurassic and continued until the Middle Jurassic, after which time the Surat Basin expanded dramatically to the south and west and corresponded with the influx of argillaceous sediments of the WCM.

The Middle Jurassic WCM are the principal coal-bearing formations of the Surat Basin and comprise laminated and thinly bedded carbonaceous shale, mudstone, siltstone, lithic sandstone, and coal. The lithic sandstones contain volcanogenic detritus and a montmorillinite matrix, indicating contemporaneous volcanism, particularly in the eastern areas of the basin (Exon et al. 1967, Houston 1972). Overlying the WCM are Middle Jurassic to Early Cretaceous fluvial sediments of the Springbok Sandstone, Westbourne Formation, Gubberamunda Sandstone, Orallo Formation, and Mooga Sandstone. These units were followed by deposition of the Early Cretaceous marine Bungil Formation and Rowlings Down Group.

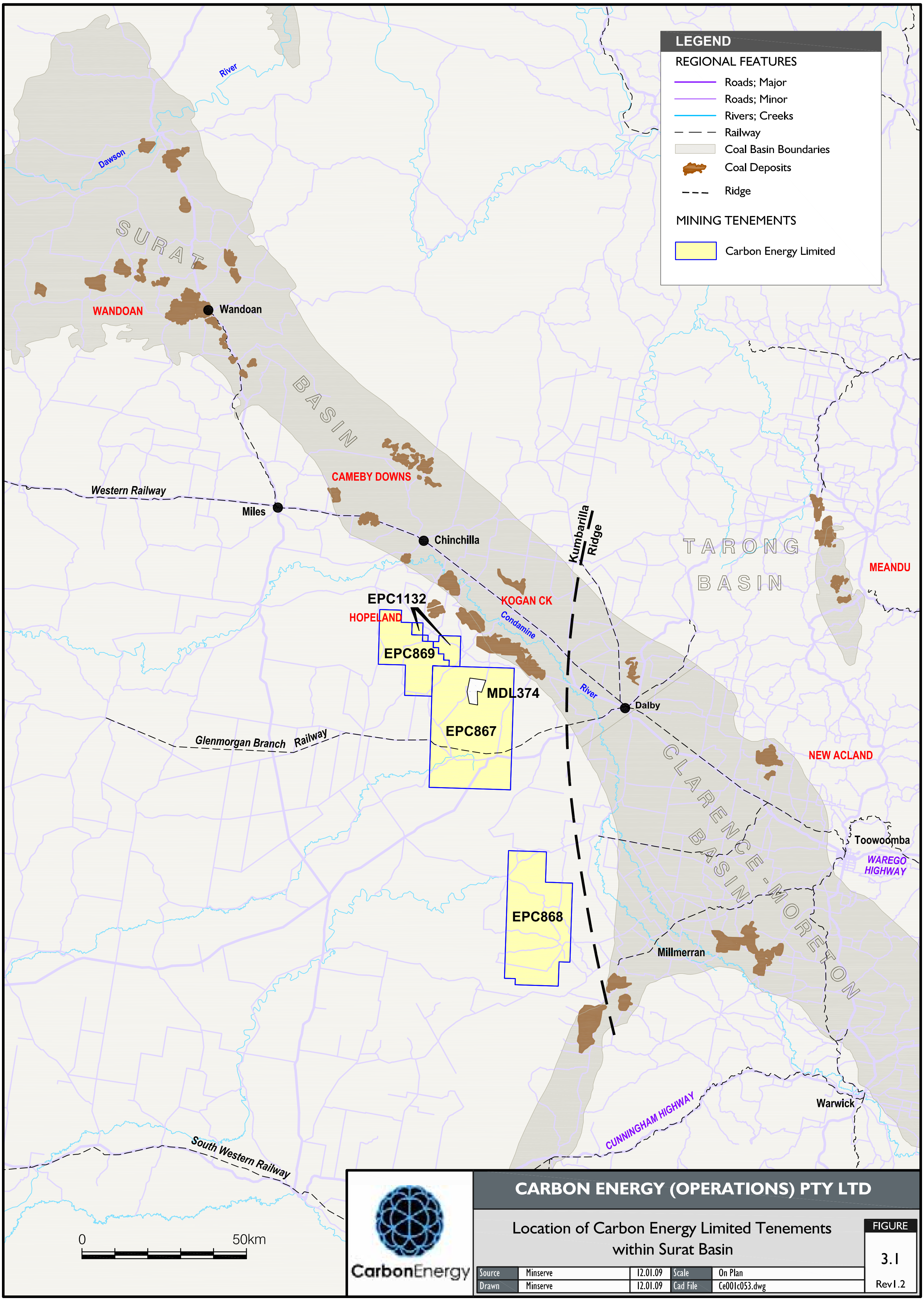
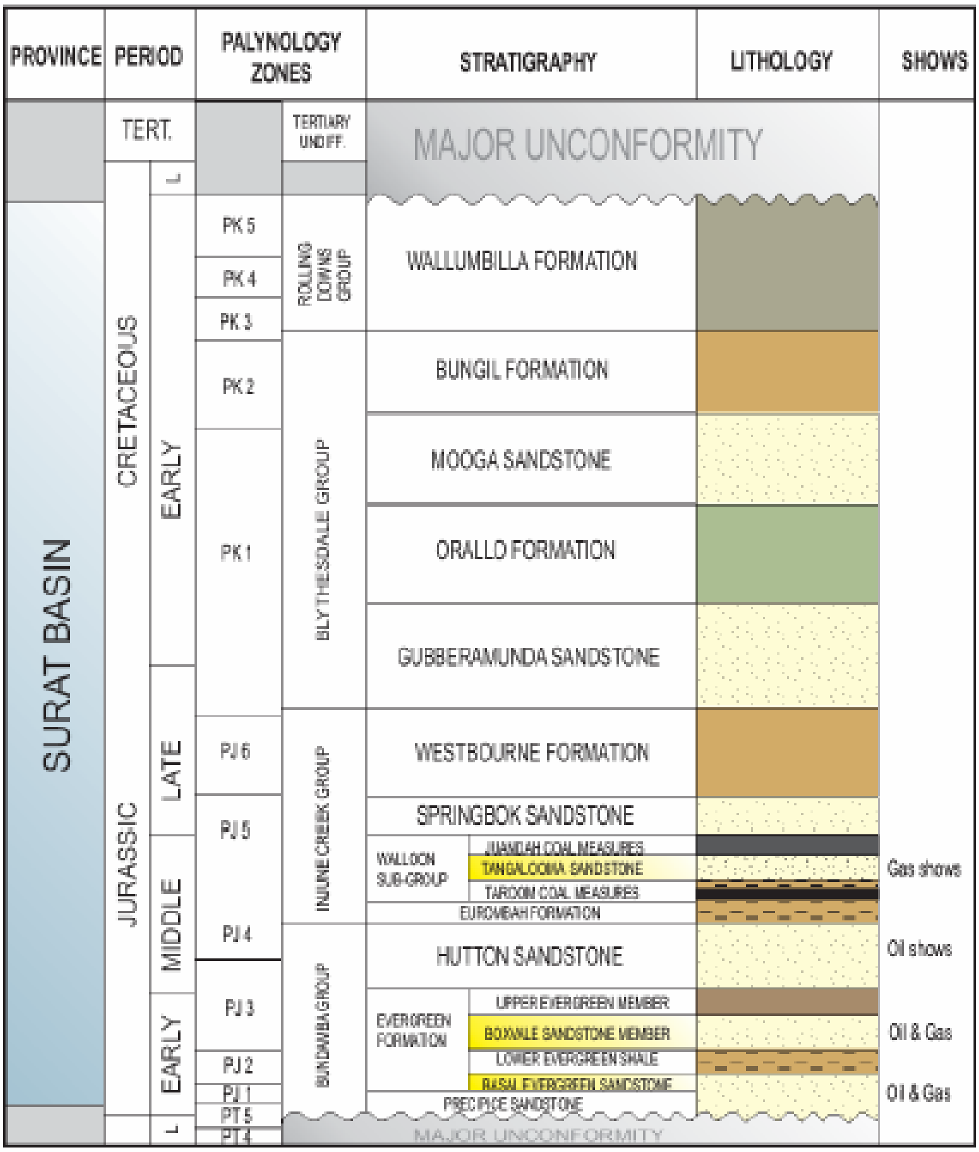
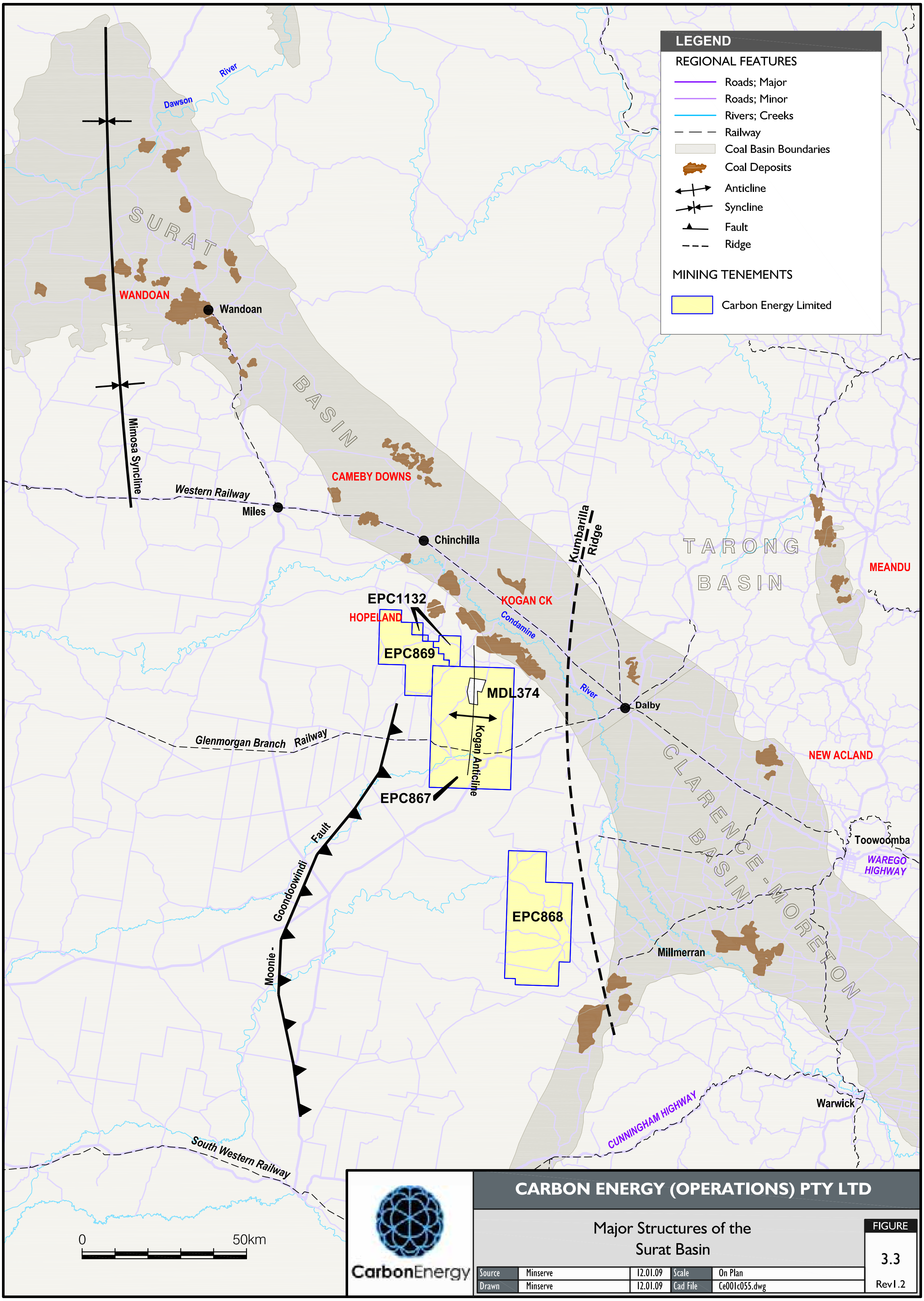

LEGEND
REGIONAL FEATURES
Roads; Major
Roads; Minor
Rivers; Creeks
Railway
Coal Basin Boundaries
Coal Deposits
Ridge
MINING TENEMENTS
Carbon Energy Limited
River
Dawson
SURAT BASIN
WANDOAN
Wandoan
CAMEBY DOWNS
Western Railway
Miles
Chinchilla
Kumbarilla Ridge
TARONG BASIN
MEANDU
KOGAN CK
EPC1132
HOPELAND
Condamine River
EPC869
MDL374
Dalby
EPC867
Glenmorgan Branch Railway
NEW ACLAND
CLARENCE-MORETON BASIN
Toowoomba
WAREGO HIGHWAY
EPC868
Millmerran
Warwick
CUNNINGHAM HIGHWAY
South Western Railway
0
50km
CarbonEnergy
CARBON ENERGY (OPERATIONS) PTY LTD
Location of Carbon Energy Limited Tenements within Surat Basin
FIGURE
3.1
Rev1.2
Source Minserve 12.01.09 Scale On Plan
Drawn Minserve 12.01.09 Cad File Ce001c053.dwg

Figure 3.2
Stratigraphy of the Surat Basin (from Cahill 2005)



3.3 REGIONAL STRUCTURE

The three main structural elements of the Surat Basin are the Chinchilla-Goondiwindi Slope in the east, the Mimosa Syncline and underlying Taroom Trough in the central area, and a western shelf area characterised by broad folds and locally developed anticlines (e.g. Kogan Anticline). The boundary between the Chinchilla-Goondiwindi Slope and central synclines is marked by the Moonie-Goondiwindi Fault, a regional reverse fault with associated throws of up to 1,000m. The location of the structures is indicated in **Figure 3.3**.



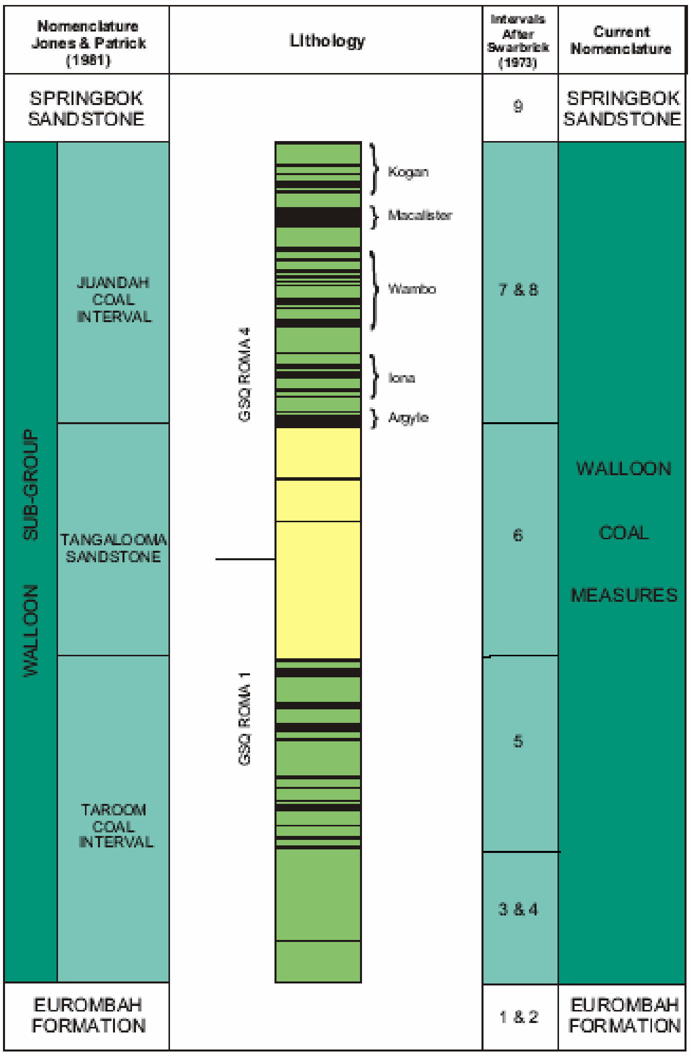
LEGEND
REGIONAL FEATURES
Roads; Major
Roads; Minor
Rivers; Creeks
Railway
Coal Basin Boundaries
Coal Deposits
Anticline
Syncline
Fault
Ridge
MINING TENEMENTS
Carbon Energy Limited
Dawson River
SURAT BASIN
WANDOAN
Wandoan
Mimosa Syncline
Western Railway
Miles
CAMEBY DOWNS
Chinchilla
Kumbarilla Ridge
TARONG BASIN
MEANDU
KOGAN CK
Condamine River
EPC1132
HOPELAND
EPC869
MDL374
Kogan Anticline
Dalby
Glenmorgan Branch Railway
EPC867
NEW ACLAND
CLARENCE-MORETON BASIN
Toowoomba
WAREGO HIGHWAY
Moonie - Goondoowindi Fault
EPC868
Millmerran
Warwick
CUNNINGHAM HIGHWAY
South Western Railway
0
50km
CarbonEnergy
CARBON ENERGY (OPERATIONS) PTY LTD
Major Structures of the Surat Basin
FIGURE
3.3
Rev1.2
Source Minserve 12.01.09 Scale On Plan
Drawn Minserve 12.01.09 Cad File Ce001c055.dwg

3.4 GEOLOGY OF THE WALLOON COAL MEASURES

3.4.1 Stratigraphy

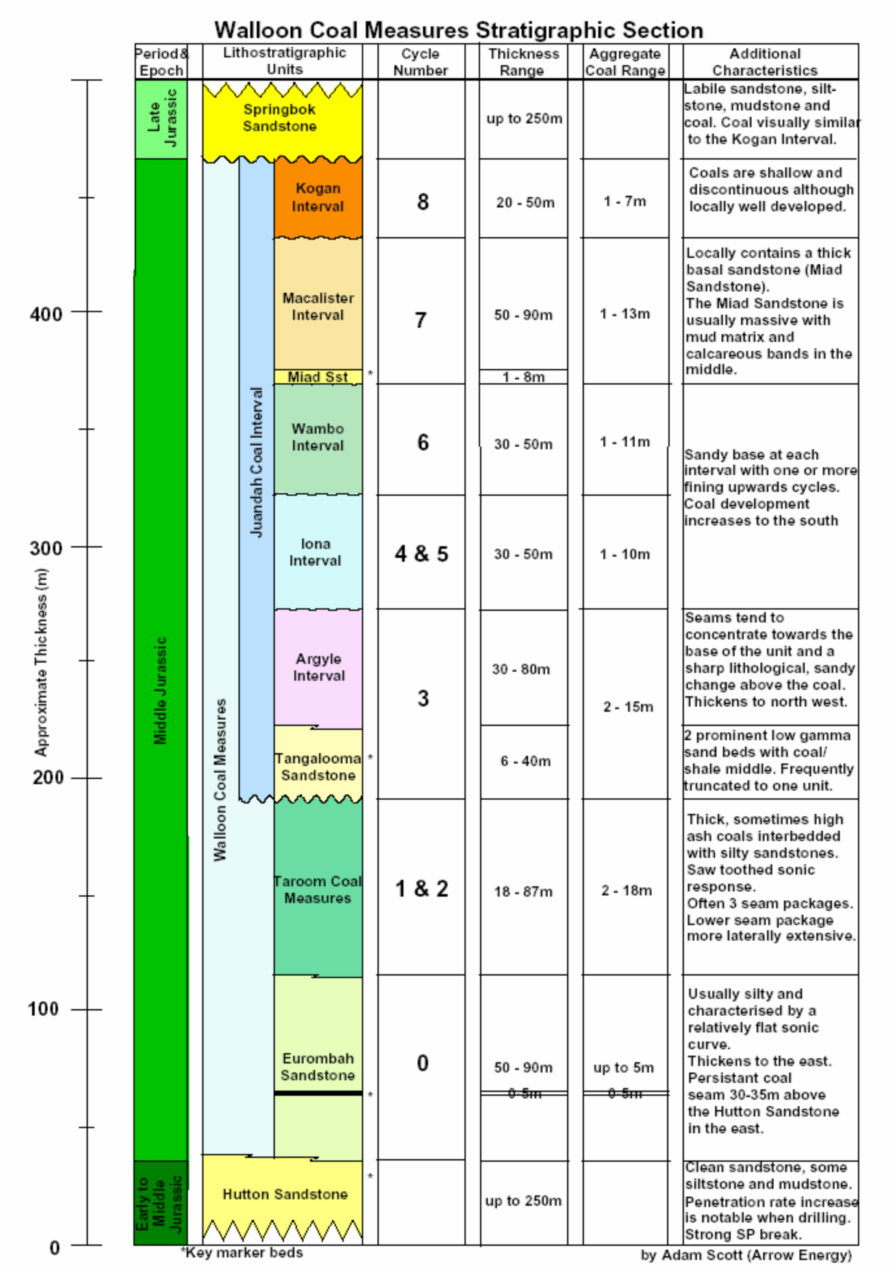
The Middle Jurassic WCM form part of the Injune Creek Group and are developed throughout the Surat and Moreton Basins, ranging in thickness from less than 50m to greater than 500m in the Miles-Chinchilla area. They comprise very fine to medium grained, labile, argillaceous sandstone, siltstone, mudstone and coal with minor calcareous sandstone, impure limestone and ironstone (Swarbrick, 1973). Within the current area of interest (i.e. the northeast Surat Basin) the formation was raised by Jones and Patrick (1981) to Subgroup status and in stratigraphic order, was divided into the Taroom Coal Measures, Tangalooma Sandstone and Juandah Coal Measures as indicated in **Figure 3.4**. Doubts remain as to the basin-wide validity of such a subdivision (e.g. Green et al. 1997) but experience in the Chinchilla-Kogan area does tend to support such a concept.

Figure 3.4
Stratigraphy of the Walloon Coal, Measures (from Queensland Gas Company 2003)



The upper coal-bearing section of the coal measures (Juandah Coal Measures) generally comprises five named coal seams, which in descending stratigraphic order are the Kogan, Macalister, Wambo, Iona and Argyle Seams. The Macalister Seam can occur over three distinct horizons and has been informally referred to by Queensland Gas Company (QGC) geologists as the Macalister Upper, Macalister Middle and Macalister Lower Seams. The Macalister seam group is the most economically significant of the upper coal measure sequence, and where coalesced can attain a thickness in excess of 12m. This is the primary target horizon of the current UCG exploration program. Locally the Macalister-Wambo interval is separated by a thick (to 8m) massively-bedded, partly calcareous, medium-grained basal sandstone unit, informally referred to as the Miad Sandstone taken from Oberhardt & Scott 2003 which is shown in **Figure 3.5**.

Figure 3.5
Lithology of the Walloon Coal Measures (from Oberhardt & Scott 2003)



Separating the upper and lower coal-bearing sequence (Taroom Coal Measures) is the Tangalooma Sandstone a unit characterised by medium-grained, lithic, labile sandstone with an argillaceous matrix and numerous conglomeratic bands (Jones and Patrick 1981). The underlying coal-bearing sequence (Taroom Coal Measures) generally comprises three coal groups or seams informally referred to by QGC geologists as the Auburn, Bulwer and Condamine Seams.

3.5 EXPLORATION DRILLING

3.5.1 Introduction

After an evaluation of available regional geological and drillhole information, a series of sites were selected by CEL within EPC 867 and EPC 869 for potential exploration drilling. The principal aim of the program was to delineate areas of thick Macalister seam development occurring within the 200m to 400m depth range, and thereafter focus exploration on areas where a UCG trial could be undertaken. Given the relative scarcity of available sub-surface data, a regional approach was adopted and drill sites spaced at nominal 5km intervals within a zone where the depth to the WCM was considered optimal.

Whilst the overall objectives of the program remained consistent throughout, the exploratory nature of the drilling necessitated occasional re-evaluation and some changes were made to original site selections, locations and scheduling priorities.

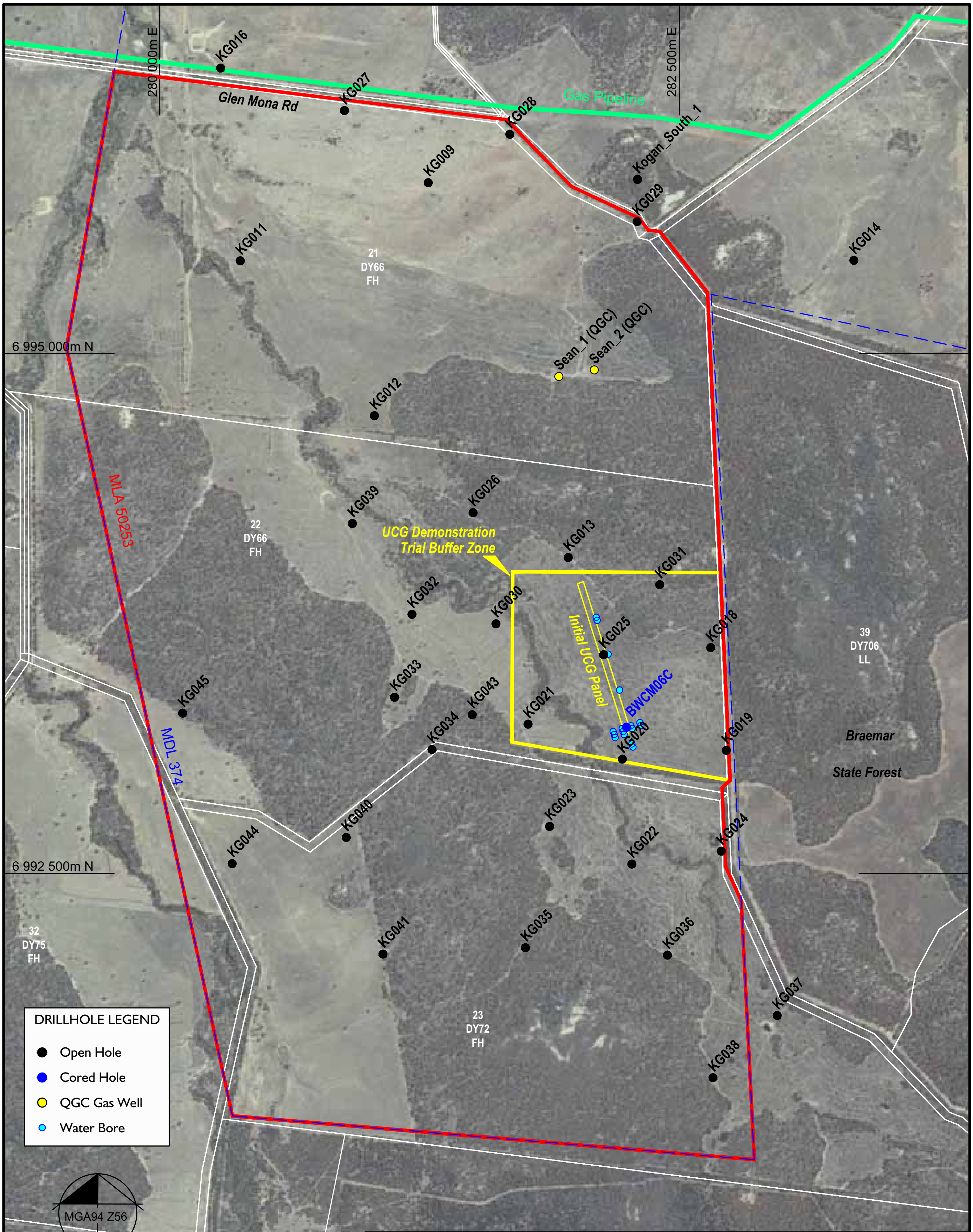
3.5.2 Exploration Drilling Outline

Exploration drilling was undertaken within EPC 867 and EPC 869 between January and March 2007 and comprised 26 open holes including two re-drills for an aggregate total of 7,239m. Hole locations are shown in **Figure 3.6**. The hole prefixes adopted throughout relate to the two tenements currently being assessed, with the Kogan (KG) series holes located within EPC 867 and the Chinchilla (CH) series within EPC 869.

3.5.3 Water Intersections

The intersection of water during the course of drilling created significant operational problems. Nonetheless, major water flows were routinely measured and where not significantly contaminated with drilling fluids tested for pH and Total Dissolved Salt (TDS) levels. A summary of these results is provided in **Table 3.1**.

The majority of significant flows occurred within the Springbok Sandstone unit, and typically from the coarser-grained sandstone horizons. Exceptions to this generalisation were the flows encountered in CH002 and CH002R (Gubberamunda Sandstone) and those from a coarse-grained sandstone unit within the Westbourne Formation (KG004). Whilst water was also intersected in coal seams of the WCM flow rates appear to be relatively minor.



CarbonEnergy

CARBON ENERGY (OPERATIONS) PTY LTD

MDL 374 - Location of Recent Drillholes

Design	N. Rich (Carbon Energy)	20.01.09	Scale	1:25,000	FIGURE 3.6
Drawn	Minserve	20.01.09	Cad File	Ce001c058.dwg	Rev1.1

Table 3.1
Summary of Major Water Flows Encountered during Drilling

			Flow Rate			Quality		
Hole	**Unit**	**Depth**	**V-notch**	**gph**	**L/sec**	**pH**	**TDS**	**Comments**
KG002	SBSS	186	50	620	0.76	8.4	2900	
		TD	65	1100	1.48	8.8	3300	Combined flow
KG004	WBFM	109	50	620	0.78	8.4	3000	
	SBSS	286	70	800	1.00	8.6	2600	
KG005	SBSS	210		~1000	1.30			Casing breach - flow estimated
KG005 R	SBSS	208		~1200	1.50			Casing breach - flow estimated
KG006	SBSS	180	55	780	1.01	8.5	3200	
KG007	SBSS	233	40	350	0.45		3400	
KG008	SBSS	192	65	1100	1.48			
KG010	SBSS	124	45	475	0.60	7.4	3500	
CH001	SBSS	228	70	1430	1.80	8.1	2600	
CH002	GBSS	57	75	1690	2.13	7.5	600	
CH002 R	GBSS	49	70	1430	1.80	7.6	650	
CH003	SBSS	232	60	980	1.23	8.4	900	
		TD	85	2300	2.93	8.5	1000	Combined flow
CH004	SBSS	165		~1000	1.30			Casing breach - flow estimated
CH005	SBSS	187		~500	0.63			Casing breach - flow estimated

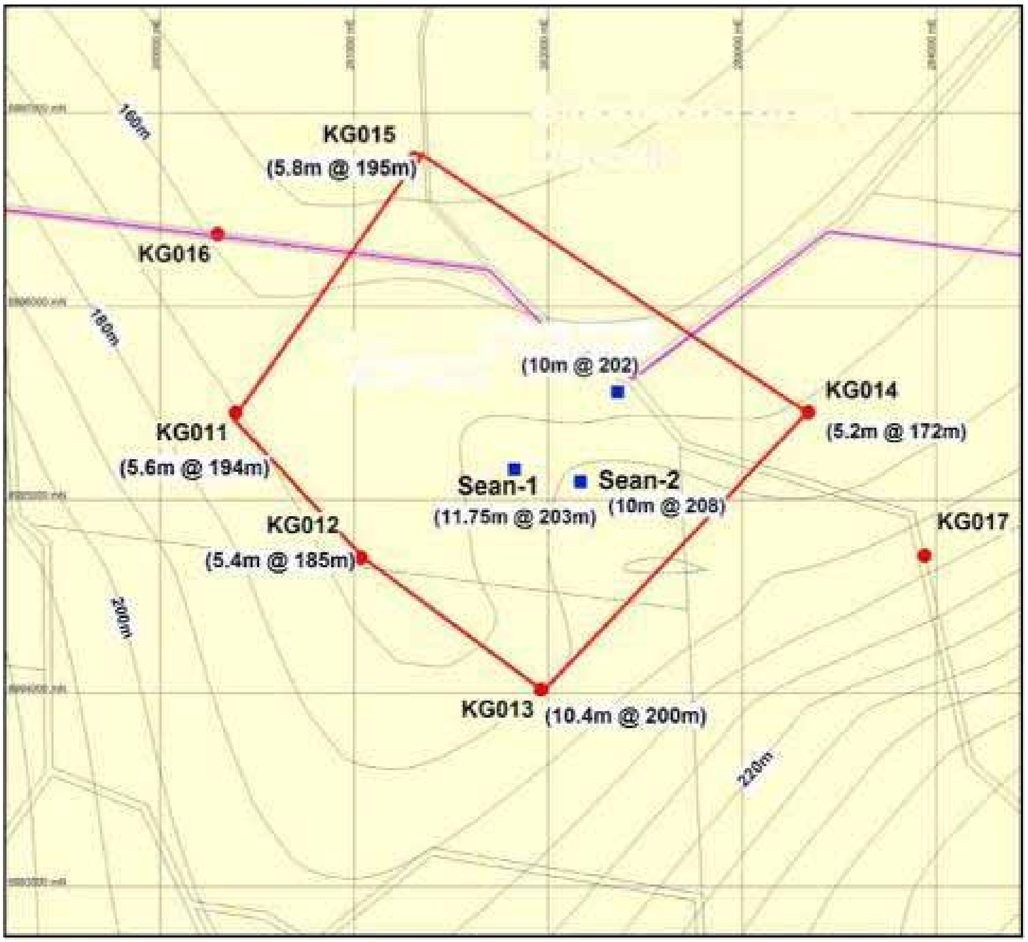
3.5.4 Bloodwood Creek Deposit

An area of thick seam occurrence occurred in the Bloodwood Creek area of EPC 867 where a series of holes were drilled at 1km centres to assess the potential of the site to host a UCG trial. The location of the holes is indicated in **Figure 3.7**. The area was targeted based on the results of previous petroleum (Kogan South-1) and CSG drilling (Sean-1, Sean-2) which intersected a 10m+ thick seam (Macalister) at around 200m depth.

The main Macalister Seam was intersected in all holes and ranged in thickness from 5.2m in KG014 to 10.4m in KG013. Although closer-spaced drilling is required before a thorough assessment of seam continuity and character can be determined some initial observations are warranted. The Macalister Seam is well developed in the Bloodwood Creek area and the deposit delineated to date has the necessary dimensions to sustain long-term production.

An assessment of structure and depth contours to the top of the Macalister Seam reveals the existence of a localised depression that trends through the deposit in a north to NNE direction. The axis of this shallow syncline also corresponds with the zone of maximum coal accumulation and suggests it may represent a primary depositional feature.

Figure 3.7
Macalister Seam Intercepts in the Bloodwood Creek Area and Depth Contours to WCM



Summary

A series of eight holes drilled in the Bloodwood Creek area partially delineated a thick occurrence of the Macalister seam at depths ranging from 195m to 200m. The seam ranged in thickness from 5.2m in KG014 to 10.4m in KG013, and confirmed results from previous oil and gas drilling indicating net coal thickness of between 9.2m and 10.6m could be anticipated. As is typical for Walloon coals, the seam is prone to lateral thinning and splitting, but current data suggests the thickest accumulation of coal occurs within a shallow syncline that follows a sinuous trace trending north to NNW through the deposit.

4.0 PROJECT DESCRIPTION

The CEL UCG project is planned to develop through three broad stages over a period of three to five years subject to the results of each preceding stage. The proposed EIS will specifically address the Stage 2 component of the overall project. In summary the stages are:

Stage 1 - Bloodwood Creek Commercial and Technical Demonstration Trial – currently approved and operating

A $A25M demonstration trial was commenced in October 2008 to achieve bankability status and to demonstrate the UCG technology and syngas production potential. The trial converted between 100 tonnes and 150 tonnes of coal per day for about 100 days to syngas at a rate of 1 PJ per year from a single coal “panel”.

A schematic representation of the Stage 1 trial is provided in **Figure 4.1**.

The initial trial continued for about 100 days and included an oxygen plant to feed oxygen to the underground gasifier. The gas produced was flared. All aspects of the UCG process were monitored including groundwater hydrology, environmental impacts, content of gas produced and project economics.

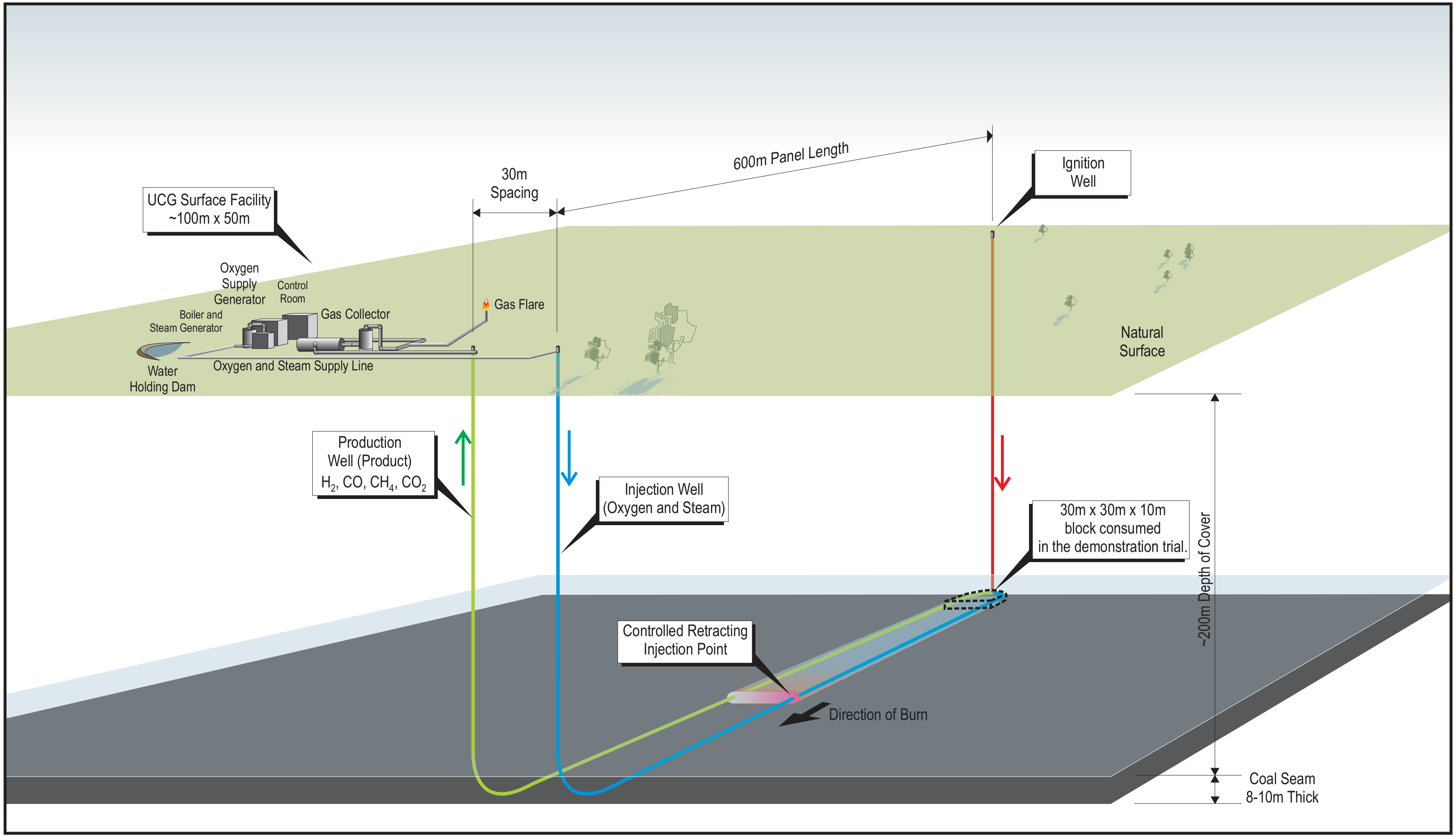
The trial, which demonstrated control over the gaseous components of syngas produced, is continuing as a demonstration of the longer term sustainability of the UCG process. The rate of gasification has been reduced to produce syngas at a rate to generate 5MW of electricity utilising internal combustion gas engines and generators. The generation of 5MW of electricity is planned to commence in January 2010 and will continue to the end of 2011.

Stage 2 - Commercial Gas Production – the subject of the proposed EIS

The 100 day demonstration trial successfully demonstrated the UCG technology and the production of commercial quantities of syngas. The commercial rate of gas production is planned to be increased in Stage 2 up to 40+ PJ per year. The Stage 2 plant will involve considerable engineering design and exploration and panel development drilling technology.

Carbon separation and sequestration is being investigated and will be included in the project.

The commercial production of up to 40+ PJ per year of syngas and the construction and operation of 30MW of power generation capacity is the subject of the IAS and the proposed EIS.



CARBON ENERGY (OPERATIONS) PTY LTD Initial Advice Statement					
Commercial and Technical Demonstration Trial Schematic Representation UCG - One Panel					FIGURE 4.1
Design	A. Armstrong	08.07	Scale	NTS	
Drawn	Minserve	08.07	Cad File	Ce001c064.cdr	Rev 1.0

The successful outcome of the mining lease application process and the environmental authority approval process will be:

(a) The capacity to produce up to 40+PJ of energy in the form of syngas produced as a result of underground coal gasification on a granted mining lease;

(b) A 5MW electrical power generation plant based on internal combustion engines fueled by syngas which already exists on the mining lease application area; and

(c) A nominal 20MW electrical power generation plant based on a gas turbine fueled by syngas.

This stage of the project will require considerable input from all levels of government, investors, utilities and local and regional communities.

Stage 3 – Power General, Ammonia, Fertilizer and Explosives Production, Methanol Production and Coal to Liquids – future potential industries

Research, demonstration trials and practical projects have been conducted both in Australia and internationally to provide the evidence of the feasibility of CTL.

The third development stage of the CEL UCG project over an approximate period of five years will result in the production of Bloodwood Creek electricity, diesels, naphtha and various transport fuels and chemicals and fetilizers. The products of the UCG process will be the input stream for a Fischer-Tropsch reactor to produce long-carbon chain fuels.

This stage will require very large capital investments which will be secured only by proven methodology and technology, sound mining tenure and community and government support.

The Stage 3 projects will require specific statutory approvals depending upon the details and capacity of the various projects which will utilise the syngas produced in the Stage 2 phase.

4.1 STAGE 1 - BLOODWOOD CREEK COMMERCIAL AND TECHNICAL DEMONSTRATION TRIAL

CEL engaged Thomas & Coffey Pty Ltd a major Australian consulting engineering company to design and construct the demonstration project to provide definitive information on the commercial and technical feasibility of UCG. The budget for the demonstration trial was about $A25M.

The site selected was within EPC 867 and MDL 374 as indicated on **Figure 3.6** in the general vicinity of Bloodwood Creek.

The initial component of the demonstration trial was nominally a 100-day trial within the four month period from 1 October 2008 to the end of January 2009.

Relevant demonstration trial design parameters were:

i) The coal "panel" was 600m by 30m and about 10m thick. The 100-day trial consumed a block of coal measuring approximately 30m by 30m by 10m thick commencing at the ignition point and retreating along the horizontal sections of the injection and the production wells.

The rate of coal consumption was between 100t and 150t per day.

ii) The production rate of gas was 1 PJ per year. The gas was flared during the 100-day trial.

iii) The feed or injection gas was steam and oxygen. The onsite oxygen plant had the capacity to produce approximately 70t oxygen per day and the boiler produced approximately 50t of steam per day.

iv) Onsite power was supplied by a conventional diesel generator with plans to utilise the syngas product to supply energy to the project as a parasitic load.

v) The demonstration trial was comprehensively monitored for:

- Syngas composition and rate of production
- Temperatures throughout the trial site and other operational parameters
- Hydrology, four sets of three monitoring bores were installed surrounding the coal panel to monitor water quality and hydrostatic heat in three local aquifers
- Environmental impacts including noise, air quality, presence of contamination, etc
- Resource recovery and utilisation.

vi) The trial controls were designed so that variables particularly the oxygen and steam feed in the injection well were changed to exert and measure control over the UCG process.

Stage 1 was a bankable feasibility trial which provided definitive commercial and technical data. The Stage 1 trial was the foundation upon which additional investment was made available to CEL to enable it to move to Stage 2.

The initial 100 day demonstration trial finished at the end of January 2009.

The rate of coal gasification was reduced by replacing the oxygen and steam content of the feed injection with air injection. The trial will continue at the lower gasification rate to demonstrate longer term sustainability of the UCG process. The syngas produced will be utilised as fuel for internal combustion gas engines coupled to generators with a nominal capacity of 5MW of electrical generation.

4.2 STAGE 2 – COMMERCIAL GAS PRODUCTION

Stage 2 is planned to expand UCG to approximately 40 panels to produce a feed gas for power generation, ammonia and fertilizer production, methanol production, methane production for LPG and/or any other uses deemed feasible at the time. The initial production rate will be progressively upgraded to a target production rate of 40 PJ per year. Specific features of the Stage 2 project are:

- Commercial and profitable production rate of syngas for electricity generation in a combined cycle gas turbine

- Multiple UCG panels joined in parallel feeding into a substantial surface facility which will clean and compress the gas before delivery to a pipeline or directly to a power generation plant
- CO_2 separation which will upgrade the quality of the syngas. An assessment of the alternatives for CO_2 sequestration will be undertaken at this stage.

A 40 PJ per year production facility would consume approximately 2Mt coal per year and the UCG site would cover an area of about 1km^2 at the Bloodwood Creek site on MLA 50253. The proposed site on MLA 50253 contains a suitable coal resource of at least 100Mt and there are similar sites identified on CEL's EPCs hence a very large potential resource for UCG to move to the next planned stage.

4.3 STAGE 3 – POWER GENERATION, AMMONIA, FETILIZER AND EXPLOSIVES PRODUCTION, METHANOL PRODUCTION AND COAL TO LIQUIDS AND GAS TO LIQUIDS

As discussed above, CTL and other products have been on the international energy agenda for many decades. The Sasol Project based in South Africa currently produces approximately

150,000 barrels/day of liquid fuels from CTL. An assessment of CTL and GTL at the Surat Basin sites has been undertaken by CEL and the potential exists for a Fisher-Tropsch process to produce various transport fuels and other products.

Other potential industries could be developed directly on a CTL/GTL plant including the production of urea as a fetilizer. This would be effective in utilising a significant proportion of the waste CO_2 produced during the gasification process.

5.0 DESCRIPTION OF EXISTING ENVIRONMENT

The proposed EIS for the project will present detailed studies of all aspects of the existing environment in response to the requirements of the ToR for the EIS. It is anticipated that the following detailed studies will be undertaken:

- Air quality
- Noise
- Nature conservation including flora and fauna and comprehensive ecological assessments
- Soils and land use
- Surface and groundwater hydrology
- Cultural heritage both Aboriginal and European
- Social impacts
- Other studies may be required as agreed during the ToR process.

The IAS will provide a brief overview of the existing environment to provide a contextual background for the proposed project.

5.1 CLIMATE

Two sets of climate statistics are presented in **Table 5.1** for general information, viz:

Dalby Post Office: Data collection commenced in 1870 and finished in 1992 - >100 years of record.

Dalby Airport: Data collection commenced in 1992 and is ongoing - 15 years of record.

The Bloodwood Creek demonstration trial site is located approximately 40km west of Dalby.

Table 5.1
Selected Climatic Annual Averages - Dalby

Statistical Element	Dalby Post Office	Dalby Airport
Mean monthly maximum TºC	26.2	26.9
Mean monthly minimum TºC	11.9	12.0
Highest monthly TºC	45.6	41.7
Lowest monthly TºC	-7.2	-6.2
Mean rainfall mm	676.4	607.4
Highest monthly rainfall mm	1,270.4	847.0
Lowest monthly rainfall mm	268	421
Mean daily evaporation mm	5.6	6.2

Source: Bureau of Meteorology www.bom.gov.au

The climate is generally described as a subtropical with hot, wet summers and warm dry winters. The prevailing winds are easterly and south-easterly during the summer months and southerly during the winter months.

5.2 AIR QUALITY

5.2.1 Description of Environmental Values

The project is located in a rural environment with air pollutants generated by fossil fuel combustion limited to local motor vehicle traffic and farm machinery. Thus, dust rather than SO_x and NO_x is the key contaminant that affects local air quality. Given the activities on surrounding lands, the potential contributors to observed dust levels in the project area are:

- Farming activities including land cultivation and grazing
- Wind blown dust from exposed soils
- Traffic on unsealed roads including rural access roads
- There are no significant sources of SO_x and NO_x or greenhouse gas emissions at the proposed mining site.

Climatic factors affect dust levels in several interrelated ways. Soil moisture affects the resistance to wind erosion, while humidity can influence the distance that a dust plume may travel after mobilisation by wind or traffic. Relevant features of the climate, including observed wind strength and seasonal variations will be presented in the Air Impact Assessment Report proposed to be undertaken in the EIS.

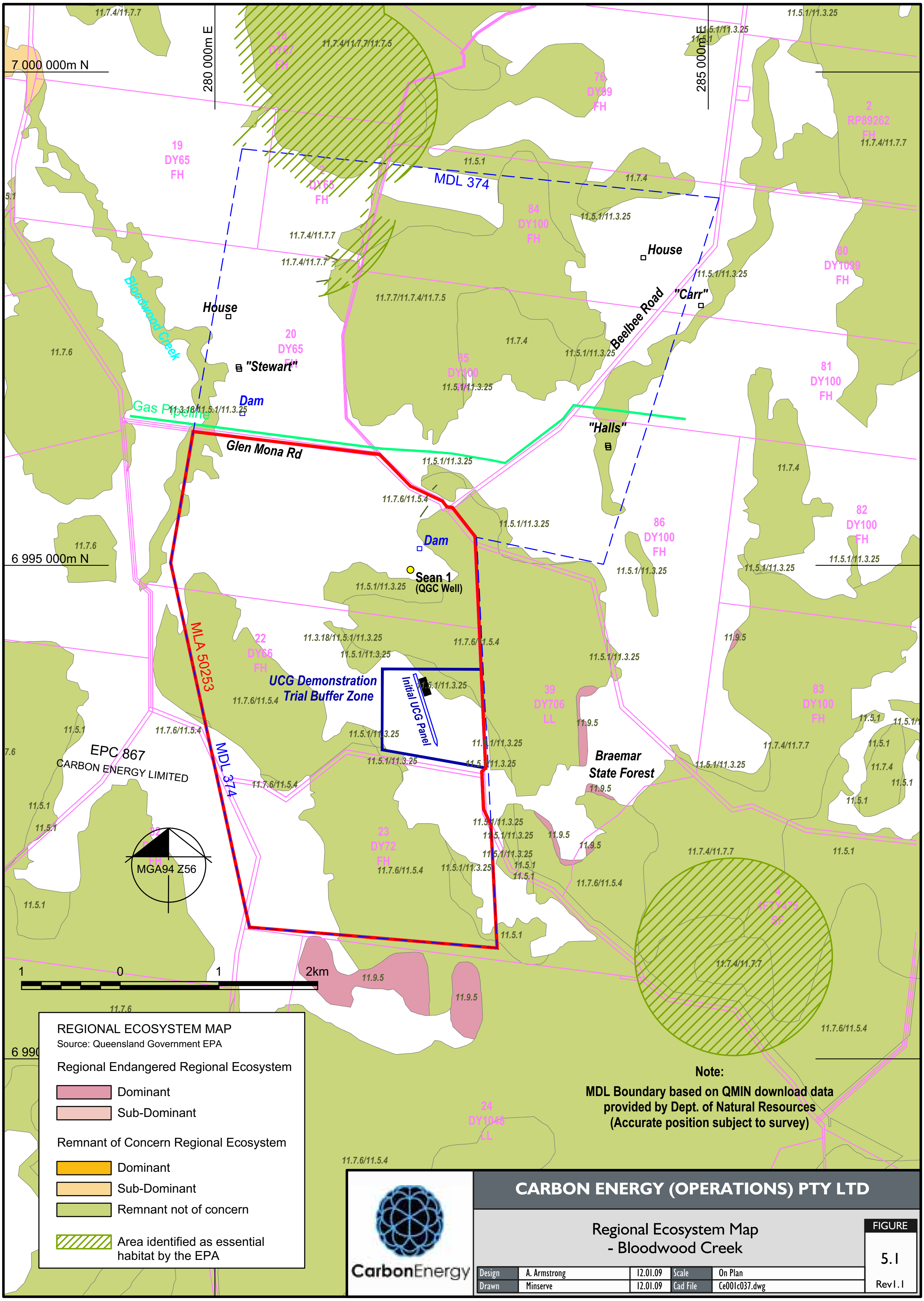
5.3 NOISE

The proposed project area and surrounding lands are generally rural farm/grazing properties and the existing noise environment is typically rural. Typical noise sources are associated with farming activities such as stick-raking and blade-ploughing with smaller bulldozers such as the Caterpillar D5.

The nearest rural residence is approximately 3km from the proposed demonstration trial site. It is unlikely that unacceptable noise will be experienced at this residence during the demonstration trial.

5.4 NATURE CONSERVATION

As indicated on the aerial photography of the proposed demonstration trial site presented in **Figure 3.6** and in the vegetation map presented in **Figure 5.1**, considerable vegetation clearing has taken place including blade-ploughing and stick-raking. The cleared land is managed by the landholders to establish improved pastures based on native graminoid species for cattle breeding and fattening. Opportunistic crops are grown on better soils when soil moisture levels are relatively high to support crop production. Either forage or grain crops are produced.



7 000 000m N
280 000m E
285 000m E
6 995 000m N
MDL 374
MLA 50253
EPC 867
CARBON ENERGY LIMITED
Glen Mona Rd
Beelbee Road
Bloodwood Creek
Gas Pipeline
House
"Stewart"
"Carr"
"Halls"
Dam
Sean 1
(QGC Well)
UCG Demonstration
Trial Buffer Zone
Initial UCG Panel
Braemar
State Forest
MGA94 Z56
1
0
1
2km
REGIONAL ECOSYSTEM MAP
Source: Queensland Government EPA
Regional Endangered Regional Ecosystem
Dominant
Sub-Dominant
Remnant of Concern Regional Ecosystem
Dominant
Sub-Dominant
Remnant not of concern
Area identified as essential habitat by the EPA
Note:
MDL Boundary based on QMIN download data
provided by Dept. of Natural Resources
(Accurate position subject to survey)
CarbonEnergy
CARBON ENERGY (OPERATIONS) PTY LTD
Regional Ecosystem Map
- Bloodwood Creek
FIGURE
5.1
Rev1.1
Design
A. Armstrong
12.01.09
Scale
On Plan
Drawn
Minserve
12.01.09
Cad File
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The regional ecosystems (RE) remaining in the general area of the demonstration trial are also indicated on the aerial photography in **Figure 5.1**. The predominant RE in the local area is described as 11.5.1 in the EPA Regional Ecosystem Description Database (REDD), Version 5.1, Updated June 2007. The description provided in REDD is:

> "Eucalyptus crebra and/or E. populnea ± Angophora leiocarpa ± E. pilligaensis (in south of bioregion) dominate the woodland (to open-woodland) canopy. A low tree layer dominated by Allocasuarina luehmannii ± Melaleuca decora ± Callitris glaucophylla ± C. endlicheri is usually present. In some areas Allocasuarina luehmannii low woodland is the dominant layer. The ground cover is usually sparse and dominated by perennial grasses. Occurs on Cainozoic sand plains, especially outwash from weathered sandstones. Duplex soils with sandy surfaces. Major vegetation communities include: 11.5.1a: Eucalyptus populnea woodland with Allocasuarina luehmannii low tree layer."

This RE is classified as "not of concern" under the Vegetation Management Act and has been given a "no concern at present" biodiversity status.

The second RE in the general area is 11.7.6 described in REDD as:

> "Corymbia citriodora and/or Eucalyptus crebra woodland. On adjacent foot slopes, scattered E. crebra, C. clarksoniana and C. tessellaris may occur. There is usually a distinct tall shrub layer often dominated by Acacia spp. The ground layer varies from sparse to moderately dense and is dominated by perennial grasses. Occurs on Cainozoic lateritic duricrust."

This RE is also classified as "not of concern" and "no concern at present" as for 11.5.1 above.

Other REs in the general area are:

11.3.25 - Eucalyptus tereticornis or E. camaldulensis woodland fringing drainage lines classified as "not of concern".

11.5.4. - E. crebra, Callitris glaucophylla, C.endlicheri, E. chloroclada on Cainozoic sand plains and remnant surfaces often on deep sands, classified as "no concern at present".

The closest endangered RE is 11.9.5 - Acacia harpophylla and/or Casuarina cristata on fine-grained sedimentary rocks located approximately 4km from the proposed demonstration trial site.

The Commonwealth Department of the Environment and Water Resources has compiled a database of matters of national environmental significance under the Environmental Protection and Biodiversity Conservation Act. A search of the database for the proposed project area has been conducted.

The project will not encroach upon endangered or "of concern" REs and the surface infrastructure will be located in cleared lands with some degree of flexibility. Minor clearing of vegetation - "not of concern REs" - may be required to locate well sites and exploration drill sites in relation to the coal resource. The location of surface pipework may also require limited clearing in the Stage 2 project subject to the final design production capacity.

5.5 SOILS AND LANDFORM

The predominant soils of the proposed demonstration trial site and the general surrounding areas are described in the Central Darling Downs Land Management Manual published by the Department of Natural Resources in 1999 as being within the Land Resource Areas (LRA):

- Ironbark/Bull Oak Sodosols; and
- Sandstone Forests.

Other soil types and LRAs will be described in detail in the soil survey and land use report contained in the EIS.

The Land Resource Area described as Ironbark/Bull Oak Sodosols are found on gently undulating plains on sandstone and rises on sandstone. They are bleached sands to loams over mottled grey or yellow clays. The vegetation complex is generally as described above i.e. narrow leaved ironbark, bull oak, cypress pine, rusty gum and poplar box open forest.

The Sandstone Forest LRA is found on rises and undulating plains on sandstone which is often lateritised. Commonly the rises grade into plateaus and low sandstone hills where lateritic scarps are common.

The soils are generally bleached sands to loams over mottled grey or yellow clays grading to shallow gravelly sands to loams and deep sands. The vegetation is generally similar to that described for the Sodosols above.

A typical soil for the area is identified as a Braemar soil, the characteristics of which are:

i) Brief Description

Braemer is a texture contrast soil with a bleached sandy surface over mottled, yellow or grey clays subsoils on coarse-grained sandstones.

ii) Landform and Distribution

- Gently undulating sandstone plains, mainly occurs west of the Condamine River on the Kumbarilla Ridge.

iii) Vegetation

- Open forest of bull oak or bull oak and cypress pine with associated narrow-leaved ironbark, rusty gum and occasionally paperbark tea tree
- Partly cleared
- Regional Ecosystem (RE) 11.5.1.

iv) Example Soil Profile Description

Depth (cm)	Description
0-5	Very dark greyish brown; sandy loam; massive; clear to:
5-15	greyish brown; sandy loam; conspicuously bleached; massive; clear to:
15-30	light grey; sandy loam; conspicuously bleached; massive; sharp to:
30-60	brown sandy clay; strong coarse columnar structure; clear to:
60-120	mottled; greyish brown; sandy clay; massive.

v) General Soil Features

- Texture contrast soil with a sharp change between the surface soil and the subsoil
- **Surface soil**: greyish brown, dark brown, hardsetting loamy sand to sandy loam, commonly 20-40cm thick. A bleached subsurface layer varying in thickness occurs above the subsoil. Slightly acid to neutral (pH 6.0-7.0)
- **Subsoil**: greyish brown, yellowish brown or brown clay, which is mottled and impermeable. Strongly alkaline (pH 8.5). Generally strongly sodic and highly saline
- Plant Available Water Content (PAWC) is very low (<50mm)
- Responds to N, P, K, Cu, Zn and Mo.

vi) Land Use Limitations

- Very low fertility, low PAWC, shallow rooting depth and hardsetting surfaces
- Shallow surface soil and impermeable subsoil make these soils extremely susceptible to erosion and waterlogging
- Sodic and relatively impermeable subsoils susceptible to gully and tunnel erosion if exposed
- Root penetration into the subsoil is negligible due to the high bulk density of this horizon
- Regrowth, particularly of cypress pine and bull oak when cleared
- Siting of dams needs careful consideration
- Many farmers have found that developing this type of country provides very little return on initial investment.

vii) Land Use Suitability

This soil is best left in its native state, and used for timber production and nature conservation. Suitable for grazing native pastures only.

- Key native pasture species include: black speargrass, wiregrass
- Good bee and native conservation country
- Narrow-leaved ironbark and cypress pine may be useful farm and millable timber.

viii) Best Management Practices

Cropping

- Not recommended.

Vegetation

- Conservation status of remnant vegetation is currently "not of concern"
- Planning guidelines and restrictions apply to clearing and land development.

Grazing

- Strategic grazing and spelling of pastures is required to maximize pasture vigour
- Development of this soil may cause severe loss of soil from wind and water erosion through exposure of the dispersible, sodic subsoil
- Siting of dams and stock watering points requires careful consideration
- Recommend strategic thinning of timber using chemical methods. Mechanical methods only will result in severe regrowth problems
- Adjust stocking rates to suit seasonal conditions
- Stock rates *native pasture* 1 AE/10-15ha.

5.6 SOCIAL AND ECONOMIC ISSUES

The demonstration trial site is located within the Dalby Regional Council administrative area.

The small township of Kogan is approximately 15km by road to the northwest of the project site. Dalby is approximately 50km east of the project site along the Dalby Kogan Road and Chinchilla is approximately 70km west of the project site.

The local area is rich in both agricultural and coal resources. Recent industrial developments include the Kogan Power Station and associated coal mine about 20km northwest of the proposed demonstration trial site and the Braemar Gas-fired Power Station is about 10km east. The coal seam gas production companies such as QGC, Arrow, Santos, Origin and others are actively exploring and producing gas for power generation and general consumption.

A detailed analysis of the social environment will be undertaken during the EIS studies and will provide an assessment of the social issues of possible concern to the local communities and to CEL resulting from the proposed UCG development.

The UCG proposal, as it develops through the demonstration, gas production and liquids production stages has the potential to become a new regional industry with attendant population, commercial and economic impacts, both positive and negative. A GTL and CTL industry is a billion dollar capital intensive industry and will attract a significant workforce and commercial opportunities to the regional economy.

5.7 CULTURAL HERITAGE AND NATIVE TITLE

Both the local landholders and the Aboriginal People who have an interest in the lands and CEL have worked in a close cooperative relationship in the past two years during which exploration activities have taken place.

The Barunggam People - descendants of Matilda Daylight and John Warner - and CEL have a registered Cultural Heritage Management Plan in place which directs the way in which cultural heritage materials, items and values will be protected and managed during the life of the UCG project.

At this stage, there appears to be no significant items or values of European post-settlement cultural heritage in the immediate vicinity of the proposed demonstration trial site or project area. A rabbit-proof fence is established on a local property boundary and the integrity of the fence will be maintained during the proposed CEL project.

5.8 COMMUNITY CONSULTATION

A comprehensive community consultation program is planned by CEL, elements of which have already commenced.

The means of consultation will include:

- Local meetings - both public meetings and one-on-one meetings with the local neighbours
- The identification of interested and affected persons for specific communications and information exchange
- Production of communications materials, fact sheets, a website, telephone hot lines
- Advertisements in local newspapers in Chinchilla and Dalby
- At strategic periods, a shop front may be established in Dalby and Chinchilla where local people can view project materials and converse with CEL staff
- At the advanced stages of the project regular newsletters and reports will be disseminated throughout the community and regular meetings will be scheduled and held in Chinchilla and/or Dalby.

6.0 INTERESTED AND AFFECTED PERSONS

6.1 AFFECTED PERSONS

The affected persons for the Bloodwood Creek UCG project are the local landholders shown in **Table 6.1**. Other affected persons are shown in **Table 6.2**.

Table 6.1
Affected Persons

Name	Address	Real Property Description	Tenure
Queensland Gas Company – as landholders and petroleum exploration tenement holder	CEO Queensland Gas Company GPO Box 3107 Brisbane Qld 4001	Lot 21 on DY66 Lot 22 on DY66 Lot 23 on DY72	Freehold Freehold Freehold
R A Dowell, H M Dowell and S R Dowell	17 Riverside Drive Muirlea Qld 4306	Lot 32 on DY75	Freehold
Dalby Regional Council	Chief Executive Officer Dalby Regional Council PO Box 551 Dalby Qld 4405	Beelbee Road, Kerrs Road and other minor gazetted roads	Road Reserve
R A Dowell, H M Dowell and S R Dowell	17 Riverside Drive Muirlea Qld 4306	Lot 24 on DY1048 (adjoining the operational land but not on the operational land)	Leased Lands
The Department of Environment and Natural Resources	Natural Resources Mineral House 41 George Street GPO Box 2454 Brisbane Qld 4001	Lot 39 on DY706 Braemar State Forest (adjoining the operational land)	Leased Lands
R J and D D Hall	MS 687 Dalby Qld 4035	Lot 86 on DY100 (adjoining the operational land)	Freehold
K Willett, L T and P M Ernst	"Kadia" MS 687 1678 Beelbee Road Dalby Qld 4405	Lot 85 on DY100 (adjoining the operational land)	Freehold

Table 6.2
Other Affected Persons

Name	
Ms D Daylight	Formerly spokesperson for the Barunggam People. Ms Daylight has provided an expression of interest in the Aboriginal Cultural Heritage associated with the Woori project

6.2 INTERESTED PERSONS

The interested persons for the Bloodwood Creek UCG project are shown in **Table 6.3**.

Table 6.3
Interested Persons

Name	Address
Rural Action Group	Dalby
Queensland Conservation Council	166 Ann Street Brisbane Qld 4000
Kogan and District Progress Association Inc.	Kogan Qld 4406

7.0 ENVIRONMENTALLY RELEVANT ACTIVITIES

The Environmentally Relevant Activities (ERA) which will be conducted at the project will include:

Table 7.1
Environmentally Relevant Activities

ERA	Description	Aggregate Environmental Score
8(1)(c)	Storage of $10m^3$ or more of class C1 and C2 combustible liquids under AS 1940 or dangerous goods class 3	No score
10	Underground gasification of coal	64
14	Generating electricity by using gas at a rated capacity of 10MW electrical or more	72
15	Fuel burning	35

8.0 PROPOSED FINAL LAND USE

At the completion of the underground gasification of coal at Bloodwood Creek it is envisaged that surface infrastructure will be removed and the current pre-project land use – cattle grazing and fattening – will be resumed. The underground combustion chamber will be flooded by the ingress of groundwater and within weeks and months of the cessation of gasification the underground temperature and pressure will return to normal.

It is envisaged that the land capability classification will not be changed due to the UCG activities. The EIS will address the issue of surface subsidence however it is unlikely that gasification will cause subsidence to an extent that will result in a reduction of the land capability classification.

9.0 PROPOSED WATER USAGE

It is anticipated that potable water will be trucked to the site from a Dalby Regional Council supply. Subject to detailed assessment, the potable water demand may be about 40Ml per year.

Process water will be derived primarily from the UCG operation by recirculation of groundwater, water treatment as required and steam generation. The process water balance will depend upon the demand for syngas and in particular the various gaseous components of syngas. A detailed water balance will be presented in the EIS.

10.0 ITEMS FOR CONSIDERATION IN THE EIS

The matters discussed briefly below will be addressed in detail in the proposed EIS.

10.1 PLANNING SCHEMES AND POLICIES

10.1.1 Smart State Strategy

The UCG project is a new technology applied to an "old" resource and as such dovetails into the Smart State Strategy which is about investment in innovation and skills. The Strategy states that:

> *Sustainable development involves all our resources - energy, water, food, land and sea. The protection of land, rivers and seas is a shared responsibility and it starts with our own practices right now. We will continue to investigate and promote alternative, renewable sources and invest in new research, technologies and processes to improve the way we use our natural resources and minimise impacts on the environment. This will complement and build on our existing investments and partnerships, such as the:*
>
> - *Sustainable Minerals Institute at the University of Queensland, and*
> - *Centre for Low Emission Technology - a joint venture between the Queensland Government, CSIRO, the University of Queensland, Tarong Energy, Stanwell Corporation and the Australian Coal Research Association.*

CEL seeks to work closely and cooperatively with the Queensland Government in the development of the UCG process and the establishment of a viable new industry based on a more efficient use of the State's resources - in accordance with the Smart State Strategy.

10.1.2 Queensland Greenhouse Strategy and ClimateSmart 2050

The CEL UCG project will support and contribute to the objectives of both the Queensland Greenhouse Strategy published in May 2004 and ClimateSmart 2050 published in June 2007 by the Queensland Government.

The aims of the ClimateSmart 2050 strategy as stated by the Queensland Premier are:

- *To engage in national and international efforts to establish emissions trading*
- *To reduce our greenhouse gas emissions by investing in technological innovation in clean coal and renewable energy sources*
- *To support Queenslanders to lower their emissions and conserve water at home, at work and in their local communities.*

The proposed CEL project will contribute to the achievement of the second major aim.

Furthermore, the ClimateSmart 2050 strategy states:

Over the next decade, as Queensland moves to a lower-emission environment, the government will balance the issues of: reducing greenhouse gas emissions, securing low-cost electricity supply to maintain our quality of life, robust economic growth and to support the coal industry—one of Queensland's major economic drivers.

Coal-fired generation will inevitably remain a major part of Queensland's generation mix, along with gas and renewable resources. As Queensland moves to a cleaner energy environment over the next few decades, new coal-fired power stations built in the State will be required to deploy newly emerging clean coal technologies, which provide for carbon capture and storage, and efficient water practices.

Where new generation capacity is required before commercial-scale clean coal technologies become available, coal-fired projects will only be considered where power stations can demonstrate:

- *The integration of electricity generation with carbon capture or with carbon capture and storage, e.g. clean coal technology demonstration plants*
- *they are associated with foreign direct investment in a major energy-intensive project in Queensland, which might otherwise be attracted to a nation that is a Non-Annex 1 country under the Kyoto Protocol, and they adopt best-practice generation technology; or*
- *Security of electricity supply in Queensland is compromised, cannot be economically met by alternative energy sources in the relevant timeframe and the project utilises best-practice generation technology.*

Clean Coal Investments

Coal-based energy sources will continue to be a significant part of Queensland's energy mix with the move to a low-carbon future. Queensland's vast coal deposits and major investments in advancing clean coal technology have the potential to position the State as a global market leader in new energy technologies and carbon capture.

The Queensland Government has also established the Centre for Low Emission Technology which will advance research and development and provide the basis for developing a future strategic direction for electricity generation in Queensland and the rest of Australia. The government also supports the Queensland Centre for Advanced Technologies and its Program of working on cutting-edge solutions to improve the performance of coal.

It is noted that the technology proposed by CEL for UCG has been developed and modelled by researchers at CSIRO working at the Queensland Centre for Advanced Technologies. CEL is 50% owned by the CSIRO who have contributed aspects of the technology to the project for the exclusive use by CEL.

One of the major aims of ClimateSmart 2050 is to reduce the Queensland emissions intensity for power generation from the current level of 0.917 tonnes CO_{2e}/MWhr to

0.794 tonnes CO_{2e}/MWhr in 2011/12. The UCG project proposed by CEL utilises CO_2 capture and storage and aims at an emissions intensity for power generation of 0.33 tonnes CO_{2e}/MWhr. This project will very significantly contribute to the Queensland Government's climate change strategy.

10.2 POTENTIAL EFFECT ON RELEVANT INFRASTRUCTURE

In practice, the CEL proposal to utilise UCG technology for power generation, gas production, liquid fuel production and fetilizer production including carbon capture and storage is the establishment of a new industry for regional Queensland. As such the project will require:

i) A secure water supply of approximately 1ML/day for a 20 PJ gas production capacity will be required. This demand will be reduced where water can be either recycled or sourced from local aquifers. The water supply will involve the local community, the local government authorities, the water supply utilities and State Government agencies and in current drought conditions will be relatively difficult to secure.

ii) Transport facilities will be required, including State roads, local roads, and possibly rail to carry equipment in to and out of the project. This will require transport infrastructure upgrades and approvals.

iii) The product - either gas, power generation capacity, liquids or solids will be carried from the site requiring road, rail, pipelines and powerlines. The infrastructure demands for the export of product from the site will be significant and will require various upgrades.

iv) Carbon capture and storage will involve CO_2 separation at the project site and storage at site or delivered to an appropriate underground repository. This exercise will require separate approvals and infrastructure and will be a complex project within the UCG project scope.

v) Communications will be established and the most recent technology will be required for all forms of voice and data transmissions.

10.3 EMPLOYMENT OPPORTUNITIES

It is anticipated that an operational workforce of up to 200 personnel will be required on a 24 hour 7 day basis when the project is fully developed. In addition, a construction workforce will be required at various stages throughout the life of the project. The flow-on employment generated by the project will be significant and could be up to 600 additional jobs.

The life of the project could be up to 40 or 50 years subject to economics, geology and other factors hence the CEL proposal represents a significant source of regional employment for decades.

10.4 POTENTIAL ENVIRONMENTAL EFFECTS

The potential environmental effects which will be studied in detail and presented in the EIS include:

- Air quality
- Noise and vibration
- Nature conservation
- Soils, land use and rehabilitation
- Surface subsidence
- Surface and underground water quality and quantity
- Contamination issues
- Cultural heritage - Aboriginal and European
- Social impact assessment
- Economic evaluation.

Potential environmental benefits include:

- Lower emissions intensity of power generated using syngas
- The utilisation of carbon capture and storage will further reduce greenhouse gas emissions
- The comparatively lower impacts of UCG over opencut or underground coal mining to produce fuel for power generation.

10.5 STRATEGIC SIGNIFICANCE TO THE LOCALITY, REGION OR THE STATE

Strategic significant issues are:

- A new industry is developed
- Large capital investments will be made in a regional locality in Queensland
- Deep cuts in the emission intensity of power generation are available
- CTL and GTL will be an import replacement project with national significance
- The first practical technical and commercial demonstration of technology developed within the CSIRO will inevitably lead to more UCG projects and applications
- The technology and skills developed will be exported; already CEL has signed MOU with Indian joint venture partners.

11.0 ABBREVIATIONS

Abbreviation	
$A	Australian Dollars
CEL	Carbon Energy Limited
CEOps	Carbon Energy (Operations) Pty Ltd
EIS	Environmental Impact Statement
CRIP	Controlled retracting injection point
CTL	Coal to Liquids
EA	Environmental Authority
EPA	Environmental Protection Agency
EPC	Exploration Permits for Coal
GTL	Gas to Liquids
IAS	Initial Advice Statement
LRA	Land Resource Areas
MDL	Mineral Development Licence
MLA	Mining Lease Application
MW	Megawatt
PAWC	Plant Available Water Content
PJ	Petajoule
QGC	Queensland Gas Company
RE	Regional Ecosystem
REDD	Regional Ecosystem Description Database
TDS	Total Dissolved Salt
ToR	Terms of Reference
UCG	Underground Coal Gasification
WCM	Walloon Coal Measures

12.0 REFERENCES

Beath, A.C., Craig, S., Littleboy, A., Mark, R. and Mallett, C, August 2004. *Underground Coal Gasification: Evaluation Environmental Barriers*. Prepared for CSIRO Energy Transformed Flagship.

Beath, A.C., 2003, *Economic Analysis of Underground Coal Gasification*, CSIRO Report 1159F.

Blinderman MS and Anderson B (2003), *Underground coal gasification for power generation: Efficiency and CO_2-emissions,* 12th Int Conf on Coal Science, 2-6 November, Cairns, Australia.

Brain, T.J., 1984: Authority to Prospect 413C, Dalby, Report on area relinquished from June 21 1984. Open-file company report held by the Queensland Department of Mines & Energy as **CR13044.**

Brown-Kenyon, D., 1985a: Authority to Prospect 411C, Chinchilla, Report on area relinquished from May 25th 1985. Marathon Petroleum Australia Limited (MPAL). Open-file company report held by the Queensland Department of Mines & Energy as **CR14708.**

Brown-Kenyon, D., 1985b: Authority to Prospect 413C, Dalby, Report on area relinquished from June 20, 1985, and Final Report. Marathon Petroleum Australia Limited (MPAL). Open-file company report held by the Queensland Department of Mines & Energy as **CR14923.**

Brown-Kenyon, D., 1986a: Authority to Prospect 411C, Chinchilla, Report on area relinquished from May 25th 1986, and Final Report. Marathon Petroleum Australia Limited (MPAL). Open-file company report held by the Queensland Department of Mines & Energy as **CR15796.**

Brown-Kenyon, D., 1986b: Authority to Prospect 413C, Dalby, Report on area relinquished from June 20, 1986, and Final Report. Marathon Petroleum Australia Limited (MPAL). Open-file company report held by the Queensland Department of Mines & Energy as **CR15797.**

Cahill, Q., 2005: Orana 1, Well Completion Report, ATP 692P, Queensland. Origin Energy.

CSG Limited. Open-file company report held by the Queensland Department of Mines & Energy as **CR38652.**

Cahill, Q., 2005: Origin: Kainama 1, Well Completion Report, ATP 692P, Queensland. Origin Energy CSG Limited. Open-file company report held by the Queensland Department of Mines & Energy as **CR38277.**

Carr, S.D., Dunn, D.L.J. & Hall, D.H., 1982: Authority to Prospect 280C, Tipton, Progress report for the period June 22, 1982 to January 1, 1983. Marathon Petroleum Australia Limited (MPAL). Open-file company report held by the Queensland Department of Mines & Energy as **CR12256.**

Craig MS and Adikary DP (2004), *Preliminary numerical investigation of Groundwater and Subsidence Aspects of Underground Coal Gasification*, CSIRO Exploration and Mining Report 2004/4.

Davis BE and Kendrick RT (1999), Carbon Dioxide Emissions: How Does UCG "Stack Up", *Fifteenth Annual International Pittsburgh Coal Conference,* Pittsburgh.

Davis BE (1999), *A Generic UCG Economic Study prepared for CSIRO,* Coal Conversion Technologies (Restricted Report).

Exon, NF, Milligan, EM, Casey, DJ & Galloway, MC, 1967: The geology of the Roma 1:250,000 sheet areas, Queensland. Bur. Min. Res. Geol. & Geophys., Record 67/63.

Exon, NF, 1976: Geology of the Surat Basin in Queensland. Bur. Min. Res. Geol. & Geophys., Bulletin 166, 160pp.

Exon, NF, 1980: The stratigraphy of the Surat Basin, with special reference to coal deposits. Coal Geology, 1, 57-69.

Green, D.C., 1963: Phillips-Sunray-Queensland American Kogan South No. 1, Authority to Prospect 71P, Queensland. Well Completion Report. Phillips Petroleum Company. Open-file company report held by the Queensland Department of Mines & Energy as **CR1026.**

Houston, BR, 1972: Petrology of sub-surface samples of Mesozoic Arenites of the Bowen and Surat Basins, In, Appendix 2, Geol. Surv. Qld., Report 71, 89-98.

Kyranis, N, 1963: Phillips-Sunray-Queensland American Kogan No. 1, Authority to Prospect 71P, Queensland. Well Completion Report. Phillips Petroleum Company. Open-file company report held by the Queensland Department of Mines & Energy as **CR1006.**

Lewis, JH & Kyranis, N, 1964: Phillips-Sunray Kumbarilla No. 1, Authority to Prospect 71P, Queensland, Well Completion Report. Phillips Petroleum Company. Open-file company report held by the Queensland Department of Mines & Energy as **CR1276.**

Mark R and Beath A (2004), *An Evaluation Of The Potential Environmental Impacts Of Underground Coal Gasification (UCG),* CSIRO Exploration and Mining Report 1187F.

McLean-Hodgson, J & Kempton, NH, 1980: The Oakey-Dalby region, Darling Downs Coalfield: stratigraphy and depositional environments. Coal Geology 1, 165-177.

Nguyen, DL, Renison, M & Gurney, EH, 1995: Southeast Teatree CBM-1, Well Completion Report, ATP 261P, Surat Basin, Queensland. Open-file company report held by the Queensland Department of Mines & Energy as **CR28117.**

Oberhardt, M & Scott, A, 2003a: Kogan North-1, Well Completion Report. Arrow Energy.

Open-file company report held by the Queensland Department of Mines & Energy as **CR35353.**

Oberhardt, M & Scott, A, 2003b: Tipton West-1, Well Completion Report. Arrow Energy.

Open-file company report held by the Queensland Department of Mines & Energy as **CR35355.**

Oberhardt, M & McDonald, A, 2004a: Tipton West-4, Well Completion Report. Arrow.

Energy. Open-file company report held by the Queensland Department of Mines & Energy as **CR37979.**

Oberhardt, M & McDonald, A, 2004b: Kogan North-3A, Well Completion Report. Arrow Energy. Open-file company report held by the Queensland Department of Mines & Energy as **CR37800.**

Pyle, DE, 1965: Well Completion Report, Union-Kern-AOC Rock Creek No. 1, Authority to Prospect 57P, Queensland. Union Oil Development Corporation. Open-file company report held by the Queensland Department of Mines & Energy as **CR1647.**

Pyle, DE & Dabney, JR, 1965: Well Completion Report, Union-Kern-AOC Wambo Creek No. 1, Authority to Prospect 57P, Queensland. Union Oil Development Corporation. Open-file company report held by the Queensland Department of Mines & Energy as **CR1603.**

R W Fisher & Associates, 1986: Teatree No. 1, Well Completion Report. Petro Energy Limited. Open-file company report held by the Queensland Department of Mines & Energy as **CR15674.**

Queensland Gas Company Limited, 2001: QGC Ridgewood 1, Well Completion Report, ATP 621P, Queensland. Open-file company report held by the Queensland Department of Mines & Energy as **CR33557.**

Queensland Gas Company Limited, 2002a: QGC Sean 1, Well Completion Report, ATP 648P, Queensland. Open-file company report held by the Queensland Department of Mines & Energy as **CR33577.**

Queensland Gas Company Limited, 2002b: QGC Owen 1, Well Completion Report, ATP 676P, Queensland. Open-file company report held by the Queensland Department of Mines & Energy as **CR33582.**

Queensland Gas Company Limited, 2003: QGC Sean 2, Well Completion Report, ATP 648P, Queensland. Open-file company report held by the Queensland Department of Mines & Energy as **CR35293.**

Queensland Gas Company Limited, 2005: QGC Jammat #1, Well Completion Report, ATP 648P, Queensland. Open-file company report held by the Queensland Department of Mines & Energy as **CR38804.**

Reed, W.G., 1980: Well completion report, Fossilwood Creek No. 1, ATP 260P, Queensland. X.L. Petroleum Pty. Ltd. Open-file company report held by the Queensland Department of Mines & Energy as **CR7942.**

Shackley S Reiche A and Mander S (2004), *The Public Perception of Underground Coal Gasification (UCG): A Pilot Study,* Tyndall Centre for Climate Change Research, Working Paper 57, UMIST Manchester, UK.

Sliwa R and Fraser S (2004), *Eastern Surat Basin - Geological Characterisation for Underground Coal Gasification Applications,* CSIRO Exploration and Mining Report 1201R.

Stephens, GJ & Le Gay Brereton, J, 1973: Well Completion Report, Rockwood Creek No. 1, AP191P, Queensland. LSG Australia Inc. Open-file company report held by the Queensland Department of Mines & Energy as **CR4631**.

Swarbrick, CFJ, 1975: Surat Basin, Queensland. In Traves, DM & King, D (eds.),

Economic Geology of Australia and Papua New Guinea, 2, Coal, Aust. Inst. Min Metall., Monograph Series, 6, 312-316.

Union Oil Development Corporation, 1964: Preliminary Final Report, Union-Kern-AOG.

Virtue R (2004, *Underground Coal Gasification Hydrogeological Model Conceptual and Numerical Hydrogeological Model,* GHD Consulting Report.

Wieambilla No. 1, Authority to Prospect 57P, Queensland. Open-file company report held by the Queensland Department of Mines & Energy as **CR1455.**

13.0 SELECTED BIBLIOGRAPHY ON UNDERGROUND COAL GASIFICATION

Cena, R. J., Thorsness, C. B. and Ott, L. L., (1982), *Underground Coal Gasification Data Base,* UCID-19169, California, Lawrence Livermore Laboratory.

Hill, R. W., Thorsness, C. B. Cena, R. J. and Stephens, D. R., (1984), *Results of the Centralia Underground Coal Gasification Test,* UCRL-90680, Lawrence Livermore National Laboratory.

Bell, G. J., Brandenburg, C. F. and Bailey, D. W., (1983), "Arco's Research and Development Efforts in Underground Coal Gasification", pp44-55 in *UCG: State of the Art.*

Cena, R. J., Britten, J. A. and Thorsness, C. B., (1988), "Resource Recovery and Cavity Growth during the Rocky Mountain I Field Tests", pp200-212 in *Fourteenth Annual Underground Coal Gasification Symposium.*

Olness, D, (1982), The Angrenskaya Underground Coal Gasification Station, UCRL-53300, California, LLNL.

Olness, D. U., (1978), The Underground Coal Gasification Station at Lisichansk, UCRL-52572, California, LLNL.

Gregg, D. W., Hill, R. W. and Olness, D. U., (1976), *An Overview of the Soviet Effort in Underground Gasification of Coal,* UCRL-52004, California, LLNL.

Olness, D. and Gregg, D. W., (1977), *The Historical Development of Underground Coal Gasification,* UCRL-52283, California, LLNL.

Davis, B. E. and Jennings, J. W., (1984), "State-of-the-Art Summary for Underground Coal Gasification", *Journal of Petroleum Technology,* 15-21.

Chandelle, V. and Li, T.-K., (1989), *Belgo-German Experiment on Underground Gasification,* Belgium: Commission of the European Communities.

Bailey, A. C, et al, (1989), The Future Development of Underground Coal Gasification in Europe, Brussels, European working group on UCG.

Li, Y, and Deyou, B., (1997), "Hydrogen Production by Undergound Coal Gasification", *Pittsburgh Coal Conference.* Taiyuan, China.

Chinese website {http://www.most.gov.cn/NewsLetter/138.htm}.

North Korean news website {http://www.kcna.co.jp/item/2000/200001/news01/18.htm}.

Energy International website information on Huntly 5-spot test {http://www.nb.net/~eic/part6.htm}.

Walker, L., (2001), "The Commercialisation of Underground Coal Gasification Technology", *Coal to Gas.* Brisbane, Australia.

US EPA, (1999), "In-Situ Fossil Fuel Recovery Wells", *The Class V Underground Injection Control Study,* EPA/816-R-99-014m, US A.

Skafa, P.V., (1975), *Gosudarstvennoe Hauchno-Teknicheskoe* (Underground gasification of coal), California, USA: Addis Translations International.

Bloomstran, M.A. and Andrews, R.D., (1988), "Rawlins UCG Demonstration Plant Environmental Program", *Fourteenth Annual Underground Coal Gasification Symposium.*

Chandelle, V. and Li, T.-K., (1989), *Belgo-German Experiment on Underground Gasification,* Belgium: Commission of the European Communities.

Covell, J. R. and Thomas, M. H., (1996), "Combined Air Sparge and Bioremediation of an Underground Coal Gasification Site", *Ninth Annual IGT Symposium on Gas, Oil, and Environmental Biotechnology and Site Remediation Technology.* Colorado Springs, Colorado.

Dvornikova, E. V. and Kreinin, E. V., (1993), "Interaction of Subsurface Waters With the Combustion Site During Underground Coal Gasification", *Fiziko-Tekhnicheskie Problemy Razrabotki Poleznykh Iskopaemykh,* V29(5), pp73-78.

Kazak, V. N. and Kapralov, V. K., (1993), "Estimating the Size of Protection Pillars in Underground Gasification of Coal Seams", *Fiziko-Tekhnicheskie Problemy Razrabotki Poleznykh Iskopaemykh,* V29(4), pp62-66.

Nordin, J. S., Barrash, W., Barteuax, W., and Nolan, T., (1987), "Groundwater Treatment at the Hoe Creek Underground Coal Gasification Site", *Thirteenth Annual Coal Gasification Symposium.* Laramie, Wyoming.

Olness, D. U., (1978), The Underground Coal Gasification Station at Lisichansk, UCRL-52572, California, LLNL.

US EPA, (1999), "In-Situ Fossil Fuel Recovery Wells", *The Class V Underground Injection Control Study,* EPA/816-R-99-014m, USA.

Davis, D. T. and Lytle, R. J., (1977), In Situ Coal Gasification Burnfront Mapping by Monitoring Reflected High Frequency Electromagnetic Waves, UCRL-52325, Livermore, California, LLL.

Shedden Pacific, (1983), "Pre-Feasibility Study: Underground Coal Gasification: Leigh Creek, South Australia", Melbourne, Shedden Pacific Pty Ltd.