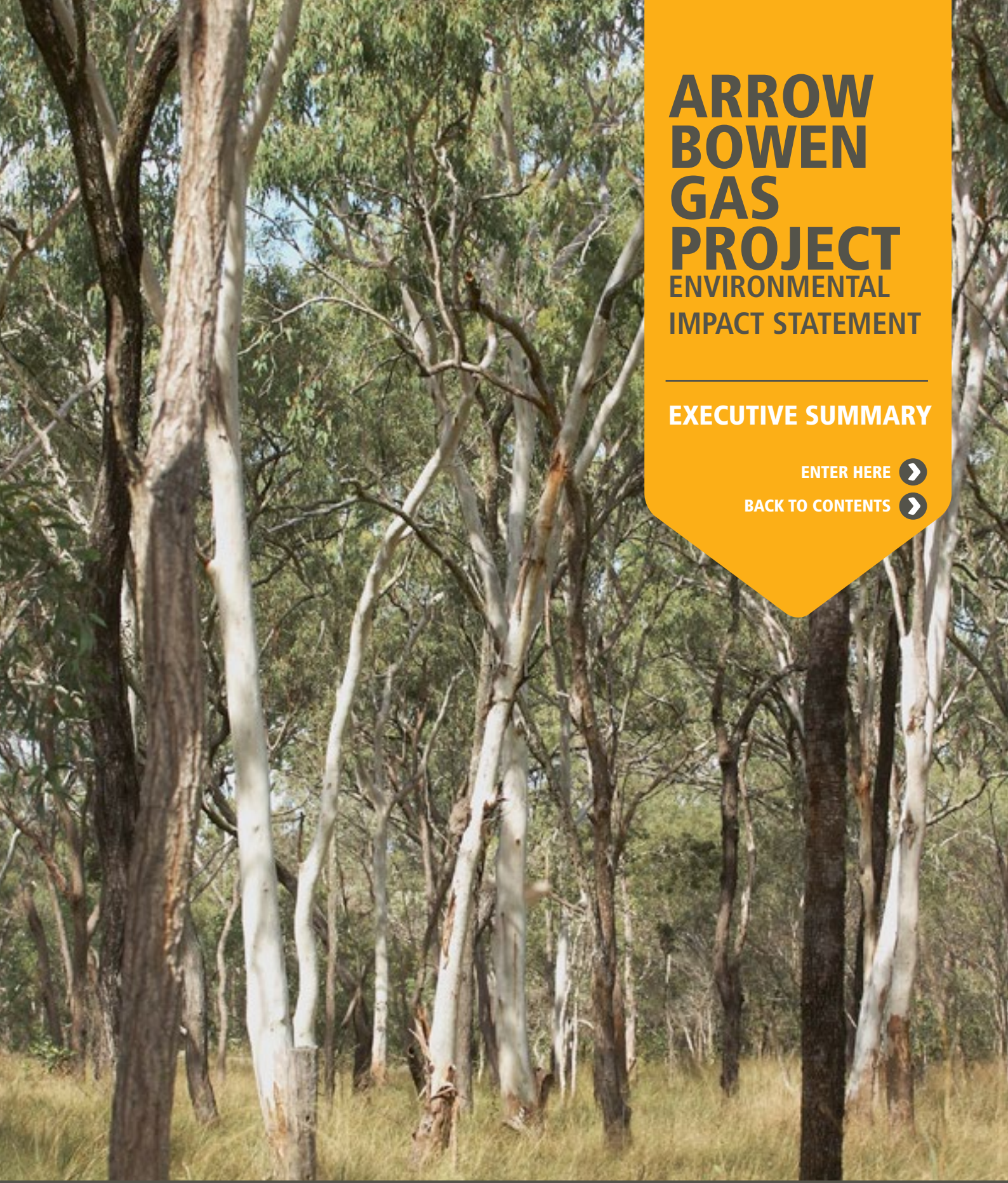

ARROW BOWEN GAS PROJECT

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1 Introduction

Arrow Energy Pty Ltd (Arrow) proposes expansion of its coal seam gas (CSG) operations in the Bowen Basin through the Bowen Gas Project (the Project). The Project arises from the growing demand for gas in the domestic and global markets and the associated expansion of liquefied natural gas (LNG) export markets.

This executive summary provides an overview of the Project and the contents of the environmental impact statement (EIS). It also provides information on how to view or obtain a copy and how to make a submission.

1.1 The Proponent

Arrow, the Project proponent, is a Queensland-based wholly owned subsidiary of Arrow Energy Holdings Pty Ltd, a 50:50 joint venture between a subsidiary of Royal Dutch Shell plc (Shell) and a subsidiary of PetroChina Company Limited (PetroChina). The joint venture took ownership of Arrow on 23 August 2010.

Shell has had a presence in Australia since 1901. Current operations and equity interests include upstream exploration and production, petroleum refining, and wholesale and retail marketing of petroleum products. Shell has been a pioneer and technology leader in LNG production and operates one of the largest LNG carrier fleets in the world.

PetroChina is a subsidiary of China's largest state-owned oil and gas producer and distributor, China National Petroleum Corporation, and is one of the world's largest oil companies.

1.2 Arrow CSG Operations

Arrow supplies gas from its Daandine and Tipton West gas fields near Dalby in the Surat Basin to the Daandine, Braemar 1 and 2 and Swanbank E power stations. Arrow and its joint venture partner AGL also supply CSG via the North Queensland Gas Pipeline from its Moranbah Gas Project in the Bowen Basin to markets in Townsville including Queensland Nickel Industries, Copper Refineries and the Townsville Power Station. Arrow's current production is based on approximately 500 wells (of which around 150 are in the Bowen Basin) and amounts to 20% of Queensland's overall domestic gas production from all sources.

1.3 Bowen Gas Project

1.3.1 Project Objectives and Function

The principal objective of the Project is to commercialise gas reserves in Arrow's petroleum tenures in the Bowen Basin. The Project involves the extraction of gas from Arrow's petroleum tenures in the Bowen Basin which will result in a major expansion of Arrow's CSG production to supply gas to the domestic market and for the production and export of LNG.

The two principal functions of the Project are to:

- Produce, dehydrate and deliver gas to existing pipelines to supply domestic customers (future contracts yet to be established), and to the proposed Arrow Bowen Gas Pipeline which will supply the proposed LNG plant in Gladstone.
- Treat CSG water and supply it for use by third parties, and to safely dispose of water treatment residues (mainly brine).

1.3.2 Project Location

The Project's petroleum tenures currently cover an area of approximately 8,000 square kilometres (km^2) within Arrow's gas exploration acreage. These tenures are located approximately 150 kilometres (km) south-west of Mackay, with the bulk of the area extending from Glenden in the north to Blackwater in the south (see Figure 1). The Project area follows the Connors Range to the east and 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 River catchment.

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. Project infrastructure, including CSG wells, gas and water gathering systems and production facilities will be located throughout the Project area but not in any of the towns.

The Project area comprises Authorities to Prospect (ATPs) 1103, 1031, 1025, and a small portion of 759; and Authority to Prospect Applications (ATPAs) 742 and 749 (see Figure 1).

1.3.3 Project Overview

Conventional oil and gas reservoirs are geological formations in which hydrocarbons have become trapped after migrating from the host rocks in which they were formed. Not all hydrocarbons form reservoirs; many migrate to the surface as gas leaks or oil seeps or remain in their host rocks. CSG is an example of the latter.

In the Bowen Basin, the main CSG host rock is the Late Permian Blackwater Group, a formation in which the CSG has been kept in place under pressure by the overlying geological strata and the water that is also trapped in the coal formation within a confined aquifer. To allow gas to flow from the coal measures, the water pressure needs to be reduced. This will be done by pumping the water from the same production wells that are drilled to access the gas.

The gas and water produced by production wells will be collected in a network of gathering pipelines and processed or treated in a series of production facilities that may include compression, power generation and water treatment infrastructure. Processed gas will be dispatched to potential domestic gas customers and to LNG production and export. Treated water will be sent to various water users or injected into suitable aquifers if proven to be technically feasible and environmentally safe.

The Project is currently at the concept select phase. On commencement of the concept select phase a reference case was developed as the basis for impact assessment in the EIS. As the Project moves into the detailed design phase (front end engineering design (FEED)) some aspects of the Project may change. While the nature of the field development is known, details of the specific locations of wells, gathering systems and associated infrastructure require progressive determination.

The reference case assumes that up to 6,625 production wells would be drilled throughout the Project area over its 40 year life (approximately). It should be noted that this number of wells has not been optimised and has the potential to be reduced upon realisation of several drilling technology opportunities currently being explored. The Project area will be divided into development areas or gas fields allowing a staged approach. The first stage is expected to involve the initial development of up to four development areas coming online in 2017 with up to approximately 600 production wells likely to be drilled in the first two years.

The Project's reference case includes the following:

- **Production wells** — to access the coal seams and evacuate in-situ water and CSG;
- **Field gathering systems** — low and medium pressure pipeline networks to gather water and gas to a production facility;
- **Production facilities** — which will include a number of the following types:
  - field compression facility (FCF) (ten of) — a gas pressure boosting station to allow onward transport of remotely located gas to a central gas processing facility or an integrated processing facility;
  - central gas processing facility (CGPF) (three of) — to treat (dehydrate) and compress the gas to export pressure, and pump water to the nearest integrated processing facility; and
  - integrated processing facility (IPF) (four of) — to treat (dehydrate) and compress the gas to export pressure, and treat water for beneficial use.
- Access roads and tracks;
- Power generation and distribution facilities; and
- Monitoring and telecommunication facilities.

Development of the CSG resources will be staged to optimise production over the life of the Project, with the rate of development influenced by energy market demand, gas sales contracts, and information gathered from Arrow's ongoing exploration program.

Further developments are planned by Arrow 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 LNG market opportunity, through the Arrow LNG Project on Curtis Island near Gladstone. The gas produced by the Project will be piped to the proposed LNG Plant via the proposed Bowen Gas Pipeline. This LNG plant and the Bowen Gas Pipeline are subject to separate environmental approval processes and are not within the scope of the Project.

1.3.4 Related Projects

The Bowen Gas Project is one of several projects that comprise Arrow's CSG development, called the Arrow LNG Project (Figure 2). The Project will be developed with the following five other separate projects to produce gas for domestic and export LNG markets:

- **Surat Gas Project.** This project proposes to expand Arrow's CSG development in the Surat Basin. Arrow has prepared a voluntary EIS under the *Environmental Protection Act 1994* (EP Act) for this project.
- **Arrow Surat Pipeline.** This 470 km long pipeline, which has been approved, will carry gas from near Kogan in the Surat Basin to Gladstone.
- **Arrow Surat Header Pipeline.** This 106 km long, high-pressure gas pipeline will deliver gas from the southern part of the Surat project development area to the Arrow Surat Pipeline. This pipeline will be subject to a separate approvals process under the *Petroleum and Gas (Production and Safety) Act 2004* (P&G Act) (Qld) and the EP Act (Qld).
- **Arrow LNG Plant.** This proposed project, which comprises an LNG plant, marine, and ancillary infrastructure on Curtis Island near Gladstone, is the subject of a separate EIS process under the *State Development and Public Works Organisation Act 1971* (Qld). To be developed in two stages, each of two trains, the proposed LNG plant will have an ultimate capacity of up to 18 million tonnes per annum.
- **Arrow Bowen Gas Pipeline.** This proposed 475 km long, high-pressure gas pipeline and associated lateral pipelines will deliver CSG from Arrow's tenements in the Bowen Basin to Gladstone. Arrow has prepared a voluntary EIS under the EP Act for this Project.

Figure 1. Project Location

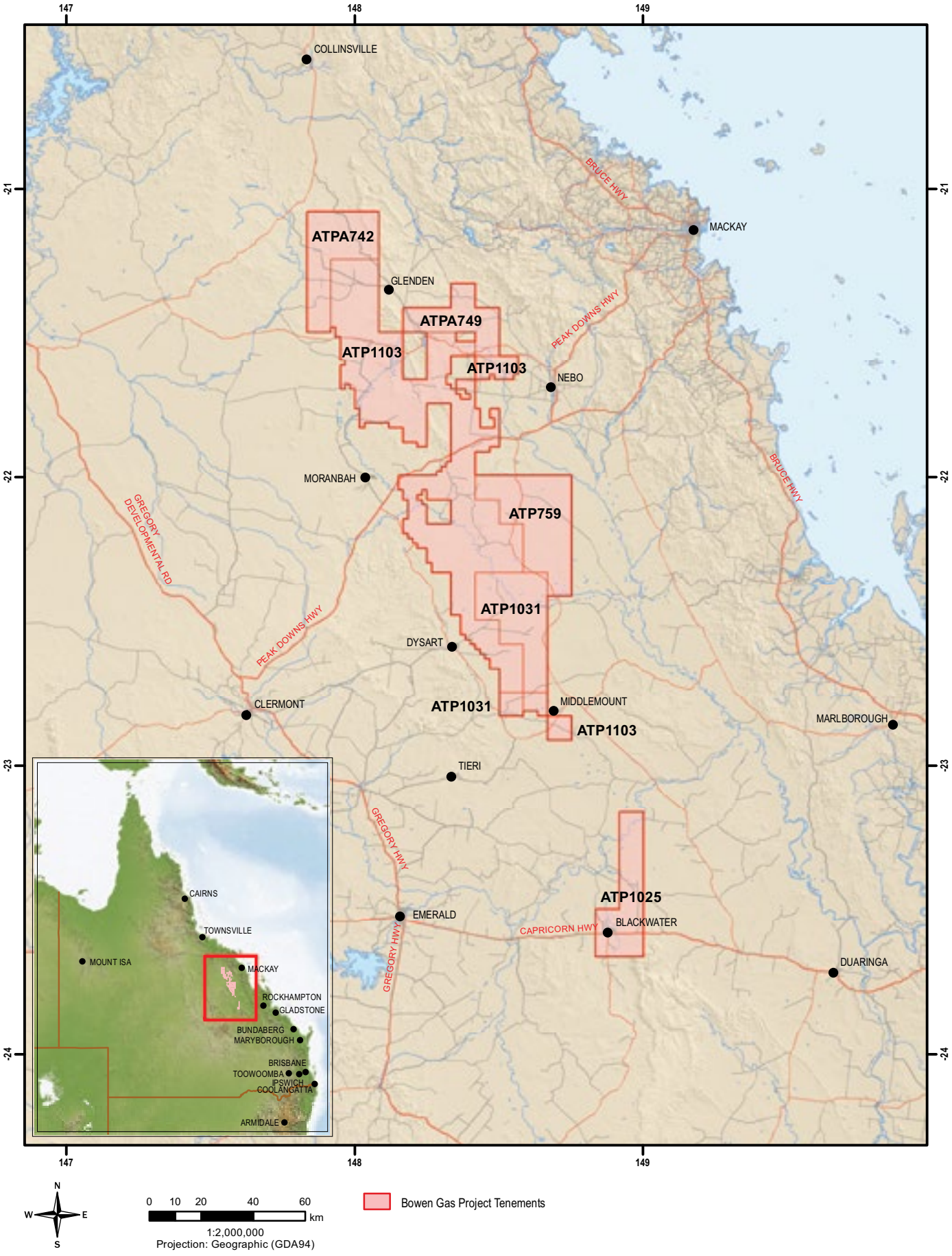
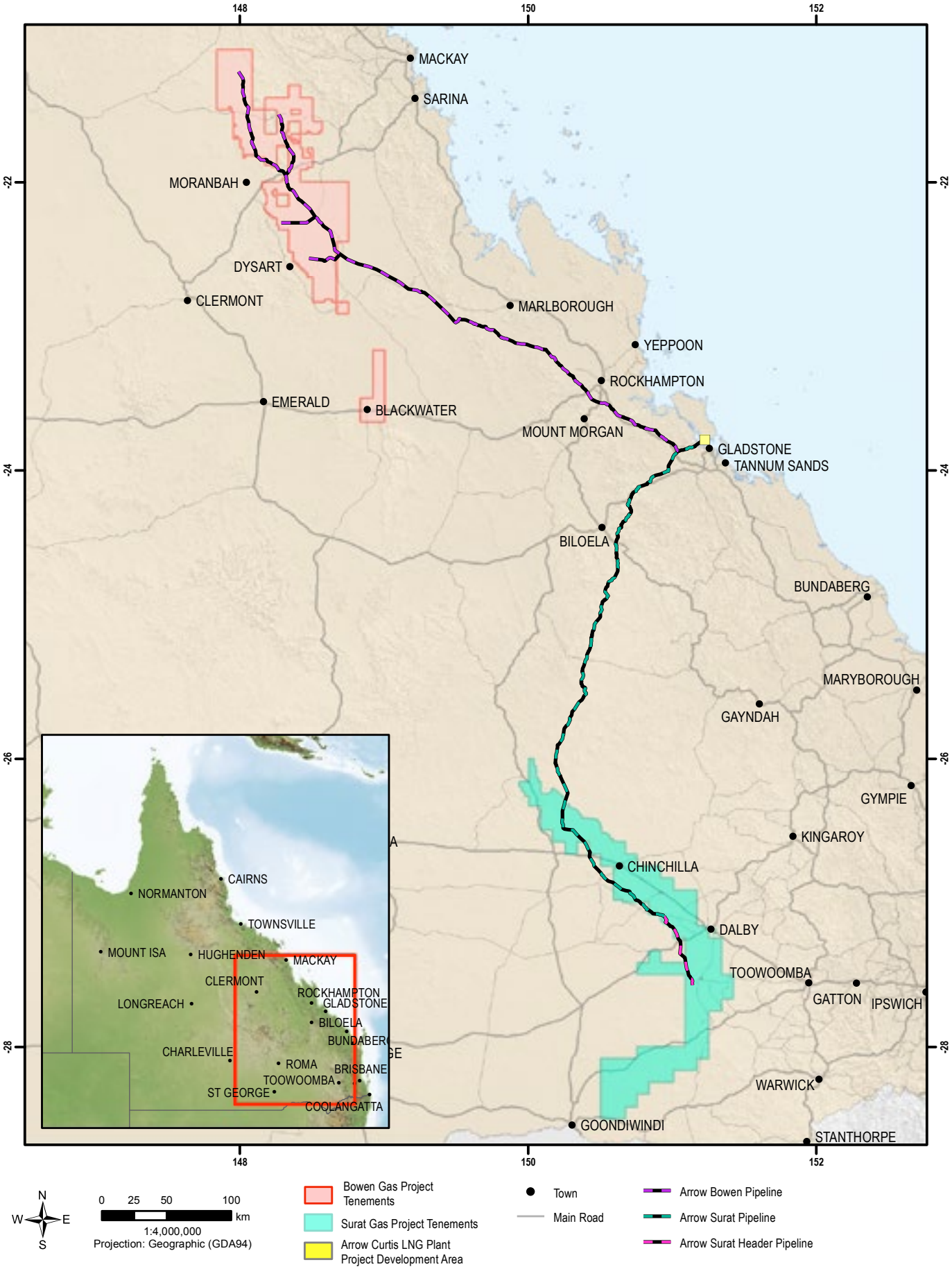


Figure 2. Arrow LNG Project



1.4 Environmental Impact Statement

1.4.1 Legislative Basis

This EIS has been prepared as a voluntary EIS under the EP Act. The Queensland EIS process has been accredited by the Australian Government under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Commonwealth) for matters of national environmental significance (MNES). The EIS will inform the decisions of the Queensland and Australian Governments on whether the Project should or should not proceed and, if so, under what conditions.

1.4.2 Objective

The objective of the EIS process is to ensure that all impacts, direct and indirect, particularly environmental, social and economic are fully examined and addressed. The EIS aims to be a self-contained and comprehensive document that provides for:

- **Interested and affected persons and organisations:** a basis for understanding the Project, alternatives and preferred solutions where possible, the existing environment that would be affected by the Project, the potential impacts that may occur, and the measures to be taken to mitigate all adverse impacts;
- **Regulatory agencies and the advisory bodies:** a framework for assessing the impacts of the Project, in view of legislative and policy provisions; and
- **The Proponent (Arrow):** a statement of measures or actions to be undertaken to mitigate any adverse impacts during and following the implementation of the Project. A draft Environmental Management Plan (EM Plan) is included in the EIS, describing potential impacts and environmental management measures designed to meet agreed performance criteria.

The EIS relates to the whole life of the Project, including construction, operation, maintenance and decommissioning. The EIS proposes reasonable, cost-effective and technically achievable conditions to ensure that the potential environmental, social and economic impacts of the Project are reduced to acceptable levels.

The content of the EIS addresses those matters identified in the Terms of Reference (ToR) (Appendix A of this EIS) issued by the Department of Environment and Heritage Protection (EHP).

This EIS has been made publicly available for comment, and submissions are sought from individuals and organisations. After consideration of this EIS and the submissions received, EHP will review the Project EIS to identify any uncertainties or omissions. A supplementary report may be necessary to cover any additional matters of concern and address stakeholder submissions. A final decision on the overall acceptability of the Project will then be made on the basis of the information provided.

1.4.3 Community Consultation

Community consultation is integral to the EIS process, as it allows community concerns and issues to be addressed in the EIS. Arrow's consultation has sought to maximise community input through various forums and in many sessions. Consultation has encompassed information sessions, workshops, call-in centres and meetings. Arrow's commitment to community consultation is outlined in Box 1.

Box 1 Community Consultation

Arrow is committed to building mutually beneficial relationships with the community throughout the life of the Project, and aspires to understand community concerns, as well as form partnerships to resolve potential issues and explore opportunities for advancement of community interests in the Bowen Basin.

1.4.4 EIS Documentation

The EIS documentation comprises eight volumes:

- Volumes 1 and 2 comprise the main report and its attachments, including the draft EM Plan and the social impact management plan.
- Volumes 3 to 8 contain the supporting studies that describe the environmental, social, cultural and economic aspects of the Project and present the findings of the impact assessments. The findings of the supporting studies are summarised in the main report.

1.4.5 EIS Schedule

Milestone and target dates for the Project are provided in Table 1 below. This program shows that the environmental approvals process commenced in Q1 2012, with a decision on the Project targeted for Q4 2013.

Table 1. EIS Milestone Dates

Milestones	Target Milestones
Initial Advice Statement lodged with EHP	24 April 2012
EPBC Act Referral lodged with the Department of Sustainably, Environment, Water, Population and Communities (DSEWPaC)	08 May 2012
EPBC Act Referral Decision	15 June 2012
Final Terms of Reference	02 November 2012
Draft EIS Submission to EHP	Q4 2012
Public Notification and Submission Phase	Q1 & Q2 2013
EIS Supplementary Report (if required)	Q4 2013
Chief Executive of EHP's Environmental Assessment Report	Q4 2013
DSEWPaC EPBC Act Assessment Report	Q4 2013

1.4.6 Viewing and Obtaining the EIS

The EIS may be viewed in the locations listed below in Table 2.

Table 2. EIS Viewing Locations

Location	Address
Isaac Regional Council	
Middlemount Library	Middlemount Shopping Mall, Middlemount, QLD, 4746
Clermont Library	Cnr. Karmoo and Herschel Streets, Clermont, QLD, 4721
Dysart Library	Council Premises, Shannon Crescent, Dysart, QLD, 4745
Glenden Library	Town Centre, Ewan Drive, Glenden, QLD, 4743
Moranbah Library	Grosvenor Complex, Batchelor Parade, Town Square, Moranbah, QLD, 4744
Nebo Library	10 Reynolds Street, Nebo, QLD, 4742
Central Highlands Regional Council	
Emerald Library	44 Borilla Street, Emerald, QLD, 4720
Blackwater Library	Wey Street, Blackwater, QLD, 4717
Bluff Library	6 Church Street, Bluff, QLD, 4702
Duaringa Library	Elizabeth Street, Duaringa, QLD, 4712
Whitsunday Regional Council	
Bowen Customer Service Centre	7 Herbert Street, Bowen, QLD, 4805
Collinsville Customer Service Centre	Cnr. Stanley and Conway Streets, Collinsville, QLD, 4804
Proserpine Customer Service Centre	3–85 Main Street, Proserpine, QLD, 4800
EHP Regional Offices	
EHP (Brisbane)	Floor 3, 400 George Street, Brisbane, QLD, 4000
EHP (Emerald)	99 Hospital Road, Emerald, QLD, 4720
EHP (Mackay)	22–30 Wood Street, Mackay, QLD, 4740

Electronic copies of the EIS can be obtained, downloaded and viewed on line at **www.arrowenergy.com.au** or obtained on compact disc by contacting **1800 038 856** or emailing **bowengas@arrowenergy.com.au**.

Hard copies can be ordered by phone or email at a small cost (see Arrow's website, **www.arrowenergy.com.au** for details).

1.5 Project Approvals Process

The assessment process that would facilitate approval of the Project reflects the phased approach to development of the CSG fields. It progressively demands more detailed information to inform decisions about whether the Project should proceed, under what conditions and whether requisite environmental authorities and permits should be granted, and under what conditions.

Each stage of the assessment process provides opportunities for stakeholders as well as interested and affected people to comment on the information provided by Arrow and the approvals sought. Public notification and comment requirements are embodied in each aspect of the approvals process.

Following completion of the EIS public review and the preparation of any supplementary information required, the Chief Executive of the EHP will consider all submissions and recommendation from advisory agencies (listed in Introduction chapter (Section 1.5.11) of the EIS) in preparing the EIS assessment report. The EIS assessment report will:

- Assess the adequacy of the EIS and the draft EM Plan;
- Make recommendations about the suitability of the Project;
- Set out the conditions under which the Project should proceed; and
- Provide direction to government agencies and regulatory authorities for the assessment and conditioning of environmental authorities and permits required subsequently to construct and operate specific parts of the Project.

The EIS process concludes when Arrow receives the EIS assessment report from the Chief Executive of EHP. Receipt of the EIS assessment report authorises Arrow to proceed to obtain the environmental authorities, permits and consents required to construct and operate the Project. Receipt of the assessment report does not give Arrow approval to commence any Project-related construction activities.

Arrow will require an environmental authority (EA) under the EP Act to commence the Project's construction and operation on a petroleum lease (PL). Arrow may apply for an EA or amend an existing EA. An EA will set out the detailed conditions under which a Project must be constructed and operated within a PL. Detailed information about the location of significant Project infrastructure (such as compression facilities) and the impacts of their construction and operation is required to enable an EA application to be assessed by EHP and is typically presented in an EM Plan, or similar document prepared as part of the EIS or as part of the EA application. If sufficiently detailed information has not been provided in the EIS or in the draft EM Plan, it must accompany the EA application and EM Plan. The EM Plan prepared to support an EA application will include detailed information about the location of facilities, the site specific impacts of construction and operation, environmental management measures and suggested conditions of approval as well as any significant changes to the Project since completion of the EIS. If the Project is deemed to have significantly changed from the EIS stage to the EA stage, that is, the environmental risks of the activity and/or the way the activity will be carried out have changed, then under the EP Act an application for an EA will be published and public comment invited. If EHP deem that the EA proposes a change that would be likely to attract a submission from the public, EHP would then consider any submissions in assessing the application in determining the conditions that apply.

Each EA application and subsequent related PL application will generally include (but not be limited to) the following typical details:

- Facility locations, and technology selections, including:
  - Compressor stations;
  - Water treatment facilities and dams; and
  - Power generation or distribution infrastructure.
- Any proposed beneficial use of water, and/or discharge to a watercourse;
- Camps and accommodation;
- Borrow pits;
- Chemical and fuel storage; and
- Waste disposal.

The EA application will demonstrate how the siting and design of this infrastructure has been developed in accordance with the constraints mapping process described within the EIS, that the environmental impacts are consistent with those identified in the EIS, and that they can be managed by the proposed mitigation measures presented in the EIS and the EM Plan attached to the EA application. Should any further environmental impacts be identified that are outside those identified and assessed in the EIS, they will be assessed and the impact assessment and proposed management and mitigation measures presented in the EM Plan.

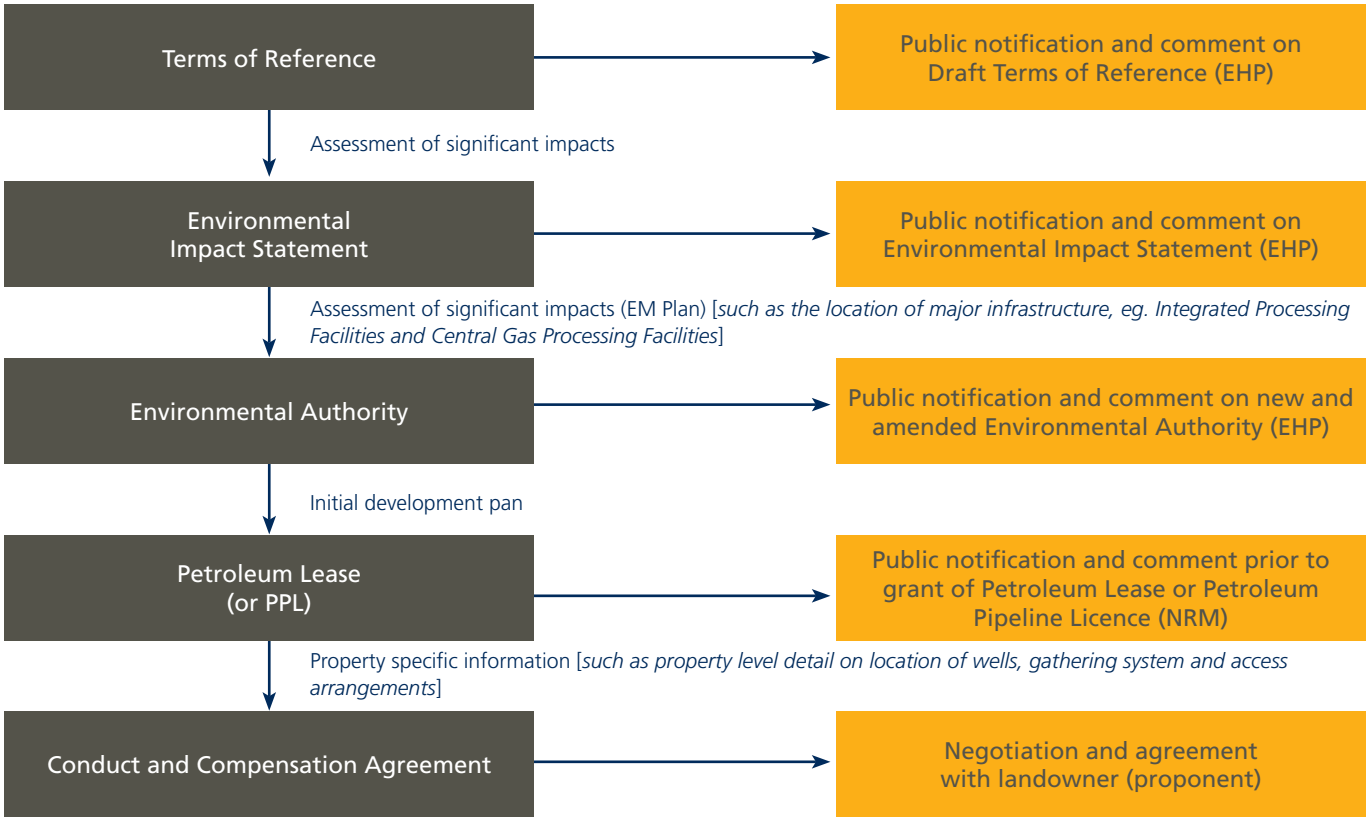
Arrow must have an approved EA before a PL can be granted by Department of Natural Resources and Mines (NRM). PL applications must be published and public comment sought prior to grant of the lease. An initial development plan, which typically covers the first five years of the Project's development, must be submitted with the application. The initial development plan would contain detailed information about the nature and extent of activities to be carried out under the lease(s) such as that listed above. Subsequent development plans would provide detailed information about subsequent development of further PLs and changes to authorised development. NRM must consider any submissions in deciding whether to grant the lease and any conditions that apply.

Arrow proposes to stage the applications for PLs and the associated environmental authorities (or amendments to environmental authorities) throughout development of the Project, as additional PLs are required to support gas field development. This staged process will mean that the development concept will have had time to mature and additional information on the development will be available (for example, locations of major infrastructure such as IPFs) to interested and affected people, the broader public and the administering authority when each of these applications is made.

Arrow must also negotiate a conduct and compensation agreement under the P&G Act with landowners on whose land the petroleum activities will be carried out. Negotiation of the agreement provides an opportunity to landowners to raise concerns specific to their property and to reach agreement with Arrow on where, how and when development will occur of their property. The location of wells and water and gas gathering lines will be finalised, in consultation with the landowner, as part of the negotiations. However all final locations will also need to comply with all relevant approval conditions. Arrow is required to provide detailed information about the proposed activities, the location and timing of activities, the measures to manage impacts, rehabilitation and compensation. Negotiation of compensation includes access to dispute resolution and to the Land Court if agreement cannot be reached through the normal process.

An outline of the Project's approval process is provided in Figure 3.

Figure 3. Approvals Process for Petroleum Gas Activities



2 Project Need

2.1 Technology

Gas supplies some 22% of the world's energy. In the nineteenth and early twentieth centuries, gas was mainly produced from coal, which was processed in municipal gas works and used for lighting, heating and industrial applications. The subsequent discovery and development of natural gas resources progressively superseded these gas works.

Historically, natural gas production was tied predominantly to markets located in the vicinity of the gas field. However, in the middle of the last century, the development of liquefaction processes overcame these limitations by enabling natural gas to be reduced to 1/600th of its original volume. This allowed LNG product to be transported by ship to distant markets.

More recently, the production of natural gas from coal seams has become technically and economically feasible. The reserves of unconventional gas far exceed the volumes of gas known to be contained in traditional gas reservoirs. This situation adds volume, competition and geopolitical diversity of supply to the global energy market.

2.2 Energy Policy

The energy policies of the Australian and Queensland Governments are driven by the need to:

- Grow a diverse economy at regional, state and national levels;
- Reduce greenhouse gas emissions from the stationary energy sector; and
- Support Australian industry and ensure Australia's security of energy supply.

Key policies which will apply to the Project are the following:

- Australian Government Energy White Paper;
- Queensland Climate Change Strategy;
- Queensland Government Gas Scheme; and
- The Blueprint for Queensland's LNG Industry.

2.3 LNG Demand and Markets

Trade of LNG accounts for 9% of global gas consumption (Geoscience Australia, 2012). Worldwide LNG sales are predicted to rise from 165 million tonnes (Mt) in 2007 to between 245 and 340 Mt per year by 2015 (IEA, 2009). By 2035, predictions show an increase in the global gas trade of around 80%, of which more than half will be LNG (IEA, 2010).

Historically, there have been two main LNG import markets: the Asia-Pacific, which includes China, Taiwan, Japan and the Republic of Korea; and the Atlantic, which includes Europe and North America. The growth of Middle East imports in 2010 signalled the introduction of new markets (ABARES, 2010).

Australia is a significant exporter of LNG, with around 50% of gas production being exported. In 2009–2010, the value of Australian LNG exports was $7.8 billion (ABARES, 2011). LNG exports are expected to grow progressively from around 24.5 billion cubic meters (bcm) in 2009/10 to 82 bcm by 2015. Potentially LNG exports could exceed 140 bcm by 2030 (IEA, 2011).

2.4 Australian Domestic Demand

ABARES (2010) forecasts Australia's primary energy consumption to increase by 1.4% per year, from around 5,772 petajoules (PJ) in 2007–2008 to 7,715 PJ by 2029–2030. While this represents an overall increase of around 35%, ABARES predicts Australia's long-term trend will weaken the move towards greater energy efficiency and the use of less carbon-intensive energy sources. ABARES predicts Australia's primary fuel mix will change, aided by policies that encourage the development of gas and renewable energy sources to reduce dependency on coal.

Domestic gas consumption in Australia was 32.8 bcm in 2010 compared to 31.4 bcm in 2009 (IEA, 2011). Natural gas demand is expected to increase at a rate of 3.4% per annum over the next two decades, reaching over 65 bcm (2,575 PJ) by 2030. Gas-fired power generation in Queensland, Victoria and New South Wales is a key driver of demand for gas (AEMO, 2010).

2.5 Australian Gas Resources

Approximately 92% of Australia's conventional gas resources are located in the Carnarvon, Browse and Bonaparte basins off the north-west coast. There are also resources in south-west, south-east and central Australia (see Figure 4) (Geoscience Australia, 2012). At the beginning of 2011, Australia's economic demonstrated resources[1] (EDR) and sub-economic demonstrated resources[2] (SDR) of conventional gas were estimated at 173,000 PJ. At current production rates there are adequate EDR (113,400 PJ) of conventional gas to last another 54 years (Geoscience Australia, 2012).

1 EDRs are "resources with the highest levels of geological and economic certainty. For petroleum these include remaining proved plus probable commercial reserves. For these categories, profitable extraction or production has been established, analytically demonstrated or assumed with reasonable certainty using defined investment assumptions" (Geoscience Australia, 2012).

2 SDRs are "resources for which, at the time of determination, profitable extraction or production under defined investment assumptions has not been established, analytically demonstrated, or cannot be assumed with reasonable certainty (this includes contingent petroleum resources" (Geoscience Australia, 2012).

For CSG resources, large deposits exist in the coal basins of Queensland and New South Wales. Presently, the Surat and Bowen Basins account for 61% and 34% of current proved (1P) and proved plus probable (2P) CSG reserves respectively, with small amounts also in the Clarence-Moreton, Gunnedah, Gloucester and Sydney Basins (Geoscience Australia and ABARES, 2010).

Australia's CSG EDR have doubled since 2009 and at the end of 2011 were 35,905 PJ which is equivalent to about a third of the recoverable reserves from Australia's conventional gas fields. Australia's total identified resources of CSG are estimated at approximately 223,454 PJ, which consist of EDR of 35,905 PJ, SDR of 65,529 PJ and inferred resources of 122,020 PJ (Geoscience Australia, 2012). Reserve life for Australia's CSG is around 150 years at current rates of production, however this is likely to change as production is estimated to significantly increase with the establishment of the CSG LNG industry (Geoscience Australia, 2012).

Queensland has 33,001 PJ (or 92%) of Australia's reserves (DEEDI, 2012 in Geoscience Australia, 2012), with the remaining 2,904 PJ in New South Wales. The majority of current reserves are found in Queensland's Surat (69%) and Bowen (23%) Basins. On this basis the Bowen Basin has EDR of 7,590 PJ.

Australia's gas reserves are shown in Figure 4.

2.6 Bowen Basin Gas Reserves

Arrow's knowledge of the gas reserves in the Project area is based on the extent of its exploration activities to date. As more extensive exploration and development has been undertaken in Arrow's existing operational tenures, the reserves in the areas adjacent to its existing field developments have a higher level of certainty of being able to be recovered. Arrow's gross gas reserves in the Project area as at 31 December 2011 are presented in Table 3.

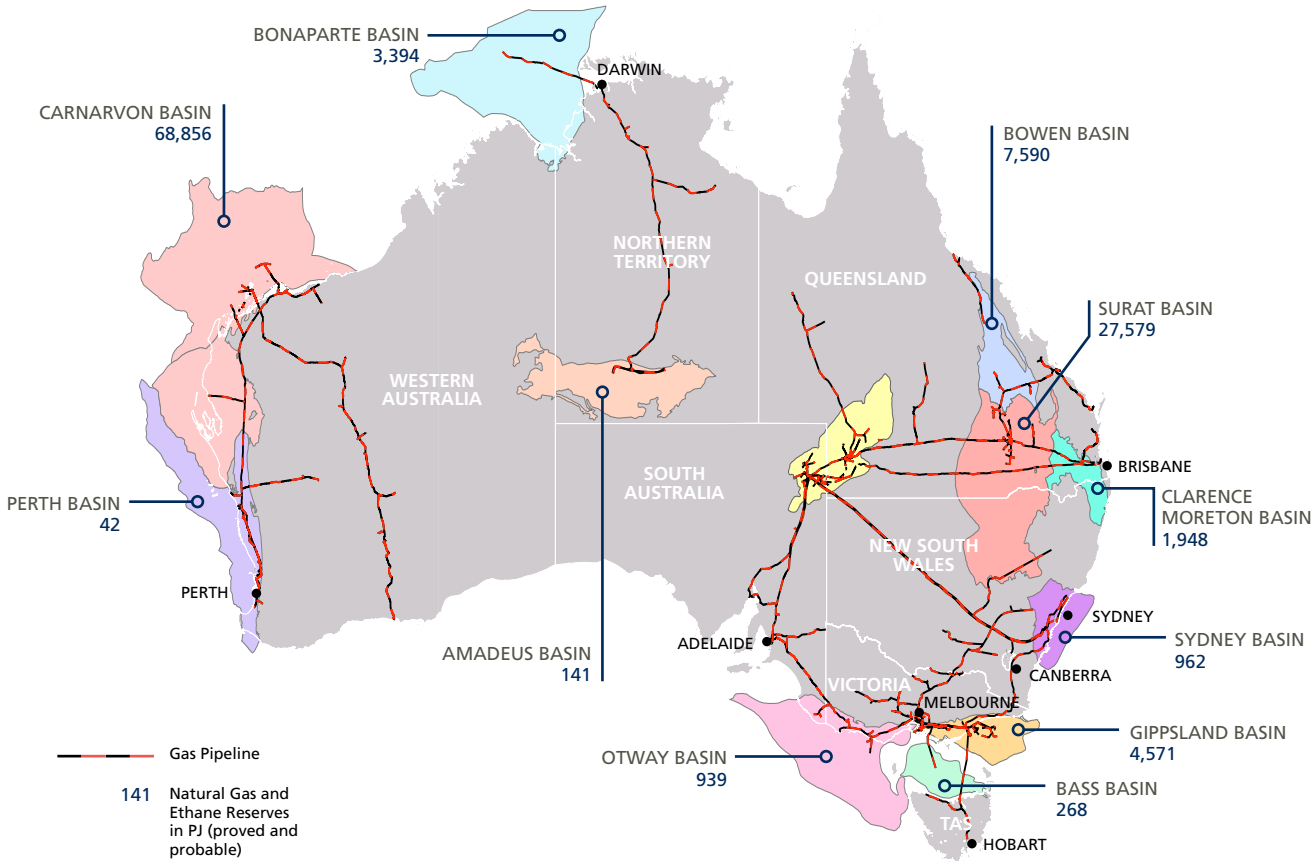
Table 3. Certified Project Area Reserves in Petajoules as at 31 December 2011

Tenure	Gross 1P* (PJ)	Gross 2P** (PJ)	Gross 3P*** (PJ)
ATP 1103	0	1,536	3,321
ATP 1025	0	148	2,480
ATP 1031	0	37	192
Subtotal	0	1,721	5,993

*1P: proven gas reserves
**2P: proven and probable gas reserves
***3P: proven, probable and possible gas reserves

Modelling suggests that the Project area would have an estimated annual production of 147 PJ per year under current export scenarios.

Figure 4. Australian Gas Resources by Basin



3 Design Process and Environmental Framework

3.1 Reference Case and Design Process

The EIS will not be able to identify the exact locations of all wells, pipelines and other associated infrastructure throughout the life of the Project. However, as required under the EP Act, the EIS must provide enough information about the impacts of the Project to help the administering authority decide whether the Project should proceed and, for the purposes of the bilateral assessment for the EPBC Act process, to provide the Commonwealth Environment Minister with sufficient information to make a decision about the Project.

Siting of CSG infrastructure is a process of progressive refinement informed by exploration, resource validation and gas field design to optimise recovery of economic reserves. The Project is currently at the concept select phase which includes the development of a reference case or conceptual layout that describes how wells, gathering systems and production facilities might be arranged to extract and process gas. This is presented as areas in which facilities might be developed, with the arrangement of gathering systems and wells within a typical grid arrangement i.e. a grid of wells at nominally 800 m intervals. A preliminary development sequence has been developed as part of this reference case to establish an indicative construction and drilling program. This reference case has been used as the basis for impact assessment in the EIS as it generally represents the worst case development scenario in terms of environmental impacts.

If required, the reference case will be updated after the concept select phase and will progress into the detailed design FEED. This updated reference case will describe in more detail how the gas fields would be laid out and developed. It will provide a greater level of detail about the number and capacity of production facilities, and confirm equipment type selection, as well as functional layouts of wells and gathering systems. Constraints mapping and the findings of the EIS will inform design and take into consideration a range of factors, including technical feasibility, constructability, cost and risk, as required by standards applicable to the design, construction and operation of petroleum and gas developments. The conceptual layout presented in the EIS will be refined to optimise the number of production facilities and wells and gathering systems required to recover the economic reserves.

Field development planning is iterative and will be ongoing through the life of the Project as gas reserves mature and actual production is realised. Hence, the reference case and development sequence are expected to be progressively optimised through the Project life.

FEED will inform detailed design of the early gas field layout which relies on access to land for information gathered in geotechnical investigations, confirmation of environmental constraints, and landowner consultation. At this stage, details on proposed facility locations for the initial phases of development would be determined and become the basis for the EA application. The initial development plan would facilitate detailed assessment of the impacts of construction and operation of the proposed infrastructure at the nominated sites which would be presented in the EM Plan prepared in support of an application for an EA or an application to amend an existing EA. The impact assessment presented in the EM plan would validate the impact assessment presented in the EIS.

The design process covers a number of activities which take approximately five years for each separate development area. The way in which the environmental framework is integrated with the design process is set out below:

Step 1 Analysis of geological and geophysical data to inform exploration program, including location of exploration wells. Undertake exploration drilling program.

Step 2 Analysis of exploration data. Installation of pilot wells to prove CSG yields and CSG water production.

Step 3 Conceptual and preliminary design of gas field. Land access negotiations with landowners initiated. Consultation with landowners and key stakeholders on gas field development. Ecological and cultural heritage preconstruction clearance surveys and geotechnical investigations.

Step 4 Detailed design of gas field and production facilities. Ongoing land access negotiations.

Step 5 Detailed design of gas field and production facilities, revision or development of work plans, preparation of site-specific EM Plans. Land access arrangements finalised.

3.2 Environmental Framework

CSG field development would be progressive, extending over the life of the Project which would be approximately 35 to 40 years. Unlike conventional gas resources, CSG resources are extensive, requiring widespread field development to recover the resource. Furthermore, the yield from target coal seams is variable across the gas field. This leads to uncertainty about the precise number, timing and location of wells required to dewater the coal seams and extract the gas. Prior to considering environmental and social constraints, selection of the ideal location of infrastructure required to treat the CSG water and process the gas is also uncertain, being driven by exploration results and optimisation of well placement and water and gas gathering systems.

The lack of certainty about the preferred location of infrastructure requires an environmental assessment approach which is different to that which would apply to a defined development at a fixed location. The approach that has been adopted for this Project is based on an assessment of the typical impacts of the various Project activities that are proposed. With that knowledge, greater certainty about potential impacts can be achieved by identifying those areas that are not amenable to certain Project activities and, if they were developed, how development would proceed. This has been achieved through the identification of constraints to development and the establishment of environmental management controls that would apply to Project activities in constrained areas.

Known as an environmental framework, this approach is an internal process developed by Arrow for avoiding and managing environmental impacts in the Project's planning, construction and operation phases through the application of environmental controls that reflect the sensitivity or vulnerability of environmental values. Constraints mapping, an integral part of the environmental framework, is informed by this EIS and guides site and route selection decisions based on the known level of environmental constraints in the area and the level of impact posed by the Project activity. In this way the conceptual design can seek to avoid or minimise impacts, thereby protecting environmental values.

This assessment process would facilitate Project approval as it reflects the phased approach to development of the CSG fields. It progressively demands more detailed information to inform decisions about whether the Project should proceed, whether requisite environmental authorities and permits should be granted, and under what conditions.

Each stage of the assessment process provides opportunities for stakeholders as well as interested and affected people to comment on the information provided and the approvals sought. Public notification and comment requirements are embodied in each aspect of the approvals process as discussed in Section 1.5.

3.3 Constraints Analysis

Environmental constraints to the Project's development have been derived from the sensitivity of the environmental values identified in the EIS, with more sensitive values imposing a higher level of constraint. Constraints that can be defined spatially (e.g. endangered vegetation communities) are maintained in the Project's geographic information system and presented in maps. These include separation distances to ensure public health and safety, particularly from air emissions, noise and hazardous facilities.

The level of environmental constraint determines the types of activities permitted and the applicable environmental management measures as set out in Table 4.

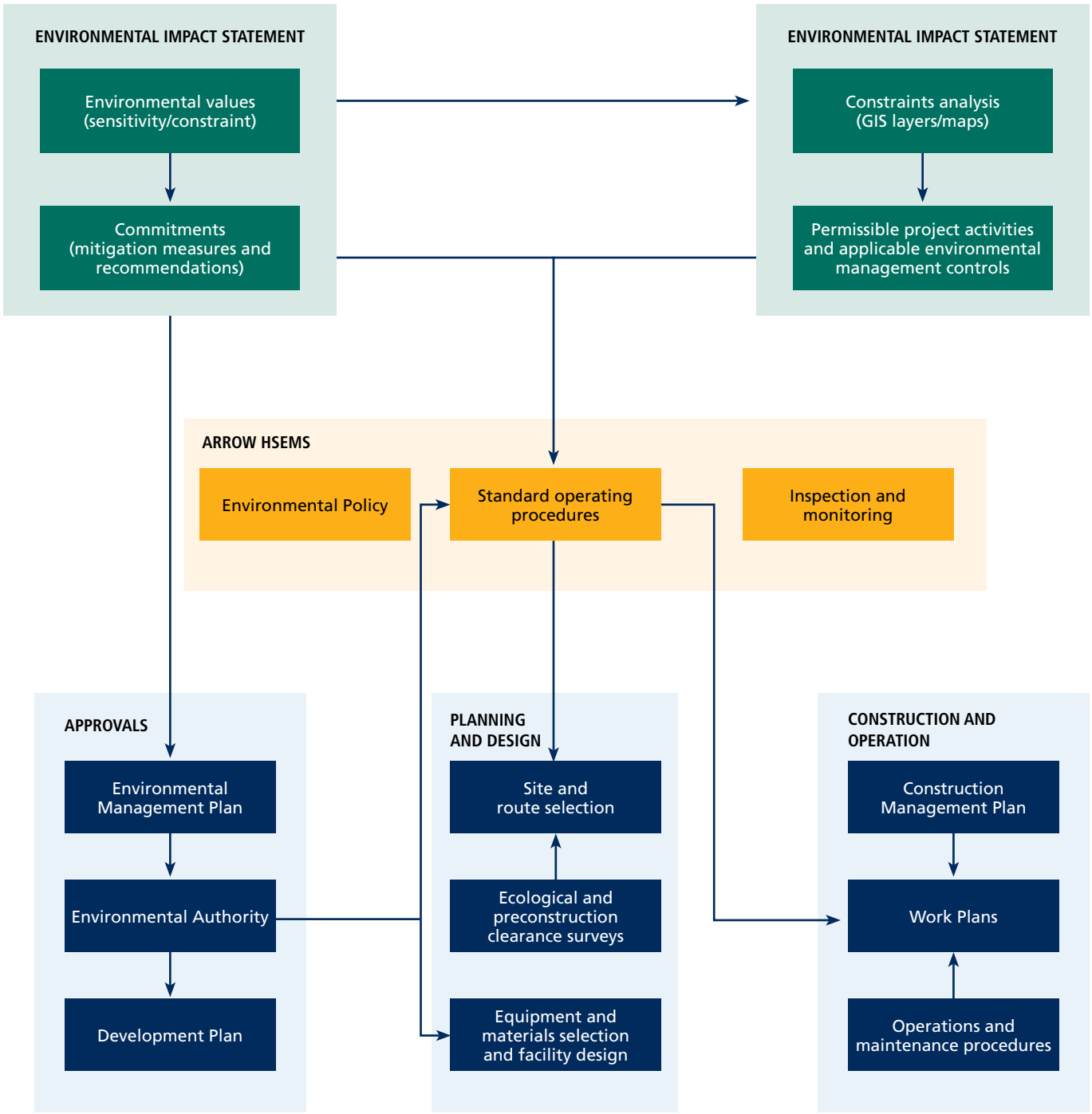
Environmental management measures will be developed and incorporated in Arrow's HSEMS, which will provide the policy, management and audit framework for construction and operations EM Plans. These measures will include a standard operating procedure that will describe the process and frequency of updates to the constraints maps. These maps are integral to the site and route selection standard operating procedure already being used by Arrow to plan development.

The relationships between the environmental framework and Arrow's HSEMS and the key information flows is shown in Figure 5.

Table 4. Permissible Project Activities based on Level of Constraint

Level of Environmental Constraint	Environmental Management Control	Project Activity		
		Wells	Gathering Systems	Production Facilities
No go	Not applicable	No	No	No
High	Site-specific environmental management measures	Yes	Yes	No
Moderate	Specific environmental management measures	Yes	Yes	Yes
Low	Standard environmental management measures	Yes	Yes	Yes

Figure 5. Relationship of the Environmental Framework to the Arrow HSEMS



3.4 Conceptual Development Sequence

3.4.1 Staged Field Development

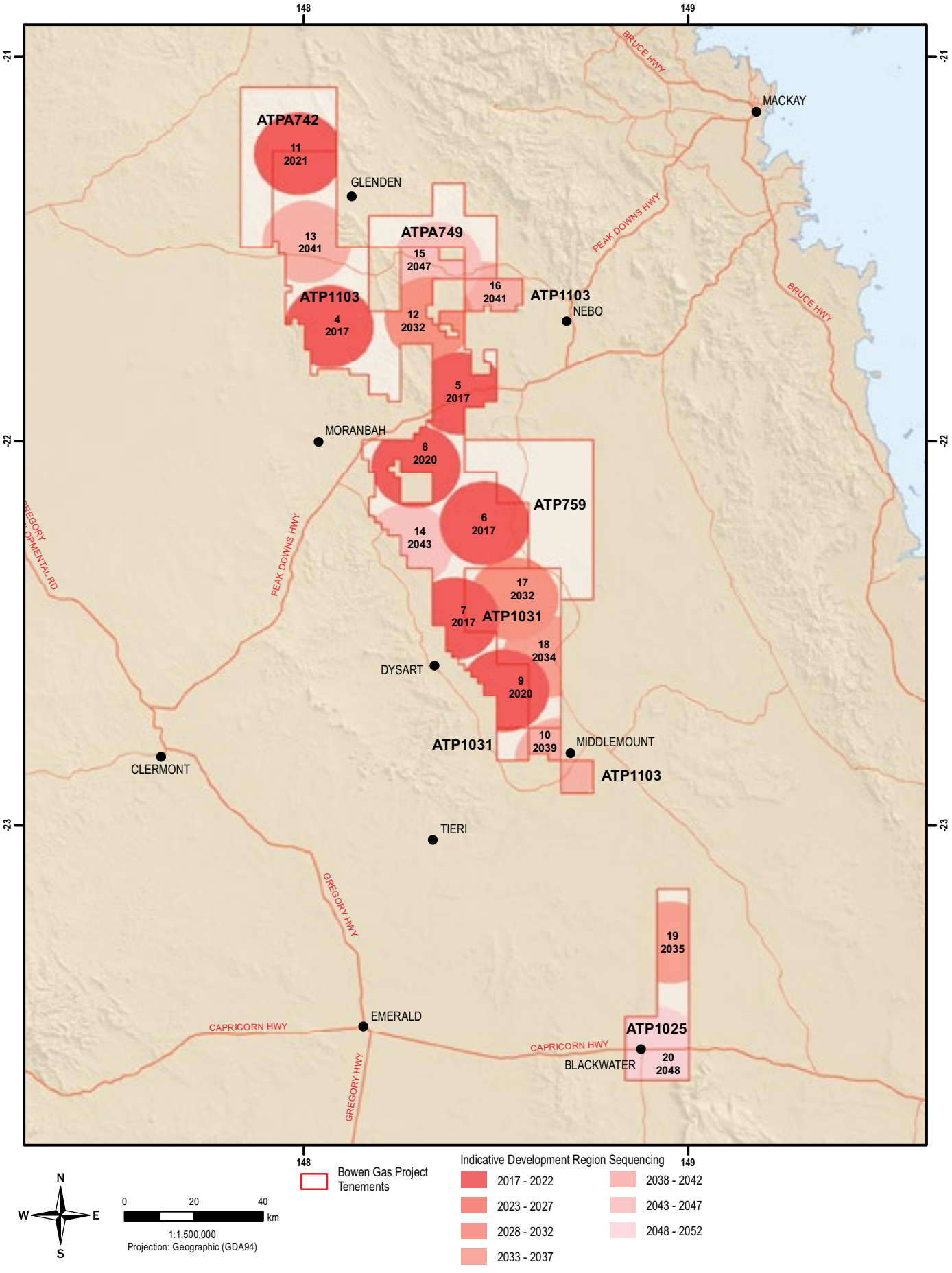
Field development would be staged in a number of separate development areas as set out in Table 5 and Figure 6. As gas production from the initial wells decreases and the wells are decommissioned, additional wells would be drilled to maintain production. The production wells and associated gathering systems would be developed in parcels in each development area. The parcels would be developed concurrently with the construction of the production facilities that are required to receive the produced gas and water. To minimise land requirements, production wells would, where possible, be located with common access and/or gathering systems.

Table 5. Indicative Field Development Timing for Reference Case

Year	Development Area [1]																
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2017																	
2018																	
2019																	
2020																	
2021																	
2032																	
2033																	
2034																	
2035																	
2039																	
2040																	
2041																	
2042																	
2043																	
2047																	
2048																	

1. Development areas 1, 2 and 3 relate to the Moranbah Gas Project and do not form part of the Project

Figure 6. Project Development Area



3.4.2 Ramp-up Period Gas Management

The ramp-up period between first gas production and sustained production for export will require the produced gas to be managed. Accordingly, gas produced during the ramp-up period will, in order of preference, be:

- Directed to Arrow's existing gas-fired power stations;
- Sold on the gas spot market;
- Managed to avoid flaring by increasing well spacing and selectively bringing wells on line; and
- Flared as a last resort.

3.4.3 Factors Influencing the Sequence and Rate of Development

Factors influencing the sequence and rate of development include:

- The supply requirements of long-term gas agreements;
- Confirmation of production rates through exploration and pilot well programs;
- PL licensing and approvals;
- Land access agreements;
- Execution capacity (drilling and construction resources);
- Capital cost of new infrastructure and access to existing infrastructure;
- Operating costs;
- The resolution of environmental and social issues;
- The development of the more productive parts of the field;
- Planning well depressurisation and developing infrastructure to manage the produced water;
- Completion of the Arrow Bowen Pipeline and the Arrow LNG Plant; and
- The availability of supporting services (such as accommodation), as these factors can encourage faster development, while others can constrain the speed of development.

3.5 Workforce

A significant workforce will be required for the Project. The peak will occur during the height of construction activity when the operations workforce is reaching its peak and has plateaued.

Workforce predictions will be influenced by decisions about the design and operations of the CSG fields, and contracted volumes of gas. Workforce requirements may increase or decrease with the rate of development.

Arrow's preference is to provide employment to people sourced locally (within the Project area); however, due to the high demand by local industry, the mining industry, other CSG proponents and low unemployment rates, Arrow recognises that labour will likely need to be sourced from further afield. Arrow's aim is to implement a hierarchy of preferred employment and contractor candidates based on the employee's or contractor's home or source location. The order of preference is as follows:

1. Local (lives within or close to the Project area);
2. Regional (lives within central and southern Queensland);
3. National (lives in Australia); and
4. International (lives outside Australia).

Based on the reference case, a peak construction workforce of approximately 1,540 personnel is expected to occur in 2016, when three IPFs in Area #4, Area #5 and Area #7 and one CGPF in Area #6 are expected to be constructed. The construction workforce is expected to reduce to approximately 1,048 personnel in 2019, after which it is expected to further reduce and fluctuate between approximately 470 and 690 personnel with peaks coinciding with overlapping production facility construction programs. The construction workforce is likely to be predominately fly-in, fly-out (FIFO) due to the specialised nature of the work, and the short term duration of construction related roles.

It is expected that operations workforce requirements would begin in 2016. The forecasted operations workforce is expected to reach its peak of approximately 610 personnel in 2034 and remain relatively constant thereafter. The operations workforce will be based at the CGPF and IPFs, with support staff and administration personnel located in towns.

While Arrow would prefer to engage operational staff who are resident within the region, and will provide incentives in employment packages to encourage this, it also acknowledges that there are likely to be a significant number of workers who choose not to relocate to the area. Arrow expects most personnel involved in decommissioning to be sourced locally. Decommissioning activities are scheduled many years in the future, allowing time for adequate skills development in the local employment base.

4 Project Components

Following exploration and appraisal, which leads to resource definition, the gas production sequence involves the following steps:

- Constructing a series of production wells, each of which will be used to depressurise the confined aquifer and extract CSG from the coal seams. The location of production wells will be informed by environmental constraints mapping and land access negotiations that culminate in landowner agreement on the location of the wells and gas and water gathering systems that transfer those products to production facilities.
- Processing gas and treating water at production facilities, including:
  - compressing gas at FCFs;
  - dehydrating and compressing gas, transferring CSG water, and generating power at CGPFs; and
  - dehydrating and compressing gas, treating CSG water, and generating power at IPFs.

The main Project components required to accomplish these activities are described in this section. A comprehensive list of the Project components, including a description of the infrastructure, is presented in Table 6. Figure 7 presents the information as a simplified gas and water production flow chart.

4.1 Production Wells

A typical production well is shown in Figure 8. An example of a production well is shown in Plate 1. Production wells will generally be 150 to 800 m deep and located on an approximately 800 m grid spacing (depending on consultation with landholders), resulting in approximately one well per 65 ha. A well spacing up to 1,500 m or greater is possible, depending on environmental, social and land use constraints, and the reservoir characteristics. Surface facilities at each wellhead (called wellhead facilities) will include a water pump, generator, and gas and water separation equipment. Wells will be operated and monitored remotely, with routine visits for weekly inspections, maintenance on an approximately monthly basis. A workover of the well (which involves the entire well site to be cleared and a rig to go to the site to replace the downhole equipment) is expected to occur every two or three years.

In the reference case development scenario for this EIS, surface-in-seam (SIS) chevron wells in a dual lateral configuration are assumed, however, a number of alternative well design concepts are being trialled in order to complement and improve upon the reference case development well design for the Project.

These include:

- Standalone horizontal production wells (no vertical producer);
- Multi-seam horizontal production wells; and
- Multi-branched lateral wells.

In combination with these innovative well designs, Arrow is developing methods to review the potential for drilling multiple wells from a single surface location.

4.2 Gas and Water Gathering System

Gas and water is separated down-hole, however some further separation of the gas and water streams may occur at the surface to remove residual gas from the water stream or vice versa. The gas and water leave the well through separate ports, are metered and controlled, and then carried away in separate pipelines. Pipelines will be buried in a single trench and will run from the wellhead to a production facility. The water pipelines will run to either a CGPF or an IPF. Field pipelines also include valve stations and vacuum break facilities which will require weekly inspections and annual routine maintenance.

4.3 Production Facilities

4.3.1 Field Compression Facilities

FCFs will provide between 10 and 120 terajoules per day (TJ/d) of gas compression for production wells that are located too far from larger production facilities to enable piping of the gas under well head pressure. FCFs provide intermediate compression generally of the order of 1,000 kilopascal (kPa), but may be higher where it is safe and efficient to do so. No water treatment or gas dehydration is expected to be carried out at FCFs. FCFs may include a water transfer station (WTS) to facilitate transfer of water to an IPF, CSG water might bypass the FCFs and be directed to either a CGPF or an IPF. Gas from FCFs will be transported in medium-pressure pipelines to a CGPF or IPF for dehydration and compression to transmission pipeline pressures. The reference case assumes CSG will be used as a fuel to generate power on site to drive the compressors, although alternatives are still being investigated.

4.3.2 Central Gas Processing Facilities

Typically, CGPF will receive, dehydrate and compress between 60 and 210 TJ/d of gas to 10,200 kPa for transport to the sales gas pipeline. A WTS at each CGPF will receive, temporarily store, and pump CSG water to a treatment and storage facility at the nearest IPF. Each facility may be electrically powered. The reference case has assumed local power generation will provide the electrical power, however alternatives such as connection to the electricity grid are also being considered. Each facility may serve as a field base for operations personnel with offices, maintenance workshops and storage.

Figure 7. Gas and Water Production and Treatment

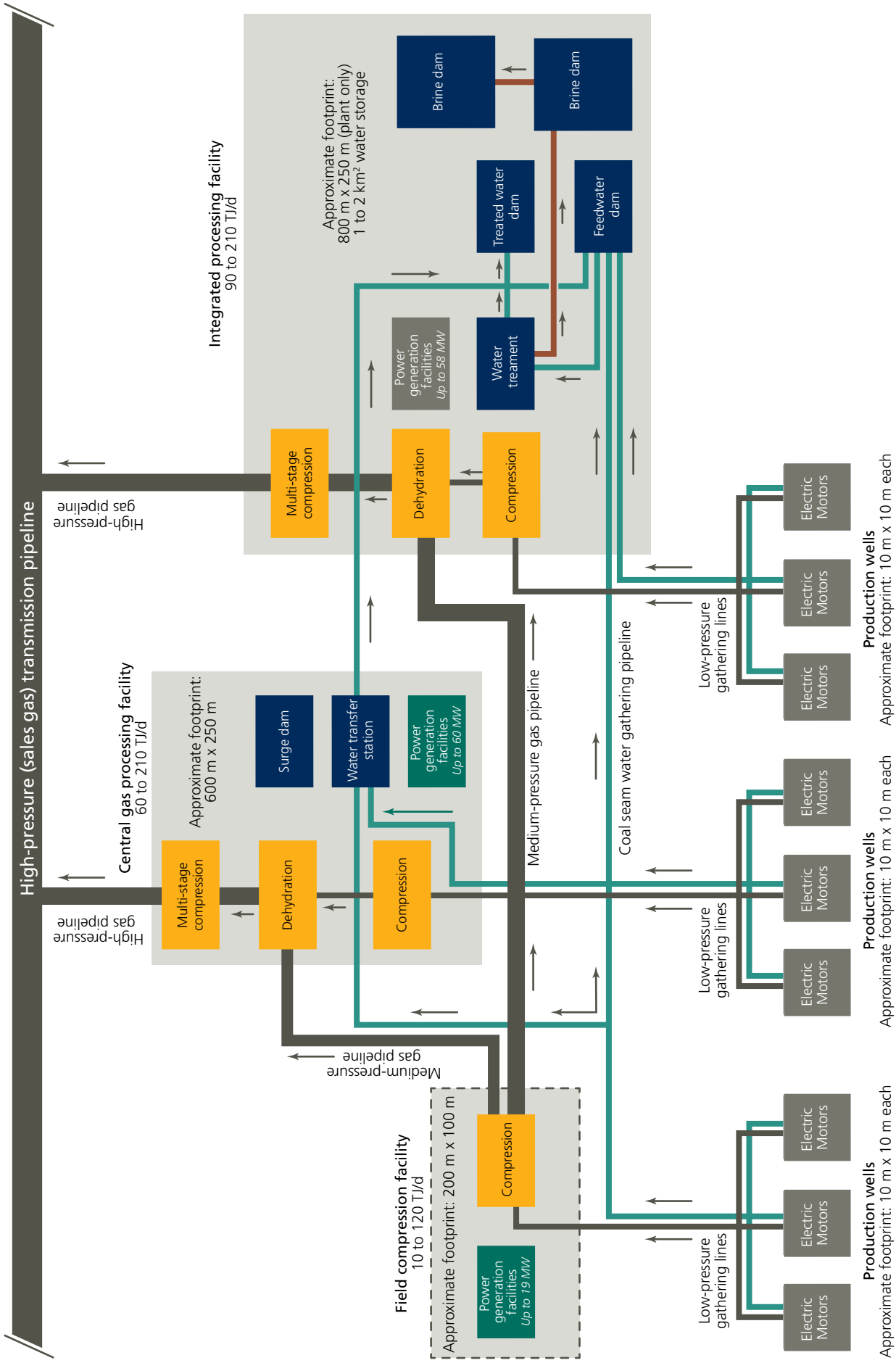
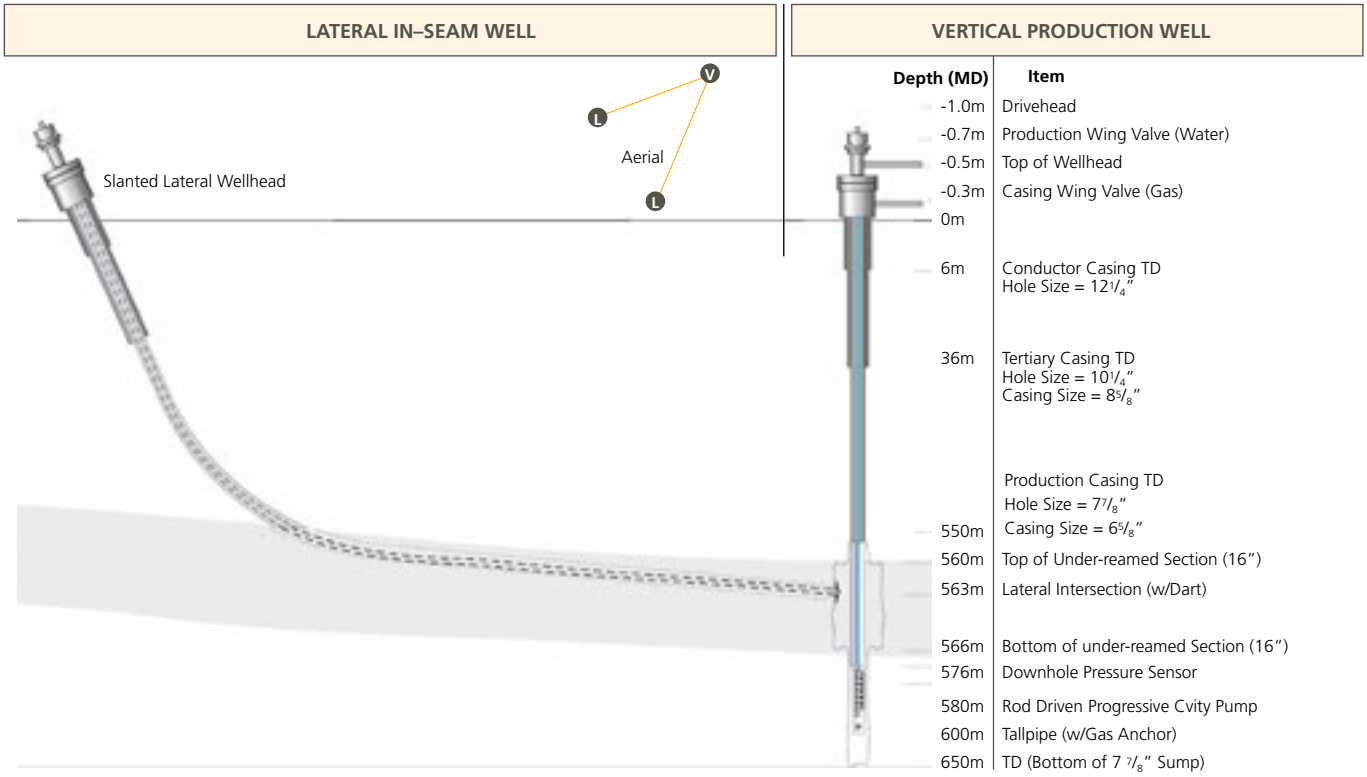


Table 6. Bowen Gas Project Main Project Components

Key Component	Description
Production wells	• Up to 6,625 wells drilled throughout the life of the Project; and • Wells will range in depth from 150 m to approximately 800 m.
Wellhead facilities	• Separator vessel (if required), piping, valving and instrumentation; and • Electrical and control panel at the wellhead to control the flow of the gas and associated water from the well to the low pressure gathering systems.
Low pressure gas and water gathering systems	• Pipeline diameters between 100 mm and 630 mm; • High-density polyethylene (HDPE) pipelines; and • Buried pipelines and associated infrastructure (low point drains and high point vents) used to transport gas and water from the wellhead.
FCFs	• Compression facilities where gas from an area of wells is compressed to increase the pressure from low pressure (approximately 30 – 100 kilopascals gauge pressure (kPag)) to medium pressure (approximately 1,000 – 2,000 kPag). FCFs will also include either power generation or a high voltage connection and substation to power the compression and other related facilities. • FCFs may also include a water transfer station (WTS) (storage tank and pumps) to facilitate transfer of water from the FCF to an IPF.
Medium pressure infield pipelines	• Medium pressure buried pipelines constructed of lightweight plastic composite, glass-fibre reinforced epoxy or lined steel used to deliver gas from FCFs to either CGPF or IPFs. Water transfer lines to move water between facilities.
CGPFs	• High pressure compression facilities where gas is dehydrated to sales specification and increased in pressure (approximately 10,200 – 15,000 kPag) to allow export to the Arrow Bowen Pipeline via a pipeline lateral. CGPFs will also include either power generation or a high voltage connection and substation to power the compression and other related facilities. • CGPFs will also include a WTS to facilitate transfer of water from a CGPF to an IPF.
IPFs	• High pressure compression facilities where gas is dehydrated to sales specification and increased in pressure (approximately 10,200 – 15,000 kPag) to allow export to the Arrow Bowen Pipeline via a pipeline lateral. IPFs will also include either power generation or a high voltage connection and substation to power the compression and other related facilities. • IPFs also include WTF for the treatment of associated water, storage of brine, and temporary storage of irrigation and associated waters.
WTFs	• Located at an IPF, WTFs include associated (FEED) water dams, brine dams and associated pumps and pipework.
WTS'	• Generally located at a FCF or a CGPF, these facilities include pumps and associated pipe work for the pumping of water to an IPF.
Supervisory control and data acquisition	• Telemetry and control systems (hardware and software) for the remote operation and monitoring of wells, pipelines and facilities from a central control room.
Other infrastructure / facilities	• Including: water monitoring bores, workshops, warehouses, offices, camps, depots, etc.

Plate 1. Typical Production Wellhead

Figure 8. Indicative SIS Well Schematic



4.3.3 Integrated Processing Facilities

IPFs perform the same function as CGPFs with the exception that they will receive and treat CSG water and store brine generated through the treatment process. Figure 9 shows a conceptual layout of an IPF. A typical gas compression facility is shown in Plate 2. The term 'integrated' is used as the facility contains both gas and water processing facilities.

Gas flows at the IPFs are likely to be between 90 and 210 TJ/d. With use of onsite sparing, the installed capacity will be higher.

Plate 2. Central Gas Processing Facility

4.4 Water Treatment, Storage and Disposal Facilities

4.4.1 Water Treatment, Storage and Transfer

Preliminary assessments indicate that the approximate amount of CSG water produced by the Project could vary over time between 15 and 30 ML/d allowing that some areas will produce more water than others. CSG water quality in the Bowen Basin varies from slightly brackish to saline. The water typically has the following characteristics:

- pH of approximately 7 to 10;
- Salinity in the range of 3,000 to 8,000 mg/L (i.e. brackish);
- Suspended solids that will usually settle out over time;
- Ions, including calcium, magnesium, potassium, fluoride, bromine, silicon and sulphate (as SO_4); and
- Trace metals and low levels of nutrients.

Water treatment and storage facilities will be designed in accordance with Queensland's CSG water management policy and the draft EHP guidelines on dams.

Water storage and transfer infrastructure at each CGPF are expected to include a nominal 600 ML storage dam and a transfer pump.

Water treatment and storage infrastructure at the IPFs are expected to include:

- 600 ML feedwater dam(s);
- 600 ML treated water dam(s);
- Reverse osmosis plant; and
- Two 960 ML brine storage dams.

Reverse osmosis technology is currently being considered as the most appropriate treatment process coupled with some form of suitable pre-treatment such as membrane or media filtration and hardness removal. With reverse osmosis, water passes under pressure through a selective membrane and the dissolved salts are retained as concentrated brine. Treated water may also be amended through the addition of trace elements so that it is suitable for a variety of beneficial end uses.

4.4.2 Management of CSG Water

Arrow has developed a strategy for the management of CSG water in line with the Queensland EHP's Coal Seam Gas Water Management Policy (DERM, 2010). This policy is implemented through the EA conditions imposed upon Arrow's operations and projects.

Figure 10 shows the Project water management concept and a range of end uses for CSG water.

Arrow's water management strategy seeks to maximise beneficial use of CSG water and minimise the environmental impacts associated with its use and disposal. The strategy also seeks (where possible) to manage CSG water in such a way as to mitigate the impacts of groundwater depressurisation on groundwater users. In order to achieve these objectives, the CSG water produced as a result of undertaking CSG extraction activities will be managed through a hierarchy of management options.

Arrow expects to implement a number of beneficial use options including the agricultural (irrigation), industrial and urban uses in addition to the current uses already employed at its existing operations.

Another option is to inject water to offset the impacts of groundwater depressurisation on users and to provide a disposal means for any water that cannot be accommodated through beneficial use. Arrow will conduct an injection feasibility study and is preparing EA applications to conduct aquifer injection trials in the Project area. The purpose of the trials is to determine the suitability of the formations for injection, and to identify the volumes and rates of water that can be sustainably injected.

Figure 9. Conceptual Integrated Processing Facility Arrangement

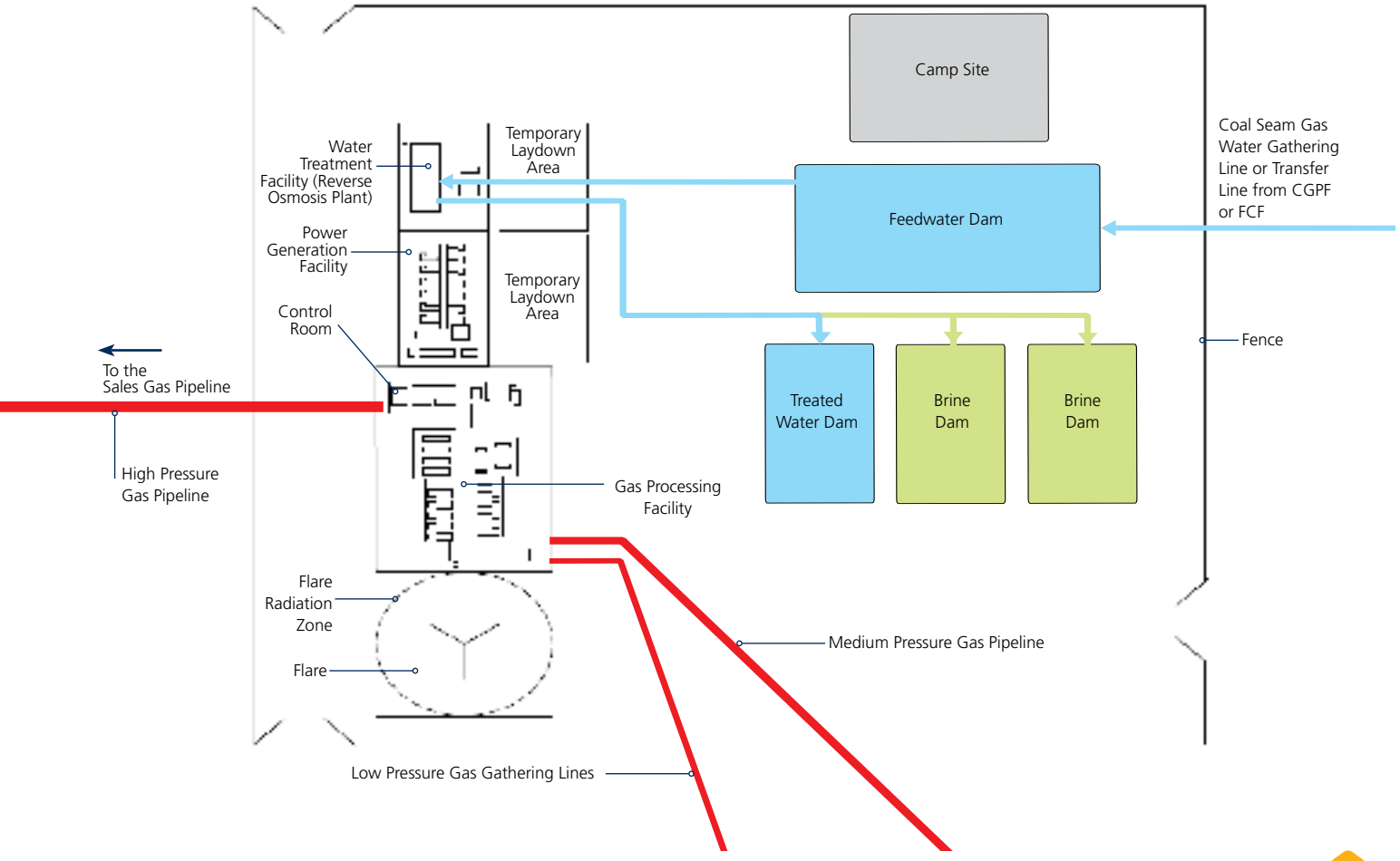
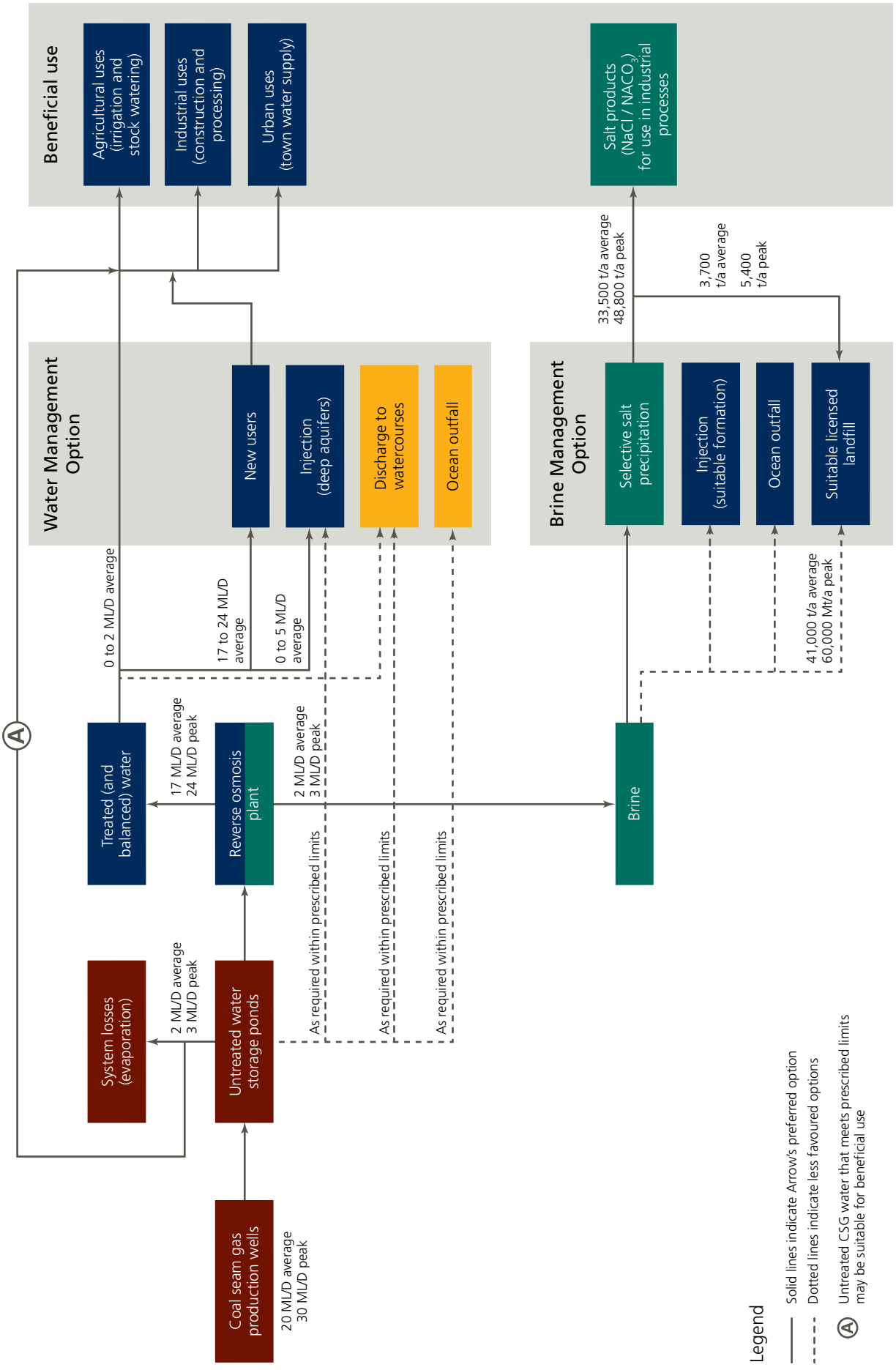


Figure 10. Conceptual CSG Water Management Overview



Less preferred options are disposal to watercourses or to the sea via an ocean outfall. These options address the situation where there are no or insufficient beneficial uses or where aquifers targeted for injection do not have the capacity to accept the produced volumes of water. These options are still being evaluated.

Arrow also expects to identify and evaluate further uses of treated and untreated CSG water.

4.4.3 Management of Brine

The management strategy also includes options for the treatment and disposal of brine, a by-product of water treatment using reverse osmosis. The preferred management option for brine is selective salt precipitation. This option allows the beneficial use of the brine in the form of salt products, which can be used in a variety of industrial processes. The main products are salt (NaCl) and soda ash ($NaCO_3$). Arrow will commission studies to understand the chemical composition of the brine, methods for enhancing precipitation of the brine, the chemical processes required to transform the brine into commercial products, and the commercial viability of this in the Bowen Basin.

Disposal of brine via an ocean outfall is a potential option for some of Arrow's areas of operation.

Another option is disposal to a suitably licensed landfill. Investigations have confirmed that such facilities exist and it is Arrow's expectation that if commercial volumes of brine exist, including as a consequence of other developments, then new facilities might be developed to respond to demand.

Implementation of the above management options will, depending on the options selected, require the development of infrastructure including pipelines, water and/or brine pumping stations, injection facilities and selective salt precipitation plants.

4.5 Power Supply

Power is required at the production wells and production facilities. The facilities will consume electricity 24 hours a day, 365 days a year, except for scheduled and unscheduled maintenance shutdowns.

Power generation facilities will likely comprise a series of high-efficiency, CSG-fired reciprocating engines with lean burn technology, which will achieve high efficiency generation (greater than 40%) with reduced emissions (low nitrogen oxide combustion technology). Each engine will be coupled to alternators generating directly at 11 kilovolts. Power generation facilities will be located within or in close proximity to the production facilities. An estimated 80 by 150 m footprint will be required to accommodate a power generation facility. These facilities will supply power for gas compression and water treatment.

The number of electrical generators for each production facility will be based on the facility load requirements, the size of each generator and the required redundancy (normally expected to be one engine). Power generation requirements will range from a minimum of 2 MW for a FCF to a maximum of 60 MW for an IPF. Other alternatives such as supply from the local electrical network will be further explored.

Local gas powered electrical generators may be used to provide power to the individual wellheads. In each case the generator will supply power to drive the water pump and control systems. Alternative solutions (such as distributing power from the processing facilities to each individual wellhead via overhead and/or underground lines) will also be investigated to determine if there are practical, economic and environmentally acceptable alternative solutions to the use of local generation for each wellhead.

5 Field Development Planning

5.1 Limitations and Opportunities

CSG field development typically proceeds on an incremental basis, with exploration and reservoir engineering confirming the most productive areas and optimum well density respectively. The actual locations of wells and production facilities are progressively identified and refined over the life of the Project.

The location of wells and gathering systems will be determined by the best compromise of environmental, social, technical and economic outcomes, and will be set out in land access agreements negotiated with landowners. The time required to recover economic volumes of gas is influenced by the density of wells. Denser patterns can enhance recovery. Less dense patterns may require longer to achieve the same recovery. Progressive planning will benefit from experience gained throughout the life of the Project including enhanced or new recovery techniques such as drilling multiple wells from a single pad.

Production facility locations are less flexible due to their scale and nature. They will be chosen to reduce overall environmental and social impacts. Sympathetic siting will be used, where practicable, to reduce land use conflicts and amenity issues.

5.2 Development Planning

Detailed development planning over the life of the Project will broadly address the following:

- The results of exploration and test drilling on which the detailed engineering design criteria for gas fields, production facilities, pipelines and ancillary facilities can be based.
- Social and environmental constraints on which the detailed, area-specific planning criteria for field facilities will be based.
- The economic and commercial risks that influence the extent and rate of field development (for example, proximity of new resources to existing infrastructure, market constraints and competition, land access and long-term gas supply contracts).
- The extended timeframe of field development, including ongoing refinement of the field development plan in response to new reservoir data from operating regions.
- New techniques, standards and practices.
- The results of operational and impact monitoring and consultation with landowners.

5.2.1 Exploration and Test Drilling

Arrow is currently conducting significant exploration across the Project area under existing approvals and hence such activities are not within the scope of this EIS.

Exploration typically begins with geophysical activities that characterise the geologic environment and identify potential coal seams. Drilling is then required to verify the geologic setting, determine coal seam properties such as thickness, permeability, gas content and gas quality, and test the production potential of the target reservoir.

5.2.2 Environmental and Social Constraints

Development planning within the Project area is guided by environmental and social constraints, including landowner preferences. The conceptual design, including the design specifications (Table 7) of Arrow's health, safety and environmental management system (HSEMS), has taken account of these constraints as Arrow currently understands them.

5.2.3 Development Plans

Development planning will be ongoing throughout the life of the Project. Development plans will be produced for each development area, guided by the results of exploration as well as environmental, over-lapping tenure, and social constraints.

A typical development plan will describe (but not be limited to):

- The exploration and appraisal history and status;
- Geological and reservoir modelling and subsurface development schemes;
- The number of wells to be drilled, their location, sequencing and spacing to meet the required production rates;
- The location, quantity and size of production facilities;
- The quantity of water to be produced and subsequent treatment and storage requirements;
- The pipeline networks needed to transport gas and water;
- The high-level operations philosophy for the field layout;
- Capital and operating expenditures as well as schedule estimates; and
- Risk and opportunity register.

Table 7. Environmental and Social Design Specifications of Arrow's HSEMS

Aspect	Design Specification
Air Quality	• Wellheads and facilities to be located sufficiently far from sensitive land uses to ensure that adverse air quality impacts do not arise.
Geology, landform and soils	• Avoid unstable slopes where possible, or design to address slope and soil stability issues.
Groundwater	• Avoid natural springs; and • Construct dams using material capable of containing the water and brine and any contaminants.
Surface water	Avoid wetlands.
Terrestrial ecology	Avoid Category A* environmentally sensitive areas; • Avoid wetlands; • Minimise construction footprint through centralisation of water treatment facilities (WTFs); and • Minimise construction footprint through placement of gas and water gathering lines within the same trench.
Social	• Manage impacts on local communities through the construction phase by using FIFO workforces and accommodating them in camps. Maximise employment of local people and minimise FIFO arrangements for operations. • Avoid locating wells within 200 m of residences.
Cultural heritage	• Avoid significant heritage sites.
Hazard and Risk	• Install and maintain fire and gas detection systems; • Install and maintain emergency shutdown systems; • Install and maintain emergency pressure release systems; and • Install and maintain fire suppression systems in high-risk locations.

*Category A environmentally sensitive areas are all areas designated as national park under the *Nature Conservation Act 1992*, as well as conservation parks, forest reserves, and the Wet Tropics World Heritage area.

6 Impact Assessment

This section summarises the potential environmental impacts of the proposed construction, operation and maintenance, and decommissioning activities of the Project assessed in the EIS. Further details on each section below can be found in the corresponding chapter within the main body of the EIS.

6.1 Climate

Climatic variations are driven by seasonal, long term and, as yet not fully understood, processes acting on the earth. The frequency, duration and severity of natural events — droughts, floods, cyclones and bushfires — often vary from historic trends which are based on a relatively short period of records.

In response, government agencies periodically review the guidelines that propose appropriate design standards that account for climatic variation. The criteria are typically conservative to recognise the inherent uncertainty in predicting future events. The standards inform engineering design, contingency planning and development preparedness for emergencies.

The Project's CSG infrastructure, particularly the production facilities, will be designed to account for the reasonably foreseeable extremes of heat, flood, drought and bushfire, as reflected in applicable guidelines and standards. Box 3 describes how Arrow will manage the impact of climatic variations on its operations.

Box 3. Climate

- Arrow will minimise the Project's vulnerability to climate change by designing infrastructure to withstand forecast climatic variations, as reflected in relevant design guidelines and standards.
- Arrow will participate in government climate change programs and monitor emerging opportunities to manage potential impacts from climate change.

6.2 Air Quality

Air emissions from the Project components included in the reference case were assessed to determine impacts on air quality. The assessment considered regional impacts (across the study area) and local impacts (within the vicinity of each facility type).

Nitrogen dioxide (NO_2) and ozone (O_3), the two key indicators of photochemical smog, were the indicators used to determine regional impacts, and they were modelled under two scenarios:

Scenario 1 – Project Operations in 2023

In 2023 (two years after the Project reaches full production capacity), it is expected that seven production facilities will be operational across the production areas. This scenario assumes 1,699 wellheads will operate at full capacity continuously for the year.

Scenario 2 – Project Operations at Maximum Capacity

Scenario 2 considered 17 proposed production facilities, and 1,980 wellheads operating simultaneously at maximum capacity. Given that field development will be undertaken in stages, this scenario is highly conservative and considers 'worst-case' emissions from Project operations.

Maximum predicted concentrations of NO_2 and O_3 for each modelled scenario are presented in Table 8 and show that emissions at a regional scale will not cause an exceedence of air quality objectives as set out in the *Environmental Protection Policy (Air) 2008* (EPP (Air)). A comparison of the maximum and average predicted NO_2 and O_3 concentrations is made with the Project criteria for Scenarios 1 and 2 in Table 8.

The similar results for the two scenarios, as shown in the last two columns of Table 8, indicate that, in the reference case, the facilities are sufficiently separated that their respective plumes do not combine to create a cumulative impact.

Table 8. Predicted Concentrations for Regional Scale Scenario 1 (Year 2023) and Scenario 2 (worst case)

Pollutant	Air EPP Objective (µg/m³)	Averaging Period	Maximum Concentration (µg/m³)		Average Concentration (µg/m³)	
			Scenario 1 (2023)	Scenario 2 (worst case)	Scenario 1 (2023)	Scenario 2 (worst case)
NO_2	250	1 hour	81.9	82.6	15.1	15.2
	62	Annual	18.7	18.8	1.2	1.3
O_3	210	1 hour	83.7	83.8	57.9	58.2
	160	4 hour	73	73.2	52.4	52.7

CSG contains only trace quantities of sulfur and carbon monoxide (CO) which are not expected to be generated at concentrations that may be harmful to human health, therefore emissions of sulfur dioxide (SO_2) and CO were excluded from modelling.

At the local level, NO_2, volatile organic compounds (VOCs) and particulate matter are the key indicators of air quality impacts. These compounds were modelled at the local level assuming typical maximum emission rates and continuous power generation or flaring as a worst-case scenario. There were no significant impacts from VOCs or particulate matter, and the maximum predicted one-hour concentrations of NO_2 (inclusive of background concentrations) met the EPP (Air) objectives within close proximity of wellhead generators and production facilities. The EPP (Air) objectives were met between 1,100 m and 1,400 m of production facility emission sources, e.g., the exhaust stacks. Box 4 lists the key mitigation measures for protecting air quality.

Box 4. Protecting Air Quality

Arrow is committed to protecting the qualities of the air environment conducive to protecting the health and biodiversity of ecosystems; human health and wellbeing; and the aesthetics of the environment.

The following key mitigation measures aim to ensure that the qualities of the air environment are maintained and relevant regulatory objectives are met:

- Design facilities to meet relevant EPP (Air) objectives at sensitive receptors and conduct site-specific air quality modelling once site locations are known to ensure objectives are met.
- Prevent venting and flaring of gas as far as practicable and where safe to do so, in accordance with the P&G Act.
- Select equipment with consideration for low emissions to air, high energy efficiency and fuel efficiency and maintain equipment in accordance with manufacturer's recommendations.
- Implement dust suppression measures and manage odours so that they do not cause a nuisance or harm to sensitive receptors.

6.3 Greenhouse Gas

For greenhouse gas accounting purposes, 'Project emissions' are those associated with the production of CSG to the point where it enters the sales gas pipeline ('Scope 1' and 'Scope 2' emissions).

Project emissions as a percentage of global, Australian and Queensland totals are shown in Table 9. The Project's predicted carbon dioxide equivalent (CO_2-e) emissions are 0.007% of global emissions (based on a 2009 baseline) for the worst-case operational year (2046).

A greenhouse gas management plan will be prepared and will detail Arrow's commitment to reducing greenhouse gas emissions, as described in Box 5, through practical measures, energy efficiency programs, and research and development into new and emerging technologies. Practical measures include minimising vegetation clearing, fuel use, flaring where appropriate, and optimising wellhead operation to reduce periods of operation at low-efficiency levels.

Box 5. Reducing Greenhouse Gas Emissions

Arrow recognises the need to reduce greenhouse gas emissions. As such Arrow will:

- Select energy efficient equipment and ensure that all equipment is operated and maintained to the highest standards.
- Minimise the Project footprint and vegetation clearing.
- Support energy efficiency programs and actively participate in any government-approved emissions trading scheme.

Table 9 Project Contribution Estimates of Greenhouse Gas Emissions

Source	Emissions per Annum (Mt CO_2-e)	Project Combustion		
		Scope 1 (%)	Scope 2 (%)	Scope 1 and 2 (%)
Global[1]	30,086.0	A0.005	B0.002	0.007
Australia (energy sector)[2]	417.4	0.4	0.1	0.5
Queensland (energy sector)[2]	98.0	1.7	0.5	2.1

1. http://mdgs.un.org/unsd/mdg/Search.aspx?q=Carbon%20dioxide%20emissions&Provider=Data. Data for 2009 was the latest year of data available when the site was accessed on 16/7/2012. Australia's total emissions inventory in 2010 is compared to the 2009 global inventory and should therefore be considered indicative.
2. Based on 2010 National Greenhouse Gas Inventory data (DCCEE, 2011).

6.4 Contaminated Land

Because the Project area comprises predominantly developed rural land, and many notifiable activities (as defined in the EP Act, including uses such as fuel storage and chemical storage) can be associated with agricultural activities, the EIS conservatively assumes that all land on which such activities may be conducted could have been contaminated by historical activities.

Disturbance of areas of contaminated land could have impacts on the surrounding environment, as well as on the health and safety of workers and members of the public. Wherever practicable, Arrow will avoid development on contaminated land. To achieve that objective, Arrow will implement a process of checking government registers and conducting site inspections before commencing intrusive works.

Wherever Arrow cannot avoid development on contaminated land, procedures will be implemented to manage any contaminated soil or groundwater that is exposed in accordance with Queensland Government requirements.

Arrow will build facilities and operate CSG infrastructure to minimise the possibility of contaminating land, as described in Box 6, and will appropriately assess and remediate any land that becomes contaminated during the course of its operations.

Box 6. Avoidance of Contaminated Land

Arrow's priority is to avoid the disturbance of contaminated soils and to minimise the potential for contamination of soil and groundwater as a result of Project activities. Avoidance requires:

- Undertake appropriate register searches and desktop investigations (i.e. avoid land or the contaminated portion of a parcel of land that is listed on the Contaminated Land Register or the Environmental Management Register, where practicable).
- Conduct physical investigations on selected parcels of land to influence facility siting decisions on a localised scale (i.e. target the portion of land that is not contaminated by understanding the extent of contamination).
- Apply appropriate international, Australian and industry standards and codes of practice for the design and installation of infrastructure associated with the storage of hazardous materials (such as chemicals, fuels and lubricants).
- Contaminated soil or groundwater that cannot be avoided will be managed through quantification of the type, severity and extent of contamination, and remediated or managed in accordance with the Queensland Government's Draft Guidelines for the Assessment and Management of Contaminated Land 1998.

6.5 Soils and Land Suitability

The Project area comprises a subdued topography of plains and uplands of reasonably low elevation and relief and support a range of slopes and soils. These materials and locations have variable properties for which management requirements are broadly known. Key features of the Project area include extensive areas that, predominantly due to soil properties, are declared as good-quality agricultural land or are known to be areas of black soils that are sensitive to disturbance. Understanding of the specific soils and land suitability at each specific facility location will be integral to Project design, Project management and the rehabilitation of completed works areas. The residual impacts are expected to be low and localised.

Box 7 presents key soils and land suitability mitigation measures.

Box 7. Soils and Land Suitability

Environmental protection objectives for geology, landform and soils are to maintain or restore soils; stabilise landforms; minimise alteration of drainage systems; and protect sensitive areas. Key mitigations to achieve these objectives include but are not limited to:

- Minimising the Project footprint and vegetation clearing.
- Clearing areas progressively and implementing rehabilitation as soon as practicable.
- Confining Project traffic to designated roads and access tracks.
- Installing and maintaining sediment and erosion-control structures.

6.6 Geology

The Project area covers a large portion of the north-south trending Bowen Basin. The Bowen Basin covers an area of approximately 200,000 km^2, and is exposed over 600 km from Collinsville in the north to Rolleston in the south. The Bowen Basin contains a sedimentary sequence of Permo-Triassic clastics, which attain a maximum thickness of 9,000 m in the depocentre of the Taroom Trough.

Regionally, the stratigraphic sequence is presented in Figure 11 and can be summarised as follows: the Permo-Triassic sediments of the Bowen Basin are overlain by a thin covering of unconsolidated Quaternary alluvium and colluvium, poorly consolidated Tertiary sediments of the Tertiary Suttor and Duaringa formations and, in places, remnants of Tertiary basalt flows. The Triassic Rewan Formation underlies the Tertiary units across most of the Project area, and few outcrops of the Moolayember Formation and Clematis Sandstone can be found in outcrops in the northern Project area. The Permian Blackwater Group, coal measures and associated over–and interburden are located below the Triassic strata and overly the Back Creek Group, the basement of the Project area.

The EIS evaluation of available geological information indicates the potential for environmental impacts associated with the Project include:

- Induced seismicity (ground stability);
- Land subsidence due to coal seam depressurisation and dewatering;
- Coal formation subsidence from depressurisation; and
- CSG migration.

All of these potential impacts to the Project area geology will be managed as part of the Project EM Plan, operational procedures and field development planning.

6.7 Groundwater

The Project will produce CSG and associated water from target coal sequences within the Blackwater Group. There are limited groundwater resources (aquifers) associated with the target coal seams and those that are present are interbedded with low-permeability, generally fine-grained formations (aquitards). The groundwater resources associated with these units are limited in extent and quality and as such are used sporadically. A conceptualisation of the geological units and associated aquifer types in the Project area is presented in Figure 11.

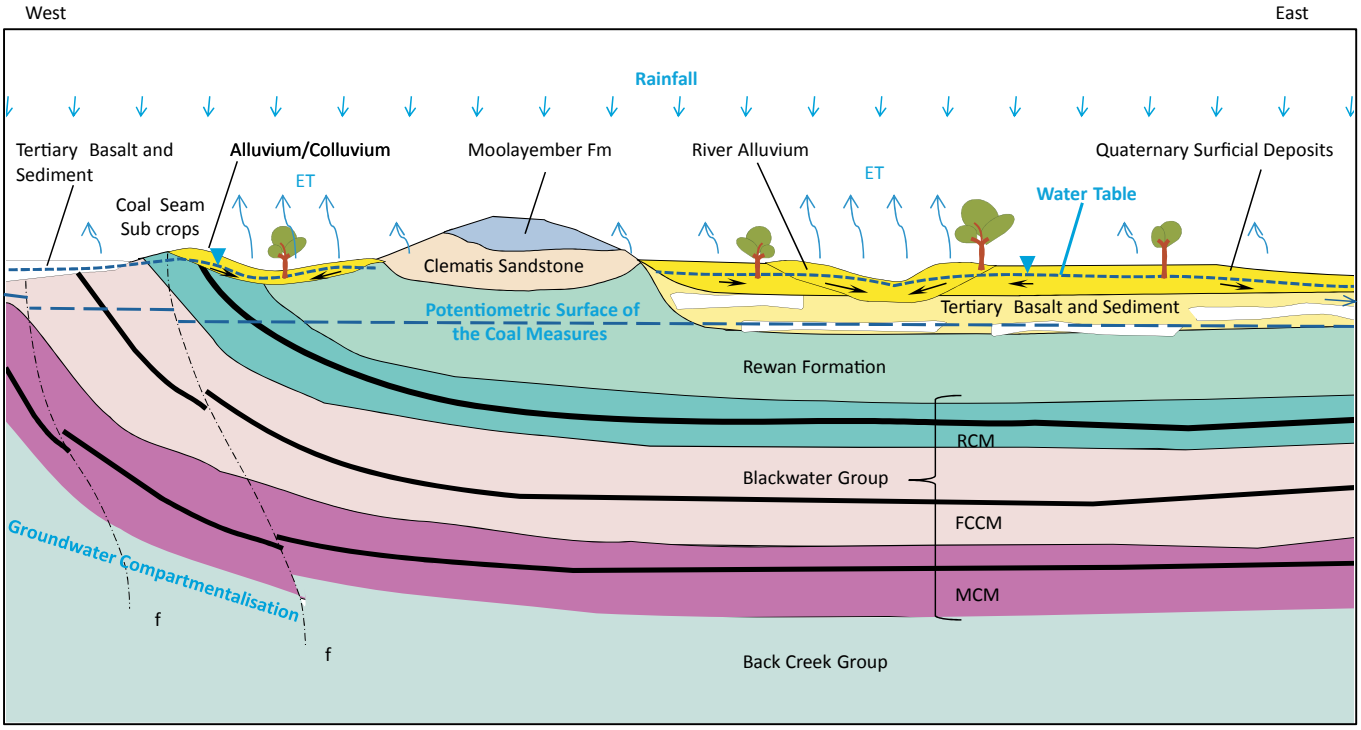
The Project area can be split into two groundwater entitlement areas; the Isaac-Connors cub-catchment and the MacKenzie sub-catchment where the principal groundwater uses are irrigation and stock watering, and industrial use respectively. The majority of the groundwater extracted is from the alluvial aquifer in the Isaac-Connors sub-catchment and from the Blackwater Group in the MacKenzie sub-catchment. The groundwater resources associated with the Blackwater Group are limited due to poor groundwater quality, depth, and limited sustainable yields.

There are no registered groundwater springs or seeps that supply surface water bodies in the groundwater study area. Shallow groundwater (in the alluvium) in the Project area may sustain baseflow in non-perennial rivers for short periods after heavy rains or flooding.

To extract the CSG it is necessary to depressurise the target coal seams. This has the potential to induce groundwater flow from the geological units overlying and underlying the coal seams.

Groundwater in the target coal seams of the Blackwater Group, within the Rangal Coal Measures and Moranbah Coal Measures will typically be depressurised to about 40 to 50 m (of hydraulic head) above the top of the target coal seams. As the groundwater model is based on target coal depths of

Figure 11. Conceptualisation of Groundwater Resources



350 to 750 m below surface with associated potentiometric pressures of approximately 50 m below surface, this translates to approximately 265 to 690 m of drawdown below the pre-development groundwater pressure in the coal seams.

Metrics that are commonly used to describe potential groundwater impacts are 0.2 m, 2 m and 5 m drawdown contours, as defined under the Queensland *Water Act 2000*. The 0.2 m drawdown is a trigger value threshold for springs and spring-associated watercourses. There are no springs or associated watercourses within the Project area. Thus only the 2 m and 5 m threshold triggers were considered to assess potential impacts on groundwater users and resources.

Predictive modelling has been undertaken of the groundwater impacts after 55 years of CSG production from 2017 to 2072. The model results indicated that a drawdown beyond 5 m from the pre-CSG operation potentiometric level associated with the target coal seam could extend up to 7 km from the CSG wells. The model predictions for 50 years post-operations suggest that the impacted area could extend an additional 0 to 4 km (approximately) depending on location. Hence the overall prediction is that the 5 m drawdown in the deep target seam aquifer could be up to 11 km from the CSG wells.

For the shallow (alluvial) aquifers, the model predicted that the drawdown would be insignificant (less than 2 m) at the cessation of operations and 50 years post-operations. Thus the potential impact area within the surficial aquifers is considered to be negligible.

Any impacts to water bores in the Project area will be managed in accordance with the framework defined in the *Water Act 2000*, which includes the preparation of a Underground Water Impact Report, identification of immediately affected area bores on a 3 year cycle, an assessment of IAA bores, and the negotiation of a make good agreement (including make good measures) as required.

A groundwater monitoring network would be installed to validate/improve model predictions.

Box 8 summarises the proposed groundwater management strategies.

Box 8. Groundwater Management

Integral to Arrow's CSG water Management Strategy is the beneficial use of CSG water. Arrow will minimise the potential for reduction in groundwater supply to existing and future groundwater users across the Project area through the provision to make good on any material supply losses to existing groundwater users during the period of realised impacts as defined in Chapter 3 of the *Water Act 2000*. Trigger levels and actions in accordance with legislative requirements to assess and manage the potential impacts will be adopted. A process of management and mitigation of the potential impacts will be adopted.

The process will allow for the application of controls or design responses to Project activities, such as optimum well field development, correct associated water production and infrastructure, etc. to ensure potential negative impacts either:

- Do not arise from the proposed activities;
- Are minor; or
- Where unavoidable, impacts are reversible over time and can be offset in the interim by make-good provisions. Arrow will also minimise impacts to groundwater quantity and quality:
    - to ensure groundwater depressurisation is not impacting the connectivity between the Blackwater Group and other aquifers Arrow will continue the investigative program that monitors / quantifies this connectivity;
    - by installation of wells, surface storage and subsurface infrastructure in accordance with relevant industry standards, and perform routine inspections and monitoring programs to ensure integrity and compliance throughout the life of the Project; and
    - Design and construct new regulated dams (either raw water, treated water or brine dams) in accordance under the supervision of a suitably qualified and experienced person, accordance with relevant EHP schedule of conditions relating to dam design, construction, inspection and mandatory reporting requirements.

Arrow is committed to better understanding the uncertainties surrounding the potential impacts to groundwater systems through ongoing investigations that include:

- Development of a strategy to implement a regional groundwater monitoring network to enable routine monitoring of groundwater levels and quality indicators in key aquifer formations over time; and
- Groundwater monitoring data will be used to validate and update the numerical groundwater model. The model will be recalibrated to reduce uncertainty in predictions and thereby provide information for improving the monitoring, management and mitigation measures.

6.8 Surface Water

The majority of the Project area is located in the Isaac-Connors catchment, within the Fitzroy basin, with the remainder split between the Mackenzie River catchment (Fitzroy) and the Suttor and Bowen catchments (Burdekin). Surface water hydrology in and adjacent to the Project area is typically characterised by extensive ephemeral stream networks with flow periods generally restricted to the wet season. The Mackenzie River is the exception as it exhibits perennial characteristics with flow periods persisting during the dry season.

The water resources in the study area represent slightly to moderately disturbed aquatic habitat that provides a valuable natural resource to people living within the region. Locally, water resources support a range of human values including water supply, cultural / spiritual, recreational, and agricultural and industrial purposes including farm use such as irrigation, grazing (modified pastures), dryland cropping and mining.

Potential impacts on surface water environmental values from the Project can arise from drilling activities, and construction, operation and decommissioning of production wells, pipelines, dams, and production facilities. These potential impacts can be mitigated through the implementation of appropriate techniques, devices and management measures, including commitments presented in Box 9. The assessment of limited impacts is based on the broad assumption that water from Arrow's operations will not be discharged to watercourses under normal conditions, without further detailed assessment.

As discussed in Section 4.4.2, Management of CSG Water, Arrow has developed a strategy for the management of CSG water in line with the Queensland EHP's Coal Seam Gas Water Management Policy (DERM, 2010). This policy is implemented through the EA conditions imposed upon Arrow's operations and projects. Arrow's water management strategy seeks to maximise beneficial use of CSG water and minimise the environmental impacts associated with water use and disposal. In order to achieve these objectives, the CSG water produced as a result of undertaking CSG extraction activities will be managed through a hierarchy of management options.

Box 9. Surface Water Management

The extensive network of watercourses within the Project area will be protected by managing impacts to surface water resources. Arrow will:

- Avoid permanent pools and mid-channel alluvial bars and islands, where practicable.
- Minimise watercourse crossings, where practicable, during route selection. Where required, select crossing locations to avoid or minimise disturbance to aquatic flora, waterholes, watercourse junctions and watercourses with steep banks.
- Construct watercourse crossings in a manner that minimises sediment release to watercourses, stream bed scouring, obstruction of water flows and disturbance of stream banks and riparian vegetation (i.e. the crossing location will be at a point of low velocity, and straight sections will be targeted, with the pipeline or road orientated as near to perpendicular to water flow as practicable).
- Disturbance exclusion zones (or management buffers) will be established and managed during construction and operations to effectively protect ESAs.
- Prepare certified erosion and sediment control plans for all construction activities with the potential to result in soil disturbance.
- Temporary and permanent hazardous chemical and fuel storage areas to be appropriately bunded.
- Develop, implement and maintain a procedure to minimise the risk of drilling waste (in the form of drilling fluids and hydraulic stimulation fluids) contaminating watercourses during drilling, completion, hydraulic stimulation and workover activities.
- Design regulated dams in accordance with relevant legislation and Queensland standards and EHP guidelines.
- Water for discharge from site will meet approved discharge criteria.
- Establish water quality monitoring stations upstream and downstream of discharge points to watercourses as part of a monitoring program to ensure compliance with EA conditions and relevant standards.

6.9 Aquatic Ecology

Historically the catchment within the Project area has been subjected to various levels of environmental disturbance a result of ongoing agricultural activity, mining and some urban development. Field surveys confirmed the desktop assessment findings that concluded that aquatic ecosystems are moderately disturbed and are in moderate health. One species, Fitzroy River turtle, listed under Commonwealth environmental legislation is known to exist within the area. Three fish species of conservation interest, Fitzroy River subspecies of golden perch, southern saratoga and leathery grunter were recorded in the Project area. Habitat type and quality was relatively uniform across the Project area, with differences between stream size being the main distinguishing factor between sites.

Water quality across the Project area showed a number of parameters that consistently exceeded the water quality objectives for watercourses including total suspended solids, dissolved oxygen, total dissolved solids, some metals and salinity.

Project impacts on surface water quality and aquatic ecology, such as erosion and sedimentation, will generally be localised and temporary in nature. Implementation of proven construction control measures and rehabilitation of completed work areas should limit sedimentation and consequential effects in severity and duration. Vehicle and equipment hygiene is intended to prevent the spread of exotic plants, and Project activities will avoid sensitive aquatic environments.

With the exception of one turtle species (Fitzroy River Turtle), aquatic ecosystem values pose few constraints on the construction and operation of the Project. Throughout most of the Project area the construction and operation of the Project as currently proposed will have minimal impact on aquatic ecosystems at a local, regional, national and international scale.

Box 10 presents the key aquatic ecology mitigation measures.

Box 10. Protecting Aquatic Ecology

The protection of aquatic ecology requires the avoidance of sensitive areas and minimisation of adverse impacts to permanent, semi-permanent and ephemeral watercourses. Protecting the aquatic environment will include, but not be limited to:

- Apply sensitive infrastructure design principles to avoid watercourse, drainage lines and riparian areas where practicable;
- Minimise watercourse crossings, where practicable, during route selection. Where required, select crossing locations to avoid or minimise disturbance to aquatic flora, waterholes, watercourse junctions and watercourses with steep banks;
- Implementation of erosion and sediment control measures; and
- Implementation of a weed and pest management plan.

6.10 Terrestrial Ecology

Approximately 60% of the Project area has been historically cleared. There are areas of remnant vegetation and native regrowth, some of which are quite large, on land that is not suited to cultivation or grazing. The most integral remnants are:

- Homevale National Park; and
- Topographically isolated areas including breakaway scarps, escarpments and plateaus.

Extensive land clearing has significantly reduced some ecological communities in Queensland to the extent that they are now listed as endangered. Threatened ecological communities present in the Project area include brigalow woodland, semi-evergreen vine thickets and natural grasslands. Brigalow (communities, woodland or individual trees) is widely distributed throughout the Project area, whereas semi-evergreen vine thickets exist only as degraded isolated remnants predominantly in the north. The natural grasslands threatened ecological community is extensive across the Project area, commonly occuring between Glenden and Moranbah.

The general condition of habitats within the Project area ranges from extremely poor to excellent dependent largely upon landscape position and underlying geology. Habitats associated with elevated sandstone escarpments, being largely inaccessible to grazing activities, are typically well preserved. Habitats occurring on alluvial and clay plains are generally heavily impacted by prior landuse activities and their state of preservation tends to be extremely poor.

Numerous state– and national–listed flora and fauna species were identified in association with the vegetation communities. Endangered flora species known from the Project area include king bluegrass, black ironbox and finger panic grass. A number of other threatened flora species were considered to have a high likelihood of presence within the Project area. Endangered fauna species known from the Project area include reptile species such as the ornamental snake and brigalow scaly-foot. Notable mammal species known to be present include the koala and little pied bat.

EIS field surveys have supplemented published studies and conservation databases to determine terrestrial ecosystems sensitive to Project impacts. Ecologically sensitive areas are shown on Figure 12.

Habitat fragmentation, degradation or loss is the principal potential impact, as this can lead to consequential impacts on plant and animal populations including fauna mortality and changed ecosystem function.

The primary Project mechanism for minimisation of impacts to ecologically sensitive areas is avoidance. Information developed for the EIS has been used to prepare constraints maps that will facilitate avoidance and the establishment of appropriate buffers and management requirements for areas in which Project facilities might be located. Conditions attached to environmental authorities will specify buffer distances to Category A, B and C environmentally sensitive areas (as defined in Section 6.11) and to watercourses and will nominate the types of activities permitted within the buffers.

Implementation of the environmental management controls recommended in the EIS such as those presented in Box 11, along with diligent site supervision, will ensure protection of the terrestrial ecological values of the Project area. Induction and training programs will ensure workers' awareness of the location of significant remnant vegetation and buffers, as well as their awareness of the management measures to be implemented. The controls and awareness programs will reduce the severity of residual impacts on terrestrial ecology.

Box 11. Protecting Terrestrial Ecology

Arrow will actively protect the terrestrial ecological values of the areas in which it operates through:

- Avoidance of Category A environmentally sensitive areas.
- Manage impacts to Category A, B and C ESAs through implementation of management buffers.
- Conduct pre-construction / pre-clearance surveys to identify any additional `areas that need to be avoided.
- Demarcate ESA buffers and educate workers in regard to necessary site access protocols and requirements.
- Development and implementation of a weed and pest management plan.

6.11 Environmentally Sensitive Areas

Queensland legislation places Environmentally Sensitive Areas (ESAs) into two categories; Category A and Category B with a further Category C defined in the Draft Code of Environmental Compliance for Level 2 Petroleum Activities (EPA, 2008). Additionally there are other environmental factors including EPBC MNES, flora and fauna species declared under the *Nature Conservation Act 1992*, listed and referrable wetlands and mature regrowth that have also been considered.

Potential impacts to ESAs would be similar to the potential impacts for terrestrial ecological values and MNES. Environmental protection for ESAs and ecological values will be primarily achieved through application of the environmental framework approach and constraint mapping which will result in a hierarchy of environmental management measures through site selection, impact minimisation, impact mitigation, and biodiversity offsetting when required.

Category A

There is one national park (Homevale National Park) within the Project area, one bordering the Project area and four national parks and one forest reserve within the surrounding area. There is one conservation park within 5 km of the Project area and one adjacent to Blackdown Tableland National Park.

The Project area is not located within or adjacent to the Wet Tropics World Heritage Area (300 km to the north) or Great Barrier Reef Marine Park Area (over 260 km downstream) and there are no marine parks within or surrounding the Project area. There is no Aboriginal or Torres Strait Islander Land (National Parks) within or surrounding the Project area.

Category B

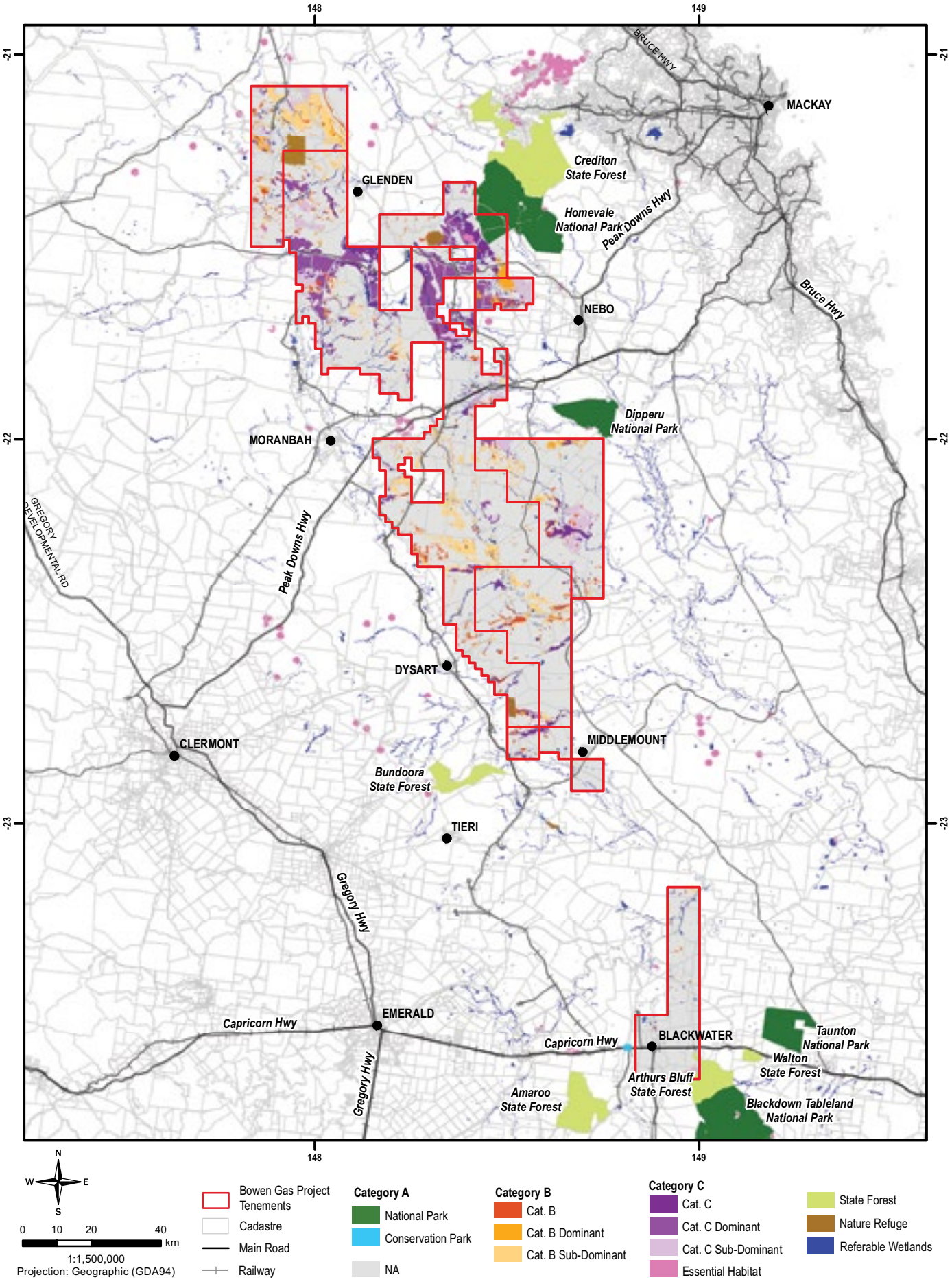
Within or surrounding the Project area there are no coordinated conservation areas, wilderness areas, Ramsar wetlands, essential habitat areas, world heritage areas, international agreement areas, general use zones of marine parks, identified places of cultural heritage significance, designated landscape areas, Feature Protection area, fish habitat areas, or areas to the seaward side of the highest astronomical tide.

Eighteen 'endangered' regional ecosystems (EREs) are mapped by the Queensland Herbarium as occurring within the Project area. Some have been confirmed or remapped during the Project's ecology ground truthing survey.

Category C

Category C ESAs found within and surrounding the Project area include, 'of concern' REs, nature refuges, resource reserves, state forests, essential habitat, and declared catchment areas.

Figure 12. Environmentally Sensitive Areas



6.12 Land Use and Tenure

The Project area contains a total of 3,086 allotments with the land tenures of freehold, leasehold, areas of protected estate, reserves and unallocated state land. Approximately 70% of the allotments are freehold, 25% leasehold and the remainder are either state land or protected estates (national parks, conservation parks, nature refuges and state forests). Across these allotments there are a variety of mining tenements and native title recognition.

The predominant land uses within the Project area are agricultural, with pastoral areas (cattle grazing) comprising approximately 722,306 ha of the Project area (90.2%) and horticulture (irrigated and dry land cropping) comprising approximately 22,347 ha of the Project area (2.7%).

While grazing and agricultural activity dominate the Project area, other land uses are important and include:

- The urban communities of Glenden, Nebo, Coppabella, Moranbah, Dysart, Middlemount and Blackwater, the mining accommodation villages at Coppabella and Burton Gorge as well as residences and homesteads throughout the rural areas;
- Twenty-two operational coal mines as well as a larger number of mining, petroleum and exploratory lease and permits; and
- Areas of conservation, tourism and recreational land uses, including Homevale National Park and Conservation Park as well as a number of Native Refuges and areas of State Forest.

Areas intended to sustain current and future agricultural land uses within the Project area have been designated under state planning policies and legislation as either Good Quality Agricultural Land (GQAL) or Strategic Cropping Land (SCL). Given GQAL and SCL is intended to sustain future agricultural land uses, there is the potential for impacts from the Project. The location and extent of GQAL and potential SCL (based on Government trigger maps) within the Bowen Basin is shown on Figure 13 and Figure 14.

Project activities have the potential to affect land use productivity and increase costs through reduced crop yields and losses, disturbance of farm animals, degraded soil structure and fertility, and increased management overheads. Potential impacts to agriculture can be summarised, as follows:

- **Reduced productivity and increased costs** — caused by changes in farm configuration (e.g., creation of more headlands), disruption to farming practices (e.g., changes to irrigation infrastructure, interference with overland flow), unsuccessful rehabilitation and temporary loss of arable land.
- **Crop losses or disturbance to stock** — caused by drilling or construction occurring during inopportune times disrupting cropping or breeding (depending on the proximity to breeding animals and the nature and intensity of the disturbance), and unsuccessful rehabilitation.
- **Soil disturbance** — caused by compaction from traffic, mixing and inversion of soil horizons, settling of pipeline trenches or soil loss from erosion caused by construction activities.
- **Increased costs of farm management** — caused by increased operating overheads from management of CSG activities and coordination of activities (e.g., spraying and withholding periods) and integration with farm plans. Increased costs may also result from limitations on development of farms to incorporate new technologies and farming techniques.
- **Loss of amenity** — caused by contractors and employees entering and working on properties, disruption to lifestyle, increased levels of noise and dust, and the visual impact of Project infrastructure.

Other potential impacts include contamination of soil and water from Project activities, and the introduction and spread of weeds and plant and animal pathogens.

Experience to date indicates that up to 2 to 3% of land associated with a typical production well spacing of 800 m, which equates to 65 ha (160 acres), will be disturbed by activities associated with the construction and operation of a production well and the associated water and gas gathering lines, and the access track. Rehabilitation of gathering system and pipeline rights of way will return land affected by these activities to productive use during the operating phase of the infrastructure. Production well sites will be partly rehabilitated post-construction of the well and then upon decommissioning will be fully rehabilitated to former land uses, removing the obstacle from the property. Rehabilitation of production facility sites would seek to re-establish endemic native vegetation communities or pasture grasses that would support grazing land use, or the sites would be redeveloped for other suitable purposes. Field development planning will focus on siting production facilities in areas where reinstatement of the former land use is possible. Production facilities will, where possible, be sited to avoid intensively farmed land.

Planning and design has been identified as the most effective way of mitigating the impacts of CSG infrastructure and activities on agricultural enterprises and production. The location and layout of production wells and associated gathering systems will be designed in consultation with landowners to minimise impacts to their properties. Activities will be planned to integrate with farm plans and include consideration of cropping cycles, withholding periods, crop rotations and farm development.

The type of CSG infrastructure — production wells, gathering systems, pipelines, production facilities — will determine the techniques, effort and investment required to achieve successful rehabilitation and reinstatement of former land use and productivity.

Figure 13. Good Quality Agricultural Land

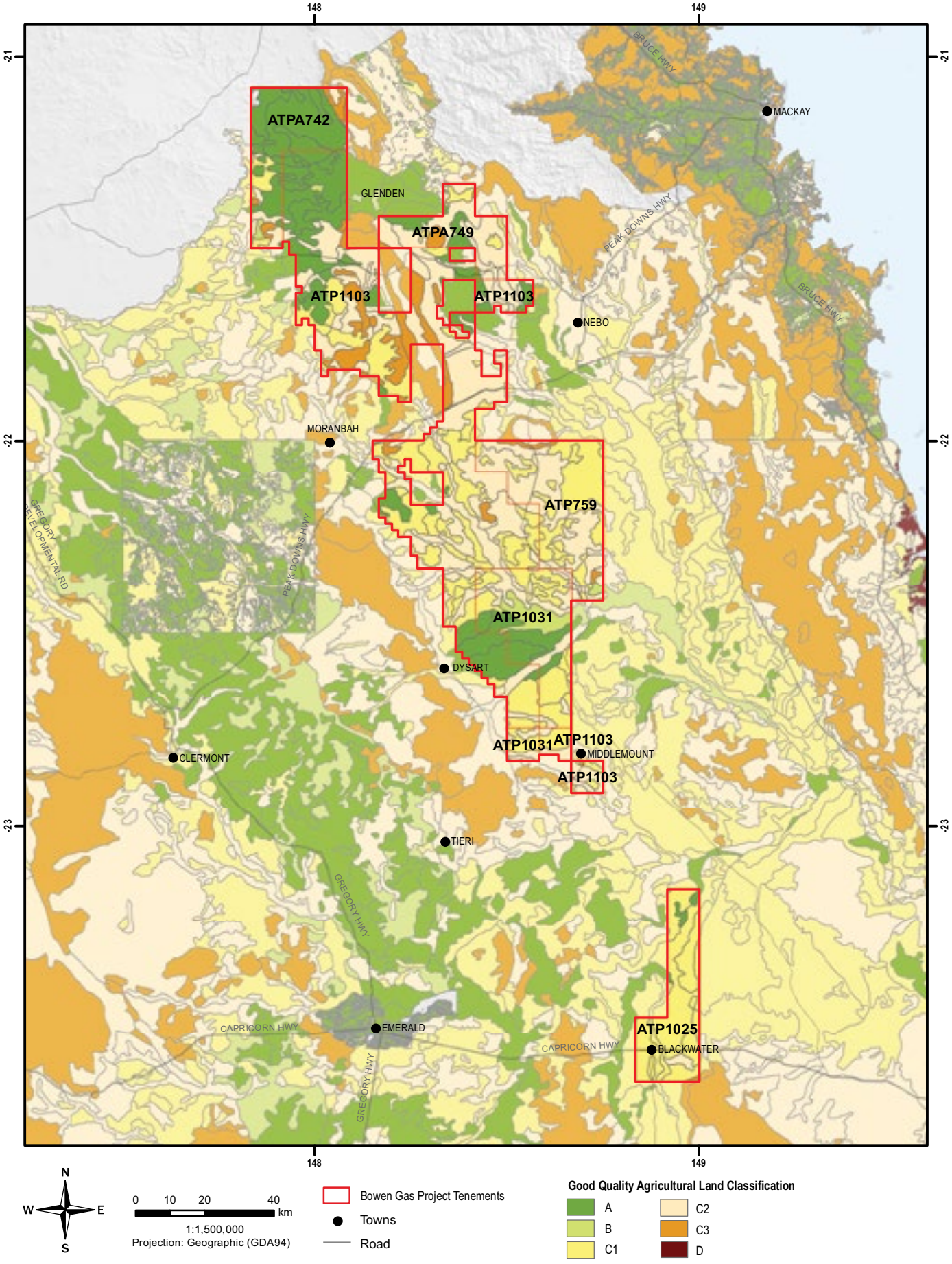
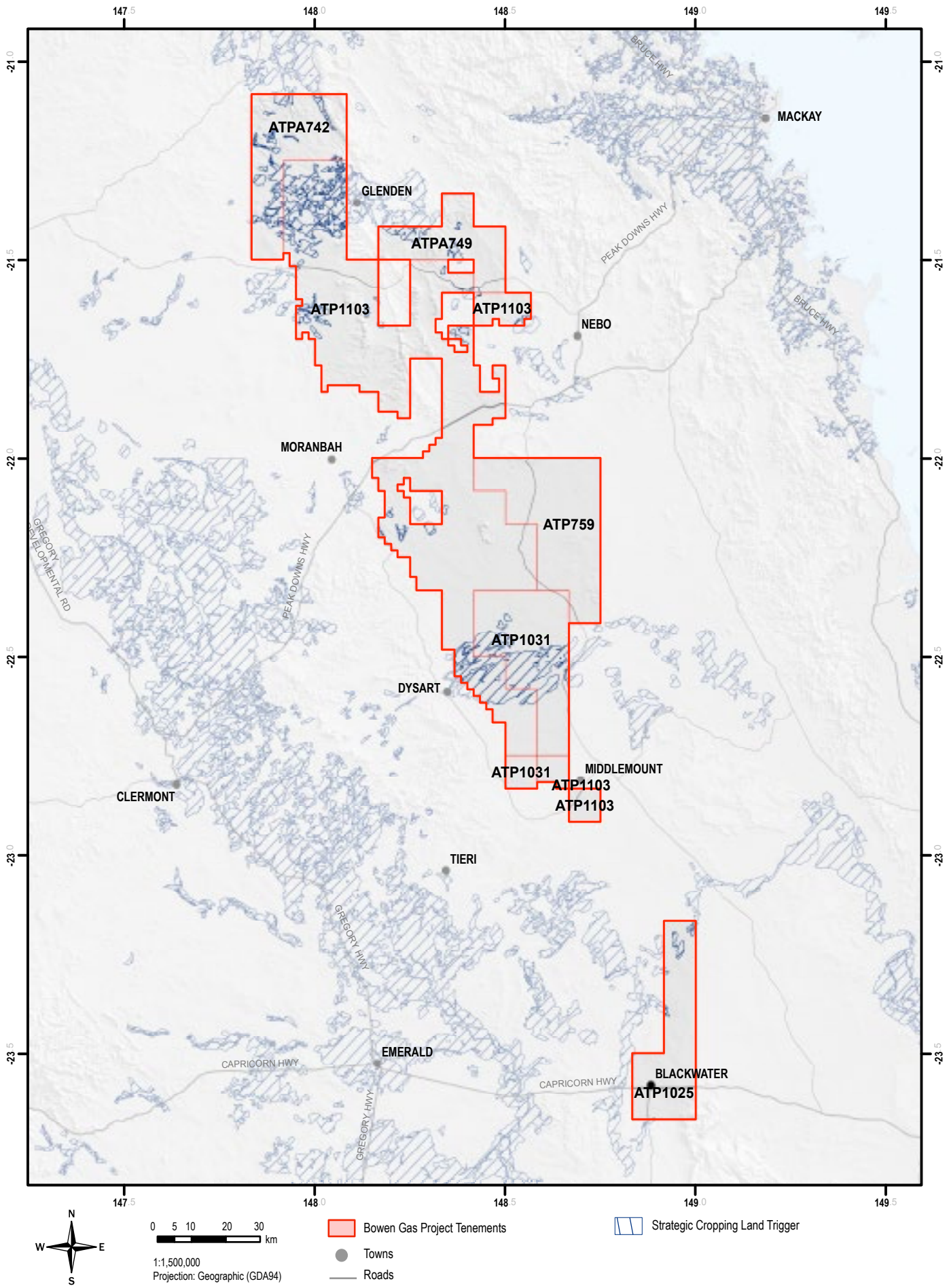


Figure 14. Potential Strategic Cropping Land



Arrow's approach to achieving environmental protection objectives for agriculture land use is set out in Box 12.

Box 12. Landuse and Tenure

The key environmental protection objectives for agriculture are to avoid or reduce adverse impacts to agricultural infrastructure, agricultural production (i.e. cropping and breeding) and farming practices (i.e. day-to-day agricultural activities) and to maintain and/or restore soils to support the intended land use.

These objectives will be achieved through implementation of the following:

- Siting of infrastructure to reduce potential impacts on agricultural land and agricultural enterprises.
- Design and development of construction and operations methods that enable Project activities to integrate with farm activities.
- Application of environmental management controls, i.e. proven methods and techniques for protecting the environment.
- Progressive rehabilitation of disturbed areas and the ongoing management for protection against the spread of weeds after the completion of construction.

6.12.1 Co-existence with Mining

The Project area overlies a number of existing mining and mineral development leases. The extraction of CSG does not preclude the extraction of the coal resource as the Project only involves the removal of the gas from the coal seam, a step that needs to be undertaken prior to the establishment of underground coal mining. Arrow will apply industry codes of practice to its drilling to ensure that management of risk is safe, and efficient mining meets or exceeds those applied by the mining industry. Underground coal mining may require gas extraction prior to mining, and gas production can also be coordinated to occur in conjunction with open cut mining.

Arrow intends to enter into agreements with existing and future coal mine operators to coordinate the extraction of gas, which is required to be undertaken prior to extraction of the coal. Through this process, the Project will ensure the placement of surface infrastructure considers future mine plans and the Project can play a role in reducing carbon dioxide emissions from the gas that is currently flared and/or vented as part of the coal mining process as some will be able to be captured and reused. In areas where there are overlapping tenements and possibilities that land use conflicts will arise, Arrow is committed to reaching outcomes with the relevant parties. In some instances, the extraction of CSG from the coal seam will assist in future mining economics. The *Mineral Resources Act 1989* and the P&G Act prescribe the process to be adhered to by persons or entities applying for a mineral resource tenement over petroleum and gas tenements and vice versa. Arrow is a strong supporter of the Joint Industry White Paper that set out a new basis for managing overlapping tenure.

Another potential impact of the Project on mining resources is that exploration permit holders for mineral extraction over the Project area will require additional safety controls for their exploration activities during the Project. Arrow already consults with the holders of exploration permits for mineral extraction to ensure permit holders are aware of Arrow activated and this will be increased to include Project staging and potential additional controls required for access and conduct of exploratory mineral activities.

Arrow has a demonstrated capacity to work with mining companies to ensure that the value of gas and coal is maximised. Arrow's experience with open cut mining is that it can place the surface and sub-surface infrastructure in a flexible fashion to avoid impacts on mining. With underground mining Arrow has similar experience where it is possible to place wells to minimise impacts on safe and efficient mining and maximise gas yield. Deep surface to inseam degassing of coal can deliver large benefits to mining in improved health and safety outcomes as well as costs. The coal and gas sectors have defined a path to work together that will ensure commercial certainty and viable co-existence.

6.13 Landscape and Visual Amenity

A large proportion of the Project area is visually characterised by a mosaic of remnant intact grasslands as well as cleared and degraded grazing lands with patches of regrowth vegetation. Areas of remnant woodland vegetation also occur within the Project area as well as riparian vegetation associated with the Isaac River riparian corridor and associated grasslands.

The Project area used pastoral grazing and agricultural cropping as well as mining, which has resulted in a number of direct and indirect changes to the character of the landscape.

The landscape within the Project area is visually dynamic and subject to ongoing modification through prospective mine development and expansion of existing urban infrastructure to accommodate a growing local and regional workforce.

Arrow's planning and design objective for the Project development is to render facilities visually unobtrusive. This will be achieved through a combination of separation from the most sensitive viewpoints, screening, and the application of design and surface treatments.

See Box 13 for landscape and visual amenity mitigation measures.

Box 13. Management of Landscape and Visual Amenity

Arrow's objective is to avoid or minimise the impact on sensitive viewsheds and the landscape character of the Project area. Arrow will:

- Avoid visually sensitive locations and landscapes when siting facilities, where practicable.
- Integrate facilities into the landscape setting where screening is not practical, considering building and structure colour, texture and lines.
- Hide or screen production facilities using natural landscape features or planted native vegetation barriers, where appropriate.

6.14 Roads and Transport

Project construction and operation will increase traffic volumes across the road network and raise issues of efficiency, safety and amenity. Staged development means that there will be times when the construction, operations and decommissioning phases will be occurring concurrently across the Project area.

A significance assessment approach has been adopted for the Project which includes a strategic evaluation of the road impacts consistent with the level of Project development schedule certainty available at time of report preparation.

Within the Project area, a low significance impact is anticipated on the Suttor Developmental Road between Elphinstone and Red Hill Road prior to implementation of management and mitigation measures. This is predominately due to the number of Project vehicles predicted to travel along this road in 2045 (peak Project traffic generating year) compared to the relatively low existing and future 2045 background traffic volumes.

All other roads assessed have a negligible magnitude and significance of impact prior to implementation of management and mitigation measures due to low Project traffic compared to future 2045 background traffic.

Project traffic volume is not, therefore, a significant increment over existing levels. Provided specific measures are in place to cater for localised areas of heavy construction traffic, the impacts should not unduly affect efficiency, safety or amenity.

Box 14 provides a summary of roads and transport mitigation measures.

Box 14. Managing Traffic and Road Impacts

The safety of the community and Arrow's workforce is paramount. Ensuring construction and operation activities do not adversely impact the road network is another priority. Potential impacts on road safety and road network efficiency will be minimised through:

- Assess and identify works required to manage the increased traffic volumes and road safety issues associated with the Project in road use management plans prepared and regularly reviewed in consultation with the relevant councils and the Department of Traffic and Main Roads (TMR).
- Assess and identify the need to upgrade unsealed roads or widen sealed roads where Project activities and traffic will create road safety issues. Such works will be done in consultation with the relevant council (if a local government road) or TMR (if a state road).
- Develop journey management plans in consideration of high-risk roads.
- Limit Project traffic on school bus routes during pick-up and drop-off times on school days or install appropriate school bus infrastructure, e.g., signage or pullover areas where necessary.
- Ensure all personnel are familiar with Arrow's 12 Life Saving Rules, which embed safe practices in the day-to-day activities of the workforce.
- Monitor compliance with the Project's road safety requirements through regular review of reports generated by the in-vehicle monitoring system.

6.15 Noise and Vibration

The predominantly rural environment of the Project area currently has very low background noise levels.

Noise emissions from the Project's construction activities and production facility operation have been modelled to provide an indication of the distances at which established noise criteria (designed to minimise sleep disturbance and nuisance) will be met. It is expected that the noise criteria will be met within 300 m of a production well and at 2 km from a production facility assuming the application of standard noise attenuation measures. Short-term noise sources (e.g. flaring noise) at the production facilities would not produce significant noise levels at distances greater than 2 km. With the application of further attenuation measures, these distances may be reduced in some circumstances.

The ultimate separation required to meet the noise criteria will be determined in detailed design when equipment selection is finalised. Following commissioning, noise monitoring will confirm whether or not the predicted noise levels have been achieved and, if not, the reduction required, which in turn will

inform the type and extent of attenuation required to ensure compliance.

Vibration during construction and operation is expected to be below the threshold of human detection and to cause no damage to structures, as blasting is not anticipated.

Box 15 summarises the noise and vibration mitigation measures.

Box 15. Managing Noise and Vibration

Arrow recognises that the Project area is typically a quiet rural environment dominated by natural sounds. The protection of amenity at nearby sensitive receptors will be achieved by:

- Selecting production facility and well sites in sparsely populated areas;
- Noise modelling of production facilities to ensure relevant guidelines are met; and
- Implementation of noise controls.

6.16 Economics

Economy underpins society, and economic issues will always be prominent in people's minds when changes are proposed. This section examines the economic changes and resulting impacts expected from the Project.

6.16.1 Regional Context

The relevant study area for the assessment of economic impacts extends beyond the Project area and comprises the Isaac, Mackay and Central Highlands local government areas (LGAs), the catchment area. The catchment area economy is dominated by resources and energy including coal, CSG and LNG projects. The catchment area is largely viewed as a mining region given its abundance of natural resources.

The following points provide a summary of existing key economic conditions within the region or catchment area:

- Mining (including energy resources) is the largest contributor to the catchment area's 2010 – 2011 Gross Value Added;
- Business attraction has led to significant Gross Regional Product growth, particularly in Mackay, which is the catchment area's urban centre;
- Mining and construction dominate employment, which is expected to continue. However, as major projects come online, the proportion of construction work is expected to decrease while the proportion of mining workforce is expected to increase;
- The catchment area has a tight labour market with lower unemployment than Queensland overall;
- The low unemployment rate is a symptom of high labour demand and limited local supply;
- The dominance of the resources sector means the regional economy and many businesses are highly exposed to commodity prices;
- The Minerals Resource Rent Tax, the extended Petroleum Resource Rent Tax, and carbon price will add financial pressure to resource companies operating in the catchment area;
- Access to improved social and community infrastructure is required to make towns more liveable and is likely to improve residents' quality of life;
- The catchment area is now largely viewed as a mining region, compared to an agricultural region historically;
- The catchment area's property market has tightened significantly in recent years, driven largely by increased demands from resource companies and their employees. This is likely to intensify as more projects are developed; and
- Rental prices have also increased significantly in the last five years, which is likely to be the result of a high transient workforce.

6.16.2 Gross Regional, State and National Product

Modelling indicates that the Project will generate significant economic benefits for the economies of the catchment area, Queensland and Australia. Potential beneficial impacts arising from the Project include significant increases in industry output, gross regional product (GRP), employment and incomes over the Project life through both direct and indirect impacts. The modelled data indicates a steady increase in the regional, state and national economies over a six year ramp up period (2015 – 2016 to 2021 – 2022). Over this time the Project's contribution to GRP, above the baseline scenario, is estimated to:

- Increase steadily over a six year ramp up period to approximately $600 million by 2021 – 2022;
- Plateau at approximately $600 to $700 million (or just over 2% of the catchment area GRP) on average once peak gas production is reached; and
- In percentage terms, slowly trend towards the baseline scenario after peak production as Project production remains steady against a backdrop of growth in the broader economy.

6.16.3 Government Taxes and Revenues

Significant positive impact in terms of government revenues will be generated by the Project. Additional revenues are estimated to be approximately $55.7 million per annum to the Queensland Government and approximately $85.5 million per annum to the Australian Government.

The Project will help to strengthen Australia's balance of trade, which will lower the cost of imports but will make Australian exports more expensive and adversely affect import-competing local industries, including manufacturing and some agricultural commodities.

6.16.4 Impacts on Employment, Workforce, Business, Population and Wages

The Project is anticipated to result in a beneficial impact to employment with a net increase of approximately 1,000 full-time equivalent (FTE) employees in the catchment area compared to the baseline scenario during peak labour demand in the ramp up period. Employment impacts fluctuate through the life of the Project due to the staging of works and general trend downward following the peak in construction activity in 2015-2016. This represents a peak increase of approximately 1.1% in employment in the catchment area provided by the Project. A lower beneficial impact is anticipated for Queensland, reflecting the high FIFO labour requirements for the Project (i.e. some labour will be drawn to the catchment area from elsewhere in Queensland). The construction and mining industries will receive the majority of benefits, primarily as a result of direct employment for the Project. Other industries in the catchment area likely to be beneficially impacted by an increase in employment compared to baseline scenario include business, finance and insurance services, transport and storage, and manufacturing. Trade employment is also expected to benefit during the ramp up period.

The most significant impact occurs in the demand for labourers, which will peak at 2.8% of the catchment area total between 2015 and 2022 followed by technicians and tradesmen at 1.5%, after which it will fall to 1.1% and 0.8% respectively for the balance of the life of the Project.

Population is anticipated to increase, in part via the Project workforce but more so via other major infrastructure and resource activities in the region. These developments and activities are expected to result in a high transient workforce, which means that workers have permanent residences outside of the region. Therefore, not all of the employment and income benefits from resources projects in the catchment area would be retained in the local economy.

The Project will contribute to a marginal increase of real wages in the catchment area by an average of 0.5, with a peak of 0.62% in 2019 – 2020. While notable, the increase is not expected to destabilise the regional labour market. Household incomes are expected to increase by 0.5% to 0.75% over the Project life.

6.16.5 Impacts on the Property Market

The housing market in the study area, particularly Moranbah, has historically been prone to boom and bust cycles. The dominance of the mining industry has resulted in market volatility, where housing prices are heavily influenced by commodity prices (reflected in the pipeline of potential projects listed for development) and resource company policies on workforce accommodation.

Recent changes in the mining industry are likely influence housing prices to a significantly different scale to that of the Project. The Project is not deemed large enough to significantly influence the housing market compared to the large scale of mining activity in the region, both existing and proposed. Should mining decline, the Project's influence on housing availability and affordability may increase. Residential property impacts from the Project are expected to be minor as temporary workers' accommodation facilities will be used to accommodate imported construction and operational labour where necessary. Even so, it is possible the Project could contribute to an increase in local housing demand, which would place upward pressure on housing prices.

Mining booms in the region are synonymous with the high housing and rental prices, low / no supply, high demand, and high levels of property investors active in the region. Mining busts are synonymous with low housing and rental prices, population decline, over supply, and lower levels of property investors active in the region. While the EIS has been developed during a boom cycle, the Social Impact Management Plan (SIMP) (Appendix V of this EIS) will be adaptive and will re-examine housing strategies as they evolve.

The Project has the potential to increase demand for industrial / commercial land as a result of flow-on supply chain and support service development. The catchment area is likely to experience shortages of industrial land as growth in resource support industries continues.

The potential for reduced grazing or horticultural productive capacity in some landholdings may result in a decline in the value of these properties, however compensation agreements will be in place for the duration of the operating infrastructure. Uncertainty currently exists regarding the impacts on agricultural production from the CSG sector, which may be affecting agricultural property values.

6.16.6 Economic Impact Issues and Mitigation

With an expected annual average contribution of $600 million to regional, state and national Gross Domestic Product and with the majority spent in the catchment area, the Project will have a positive impact in the region through:

- Enhancing the stability and sustained growth of the catchment area economy;
- Increasing employment rates by up to 1.1%;
- Increasing household incomes by providing high paying jobs for those directly employed by the Project;
- Providing opportunities for local business to secure new contracts and increase sales to supply and service the needs of both the Project and the workforce;
- Increasing population (through attraction of labour to the catchment area) and business activity that will provide additional demand for local household and business services;
- Lifting the local skills base through implementation of skills development and training strategies as part of the Project;
- Increasing job and income earning opportunities; and
- Increasing local, Queensland and Australian government taxation revenues through a variety of taxes and duties.

However, a number of local and regional impacts will require mitigation. See Box 16 for the proposed economic mitigation measures.

Box 16. Economic Growth

The nature of the potential impacts requires a collaborative approach to mitigation, with the CSG industry engaging with state and local government in forecasting needs and monitoring trends to enable effective planning for the provision of labour, infrastructure and services. Initiatives proposed to address the issues include:

- Continue working with Construction Skills Queensland to identify potential strategies for increasing the capacity of local job seekers to develop appropriate skills for construction.
- Collaborate with other CSG proponents and Energy Skills Queensland to access the Skills Queensland Strategic Investment Fund.
- Collaborate with state government, local councils, local industry, industry organisations, and CSG proponents to develop programs and strategies aimed at addressing issues of skill retention and back-filling vacancies as a result of labour being drawn to the Project from other sectors.
- Continue support for the CSG / LNG Industry Training Program.
- Inform local councils, economic development organisations, the Industry Capability Network and state government of goods and services required by the Project that are not currently available or under-serviced from within the catchment area.
- Establish and implement a local business strategy that assists qualified local and regional businesses to tender for provision of goods and services that support the Project.

6.17 Social

The ability of a community to foster and support fulfilling social relationships between its members is important to its liveability and long-term sustainability. This ability is founded on a number of factors such as the creation and maintenance of a secure and safe environment for community members (particularly its children), having adequate resources for the delivery of essential municipal and social services (in particular for health and education), supporting the development of infrastructure conducive to meaningful work and enterprise, and creating the environment for diverse cultural and recreational activity. Change, either direct or induced, imposed by the development of a project has the potential to compromise any or all of these factors.

6.17.1 Regional Context

The study area for the Project assessment primarily comprises the communities of Moranbah and Dysart, with regional consideration of Glenden, Nebo, Middlemount and Blackwater. Agriculture and public administration have traditionally been the dominant employment sectors in this area and have been the main influences on the social fabric at the regional scale.

The economy began changing substantially in the mid to late 1960s when coal mining dramatically increased in scale. Today, while coal mining is the significant industry in the region; agriculture remains a very important part of the economy and community identity.

The communities of interest have experienced rapid population growth in recent years in response to the mining boom. However growth of the residential population in the study area is not reflective of the overall growth, as a significant portion of workers in the mining industry in the Bowen Basin region operate on a non-residential basis. Unemployment is generally very low.

The housing market in the study area, particularly Moranbah, has historically been prone to boom and bust cycles. The dominance of the mining industry has resulted in market volatility, where housing prices are heavily influenced by commodity prices (reflected in the pipeline of potential projects listed for development) and resource company policies on workforce accommodation. Hotel and motel accommodation is limited.

Educational facilities are distributed across the townships included in the study area and are generally of good quality.

The study area enjoys generally good health and emergency services, a safe and healthy living environment and low crime rate, and a more comprehensive range of services generally available in the larger towns. Facilities for youth and children, specialist counselling and aged care are generally limited.

6.17.2 Social Impact Issues and Mitigation

Arrow's characterisation of the social impact issues has relied not only on demographic statistics but also on the attitudes and opinions that people have expressed in a region-wide (and continuing) process of inclusive community engagement (including Project briefings, focus groups, interviews, telephone surveys, discussions with government agencies and councils, and feedback in numerous forms).

During successive stages of consultation, stakeholders and communities were asked to contribute their knowledge and preferences in regard to the management of potential impacts. Their responses are presented in Table 10.

Table 10. Stakeholder Contributions on Managing Project Impacts

Management of Adverse Impacts	Opportunities
Put things in place to manage water use, quality, use and discharge.	Assist local economic growth and job creation and use local businesses.
Look after agricultural and farm lands (including weed management).	Communicate, get involved and interact with the local community.
Provide greater communication and consultation before and during the Project.	Provide more facilities and infrastructure.
Carry out traffic management and road infrastructure.	Provide additional sources of water and reduce water wastage.
Provide compensation for farmers' and landowners' rights and cooperation.	Upgrade or maintain roads.
Assist local employment and support local business.	

Key potential negative impacts identified in the social impact assessment relate to the affordability and availability of housing and accommodation, increased demand for health services and on medical facilities, uncertainty for landowners and community members, heightened road safety risk due to increased traffic levels, and the impact that higher wages may have on the viability of local businesses. While the anticipated changes are not large, the relatively rapid establishment of a new economic driver along with the cumulative effect of simultaneous projects may exacerbate the impacts, at least in the short term.

Not all impacts are negative. The Project will deliver a range of positive social effects, including direct and indirect employment, enhanced training and skill development prospects, additional local business opportunities and an injection of wealth and vitality into local communities. Industry diversification also may improve the economic and social resilience of both communities and agricultural enterprises, as the latter are exposed to seasonal variations and international trading conditions.

Social impacts will be managed through the social impact management plan prepared by Arrow and attached to the EIS. The social impact management plan details the commitments — incorporated in action plans — made by Arrow to address the identified issues and impacts. A living document, the social impact management plan will be updated to incorporate further information, particularly the outcomes of programs and initiatives implemented by other proponents. This will enable a more measured and targeted response to the prevailing issues at the time Arrow embarks on this major expansion of its operations.

Box 17 provides a summary of the proposed social mitigation measures. A complete list of the proposed social mitigation measures is provided in the Project's SIMP (Appendix V of this EIS).

Box 17. Social Responsibility

The Project will deliver a range of opportunities that increase direct and indirect employment, enhance training and skills development, provide local business opportunities and inject wealth and vitality into local communities. To ensure these opportunities are realised and adverse impacts are minimised, Arrow will:

- Maximise the positive benefits of the Project through investment in community programs.
- Participate in forums convened by the Queensland Government to reduce the impact of housing stresses in the region.
- Minimise additional demands on existing services and social infrastructure.
- Expand the opportunities available for the region under the Brighter Futures program and the Social Investment Plan.
- Make a positive contribution to community wellbeing and liveability through supporting community values and lifestyles.

Arrow will continue to actively engage the community throughout the ensuing phases of the Project to inform its responsible design, construction, operation and decommissioning.

6.18 Cultural Heritage

6.18.1 Indigenous Cultural Heritage

The Project area contains known and unknown Indigenous Cultural Heritage sites relating to Aboriginal people.

Within the Project area, there are 2,300 (2,700 including those partially within the Project area) Indigenous Cultural Heritage places listed on the Indigenous Cultural Heritage Register and Database (ICHRaD). Cultural material predominantly consists of stone artefacts. Significantly, there are a number of

places that contain multiple heritage values, such as scarred trees, pathways, and stone artefacts. These Cultural Heritage 'precincts' are located in the central and northern portions of the Project area, and are often in close proximity to major waterways.

Arrow recognises that in addition to sites listed in Cultural Heritage databases, places and artefacts of significance to Aboriginal persons may be encountered virtually anywhere in the Project area, particularly those areas that have not yet been developed.

Arrow recognises that the Aboriginal parties will retain a strong interest in ensuring that the cultural heritage areas, objects and values identified throughout the Project area are protected or managed in a culturally appropriate fashion and with their direct input. It is anticipated that the Aboriginal parties will require the implementation of a management process that embodies culturally appropriate measures for the protection of management of their cultural heritage.

With this understanding, Arrow proposes to meet its 'duty of care' obligations under Queensland legislation either through a suitable native title agreement or agreements that do not expressly exclude Cultural Heritage or through an approved Cultural Heritage management plan. Arrow proposes to seek approval of process and site management Cultural Heritage management plans to address the difficulties with a staged development.

The specific processes for management of Cultural Heritage will be formalised in the Cultural Heritage management plan and will include protocols for clearance surveys, avoidance of known places, monitoring of works areas, and courses of action to be taken when artefacts are discovered. The protocols will be implemented through the site management Cultural Heritage management plans, which will serve to minimise the impact on Indigenous Cultural Heritage places and artefacts, as well as to improve the knowledge of Indigenous Cultural Heritage in the Project area.

6.18.2 Non Indigenous Cultural Heritage

The region in which the Project area is located has experienced non-Indigenous visitation dating from the mid-nineteenth century with the arrival of the earliest explorers, soon followed by pastoralists venturing out into newly-declared pastoral districts.

Many of the known non-Indigenous heritage places within the Project area are associated with early settlement and include early pastoral stations and associated services such as roads and stock routes, towns, railway infrastructure and contact places. There are also remnants of a number of early mining ventures in the Project area; they are significant as the precursors to later major mines. No sites of national significance or of world heritage significance were identified as part of the assessment. Twenty one places, including several of potential regional or state significance, were identified during the course of background research and consultation. There are no places within the Project area listed on the Queensland Heritage Register.

6.18.3 Mitigation Measures

Box 18 summarises the proposed heritage mitigation measures.

Box 18. Conservation of Heritage

Arrow's objective is to avoid or minimise disturbance by Project activities to Cultural Heritage sites and artefacts. Key measures to achieve this objective include:

- Negotiate cultural heritage management plans with the Aboriginal Parties, based on the avoidance / manage / mitigate principle.
- Maintain a GIS database of sites of Indigenous cultural heritage that are known or found during the course of investigations and works (where Aboriginal parties allow the listing of the sites).
- Ensure site inductions provide cultural heritage awareness for places and objects (to avoid) and the appropriate procedures to follow should there be any new discoveries.
- Develop a 'chance-find' procedure for the discovery of unknown heritage places during construction as part of the cultural heritage management plan.

6.19 Preliminary Hazard and Risk

CSG is predominantly comprised of methane, which is flammable and, when confined, potentially explosive. In addition, methane can displace air, creating an oxygen-deficient atmosphere. These characteristics have the potential to impact on public safety and the safety of the Project's workforce.

The separation required from hazardous facilities and infrastructure to ensure public and worker safety was assessed in a quantitative risk assessment that considered three credible scenarios:

- Jet fires, involving a continuous release of gas under pressure producing a long, stable flame;
- Flash fire, where a flame travels through a cloud of gas in the open; and
- Vapour cloud explosion of gas in a confined space.

Petroleum facilities are designed and engineered in accordance with international, Australian and industry-accepted standards. Examples include the routine installation of automatic and manual isolation valves (that limit the volume of gas available to feed any release or subsequent fire), the routine installation of automated emergency shutdown valves, and the periodic internal inspection of high-pressure steel pipelines to detect any evidence of corrosion. Threats from wildlife and natural disasters, such as bushfires, cyclones, floods, and earthquakes, are an integral part of the risk assessment.

Arrow's objective is to reduce residual risk to 'as low as reasonably practicable', an internationally recognised concept that is embodied in relevant Australian standards. Where this cannot be achieved purely through design, Arrow will apply procedural controls and behavioural programs.

Box 19 summarises the proposed hazard and risk mitigation measures.

Box 19. Hazard Identification and Risk Management

Hazard identification and risk management is integral to Arrow's integrated health, safety and environmental management system. Arrow is committed to minimising the potential risks to employees, the community, property and the environment from activities associated with the Project.

Arrow plans to achieve this commitment through their high standards of occupational health and safety, and environmental management, which include:

- Detailed engineering design, construction and operation of facilities in accordance with relevant Australian and international standards and industry codes of practice.
- Select locations for Project infrastructure with full consideration of and allowance for the minimum buffer zones indicated by the quantitative risk assessment.
- Conduct systematic risk assessments (which include hazard identification, assessment, treatment and monitoring) in accordance with relevant legislation and standards during design, construction and operations.

6.20 Waste

Project activities will generate solid, liquid and gaseous waste streams; the potential impacts of which can be managed responsibly with the implementation of the standard waste hierarchy of avoidance, reuse, recycling and disposal. Liquid wastes and brine management are discussed in Section 6.8 and gaseous wastes are discussed in Section 6.2.

Box 20 provides a summary of the proposed waste mitigation measures.

Box 20. Waste Management

Arrow aims to minimise the release of any harmful substances to the air, water or the land through the responsible management of its wastes, including:

- Solid wastes, chemicals and other wastes to be disposed or recycled at appropriate facilities in accordance with legislative requirements and the Arrow Waste Management Procedure.
- An environmental awareness program for personnel and contractors associated with equipment or procedures specific to waste, will be conducted prior to and during activities, to discuss environmental impacts and proposed management measures to reduce waste impacts Sites will develop a plan that considers minimisation, storage, segregation, treatment, reuse, recycling and disposal. This plan will be a standalone document or part of a broader Operational EM Plan.
- Reducing the quantity of waste that is sent to landfills by recycling and reuse of waste.

6.21 Decommissioning and Rehabilitation

The Project infrastructure will be progressively decommissioned and the land rehabilitated throughout the Project life. Final decommissioning and rehabilitation will occur on an as needs basis as individual Project components (wells, pipelines etc.) reach the end of their productive life. This process will be undertaken in accordance with the Project schedule and in line with the relevant approvals and regulatory requirements.

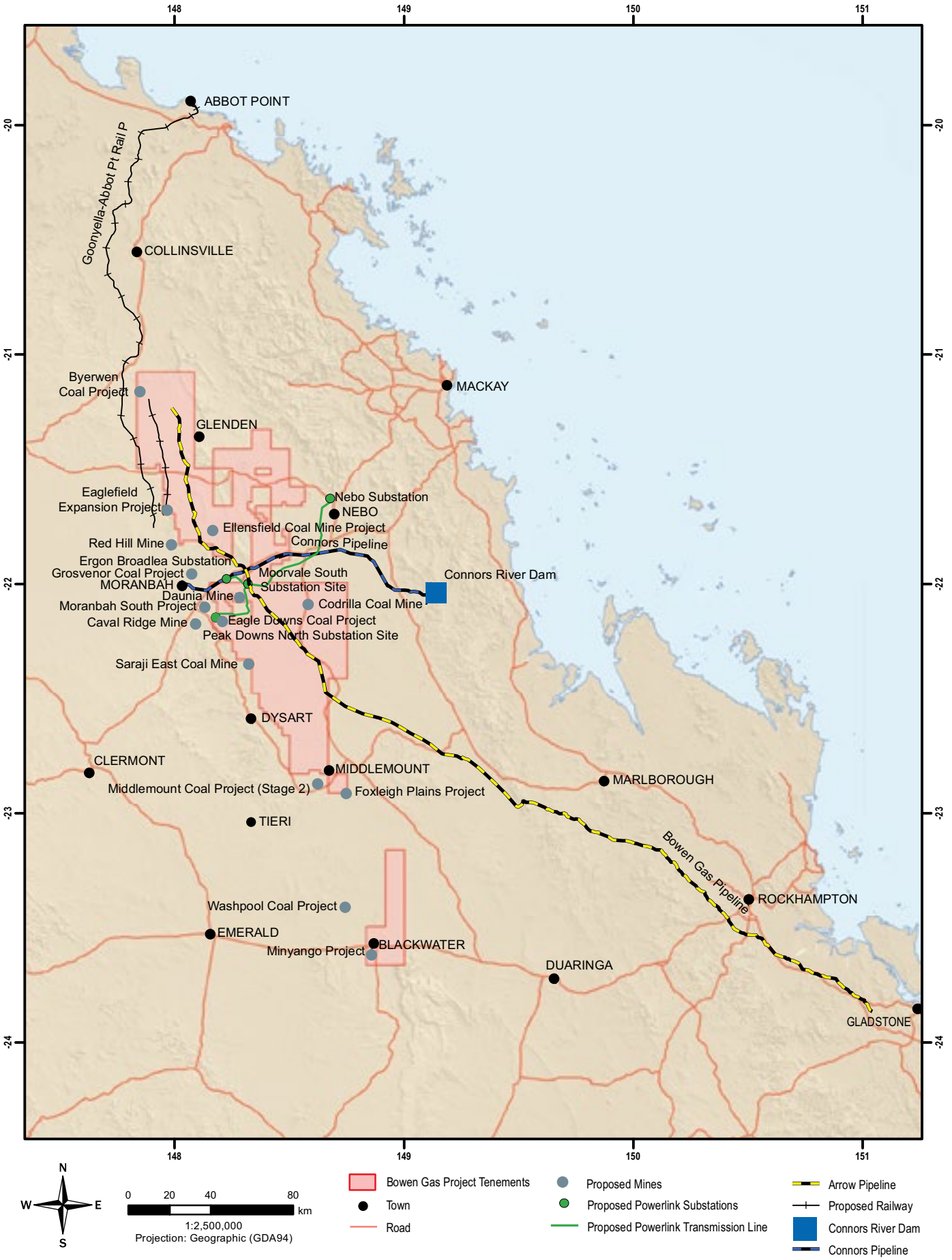
The objectives of the decommissioning and rehabilitation strategy are to ensure that:

- Decommissioning and rehabilitation activities meet stakeholder expectations and comply with relevant regulatory requirements and/or industry best practices;
- Infrastructure, except for buried pipelines, developed for the purpose of the Project will be decommissioned, safely removed and appropriately disposed of;
- Opportunities for progressive rehabilitation will be maximised;
- The final landform is stable and an acceptable final land-use for the disturbance area is achieved; and
- The potential for adverse environmental impact is minimised.

7 Cumulative Impacts

The potential environmental, economic, social and cultural impacts identified in the EIS, when combined with the impacts of other developments in the region (Figure 15), will, in some instances, have a cumulative impact. The severity and duration of the cumulative impact will depend principally on the timing and duration of construction activities, as operations activities will, over time, establish a new equilibrium in supply and demand.

Figure 15. Projects Considered in Cumulative Impacts Assessment



The geographic separation of known and proposed developments in the region will reduce the severity of some impacts, particularly where the impacts are concentrated at or near the Project areas.

However, in some instances, this also serves to increase the severity of cumulative impacts, as activities are concentrated in the larger towns that provide the necessary infrastructure and services.

Environmental aspects that will experience cumulative impacts, the severity of which will be largely determined through environmental management at the sites of disturbance, include:

- Terrestrial ecology through habitat fragmentation;
- Aquatic ecology through diminished water quality; and
- Visual amenity of the affected community through industrialisation of a rural landscape.

Three aspects of the environment are subject to potential impacts that will potentially have a significant cumulative impact and will require an integrated approach involving all proponents to ensure the impacts are managed to reduce their severity and duration. These aspects are groundwater, social and economic, and roads and traffic and are discussed below.

7.1 Groundwater

CSG production and groundwater depressurisation activities in the Project area will have varying impacts on regional groundwater levels depending on the development schedule and management requirements. Due to the low permeability of the confining Rewan Formation and the low permeability of the interburden layers (aquitards) of the Blackwater Group, the predicted groundwater drawdown is relativity restricted to the coal seams (aquifers) and proximal to the proposed CSG fields. A review of the projects that could potentially have a cumulative impact on groundwater resources within or near the Bowen Gas Project indicated that the vast majority of the projects were mining related.

A review of publicly available mine data for the projects within the Project area yielded insufficient information (i.e. geometries, schedules and dewatering rates) to enable the accurate modelling of their cumulative groundwater impacts. Consequently, cumulative impacts from coal mining were not able to be included in the numerical groundwater model.

During the detailed Project planning phases, locations within the Project area that could potentially be constrained or restricted for development purposes will be identified based on the sensitivity of the groundwater environmental values to be protected.

After CSG operations are completed, the groundwater system will re-adjust over the long-term. However, due to relatively low rates of diffuse recharge into the Permian-Triassic outcrops (including the coal seams), the pre-development conditions appear to involve relatively low rates of regional groundwater flow through the deep aquifers, and effectively 'zero' regional flow through the deep aquitards. Further, the rate of groundwater recovery may be slowed even more by the mining operations. The significance of the cumulative groundwater impacts is considered to be low.

7.2 Social and Economic

The cumulative community effect of more than one resource project in the Bowen Basin is likely to manifest as an amplification or exacerbation of the Project impacts assessed in the SIA and economic assessment. Further, existing operations in the region have already produced a cumulative impact, such as increased demand on social infrastructure and housing in Moranbah and Dysart, and were considered as part of the baseline for the proposed Project.

Impacts of a social and economic nature can be either beneficial or detrimental to the community and/or region. While as a result of cumulative pressures, there may be some detrimental local impacts on housing affordability etc. due to increased demand, there will likely be beneficial impacts such as an increased gross regional product putting more money back into the community.

The key to managing cumulative impacts is to have all projects' proponents considering more than their own project in the development and implementation of their strategies, policies and programs. This is best achieved through a high level, strategic forum which will enable key stakeholders to better understand the requirements and outcomes of multiple projects.

7.3 Roads and Traffic

Due to the potential for the Project to take place concurrently with other projects, the impacts of all significant committed projects in the area were considered. The cumulative roads and traffic assessment considered the Project together the Caval Ridge Mine Project and the Alpha Mine Project. Projects already in operation are accounted for in the 2011 traffic baseline numbers. As part of the cumulative assessment the significance of impacts for each assessed road section taking account of all development projects in the area prior to implementation of management and mitigation measures was undertaken. All identified cumulative impacts remained negligible, except for the impact on Suttor Developmental Road between Elphinstone and Red Hill Road, which remained low.

A Level of Service (LOS) analysis was also undertaken which showed that, with the Project operational, all of the roads assessed would operate at LOS A (free flow conditions) with predicted 2045 background traffic flows. With the addition of cumulative traffic from all other identified projects all roads would continue to operate at LOS A.

8 Environmental Management

The potential environmental, economic, social and cultural impacts identified in the EIS, when combined with the impacts of other developments in the region (Figure 15), will, in some instances, have a cumulative impact. The severity and duration of the cumulative impact will depend principally on the timing and duration of construction activities, as operations activities will, over time, establish a new equilibrium in supply and demand.

8.1 Environmental Management System

Arrow maintains an integrated health, safety and environmental management system (HSEMS) based on the principles of international standard ISO 14001 *Environmental Management Systems — Requirements with Guidance for Use* (ISO, 2004), and AS / NZS 4801:2001 *Occupational Health and Safety Management Systems — Specification with Guidance for Use.*

The HSEMS incorporates an environmental policy that sets out Arrow's approach to the management of health, safety and the environment. Arrow's environmental policy will be implemented by:

- Seeking continuous improvement in managing significant environmental impacts by clearly defining objectives and targets and evaluating them through transparent review and implementation processes;
- Establishing programs to reduce environmental impacts, conserve and recycle resources, reduce waste and pollution, and improve processes to help protect the natural environment, as well as monitoring and measuring performance;
- Ensuring all activities comply with all applicable environmental laws and regulations;
- Promoting a culture in which employees and service providers are aware of environmental impacts affecting their work and promptly report any environmental impacts or incidents encourage improvements; and
- Monitoring policy implementation at all relevant Arrow-controlled workplaces and periodically reviewing and updating.

The roles and responsibilities of Arrow in ensuring the performance of its employees and contractors are set out in Table 11.

Table 11. HSEMS Roles and Responsibilities

Role	Responsibility
Chief Executive Officer	• Performance of Arrow; Corporate environmental policy; and • Fostering a partnership that promotes 'ownership' of Arrow's environmental responsibilities.
Chief Operating Officer	• Implementation of corporate and environmental policy; and • Systems and resources to ensure compliance with environmental policy.
Vice President Health, Safety, Sustainability and Environment	• Performance measurement and reporting, including recommendations for improvement and corrective actions; and • Ensuring management and monitoring practices and procedures are documented and clearly communicated within the organisation.
General Manager (Water)	• Authorised officer for signing water documentation; and • Ensuring management and monitoring practices and procedures are documented and clearly communicated within the organisation.
General Manager (Assets)	• Implementation of management and monitoring practices and procedures in all operation areas; Resourcing; and • Accountable for compliance.
Environment managers	• Environmental approvals management; • Development of operational procedures and practices relevant to the environment; • Coordinating incident response; and • Reporting and compliance related issues.
All site and field personnel	• Environmental approvals management; • Development of operational procedures and practices relevant to the environment; • Coordinating incident response; • Reporting and compliance-related issues; • Training in and implementing procedures, including those that address environmental management, at a site / operational level; • Overseeing day to day activities; and • Carrying out specific activities that ensure compliance with EA conditions, including monitoring and data collection.

8.2 Environmental Management Plans

A draft EM Plan that incorporates the mitigation measures (commitments) proposed to address the potential environmental and cultural impacts of the Project is included in the EIS. The social impact management plan that proposes measures to address social impacts of the proposed development is also included.

Following approval of the EIS, Arrow will require an EA under the EP Act to commence the Project's construction and operation on a PL. Detailed information is required to enable an EA application to be assessed by EHP and is typically presented in an Operational EM Plan. The draft EM Plan in the EIS will be updated to include the initial development plan which will be been developed as part of the Project's ongoing design process as described in Section 3.3. It will be the updated Operational EM Plan that will support the EA application.

The Operational EM Plan accompanying the EA application will addresses the requirements set out in the EHP guideline 'Preparing an Environmental Management Plan for Coal Seam Gas Activities'. The EA is the principal regulatory document and sets out the conditions that apply to the construction and operation of the CSG fields.

Management plans will be prepared by Arrow or its contractors for management of the identified environmental, cultural and social impacts during construction. Standard operating procedures or similar documents incorporated in Arrow's HSEMS will detail environmental management measures for operations and maintenance activities and, where relevant, will also be incorporated in or form the basis for construction EM Plans.

Accountability for implementation of the environmental management measures and EM Plans rests with Arrow, and it will ensure the performance of contractors through conditions in contracts.

9 Ecological Sustainable Development

The planning phase of the Project has considered the principles of ecologically sustainable development.

There are five key principles of ecologically sustainable development that are relevant to the Project and provide guidance for achieving ecologically sustainable development (Preston, 2006).

These are summarised as follows:

- Integration of economic, social and environmental considerations;
- Application of the precautionary principle;
- The pursuit of intergenerational equity;
- Conservation of biological diversity and ecological integrity; and
- Improvement of valuation, pricing and incentive mechanisms.

During the construction, operation and decommissioning of the Project these principles will be applied through commitments made within the EIS and the EM Plan and through Arrow's HSEMS and sustainable development policy.

10 Submissions

The EIS has been publically advertised and the Chief Executive of EHP has allowed a 30 business day period for acceptance of public submissions on the EIS. The Chief Executive must accept all properly made submissions and may accept submissions even if they are not properly made.

It is a statutory requirement that all submissions will be forwarded to Arrow for consideration and provision of a response to EHP. The Chief Executive of EHP may require Arrow to prepare responses to properly made submissions on the EIS.

The requirements for making a submission and the address to which all submissions, comments and enquiries regarding this EIS process should be sent are provided in Table 12.

Table 12. Requirements for Public Submission

Submissions must:	Submissions will be forwarded to the proponent for consideration and provision of a response to EHP.
• Be written and signed by or for each person (signatory) who made the submission. • State the name and address of each signatory. • Be made to the Chief Executive of EHP. • Be received on or before the last day of the submission period.	Submissions should be addressed to: The Chief Executive State-wide Impact Assessments Department of Environment and Heritage Protection **Attention:** The EIS Co-ordinator (Bowen Gas Project) Floor 3, 400 George Street, BRISBANE, QLD, 4000 GPO Box 2454, 400 George Street, BRISBANE QLD, 4001

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BRISBANE DALBY MORANBAH GLADSTONE

Arrow Energy Pty Ltd
ABN: 73 078 521 936