

Bowen Gas Project

INITIAL ADVICE STATEMENT

Prepared for

Arrow Energy Pty Ltd

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Brisbane QLD 4001

Document delivery

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Executive Summary

The proposed Bowen Gas Project (Project) has been designed to assist in meeting the growing demand for gas supply. The Project is located approximately 850 km north of Brisbane and 150 km south west of Mackay, Queensland. It involves the development of coal seam gas (CSG) infrastructure in an area that extends north to south from Glenden to Blackwater.

In the region of 7,000 production wells will be drilled throughout the Project's development area over the approximate 35 - 40 year life of the Project. Development will be staged and areas subdivided into development regions allowing a phased approach to development.

The Project proponent is Arrow Energy Pty Ltd (Arrow), a Queensland-based wholly owned subsidiary of Arrow Energy Holdings Pty Ltd. Arrow Energy Holdings was established in 1997 and listed on the Australian Stock Exchange in August 2000. In August 2010, Arrow Energy Holdings was acquired by CS CSG (Australia) Pty Ltd which is a 50/50 joint venture between a subsidiary of Royal Dutch Shell plc (Shell) and a subsidiary of PetroChina Company Limited (PetroChina).

The purpose of this Initial Advice Statement (IAS) is to:

- Provide the Queensland Department of Environment and Resource Management (DERM) with sufficient information about the project and its potential environmental and social impacts to determine whether to accept Arrow's application to prepare a voluntary EIS under the *Environmental Protection Act 1994* (Qld).
- Enable terms of reference to be developed for the Bowen Gas Project environmental impact statement (EIS).
- Inform key Queensland Government departments and other statutory and public stakeholders about the proposed project.

The Project's development area is predominantly used for grazing and agricultural land, black coal mining and processing, oil and gas development and forestry. Local regional centres include the towns of Glenden, Moranbah, Dysart and Blackwater. The topography is gently sloping and the geology generally consists of fine grained sedimentary rocks, intersected by quaternary alluvium systems associated with creek and river flats, floodplains and alluvial plains.

Development of the project has the potential to impact on some of the areas existing environmental values. Some of the key potential environmental, social and economic impacts could include:

- Incompatibility of CSG development with existing mining and grazing or agricultural activities;
- Impacts to soils, landform and geology during construction and rehabilitation activities;
- Disturbance to significant habitats and remnant vegetation during construction and operation;
- Impacts may occur to the flow and the quality of surface waters during all phases of the project;
- Impacts to the local groundwater regime;
- Adverse impact on local and regional air quality, as well as contributing to global greenhouse gas concentrations;
- Impacts to existing landscape features, panoramas and views;
- Increases in traffic volumes and percentages of heavy truck traffic;
- The potential to interact with areas containing cultural heritage;
- Potential disturbance of known or currently unknown sites of Indigenous cultural heritage significance;
- Impacts on existing businesses and local industry competition for limited resources;

- Competition for skilled labour and technical personnel;
- The ability of local businesses to take up opportunities; and
- Potential to alter the population and demographic profile.

Detailed baseline studies and impact assessments will be undertaken as part of the Project's EIS, which in turn will inform the development of impact mitigation measures and environmental management plans.

The Project will require a number of approvals, including an EIS under Queensland and Commonwealth legislation. Key applications are discussed below:

- Under the *Petroleum & Gas (Production and Safety) Act 2004* (Qld) (P&G Act) approvals will be sought for the following:
- Petroleum Survey Licence, required to access land for survey purposes.
- Petroleum pipeline licence, required for the construction and operation of pipelines.
- Petroleum leases (PLs), required to develop fields and facilities.
- Arrow will apply for an environmental authority (EA) under the *Environmental Protection 1994* Act (Qld) which will govern the extent of activities allowed on each petroleum tenure. Arrow must comply with the conditions of its EA, or have these amended, prior to undertaking significant new work. For projects of significant scale (such as this Project), preparing an EIS is generally considered the most appropriate assessment method to determine if an EA should be granted.
- In accordance with the *Sustainable Planning Act* 2009 (Qld), an activity authorised under the *Petroleum & Gas (Production and Safety) Act* 2004 and subject to a PL is exempt from local government planning schemes. However, any activity outside of the area of a PL (e.g., depots) will require both an assessment under the *Sustainable Planning Act* and relevant local government planning scheme, and development approvals under the planning scheme. Relevant applications will be submitted for such approvals as required.
- Arrow will refer the project to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities for determination as to whether it constitutes a 'controlled action' under the *Environmental Protection and Biodiversity Conservation Act 1996* (C'lth). The decision will be made with consideration of the Project's potential to significantly impact matters of national environmental significance.

1 Introduction

1.1 Overview

The Project proponent is Arrow Energy Pty Ltd (Arrow), a Queensland-based wholly owned subsidiary of Arrow Energy Holdings Pty Ltd. Arrow Energy Holdings was established in 1997 and listed on the Australian Stock Exchange in August 2000. In August 2010, Arrow Energy Holdings was acquired by CS CSG (Australia) Pty Ltd which is a 50/50 joint venture between a subsidiary of Royal Dutch Shell plc (Shell) and a subsidiary of and PetroChina Company Limited (PetroChina).

Arrow is an emerging leader in coal seam gas (CSG) development. In Queensland, it operates gas projects at Moranbah in the Bowen Basin, and around Dalby in the Surat Basin. Arrow's five producing projects currently account for more than 20 per cent of Queensland's overall domestic gas consumption.

Arrow is seeking to develop additional gas reserves in the Bowen Basin for growing overseas gas markets. The Shell and PetroChina investment in Arrow means that it will be underpinned by significant gas field development expertise, established LNG technology, production and supply experience, and industry and market knowledge.

Arrow's current petroleum operations in the Bowen Basin are located approximately 300 km south of Townsville and 150 km south west of Mackay. Their Moranbah Gas Project (MGP) is one of the largest operating CSG projects in Australia. Total gas production for the year ended 30 June 2010 was 17.32 PJ. The Moranbah Gas Processing Facility comprises inlet gas conditioning, four 2.6 MW reciprocating gas engine compressor units, a triethylene glycol gas dehydration unit, and export gas metering and monitoring. The facility is used to process gas for injection into the North Queensland Gas Pipeline which delivers gas to markets in Townsville including Queensland Nickel Industries, Copper Refineries and the Townsville Power Station.

The proposed Bowen Gas Project (Project) is expected to assist in meeting the growing demand for gas supply. The area covered by the Project extends 100 km north and south of Moranbah in Central Queensland, an area in which Arrow holds a number of petroleum exploration and production tenures. The Project also includes tenements approximately 100 km further south near Blackwater. The Project also includes the tenures formerly owned by Bow Energy which was purchased by Arrow in 2011. The locations of the Project's tenements are shown on Figure 1.

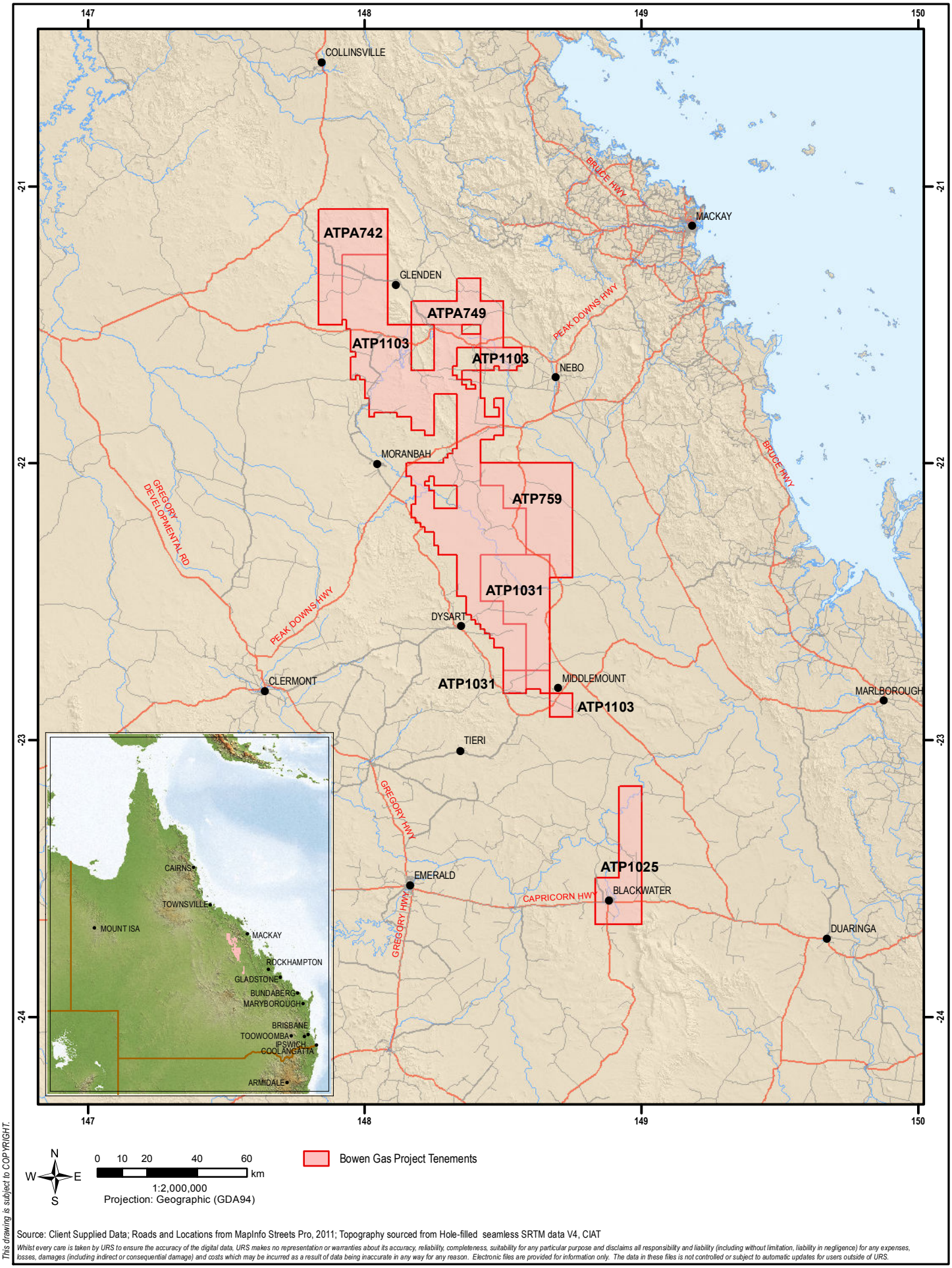
In the region of 7,000 production wells will be drilled throughout the Project area over its 35-40 year life (approximately). Development within the Project's development area will be staged and areas subdivided into development regions allowing a phased approach to development.

Further developments are planned as domestic and export expansion opportunities arise in the energy market.

In addition to providing ongoing supply to the Queensland domestic gas market, Arrow is presently pursuing an export liquefied natural gas (LNG) market opportunity, through the Arrow Energy LNG Project at Curtis Island near Gladstone. Much of the gas produced by the Bowen Gas Project will be piped to the proposed Curtis Island LNG Plant. This plant and the transmission pipeline to it are subject to separate environmental approval processes and are not included in the Bowen Gas Project.

Section 1 Introduction

Before the Project can proceed, Arrow must gain approval from the Queensland and Commonwealth governments. Regulatory authorities must be satisfied that Arrow's activities have been properly assessed, and that appropriate measures are in place to avoid or minimise environmental impacts. To do this, Arrow will prepare an Environmental Impact Statement (EIS) that examines the entire development.



Source: Client Supplied Data; Roads and Locations from MapInfo Streets Pro, 2011; Topography sourced from Hole-filled seamless SRTM data V4, CIAT

arrow energy
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BOWEN GAS PROJECT

BOWEN GAS PROJECT TENEMENTS

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INITIAL ADVICE STATEMENT

Figure: 1

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1.2 The Proponent

Arrow was established in 1997 and listed on the Australian Stock Exchange in August 2000. In August 2010, Arrow was acquired by CS CSG (Australia) Pty Ltd which is jointly owned by Shell and PetroChina. Both companies have an established history of working together on the development of energy projects and bring the technical capabilities, capital backing, major project experience and LNG marketing ability to accelerate the realisation of Arrow's business goals.

Arrow's domestic and international interests span gas field developments, pipeline assets, electricity generation and proposed investment in LNG projects. Arrow currently operates, or is a major participant in, a number of gas production facilities and supporting infrastructure as well as power stations. Within Australia, Arrow has interests in more than 65,000 km^2 of petroleum tenures mostly covering Queensland's Surat and Bowen Basins. These petroleum tenures are located close to Queensland's three key markets – Townsville, Gladstone, and Brisbane. The MGP in the Bowen Basin, and the Tipton West, Daandine, Kogan North Projects in the Surat Basin near Dalby, comprise Arrow's existing gas producing projects.

The company's five producing projects currently account for around 20% of Queensland's overall gas consumption. Most of this gas is supplied to the Daandine (33 MW), Townsville (235 MW) and Braemar 2 (450 MW) power stations with the electricity being sold into the national grid.

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1.3 Purpose of this Initial Advice Statement

This Initial Advice Statement (IAS) has been prepared for Arrow's Bowen Gas Project. The purpose of this IAS is to:

- Provide the Queensland Department of Environment and Resource Management (DERM) with sufficient information about the project and its potential environmental and social impacts to determine whether to accept Arrow's application to prepare a voluntary EIS under the *Environmental Protection Act 1994 (Qld)*;
- Enable terms of reference to be developed for the Bowen Gas Project EIS; and

- Inform key Queensland Government departments and other statutory and public stakeholders about the proposed project.

Detailed baseline studies and impact assessments will be undertaken as part of the EIS, which in turn will inform the development of impact mitigation measures and environmental management plans. As these studies have not yet commenced, the information provided in this IAS is necessarily limited and includes data from desktop studies undertaken to date and current information relating to the Project sites and conditions.

2 Project Context and Justification

2.1 Project Rationale and Need

There is an increasing global demand for cleaner, carbon-efficient energy. Over the past decade, coal seam gas has emerged as a source of energy which produces lower greenhouse gas emissions than other types of fossil fuels. Arrow is a leader in CSG development in Queensland, with the Bowen Gas Project forming part of Arrow's vision to deliver gas to the market by:

- Developing Queensland's gas reserves and presenting a commercially sound and reliable investment in the Queensland economy;
- Developing identified opportunities in export LNG markets at a time when energy supply is in deficit and continued growth of global demand is expected;
- Utilising a fuel source regarded internationally as a cleaner fuel source with lower greenhouse gas emissions compared to other fossil fuels;
- Providing additional resources to supply Arrow's proposed Curtis Island LNG Plant; and
- Strengthening Arrow's position as a leader in CSG development in Australia and globally.

2.2 Project Resource

The Bowen Basin underlies the Duaringa and Surat Basin and extends across an area of approximately 160,000 km^2. The Bowen Basin is one of Australia's major coal producing regions and contains much of the known Permian coal resources in Queensland, which are one of the main targets for the CSG industry. Arrow aims to certify significant CSG reserves with the intent to supply gas to its proposed LNG Plant in Gladstone. The gas resources associated with these deposits are significant and have the ability to supply large volumes of gas for development.

CSG exploration and production within the Bowen Basin has been predominantly associated with the coal measures of the Blackwater group, which have established the Bowen Basin as an important gas resource. The target coal reservoirs within the Blackwater group are the Rangal, Fort Copper and Moranbah Coal Measures. These coal measures are both the source and reservoir of the gas, which is held in the coal measures by overlying rock and hydrostatic (water) pressure. The relatively shallow nature of coal in the Bowen Basin contributes to lower drilling and completion costs, which makes the Project more viable.

2.3 Market Analysis

LNG comprises around 7% of global gas sales. Global production is predicted to increase from 2007 levels of 165 million tonnes per annum to between 245 and 340 million tonnes per annum by 2015 (IEA, 2009).

Australian LNG exports are predicted to rise from 19 million tonnes per annum in 2010/11 to around 41 million tonnes per annum by 2015/16 (ABARES, 2011). Australia's main LNG markets currently include Japan, Korea and China. New markets are expected to develop in India, Thailand, Chinese Taipei and Singapore (ABARE, 2010). Australia's proximity to these existing and new markets provides a significant competitive advantage for local LNG producers. By 2015, Australian LNG

exports from conventional gas fields in Western Australia will be joined by a substantial contribution from coal seam gas fields in Queensland.

The nature of LNG markets has also evolved to the advantage of both producers and customers. Over recent years, a growing global LNG customer base with newly constructed LNG receival and regasification infrastructure has seen the LNG business mature. Trading arrangements are accordingly becoming more flexible.

Strong demand in international energy markets (especially for LNG) and the existence of a gas resource that will contribute to meeting that demand are the primary drivers for the Bowen Gas Project. In addition, new extraction technology, declining reserves in conventional gas fields in eastern Australia, government energy policies, and Australia's advantages over its international competitors in the country's gas resource base, human capital, coal seam gas operating experience and proximity to export LNG markets in East Asia all underpin the viability of the Project.

2.4 Socioeconomic Benefits

The Project is expected to have overall positive socioeconomic impacts on a regional, State and national scale. Expected benefits include:

- Direct employment opportunities through gas field job creation, and indirectly through goods and services provision. Drilling, construction and operational activities are expected to extend through the life of the development. Within the next two years, Arrow expects to almost double its current operational workforce in the Moranbah area. In addition, many jobs will be required in specialist, highly skilled and technical positions. The local government areas covered by the Project's development area are shown on Figure 2.
- Growth of economies in local townships such as Gladstone, Rockhampton, Blackwater, Emerald and Moranbah through the provision of goods and services. Arrow intends a multi-billion dollar initial investment in the project development area (including the Bowen to Gladstone Pipeline and Curtis Island LNG facility). Arrow will continue to use suppliers and contractors from local and surrounding areas wherever possible to maximise local benefits.
- The CSG industry provides diversification to many local and national industries and economies through the introduction of new technology and business in the region.
- Substantial cash flows expected to accrue to the Australian Government through increased Goods and Services Taxes, company tax and personal income tax and to the Queensland Government through royalties and payroll tax.

The Project will synergise with local industry and businesses throughout its life to work towards maximising economic benefits. Coordinating the supply of Project inputs and demand for the commodity outputs will serve to integrate the Project with local and regional industries and businesses

Arrow will investigate the economic impacts of the project on a regional, State and national scale during the EIS process. Among other matters, the EIS will also consider the impact of the gas development on land use and industry in the region. Arrow recognises there may be a shortfall in sectors of the labour market which the EIS will investigate.

3 Permitting Requirements

The Project will require a number of approvals, including an environmental impact assessment under Queensland and Commonwealth legislation.

This section describes the relationship of the Project's approval process to other project proponents' approvals processes, as well as the legislation, regulations, treaties and conventions that might apply to the Project.

3.1 Approvals Processes for Related Projects

This IAS applies to the Bowen Gas Project, Arrow's proposed gas field development in the Bowen Basin.

In the case of export LNG market opportunities, approvals for other related projects are being addressed separately. The related projects are:

- **Arrow Bowen Pipeline (ABP):** The proposed 475-km-long, high-pressure, gas transmission pipeline consists of a main pipeline and several lateral pipelines to convey coal seam gas from Arrow's gas fields in the Bowen Basin to Gladstone for eventual export as LNG. The project is presently undergoing an EIS process under the EP Act
- **Arrow LNG Plant Project:** (formerly the Shell Australia LNG Project). The proposed LNG export facility on Curtis Island will have a base-case capacity of 16 million tonnes per annum (Mtpa), with a total plant capacity of up to 18 Mtpa. The plant will consist of four LNG trains, each with a nominal capacity of 4 Mtpa. The project will be undertaken in two phases of two trains (nominally 8 Mtpa) with a financial investment decision undertaken for each phase. Associated infrastructure includes marine facilities and an approximately 8-km-long, feed-gas pipeline from the Arrow Surat Pipeline to the LNG plant on Curtis Island. A tunnel is proposed for the feed gas pipeline crossing of Port Curtis. The project is presently undergoing an EIS process in accordance with Part 4 of the *State Development and Public Works Organisation Act* 1971. The project is a controlled action under the EPBC Act.
- **Surat Gas Project:** the proposed development of CSG resources in the Surat Basin. This development will include approximately 7,000 production wells and associated infrastructure in an area with known gas reserves adjacent to Arrow's existing development. An EIS under the EP Act has been prepared for this project.
- **Surat to Gladstone Pipeline:** (formerly the Surat to Gladstone Pipeline Project). The proposed 470 km long, high-pressure, gas transmission pipeline extends from the Kogan area of the Surat Basin to Fisherman's Landing at Gladstone. The EIS process for the project was completed on 15 January 2010 under the EP Act and a petroleum pipeline licence (PPL 144) granted in February 2010.
- **The Power Development Project**. This project is to provide electrical power to run the facilities. The power requirements, via network supply and/or construction of power station facilities, are being investigated as alternatives to the supply of power requirements from within the facilities, for both the Surat and Bowen Gas Projects and the Arrow LNG Plant Project.

3.2 Principal Approvals, Licences and Permits

3.2.1 Queensland

The *EP Act and the Petroleum & Gas (Production and Safety) Act 2004* (P&G Act) govern Arrow's petroleum activities.

Petroleum & Gas (Production and Safety) Act

The main purpose of the P&G Act is to facilitate and regulate the carrying out of responsible petroleum activities and the development of a safe, efficient and viable petroleum and fuel gas industry.

Under the P&G Act, approvals will be sought for the following:

- Petroleum Survey Licence, required to access land for survey purposes;
- Petroleum pipeline licence, required for the construction and operation of pipelines; and
- Petroleum leases (PLs), required to develop fields and facilities.

An ATP allows for exploration activities but does not allow the sale of gas. Arrow holds various ATPs and authority to prospect applications (ATPAs) within the Project area which the company must convert into PLs in order to undertake the Project. At present Arrow holds the following ATPs and ATPAs over the area:

- ATPA 742
- ATPA 749
- ATP 1103
- ATP 1031
- ATP 759
- ATP 1025

An application will be submitted for a petroleum survey licence under the P&G Act to authorise access to land to investigate, survey and identify pipeline routes associated with a petroleum pipeline licence.

An application will be submitted for a petroleum licence under the P&G Act for the construction and operation of any pipelines required to transport CSG outside of the area of the PLs.

An application will be submitted for a PL to enable the Project to be developed. The PL will authorise exploration activities as well as CSG production. The development of supporting infrastructure within the lease area will also be authorised. As part of the application for a PL, Arrow will be required to prepare an initial development plan which will describe the nature and extent of activities proposed.

Environment Protection Act

The EP Act is intended to protect the environment of Queensland, and sets out the relevant approval and regulation framework.

Arrow will apply for an environmental authority (EA) under the EP Act which will govern the extent of activities allowed on each petroleum tenure. Arrow must comply with the conditions of its EA, or have these amended, prior to undertaking significant new work. For projects of significant scale, preparing an EIS is generally considered the most appropriate assessment method to determine if an EA should be granted.

The EP Act requires that the Project's likely environmental impacts should be assessed and measures proposed to avoid or minimise any adverse impacts. Arrow proposes to prepare a voluntary EIS for the Project in accordance with the EP Act. The EP Act EIS statutory process involves:

- Application by Arrow to the chief executive to prepare an EIS for a project (s.70);
- Chief executive determines whether an EIS is appropriate for the project (s.72);
- Chief executive prepares a Terms of Reference notice for the project (s.42);
- Public Notification of draft Terms of Reference for comment (s.43);
- Chief executive to issue Final Terms of Reference for the project (s.46);
- Preparation of a voluntary EIS by Arrow in accordance with the Terms of Reference;
- Submission of the voluntary EIS to the chief executive (s.47);
- Chief executive decides whether the EIS addresses the Final Terms of Reference and may proceed to public notification (s.49);
- Public notification of the EIS for comment (s.51);
- Public submissions on the EIS made to the chief executive (s.54);
- Arrow is provided copies of submissions and prepares a response (s.56); and
- Chief executive prepares an Assessment Report making a recommendation whether to approve, approve with conditions, or not approve the project (s.57).

This IAS has been prepared to assist the Chief Executive determine whether an EIS is appropriate for the project (s.72).

Sustainable Planning Act

In accordance with the *Sustainable Planning Act 2009*, an activity authorised under the P&G Act and subject to a PL is exempt from local government planning schemes. However, any activity outside of the area of a PL (e.g., depots) will require both an assessment under the Sustainable Planning Act and relevant local government planning scheme, and development approvals under the planning scheme. Relevant applications will be submitted for such approvals as required.

3.2.2 Commonwealth

The project has been determined to be a controlled action under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on the 15 June 2012. The controlling provisions are sections 18 and 18A (listed threatened species and communities) and sections 20 and 20A (listed migratory species). As a result the project is to be assessed under the bilateral agreement between the Commonwealth and Queensland governments by voluntary environment impact statement under Part 1 of the Queensland Environment Protection Act 1994.

Information on the assessment of projects under the EPBC Act, including referrals and public notices, can be found at: http://www.environment.gov.au/epbc/index.html

3.3 Other Approvals

3.3.1 Aboriginal Cultural Heritage

Section 87 of the *Aboriginal Cultural Heritage Act 2003* (Qld) requires a cultural heritage management plan to be prepared for Project's requiring an EIS, or for cultural heritage to be addressed in a native title agreement, prior to project approval being granted.

3.3.2 Native Title

In accordance with the Commonwealth *Native Title Act 1993*, a native title agreement is proposed over lands for which native title has not been extinguished. The purpose of the *Native Title Act* is to provide for the recognition and protection of native title rights for Australia's Indigenous people, as well as providing a legislative approach for dealing with issues concerning native title.

3.3.3 Other Relevant Conventions, Acts and Regulations

Other legislation, regulations, conventions and treaties that may be relevant to the project are listed below.

International Conventions and Treaties

- Japan-Australia Migratory Bird Agreement (JAMBA)
- China-Australia Migratory Bird Agreement (CAMBA)

Commonwealth Legislation and Regulations

- National Greenhouse and Energy Reporting Act 2007

Queensland Legislation and Regulations

- Aboriginal Cultural Heritage Act 2003
- Electricity Act 1994
- Integrated Planning Act 1997
- Integrated Planning Regulation 1998
- Land Act 1994
- Land Protection (Pest and Stock Route Management) Act 2002
- Mineral Resources Act 1989
- Nature Conservation Act 1992
- Nature Conservation Regulation 1994
- Queensland Heritage Act 1992
- Roads Act 2000
- Soil Conservation Act 1986
- Transport Infrastructure Act 1994
- Vegetation Management Act 1999
- Water Act 2000

4 Project Description

4.1 Location

Arrow's Bowen Gas Project petroleum tenures currently covers an area of approximately 8,000 km^2 within their gas exploration and production acreage, approximately 150 km south west of Mackay, with the bulk of the area extending from Glenden in the north to Middlemount in the south. The project follows the Connors Range to the east and on the Denham Range to the west and is located within the Isaac River and Mackenzie River sub-catchments of the Fitzroy River Catchment and the Belyando Suttor sub-catchment of the Burdekin Catchment.

The area is predominantly used for grazing and agricultural land, black coal mining, metals processing, oil and gas development and forestry. The topography is gently sloping and the geology generally consists of fine grained sedimentary rocks, intersected by quaternary alluvium systems associated with creek and river flats, floodplains and alluvial plains.

The area falls within the Brigalow Belt Bioregion which experiences a subtropical, subhumid climatic zone, with a marked wet summer and moderately dry winter. Mean annual rainfall over most of the area ranges from 500 - 700 mm, with nearly half of the annual rainfall occurring in the summer months of December through to February. Rainfall decreases from north to south and with inland distance from the coast. Cold to moderate annual mean temperatures are prevalent. This bioregion is characterised by previously cleared and degraded grazing lands with patches of regrowth scrub (mostly Brigalow (*Acacia harpophylla*) and eucalypt regrowth) and areas of remnant vegetation (forest woodland dominated by eucalypts, Brigalow and paperbarks, and riparian vegetation associated with the Isaac River and grasslands). The extensive clearing has resulted in remnant vegetation being largely confined to the riparian zones, predominantly along drainage lines, protected areas and unallocated state land.

Other large tracts of vegetation, not located within but in the vicinity of the Project area include the Dipperary National Park north of Nebo, and Homevale, Blackdown Tabelands and Eungella National Parks, and the Arthurs Bluff, Dawson and Duaringa state forests.

A number of towns and built up areas fall within or adjacent to the Project area. These include the towns of Moranbah, Glenden, Dysart, Middlemount and Blackwater. Arrow has excluded these towns from the Project's development area.

4.2 Site Investigations

Preliminary desktop assessment and constraint mapping has been conducted over the Project development area. This desktop study has identified landform, terrestrial flora and fauna and locations of environmental significance that will be considered in infrastructure and facility planning. Targeted field work and ground truthing investigations will be undertaken as part of the EIS.

4.3 Proposed Project Activities

The Bowen Gas Project is currently expected to supply approximately 35% of the Arrow LNG Project's gas requirements, which for the first phase of development is expected to be approximately 520TJ/d, which is inclusive of infield gas usage (approximately 10%).

The Project's development area will be split into development regions for progressive development.

The first stage of the Project will involve the development of four development areas (most likely at Red Hill, South Walker, Coxendeean and Saraji) with around 600 production wells being drilled in the first two years.

Arrow will stagger the development of subsequent resource areas to sustain the required production rate, and increase it subject to the LNG Plant demand. Production well installation, facility construction, operation, decommissioning and rehabilitation will therefore occur concurrently at different locations throughout project life.

The life of a production well will vary in accordance with the density of wells, the gas extraction rate and the production performance of the well. Production performance is predominantly dependent on the physical characteristics of the coal. Modelling of well life is based on probabilities and averages and Arrow's current modelling suggests an average well life of 15 to 20 years. Once the wells cease production, the well sites are decommissioned and rehabilitated and new wells are established in new development areas.

It is important to note that at this stage, it is not possible to be specific about the location of all infrastructure or its design or layout. This is due to a number of factors including:

- The extent of the exploration area that needs to be commercially and environmentally assessed.
- The ongoing identification of viable gas reserves through exploratory drilling and pilot well programs, and the period of time over which this is scheduled to occur.
- The need to refine petroleum development plans as new reservoir data from operating gas fields is collected and assessed.
- The number of production wells and associated infrastructure across the project development area, and the ability to integrate petroleum operations with existing land uses and environmental constraints.

Impact assessment will be based on the premise that detailed knowledge of the environmental values and the processes that threaten those values will inform decisions about whether Project activities are likely to have an adverse impact, assuming activities are conducted according to industry methods and best practice.

For the purpose of this IAS The Project refers to the proposed construction and operation activities for the CSG fields outlined above and specifically does not include:

1. Current exploration or appraisal activities in the Bowen Gas Project development area;
2. Ongoing exploration and production activities for Arrow's Moranbah Gas Project; or
3. Arrow's current activities for supply of natural gas to the domestic market from the Moranbah Gas Project.

4.4 Proposed Infrastructure

As stated above, Arrow will divide the project area into development regions, with timing of the development of each of these regions sequenced to meet production targets. Each development region will include:

- Production Wells - to access the coal seams and evacuate in-situ water, and (separately) evacuate coal seam gas,
- Field Gathering Systems – low pressure pipeline networks to gather water and (separately) gas from the wells for transport to a production facility.
- A Production facility - which may be a:
  - Central Gas Processing Facility (CGPF) - to treat (dehydrate) and compress the gas to export pressure, and pump water to the nearest Integrated Production Facility.
  - Integrated Processing Facility (IPF) - to treat (dehydrate) and compress the gas to export pressure, and treat water for beneficial use.
  - Field Compression Facility (FCF) – a gas pressure boosting station to allow onward transport of remotely located gas to a CGPF or an IPF.
- Associated Pipelines.
- Power Generation and Distribution Facilities.
- Monitoring and Telecommunication Facilities.

Further details are provided below, followed by additional information relevant to the currently proposed infrastructure.

4.4.1 Wells and Field Gathering Systems

Development of each area will comprise the drilling of production wells, the installation of surface wellhead facilities, and the installation of gas gathering and associated water gathering facilities.

Wells

A number of well types are currently under review and it is possible that a variety of well types will eventually be installed. In the base case development scenario, surface-in-seam chevron wells in a dual lateral configuration will be used on a nominal 800 m grid pattern (potential range is 700-1500 m) with an indicative density of one producer well per 65 – 130 ha.

One alternative well type under consideration is a multi-seam hydraulically stimulated vertical well which is particularly suited to regions with complex geology. These wells would have a nominal 600 m grid pattern (potential range is 350-1000 m) with an indicative density of 1 well per 12 – 100 ha. This is due to the need for several water production wells associated with each gas production well.

Prior to drilling a well, a temporary drilling site will be prepared. Preparation will involve construction of temporary pits to hold the fluids used for drilling. In some locations, vegetation trimming may be required. To ensure safe operation of the drilling rig and associated equipment, drilling sites are normally prepared with dimensions of up to 80 m by 80 m.

Once the well is installed, the footprint is reduced to approximately 10 m by 10 m. This is sufficient to house the wellhead and associated equipment. The larger drilling site footprint is then rehabilitated to its original state.

Production wells are typically drilled to between 150 m to 800 m deep. To prevent the loss of water from any upper groundwater aquifers that may be intersected, the top section of each well is cased with steel and cement.

To promote gas and water flow in the well, a specialised rotating blade is lowered to the bottom of the well to ream out cavities in the coal seam. This production zone is then lined with alternating perforated and blank steel casing. Within the casing of each well, a tube is inserted to transport water from each well, separately from the gas.

Artificial lift (most likely a top drive electric powered motor driven progressive cavity pump) is usually installed into the production tubing to allow removal of water released from the coal seam, via the well bore. The removal of water from the well removes the static pressure on the coal seam, thereby releasing gas from the coal seam.

During the well production phase, gas from the well will flow up the annulus (between the liner and the tubing) before exiting the wellhead and entering the metering and control skid. The metering and control skid will comprise gas and water metering, a gas control valve (throttling and pressure management), a control and communications unit, and power to the well. Where downhole well separation proves to be insufficient, surface separators are installed to separate the water from the gas.

Gathering Systems

Each well also requires the construction of water and gas gathering lines, access tracks and electrical connection (where appropriate) to link the well back to a production facility. The water and gas gathering lines are constructed of high-density polyethylene (HDPE) pipe. Gas gathering lines will include low point drains to manage any water not separated from the gas at the wellhead, which may accumulate in low points of the system. Similarly, water gathering lines will include high point vents to allow the removal of trapped gas.

Gathering lines will typically be buried at a minimum depth of 0.75 m. The final depth of burial will be agreed with the landowner to minimise disruption to other land uses and risk of damage to infrastructure.

4.4.2 Production Facilities

Three types of production facilities are currently envisaged with selection dependent on location, and timing of development. These types are described below.

Central Gas Processing Facility

CGPFs are high pressure compression facilities where gas is dehydrated to sales specification and compressed to allow export to the Arrow Bowen Pipeline via a pipeline lateral. CGPFs will also include a water transfer station and transfer dam to facilitate transfer of water to an IPF.

It is currently envisaged that CGPF's will be manned during the day.

CGPFs are expected to have multiple compression trains that will consist of:

- Drive engines and/or motors
- Compressors
- Cooling fans
- Separators and gas dehydration
- Control and safety systems

- Electrical panels
- Station pipework
- Pig launcher / receiver
- Supervisory Control and Data Acquisition (SCADA)
- Control rooms
- Ancillary systems
- Flare and/or vent

It is currently envisaged that the gas dehydration will be comprised of Tri-ethylene Glycol (TEG) units.

At a CGPF, water can be received from the local production area gathering systems, or from gathering systems of adjacent production areas via low pressure trunklines. This water will be collected in a dam and pumped, via a water transfer station, to an IPF.

CGPF's may be co-located with Integrated Power Generation Facilities which will provide power to the facility and to a local area power grid. Alternatively CGPF power could be supplied from an IPF (see below). Connection to the electricity transmission network is also being investigated as an alternative.

Integrated Processing Facility

IPFs will contain the same gas compression and processing equipment as the CGPFs, but will also contain a Water Treatment Facility (WTF) to treat associated water. The term "integrated" is used as the facility contains both gas and water processing facilities.

The volume of associated water expected to be produced over the life of the Project is presently unknown, due to the extensive exploration yet to occur outside the existing field development area. However allowing that some areas will produce more water than others, preliminary assessments indicate that the amount could vary over time between 15 and 50 ML/day

At the WTF, produced water will be collected in feed dams, treated, and then stored onsite for distribution to the end user, which may include irrigation, mine wash water, water utility company water, power station cooling water, town water supply or reinjection.

The feed dam is an important part of the treatment process as it will allow for surge capacity, sediment settlement, homogeneous mixing, liberation of residual volatile compounds and oxidation of some organics and metals.

Reverse osmosis (R.O.) technology is currently being considered as the most appropriate treatment process coupled with some form of suitable pre-treatment. Arrow is undertaking modelling to forecast water production, as well as extensive investigations into short, medium and long term solutions for the beneficial use of associated water and brine. Treatment will produce appropriate quality water for beneficial reuse and will be stored in treated water dams prior to being distributed to customers in the local area.

Brine from the R.O unit will be discharged into concentrated brine dams where salt will concentrate through the evaporation process before it is beneficially reused or ultimately disposed of in registered landfills, or utilised.

It is currently envisaged that the WTFs will also manage and store treated wastewater prior to its disposal, and so will likely also require a chemical storage dam and an oily water dam.

The volume of each dam will be dictated by the quantity of water that will flow through the dam during its life and the need for the pond to attenuate, buffer or store flows.

All dams will have metering on inlets and outlets with telemetry controls on pump rates and levels.

IPF's will be co-located with Integrated Power Generation Facilities which will provide power to the facility and to a local area power grid. Connection to the electricity transmission network is also being investigated as an alternative.

It is currently envisaged that IPFs will be manned during the day.

Field Compression Facility

Where there is insufficient pressure within low pressure flow lines or trunklines to move gas from the wells directly to a CGPF or IPF, Field Compression Facilities (FCF) will be installed to boost the gas pressure to enable the transportation of the gas over longer distances.

Gas will be received at a FCF from the low pressure gathering lines, compressed to medium pressure and discharged to medium pressure infield pipelines which will transport the gas to a CGPF or IPF.

A FCF may contain one compression train or multiple compression trains depending on the quantity of gas being delivered from wells in the area.

It is currently anticipated that an FCF will be operated remotely with manning on a maintenance basis only.

FCFs consist of compression trains that are made up of:

- Drive engines and/or motors
- Compressors
- Cooling fans
- Separators
- Control and Safety systems
- Electrical panels
- Pipework
- Pig launcher
- SCADA
- Flare and/or vent

FCFs will most likely be of skid based modular construction to minimise onsite construction and periods of disturbance.

4.4.3 Power Generation and Distribution

Three power supply options are being investigated for the supply of electrical energy to the Project. These are:

- Grid connection (at high voltage and/or medium voltage)
- Infield integrated electrical power generation at compression facilities (multiple gas-fired reciprocating engine units)
- Stand-alone generators

Key criteria which will be considered for the supply of power to each facility will be safety considerations, environmental considerations, land use considerations, availability, reliability and integrity of power supply, economics, operability and maintainability.

The following sections outline the basis of each solution and how each solution may be adopted to a particular situation. However, the base case to be adopted for the Project is a combination of infield integrated electrical power generation for the facilities and infield local power generation for the wellheads. The infield integrated electrical power generation facilities will be co-located at the IPFs and/or CGPFs, supplying power to that facility and where possible to adjacent facilities (such as FCF) via a local power grid.

Grid Connection

It is expected that bulk electricity supply will be achieved at either 66 kV or 132 kV with the preferred option being to connect to existing state transmission grid and/or distribution infrastructure. Arrow will work with the network service providers to establish, subject to availability and location, suitable 66 kV or 132 kV connections at new zone or local substations on Arrow's petroleum leases in the vicinity of the major facilities to be developed.

Integrated Power Generation

Use of integrated power generation to provide electrical power is the preferred method to be adopted for the supply of power to each IPF or CGPF and, where possible, to a wider area grid to power other facilities. It is proposed to generate power using CSG as a fuel source. The proposed power generation equipment will use high efficiency low emission reciprocating gas engines or other high efficiency technology options.

Stand Alone Generators

Individual local gas powered electrical generators may be used to provide electrical power to the wellheads. In each case the generator will supply electrical power to drive the water pump and control systems. The technology selected for this application will be a high efficiency gas engine with low emission.

It should be noted that alternative solutions (such as distributing power from the processing facilities to each individual wellhead via individual overhead and/or underground lines) will be investigated to determine if there are practical, economic and environmentally acceptable alternative solutions to the use of local generation for each wellhead.

4.4.4 High Pressure Gas Pipeline Infrastructure

Pipeline laterals are large diameter steel pipelines and associated infrastructure that will connect the outlets of CGPFs and IPFs to the inlet of the Arrow Bowen Pipeline which is the high pressure pipeline to be used to transport the gas to the proposed LNG Plant at Gladstone. The Arrow Bowen Pipeline is outside of the Project's EIS scope.

4.4.5 SCADA and Telecommunications

For telecommunications, it is envisaged that the following systems will be deployed in the field:

- Well site telemetry systems.
- Access to Arrow's corporate voice and data network from manned locations, remote offices, etc.
- Mobile (wireless) communications e.g. mobile phones and two way voice communications such as handheld radios and vehicle mounted radios.
- Vehicle tracking (vehicle location, speed, braking force etc.)
- Man down alarms
- Closed circuit television (CCTV) for security and site monitoring e.g. water dam levels
- Intruder detection systems – either perimeter (fence-line) mounted or sub-surface "listening" devices.

These systems will be supported by a combination of a High Speed Backbone Network (HSBN) and Secure Wireless solutions.

The HSBN will interconnect the FCFs, CGPFs and the IPFs as well as extending where required into the well fields. Consideration will be given to extending the HSBN along the length of the Arrow Bowen Pipeline to the Gladstone LNG plant. The HSBN could be accomplished by either buried fibre optic cable or microwave links and would require further study to determine the most cost effective approach. Fibre optic cables will also be assessed for use within upstream facilities to also reduce site cabling installations.

A Secure Wireless System will be used to cover the gas fields and specifically to provide telecommunications to the wellhead sites for telemetry and possibly CCTV applications. Wireless coverage of the field would require a survey to determine the number and location of transmitters.

Consideration will be given for the early installation of the wireless network to facilitate communications during the Project's construction phase.

4.4.6 Existing Infrastructure

Use of existing infrastructure, for example use of spare processing capacity which may be available Arrow's existing facilities at Grosvenor Field, Moranbah East, Peak Downs, Annandale and Moranbah West, together with new facilities developed under separate Environmental Authority applications (preceding the scope of this EIS) will be reviewed for possible reuse as part of the Project's initial field development.

4.4.7 Access

Final infrastructure locations will influence access arrangements for the various Project activities. Vehicular access to well sites will be required, with methods for accessing sites agreed between Arrow and landholders prior to activities commencing. After wells are installed, ongoing operational and maintenance visits to wellheads will be required however the number required will be reduced through the use of remote monitoring.

The establishment of the integrated production facilities will increase construction and operational traffic to the Bowen Basin in general and to facilities sites in particular.

Arrow will identify and assess traffic and road requirements for all of the proposed sites. Arrow will undertake this assessment according to the framework approach set out by the EIS. For further details of the framework approach, please see Appendix A.

4.4.8 Maintenance

During operation of the gas field, regular maintenance will be required. Key tasks to be completed during gas field maintenance include:

- Wellhead equipment maintenance. Field maintenance technicians will visit wells daily for the first few weeks after their installation. This requirement will reduce over time as the well becomes self-sufficient and remote telemetry monitoring provides sufficient access.
- Downhole water pump maintenance. Telemetry systems will alert operators in the event of any downhole pump failures. Should this occur, workover crews will conduct work at the well to extract and repair the pump.
- Gas compression, water treatment, power stations and electrical infrastructure. Facilities will be configured to enable scheduled maintenance to be conducted.
- Re-drilling wells. Occasionally wells may fail and repairs are unsuccessful. This would require a new well to be drilled in close proximity to the initial well (with limited additional ground disturbance).
- General monitoring. Arrow's various project activities are appropriately monitored for environmental performance, including noise, water quality, upper aquifer and dam water concentrations.

4.4.9 Decommissioning and Rehabilitation

Once installed, production wells generally operate for at least 15 to 20 years. Over time the gas production rates from individual well decline and when they are no longer commercially viable, the wells are decommissioned. Decommissioning typically involves removing the wellhead, cutting off the casing at least 1.5 m below ground level, plugging the well hole with concrete, and rehabilitating the site to its former use (in consultation with the landholder). Access roads may be left in place if the landholder wishes or if the road was in existence before the well was developed. Otherwise, access roads are also rehabilitated. Similarly, when gas compression and water treatment is no longer required, these facilities will also be decommissioned and the sites rehabilitated.

4.4.10 Management of Occupational Health and Safety

Arrow deploys the "Target Zero" occupational health and safety system. Arrow believes that no less than zero harm is acceptable and no other goals matter if people are injured in the process of achieving them.

Target Zero exceeds the occupational health and safety requirements as detailed in Australian Standard (AS/NZS) 4801 and International Standard OHSAS 18001. The system focuses on accountability, visible leadership and integration of safety into all business practices, as well as specific action items to drive changes and sustain gains. Target Zero involves 11 main activities, bound by a commitment to continuous improvement. These include:

- Leadership & Commitment
- Risk Management
- Change Management
- People
- Incident & Emergency Management
- Asset Management
- Information Management
- Customers, Contractors & Suppliers
- Communication & Consultation
- Performance Monitoring, Measurement & Reporting
- Systems Review.

Arrow considers safety performance begins with unwavering leadership that starts at the top and extends to all levels of the company to help recognise and respond to risks and problems. This drives improvements in equipment, processes, work methods, and individual and group performance. Target Zero is continually reviewed by Arrow's senior management to ensure continued suitability, adequacy, and effectiveness of the system.

4.5 Working with Landholders

Arrow recognises every piece of land as unique. The company is committed to working closely with landholders to ensure work practices minimise impacts on land and existing agricultural activities.

Prior to undertaking any activities on private property, including environmental investigations, Arrow communicates with landholders. When determining temporary and permanent locations for plant and equipment, all aspects of the property are considered in consultation with the landholder. Agricultural activities, stock considerations, seasonal conditions, topography, drainage lines, service corridors and vegetation and fauna communities are all taken into account.

Arrow's preference is to develop working relationships with landholders on whose properties they would like to operate, and work together with landholders to resolve concerns. Arrow prefers to work with landholders to gain voluntary access agreements.

Under legislation, companies like Arrow have a set of rights and obligations with respect to the accessing of the resource and the land under which the resources are located. More details can be found at www.dme.qld.gov.au/mines/petroleum_gas_exploration.cfm.

4.6 EIS Schedule

Target dates for the project are provided in Table 2. This program shows the environmental approvals process commencing in Q1 2012, with a decision made on the project in Q2 2013. Arrow aims to submit the draft EIS for government review in Q4 2012.

Table 1 Target EIS Program

Milestone	Target Milestone
IAS	Q1 2012
EPBC Act Referral	Q1 2012
Final Terms of Reference	Q2 2012
Draft EIS submission	Q4 2012
Public Notification and Submission phase	Q1 2013
EIS Supplementary Report	Q2 2013
Chief Executive Department of Environmental and Resource Management assessment report	Q2 2013

5 Risk-Based Framework Approach

The EIS will inform a risk-based environmental management framework. The principal objective of the framework approach is to protect the environmental values of the project development area, and to identify appropriate environmental management measures for project activities having regard to the constraints imposed by the environmental values and maintaining a high level of safety.

The framework approach ensures planning and development of CSG fields will occur in a safe and orderly manner, by stipulating environmental management controls reflective of the level of environmental sensitivity.

Environmental values of the project development area are identified in the framework approach, placing them in context with respect to:

- Significance;
- Exposure to threatening processes; and
- Capacity to adjust to changes resulting from the proposed project activities.

Environmental values and their significance (e.g. local, regional, state, national) will be determined through the EIS process. To support implementation, a set of environmental management controls will be developed for each level of constraint.

The framework approach will define the spatial extent of environmental values (e.g., the presence of significant flora and fauna species or communities, wildlife corridors, cultural heritage, good quality agricultural land) enabling informed site and route selection. It will result in a land capability or constraint maps that will identify the environmental values, including the level of environmental constraint they impose, across the entire project development area. For non-spatial environmental values (e.g., air, noise), the framework approach will provide thresholds and triggers that guide design and equipment selection.

Collectively, the spatial and non-spatial controls will inform decision-making during design, exploration, construction and operation. Arrow will identify the proposed controls in the EIS, and implement the controls through the Environmental Management Plan (EM Plan) prepared for the project.

Further details of the framework approach are given in Appendix A.

6 Existing Environment and Key Issues

This section outlines the existing environment for the project development area. It identifies key environmental issues requiring investigation in the EIS.

6.1 Land Use and Tenure

6.1.1 Existing Environment

The Bowen Basin is a long settled agricultural region in central Queensland extending from Collinsville in the north to Theodore in the south. The basin is serviced by 22 small communities with larger regional centres of Rockhampton, Mackay, Gladstone and Bowen along the coast acting as bases for mining and petroleum industries.

The Bowen Basin has vast coal resources, with major open cut and underground coal mines in the north of the basin. Large volumes of methane gas are held at shallow depths within Permian coals in the north and have potential for CSG developments (Australian Government Geoscience Australia website www.ga.gov.au).

The Project's development area extends from Glenden in the north to Blackwater in the south, approximately 300 km south of Townsville and 150 km south west of Mackay. While some communities (e.g. Glenden, Moranbah) have been purpose-built to serve the mining industry, others (e.g. Emerald, Springsure) are predominantly agricultural towns or regional service communities that have expanded to service the coal industry. These, together with the coastal regional centres, are key bases for the mining industry and for many employees and companies.

Much of the Project's development area supports low density, low intensity grazing and agricultural activity. The topography is gently sloping and the landscape generally comprised of fine grained sedimentary rocks, intersected by quaternary alluvium systems associated with creek and river flats, floodplains and alluvial plains. The Proposed Project development runs north-south parallel to the Great Dividing Range and is entirely located within the Isaac and Mackenzie River sub-catchments of the Fitzroy River Catchment. Areas of arable cropping land occur along the parts of the river valleys. As part of the EIS process further investigation will be completed to identify any land that may classified as Strategic Cropping Land (SCL).

Apart from grazing and agricultural land, black coal mining and processing is another significant land use in the area. The Bowen Basin has the largest coal reserves in Australia and there are 34 operational coal mines in the area extracting over 100 million tonnes of coal annually. This represents some 83 per cent of Queensland's annual coal production. Most of the Project's ATPs and ATPAs are overlain by mining tenures.

Existing land uses and infrastructure across the Project area include the following:

- Roads
- Railways
- Transmission line
- Residential and homesteads
- Urban areas
- Social infrastructure (e.g. schools, hospitals)

- Mineral resource activities and areas of economic mineralisation
- Grazing and agriculture
- Forestry.

6.1.2 Key Issues

The key issue for investigation through the EIS will be the compatibility of CSG development with existing mining and agricultural activities. Community concerns expressed to Arrow include the impact of Project activities on high quality agricultural land and the management of overlying mining operations. The framework approach will consider the impacts of Project activities to the productivity of this land, including management measures Arrow would need to put in place for multiple land use activities to coexist.

6.2 Geology, Landform and Soils

6.2.1 Existing Environment

The Bowen Basin represents a major rifting event that took place in the Late Permian along the eastern part of the current Australian continental landmass. The 'rift valley' extended from northern Queensland, south of Townsville, and extended southward, approximately parallel to the current coastline, through Queensland and New South Wales, intersecting the current coast around Sydney.

This was an environment characterised by major coal measure development in several basins along the length of this large rift valley. During this time, the major Late Permian coal measure sequences were deposited in the Bowen Basin in central Queensland and the Bowen Basin sequence underlying the Surat Basin in southern Queensland. Across into New South Wales, analogous coal measures were deposited in the Gunnedah Basin, and across the Sydney Basin from the Hunter to the Illawarra regions.

The tectonic/depositional model for the Bowen Basin consists of a narrow NNW-SSE striking depocentre, rapidly subsiding during the Late Permian, with thick sequences of organic rich, argillaceous and lithic, sediment wedges prograding southward into marine environments. A nearby volcanic arc and associated intrusive activity to the east provided both high geothermal gradients and a source of lithic and occasionally tuffaceous sediment input.

The three cycles of sedimentation most relevant to Bowen Basin coal deposition, from oldest to youngest, are the Moranbah-German Creek Coal Measures, the Fort Cooper Coal Measures, and the Rangal Coal Measures. The coal seam gas exploration and production is focussed on these three coal measures.

The topography is gently sloping and the landscape generally comprised of fine grained sedimentary rocks, intersected by quaternary alluvium systems associated with creek and river flats, floodplains and alluvial plains. The soils that have resulted from the erosion and deposition processes are dominated by surficial deposits of the tertiary and quaternary age. These include sandy clays, sands, sandstone, breccia, laterite, alluvium, sand and gravel and soil.

The waterways of the Bowen Basin show signs of channel migration, with clear meander scars and evidence of major channel avulsion. The combined processes of the degradation of the underlying sedimentary strata, channel meandering and migration, erosion from nearby igneous outcrops, and deposition from flooding events have generated a landform that comprises broad expanses of gently undulating land with some outcrops that have been resilient to the deposition and erosion processes.

The richness of these soils resulted in clearance of the original dense woodland for agriculture. Agricultural practices include irrigation, cropping and cattle grazing. Many paddocks have been laser-levelled to achieve efficient flood irrigation. Soil erosion occurs within the disturbed clay soils, where suitable land management practices have not been adopted. In some areas, deep incised ephemeral channels have formed.

6.2.2 Key Issues

Key issues pertaining to soils, landform and geology will relate to project construction and rehabilitation activities. Issues can be described in two categories:

- Impacts on soils, landform and geology caused by the project (e.g., soil erosion, slope stability); and
- Impacts of soils, landform and geology on the project (e.g., influencing the siting of facilities and selection of construction methods).

Key issues are related to the physical, chemical and structural properties of surface and sub-surface material and geology. These properties can potentially cause ground instability, pose risk to rehabilitation programs, and reduce the quality of stormwater flowing over disturbed areas. Within agricultural areas, soil erosion and slope stability need to be managed to avoid residual effects on landholder's farming practices and productivity. Heavy metals naturally occurring in the soil may also be released from sorbed geological materials.

The compaction and/or erosion of clay soils could also cause damage to agricultural fields if not properly managed (e.g., traffic movement during construction that may impact the load-bearing capacity of land). Despite the ability for gas operations and agriculture to coexist, disruption to agricultural activities must be carefully managed.

Mapping will be prepared as part of the framework approach to identify constraints based on soil type. Effective soils management, rehabilitation techniques and erosion mitigation will aim to reduce the impacts and frequency of the issues described above.

6.3 Terrestrial Flora and Fauna

6.3.1 Existing Environment

The Project's development area falls within the Brigalow Belt Bioregion. This bioregion is characterised by dense woodland and forest communities of Brigalow (*Acacia harpophylla*), with scattered ecosystems dominated by other species including eucalypt, cypress pine, acacia species and grasslands. Expansive areas of land have been cleared in the region for agricultural purposes.

Some tracts of remnant vegetation still exist as intact patches and isolated stands. National parks, state forests, conservation areas and reserves are also present.

A search of the Commonwealth Matters of National Environmental Significance (MNES) online database on the 16 February 2012 for the Project's development area was conducted to identify any potentially threatened ecological communities, endangered regrowth, and areas identified as habitat for endangered, rare, threatened and vulnerable flora and fauna species. The search area was separated into the Northern and Southern CSG fields. The two defined regions include:

North CSG fields encompassing ATPA 742, ATPA749, ATP1103, ATP759 and ATP1031 and running south from Collinsville to Middlemount (Figure 1).

South CSG fields encompassing ATP1025, located ~ 40 km north and 10 km south of Blackwater (Figure 1)

North CSG Fields

The EPBC Protected Matters search identified 28 threatened species and 3 threatened ecological communities as being potentially present within 5 km of the project area (Figure 3). Threatened species included 5 bird species, 4 mammal species, 9 reptile species and 10 plant species. This list is based on the likelihood of occurrence according to the distribution of species and their habitats. The search identified 15 migratory species as being potentially present within 5 km of the search area. Threatened species included 3 migratory marine birds, 1 migratory marine species, 8 migratory terrestrial species and 5 migratory wetlands species. This list is based on the likelihood of occurrence according to distribution of species and their habitats from various government databases.

The DERM Wildlife Online database search for the North CSG fields yielded a total of 1,471 species records including 20 frog species, 213 bird species, 59 mammal species, 70 reptile species, 7 fish, 15 insect species, 1,052 plant species and 35 fungi. Of these, 2 additional EPBC-listed plant species were identified: holly-leaved graptophyllum (*Graptophyllum ilicifolium*) and *Dichanthium setosum*. These species are listed as Vulnerable under the EPBC Act. A total of 35 additional EPBC-listed of migratory and/or marine species were identified from the Wildlife Online database search for the North CSG fields.

HERBRECS records indicated a total of 1,876 plant species. Of these, and additional 5 additional EPBC-listed plant species were identified: *Aristida annua, Dicanthium setosum, Ozothamnus eriocephalus, Polianthion minutiflorum,* and *Trigonostemon inopinatus*.

Within the North CSG field, a total of 77 regional ecosystems (REs) have been identified as being potentially present (Figure 4). Of these, 15 REs are listed as Endangered and 15 REs are listed as Of Concern under the VMA.

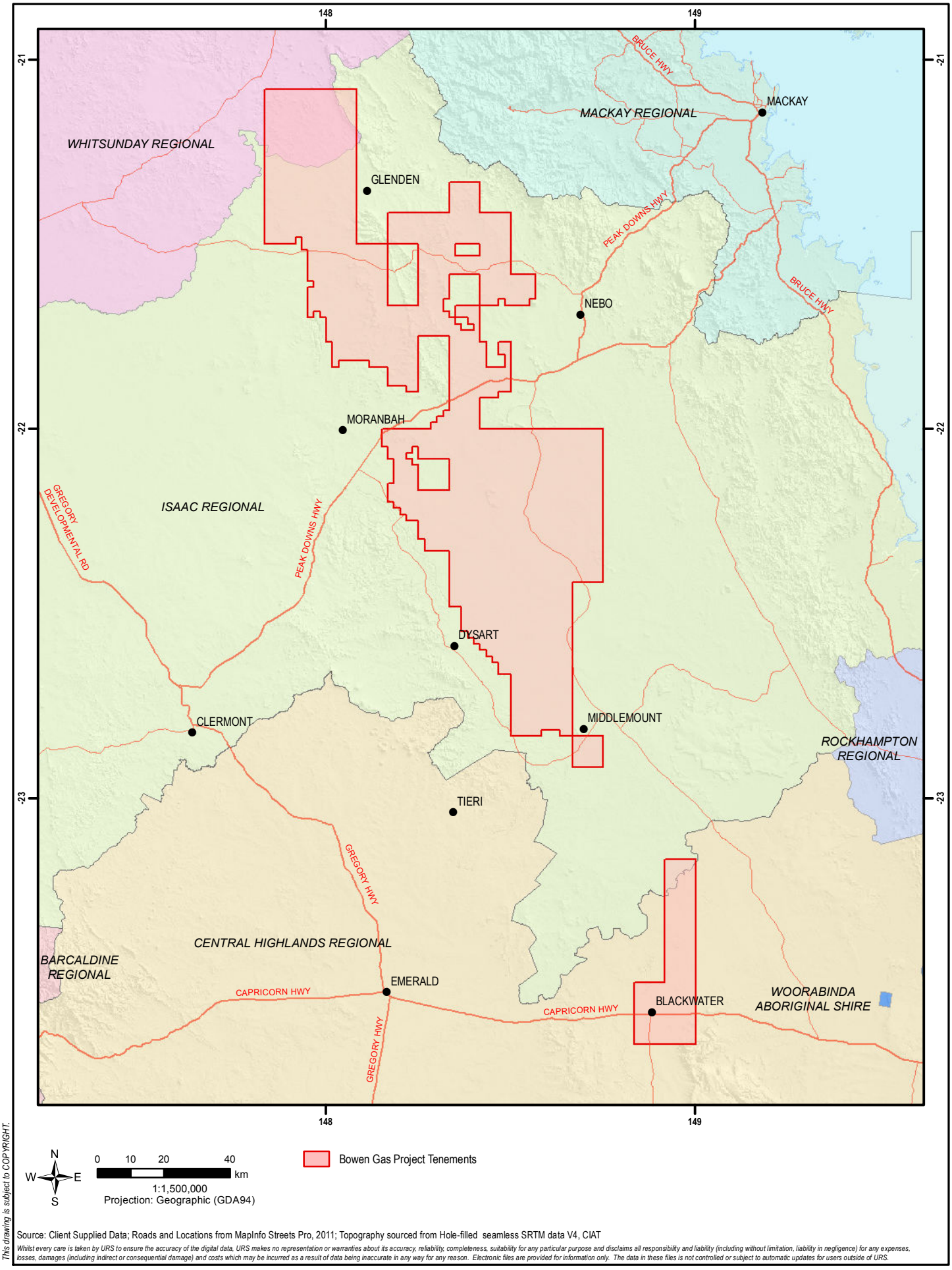
Further ground surveys during the EIS will be used to investigate the presence and define the extent of these communities to enable an assessment for any potential loss of significant habitat and overall impacts to regional biodiversity.

South CSG Fields

The search identified 18 threatened species and 5 threatened ecological communities as being potentially present within 5 km of the South CSG fields (Figure 4). Threatened species included 5 bird species, 5 mammal species, 5 reptile species and 3 plant species. This list is based on the likelihood of occurrence according to the distribution of species and their habitats.

A total of 12 migratory species are potentially present within 5 km of the search area. Threatened species included 3 migratory marine birds, 6 migratory terrestrial species and 5 migratory wetlands species.

The DERM Wildlife Online database search for the South CSG fields yielded a total of 492 species records including 16 frog species, 148 bird species, 16 mammal species, 37 reptile species, 21 fish, 14 insect species and 240 plant species. A total of 25 additional EPBC-listed of migratory and/or marine species were identified from the Wildlife Online database search for the South CSG fields.



Source: Client Supplied Data; Roads and Locations from MapInfo Streets Pro, 2011; Topography sourced from Hole-filled seamless SRTM data V4, CIAT

arrow energy
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BOWEN GAS PROJECT

BOWEN BASIN LOCAL COUNCIL GOVERNMENT AREAS

URS

INITIAL ADVICE STATEMENT

Figure: 2

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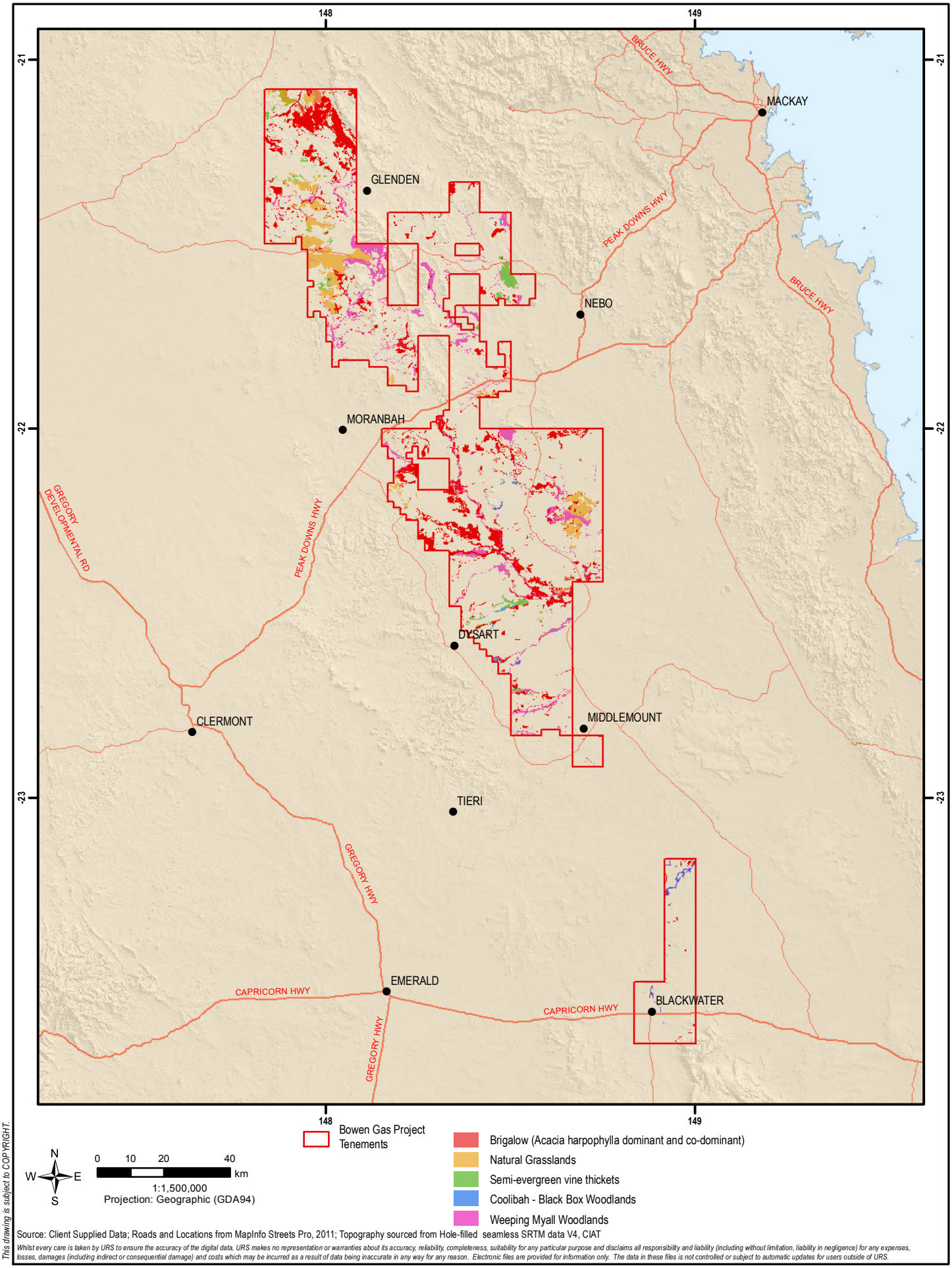


Source: Client Supplied Data; Roads and Locations from MapInfo Streets Pro, 2011; Topography sourced from Hole-filled seamless SRTM data V4, CIAT

BOWEN GAS PROJECT

EPBC ACT THREATENED ECOLOGICAL COMMUNITIES

URS

INITIAL ADVICE STATEMENT

Figure: 3

File No: **42626960-g-124.mxd** Drawn: **RG** Approved: **DS** Date: **17-04-2012** Rev. **B** A4

HERBRECS records indicated the presence of a total of 161 plant species. No additional EPBC-listed plant species were identified.

Within the South CSG field, 19 REs have been identified as being potentially present (Figure 4). Of these, 7 communities are listed as Endangered and 4 communities are listed as Of Concern under the VMA.

Further ground surveys during the EIS will be used to confirm the presence and define the extent of these communities to enable an assessment for any potential loss of significant habitat and overall impacts to regional biodiversity.

Environmentally Sensitive Areas

Environmentally sensitive areas (ESAs) are defined under the Environmental Protection Regulation 1998 (Qld) (EP Regulation) as a location that has environmental values that contribute to maintaining biological diversity and integrity, has intrinsic or attributed scientific, historical, or cultural heritage value, or is important in providing amenity, harmony or sense of community. ESAs are broken down into three categories. Category A and B areas are defined in the EP Regulation, while Category C areas are generally defined in environmental authorities which have been prepared for specific mining or petroleum activities. Category A areas that have significant ecological values include national parks, marine parks, conservation parks and forest reserves. Category B areas include endangered regional ecosystems (REs), Ramsar wetlands, state forest parks, and wilderness areas. Category C areas typically include Of Concern REs, essential habitat, referable wetlands, nature refuges, state forests, timber reserves, declared water catchment areas, Koala habitat areas and resources reserves.

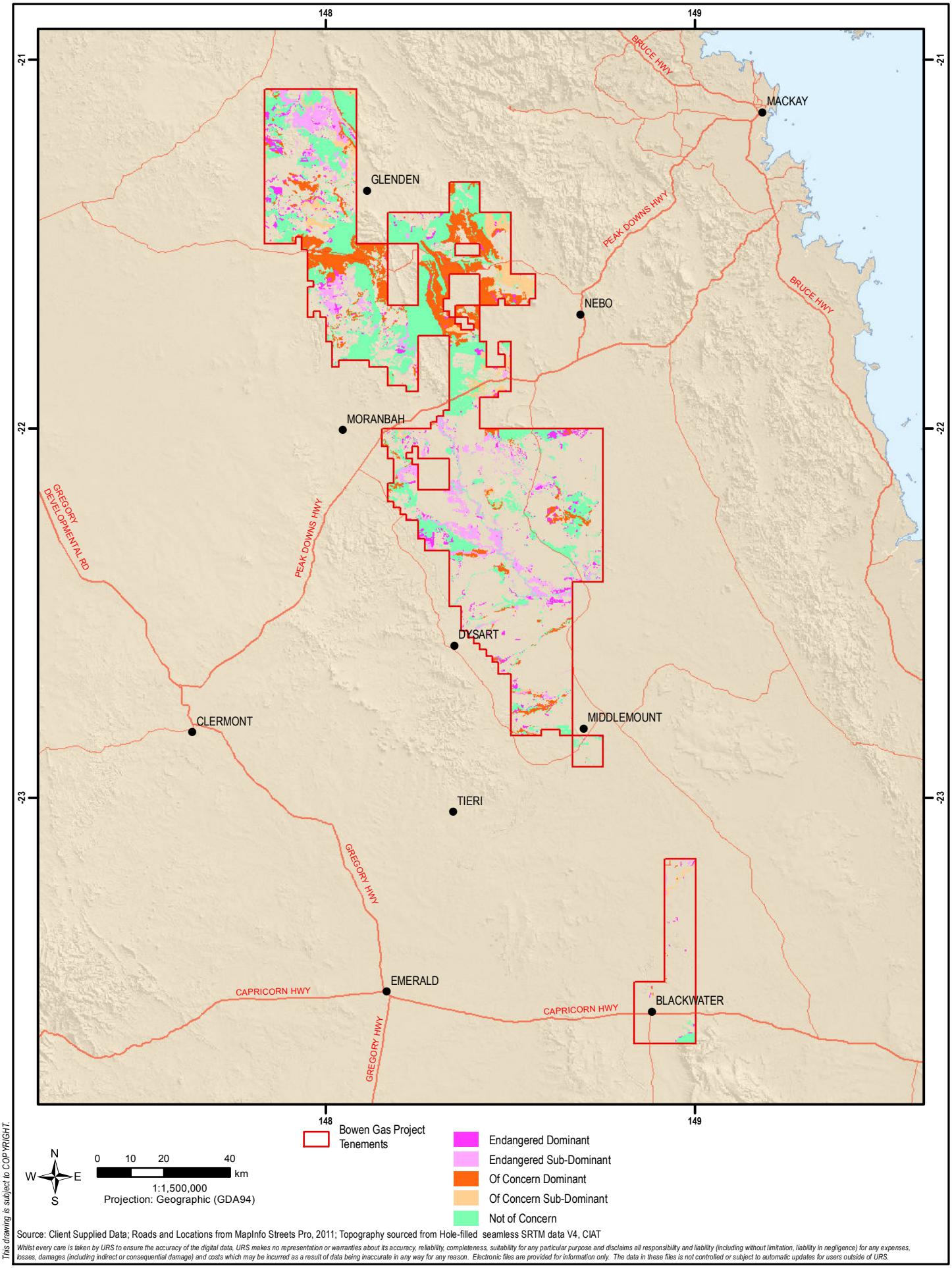
The areas located within the Project's development area that are designated as ESAs under the EP Regulation are listed below:

- Dipperu National Park (Scientific)
- Homevale Resources Reserve
- Newlands Nature Refuge
- Kemmis Creek Nature Refuge
- Coolibah Nature Refuge
- Arthur's Bluff State Forest

The extent of ESAs in and surrounding the Project's development area is shown on Figure 5.

6.3.2 Key Issues

As a result of the Project's construction activities and establishment of facilities and infrastructure, areas of significant habitat and remnant vegetation may be disturbed. This can result in direct and indirect impacts (e.g. invasion of exotic species affecting habitat integrity) for particular flora and fauna species of concern. Loss of native ground cover can also result in effects to habitat suitability for native rodents, which in turn decreases the availability of prey for foraging predators. Habitat fragmentation through clearing of transport corridors may result in loss of connectivity between remnant species. Similarly, new habitat (e.g. new water storage facilities) may be created and could lead to effects (e.g. competition from previously non-resident species).



Source: Client Supplied Data; Roads and Locations from MapInfo Streets Pro, 2011; Topography sourced from Hole-filled seamless SRTM data V4, CIAT

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BOWEN GAS PROJECT

REGIONAL ECOSYSTEMS OF THE PROJECT AREA

URS

INITIAL ADVICE STATEMENT

Figure: **4**

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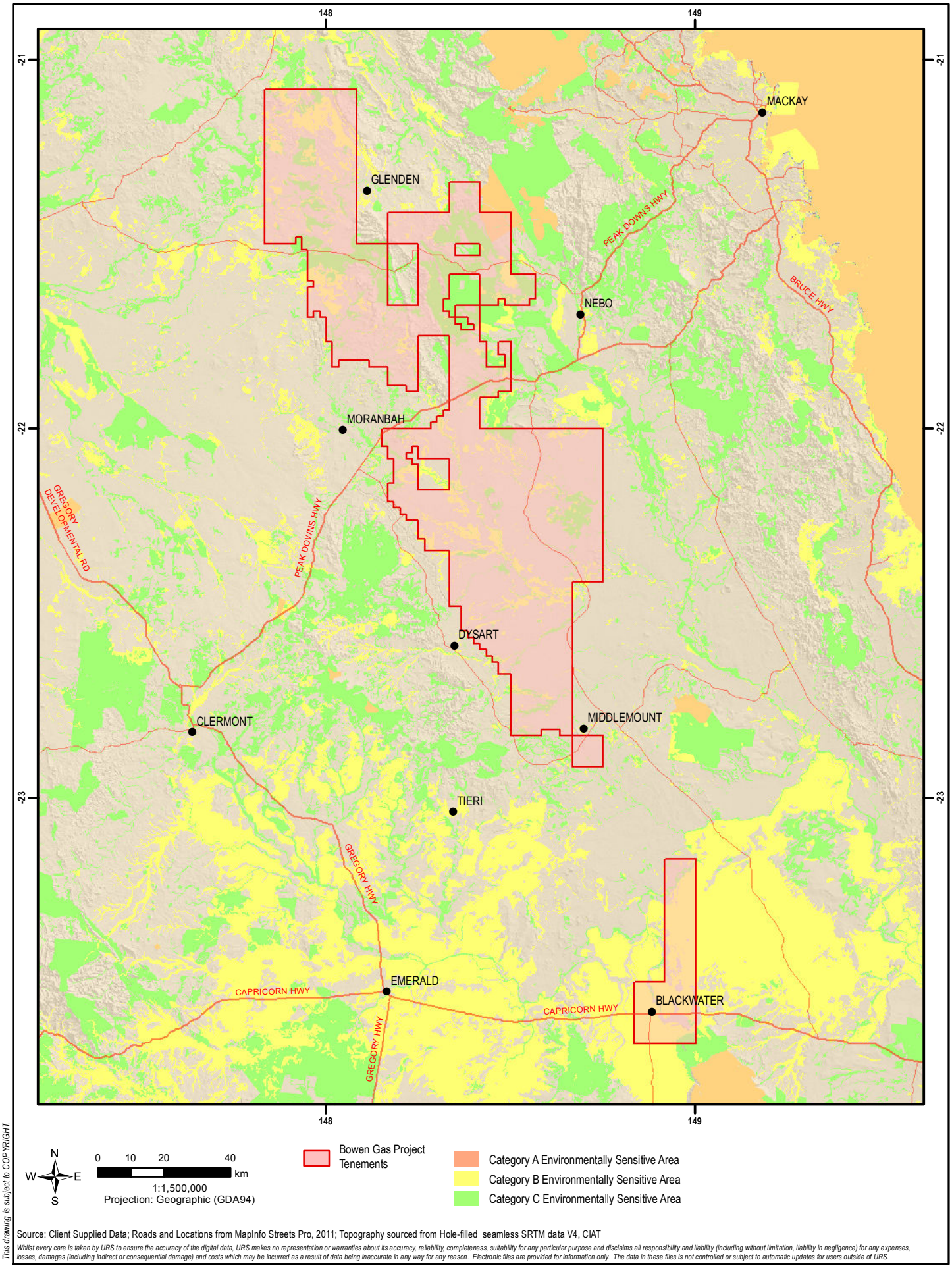

Source: Client Supplied Data; Roads and Locations from MapInfo Streets Pro, 2011; Topography sourced from Hole-filled seamless SRTM data V4, CIAT

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BOWEN GAS PROJECT

ENVIRONMENTALLY SENSITIVE AREAS

URS

INITIAL ADVICE STATEMENT

Figure: 5

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Land clearing and indirect impacts such as emission of dust and changes to hydrological and hydrogeological regimes can result in the reduction in abundance, distribution, condition, and ecosystem function of significant flora species and communities.

The framework approach will identify the ecological values of the Project's development area according to their local, state, national and international significance. The ability of these values to adjust to changes resulting from Project activities will be explored. The values will be spatially mapped and environmental management controls recommended according to the sensitivity and significance of the area's environmental values.

6.4 Aquatic Flora and Fauna

6.4.1 Existing Environment

The majority of the Project's development area is located within the Fitzroy River catchment with a small northern part of the development area being located within the Burdekin River catchment (see Figure 6). Within the Fitzroy catchment, the Project's development area is spread across three sub-catchments – the Mackenzie, Isaac and Connors sub-catchments. The northern reaches of the Project's development area fall within the Suttor and Bowen sub-catchments of the Burdekin River.

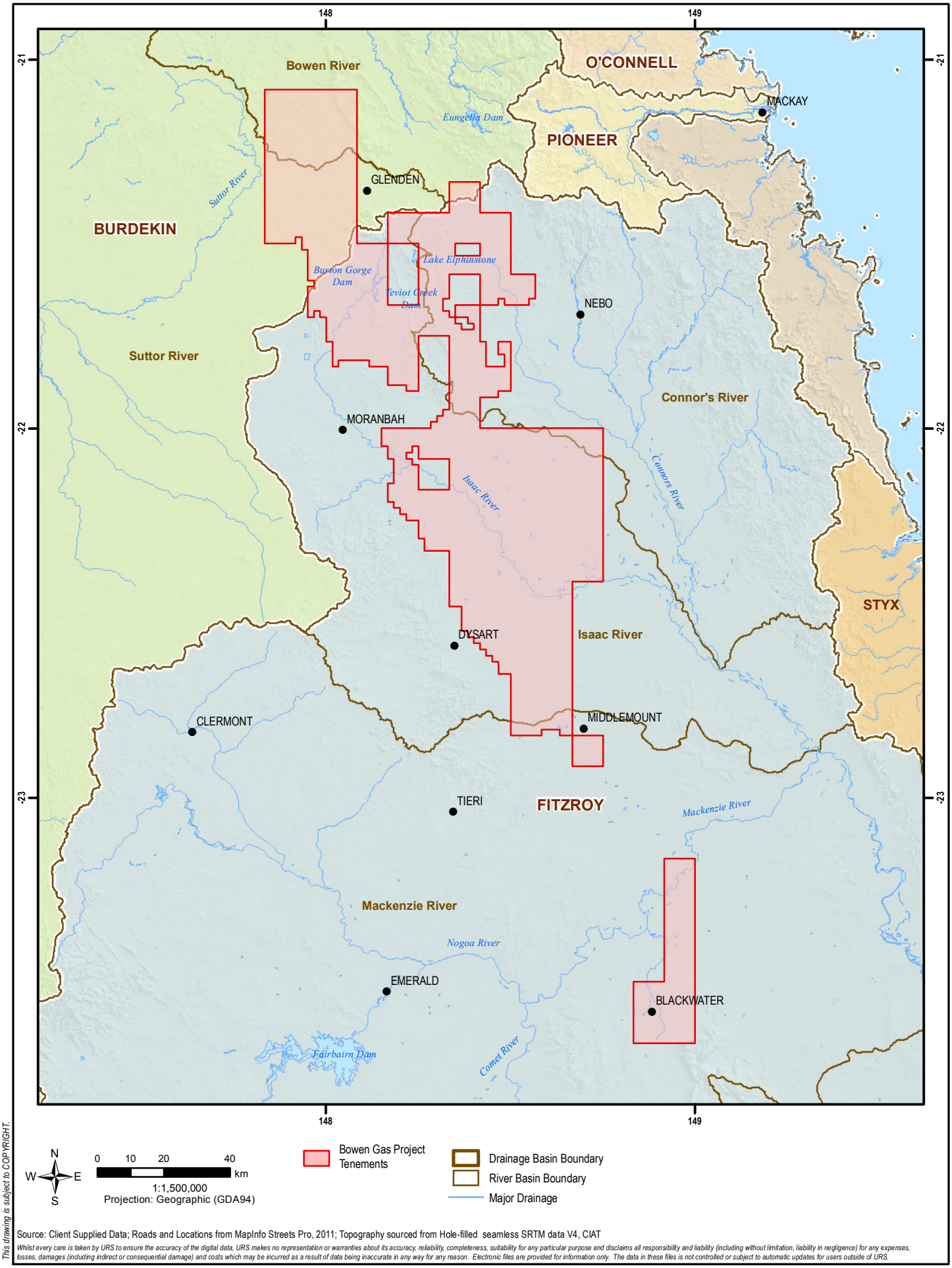
The Fitzroy is the largest catchment in Queensland and incorporates a diverse array of aquatic and riparian habitats. These habitats are influenced by a multitude of human pressures and natural drivers. These pressures include land use, riparian management, water infrastructure and point sources of pollution. The catchment is substantially modified due to agricultural practices, predominantly low density cattle grazing (NAPSWQ Water Quality State-level Investment Project).

Due to the large area covered by the Project, a diverse range of potential fish species may occur in any specific location. Freshwater fish species occurring in the Fitzroy catchment contain an overlap of species from the tropical northeast coast catchments of Queensland.

The only listed fish species known within the project development area is the Murray cod (*maccullochella peelii peelii*). This species is listed as vulnerable under the EPBC Act. Four fish species within the Project's development area are considered to be potentially and/or locally threatened. These include the silver perch (*bidyanus baidyanus*), purple-spotted gudgeon (*mogurnda adspersa*), blackfish (*gadopsis marmoratus*) and mountain galaxias (*galaxias olidus*) (Morris *et al* 2001, Pusey *et al*. 2004, Lintermans 2007).

Six vulnerable, rare or threatened frog species are present in the project development area. The only aquatic reptile that is listed under relevant State and national conservation acts within the Project's development area is the Fitzroy River Turtle (*rheodytes leukops*).

A risk based approach to the assessment of aquatic ecosystems will be adopted. This will involve an intensive desktop assessment of archival data and literature followed by highly targeted field surveys designed to fill gaps in the existing knowledge aquatic ecosystems within the study area.



Source: Client Supplied Data; Roads and Locations from MapInfo Streets Pro, 2011; Topography sourced from Hole-filled seamless SRTM data V4, CIAT

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BOWEN GAS PROJECT

SURFACE WATER HYDROLOGY

URS

INITIAL ADVICE STATEMENT

Figure: 6

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The Isaac and Mackenzie Rivers have been identified as the major watercourses within the study area, although a preliminary desktop review has also identified the following significant waterways:

- Bee Creek
- Blackwater Creek
- Cherwell Creek
- Funnel Creek
- Connors River

A small part of the study area is within the Burdekin River Catchment (Suttor Creek converges with the Belyando River upstream of the Burdekin Dam). Waterways adjacent to the study area that may either be impacted upon (downstream/cumulative impacts) or may be used as reference or offset sites include:

- Logan Creek
- Diamond Creek

6.4.2 Key Issues

Construction of facilities and infrastructure may have potential impacts on fish, amphibians, macro-invertebrates, reptiles and macrophytes if not appropriately managed. The most significant potential effect to aquatic communities is the threat of decreased water quality, caused from construction activities or point and non-point source discharges. Decreased water quality causes degradation of habitat and reduces species diversity and abundance. Degradation can also be caused by sedimentation during construction and loss of riparian and in-stream habitat and associated reduction in species abundance and diversity.

Other key issues include impacts to macro-invertebrates from potential reductions in physico-chemical parameters of water such as dissolved oxygen, turbidity and temperature. Increased nutrients associated with riparian vegetation removal, ground breaking activities and associated accelerated in-stream primary production (excessive plant growth/ algal blooms / eutrophication).

Downstream effects from the project could potentially influence a much broader range of fish species than those listed above, particularly in the Mackenzie River sub-catchment of the Fitzroy catchment. Changes in water quality (e.g. increased turbidity and salinity), reduction of overall flows, minimised flood event duration and occurrence, and barriers to fish passage either during construction or operation are of most concern for fish communities downstream of the project. Another concern is changed flow patterns resulting from discharges that do not reflect seasonal patterns and associated fish migration and breeding cycles.

The framework approach will identify areas of key ecological significance and sensitivity and recommend appropriate levels of environmental management control.

6.5 Surface Water Hydrology and Water Quality

6.5.1 Existing Environment

The majority of the Project's development area is located within the Fitzroy catchment with a small northern part of the development area being located within the Burdekin catchment (see Figure 6).

Within the Fitzroy catchment, the Project's development area is spread across three sub-catchments – the Mackenzie, Isaac and Connors sub-catchments. The Fitzroy catchment is the largest river basin draining to the east coast of Australia and flows into the southern end of the Great Barrier Reef near Rockhampton. The catchment is characterised by a sub-tropical, semi-arid climate with high rainfall variability. This rainfall variability is a key factor in managing land use to minimise impact on catchment resources.

The northern reaches of the Project's development area fall within the Suttor and Bowen sub-catchments of the Burdekin River.

Apart from the Murray River, the Burdekin River is economically the most important river in Australia, and has the fourth-largest watershed of any exorheic drainage system in Australia. It is also the fourth-largest river in Australia by volume of flow, but is so erratic that its discharge can reach the mean discharge of the Yangtze (after two severe cyclones in 1958) or have as many as seven months with no flow whatsoever (as in 1923). This exceedingly erratic flow is due to the extreme variability of precipitation throughout the entire basin.

Within the Project's development area there are numerous small creeks and drainage lines, many of which are ephemeral. Streams in much of the catchment are slow flowing and seasonal, with long periods of low or zero flows during which the streams can become a series of waterholes.

Water quality and stream flow monitoring has occurred throughout the extended catchments, through support of the state governments Healthy Waters Management Plans (HWMPs). DERM through the use of the Environmental Protection (Water) Policy 2009 has established key planning mechanisms to improve the quality of Queensland waters. The key aspects of the process was to develop Environmental Values (EVs) that include appropriate consultation with the community and consideration of social and economic impacts of protecting the EVs.

To date, surface water quality in the Burdekin River catchment has been assessed as moderate to good for irrigation and stock use, poor to moderate in condition for domestic use, and of a poor quality for aquaculture. For recreational use, water quality ratings vary considerably between sites. Surface water monitoring results for the Fitzroy Catchment indicate that high turbidity / total suspended solids, high nutrient levels and elevated nutrient levels are common, but that salinity is generally low.

6.5.2 Key Issues

Potential impacts may occur to the flow and the quality of surface waters during all phases of the Project. Particular investigations as part of the EIS will be undertaken with regards to:

- Potential of barriers to overland flow causing erosion and channel avulsion resulting in changed hydrology and potential loss of soils and agricultural productivity.

- Land degradation resulting from removal of vegetation, landscaping activities, and runoff from disturbed ground, stockpile materials and facilities.
- Impacts of wastewater, including point source and non-point source stormwater discharge to natural surface water.
- Contamination of surface water by hydrocarbon or chemical spills and waste; and
- Management of associated water including:
  - Current and proposed activities including beneficial uses of treated water, quality and containment of brine from reverse osmosis plants.
  - Treatment and potential interaction with surface water environments.

The framework approach will consider the potential for and consequence of these impacts across the Project's development area. Constraints will be identified and where appropriate, specific management measures recommended.

6.6 Groundwater

6.6.1 Existing Environment

The project development area runs parallel with the Great Dividing Range and in close proximity to the groundwater recharge areas along the eastern edge of the Great Artesian Basin (GAB). The project falls within the Burdekin River catchment in the north and the Fitzroy River catchment in the south.

Most of the Burdekin River catchment's groundwater resources have already been developed. These resources have been used extensively for farming activities, such as irrigation and stock watering (NRM, 2002). The results of groundwater monitoring in the Burdekin River Irrigation Area indicates that extensive irrigation has resulted in saline groundwater being less than 2 m from the surface in some areas. This has resulted in a loss of agricultural production in some of the areas across the catchment (Roth, Lawson and Cavanagh, 2002). Groundwater extraction is largely unmetered in the Burdekin River catchment due to no assigned groundwater allocations.

Groundwater use is less developed in the northern Fitzroy River catchment. The creeks within the Fitzroy catchment are ephemeral and recharge of the alluvium is by direct infiltration of rainfall or infiltration of surface water during creek flow. Groundwater from the alluvial aquifer is highly variable, with minimal available drawdown limiting the use and development of the groundwater resource. Stakeholders considered the groundwater resources of the Fitzroy catchment to be mostly limited and only able to meet the requirements of stock watering and domestic use.

There are three discrete groundwater regimes of interest for the Project. These are:

- Shallow subsurface groundwater associated with the Isaac River alluvium and the Tertiary Basalt.
- Deeper subsurface groundwater in direct communication with each of the coal measures, Rangal, Moranbah-German, and Fort Cooper.
- Deep subsurface groundwater of the Great Artesian Basin (GAB).

Tertiary basalts and the Isaac River alluvium directly overlie the coal measures. The connectivity of coal measure aquifers with overlying and underlying groundwater aquifers is not well known in Queensland.

Past evidence from water quality analysis suggests that connectivity between the alluvium and coal measures occurs. Conversely, the groundwater that occurs in the coal seams of the Rangal, Moranbah-German, and Fort Cooper Coal Measures function as fractured aquifers (Helmuth, 2008).

The Environmental Protection (Water) Policy 1997 (EPP, Water) is designed to protect Queensland waters, including groundwater. It provides a framework for identifying the environmental values for waters, and establishing water quality guidelines and objectives to enhance or protect the environmental values.

The EPP Water presents a range of environmental values for consideration. Although no grouping is provided in the EPP Water, for discussion purposes it is convenient to aggregate or classify the environmental values into the following categories:

- Biological environmental values.
- Aesthetic and human interaction values.
- Consumptive or productive use values.
- Anthropomorphic values.

Future geological and groundwater surveys will further investigate any sign of connectivity with the CSG field coal seams and the surrounding groundwater resources. These investigations will commence and the key findings will be fully addressed in detail in the EIS.

6.6.2 Key Issues

The diverse range of groundwater aquifers containing accessible water is a result of both the size of the Project's development area and the complex Bowen Basin stratigraphy. Because of this, a structured consideration of environmental values is appropriate to the EIS. This should include all main water-bearing formations within the Bowen Basin potentially influenced by the development, either directly or indirectly.

Key issues include the potential impacts to the local groundwater regime, or groundwater dependent ecosystems or activities, as a result of:

- Altered porosity and permeability generated by land disturbance.
- Potentially lower potentiometric heads in the target coal seams and, if interconnection exists, adjacent aquifers.
- Cross-contamination in the event of intersecting contiguous aquifers and potential disturbance to natural groundwater levels, flow and quality.

The framework approach will establish a monitoring program based on adaptive management controls. This will enable early detection of trends in groundwater behaviour and the implementation of timely responses. The monitoring program will be informed by detailed hydrogeological modelling that will be updated progressively as information becomes available.

6.7 Air Quality and Greenhouse Gases

6.7.1 Existing Environment

There is currently no monitoring of ambient air quality performed by DERM in the region immediately surrounding the Project's development area. The closest DERM air quality monitoring instruments are located at Gladstone, approximately 250 km to the south east.

Nevertheless, industrial sources in the Project's development area have been identified through a review of the National Pollutant Inventory (NPI) and their contribution to air quality considered. In addition to grazing and agricultural sources, the identified major industrial sources include:

- Coal mining
- Electricity generation
- Gas supply

CSG exploration and production activities and coal mining are continuing to grow in the Bowen Basin. This is a significant change from the historical agricultural land uses that have been established in the region and is resulting in a change to the region's air quality characteristics.

6.7.2 Key Issues

The project could have an adverse impact on local and regional air quality, as well as contributing to global greenhouse gas concentrations. Local and regional air and greenhouse gas emissions are associated with but not limited to:

- Dust and emissions generated during construction activities;
- Emissions from drilling activities (emissions from burning diesel (CO_2, CO, NO_x, SO_x etc.);
- Fugitive emissions from wellheads and gas gathering lines and associated equipment (VOCs, CH_4);
- Emissions associated with the generation of electricity to run gas compression and water treatment facilities (SO_x, NO_x, CO, CO_2, particulates etc.);
- Energy consumption associated with the operation of pumps, separators, compressors, water treatment facilities;
- Greenhouse gas emissions from downstream combustion of produced gas; and
- Seasonal influences on local and regional air quality (e.g. dust storms).

Potential cumulative effects on regional air quality must also be estimated based on the development of other gas field and coal mine developments in the region.

Impacts associated with Arrow's development will be considered in the EIS in the context of existing regional air quality. This will take into account cumulative effects of regional development on the airshed (so far as information is publicly available). Assumptions will be applied to model emissions over time. In the case of air quality, a non-spatial environmental value, the framework approach will apply thresholds and limits to Project activities. Greenhouse gas intensity information will be used to inform equipment selection and operating procedures.

6.8 Noise

6.8.1 Existing Environment

There are numerous, widely varied sources that contribute to ambient noise levels from both natural and manmade activity. Urban areas, coal mine operations, industrial zones, and agricultural practices generate ambient noise levels in the project development area that serve to elevate the background noise levels. However overall, the ambient noise level for the project development area is expected to be typical of rural areas.

6.8.2 Key Issues

Noise concerns are relative to the separation distances to residences (also known as 'sensitive receptors'), the level and duration of disturbance and the hours of disturbance. Identification of residences and other sensitive locations ("sensitive receptors") throughout the project development area will occur as part of the EIS. The location of noise sensitive fauna will also be identified and considered in facility site selection.

Noise modelling will be based on metrological inputs, using topographical effects or land contours and potential locations of sensitive receptors. Uncertainty associated with the timing of the Project's development, including the eventual location of all plant and equipment, will be addressed by the framework approach. The framework approach will seek to establish a set of noise mitigation measures that may be applied to the future development, including integrated production facility sites.

6.9 Landscape and Visual

6.9.1 Existing Environment

The topography of the Project's development area is gently sloping and the landscape generally comprised of fine grained sedimentary rocks, intersected by quaternary alluvium systems associated with creek and river flats, floodplains and alluvial plains. The area was first explored in the mid-19th Century and identified by early explorers as a favourable area to establish grazing lands, with grazing accounting for the principal rural land use within the local area.

Significant land clearing from around the 1950s onwards, together with fire, have altered the mosaic of indigenous vegetation communities and significantly reduced the extent of brigalow acacia forests and open grassy eucalypt woodland that would have been widespread pre-European settlement.

The extensive utilisation of land for agriculture and pastoral grazing has resulted in a number of direct and indirect changes to the character of the landscape, including:

- Reduction of natural habitat density and diversity.
- Introduction of weed species.
- Erosion (sheet, gully and stream bank).

In addition to the significant landscape changes that have occurred through the adoption of European agricultural practices, exploration in the mid-19th Century also identified coal deposits including those around Blackwater. Changes to the landscape have also resulted from a number of existing and historic mining projects, including open cut, underground and coal seam gas projects within, and beyond, the study area. As well as large scale industrial infrastructure associated with existing coal mine projects, the landscape has also accommodated an expansion of early settlements and the establishment of purpose built urban development to house mine workers including associated networks of road and utility corridors.

6.9.2 Key Issues

Arrow's preference is to install integrated production facilities on Arrow owned land, ideally within proximity to existing infrastructure. The proposed facilities may impact existing landscape features, panoramas and views, however where practicable will be sited away from those that have or are expected to have value to the community. Through the framework approach, the EIS will identify features or places where this is expected to be the case, as well a suite of measures based on land zone type to mitigate the visual impact of the project.

6.10 Traffic, Roads and Infrastructure

6.10.1 Existing Environment

The Project's development area is serviced by a range of State highways, Council roads and unformed single tracks providing access to private properties. The major transport routes connecting major townships in the region include:

- Mackay to Nebo: Peak Downs Highway;
- North of Nebo towards Glenden: Suttor Development Road;
- Nebo to Moranbah: Peak Down Highway;
- Moranbah to Dysart: Dysart Road;
- Dysart to Middlemount: Middlemount Road;
- Middlemount to Blackwater: Fitzroy Development Road; and
- Blackwater to Gladstone: Capricorn Highway.

6.10.2 Key Issues

Increase in traffic volumes and percentages of heavy truck traffic due to Project activities may result in:

- Deterioration of road infrastructure not designed for more frequent light and heavy traffic.
- Requirements for road upgrades (asphalting, turning lanes, road widening) to ensure local or State roads meet safety standards for changed traffic patterns (including roads used as school bus routes).
- Increased traffic on local roads, particularly during major construction activities.
- Cumulative effects on the road network due to other gas field developments and energy industry expansion in the region, and altered travel routes.

Traffic investigations for the EIS will reflect the evolving nature of the project and also the different timings and durations of field and facility development. As applied to the traffic assessment, the framework approach will involve:

- Review of the existing road network in terms of standard, hierarchy, capacity, adjacent land uses and base traffic volumes and the appropriateness of these roads to carry additional gas field development and energy industry traffic;
- Identify particularly suitable and unsuitable access roads and locations; and
- Development of a series of guidelines to determine mitigation measures required for different activities on various standards of roads.

6.11 Non-Indigenous Cultural Heritage

6.11.1 Existing Environment

The Bowen Basin is rich in cultural heritage associated with early European expansion into Queensland and the associated agricultural development that followed. Non-Indigenous cultural heritage may be present across the Project's development area in the form of old or heritage listed buildings and structures, but also including markers left by early explorers. The non-built environment and pastoral landscapes of the region may also hold historic significance and value resulting from settlement patterns.

6.11.2 Key Issues

As the proposed CSG development will be broadly dispersed across the Project's development area, there is potential for Project interaction with areas containing cultural heritage.

Disturbance to known non-Indigenous historic and cultural heritage sites may occur through direct impacts associated with the placement of infrastructure and operational equipment. The placement of infrastructure may affect the heritage value of specific items or sites rich in cultural heritage, even where the item or site is not itself damaged (e.g. through effects to the landscape or increases in traffic).

The framework approach will identify the non-Indigenous values of the Project's development area according to their local, state, national and international significance. The compatibility of project activities with historic sites and archaeological material will be investigated. Identified values will be spatially mapped and environmental management controls recommended according to values' significance and sensitivity.

6.12 Indigenous Cultural Heritage

6.12.1 Existing Environment

The nature and distribution of many forms of Indigenous cultural heritage in a landscape is in part associated with environmental factors such as geology, climate and landforms which affect the availability of plants, animals and water, the location of suitable camping places and suitable surfaces

upon which rock art could be performed. Given the environment and resources available in the Project's development area, it is expected that it would have been used by Aboriginal people. This use would have related to flora, faunal material and lithic raw material for the manufacture of stone artefacts. A range of archaeological site types may be present reflecting these strategies. However, the detection and survival of such visible markers is often conditional upon natural (e.g. erosion, deposition) and cultural (e.g. clearing, ploughing) processes.

6.12.2 Key Issues

Key issues are associated with the potential disturbance of known or currently unknown sites of Indigenous cultural heritage significance. As gas development will be broadly dispersed across the project development area, there is high potential for project interaction with areas of Indigenous cultural heritage value.

A CHMP will set identification, management and mitigation measures for Indigenous cultural heritage during construction and operation phases of the project. The CHMP will form part of the framework approach as it applies to Indigenous cultural heritage. As with the case of non-Indigenous cultural heritage, and consistent with the CHMP, Indigenous cultural heritage sites and material will be mapped for use in site and route selection.

6.13 Economic

6.13.1 Existing Environment

The Bowen Basin is currently experiencing economic development, which is driving employment and business opportunities. There are fourteen coal mine and five gas projects within the region which have recently completed the EIS process. Coal mining in particular is stimulating economic development in the region and this growth is expected to continue for some time.

It is anticipated that the projects recently approved within the region will place significant pressure on the local labour market.

6.13.2 Key Issues

Key issues are often driven by the perceptions of the public and existing business and industry. Economic issues to be addressed by the EIS will include:

- Impacts on existing businesses and local industry through the drawing of labour away from those businesses to this Project or other projects in the region.
- Competition for limited resources (e.g. equipment, plant, services) may develop between existing industry, this and other projects having a negative effect on the economic base of the region.
- The availability and quantum of government and proponent expenditure on utility infrastructure and service provision.

Impacts such as business confidence, property market movement and implications on future development in the region are similarly driven by public perceptions and experience. The proposed framework approach to impact assessment will identify areas requiring initiatives to address potential adverse impacts on the local and regional economy.

6.14 Social

6.14.1 Existing Environment

The Project's development area and surrounds comprise small to medium sized country towns, and dispersed rural populations. Predominant land uses include grazing, mining, and forestry (natural and commercial). With the growth of the energy and mining industries, the traditional rural base is being industrialised.

6.14.2 Key Issues

Social issues facing the Project include:

- Competition for skilled labour and technical personnel, including the impact gas and mining industries have on existing industries.
- The ability of local businesses to take up opportunities presented by the Project.
- Potential to alter the population and demographic profile, leading to pressure on local services, local facilities and the housing sector (e.g. increased cost of living, higher rents and purchase prices from an inflated economy).

The framework approach will identify community perceptions and needs, leading to the development of initiatives to:

- Mitigate adverse effects of accelerated growth.
- Providing opportunities for the region to benefit from coal seam gas development.

6.15 Hazard and Risk

6.15.1 Existing Environment

CSG comprises predominantly methane (CH_4), which is a colourless and odourless but highly flammable gas. Gas developments involving the extraction, gathering, compression and distribution of CSG carry the inherent risk of fire and explosion.

6.15.2 Key Issues

The development of CSG projects in rural communities has the potential to expose the population to hazards not otherwise experienced. The exposure may be affected by, but not limited to, any of the following:

- Proximity of dwellings to CSG infrastructure (wells, gas gathering lines, transmission pipelines and compression facilities);

- Presence of gas infrastructure (wells) in fields previously dedicated to agricultural or grazing activities;
- Presence of gas gathering lines beneath agricultural, grazing or mining land; and
- Traffic accidents through increased light and heavy traffic on the rural road network.

In accordance with Arrow's safety management system, a risk assessment will identify the controls to be implemented to manage the identified risks.

7 Environmental Management

An EM Plan will be prepared for the project as part of the EIS. The EM Plan will provide a mechanism for implementing mitigation strategies for avoiding or reducing potential environmental impacts. The purpose of the EM Plan is to:

- Implement the framework approach;
- Outline the commitments of the project to avoid or minimise and monitor the potential environmental impacts;
- Enable Commonwealth, State and local government authorities to make informed decisions and recommend any conditions for approval; and
- Provide reassurance to the community that Arrow is effectively managing and monitoring impacts.

The EM Plan will detail management of key issues including:

- Management of impacts on water (associated water and process effluents);
- Greenhouse gas emissions, including energy efficiency initiatives;
- Endangered, vulnerable and of concern ecosystems and species;
- Disposal of solid and liquid waste;
- Spill response preparedness;
- Flaring and venting;
- Management of air emissions; and
- Road safety and traffic management.

The EM Plan will be activity-based. The EM Plan will enshrine the framework approach through:

- Standard operating procedures that Arrow must apply across its operations.
- Site-specific controls that Arrow must apply in areas of medium or high constraint. Arrow will develop site-specific controls to protect environmental values of the project development area identified through the EIS.

The framework approach will inform the selection of preferred locations for future development and ensure that environmental management controls are appropriate for the sensitivity of the development location.

8 EIS Studies Program

Table 3 outlines the preliminary studies program.

Table 2 Preliminary Studies Program

Environmental Effects	Social Impacts
Landform, geology and soil Surface water hydrology Groundwater Terrestrial flora and fauna Aquatic flora and fauna Greenhouse gas	Planning, land use and tenure Air quality Noise Non Indigenous cultural heritage Indigenous cultural heritage Traffic and road infrastructure Social assessment Economic assessment Preliminary hazard and risk

The detailed scopes of work for the studies will be tailored to the Bowen Gas Project Final Terms of Reference. The proposed studies will describe the existing environment, assess the potential impacts of proposed activities on the environment, recommend mitigation measures to address those impacts, and provide a framework (see Section 6) to ensure environmental values are protected.

9 Consultation

Stakeholder engagement and consultation is an integral part of Arrow's project development process. Engagement will help to both inform business decisions and identify issues that require action.

Stakeholder engagement is a key part of any EIS. For the Bowen Gas Project, it will be a systematic process, starting with the identification of stakeholders, development of a Stakeholder Engagement Plan, and then creating and maintaining stakeholder relationships and partnerships to ensure stakeholders are informed and their issues are understood and responded to.

Stakeholder engagement is seen as a two-way process, with a willingness to listen, discuss, and where appropriate act to resolve stakeholder issues. Processes will be built around timeframes that permit stakeholders to understand, absorb, respond and interact. Stakeholder engagement will comprise multiple opportunities in multiple locations and at different stages of the project and involve at least the following:

- Information sessions for key stakeholders and local agency briefings;
- Advertised community display sessions;
- Ongoing presence of a Community Information Centre; and
- Free call 1800 number and email.

Arrow has internal policies and processes that outline the requirements of stakeholder engagement. These are underpinned by Arrow's general business principles, which govern how the company conducts its affairs. Arrow is committed to:

- Informing stakeholders about the project;
- Maximising the level of accurate and accessible information about the project;
- Providing adequate time for stakeholders to consider and engage in meaningful dialogue;
- Identifying and attempting to resolve potential issues; and
- Using stakeholder feedback to inform and improve business decisions.

Arrow anticipates consultation for the project will involve a wide range of stakeholders, including but not limited to:

- Regulatory authorities;
- Landowners;
- Local business and community groups;
- Traditional owners; and
- General public.

Regular consultation with identified stakeholders will continue throughout the project lifespan, ensuring that queries and concerns raised are, where feasible, addressed in project design and associated management plans.

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Appendix A Risk-based Framework Approach

Objective of Framework Approach

The principal objective of the framework approach is to protect the environmental values of the project development area, and to identify appropriate environmental management measures for petroleum activities having regard to the constraints imposed by the environment values.

The framework approach ensures planning and development of coal seam gas fields will occur in an orderly manner, by stipulating environmental management controls reflective of the level of environmental and social sensitivity.

Basis for the Framework Approach

Coal seam gas development is challenging to plan. Factors that influence development schedules include:

- Exploratory drilling and pilot well programs successfully identifying viable gas resources.
- Economic and commercial risks influencing the extent and rate of field development1.
- Timing of regulatory approvals for petroleum tenements, environment, land access, etc.
- The need to refine development plans as new reservoir data is collected and assessed.
- The extent and pace of other developments that will provide the 'market' for the gas produced.

Arrow is currently developing plans for a number of its Queensland petroleum tenures. To meet market demand, Arrow may need to undertake production well drilling on a significant scale. Arrow has a legal responsibility to assess the environmental and social impacts of proposed activities before undertaking development. Adverse environmental, social and economic impacts must be reduced through appropriate site selection and effective environmental management. Assessment must consider the scope of the entire development as well as the cumulative impacts associated with other similar developments in the area (to the extent information is publicly available). Regulatory authorities must be satisfied that Arrow's activities have been properly assessed, and the company has put appropriate measures in place to avoid or minimise adverse environmental and social impacts, prior to the grant of government approvals.

While it is too early to state definitively 'when' and 'where' project activities will occur over the entire project life, using knowledge of existing activities and early concept development, it is possible to set out the method by which future development will be planned and implemented. As such, the environmental and social impact assessment (ESIA) process will use a risk-based framework approach to identify and assess impacts. The framework approach will be used to inform ultimate project development and avoid and reduce potential impacts.

What is the Framework Approach?

The framework approach identifies the environmental values of the development area and places them in context with respect to:

- Significance.
- Exposure to threatening processes.
- Capacity to adjust to changes resulting from the proposed activities.

It provides spatial context by defining the extent of the environmental values enabling informed site and route selection. For non-spatial environmental values, the framework approach provides

[1] Considerations include the proximity of new resources to existing infrastructure, market constraints, land access, and long term gas supply contracts with positive rates of return on the capital invested

thresholds and triggers that guide decision-making during design, exploration, construction and operation.

Environmental values and their significance (e.g., local, regional, state, national) will be determined through the ESIA process. The framework approach will result in a land capability or zoning map(s) that will identify the environmental values, including the level of environmental constraint they impose, across the entire project development area. Environmental management measures will be identified in the Environmental Impact Statement (EIS) and implemented through the Environmental Management Plan (EM Plan) prepared for the project in the form of standard operating procedures and site-specific controls.

How will it be prepared?

The framework adopts a risk-based approach to overcome the difficulties imposed by the extent of petroleum tenures to be assessed.

It is based on the premise that detailed knowledge of the environmental values and threatening processes informs decisions about whether the planned activities are likely to have an adverse impact on the values if the activities are conducted in prescribed ways.

Stage 1 involves detailed desktop studies to identify the environmental values of the development area, their significance and the threatening processes. Where applicable targeted field surveys will follow this activity and validate the information compiled during this stage, with emphasis on confirming the extent of environmental values.

Stage 2 will identify the proposed petroleum activities and the exploration, construction and operation methods. It will then determine the degree of impact each activity might have on the environmental values[2].

Stage 3 will involve levels of constraint being applied to the environmental values of the development area. The constraints will reflect the capacity of the environmental values to adjust to impacts arising from the proposed activities. Constraints will be assigned on the following basis:

- 'No go': the project activities could cause significant adverse impact to the environmental value. Project activities will not be permitted to disturb the environmental value.
- High constraint: the environmental value is at risk from project activities. Only certain types of activities might be permitted under stringent environmental controls.
- Moderate constraint: the environmental value is at risk from project activities but the application of standard environmental procedures in conjunction with site-specific controls would ensure likely impacts would not exacerbate threatening processes.
- Low constraint: no specific environmental values have been identified and the application of standard operating procedures will ensure minimal impact as a result of the project activities.

For each level of constraint, criteria and recommended controls will be established for project activities. Table 1 provides an example of how this would be applied.

[2] For example, the placement of a facility may have a greater impact on an environmental value, than the installation of a flowline or pipeline which then remains buried for the period of operation.

Table 3 Example of Framework Approach

Constraint	Project Activity			Applicable Framework
	Drilling wells	Installing Gathering Lines / Pipelines	Facilities Installation	
"No Go"	N	N	N	No activity is permitted. Procedural and behavioural controls will be applied to ensure all staff and contractors comply with the constraint.
High	Y	Y	N	Very strict controls will be applied. (e.g., narrowing of pipeline right of way, certain types of construction methods prohibited, specific adjacent areas will be protected etc.).
Moderate	Y	Y	Y	Standard operating procedures in conjunction with site specific controls will be applied to minimise impact to acceptable levels (variability may arise when operating on different soil or land use types e.g., grazing, irrigation).
Low	Y	Y	Y	Standard operating procedures will be applied to activity (emergency and incident conditions must be considered and mitigated).

The framework approach will define the spatial extent of environmental values (e.g., the presence of significant flora and fauna species or communities, wildlife corridors, cultural heritage, good quality agricultural land) enabling informed site and route selection. For non-spatial environmental values (e.g., air, noise), the framework approach will provide thresholds and triggers that guide design and equipment selection. Collectively, the spatial and non-spatial controls will inform decision-making during design, exploration, construction and operation. To support implementation, Arrow will develop a set of environmental management standard operating procedures or site-specific controls for each level of constraint.

Through submission of the EIS and EM Plan, Arrow commits to applying the framework approach appropriately to future activities across the entire project development area.