Department of Environment and Heritage Protection

Environmental Impact Statement (EIS)

Report under the *Environmental Protection Act 1994*

Arrow Energy Surat Gas Project

Proposed by Arrow Energy Pty Ltd

Great state. Great opportunity.

Queensland Government

Prepared by: Statewide Environmental Assessments, Department of Environment and Heritage Protection

October 2013

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List of acronyms and abbreviations

AADT	Annual average daily traffic
ACH Act	*Aboriginal and Cultural Heritage Act 2003*
AEP	Annual exceedence percentage
AIFLC	Arrow Intensively Farmed Land Committee
ARI	Average reoccurrence interval
ASCRG	Arrow Surat Community Reference Group
ATP	Authority to prospect
CGPF	Central gas processing facility
CHMP	Cultural Heritage Management Plan
CMA	Cumulative Management Area
CRG	Community Reference Group
CSG	Coal Seam Gas
CTM	Chemical Transport Model
Cwth	Commonwealth
DAFF	Department of Agriculture, Fisheries and Forestry
DATSIMA	Department of Aboriginal and Torres Strait Islander and Multicultural Affairs
DCCSDS	Former Department of Communities, Child Safety and Disability Services
DCS	Department of Community Safety
DDRP	Darling Downs Regional Plan
DDSD	Darling Downs Statistical Division
DERM	Department of Environment and Resource Management
DSEWPaC	Former Commonwealth Department of Sustainability, Environment, Water, Population and Communities
DHPW	Department of Housing and Public Works
DLG	Department of Local Government
DNRM	Department of Natural Resources and Mines
DO	Dissolved oxygen
DOE	Commonwealth Department of Environment
DSDIP	Department of State Development, Infrastructure and Planning
DSITIA	Department of Science, Information Technology, Innovation and the Arts
DTMR	Department of Transport and Main Roads
EA	Environmental authority
EHP	Department of Environment and Heritage Protection
EIS	Environmental impact statement
EM plan	Environmental management plan
EP Act	*Environmental Protection Act 1994*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPBCAEOP	EPBC Act Environmental Offsets Policy
EPP (Air)	Environmental Protection (Air) Policy 2008
EP Regulation	Environmental Protection Regulation 2008

ERA	Environmental relevant activities
ESA	Environmentally sensitive area
EVNT	Endangered, Vulnerable or Near Threatened
FCF	Field compression facility
GAB	Great Artesian Basin
GARID	Guidelines for Assessment of Road Impacts of Development
GHG	Greenhouse Gas
GQAL	Good quality agricultural land
HEV	High ecological value
IAS	Initial advice statement
IESC	Independent Expert Scientific Committee
IFL	Intensively farmed land (See EIS)
IIESC	Interim Independent Expert Scientific Committee
IESC	Independent Expert Scientific Committee
Land Act	*Land Act 1994*
LNG	Liquefied natural gas (LNG)
MIA	Mine infrastructure area
ML	Mining lease
MLA	Mining lease application
MNES	Matters of National Environmental Significants
MR Act	*Mineral Resources Act 1989*
NC Act	*Nature Conservation Act 1992*
NEPM	National Environment Protection (Ambient Air Quality) Measures
NOX	Oxides of nitrogen
NT Act	*Native Title Act 1993*
OCG	Office of the Coordinator General
OGIA	Office of Groundwater Impact Assessment
PAA	Priority Agricultural Areas
PLA	Priority Living Areas
PL	Petroleum Lease
PPL	Petroleum Pipeline License
PVMO	Policy for Vegetation Management Offsets
P&G Act	Petroleum and Gas (Production & Safety) Act 2004
QBOP	Queensland Biodiversity Offsets Policy
QGEOP	Queensland Government Environmental Offsets Policy
QH	Queensland Health
QMDC	Queensland Murray-Darling Committee
QPS	Queensland Police Service
QTT	Queensland Treasury and Trade
QWC	Queensland Water Commission
RAP	Remediation Action Plan

RE	Regional Ecosystems
RIA	Road impact assessment
RMP	Road-use management plan
RO	Reverse Osmosis
ROW	Right of Way
SCL	Strategic Cropping Land
SCL Act	*Strategic Cropping Land Act 2011*
SDPWO Act	*State Development and Public Works Organisations Act 1971*
SMP	Species management plan
SP Act	*Sustainable Planning Act 2009*
SREIS	Supplementary report to the EIS
TAPM	The Air Pollution Model
TEC	Threatened Ecological Community
TMP	Traffic Management Plan
TOR	Terms of reference
TRC	Toowoomba Regional Council
TSS	Total suspended solids
TWAF	Temporary workers accommodation facility
VM Act	*Vegetation Management Act 1999*
VOC	Volatile organic compounds
WDRC	Western Downs Regional Council

1 Introduction

Arrow Energy Pty Ltd (Arrow) is seeking approval to construct, operate and decommission the Surat Gas Project (herein referred to as the 'project'), located approximately 160km west of Brisbane in Queensland's Surat Basin. The project would form an expansion to Arrow's existing operations in the Surat Basin to cater to growing demand for gas in the Australian and global liquefied natural gas market.

This report provides an evaluation of the environmental impact statement (EIS) process pursuant to Chapter 3 of the *Environmental Protection Act 1994* (EP Act) for the project proposed by Arrow. An application to prepare a voluntary EIS was granted by the former Department of Environment and Resource Management (DERM; now Department of Environment and Heritage Protection) and the draft terms of reference (TOR) were advertised in March 2010. Following a period of public consultation, the TOR was finalised in September 2010.

The Department of Environment and Heritage Protection (EHP), as the administering authority of the EP Act, coordinated the EIS process. This EIS assessment report (herein referred to as the 'assessment report') has been prepared pursuant to sections 58 and 59 of the EP Act. Section 58 of the EP Act lists the matters that EHP must consider when preparing an assessment report, while section 59 of the EP Act states what the content must be.

The EP Act requires that an assessment report must:

- address the adequacy of the EIS in addressing the final TOR
- address the adequacy of the draft environmental management plan (EM plan)
- make recommendations about the suitability of the project
- recommend any conditions on which any approval required for the project may be given
- contain other matters as prescribed under section 59(e) of the Environmental Protection Regulation 1998 (EP Regulation).

Section 9 of the EP Regulation lists the following matters that must be included in an assessment report:

(a) A description of
  (i) the project
  (ii) the places affected by the project
  (iii) any matters of national environmental significance likely to be affected by the project.
(b) A summary of the project's relevant impacts.
(c) A summary of feasible mitigation measures or changes to the project or procedures to prevent or minimise the project's relevant impacts, proposed by the proponent or suggested in a relevant submission.
(d) To the extent practicable, a summary of feasible alternatives to the project identified in the assessment process and the likely impact of the alternatives on matters of national environmental significance.
(e) To the extent practicable, a recommendation for any conditions of approval for the project that may be imposed to address impacts identified in the assessment process on matters of national environmental significance.

In meeting the requirements of the EP Act, this assessment report describes the project and the places likely to be affected by the project. It summarises the key issues associated with the potential adverse and beneficial environmental, economic and social impacts of the project. It also discusses the management, monitoring, planning and other measures proposed to minimise adverse environmental impacts. Finally, this assessment report identifies those issues of particular concern that were not resolved or require specific conditions for the project to proceed.

As the project is a 'controlled action' under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Commonwealth legislation), impacts on matters of national environmental significance (MNES) and their management were addressed in the EIS documents[1].

[1] The term 'EIS documents' refers to the EIS, supplementary report to the EIS (SREIS) and associated documents as defined in section 3.5.2 The submitted EIS of this assessment report.

Section 2 of this assessment report describes the project to provide context for the findings of the report. **Section 3** outlines the EIS process that was followed for the project and the approvals that would be necessary for its commencement. **Section 4** addresses the adequacy of the EIS documents in addressing the TOR, discusses the main issues with regard to the environmental management of the project and outlines the environmental protection commitments made in the EIS documents. **Section 5** assesses the adequacy of the EIS documents in addressing potential impacts on matters of national environmental significance (MNES). **Section 6** assesses the adequacy of the EM plan for the project.
Section 7 makes recommendations about the suitability of the project. **Section 8** makes recommendations and identifies outstanding matters required for the project to proceed.

The giving of this assessment report to the proponent completes the EIS process under the EP Act.

2 Project details

This section provides a broad summary of the proposed project as outlined in the EIS (Chapter 5) and the supplementary report to the EIS (Supplementary report to the EIS (SREIS); Chapter 3).

2.1 Project proponent

The proponent for the project is Arrow Energy Pty Ltd (Arrow), a wholly owned subsidiary of Arrow Energy Holdings Pty Ltd—a 50:50 joint venture between a subsidiary of Royal Dutch Shell plc (Royal Dutch Shell) and a subsidiary of PetroChina Company Limited (PetroChina). Royal Dutch Shell operations in Australia include:

- petroleum refining
- sale of petroleum products and retail businesses
- exploration and development of large gas resources off the coasts of Western Australia and the Northern Territory.

Royal Dutch Shell has developed liquefied natural gas (LNG) projects in Qatar, Nigeria, Russia and Southeast Asia and through a subsidiary, operates a large LNG carrier fleet. PetroChina is a subsidiary of China National Petroleum Corporation, and is one of the world's largest oil companies with extensive experience in exploration, refining and marketing of oil and natural gas in China and other countries.

Arrow has interests in more than 65,000km^2 of petroleum tenures, mostly within Queensland's Surat and Bowen basins but also in the Clarence-Moreton, Coastal Tertiary, Ipswich, Styx and Nagoorin Graben basins. Arrow currently operates existing gas fields, facilities and infrastructure in an area near Dalby, and supplies gas to the domestic market for power generation and other domestic uses. Production facilities are located at Daandine, Kogan North, Stratheden and Tipton West. Arrow and its equity partner, AGL Energy, have access rights to the North Queensland Pipeline, which supplies gas to Townsville from the Moranbah Gas Project, and hold the pipeline licence for the proposed Central Queensland Pipeline between Moranbah and Gladstone.

2.2 Objective of the project

The EIS documents state that the principal objective of the project is to commercialise gas reserves held in the company's Surat Basin petroleum tenures.

2.3 Need for the project

The EIS documents state that the Australian and global demand for gas presents an opportunity to develop Arrow's gas resources for export while supporting and expanding the existing domestic market. It also presents supporting information on gas resources, demand for energy and gas, and the influence of greenhouse gas reduction measures on demands for gas. The EIS documents assert that the project would benefit Queensland and Australia through long-term royalty contributions to the state economy, have direct benefits to areas surrounding the project through the creation of employment and small business opportunities, promote the development of a highly skilled workforce, and contribute to diversification of the regional, state and national economies. Should LNG export not proceed, Arrow's gas field developments in the Surat Basin would progress but on a smaller scale, at a slower rate, and with a reduced level of investment and economic output.

The EIS outlines a range of consequences should the project not proceed, including positive and negative environmental, economic and social impacts, such as:

- the potential adverse impacts on land, biodiversity, water and air, and the associated visual and social impacts, would not occur
- the potential adverse impacts on the local and broader economy, labour market, and community services would not occur
- the potential for economic benefits to the Queensland economy (estimated at $1.66 billion), job creation (approximately 1,000 jobs during construction, up to 400 jobs during operation), investment in local and regional infrastructure and services, and increased export and local use of LNG, would not be realised.

2.4 Alternatives

The EIS documents outline a range of options for gas field infrastructure, and for the design and location of specific infrastructure. Final selection would be based on further planning, technology development, engineering and economic considerations, and environmental (including land, water, biodiversity and air) and social constraints. Consultation with landholders would inform the location of gas wells and associated infrastructure to limit impacts on current land uses.

The SREIS presents significant changes to the proposed project which would reduce some impacts and increase others. The SREIS also provides details of sites for gas processing and water treatment infrastructure and temporary accommodation camp for the initial development phase of the project. A more detailed outline of project infrastructure and potential location is provided in section 2.6 (Project description) of this report.

The EIS documents present a planning and management approach, referred to as the environmental framework approach, used by Arrow to manage the impacts of coal seam gas (CSG) development (site selection, construction and operation) where the location of infrastructure becomes progressively known over the life of the project. The framework approach provides for the application of environmental management controls (avoidance, mitigation and management) that reflect the level of sensitivity of environmental values, and is supported by a process of description, classification and mapping of a range of constraints.

2.5 Relationship to other projects

The project forms part of a larger Arrow LNG Project with separate approvals being sought for each component. Components include:

- Arrow LNG export facility on Curtis Island. Assessment has been completed under Part 4 of the *State Development and Public Works Organisation Act 1971* (SDPWO Act)
- Arrow Surat Pipeline from the Kogan area of the Surat Basin to Fisherman's Landing (Petroleum Pipeline License (PPL) 144 granted in February 2010)
- Surat Header Pipeline to connect the Arrow Surat Pipeline to Arrow production facilities in the southern region of the project development area
- Bowen Gas Project with proposed gas field development in the Bowen Basin between Collinsville in the north and Middlemount in the south. This component is currently undergoing assessment by EIS under the EP Act
- Arrow Bowen Pipeline to convey CSG from Arrow's gas fields in the Bowen Basin to Gladstone. Assessment by EIS under the EP Act was completed in March 2013.

2.6 Project description

2.6.1 Location

The project would be located approximately 160km west of Brisbane—extending in an arc from Wandoan in the north to the south-west of Millmerran (Figure 1). Townships within or in close proximity to the project development area include Wandoan, Chinchilla, Kogan, Dalby, Cecil Plains, Millmerran, Miles and Goondiwindi. Project infrastructure, including CSG production wells and production facilities (including water treatment and power generation facilities where applicable), would be located throughout the project development area but not in towns. Facilities supporting the petroleum development activities, such as depots, stores and offices, may be located in, or adjacent to, towns.

Preliminary constraints mapping has been completed and was provided in the EIS and updated versions were included in the SREIS. The project development area was analysed using a number of criteria to determine a range of land classes from 'low constraint' to 'no go'. The classes represent increasing restrictions on the siting of various project components as well as increasing management requirements associated with operating in the areas of higher constraints. All towns, as well as several areas of high ecological value, were determined to be 'no go' areas. The townships of Brigalow, Cecil Plains, Chinchilla, Columboola, Dalby, Macalister, Millmerran and Warra were excluded from the project development area.

Arrow has identified four properties within which it proposes to locate central gas processing facilities (CGPF)—two of these would have water treatment facilities located adjacent to them (see Figure 1**Error! Reference source not found.**). A property within which Arrow proposes to locate a temporary workers accommodation facility (TWAF) has also been identified. The exact locations of infrastructure within the four identified CGPF sites and one TWAF site has not been determined. The final siting of infrastructure and the specific orientation and layout of each facility would depend on site-specific land and environmental features, such as remnant vegetation, topography, soil and the proximity of sensitive receptors.

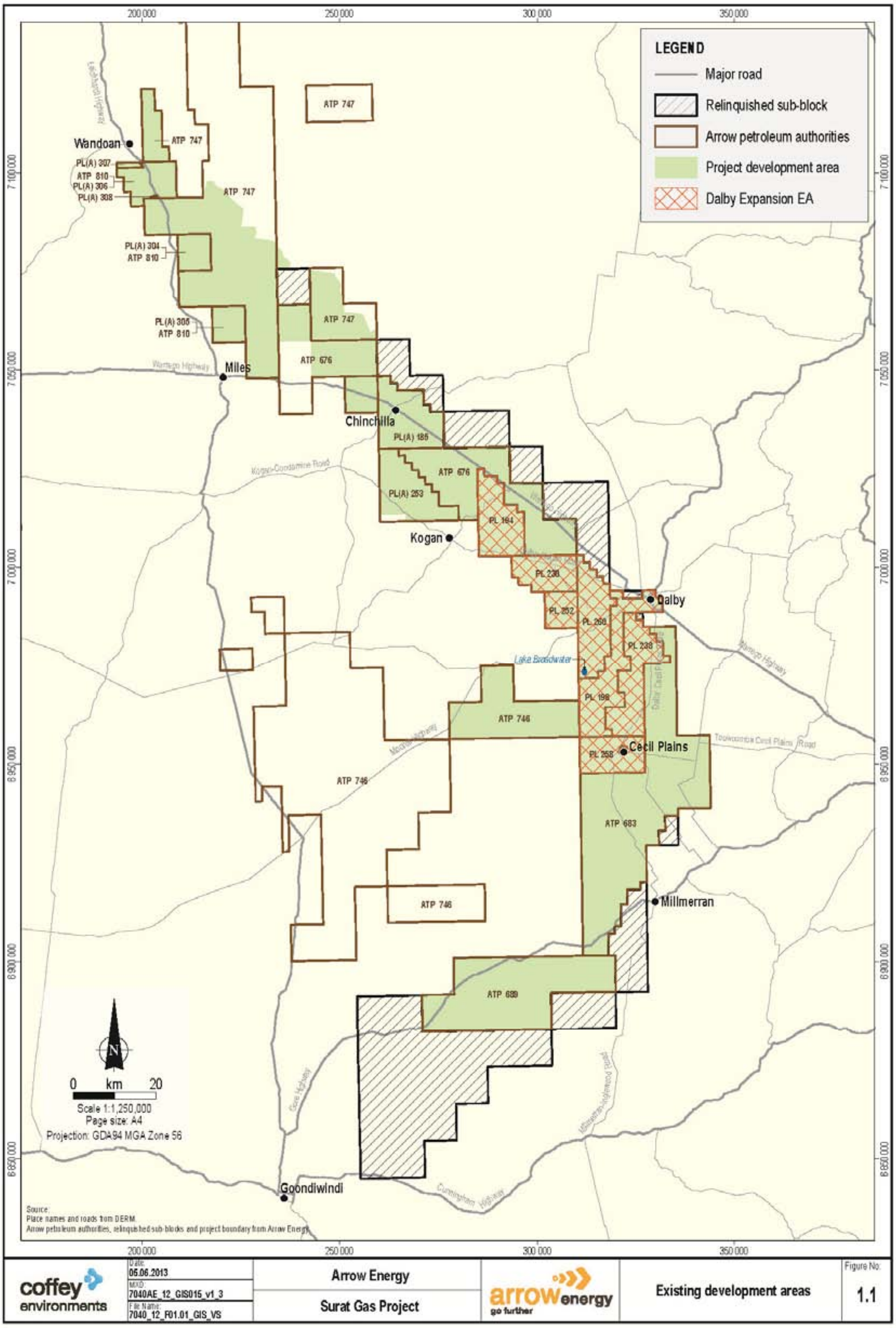

Figure 1 Project development and existing development areas (source: SREIS, Figure 1.1)

2.6.2 Tenements and tenures

The EIS documents describe the proposed project as including: all or part of petroleum leases 194, 198, 230, 238, 252, 258, 260; petroleum lease applications 185, 253, 304, 305, 306, 307, 308; authority to prospect 676, 683, 689, 810 and part of 747; and parts of authority to prospect application 746.

Arrow relinquished some parcels of land within exploration tenements that had been included in the project development area defined in the EIS. This significantly reduced the size of the proposed development area from approximately 8,600km^2 to approximately 6,100km^2 (Figure 1).
Areas relinquished comprised parts of authority to prospect 689, 683, 676, 683 and petroleum leases 198, 238 and 260.

2.6.3 Resource base, reserve life and extraction sequencing

The gas resources for the project lie within the coal seams of the Walloon Coal Measures of the Surat Basin. The Walloon Coal Measures are characterised by carbonaceous mudstone, siltstone, minor sandstone and coal and include the Juandah Coal Measures, Tangalooma Sandstone, Taroom Coal Measures and Durabilla Formation. Of these four formations, the Juandah and the Taroom coal measures, which generally range in depth from 150–750m below ground surface across the project development area, are targeted by Arrow for exploration and production.

Coal seam gas refers to the methane gas lining the open fractures between the coal and the inside of pores within the coal. Coal seams store both gas and water. The water, which is under pressure from the weight of overlying material, holds the gas in place. When the water pressure is reduced by pumping from a well drilled into a coal seam, the gas is released and flows to the surface. Gas and water are separated below ground in the well, with water being transferred to centralised collection and treatment points and the gas being piped to production facilities where it is dried, compressed and piped to market.

The EIS documents propose five development regions for the project: Wandoan, Chinchilla, Dalby, Millmerran/Kogan and Goondiwindi. Each development region would contain a number of gas fields and each gas field would contain a number of wells and facilities. The SREIS presented a revised development plan based on 11 (gas) drainage areas, each with varying numbers of wells. Eight of these drainage areas (drainage areas 1, 2, 5, 7, 8, 9, 10 and 11) are expected to be initially developed with the development of the remaining three drainage areas possible. The revised development plan reduces the proposed number of CGPF from twelve to eight and production wells from approximately 7,500 to 6,500. The number of water treatment facilities is also reduced from six to two and would be co-located with the CGPF in drainage area 2 and drainage area 9. The revised development plan proposes to use of multi-well pads in addition to single-well pads (as described in the EIS). Up to six field compression facilities (FCF) may also be required to boost gas pressure between production wells and CGPF.

The EIS indicated a 35 year life span for the project, with production increasing from 2014 to 2019, reaching a sustained production rate of 1,050TJ/day in 2019—970TJ/day to be exported and 80TJ/day to be used for domestic consumption. The SREIS revised the production rate in the EIS to a sustained production rate of 1,215TJ/day, of which 1,135TJ/day would be exported and 80TJ/day would be used for domestic consumption. Gas production is predicted to decline after approximately 20 years.

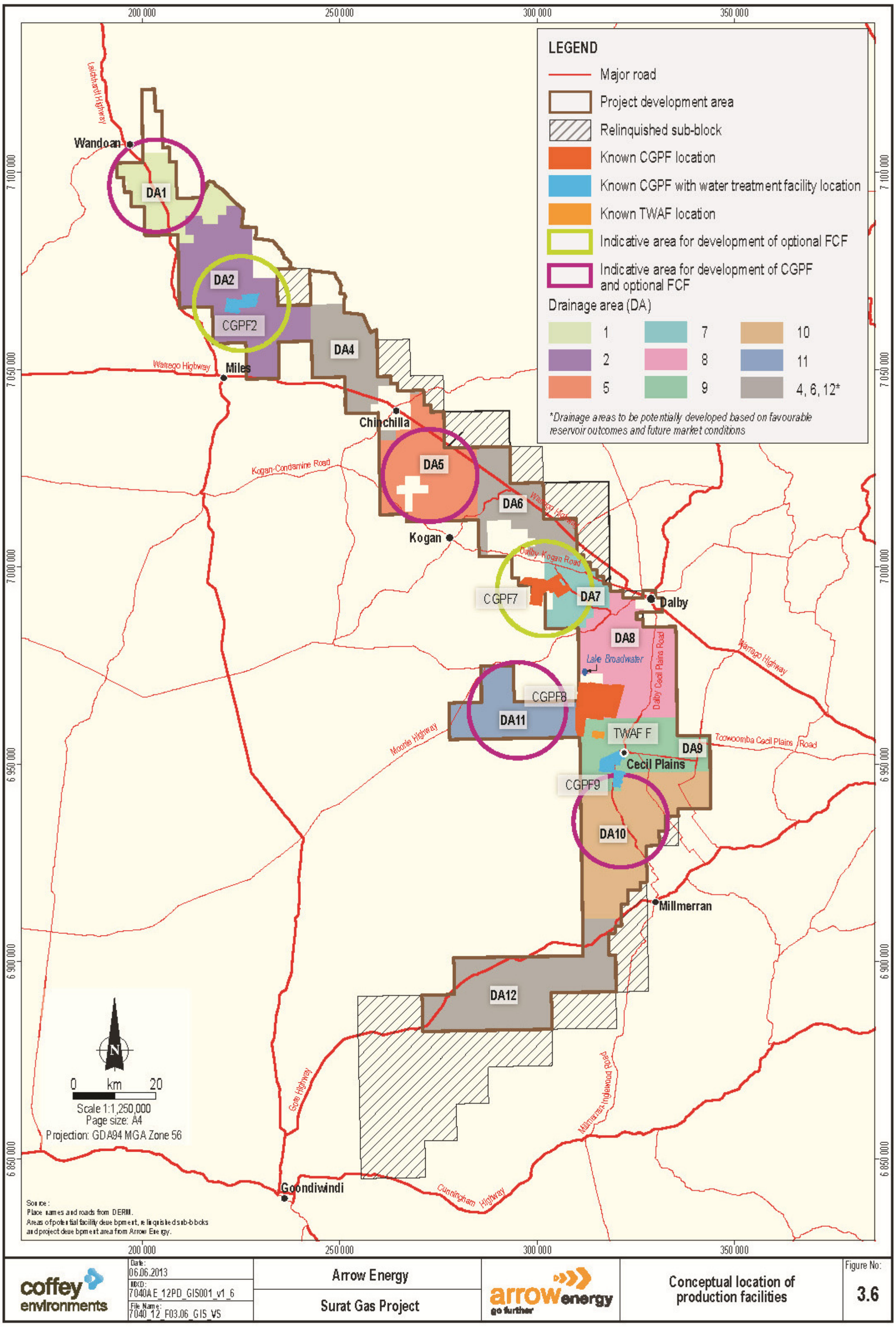

Figure 2 Conceptual location of production facilities (source: Figure 3.6, SREIS)

2.6.4 Exploration

Arrow has conducted significant exploration across the project development area under existing approvals. They intend to continue the exploration program, particularly in the north-west and south of the project development area, to prove gas reserves as needed and to reduce geological uncertainties surrounding coal seam extent, gas content and permeability.

A three-phased approach is generally employed for exploration drilling:

- **Phase 1 stratigraphic holes** to test for the presence, depth and lateral extent of coal.
- **Phase 2 core holes** to determine the permeability and gas composition of coal seams.
- **Phase 3 pilot wells** involving the installation of five to six wells spaced up to 200m apart on a diamond-shaped layout to assess the production potential of the gas reserve typically over a period of 6 to 24 months, with pilot well testing spaced at approximately 10 to 20km intervals.

Exploration drilling results influence the sequence of field development and inform the regional development plans.

2.6.5 Gas field and facility development

The main infrastructure components of the project are:

- production wells
- gas and water gathering systems
- gas processing facilities
- water treatment and storage facilities
- electricity generation facilities and or electricity distribution infrastructure
- high pressure gas pipelines
- supporting infrastructure and logistics
- groundwater monitoring bores.

2.6.5.1 Production wells

Gas production wells are proposed to be drilled from both single-well pads (as described in the EIS) and multi-well pads (as described in the SREIS). The single-well pads would typically be vertical production wells, while the multi-well pads would comprise vertical and deviated production wells (up to 12 wells per pad). A single well site may disturb an area of approximately 100m x 100m, while a multi-well pad containing up to 12 wells may disturb an area of approximately 200m x 100m.

Gas production wells would generally be 300–750m deep (depending on the depth of the coal seams) with an average spacing of 800m. The spacing and layout of wells may vary to address land use, environmental and economic constraints, and where coal depth and permeability allow for use of alternative drilling technology such as deviated well technology and multi-well pads. Surface facilities associated with a production well include a water pump, gas-water separation equipment, and electricity supply (overhead line, underground cable or gas fired generators). The period of use of a gas production well would vary with the density of wells, the gas extraction rate and the production performance of the well, and is estimated to average 15 to 20 years.

Arrow committed to enforcing a no hydraulic fracturing (fraccing) policy in the project development area.

Arrow does not propose to define the actual location of production wells and associated infrastructure until after agreements have been reached with affected landholders. Under current approval and tenure arrangements, this would occur after the environmental authority (EA) and petroleum lease (PL) are issued. The final selection of electricity supply to the well heads would influence the nature and extent of impacts.

2.6.5.2 Groundwater monitoring bores

The Underground Water Impact Report for the Surat Cumulative Management Area prepared by the Office of Groundwater Impact Assessment (formerly the Queensland Water Commission) requires Arrow to monitor and report groundwater levels in the project development area. Arrow proposes to design and implement groundwater monitoring programs in accordance with the Office of Groundwater Impact Assessment requirements and conditions of environmental authorities.

2.6.5.3 Gas and water gathering systems

CSG and water would be produced at low pressures (approximately 100kPa) and piped separately to production facilities through buried low-pressure, high-density polyethylene pipelines (100–630mm diameter). Gas transport between production facilities would be through buried medium-pressure, plastic-composite, glass-reinforced epoxy, or steel pipelines. Water pumping stations are proposed to be installed in low-lying areas.

The cleared and formed right-of-way for gathering pipelines would be up to 20m wide with pipes buried to a minimum of 750mm and deeper where needed for particular land uses.

2.6.5.4 Gas processing facilities

Gas collected in the gathering systems would be transported to one of eight proposed CGPF. The facilities would remove any bulk water remaining in the gas, compress and dehydrate gas for delivery to the sales gas pipeline, and in the event of plant upset conditions or control failure, flare or vent the gas. FCF may be located between the production wells and the CGPF. CGPF are estimated to require 10ha of land, and FCF may disturb an area of approximately 100m by 50m. Arrow proposes to refine production facility configurations and equipment prior to and during front-end engineering design.

The SREIS identifies properties within drainage areas DA2, DA7, DA8 and DA9 on which Arrow proposes to locate four CGPF. The specific locations of each CGPF are not defined in the SREIS. The exact location is to be determined after consideration of a range of technical, environmental and social features, including ground stability, elevation, remnant vegetation, topography, and proximity of sensitive receptors. The remaining four CGPF would be located in drainage areas DA1, DA5, DA10 and DA11.

2.6.5.5 Water treatment and beneficial use network

CSG production typically requires the extraction of large quantities of groundwater to depressurise coal seams and allow gas to flow. Arrow indicates that six months of dewatering is typically required to allow gas flow from a particular well and 18 months of dewatering is required to reach peak gas production (although it could take several years depending on the characteristics of the coal seam). Water quality from the Walloon Coal Measures can vary considerably but is typically relatively high in salinity and other dissolved solids and requires management and treatment consistent with Queensland's Coal Seam Gas Water Management Policy (EHP, 2010a).

Average CSG water production is estimated at 13GL/a, with peak production estimated at 34GL/a. This is a reduction to the estimates reported in the EIS (average 22GL/a and peak 43GL/a respectively). The estimate of total water production for the project decreased from 694GL over 35 years in the EIS, to 510GL over 40 years in the SREIS. This was due to relinquishments of tenures and subsequent reduction in the number of wells.
The model used to estimate CSG water production and predict impacts on aquifers differed between the EIS and SREIS—the EIS used an Arrow generated model while the SREIS used the Office of Groundwater Impact Assessment model for the Surat Cumulative Management Area.

The EIS proposed six integrated gas and water processing facilities at conceptual locations. In the SREIS the number of water treatment facilities was reduced to two as a result of revised project planning. A northern facility co-located with CGPF2, is proposed north of Miles, to treat approximately 35ML/d, and a southern facility co-located with CGPF9 is proposed near Cecil Plains to treat approximately 90ML/d. A water treatment facility could require up to 202ha of land due to the large water and brine storage dams required. Infrastructure proposed for the treatment and storage of CSG water includes feedwater and treated water storage dams, reverse osmosis water treatment plant, and brine storage dams. A distribution network for beneficial use of treated water, and brine treatment facilities, may also be developed.

Project water management would require raw (untreated) water dams with a storage capacity of approximately 450ML to 1,050ML and treated water dams with a capacity of approximately 900ML to 4,200ML. In addition, brine dams with an overall capacity of approximately 90ML to 2,880ML would be needed.

The EIS documents state that beneficial use of treated CSG water and brine is the preferred management option.

2.6.5.6 High-pressure gas pipelines

High-pressure gas pipelines (10,200kPa) would transport gas from the outlet of CGPF to the main Arrow Surat Pipeline, Surat Header Pipeline or Daandine gas hub. These steel pipelines would be buried but the actual locations of pipeline routes were not defined by the EIS documents.

The right of way required for high-pressure gas pipeline construction is stated to be 25 to 30 m wide, except where underboring was used to reduce impacts. The trench depth would vary depending on the land use but would usually be between 750mm and 1,500mm.

2.6.6 Electricity supply

The EIS outlined options for electrical power generation facilities at production wells and processing facilities, and for connection to existing electricity supply networks. The SREIS stated that electric power sourced from the existing electricity grid is now Arrow's preferred power supply option, although onsite power generation may be temporarily required in the initial phase of operation until processing facilities, production wells and associated infrastructure are connected to the electricity transmission grid.

Arrow proposes power grid connection through high voltage (132kV or 275kV) overhead transmission lines connecting to Arrow substations located near CGPF. Distribution to facilities and wells would be through overhead and underground lines. Underground cables to gas wells would be laid in the same trench or easement as the gas and water gathering systems. The depth of the cable from the ground surface would vary depending on land use, landholders' requirements and other subsurface features, but would typically be 1.2m. Wells may also be supplied with electricity directly from the grid. Emergency diesel engine generators would be required at each CGPF to maintain power supply in the event of a trip or fault on the electricity grid.

Arrow substations would require an area 330m by 280m for a 132kV substation or 500m by 500m for a 275/132kV substation.

2.6.7 Telecommunications

Telecommunication systems would include a range of fixed and mobile devices supported by high speed fibre optic networks and secure wireless systems. Fibre optic cables would be co-located with the low and medium pressure gas pipelines.

A number of submissions raised concerns with potential interference or overloading of existing telecommunications by project activities and use of these systems by the project. Arrow stated in response to these submissions that the capability of existing telecommunications networks would be assessed and Arrow would work with telecommunications providers to make appropriate infrastructure available for the project, without disrupting existing services. Arrow also proposes to consult with relevant providers/agencies prior to defining the location of infrastructure to ensure adequate buffer distances to sensitive locations and equipment. Some submissions also sought a commitment by Arrow to upgrade existing telecommunication infrastructure and this was addressed generally in commitments to mitigate social impacts (see section 4.17).

2.6.8 Supporting infrastructure and logistics

Where existing supporting infrastructure needed for the project is not in place, Arrow proposes to construct additional infrastructure such as depots, borrow pits, accommodation facilities, telecommunications facilities and potable water supplies. The EIS stated that the depots would accommodate administration, engineering and production, supervisory support, occupational health and safety management, stores, workshops, laboratories and associated personnel, and may be located in Dalby, Miles, and Millmerran. The SREIS reported that the proposed depot at Millmerran is not expected to be required.

2.6.9 Construction

2.6.9.1 Conceptual development sequence

The EIS presented an indicative development sequence over 35 years based on five development regions each having a number of gas fields. The SREIS presents a revised development plan based on 11 drainage areas each with a CGPF, possible field compression facility (FCF), and varying numbers of wells (see Table 1).

Table 1. Indicative development sequence for production facilities (source: Table 3.4, SREIS).

<table>
<tr><th rowspan="2">Year</th><th colspan="8">Production facility construction</th></tr>
<tr><th>DA9</th><th>DA2</th><th>DA8</th><th>DA1</th><th>DA7</th><th>DA5</th><th>DA10</th><th>DA11</th></tr>
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Construction activities for the project are proposed to occur over the expected 40 year project life at a rate that maintains constant gas production. Production wells would be installed progressively throughout the project life starting in 2014.

Construction of wells, gathering pipelines, gas processing facilities, water treatment facilities, and high pressure pipelines would involve a similar sequence of planning, construction and rehabilitation, including:

- survey, geotechnical investigations, consultation, and planning to determine most appropriate location based on technical, environmental, social and landowner constraints
- clearing and earthworks to specified and agreed requirements, including topsoil and erosion management
- construction and testing or commissioning
- progressive rehabilitation and waste removal.

The EIS outlined the proposed method of construction, equipment and chemicals used, and likely disturbance areas for construction and operation. The SREIS presented revised estimates for the quantity of aggregate required for all construction over the life of the project with a total requirement of up to 2,329,133m^3. The proposed source/s of aggregate is not specified in the EIS documents.

2.6.10 Operation and maintenance

2.6.10.1 Production wells

Production wells are proposed to be remotely operated and monitored and subject to regular inspection and maintenance. Well work-overs, involving cleaning the production zone, maintaining or replacing the pump, and possibly replacing the well tubing and rods, are estimated to be required at least every three years to ensure continued flow of gas and/or water from the coal seam. A work-over drilling rig would be required for well maintenance.

2.6.10.2 Gas and water gathering pipelines

Gas and water gathering pipeline flow rate would be remotely monitored and the right of way and surface equipment subject to regular inspection and maintenance. Any water collected in low points of the pipelines would be removed by inserting a plug (pig) in one end of the pipeline and allowing the pressure of the gas in the pipeline to push it along the pipe until it reaches a receiving station.

2.6.10.3 Production facilities

CGPF and FCF would be fully automated and operate 24 hours a day, seven days a week. The EIS indicated that the production facilities would be managed from a control centre at each CGPF. The SREIS presented a revised approach based on remote surveillance monitoring and control for all critical process and condition parameters from a Brisbane Central Control Room with staff only visiting facilities as required after an initial transition period.

2.6.11 Coal seam gas water and brine management

A CSG water management strategy for associated water produced as a by-product of extracting CSG was provided in the EIS. The strategy covered regulatory requirements, the source of associated water and a general description of the quality of associated water. Aggregation dams, treated water dams, waste water dams and brine dams would be required. Reverse Osmosis (RO) plants would be used to treat associated water. The gathering and distribution network would include water gathering lines, transfer pipelines and distribution pipelines. CSG water management options were described including substitution of allocations, injection, disposal to watercourses, and ocean outfall. Arrow's preference was to use substitution of allocations as the primary management method. Similarly, a range of brine management options, based on an average salt generation rate of 4.5t per mega litre of CSG water, were described including selective salt precipitation, brine injections, ocean outfall and suitably licensed landfill. Groundwater management was also described in general terms.

The EIS provided a Coal Seam Gas Water Management Strategy which presented a range of options for disposal and beneficial use of CSG water. The SREIS presented revised management options for CSG water, partly in response to the release of a revised Coal Seam Gas Water Management Policy by EHP in December 2012, including:

- distribution to existing or new users for beneficial use, including via watercourses forming part of managed schemes
- injection into a suitable aquifer
- disposal to watercourses and/or the ocean under defined conditions.

The revised Coal Seam Gas Water and Salt Management Strategy endorsed beneficial use as the preferred management option with a range of methods for distributing the water including using pipelines, watercourses, and injection into suitable aquifers. A brief appraisal of each of these was provided. Brine and salt management options including selective salt recovery at a joint-industry facility, selective salt recovery at an Arrow-only facility, injection into a suitable geologic formation, discharge to the ocean and disposal to landfill. Of these, beneficial use (selective salt recovery) is preferred by Arrow with disposal to landfill a base case (but not to the regulated waste facility at Swanbank as described in the EIS). Arrow considers that suitably licensed landfill sites, other than the waste facility at Swanbank, would be developed in response to the increased demand created by the broader CSG industry, for facilities that accept brine. A hypothetical site for this facility was used in the road transport impacts modelling (a key concern with the Swanbank option) used in the SREIS.

Strategies for the management of associated water must take account of the cumulative impacts of the production, storage and use of associated water that would be produced by all CSG activities within each field (including adjacent tenements) so that the associated water can be managed in an environmentally sustainable manner.

Details should be provided on the proposed monitoring of storages used for raw water or saline waste products.

2.6.12 Workforce and accommodation

The EIS provided an estimate of workforce requirements over the life of the project with an estimated peak construction workforce of approximately 710 personnel in 2016 and approximately 400 personnel for ongoing operations. The SREIS presented a revised workforce estimate reflecting changes to the proposed development sequence and staffing of gas processing facilities. The construction workforce is projected to peak at approximately 2,300 workers in 2017 (an increase of 1,590) and the operating workforce expected to peak at 400 (a decrease of 60).

Arrow does not propose to establish fly-in fly-out operations for personnel. The EIS documents state that housing the majority of the construction workforce in TWAF is the preferred option. Small mobile camps may also be required for drilling activities. Arrow proposes to use permanent housing for operations staff.

The EIS proposed five TWAFs, each accommodating between 200 and 350 personnel, co-located with an integrated gas and water processing facility. The SREIS presented a revised proposal of six TWAFs, each accommodating between 450 and 1,050 personnel, located within the same property as the nearest CGPF. One property location is identified in the SREIS for a TWAF (TWAF-F).

2.6.13 Water supply and storage

The EIS stated that potable water (approximately 7ML per annum for construction and 12ML per annum for operational activities) would be sourced from existing town water supplies, groundwater bores or treated CSG water depending on the location of the activities and production facilities. Concerns were raised in submissions on the EIS that existing urban water supplies may not be adequate to supply water for the project and that treated CSG water should be considered for augmentation of town water supplies.

The SREIS provides an estimate of the volumes of water required for construction and states that Arrow does not plan to source water from town water supply networks. Approximately 450ML of water would be required in the first few years of construction, with the volume of water reducing after the CGPF and water treatment facilities have been constructed. A range of potential sources of construction water are identified, including:

- treated and untreated water from gas processing facilities
- watercourses
- bores
- farm dams
- licensed water service providers.

2.6.14 Transport

Arrow proposes to use road transport rather than rail for project materials and does not intend to establish fly-in fly-out operations for personnel. Project related materials that require freight by sea would be shipped as general freight and not require special cargo ships. The EIS provided estimates of traffic generated by the project.

Traffic modelling was conducted for the SREIS to revise the predicted project traffic generation based on new data, submissions on the EIS, and project changes including reduction of the area included in the project, revised project components, layout and development sequencing, and revised staffing arrangements. As the exact locations for gas field infrastructure is not defined, and development sequencing may change over time, the road traffic assessment relied on predictions of potential increased road traffic (i.e. at least 5% above existing (2011) annual average daily traffic (AADT)) based on the revised project concept as a basis for case studies to demonstrate the effectiveness of proposed management measures.

2.6.15 Waste

Wastes generated during construction would include:

- solid wastes—general trash, scrap metal, cleared vegetation, cut and fill material, empty drums and containers, timber, drill cuttings, plastic pipe, steel pipe offcuts, filter cartridges, batteries, concrete, cardboard and other packaging materials, pallets, soil contaminated with chemicals/oils, oily rags and sorbents, x-ray film, sandblast grit, electrical cable and tyres
- liquid wastes—drill fluids, residual drilling mud, CSG water, hydrostatic-test water, filters and filter media, used lubricating oil and filters, acids and caustics, glycol, paints and paint wastes, unused or spent chemicals/oils/solvents, grey water, stormwater, sewage from amenity blocks, radioactive wastes from integrity testing, pesticides and herbicides
- gaseous waste—CSG, flare emissions, and engine emissions.

Wastes generated during operation and maintenance would include:

- solid wastes—filter cartridges, activated carbon, membrane modules, batteries, general trash, scrap metal, empty drums and containers, sandblast grit, cardboard and other packaging materials, wood pallets, oily rags and sorbents, electric cable, spent filter media bulk bags and tyres
- liquid wastes—workover drilling fluids, cleaning acids, domestic cleaners, fuel, greases, lube oils, glycol, paint waste, water treatment chemicals, sewage from amenity blocks, triethylene glycol, brine, CSG water, stormwater, pigging waste, pesticides and herbicides
- gaseous waste—CSG, engine emissions and flare emissions.

Sewage generated at production facilities would be transported off-site to a municipal treatment facility or treated onsite with sludge disposed off-site at a regulated waste facility.

2.6.16 Decommissioning and rehabilitation

The project infrastructure has a design life ranging between 15 and 35 years and decommissioning and rehabilitation would occur progressively throughout this period. Final decommissioning and rehabilitation would occur at the end of individual infrastructure life in accordance with relevant approvals and regulatory requirements.

The EIS states that detailed objectives, criteria and performance indicators for decommissioning and rehabilitation would be developed in consultation with the regulatory agency and landholders with the goal of ensuring the project development area is left safe for humans and wildlife, non-polluting, stable (landforms), and able to sustain a useful land use.

2.6.16.1 Production wells

Rehabilitation after installation of wells would result in a construction footprint of 100m by 100m and an operational footprint area of approximately 10m by 10m per well for single pad wells. Multiple well pads would require up to 100m by 200m for construction and an operational area of up to 10m by 20m. The wells would be decommissioned at the end of their production life (approximately 15 to 20 years) in accordance with requirements of the Petroleum and *Gas (Production and Safety) Act 2004* (P&G Act). Well casing and the gathering line connections would be cut off below ground surface and the well plugged with concrete to isolate formations and prevent gas leakage to the surface. Well sites are proposed to be rehabilitated to a standard consistent with the surrounding land use, or as agreed with the landholder.

2.6.16.2 Gas and water gathering systems

Gathering lines would be left in the ground but isolated, purged of gas and filled with an inert gas or water. Where necessary, the pipe would be filled with a stabilising material such as concrete to prevent subsidence under roads, utilities or railway lines.

2.6.16.3 Production facilities, water treatment and storage facilities and power generation facilities

These facilities may be decommissioned and rehabilitated progressively or at the end of life (approximately 30 years). Any potentially contaminated soil would be remediated or removed to an appropriate treatment or disposal facility. Sites would be rehabilitated to a standard consistent with the surrounding land use, or as agreed with the landholder. Any infrastructure, such as roads, tracks or dams, left on site would be subject to an agreement with the landholder and acceptance by the relevant regulatory agency.

The EIS states that any brine residue would be removed as waste and disposed of at an appropriately licensed facility. An updated strategy for management of brine residue that includes selective salt recovery is described in the SREIS.

2.6.16.4 High-pressure gas pipelines

High-pressure gas pipelines would be either suspended for future use or decommissioned in accordance with Australian Standard AS 2885: Pipelines-Gas and liquid petroleum. Suspending a pipeline would involve filling it with inert gas (e.g. nitrogen) or water containing corrosion-inhibiting chemicals and capping the ends. Decommissioning of high-pressure pipelines would be consistent with the gas gathering pipelines methods.

2.6.16.5 Supporting infrastructure

Accommodation camps would be removed and the sites rehabilitated to a standard consistent with the surrounding land use, or as agreed with the landholder and the relevant regulatory agency.

2.7 Location of project infrastructure

Arrow has yet to determine the exact locations of production wells, gas processing facilities, water treatment facilities, temporary workers accommodation, and other project infrastructure. The EIS presented conceptual designs and potential areas for development for the purposes of identifying, describing and assessing the likely impacts. The SREIS presented a significantly revised development area and conceptual design, including the properties on which each of five CGPF (of a potential eight CGPF), two water treatment facilities, and one TWAF (of a potential six TWAFs) are proposed to be located. Uncertainty about the exact location of wells, pipelines, production facilities and other infrastructure remains a limitation of the SREIS.

The EIS outlined the following key factors as influencing the location of project components:

- ongoing exploratory drilling and pilot well programs to define viable gas reserves
- consultation with landholders
- environmental and social impact management
- economic and commercial risks that influence the extent and rate of field development
- ongoing refinement of the field development plan over the life of the project
- development of new technologies, standards and practices.

Specific locations for project infrastructure would be defined as engineering studies progress.

The EIS presented a planning and management process based on technical studies and defined constraints (referred to as an 'environmental framework') to inform site selection of project components and to manage the potential impacts of project development.

3 The EIS process

3.1 Legislative basis for the EIS

On 1 February 2010 Arrow applied for approval to prepare a voluntary EIS for the project under Chapter 3 of the EP Act and the former DERM (now EHP) granted approval on 5 February 2010.

On 27 January 2010 the project was referred (EPBC 2010/5344) to the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities (hereafter referred to as the Commonwealth Environment Minister) for a determination as to whether the project would constitute a 'controlled action' with respect to potential impacts on MNES under sections 75 and 87 of the EPBC Act.

The EPBC Act establishes an Australian Government process for assessing environmental impacts and approving proposed actions that are likely to have a significant impact on MNES or on Commonwealth land.

On 26 March 2010, the delegate of the Commonwealth Environment Minister determined the project to be a 'controlled action' pursuant to section 75 of the EPBC Act. The relevant controlling provisions for the project were determined as:

- sections 18 and 18A (listed threatened species and communities)
- sections 20 and 20A (listed migratory species).

Coal seam gas and large coal mining developments with the potential to have a 'significant impact' on water resources now require referral to, and possibly approval from, the Commonwealth Environment Minister under the EPBC Act. Under the transitional arrangements for commencement of the amendments to the EPBC Act, the project was assessed as to whether the new water trigger would apply. On 24 September 2013, the Commonwealth Minister for the Environment made a proposed decision that the water trigger applied to the project. On 17 October 2013 the Commonwealth Environment Minister made a final decision that the water trigger applied to the project. Section 5, MNES of this assessment report does not include an assessment of impacts on water resources.

3.1.1 Independent Expert Scientific Committee

The Australian Government established an Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) in late 2012 through amendment to the EPBC Act. The IESC provides advice to the Commonwealth Environment Minister on research priorities to improve the understanding of potential impacts of CSG and large mining developments on water resources. The committee can be requested by federal, state and territory governments to provide advice on water-related aspects of environmental impact assessments for CSG and large coal mining proposals.

The Surat Gas Project EIS was referred to the IESC on 14 January 2013 by the former Australian Government Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC). The committee's advice to the department dated 20 February 2013 was published on its website in March 2013. Due to the changes in the project in the SREIS, particularly the use of the Office of Groundwater Impact Assessment (OGIA) Surat Cumulative Management Area (CMA) Groundwater Model, the SREIS was jointly referred by the Commonwealth and Queensland Governments to the IESC for review and comment on 22 July 2013. Advice from the IESC was received on 26 August 2013 and has been considered in the preparation of this assessment report.

3.2 Timeline of the EIS process

Table 2 outlines the stages, timing and actions undertaken in the EIS assessment process for the project.

Table 2 EIS process stages, timing and actions

Stage	Section of EP Act	Relevant Dates and Actions
Application for voluntary EIS under section 71 of the EP Act	71	An application for a voluntary EIS was lodged with the former DERM on 1 February 2010
Decision on application for voluntary EIS	72	Voluntary EIS process for the project was approved by the DERM on 5 Feb 2010
TOR stage		
Arrow prepared and submitted draft TOR	41	Lodged with the DERM 25 February 2010 The Former DEWHA[2] decision on controlling provisions made 26 March 2010
DERM prepared TOR Notice	42	TOR Notice was finalised and provided to Arrow on 25 March 2010
DERM published TOR Notice	43(1)	TOR Notice was published on 29 March 2010
Arrow gave TOR notice to affected and interested persons	43(3)	29 March 2010
Public review and submissions	42(3)	The period for public review and submissions on the draft TOR commenced 29 March 2010 and ended at close of business 13 May 2010. A total of 167 submissions were received.
DERM provided comments to Arrow	44	Former DERM provided all submissions to Arrow on 27 May 2010
Arrow responded to comments (period can be extended by request)	45	Arrow provided a response to comments on the draft TOR to DERM on 6 August 2010 (30 day extension granted)

[2] Now the Department of Environment (DOE)

Stage	Section of EP Act	Relevant Dates and Actions
DERM prepared and published final TOR	46	The TOR were finalised by DERM and issued to Arrow on 7 September 2010 and made available to the public on 11 September 2010
EIS preparation stage		
Arrow prepared and submitted the EIS	47	Arrow submitted the EIS to DERM on 16 December 2011
EIS submission and assessment stage		
DERM initial review and decision on whether or not the EIS could proceed	49(1) & (2)	DERM decided that the EIS could proceed on 17 February 2012. The decision period was extended to allow Arrow to make changes to the submitted EIS.
DERM prepared and gave notice of decision to Arrow	49(5)	17 February 2012
Arrow gave EIS notice to affected and interested persons	51	Posted 12 March 2012
DERM published EIS Notice	51	The EIS Notice was published on 16 March 2012. The publishing date was extended from 3 March 2012 to 16 March 2012 at the request of Arrow.
EIS public submission period	52	The period for public review and submissions on the EIS commenced 16 March 2012 and ended at close of business 14 June 2012. A total of 166 submissions were received.
Arrow provided statutory declaration of compliance with notice requirements	53	30 March 2012
EHP provided all submissions to Arrow	56(1)	EHP provided all submissions on the EIS to Arrow on 28 June 2012
Former DSEWPaC refers project to the Independent Environmental Scientific Committee (Cwth)		14 January 2013
Advice from Independent Environmental Scientific Committee (Cwth) provided and published.		Received by former DSEWPaC 20 February 2013 and published in March 2013.
Arrow responded to submissions in a supplementary report to the EIS	56(2) & (3)	The response period was extended to 31 July 2013 at the request of Arrow. Arrow provided an ‘advance copy’ of the supplementary report on 28 June 2013. The supplementary report to the EIS was lodged on 31 July 2013.
Commonwealth and Queensland referral to the Independent Environmental Scientific Committee (Cwth)		22 July 2013
Advice from the IESC		26 August 2013
EHP decided if EIS and response to submissions were adequate for the EIS process to proceed	56A(2) & (3)	29 August 2013
EHP prepared and gave decision notice to Arrow	56A(4)	12 September 2013

Stage	Section of EP Act	Relevant Dates and Actions
EHP prepared the EIS assessment report	57	25 October 2013
EHP gives EIS assessment report to proponent—completes EIS process	60	25 October 2013

3.3 Approvals

The EIS and the SREIS provide adequate information on relevant approvals, approval processes, and the relevant agencies with jurisdiction for approvals. The likely timing of applications in relation to gas field development is outlined, and important linkages between approvals discussed. A summary of key approvals follows.

3.3.1 *Petroleum and Gas (Production and Safety) Act 2004*

The project requires petroleum leases under the P&G Act before sale of gas can commence.

The project requires a petroleum pipeline licence under the P&G Act for the construction and operation of any pipelines required to transport CSG outside the area of a petroleum lease.

The project may require a petroleum survey licence to allow access to land to investigate, survey and identify a pipeline route associated with a petroleum pipeline licence.

An authority to prospect (ATP) under the P&G Act allows the holder to undertake gas exploration activities (such as geological and geophysical surveys), chemical or other analyses and environmental, engineering and design studies to evaluate the development potential of CSG. Arrow holds various ATPs and authority to prospect applications within the project development area, which the company must convert to petroleum leases in order to undertake the project.

Arrow must satisfy the minimum requirements of the Land Access Code in order to gain land access for the project. The Land Access Code requires an entry notice for ‘preliminary activities’ that cause no impact or only minor impact on landholders, a negotiated Conduct and Compensation Agreement, and a process for negotiation and resolving disputes about agreements

3.3.2 *Environmental Protection Act 1994*

The project (with the exception of the environmental authority to support a petroleum survey licence) requires a site-specific environmental authority for petroleum activities to provide for the proposed infrastructure, along with other environmentally relevant activities (ERAs) associated with the project.

An environmental authority imposes environmental management conditions on petroleum activities undertaken on a petroleum lease or petroleum pipeline licence and must be issued before a petroleum lease can be granted. The SREIS (Section 2.3.2) states that Arrow may apply to amend the Dalby Expansion Project environmental authority (PEN100449509) or apply for a new environmental authority for each stage of the development. The EIS process under the EP Act must be finalised before an environmental authority can be issued for the project.

In addition, the SREIS identified the following environmentally relevant activities (ERAs) that are currently regulated under the EP Act, which may be undertaken in the course of constructing, operating and decommissioning the project (Table 3).

Table 3 Project environmentally relevant activities (source: SREIS)

Environmentally Relevant Activities	Description	Applicable project activities
Resource activity		
A Petroleum Activity	An activity that, under the *Petroleum Act 1923* (Petroleum Act), is an authorised activity for a 1923 Act petroleum tenure under that Act; or an activity that, under the P&G Act, is an authorised activity	Activities relating to gas production.

Environmentally Relevant Activities	Description	Applicable project activities
	for a petroleum authority under that Act; or	
	Exploring for, exploiting or conveying petroleum resources under a licence, permit, pipeline licence, primary licence, secondary licence or special prospecting authority granted under the *Petroleum (Submerged Lands) Act 1982*.	
Schedule 2 - Prescribed ERAs		
ERA 8 – chemical storage	$10m^3$ or more of chemicals of class C1 or C2 combustible liquids under AS 1940 (Standards Australia, 2004a) or dangerous goods class 3.	Storage of chemicals used for CSG water treatment.
ERA 14 – electricity generation	Electricity generation (the relevant activity) consists of generating electricity by using gas at a rated capacity of 10 megawatt (MW) electrical or more.	Power generation for electricity supply to gas compression and water treatment facilities.
ERA 15 – fuel burning	Fuel burning (the relevant activity) consists of using fuel-burning equipment that is capable of burning at least 500kg of fuel in an hour.	Flaring of gas at production facilities including CGPS and FCF.
ERA 43 – concrete batching	Concrete batching (the relevant activity) consists of producing 200t or more of concrete or concrete products in a year, by mixing cement with sand, rock, aggregate or other similar materials.	Onsite concrete batch plant if established at production facility construction site.
ERA 56 - regulated waste storage	Regulated waste storage (the relevant activity) consists of operating a facility for receiving and storing regulated waste for more than 24 hours.	Storage of regulated waste (brine) at water treatment facility.
ERA 58 – regulated waste treatment	Regulated waste treatment (the relevant activity) consists of operating a facility for receiving and treating regulated waste or contaminated soil to render the waste or soil non-hazardous or less hazardous.	Operation of a brine treatment facility (the preferred option for disposal of brine).
ERA 60 – waste disposal	Operating a facility for disposing of regulated waste; more than 200,000t.	Operation of a brine treatment facility (the preferred option for disposal of brine).
ERA 63 – sewage treatment	Operating one or more sewage treatment works at a site that has a total daily peak design capacity of more than 21 equivalent persons.	Sewerage facilities at construction camp sites and/or production facility sites.

Arrow would be required to obtain either a beneficial use approval under the EP Act, or an environmental authority that specifically provides for the use of the CSG water for beneficial use(s).

3.3.3 *Water Act 2000*

A petroleum tenure holder’s right to take underground water as part of authorised activities is regulated under the P&G Act and the *Water Act 2000* (Water Act). The holder is required to ‘make good’ if the taking of water causes a landholder bore to have impaired capacity.

A development permit may be required to take or interfere with water from a watercourse, artesian water, subartesian water or overland flow.

Any disturbance (the destruction of vegetation, excavation or placing of fill) to the bed and banks of a watercourse outside a proposed petroleum authority would require a riverine protection permit as per section 266 of the Water Act.

Water licenses may be required under the Water Act to supply CSG water outside of the purposes permitted under the P&G Act.

3.3.4 Strategic Cropping Land Act 2011

The *Strategic Cropping Land Act 2011* (SCL Act) requires resource companies to apply for a compliance certificate or a protection decision for development on SCL.

The SCL Act (Qld) allows for certain resource activities that have a temporary impact on SCL or potential SCL to apply for a compliance certificate to operate under the Strategic Cropping Land: Standard Conditions Code for Resource Activities. Under section 81 of the SCL Act, this code cannot be used for a resource activity that would have a permanent impact in a protection area. In the SREIS, Arrow maintains that most of its activities on SCL would meet the requirements of the code.

3.3.5 *Nature Conservation Act 1992*

Requirements relevant to the project that applied at the time were described in the EIS. Since then, a number of changes to the *Nature Conservation Act 1992* and the Nature Conservation (Wildlife Management) Regulation 2006 have occurred in relation to approvals for resource activities.

EHP advises that the following requirements would apply to the project, particularly in relation to native fauna.

The Nature Conservation (Wildlife Management) Regulation 2006 (s332 (1)) specifies that, “A person must not, without a reasonable excuse, tamper with an animal breeding place that is being used by a protected animal to incubate or rear the animal’s offspring”. It is important to note that this includes ‘least concern’ wildlife.

However, s332(3) allows that, “It is a reasonable excuse for a person to tamper with the breeding place if—

> (a) the tampering happened in the course of a lawful activity that was not directed towards the tampering; and
>
> (b) the tampering could not have been reasonably avoided”.

In addition, s332(4) allows that, “ Also, subsection (1) does not apply to a person removing or otherwise tampering with the breeding place if—

> (a) the removal or tampering is part of an approved species management program for animals of the same species; or
>
> (b) the person holds a damage mitigation permit for the animal and the permit authorises the removal or tampering”.

An approved species management program (SMP) ensures adequate management of the animal’s population and habitat. Currently these fall into two broad categories:

- industry-generic SMPs for the majority of least concern animal species
- specific SMPs for endangered, vulnerable or near threatened (EVNT) and special least concern species.

It is important that project proponents enter into discussions with EHP to confirm their compliance with the statutory provisions.

3.3.6 Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

As a controlled project, the project requires approval by the Australian Government Minister for the Environment under the Commonwealth EPBC Act. The assessment provided in Section 5 of this assessment report would inform the Minister in making this decision.

3.3.7 Other Approvals

If a petroleum tenement is to be granted over land where native title has not been extinguished, the requirements of the *Native Title Act 1993* must be met, and agreements may need to be reached with relevant Aboriginal groups, before petroleum tenements can be granted. Arrow has lodged an Indigenous Land Use Agreement for Western Downs Unclaimed Area with the National Native Title Tribunal for registration.

3.3.7.1 *Cultural Heritage Act 2003*

A Cultural Heritage Management Plan or equivalent agreements would need to be developed and approved in accordance with the Aboriginal *Cultural Heritage Act 2003*.

3.3.7.2 *Sustainable Planning Act 2009*

Operational works approval under the *Sustainable Planning Act 2009* for waterway barrier works to carry out activities through or across watercourses may be required.

3.3.7.3 *Water Supply (Safety and Reliability) Act 2008*

Arrow would be required to operate under the requirements of the *Water Supply (Safety and Reliability) Act 2008* when providing water commercially. Under the act, water service providers must submit and maintain certain management plans including recycled water management plans.

3.3.7.4 *Forestry Act 1959*

Department of Agriculture, Fisheries and Forestry (DAFF) also advised that the location and conduct of any petroleum activities would need to conform to state, regional and local plans for the area.

3.3.7.5 *Land Protection (Pest and Stock Route) Management Act 2000*

DAFF advised that any project activities would need to comply with this Act, particularly in relation to crossing and working around pest fences. They advised that it would be useful in planning the project layout to overlay maps showing Barrier Fences (http://www.daff.qld.gov.au/plants/weeds-pest-animals-ants/pest-animals/barrier-fences) and the project site with accompanying explanations of process and possible crossings. Refer to *Land Protection (Pest and Stock Route) Management Act 2002*, section 52 for the making of fence openings, section 53 for the restoration of *Chemical Usage (Agricultural and Veterinary) Control Act 1988* and *Agricultural Chemicals Distribution Controls Act 1966.*

3.3.7.6 *Chemical Usage (Agricultural and Veterinary) Control Act 1988* and *Agricultural Chemicals Distribution Controls Act 1966*

Arrow should make certain that the project is compliant with both the *Chemical Usage (Agricultural and Veterinary) Control Act 1988* (use controls) and *Agricultural Chemicals Distribution Controls Act 1966* (licensing controls) to ensure that the use of agricultural chemicals or other industrial chemicals does not have an adverse impact on human health, trade or the environment through contamination of agricultural produce. DAFF commented that it is essential that landholders are involved in consultation on uses of herbicides (regardless of whether the operation is organic or biodynamic) to ensure that appropriate risk management actions can be implemented where stock could be exposed.

3.3.8 Planning Framework

The EIS notes that petroleum activities (activities within a Petroleum Lease (PL) or PPL) are exempt from the requirements of State Planning Policies and local planning schemes, but includes consideration of key state planning policies and local planning schemes as they relate to the project. The state planning policies listed in the EIS have now been consolidated into a single state planning policy with some changes to policy.

The following policies and plans are also listed, and their purpose outlined in the EIS:

- Draft Policy for the Queensland Murray-Darling Basin (QMDC, 2009)
- Water Resource (Condamine and Balonne Basin) Plan
- Water Resource (Fitzroy Basin) Plan
- Water Resource (Great Artesian Basin) Plan
- Water Resource (Moonie Basin) Plan.

The project development area includes three local government jurisdictions: Western Downs Regional Council, Goondiwindi Regional Council and Toowoomba Regional Council and relevant planning scheme codes are included in an appendix to the EIS. The majority of the project development area is zoned rural with some rural residential zones.

3.3.8.1 Darling Downs Regional Plan

On 18 October 2013 the Qld Government Gazette included notifications under section 64 of the *Sustainable Planning Act 2009* (SPA) of the making of the Darling Downs Regional Plan. The project is located within the area of the Darling Downs Regional Plan area and a substantial portion (over half of the project development area) lies within an area mapped as a Priority Agricultural Area in the Plan.

The EP Act requires that the standard criteria (Schedule 3 EP Act) must be considered in preparing this assessment report. This includes consideration of 'any applicable Commonwealth, state or local government plans, standards, agreements or requirements'.

In terms of the applicability of the Darling Downs Regional Plan to this assessment, DSDIP (who administer the SPA) advised that:

- *"The Darling Downs regional plan has been finalised and took effect from the date of gazettal on 18 October 2013.*
- *The plan contains policies that will influence planning and development activities under the Sustainable Planning Act 2009, including the preparation of local government planning schemes.*
- *The policies in the plan are also intended to influence decisions about resource activities. However, as regional plans are statutory instruments under SPA, the policies are not currently required to be considered in the assessment of resource activities.*
- *These policies are also informing the development of a Regional Planning and Development Bill which is intended to be introduced to the Legislative Assembly before the end of 2013 to give legislative effect to important regional interests in a range of decision making. The proposed Bill will require resource activities authorised under resources Acts to consider and align with the land use policies expressed in a new of generation regional plan.*
- *The proposed Bill will also enable the government to identify in a regulation other regional interests that resource activities need to consider and align with.*
- *Co-existence criteria are being prepared to ensure the approval of any proposed resource development cannot materially impact or threaten the ongoing viability of a priority agricultural land use identified as a regional interest through a regulation supporting the Regional Planning and Development Bill."*

Should the Regional Planning and Development Bill be passed and enacted, future decisions in relation to CSG activities proposed with this project, including applications for an environmental authority or amendment to an environmental authority under the EP Act, would have to meet the requirements of the new Act and any subordinate legislation (including, for example, any finalised co-existence criteria).

3.4 Consultation program

3.4.1 Public consultation

In addition to the statutory requirements for advertising the TOR and EIS notices, and the mailing of the notices to interested and affected parties, Arrow undertook community consultation as part of the EIS process. The EIS provided details of a series of four consultation phases with a range of stakeholders and focus groups involving a variety of consultation tools and activities, with consultation centred on major service centres within the project development area including Cecil Plains, Chinchilla, Dalby, Goondiwindi, Miles, Millmerran and Wandoan. Consultation phases prior to submission of the EIS included:

- Phase 1 from September 2009 to the end of 2009 introduced the project, identified key stakeholder and community issues or concerns and began the process of building relationships
- Phase 2 from January 2010 to June 2010 covered landholder relations, regulatory framework, technical aspects, water and salt management, social and economic concerns
- Phase 3 from July 2010 to December 2010 covered changes to project and ownership, formation of the 'Arrow Intensively Farmed Land Committee' and 'Arrow Surat Community Reference Group', water and salt management, community concerns including hazardous chemicals and fraccing, social and economic concerns
- Phase 4 from January 2011 to June 2011 covered landholder relations, regulatory framework, technical aspects, water and salt management strategy, outcomes from reference group meetings, social and economic concerns.

The SREIS reports that since the consultation report was prepared for the EIS, Arrow has continued to consult and engage with the community and relevant stakeholders. Further consultation phases to support the public review stage for the EIS and prior to submission of the SREIS included:

- Phase 5 from July to December 2011 covered the Arrow Surat Community Reference Group, the Arrow Intensively Farmed Land Committee, promotional activities, printed information materials and community information sessions
- Phase 6 from January to July 2012 covered the Arrow Surat Community Reference Group, the Arrow Intensively Farmed Land Committee, public exhibition of the EIS, promotional activities, printed information materials and community, agency and stakeholder information sessions on the EIS.
- Phase 7 from August 2012 and ongoing involved one-on-one stakeholder meetings, stakeholder meetings, drop-in sessions, community information sessions, shed meetings, Area Wide Planning meetings, bi-monthly

meetings of the Arrow Surat Community Reference Group (ASCRG) and the Arrow Intensively Farmed Land Committee (AIFLC), and the opening of the Community Information Centre in Dalby.

The SREIS reported a range of key stakeholder issues identified in consultation activities that were reflected in submissions to the EIS including:

- public engagement and input at the EIS and environmental authority stages
- safety and amenity issues
- potential impacts to cropping land and conflict with agricultural activities, especially within the Condamine Flood Plain
- CSG water and salt management, including the impacts of treated and untreated CSG water and brine disposal options
- potential impacts to groundwater and obligations on CSG producers to 'make good' on any impacts
- compensation for project activities on third-party properties and the influence of the project on property values, existing and future farm plans, and rural amenity and lifestyle
- social and economic impacts, such as employment opportunities and pressure on services.

3.4.2 Advisory bodies

The administering authority invited the following organisations to assist in the assessment of the TOR and the EIS by participating as members of the advisory body for the project. Due to the change in the structure of government, ('machinery of government'), the names and responsibilities of a number of Queensland departments changed on 3 April 2012 (refer to Appendix 1).

- Former Commonwealth Department of Sustainability, Environment, Water, Heritage and the Arts (DSEWPaC); now Commonwealth Department of the Environment (DOE)
- Former Department of Environment and Resource Management (DERM)
- Former Department of Communities (DOC)
- Former Department of Employment, Economic Development and Innovation (DEEDI); now Department of State Development, Infrastructure and Planning (DSDIP)
- Former Department of Education and Training (DET); now Department of Education, Training and Employment (DETE)
- Former Queensland Treasury (QT); now Queensland Treasury and Trade (QTT)
- Former Department of Communities, Child Safety and Disability Services (DCCSDS)
- Department of Community Safety (DCS)
- Department of Justice and Attorney-General
- Department of Energy and Water Supply (DEWS)
- Department of Housing and Public Works (DHPW)
- Department of Local Government (DLG)
- Department of Agriculture, Fisheries and Forestry (DAFF)
- Department of Natural Resources and Mines (DNRM)
- Department of Science, Information Technology, Innovation and the Arts (DSITIA)
- Department of National Parks, Recreation, Sport and Racing (NPRSR)
- Department of Aboriginal and Torres Strait Islander and Multicultural Affairs (DATSIMA)
- Department of Tourism, Major Events, Small Business and the Commonwealth Games (DTESB)
- Department of Transport and Main Roads (DTMR)
- Queensland Police Service (QPS)
- Queensland Health (QH)
- Skills Queensland
- Queensland Murray-Darling Committee (QMDC)
- Condamine Alliance
- Southern Downs Regional Council
- Western Downs Regional Council
- Toowoomba Regional Council
- Goondiwindi Regional Council.
- SunWater Limited
- Ergon Energy
- Powerlink Queensland.

3.4.3 Public notification

In accordance with the statutory requirements, public notifications of the draft TOR and EIS and public comment periods were made through notices in *The Australian, The Courier-Mail, Toowoomba Chronicle, Dalby Herald, Northern Downs News, Chinchilla News, Pittsworth Sentinel, Goondiwindi Argus, Queensland Country Life (South Edition)*, and on EHP (and former DERM) and the proponent's websites.

The draft TOR and EIS were placed on public display at the locations listed in Table 4 during their respective public comment and submission periods.

Table 4 Locations for the public display of documents

Display Location	Public Display Document
DERM's web site: www.derm.qld.gov.au	TOR
Arrow's website: www.arrowenergy.com.au	EIS
Department of Environment and Resource Management, George Street Brisbane Business Centre	TOR and EIS
Department of Environment and Resource Management, Toowoomba Business Centre	TOR and EIS
Toowoomba Regional Council, Millmerran Service Centre	TOR and EIS
Western Downs Regional Council, Dalby	TOR and EIS
Western Downs Regional Council, Chinchilla Customer Service Centre	TOR and EIS
Cecil Plains Library	EIS
Miles Library	EIS
Wandoan Visitor Information Centre	EIS
Goondiwindi Regional Council Library	TOR and EIS

Copies of the draft and final TOR were available from EHP's web site, while the EIS was available on Arrow's web site and by request throughout the submission period. Copies of the SREIS were made available upon request from Arrow.

3.5 Matters considered in the EIS assessment report

As required under section 58 of the EP Act, this assessment report considered the following matters:

- the final TOR for the EIS
- the submitted EIS
- all properly made submissions and any other submissions accepted by the chief executive
- the response to submissions and amended EIS (Supplementary Report to the EIS – referred to as the SREIS)
- the standard criteria
- another matter prescribed under a regulation.

These matters are further described in the following subsections.

3.5.1 The final TOR

The final TOR was considered when preparing this assessment report. While the TOR was written to include all the major issues associated with the project that were required to be addressed in the EIS, they were not exhaustive, nor were they to be interpreted as excluding other matters from consideration.

Where matters outside of those listed in the final TOR were addressed in the EIS, those matters have been considered when preparing this assessment report.

In deciding to allow the EIS to proceed to the preparation of an assessment report, EHP was required to consider the submitted EIS documents and determined if the information provided in this documentation adequately met the requirements of the TOR. In making this determination, EHP considered not only the information provided by Arrow, but also the scale and nature of the project, including the commitment by Arrow to use the environmental framework in determining the specific siting of the project infrastructure, details provided on the siting of major infrastructure associated with the first phase of the project development, and the general details provided on the siting, extent and timing of delivery and management of the various project components.

3.5.2 The submitted EIS

The submitted EIS was considered when preparing this report. The submitted EIS comprises:

- Surat Gas Project EIS that was made available for public review
- Supplementary Report to the Surat Gas Project EIS incorporating details of submissions received on the EIS, responses to submissions, changes to the project, and additional technical information.

In this assessment report, the term 'EIS documents' refers to the combined documents consisting of the submitted EIS, the SREIS that includes amendments made to the EIS following public submission and any other documentation provided by Arrow including attachments, appendices and other specialist reports provided by Arrow.

The term 'EIS' in this document refers to the submitted EIS document that was made available for public review, while the Supplementary Report to the EIS is referred to as the 'SREIS'.

In addition, EHP requested additional information from Arrow on the extent of impacts of the project on MNES that was required to complete the assessment of those impacts. The request and Arrow's response is provided in Appendix 2. This document was used only in the preparation of section 5 Matters of National Environmental Significance of this assessment report.

3.5.3 Properly made submissions

EHP accepted 166 submissions on the EIS, 15 from local and state government agencies, 127 from private submitters, and 24 from non-government organisations. EHP and former DSEWPaC also made submissions on the EIS.

All government agencies that made submissions stating outstanding issues arising from their review of the EIS were given the opportunity to review and provide comments on any amendments made to the EIS. This included comments on conditions that should apply to the project and on the adequacy or otherwise of the amended EIS chapters in addressing concerns raised in submissions. Letters were sent to all private submitters advising them on the submission of the SREIS together with details for obtaining Arrow's response to their submission and information on the changes to the project as a result of the submissions.

The EIS documents were referred to the IESC for advice. Although not formally a submission, the Committee's advice, provided on 20 February 2013 and 26 August 2013, to former DSEWPaC and EHP, was considered in the relevant (groundwater and surface water) sections of this assessment report.

3.5.4 The standard criteria

Section 58 of the EP Act requires that, among other matters, the standard criteria listed in schedule 3 of the EP Act must be considered when preparing the EIS assessment report.

The standard criteria under the EP Act are:

a) the principles of ecologically sustainable development as set out in the National Strategy for Ecologically Sustainable Development
b) any applicable environmental protection policy
c) any applicable Commonwealth, state or local government plans, standards, agreements or requirements
d) any applicable environmental impact study, assessment or report
e) the character, resilience and values of the receiving environment
f) all submissions made by the applicant and submitters
g) the best practice environmental management for activities under any relevant instrument, or proposed instrument, as follows—
    i. an environmental authority
    ii. a transitional environmental program
    iii. an environmental protection order
    iv. a disposal permit
    v. a development approval; and
h) the financial implications of the requirements under an instrument, or proposed instrument, mentioned in paragraph (g) as they would relate to the type of activity or industry carried out, or proposed to be carried out, under the instrument
i) the public interest
j) any applicable site management plan

k) any relevant integrated environmental management system or proposed integrated environmental management system; and
l) any other matter prescribed under a regulation.

The department has considered the standard criteria when assessing the project.

3.6 Matters of National Environmental Significance

The MNES potentially impacted by the project as listed by the controlled action decision under section 75 of the EPBC Act are listed threatened species and communities and listed migratory species.

Under recent changes to the EPBC Act, an additional Matter of National Significance, coal seam gas and large coal mining development impacts on water resources (water trigger), was added. In October 2013, the Commonwealth Environment Minister decided that the ‘water trigger’ would be a controlling provision under EPBC Act for the project.

In December 2012, the Commonwealth Government established the Independent Environmental Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the Committee) (IESC). The IESC provides scientific advice to decision makers on the impact that coal seam gas and large coal mining development may have on Australia's water resources.

The Committee was established as a statutory committee in 2012 by the Australian Government under the EPBC Act in response to community concerns about coal seam gas and coal mining. The Committee provides:

- independent, expert scientific advice on coal seam gas and large coal mining proposals as requested by federal and state government regulators
- advice to the Australian Government on bioregional assessments and research priorities and projects.

The EIS was referred to the IESC on 14 January 2013 by DSEWPaC. The committee’s advice to the department dated 26 February 2013 was published on its website in March 2013. The Supplementary Report to the project EIS was referred by both the Australian and Queensland Governments to the IESC on 22 July 2013. The IESC’s advice was received on the 23 August 2013 and has been considered in preparing this assessment report.

An assessment of impacts and the management of the relevant MNES to the project are contained in Section 5 of this assessment report.

4 Adequacy of the EIS

This section of the assessment report discusses in more detail the adequacy of the EIS submitted by Arrow, taking into account key matters. Where relevant outstanding issues are discussed together with any environmental protection commitments made by Arrow.

Specifically, each EIS chapter is discussed in the following manner:

- a brief outline of the environmental values identified
- statement of impacts as identified in the EIS documents
- adequacy of the avoidance, minimisation and management measures proposed
- assessment on how Arrow responded to the EIS submissions and if amendments addressed the comments adequately
- summary of the adequacy of the EIS chapter, including any outstanding issues identified during the EIS assessment process
- assessment of the Arrow's environmental protection commitments in regards to each particular chapter/subject heading.

The full list of commitments made by Arrow (including changes described in the SREIS) is shown in Appendix 3.

The following sections of this assessment report provide an assessment of the matters of concern identified in the EIS documents and particularly those of significant interest raised in submissions. The level of detail of the assessment is proportional to the significance of the potential impacts of the project, particularly on environmental values. Where possible, outstanding matters that need further assessment are identified, particularly those required by Arrow to meet State and Commonwealth policy and legislative requirements.

4.1 Introduction

Chapter 1 of the EIS provided background on the proponent, an overview of the project, its objectives and scope, and an outline of the EIS process including the process for public review and submissions. The SREIS (Chapter 1) outlined changes to the footprint and staging of the project.

Chapter 2 of the EIS outlined key approvals required for the project, assessment processes, and relevant policies, guidelines, planning policies and planning schemes to be considered in assessing the project or specific applications for aspects of the project. A number of submissions, including one from the former DERM, raised concerns that the EIS did not adequately define the specific locations of project infrastructure and the implications of this uncertainty on compliance with the TOR, specific approval requirements, availability of relevant information to the public and regulators prior to issue of approvals, and compliance with specific legislative requirements including the 'standard criteria' under the EP Act. Arrow responded to these concerns by referring to the proposed framework approach (EIS Chapter 8, Framework Approach) to inform the siting of infrastructure and stating that development may occur on any parcel of land within the project development area, except urban areas, 'no go' areas, and areas subject to other environmental constraints. This issue is discussed further under section 4.3 of this assessment report.

The SREIS provides an updated overview of the assessment and approval requirements and processes, having regard to significant changes in the project description and development staging, and to changes in relevant State and Commonwealth legislation, including the proposed new water resources MNES trigger under the EPBC Act. The SREIS also provided a more comprehensive overview of the requirements of the SCL Act.

Chapter 6 of the EIS outlined the consultation carried out, including the targeted audience, locations, methodology, content and the concerns raised and discussed. Chapter 4 of the SREIS provides information on further consultation phases before and after the public review stage for the EIS, including proposed ongoing consultation. A large number of submissions raised a variety concerns about the adequacy of consultation and community engagement, including, but not limited to:

- the capacity of potentially affected stakeholders to review the EIS due to the size and technical nature of the documents and the short time frame available for review (60 business days)
- the lack of clarity on likely locations of infrastructure and therefore relevance of the project to individuals, coupled with the difficulty individuals have in making time available for consultation and review
- the lack of progress in resolving landholder issues, especially for properties on the Condamine River floodplain.

In response, Arrow provided further detail on consultation with individuals and organisations, including support provided to review the EIS and to make submissions. Arrow highlighted continuing processes of engagement with stakeholders through a range of forums including the Arrow Intensively Farmed Land Committee, Arrow Surat Community Reference Group, Gas Fields Commission Queensland, irrigator groups, community information sessions, individuals and interested groups.

Arrow noted in the response to submissions that most landholders would be particularly concerned with the location of infrastructure and impacts to their properties, acknowledging that the location of infrastructure was unknown and would only become known progressively through the life of the project. The response by Arrow referred to the commitment that project personnel would only access land in accordance with the Land Access Code under Section 24A of the P&G Act and Arrow’s land access rules and protocols (C365). A further response was made that consideration for interference to farming activities through placement of project infrastructure would form part of any discussions for developing a conduct and compensation agreement with landholders. Although the P&G Act and the Land Access Code provide for a conduct and compensation agreement, this is not a mandatory requirement and Arrow has not stated a commitment to developing such agreements, only to consultation and agreement with landholders on the appropriate location for infrastructure and access routes (C084).

4.2 Project need and alternatives

Chapter 3 of the EIS provided an overview of the justification for the project, based on availability of gas resources within tenures held by Arrow and projected Australian and global demand for gas. It presented supporting information on gas resources, demand for energy and gas, and the influence of greenhouse gas reduction measures on demand for gas. The EIS asserted that the project would benefit Queensland and Australia through:

- long-term royalty contributions to the state economy
- potential to increase the use of gas in Queensland electricity generation
- direct benefits to local and regional employment and small business
- development of a highly skilled workforce
- contribution to diversification of the regional, state and national economies.

The EIS further stated that, should LNG export not proceed, Arrow's gas field developments in the Surat Basin would progress but on a smaller scale, at a slower rate, and with a reduced level of investment and economic output.

The EIS outlined a range of options for gas field infrastructure, and for the design and location of specific infrastructure. Final selection would be based on further planning, technology development, engineering and economic considerations, and environmental (land, water, biodiversity, air) and social constraints. Consultation with landholders would inform the location of gas wells and associated infrastructure to limit impacts on current land uses. The SREIS presented significant changes to the proposed project which would reduce some impacts and increase others. A more detailed outline of project infrastructure and location is provided in section 2.6 (Project description) of this assessment report.

The EIS presented a planning and management approach, referred to as the Environmental Framework Approach, used by Arrow to manage the impacts of CSG development (site selection, construction and operation) where the location of infrastructure becomes progressively known over the life of the project. The framework approach would provide for the application of environmental management controls (avoidance, mitigation and management) that reflect the level of sensitivity of environmental values, and would be supported by a process of description, classification and mapping of a range of constraints.

The EIS outlined a range of consequences should the project not proceed, including positive and negative environmental, economic and social impacts, such as:

- the potential adverse impacts on land, biodiversity, water and air, and the associated visual and social impacts, would not occur
- the potential adverse impacts on the local and broader economy, labour market, and community services would not occur
- the potential for economic benefits to the Queensland economy (estimated at $1.66 billion), job creation (approximately 1,000 jobs during construction and up to 400 jobs during operation), investment in local and regional infrastructure and services, and increased export and local use of LNG, would not be realised.

Submissions questioned the need to develop all CSG resources to meet demand, the validity of projections for gas demand, the sustainability of domestic gas supply, the adequacy of demonstration of ‘overriding need’ as defined by SCL Act, and the stated economic benefits particularly when potential adverse impacts to land use and water resources are considered. In response, Arrow referred to demand projections (EIS Chapter 3, Section 3.4), estimates of domestic gas resources by Geoscience Australia and ABARES (EIS Chapter 3, Section 3.2.1), and assessment of impacts in the EIS documents.

4.3 Description of the project

Chapter 1 of the EIS described the project location including a list of tenures and a map showing the extent of the project development area, scope of the project in terms of gas extraction estimates and project infrastructure, staging, and general considerations that could influence project development. Chapter 4 of the EIS provided a high level description of the natural, social, and economic environment within the project development area as defined in Chapter 1. Chapter 5 of the EIS provided a description of the gas resource, project components including options for electrical power supply and CSG water management, conceptual development sequencing and infrastructure location, exploration activities, proposed environmental and social constraints to location of infrastructure, proposed construction, operation, maintenance, decommissioning and rehabilitation activities. The description of the project was presented as 'conceptual' and the actual location of infrastructure was not defined.

The submission on the EIS from the former DERM stated that the conceptual gas project design detail provided was insufficient to enable assessment of cumulative, regional, site and local impacts of the project. The former DERM requested detailed information on the location of major infrastructure such as gas compression and water treatment plants, and quarries to enable assessment of impacts, at least for the Dalby, Wandoan and Millmerran/Kogan development regions which were proposed to be developed between 2014 and 2022.

The SREIS (Chapter 3) presented a significantly revised project in terms of reduced project development area; revised production areas; development sequencing; infrastructure requirements; power supply; CSG water management; workforce and accommodation. Table 5 provides a summary of key project description components and changes outlined these changes.

Table 5 Summary of key project description components and changes (source: Table 3.1, SREIS)

Component	EIS Chapter 5 Project description	SREIS Project description refinements
Project development area		
Project development area	• Project development area of 8,600km^2. • Five development areas (each with approximately 1,500 wells).	• Project development area of 6,100km^2. • 11 drainage areas (each with varying numbers of wells), which take advantage of natural topography, encouraging flow of gas and water to natural low points.
Field Production		
Sustained production estimate	• 80TJ/d of gas for supply to the domestic gas market and 970TJ/d of gas for export overseas (including 10% feed gas). • Sustained gas production aimed at 1,050TJ/d.	• 80TJ/d of gas for supply to the domestic gas market and 1,135TJ/d of gas for export overseas. • Sustained gas production aimed at 1,215TJ/d.
Coal seam gas water production estimate	• Average production 22GL/a. • Peak production 43GL/a. • Total production 694GL (over 35 years).	• Average production 13GL/a. • Peak production 34GL/a. • Total production 510GL (over 40 years).
Wells and Facilities		
Well number	Well count approximately 7,500.	Well count approximately 6,500.
Well type	Vertical production wells.	• Production well types include vertical (single-well pad) and deviated (allowing for multiple wells located at a central surface location (multi-well pad)). • Maximum of 12 production wells on a multi-well pad. • Multi-well pad will typically contain nine production wells. • Groundwater monitoring bores in

Component	EIS Chapter 5 Project description	SREIS Project description refinements
		accordance with Arrow's statutory obligations.
Integrated processing facilities	• Six integrated processing facilities producing 30 to 150TJ/d of gas. • No integrated processing facilities.	
Central gas processing facility	• Six CGPF producing 30 to 150TJ/d of gas. • Conceptually located somewhere within a 12km-radius area.	• Eight CGPF producing 75 to 225TJ/d of gas. • Properties where CGPF will be located in drainage areas DA2, DA7, DA8 and DA9 have been identified.
Field compression facility	Six FCF processing 30 to 60TJ/d of gas.	No change. Potentially six FCF operating at 30 to 60TJ/d (if required).
Water treatment facilities	Six water treatment facilities with 60ML/d capacity.	Two water treatment facilities, one at CGPF2 and one at CGPF9, with 35ML/d and 90ML/d capacities, respectively.
Power Requirements		
Power generation	• Primary power requirements fulfilled through self-generation. • Alternate power supply option as connection to Queensland's electricity grid.	• Primary power requirements fulfilled through connection to Queensland's electricity grid. • Self-generation option maintained as per EIS. Temporary self-generation may support facilities during initial production for a period until an electricity grid connection is established (not expected to exceed two years) and with a maximum capacity of temporary self-generation of 50MW for each CGPF.
High-pressure Gas Pipeline	Right of way (ROW) 25- to 30m-wide construction ROW.	Up to 40m wide construction ROW.
Supporting Infrastructure and Logistics Workforce	Peak construction workforce estimated at 710. Peak operations workforce estimated at 460.	Peak construction workforce estimated at 2,300. Peak operations workforce estimated at 400.
Temporary workers accommodation facilities (TWAFs)	• Each TWAF typically accommodates between 200 and 350 personnel. • Five TWAFs. • Co-located with an integrated processing facility; maximum travel distance of approximately 30km for the facilities construction team.	• Each TWAF typically accommodates between 450 and 1,050 personnel. • Six TWAFs. • Property for siting TWAF-F identified. Remaining five TWAFs to be located within the same property as the nearest CGPF.
Coal Seam Gas Water Management		
Discharge to watercourses	Emergency discharge to watercourses when the structural or operational integrity of dams is at risk.	Emergency discharge to watercourses when the structural or operational integrity of dams is at risk. Operational discharge to watercourses to distribute water to managed schemes, or to dispose of water when: • constraints to supply for beneficial

Component	EIS Chapter 5 Project description	SREIS Project description refinements
		use occur • unforeseen events occur such as significant weather events • operational upset conditions necessitate discharge.

4.4 Impact assessment method and environmental framework

4.4.1 Adequacy of assessment method

Chapter 7 of the EIS provided a description of the assessment approach adopted to determine potential impacts of the project. Potential impacts of the proposed development on environmental values for each environmental aspect have been assessed using one of three methods: significance assessment, risk assessment or compliance assessment.

The EIS described how significance assessment was adopted for technical studies where an understanding of the vulnerability of the environmental asset or resource was important to the assessment. For example, an understanding of the sensitivity of ecosystems in their current state provides a sound basis for determining the severity of potential impacts. The EIS contented that potential impacts that arise through the management of materials and substances (e.g., waste) are more appropriately assessed using the principles of risk management. Compliance assessment was adopted for environmental aspects regulated by statutory guidelines, e.g. air and water quality, noise and vibration. Application of these methods required an understanding of the affected environmental values which were described in the relevant sections of the EIS as required by the TOR.

The EIS acknowledged that a key premise of environmental impact assessment should be that the location, type, scale and duration of development is known; thus enabling the impacts of the proposed construction, operation and maintenance activities on the environmental values at that place, at the nominated time, to be assessed. However, for this project, while the type of development, and construction, operation and maintenance activities are known, as is the duration for installing individual items of project infrastructure and the operational life, the specific location of the gas wells, gathering pipelines and production facilities are not known. Hence, for the assessment of this project, the lack of certainty about preferred location of project facilities and infrastructure is an issue for environmental impact assessment because the impacts at a specific location cannot be fully understood.

4.4.2 Environmental framework

It is argued in the EIS that, while locations and timing of the full development of the project are not known—largely because of the spatial variability of the gas resource in the project development area—the typical impacts associated with project construction and operations are known. Further, that a greater level of certainty of impacts at a location can be obtained by identifying those areas that offer restrictions to the conduct of certain activities and if they were, how they could be accommodated. Arrow considered that this can be done by the identification of constraints to development and the application of management controls that should apply to project activities in constrained areas.

To a large extent, the requirements of the TOR for the project are predicated on the location of project activities being known, and hence the specific impacts at a site can be identified, described and specific mitigation measures proposed. When there is limited flexibility in the siting of development activities, this approach is appropriate. However, the flexibility in the location of project facilities provides an opportunity, if the appropriate planning approach is used, to select sites for project activities where impacts are minimised, and residual impacts can be managed.

EHP considers that, for the purposes of the EIS under the EP Act that the constraints approach encapsulated in the Environmental Framework described in the EIS, is appropriate for the overall assessment of a project of this nature and scale. The approach is also consistent with the priority sequence of avoiding, minimising, managing and offsetting impacts approach endorsed by EHP (and mandated in the EP Act) in dealing with the adverse environmental impacts of development.

Even so, in submissions on the EIS, EHP and other submitters, while acknowledging that the project needed to be developed progressively across the project development area, requested that Arrow practically demonstrate how the siting of facilities would be determined, and where they would be located, for at least the initial (3 to 5 years) phase of the project.

In response, the SREIS, as well as describing a number changes to the project that would reduce overall impacts, outlined the proposed sites for four of the eight central gas processing facilities (CGPF), one of six temporary workers accommodation facilities (TWAF) (although the remaining five TWAFs are to be located on the same properties as the CGPFs) and the 11 drainage areas which would be sequentially developed to feed gas to the CGPF located within each drainage area. The preferred locations of the two water treatment plants (and proposed water discharge sites) were also described. Impacts associated with the construction, operation and decommissioning of these facilities was also provided. What cannot be provided at this stage of the project, and is a matter of key concern to some landholders, are the specific location of gas wells, gas and water gathering systems, and the location of other facilities including FCF. Arrow notes that the location of these facilities would be negotiated on a site by site basis with landholders and others, as further approvals to proceed were obtained.

A number of submissions considered that the lack of specific details regarding the siting and other aspects of the project description meant that the EIS did not adequately identify environmental values, restricted the community's capacity to fully understand and assess the environmental impact of the project and generally undermined the purpose of the EIS.

In it's response to these comments Arrow noted that the studies undertaken for the EIS include the assessment of project impacts at regional, state, national and sometimes global level. The outcomes of these studies have informed the design of the project and the measures Arrow has committed to implement in order to avoid, minimise, manage and offset the identified impacts. In many cases, further studies, monitoring, and review of mitigation measures would take place, including when final sites for the facilities are determined.

Concerns were also raised in some submissions that the adaptive management framework proposed by Arrow to deal with a number of impacts was not workable as it did not guarantee an acceptable level of impact at a specific site, nor could it deal with impacts having the potential to cause unknown catastrophic and irreversible impacts. Arrow correctly identified adaptive management of environmental impacts (particularly water) as outlined in the EHP Information Sheet 'Integrated laws to manage water impacts' (2013b), as an endorsed approach by EHP in dealing with new technologies and on ground experience. Arrow also intends to apply adaptive management framework to key aspects of the project that require best management strategies to evolve over time.

A number of submissions were critical of the extent to which cumulative impacts had been described, assessed and mitigated measures developed in the EIS Chapter 8 Cumulative Impacts. EHP considers that while it is agreed that there is no standard framework or criteria for assessing cumulative impacts, the approach adopted in the EIS did substantially meet the requirements of the TOR. This assessment has dealt with any cumulative matters that required attention in the relevant section.

4.4.3 Conclusions and recommendations

EHP considers that the assessment process used in the EIS was appropriate for the nature and scale of the proposed project, and used methodologies that enable the EIS to adequately meet the requirements of the TOR and other requirements of the EIS process under the EP Act.

4.5 Air

4.5.1 Overview

EIS Chapter 9, Air Quality, provided a description of the air quality environmental values within the project development area and a wider region of potential impact, and an assessment of the potential for these values to be affected by direct and indirect impacts associated with the construction, operation and decommissioning of the project. EIS Appendix C, Air Quality Impact Assessment, provided a detailed assessment of air quality impacts, including atmospheric dispersion modelling.

Environmental protection objectives were stated and the mitigation and management measures to achieve these objectives identified. The residual impact assessment assumed that the proposed mitigation and management measures would be effectively implemented.

SREIS Chapter 5, Air Quality, presented a summary of a supplementary air quality assessment (SREIS Appendix 2, Supplementary Air Quality Assessment) undertaken to address updates to the project description as outlined in SREIS Chapter 3.

4.5.2 Assessment methodology

Atmospheric dispersion modelling was used to assess the impact of emissions on air quality with two separate modelling approaches used: one to determine the existing air quality and regional impacts of the project, and another to determine the localised (near field) impacts. The assessment study area included the project development area as well as a wider region likely to be affected by emissions from the project development area.

The Chemical Transport Model (CTM), which is a photochemical dispersion model, was used to determine existing and predicted concentrations of ground-level nitrogen dioxide (NO_2) and ozone (O_3). Localised ambient air quality impacts (close to emission sources) were assessed using AUSPLUME, a plume dispersion model. Meteorological data for the CTM and AUSPLUME modelling was generated using The Air Pollution Model (TAPM) and included wind, temperature, humidity, cloud, rain, snow, turbulence, eddy and radiative flux factors.

A number of submissions on the EIS questioned the appropriateness of the baseline air quality and meteorology data used in the assessment. In response, Arrow argued that the use of air quality data from EHP's Toowoomba and Flinders View monitoring stations to set the baseline for the project development area was considered conservative (i.e. 'worst-case'), due to industrial and urban land uses around Toowoomba and Flinders View, which would typically produce higher air pollutant concentrations than those in rural areas (EIS Appendix C, Section 5). Arrow asserted that the monitoring data used to set the baseline for the air quality impact assessment included higher background air pollutant concentrations than expected in the project development area.

EHP considers that the use of this data, and the predictive air quality models used in the EIS were sufficient to characterise and predict regional and local impacts of the project on air quality.

The supplementary air quality assessment adopted the same methods for emission estimation and modelling as those used for the EIS. Where the updated project description presented the potential for greater emissions to air than those calculated for the EIS assessment, further modelling, was undertaken. Where the EIS had already assessed the worst-case scenario (e.g. construction and decommissioning), no further assessment was undertaken.

Emission sources used in the regional and local models included point sources from wellheads and production facilities including flares and generation of project electricity requirements. As the specific locations of project facilities were not defined, regional modelling was carried out using conceptual locations of wellheads and production facilities.

The key air pollutants were determined to be nitrogen dioxide (NO_2) and ozone (O_3). Oxides of nitrogen (NOX) generated by gas combustion processes lead to elevated concentrations of NO_2 in the near-field when nitric oxide is oxidised to form NO_2. Ozone, a secondary pollutant (also known as photochemical smog), forms in a chemical reaction between NO_2 and volatile organic compounds (VOC) and was considered in the regional assessment. Other pollutants (such as sulfur dioxide, carbon monoxide, and particulate matter) were anticipated to be emitted in low quantities by the project and also had low concentrations in the existing environment, and on this basis were not further assessed.

Odourants, including hydrogen sulphide, were stated to be present in trace quantities in CSG, and emissions of CSG were assumed to be low. On this basis, odour impacts were not further assessed. Estimates of fugitive emissions were included in EIS Chapter 10, Greenhouse Gas Emissions, and the associated technical study (EIS Appendix D, Greenhouse Gas Impact Assessment).

The EIS reported that cumulative impacts of the relevant regional pollutants, NO_2 and O_3, were assessed through inclusion of emission sources from current and proposed projects within the project development area and surrounding region. Regional modelling was used to estimate concentrations under two scenarios: scenario one based on all production facilities being operational, and scenario two using the indicative field development sequence period when the maximum number of wells and facilities would be operational at the one time. Emissions from traffic and flaring were included in these scenarios.

A number of submissions called for the estimation of impacts on air quality to be assessed under worst-case conditions. The EIS reported that 96 emission sources, including emissions from future projects, were used in the cumulative impact assessment of air quality under worst-case environmental conditions.

The outputs from the regional air quality modelling were presented as predicted ground level concentrations of NOX and $O_{3,}$ while local impacts were presented as concentrations at distances from key infrastructure—integrated processing facilities, gas processing facilities, FCF and well heads.

To predict local impacts, localised dispersion modelling, using the AUSPLUME model was used to predict ground-level concentrations of air pollutants close to the emission sources, including a CGPF operating at maximum capacity, a FCF and a single well. The meteorology for the regional assessment, which captured the variation in meteorological conditions for the northern, central and southern regions of the project development area, was also used in the localised assessment.

4.5.3 Existing environment

Table 9.2 of EIS Chapter 9 presented the modelled existing maximum ground level concentrations of pollutants within the study area against Environmental Protection (Air) Policy 2008 (EPP (Air)) objectives (health and wellbeing). It indicated that existing ground level concentrations of all key pollutants within the study area would be below EPP (Air) objectives.

4.5.4 Impacts

The EIS identified the key project-related emission sources as power generation, using gas fired turbines, and flaring of gas. Table 9.4 of EIS Chapter 9 provided a list of emission sources associated with each phase of the project.

The majority of emission sources associated with construction would be transient and limited in duration, with the exception of ramp-up flaring prior to production facility commissioning. Operational emissions would be ongoing sources, which have the greatest potential to have detrimental impacts.

Regional modelling for the EIS, using TAPM-CTM, of the dispersion and chemical formation of regional air pollutants (NO_2 and O_3) provided an estimate of the concentrations due to project activities under two scenarios intended to represent the worst case emission levels. The modelling predicted that the EPP (Air) objectives for NO_2 and O_3 would not be exceeded on a regional scale due to emissions from project activities for either scenario (Table 9.5, EIS Chapter 9).

Localised dispersion modelling for the EIS, using the AUSPLUME model, indicated that, in order to achieve the EPP (Air) objectives for NO_2, a separation distance from the nearest sensitive receptor of 225m would be required for a CGPF co-located with a water treatment facility, and a separation distance of 175m would be required for a stand-alone CGPF. Maximum air pollutant concentrations at a FCF and a single well were less than EPP (Air) objectives.

The supplementary air quality assessment predicted air quality impacts for the updated project description. The most significant changes in the updated project description that would impact on air emissions related to the operation phase and included the reduction in the number of wells, CGPF and water treatment facilities, as well as possible connection to grid power where available. No additional regional air quality assessment was carried out in the SREIS would have, as the regional assessment presented in the EIS was considered to have assessed the worst case. The localised assessment of air emissions resulting from CGPF operation concluded that the distance at which the EPP (Air) objectives would be met would depend on final equipment selection, and that estimated air pollutant concentrations based on the revised project description were less than predicted in the EIS and therefore required no changes to the air quality commitments.

The SREIS noted that the proposed sourcing of project electricity from the Queensland electricity grid would have the potential to significantly reduce emissions of nitrogen oxides (NO_2, NO_3) from the project within the project development area.

Several air quality concerns raised in submissions on the EIS by individuals and groups were adequately addressed in the EIS documents (e.g. assessment method and worst-case assessment, effect of temperature inversions, flaring and venting and associated mitigation measures, nitrogen oxide emissions and impacts, dust, air quality monitoring), or deferred to assessment of an application for an environmental authority or amendment of an environmental authority when site-specific information would be made available. The EHP submission listed extensive requirements for site-specific information on emissions, impacts and mitigation measures.

Claims were made in a submission from landholders that the predicted air quality (Chapter 9, Table 9.8) exceeded statutory guidelines and standards. In response, the SREIS provided a comprehensive discussion on the standards and air quality objectives used in the EIS. It acknowledged that the proposed well head engines would not meet some engine emission standards, but considered that those standards were not specifically relevant. The EIS has demonstrated that NOX concentrations would meet EPP (Air) objectives and the National Environment Protection (Ambient Air Quality) Measures (NEPM) which are based on impacts to sensitive receptors. EHP will use the EPP (Air) objectives, which are largely based on NEPM objectives, in regulating air emissions associated with the project.

Several submissions questioned the impacts of flaring on air quality. In response, the SREIS stated that the flaring assessment in the EIS (Appendix C, Section 7.2) considered the maximum ramp up flaring emissions as well as upset flaring rates. Flaring was considered to be continuous during the modelling period, which was considered by Arrow to result in a conservative estimate of emissions as ramp-up is typically three months prior to commissioning and upset flaring is intermittent. Results indicated that with separation distances, EPP (Air) objectives could be met at sensitive sites. In addition, Arrow committed to prevent venting and flaring of gas as far as practicable and where it is safe to do so.

Comments on the EIS documents by landholders and Queensland Health (QH) raised concerns that water storage and brine storage dams could be a source of airborne emissions (VOCs, odour, etc.) and should have been assessed in the EIS. In the SREIS, Arrow stated that CSG contains only trace quantities of sulphides (the main potential source of odour) and that CSG is separated from the water prior to treatment and storage. Further, Arrow reported that VOCs would not be added to the groundwater during well construction. An inert, water-based drilling fluid would be used containing water and 2 to 3% salts and a small amount of bentonite clay.

4.5.5 Avoidance and mitigation measures

The EIS stated commitments to mitigation measures to minimise air quality impacts associated with the project and no changes were made to these measures as a result of the supplementary assessment (SREIS Table 5.1). Additional mitigation measures relating to dust suppression were provided in EIS Chapter 12, Geology, Landform and Soils, and EIS Chapter 19, Roads and Transport.

Commitments made by Arrow to mitigate impacts on air quality reflected the uncertainty of equipment and infrastructure design, capacity, location and operating procedures, which were not fully defined for the assessment, and therefore the uncertainty of actual emissions to air and concentrations of pollutants at sensitive receptors.

The use of separation distances between project emission sources and sensitive receptors to achieve air quality objectives was a significant matter of concern in submissions on the EIS. Arrow clarified that separation distances were designed to be a conservative, first-pass method of establishing whether a proposed development would be likely to have an adverse impact on air quality in nearby areas, and the separation distances presented in the air quality assessment were based on the maximum (peak) concentrations that may occur under a worst-case scenario. Arrow stated that site-specific modelling (local meteorology and topography) for the final equipment, layout and location would, in most cases, indicate a reduction in dispersed emissions concentrations.

A number of individual submissions, and a submission by the Basin Sustainability Alliance, raised concerns in relation to the potential leakage of gas from depressurised coal seams, and referred to recent reports of methane bubbling from the Condamine River. In response, Arrow confirmed that such ‘gas migration’ emissions were not included in emission estimates as no emission factor or alternative methods were available to account for such emissions. Arrow further advised:

- the preferential path for gas flows, as a result of CSG development, would be through the production wells as a reduction of the reservoir pressure in the Walloon Coal Measures would cause a cone of depression around the well that would promote gas flow to the well
- depressurisation of the Walloon Coal Measures through extraction of CSG water for the project would cause a flux from the Condamine Alluvium to the coal measures and the hydrostatic pressure created by the flux would limit the potential for gas migration to bores which draw water from the Condamine Alluvium
- that it had proposed gas migration investigations to consider the nature of the interface between the Condamine Alluvium and Walloon Coal Measures, and whether legacy coal and mineral exploration bores are conduits for fugitive gas emissions
- that it would consider plugging and abandoning those wells where a significant gas migration risk exists.

In response to concerns regarding the potential impact of odour from project activities, including water storage dams and traffic, Arrow advised that:

- limited air emissions (below guideline levels) would occur from water storage dams as CSG contains only trace

quantities of sulfides (the main potential source of odour) and entrained CSG is removed from the water prior to treatment and storage
- VOCs would not be added to the groundwater during the well construction
- Odour does not currently present an issue at Arrow's existing, operating water treatment facilities or dams
- Hydrogen sulphide is present only in trace quantities in the gas stream and is destroyed by flaring.

Both, Arrow and the DNRM noted that odour has not presented as an issue at existing CSG water treatment facilities and dams. However, DNRM recommended that an appropriate complaint management process be implemented by Arrow to deal with known and potential CSG industry issues (including odour) during construction and operation. Any odour causing nuisance would be regulated in any environmental approvals issued for the proposed project under the EP Act.

While not explicitly stated in the EIS documentation, it is imperative that the siting of CSG facilities not only consider potential impacts within the property on which facilities would be located, but also the incidental impacts of air emissions and other issues (traffic, noise, etc.) on neighbouring landholders, and other businesses and facilities. Whilst the SREIS referred to Area Wide Planning as the method Arrow intends to use to ensure appropriate siting of infrastructure, there was insufficient detail about how the process would involve relevant landholders and others that may be affected. For Area Wide Planning to be of any real value, it would require effective consultation and determined implementation.

4.5.6 Cumulative Impact

Section 28.3.1, Air Quality, of EIS Chapter 28, Cumulative Impacts, discussed the potential cumulative impacts of existing and approved future developments on air quality in the region. NO_2 concentrations were predicted to increase but maximum levels would remain well below well relevant guidelines in the EPP (Air) for health and wellbeing. Modelling of scenarios indicated that the separation distance between conceptual locations of production facilities and sensitive receptors would ensure that the dispersion of plumes would not result in a cumulative air quality impact with no exceedences of the ground-level EPP (Air) objectives for NO_2 and O_3 predicted in the region.

A number of submissions on the EIS were concerned with the adequacy of the assessment of cumulative impacts on regional air quality. In response, Arrow noted that the emission sources list used for the air quality assessment was comprehensive and included emissions from existing and approved oil and gas extraction, coal mines, electricity production and other industrial emissions, agricultural industries and fuel storage and distribution depots. Modelling of cumulative regional scenarios represented a theoretical worst-case scenario by including 96 potential or existing emission sources as well as the emissions from all of Arrow's proposed 18 production facilities operating simultaneously at maximum compression across the entire project development area.

4.5.7 Conclusion and recommendations

For the purposes of the assessment of the project, the EIS has adequately described the existing condition of the air shed, identified emissions sources and predicted the impacts of the project at a regional and local level.

Although the assessment was based on several assumptions – as described in the EIS documents, and particularly in regard to infrastructure locations and plant/equipment performance – Arrow acknowledged the need to undertake more detailed air dispersion modelling studies when locations and plant/equipment had been determined. Many of the submissions raised concerns about the validity and reliability of the dispersion modelling undertaken for the EIS. These concerns would need to be addressed by Arrow's commitment to undertaking more detailed air dispersion modelling once locations and plant/equipment have been selected. This and other commitments made by Arrow (see Appendix 3) would be necessary to achieving an acceptable EA application under the EP Act.

Arrow would need to site CSG production facilities (with and without water treatment plants) with an adequate set back (as determined in the EIS—175m without a water treatment facility and 225m if co-located with a water treatment facility) to ensure acceptable air quality would be achieved at sensitive receptors. In some locations, this may pose a constraint to the siting of these facilities. If these facilities are to be located closer to sensitive receptors than the distances indicated in the EIS, a detailed assessment demonstrating that EPP (Air) quality standards could be achieved, would be required.

EHP would assess and impose relevant air emission conditions (including the control and management of nuisance odour) on environmental authorities required by the project. These conditions would include requirements for monitoring and reporting. In preparing an application for an environmental authority, or an amendment to an environmental authority, Arrow should consider the guideline "Application requirements for petroleum activities" (EM705) and should ensure that the information provided in the application meets the requirements of section 125 and section 126 of the EP Act. Details of these requirements for all aspects of an EA application are provided in Appendix 4 of this assessment report.

Fugitive emissions, particularly from wells and other infrastructure are discussed in Section 4.6 Greenhouse Gas Emissions and Section 4.11 Aquatic Ecology of this assessment report.

4.6 Greenhouse gas emissions and climate change adaptation

EIS Chapter 10, Greenhouse Gas Emissions, provided an inventory of estimated project greenhouse gas emissions, a qualitative object to minimise emissions, and proposed mitigation and management measures. Detailed information on the project's greenhouse gas emissions and abatement measures was included in EIS Appendix D, Greenhouse Gas Impact Assessment.

EIS Chapter 11, Climatic Adaptation, provided a summary of the existing climate and climate extremes in the vicinity of the project development area in terms of rainfall, air temperature, wind and other factors that could affect the project, an assessment of the project's vulnerabilities to climate change, and proposed climate change adaptation measures. Detailed information on climate change adaptation was included in Appendix D, Greenhouse Gas Impact Assessment.

SREIS Chapter 6, Greenhouse Gas Emissions, presented a summary of a supplementary greenhouse gas assessment (SREIS Appendix 3, Supplementary Greenhouse Gas Assessment Report) undertaken to address updates to the project description as outlined in SREIS Chapter 3.

4.6.1 Greenhouse gas emissions

4.6.1.1 Assessment methodology

The EIS adopted the Australian greenhouse reporting and measurement methods in its assessment of greenhouse gas (GHG) emissions. The EIS categorised the sources of greenhouse gas emissions into three 'scopes' (Scope 1, Scope 2 and Scope 3) in order to understand, quantify and manage GHG emissions for the project in accordance with The Greenhouse Gas Protocol accounting tool. The EIS estimated the project's contribution to national and global emissions in the three types of emissions associated with project.

Scope 1 emissions (direct emissions) from project activities included:

- generation of electricity, where emissions result from combustion of fuels in stationary sources, such as on-site self-generated gas turbines and diesel electricity generators
- construction activities and transport of materials, waste and employees, where emissions result from fuel combustion in Arrow-owned or controlled mobile combustions sources such as light and heavy vehicles (e.g. cars and buses), industrial vehicles and equipment (e.g. earthmoving and construction equipment)
- planned or unplanned releases of gas from flaring and or venting
- fugitive emission from equipment operations and maintenance
- clearing of vegetation.

Scope 2 emissions (indirect emissions) were assumed to include emissions from the generation of energy products purchased from third parties for use by the project during construction and operations phases, including electricity purchased from the grid.

Indirect Scope 3 emissions were assumed to include all other emissions not included in Scope 1 or Scope 2 emissions, such as the emissions associated with fuel production, through to the end-use of the produced liquid natural gas (LNG). The Scope 3 emissions included in the assessment did not include emissions associated with LNG product shipping, waste products management and construction material embedded energy due to the difficulty of quantifying these emissions.

4.6.1.2 GHG emission estimates

The EIS documents adequately described and detailed the applicable international, national and state regulatory framework for GHG emissions, and regulations which would apply to emission sources associated with the project.

The EIS (Table 10.3) and SREIS (Table 6.4) provided estimates of annual emissions for Scope 1, Scope 2 and Scope 3 emissions in accordance with current reporting protocols. The revised estimates of GHG emissions provided by SREIS related to the updated project description including:

- the change in the primary power supply option to include temporary self-generation until connection to the Queensland electricity grid is available (estimated to be a period of up to two years)
- an increase in Scope 2 emissions attributed to the shift towards power supply from the Queensland electricity grid and away from the self-generated power option (a Scope 1 emission)
- the predicted increase in the distances travelled by project vehicles
- refined project scheduling (i.e. commissioning and decommissioning) for the production wells and facilities.

The SREIS estimated peak annual Scope 1 and Scope 2 emissions at 3.6 million tonnes of CO_2-equivalent per year (Mt CO_2-e/year) (Scope 1 emissions 1.05 Mt CO_2-e/year and Scope 2 emissions 2.59 Mt CO_2-e/year). The EIS stated that the year expected to produce the greatest Scope 1 and Scope 2 greenhouse gas emissions for each phase of the development would be: ramp–up year 2019; operations year 2029; and ramp-down year 2040.

The peak Scope 1 and Scope 2 emissions would occur during the sustained production period of the project when large numbers of production wells and all facilities would be operating concurrently (expected to be 2029). The estimated Scope 1 and 2 emissions for the year 2029 were equivalent to 0.87% of Australian and 0.012% of global emissions for the year 2009.

The overall cumulative GHG emissions over estimated 35 year life of the revised project decreased by 21% compared to the estimated emissions presented in the EIS, despite the higher forecast volume of CSG produced. This was attributed to improved understanding of the power requirement for wells and facilities, and the further development of the project schedule.

Arrow would be required to report GHG emissions and energy consumption or production from the project to the Australian Government (Clean Energy Regulator) under the *National Greenhouse and Energy Reporting Act 2007.*

A number of individual submissions, and a submission by the Basin Sustainability Alliance, requested reasons for not including fugitive methane emissions from the earth, and from uncapped irrigation bores in the Condamine Alluvium, resulting from gas migration from the target coal seams (due to dewatering) in the greenhouse gas emission estimates, and recommended baseline monitoring data for such emissions. Concerns were raised that such leakage of gas into surface waters could impact on aquatic ecology, again making reference to recently recorded occurrence of methane bubbling from the Condamine River. In response, Arrow provided the following information:

- The DIICCSRTE (formerly DCCEE) National Greenhouse Accounts Factors and current methodologies in the National Greenhouse and Energy Reporting (Measurement) Determination 2008 were used to estimate emissions for the greenhouse gas impact assessment (EIS Appendix D, Greenhouse Gas Impact Assessment) and the updated 2012 NGER Determination was used in the preparation of the supplementary greenhouse gas assessment.
- The American Petroleum Institute's Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Gas Industry was consulted but no default emission factor or alternative methods was available to account for gas migration emissions.
- Arrow and other CSG proponents have been working in consultation with the Clean Energy Regulator to improve estimation of fugitive greenhouse gas emissions from CSG exploration and production.
- The preferential path for gas flows as a result of CSG development would be through the production wells, as a reduction of the reservoir pressure in the Walloon Coal Measures would cause a cone of depression around the well that promotes gas flow to the well.
- Depressurisation of the Walloon Coal Measures through extraction of CSG water for the project would cause a net flux from the Condamine Alluvium to the coal measures and the hydrostatic pressure created by the flux would limit the potential for gas migration to bores which draw water from the Condamine Alluvium.
- Arrow had proposed gas migration investigations to consider the nature of the interface between the Condamine Alluvium and Walloon Coal Measures, and whether legacy coal and mineral exploration bores are conduits for fugitive gas emissions.
- Arrow would consider plugging and abandoning those wells where a significant gas migration risk was found to exist.

4.6.1.3 Mitigation measures

Arrow provided commitments to a number of measures intended to reduce the project's greenhouse gas emissions and to mitigate potential impacts. These commitments are reproduced in Appendix 3 to this assessment report. As part of its commitment to reduce GHG emissions generated from the project, Arrow proposed to prepare a greenhouse gas management plan which would detail practical measures, energy efficiency programs, and research and development into new and emerging technologies, in order to reduce the project's GHG emissions. The practical measures proposed in the EIS to reduce GHG emissions included: minimising the disturbance footprint and vegetation clearing, management of fuel use and other energy efficiency measures, prevention of flaring and venting as far as practicable and safe, optimising well-head gas engine operation to reduce periods at low efficiency levels, and regular plant and equipment maintenance.

Submissions received on the EIS raised a range of issues relating to GHG emissions. The SREIS responded to the issues which it identified as falling into the following broad topic areas:

- accuracy of emissions estimation from brine and aggregate transportation
- application of the definition for fugitive emissions
- Arrow's commitment to the application of the mitigation measures and commitments for GHG emissions
- comparison of life cycle emissions for CSG and coal
- consideration of alternative forms of power to run the project e.g. solar power
- consideration of cumulative emissions
- consideration of emissions from exploration activities

- consideration of gas migration emissions
- consideration of GHGs including hydrofluorocarbons, perfluorocarbons and sulfur hexafluorides
- currency and accuracy of emission factors used in emissions estimation
- GHG emission field data collection process
- identification of GHG legislation and presentation of emissions
- level of detail on GHG offsets
- method for capture of vented emissions
- project's impact on climate change and compliance with climate change legislation
- scope of assessment of the resilience of the environment
- scope of the Scope 3 emissions assessment.

Arrow adequately addressed matters raised in submissions received on the EIS and updated the GHG emissions assessment to address submissions on the EIS and changes to the project description. The SREIS concluded that the potential GHG emission impacts and proposed mitigation measures were broadly consistent with the finding of the EIS and adequate and relevant to reducing GHG emissions.

4.6.1.4 Conclusions and recommendations

The EIS documents adequately address GHG emission sources, estimated potential emissions, and proposed appropriate mitigation measures including commitments to reduce and report GHG emissions consistent with current legislative requirements. In order to minimise GHG emissions Arrow should update and implement the commitments presented in the SREIS Table 6.2, EIS greenhouse gas commitments.

Given that the EIS reported that there would be potential for impacts to the Earth's atmosphere from the greenhouse gas emissions from the project's activities, it is recommended that a number of Arrow's commitments be reworded and strengthened to ensure reduction in greenhouse gas emissions by the timely uptake of greenhouse emissions programs and initiatives. Recommended changes to commitments are outlined in Table 6.

Table 6 Commitments for greenhouse gas emissions and recommended changes

No.	Commitments	Recommendation
C007	Consider energy efficiency programs both locally and across the company that contribute to greenhouse gas emission reductions	Re-word and strengthen to ensure reduction in in greenhouse gas emissions by the timely uptake of greenhouse emissions programs and initiatives
C008	Arrow will participate actively in any government-approved emissions trading scheme	Implement if and when required
C010	Consider supporting, through corporate community involvement programs, the development of energy efficiency initiatives in the areas where Arrow operates	Re-word and strengthen to ensure reduction in in greenhouse gas emissions by the timely uptake of greenhouse emissions programs and initiatives
C018	Optimise gas-engine operation to maintain high efficiency levels to keep greenhouse gas and air emissions as low as practicable	Re-word and strengthen to ensure reduction in in greenhouse gas emissions by the timely uptake of greenhouse emissions programs and initiatives
C021	During the construction phase, minimise greenhouse gas emissions as much as reasonably practicable through selection of equipment and the commitment to clear areas progressively. Implement rehabilitation as soon as practicable following construction activities	Re-word and strengthen to ensure reduction in in greenhouse gas emissions by the timely uptake of greenhouse emissions programs and initiatives

No.	Commitments	Recommendation
C022	Consider supporting gas industry initiatives that seek to improve technology or processes, such as contributions or sponsorship of research and development	Reword and strengthen to ensure reduction in in greenhouse gas emissions by the timely uptake of greenhouse emissions programs and initiatives

4.6.2 Climate change adaptation

This section reviews the assessment of the project's vulnerabilities to changing climate patterns, Arrow's climate change adaptation strategies as provided in EIS Chapter 11, Climate Adaptation, and the main conclusions from that assessment.

4.6.2.1 Assessment method

The EIS documents adequately described the existing climate and summarised the climate extremes likely in the vicinity of the project development area. The EIS acknowledged the inherent uncertainties related to climate change projections and stated that a balance must be found between the costs associated with preparing for climate change and the uncertainty of outcomes. The EIS adequately considered national and State legislation, planning policies, guidelines and action plans requirements that focus on climate change adaption. The EIS described climate change adaptation strategies for the project during the planning and design, construction, operation and decommissioning stages consistent with legislative and policy frameworks. The EIS also adequately assessed the project-related risks associated with the projected climate change.

Potential impacts of climate change

The EIS documents reported that the project could be affected by long-term changes in temperatures, rainfall and evaporation, potentially resulting in:

- altered frequency and intensity of extreme weather events e.g. cyclones, storms, droughts, dust storms, bushfires and floods
- negative impacts on agricultural activities and biodiversity values compounding with project impacts
- increased costs associated with purchase of potable water as water supplies are affected and water infrastructure becomes more costly
- increased operational temperature range over which project infrastructure, equipment and construction materials must operate
- decreased efficiency of power generation through gas engines, which can be adversely affected by increasing ambient temperatures
- altered risks to the health of workers, in particular incidence of heat stress and insect-borne diseases.

4.6.2.2 Mitigation measures

The EIS documents included a range of measures to ensure the effects of climate change were considered in the planning and design, construction, operations and decommissioning phases of the project. Arrow committed to the following actions that form the project's climate change adaptation strategy:

- ensure the maximum design temperatures of infrastructure, equipment and materials are sufficient to account for future increases in ambient air temperature
- design and construct the production facilities in accordance with current Australian standards addressing climatic factors including wind, bushfires and floods
- deploy preventive and responsive measures for bushfire management and flooding
- incorporate climate change-induced health risks into future workplace health, safety and environmental management plans
- estimate and include climate change costs in business cost projection and consider emerging business opportunities that climate change may generate
- engage in government or industry climate change programs.

The EIS documents concluded that, based on the current understanding of predicted changes to climate across the project development area, the significance of any residual impacts to the project resulting from climate change would be low.

Arrow adequately addressed the three submissions received on the EIS that were related to climate change adaptation. Arrow referred the uncertainties related to climate and proposed to incorporate climate change adaptation strategies in project planning and design, construction and decommissioning stages of the project, including preventative and response measures for project infrastructure facilities and equipment.

4.6.2.3 Conclusion and recommendations

The EIS adequately addressed the requirements to address climate change adaptation.

In order to ensure that the project is fully prepared for the effects of climate change it is recommended that the climate change adaptation strategy commitments stated in the SREIS be fully implemented (Appendix 3).

In addition, the EIS stated that Arrow would seek ways to lower water consumption through water-efficient technologies and practices and/or by installation of water-efficient devices, in recognition of the importance of this valuable resource and its potential to be affected by changes in climate. It is recommended that Arrow include this as a climate change adaptation commitment.

4.7 Geology, landform and soils

Chapter 12 Geology, Landform and Soils of the EIS described the existing geology, landform and soil values within and surrounding the project development area and provided an assessment of the potential for these values to be affected by direct and indirect impacts associated with the construction, operation and decommissioning phases of the project. Detailed information on the geology, landform and soils assessment was included in EIS Appendix E, Geology, Landform and Soils Impact Assessment. Broad environmental protection objectives, to avoid or minimise impacts to geology, landform and soils were stated and avoidance, mitigation and management measures to achieve these objectives, identified. The residual impacts identified were based on the assumption that the proposed avoidance, mitigation and management measures had been applied.

The SREIS reported that changes to the project (outlined in SREIS Chapter 3, Project Description) had considerably reduced the impact on geology, landform and soils from that described in the EIS and that none of the matters raised in the submissions required a change to the avoidance, mitigation and management measures outlined in the EIS. As a result there were no changes to the assessment.

4.7.1 Legislative context

The EIS documents adequately described the legislative, policy and guidelines relevant to identifying values, mitigating and managing impacts on geology, landform and soils that applied at the time the EIS was drafted.

Legislative and policy changes have occurred since the publication of the EIS and these were described in the SREIS Chapter 2, Project Approvals. Particular legislative and policy changes relevant to geology, landform and soils were identified as being amendments to the EP Act (concerning contaminated land and waste) and the implementation of the SCL Act. Concerns raised in some submissions about the implications of the SCL Act for the project were also addressed in Chapter 2 Project Approvals, particularly potential impacts on the agricultural soils of the project development area.

4.7.2 Assessment methodology

The potential impacts of the project on environmental values were assessed using two methods described in the EIS Chapter 12, Assessment Methods. Methods used comprised desktop studies and field surveys to assess and describe the existing environment. The desktop study included a review of geology, landform and soils legislation, previous studies, databases and maps. A GIS database was constructed to enable preliminary mapping of environmental constraints and sensitive areas.

Two field studies were undertaken. The first was to ground-truth desktop study findings and to identify any areas requiring further investigation. This assessment was based on the land resource areas mapped by the Queensland Government and the field studies were used to review the mapping in relation to the project development area. A subsequent field survey was conducted to assess geology and soils using geological mapping of rock exposures and test pits.

The geological assessment included observation of rock exposure at 109 locations in the project development area. Land assessment to map terrain used site observations, aerial imagery and desktop information. A digital terrain elevation model was produced. Land resource areas were mapped and ground-truthed and 16 pits were excavated on commonly occurring soils across the project development area.

This information was then used to undertake Terrain Mapping and Environmental Values Assessment and a Landscape Sensitivity and Constraints Assessment to provide an indication of the susceptibility of the landscape to change following disturbance. Possible landscape constraints on the project were also assessed.

Submissions on the EIS from the Queensland Murray Darling Basin Committee and the Logan and Albert Conservation Association, questioned: whether the use of land resource areas for soil mapping was appropriate as land resource areas contain a number of soil types; the appropriateness of the scale of mapping; and whether site-specific impacts had been adequately assessed. Arrow responded that, due to the nature of the project, specific sites for wells, gathering lines and larger infrastructure had not been determined. Arrow also considered that the mapping and site investigations undertaken in the EIS were sufficiently representative of the project area and appropriate for understanding the soils and geology of the project development area for the EIS stage of the assessment process. Arrow committed to undertaking geotechnical investigations, prior to construction, to assess the physical and chemical properties of the soils to inform management strategies. Comments from the former DERM questioned whether the environmental values of the soil health and function and the ability for soil to sustain growth of native vegetation, crops and/or other flora had been adequately described in the EIS. Arrow contended that these matters had been adequately dealt with in the EIS Chapter 13, Agriculture and the associated technical study (Appendix F, Agricultural Report). They provided some additional information in the Strategic Environmental Management Plan (SREIS Attachment 2).

The methods used to assess contaminated land included a desktop study to identify the nature and frequency of contaminated sites within the project development area.

The desktop review in the EIS established that there were a number of challenges assessing with a level of certainty, contaminated land in the project development area. These constraints were primarily related to:

- how contaminated land is identified (usually by notifiable activities being undertaken on the subject land or by investigation when land use changes)
- not all contaminated sites in the project area are likely to have been listed on the Environmental Management Register (EMR) or Contaminated Land Register (CLR)
- listing of a parcel of land does not mean that the whole parcel is contaminated
- it is not possible to search the EMR or CLR database spatially to locate contaminated sites and it is not reasonable, practical or useful to conduct a search of all lots in the project area.

After considering such constraints, no specific field sites were investigated as part of the EIS assessment. Arrow noted that assessments for the presence of contaminants would occur when facility and infrastructure locations are identified through Arrow's site selection process. Arrow acknowledged that, should contaminants of concerns or notifiable activities be encountered during project development, it would be Arrow's responsibility to ensure EHP was notified and to implement appropriate management plans.

4.7.3 Existing environment

4.7.3.1 Geology

Details of the geology of the project development area were adequately described in EIS Chapter 12 and Appendix E. Further details on the geology were provided in EIS Chapter 14, Groundwater as well as SREIS Chapter 8, Groundwater and Appendix 4, Supplementary Groundwater Assessment.

4.7.3.2 Landform

The EIS documents reported that the landscape of the project development area is strongly linked to the underlying geology and geomorphological evolution of the area and characterised by three physiographic regions: the Great Dividing Range highlands; the Kumbarilla Ridge uplands; and four drainage basins—Condamine-Culgoa, Fitzroy, Border Rivers and the Moonie basin. Features of each of the drainage basins were described and a stylised diagram of the landform and soils along the Condamine River provided (see Figure 3). As well as describing the physical landform of the project area, an outline of the past and current geomorphic processes contributing to the features of the landscape was provided.

4.7.3.3 Soils

Seven broad soil types, classified using the Australian Soil Classification System (Isbell, 2002) were identified in the project development area: gilgai clays, cracking clays (both black cracking clays and uniform cracking clays); uniform non-cracking clays; texture contrast soils; uniform loams and clays; sands and sandy loams; and skeletal, rocky or gravelly soils. These were outlined in the EIS and their general location, profile and properties described.

As well as identifying the important agricultural soils (cracking clays) a range of potentially problematic soils (particularly sodic and saline soils) which require particular management if they are disturbed (which should be avoided), were located and described. The EIS reported that field investigations confirmed that the soil types found were broadly consistent with those expected from the land resource area and desktop assessment.

Laboratory testing showed that the soils of the project development area generally comprise soft, low-plasticity clay with poor bearing capacities. They are likely to provide a poor subgrade for road pavements. They are also highly dispersive, erodible materials, with high linear shrinkage values, indicating they are prone to cracking. The soils are moderately to highly reactive to moisture, and significant ground movements in response to wetting and drying are likely.

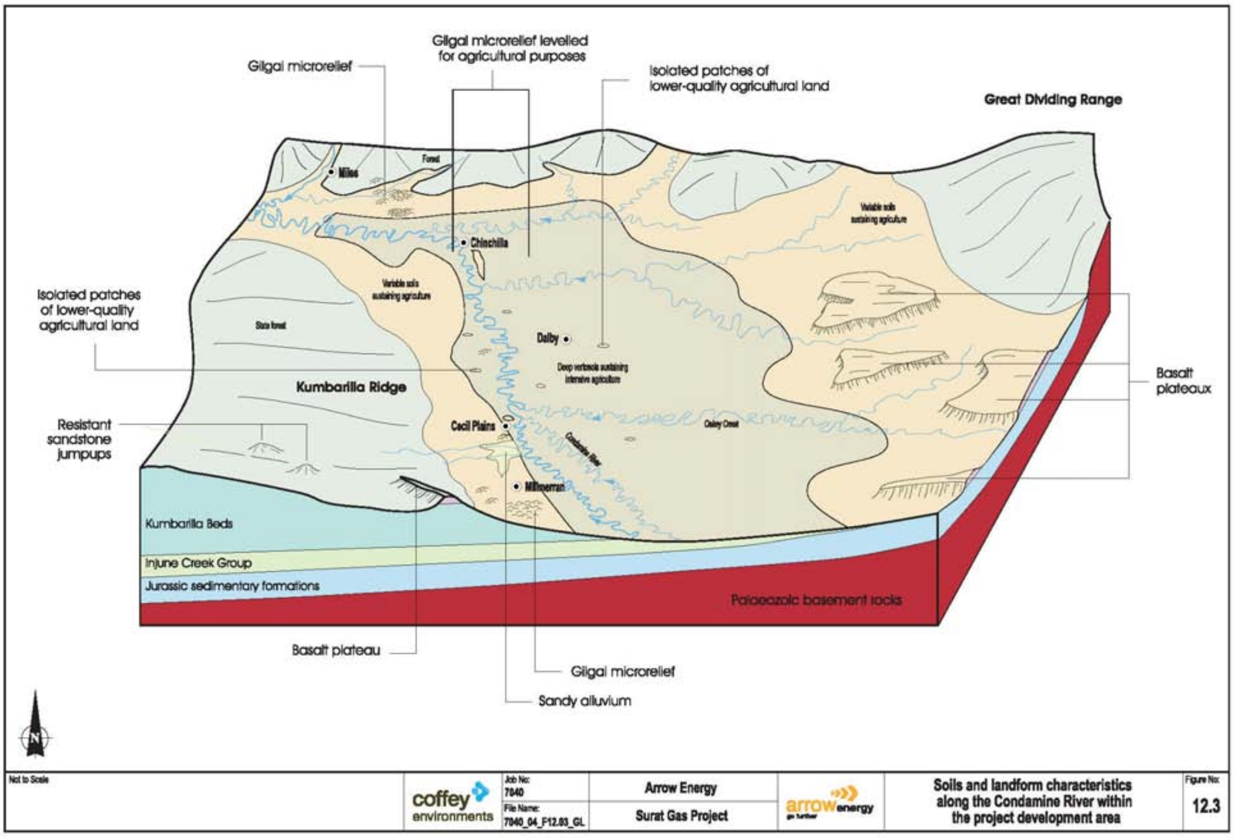

Figure 3 Soils and landform characteristics along the Condamine River within the project development area (source: EIS, Figure 12.3, Chapter 12 Geology, Landforms and Soils).

4.7.3.4 Good Quality Agricultural Land and Strategic Cropping Land

The EIS documents identified the extent of each of the four (A, B, C and D) classes of GQAL across project development area. The spatial extent of each class is shown in Table 7.

Table 7 Spatial extent and percentage of GQAL within the project development area (source: EIS Chapter 12).

GQAL Class	Area (ha)	% of project development area	Agricultural classification
A	438,000	52	GQAL
B	63,000	7	
C	347,000	41	Pasture land
D	400	Negligible	Non-agricultural land

Three specific sites of Geoheritage Environmental Significance were identified in the EIS. These are the Lake Broadwater Conservation Park, Chinchilla Sands Local Fossil Fauna Site and the Barakula State Forest Area and Scientific Area.

4.7.3.5 Terrain unit mapping

The overall landscape environmental values of the project development area, in terms of geology, landform and soils, were summarised using six broad terrain units. Each unit was subdivided on the basis of geology, landforms, soils, properties and processes. Sensitivity of the each unit to disturbance was also identified. All terrain units were rated as having a moderate sensitivity to disturbance.

4.7.3.6 Contaminated land

The EIS documents identified that the project development area comprised large tracts of ‘greenfield’ land that had not been subject to notifiable activities, uncontrolled activities or other contaminating land practices. Greenfield sites were considered to have relatively high environmental value in terms of contamination (as they are most likely to be free from contamination) that should be protected from:

- contamination resulting from the disturbance of any contaminated land encountered during works for the proposed project
- contamination caused by notifiable activities associated with CSG development (particularly chemical storage and petroleum product or oil storage).

The EIS noted that sites that already are contaminated or are at a higher risk of contamination due to historical or current activities have lower environmental values.

The EIS acknowledges that the project is likely to encounter some existing contaminated land and Arrow committed to avoiding these sites, to the extent possible. However, Arrow argued that complete avoidance of all contaminated sites was not always possible, as existing recording methods for contaminated land environmental values (i.e. the EMR and CLR) do not allow these values to be mapped and largely precludes consideration of site contamination as a tool for site selection. Also, as CSG is predominantly an industrial activity, the development of infrastructure may proceed on land that has existing or potential contamination (i.e. land of low and medium environmental value). Some activities associated with CSG development are notifiable activities in their own right (e.g. petroleum product storage and chemical storage).

4.7.4 Impacts

The EIS considered that the potential impacts on geology, landform and soil values from project activities include:

- land degradation as a result of erosion and associated sedimentation, dust generation and reduction in soil quality
- land contamination, including disturbance of existing contaminated land and potential to cause land contamination through project activities
- disturbance or accidental damage of recognised fossil sites.

Activities with the potential to cause these adverse impacts were identified for the construction, operational and decommissioning phases of the project. EIS, Sections 12.4.1; 12.4.2 and 12.4.3 described project activities for each phase and their potential impacts. Similarly, Section 12.4.4 described project activities likely to impact on contaminated land including the potential to cause contamination as a result of disturbance to contaminated land during project activities.

4.7.5 Avoidance and mitigation measures

EIS sections 12.5 and 12.6 outlined environmental protection and objectives for geology, landform and soil environmental values and the proposed avoidance, mitigation and management measures to be undertaken by Arrow to achieve the relevant objectives.

The objectives were identified as:

- maintain or restore soils and stabilise landforms to support the intended land use
- minimise alteration of drainage systems (natural and man-made)
- protect the Chinchilla Sands Local Fossil Fauna Site
- implement erosion and sediment control techniques to minimise project impacts
- protect the Barakula State Forest Area and Scientific Areas and the Lake Broadwater Conservation Park.

Environmental protection objectives with respect to land contamination are to:

- avoid or minimise the disturbance of contaminated land
- avoid the contamination of land (including soil and groundwater) or watercourses as a result of project activities (from exploration to decommissioning).

Avoidance, mitigation and management measures were proposed in the EIS to achieve the identified environmental protection objectives.

The EIS asserted that the primary means to achieve avoidance of geological, landform and soil related impacts would be through sound design and site selection. Arrow's framework approach focuses on early identification of sensitive locations that should be avoided by project activities, as described in Chapter 8, Environmental Framework.

Regarding contaminated land, the EIS outlines a number of general commitments by Arrow to avoid and manage contaminated land and prevent new contamination occurring. In terms of responsibility, Arrow clarified that for areas where Arrow is the landholder, the company would have full responsibility and control of the management of any contamination that is disturbed or caused. On land under other tenure, Arrow would need to consider the requests of the landholder while fulfilling its requirements under the EP Act.

4.7.6 Submissions

Submissions received on the EIS regarding the management of impacts on geology, landform and soils raised concerns regarding:

- soil compaction that would reduce agricultural productivity, even after restoration
- maintenance of fertility in stockpiled topsoil
- siting of tracks, pipelines that may divert water leading to soil erosion
- sediment and erosion management
- spoil stockpiles from underground infrastructure (pipes, cables, etc.) located near waterways diverting overland flow.

Key matters and responses by Arrow in the SREIS are discussed below.

4.7.6.1 Soil restoration

One of the most significant matters raised in submissions from several government agencies, catchment groups and particularly landholders, concerned the restoration of productive soils that had been compacted during the construction or operational phases. Of particular concern was the need to retain and restore productivity of the black clay (vertosol) soils of the Condamine floodplain. A number of submissions extended this concern to cover the restoration of all project impacts, not only compaction on areas of hilghyproductive agricultural soil such as vertosols.

Arrow acknowledged in the SREIS, the potential for these to be residual impacts on productive soils depending on the ability to rehabilitate disturbed land to its former use. Land that cannot be rehabilitated to its former use may lead to a residual permanent change in that land use.

In regards to vertosol soils, Arrow acknowledged that for CGPF and WTF, ground disturbed during the construction and operational phases would not be able to be restored to its original land use; however, these facilities are not proposed to be located on vertosols. For other impacts, Arrow contends that vertosols can and have been successfully rehabilitated and restored to their former use. An example given in the EIS documents is the restoration of the right of way (ROW) for the Roma to Brisbane gas pipeline which, for part of its length, passes between Dalby and Gatton. Arrow argued that the alignment has been successfully rehabilitated and farmed for over 20 years. To minimise and manage impacts on vertosols, Arrow commits to considering the site-specific conditions and the results of negotiations with landholders on specific farming practices in the layout, design, and construction methods used to install production wells and access tracks on vertosols for the project.

Regarding soil compaction, Arrow reported that it is undertaking additional work programs which include a review of the best methods to limit and manage soil compaction around project infrastructure. Methods being investigated include avoidance where possible and alternative access and vehicle specifications such as swamp matting or caterpillar tracks.

In addition, should the project proceed, Arrow noted that it would be required to meet the regulatory requirements of an environmental authority issued under the EP Act which would specify rehabilitation outcomes that would need to be achieved. DNRM advised that this matter would be assessed and regulated under the SCL Act

Rehabilitation of vertosols is also a matter dealt with in Section 4.8 (Agriculture) of this assessment report.

Submissions from a number of landholders, Cotton Australia and Cotton Growers raised concerns regarding the challenges of successfully rehabilitating floodplain soils that would be used for gravelled tracks that were not existing roadways. Arrow's response included the commitment to consult and seek to reach agreement with landholders on the appropriate location for infrastructure and access routes (e.g. to well sites and to and along pipelines). Arrow also committed to clearly identifying the outcomes of individual discussions on scaled plans of properies and to clearly indicate agreed access routes using signs, temporary fencing, barricade tape or traffic control measures (C084). The company also reported that in many cases, it is likely that, at landholders request, gavelled access tracks would remain in place after completion of the project. Where the aggregate material required removal after project-related infrastructure was no longer required, the area would be rehabilitated. Arrow committed to developing a rehabilitation plan based on environmental sensitivities that address ground preparation requirements, natural and constructed drainage patterns, soil erodibility, contamination, slope steepness and length, rainfall frequency and intensity, potential flow magnitudes, vegetation cover, land use and landholder requirements (C070). Further, Arrow stated that these site-specific details would be provided as the development progressed, and infrastructure locations were determined and negotiated with landholders. The rehabilitation plan would be developed prior to commencing ground disturbance activities, and would detail the procedures and methods to be used.

However, Arrow did not provide compelling evidence to demonstrate that all gravelled access tracks could be successfully rehabilitated to an acceptable degree. If the tracks are on SCL, then the requirements of the SCL Act would need to be met, which would include either meeting the Strategic Cropping Land Standard Conditions Code for Resource Activities (DNRM, 2012) or obtaining a compliance certificate under the SCL Act. DNRM stated that the project would need to demonstrate successful reinstatement of disturbed areas, including gravelled access tracks and padded areas, to meet the current SCL criteria.

A related concern highlighted in some submissions on the EIS was the proposal to rehabilitate and stockpile top soils subject to long term storage. Arrow reported that it is investigating ways to reduce the loss of organic content and fertility in productive soils expected to require long term storage. This may include avoiding the use of stockpiles, and alternative placement and management methods. A new commitment to address this issue has been included in the SREIS which states that Arrow would 'stabilise and revegetate long-term stockpiles as soon as possible to reduce potential for erosion' (C542). Arrow contends that detailed management measures associated with long-term soil storage would be developed when infrastructure locations are identified, and specific soil conditions are determined. These stockpile management measures would be negotiated and agreed with landholders prior to the commencement of ground disturbance activities.

4.7.6.2 Impacts on farming activities

In submissions on the EIS, the former DERM and landholders raised concerns with the location and rehabilitation of tracks. In brief, the concerns incuded difficulties of access during wet conditions (produced by rainfall or irrigation) or flood conditions, particularly on black clay soils; the diversion of overland flow by soil stockpiles or tracks affecting farming practices and resulting in erosion; and the potential for flood debris causing damage to gas infrastructure necessitating attention during wet conditions.

Arrow responded by acknowledging the issues associated with built up roads. Commitments were made to locate infrastructure through agreement with relevant landholders. Further, Arrow would avoid disrupting overland flow paths, and where avoidance was not practicable, maintain connectivity of flow in watercourses (C053). This commitment would assist in mitigating the effects of project infrastructure on erosion and sedimentation due to overland flow. Arrow would develop an erosion and sediment control plan and install and maintain appropriate site-specific controls, established on the basis of the sensitivity of the surrounding environment (C034). The Best Practice Erosion and Sediment Control Manual (IECA, 2008) would be used in the preparation of the erosion and sediment control plan, along with topographic LIDAR data and landholder information.

Regarding access and potential for floods causing damage to infrastructure, Arrow reported that well site remote telemetry units (RTUs) would be used to monitor well site infrastructure, and to initiate shutdown in response to incidents. Well site infrastructure would be fenced which would help to protect it from flood related debris; the design of the fence would be dependent on considerations such as location, risk assessment, and outcomes of liaison with landholders. Any potential damage resulting from debris movement during a flood event would be dealt with through Arrow’s emergency response plan.

Regarding the positioning of soil stockpiles, Arrow committed to negotiating with landholders, and to implementing agreed erosion and sediment control plans tailored to the specific impacts and mitigation measures required for individual sites. The Best Practice Erosion and Sediment Control Manual (IECA, 2008) would be used in the preparation of the erosion and sediment control plan, along with topographic LIDAR data and landholder information. Also, where relevant, the Strategic Cropping Land Standard Conditions Code for Resource Activities (DNRM, 2012) would be met. If stockpiles are to be stored within a road reserve, the final placement would be agreed with the relevant road authority (whether local, state or federally controlled).

4.7.6.3 Contaminated land

Submissions on the EIS regarding proposed measures to manage impacts related to contamination included:

- responsibility for listing notifiable activities
- risks of brine storage and potential contaminants
- particular requirements for preventing spills and leaks on cracking clay soils
- dealing with exiting contaminated sites.

A number of submissions, from landholders and a community group, requested clarification on the responsibility for listing brine waste facilities on the EMR. In response, Arrow stated its preference, as set out in SREIS Attachment 5, Coal Seam Gas Water and Salt Management Strategy, was to pipe brine to a selective salt recovery plant for treatment. Using enhanced precipitation and chemical processes, the brine could then be transformed into commercial products including various salts including soda ash. It is intended by Arrow that all the properties identified for major facilities (such as compressor stations, water treatment facilities, etc.) would either be owned by Arrow, or held under a long-term lease arrangement. Facilities would need to be registered as waste facilities and may require listing on the EMR. Arrow would be responsible for obtaining these listings. Brine dams for the temporary storage of brine will be designed in accordance with the Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (EHP, 2012c).

In response to other concerns raised in submissions regarding the potential for environmental contamination from spills and leaks. Arrow committed to designing, constructing and maintaining the gathering system network in accordance with the APIA code of practice Upstream PE gathering networks CSG industry version 2.0, or relevant Australian standards to reduce the potential for failure (C444).

On the matter of decommissioning, one submission questioned whether the inert gas/water used to decommission gas pipelines leaks would result in contamination of the soil. Arrows responded that the inert material used to fill the pipelines for decommissioning would be non-reactive and isolated from any source of potential contamination.

Landholders questioned who would be responsible for notifying EHP of notifiable activities (as defined under the EP Act) occurring on their properties. Arrow clarified these responsibilities in its SREIS response. For project infrastructure located on private properties, such as wells, gathering lines and access tracks, there would be no requirements to list land parcels on the EMR as no notifiable activities would be associated with the construction, operation and decommissioning of this infrastructure. For non-facility sites, a maximum hydrocarbon storage capacity of 25kL would be enforced to prevent the need for EMR listing. Arrow also clarified that a property would only be listed on the Contaminated Land Register (CLR) by EHP if a scientific investigation shows the land is contaminated, and that action was needed to remediate or manage the land. In addition, Arrow contended that application of the mitigation and management measures detailed in EIS Chapter 12, Soils, Landform and Geology, Section 12.6.3 would reduce the potential for soil or groundwater to be contaminated by project. EHP has confirmed that the information provided by Arrow on notification is correct.

A number of comments in submissions were made about the potential for spills and leaks, particularly leaks from pipes laid in cracking clay soils. Arrow stated that it would design, construct and maintain the gathering system network in accordance with the APIA code of practice Upstream PE gathering networks CSG industry version 2.0, or relevant Australian standards (C444) including those pipelines built on cracking clays to reduce the potential for failure. High pressure gas pipelines would be constructed in accordance with AS 2885.1-2012. Also, if necessary, pipelines would be buried deeper in cracking clay soils. Under the EP Act, Arrow is legally required to remediate any contamination caused by project activities. Remediation goals including the identification of proposed land uses would be determined as part of a Remediation Action Plan (RAP) which would be developed in line with the Guidelines for Contaminated Land Professionals (EHP, 2012a) should land contamination occur. A validation sampling program would be conducted to verify that the site has been successfully remediated according to the objectives identified in the RAP.

A number of submissions on the EIS by landholders and landholder organisations raised concerns with the potential for contamination of cropping land and groundwater by salt contained in CSG water as a result of deliberate or accidental release from wells, pipelines, and storages. Submissions also challenged the feasibility of options for use or disposal of water and associated salt.

Arrow stated that the feasibility of potential management strategies remained under investigation and consequently that the actual use or disposal of CSG water remains undefined. In selecting one or more option, Arrow noted that it would have to comply with the requirements of an environmental authority under the EP Act as well as the *Water Supply (Safety and Reliability) Act 2008* for beneficial uses. Arrow has made a number of commitments relating to the design and management of water gathering, storage, treatment and use/disposal systems which, if implemented, would minimise the risk of land contamination by salt. These commitments include meeting industry design and construction standards designed to minimise risk of failures that would result in contaminants being discharged.

4.7.7 Conclusion

The description of geology, landform and soils within the project development area was adequate to meet the requirements of the TOR. The EIS documents provided a qualitative assessment of potential impacts of the project, estimates of mitigation of impact through implementation of stated measures, and estimates of the residual impact on specific aquatic ecology values.

As the actual location of project infrastructure was not defined, the impacts on geology, landform and soils could not be expressed quantitatively and auditable objectives were not stated. A number of commitments to avoid, minimise and manage impacts on landform and soils in particular were provided in EIS Chapter 12, section 12.6. This included initiatives to provide greater certainty regarding the restoration and rehabilitation of vertosols impacted by compaction.

Detailed measures for management of risks associated with accidental releases or spills were proposed to be included in management plans, to be developed as part of the approvals for the delivery of the project.

4.7.8 Outstanding matters for approvals

Arrow has acknowledged the need to provide further detailed technical information to support applications to amend the existing the environmental authority of the Dalby Expansion Project, or to apply for new environmental authorities. Details of the information requirements for an application under EP Act are provided in Appendix 4.

DNRM advised that additional information would be needed to meet the application requirements under the SCL Act, particularly regarding the reinstatement of soils impacted by disturbance and/or compaction, or that were gravelled and used as access tracks and padded areas.

The EIS included a number of commitments relevant to avoiding, minimising and managing impacts on geology, landform and soils. These commitments, some of which were updated in the SREIS due to changes in the project description and in response to submissions on the EIS, are stated in Appendix 3. Table 8 outlines geology, landform and soils commitments and recommended changes includes recommendations for changes to some of the suite of commitments made by Arrow relevant to geology, landforms and soils. All commitments should be implemented by Arrow (once appropriate changes have been made) and fully integrated in the proposed project delivery plans, operational plans and rehabilitation plans.

Table 8 Geology, landform and soils commitments recommended changes

Commitment Number	Commitment	Recommendation
C034	Develop an erosion and sediment control plan and install and maintain appropriate site-specific controls, established on the basis of the sensitivity of the surrounding environment	The plan should be tailored to meet the particular constraints and sensitivities encountered in the project's drainage areas, and incorporated in the wide area planning activity. Plans should include procedures for regular inspection and remediation when necessary
C040	Undertake an environmental site assessment in response to the identification of contamination that may have occurred as a result of project activities	If necessary, undertake remediation actions relevant to the contamination
C041	Avoid the Chinchilla Sands Local Fossil Fauna Site and educate project personnel on the importance of the site	The Chinchilla Sands Local Fossil Fauna Site should be a 'no go' area in the constraints maps
C045	Time construction works and access to sites to avoid wetter periods, where practicable	This should include irrigation scheduling, where relevant
C049	Avoid development on contaminated land through the completion of appropriate register	Should be undertaken as part of the site selection planning process

Commitment Number	Commitment	Recommendation
	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)	
C053	Avoid disrupting overland natural flow paths and, where avoidance is not practicable, maintain connectivity of flow in watercourses	Infrastructure should be designed and constructed to maintain overland flow paths. On-going maintenance, particularly after major rainfall events, should be undertaken
C067	Ensure coal seam gas water used on highly productive soils is of comparable water quality to that used for irrigation in the specific area	Untreated CSG water should not be used for dust control and other purposes unless specifically regulated by the environmental authority
C073	Excavate any saline material during rehabilitation of coal seam water dams or brine dams and select an appropriate option for management for the material (e.g., treat for reuse, or dispose of in a registered landfill)	Coal seam water dams should not and brine dams should not be constructed on SCL or IFL

4.8 Agriculture

Chapter 13 Agriculture of the EIS described the existing agricultural industries within the project development area and provided an assessment of the potential for these industries to be adversely impacted by the project. Appendix F Agriculture provided detailed information as a basis for the assessment. The SREIS Chapter 7 provides revised information on project impacts on Agriculture due to changes in the project description (SREIS Chapter 3 Project Description) including an update on agricultural economics (Appendix 3 Supplementary Agricultural Economics Report).

Other Chapters of the EIS documents relevant to agriculture deal with potential project impacts include geology, landform and soils, surface and groundwater, air, noise, waste, economics, transport and social. These are dealt with separately in the relevant sections of this assessment report.

Submissions on the EIS, many from landholders in the project area, raised a number of concerns regarding the detrimental impacts of the project and the likely success of proposed mitigation measures. The SREIS describes these concerns as fitting into the following broad areas: land access, agricultural value, animal welfare/biosecurity concerns, brine management, co-existence, farming practices, good quality agricultural land and requirements of SCL legislation, management measures, electricity, pipelines and rehabilitation. A summary of submissions concerning agriculture was provided in the SREIS, as well as a response to the substantial matters raised in the submissions. Key matters raised in the EIS submissions and responses by Arrow in the SREIS are discussed in the relevant sections below.

4.8.1 Assessment methodology

The EIS described the legislative context of the project in terms of the laws, policies and guidelines that provide the planning framework for the protection of high quality agricultural land. It described the implications of this framework for CSG operations and the project overall. The SCL Act had not commenced when the EIS was prepared. As a result, details of the implications of this legislation for the project were provided in the SREIS (Section 2.4.1).

The assessment methods for agriculture used in the EIS comprised a desktop study of the project development area to identify and describe agricultural enterprises and activities, features of the project development area contributing to their success and viability, potential detrimental impacts of the project, and propose management measures to address such impacts.

Sources of information used in the assessment included the Australian Bureau of Statistics, government websites and literature reviews of related studies. The assessment was supported by a technical report (EIS, Appendix F) which provided details of the agricultural resource base, agricultural industries (including forestry), agricultural management practices and timing, potential impacts, and mitigation measures (including comments on the effectiveness of the proposed measures).

The revised project description in the SREIS outlines changes to the project having the potential to reduce impacts on agriculture as a result of advances in field development planning. In brief, changes would result in a:

- reduction in the size of the project development area from 8,600km^2 to 6,100km^2
- revision of project development sequence and timing:
  - this would include the separation of the project development area into 11 drainage areas. The project would initially develop in eight of the identified project drainage areas (drainage areas 1, 2, 5, 7, 8, 9, 10 and 11). Each drainage basin would incorporate wells, a water gathering network, a gas gathering network and a CGPF. A further three drainage areas may be developed, depending on favourable reservoir outcomes and future market conditions.
  - development of six CGPFs and associated wells, gathering lines and other infrastructure in the first six years of the project.
  - no integrated processing facilities are proposed in the updated conceptual development plan however, eight CGPFs would be operational in the initial six year period.
- reduction in the number of facilities and wells with the total number of wells reduced from 7,500 to 6,500.
- the use of multi-well pads. Arrow has proposed that 30% of wells would be conventional vertical wells (with a disturbance area of 1ha) and the rest multi-well pads (with up to 12 wells per pad and a disturbance area of 2ha). The use of multiwell pads provides more flexibility in well location, a significant matter in IFL
- an increased requirement for aggregate
- the preference for grid power to be installed with the gathering systems (in the same right of way) where possible
- a reduction in the number of water treatment facilities.

The implications of these changes for agricultural production, as well as changes in the legislative and regulatory environment for agriculture, are described in the SREIS Chapter 7.

Several submissions on the EIS, including those by Agforce and Australian Farmers Federation, were critical of the desktop study method used to describe and assess impacts on agriculture. The SREIS stated that the desktop study was supplemented with advice obtained in consultation with the Arrow IFL Committee and other forums comprising representatives of the main farming enterprises undertaken in the project development area.

4.8.2 Existing values

4.8.2.1 Agricultural industries

The EIS identified the main agricultural industries undertaken in the project area. These include broad acre farming of cereal, pulse and cotton crops, irrigated broad acre farming primarily of cotton and cereal crops, horticulture, fruit production, vineyards, intensive livestock industries, rangeland grazing, and timber production.

The total gross value of agricultural production in the Darling Downs Statistical Division (DDSD) was reported in the EIS as being $1.7 billion in 2006. This value was challenged in submissions on the EIS as due to the drought conditions affecting production at that time. A Supplementary Agricultural report was provided in the SREIS (Appendix 14) using data from the 2010–11 Agricultural Census and other data sources. The 2010–2011 figures show a large increase in the value of agricultural production in the DDSD due to increases in production of wheat, sorghum, barley, maize, mung beans and record crops of cotton. It was noted that this growth was largely a result of improved cropping seasons. The Supplementary Agricultural report also provided an outline of trends in the mix of agricultural activities in the DDSD:

- Cereal crop and cotton production levels were considerably higher in 2000–01 and 2010–11 compared to those recorded in 2006–07 during a period of drought.
- Horticulture and crops cut for hay experienced lower production levels in 2000-01 and 2010-11 compared to 2006–07.
- Sheep and lamb numbers have declined since 2000–01.
- Poultry numbers have increased since 2000–01.
- Area used for agriculture has declined by approximately 2 million hectares from 2000–01 to 2010–11.

The Supplementary Agricultural report identifies flood and droughts as being the most notable influences on agriculture in the project area contributing to increased industry costs. The report also stated that there has been a decline in demand for products due to the global financial crisis. The Supplementary Agricultural report also projected that competition for resources (particularly land) from future residents and non-agricultural industry expansion will continue.

4.8.2.2 Agricultural productivity

A brief description of climate and soils was provided in the EIS and Appendix F. A detailed description of soils was provided in Chapter 12 Geology, Landform and Soils and in the EIS Appendix E Geology, Landform and Soils.

The EIS (Appendix F, Agriculture Report), states that good quality agricultural land (GQAL) covers approximately 59% of the project development area with the balance comprising other agricultural areas, crown land, state forest and industrial areas. Potential SCL comprises approximately 49% of the project development area and is mostly coincident with mapped GQAL.

Arrow puts a new category of agricultural land forward in the EIS documents which it termed ‘intensively farmed land’ (IFL) and provides specific conditions for managing impacts on such land. IFL is considered by Arrow as being a subset of SCL. As defined by Arrow, IFL refers to land actively being used for broad acre cropping, using either dry land or irrigated farming practices having been altered to suit those particular cropping purposes—e.g. laser levelled, irrigation channels and water supply dams. For the purposes of Arrow’s petroleum tenures, IFL applies to areas over the Condamine Alluvium, on Authority to Prospect (ATP) 683 and 676.

4.8.3 Impacts

The EIS (Chapter 13 and Appendix F agriculture report) and SREIS (Chapter 7) provided an overview of the potential impact of the project on agriculture. Activities associated with the construction, operational and decommissioning phases of the project were considered in terms of the potential of the project to cause adverse impacts on agricultural enterprises in the project development areas. Consideration was given to disturbance to the soil profile and its function, disruption of machinery operations, impediments to farm workability, increased or new management overheads, and loss of amenity. More specifically, potential direct and indirect impacts of the project on agriculture considered in the EIS documents included:

- loss of productive land (temporarily and potentially permanently) from the development of CSG production facilities
- temporary or permanent disturbance and potential diminished productivity as a result of the development of

wells, gathering systems, pipelines and access tracks
- reduced crop yield from unsuccessful rehabilitation
- disruption to farm operations, such as tillage, planting, irrigation, weed control and harvesting, from inappropriate placement of wells, gathering systems, pipelines and access tracks
- disruption to intensive farming operations, including piggeries, poultry operations, feedlots and dairy farms, from inappropriate placement of production facilities, wells, gathering systems, pipelines and access tracks
- soil degradation from disturbance of the soil structure from all project activities, resulting in impacts to fertility and biologic function and crop yield
- changes to surface irrigation infrastructure, including head ditches, bays and tail drains, from inappropriate placement of wells, gathering systems, pipelines and access tracks
- diversion of flows and changes to the hydrology of the landscape from poorly sited or constructed access tracks
- farm hygiene issues relating to weeds and disease management from construction and operations vehicles, plant and equipment
- site contamination from all project activities.

A general discussion of these impacts on agriculture in the project development area was provided in the EIS (section 13.4). However, limited information was provided on the potential or real extent of impacts and the significance of such impacts on agricultural industries and enterprises.

4.8.3.1 Area of impact

Overall, the EIS documents provide limited quantitative assessment of agricultural impacts of the project. This was in large part due to the scale and necessary scheduling of the project under consideration. The following quantitative estimates of impacts were reported:

- **Area of infrastructure disturbance**—The EIS documents describe the maximum areas of disturbance for specific types of infrastructure associated with the project that would be likely to impact on agriculture, including easement widths, pipe burying depths and other details associated with the proposed infrastructure. These are summarised in Table 4.8.1. For some project infrastructure, the footprint and area of disturbance was not, or could not be, quantified in the EIS documents. These are summarised in Table 4.8.2.
- **Total disturbance footprint**—The EIS documents report a direct disturbance footprint of 2 to 3% for each production unit. This provides an indication of the likely extent of disturbance on each property where development would occur. This estimate is based on Arrow's current operations and their experience in working with landholders to site CSG infrastructure on their properties. It includes production well sites and associated gathering lines and access track footprints. No further information was provided in the EIS on the proportion of agricultural land likely to be impacted within this footprint. However, considering the main land use within the project development area is agriculture, a major proportion of the direct footprint of the project is likely to be on agricultural land.
- **Impact on intensive farming operations**—The EIS documents contend that there would be negligible direct impacts of the project on intensive farming enterprises. This view was based on the assumption that Arrow would deliver on its commitment that the project would avoid infrastructure and associated farm management areas of intensive farming operations, including: piggeries; feedlots; vineyards; orchards; horticultural enterprises; poultry farms and small lot plantations.
- **Impacts on IFL**—the EIS documents concluded that direct impacts of the project's operation activities on IFL, would be restricted to some 2% (on average) of the overall area of IFL in the project development area. This estimate assumes Arrow deliver commitments to mitigate impacts on IFL (this is discussed further in section 4.8.1.3 of this assessment report).

The EIS documents did not provide quantitative estimates of the:

- direct or indirect impacts on agriculture (other than providing indicative estimates of the likely area of disturbance of individual infrastructure facilities—see Table 9 and Table 10)
- direct or indirect impacts of the project on specific parcels of IFL, GQAL, SCL and agricultural enterprises (which could include multiple properties). Arrow argued that it was not possible to accurately estimate such impacts during the EIS process because the locations of all proposed infrastructure are not known, particularly wells, gathering lines and related infrastructure.

Table 9 Disturbance area estimates for specific infrastructure (source: EIS documents)

Infrastructure	Disturbance area/footprint
Low pressure gas gathering line corridors	20m wide
Medium pressure gas gathering line corridors	25m wide; 15–25km long
Single gas well pads	100m by 100m (1ha) for construction. Less during operation
Multi-well pads	200 by 100m for construction. Less during operation
Field compression facilities	100m by 50m – maximum 6 facilities
Central Gas Processing Facility	350m by 520m (four of six located)
Coal seam gas water treatment facilities	202ha (two required, two located)
Underground power line corridors	20m and 1.2m deep (typical) – possibly co-located with pipelines
132-kV overhead transmission lines corridors	up to 60m
275-kV overhead transmission lines	up to 120m wide easements
Temporary Workers Accommodation Facilities	500m by 500m (one of four located)
Total disturbance footprint	estimate of 2–3% of area of each production unit
TOTAL PROJECT AREA	**6,100 km^2**

Table 10 Disturbance area estimates for additional project infrastructure (source: EIS documents).

Infrastructure	Comments and predicted impacts
Small mobile drilling camps (less than 20 persons)	Small mobile drilling camps may be established on Arrow-owned or leased properties
Infrastructure associated with groundwater monitoring program	A groundwater monitoring program will be required by the Office of Groundwater Impact Assessment (DNRM) that would detect impacts from authorised petroleum activities which pose a significant risk to groundwater quality and seepage from any regulated dam. The number and location of bores needed would be determined for each environmental authority
Gas and water gathering systems	Gas and water gathering systems would need to be installed as well as low-point drains (disturbance area of 5m by 5m), high-point vents (3m by 3m) and pump transfer stations (50m by 50m)
Infrastructure associate with Brine and Salt management	Arrow reported in the SREIS that a range of options for managing brine were being investigated and these are described in the Brine and Salt Management Options section in the SREIS. Arrow’s preferred option is a salt recovery plant requiring brine concentrators and possibly transfer pipelines would be required. The siting and disturbance associated with the preferred or other options has not been identified. Specific approvals, necessitating Arrow to provide information on the location, impacts, mitigation and management would be required. Proposed management of brine is dealt with in section 4.21 Waste, of this report

Infrastructure	Comments and predicted impacts
Infrastructure associate with beneficial use of coal seam gas water	Arrow plans to distribute treated and untreated coal seam gas water to end users for beneficial use. This would be likely to entail a pipeline between the water treatment facilities to be co-located with GCPF2 (located north of Miles on Bottle Tree Creek) and CGPF9 (located near Cecil Plains) as well as a distribution network. No estimate of the disturbance associated with the pipelines was provided. According to the SREIS the pipelines will be co-located with water and gas gathering lines
Water discharge sites	Another potential impact of the project described in the SREIS is the proposal to discharge treated and possibly untreated CSG water at two sites within the project area. The proposed discharge of water from the treatment plants is assessed in section 4.10 of this report

4.8.3.2 Location of impacts

The EIS Chapter 8 Environmental Framework describes an environmental framework to address uncertainty about the location of infrastructure. The framework approach analyses potential constraints on the location of project infrastructure and uses constraint maps and environmental controls to inform site selection and development plans, as well as the environmental management of construction, operation and decommissioning activities. However, apart from the identification of constraints associated with the proximity to sensitive receptors (mainly dwellings), and the avoidance of intensive agricultural facilities (piggeries, feedlots, etc.), the constraints mapping approach does not include site-specific impacts on agriculture.

A number of submissions on the EIS requested more detailed information, not only in the sequence and layout of the project across the project development area, but more importantly, in the specific siting and layout of the wells, gathering lines and associated infrastructure, at a property and district scale. Arrow did not provide the full details of the location of facilities needed by the project in the amended project description in the SREIS. However, it did provide some additional information in the SREIS. This included:

- an example of how Arrow would apply its ‘framework approach’ in conjunction with the relevant commitments to locate major infrastructure components of the project
- details of the siting of four of the eight CGPFs, co-location of two water treatment plants with CGPFs, and the location of one of five TWAF
- a description of two proposed sites for process water discharges as well as indicative development sequence for the first 20 years of the project life
- additional details on how Arrow would determine the location of wells and gathering lines (e.g. well spacing, use of multi well pads, etc.), particularly on IFL.

The specific locations of wells, gathering lines and other CSG infrastructure were not provided in the EIS documents. Arrow argued this was because the location of these facilities would be subject to negotiation and formal access and compensation agreements, would only be finalised after Arrow had obtained the necessary environmental and tenure approvals.

4.8.3.3 Significance of impacts

The EIS documents does not adequately consider the differences in the significance of potential impacts for different agricultural enterprises/types. It acknowledges differences between agriculture types (e.g. grazing versus farming) and identifies that each agricultural enterprise is unique and has developed practices to maximise productivity of the land. However, there is limited assessment in the EIS recognising that the magnitude and significance of impacts would differ significantly, depending on the type of agricultural activities involved and for individual landholders and enterprises.

4.8.3.4 Other impacts

As almost all CSG activities have the potential to impact on agriculture, other sections of this report address these matters relevant to agriculture. One matter of concern to the farming industry (and to some extent grazing interests), particularly those using groundwater from the Condamine Alluvium, is the potential for the project to adversely impact on the quantity and quality of groundwater supplies by the extraction of associated water. This matter is addressed in section 4.9 Groundwater of this assessment report. Similarly, potential impacts on surface water and details of measures that would be used to avoid and minimise impacts on surface water are assessed in section 4.10 Surface Water of this assessment report.

The EIS acknowledged that the project would have an economic impact on agriculture and an analysis of this impact was provided in Chapter 21 and Appendix O. A cost benefit analysis of the project was included in this economic assessment. While the SREIS included an Analysis of Agricultural Production and Issues in the Darling Downs: Surat Gas Project Supplementary Report to the Environmental Impact Statement as Appendix 14 to the SREIS, this report was not intended to address the impacts of the project on agriculture in the project development area, but provided an updated description of agriculture in the Darling Downs statistical division from that given in the EIS.

An assessment of the economic analysis from the EIS documents is provided in section 4.16 of this assessment report.

4.8.4 Avoidance and mitigation measures

The EIS (Chapter 13 and Appendix F agriculture report) and SREIS (Chapter 7) outlined strategies that would be applied to avoid and minimise detrimental impacts from the project. Twelve performance based objectives for the implementation of the project and the mitigation of its impact on agriculture were outlined. These 12 objectives are supported by 55 commitments in the EIS documents that would be applied by Arrow in order to avoid, minimise or compensate for impacts.

These commitments address a range of issues such as: meeting legislative requirements (including consultation with landholders) and rehabilitation; reducing impacts on productivity and production costs; reducing crop losses and disturbance to stock; managing soil disturbance; minimising increased costs of farm management; and addressing the loss of amenity due to potential impacts of the project. The SREIS describes an update to one commitment concerning management of topsoil stockpiles and buried pipelines on potential SCL. Commitments to engage with the Condamine River floodplain community through Arrow's Intensively Farmed Land Committee, Arrow Surat Community Reference Group, GasFields Commission Queensland, irrigator groups, community information sessions and ongoing consultation with individuals and interested groups are also provided.

Most measures and commitments outlined in the EIS to avoid and minimise detrimental impacts on agriculture are general and would apply to both grazing and cropping land. Opportunities to avoid, minimise and manage these impacts will vary depending on the specific agricultural enterprises/types. To this extent, the EIS documents include a number of avoidance and mitigation measures for impacts on cropping land, particularly irrigated cropping on the extensive floodplains of the Condamine River. These measures are the subject of many of the concerns raised in submissions on the EIS and are discussed further in section 4.8.5 of this assessment report. The EIS documents also outline Arrow's intentions to investigate the effectiveness of the proposed environmental management controls through trials and case studies, primarily focused on the rehabilitation of black cracking clays - a matter identified as requiring particular attention due to the recovery time needed to restore soil function.

Submissions on the EIS were critical of the wording in some of Arrow's commitments. In responding to these concerns, Arrow stated that commitments had been made on the basis that, in the majority of cases, these management measures can be implemented. The use of 'where practicable' or 'to the greatest extent practicable' had been included to cover those circumstances where management measures may not be feasible or able to be implemented as stipulated, due to other constraints; for example, weather or seasonality issues, or specific land use on properties that required a different approach. Arrow would need to address the exceptions, where their commitments would not apply, in the site-specific planning and management plans that would be required to obtain the necessary approvals to carry out petroleum activities at those sites.

The following three sections of this assessment report discuss the key avoidance strategies, mitigation measures and commitments for relevant stages of the project: site planning and construction of infrastructure (wells, facilities, linear infrastructure, etc.); operations; and rehabilitation. Measures for biosecurity are also discussed.

4.8.4.1 Siting and construction of project infrastructure

The EIS documents state that the final siting of infrastructure and the specific orientation and layout of each facility would be determined based on site-specific land and environmental features, such as remnant vegetation, topography, soils and the proximity of sensitive receptors. Commitments to undertake site-specific surveys for particular features (e.g. soils and vegetation) are included in the EIS. Arrow also committed to designing and constructing facilities to minimise its footprint and environmental impact. Arrow contends that specific issues of planning and operating infrastructure will be addressed with individual landholders through the negotiation of a conduct and compensation agreement.

4.8.4.2 Co-existence of coal seam gas and agriculture

In the SREIS, Arrow provided a brief discussion on how it would pursue co-existence between the project and agriculture. Arrow considers co-existence to mean allowing the region to enjoy the full benefits of both agricultural enterprises and resource industries, while ensuring that the resource footprint is minimised, that there is no permanent damage to the productive capacity of that land, and that landholders are fairly compensated for short-term impacts. Arrow considers that it will demonstrate coexistence in collaboration with landholders by undertaking:

- predevelopment design work to minimise Arrow's footprint
- best practice construction management to minimise Arrow's impact on soil during the drilling phase
- best practice operational management to minimise Arrow's impact on farm productivity.

The SREIS also reports that Arrow is investigating best practise management to minimise impact on soil during the construction of well pads, wells and their gathering systems as well as developing a method for assessing impacts to productivity (crop yields).

In the SREIS, Arrow described a range of measures it would apply to achieve integrateion of acceptable CSG activities and coexistence with agriculture, particularly on IFL. These proposed measures include:

- application of Arrow's 12 coexistence commitments
- mapping IFL at a property scale and taking this into account in deciding the location of CSG facilities
- area wide planning of multiple properties. Arrow has commenced a process of area wide planning which incorporates negotiations with individual landholders into an integrated plan across neighbours and catchment areas. This process aims to balance individual needs of landholders with the needs of neighbouring properties to understand the potential impacts gas field infrastructure may have on farming operations and address how these impacts can be mitigated or reduced
- demonstration of the integration of CSG activities and agriculture at Arrow's Theten property
- access protocol—being developed to minimise disruption to farming activities
- a compensation business case.

4.8.4.3 Individual farming activities

In terms of the mpacts of the project on farm workability, the EIS acknowledged that each agricultural enterprise is unique and has developed particular practices to maximise productivity of the land. While the EIS (EIS Chapter 13.4.3) identified the potential impacts ofCSG facilities on farm layout and workability (particularly on irrigated soils) and a number of mitigation measures (mainly through site selection for infrastructure and footprint minimisation) were provided, landholders raised numerous concerns about how disruptions to agricultural activities and farm workability at a property/enterprise scale would be minimised and managed on an ongoing basis.

In response to specific concerns in submissions by landholders in the EIS on the location of CSG infrastructure at a field scale, Arrow responded by referring to a number of commitments made in relation to negotiating the siting of infrastructure on individual properties. These included a commitment to consider the following measures in reaching agreement with landholders:

- Location of infrastructure (in order of preference) outside of cultivation areas, in headlands or at the corners of cultivated areas, adjacent to boundary fences or in areas of a paddock with the lowest-quality soil.
- Location of access tracks in headlands or adjacent to boundary fences.
- Utilisation of existing access tracks and trafficked areas.
- Alignment of gathering lines and new access tracks parallel to the direction of cultivation, soil conservation structures and controlled traffic runs and avoid perpendicular or lateral connections.
- Laying out drill pads in accordance with landholder requirements, subject to safety requirements, to reduce the overall impact on cultivation, where practicable (C088).

In response to landholders concerns about disruptions to farm workability, Arrow made a commitment to negotiate with farmers to minimise disruption to cultivated paddocks, particularly where farming techniques include controlled traffic. Arrow also identified a number of measures that could be applied including: the use of additional headlands; aligning gathering lines and new access tracks parallel to the direction of cultivation; soil conservation measures and controlled traffic runs; avoiding perpendicular and lateral connections; and utilising existing access tracks and trafficked areas. In response to concerns raised in some submissions on the EIS, Arrow committed to consider property-specific requirements in discussions with landholders during the negotiation of conduct and compensation agreements. Commitment was also made that pipelines would be designed to account for land-use in accordance with applicable standards, including the depth of burial which would be influenced by the nature of traffic on the easement (e.g., cotton pickers).

Some submissions on the EIS recommended that approval conditions be applied to the project requiring Arrow to ensure the location of any infrastructure be agreed with landholders prior to work commencing, and for any proposed changes to be re-negotiated. In response, Arrow committed to complying with the provision of the

Petroleum and Gas (Production and Safety) Act 2004 (Qld) and the Land Access Code (DEEDI, 2010) prior to accessing any private land. In accordance with these requirements, a conduct and compensation agreement (with accompanying maps of the area of interest and detail on infrastructure development) would be in place prior to the entry onto the land.

EHP notes that the projected disturbance area referred to in the EIS documents is likely to be a conservative estimate. It was not based on a layout of wells and gathering line that had been 'optimised' to minimise impacts. The 'environmental framework' method of planning the actual layout incorporates consideration of siting and operational constraints as well as consideration of specific landholder requirements for siting infrastructure.

One area of concern, particularly in areas where there are significant constraints to the siting of CSG facilities and infrastructure, is wether appropriate compromises can be negotiated and agreed with landholders to minimise impacts their agricultural activities.

4.8.4.4 Intensively farmed land

Many of the avoidance and mitigation commitments given in relation to agriculture in the EIS documents are concerned with impacts on intensively farmed land. Specific commitments include a statement that the company would not develop on IFL until it had satisfactorily addressed landholder concerns, particularly through the Arrow Intensively Farmed Land Committee. Arrow advised that planning would need to occur and access would be required for some activities, such as establishing groundwater monitoring bores (SREIS Chapter 19 Issue R10011).

Arrow's stated intentions with regard to the placement of CSG infrastructure on IFL, SCL and good quality agricultural land (GQAL) are:

- Arrow will ensure dams for CSG water and brine are not constructed on IFL (C092).
- Arrow will not locate major infrastructure facilities (e.g., central gas processing facilities) on IFL as part of the 12 commitments made to coexistence on IFL in the Surat Basin. It is Arrow's intention to avoid locating CGPFs on GQAL and SCL.
- Reduction in the portion of the project development area in the Jimbour Plain (SREIS, Chapter 3, Fig 3.1).
- Concerning buried linear infrastructure, including gathering lines and power lines, well leases and access tracks, all project activities on SCL will meet the requirements of the SCL Act Part 3 Strategic Cropping Land Standard Conditions Code for Resource Activities.
- Meet other statutory and policy requirements including compliance with the Land Access Code.

Many submissions from landholders contended that the EIS has failed to demonstrate how the project could be compatible with intensive, irrigated agricultural systems that dominate much of the project area. It was argued that the installation of rigid CSG infrastructure on the floodplain would seriously impact on day-to-day operations and impede landholder's future ability to adapt farming practices to maintain or improve productivity or profitability. It is unclear how this flexibility is maintained with the imposition of rigid CSG infrastructure over farms. Several submissions noted that the EIS provided little assurance that existing agriculture activities would be able to continue successfully should the development proceed. The lack of detail associated with the location of gas field infrastructure and facilities and the overall footprint of the CSG activities makes it almost impossible for landholders to appreciate the likely impacts of the proposed development.

In response, Arrow stated in the SREIS that, where infrastructure was proposed on private property, Arrow would consult and agree with landholders on the appropriate location for infrastructure and access routes with specific terms set out in conduct and compensation agreements with affected landholders. Arrow aims to accommodate landholders' requirements and undertake activities considering existing and future land uses. Further, Arrow committed to (where possible) be flexible in the location of wells and infrastructure. Arrow noted that it is working with the Arrow Intensively Farmed Land Committee to resolve how and when it will operate on intensively farmed land (IFL) to not unreasonably interfere with the ability to farm the property.

In addition, Arrow proposed that the siting of wells in consultation with landholders in locations which reduce impacts on productive areas and provide the best opportunity for rehabilitation, as well as locating production facilities in less productive land. Arrow considers that these are key strategies for reducing the potential for permanent alienation of IFL.

EHP considers that, while experience with existing CSG operations indicate that acceptable layouts (albeit with compensation) can be applied on land predominately used for grazing, Arrow will face additional challenges in designing and agreeing appropriate layouts on IFL, particularly in those areas under irrigation. Arrow's commitments to consultation with landholders on the siting of infrastructure would be particularly important in achieving acceptable development on IFL, as described in the EIS documents, including meeting Arrow's 12 objectives for managing impacts on agricultural land.

4.8.4.5 Strategic cropping land

A substantial number of submissions on the EIS raised concerns regarding the large area of SCL that would potentially be affected by the project, particularly the black cracking clay soils of the Darling Downs. Several submissions considered that the project would have a permanent impact on the soils and hence should not be permitted under the conditions of the SCL Act. In the EIS documents, Arrow argued that, apart from the major facilities (CGPF, water treatment plants, TWAFs) that would not be located on IFL, project impacts would be temporary, and hence, would be permitted under the SCL Act. As stated in the SREIS, Arrow would need to address this matter when applications are made for project approvals. Arrow also correctly states that it would be required to comply with the SCL Standard Conditions Code for Resource Activities, to carry out the project on potential SCL within the Southern Protection Area.

In response to claims that siting CSG infrastructure on black soil plains would result in increased erosion and other adverse impacts in the SREIS, Arrow cited the successful construction of the Roma to Brisbane gas pipeline across the project development area as an example of how large CSG infrastructure could be sited, constructed and operated successfully without causing major erosion, or resulting in the extensive diversion of overland flow. Similarly, Arrow claims to have constructed access tracks on black soil, that were exposed to overland flow without any evidence of erosion or disturbance of cultivated areas.

A number of submissions on the EIS raised concerns regarding the impact of 800m spaced well grids on SCL and the broader floodplain. Further impacts from ‘infill’ operations were considered to not have been adequately addressed by some submitters. In response, Arrow stated that, with regard to ‘infilling’, the SREIS Chapter 3, Project Description, Section 3.4.1 clarifies Arrow’s position. In brief, Arrow advised that the grid of production wells would be drilled in sequence, or in stages to enable learning from the performances of early wells having a wider spacing, before adding remaining wells to complete the grid (this historically has been referred to as infilling). The most favourable reserves would be targeted initially, with infill drilling occurring where production was less than predicted or yields depleted over time. Infill drilling may reduce the well spacing presented in the EIS but would still average 800m. As part of the 12 commitments made to coexistence on intensively farmed land (IFL) in the Surat Basin, Arrow has committed to maximise spacing between wells on IFL (between 800m and 1.5km). The use of deviated drilling technology may allow the surface well pad sites for multi-well pads to be separated over a distance of up to 2,000m where practicable. Siting of gas field infrastructure would be negotiated with landholders and agreed upon by both parties as part of conduct and compensation agreements. Furthermore, Arrow stated that it should not be inferred that ‘infilling’ wells would be drilled at a spacing less than the stated average (i.e. a minimum 800m grid spacing).

Arrow further noted that Environmentally Sensitive Areas (ESAs) identified in the project development area had been included in the constraints mapping that identified ‘no go’ areas and areas of high, moderate and low constraint to development (EIS Attachment 10, Preliminary Constraints Maps and SREIS Attachment 8, Constraints Mapping Update). EIS Chapter 17, Terrestrial Ecology, Figure 17.2 and EIS Appendix K, Terrestrial Ecology Impact Assessment, Figure 14 present all Category C Environmentally Sensitive Areas (ESAs) within the project development area.

Some submissions on the EIS questioned why potential impacts on SCL were not fully assessed in the EIS. In the response to these submissions, Arrow incorrectly stated that SCL requirements would be built into the environmental authority or environmental authority assessment process. Approval under the SCL Act is treated separately to the assessment and approval of the Environmental Authority under the EP Act. Both the environmental authority and the protection decision (if an application could not comply with the Strategic Cropping Land Standard Conditions Code for Resource Activities) can apply conditions which are considered relevant to the project and are appropriate for meeting the requirements of the relevant legislation. For project approvals required under the SCL Act and EP Act, due to the lack of certainty of the location and hence information about site specific impacts (particularly for the project components having a large and more permanent footprint), a full assessment cannot be undertaken at this time. This would occur when Arrow makes applications for these approvals.

EHP notes that activities proposed by Arrow on potential cropping land that do not meet the Strategic Cropping Land Standard Conditions Code for Resource Activities, under the SCL Act, would require a protection decision. To obtain a protection decision on land accepted as SCL or which has been validated as SCL and is located within a protection area, then the activity could not have a permanent impact on SCL. This would need to be demonstrated. A number of the commitments in the EIS are aimed at achieving this, for example, the commitment for not locating dams for CSG water and brine and central gas processing facilities (and, hence, water treatment plants) on IFL or SCL.

4.8.4.6 Power lines and pipes

Landholders raised concerns regarding overhead power lines and gas pipelines on agricultural properties. In response, Arrow stated its preference for placing electrical cables underground, where possible and committed to providing landholders the option of above or below ground power supply. Arrow anticipates that most landholders will opt for underground power which will be co-located with the gathering pipelines.

Arrow also notes that it will design, construct, maintain and rehabilitate the gathering system network in accordance with the APIA code of practice Upstream PE gathering networks CSG industry version 2 or the relevant Australian standards, as revised from time to time. Arrow would also adhere to design and construction standards defined in AS 2885.1-2012 for gas pipelines, and for gathering lines constructed on cracking clays. In the case of cultivation, Arrow would seek to align gathering lines and new access tracks parallel to the direction of cultivation, soil conservation structures and controlled traffic runs and avoid perpendicular or lateral connections.

In responding to submissions, Arrow described the limitations of the weight bearing capacity of pipelines as part of a risk assessment. However, it is not clear from this information what would this mean in terms of the type and size of machinery that can safely cross the pipelines. This would need to be considered in the layout of the gathering pipelines and negotiated with landholders and other affected parties.

4.8.4.7 Operations

While most disturbances would occur during construction, there would also be impacts during the operating phase as gas production was rolled out in the 11 drainage areas of the project development area. The EIS acknowledged that mitigation measures would be necessary to address potential amenity issues due to contractors and employees entering and working on properties, disruption of lifestyle, increased levels of noise and dust, and visual impact of the project infrastructure. These measures are described in EIS Chapter 13, Section 13.6.6.

A number of Arrow's commitments concern the maintenance of soil erosion and sediment control structures during gas production, limiting access during wet conditions, management of dust and other measures during gas production. While not explicitly stated in the EIS documents, it is expected that these commitments would also be relevant to meeting conditions imposed in the environmental authority and, if appropriate, incorporated in conduct and compensation agreements with landholders.

Landholders raised concerns that the installation of CSG facilities on their properties would result in restrictions on access and other disruptions. In response, Arrow considered that this matter would be dealt with adequately in conduct and compensation agreements. They indicated that they would try to avoid any restrictions but that matters of safety would override any agreement on access.

Several concerns were raised in submissions regarding the potential for fire (both controlled and wildfire) to affect CSG facilities, particularly well heads and other dispersed facilities. In response, Arrow reported that wells can be located in areas where fire may occur but that provided appropriate measures are taken, including buffer areas around facilities to reduce fire risk and intensity, fire is not a major concern. Arrow also stated that well pads in fire risk areas do not have flares to reduce fire risk.

4.8.4.8 Biosecurity

The EIS and the SREIS identified the need for the project to appropriately manage impacts and risks to biosecurity associated with the delivery of the project. A number of submissions raised concerns that the project had the potential to seriously impact on biosecurity, particularly in relation to spread of weeds, pest plants and pest animals.

Arrow committed to undertake a number of actions to minimise the risk the project would spread weeds and other pests. These commitments include:

- developing a declared weed and pest management plan in accordance with the Petroleum Industry's Minimising Pest Spread Advisory Guidelines (Biosecurity Queensland, 2008), or relevant legislation at the time. This includes undertaking species-specific management for identified key weed species (mesquite, parthenium, African lovegrass and lippia)
- increasing weed control efforts in areas particularly sensitive to invasion. The pest management plan should include, as a minimum, training, management of pest spread, management of pest infestations, requirements for crossing and working around pest fences and monitoring the effectiveness of control measures.

The EIS outlined that biosecurity issues would be managed at an individual property level based on negotiations between Arrow and individual landholders. Land access conditions, negotiated with landholders during preparation of the conduct and compensation agreements, would address biosecurity measures including weed, seed and disease free status of vehicles accessing a landholder's property. Arrow stated that it would negotiate with individual landholders any specific requirements required to maintain best management practice compliance on their properties.

WDRC recommended the extensive use of wash-down facilities for vehicles entering and leaving properties, as well as Arrow making a contribution to the establishment and management of vehicle wash-down facilities on major routes within drainage catchments as they are developed. Arrow responded that weed wash-down requirements and responsibilities would be addressed in the declared weed and pest management plan to be developed for the project.

DAFF comments on the SREIS endorsed the commitments made by Arrow in the EIS to manage biosecurity matters associated with the project.

DAFF also advised that that there is no reference to the possible application of the *Queensland Plant Protection Act 1989* in the EIS documentation. The whole of Queensland is a pest quarantine area for grape phylloxera. Machinery used for the project could traverse the Special Control Zone, which is designated as a phylloxera exclusion zone. The movement of machinery, equipment, soil, grape plants and other phylloxera risk items that have been in contact with grape vines are restricted; refer s73 of the Plant Protection Regulation 2002. DAFF considered that complying with these measures should not be a major problem for the project.

However, DAFF considers that machinery contaminated with plant pests (e.g. insects) or disease (e.g. fungi) could move to, or from, sensitive zones in the project area. While it is unlikely that equipment and machinery to be used in the project would have been in contact with grape vines, general biosecurity awareness of plant risks amongst the workforce can reduce the risk of introducing pests of concern into Queensland.

4.8.4.9 Land restoration

According to the EIS, CSG wells, gathering lines and access tracks are proposed on IFL, SCL and GQAL. Gathering lines would be rehabilitated following installation of the pipes and ancillary infrastructure (low point drains, high point vents, and gas and water nodes) enabling former land uses to resume and continue for the duration of CSG production from the associated production wells. Production wells would be decommissioned after 15 to 20 years of operation when gas resources are exhausted or become uneconomic to extract. The wells would be decommissioned in accordance with relevant guidelines. Access tracks, if not required by the landholder, would be removed and the land rehabilitated to its pre-development condition.

Arrow acknowledges that it may not be able to rehabilitate all production facility sites back to cropping standard, but notes that where this was the case, Arrow intends to acquire a long term lease of these sites. Arrow has committed to avoiding locating production facilities and other facilities (including dams for CSG water and brine) on IFL, minimising the extent of this impact. Arrow would also need to meet the requirements of the SCL Act for any disturbance on SCL that is likely to have a long term impact.

A number of the submissions from landholders and agricultural organisations, including Cotton Australia and Central Downs Irrigators, considered that the project development area should exclude the floodplain east of the Condamine River on ATP683 until Arrow has met its commitments to satisfactorily address stakeholders concerns. The basis of this recommendation was that impacts on this land cannot be mitigated, and that adaptive management cannot restore and rehabilitate soils to their original condition. A 20-year delay in the development of the project in this area is requested to give time to understand the potential impacts, particularly those impacts on IFL and on the groundwater of the Condamine Alluvium. In response, Arrow stated that it considered that it has demonstrated in the EIS documents that the project can be developed in this area without unacceptable impacts on farming land and potential soil productivity.

However, in response to concerns raised in submissions on the EIS regarding the effectiveness of restoration, particularly on SCL, Arrow reported that the effectiveness of the proposed environmental management controls in addressing the identified impacts is being investigated through trials and case studies that are currently focused on rehabilitation of black soils (vertosols and dermosols) and construction methods for work on those soils. This matter will need to be addressed in achieving approvals under the SCL Act.

4.8.5 Outstanding matters

4.8.5.1 Legislation

For the project to proceed the following requirements would need to be met:

- Details of site-specific delivery of the project, sufficient to achieve the granting of an environmental authority will be required with any application under the EP Act. These requirements are set out in the guideline 'Application for petroleum activities' (EM705)3. In addition any application should meet the requirements of s.125 and s.126 of the EP Act. It should be noted that an environmental authority under the EP Act is primarily concerned with regulating environmental harm and nuisance. However, a number of matters relevant to agriculture in the project development area including emissions to air and water, beneficial reuse of water, dams, noise and rehabilitation, are regulated by the environment authority.
- Arrow would also need to lodge applications, supported by site-specific details of impacts, with DNRM to obtain a protection decision or compliance certificate under the *SCL Act 2012*.
- Requirements under the *Land Protection (Pest and Stock Route) Management Act 2002*, section 52 *Agricultural Chemicals; Chemical Usage (Agricultural and Veterinary) Control Act 1988*; *Agricultural Chemicals Distribution Controls Act 1966;* and the *Forestry Act 1959* would have to be met for the project to proceed.

4.8.5.2 Policy

The SREIS provided a brief discussion of Arrow's understanding and position with regards to the co-existence of CSG with other land uses (SREIS, Chapter 7, section 7.6). Arrow outlined its key strategies for reducing permanent detrimental impacts on IFL. These include processes for siting of wells and other infrastructure in consultation with landholders in locations that minimise impacts on productive areas and that provide the greatest opportunity for rehabilitation, as well as locating gas production facilities on less productive land.

In regards to co-existence with agriculture, DAFF advised that the project commitments should be amended to appropriately involve landholders in planning the management of impacts as well as improving the level of certainty of impact associated with the implementation of the project.

4.8.6 Conclusion and recommendations

EHP considers that the EIS documentation has adequately identified the agricultural values of the project development area, and identified the likely impacts on those values. It has also identified the specific impacts that would occur on agricultural land and the measures that would be taken to minimise and manage those impacts. However, the EIS did not provide the specific location of impacts at a property or farm scale (other than in general terms and only for some major gas processing facilities and accommodation camp) and as a result, it is difficult to assess/determine, at a farm or property scale, the acceptability or otherwise of impacts. This is particularly so for agricultural holdings and enterprises that would be particularly sensitive to detrimental impacts due installation and operation of CSG infrastructure (i.e. on irrigated cropping land). EHP considers that:

- the EIS documents have adequately described the potential impacts of the project and their implications for grazing land and for some aspects of dry land cropping land. The proposed mitigation measures—planned siting of infrastructure that minimises disruption of agricultural activities ('environmental framework') and appropriate management measures (outlined in commitments)—are appropriate to limit impacts on grazing and dry land cropping lands
- the EIS documents have provided a limited assessment of the impacts of the project on intensively farmed land used for broad-acre irrigated agriculture and proposed objectives and a range of mitigation measures, that if applied, would minimise and mitigate impacts to an acceptable level. Achieving acceptable outcomes would be dependent on Arrow successfully meeting its performance outcomes described in the EIS documents through implementation of commitments and complying with the regulatory conditions applied.

[3] Available on EHP's website at: http://www.ehp.qld.gov.au/management/non-mining/documents/application-requirements-petroleum-guideline.pdf

4.8.6.1 General recommendations

It is recommended that Arrow addresses the following matters:

- For intensively farmed land, EHP notes Arrow's commitment ' that the company would not develop on intensively farmed areas until it had satisfactorily addressed concerns' (SREIS Chapter 19, Table 19.10 Issue R10011) and should continue with efforts described in the EIS documents to achieve this.
- Implement all commitments made in the EIS concerning agriculture (Appendix 3) as amended by recommended changes in Table 11. These commitments should be taken into consideration by administering authorities when assessing and conditioning any approvals for the project concerning impacts on agriculture.
- Additional (site-specific) information would need to be provided to DNRM for it to assess impacts on SCL. This would include information that demonstrated that gravelled access tracks and infrastructure padded areas are temporary impacts on SCL. Also, that if any impacts are likely to be permanent within the protection area, exceptional circumstances would be required.

4.8.6.2 DAFF recommendations

DAFF recommends that Arrow demonstrates that the proposed CSG activities are mutually beneficial to agricultural industries, by:

- not impacting directly on a current agricultural land use including farming activities of an affected agribusiness enterprise to the extent that it is no longer economically and/or financially viable
- not cause agricultural activity to pause then restart in order to fit in with CSG development schedules
- not result in changes that diminishes the characteristics of the current land condition and productive capacity as a direct impact of the project
- recognise and ensure the continual and ongoing agricultural production in areas affected by CSG activities
- ensure agricultural production is maintained and its capacity and values are enhanced.
- ensure that construction and infrastructure works do not prohibit stock from accessing water or feed or make appropriate arrangements with landholders
- commit to ensure that construction and post works areas should restrict livestock access where injury or death may occur, until these areas are safe for livestock to access

With regards to pest management, Biosecurity Queensland, DAFF recommends:

- the proponent updates commitment C188 to indicate the proponent's commitment to plan for prevention/control weeds species in addition to mesquite, parthenium, African lovegrass and lippia. They noted that declared species with the potential to spread to the project area include prickly acacia, hymenachne, giant rat's tail grass, honey locust, and African boxthorn, but are not necessarily limited to these species. Further they stated that plans should be informed by the pest management plans of the relevant local governments in which the project traverses
- with reference to the statement: 'The pest management plan should include, as a minimum, training, management of pest spread, management of pest infestations, requirements for crossing and working around pest fences and monitoring the effectiveness of control measures.', Biosecurity Queensland considered that insufficient detail was provided about where fence crossings would occur, and the process of obtaining relevant permissions/permits required by for each crossing (i.e. Biosecurity Queensland Darling Downs Moreton Rabbit Board; local government). It recommended that this commitment should be replaced with 'The pest management plan should include, as a minimum, training, management of pest spread, management of pest infestations, requirements for crossing and working around pest fences and monitoring the effectiveness of control measures.'
- the proponent should consider Barrier Fences in its constraints mapping and use of the environmental framework for site selection and management. Refer to *Land Protection (Pest and Stock Route) Management Act 2002*, section 52 for the making of fence openings, section 53 for the restoration of a declared pest fence, and section 56 for not obstructing a declared fence.

With regards to Agricultural Chemicals DAFF recommends:

- the proponent should ensure that the project is compliant with both the *Chemical Usage (Agricultural and Veterinary) Control Act 1988 (use controls)* and *Agricultural Chemicals Distribution Controls Act 1966* (licensing controls) to ensure that use of agricultural chemicals or other industrial chemicals does not have an adverse impact on human health, trade or the environment through contamination of agricultural produce. DAFF considers that it is essential that landholders are involved in consultation on uses of herbicides (regardless of whether the operation is organic or biodynamic) to ensure that appropriate risk management actions can be implemented where stock could be exposed.

DAFF Forestry makes the following recommendations concerning managing impacts on forestry resources potentially impacted in the project development area:

- The SEIS should ensure that the proponent works with private landholders to facilitate the salvage harvesting of any privately owned (freehold land) commercial forest products that may be cleared, interfered with or sterilised from utilisation as a result of project related activities. It is recommended that salvageable log timber should not be burnt or chipped as part of the clearing process.

In relation to compliance with the *Forestry Act 1959*, DAFF recommends:

- the proponent should contact DAFF prior to the commencement of any project work to arrange any necessary authorisation (sales permit/s) if State-owned quarry material, administered under the *Forestry Act 1959*, is to be used for any part of the project and associated activities
- the proponent should liaise with DAFF and other affected parties to ensure, where possible, that the location and positioning of the project's infrastructure (i.e. pipelines, crossings, etc.) and/or proposed offset areas avoid sterilising and/or restricting the future utilisation and/or access to currently exploited or known commercial deposits of State-owned quarry material.
- the proponent ensures that if State-owned quarry material, administered under the *Forestry Act 1959*, is used for the project, from a new or existing quarry located within or outside the project area, the quarry operator must hold:
  - a current Sales Permit under the *Forestry Act 1959*
  - planning approvals under the *Sustainable Planning Act 2009*, relevant environmental authorities under the *Environmental Protection Act 1994*
  - any other relevant authorities, approvals and supply chain arrangements.
- the proponent should contact DAFF to arrange possible salvage harvesting of any State-owned forest products, as administered under the *Forestry Act 1959*, that may be cleared, interfered with or sterilised from utilisation (including in offset areas) as part of the project. Note that salvageable log timber should not be burnt or chipped as part of the clearing process.

4.8.6.3 Recommendations on commitments

This assessment has reviewed the commitments in the EIS documents. While endorsing the commitments, makes the following recommendations in Table 11 regarding changes and additions.

Table 11 Agriculture commitments and recommendations

No.	Commitment	Recommendation
C015	Clear areas progressively and implement rehabilitation as soon as practicable following construction and decommissioning activities	Performance criteria for rehabilitation will be conditioned in the environmental authority and any approvals required under SCL Act.
C034	Develop an erosion and sediment control plan and install and maintain appropriate site-specific controls	Include consultation with landholders in the development of the plan
C076	Avoid infrastructure and associated farm management areas of intensive farming operations, including piggeries, feedlots, vineyards, orchards, horticultural enterprises, poultry farms and small-lot plantations	Broad acre farming where underground irrigation mains are located should also be avoided
C080	Plan and integrate construction and operations activities with harvesting, spraying and withholding periods	Consultation with landholders is required
C085	Study methods to reduce impacts and maintain the soil profile during gathering system pipeline construction by understanding the soil type, reducing pipe diameters, plowing (instead of trenching) and potentially burying deeper than the minimum standard	Methods should not only be studied but also implemented in the form of best management methods available to reduce impacts
C087	Investigate alternative drilling technologies, such as using directional drilling to access	Alternative drilling technologies should be implemented where applicable and practicable.

No.	Commitment	Recommendation
	coal measures, reducing gathering system pipe diameters and drilling multiple wells from one drill pad to potentially reduce the footprint on strategic cropping land	
C089	Develop construction methods and design access tracks in cultivation paddocks to maintain the existing hydrologic and hydraulic regime of the site and in a way that does not cause erosion	The siting and construction of access tracks should not interfere with overland flow
C094	Ensure an Arrow representative is in attendance at the time of first entry to check contractors have the appropriate environmental management procedures and property specific information	The Arrow representative should be appropriately trained and authorised
C099	Clean down vehicles and equipment that have potentially been in contact with weeds before entering new work sites	Cleandown facilities should be installed at appropriate locations after consultation with landowners, council and other affected parties
C118	Deep rip and cross rip all construction areas and temporary access tracks to a depth of at least 0.4 m. Repeat following topsoil reinstatement to promote infiltration and assist the re-establishment of connections between soil horizons	This method of restoration is not necessarily applicable to all soil types. It is recommended that all construction areas and temporary access tracks be restored to a suitable agreed condition using appropriate methods based on soil type and in consultation with the landholder. Restoration disturbed land is also a matter for the plan of operations required to be submitted by the proponent and in financial assurance considerations.
C121	Rehabilitate clean water diversions, down-gradient soil erosion control works and temporary sediment dams to preconstruction site levels, and rip prior to sowing with crops or pasture grasses	Rather than specifying ripping, replace with 'rehabilitate using applicable methods……'
C188	The pest management plan should include, as a minimum, training, management of pest spread, management of pest infestations, requirements for crossing and working around pest fences and monitoring effectiveness of control measures	Amend to include prevention/control of prickly acacia, hymenachne, giant rat's tail grass, honey locust, African boxthorn, and other relevant species in addition to mesquite, parthenium, African lovegrass and lippia
C497	Ensure coal seam gas water used for dust suppression on roads or for construction and operation activities is treated if required	Water intended for use is fit for purpose
C506	Inspect pipeline ROWs routinely until ground stabilisation and natural revegetation or pasture grasses or crops are established	Add to this commitment 'Remediate when necessary'
C540	Ensure that the quality of coal seam gas water used for dust suppression meets the prescribed limits	Water intended for beneficial use must be fit for purpose

4.9 Groundwater

Chapter 14, Groundwater of the EIS described the existing groundwater values within and surrounding the project development area and provided an assessment of the potential for these values to be affected by direct and indirect impacts associated with the construction, operation and decommissioning phases of the project. Detailed information on the groundwater assessment was included in EIS Appendix G, Groundwater Assessment. The EIS described the aquifers of the Surat Basin, particularly those likely to be affected by the project, and the outcomes of modelling to predict the impacts of the project on these aquifers.

The SREIS Chapter 8, Groundwater provided updated information on groundwater resulting from changes to the project description (SREIS Chapter 3, Project Description), submissions on the EIS, and the results of using the OGIA's model (as opposed to Arrow's groundwater model used in the EIS) to assess impacts on groundwater. Detailed information on the supplementary assessment was contained in SREIS Appendix 4, Supplementary Groundwater Assessment.

Submissions on the EIS raised a number of concerns regarding the groundwater modelling and the impacts of the project on groundwater and mitigation measures. Key matters are discussed in the relevant sections below.

4.9.1 Legislative context

The EIS adequately described the legislation, policy and guidelines relevant to identifying values and avoiding, mitigating and managing impacts on groundwater that applied at the time the EIS was drafted. The SREIS outlined the significant legislative and policy framework changes associated with CSG developments and the management of groundwater resources since the publication of the EIS.

4.9.2 Regulatory framework

The Queensland Government has a multi-faceted regulatory framework to support the sustainable development of the CSG industry. This framework includes a role to assess and manage the impacts from CSG water extraction on aquifers. The main components are:

1. **P&G Act and the Petroleum Act** [4]—Production rights to extract gas and co-produced (associated) water are provided under the P&G Act and the Petroleum Act. These acts give tenure holders the right to take or interfere with groundwater to the extent necessary to extract the desired petroleum/gas.
2. **Water Act**[5]—Chapter 3 of the Water Act establishes the responsibility for tenure holders to monitor and manage any impacts caused by the exercise of these groundwater rights and to 'make-good' any impairment of private bore water supplies. The make-good obligations of a petroleum tenure holder are to undertake an assessment of the bore; and enter into, and comply with, a make-good agreement with the bore owner. These provisions exist because water is found in association with petroleum and gas and it is not practicable to manage the water separately. Chapter 3 also requires the preparation of underground water impact reports on the cumulative impacts of all groundwater users and establishes underground water management objectives.
3. **EP Act**[6]—The EP Act regulates the management of the associated (co-produced) water once produced. The State's policy position on this is stated in EHP's 'Coal Seam Gas Water Management Policy 2012'. It also encourages CSG operators to consider the feasibility of using CSG water to meet make-good obligations as part of developing their CSG water management strategies and plans.

[4] The P&G Act and the *Petroleum Act 1923* are administered by DNRM.

[5] The EP Act and Chapter 3 of the Water Act are administered by EHP.

[6] The EP Act and Chapter 3 of the Water Act are administered by EHP.

Other legislation that may regulate the use of CSG water, depending upon how it is to be managed and used, includes:

- *Water Supply (Safety and Reliability) Act 2008* (Water Supply Act)—where operators undertake a water supply service such as supplying treated CSG water for the purposes of a municipal drinking water supply
- *Waste Reduction and Recycling Act 2011*—for authorising particular and general beneficial uses of CSG water and what would otherwise be coal seam gas-related wastes.

4.9.2.1 Underground Water Impact Report 2012 and OGIA Groundwater model for the Surat Basin

In accordance with Chapter 3 of the Water Act[7], the Queensland Water Commission, now the Office of Groundwater Impact Assessment (OGIA) within DNRM[8], prepared an 'Underground Water Impact Report[9]' (2012) (UWIR) for the Surat Cumulative Management Area (CMA) (which includes the area of the Arrow project; see Figure 4) The UWIR assessed the impacts of water extraction by petroleum tenure holders on underground water in the Surat CMA, and established integrated management arrangements. In accordance with the Water Act, the UWIR was approved by the Chief Executive of EHP. This makes the report a statutory instrument under the Water Act.

To inform the UWIR, QWC/OGIA, developed a regional groundwater flow model covering the Surat CMA (OGIA Surat groundwater model). The model predicts the cumulative impacts of groundwater extraction by CSG activities (including the Arrow project as described in the EIS) in the Surat basin by assessing future water level impacts in the coal seams as well as in adjacent aquifers. This model includes a consideration of impacts on the Condamine Alluvium by DNRM. The findings of the OGIA Surat groundwater model are reported in the UWIR.

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[7] Chapter 3 of the Water Act requires the preparation of underground water impact reports that establish underground water obligations, including obligations to monitor and manage impacts on aquifers and springs. It also gives the chief executive of EHP, and the OGIA, functions and powers for managing underground water.

[8] The OGIA within DNRM provides groundwater management functions as specified in the Water Act which includes:

- preparation of annual reports on the implementation of the Surat UWIR
- updates to the modelling and the UWIR every three years
- monitoring of the development of the petroleum and gas industry in relation to the potential impacts of water extraction and the provision of advice on issues such as any emerging need for additional CMAs
- maintenance of a database to store baseline and monitoring data collected under monitoring plans carried out in accordance with water monitoring strategies in approved UWIRs.

[9] Chapter 3 of the Water Act states that an underground water impact report must include each of the following: a map showing the area of the aquifer where the water level is predicted to decline, because of the taking of the quantities of water, by more than the specified bore trigger threshold within 3 years after the consultation day for the report; and a map showing the area of the aquifer where the water level is predicted to decline, because of the exercise of relevant underground water rights, by more than the bore trigger threshold at any time in the future.

A bore trigger threshold, for an aquifer, means a decline in the water level in the aquifer that is:

- if a regulation prescribes the bore trigger threshold for an area in which the aquifer is situated—the prescribed threshold for the area; or
- otherwise—
  - for a consolidated aquifer—5m; or
  - for an unconsolidated aquifer—2m.

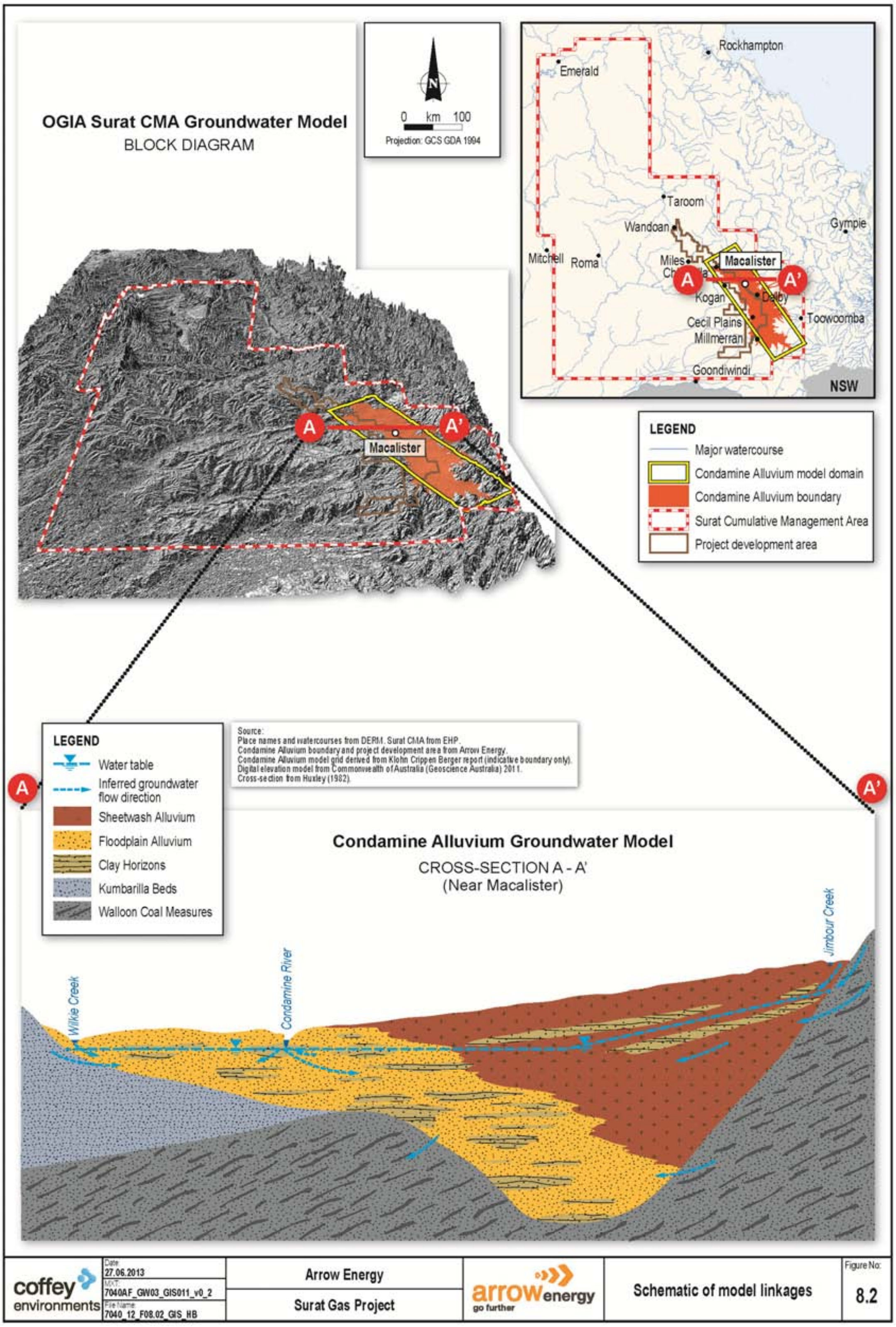


Figure 4 OGIA Surat cumulative management area (source: Figure 8.2, SREIS)

4.9.3 Assessment methodology

The groundwater impact assessment in the EIS comprised:

- A desktop study of geological and hydrogeological information to gain an understanding of the existing environment using information from relevant publications, government databases, published literature and reports of similar projects in the Surat Basin.
- The development of a numerical groundwater model (termed the 'Arrow EIS groundwater model') to predict the groundwater drawdown response in particular aquifer units as a result of CSG extraction. This model also presented cumulative drawdown predictions that included extraction associated with the QCLNG, GLNG and the APLNG Projects (model scenario 3).

Since the EIS was finalised, OGIA developed an independent numerical groundwater model (OGIA Surat groundwater model) to predict the cumulative impacts of all CSG developments in the CMA of the Surat Basin. It is based on a combination of the OGIA Surat groundwater model, null space monte carlo method (a probabilistic uncertainty analysis method) (WaterMark Numerical Computing, 2012) and the Condamine Alluvium groundwater model (KCB, 2011b). All modelling work was undertaken in accordance with the recommendations of the Murray Darling Basin Commission Groundwater Flow Modelling Guideline (Aquaterra, 2000). In the future, periodic reviews and updates of the UWIR (by OGIA) will assess changes to predicted impacts resulting from changes to the development plans of all CSG operations (such as changes outlined in the SREIS for the Arrow project).

In the SREIS, Arrow used the OGIA Surat groundwater model, with slight modifications in consultation with OGIA, to predict the impacts of the project on groundwater drawdown for the project development area[10]. Arrow termed this integrated model the 'Arrow SREIS groundwater model'. This assessment incorporated the updated information on groundwater resulting from changes to the project description in the SREIS and a revised water production profile (referred to as the Arrow current development case) to run a specific set of predictive scenarios for the SREIS.

A number of predictive extraction scenarios were simulated using the Arrow SREIS groundwater model for the purposes of determining Arrow's contribution to cumulative drawdown impacts within the Surat CMA. These were: non CSG case, base case, arrow-only case, cumulative case and substitution case.

4.9.3.1 Adequacy of the Arrow SEIS groundwater model—OGIA

OGIA confirmed that the OGIA Surat groundwater model provides the most comprehensive and up-to-date tool for the assessment of the impact of planned CSG development on the groundwater flow system in the Surat Basin. Arrow has essentially used the OGIA Surat groundwater model for its supplementary EIS (the SREIS Groundwater Model) with a very minor adjustment to the operating pressure surface to run a new Arrow development scenario. This was done in consultation with OGIA.

OGIA provided modelling files to Arrow for use in assessing its new development scenario. The consultant retained by Arrow to operate the model is the same consultant that constructed the calibrated model for OGIA as part of the OGIA modelling team. OGIA used a different team to undertake the uncertainty analysis on this calibrated model and impact assessment for the Condamine. However, OGIA provided guidance to Arrow on undertaking uncertainty analysis and using the model in conjunction with the DNRM Condamine model. In short, OGIA advised that it had 'no reason to believe that the predicted impacts on the Condamine Alluvium have not been properly represented for the proposed Arrow development scenario using the SREIS model'.

OGIA raised queries in their SREIS review about Arrow's SEIS Groundwater Model. These were:

- **Uncertainty analysis**—OGIA noted that the assessment in the main body of the Arrow SREIS, about the volume of water that would transfer between formations, does not fully reflect the uncertainty analysis results. Incorporating the uncertainty analysis results may lead to slightly higher volumes of water transfers. While uncertainty analysis results (calibration case and the 95 percentile case) were provided in SREIS Appendix 4, the main body of the report only quotes the figure for the calibrated case. In deriving results using the model, OGIA always used the 95 percentile case. This resulted in a conservative assessment which, given that the groundwater model is to be updated by 2015, is considered an appropriate way in which to consider and manage risk.

  In response, Arrow confirmed that the assessment in the SREIS of the volume of water that would transfer

[10] The consultant retained by Arrow to operate the model is the same consultant that constructed the calibrated model for OGIA as part of the OGIA modelling team.

between formations *did* incorporate the uncertainty analysis results, resulting in a full spectrum of values both more than and less than the values from a single realisation. However, Arrow argued that, “To only look at the results at the higher end of the scale is to knowingly bias the results high”. Arrow stated that its approach to the uncertainty analysis was twofold: 1) for the Condamine Alluvium, Arrow mirrored the OGIA approach as discussed on page 47 of the SREIS Groundwater Modelling Report; 2) for other aquifers, the peak net interlayer flux was reported for the calibration realisation. As discussed on page 49 of the SREIS Groundwater Modelling Report, this estimate was already considered to be an overestimate.

- **Lower permeability layer**—OGIA indicated that Arrow in the SREIS (Appendix 4) stated that the OGIA Surat groundwater model does not explicitly simulate a low permeability layer between the Condamine Alluvium and the coal seams. However OGIA advised that this is incorrect. The low permeability layer at the base of the Condamine alluvium is represented in the regional model and resulting simulated flow is then used in the separate Condamine Alluvium model (the DNRM Model).

  With regard to the importance of the low permeability layer, the anisotropy of the permeability of the Walloon Coal Measures is also a significant factor in relation to the interconnectivity between the formations. OGIA supports the views expressed in the Arrow Report concerning the anisotropy of the Walloon Coal Measures. In developing the OGIA Surat groundwater model, initial lower estimates of anisotropy were calibrated persistently to as high as 5000. Conceptually, values as high as this are considered appropriate for a highly stratified formation such as the Walloon Coal Measures.

  OGIA advised that although the OGIA model (and therefore the Arrow SREIS Groundwater Model) provides a sound basis for assessing future impacts, OGIA is carrying out research to improve knowledge about the nature of the interconnection between the alluvium and the coal measures. Initiatives to address this matter are discussed in section 4.9.3 of this assessment report.

4.9.3.2 Adequacy of the Arrow SEIS Groundwater Model—IESC

The Arrow EIS documents were reviewed by the Commonwealth’s Independent Expert Scientific Committee (IESC) which was satisfied that, by adopting the OGIA Surat groundwater model in the SREIS as a basis for its assessment of groundwater depressurisation, Arrow has, compared to the draft EIS, provided a higher level of confidence in its ability to predict impacts resulting from proposed project. However, the IESC also identified a number of matter about the OGIA Surat groundwater model which OGIA advised were already addressed in the existing model or being considered for subsequent versions and updates. These matters included:

- **Modelling type**—The IESC noted that the OGIA model is a single phase flow model and that there is a discrepancy between the predicted water production from the OGIA model and dual phase (water and gas) reservoir models. The IESC recommended that this discrepancy be resolved. OGIA advised that the next generation OGIA model will address this issue and that possible approaches to future modelling are being assessed. This is not considered a major issue.
- **Model fluxes**—IESC stated that, in relation to the interflow between the Condamine Alluvium and the Walloon Coal Measures, there is a lack of flux differentiation and lack of recognition of flow reversal in the OGIA Surat groundwater model. The OGIA considered that this advice suggested the IESC misunderstood the use of the OGIA Surat groundwater model. The OGIA model generates flux values between the Condamine Alluvium and the Walloon Coal Measures differentiated on a 1.5km grid spacing. These values are then provided to the Condamine model. The flux at any node at any time may be positive or negative. These matters are more fully explained in OGIA modelling reports.
- **Inter-connectivity between Condamine Alluvium and the Walloon Coal Measures**—The IESC considered that the SREIS contained ‘insufficient information to inform the degree of interconnection between the Condamine Alluvium and the Walloon Coal Measures’ but noted that new knowledge would result from the Condamine Interconnectivity Research Project and this should be incorporated into groundwater modelling. In response to this issue, OGIA noted that to the extent that the IESC sees a need for further work on this matter, the OGIA’s Condamine Interconnectivity Research Project will be an important project. Revised predictions of impacts using an updated model and the latest industry development profile will be incorporated into the update of the Surat Underground Water Impact Report which will be finalised December 2015.

4.9.4 Existing values

EIS Chapter 14, Groundwater and SREIS Chapter 8, Groundwater adequately described the aquifers of the Surat Basin, including those likely to be affected by the project.

The Walloon Coal Measures, which is the target CSG formation in the geology of the Surat Basin, are in a geologic layer of the Great Artesian Basin (GAB) which itself comprises layers of lower permeability rocks alternating with aquifers of high economic importance. The GAB also feeds springs of high ecological and cultural importance.

The project is the fourth major CSG project proposing to take CSG from the Walloon Coal Measures. The adjacent formations in the GAB are the Springbok Sandstone, the Gubberamunda Sandstone and Mooga Sandstone above the Walloons, and the Hutton Sandstone and the Precipice Sandstone below the Walloons.

The Condamine Alluvium overlies the Walloon Coal Measures, (see Figure 5) and is also a significant aquifer which supports a range of agricultural, urban, industrial and commercial uses. The Walloon Coal Measures represent the main basement unit for most of the central area of the Condamine Alluvium. The alluvium is incised into the Walloon Coal Measures by up to 130m.

A layer of weathered clay and low permeability material exists between the lowermost productive parts of the Condamine Alluvium and the uppermost coal beds in the underlying Walloon Coal Measures. This layer is a combination of low permeability basal alluvial clays of the Condamine Alluvium and the weathered upper part of the Walloon Coal Measures.

Groundwater in the Surat Basin is primarily used for consumptive purposes such as agriculture, industry, urban, stock and domestic. The total amount extracted for these purposes is some 215GL/yr. Of this total, about 55GL/yr is extracted from the Condamine Alluvium, about 85 L/yr from the Great Artesian Basin aquifers, with the balance extracted from volcanic sediments and deeper formations beneath the Great Artesian Basin. Groundwater extraction from the Condamine Alluvium has exceeded sustainable levels for many years, and a water planning process is underway to address declining water levels in the aquifer.

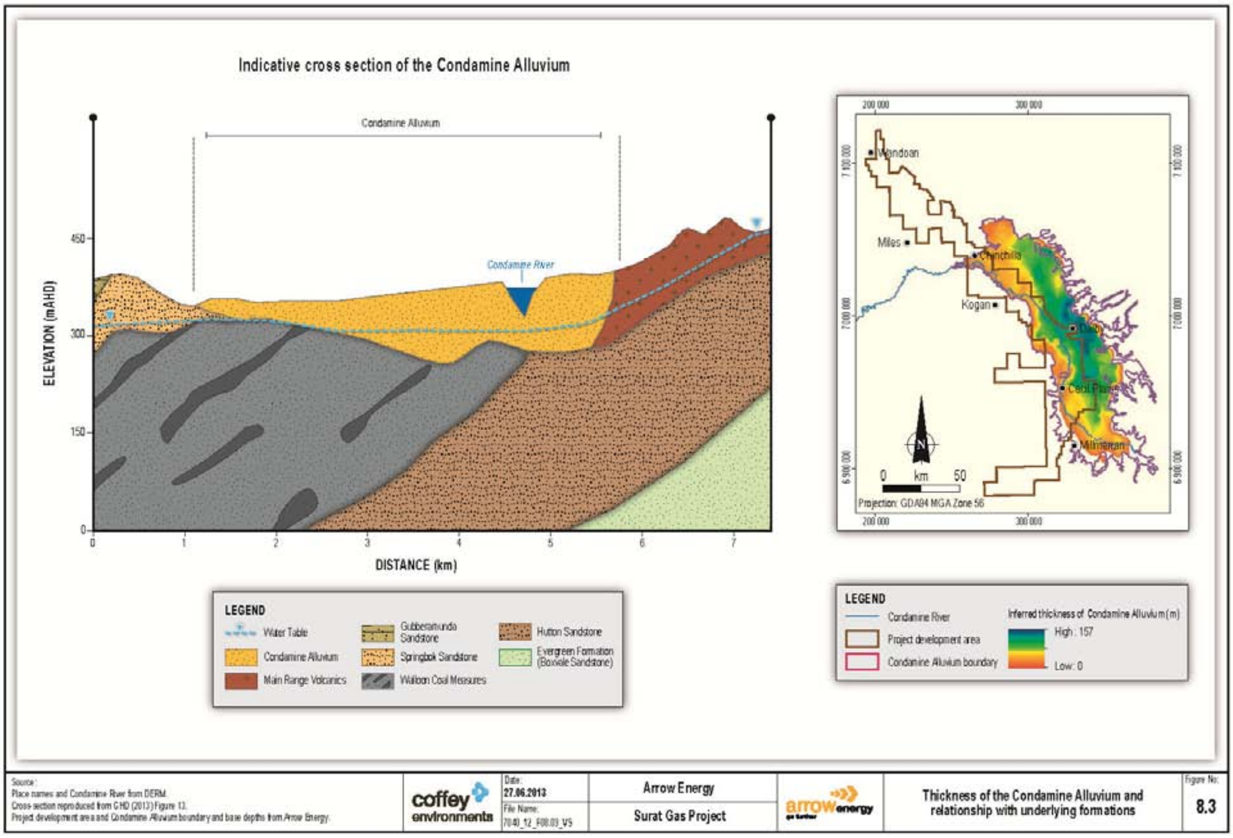


Figure 5 Cross section of the Condamine Alluvium and Walloon Coal Measures (source: SREIS Figure 8.3)

4.9.5 Impacts

Chapter 14, Groundwater of the EIS described the outcomes of Arrow groundwater modelling to predict the impacts of the project on aquifers of the Surat Basin, particularly those likely to be affected by the project. Chapter 8, Groundwater of the EIS outlined the results of the Arrow SREIS groundwater model and compared the modelling approach and assumptions adopted in the Arrow EIS groundwater model and Arrow SREIS groundwater model (which uses the OGIA Surat CMA groundwater model files updated with Arrow's current development case).

4.9.5.1 Arrow SREIS Groundwater Model

All aquifers

The Arrow SREIS provided a summary of the predicted maximum groundwater drawdown impacts in the key aquifers for the Arrow-only scenarios. Table 12 shows the Arrow-only drawdown comparison reported in the EIS and SREIS .

Table 12 Arrow's drawdown comparison (source: SREIS Appendix 4, Supplementary Groundwater Assessment)

Key Aquifers	EIS			SREIS		
	Average Drawdown (m)	Maximum Drawdown (m)	[1]Time to Maximum Drawdown	Average Drawdown	Maximum Drawdown (m)	[2]Time to Maximum Drawdown
Condamine Alluvium	<0.5	1	48	0.18	0.5	105
Springbok Sandstone	<5	30	13	<2	10	50
Walloon Coal Measures	<2	75	13	<50	350	30
Hutton Sandstone	<10	30	16	<5	8	105
Precipice Sandstone	<5	15	31	-	0.7	110

[1]Time of maximum drawdown in years from commencement of project development
[2]Time of maximum drawdown in years from 1995.

Condamine Alluvium

The Arrow SREIS predicted that the maximum Arrow only drawdown in the Condamine Alluvium simulated by the Arrow SREIS Groundwater Model would be 0.5m. The earlier EIS model found this to be just over 1m. The maximum cumulative drawdown in the Condamine alluvium was estimated to be 0.9m. This too was significantly less than the earlier EIS model finding of 2.5m. Under offsetting scenarios, groundwater level increases of up to 0.2 m in the modelled substitution area were indicated.

The Arrow SREIS found that the maximum predicted drawdown of 0.5m would occur in the central parts of the alluvium. However, this maximum drawdown was only evident in less than 10% of the alluvium area and drawdowns were typically less than 0.18m across the rest of the alluvium.

Water extraction from the Condamine Alluvium by non-coal seam gas stakeholders is currently estimated as approximately 55GL per year. By comparison, the predicted Arrow net adverse flux impact would be 63GL over 100 years.

Arrow advised that the Surat UWIR validated the findings of the groundwater impact assessment presented in EIS Chapter 14, Groundwater; and EIS Appendix G, Groundwater Impact Assessment, and that it confirmed that Arrow's assessment was conservative.

OGIA has concluded that 'although there are differences between the predictions made by the OGIA model and the Arrow EIS model, the work by OGIA supports the view that the Arrow EIS model is unlikely to have under-represented the groundwater impacts on aquifers adjacent to the (Walloon) coal measures'.

4.9.5.2 Cumulative impacts

The following information summarises the cumulative impacts of all CSG developments in the Surat Basin CMA on groundwater aquifers as outlined in the UWIR and predicted using OGIA's groundwater model. It includes the project's components as per the EIS, using OGIA groundwater model.

All aquifers

The OGIA regional groundwater model estimated, in terms of pressure loss, that for the Walloon coal measures itself, for most of the area the long-term impact is expected to be less than 150m. Of the other key aquifers the Surat UWIR estimated the maximum impact to be in the Springbok Sandstone but less than 20m, with 104 bores that source water from the formation being located in the affected area. (The Arrow SREIS model finds an Arrow-only average drawdown of <2m and a maximum of 10m). In the Hutton Sandstone the maximum impact is expected to be less than 5m. There are 23 private bores sourcing water from the formation in the affected area. (The Arrow SREIS model finds an Arrow-only average drawdown of <5m and a maximum of 8m).

The OGIA's UWIR provided a summary of its findings on the long-term impacts as follows:

- **Walloon Coal Measures:** This is the target CSG formation in the Surat Basin. For most of the area, the long-term depression of groundwater water level is expected to be less than 150m. Within the production area, the magnitude of impact reflects the depth of the top of the coal formation because operational practice for CSG production is to lower the pressure in coal seams to approximately 35 to 40m above the top of the uppermost coal seam. As a result, in the more westerly areas, where the coal formation is relatively deep, the groundwater levels are expected to be lowered by up to 700m. There are 400 private water bores that source water from the formation in the affected area. Most of these are located further to the east where the formation is shallow and impacts are smaller. Half of the affected bores are likely to experience an impact of less than 21 m.
- **Bandanna Formation:** This is the target CSG formation in the Bowen Basin. In most of the area, the long-term impact is expected to be less than 200m. For similar operational reasons to the Walloon Coal Measures, impacts in Bandanna Formation are also greater in areas where the coal formation is deep. The impact in these areas is expected to be up to 1,000m. However, in areas where private bores tap the formation, the impacts are expected to be much smaller. It is expected that impacts would not exceed 5m in any bore.
- **Springbok Sandstone:** This aquifer overlies the Walloon Coal Measures. It is separated from the productive coal seams for the most part by the upper aquitard of Walloon Coal Measures. Over most of the affected area the maximum impact is expected to be less than 20m, although there is a small area south of Miles where impacts are expected to reach 90 m. (The Arrow SREIS model found an Arrow-only average drawdown of <2m and a maximum of 10m) There are 104 bores that source water from the formation in the affected area. It is expected that the impact would not exceed 20 m in any of those bores and would be less than 10 m in more than half of them.
- **Hutton Sandstone:** This aquifer underlies the Walloon Coal Measures. It is separated from the productive coal seams by the lower aquitard of the Walloon Coal Measures. Over most of the affected area the maximum impact is expected to be less than 5 m, although there are small areas where maximum impacts may reach up to 18m. (The Arrow SREIS model found an Arrow-only average drawdown of <5m and a maximum of 8m). There are 23 private bores sourcing water from the formation in the affected area. The maximum impact in any bore would be 13m, but more than half of the bores would experience an impact of less than 7m.
- **Precipice Sandstone:** Over most of the affected area the maximum impact was expected to be less than 2m. West of CSG fields of the Bowen Basin near Injune, the aquifer is in direct contact with the Bandanna Formation and therefore the maximum impact in that area is predicted to reach about 10m. (The Arrow SREIS model found an Arrow-only average drawdown of zero and a maximum of 0.7m). Near Moonie there are very small areas of local impacts where conventional petroleum and gas is currently being produced directly from the Precipice Sandstone and equivalent formation. However, there are no private bores that tap the Precipice Sandstone in the impact areas of more than 5m in this formation.
- **Gubberamunda Sandstone and Mooga Sandstone:** These are shallow aquifers that are not well connected to the coal formations. Generally impacts were expected to be less than 3m and only in relatively small areas. There is one bore that sources water from the Gubberamunda Sandstone in its Long-term Affected Area (LAA). The impact in that bore was expected to be 5m.
- **Clematis Sandstone:** There are small areas where an impact of up to 2m was predicted. Near Moonie there are very small areas of local impact where conventional petroleum and gas is currently being produced directly from the formation.

The maximum impacts in any aquifer would occur at different times at different geographic locations. Maximum impacts in the coal formations would occur towards the end of the life of the CSG industry, generally between 2030 and 2055. Maximum impacts in the Springbok Sandstone and the Condamine Alluvium were predicted to occur between 2060 and 2075. In indirectly connected aquifers where the predicted impacts are comparatively small, such as the Hutton, Precipice, and Gubberamunda Sandstones, there would be a significant time lag before maximum impacts occurred.

For the whole of the CMA, the total amount of induced flow from the formations overlying and underlying the Walloon Coal Measures was predicted to be about 50 per cent of the total water extracted for CSG production from the coal formations.

Impacts in aquifers were predicted to persist for long periods in the absence of re-injection of treated CSG water into affected aquifers, or similar measures. The rate of recovery would be greatest in the years after water extraction ceased, but would reduce exponentially with time. It was estimated that, for the coal measures and the significantly affected aquifers, there would be a 50 per cent recovery from maximum impact, 30 to 80 years after maximum impact.

Also, work carried out by OGIA in the development of the UWIR suggests that water extraction by Arrow is not expected to materially impact on the flow of water to springs.

Condamine alluvium

A feature that distinguishes the Arrow project from other major CSG projects is that it has the potential to have the greatest relative impact on the Condamine Alluvium. The Arrow SREIS finds that the maximum Arrow only drawdown in the Condamine Alluvium simulated by the Arrow SREIS Groundwater Model is 0.5m. The predicted Arrow net adverse flux impact is estimated at 63GL over a period of 100 years. As indicated above, the currently estimated rate of water extraction is approximately 55GL per year. Assuming these predictions to be correct, the extraction soley due to Arrow's activities would be in the order of one hundred times less than the current total rate of extraction.

The UWIR notes that the current difference in water levels suggests a current net flow of water from the Walloon Coal Measures to the Condamine Alluvium. Water levels have been lowered in the alluvium due to water extraction for irrigation, resulting in the water levels in the Walloon Coal Measures now being generally higher than in the alluvium. While water levels have consistently declined in the Condamine Alluvium over the past 40 years, the water level in the Walloon Coal Measures has remained largely unchanged.

The UWIR shows that the planned CSG development would result in some leakage of water from the Condamine Alluvium to the underlying Walloon Coal Measures over a long period. The average estimated net loss is expected to be about 1,100 ML/year over the next 100 years (1100GL). In any year the volume would be relatively small in comparison to other discharge and recharge components of the Condamine Alluvium water balance. However, the leakage is important because the Condamine Alluvium is an essential water resource for irrigation.

The UWIR finds that the maximum predicted drawdown impact of Arrow's activities on the Condamine Alluvium is about 1.2m on the western edge of the alluvium with an average of about 0.5m for most of the area. This is less than the statutory trigger threshold of 2 m for unconsolidated aquifers. Therefore the UWIR does not identify a 'Long-term Affected Area' for the Condamine Alluvium.

Generally there is a significant difference in water quality between the two formations. Salinity within the Walloon Coal Measures is high ranging from approximately 1,000mg/L to over 14,000mg/L, whereas salinity in the alluvium is lower averaging around 1,000mg/L. Despite the water level difference, there has not been a widespread deterioration in water quality in the Condamine Alluvium. This suggests a relatively small amount of flow and that the interconnection between the two formations is not strong.

The declining water levels in the Walloon Coal Measures would be likely to start affecting the Condamine Alluvium around 2017 and the induced leakage would continue long after the cessation of CSG water extraction. The average estimated net loss from the Condamine Alluvium to the Walloon Coal Measures is expected to be about 1,100ML/year over the next 100 years (1100GL).

As part of its work in gaining a better understanding about interconnectivity in the Surat Basin, the OGIA is undertaking a research project in the Condamine area. The project is part of the implementation of the Surat UWIR. The Condamine Interconnectivity Research Project (CIRP) will improve understanding of the interconnectivity between the Condamine Alluvium and underlying coal formation. The project involves analysis of existing lithologic and water chemistry data; collecting new data from existing private bores; and undertaking aquifer pump testing in association with the construction of new monitoring bores. The research project will build new knowledge about the potential cumulative impacts of CSG development. The research is being led by OGIA with Arrow carrying out drilling and pump testing in accordance with OGIA design. Outcomes from the research project will be incorporated into the next revision of the regional groundwater flow model that will be used to update the UWIR in late 2015.

OGIA has established a stakeholder reference group for the Condamine Interconnectivity Research Project and has an external Technical Advisory Panel to review the work carried out. There is wide community support for the research project.

4.9.5.3 Submissions

Submissions on the EIS raised a number of concerns regarding the impacts of the project aquifers and water availability. Key matters in particular Arrow's responses in the SREIS are discussed in the relevant sections below.

Explanation for the decline in water extraction

Submissions on the EIS considered that the explanation for the decline in water extraction volume over time was inadequate and requested further information on the reasons for the decline. Arrow explained that the decline in water extraction presented in EIS Chapter 14, Groundwater, Figure 14.2 represented the normal decline in CSG water as the wells mature and gas production rates increase. This process was described in EIS Chapter 5, Project Description, Section 5.2.4 (Water Treatment and Storage Facilities) and Figure 5.7.

Groundwater recovery timeframes

Concerns were raised in submissions that the EIS contained no information on groundwater recovery and stated that the EIS should outline the long term impacts on groundwater beyond the life of the CSG industry and when full recovery is expected, if at all. In response, Arrow stated that the model was designed to predict maximum drawdowns in various aquifer units prior to the implementation of mitigation measures. The temporal scale of the model was designed to predict when these peaks are likely to occur in the future. In some cases, this timeframe captures some of the recovery phase, but in others it does not. Arrow recognised that management and mitigation measures would need to be in place well before the recovery phase, and proposed to work to mitigate the effects before they are realised. A longer temporal scale was stated to limit the accuracy of the model, and also would not reflect the more likely recovery profiles associated with the implementation of proposed mitigation measures. SREIS Chapter 8, Groundwater presented and discussed the revised groundwater drawdown predictions based on Arrow's current development plan.

Potential impacts on the Great Artesian Basin

A number of submitters, including state agencies, considered that the potential for impacts on the Great Artesian Basin (GAB) had been inadequately described in the EIS, having only been discussed in connection with the deeper formations. It was argued that the intermediate and coal seam groundwater systems should also be considered. All of these systems contain water resources used at least for stock water purposes and are managed as part of the Water Resource (Great Artesian Basin) Plan 2006. In responding, Arrow pointed out that the potential impacts to the groundwater values (including the Great Artesian Basin) were assessed in EIS Chapter 14, section 14.4, Issues and Potential Impacts. A framework for the management of impacts to the groundwater systems, which include Great Artesian Basin resources, was included in the EIS. The results of the SREIS model, presented in Chapter 8, Groundwater, confirmed that the results presented in the EIS were conservative. Land subsidence study and related impacts

In submissions from landholders, agriculture industry bodies and state government departments on the EIS, it was stated that inadequate information was provided on land subsidence and related impacts. Information was requested on any local or national examples on subsidence associated with CSG extraction, possible impacts from subsidence, and proposed mitigation measures.

In responding to this concern, Arrow referred to the literature review of available publications relevant to subsidence as a result of CSG extraction in EIS Appendix G, Groundwater Impact Assessment, Section 8.4. No local examples of subsidence were available. As part of the SREIS, a desktop assessment of additional information available since the EIS was undertaken and included in SREIS Chapter 8, Groundwater and Chapter 9, Surface Water. The desktop study included examples of potential subsidence associated with CSG extraction, and presented the results of a collaborative baseline surface deformation study conducted by CSG proponents within the Surat Cumulative Management Area (Altamira Information. 2012a). The information was used to expand on the discussion and conclusion provided in the EIS that subsidence as a result of CSG extraction would be unlikely to occur in the region.

SREIS Chapter 9, Surface Water provides an assessment of potential impacts associated with subsidence. If available, Arrow proposed to review subsidence related information available from the Australian Government's Office of Water Science (a group within DSEWPaC) to further enhance its understanding of the potential impacts of subsidence.

Groundwater and surface water connectivity

In its submission on the EIS, the former DERM considered that the EIS should state explicitly where surface water-groundwater interactions are believed to occur. Specifically, the EIS should have identified the reaches in the Condamine River that are connected to groundwater within the project development area and provided an assessment of connectivity.

Arrow responded by directing attention to Section 14.5.3 of the EIS which provided a broad discussion on the areas and mechanisms of groundwater and surface water interconnectivity within the project developments area.

Following the release of the EIS, and the additional information available on the types and distribution of groundwater dependent ecosystems within the broader Surat Cumulative Management Area, a more detailed discussion on the location and mechanisms of groundwater and surface water connectivity was included in SREIS Chapter 8. The groundwater modelling results presented in EIS Chapter 14, Groundwater indicated that the groundwater drawdown in areas where groundwater/surface water interactions may occur, specifically in the Condamine Alluvium, would be low. Under the cumulative scenario, the predicted maximum drawdown in the Condamine Alluvium would be 2.5 m.

Groundwater dependant ecosystems

Submissions from DTMR, Fitzroy Basin Association, Queensland Murray Darling Basin Committee, and the former DERM (now DSITIA) stated that groundwater dependent ecosystems (GDEs) had not been specifically identified in the groundwater chapter (EIS Chapter 14, Section 14.3.3). Submissions stated that the potential presence of the full suite of GDE types, including aquifer and cave ecosystems, all ecosystems dependent on the surface expression of water (e.g. base-flow of rivers and streams, wetlands, floodplains and springs), and all ecosystems dependent on the subsurface presence of groundwater (e.g. river red gum), should be assessed based on a conceptualisation of the aquifers, groundwater flow paths, and recharge and discharge points. It was noted that the National Water Commission was currently funding the completion of a national Atlas of Groundwater Dependent Ecosystems which would provide a mapping of potential GDEs at a coarse scale.

The IESC proposed that data be collected on groundwater dependent ecosystems (GDEs) (springs) beyond that itemised in the Surat UWIR. OGIA advised that the source aquifer for spring complex 584 will be assessed. Watercourse springs will be assessed including a preliminary assessment of the nature of the connection and that work will incorporate EHP’s GDE mapping dataset.

Since the release of the EIS, a number of ecological, hydrogeological and botanical studies and surveys of groundwater dependent ecosystems (predominately springs) within the Surat Cumulative Management Area (CMA) have been conducted. The majority of these investigations were commissioned by OGIA to inform the Surat CMA Underground Water Impact Report (UWIR). The findings of these studies were presented in Chapter 8 of the SREIS, and indicated that no groundwater dependent ecosystems are currently identified in the project development area. Under the UWIR, Arrow is not identified as the tenure holder responsible for the management or monitoring of any groundwater dependent ecosystem within the Surat CMA.

SREIS Chapter 8, Groundwater presented Arrow’s framework for the management of potential impacts on groundwater dependent ecosystems that may be identified in the future. Arrow would continue to participate in the early warning industry-wide programs and investigations on the location of springs, the type and extent of groundwater dependent ecosystems, and the affected environmental values. This work is being conducted within the framework of the UWIR and required Spring Monitoring Program and Spring Impact. Chapter 8, Groundwater, confirmed that the results presented in the EIS were conservative.

State agencies considered that the EIS assessment of the potential impact of the proposed project on springs was inadequate, that options to prevent or mitigate impacts on springs had not been adequately considered, and stated that monitoring and assessment of springs should be implemented before, rather than during, the operations phase. The EIS did not provide an adequate assessment of whether springs outside the project area would be affected by the project. A number of submissions on the EIS considered that the detail on mitigation measures for indirect depressurisation of adjacent aquifers provided in the EIS was inadequate, and requested more detail on the specific mitigation measures that would be applied to minimise impacts of depressurisation on groundwater dependent ecosystems. It was also recommended that, before an environmental authority is granted, monitoring should be undertaken to determine the connectivity of discharge springs to aquifers potentially influenced by the project.

In response, Arrow stated that, following the release of the EIS, additional information on the types and distribution of groundwater dependent ecosystems within the broader Surat CMA had become available and allowed a more detailed discussion on the location and mechanisms of groundwater and surface water connectivity, as provided in SREIS Chapter 8, Groundwater. No springs were identified within the Arrow project development area.

Arrow stated that its groundwater management framework targets potential impacts to groundwater users and ecological receptors such as springs and groundwater dependent ecosystems. Arrow would implement the framework required under the Water Act for the management of these potential impacts. This framework requires Arrow to comply with make-good obligations and to work within the requirements of the Underground Water Impact Report (UWIR), which includes the Spring Impact Management Strategy (SIMS). In the event that groundwater-dependent springs are identified in the future and assigned to Arrow for monitoring or management, Arrow would comply with the requirements of the Spring Impact Management Strategy (SIMS) framework, as detailed in SREIS Chapter 8, Groundwater.

Arrow stated that it is involved in a number of current and future research programs associated with the groundwater systems of the Surat Basin, including the OGIA Condamine Interconnectivity Research Project and the Joint Industry Plan for an Early Warning System for the Monitoring and Protection of EPBC Springs. The research programs are intended to improve capacity to predict groundwater impacts, and provide additional detail in future UWIRs.

4.9.6 Avoidance, mitigation and offsetting measures

The EIS documents outline commitments, linked to Arrow's CSG water management strategy, to mitigate, manage and monitor impacts of the project on groundwater values predominately focused around substitution of groundwater allocations and injection.

The EIS documents outlined that flux change impacts on the Condamine Alluvium can be mitigated or offset by several strategies including:

- infiltration from surface water storages
- deep well injection
- 'virtual injection' through substitution.

Much consideration was given to the first two strategies by Arrow in the EIS documents and by the Healthy Head Waters Coal Seam Gas Water Feasibility Study and at this stage it has been concluded that these options have limitations and further investigation is needed.

The Arrow SREIS states that it is currently not considered feasible to undertake deep well injection for the following reasons:

- An appropriate regulatory framework is not in place, including approvals process and provision of an indemnity framework.
- The timeframe for approvals, including completion of trials, would significantly delay project schedules.

4.9.6.1 Substitution

Arrow has made commitments relevant to groundwater substitution, including:

- If impaired capacity is confirmed (e.g. a bore can no longer produce quality or quantity of groundwater for the authorised purpose, and the impact is due to CSG activities), Arrow would implement make-good measures in accordance with the Water Act.
- Arrow would include, where possible, make-good measures such as substitution of groundwater allocations of equal or better quality to maintain user supply, deepening of bores, modification of pumps, or supply of groundwater from an alternative source.
- Arrow would verify the preferred water management strategy by modelling the effectiveness of substitution ('virtual injection') and injection (if conducted) in offsetting depressurisation impacts in the Condamine Alluvium.

Arrow has proposed a substitution area to the west of Dalby, in an intensively developed location within the greater Condamine Alluvium. Arrow proposes to make a substitution supply (i.e. supplying water to users) of 2.5GL/yr over the 25 year life of the project. This would result in approximately 63GL being redressed within 25 years (the actual amount that would need to be substituted would be determined by OGIA based on the results of monitoring and actual extraction quantities). The modelling indicated that this would reduce average drawdown by 0.15m. The area was selected because maximum CSG related drawdowns are expected in this part of the Condamine Alluvium, and it has been assumed that sufficient existing entitlement holders would agree to substitution in order to offset Arrow's proportion of the predicted flux impacts (63GL) for the calibrated model.

While there is currently no regulatory framework for the substitution of groundwater allocations, Arrow has developed a commercial framework to support the supply of treated and untreated CSG water to some groundwater users holding allocations from the Condamine Alluvium. Under the proposed framework, end users would receive and utilise water supplied by Arrow in lieu of utilising their groundwater allocations. Third-party users would be expected to accept legal and practical responsibility for the impacts of their use of the delivered CSG water. Arrow would be responsible for ensuring that CSG water provided to third party users meets relevant water quality guidelines with quality to be confirmed at monitoring points within Arrow's control. Water quality requirements would be determined by the end use of the water and recognised standards for that use.

Submissions on the EIS by State agencies and others sought detailed information on how water supply substitution would take place as this practice has the potential to create significant issues. Information requested included how water would be delivered (e.g. pipelines, water trucks) and stored, and the potential impacts this would have on environmental values.

In response, Arrow advised that the substitution strategy was described in Section 5.6.4 and Attachment 9 of the

EIS. Potential impacts associated with the substitution network were considered to be consistent with impacts associated with the construction, operation and decommissioning of underground water gathering lines and storage dams, which were assessed in the EIS.

SREIS Chapter 3, Project Description, and Attachment 5, Coal Seam Gas Water and Salt Management Strategy provided additional information on the substitution strategy. Arrow proposed to enter into commercial water off-take agreements with third parties to facilitate the provision of a specified volume of CSG water, at a specific quality and over a given time period, in lieu of the third party's access to groundwater allocations from the Condamine Alluvium. The SRIES also provided additional information on CSG water management options within the vicinity of the proposed two water treatment facilities, based on land use, seasonal water supply and demand patterns, and the potential for new uses to emerge during the life of the project.

Arrow used the OGIA model to evaluate impacts for the current development case. This model was used to predict groundwater drawdown under a cumulative scenario, and the results were presented in SREIS Chapter 8, Groundwater. The revised development case included a scenario using substitution of groundwater allocations from the Condamine Alluvium to offset Arrow's component of modelled likely flux impacts to the Condamine Alluvium in the area of greatest predicted drawdown, as a result of CSG water extraction from the Walloon Coal Measures. Modelled likely flux impacts were defined as those simulated in the calibrated OGIA Surat Cumulative Management Area (CMA) Groundwater Model realisation, occurring over the period referred to in the UWIR for the Surat CMA (OGIA, 2012) i.e. the next 100 years. Substitution will be presented in the context of a modelled water balance and will rely on end users signing up to substitution.

4.9.6.2 Make good arrangements

The Arrow EIS included commitments to make-good loss of access to groundwater consistent with the Water Act on water groundwater impairment of private bore water supplies within the cumulative management area, and to verify the preferred water management strategy by modelling the effectiveness of substitution (‘virtual injection’) and injection (if conducted) in offsetting depressurisation impacts in the Condamine Alluvium.

A number of submissions on the EIS sought detailed information on how make-good measures would be implemented, particularly how water would be supplied to landholders in the short term, any adverse impacts on environmental values, and how make-good would be achieved once operations cease. In response, Arrow referred to the commitment that ,if impaired capacity is confirmed (e.g. a bore can no longer produce quality or quantity of groundwater for the authorised purpose, and the impact is due to CSG activities), Arrow would implement make-good measures in accordance with the Water Act. Additional detail on how make-good measures would be implemented was not provided on the basis that make-good measures are determined on a case by case basis, as required by the Water Act. Arrow's make-good obligations would be determined under the Water Act independently of the project’s gas production time frame.

SREIS Attachment 5, Coal Seam Gas Water and Salt Management Strategy presented Arrow's hierarchy of make-good options, which predominantly involved modifying the pumping infrastructure, deepening the bore, or drilling a new bore in preference to supplying an alternative source of water (including treated or untreated CSG water). This approach would avoid impacts associated with the provision of water via trucks, pipelines or surface storage.

4.9.7 Monitoring program

Submissions on the EIS considered that the monitoring program proposed was inadequate and argued that, whereas the EIS should have described in detail the groundwater monitoring that would take place in the targeted coal seams and the underlying and overlying aquifers, including the frequency of monitoring (both water levels/pressure and water quality). The former DERM stated that, as a minimum, the groundwater monitoring program (not including shallow “pond monitoring”) should include 80 monitoring sites and sixty of these monitoring sites should include 3 monitoring points:

- 60 monitoring points in the targeted coal seams
- 60 monitoring points in the consolidated aquifers above the targeted coal seams
- 60 monitoring points in the consolidated aquifers below the targeted coal seams.

The former DERM further stated that the other 20 monitoring sites should have monitoring points located in the Condamine Alluvium

In response, Arrow committed to meeting its obligations under the UWIR to implement a groundwater monitoring plan in consultation with, and regulated by the Office of Groundwater Impact Assessment (OGIA) as part of the Surat Cumulative Management Area (CMA) and the associated draft Underground Water Impact Report (UWIR). Details of the monitoring plan, including the approximate locations of monitoring wells, the frequency of monitoring and the type of data to be collected would be provided as part of the statutory information requirements to support an application for an environmental authority (EA) or EA amendment, in accordance with the EHP Guideline

"Application requirements for petroleum activities".

The IESC noted that there may be a need for an water monitoring network beyond that required under the Surat UWIR, 'to facilitate early detection of potential impacts on environmental assets at a local scale, particularly where greater drawdown than predicted may result in more adverse impacts on environmental values and other groundwater users'.

OGIA advised that, in addition to the monitoring works that are being installed under the Surat UWIR, there is an extensive network of government owned Condamine Alluvium monitoring bores already in place. Also, it is likely that additional monitoring works will be installed as part of the Condamine Interconnectivity Research Project. There may also be amendments to the water monitoring requirement for petroleum tenure holders when the Surat UWIR is updated to incorporate new knowledge in December 2015.

A number of submissions expressed concerns with potential contamination resulting from leakage of CSG water storage dams and requested further information on groundwater monitoring bores associated with such storages, including monitoring depth, parameters and frequency, including arrangements at end of project. Arrow stated that it has committed to install groundwater monitoring bores near dams as a leak detection measure. Groundwater monitoring programs would be required as a condition of the environmental authority. Details of the monitoring plan associated with water storage dams, including the approximate locations of monitoring wells, their depth, the frequency of monitoring and the type of data to be collected would be provided to support an application for an environmental authority or an environmental authority amendment, in accordance with EHP Guideline "Application requirements for petroleum activities".

4.9.8 Conclusion

The *Petroleum and Gas (Production and Safety) Act 2004* and Petroleum Act give tenure holders the right to take or interfere with groundwater to the extent necessary to extract the desired petroleum/gas.

Arrow undertook its own groundwater modelling in the EIS and used a modified version of the OGIA model for the Surat Basin in the SREIS which considered the revised project description, including revised water and gas extraction rates and quantities. Although there are differences between the predictions made by the two models (OGIA and Arrow's use of OGIA model), OGIA advised that the Arrow SREIS model is unlikely to under-represent the groundwater impacts on aquifers adjacent to the Walloons.

The expected impact of the Arrow project on the Springbok Sandstones is an average drawdown of <2m and a maximum of 10m and on the Hutton Sandstones an average drawdown of <5m and a maximum of 8m. The expected impact of the Arrow project on the Condamine Alluvium is an average of about 0.5m for most of the area.

The Water Act requires CSG tenure holders to monitor and manage the impacts caused by the exercise of these groundwater rights and to make-good impairment of private bore water supplies (within certain parameters), and Arrow has committed to do this.

Hence, as with other CSG projects in the Surat Basin, this assessment report reaches the conclusion that the groundwater modelling to date has indicated that the likely impacts of drawdown of groundwater are acceptable and can be managed through existing regulatory mechanisms.

The proximity of Arrow's proposed treated CSG water discharge points to the intakes of town water supply schemes would necessitate consideration of the requirements of the *Water Supply (Safety and Reliability) Act 2008*.

4.9.9 Recommendations

With regard to groundwater and associated CSG water management, if the project proceeds, the following need to be addressed.

In relation to the EP Act, EHP notes that Arrow has committed to providing information relevant to CSG water management to support applications for environmental authorities under the EP Act. The suite of information required under the EP Act is outlined in Appendix 4. Any application for beneficial reuse of treated CSG water would also require application for a beneficial use approval under the *Waste Reduction and Recycling Act 2011* or the EP Act.

It appears likely that the proposed treated CSG water discharges would enter watercourses upstream of the urban water supply schemes for Dalby and Miles. Detailed information on this is yet to be provided but if that is the case Arrow would have to comply with the requirements of the *Water Supply (Safety and Reliability) Act 2008*. This will entail a requirement to have an approved Recycled Water Management Plan (or an exclusion decision).

In summary, Arrow will need to:

- Comply with the requirements of the Water Act (and the complementary Underground Water Impacts Report for the Surat Cumulative Management Area).

- Comply with the requirements of the *Water Supply (Safety & Reliability Act) 2008* in regard to any discharges of treated CSG water to a watercourse upstream of a drinking water supply intake.
- Comply with the requirements of the Darling Downs Regional Plan when it is finalised.
- Comply with information requirements and the approval conditions of the necessary environmental authority under the EP Act.
- Meet any requirements under the *Waste Reduction and Recycling Act 2011* for the beneficial reuse of CSG water.

4.10 Surface water

This section describes surface water values potentially affected by the project, potential impacts on these values, and proposed mitigation measures. Particular consideration is given to overland flow, flooding, water quality, the discharge of CSG water to surface waters, erosion and sedimentation, stormwater management, the management of hazardous substances, and potential effects of subsidence.

A number of other matters addressed by the EIS are linked to potential impacts of the project on surface waters. The adequacy of the EIS in assessing these related matters is discussed in other sections of this assessment report as follows:

- section 4.8 Agriculture: Erosion as it relates to agriculture
- section 4.9 Groundwater: Subsidence
- section 4.11 Ecology: Impacts to aquatic ecology.
- section 4.20 Hazards and risk: Catastrophic events, such as dam failure, uncontrolled releases or extreme weather events, and the management of potential contaminants and hazardous substances.
- section 4.21 Waste: The management of hydrotest water and CSG water management

4.10.1 Assessment methodology

Surface water values and potential impacts to surface water values were described in EIS chapter 15, Surface water. Technical information, including overland flow assessments and flood modelling, was included in EIS appendix H, Part A: Fluvial Geomorphology and Hydrology and in EIS appendix H, Part B: Water Quality.

EIS chapter 15 provided a desktop review of existing information on surface waters within the project development area and surrounding sub-basins, an overview of field surveys of surface water, hydrology, geomorphology and condition, and a general description of existing and potential surface water uses.

Field surveys were conducted for water quality, geomorphology and benthic sediments at sites indicated in Figure 15.1 of EIS Chapter 15. Water quality data was collected at 46 sites in October 2009, November 2009, March 2010, and May 2010. The geomorphology and hydrology of watercourses were categorised at 112 sites in October and December 2009.

The SREIS Chapter 9, Surface water, included additional information on geomorphology, hydrology, and surface water quality assessment at, or adjacent to, sites proposed for central gas processing facilities, CSG water treatment facilities, and proposed CSG water discharge locations. Detailed information was included in the following technical reports:

- SREIS appendix 5, Supplementary Surface Water Assessment, Part A—Geomorphology and Hydrology
- SREIS appendix 6, Supplementary Surface Water Assessment, Part B—Water Quality
- SREIS appendix 7, Supplementary Surface Water Assessment, Part C—Preliminary Environmental Flows Assessment.

The findings of a collaborative study of the potential for natural surface deformation as a result of CSG water extraction were described in SREIS Chapter 8, Groundwater. The significance of potential subsidence impacts on surface waters, particularly overland flow, was discussed in SREIS Chapter 9, Section 9.7. It was stated that this information was used to refine the geomorphic assessment of the watercourses and overland flows in the SREIS.

SREIS Appendix 5 provided an assessment of the geomorphology and hydrology of surface waters (including wetlands mapped in the Queensland Wetlands Programme, Version 3) within or adjacent to properties identified for the location of major project infrastructure and CSG water treatment including Bottle Tree Creek at the CGPF2 property, and the Condamine River at the CGPF9 property. The assessment was based on field surveys at discharge sites in February 2013, and downstream reaches (Bottle Tree Creek and Dogwood Creek to approximately 21km downstream from the CGPF2 property (and the Condamine River to 14km downstream from the CGPF9 property) in March 2013. The geomorphological assessment included information on physical characteristics such as bank stability, channel dimensions and existing erosion. The hydrological information, based on flood modelling, hydraulic modelling and field assessments, was used to identify areas within the properties proposed for location of CGPF2, 7, 8, 9 and TWAF F that could be vulnerable to flooding, and the extent and direction of likely overland flow on these properties resulting from localised rainfall.

SREIS Appendix 6 provided a surface water quality assessment based on water quality data from Arrow's existing operations in the Surat basin, the DNRM surface water quality database, and water quality sampling for the SREIS at the proposed CSG water discharge locations. The assessment was undertaken to determine the capacity of potentially affected watercourses to accept the proposed discharges and to determine the water quality objectives for those watercourses. Surface water quality sampling for the SREIS was conducted on Bottle Tree Creek, Dogwood Creek and the Condamine River between 12 February 2013 and 14 February 2013 following high rainfall in the catchments.

SREIS Appendix 7 provided a preliminary environmental flow assessment to aid determination of acceptable frequencies, timing and volumes of flow at the proposed discharge sites at the CGPF2 and CGPF9 properties, and provided recommendations for further development and assessment of proposed discharge regimes. The assessment comprised a literature review of approaches to the description and determination of environmental flows with consideration of application to watercourses in the project development area, a flow spells analysis to describe the current flow regime at both sites, and a workshop to determine a range of flows that could be sustainably discharged without compromising ecosystem function.

4.10.2 Existing environment

4.10.2.1 Overland Flow

While not specifically identified as an environmental value, overland flow is an important source of water for agriculture on the Jimbour and Condamine floodplains. While this is acknowledged in the Arrow response to submissions included in the SREIS, particularly in the commitments to minimise disruption of overland flows, there is little mention in the main reports of the extent and value of overland flows, either for environmental requirements or for use by agriculture.

4.10.2.2 Streams

The SREIS noted that the geographic extent of potential impacts to surface water would include the sub-basins of the Balonne River, Condamine River, Macintyre Brook, Moonie River, Dawson River and Macintyre and Weir rivers. The sub-basins were further divided into 64 sub-catchments within the project development area.

The EIS documents report that the watercourses in the project development area were predominantly ephemeral with some semi-permanent, and displayed geomorphic and habitat diversity. Intermittent rivers and creeks were characterised by disconnected pools and dry beds during the dry season.

4.10.2.3 Wetlands

The EIS identified riverine, lacustrine and palustrine wetlands within the project development area and estimated total wetland areas as follows:

- riverine wetlands—4182ha
- lacustrine wetlands—4878ha (including Lake Broadwater west of Dalby)
- palustrine wetlands—1544ha.

The EIS stated that palustrine and lacustrine wetlands of the Condamine River floodplain, including Lake Broadwater and Long Swamp, would support a high number of listed flora and fauna species, and migratory species identified under the China-Australia Migratory Bird Agreement, Japan-Australia Migratory Bird Agreement, and Republic of Korea–Australia Migratory Bird Agreement.

The EIS highlighted the values of Lake Broadwater, located within Lake Broadwater Conservation Park, as a permanent freshwater lake of national significance, migratory bird habitat, recreational value (e.g. skiing, swimming, boating), and of value in supporting ecological processes including acting as a filter for water, sediment and other pollutants. Eight other nationally listed wetlands were identified downstream in the Condamine River catchment and outside of the project development area, but were not further assessed. The Ramsar-listed Narran Lakes Nature Reserve in north-central New South Wales, located 500km downstream, was considered unlikely to be impacted by project activities. Similarly, the Ramsar wetlands of the Shoalwater and Corio Bays Area were considered to be too distant to be affected and are also not directly linked to the Fitzroy River catchment.

The surface water environmental values, their function and sensitivity were summarised in the EIS and reproduced in Table 13

Table 13.

Table 13 Surface water environmental values (source: EIS Chapter 15, Surface Water, Table 15.5)

Existing Environment	Characteristics Contributing to the Value	Sensitivity of the Value
Lake Broadwater	• high degree of ecological intactness • valuable aquatic habitat, in particular for: – national- and state-listed aquatic fauna species of significance, including the Murray cod – locally significant species • facilitates important ecological processes for maintaining water quality and filtering sediment and other pollutants	high
Other wetlands	• generally high degree of ecological intactness but site-specific variation • support terrestrial and aquatic species • contribute to habitat diversity • provides aquatic habitat • facilitates ecological processes for maintaining water quality and filtering sediment and other pollutants	moderate
High-order streams (permanent and semi-permanent watercourses)	• moderate degree of ecological intactness with clear evidence of disturbance • continuous flow supports downstream use • contribute to habitat diversity • chains of ponds are sensitive to disturbance • support recreational activities • reduction of flood peaks and extending base flows	moderate
Low-order streams (ephemeral watercourses)	• provide marginal habitat • facilitate marginal ecological processes	low

4.10.3 Impacts

The EIS stated that impacts to surface water may occur during construction, operation and project maintenance, consistent with the known impacts of existing Arrow gas field operations. The major potential impacts to surface waters were identified as:

- interference with naturally occurring overland flow and flooding
- degradation of surface waters resulting from the discharge of treated or untreated CSG water
- increased erosion and sedimentation associated with overland flow restrictions, CSG water discharge, and other construction, operation and decommissioning activities
- uncontrolled releases of stormwater and contaminants.

More specifically, the EIS identified, for each of the phases of the project, the following impacts that could occur:

During construction of wells, gathering lines and production facilities:

- changes to physical form and diminished water quality from the removal of riparian vegetation, with subsequent reduced bank stability and increased erosion and sediment mobilisation
- diminished water quality due to the removal of terrestrial vegetation leading to increased runoff and sedimentation in the watercourses
- changes to physical form and hydrology, and diminished water quality resulting from controlled and uncontrolled releases of hydrotest fluids
- diminished water quality resulting from spills of hazardous substances or drill muds
- damage to farmers' assets resulting from placement of infrastructure on floodplains

- flooding, changes to physical form and changes to hydrology resulting from placement of infrastructure in overland flow paths
- diminished water quality resulting from earthmoving and soil stockpiling leading to increased sedimentation in watercourses
- changes to physical form and diminished water quality resulting from pipeline or vehicle watercourse crossings causing bed and bank erosion and subsequent mobilisation of sediment
- changes to hydrology due to blockages in streams associated with pipeline watercourse crossings (open-cut crossings).

During operation of the wells and production facilities:

- changes to hydrology, diminished water quality and changes to physical form resulting from controlled and uncontrolled releases of CSG water and hydrotest fluids
- diminished water quality resulting from increased runoff from compacted areas leading to sedimentation in the watercourses
- surface water degradation and injury to people or property resulting from a catastrophic release of a water storage dam
- diminished water quality resulting from spills of hazardous substances
- damage to farmers' assets resulting from placement of infrastructure on floodplains
- flooding, changes to physical form and changes to hydrology resulting from placement of infrastructure in overland flow paths
- changes to hydrology caused by changed overland flow paths
- changes to physical form due to scour and generation of sediment at watercourse crossings caused by the use and maintenance of access tracks
- surface water quality degradation due to contaminated runoff.

During decommissioning of wells, gathering lines and production facilities:

- diminished water quality resulting from spills of hazardous substances
- diminished water quality resulting from earthmoving and soil stockpiling leading to increased sedimentation in watercourses
- diminished water quality resulting from increased runoff in cleared areas leading to sedimentation in watercourses
- changes to physical form causing sediment movement into watercourses due to the proximity of works to watercourses and wetlands.

The SREIS stated that downstream transport of eroded material from the watercourse running through the CGPF8 property could impact on Lake Broadwater.

4.10.3.1 Coal seam gas water discharge

The EIS stated that the discharge of treated CSG water would only occur during high rainfall events and in emergencies at unspecified locations. A large number of submissions on the EIS, including the submission by the former DERM, raised concerns with the lack of information on the use or disposal of CSG water, and particularly in relation to the proposed discharge of untreated CSG water to surface waters.

The SREIS stated that discharge of CSG water to watercourses (Condamine River and to Bottle Tree Creek, a tributary of Dogwood Creek) located adjacent to water treatment facilities on properties identified for the location of CGPF2 and CGPF9 would occur during normal operations and through emergency releases, including during no-flow and low-flow events. The frequency, volume and quality of discharge during normal operations were not defined. Emergency releases were proposed to occur in order to maintain the structural or operational integrity of water storage dams.

The water treatment facility located on the CGPF2 property would have a potential capacity of 35ML/day and would discharge to Bottle Tree Creek. The water treatment facility located on the CGPF9 property would have a potential capacity of 90ML/day and would discharge to the Condamine River. The SREIS stated that CSG water disposal would occur when the water could not be used by third parties and could not be stored on site. Discharge from CGPF2 would enter Bottle Tree Creek at either of two potential sites, located approximately 18km north-north east of the town of Miles. The second discharge location would be located on property CGPF9 on the Condamine River with discharge either to Cecil Weir, near the town of Cecil Plains, or several kilometres downstream from Cecil Weir at a point where there was adequate channel stability.

Disposal to watercourses is the least preferred option under the CSG waste hierarchy in EHP's CSG Water Management Policy 2012, which promotes avoidance, reduction, reuse, recycling, recovering, treatment and disposal. Section 4.21 Waste of this assessment report contains further information on proposed CSG water management, including disposal.

The SREIS Strategic EMP stated that untreated CSG water from the Walloon Coal Measures had the following characteristics, based on samples taken from 67 wells in the Surat basin currently extracting CSG:

- pH range 7.0 – 11.4
- electrical conductivity 830 – 31000 μS/cm)
- total dissolved solids 534 – 20150 mg/L
- calcium 4 - 1160 mg/L
- magnesium 2 – 850 mg/L
- sodium 135 – 6950 mg/L
- chloride 65 – 12 770 mg/L
- bicarbonate 5.2 1980 mg/L
- sulfate 0 – 355 mg/L.

Treated CSG water was not characterised in the EIS documents. The SREIS indicated that treated CSG water may be blended with untreated CSG water to meet the water quality guideline values for the protection of beneficial uses, including crop irrigation, stock watering, drinking water and aquatic ecosystem function.

While CSG water discharge frequencies, timing and volumes were not defined, the SREIS proposed a potential discharge volume limit based on a maximum of 20% deviation from natural flow conditions in the receiving watercourse, indicating that such increases in flow should not result in significant adverse impacts on watercourse geomorphology, water quality and aquatic ecology. However, the SREIS recommended further assessments to determine appropriate frequency, timing and volume of the proposed discharges. As approval for any discharge would be required under the EP Act and the *Water Supply (Safety and Reliability) Act 2008*, this information would be needed by the administering authority to assess and condition the proposed discharge. Queensland Health noted that, although not stated in the EIS or SREIS, a Coal Seam Gas Recycled Water Management Plan would be required if the release of water is determined (by the Office of the Water Supply Regulator) to have a 'material impact' on a drinking water source, and that in all other circumstances an Exclusion Decision would be required, whether or not the water is provided commercially.

Hydraulic modelling (SREIS appendix 5) for Bottle Tree Creek used the nominal capacity of the planned water treatment facility adjacent to CGPF2 of 35 ML/d as the discharge volume. The sensitivity of the watercourse to higher flows was also modelled using a discharge volume of 86 ML/d. Hydraulic modelling of Bottle Tree Creek considered the following scenarios:

- no seasonal flow (and an additional 35ML/d)
- no seasonal flow (and an additional 86ML/d)
- the 1-in-2-year average recurrence interval (ARI) flow event (no discharge)
- the 1-in-2-year ARI flow event (and an additional 35ML/d)
- the 1-in-2-year ARI flow event (and an additional 86ML/d).

The SREIS stated that modelling indicated that hydraulic parameters remain generally unchanged across the assessed reach for a no seasonal flow event (also referred to as a cease to flow event) or a 1-in-2-year ARI flow event, in combination with a discharge of 35 ML/d. Similar results were observed for a cease to flow event or a 1-in-2-year ARI flow event, in combination with a discharge of 86 ML/d, indicating geomorphic changes were unlikely to occur as a result of planned discharges provided the flow is relatively continuous and varied gradually to reflect aquatic and terrestrial ecology requirements. Stage discharge curves for the proposed gauging station sites on Bottle Tree Creek showed the depth of water would range from 0.51m for a $0.1m^3/s$ flow (8ML/d) to 0.88m for a $1.0m^3/s$ flow (86ML/d).

Hydraulic modelling for the Condamine River used the nominal output of the planned water treatment facility to be located adjacent to CGPF9 (90ML/d) as the discharge volume. The sensitivity of the watercourse to higher flows was also modelled using a discharge volume of 130 ML/d. This value was derived from the stage discharge curves calculated for the Condamine River. Hydraulic modelling of the Condamine River considered the following scenarios:

- no seasonal flow (and an additional 90ML/d)
- no seasonal flow (and an additional 130ML/d)
- the 1-in-2-year ARI flow event (no discharge)
- the 1-in-2-year ARI flow event (and an additional 90ML/d)
- the 1-in-2-year ARI flow event (and an additional 130ML/d).

The SREIS concluded that hydraulic parameters remained generally unchanged across the assessed reach for a cease-to-flow event or a 1-in-2-year ARI flow event, in combination with a discharge of 90 ML/d. Similar results were observed for a cease-to-flow event and a 1-in-2-year ARI flow event, in combination with a discharge of 130ML/d, indicating geomorphic changes are unlikely to occur as a result of planned discharges provided the flow is relatively continuous and varied gradually to reflect aquatic and terrestrial ecology requirements. Stage discharge curves for the gauging station at the Cecil Plains weir pool showed the depth of water would range from 0.16m for a 0.1m^3/s flow (8ML/d) to 0.36m deep for a 1.5m^3/s flow (130ML/d). Stage discharge curves for the proposed gauging station downstream of the Cecil Plains weir showed the depth of water would range from 0.33m for a 0.1m^3/s flow (8ML/d) to 0.83m deep for a 1.5m^3/s flow (130ML/d).

The SREIS stated the following potential impacts associated with the proposed discharges:

CGPF2 property:

- changed hydrology (flow regime) in Bottle Tree Creek and Dogwood Creek
- reduced access at vehicular and stock crossings on Bottle Tree Creek and Dogwood Creek due to extended period of flows
- exacerbated existing bank and bed erosion in Bottle Tree Creek and Dogwood Creek
- slumping at the toe of creek banks in sandy soils.

CGPF9 property:

- changed hydrology (flow regime) in the Condamine River
- exacerbated existing bank and bed erosion in the Condamine River and Crawlers Creek
- exacerbated bank erosion of the flood channel linking the Condamine River and the Condamine River (North Branch) if flows in this channel are increased due to discharge
- exacerbated bank erosion downstream of a palustrine wetland located downstream of the CGPF9 property if there are prolonged increased flows resulting from discharge.

4.10.4 Avoidance and mitigation measures

4.10.4.1 Overland flow

A large number of submissions on the EIS from landholders and organisations, including Central Downs Irrigators, Basin Sustainability Alliance, and Jimbour Action Group expressed concern about potential changes to overland flow and flood flows with the potential for erosion, water-logging, interference with irrigation systems and infrastructure, loss of access to water, impacts to general farming operations, and potential conflict between neighbouring landholders.

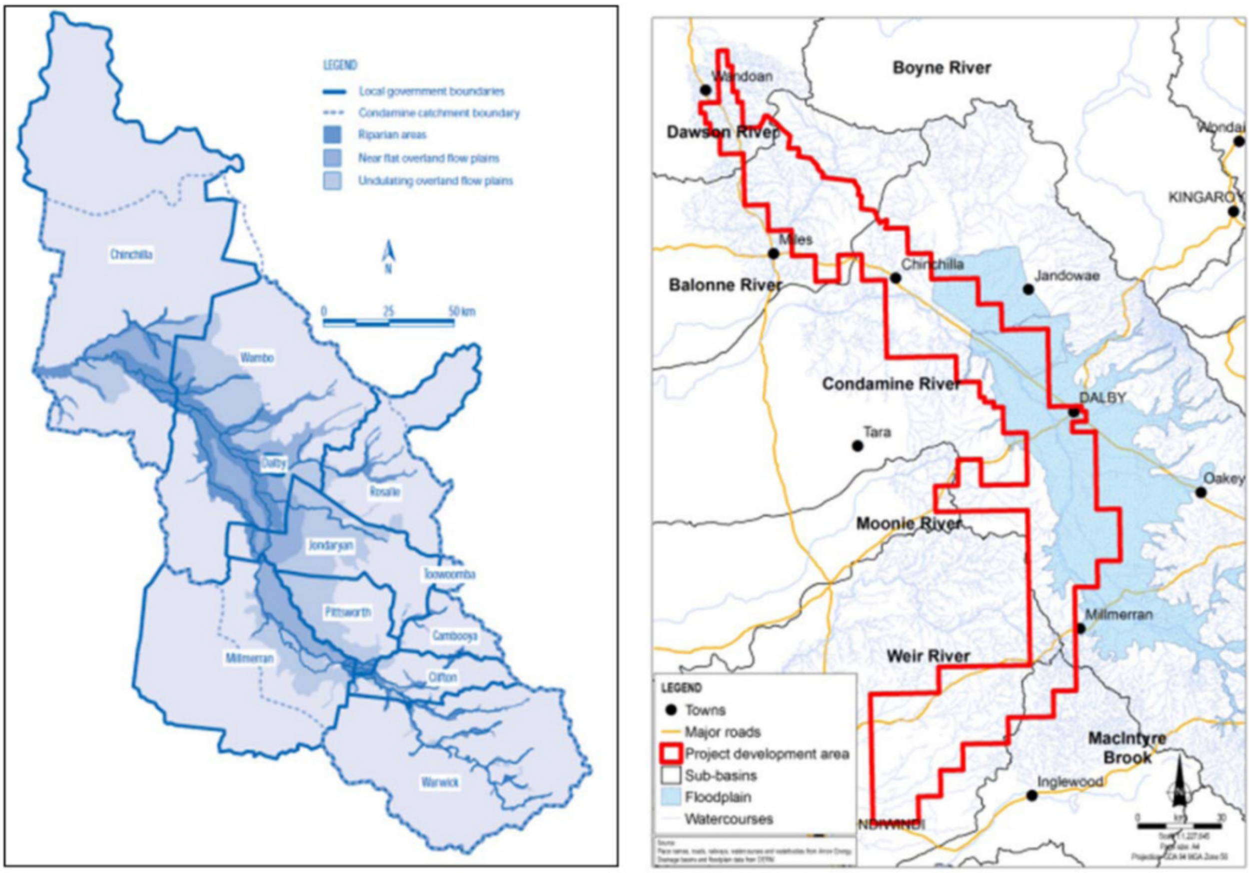
Arrow committed to implementation of the following mitigation measures:

- avoid disrupting overland natural flow paths and, where avoidance is not practicable, maintain connectivity of flow in watercourses
- communicate and negotiate with landholders according to the Arrow Area Wide Planning process
- reach agreement with landholders on the need and location for access tracks and other infrastructure prior to installation to minimise disruption to overland flow
- seek landholders' knowledge of overland flow regimes on their properties
- design access tracks, gathering lines and well pads so they do not impede overland flow
- construct all weather access tracks to maintain the existing hydrologic and hydraulic regimes including overland flows
- reinstate natural drainage lines and follow fence lines, roads or tracks to minimise disturbance
- decommission infrastructure in such a manner that it will not adversely affect overland flow
- develop erosion and sediment control plans based on Best Practice Erosion and Sediment Control Manual (IECA, 2008) supported by topographic LIDAR data and landholder advice
- stockpiling of soil may be avoided in irrigated floodplain areas to avoid impacts to overland flow
- fence design to take into consideration security, impacts on surrounding land use and overland flow.

4.10.4.2 Flooding

The EIS (appendix H) included information on flood levels and flooding history from the Bureau of Meteorology, former DERM, and from Condamine River overland flow modelling undertaken by Land Resource Assessment and Management Pty Ltd (LRAM). LRAM reportedly mapped overland flow paths, estimated the extent of flooding, and provided spatial information tools to assist with Local Government planning. The delineation of the Condamine River floodplain, as prepared by LRAM, was published in the Guidelines for Incorporating Runoff and Flow Coordination into Local Government Planning Schemes on the Condamine Floodplains (DLGP, 2003), however the scale is coarse and incomplete in certain sections.

The EIS stated that it should therefore only be considered as a guide. The maps of overland flow and flooding shown below were included in EIS appendix H. See Figure 6.



(a) Prepared by LRAM Pty Ltd (DLGP, 2003, pg 12)

(b) GIS flood plain information provided by DERM

Figure 6 Condamine River Floodplain Mapping (source: EIS Appendix H, Figure A4-3)

The EIS stated that a flood frequency analysis had been undertaken for the Condamine River (Dogwood Creek, Oakey Creek, Canal Creek, Macintyre Brook and Juandah Creek, a tributary of the Dawson River). It was concluded that, given the extent of the project development area, the number of weirs, off-channel storages and the complexity of modelling overland flow paths, the statistical analysis of flood frequency based on stream flow alone was limited in its usefulness. However, a comparison of peak flows for the recent floods in December 2010 and January 2011 provided an estimate of their ARI and was considered more useful. Detailed flood modelling, and modelling of overland flow paths, was recommended if project infrastructure is proposed to be situated in flood prone areas or where likely to influence flood flows. This recommendation was not directly reflected in commitments although the following commitments were relevant:

- When siting production facilities, avoid wetlands and consider flooding regimes and areas subject to inundation.
- Site facilities above the 1-in-100-year average flood recurrence interval where practicable and design infrastructure taking into consideration overland flow and flooding regimes to reduce impacts on immediate and surrounding areas.

A number of submissions on the EIS, including from the former DERM, raised concerns with the potential impact of floods on project infrastructure (gas leaks, CSG water leaks (from wells, dams, or pipelines), dam failure, brine release). The former DERM requested further detail on the proposed location of infrastructure relative to 1% annual exceedance probability (AEP) flood events, and assurance of the integrity of infrastructure following flood events.

In response, SREIS appendix 5 included overland flow path modelling to determine the 1% AEP event flood for the properties proposed for location of CGPF2, 7, 8 and 9 and the TWAF F. The SREIS stated that infrastructure in the Jimbour floodplain area (Jimbour Creek, Cooranga Creek and Myall Creek) was limited to wells, tracks and gathering lines, and any resulting erosion could be adequately managed and mitigated by measures stated in the EIS without the need for complete overland flow modelling.

Arrow stated that the location and design of infrastructure would have regard to flood mapping and natural flow paths on floodplains and maintenance of overland flow would be a key input to route selection and rehabilitation methods determined at a property level. A commitment was made to avoid disrupting natural overland flow paths and, where avoidance was not practicable, to maintain connectivity of flow in watercourses.

Further details were proposed to be made available after the completion of detailed field development planning and as required to meet statutory information requirements in accordance with the EHP Guideline Application requirements for petroleum activities to accompany the application for an environmental authority (EA) or EA amendment.

4.10.4.3 Erosion, sedimentation, stormwater management and hazardous substances

Submissions on the EIS expressed concern about accidental spills and potential contamination associated with hazardous substances, drilling fluids, and CSG water, and the lack of defined locations for project infrastructure, which made it impossible to determine the actual risk. In response, Arrow referred to EIS Chapter 25, Preliminary Hazard and Risk, Section 25.4.2, and to a number of relevant commitments, including:

- Develop and implement emergency response and spill response procedures to reduce impacts that could occur as a result of releases of hazardous materials or any loss of containment of storage equipment.
- Apply appropriate international, Australian and industry standards and codes of practice for the storage and handling of hazardous materials such as chemicals, fuels and lubricants.
- Minimise the inventory of hazardous materials stored on site.
- Carry out corrective actions immediately upon the identification of any contamination of soil or groundwater that has occurred as a result of project activities.
- Select drilling fluids to minimise potential groundwater impacts and to not use oil-based drilling fluids.
- Design brine dams in accordance with the requirements of the most recent version of manual for assessing hazard categories and hydraulic performance of dams (EHP, 2012c).
- Consider state planning policy 1/03, mitigating the adverse impacts of flood, bushfire and landslide when designing, constructing and operating the project.
- Site facilities above the 1-in-100-year average flood recurrence interval, where practicable, and design infrastructure taking into consideration overland flow and flooding regimes to reduce impacts on immediate and surrounding areas.

A number of submissions on the EIS raised concerns with the adequacy of assessment and management of erosion and subsequent sedimentation and water quality risks, including:

- surface water flows along subsided pipeline trenches potentially causing major erosion
- construction of elevated formed roads and well pads on level floodplains causing changes in overland flows resulting in erosion
- stockpiling of soil on floodplains
- erosion of watercourse crossings for pipelines and access tracks
- lack of detailed erosion and sediment control measures
- special sensitivity of the Jimbour flood plain, Captains Mountain and Bora Creek areas.

In response, Arrow outlined a range of commitments and other measures intended to provide effective control of erosion, which were included in the SREIS Attachment 4, Commitments, and the SREIS Strategic EMP.

CGPF layouts would typically include stormwater runoff retention and sediment control ponds (SREIS chapter 3, Figure 3.4). To manage stormwater, contaminants and hazardous materials, the SREIS Strategic EMP proposed a number of mitigation measures:

- Segregate stormwater discharge from potential contaminant process areas.
- Install and maintain diversion drains to divert clean surface runoff water around production facilities and away from construction areas.
- Design washdown facilities to ensure that runoff is contained on site and does not transfer weed seeds, spores or infected soils to adjacent areas.
- Treat or dispose of washdown solids in a registered landfill.
- Visually inspect physical form and monitor hydrology, turbidity and pH upstream and downstream of central gas processing and integrated processing facility stormwater and CSG water discharge points.
- Apply appropriate international, Australian and industry standards and codes of practice for the handling of hazardous materials (such as chemicals, fuels and lubricants).

4.10.4.4 Coal seam gas water discharge

Commitments given in the EIS for the emergency discharge of CSG water included:

- discharge water from project activities at a rate and location that would not result in erosion
- install erosion protection measures, including energy dissipation structures, at discharge outlets
- develop procedures for the controlled discharge of CSG water under emergency conditions
- develop a monitoring program including water quality monitoring stations upstream and downstream of discharge points to determine any changes in water quality that could be caused by the project
- conduct discharge events in accordance with specific parameters, including discharge volumes, flows and duration, and water quality.

The SREIS Chapter 9 addressed the potential impacts associated with the proposed discharge of treated and untreated CSG water during normal operations and in emergency situations. The water quality assessment was limited to a single sampling event which was not adequate to define local water quality objectives. The potential impact on water quality as a result of discharges was not adequately assessed. The SREIS did not clarify whether discharge of untreated water is proposed other than in emergency situations, and the proposed discharge water quality for routine discharge ('normal operation') was not defined. SREIS appendix 8 included recommendations for additional studies of the natural flow regime, stream geomorphology, water quality and ecological response to changed habitat as a result of discharges, to inform development of a discharge strategy.

The SREIS stated that the following recommendations would be considered in selecting and designing the discharge point on the CGPF2 property and in developing the discharge strategy:

- establish a gauging station on Bottle Tree Creek downstream of the selected discharge point to monitor seasonal variability in stream flow in order to develop an appropriate discharge regime
- locate the discharge point at one of the two sites of exposed bedrock and sound channel stability identified in Bottle Tree Creek
- design discharges to not exceed 1m^3/s (equal to approximately 86 ML/d) during 'no seasonal flow' and higher flow conditions to reduce the risk of erosion and geomorphic change
- vary discharge rates gradually to ensure that rapid drawdown of flow does not cause slumping, which would exacerbate bank erosion in susceptible reaches.

The SREIS stated that the following recommendations would be considered in selecting and designing the discharge point on the CGPF9 property and in developing the discharge strategy:

- locate the discharge point immediately upstream of the Cecil Plains weir pool or downstream of the weir at a point of sound channel stability
- if practicable, do not discharge CSG water to Crawlers Creek due to its inherent instability and sensitivity to erosion
- design discharges to not exceed 1.5 m^3/s (equal to approximately 130 ML/d) during 'no seasonal flow' and higher flow conditions to reduce the risk of erosion and geomorphic change
- if the Cecil Plains weir pool is chosen as the discharge point, use the Cecil Weir gauging station to assess seasonal variability in stream flow to develop a suitable discharge regime.

Further commitments in relation to the proposed discharge of CSG water were provided in the SREIS, including:

- development of a strategy for the discharge of CSG water to watercourses in accordance with relevant legislation, including:
  - a water quality monitoring program with locations upstream and downstream of the discharge point to inform site-specific water quality objectives
  - a detailed environmental flows assessment informed by water quality monitoring data
  - an aquatic ecology monitoring program
  - periodic inspections of the physical form and hydrology of the watercourse to monitor geomorphic performance
- consultation with landholders downstream of discharge points on access requirements for vehicular and stock crossings of the affected watercourse reaches, and management of discharges to reduce disruption to existing access arrangements
- identification of reaches vulnerable to bank erosion from the discharge of CSG water and development of site-specific erosion control and management plans for vulnerable reaches.

DSITIA reviewed the SREIS and confirmed that the information provided to describe the receiving surface water quality, and the proposed quality and quantity of discharge water, was inadequate to: provide a baseline for receiving water quality; to define water quality objectives for receiving waters; to set limits for discharge water quality and quantity; or to determine if discharge to watercourses would be a practicable option while still achieving the water quality objectives. DSITIA also expressed concerns regarding potential impacts to receiving waters during low-flow and no-flow flow events and potential impacts to aquatic ecology, noting that proposed discharges could be of high risk to the environment due to the estimated volume of CSG water (510 GL over the life of the project). (Refer to section 4.11 of this report for further information on aquatic ecology.)

DSITIA recommended:

- further assessment of proposed discharge scenarios, using available data on stream discharge flow rates and expected discharge water quality, to derive expected dilution rates for potential contaminants and the extent of the mixing zone
- further ecological surveys in reaches of watercourses proposed to receive discharges to account for the natural variability in aquatic ecosystems (seasonal and /or flow periods)
- ecological impact assessment of potential changes in water quality (physical and chemical stressors and toxicants).

Advice provided by the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) reinforced concerns relating to the adequacy of assessment of impacts of discharge of CSG water and supported the need for further assessment, as outlined in the SREIS. The IESC also recommended consideration of the following:

- End of catchment salinity targets for the Condamine-Balonne catchment referred to in the Murray Darling Basin Plan.
- Published studies of aquatic conservation values in the vicinity of proposed discharge locations.
- Additional CSG water quality testing to enhance understanding of the quality of CSG water across the project development area.
- The potential for altered flow regimes in receiving waters to increase susceptibility to flood-induced erosion of creek channels downstream of discharge points.
- Potential cumulative impacts with other developments within the catchments of watercourses that would receive CSG water discharges.
- Site-specific investigation of the long-term ecological impacts of flow regime variation, during the operational phase and after decommissioning, on aquatic ecosystems, including reduced duration or number of natural cease to flow events.
- The life-cycle sensitivities of species of conservation significance (such as Murray cod *Maccullochella peelii peelii*).
- The water quality needs of downstream water users.

DAFF reviewed the SREIS and advised that the discharge of CSG water to a watercourse during natural low-flow periods was not supported and commented that elevation of flows (even if limited to a 20% increase) in these systems during the dry season has the potential to disrupt lifecycles and population processes of all aquatic species. DAFF recommended that there be no discharge during the dry season (April to September).

DNRM provided further advice following review of the SREIS and responses by Arrow in relation to proposed discharge of CSG water, highlighting the recently completed Healthy HeadWaters Coal Seam Gas Water Feasibility Study (http://www.nrm.qld.gov.au/water/health/healthy-headwaters/feasibility-study/index.html). The study indicated that, due to infrequent rainfall and run-off in the Condamine-Balonne catchment and resultant limited number of flow events of sufficient duration or magnitude to allow discharges, large CSG water storages would be required. DNRM recommended that the SREIS water management strategy consider the findings of this study and use the cumulative impact assessment methodology to examine the impacts of any proposed discharge to streams. (Refer to section 4.11 of this report for additional comment on aquatic ecology impacts).

4.10.4.5 Hydrostatic test water

A number of submissions, including from the former DERM, requested additional information on the source, chemical treatment, and disposal of pipeline hydrostatic test water. In response, Arrow referred to the commitment to develop and implement a hydrostatic testing procedure prior to commencement of hydrotest activities, including consultation with landholders and regulatory authorities prior to sourcing and disposing of hydrotest water. Specific details on hydrostatic test water would be provided in support of applications for environmental authorities or amendment of environmental authorities. Further discussion regarding hydrostatic testing activities was provided in SREIS Chapter 3, Project Description, and Section 3.6.2.

4.10.4.6 Residual impacts

The EIS claimed that the stated avoidance, mitigation and management measures would avoid or reduce the severity of potential impacts on surface water environmental values. The use of buffer zones to restrict project activities near watercourses, and location of facilities above the 1-in-100-year ARI flood event were highlighted as significant measures to limit residual impacts, although the width of buffers was not defined and the location of facilities above the 100 year ARI would only occur where this was considered by Arrow to be practicable.

Table 15.7 of EIS chapter 15 summarised the estimated significance of residual impact on each defined category of surface water, based on assumed effective implementation of stated mitigation measures and only emergency discharge of CSG water. Estimates ranged from no impact on Lake Broadwater, negligible impact on low order streams, and moderate impact on high order streams and other wetlands.

SREIS chapter 9 and appendix 5 noted that potential changes to hydrology associated with construction and operation of CGPF8 could impact on the values of Lake Broadwater, including:

- increase in flows in a watercourse on the property potentially eroding the watercourse bed and banks and affecting water quality in Lake Broadwater
- reduced flows in watercourses potentially reducing water supply to Lake Broadwater with potentially significant impact in dry years.

The potential for residual impact due to the diversion of overland flows does not appear to have been considered. However, in responses to submissions on the EIS relating to diversion of overland flow, Arrow stated that, if it is alleged that loss or damage has occurred to existing water users that is not covered under an existing compensation agreement, compensation may be sought through a variety of different avenues involving the appropriate authorities, depending on the details of the situation. The specifics of these processes have not been provided. Arrow would be required to meet the requirements of the Strategic Cropping Land: Standard Conditions Code for Resource Activities that are triggered for assessment under the SCL Act and other relevant legislative requirements.

As indicated above, the potential impacts resulting from the proposed discharge of treated or untreated CSG water at the two locations specified in the SREIS have not been sufficiently assessed, and the effectiveness of proposed mitigation measures for such impacts is not able to be determined. However, the EIS documentation did identify the range of matters that would need to be addressed in any application for an approval to discharge. Arrow has committed to providing the site-specific details when applying for an approval.

4.10.4.7 Cumulative Impacts

EIS Chapter 28, Section 28.3.4, Surface Water, provided a high level qualitative assessment of cumulative impact of CSG water discharges based on the project not discharging under ‘normal’ operating conditions, with discharge limited to controlled emergency releases during high rainfall events. The assessment highlighted only changes to watercourse hydrology as a potential cumulative impact and concluded that the project would not significantly contribute to cumulative impact. While it was recognised that numerous CSG developments in the region had indicated that CSG water could be released to watercourses during operations, no cumulative impact assessment of current and approved discharges was carried out for the EIS.

The cumulative impact assessment of EIS Chapter 28 was not updated by the SREIS. However, SREIS Chapter 9 provided a qualitative assessment of the potential cumulative effect of all Arrow CSG water discharges and the approved discharge of treated CSG water by Queensland Gas Company to Chinchilla Weir, and concluded that, although not assessed in detail; cumulative impacts were expected to be negligible after implementation of planned mitigation measures. The SREIS indicated that the few known discharge locations were at such distances from each other that the radius of influence for geomorphic change would not overlap. However, this assessment did not consider discharges from other CSG operations and coal mines. The SREIS stated that the development of the discharge strategy would consider potential impacts from Arrow discharges and other relevant discharges, to watercourses potentially affected by the proposed discharges at the CGPF2 and CGPF9 properties.

Advice from Queensland Health, DSITIA and IESC, based on review of the SREIS, reinforced concerns that the cumulative impact of CSG water and coal mine discharge required further assessment and the development of integrated management and monitoring, preferably using a collaborative approach. The IESC also recommended further assessment of potential cumulative impacts on groundwater dependent ecosystems; particularly those not listed in the Underground Water Impact Report (refer to section 4.9 of this assessment report for details). DSITIA commented that the SREIS did not include any investigation of the potential for coal mine discharge in the region despite several coal mines having been identified as relevant for regional cumulative impact assessment in the EIS (Table 28.1, chapter 28).

4.10.5 Conclusion

The EIS process has partially addressed the overland flow and flooding requirements of the TOR. However the impacts of the project on overland flow and flooding remain unclear due to the lack of information provided on the locations of project infrastructure and qualified commitments in relation to locations and design. While the commitments to mitigation measures outline a generally acceptable approach, specific and measurable/auditable measures need to be developed. Notably, the EIS documents did not describe how, and to what extent, connectivity of flow would be maintained when infrastructure interferes with overland flow.

While the EIS has generally demonstrated a sound understanding of erosion, sedimentation, stormwater and hazardous goods management, the environmental values to be protected have not been adequately identified, and a detailed risk assessment has not been completed, because the exact locations for specific activities are unknown. Site-specific and measurable mitigation measures need to be developed. This was recognised in the SREIS, which recommended the development of site-specific management plans for certain activities. The requirements of the TOR for erosion, sedimentation, stormwater and hazardous substances have therefore been only partially addressed.

Water quality surveys in the EIS documents were inadequate, in terms of sampling locations and data sets, to provide a basis for defining local water quality objectives for all waters potentially affected by project activities and particularly for waters proposed to receive discharges of CSG water. This deficiency was recognised in the SREIS, which included a commitment to further monitoring of water quality, although the scope and timing of the proposed monitoring program was not specified.

The EIS documents did not provide sufficient information to fully determine the feasibility of the proposed CSG water discharge or to formulate proposed conditions that would be applied to an approval for the discharge. Details of the quantity and timing of discharges, and particularly the quality of proposed discharges would be required. Assessment focused on hydrological and geomorphological impacts while deferring water quality and aquatic ecology considerations to further studies and provision of information with applications for environmental authorities or amendment to environmental authorities.

Arrow identified potential CSG water discharge points upstream of the water supply intakes for town water supplies. Hence, Arrow would have to comply with the requirements of the Water Supply (Safety and Reliability) Act 2008. In this regard, Arrow appears to have identified the necessary legislative approvals required to undertake this project. As the Queensland Water Supply Regulator (QWSR) approval process is one which can only be undertaken once the water treatment plants are built and in operation, it is envisaged that there would be some time before QWSR could expect to see an application relating to this project. As such, QWSR was satisfied that the information contained within the EIS documentation, and that which could be gathered as the need arises, would be sufficient.

The assessment of cumulative impacts has not adequately considered the combined effect of proposed discharges of CSG water from Arrow's operations (existing and project) in conjunction with current and approved discharges (CSG and coal mining) into the same catchments. It is acknowledged that this is a matter beyond the scope of any one proponent, or any one industry in the region, to effectively address. Currently there is no integrated framework which considers all major water users including potable water supplies, agriculture (grazing and irrigation) and CSG production.

4.10.6 Recommendations

In preparing an application for an environmental authority, or the amendment of an environmental authority, Arrow should consider the EHP guideline, Application requirements for petroleum activities (EM705) and should ensure that the information provided in the application meets the requirements of section 125 and section 126 of the EP Act.

Arrow has acknowledged the relevance of these sections of the EP Act and has committed to prepare more detailed technical information to support applications to amend the Dalby Expansion Project's environmental authority or when applying for new environmental authorities. Appendix 4 of this assessment report provides an outline of the information to be provided.

Relevant, site-specific discharge conditions should be established based on data obtained from further assessment of treated and untreated CSG water quality, receiving water quality, stream flow regimes, and aquatic ecology, before applying for approval to discharge CSG water. Specifically, the following information, where relevant, should be provided with an application for an EA or EA amendment:

- To determine appropriate water quality critieria for the proposed discharge water, either (1) a baseline assessment of receiving water quality, consistent with the recommendations of SREIS appendix 6 (minimum of 18 data sets from one or two reference sites, or 12 data points from three or more reference sites, over a minimum period of 12 months, ideally under base flow (ambient) conditions) be undertaken to provide a basis for deriving site□specific guideline values for individual surface water quality parameters, or (2) appropriate ANZECC water quality criteria are applied.
- Proposed discharge water quality. Note that, based in the CSG water quality described in the EIS documents, it is unlikely untreated CSG water would meet the discharge critieria and hence, only treated CSG water would be considered for potential discharge.
- Ecological survey data for reaches of watercourses proposed to receive discharges to account for the natural variability in aquatic ecosystems (seasonal and flow related).
- A detailed environmental flows assessment informed by water quality monitoring and aquatic ecology assessments, including consideration of the sensitivity of species to variation in hydrology and geomorphology

(e.g. cover, water quality, food supply, breeding, movement patterns).
- Further assessment of proposed CSG water discharge scenarios, using information on natural flow regime, water quality, and expected discharge water quality, to derive expected dilution rates for potential contaminants and the extent of the mixing zone.
- An assessment of the overall project water balance to demonstrate that the proposed discharge options assessed, and proposed limits to receiving water quality and flow rate change, could be implemented throughout the life of the project, having regard to potential changes in beneficial use demand (e.g. irrigation water demand).
- Site-specific assessment of the potential ecological impact of changes in water quality (physical and chemical stressors, and toxicants) resulting from discharge of treated and untreated CSG water.
- Site-specific assessment of the long-term impacts of flow regime variation, during the operational phase and after decommissioning, on aquatic ecosystems and riparian habitat, including reduced duration or frequency of natural cease to flow events. Particular consideration should be given to: known aquatic conservation values; the life-cycle sensitivities of species of conservation significance (such as Murray cod *Maccullochella peelii peelii*); and the response by exotic species to changed conditions.
- Identification of reaches vulnerable to bank erosion resulting either directly from the discharge of CSG water, or from altered flow regimes leading to increased susceptibility to flood-induced erosion of channels downstream of discharge points, and proposed site-specific erosion control measures for vulnerable reaches.
- An assessment of the potential impact of changes in water quality on downstream water users, including potable water use.
- An assessment of the impact of proposed discharges on downstream vehicle and stock crossings and proposed management measures to reduce disruption to existing access arrangements.
- An assessment of the potential cumulative impact of CSG water discharges from the project and approved discharges from other CSG and coal mining activities in the catchment, with consideration of changes to hydrology, geomorphology, water quality, and potential impacts to aquatic ecology (aquatic and riparian habitat, native species, exotic species) and water users at a local and catchment scale. Specific consideration should be given to end of catchment salinity targets referred to in the Murray Darling Basin Plan.
- Proposed discharge water quality parameters and limits, location of discharge points, discharge rates, and receiving water quality monitoring parameters, locations, objectives and limits forming part of a strategy for the discharge of CSG water to watercourses in accordance with requirements of the EP Act and the Queensland Government's Coal Seam Gas Water Management Policy.

In addition, the following specific information should be provided with an application for an EA or EA amendment, where relevant to the application:

- An assessment of site-specific risks and impacts from changes to overland flow or flooding at site and farm level and appropriate site-specific mitigation measures.
- An assessment of potential impacts to Lake Broadwater resulting from altered flows or water quality resulting from CGPF development, as recommended in the EIS, and site-specific mitigation measures.
- Management plans for watercourse crossings, particularly for sediment and erosion control.
- Site-specific CSG water discharge conditions based on data obtained from further water quality, aquatic ecology, and stream flow assessments, and an assessment of the potential cumulative impact of existing and approved discharges from CSG and coal mine operations within the Condamine-Balonne catchment on environmental values of these waters.

Proposed beneficial use of CSG water involving delivery to users through discharge to watercourses may also require applications to amend The Basin Plan (Cwth) (for use of water discharged to the Condamine River system in the Murray Darling Basin) and/or the Water Resource (Condamine and Balonne) Plan 2004 and associated Resource Operations Plan (ROP) under the Water Act.

The commitments made by Arrow (listed in Appendix 3 of this assessment report) that are relevant to avoidance, mitigation and management of impacts to surface water values and erosion resulting from project activities should be considered appropriate and should be implemented. Table 14 provides recommendations on changes to a number of specific commitments concerning surface water management for the project.

Table 14 Arrow commitments – recommended changes.

	Arrow Commitment	Recommendation
C053	Avoid disrupting overland flow paths, and where avoidance is not practicable, maintain connectivity of flow in watercourses	Concentration of water flow should also be avoided or minimised to prevent significant increased erosion
C046	Design and plan the project to avoid steep slopes and areas dissected by gully networks, where practicable. Where these are unavoidable, ensure the required infrastructure (e.g., roads) is appropriately designed for erosion control purposes	Unsealed roads and tracks must be subject to maintenance programs, particularly following major rainfall and runoff events.
C152	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	Disturbance of flows and barriers to fish movement may require approval under the *Fisheries Act 1994* for waterway barrier works.

4.11 Aquatic ecology

Chapter 16 Aquatic Ecology of the EIS described the existing aquatic ecological values within and surrounding the project development area and provided an assessment of the potential for these values to be affected by direct and indirect impacts associated with the construction, operation and decommissioning phases of the project. Detailed information on the aquatic ecology assessment was included in EIS Appendix J, Aquatic Ecology Assessment. Broad environmental protection objectives, to avoid or minimise impacts to aquatic ecology and to control the introduction or spread of exotic aquatic flora or fauna species, were stated and avoidance, mitigation and management measures to achieve these objectives, identified. The residual impact identified was based on the assumption that the proposed avoidance, mitigation and management measures had been applied.

The SREIS Chapter 10 provided updated information on aquatic ecology resulting from changes to the project description (SREIS Chapter 3, Project Description), submissions on the EIS, and further desktop and field studies. Detailed information on the supplementary assessment was contained in SREIS Appendix 8, Supplementary Aquatic Ecology Assessment.

The assessment of MNES was addressed as part of the aquatic ecology assessment and as a stand-alone assessment in SREIS Attachment 1 Matters of National Environmental Significance which superseded EIS Attachment 3. The evaluation of the assessment of MNES is in section 5 of this report.

4.11.1 Assessment methodology

The potential impacts of the proposed development on environmental values were assessed using one of three methods described in the EIS Chapter 7, Impact Assessment Method. Significance assessment was adopted where an understanding of the vulnerability or sensitivity of the environmental asset or resource was important to the assessment, risk assessment where impacts were more related to management actions, and compliance assessment where impacts were subject to regulatory guidelines. The magnitude and significance of the impacts was estimated in the EIS and impacts with a high significance were given priority for the development of mitigation measures.

The aquatic ecology baseline assessment comprised a desktop study and a field survey to gain an understanding of, and describe, the existing environment. The significance approach was used to undertake the assessment of impacts and the methodology for impact assessment for aquatic ecology was outlined in Chapter 16 of the EIS, and detailed in Section 3.10 of EIS Appendix J, Aquatic Ecology Assessment, and Section 3.5 of SREIS Appendix 8, Supplementary Aquatic Ecology Assessment. The SREIS provided an updated assessment of impact significance for discharge of CSG water to watercourses and for transfer of water between treatment and holding sites.

4.11.1.1 Aquatic ecology surveys

EIS Appendix J provided detailed information on aquatic ecology surveys conducted in November 2009 and May 2010, including justification for selection of survey sites. Figure 3-2 Aquatic ecology sampling sites of EIS Appendix J showed the approximate location of aquatic ecology survey sites for the EIS. Table 16.1 of EIS Chapter 16 provided a summary of field survey site locations, site hydrology and substrate, and survey type.

Submissions on the EIS by EHP and Toowoomba Regional Council asserted that the extent of survey was not representative of the total project area and requested further surveys in catchments potentially affected by the project that were not surveyed for the EIS, including the Dawson River and Weir River catchments. The former DEEDI submission on the EIS requested further assessment of fish habitat values, particularly for ephemeral watercourses.

In response, Arrow acknowledged that ephemeral streams were under-represented in the surveys undertaken for the EIS due to the dry conditions at the time of sampling but argued that the permanent/semi-permanent streams were considered more likely to contain dry season refugia for aquatic biota and more likely to contain less resilient species, communities and habitats than the low order ephemeral streams typical of much of the project development area. Arrow further stated that surveys and associated sampling focussed on those streams that held sufficient permanent water to contain aquatic values representative of those across the project development area.

Additional surveys were carried out for the SREIS targeting aquatic ecosystems within the Dawson River and Weir River catchments, in watercourses proposed to receive controlled discharges of treated and untreated CSG water, and in areas proposed for the location of central gas processing facilities and worker accommodation. Figure 10.1 of SREIS Appendix 8 showed the approximate location of aquatic ecology assessments for the EIS documents.

A submission on the EIS by the Lock the Gate Alliance stated that the EIS should assess impacts on stygofauna. In response, Arrow advised that stygofauna species are unlikely to occur in the project development area as the typical habitat for stygofaunal communities (shallow groundwater aquifers containing spaces larger than 75 μm which allow lateral flow of groundwater) is not present. The TOR did not specifically require assessment of stygofauna.

DSEWPaC (former) and EHP submissions on the EIS requested further information on springs, and particularly the community of native species dependent on natural discharge of groundwater from the Great Artesian Basin, that could be affected by groundwater extraction by the project and possible changes to groundwater quality. In response, Arrow referred to the discussion of spring complexes and groundwater dependent ecosystems in EIS Chapter 14, EIS Appendix G, Groundwater Impact Assessment, and EIS Appendix K, Terrestrial Ecology Impact Assessment which concluded that there are no known groundwater dependant springs and associated ecosystems in the project development area. SREIS Attachment 1, Section 5.5.1 Groundwater dependant ecosystems and species, identified three EPBC Act listed flora species *as* potentially present in association with a spring complex located outside of the project development area but stated that the spring is unlikely to be directly impacted by project related activities. A map of known spring locations within and adjacent to the project development area was included as Figure 5.5 in SREIS Attachment 1.

4.11.2 Existing environment

The EIS documents stated that aquatic ecosystems within the study area are diverse with permanent, semi-permanent and highly seasonal lotic (flowing water) and lentic (non-flowing water) environments represented in four drainage basins (Condamine-Culgoa Drainage Basin, Fitzroy Drainage Basin, Border Rivers Drainage Basin and Moonie Drainage Basin.

Field surveys for the EIS identified 23 species of native aquatic flora, none of which are listed as threatened species under the NC Act or the EPBC Act and three introduced aquatic flora species.

The desktop study identified 20 native fish species and three introduced fish species likely to occur within the project development area. Seventeen of these fish species were recorded in field surveys either within and/or immediately adjacent to the project development area. Two species of turtle (*Emydura macquarii* and *Chelodina expansa*) were found in field surveys although a number of turtle species, including the vulnerable Fitzroy River turtle (*Rheodytes leukops*) may occur in the Fitzroy River catchment.

The Murray cod (*Maccullochella peelii peelii*), listed as vulnerable under the EPBC Act, was known to occur within the project development area and was recorded at one site in surveys for the SREIS. Oakey Creek (site C) was assessed as providing suitable habitat for the purple-spotted gudgeon and river blackfish (potentially threatened, locally significant species) and these species were recorded approximately 48km upstream of the project development area.

The EIS documents identified nine fish species considered to be potentially and/or locally threatened but not currently listed under State legislation that are known or likely to be present within the project development area:

- Murray cod (*Maccullochella peelii peelii*)
- River blackfish (*Gadopsis marmoratus*)
- Dwarf flathead gudgeon (*Philypnodon maculates)*
- Eel-tailed catfish (*Tandanus tandanus*)
- Mountain galaxias (*Galaxias olidus*).
- Purple-spotted gudgeon (*Mogurnda adspersa*)
- Rendahls tandan (*Porochilus rendahli*)

- Silver perch (*Bidyanus bidyanus*)
- Agassiz's glassfish (*Ambassis agassizii*).

Three introduced species of fish were found during field surveys:

- Mosquito fish (*Gambusia holbrooki*)
- Common or European carp (*Cyprinus carpio*)
- Goldfish (*Carasius auratus*).

Macroinvertebrate communities were assessed as characteristic of watercourses experiencing significant impacts through anthropogenic processes such as water extraction and agricultural land use.

Aquatic ecosystems were broadly classified as environmentally sensitive areas, permanent and semi-permanent watercourses, and ephemeral watercourses. A portion of Oakey Creek (upstream of survey site C as shown on Figure 16.1, EIS Chapter 16) was also assessed for potential impact due to the potential presence of locally threatened fish species. Table 16.5 of EIS Chapter 16 provided an estimate of the sensitivity of these aquatic ecosystems as reproduced in Table 15.

Table 15 Sensitivity of the value of the existing environment

Existing Environment	Characteristics Contributing to the Value	Sensitivity
Lake Broadwater Conservation Park	• High degree of ecological intactness • Valuable aquatic habitat, in particular, for: – national and state listed aquatic fauna species of significance, including the Murray cod – locally significant species • Provision of important ecological processes for maintaining and filtering water quality, sediment and other pollutants	High
Oakey Creek (upstream of site C)	• Provision of habitat for locally threatened species (*Mogurnda adspersa* and *Gadopsis marmoratus*). The tolerance of these species to disturbance and the replacement potential is very low • Valuable aquatic habitat	High
Permanent and semi-permanent watercourses (excluding Lake Broadwater Conservation Park and upstream of Oakey Creek site C)	• Valuable aquatic habitat, in particular, for: – national and state listed aquatic fauna species of significance, including the Murray cod (*Maccullochella peelii peelii*) and Fitzroy river turtle (*Rheodytes leukops*) – locally significant species (for both conservation and recreation), such as river blackfish (*Gadopsis marmoratus*), golden perch (*Macquaria ambigua*) and silver perch (*Bidyanus bidyanus*) • Species diversification: aquatic ecosystems (unique at a local scale), ranging from minimally disturbed to highly disturbed, contain many areas of good quality aquatic habitat that are known to support a relatively diverse range of aquatic species, including fish, turtles and invertebrates • Spawning habitat for aquatic species is present but does not represent critical spawning habitat • Deeper pools and remnant waterholes providing refuge for a range of aquatic species, and these communities 'seed' populations when wet season	Moderate

Existing Environment	Characteristics Contributing to the Value	Sensitivity
	flows provide connectivity between watercourses • Habitat for longer-lived species (than those from ephemeral systems), which are less likely to recolonise following disturbance (hence there is greater possibility of these species or communities becoming locally extinct)	
Ephemeral watercourses	• Marginal aquatic habitat	Low

4.11.3 Impacts and significance of impact

Table 16.7 of EIS Chapter 16, Summary of aquatic ecology impact assessment, provided a summary of potential impacts prior to mitigation, along with proposed mitigation and management measures and the subsequent residual impacts, assuming implementation of proposed mitigation and management measures. The significance of impacts was assessed for three aquatic ecology environments during construction, operation and decommissioning:

- Lake Broadwater and Oakey Creek (upstream of site C as shown on Figure 16.1, EIS Chapter 16)
- Permanent and semi-permanent watercourses
- Ephemeral Watercourses.

The following potential impacts were assessed for significance:

- erosion and sediment transport causing changed flow patterns, high turbidity or smothering of benthic aquatic habitat
- decline in water quality and increased algal blooms
- introduction of exotic aquatic flora species
- reduced aquatic biota movement or feeding patterns
- habitat loss, modification or fragmentation.

Mitigation measures for each assessed impact were supported by stated commitments and the estimated magnitude and significance of residual impact on each value was based on effective implementation of the measures. All residual impacts were estimated to be negligible or low except for the potential impact of construction activities on Lake Broadwater and part of Oakey Creek which was assessed as 'moderate' due to the high sensitivity of these habitats.

In submissions on the EIS, the former DEEDI and a member of the public raised concerns with the assessment of recreational fishery values within the project development area. In response, Arrow stated that recreational fisheries are dependent on the general aquatic ecosystem health and referred to the mitigation measures stated in EIS Chapter 16, Aquatic Ecology, Section 16.6 and to a partnership arrangement between Arrow and the Condamine Alliance to restore native fish populations at the Loudin Weir on the Condamine River. Arrow also stated that infrastructure associated with the project is not expected to impede access to public waterways, and thus will not cause a loss of recreational fishing opportunities.

The former DEEDI requested additional information on potential impacts on the Murray cod and river blackfish. In response, Arrow referred to the assessment of impact in EIS Chapter 16, Aquatic Ecology, Section 16.6 (summarised in Table 16.7) and to additional studies on the water quality and aquatic ecology of watercourses where CSG water discharge points are proposed (SREIS Chapter 10, Aquatic Ecology and SREIS Appendix 8, Supplementary Aquatic Ecology Assessment).

Submissions by Toowoomba Regional Council, QMDC, and former DEEDI sought an assurance that the values of Lake Broadwater would be protected from direct and indirect impacts of the project. Arrow has committed to avoiding undertaking project activities in the Lake Broadwater Conservation Park and to manage potential impacts on Lake Broadwater Conservation Park through implementation of buffers in accordance with legislative requirements at the time of development in the area.

A number of submissions, including from the former DEEDI, requested more information on the proposed option of ocean discharge of CSG water. Arrow advised that the option of disposal of CSG water to the sea via an ocean outfall pipeline (as outlined in SREIS Attachment 5, Coal Seam Gas Water and Salt Management Plan) would be assessed under a separate approval process if determined to be the preferred option.

The Fitzroy Basin Association raised concerns with potential cumulative impact on waterways and the Great Barrier Reef Marine Park and the need to manage impacts to the Great Barrier Reef (GBR). In response, Arrow stated that, due to the distance separating the Great Barrier Reef Marine Park and the project development area, and the relatively small proportion of the project development area within catchments of the GBR, the potential for impact from the project was discounted and was therefore not assessed in the EIS. Arrow provided the following information in support of this determination:

- EIS Appendix I, Surface Water Part B: Water Quality Impact Assessment estimated that the Great Barrier Reef Marine Park receives water from less than 1% of a catchment within the project development area and water from this catchment has to flow approximately 700km before discharging to the sea
- EIS Chapter 16, Aquatic Ecology, Section 16.6 identified mitigation measures that Arrow would implement to protect water quality and prevent contamination entering watercourses including commitments to emergency response and spill response procedures
- Arrow's Coal Seam Gas Water and Salt Management Strategy provided in SREIS Attachment 5 and Arrow proposed to develop a strategy for the discharge of CSG water to watercourses in accordance with relevant legislation and the EHP Guideline Application requirements for petroleum activities.

A number of submissions on the EIS, including from EHP, former DEEDI, QMDC, and individuals, raised concerns with the lack of site-specific information on the impacts of construction and operation on aquatic habitats and species, including potential for contamination of aquatic habitat by sediment and spills, creation of barriers to movement of aquatic species, and accidental or controlled discharge of CSG water. In response, Arrow outlined a generic framework that is proposed to protect aquatic values across the study area without the need to identify precise locations at which infrastructure/activities will impact on aquatic systems, including:

- the risk-based approach used for the assessment of impacts to aquatic ecology values based on sampling a number of sites representative of the aquatic systems of the study area
- the use of constraints mapping to plan the location of project related infrastructure
- guidelines for acceptable activities and associated mitigations for habitat of high, moderate and low conservation value (EIS Chapter 16, Aquatic Ecology and EIS Appendix J, Aquatic Ecology Impact Assessment)
- possible additional field surveys where infrastructure has the potential to impact directly on watercourses, including watercourse crossings and CSG water discharge points
- adoption of buffer distances between project activities and environmentally significant areas to be determined by legislative requirements at the time of development (excluding construction of watercourse crossings for roads and pipelines, discharge infrastructure and associated stream monitoring equipment)
- commitment to develop and implement emergency response and spill response procedures
- compliance with legislative requirements for construction of waterway barriers or disturbance of fish habitat
- development of a strategy for the discharge of CSG water to watercourses.

One matter raised in comments on the SREIS concerned the fact that the report does not specifically address the risk of untreated or treated CSG water leakage through rupture of pipelines but relies on as yet undefined spill response procedures.

Weed and pest management for the project was a major concern for many submitters. Risks to aquatic ecology relate to both the effectiveness of weed and pest management and the risk of contamination from herbicides. A submission on the EIS by DAFF noted that salvinia, water lettuce and water hyacinth are known to occur in the region (though not in the project development area) and therefore pose a potential risk of introduction. Arrow made a commitment to develop a declared weed and pest management plan in accordance with the Petroleum Industry - Pest Spread Minimisation Advisory Guide (Biosecurity Queensland, 2008).

In response to submissions and in the SREIS, Arrow confirmed that the discharge of significant quantities of treated and untreated CSG water to watercourses is now proposed during project operation not only during emergency conditions. Additional surveys were carried out for the SREIS targeting aquatic ecosystems within the Dawson River and Weir River catchments and in watercourses proposed to receive controlled discharges of treated and untreated CSG water. Figure 10.1 of SREIS Appendix 8 showed the approximate location of aquatic ecology assessments for the EIS documents.

SREIS Chapter 10, Section 4 provided information obtained from additional surveys at one site in each of the Fitzroy and Border Rivers catchments. The assessment concluded that the significance of potential impacts and the mitigation measures presented in the EIS remain valid for the Dawson River, Macintyre River and Weir River sub-basins.

The SREIS Chapter 10, Aquatic Ecology, Section 10.4, identified the waterways where the discharge of CSG water is proposed and provided site details of the aquatic environment at the two locations. Potential impacts of the discharges on aquatic ecology values were identified, additional mitigation and management measures proposed, and a site-specific residual impact assessment was summarised in Table 10.10. Residual impact was assessed as 'low' for discharge during high flow events and 'moderate' for discharge during low flow events provided that the discharge rate was limited to give a maximum streamflow increase of 20%. However, the water quality assessment to support the ecological assessment (SREIS Chapter 9) was limited to a single sampling which is not adequate to define local Water Quality Objectives and the potential impact on aquatic ecology as a result of discharges was not adequately assessed. The SREIS does not clarify whether discharge of untreated water is proposed other than in emergency situations and the proposed discharge water quality for routine discharge ('normal operation') is not defined. SREIS Appendix 08 included recommendations for additional studies of the natural flow regime, water quality and ecological response to changed habitat as a result of discharges to inform development of a discharge strategy.

DSITIA has reviewed the SREIS and has confirmed that the information provided to describe the receiving environment (surface water quality and aquatic ecosystem condition), and the proposed quality and quantity of discharge water, is inadequate to provide a baseline for receiving water quality, define water quality objectives for receiving waters, to set limits for discharge water quality and quantity, or to determine if discharge to watercourses would be a practicable option while still achieving the water quality objectives. DSITIA recommended:

- further assessment of proposed discharge scenarios using available data on stream discharge flow rates and expected discharge water quality to derive expected dilution rates for potential contaminants and the extent of the mixing zone
- further ecological surveys in reaches of watercourses proposed to receive discharges to account for the natural variability in aquatic ecosystems (seasonal and /or flow periods)
- ecological impact assessment of potential changes in water quality (physical and chemical stressors and toxicants).

Advice provided by the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) reinforced concerns relating to the adequacy of assessment of impacts of discharge of CSG water and supported the need for further assessment as outlined in the SREIS. The IESC also recommended consideration of the following:

- end of catchment salinity targets for the Condamine-Balonne River referred to in the Murray Darling Basin Plan
- published studies of aquatic conservation values in the vicinity of proposed discharge locations
- additional water quality testing to enhance understanding of the quality of co-produced water across the development area
- the potential for altered flow regimes in receiving waters to increase susceptibility to flood-induced erosion of creek channels downstream of discharge points
- potential cumulative impacts with other developments within the catchments of watercourses that will receive co-produced water discharges
- site-specific investigation of the long-term ecological impacts of flow regime variation, during the operational phase and after decommissioning, on aquatic ecosystems, including reduced duration or number of natural cease to flow events
- explicit consideration of the life-cycle sensitivities of species of conservation significance (such as *Maccullochella peelii peelii*), as well as the water quality needs of downstream water users.

NRM provided further advice following review of the SREIS and responses by Arrow in relation to proposed discharge of CSG water. The advice highlighted the recently completed Healthy HeadWaters Coal Seam Gas Water Feasibility Study (http://www.nrm.qld.gov.au/water/health/healthy-headwaters/feasibility-study/index.html), which includes research focussed on the Murray Darling Catchments, with particular focus on the Central Condamine Alluvium and therefore is relevant to the management of Arrow's CSG water. NRM stated that, due to the seasonality of irrigation demand, and because irrigation demand will not account for the full volume of co-produced water, substitution of CSG water for allocated groundwater may not be available for five months per year. The study identified the key stressors to the environment, assessed the potential impact of disposal to streams, and developed a cumulative impact assessment framework for assessing multiple discharges to streams. All CSG water discharge scenarios considered by the Healthy HeadWaters Coal Seam Gas Water Feasibility Study resulted in additional water in the system which increased longitudinal connectivity between waterholes which has the potential to benefit exotic fish species. Due to infrequent rainfall and run-off in the Condamine-Balonne catchment and resultant limited number of flow events of sufficient duration or magnitude to allow discharges, large CSG water storages would be required. NRM recommended that the SEIS water management strategy consider the findings of this study and use the cumulative impact assessment methodology to examine the impacts of any proposed discharge to streams.

4.11.4 Cumulative impacts

EIS Chapter 28 Cumulative Impacts, discussed the potential cumulative impacts of future developments on the environmental values of the project development area. Section 28.3.5 addressed cumulative impacts on aquatic ecology, focusing on diminished water quality in watercourses as the primary concern. The assessment focused on increased sediment loads and did not address other contaminants, such as CSG water. However, the EIS Chapter 28, Section 28.3.4 Surface Water provided a high level qualitative assessment of cumulative impact of discharges based on the project not discharging under 'normal' operating conditions, with discharge limited to controlled emergency releases during high rainfall events.

The assessment highlighted only the change to watercourse hydrology as a potential cumulative impact and concluded that the project would not significantly contribute to cumulative impact.

Submissions on the EIS by Toowoomba Regional Council, Fitzroy Basin Association and The Greens raised concerns with the potential cumulative impact of the project on water quality and aquatic ecology. In response, Arrow referred to the assessment in Section 28.3.4 Surface Water and Section 28.3.5 Aquatic Ecology of EIS Chapter 28, and in response to FBA concerns for the Fitzroy River catchment, stated that the watercourses identified for discharge of CSG water would not be in the Fitzroy basin. The cumulative impact assessment of EIS Chapter 28 was not updated by the SREIS and SREIS Chapter 10 Aquatic Ecology did not provide an update of the cumulative impact assessment. However, SREIS Chapter 9, Surface Water, Section 9.6.4, provided a qualitative assessment of the potential cumulative effect of proposed discharge of CSG water from the project in conjunction with existing approved CSG water discharges by Queensland Gas Company and Arrow. This assessment did not consider discharges from several coal mines identified in the EIS (Table 28.1; Chapter 28) as relevant for regional cumulative impact assessment. The assessment concluded that, although not assessed in detail, cumulative impacts were expected to be negligible based on implementation of proposed mitigation measures and that development of a discharge strategy would consider potential cumulative impacts from these and other relevant discharges, to watercourses potentially affected by the proposed discharges from the project.

Advice from DSITIA and IESC, based on review of the SREIS, reinforced concerns that the cumulative impact of CSG water and coal mine discharge requires further assessment and development of integrated management and monitoring, preferably using a collaborative approach. The IESC also recommended further assessment of potential cumulative impacts on groundwater dependent ecosystems, particularly those not listed in the Underground Water Impact Report, including:

- integration of groundwater model outputs with known and potential groundwater dependent ecosystems and mapping of potentially impacted ecosystems
- confidence interval assessment for localised groundwater drawdown impacts
- confirmation of the source aquifer for Spring Complex 584
- field-based investigations to determine the groundwater-dependency of ecosystems, where uncertainty exists, and to assess the hydrogeological and ecological characteristics of potentially impacted watercourse springs
- incorporation ground water dependent ecosystems confirmed by field survey in the OGIA groundwater model
- identification of predicted changes in stream connectivity due to groundwater drawdown
- assessment of potential impacts on non-spring based ecosystems with a moderate to high potential for interaction with the sub-surface expression of groundwater
- groundwater monitoring and management program to allow for early detection of, and response to, potential impacts on groundwater dependent ecosystems, including monitoring of Lake Broadwater and the Long Swamp wetland.

4.11.5 Offsets

SREIS Attachment 6, Draft Environmental Offsets Strategic Management Plan, presented a high-level strategy outlining a proposed approach to meet environmental offset obligations for the project. The draft plan refers to measures stated in the EIS documents to avoid and minimise impacts, including pre-construction clearance surveys, proposed environmental constraints and commitments to mitigation and management. Table 7.1 of SREIS Attachment 6 presents a summary of state significant biodiversity values (as listed in Appendix 1 of the Queensland Biodiversity Offsets Policy) and the relevance of the values to the project. Wetlands and watercourses are included in the list of state significant biodiversity values.

Table 8.1 of SREIS Attachment 6 provided an estimate of the potential area of disturbance of regional ecosystems in the project development area based on the conceptual field layout, publicly available mapping and mapping prepared for the SREIS. SREIS Appendix 9 presented comparisons between detailed mapping of regional ecosystems completed for the SREIS and publicly available regional ecosystem mapping which indicated significant errors in the published mapping. The actual area of these communities within the project development area may vary significantly from the estimated area. EHP may accept amended regional ecosystem mapping for the purpose of offset area estimation provided that the mapping is supported by adequate site data, photographs and justification. This detailed information was not provided in the EIS or SEIS.

Table 8.2 of SREIS Attachment 6 provided an estimate of the potential area of disturbance of threatened ecological communities and core habitat for species listed under the EPBC Act, and threatened species listed under the NC Act, based on a conceptual field layout. It was noted that the habitat of species may overlap and the total area of disturbance for threatened species would likely be less than the sum of estimated areas for each species. DSEWPaC (former advised that an estimate of disturbance limits for listed threatened species and migratory species for core habitat known, core habitat possible, and general habitat for each species is required for the whole of the project (not just for core habitat as provided).

Table 9.1 of SREIS Attachment 6 provided an estimate of the area of regional ecosystems, representing an ecological community or species habitat potentially required to be offset, within the Brigalow Belt South Bioregion and the area the regional ecosystem potentially available to meet offset requirements, indicating that adequate offset areas may be available. The SREIS does not include an estimate of the area of other state significant biodiversity values within the project development area.

Section 10 of SREIS Attachment 6 outlined Arrow's preferred staged approach to the provision of environmental offsets. Environmental offsets were not proposed in the SREIS as the actual offset area requirements would not be determined until pre-construction surveys are completed and the actual location of infrastructure is defined.

4.11.6 Conclusion

The description of aquatic plants and animals and their habitat within the project development area was adequate to meet the requirements of the TOR. The EIS provided a qualitative assessment of potential impacts of the project, estimates of mitigation of impact through implementation of stated measures, and estimates of the residual impact on specific aquatic ecology values. As the actual location of project infrastructure was not defined, the impacts on aquatic ecology could not be expressed quantitatively and auditable objectives were not stated. A number of qualitative commitments to inspection and monitoring related to protection of aquatic values were provided in Section 16.8 of EIS Chapter 16.

Detailed measures for management of risks associated with accidental releases or spills, and for weed and pest management, were proposed to be included in management plans developed as part of the approvals for the delivery of the project.

Assessment of the potential impact of discharge of treated and untreated CSG water to watercourses, including the assessment of potential cumulative impact on water quality, was not adequate to meet the requirements of the EP Act to support an application for an environmental authority for an activity involving such discharge.

Environmental offsets were not proposed as the actual offset area requirements will not be determined until pre-construction surveys are completed and the actual location of infrastructure is defined. A draft strategy outlining a proposed approach to meet environmental offset obligations under Queensland and Commonwealth legislation was provided.

4.11.7 Recommendations

In preparing an application for an environmental authority, or an amendment to an environmental authority, Arrow should consider the guideline Application requirements for petroleum activities (EM705) and should ensure that the information provided in the application meets the requirements of s.125 and s.126 of the EP Act.

Arrow has acknowledged the relevance of these sections of the EP Act and has committed to preparing detailed technical information to support applications to amend the Dalby Expansion Project's environmental authority or when applying for new environmental authorities. Matters that Arrow has committed to address are outlined in Appendix 4. Detailed information requirements relating to proposed discharge of CSG water, potential impact on aquatic ecology, and measures to limit impacts, are listed in section 4.10.6, Surface water, of this assessment report.

DAFF advised that they have released a waterway determination spatial data layer: Queensland Waterways for Waterway Barrier Works. This layer will negate the need for Arrow to 'design flumes to construct watercourse crossings to a suitable size to maintain flows and enable fish passage and protect the bed from scouring' as the layering system has identified all waterways within Queensland and has determined the impact waterway barrier works will have on fish passage, (both permanent and temporary works), using five different colours. These colours are then linked back to the waterway barrier works self-assessable codes, which set out the guidelines for fish passage on each coloured system. If works cannot meet the standards of the self-assessable codes, a development approval will be required, and consultation with DAFF can help determine the fish passage requirements for such an approval.

The commitments made by Arrow (listed in Appendix 3 of this assessment report) that are relevant to management of impacts to aquatic ecology should be considered appropriate and should be implemented. However, Table 16 provides recommendations on changes to a number of specific commitments relating to aquatic ecology.

Table 16 Aquatic ecology commitments and recommended changes

	Commitment	Recommended Amendment
C036	Develop and implement emergency response and spill response procedures to reduce impacts that could occur as a result of releases of hazardous materials or loss of containment of storage equipment	Contingency and response plans will be required in any EA granted for the project
C048	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).	Would be required by conditions in the EA
C071	Backfill and rehabilitate excavations, particularly pipeline trenches and drilling sumps. Conduct backfilling in a manner that will promote successful rehabilitation, including capping of exposed subsoil with topsoil and replacement of the land surface to preconstruction levels to reduce trench subsidence and concentration of flow. Mounding of soils to allow for settling may be required in some areas. However, in laser-levelled paddocks, this may not be practicable, and backfilling should be carried out in consultation with the landowner	The commitments should include the need to follow up on rehabilitation to ensure any slumping or subsidence is corrected and does not interfere with overland flows
C184	Design watercourse crossings to enable passage of flows resulting from a 1 in 100 year average recurrence interval flood event, as a minimum	This would apply to major crossings. In situations where a high level of flood immunity is not needed a lower level of flood protection would be preferred
C185	Design the width of the pipeline ROWs to be narrower at watercourse crossings, where practicable	Careful siting to pipeline crossings is needed to minimise disturbance of riparian vegetation and to avoid steep banks that are difficult to stabilise
C187	Design washdown facilities to ensure that runoff is contained on site and does not transfer weed seeds, spores or infected soils to adjacent areas. Treat or dispose of washdown solids in a registered landfill	Replace ‘washdown’ with ‘cleandown’
C192	Obtain all relevant permits required under the *Fisheries Act 1994*, including permits for construction of waterway barriers or disturbance of fish habitat	Requirements would be determined on a site by site basis
C199	Limit the use of herbicides in the vicinity of watercourses or within riparian zones. Use non-toxic, non-persistent (i.e., biodegradable) herbicides to treat weeds, except on properties where organic or biodynamic farming is practised, for which the method of weed treatment is to be agreed with the landowner	Use of wetlands friendly biocides and herbicides is recommended around creeks and wet areas

4.12 Terrestrial ecology

EIS Chapter 17, Terrestrial Ecology, described the terrestrial ecology values within the project development area and provided an assessment of the potential for these values to be affected by direct or indirect impacts associated with the construction, operation and decommissioning phases of the project. Detailed information on the terrestrial ecology assessment was included in EIS Appendix K, Terrestrial Ecology Impact Assessment. Broad environmental protection objectives, to avoid or minimise impacts to terrestrial ecology and to control the introduction or spread of exotic flora or fauna species, were stated. Avoidance, mitigation and management measures to achieve these objectives were stated as commitments. The estimate of residual impacts to terrestrial ecology by the project assumed that the proposed avoidance, mitigation and management measures had been applied.

SREIS Chapter 11, Terrestrial Ecology, provided updated information on terrestrial ecology resulting from changes to the project description stated in SREIS Chapter 3, Project Description (refer to section 4.3 of this assessment report), submissions on the EIS, and further desktop and field studies. Detailed information on the supplementary assessment was contained in SREIS Appendix 9, Supplementary Terrestrial Ecology Assessment.

The assessment of MNES was addressed as part of the terrestrial ecology assessment and as a stand-alone assessment in SREIS Attachment 1 Matters of National Environmental Significance which superseded EIS Attachment 3. The evaluation of the assessment of MNES is contained in section 5 of this assessment report.

4.12.1 Assessment methodology

The methodology for impact assessment for terrestrial ecology was outlined in Section 17.2.4 of EIS Chapter 17, and detailed in Section 4.5 of EIS Appendix K. The potential impacts of the proposed development on environmental values were assessed using one of three methods described in the EIS Chapter 7, Impact Assessment Method. Significance assessment was adopted where an understanding of the vulnerability or sensitivity of the environmental asset or resource was important to the assessment, risk assessment where impacts were more related to management actions, and compliance assessment where impacts were subject to regulatory guidelines. The significance assessment approach was used to undertake the assessment of impacts on terrestrial ecology values using criteria outlined in Section 17.2.4 of EIS Chapter 17. The magnitude and significance of the impacts was estimated in the EIS and impacts with a high significance were given priority for the development of mitigation measures.

The terrestrial ecology baseline assessment comprised a desktop study, habitat suitability assessment (to identify areas likely to support ‘general’ habitat and ‘core’ habitat for threatened species), and field surveys.

4.12.1.1 Terrestrial ecology surveys

Section 4 of EIS Appendix K provided information, based on detailed information in Section 4.4 of EIS Appendix K, on terrestrial ecology surveys conducted between 21 October 2009 and 4 December 2009, and between 4 May 2010 and 9 May 2010, including justification for selection of survey sites. Figure 17.1 of EIS Chapter 17 showed the approximate location of terrestrial ecology survey sites for the EIS.

Submissions on the EIS by Toowoomba Regional Council and individuals asserted that the level of survey was not adequate to support a description of flora and fauna values within the project development area over all seasons and in all areas, and requested further survey. In response, Arrow referred to the desktop literature and database review, habitat suitability assessment, and field surveys used to establish terrestrial flora and fauna values within the project development area as detailed in EIS Appendix K. Arrow also referred to the environmental framework process outlined in EIS Chapter 8, Environmental Framework, and associated pre-construction survey requirements, recommended threatened species survey methodology in SREIS Appendix 9, Supplementary Terrestrial Ecology Assessment, Section A5, and to additional targeted surveys for the SREIS in areas identified as potential facility locations.

The former DSEWPaC submission on the EIS requested justification for not conducting surveys in areas where there are known records of listed threatened species and communities and listed migratory species within the project area. In response, Arrow acknowledged that the extent of surveys did not fully address the requirements of the EPBC Act for the entire project development area.

Arrow stated that the size of the project development area made a detailed survey for listed species and communities impractical and outlined the approach proposed by Arrow to determine the extent of MNES present within the project development area, including:

- desktop assessment and field surveys carried out for the EIS.
- the 'environmental framework' approach outlined in Chapter 8 of the EIS
- proposed site validation of environmental values (SREIS Chapter 11, Terrestrial Ecology, Section 11.5)
- proposed preconstruction clearance surveys in accordance with guidelines detailed in Appendix C of SREIS Attachment 1, Matters of National Environmental Significance
- additional surveys for the SREIS.

Additional surveys were carried out for the SREIS targeting the properties identified for possible location of four central gas processing facilities and a temporary works accommodation facility. Figure 11.1 of SREIS Chapter 11 showed the approximate location of terrestrial flora surveys for the EIS documents, including areas where regional ecosystems were remapped based on survey findings. Figure 11.2 of SREIS Chapter 11 showed the approximate location of terrestrial fauna surveys for the EIS documents.

4.12.1.2 Terrestrial ecology values

The EIS identified three Category A environmentally sensitive areas (as defined by the EP Regulation) within the project development area:

- Wondul Range National Park
- Bendidee National Park (not included in the revised project development area)
- Lake Broadwater Conservation Park.

Two EPBC Act listed threatened ecological communities were identified within the project development area during field surveys and an additional four communities were considered as 'possible' or 'likely' occurrences:

- Brigalow (*Acacia harpophylla* dominant and co-dominant)—confirmed by field survey
- Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland—confirmed by field survey
- Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions
- Weeping Myall Woodlands
- White Box—Yellow Box—Blakely's Red Gum grassy woodland and derived native grassland
- Coolibah—Black Box Woodlands of the Darling Riverine Plains and Brigalow Belt South Bioregions.

The EIS identified 35 regional ecosystems within the project development area with 11 'endangered', 7 'of concern' and 17 'least concern' regional ecosystems based on biodiversity status as used by the EP Act (endangered regional ecosystems are classified as a Category B environmentally sensitive areas and 'of concern' regional ecosystems are classified as Category C environmentally sensitive areas). Figure 17.2 of EIS Chapter 17 provided a map of the location of Category A, B, and C environmentally sensitive areas and Figures 17.3a, 17.3b and 17.3c of EIS Chapter 17 showed the regional ecosystems mapped by VM Act class over the project development area. Table 17.4 of EIS Chapter 17 presented a summary of regional ecosystems within the project development area including the estimated sensitivity of the community (based on detailed assessment in Section 5.8 of EIS Appendix K, Summary of Ecological Values), status (EPBC Act, VM Act, biodiversity) and estimated extent (based on desktop and field assessment).

The SREIS (Chapter 11 and Appendix 9) reported a number of changes to the extent of regional ecosystems and threatened ecological communities based on inclusion of mature regrowth vegetation, additional surveys, and the significantly reduced project development area. Table 4 of SREIS Appendix 9 presented a revised summary of the extent of EPBC Act listed ecological communities in the project development area and Table 6 presented a revised summary of the extent and status of regional ecosystems. Table 11.4 of SREIS Chapter 11 provided a summary of changes to terrestrial ecology values between the EIS documents (status, occurrence, and sensitivity). The estimated extent of regional ecosystems within the project development area, based on published mapping and revised mapping, supported by field surveys for the EIS documents, was summarised in Table 11.6 of SREIS Chapter 11.

The EIS provided an indication of areas of significant biodiversity value, including likely habitat for listed (EPBC Act, NC Act) threatened species (Figure 17.4 of EIS Chapter 17), vegetation corridors, and wetlands. Specific mention was made of the biodiversity values of the following areas:

- Lake Broadwater Conservation Park
- Bendidee National Park
- Bendidee, Barakula, Western Creek, and Whetstone State Forests
- Chinchilla rifle range
- Dalby-Kogan, Dalby-Cecil Plains, and Dalby-St George Road reserves.

Bendidee National Park and Bendidee State Forest were located outside the revised project development area described in SREIS Chapter 3.

The EIS concluded that no groundwater dependant ecosystems were known to occur in the project development area. Section 11.4.8, Groundwater Dependent Ecosystems, of SREIS Chapter 11 provided an updated assessment based on the Underground Water Impact Report (UWIR) prepared for the Surat Cumulative Management Area. Additional information on groundwater interactions with vegetation communities was included in SREIS Chapter 8, Groundwater and SREIS Attachment 1, Matters of National Environmental Significance, Section 5.1. The SREIS stated that no potentially impacted springs were identified within the project development area and that Arrow was not the designated responsible tenure holder (under the UWIR) for any potentially impacted springs located outside of the project development area.

The EIS identified 1,390 flora species as present or potentially present in the project development area, including:

- 37 threatened species (NC Act, EPBC Act)
- 8 regionally significant species
- 218 pest species.

A number of threatened species identified by database searches were excluded from further assessment for reasons outlined in EIS Appendix K, Terrestrial Ecology Impact Assessment, including a lack of recent records and/or a lack of suitable habitat. The SREIS made a number of changes to the list of threatened flora species, mostly due to changes in the project development area footprint and updated data (refer Table 7 and Table 8 of SREIS Appendix 9). Six threatened flora species listed under the NC Act, and two threatened flora species listed under the EPBC Act, were recorded during field surveys for the EIS, with no additional records from surveys for the SREIS. An updated list of threatened flora species was presented in Table 11.8 of SREIS Chapter 11 provided an updated assessment of likelihood of occurrence and estimated sensitivity for threatened flora species listed under the EPBC Act. Table 17 summarises information from the EIS documents.

Table 17 Assessment of likelihood of occurrence and estimated sensitivity for threatened flora species (EPBC Act)

Scientific Name	Common Name	Status	Sensitivity (SREIS)
Acacia barakulensis	Waajie wattle	EPBC Act – NC Act - V	high
Acacia handonis	Hando's wattle	EPBC Act – V NC Act - V	moderate
Acacia curranii	Curly-bark wattle	EPBC Act – V NC Act - V	moderate
Acacia lauta	Tara wattle	EPBC Act – V NC Act - V	moderate
Acacia tenuinervis		EPBC Act – NC Act - NT	
Acacia wardellii	Wardell's wattle	EPBC Act – V NC Act - V	moderate
Apatophyllum teretifolium		EPBC Act – NC Act - V	high
Aristida forsteri		EPBC Act – NC Act - E	extremely high
Bothriochloa biloba	Lobed blue grass	EPBC Act – V NC Act -	
Cadellia pentastylis	Ooline, scrub myrtle	EPBC Act – V NC Act - V	extremely high
Callitris baileyi	Bailey's cypress pine	EPBC Act – NC Act - NT	
Calotis glabrescens	White Burr-daisy	EPBC Act – NC Act - NT	
Calytrix gurulmundensis	Gurulmundi fringe-myrtle	EPBC Act – V NC Act - V	extremely high

Scientific Name	Common Name	Status	Sensitivity (SREIS)
Cryptandra ciliata		EPBC Act – NC Act - NT	
Cymbonotus maidenii	Darling Daisy	EPBC Act – NC Act - E	moderate
Cyperus clarus		EPBC Act – NC Act - V	high
Denhamia parviflora	Small-leaved denhamia	EPBC Act – V NC Act - V	extremely high
Digitaria porrecta	Finger panic grass	EPBC Act – E NC Act - NT	high
Eleocharis blakeana		EPBC Act – NC Act - NT	
Eucalyptus argophloia	Queensland white gum	EPBC Act – V NC Act - V	moderate
Eucalyptus curtisii	Plunkett Mallee	EPBC Act – NC Act - NT	
Eucalyptus virens	Shiny-leaved ironbark	EPBC Act – V NC Act - V	high
Fimbristylis vagans		EPBC Act – NC Act - NT	
Gonocarpus urceolatus		EPBC Act – NC Act - V	
Homopholis belsoni	Belson's panic	EPBC Act – V NC Act -	high
Macrozamia machinii	Machin's macrozamia	EPBC Act – V NC Act - V	extremely high
Microcarpaea agonis	An unnamed member of the Scrophulariaceae family	EPBC Act – E NC Act - E	very high
Micromyrtus carinata	Gurulmundi heath-myrtle	EPBC Act – NC Act - E	high
Philotheca sporadica	Kogan wax flower	EPBC Act – V NC Act - V	moderate
Picris barbarorum	Plains Picris	EPBC Act – NC Act - V	high
Picris evae	Hawkweed	EPBC Act – V NC Act - V	moderate
Pomaderris coomingalensis		EPBC Act – NC Act - E	high
Prostanthera sp. (Dunmore)	An unnamed mint-bush	EPBC Act – V NC Act - V	extremely high
Pterostylis cobarensis	Cobar greenhood orchid	EPBC Act – V NC Act -	
Ptilotus extenuatus		EPBC Act – NC Act - E	high
Rhaponticum australe	Austral cornflower	EPBC Act – V NC Act - V	moderate
Rutidosis lanata		EPBC Act – NC Act - E	high
Solanum papaverifolium		EPBC Act –	

Scientific Name	Common Name	Status	Sensitivity (SREIS)
		NC Act - E	
Solanum stenopterum		EPBC Act – NC Act - V	high
Thesium australe	Austral toadflax	EPBC Act – V NC Act - V	high
Xerothamnella herbacea	Xerothamnella	EPBC Act – V NC Act -	extremely high

The EIS identified 218 exotic plant species and highlighted the following species as being of primary concern for the project:

- Lippia (*Phyla canescens*)
- African lovegrass (*Eragrostis curvula*)
- Parthenium (*Parthenium hysterophorus*)
- Mesquite (*Prosopis glandulosa* var. *glandulos, Prosopis velutina*).

The desktop study for the EIS identified 497 terrestrial vertebrate species (29 frogs, 97 reptiles, 308 birds and 63 mammals) and 63 terrestrial invertebrate species (49 butterfly and 14 dragonfly species) as known to occur, or potentially occurring, within the project development area, including 27 fauna species listed as threatened under the EPBC Act and/or the NC Act (2 butterflies, 1 amphibian, 9 reptiles, 12 birds and 3 mammals). Table 18 was derived from Table 17.7 of EIS Chapter 17, Table 38 of EIS Appendix K, and Table 11.9 of SREIS Chapter 11, lists the threatened fauna species and their status at the time. Two species identified in the EIS, spotted-tail quoll (*Dasyurus maculatus maculatus*) and platypus (*Ornithorhynchus anatinus*), were excluded from assessment in the SREIS on the basis that they were unlikely to occur within the project development area.

Table 18 Assessment of likelihood of occurrence and estimated sensitivity for threatened fauna species (EPBC Act)

Group	Scientific Name	Common Name	Status	Sensitivity (SREIS)
Insects	*Hypochrysops piceatus*	Bull oak jewel butterfly	EPBC Act – not listed NC Act - endangered	extremely high
	Jalmenus eubulus	Pale imperial hairstreak	EPBC Act – not listed NC Act - vulnerable	high
Amphibians	*Cyclorana verrucosa*	Rough-collared frog	EPBC Act – not listed NC Act – near threatened	moderate
Reptiles	*Strophurus taenicauda*	Golden-tailed gecko	EPBC Act – not listed NC Act - NT	moderate
	Delma torquata	Collared delma	EPBC Act – vulnerable NC Act - vulnerable	extremely high
	Paradelma orientalis	Brigalow scaly-foot	EPBC Act – vulnerable NC Act - vulnerable	moderate
	Anomalopus mackayi	Five-clawed worm-skink	EPBC Act – vulnerable NC Act - endangered	extremely high
	Egernia rugosa	Yakka skink	EPBC Act – vulnerable NC Act - vulnerable	high
	Tympanocryptis cf. *tetraporophora*	Grassland earless dragon	EPBC Act – endangered NC Act - endangered	extremely high

Group	Scientific Name	Common Name	Status	Sensitivity (SREIS)
	Acanthophis antarcticus	Common death adder	EPBC Act – NC Act - NT	moderate
	Furina dunmalli	Dunmall's snake	EPBC Act – vulnerable NC Act - vulnerable	moderate
	Hemiaspis damelii	Grey snake	EPBC Act – not listed NC Act - endangered	moderate
Birds	*Accipiter novaehollandiae*	Grey goshawk	EPBC Act – NC Act - NT	moderate
	Lophoictinia isura	Square-tailed kite	EPBC Act – not listed NC Act - NT	moderate
	Nettapus coromandelianus	Cotton pygmy-goose	EPBC Act – not listed NC Act - NT	moderate
	Stictonetta naevosa	Freckled duck	EPBC Act – not listed NC Act - NT	moderate
	Calyptorhynchus lathami	Glossy black-cockatoo	EPBC Act – not listed NC Act - vulnerable	moderate
	Ephippiorhynchus asiaticus	Black-necked stork	EPBC Act – not listed NC Act - NT	moderate
	Geophaps scripta scripta	Squatter pigeon (southern)	EPBC Act – vulnerable NC Act - vulnerable	high
	Anthochaera phrygia[§§]	Regent honeyeater	EPBC Act – endangered NC Act - endangered	high
	Grantiella picta	Painted honeyeater	EPBC Act – not listed NC Act - NT	high
	Melithreptus gularis	Black-chinned honeyeater	EPBC Act – not listed NC Act - NT	low-moderate
	Neophema pulchella	Turquoise parrot	EPBC Act – not listed NC Act - NT	moderate
	Rostratula australis	Australian painted snipe	EPBC Act – vulnerable NC Act - vulnerable	high
Mammals	*Dasyurus maculatus maculatus*	Spotted-tailed quoll	EPBC Act – endangered NC Act - vulnerable	unlikely to occur
	Chalinolobus picatus	Little pied bat	EPBC Act – not listed NC Act - NT	moderate
	Nyctophilus corbeni	South-eastern long-eared bat	EPBC Act – vulnerable NC Act - vulnerable	moderate

The desktop study for the EIS identified 29 migratory fauna species listed under the EPBC Act as potentially occurring in the project development area, and six of these species were sited during field surveys. Lake Broadwater, and other permanent and semi-permanent watercourses, were highlighted as likely to provide suitable habitat for threatened migratory species. Section 11.4.9 of SREIS Chapter 11 provided updated information on the potential and known occurrence of migratory species within each of the five properties identified for possible location of major infrastructure. Section 5 of this assessment report includes a summary of listed migratory fauna species along with their likelihood of occurrence within the project development area.

The former DSEWPaC submission on the EIS requested maps showing where migratory species have been recorded in the project development area, the type of habitat, and the numbers of the species recorded. In response, Arrow advised that many migratory species potentially present in the study area, and particularly species such as the rainbow bee-eater and the great egret, are generalist species and it is not possible to isolate a particular habitat type of importance to such species. The SREIS did not include specific mapping of the habitat of migratory species.

The EIS identified 47 fauna species of bioregional significance based on scientific value or cultural significance.

The EIS identified seven Class 2 declared pest fauna species:

- wild dog (*Canis familiaris*)
- European red fox (*Vulpes vulpes*)
- feral cat (*Felis catus*)
- feral deer (*Cevus* spp.)
- feral goat (*Capra hircus*)
- European rabbit (*Oryctolagus cuniculus*)
- feral pig (*Sus scrofa*).

The cane toad (*Rhinella marina*) was also considered to have a substantial risk of proliferation and impact.

4.12.2 Impacts and significance of impact

EIS Appendix K presented a detailed review of project development activities and potential associated impacts and provided a list in Table 26. Section 17.4 of EIS Chapter 17 summarised the potential direct and indirect impacts of project activities on terrestrial ecology values including:

- habitat fragmentation and isolation of populations through clearing of vegetation, including the impact of clearing of wildlife movement corridors
- habitat loss and degradation through clearing (and associated habitat and ecological process changes), dust deposition, release of contaminants, noise, light spill, and spread and invasion of pest flora and fauna species
- fauna mortality from entrapment in excavations, vehicle strikes, or displacement and starvation as a result of vegetation clearance.

The following project activities were identified as having potential to cause adverse impacts on terrestrial ecology values during the construction, operations and decommissioning phases of the project (Table 19).

Table 19 Activities that have the potential to cause adverse impacts on terrestrial ecology values during the different phases of the project

Construction	Operations	Decommissioning
• Site clearance • Ground disturbance and soil movements • Potential spills of hazardous materials • Vehicle movement (which potentially leads to fauna strikes and the spread of weeds and pathogens) • Barriers to fauna movement or pathways for pest species • Trenching (which, when left open, may entrap animals and interfere with fauna movement pathways) • Light and noise emissions • Storage of putrescible waste	• Release or spill of waste water or hazardous materials • Vehicle movements • Light and noise emissions • Storage of putrescible waste	• Impacts similar to construction and operations although decommissioning activities would occur mainly in previously disturbed areas

Section 17.5 of EIS Chapter 17 indicated the following broad objectives for terrestrial ecology:

- Minimise habitat loss and fauna mortality.
- Avoid or minimise adverse effects on biodiversity and habitat of state and national conservation significance.
- Avoid or minimise adverse impacts on environmentally sensitive areas.
- Prevent project activities from introducing or spreading new or existing exotic terrestrial flora or fauna.

The EIS referred to the proposed use of the Arrow environmental framework, as described in EIS Chapter 8, as the means by which sensitive locations would be identified and avoided. However, a commitment to avoiding such areas (C217, EIS Attachment 8) was only provided for the following terrestrial ecology values:

- Category A environmentally sensitive areas (ESAs) - Wondul Range National Park, Bendidee National Park (now located outside of the project development area) and Lake Broadwater Conservation Park.
- Chinchilla Sands Local Fossil Fauna Site.
- 'Critically endangered' EPBC Act communities (regional ecosystems 11.3.21, 11.3.24, and 11.8.2a), including three natural grassland road reserves (Dalby Kogan, Dalby Cecil Plains and Dalby St George Road).

Section 11.5.1 of SREIS Chapter 11 clarified that the Arrow environmental framework approach provided for the identification of sites and routes for project infrastructure and activities to be informed by constraints imposed by environmental values and buffer requirements supported by preconstruction surveys. Preliminary constraint mapping was included in EIS Attachment 10 and updated in SREIS Attachment 8. Figure 11.13 of SREIS Chapter 11 presented an overview of the proposed approach to site validation of terrestrial ecology values.

The EIS listed a number of terrestrial ecology values that Arrow would aim to avoid (C218, EIS Attachment 8) including:

- additional national- and state-listed communities: brigalow (regional ecosystems 11.3.1, 11.4.3, 11.4.10, 11.9.5, and 11.9.6), semi-evergreen vine thickets (regional ecosystems 11.9.4a and 11.8.3), weeping myall woodlands, and Coolibah-Blackbox woodlands (regional ecosystem 11.3.3)
- Category B ESAs
- Category C ESAs (as listed in Draft Code of Environmental Compliance for Level 2 Petroleum Activities, EPA 2008), including Gurulmundi State Forest, Bendidee State Forest (now located outside of the project development area), Binkey State Forest and Barakula State Forest)
- Wyaga-Kindon ooline (*Cadellia pentastylis*) populations
- stock routes and state or bioregional wildlife corridors
- essential and core habitat for threatened species
- State forests and resource reserves
- regional ecosystems with 'of concern' status.

In addition, Section 17.6 of EIS Chapter 17 stated a number of commitments to general and specific mitigation measures for potential direct and indirect impacts of project activities proposed to be implemented during construction, operations and decommissioning. The mitigation measures stated throughout the EIS were presented as a list of commitments in EIS Attachment 8, Commitments Summary, that was updated in SREIS Attachment 4, Commitments Update. Many of the commitments relating to terrestrial ecology were either qualitative (e.g. proposed to 'minimise' impact) or qualified (e.g. by inclusion of the words 'where practicable' or 'where possible'). Furthermore, submissions on the EIS and comments on the SREIS, notably by former DSEWPaC and QMDC, highlighted the uncertainty of outcome where Arrow has stated that the development would 'aim' to avoid impacts on sensitive environmental values, rather than avoid impacts on such values.

The assessment of residual impact, based on assumed effective implementation of all relevant mitigation measures, was limited to the following terrestrial ecology values (Section 8.1, EIS Appendix K):

- Threatened ecological communities.
- Environmentally sensitive areas.
- Threatened flora species assemblages.
- Threatened fauna species assemblages.
- Migratory fauna species.

The residual impact assessment was detailed in EIS Appendix K and reflected in Table 17.11 of the EIS Chapter 17. Detailed information on the basis for residual impact assessment, methodology used, and the assessment of impact to specific values, was included in appendices to EIS Appendix K. The significance of residual impact, for terrestrial ecology values (for which a commitment to avoidance was not applicable) was rated as insignificant, low or moderate except for Bendidee State Forest which was assessed to have high magnitude and significance of impact for most of the stated potential direct and indirect impacts of the project. Bendidee State Forest was subsequently excluded from assessment as it is located outside of the reduced project development area described in SREIS Chapter 3.

The SREIS did not provide a full update of the residual impact assessment provided in the EIS but included assessments for each MNES (Appendix B, C, D, E of SREIS Appendix 9) and provided an indication of the effectiveness of the proposed approach to mitigation through the assessment of terrestrial ecology values in each of the five properties identified for the possible location of major infrastructure. SREIS Appendix 9 noted significant variation between existing regional ecosystem mapping and detailed mapping for the EIS documents (based on field surveys) that could affect the mapping and estimate of extent of terrestrial ecology values, and therefore the estimates of potential impact on these values. The SREIS confirmed the need for detailed surveys prior to development to adequately determine terrestrial ecology values, including:

- pre-clearance surveys of the proposed infrastructure footprint and an appropriate buffer area
- targeted pre-clearance surveys in all areas identified as 'core habitat known', 'core habitat possible' and 'general habitat' for threatened species.

Arrow provided commitments to conduct pre-construction clearance surveys, including: vegetation mapping at a scale suitable for site-specific planning, identification of core habitats and threatened species listed under the EPBC Act or NC Act, and identification of site-specific sensitive areas that require avoidance or buffer areas. The methodology adopted for pre-clearance surveys, and the effective application of the methodology at each site, will influence the actual impact on terrestrial ecology values and the estimation of offset requirements. Although presented as a validation of the proposed approach to pre-clearance surveys, the scope of surveys carried out for the SREIS (within the five properties identified for possible location of major infrastructure) varied significantly and completion of the planned surveys was affected by flooding.

In response to a request by former DSEWPaC for additional information on pre-clearance surveys, Arrow referred to the approach outlined in SREIS Chapter 11, Terrestrial Ecology, Section 11.5, and stated that field verification of vegetation communities and habitat features would be undertaken prior to pre-construction clearance surveys to determine the level of survey effort required, appropriate to each species as outlined in species dossiers within Appendix C of SREIS Attachment 1. DSEWPaC has further advised that conditions of approval (under the EPBC Act) are likely to require preconstruction surveys to be undertaken in accordance with DSEWPaC survey guidelines and best practice methodologies.

The EIS provided a number of qualitative commitments to inspection and monitoring activities relevant to implementation of mitigation measures for terrestrial ecology, including a commitment (C303) to develop site-specific risk-based monitoring programs. Arrow has also provided a commitment (C224) to develop a species management plan that would include species specific measures for avoidance and mitigation of impact.

A number of submissions on the EIS, including from Toowoomba Regional Council and Queensland Murray Darling Committee, expressed concern about the lack of information on the actual location of project infrastructure, the limited extent of field surveys, and therefore the resultant uncertainty of impact to terrestrial ecology values. In response, Arrow referred to the proposed use of the environmental framework outlined in EIS Chapter 8 and the associated planning and design processes, including constraints mapping and staged refinement of mapping, as the means to avoid or minimise impacts. Arrow also referred to the targeted surveys for the SREIS in properties identified for the location of four CGPFs and one TWAF (SREIS Chapter 11, Terrestrial Ecology, sections 11.3. and 11.5), and updated constraints mapping in SREIS Attachment 6, Constraints Mapping Update, as a demonstration of the proposed approach to refining knowledge of regional ecosystem extent and the presence of fauna and flora habitat.

EHP recommended that the sensitivity rating of all regional ecosystems in fragmented subregions be elevated to at least 'High', based on the regional context of a fragmented subregion with less than 30% remaining vegetation, and requested reassessment of the significance of vegetation clearing impacts on terrestrial ecology. In response, Arrow referred to further validation of the significance assessment (as presented in the EIS) contained SREIS Appendix 9, Supplementary Terrestrial Ecology Assessment, Section A4 (Sensitivity, Impact Magnitude and Impact Significance Assessment). The revised criteria were applied to all species assessed in the EIS, and additional species identified by the SREIS, and an updated assessment of sensitivity was presented in Table 42 of SREIS Appendix 9, Supplementary Terrestrial Ecology Assessment.

Submissions on the EIS by the former DERM, the former DEEDI and Queensland Murray Darling Committee sought further information on wildlife corridors or habitat connectivity, including riparian corridors, and requested higher priority be given to protection of such corridors due to the existing fragmentation of habitat and potential impacts of future climate change. In response, Arrow referred to the identification of riparian corridors and essential habitat areas in EIS Appendix K, Terrestrial Ecology Impact Assessment, information on MNES species movement corridors in SREIS Attachment 1, MNES, Section 5.6.2, and mapping of bioregional corridors in SREIS Chapter 11, Figure 11.8.

The Queensland Murray Darling Committee submission on the EIS sought assurance that adequate buffer zones would be maintained between project infrastructure and natural resources, and recommended that the buffer zone around Lake Broadwater be 2km rather than the 200m indicated in the EIS. In response, Arrow advised that buffers would be implemented in accordance with regulatory requirements (conditions of an environmental authority).

The former DERM (now part of NPRSR) submission on the EIS stated concerns with the uncertainty of impact to Category C environmentally sensitive areas, and particularly to State forests. In response, Arrow referred to Figure 17.2 of EIS Chapter 17, Terrestrial Ecology and Figure 14 of EIS Appendix K, Terrestrial Ecology Impact Assessment which show all Category C Environmentally Sensitive Areas (ESAs) within the project development area. In comments based on review of the SREIS, NPRSR continued to have concerns with the extent of potential impact on State forests, partly due to the different values or sensitivity applied to State forests and partly relating to uncertainty of the extent of the project development area in relation to State forests, especially Braemar State Forest. Braemar State Forest is located immediately adjacent to the proposed location of CGPF7.

NPRSR was also concerned with the potential impact on State forests and resource reserves by electricity infrastructure required for the project, including the potential for a significant amount of commercial timber (a buffer twice the height of the tallest tree in the felling zone) to become unavailable to the State, unless the area adjacent to the proposed powerline is harvested prior to construction. In response, Arrow stated that the location and type of distribution infrastructure would be determined in detailed design of the gas fields and through negotiation with landholders. Any potential impacts on Category C environmentally sensitive areas from power distribution infrastructure would be described as part of the statutory information requirements to support the application for an environmental authority (EA) or an EA amendment. Section 2.7 of this assessment report addresses uncertainties in proposed electricity supply for the project. NPRSR has advised that underground cabling would be requested for any powerline transecting a State forest or resource reserve in order to reduce potential adverse impacts to environmental values and forest management activities.

Weed and pest management for the project was a major concern for many submitters, including DAFF. The DAFF submission indicated that rabbits, deer and pigs were of higher concern than indicated in the EIS, and identified additional high risk weeds known to be in the area including: prickly acacia, hymenachne, giant rats tail grass, honey locust, and African boxthorn. DAFF recommended the use of Biosecurity Queensland's Annual Pest Distribution Survey data and predictive pest maps, in conjunction with Queensland Herbarium naturalised flora data, to identify pest plants, and use of local government area pest management plans to determine the occurrence and distribution of pest animals in the project area. Arrow committed to develop a declared weed and pest management plan in accordance with the Petroleum Industry—Pest Spread Minimisation Advisory Guide (Biosecurity Queensland, 2008). Arrow further advised that development of the plan would be consistent with DAFF recommendations and would include training requirements for project staff.

In advice based on review of the SREIS, the IESC recommended further assessment of potential cumulative impacts on groundwater dependent ecosystems, particularly those not listed in the Underground Water Impact Report, including:

- integration of groundwater model outputs with known and potential groundwater dependent ecosystems and mapping of potentially impacted ecosystems
- confidence interval assessment for localised groundwater drawdown impacts
- confirmation of the source aquifer for Spring Complex 584
- field-based investigations to determine the groundwater dependency of ecosystems where uncertainty exists, and to assess the hydrogeological and ecological characteristics of potentially impacted watercourse springs
- inclusion of groundwater-dependent ecosystems confirmed by field survey in the OGIA groundwater model
- identification of predicted changes in stream connectivity due to groundwater drawdown
- assessment of potential impacts on ecosystems (other than springs) with a moderate to high potential for interaction with the sub-surface expression of groundwater
- a groundwater monitoring and management program to allow for early detection of, and response to, potential impacts on groundwater dependent ecosystems, including monitoring of Lake Broadwater and the Long Swamp wetland.

4.12.3 Cumulative impacts

EIS Chapter 28, Cumulative Impacts, discussed the potential cumulative impacts of future developments on the environmental values within the project development area. Section 28.3.6 addressed cumulative impacts on terrestrial ecology focusing on habitat loss, habitat fragmentation and fauna mortality resulting from vegetation clearance and earthworks. Three threatened ecological communities (EPBC Act), 14 flora species and 11 fauna species with high potential for cumulative impact were identified. Although the desirability of a cooperative approach with other development proponents was recognised, no specific measures were proposed to mitigate the potential cumulative impacts, other than the general and value specific mitigation measures stated in the EIS documents.

Section 6.6 of SREIS Appendix 9 provided updated information on the potential cumulative impact on EPBC Act listed threatened ecological communities, flora species and fauna species.

The Toowoomba Regional Council submission on the EIS requested additional studies to identify cumulative impacts to terrestrial ecology and to determine the significance of impacts from multiple developments, or alternatively, proposal of stronger avoidance measures as a precautionary approach. The submission referred to the historical impact of agriculture and the need to ensure that cumulative impacts do not push ecosystems beyond threshold limits. In response, Arrow referred to the assessments in EIS Chapter 28, EIS Appendix K, SREIS Attachment 1, commitments to mitigation measures, and the constraints based approach to siting of infrastructure.

4.12.4 Offsets

The EIS did not include information required by the TOR in relation to offsets for residual impact to terrestrial and aquatic ecology values, including MNES. EHP requested detailed information to meet the requirements of the Queensland Biodiversity Offset Policy including the extent of impact on each State Significant Biodiversity Value. The former DSEWPaC requested detailed information on offsets, including offsets for residual impacts to MNES, consistent with the draft EPBC Act Environmental Offsets Policy.

SREIS Attachment 6, Draft Environmental Offsets Strategic Management Plan, presented a high level strategy outlining a proposed approach to meet environmental offset obligations for the project. The draft plan referred to measures stated in the EIS documents to avoid and minimise impacts, including pre-construction clearance surveys, proposed environmental constraints, and commitments to mitigation and management. Table 7.1 of SREIS Attachment 6 presented a summary of state significant biodiversity values (as listed in Appendix 1 of the Queensland Biodiversity Offsets Policy) and the relevance of the values to the project.

Table 8.1 of SREIS Attachment 6 provided an estimate of the potential area of disturbance of regional ecosystems in the project development area based on the conceptual field layout, publicly available mapping and mapping prepared for the SREIS. SREIS Appendix 9 presented comparisons between detailed mapping of regional ecosystems completed for the SREIS and publicly available regional ecosystem mapping which indicated significant errors in the published mapping. The actual area of these communities within the project development area may vary significantly from the estimated area. In relation to the revised regional ecosystem mapping presented in the SREIS for areas subject to field survey, it should be noted that EHP may accept amended regional ecosystem mapping for the purpose of offset area estimation provided that the mapping is supported by adequate site data, photographs and justification. This detailed information was not provided in the SREIS.

Table 8.2 of SREIS Attachment 6 provided an estimate of the potential area of disturbance of threatened ecological communities and core habitat for threatened species listed under the EPBC Act and the NC Act, based on a conceptual field layout. It was noted that the habitat of species may overlap and the total area of disturbance for threatened species would likely be less than the sum of estimated areas for each species. The SREIS did not include an estimate of the area of other state significant biodiversity values within the project development area. The former DSEWPaC has advised that an estimate of disturbance limits for core habitat known, core habitat possible, and general habitat for EPBC Act listed threatened species and migratory species is required for the whole of the project development area (not just for core habitat as provided).

Table 9.1 of SREIS Attachment 6 provided an estimate of the availability of ecological communities and habitat (based on regional ecosystems) in the Brigalow Belt South bioregion to meet potential requirements for offsets. The estimate of maximum impact and available offset areas indicated that adequate offset areas may be available for the offset requirements considered.

Section 10 of SREIS Attachment 6 outlined Arrow’s preferred staged approach to the provision of environmental offsets. Environmental offsets were not proposed in the SREIS as the actual offset area requirements would not be determined until pre-construction surveys are complete and the actual location of infrastructure is defined.

4.12.5 Conclusion

The description of terrestrial ecology values within the project development area was adequate to meet the requirements of the TOR. The EIS provided a qualitative assessment of potential impacts of the project, estimates of mitigation of impact through implementation of stated measures, and estimates of the residual impact on specific terrestrial ecology values. As the actual location of project infrastructure was not defined, and the accuracy of mapping of values within the project development area is uncertain except where detailed ground surveys have been completed, estimates of the area of disturbance to ecological communities and threatened species habitat have uncertain accuracy.

A number of qualitative commitments to inspection and monitoring related to protection of terrestrial biodiversity values were provided but key species for monitoring were not identified. However, Arrow stated it is committed to develop a species management plan that would include species specific measures for protection and mitigation of impact.

Detailed measures for management of risks associated with weed and pest management, were proposed to be included in management plans to be developed after the EIS process.

The EIS included a number of general commitments relevant to terrestrial ecological values for rehabilitation and decommissioning including to implement site planning, preparation and management requirements in accordance with an approved plan.

Environmental offsets were not identified as Arrow proposed that the actual offset area requirements would not be determined until pre-construction surveys are completed and the actual location of infrastructure is defined. A draft strategy outlining a proposed approach to meet environmental offset obligations under Queensland and Commonwealth legislation was provided.

4.12.6 Recommendations

In preparing an application for an environmental authority, or an amendment to an environmental authority, Arrow should consider the guideline Application requirements for petroleum activities (EM705) and should ensure that the information provided in the application meets the requirements of s.125 and s.126 of the EP Act.

Arrow has acknowledged the relevance of these sections of the EP Act and has committed to preparing detailed technical information to support applications to amend the Dalby Expansion Project's environmental authority or when applying for new environmental authorities. Appendix 4 of this assessment report provides an outline of the information to be provided.

The commitments made by Arrow (listed in Appendix 3 of this assessment report) that are relevant to management of impacts to terrestrial ecology are considered appropriate and should be implemented. However, Table 20 Arrow commitments—recommended changes, provides recommendations on changes to a number of specific commitments relating to terrestrial ecology.

Table 20 Arrow commitments—recommended changes

	Commitment	Recommended Amendment
C217	Avoid the following areas: • Wondul Range National Park, Bendidee National Park and Lake Broadwater Conservation Park (Category A ESAs) • Chinchilla Sands Local Fossil Fauna Site • 'Critically endangered' EPBC Act communities within the project development area (REs 11.3.21, 11.3.24, 11.8.2a) including three natural grassland road reserves (Dalby Kogan, Dalby St George and Dalby Cecil Plains)	Endorsed
C218	Aim to avoid: • Additional national- and state-listed communities: Brigalow (REs 11.3.1, 11.4.3, 11.4.10, 11.9.5, 11.9.6), Semi-evergreen vine thickets (REs 11.9.4a, 11.8.3), Weeping Myall Woodlands, and Coolibah-Blackbox Woodlands (RE 11.3.3) • Category B ESAs • Category C ESAs, including Gurulmundi State Forest, Bendidee State Forest, Binkey State Forest and Barakula State Forest • Wyaga-Kindon Ooline populations • Stock routes and state or bioregional wildlife corridors • Essential and core habitat (supporting listed wildlife species) • State forests and resources reserves	Endorsed Note that siting of activities will need to comply with current EHP restrictions on CSG activities in Environmentally Sensitive Areas

	Commitment	Recommended Amendment
	• State-listed 'of concern' regional ecosystems	
C219	Where avoidance is not possible, and significant residual impacts remain to threatened species and communities, implement an offset strategy approved by a relevant government agency and comply with reporting conditions of an offset plan	The offset strategy should address State (NC Act) and Commonwealth (EPBC Act) matters
C220	Conduct preconstruction clearance surveys to identify any additional areas that may need to be avoided	Preclearance surveys should also identify the values that will be disturbed by construction
C232	Conduct preconstruction clearance surveys and include as a minimum: • vegetation mapping at a scale suitable for site-specific planning • identification of core habitats and listed species • identification of site-specific sensitive areas that require avoidance or buffer areas	Preclearance ecological surveys should be consistent with Australian government (DOE) survey guidelines and practice methodologies for EPBC Act listed threatened species habitat and threatened ecological communities, Queensland government requirements for NC Act listed threatened species and for environmentally sensitive areas, and to meet the requirements for offset area determination under State and Commonwealth legislation
C221	Design facilities to ensure natural surface water flows are not impounded, e.g., by installing culverts on roads and stormwater diversion ditches around production facilities	Particularly important in low sloping and floodplain areas
C223	Develop fire plans for production facilities	
C224	Develop management procedures, inclusive of buffers where required, for threatened communities and species as and when project activities are identified as likely to have an impact on these values	Buffer areas should be identified in preclearance surveys
C225	Avoid construction activities in waterbodies frequented by migratory species	Endorsed
C227	Manage potential impacts on Category A, B and C ESAs through implementation of buffers in accordance with legislative requirements at the time	Endorsed
C233	Minimise the time a trench is left open. Construct exit points when construction is within 1 km of native vegetation, using appropriate material. Provide fauna refuges, such as sawdust-filled bags, regularly through areas of high fauna activity	Suitably qualified fauna spotter/catchers should be used to clear open trenches of fauna in the mornings and evening
C236	Identify key koala trees (*Eucalyptus tereticornis* and *Eucalyptus populnea*), and visually inspect prior to clearing to ensure that they are free of koalas. If koalas are located, the tree should be retained until the animals have moved on, typically overnight	Have spotter catchers on hand during clearing operations even if surveys indicate that koalas and other aboreal animals have left the area
C239	Translocate or propagate significant species where it is deemed necessary for use during rehabilitation or in offsets in accordance with relevant legislation	Incorporate in to the plans for the delivery of offsets
C243	Erect fauna-exclusion fences around project dams	Particularly important for dams containing CSG water or any water of poor quality
C245	Implement site planning, preparation and management requirements in accordance with a developed and approved decommissioning and rehabilitation plan	Plan should be prepared and review well before initial clearing takes place

	Commitment	Recommended Amendment
C247	Identify areas for rehabilitation	Needs to be done progressively as construction and production phases are concluded
C303	Develop site-specific monitoring programs for threatened species and communities based on the identified risk to the conservation or maintenance of a viable population	Monitoring programs for threatened species and ecological communities need to be consistent with the requirements of relevant authorities and approvals
C478	Carry out routine monitoring of rehabilitation success	Identify and remediate any areas where successful rehabilitation milestones are not being achieved in accordance with agreed rehabilitation plans.
C500	Inspect and manage open trenches in accordance with the following: • Inspect trenches for the presence of fauna daily (preferably in the morning), as well as immediately prior to closing a trench • Have appropriately trained personnel remove any fauna from a trench to minimise stress to the animal and to avoid personal injury • Record details of trapped fauna for inclusion in the EHP Wildnet database.	If trenches are left unattended during the day, they should be checked for fauna in the evening as well
C541	Salvage seed from threatened flora species unavoidably disturbed for use in rehabilitation as propagation material or natural regeneration	Collection of propagating material and translocation of threatened plants is subject to the requirements of relevant approvals under State and Commonwealth legislation
C562	Ensure Arrow's overhead distribution powerlines are visible when construction is planned in proximity to waterbodies frequented by an important population of listed migratory bird species	Bird deflection devices should be installed on powerlines located above or immediately adjacent to wetlands used by large waterbirds (e.g. pelicans, swans) or where impact by waterbirds is recorded
C099	Wash down vehicles and equipment that have potentially been in contact with weeds before entering new work sites	Replace 'washdown' with 'cleandown'

Statutory requirements under the *Nature Conservation Act 1992* are explained in section 3.3.5 of this assessment report. The proponent would need to comply with these requirements.

4.13 Landscapes and visual amenity

EIS Chapter 18, Landscape and Visual Amenity, provided a summary of landscape and visual amenity values within and surrounding the project development area, and an assessment of the potential for these values to be affected during construction, operation and decommissioning phases of the project. Detailed information was included in EIS Appendix L, Landscape and Visual Impact Assessment Report.

Environmental and social protection objectives were proposed, and avoidance, mitigation and management measures to achieve these objectives were outlined.

4.13.1 Assessment methodology

The EIS stated that there are currently no accepted national or state level guidelines for landscape and visual assessment. Consequently, the EIS developed an assessment approach based on the Guideline for Landscape and Visual Impact Assessment (the Landscape Institute & the Institute of Environmental Management and Assessment, 2002) in conjunction with reference to other relevant guidelines, documentation of values using photography and photomontage in landscape and visual assessments, and sensitivity analysis including temporal and spatial impacts of project elements.

The landscape and visual assessment involved a desktop assessment, field surveys and a significance assessment. The desktop study involved a review of key information sources, and a baseline landscape character assessment to map and describe broad landscape character types and discrete landscape character areas within each type. The EIS presented maps of landscape character at a project development area scale. Field surveys were conducted to ground-truth the findings of the desktop study, collect photographic records that portrayed the existing landscape character, inform the viewpoint selection and assessment of viewpoints, and provide data for the production of photographic visualisations.

The objective of the assessment was to identify the potential significant adverse impacts of activities associated with project on the landscape character, views and visual amenity values within the study area from the design, construction, installation, operation, maintenance, decommissioning and rehabilitation phases of the project. In the absence of established, objective thresholds for significance of change for landscape and visual impacts, the significance of impacts was determined qualitatively by considering the sensitivity of the landscape or visual receptor and the magnitude of change expected as a result of the development.

The EIS noted that the location of proposed CSG infrastructure facilities would not be known until detailed planning was completed as development progressed across the project development area. Consequently, potential changes as a result of a range of project activities were qualitatively considered for defined landscape types of estimated sensitivity.

Submissions on the EIS by the Jimbour Action Group and others maintained that the unrestricted views that occur on the native grassy floodplains were not represented in the viewpoints assessment. In response, Arrow stated that representative viewpoints were selected on the basis of showing a general view within each landscape character type and the settled arable plains landscape character type, shown on the western side of the Condamine River between Chinchilla and Millmerran, was represented by viewpoint B2.

4.13.2 Existing environment

The EIS adequately described the existing landscape and visual amenity values within and surrounding the project development area. The description considered a variety of landscapes, including broad open arable land, lowland and elevated native forests, forested steep slopes and wooded river valleys, noting that the landscapes have been shaped by variations in geology, soils, landform vegetation, human settlement and land use. For the purposes of the assessment, the landscape was categorised as ten landscape types with common landscape elements, attributes and values. The key characteristics of these landscape types were summarised in Table 18.3.

The visual baseline was described in terms of views from selected representative viewpoints, which corresponded to the location of residents, settlements, work places, recreational features, recognised vantage points, tourist trails and roads. Key sensitive visual receptors in the project development area were identified and shown on Figure 18.4. The only prominent elevated locations or lookouts identified within the study area were panoramic south-westerly views from Jimbour House and panoramic northerly views over Millmerran from Commodore Peak lookout.

Estimated landscape sensitivity levels varied for each development activity considered in the assessment (see Appendix L, Landscape and Visual Impact Assessment Report) and the sensitivities of each landscape type were presented as an average in Table 18.4 of the EIS.

The following landscape types and average sensitivities were listed:

- Landscapes of high sensitivity to modification
  - Type I, forested steep hills e.g. Captain's Mountain
- Landscapes of medium sensitivity to modification
  - Type A, wooded river valley occurring along the Condamine River
  - Type B, settled arable plains
  - Type D, lowland native forests
  - Type E, elevated native forest
  - Type F, foothills plains and valleys
  - Type H, terraced brigalow farmland such as the terraced farmland associated with Captain's Mountain, south of Millmerran
- Landscapes of low sensitivity to modification
  - Type C, sodic transitional pastures
  - Type G, lowland brigalow plains,
  - Type J, cromosol undulating lowlands

4.13.3 Impacts, avoidance and mitigation measures

The EIS outlined the type, nature and scale of proposed project activities during the construction, operation and decommissioning phases, and the associated potential changes in landscape characteristics and visual amenity. The following were considered in the assessment:

- Construction activities—construction of production wells, gas and water gathering lines, production facilities, construction camps and power lines. Construction activities would involve the excavation of soil, trenching, vegetation clearing using vehicles, machinery, plant and equipment.
- Operation phase—production wells, gas and water gathering lines, power distribution, production facilities and associated infrastructure, maintenance, accommodation camps and associated vehicle use.
- Decommissioning phase—decommissioning, deconstruction and removal of production wells, gas and water gathering lines, power distribution, production facilities and associated infrastructure, vehicles, machinery, plant and equipment.

Visual sensitivity was determined according to the inherent landscape values and the potential for the project's activities to be absorbed into the landscape. The magnitude of change affecting the landscape or visual receptor(s) was estimated, including the nature, scale and duration of a particular change that could be expected to occur. The nature, scale and duration of impacts associated with the construction and operational phases of the project were determined to be dependent on the landscape type, the location of visual receptors, the nature of the project activity, and the size of the infrastructure at a particular location.

In order to achieve the stated objectives for landscape and visual amenity, Arrow proposed a range of mitigation and management measures, with the main focus on design and site selection. Arrow's environmental framework approach focused on early identification of sensitive locations that should be avoided by project activities, as described within the project's environmental framework. Commitments relating to minimising impacts on landscape and visual amenity values were stated in EIS Chapter 18 and included in the final set of commitments in SREIS Attachment 4 which is reproduced in Appendix 3 of this report.

Table 18.5 of the EIS summarised the potential unmitigated impact, and estimated residual impact, to the landscape and visual amenity values of each landscape type for each potential impact associated with the project during construction, operation and decommissioning. The estimation of residual impact assumed effective implementation of stated mitigation measures.

The EIS concluded that the final constructed forms of the project infrastructure would likely have some visual intrusion, particularly as vegetation may take up to 10 years to provide effective screening. In areas where screening was not the preferred or most effective mitigation measure, final constructed infrastructure would likely be visible from sensitive viewing points. The potential extent of such intrusion remains uncertain as the location of project infrastructure including CSG production wells, compression facilities, and other associated petroleum production support facilities, such as electricity distribution substations, temporary workers camps, access roads, water storage systems, fencing, compounds, depots, workshops, stores and offices have not been defined.

The EIS did not specifically detail, nor adequately address, the potential impacts on local landscape and visual amenity from raw and treated CSG water dams and brine storage ponds, other than 'generic' mitigation measures proposed for all infrastructure facilities. Specific detailed mitigation measures would be required to fully address the potential impacts on landscape and visual amenity from the proposed water and brine treatment facilities including raw and treated water dams and brine storage ponds.

The EIS stated that treated and untreated CSG water would be distributed through a beneficial use network comprising a trunk pipeline from the water treatment facility and a reticulation network to end users. The network was proposed to be co-located with gas and water gathering pipelines, where practicable. If the distribution network is not co-located with the gathering pipelines, further consideration should be given to potential impacts on landscape character and visual amenity, and to appropriate mitigation measures.

Submissions on the EIS raised a number of concerns in relation to the potential impacts on landscape character and visual amenity, including:

- the impact of lighting, including construction lighting, sudden light impacts (vehicles, flaring), gas flaring, gas infrastructure facility lighting, brightness levels, cumulative light impacts, and light from routine maintenance
- the incomplete information and representative viewpoints, including sensitive viewpoint locations on the settled arable plains landscape character type e.g. Jimbour Plain
- significant changes expected to the local environment, including: changes from the rural landscape character of the project area (i.e. farming and grazing) to one characterised by CSG development, infrastructure site selection locations, location of project infrastructure on sensitive soils, and visually sensitive locations and landscapes
- cumulative impacts, including changes in the perception of the landscape from agricultural to gas development, and the applicability of progressive rehabilitation to some local sites
- screening of gas infrastructure facilities including alternative strategies to integrate the facilities into the landscape.

Arrow provided an adequate response to submissions received on the EIS and included the following responses (summarised):

- Night light would vary during different phases of the project. While gas production facilities would be lit a night, Arrow committed to the design and use of shrouded, downcast lighting in order to minimise light spill, and to use of the minimum light levels required for safety and security. Lighting would be designed in accordance with AS 4282-1997, Control of Obtrusive Effects of Outdoor lighting.
- Gas flaring and maintenance would be carried out during daylight hours to minimise light spill, where practicable. Planned scheduled flaring events e.g. those preceding shut-down maintenance, would occur between 6am and 10pm.
- Representative viewpoints were selected on the basis of showing a general viewpoint for the landscape character type. The SREIS updated the Preliminary Constraints Maps to include other identified houses and sensitive receptors.
- Visually sensitive locations, landscapes and viewsheds would be avoided, where practicable, when siting facilities.
- Ground-truthing activities at sensitive viewpoints (including Lake Broadwater, Captains Mountain, Jimbour House, towns, schools and private residences) would be required when considering site selection. Arrow noted that the reduced project development area within the Jimbour Plain would result in a larger separation distance between Jimbour House and project activities and thereby reduce the potential project impact.
- Clearing would occur progressively and rehabilitation would be implemented for all disturbed areas as soon as practicable following construction and decommissioning.
- All disturbed infrastructure would be replaced or rehabilitated to a pre-disturbance condition in order to reduce visual impacts. Arrow also committed to install gates in fences of appropriate standard to restrict access to authorised personnel, vehicles, plant and equipment as a standard safety and security measure.
- In some cases, screening may not be practicable and alternative strategies to integrate facilities (e.g. consideration of building structure, colour and texture) into the landscape would be required. The use of trees for screening may not be an option in areas that were naturally treeless (e.g. Jimbour Plains).
- Further detailed work would be required to understand how to best manage project impacts on sensitive soils.
- Arrow noted that the landscapes of the project development area have been highly modified for agricultural practices including clearing of native vegetation (although some areas were naturally treeless), and levelling of land for cultivation of arable land and pasture for grazing. Arrow acknowledged that the introduction of the linear elements such as wells field gas and water gathering systems would contrast with the perceived strong rural character, sense of remoteness and tranquillity of the project development area. Arrow also recognised community concerns about the potential loss of amenity due to the project and that it would not be possible for the installation of wells, gathering lines and the construction of gas infrastructure and production facilities to have no visual impact.
- Arrow acknowledged that cumulative impacts of the project, together with existing and proposed developments, would be likely to change the perception of the landscape from one defined by farming and grazing, to a landscape strongly characterised by CSG development. The EIS reported that affected sites were likely to return to a more rural appearance over time, as sites were rehabilitated (e.g. vegetation screening) and the vegetation established and matured, noting that effective screening of gas infrastructure facilities would be best achieved by augmenting existing stands of remnant vegetation with new plantings.

4.13.4 Conclusion and recommendations

The EIS provided commitments to avoidance, mitigation and management measures, relating to impacts to landscape and visual amenity values, for each phase of the project. Arrow should update and implement these commitments. It is recommended that the commitments be reworded to strengthen the commitment so that each commitment is quantifiable, measureable and auditable (see Table 21). Relevant commitments include C012; C031; C032; C034; C263 to C275; C277; C278; C283 and C313.

Table 21 Landscape and visual amenity commitments and recommendations

No.	Commitments	Recommendation
C012	Implement dust suppression measures for roads and construction sites where there is a potential for dust to cause nuisance effects	Require that dust does not cause a nuisance at any sensitive receptor
C031	Maintain the integrity of private roads and tracks and minimise dust generation, where appropriate, in consultation with relevant landowners and council	Dust generation should be minimised
C032	Use existing roads and tracks, where practicable	Use existing roads and tracks where practicable

The following additional measures are recommended:

- Arrow should prepare and implement a Landscape and Visual Amenity Management Plan for the planning and design, construction, operation and decommissioning phases of the project, detailing measures to minimise visual impacts on landscape.
- When siting facilities, a landscape planner and/or landscape architect should be engaged to assist with minimising adverse impacts on the landscape and visual amenity.
- Construction sites should be landscaped following completion of construction to improve the visual amenity of the new plant site.
- Specific detailed mitigation measures should be developed to address potential impacts to landscape and visual amenity from proposed water and brine treatment facilities including raw and treated water dams and brine storage ponds.

4.14 Roads and transport

The EIS Chapter 19, Roads and Transport provided a summary of the roads within and associated with the project development area, the existing and projected use of these roads, and an assessment of the potential direct and indirect impacts on these roads and road use associated with the construction, operation and decommissioning phases of the project. Road transport was proposed to be the main mode of transport for the project. Detailed information on the assessment was included in Appendix M, Road Impact Assessment.

A qualitative objective to avoid or minimise impacts on roads and road transport values was stated and mitigation and management measures to achieve the objective were outlined. The assessment of residual impact assumed that the proposed mitigation and management measures would be effectively implemented.

SREIS Chapter 12, Roads and Transport, presented a summary of a supplementary roads and transport assessment (based on SREIS Appendix 10, Supplementary Roads and Transport Assessment) undertaken to address changes to the project description as outlined in SREIS Chapter 3, and to address issues raised in submissions on the EIS.

4.14.1 Assessment methodology

Arrow undertook a Road Impact Assessment (RIA) to estimate the significance of the potential project-related traffic impacts on the values of affected roads. The RIA included the following key components:

- Collection of data from the Transport and Main Roads (TMR) and local councils on existing road conditions including traffic volumes, road construction standard, rail crossings, stock routes, vehicle crash history, and school bus routes.
- Identification and evaluation of road network values and classification of the sensitivity of these values to changed traffic conditions.
- Estimation of the number and type of vehicles likely to be generated during the various phases of the project based on a preliminary project development plan, supported by data on the traffic generated by existing Arrow gas field operations.
- Estimation of the magnitude of the project's potential impacts on road transport values on each road link (travel route) over the life of the project using traffic modelling. Modelling considered the type of vehicles, conceptual travel routes, period over which each travel route would be used, and anticipated travel volume to estimate the project traffic.
- Estimation of the significance of the project's impact on the road network values.
- Development of management strategies for the road network proposed to be incorporated in Road Use Management Plans to be developed by Arrow. It was noted that measures generally aimed to reduce the sensitivity of the various road types to changed traffic conditions as the traffic generated by the project typically could not be reduced.
- Estimation of the significance of residual impacts on the safety, efficiency and amenity of the road network following implementation of the proposed management strategies.
- Consideration of potential cumulative impacts, accounting for other major projects in the vicinity.

Traffic modelling was based on assumptions of the infrastructure likely to be constructed, operated and decommissioned within defined zones within the project development area for each year of the project life based on the conceptual development schedule outlined in EIS Chapter 5, Project Description. The EIS acknowledged limitations in the assessment of the expected traffic volumes and impacts given that the actual location of project infrastructure was not defined.

The assessment did not consider impacts associated with other transport modes (e.g. air, rail and sea) on the basis that:

- rail was not proposed as a mode of transport for project materials and potential impacts associated with rail would be limited to the construction of any new roads or pipelines that cross rail lines
- fly-in fly-out operations were not proposed
- freight delivered by sea would be shipped as general freight with no project-specific cargo ships required.

The TMR submission on the EIS stated that the averaging of project traffic over large areas, as used in the traffic modelling for the EIS, would not reflect the likely concentration of project traffic on a fairly small number of roads, including sections of state-controlled roads. WDRC also raised concerns that workforce vehicle movements had been underestimated. In response, Arrow acknowledged that a large proportion of the traffic associated with the project would result in localised impacts on specific roads (e.g. associated with the location of facilities) and stated that this would be addressed in road use management plans prepared and reviewed in consultation with the relevant council or TMR following the EIS process.

TMR advised that the RIA, including the likely impacts on road safety, transport efficiency, amenity, condition of the road network (pavements and intersections), and any proposed mitigation measures, should be undertaken in accordance with the TMR's Guideline for Assessment of Road Impacts of Development (GARID). TMR stated that the sensitivity to impact approach used for the EIS did not meet GARID requirements and was therefore not adequate to identify all significant impacts of project traffic and did not provide a sound basis for appropriate mitigation measures. TMR also stated that the EIS should identify the specific location of key project-related infrastructure, assets, accesses and activities, to help determine road link intersections and pavement areas that would experience the greatest development-related pressures, including all temporary and full-time worker trips. In response, Arrow argued that the strategic traffic assessment undertaken for the EIS, due to the unknown location of project infrastructure, was consistent with the GARID in terms of road design standards, acknowledged that traffic associated with the project would result in localised impacts, and again stated that localised impacts would be addressed through road use management plans. SREIS Chapter 12, Roads and Transport, and SREIS Appendix D and E of Appendix 10, Supplementary Roads and Transport Assessment provided assessments and case studies for road sections in proximity to four central gas processing facilities and a temporary workers accommodation facility, including specific management strategies and recommended infrastructure upgrades.

Arrow also advised, in response to TMR concerns with the format and detail of traffic generation information provided in the EIS, that further traffic generation information, including a breakdown of heavy vehicle types, would be established during preparation of road use management plans, and referred to updated information on predicted traffic generation in SREIS Chapter 12.

In response to TMR and TRC concerns that 2006 traffic data was used in the EIS assessment rather than 2010 data, Arrow advised that the data used was the latest available at the time and that, where possible, more recent traffic volume data was included in traffic modelling undertaken for the SREIS.

4.14.2 Impacts, avoidance and mitigation measures

EIS Chapter 19 stated that increases in traffic volumes across the road network within the project development area could impact the efficiency, safety and amenity of roads, and provided estimates of traffic generation during construction, operation and decommissioning phases of the project. However, the EIS did not undertake a comprehensive road impact assessment for the project, including only a general description of road transport values, the assumed sensitivity of these values to impacts, and estimates of the magnitude and significance of potential impacts associated with the project. The assessment considered a broad hierarchy of roads (highways, regional connecting roads and rural connecting roads/rural access roads) and did not provide a detailed assessment for specific roads of traffic generation, impacts, and mitigation measures. Detailed information required, but not provided, included:

- estimates of pavement impact
- increase in road safety risk (e.g. school bus routes and crashes)
- congestion and intersection performance
- access roads and transport corridors including railways and rail level crossings
- impacts on road structures (e.g. floodways and bridge load limits
- maintenance of community access and amenity.

The EIS proposed generic management strategies for potential project impacts to the road traffic network and stated that consideration of site-specific constraints would need to occur at each location to ensure that the appropriate engineering outcome was achieved. Arrow committed to a range of assessments, plans and other measures to address potential project impacts, including:

- Assess and identify works, including road upgrades, required to manage the increased traffic volumes and road safety issues associated with the project through development of road use management plans prepared and regularly reviewed in consultation with the relevant council and/or TMR.
- Threshold assessments to determine whether upgrading of rail crossings is warranted.
- Project logistics plans for safe movement of people and materials, as well as to minimise traffic volumes.
- Journey management plans for use of high-risk roads.
- Driver training and fatigue awareness for employees and contractors.
- In-vehicle monitoring system for project vehicles.
- Roster changes to be scheduled to avoid peak traffic times.
- Where assessed necessary to address road safety issues, identify and implement improvement measures (e.g. protected turning lanes) for entry to permanent facilities.
- Access driveways to project facilities and infrastructure to have appropriate sight distances.
- Implementation of traffic controls, including signage (e.g. reduced speed limits, warning signs) and restrictions of movements (e.g. no travel during school bus pick-up and drop-off times).
- Coordinate the movement of heavy or oversized loads with relevant authorities.

Submissions received on the EIS from landholders, WDRC, TRC, TMR and Queensland Police Service (QPS) were highly critical of the lack of specific detailed information on road condition, road use by the project, and the likely impacts on road condition, road use and safety, especially for local and minor rural roads. Submitters also expressed concerns that road safety is a primary transport issue but the consideration of road safety issues appeared to be substantially deferred until road use management plans are developed. Submissions also indicated that some project related traffic, such as heavy vehicles and some construction related traffic, may not have been adequately considered.

In response to the submission on the EIS by TMR, Arrow acknowledged that TMR's Road Planning and Design Manual provides guidance on the road design standards and warrants for various road elements, including auxiliary turn lanes at intersections, to suit different traffic situations. TMR considers that a Road Impact Assessment on specific intersections and roads is necessary where developments generate an increase in traffic of equal to or greater than 5% on the road section, intersection movements or turning movements, and the assessment of rail crossings needs to be in accordance with Australia Level Crossing Assessment Model to determine whether upgrading of rail crossings is warranted in response to project related traffic. Arrow has not specifically committed to meeting these requirements, referring only to the proposed development of road use management plans.

EIS Chapter 19, Table 19.7 summarised the potential impacts prior to mitigation, proposed avoidance, mitigation and management measures, and the subsequent residual impacts assuming implementation of these measures. It was stated that residual impacts were likely to be managed effectively within the typical road authority planning framework and through infrastructure agreements, and that positive benefits may result from improved transport infrastructure such as intersection and general road upgrades and improvements that offer safety benefits to the community. However, the assessment provided limited guidance as to the potential impacts of the project on specific roads and road use values for reasons outlined above.

The TMR submission on the EIS maintained that the level of road categorisation used in the traffic assessment was not adequate to address pavement strength, width or condition concerns at a local road level and requested further road condition information for council controlled roads (e.g. a summary of current pavement, speed environments, intersection standards, rail crossings, school bus routes) to support sensitivity and impact assessment. TMR argued that, rather than a strategic outline, a more definitive estimation of the type and specific locations of infrastructure works and roads likely to be affected by project traffic is required. Detailed mitigation strategies should include road-use management strategies (e.g. use of variable message signs, bussing workers, avoiding peak hour traffic especially near schools or bus routes and fatigue management strategies) and infrastructure strategies (e.g. upgrading intersections or contributing to maintenance).

The QPS submission on the EIS recommended that project logistics plans be developed to provide safe movement of people and materials, as well as to minimise traffic volumes, with a suggestion that private vehicles be discouraged in preference for company-related transport to and from camps. Arrow has committed to develop journey management plans taking into consideration high-risk roads, and to develop project logistics plans to provide safe movement of people and materials, as well as to minimise traffic volumes.

WDRC requested more detail on road construction standards, safety attributes, road condition, and upgrade requirements, and sought assurance that all mitigation, management and maintenance measures would be funded by Arrow and subject to agreements with relevant councils. TRC expressed similar concerns with the need for traffic modelling of local roads, and more detailed assessment of potential impacts to roads, road traffic and road safety, and stated that Arrow should be required to enter into infrastructure agreements with Councils. The EIS stated that any infrastructure agreements developed with relevant councils would identify contributions towards any necessary new roads, road maintenance and upgrades identified in the road use management plans.

In response to concerns with the lack of detailed assessment of impact, particularly for local roads, Arrow stated that it was not feasible to incorporate this level of information in the EIS and that localised impacts would be addressed in road use management plans prepared after finalisation of project planning. When preparing these plans, Arrow proposed, where required, to undertake a ‘fitness for use’ investigation which would consider various road characteristics (including pavement strength and width) likely to influence the ability of roads to safely and efficiently accommodate the increased traffic demands. The road use management plan would document the current condition of specific roads affected by the project.

The SREIS included an updated assessment based on the revised project description using data on traffic volumes, multi-combination vehicle routes, school bus routes, rail crossings stock routes, pedestrian, cycle and public transport networks, motorist rest areas and a safety assessment of historic crash sites and traffic growth from other likely projects in the region. The SREIS also provided an update of the key roads and transport routes impacted by the project roads (state-controlled and local) and major transport corridors.

Case studies undertaken for the SREIS, based on defined locations for major project infrastructure, included fitness-for-use investigations, intersection assessments and pavement impact assessments, and were intended to demonstrate the process that would be implemented when project facility locations are confirmed. The SREIS proposed that application of the planned management strategies would result in intersection works, link works, and pavement contributions that meet or exceed typical engineering practice requirements. Comments provided by TMR following review of the SREIS and Arrow's response to submissions, advised that the case studies based on proposed location of major infrastructure were not adequate to accurately identify the potential impacts from all project traffic.

Following review of the SREIS and Arrow's response to submissions, WDRC advised that its concerns with the proposed project were either dismissed or not appropriately addressed in the SREIS. WDRC expressed the view that, for the project to proceed, its concerns should be appropriately addressed, including the development and implementation of effective monitoring and evaluation programs consistent with community expectations and standards. WDRC outlined the following requirements expected to be met by the project prior to approval to proceed:

- a comprehensive traffic impact study
- compensation funding to WDRC for impacts to each council road used by the project
- provision of in-vehicle monitoring system data to WDRC on a monthly basis
- traffic management plans to be approved by WDRC prior to the commencement of construction and before any road is approved for use by the project
- mitigation and management measures to be approved by WDRC before any road is approved for use by the project
- an infrastructure agreement with WDRC for the life of the project
- all roads providing access to key infrastructure (e.g. work camps) to be constructed to an all-weather access standard
- roads to meet standards for access by emergency vehicles
- all stakeholders, including WDRC, to be informed regarding changed or impacted bus routes.

Following review of the SREIS and Arrow's response to submissions, TRC advised they required further traffic modelling, including estimates of heavy vehicle (Over Size, Over Mass) movements, road condition information for council-controlled roads, and assessment of potential impacts during the detailed project development phase and well before the project was commenced.

The TMR submission on the EIS noted that many roads expected to carry project related traffic were in a dangerous condition, and stated that Arrow should identify any road infrastructure upgrade and maintenance requirements resulting from increased traffic from the project, and should financially contribute to these road upgrades. Concerns with the existing state of roads and potential for significant further degradation was reinforced by the Queensland Police submission. In response, Arrow stated that works required to support the increased traffic volumes and address road safety issues associated with the project (including works on council roads), and financial contributions to support these works, would be determined through road use management plans.

TMR indicated that there is risk that insufficient time would be available to adequately action road use management plans due to the time required to assess the condition of roads, negotiate required mitigation measures and funding agreements, and arrange for tenders. As an example, Arrow has stated that the soil type underlying road pavements or shoulders would be assessed after completion of the EIS process when fitness-for-use surveys would be undertaken. Cracking black clay soils underlying pavements are known to be vulnerable to surface water flows and roads constructed on such soils may require significant upgrade before use by project traffic.

TMR recommended that the following additional strategies be included in road-use management plans:

- for safety with school bus routes: strategies to advise school bus operators of any traffic peaks and to provide a complaints hotline in case of issues or concerns regarding project traffic
- for community amenity: strategies relating to route selection, hours of operation, transport mode choice for construction haulage.

A number of submissions on the EIS, including from TRC and TMR, raised concerns with potential road and traffic impacts associated with proposed disposal of brine at Swanbank, east of Toowoomba. TMR recommended that Arrow evaluate the potential to use rail transport in order to limit impacts to current road improvement works and minimise potential delays to other heavy vehicles and road-users. In response, Arrow stated that disposal of brine to landfill was not the preferred strategy and that disposal to the registered landfill at Swanbank was assessed as a 'worst-case' scenario in terms of transport impacts. It was stated that impacts to specific roads would be assessed in greater detail when the brine management strategy is finalised. Similar concerns were raised in relation to transport of quarry materials and Arrow stated that a study into the availability of suitable material from existing quarries would be undertaken during detailed planning for the project delivery.

TMR recommended that rail transport be considered for the transport of pipes and other equipment to avoid additional road-train traffic. Although rail use was considered in the EIS documents, Arrow stated that the use of existing rail networks was being considered in preliminary logistics plans to reduce traffic and that detailed logistics planning carried out in conjunction with front end engineering and design would further investigate the feasibility of rail as a mode of transport for project materials.

Submissions on the EIS by TMR, TRC, and QPS raised concerns with the potential cumulative traffic generation from a number of existing and proposed developments in the region, the lack of actual traffic generation data for existing gas projects, and omission of some roads potentially subject to cumulative impact. The QPS submission stated that the reduced efficiency and safety of higher order roads such as highways and regional connecting roads due to cumulative impacts from the three major gas projects is a significant risk, with particular reference to the Warrego Highway. In response, Arrow stated that actual traffic generation data is not publicly available, and therefore not available to Arrow, and referred to estimates provided in the EIS Chapter 28, Cumulative Impacts, Section 28.3.8 which indicated a total increase in traffic from all developments in the region of between 2% and 8%, equating to approximately 2 to 4 years of historical traffic growth. Modelling undertaken for the SREIS assumed a growth rate of 3% to account for project traffic generated by other proponents. The cumulative impact assessment in the EIS Chapter 28 assumed that most of the traffic generated by other projects would contribute to increased traffic volumes on ‘through routes’ (i.e. highways and rural connecting roads). Localised impacts, such as impacts on the Warrego Highway, are proposed to be addressed in road use management plans. It was stated that there would be negligible cumulative impact on rural connecting roads and rural access roads in the project development area, as these were not anticipated to service facilities associated with other projects.

TMR provided the following advice and recommendations following review of the SREIS, Arrow’s response to submissions on the EIS, and following discussions with Arrow:

- The infrastructure agreement development process proposed by Arrow did not leave sufficient time for approval of design plans (generally 3 months) and construction of augmentation works which could take up to 6 months. TMR recommended close consultation between Arrow and TMR officers as detailed information on the traffic use of specific roads becomes available to ensure that required actions to address risks to road safety, network condition, transport efficiency and community amenity are completed prior to commencement of use roads by the project.
- Special emphasis must to be placed on any works needed to address road safety concerns and these must be completed before significant commencement of project traffic use.
- The extent of overlap of project construction timelines with other CSG projects may be significantly greater than assumed in the EIS and should be reviewed along with potential cumulative impacts of increased road traffic.
- All impact assessment should be documented in an updated RIA including all traffic generation information, impact assessment, and first-pass mitigation proposals, in accordance with the GARID and supported by detailed traffic estimates based on actual location of project infrastructure.
- The road use management plan should document the non-infrastructure commitments and requirements in accordance with TMR’s Guideline for preparing a Road Use Management Plan and summarised in an auditable ‘Compliance Table of Commitments’.
- The Traffic Management Plan principally documents how any works in or near a state road would be safely undertaken.
- The Infrastructure Agreement should document all works and contribution requirements.
- Development of a logistics plan (consistent with the TMR Guideline for a Logistics Plan) is recommended to demonstrate Arrow’s commitment to comprehensively minimising transport impacts.

TMR advised that it is satisfied with some of Arrow’s intentions to update the road impact assessment, draft road use management plans, and to provide suitable mitigation measures. However, further consultation, information and specific action is required regarding a number of significant issues not adequately addressed in the EIS or SREIS.

TMR recommends that Arrow provide:

- information on the proposed upgrading of the State-controlled road network to ensure the ongoing safety efficiency and existing conditions of state-controlled roads and local roads is in accordance with the objectives and provisions of the relevant legislation including the *Transport Infrastructure Act 1994*, the *Transport Operations (Road-use Management) Act 1995* and TMR policies and guidelines (e.g. GARID)

Once traffic information based on the final design and construction of the project, including traffic generation, is available, finalised road impact assessment (RIA), road-use management plan(RMP) and any traffic management plan(s) (TMP) are to be provided to clearly identify any necessary improvement works, rehabilitation and maintenance and road-use management strategies to mitigate the impacts of project traffic.

Similarly, WDRC advised that there were a number of outstanding requirements that they expected to be met prior to the project proceeding including a detailed traffic study, traffic management plans, infrastructure agreement with WDRC for the life of the project, road standards to be specified and ongoing consultation particularly regarding any impacts on bus routes.

QPS recommend that project logistics plans be developed to provide safe movement of people and materials for each stage of the project.

4.14.3 Recommendations

It is recommended that the proponent continue to engage with TMR, local government and other relevant parties to identify and resolve the outstanding issues in relation to roads and transport. The proponent should contact TMR and relevant local governments no later than nine months prior to the commencement of any project construction works, to finalise their requirements regarding the RIA, RMP and TMP.

The following transport related conditions are recommended by TMR:

For approvals under the *Transport Infrastructure Act 1994*

Pre-construction road works (related Act: *Transport Infrastructure Act 1994*, s33)

In accordance with the agreed schedule of works between the proponent and TMR, the construction of required road works must be completed prior to the commencement of project construction activities unless agreed in writing with TMR and the relevant local government.[11]

Road impact assessment and road-use management plan

To identify and deal with transport impacts on the safety, efficiency and condition of state-controlled and local roads, the proponent must consult with the TMR contacts with regard to the preparation, approval and implementation of a finalised road impact assessment (RIA) and a road-use management plan (RMP).

For each phase of the project, a RIA must:

- be developed in accordance with the TMR Guidelines for Assessment of Road impacts of Development (2006) (GARID) and include a competed TMR ‘Transport Generation proforma’[12] detailing project-related traffic and transport generation information for road, rail and sea modes
- clearly indicate where detailed information is not available and utilise assumptions and methodologies that have been previously agreed in writing with TMR, prior to RIA finalisation
- detail the final impact mitigation proposals, listing infrastructure-based mitigation strategies, including contributions to road works/maintenance and summarising key road-use management strategies
- be approved in writing by TMR no later than six months prior to the commencement of project construction.

For each phase of the project a RMP must:

- be developed in accordance with TMR’s Guide to Preparing a Road-use Management Plan2 and with a view to optimising project logistics and minimising road-based trips on all state-controlled and local roads
- incorporate TMR’s Table for listing RMP commitments and detail how and when the identified commitments would be achieved
- include a complete list of RMP strategies, and provide confirmation that all works and road-use management strategies have been designed and/or would be undertaken in accordance with all relevant TMR manuals and practices[13]
- be approved in writing by TMR no later than six months prior to the commencement of project construction.

Infrastructure Agreement with TMR

To formalise infrastructure works and contributions detailed and required under the approved RIA and RMP, the proponent should enter into an infrastructure agreement with TMR.

[11] *Commencement of construction. physical construction, including significant and continuous site preparation work such as major clearing or excavation for foundations or placement, assembly or installation of facilities or equipment at any site related to the project.*

[12] Available from DTMR regional contacts or Planning Management Unit, Brisbane

[13] Available at: http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications.aspx

- The infrastructure agreement/s should identify all required works and contributions, and incorporate the following:
  - Project specific works and contributions required to upgrade impacted road infrastructure and access project sites as a result of the proponent's use of state-controlled roads by project traffic.
  - Project specific contributions towards the cost of maintenance and rehabilitation to mitigate road or pavement impacts on state-controlled road infrastructure.
  - Infrastructure works and contributions associated with shared (cumulative) use of state-controlled and local road infrastructure by other projects subject to an EIS. The proponent should use TMR's "Notes for contribution calculations" (Fitzroy Region methodology) 2 to calculate contribution requirements unless TMR agrees to another methodology in writing.
- Performance criteria that detail protocols for consultation and for reviewing and updating of project-related traffic assessments and impact mitigation measures that are based on actual traffic volume and impacts, should previously advised traffic volume and/or impacts change.
- The proponent's undertaking to fulfil all commitments as detailed in the "Table for listing RMP commitments".
  - Any infrastructure agreement between the proponent and TMR should be concluded three (3) months prior to commencement of significant project construction.

4.15 Noise and vibration

This section provides an assessment of the noise and vibration impact assessment completed for the EIS and subsequently amended by SREIS, and the main conclusions from that assessment.

EIS Chapter 20, Noise and Vibration, provided a summary of the acoustic environment values within the project development area and an assessment of the potential for these values to be affected by direct and indirect impacts associated with the construction, operation and decommissioning phases of the project. Detailed information on the assessment of noise and vibration impacts was included in Appendix N, Noise and Vibration Impact Assessment.

Environmental protection objectives were proposed and the mitigation and management measures to achieve these objectives identified. The assessment residual impacts assumed that the proposed mitigation and management measures were effectively implemented.

SREIS Chapter 13, Noise and Vibration, provided a summary of the supplementary noise and vibration assessment (SREIS Appendix 11, Supplementary Noise and Vibration Assessment) undertaken to address changes to the project description detailed in SREIS Chapter 3, Project Description, and submissions on the EIS.

4.15.1 Assessment methodology

The noise and vibration impact assessment involved identification of the baseline noise environment, modelling of potential noise sources, and assessment of potential noise impacts associated with the project. At the time the assessment was conducted, the site location and facility design were yet to be finalised. As such, the noise and vibration impact assessment was based on a typical site layout and indicative equipment, with the site assumed to be located in an acoustic environment typical of the project development area.

For the assessment, predictions of noise levels generated by the project were compared to noise criteria at sensitive receptors established by the gas industry procedural guide (DERM, 2011) for short-term, medium term and long-term activities.

The assessment involved a desktop study to determine the existing acoustic environmental values that may be affected by noise and vibration from the project, consistent with the Environmental Protection (Noise) Policy 2008. Noise measurements were conducted at four locations (reference sites) to determine the existing acoustic environment within the project development area. Rating background levels were established for the reference sites in accordance with the guidelines for planning for noise control (DERM, 2004). Two of the four monitoring sites were subject to industrial noise (existing production wells and a gas processing facility).

The EIS reported that the results of this investigation indicated that generally a low noise environment exists through the project development area, even where there is influence from existing industrial activity. Rating background levels at the sites not affected by industrial noise were in the range of 19 to 29 dB(A) while those affected by industrial noise ranged from 26 to 34 dB(A).

Potential noise sources from the project which have the potential to cause impact were identified and described for each phase of the project – construction, operation and decommissioning.

Noise modelling was undertaken for expected noise sources at a typical production facility and production well. Receptor sites for the modelling of noise were selected to represent a range of distances and directions from any nominal location. Noise levels were modelled based upon known sound levels from typical construction and operational equipment.

Noise was modelled for a range of distances from the project components using the CONCAWE noise propagation model. This sound propagation model predicts noise over significant distances, and takes into account topography, ground absorption, air absorption and meteorological conditions.

The assessment of vibration impacts of the project on sensitive receptors was based on previous measurements of vibration levels at similar facilities, with similar equipment and settings.

With the changes in the project description, and in response to matters raised in submissions on the EIS, a revision of the noise and vibration assessment was undertaken. The SREIS outlined the methods and outcomes from the revised assessment and stated that the revised assessment was conducted in accordance with the methods described in the EIS. The CONCAWE model was rerun for relevant project components during the operations phase with noise level data revised to reflect the project description updates.

A refined selection of equipment types and configurations at the CGPFs and multi-well pads were modelled in the supplementary noise and vibration assessment to represent indicative equipment to be used during operations. These revisions reflected project description changes and were detailed in Section 5.5 of SREIS Appendix 11, Supplementary Noise and Vibration Assessment.

Permanent and temporary power generation scenarios and modelling configurations were considered for the operation of a maximum capacity CGPF, and multi-well pad of up to 12 wells, as a part of the supplementary noise and vibration assessment. For the temporary power scenario at a CGPF, a review of available power generation equipment found that small and medium capacity units would be suitable. As the detailed design and procurement strategy has not yet been developed, the specific type of power generation equipment has not been selected. To capture the range of possible scenarios to meet the 50 MW of temporary power generation requirement for a CGPF, the assessment considered a configuration (configuration 1) comprising 47 engines each with a capacity of 1.1 MW, and another configuration (configuration 2) comprising 10 gas turbines each with a capacity of 5.7 MW. Modelling configurations for the CGPF were also revised to include the co-located water treatment facilities and revised flaring strategy.

A number of revised modelling scenarios were used to determine the likely noise impacts associated with various configurations of well pad design, powering options for wells and CGPF, water treatment facility locations and the revised flaring strategy. The revised assessment locations and relative directions were selected to provide a reasonable indication of the variations in noise levels at different distances from the facilities. The predicted noise levels were determined for both pre- and post-implementation of noise mitigation measures.

4.15.2 Impacts

4.15.2.1 Construction

Predicted construction noise levels for production facilities, under worst case meteorological conditions where noise propagation is pronounced, met the daytime long-term noise criterion of 40 dB(A) at locations 3km or more from the facility site. Construction activities at sites less than 3km from the nearest noise sensitive location would require acoustic treatment to keep noise levels at the sensitive location to the 40 dB(A) criterion. The EIS also reported that the modelling predictions indicate that, for the construction of wells and pipelines at a distance of less than 1 km from the nearest noise sensitive location, acoustic treatment would be needed to meet the criterion.

The SREIS stated that the predicted noise levels outlined in the EIS for construction equipment, and noise levels associated with decommissioning activities, remained valid.

4.15.2.2 Operation – wells

The EIS reported that the 28 db(A) night-time, long-term noise criterion would be met at a distance of 300 m or more from production well facilities, at 200 m if the gas generator was replaced by grid supplied power, and at 80 m if acoustic treatment was incorporated.

The SREIS provided an assessment of operational noise levels associated with multi-well pads for the permanent and temporary power scenarios. Predicted noise levels associated with the operation of the maximum size multi-well pads for both the permanent and temporary power scenarios were higher than those reported in the EIS for the single wells. Under the grid power scenario, the long-term night-time noise criterion of 28 dB(A) would be achieved at separation distances of 400 m without attenuation, compared to 200 m for single wells in the EIS. Operational noise levels associated with the multi-well pads with temporary power supply may exceed the noise criterion of 28 dB(A) for all of the assessment locations considered (up to 500 m from a multi-well pad) unless attenuated by additional acoustic treatment or natural noise mitigating features such as trees.

4.15.2.3 Operation – central gas processing facilities

The EIS reported that the 28 db(A) night-time, long-term noise criterion would be met at a distance of 5 km or more from a production facility under a worst-case noise scenario with all equipment operating simultaneously and continuously.

Modelling for the SREIS indicated that operational noise levels associated with a CGPF would exceed the long-term night-time noise criterion of 28 dB(A) at the majority of assessment locations under the three power scenarios assessed, unless additional acoustic treatment was applied. The noise criterion would be met at a distance of at least 5 km from facilities for the permanent and temporary power configuration 1. However, noise modelling indicated that operational noise levels from a facility with acoustic treatment could achieve the long-term night-time noise criterion of 28 dB(A) at distances of 1.5 km or greater. Siting constraints would determine the need for acoustic treatment.

4.15.2.4 Operation – central gas processing facility and water treatment facility

Water treatment facilities would be located adjacent to the CGPFs, hence the cumulative noise levels associated with the operation of the two facilities were considered for the SREIS. Based on the assumption that the CGPF would be designed to achieve the long-term night-time noise criterion of 28 dB(A), the noise contribution from the water treatment facility would need to be 18 dB(A) or less to ensure that it did not increase the total noise level above the criterion. Modelling indicated that the unattenuated water treatment facility noise contribution limit of 18 dB(A) could be achieved at distances of 3 km or greater from the facility. In order to achieve the criterion at distances within 3 km of facilities, acoustic treatment may need to be incorporated.

4.15.2.5 Low frequency noise

Low frequency noise sources were modelled for the EIS and the results indicated that, with the application of acoustic treatment, the criterion of 20 dB(A) during the evening or night and 25 dB(A) during the day, would be met at all reference locations. Potential low-frequency noise levels that could result inside typical dwellings were re-modelled for the SREIS as a result of updates to the project description. The modelling indicated that low frequency noise levels from a CGPF for which acoustic treatment had been applied, would achieve the noise criterion of 20 dB(A) during the evening and night-time and 25 dB(A) during the day.

4.15.2.6 Operation – flaring

The EIS reported modelling results for short term noise sources, including gas flaring. Results indicated that the short-term night-time criterion of 28 dB(A) would be exceeded at reference locations within 1km of a typical integrated processing facility. Noise modelling of unattenuated flaring indicated that noise levels from gas flaring would achieve the night-time criterion of 28 dB(A) at locations 2 km or greater from the flare. It was acknowledged that, depending on the location of the facilities, short-term exceedences might occur under emergency conditions. Revised modelling of noise levels in the SREIS for the ramp-up and upset condition (planned and unplanned maintenance) flaring indicated that noise levels at least 1.5 km from the CGPF would achieve the long-term night-time noise criterion of 28 dB(A).

4.15.2.7 Blasting

Blasting was mentioned in the EIS, but only to the extent that it is not anticipated to occur at any stage of the project. The EIS stated that, if blasting does occur, it would be conducted in accordance with EHP guidelines for blasting noise and vibration, and in compliance with statutory conditions.

4.15.2.8 Vibration

Vibration levels were predicted to be below the threshold of human detection and to not cause structural damage at sensitive receptors located at distances greater than 100 m from the activity. Should construction activity occur within 100 m from a sensitive receptor, vibration monitoring at that receptor would be undertaken to monitor against the proposed vibration criteria.

4.15.2.9 Traffic

Estimates of project related traffic based on the revised project description were provided in the SREIS Chapter 12, Roads and Transport based on detailed assessment information in SREIS Appendix 10. The use of rail transportation was not proposed for the project and the potential noise and vibration impact from rail was not considered in the assessment. Using the results of this assessment, which indicated that a maximum 4% increase in traffic volume would be expected to be generated by the project across the region, an increase in noise due to increased traffic of less than 1 dB(A) above current noise levels was predicted. Similarly, a 35% cumulative increase in traffic volumes expected to be generated by all activity in the region by 2025 is predicted to result in an increase in noise levels of approximately 1 dB(A) above current levels.

For vibration, the impact from additional vehicles on the road would be similar to the impact from existing vehicles using the road network and not expected to change the existing vibration levels at sensitive receptors.

In response to concerns raised in submissions regarding the potential for significant noise impacts associated with construction activities, Arrow acknowledged that any increase in noise would depend on the volume and nature of traffic on particular roads and that this would vary considerably across the project development area. The following examples were given:

- Installation of wells and gathering lines may increase traffic for the 10 to 14 day construction period for each well, following which traffic would drop back to operational levels necessary to conduct well maintenance and well workovers.
- Construction and operation of a processing facility on a rural road may see traffic volumes increase by more than 2% in a particular location over an extended period, in which case, Arrow proposed that appropriate mitigation measures for noise would be determined.

4.15.3 Avoidance and mitigation measures

The EIS outlined a series of commitments dealing with the siting of gas infrastructure (particularly the separation distances estimated in the modelling), undertaking measures to limit and manage noise emissions including: acoustic treatment, timing of activities, risk based assessments prior to undertaking activities, and management and maintenance of equipment to achieve the identified noise level objectives.

The SREIS concluded that, based on the updated modelling, the long-term night-time noise criteria could be achieved at a specified distance from the project activity, with or without acoustic treatment, and that this distance could be reduced by implementation of varying levels of acoustic treatment. Siting constraints and equipment selection would determine any requirement for further acoustic treatment. The potential acoustic treatment options considered in the supplementary noise and vibration assessment were stated to be consistent with those outlined in the EIS and were proposed to be refined during detailed design.

The EIS stated that the predicted noise and vibration levels that livestock would experience would be similar to the levels experienced when grazing near road or rail infrastructure. The SREIS stated that noise and vibration levels from the project were expected to be similar to those outlined in the EIS and the potential impacts on livestock indicated in the EIS remained valid.

Potential cumulative impacts of noise and vibration were considered in Chapter 28, Cumulative Impacts, section 28.3.9, Noise and Vibration. As noise and vibration impacts from project activities would be relatively localised, and the residual impact of project activities on the acoustic environment at sensitive receptors was assessed as 'negligible' provided that appropriate mitigation measures were implemented where necessary, no cumulative impacts were predicted. The SREIS confirmed this assessment and the adequacy of proposed management measures presented in the EIS.

Commitments relating to the mitigation and management of noise and vibration impacts from the project were listed in EIS Chapter 20 and Attachment 8, and were retained unchanged in SREIS Chapter 13, Table 13.1 and SREIS Attachment 4.

4.15.4 Submissions

In its submission on the EIS, the former DERM acknowledged that the noise criteria have been correctly established. The former DERM recommended that the criteria should be represented on a graphical output in coordination with the output of the noise modelling. This was addressed in the SREIS and noise criteria modelled for the SREIS were shown on contour plots within SREIS Appendix 11, Supplementary Noise and Vibration Assessment. Arrow stated that contours were developed at various assessment locations from which the predicted noise levels generated by the central gas processing facility and multi-well pads for the temporary and permanent power options were modelled in the assessment. It was argued that contour plots were not overlaid on map areas as exact locations of facilities were not known.

In response to concerns raised by the former DERM that the noise measurements used to establish background levels were not taken over a number of seasons to determine variability, Arrow stated that background noise measurements were undertaken in relevant locations in order to establish worst case noise impacts on the receiving environment. This involved considering worst-case (CONCAWE Category 6) meteorological conditions and accounting for seasonal variation as well as project scenarios that included a worst-case temporary power configuration.

Arrow provided a commitment to provide graphical representation of the noise contours relating to a specific site, once the exact facility and infrastructure locations are known. The location would be re-modelled and the noise abatement measures required at each facility to meet the statutory noise compliance limits would be determined with consideration for the nearest sensitive receptor, local meteorological and topographical conditions, and background noise levels. This information would be provided as part of the statutory information requirements to support the application for an EA or an EA amendment, in accordance with EHP Guideline "Application requirements for petroleum activities".

The former DERM also raised concerns that the noise levels indicated for gas engines to be used for water pumping was high and could cause problems at night. It was suggested that changes to the unit be investigated to reduce noise emissions. The supplementary noise assessment in the SREIS incorporated a refined selection of equipment types and configurations at the central gas processing facilities (CGPFs) and multi-well pads. Where modelled noise levels associated with operation of the facilities exceeded the established noise criteria, conceptual acoustic treatment options were considered to manage impacts. This included consideration of acoustic treatment incorporated into the design of the water treatment facility. Treatment options would be developed further during the design stages of the project.

While the EIS reported that any potential impacts from vibration would be minor, concerns with the possible impact of vibration, particularly on existing dwellings and commercial premises, were raised in submissions. In response, Arrow committed to meeting Australian Standard AS 2670.2 – 1990 and the German Standard DIN 4150.3 – 1999 at any sensitive site.

The validity of the mapping of sensitive sites presented in the EIS which was then used in generating the constraints maps for the location of facilities was challenged in submissions. The submissions stated that ground truthing of sites within the entire project development area was needed prior to undertaking specialist environmental impact assessments. In response, Arrow indicated that areas where access was possible (the Dalby

Expansion Project) had been ground-truthed, and the constraints mapping (which showed the location of sensitive receptors) was updated for the SREIS (SREIS Attachment 8) using recent high resolution aerial imagery over the entire project development area. Arrow also committed to undertaking site-specific noise and vibration impact assessments as part of applications for an EA or an EA amendment.

Similarly Arrow committed to avoid impacts on intensive farming operations (piggeries, feedlots, vineyards, etc.) by the appropriate siting of project facilities. Also, for this matter, and a number of others concerning the potential for impacts on specific sensitive sites, Arrow has committed to undertake consultation with potentially affected landholders concerning the location of project facilities as well as the management of noise sources (for example, reversing beepers) on a site by site basis.

Other submissions on the EIS raised a range of issues relating to noise and vibration. The SREIS responded to the issues which it identified as falling into the following broad topic areas:

- Buffer distances and sensitive receptors.
- Compliance with noise and vibration criteria.
- Construction noise and vibration.
- Consultation on noise and vibration impacts.
- Environmental authority conditions.
- Mitigation and management measures.
- Modelling results and analysis.
- Noise impacts on farming activities.
- Noise impacts on flora and fauna.
- Study method.
- Traffic noise and vibration.

As well as addressing these matters directly in the response to submissions (SREIS Part B Chapter 19) the SREIS provided an updated assessment of noise and vibration impacts that took into account the changes to the project description that had occurred since the EIS. The SREIS assessment retained the noise and vibration criteria described in the EIS, with focus on the night-time noise criterion of 28 dB(A) as the most stringent criterion.

While the SREIS concluded that the potential noise and vibration impacts from the project would be largely consistent with the findings of the EIS, and that the management measures and commitments presented in the EIS remained valid, potential requirements for specific management measures relating to changes to the project were outlined.

4.15.4.1 Multi-well pads

Mitigation and management measures, such as an insulated acoustic barrier, may be required to achieve the long-term night-time noise criterion of 28 dB(A) at nominated separation distances (between the nearest assessment location and the multi-well pad) for the multi-well pads (comprising 12 well heads) with temporary power supply. Application of typical attenuation measures (such as those presented in the EIS which resulted in an 80 m separation distance from single well pads), resulted in a separation distance of 400 m for a multi-well pad with 12 well heads. Noise levels associated with the grid power scenario modelled for the multi-well pad were predicted to meet the long-term night-time noise criterion at 400 m or greater without attenuation. Siting constraints would determine any requirement for further acoustic treatment.

4.15.4.2 Central gas processing facility

Modelling indicated that, with the application of acoustic treatment for all power scenarios, the long-term night-time noise criterion of 28 dB(A) would be achieved at a separation distance 1.5 km from the CGPF. This criterion could be achieved for all distances assessed by the application of noise attenuation to specific noise sources at the CGPF. Application of typical attenuation measures (such as those presented in the EIS which resulted in a 1 km separation distance), resulted in a separation distance of 1.5 km for a CGPF with the updated configurations. Siting constraints would determine any requirement for further acoustic treatment.

Modelling of low-frequency noise levels that could result inside typical dwellings indicated that low frequency noise levels from a CGPF for which acoustic treatment had been applied, would achieve the noise criterion of 20 dB(A) during the evening and night-time, and 25 dB(A) during the day, consistent with the findings of the EIS.

4.15.4.3 Central gas processing facility and water treatment facility

Acoustic treatment was considered at the main noise sources at the CGPF and water treatment facility to achieve the cumulative long-term night-time criterion of 28 dB(A) at assessment locations 1.5 km, 2 km and 3 km from the facilities. As such, attenuation at the water treatment facility would be designed to achieve a noise level of 18 dB(A) so as not to exceed the criterion. Modelling indicated that the noise level of 18 dB(A) could be achieved at distances of 1.5 km or greater, following implementation of acoustic treatment at the water treatment facility. Siting constraints would determine any requirement for further acoustic treatment.

4.15.5 Conclusions and recommendations

The EIS documents adequately describe, at a project scale, the exiting noise environment of the project, the projected impacts of the project and that with appropriate siting and separation distances between sensitive receptors and project facilities and (where necessary) the use of appropriate attenuation techniques, noise levels within statutory and WHO recommended levels can be achieved.

However, achieving these levels and management of acceptable levels of nuisance from noise is dependent on the Arrow applying the commitments outlined in the EIS documents (see Appendix 3). A number of commitments need to be amended as outlined in **Table 22** to ensure appropriate noise levels are achieved and that Arrow stays within compliance limits set by regulators.

Table 22 Noise and vibration commitments requiring amendment (source: SREIS, Chapter 13, Table 13.1)

No.	Commitment	Recommendation
C304	Manage noise in accordance with the relevant environmental authority conditions. Where night-time activities are planned (10 p.m. to 6 a.m.) and are likely to exceed the prescribed noise criteria, conduct prior consultation with affected parties.	The proponent will be required to meet statutory requirements which require that exceedences do not occur. Trigger levels for potential noise impacts that would require consultation and additional remedial actions should be determined by the proponent. These trigger levels should be lower than the statutory requirements. Appropriate mechanisms (monitoring, risk assessments, etc.) should be used to indicate when these levels are likely to be triggered and action is required.
C305	Consult with those who may be affected by increased noise levels due to construction activities with particular reference to the type and timing of works.	Implement consultation but include the need to manage noise levels to make any impacts acceptable.
C306	Conduct a risk-based assessment or potential vibration monitoring during any construction activity that occurs within 100 m of a sensitive receptor that might be subject to vibration	Due to the acceptable separation distances identified in the SREIS, assessment of potential impacts should be undertaken when construction activity is to occur within 200m of a sensitive receptor.
C307	Implement a grievance management system that responds to noise complaints. If necessary, undertake noise monitoring of construction activities to facilitate a response to the grievance.	Implement. Response should include action to reduce noise emissions if monitoring indicates construction noise is likely to cause a nuisance.

In addition, the following recommendations should be implemented:

Queensland Health requirements

- Further assessments in regard to the maximum sound pressure level ($LA_{1,\ adj,\ 1hr}$) inside habitable dwellings to determine if sleep is likely to be disturbed.
- A noise management and monitoring strategy that includes proactive as well as reactive management strategies;
- NOTE: Preventative management strategies are to be implemented prior to the criterion being exceeded, rather than waiting for it to be exceeded. Noise attenuation at sensitive receptors (e.g. noise attenuation at residences) has not been discussed as a mitigation measure and an effective complaints management system is considered essential in managing noise issues.

EHP requirements

Any application/s for an environmental authority or amendment to an environmental authority under the EP Act for petroleum activities within the project areas must provide:

- Site-specific noise and vibration assessments for each proposed infrastructure location.
- Site-specific identification of sensitive receptors and potential impacts on sensitive receptors.

Impacts identified should at least meet the noise objectives in the Environmental Protection (Noise) Policy 2008.

DNRM advice

Site selection and applications for approvals for infrastructure should take into consideration the potential for nuisance impacts to neighbours, and to sensitive receptors not located on land parcels subject to compensation agreements or the property where the infrastructure is proposed to be located.

4.16 Economics

Chapter 21 of the EIS provided a description of the existing economic environment within the Darling Downs area and assessed the potential impacts associated with the project's activities on these values. A more detailed assessment of the project's economic impacts was presented in Appendix O, Economic Impact Assessment of the EIS.

Submissions on the EIS raised numerous issues about the methodology of the economic impact assessment, economic impacts of the project and mitigation measures. A summary of submissions concerning agriculture was provided in the SREIS as well as a response to the substantial matters raised in the submissions. Key matters raised in the EIS submissions and responses by Arrow in the SREIS are discussed in the relevant sections below.

4.16.1 Methodology

The economic impact assessment was conducted as a desktop study and comprised the following:

- Characterisation of the existing economic environment and assessment of the broader economic context and issues relevant to the project through review of relevant data, polices, models and documents and consultation with local businesses and peak industry bodies.
- Establishment of a project 'base case' for project-related expenditure and revenue, including the associated distribution of expenditure and revenue across geographies and sectors as inputs to project-specific economic models.
- An assessment of the economic impacts of the project. This involved a comparison of the economic impacts specific to the project compared to what would be anticipated if the project did not proceed (i.e. the baseline scenario). The baseline scenario considered the existing economic environment and the future anticipated economic growth in the local, regional, state and national economies based on available projections of future economic activity from relevant government bodies.

Submitters raised a range of specific concerns regarding the currency of the data and appropriateness of using certain values, the choice and transparency of data sources and limited justification of assumptions. For example, questions were raised regarding the choice and transparency of the data used to estimate production costs and the range in royalty payments and tax calculations. Arrow responded to these issues in the SREIS by further explaining or justifying the data used to populate the models and analysis. They argued that estimates were based on the best data available, experience of similar energy and gas projects in Australia and worldwide, and the specific requirements for developing the Surat gas field. Much of the economic data was deemed as being commercially sensitive and Arrow did not publically release the data.

Numerous submitters raised various concerns about the scope of the economic impact assessment and cost benefit analysis. Arrow responded to these issues in the SREIS by further explaining or justifying their modelling methodology. They argued that the approach in the EIS was consistent with the requirements of the TOR and Queensland and Australian government methods. Key issues raised by submitters included:

- **Timeframes**: Concerns regarding the limited time period for which the impacts were assessed and the lack of consideration for impacts of the cessation of the project on the local and regional economy. Arrow responded that that they had only conducted economic modelling for the first 13 years of the project as the economic impacts are expected to remain relatively stable once steady state production is achieved. Further, they commented that the underlying assumptions of the model (regional, Queensland, national and global economic and population growth and activity) become increasingly uncertain the further into the future the modelling period extends and therefor the reliability of project related economic impacts compared to the base case becomes increasingly unreliable. The cost benefit analysis included rehabilitation expenditure and impacts to agriculture beyond the 25 years of the project (as salvage values) which is consistent with Queensland and Australian government approaches to cost benefit analysis.
- **Consideration of social and environmental impacts**: Submitters criticised that the economic model had not adequately factored in the economic costs associated with the environmental and social impacts of the project such as noise, dust, groundwater impacts, tree clearing, damage to natural habitats, greenhouse gas emissions, aggregate requirements, changes in environmental authority conditions, reduced land tax and stamp duty from reduced values of agricultural land, potential draw-down of employment in other sectors, travel times, safety and transient populations. In response, Arrow clarified that the draw down effect on other sectors was captured within the computable general equilibrium (CGE) modelling. They clarified that the remainder of the social and environmental questions had not been included in the modelling due to data limitations but argued that these impacts had been assessed in other sections of the EIS using appropriate risk frameworks (EIS Appendices A to S). In regards to the inclusion of carbon emissions in the economic analysis presented in EIS Appendix O, Economic Impact Assessment, Arrow argued that greenhouse gas emissions were not a Queensland or Australian specific issue, but global. Global demand for energy resources suggests it is likely if the project did not proceed, an alternative project would be developed elsewhere to meet demand. This would result in similar

carbon effects (or potentially greater, if traditional coal technologies are used). On this basis, carbon emissions were excluded from the economic assessment which examines the impacts to Queensland.

- **Variability in gas prices**: Numerous individual and group submitters including Coast and Country, Friends of Earth, QMDC and Queensland Conservation, argued that the economic benefits of the project predicted in the EIS had not considered the full range of economic scenarios associated with changing market demands and the variability and uncertainty of future gas prices e.g. cost blowouts or low LNG prices or time delays causing excess gas production resulting in the need for re-injection. Arrow responded that a sensitivity analysis of all inputs used in the cost benefit analysis was undertaken (Appendix H, EIS Appendix O, Economic Impact Assessment). While the sensitivity analysis did not explicitly examine scenarios of cost blowouts, low LNG prices or time delays, sensitivity testing of the value added activity implicitly captured these factors. Further, Arrow responded that estimates of operating expenditure for the project were based on their experience of similar energy and gas projects in Australia and worldwide and the specific requirements for developing the Surat gas field using the best available information at the time of writing.

4.16.2 Existing values

The EIS characterised the existing economic environment of the project development area using the Darling Downs Statistical Division (DDSD) — which encompassed the Toowoomba, Western Downs, Southern Downs and Goondiwindi local government areas. This included a detailed description of the region's gross regional product, dominant industries, population growth and labour demand, wages, property markets, local business and transport and telecommunications infrastructure.

Numerous submitters, including the Queensland Farmer's Federation, Ag Force, WDRC, commented that the EIS did not provide an accurate, adequate and current assessment and description of the existing economic environment, particularly the agricultural, forestry and fisheries sector. DAFF, former DEEDI, QMDC, Queensland Farmer's Federation, Agforce Queensland and other submitters requested the economic assessment be redone using relevant and up-to-date data on agriculture and agricultural practices. As a result, the SREIS provided further analysis of agricultural production and trends in the Darling Downs using updated data from the 2010–11 Agricultural Census in Appendix 14, Supplementary Agricultural Economics Report.

4.16.3 Impacts

Table 21.7 of the EIS summarised the pre-mitigated and residual impacts of the project on economic values. The EIS concluded that the overall economic impact of the project as positive, with significant economic benefits for the Darling Downs, Queensland and Australian economies and added investment and diversity in the Darling Downs region.

The EIS reported the following economic benefits:

- Increase gross regional product for the Darling Downs, Queensland and Australia economies with the project estimated to increase gross regional product by approximately $75 million in 2013/14 (or just under 6% of 2009/10 Darling Downs gross regional product), rising to approximately $1.15 billion from 2018/19 and continuing at approximately $1.3 to $1.4 billion on average, once peak gas production is reached. The Darling Downs is anticipated to receive the vast majority of growth generated by the project.
- Increased government taxes and revenues estimated at approximately $120 million per annum to the Queensland Government and approximately $230 million per annum to the Australian Government. The project would help to strengthen Australia's balance of trade, which would lower the cost of imports but would make Australian exports more expensive and adversely affect import-competing local industries, including manufacturing and some agricultural commodities.
- Increased employment, population, wages and business opportunities. The project is estimated to create 500 full-time equivalent employees in the Darling Downs during peak labour demand in 2015/16 and 2016/17. The EIS predicted population to increase, in part via the project workforce and employment growth in local businesses and recreational and community services, all of which encourage beneficial flow-on for business investment to other areas of the economy.
- Benefits for local business and supply chain as a result of opportunities to secure new contracts and increase sales to supply and service the needs of both the project and the workforce. Around 38% of the project's well development capital cost is expected to be expended on local labour and business in the Darling Downs.

In addition to the economic benefits of the project, the EIS identified potential adverse impacts of the project on economic values. These included:

- A deepening of the existing skills shortage and competition for labour in the construction and CSG industries. The most significant impact was predicted to occur in the demand for technicians and tradesmen, which will peak at 1.2% of the Darling Downs total in the lead-up to peak production in 2020, after which it will fall to 0.8% for the balance of the life of the project. Additionally, the EIS predicted an increase in real wages in the Darling

Downs by an average of 0.5% (2013/14 to 2027/28), but it did expected this to destabilise the regional labour market.

- There may be a direct or indirect increase in the demand for residential, industrial or commercial property resulting in inflated prices. The project is expected to add to the existing demand for industrial and commercial land in the Darling Downs, where land ready for development is already insufficient and prices have doubled in some areas in the past two years.
- Potential for negative impact on agricultural production and rural property values as a result of disturbance of agricultural lands and any reduction in productive capacity. With regard to quantifying the scale and severity of the impact across the project development area, the EIS contended that the impact to productivity would be restricted to agricultural land on which Arrow's facilities are located and temporary in nature due to the limited life of the project's production facilities and the ability to rehabilitate land to a standard agreed with the agricultural producer. At a property scale, the EIS predicted that the scale of impacts on agricultural productivity would vary across the project development area according to the particular farming practices. The overall financial impact of lost productivity from the project was not estimated in the EIS which Arrow argued was due to the variability in the productivity of land and variability in the financial impact of reduced productivity.
- Adverse impacts on some businesses and industry in the Darling Downs and the rest of Queensland. This was as a result of:
  - Competition for and draw of labour to the project and its supply chain. This has the potential to exacerbate skills shortages in the region and Queensland (for both construction and energy-related skills) and place upward pressure on labour prices.
  - • Escalating costs of labour and other inputs to production, which could reduce business profits and viability for some businesses or industries, particularly for local business already operating at or near 'the margin'.
  - • The limited capacity of some local businesses to supply large contracts or to meet the quality-control requirements necessary to achieve the standards required for safety and integrity in the petroleum industry. Thus, they may not benefit from the opportunities arising from the project.
  - • The high level of gas exports (in the form of LNG) generated by the project will support the Australian dollar, which can adversely impact on those sectors that are 'trade exposed', such as agriculture, manufacturing and tourism, resulting in these products and services becoming more expensive to foreign buyers.
- Pressure on existing infrastructure and generation of the need for upgrades and maintenance to a range of economic and social infrastructure types.

4.16.4 Avoidance and mitigation measures

The EIS proposed a suite of avoidance, mitigation and management measures and enhancement strategies (commitments) to minimise adverse impacts of the project on economic values and maximise economic benefits. The EIS documents provide the full list of commitments by Arrow to minimise negative impacts of the project and maximise benefits. Key commitments relevant to managing social impacts included:

- Population, employment, workforce and wages: Encouraging contractors engaged by the project to utilise Australian and Queensland Government skills and training programs where possible, supporting industry training programs, and collaborating with government, industry, CSG proponents and job referral agencies to develop programs and strategies aimed at addressing issues of skill retention and back-filling vacancies.
- Increased demand and inflated industrial or commercial property: Provision of Temporary Workers Accommodation Facilities, an integrated housing strategy and collaboration with government and other proponents to support housing affordability initiatives.
- Economic impacts on agricultural production and rural property values: Arrow is required to compensate landholders for any economic impacts on productivity. The EIS outline that this compensation would be through direct negotiation with impacted agricultural producers. Arrow commitment that they would endeavour to use the compensation framework to 'add value' rather than just compensating for impacts.
- Local businesses and supply chain and to increase local expenditure on goods and services: Strategies to encourage local supplier's involvement and local expenditure on goods.
- Local infrastructure and services: Strategies to encourage local population growth where it is desired and planned for by authorities and liaise with local and state government and other proponents of major projects.

4.16.5 Submissions

4.16.5.1 Population, employment, workforce and wages

Numerous submitters, including individual submitters, Friends of the Earth, Brisbane, Coast and Country Association of Queensland, raised concerns that the EIS had not adequately addressed the economic impacts of changed employment profiles and opportunities in other industry sectors e.g. potential depletion of jobs in other non-energy industry sectors such as agriculture and manufacturing as a result of the labour/skills drain to the energy sector. Further, mitigation measures to minimise economic losses to non-energy industries relating to increased difficulty for agricultural sectors to attract staff to the agricultural industry), were inadequate. Arrow responded that the economic model (computable general equilibrium) included consideration of a draw of activity and labour from one sector to another. They acknowledged that the project would increase real wages and place pressures on the local labour force but did not anticipate that this would destabilise the existing labour market in the region. A new commitment was included in the SREIS, committing to regular reviews by Arrow of non-project related labour requirements and current skills sets for the study area by engaging with state agencies and other skills bodies.

4.16.5.2 Increased demand and inflated industrial or commercial property

Individual submitters and the WDRC raised concerned that the EIS does not adequately provided mitigation measures to address increased demand for, and cost of, accommodation and housing affordability and in the local area. In response, Arrow updated commitments aimed at managing the project's impact on cost of living and housing affordability (SREIS Attachment 3, SIMP, Section 2.1). These include commitments to develop an Operations Accommodation Strategy 12 months prior to the commencement of operations and a Construction Workforce Accommodation Strategy three months after Financial Investment Decision.

4.16.5.3 Economic impacts on agricultural production and rural property values

Numerous submitters including landholders, DAFF, former DEEDI, QMDC, Queensland Farmers Federation, Agforce Queensland, WDRC, raised concerns that the economic model and cost benefit analysis had not:

- Included compensation payments to landholders for both lawful and unlawful impacts. Arrow clarified that compensation payments were not presented in the cost profile. They argued that compensation payments would represent a transfer of monies between parties rather than genuine economic activity.
- Considered the full range indirect and direct impacts of the project on the agricultural productivity or profitability for primary producers. Examples include: increases in the cost of living and increased costs as a result of running business; staff recruitment and retention; alienation of SCL; loss of production due to land disturbance; loss of labour and other social factors that affect landholder's economic viability and/or profitability.
- Considered the wider economic implications/ramifications of these impacts on commodities and the agricultural sector and implications of the lost opportunities in the agriculture sector had not adequately considered or been quantified in the economic analysis in the EIS. In response, Arrow stated that they had estimated a decline in output of the agricultural sector (compared to what would be expected to occur without the project) of 0.2% to 0.3%. They stated that this was not sufficient to affect the long term viability of the industry. Further, any lost productivity as a result of the project would be offset or negated in financial terms through compensation arrangement to be negotiated with landholders. Arrow did not provide any additional quantitative assessment of the potential economic impacts (at either an industry or commodity level) on the agriculture industry in the SREIS.

One submitter argued that the cost benefit analysis incorrectly assumes that affected land would be rehabilitated to pre-project conditions. They argued that the residual effects of CSG development on agricultural enterprises may not be known for some time due to the recovery times for soil function which is dependent on numerous site-specific factors. The success of rehabilitation will determine the degree and extent to which the disturbed land will achieve pre-disturbance productivity. In response, Arrow stated that they had demonstrated that vertosols (black soils) can and have been successfully rehabilitated and restored to their former use. The layout, design and construction methods used to install production wells and access tracks on vertosols will consider site-specific conditions and the outcome of landholder negotiations on particular farming practices.

Concerns were raised by a submitter regarding the impact of the project on commercial livestock operations (including Tony Park piggery). Arrow committed to avoiding infrastructure and associated farm management areas of intensive farming operations including piggeries, feedlots [C076] and to compensate landholders for any impact on productivity through direct negotiations with impacted agricultural producers.

A number of submitters raised specific questions about the scope of the compensation agreements such as whether the agreements would account for the potential depreciation of the value of the land on which the CSG operations are occurring and if the agreement could account for extra time required to complete jobs resulting from the need to avoid travelling over project infrastructure with heavy machinery and losses from a reduction in area and potential damage to equipment from the construction of access tracks? Arrow answered these questions and clarified the compensation process in the SREIS.

4.16.5.4 Local infrastructure and services

Submitters identified that the EIS did not quantify costs to government at various levels for infrastructure maintenance and/or improvements; e.g. roads, waste facilities, emergency services, law enforcement and health services. They questioned the financial viability of the project and the predicted revenue costs to the government if all the infrastructure costs for government were considered in the cost benefit analysis. Submitters questioned whether Arrow would be required to contribute to rural power and water systems. Arrow responded that they were committed to paying developer contribution and head works charges for infrastructure. In repose, Arrow stated that taxes paid to government are developed based on a benchmark approach, and thereby implicitly capture deductions. The cost benefit analysis undertaken for the project (EIS Chapter 21, Economics, Section 21.6) excludes taxes, as they represent a transfer payment between two parties without generating a genuine increase in economic activity. While this revenue to government can be spent in a manner to generate economic benefit, it is standard practice to exclude taxation revenue as there is potential for those paying the taxes to have used this money in an alternative manner, also capable of generating economic benefit.

Local governments requested further detailed information on the economic impacts on the project on their specific council infrastructure. WDRC and TRC requested provided a breakdown of specific costs that it requested Arrow to pay. Local governments also raised concern about their capacity to deal with assessment of the project and ongoing responsibilities and requested financial contribution to assist. Arrow noted their concerns in the SREEIS. In response to the SREIS, WDRC reiterated their request for financial contributions towards assessment of the project and particular aspects including key development and initiatives such as Western Downs Housing Trust, Worker accommodation facilities and infrastructure, wash down facilities and telecommunications infrastructure.

4.16.6 Conclusion and recommendations

The EIS documents have adequately met the requirements of the TOR in relation to economic impacts. The EIS documents have adequately described, at a project scale, the exiting economic environment of the project development area, provided qualitative and some quantitative predictions on the impacts of the project and outlined broad strategies to minimise economic impacts of the project.

The EIS outlines a strategy for individual compensation arrangements for primary producers for any impacts of the project on productivity. The cost-benefit analysis for the project did not consider the costs to be paid by Arrow to landholders to compensate for economic impacts. The economic impact of the project on individual landholders, farming sectors or regions or the agricultural industry as a whole has not been quantified.

It is recommended that Arrow, in consultation with relevant local and state government departments, non-government organisations and communities, consult with each affected Darling Downs local government in the project development area regarding:

- Detailed analysis of the economic impacts on their jurisdiction.
- Infrastructure requirements and costs.
- Resource their capacity to assist with ongoing project planning.

Successful mitigation of impacts will be dependent on Arrow applying the commitments outlined in the EIS documents and Appendix 3 of this report.

Commitments made by Arrow in the EIS (see Appendix 3) should be implemented, particularly the following commitments relevant to the social impacts of the project:

- Population, employment, workforce and wages – C316; C351; C319; C320; C363
- Impacts on local businesses and supply chain and to increase local expenditure on goods and services – C358; C559; C361; C362; C327; C328
- Local infrastructure and services – C331; C284; C332; C334.

4.17 Social

Chapter 24 Social of the EIS provided a description of the social environment within the project development area and assessed the potential social impacts associated with the project's activities. A more detailed assessment of the project's social impacts was presented in Appendix P, Social Impact Assessment (SIA) of the EIS. The SREIS provided updates to the SIA and an updated draft Social Impact Management Plan (SIMP) was presented in Attachment 3 of the SREIS.

4.17.1 Methodology

The following methodology was used to characterise the social environment and assess the impacts of the project's activities.

- Characterisation of the existing social environment and assessment of the broader social context and issues relevant to the project through the analysis of data from the Australian Bureau of Statistics, Commonwealth, State and Local government agencies, Arrow and other relevant and publicly available sources and a review of policies, programs, strategies and regional studies relevant to the project. The EIS characterised the existing social environment of the project development area using the Darling Downs Statistical Division (DDSD) which encompassed the Toowoomba, Western Downs, Southern Downs and Goondiwindi local government areas.
- Consultation with key stakeholders to assist in understanding the community's perception of the likely impacts of the project. This process included: a series of focus groups held in Toowoomba, Dalby, Chinchilla, Millmerran and Goondiwindi attended by approximately 80 people, a quantitative telephone survey of 403 residents of the study area and targeted meetings and interviews with key stakeholders.
- A qualitative risk assessment to assess the likely of harm to the social environment from the project's activities, and the consequences of those impacts. Potential social impacts associated with project activities during the construction and operations phases were identified and assessed in light of the social baseline and issues raised during stakeholder consultation. The significance of impacts was assessed based on the probability and consequence of their occurrence (i.e. likely nature, magnitude, timing and duration of potential impacts) with impacts determined as being of low, medium, high, or very high significance.

The EIS stated that only limited analysis of the social impacts associated with the decommissioning phase of the project was undertaken in the SIA. Submitters on the EIS raised concerns about the lack of consideration for the decommissioning stage in the SIA and SIMP. Arrow argued that the lengthy project life span militates against the accuracy of such an assessment and that they would be required to decommission project infrastructure and rehabilitate land in accordance with the conditions of the environmental authority for the project. EHP contends that the Environmental Authority is not the appropriate mechanism to address all the potential social impacts of the decommissioning project. It recommends that Arrow, update the SIA and SIMP to address impacts associated with the decommissioning phase of the project in consultation with the former DEEDI.

The SREIS presented an updated social impact assessment (Chapter 14) which considered:

- Updates to the project description in the SREIS as a result of further refinement of the field development plan. Changed relevant to the social impact assessment included: a reduction in the project development area footprint; a major increase to the peak construction workforce from approximately 710 described in the EIS to approximately 2,300 personnel, a change in the year the peak is predicted to occur to 2017 and a decrease in the peak operations workforce from approximately 460 people described in the EIS, to around 400; the location and number of temporary workers accommodation facilities (TWAFs) was revised from five to approximately six.
- Updates to plans and strategies of relevance to the SIA that had been released since the EIS was released including the Toowoomba Regional Council Community Plan (Toowoomba Regional Council, 2010), the Goondiwindi Regional Council Community Plan 2012-2022 (Goondiwindi Regional Council, 2012) and Western Downs Regional Council Housing Affordability Strategy (KPMG, 2012).
- Changes to key demographic indicators reflected in the 2011 census and data from other sources since the EIS was finalised. This arose due to QH and other submitter's recommendation that the demographic data used in the SIA of the EIS, including that sourced from the 2006 census, should be updated to reflect the release of 2011 census data and demographic data from other sources since the EIS was finalised.

The approach used for assessing the significance of social impacts in the supplementary social assessment was consistent with that reported in the EIS. A draft SIMP, presented in Attachment 3 of the SREIS, included updates to the commitments/strategies to reflect changes to impacts or new impacts identified in the supplementary social impact assessment (Chapter 14).

4.17.2 Existing environment

The EIS included a baseline study to characterise the existing social environment of the DDSD and defined the characteristics, strengths and vulnerabilities of the communities within it using the 2006 census data (Australian Bureau of Statistics). The study was updated in the SREIS to reflect additional data from the 2011 census and data from other sources since the EIS was released. The findings of the supplementary social assessment indicated that there had been some changes to demographic indicators following the release of the 2011 census data and other information sources since the EIS was finalised. Key changes of relevance to the project related to population growth, changes in the housing market, and an increase in the number of people identifying as Indigenous.

4.17.3 Impacts

Table 22.11 of the EIS summarised the pre-mitigated and residual impacts of the project on the social environment. The EIS reported that the project would result in a suite of beneficial social impacts to the DDSD region including direct and indirect employment, enhanced training and skill development and enhanced local business prospects. The EIS predicted the following potential beneficial social impacts if the project were to proceed:

- Population and demographics:
  - An increase in resident population and an increase in families associated with operations workforce with a total of 759 new residents predicted to move into or in close proximity to the study area by 2021.
  - Offsets to population declines in smaller rural communities.
  - Higher skilled resident workforce as the majority of jobs would be in occupations requiring technical skills, such as drilling, production facility operation and maintenance and diesel fitting.
  - Increased retention of younger population.
  - An increase in families associated with operations workforce with a total of 759 new residents predicted to move into or in close proximity to the study area by 2021.
- Employment, skills and business:
  - Increased local employment opportunities with the creation of jobs for up to 2700 personnel across the construction and operations phases.
  - Increased labour force participation and reduction in unemployment.
  - Increased training and skills development opportunities for the local population.
  - Increased local expenditure on local goods and services through project activities and by incoming workers and residents and higher wages.
  - Increased potential for local business expansion or business establishment in local area through both direct procurement of goods and services and through expanding and diversifying economic activity in the region.
  - Increased range, diversity and lower cost of goods.
- Landuse and property: Increased diversification of the economy and improved resilience to externalities, such as drought and market fluctuations.
- Community values and lifestyles: Increased participation and support in the community (e.g., volunteers, involvement in sport and social organisations, support for local events).
- Housing and accommodation availability and affordability: Increased returns to existing residents through higher house, land and rental prices.

The EIS outlined a suite of impacts that have the potential to negatively impact on the social environment which are summarised in Table 23

Table 23. Key negative impacts reported in the EIS were: impacts on local businesses faced by operating in a changing environment; increased landholder and community uncertainty; increased demand on medical and health facilities; heightened road safety risk; increased house, land purchase and rental prices resulting in diminished levels of housing affordability; and increased community anxiety on health, safety and environmental effects of the project.

The SREIS (Chapter 3 and Attachment 3) outlined a small number of changes to the social impacts reported in the EIS as a result of updates to key demographic indicators and the project description. Population increase in excess of organic growth was identified as a new impact with a significance ranking of medium. Other changes to impacts as assessed in the EIS were an increased likelihood of both local employment opportunities and local expenditure on goods and services (by incoming workers and residents) being generated by the project as a result of increases in construction workforce numbers. The draft SIMP presented in the SREIS (Attachment 3) included strengthening of existing actions and additional actions to address comments on the EIS and reflect changes to impacts as a result of project changes. With these additional actions in place, the SREIS concluded that the residual social impacts were found to be consistent with those outlined in the EIS.

Table 23 Summary of potential negative impacts of the project on the social environment and overall risk rating assigned in the EIS (Table 22.11, Chapter 22) and SREIS (Table 14.2).

Impact	Premitigated impact (overall risk)	Residual impact (overall risk)
Population and Demographic Profile:		
Influx of young, male-dominated construction workforce	Low	Low
Population increase in excess of organic growth *	NA*	Medium
Employment, skills and Business:		
Local business difficulties faced by operating in changed environment (increased costs, competition and labour)	High	Medium
Landuse and Property:		
Reduction or loss of farm income	Low	Low
Disruption to farm operations	Low	Low
Increased landowner and community uncertainty	High	Medium
Loss of good-quality agricultural land affects food supply and security	Low	Low
Loss of social connection to land or of agricultural production	Medium	Medium
Community values and lifestyles:		
Increased potential for social division and social tension	Medium	Low
Change in character of towns and to rural amenity of area	Low	Low
Increased criminal activity and anti-social behaviour	Low	Low
Potential for increased community conflict if overseas workers are employed by the project and move into the community	Medium	Low
Community infrastructure and services:		
Increased demand on community support services	Low	Low
Increased demand on emergency services	Medium	Low
Increased demand on recreational facilities	Low	Low
Increased demand on medical and health facilities	High	High
Increased demand on schools and childcare	Low	Low
Increased demand on utilities	Low	Low
Heightened road safety risk	High	Medium
Unable to attract and retain service provider workers (e.g. police, teachers, doctors) due to increased living costs	Low	Low
Housing and accommodation availability and affordability:		
Increased house, land purchase and rental prices resulting in diminished levels of housing affordability	High	Medium
Serviced land not available to meet demand	Low	Low
High demand for hotel, motel, caravan park accommodation	Medium	Low
Reduction in availability of accommodation for low income and vulnerable groups including Indigenous groups.	High	Medium
Health, safety and environment:		
Increased community anxiety on health, safety and environment effects of project	High	Medium
Heightened road safety risk	High	Medium

Impact	Premitigated impact (overall risk)	Residual impact (overall risk)
Increased ambient noise impacting on amenity	Low	Low
Reduced air quality	Low	Low
Light pollution impacting on amenity	Low	Low

* New impact identified in the SREIS that was not in the EIS.

4.17.4 Avoidance and mitigation measures

The EIS proposed a suite of avoidance, mitigation and management measures and enhancement strategies (commitments) to address potential social impacts of the project. The draft SIMP (Appendix P of the EIS) provided specific commitments and associated monitoring and verification measures for impacts with a medium to high impact. The draft SIMP was updated in the SREIS (Attachment 3) to reflect changes to impacts or new impacts identified in the supplementary social assessment.

Appendix 3 to this assessment report contains the full list of commitments by Arrow to minimise negative social impacts of the project and maximise benefits. Key commitments relevant to social impacts included:

- **Population and demographic profile**—encouraging local population growth where it is desired and planned for, preference for local residence for operations staff, implementing an Operations Workforce Policy, providing opportunities for people from under-represented groups, providing training and employment programs for local school leavers and cultural awareness briefing for overseas workers and their families.
- **Community values, lifestyle and connections**—liaising with councils and regional community consultative committee to identify any social, community or recreational infrastructure being directly impacted by the project in Western Downs region , liaising with the relevant bodies to coordinate efforts across all proponents and identify opportunities that may potentially ease or mitigate impacts, expanding opportunities available for the region under the Brighter Futures program, policies to encourage resident employees and contractors to integrate and become involved in their local communities.
- **Employment, skills and business**—the provision of training and skills for Arrow workers and the community, graduate development programs and scholarships, equal opportunity policies, strategies to encourage local supplier's involvement and local expenditure on goods.
- **Landuse and property**—adherence to land access rules by all project personnel and a workforce Code of Conduct and policy on appropriate worker behaviour and interaction with the public, provision of Community Officers, Land Liaison Officers and a1800 free-call number for people to ask questions or raise concerns about Arrow's activities.
- **Community infrastructure and services**—consultation with councils and the regional community consultative committee regarding community infrastructure needs, provision of developer contribution and head works charges for infrastructure, the provision of a medivac service to respond to community or project-related emergency situations.
- **Housing and accommodation availability and affordability**—provision of Temporary Workers Accommodation Facilities, an integrated housing strategy and collaboration with government and other proponents to support housing affordability initiatives.
- **Health, safety and environment**—implementation of the community engagement program and other measures to notify community of project activities and to identify and address community issues and maintenance of a grievance process for the community to register complaints, issues, comments and suggestions.

4.17.5 Submissions

Submissions on the EIS raised a range of issues relating to social impacts. Arrow provided a responses to all issues raised in the submissions relating to social impacts under the heading Social in Part B, Chapter 19, Submission Responses. A summary of key issues and brief assessment of their adequacy and outstanding matters is provided below.

4.17.5.1 Social Impact Management Plan

Submitters raised a number of issues regarding the SIMP in the EIS which Arrow responded to in the SREIS:

- The former DEEDI requested that Arrow, when lodging the final Draft SIMP, clarify if specific mitigation and management strategies in individual Action Plans have been agreed by an agency or key stakeholder or indicate if the current status of the agreement if consultation and negotiations are continuing. Arrow did not provide this information in the updated SIMP (Attachment 3) of the SREIS.
- One submitter commented that a number of the negative impacts identified in the SIMP are not adequately quantified e.g. impacts to existing rates of employment, impact of high wages and the ability of local business to attract and retain staff, long term viability of local business and impacts to memberships of local organisations. Arrow responded that these impacts had been considered qualitatively using a risk framework and argued that this approach was consistent with other assessments of this nature.

4.17.5.2 Population and demographic profile

Submitters raised concern that the EIS had not adequately considered or addressed potential demographic changes to towns as a result of rapid community and economic growth and the project's fly-in, fly-out construction workforce. Potential issues raised included a male dominated construction force, increase in single men, increased rates of drug and alcohol abuse, motor vehicle incidents, increased crime rates and a decline in community organisations. Further, submitters were concerned that the potential cumulative impacts of a male construction workforce as a result of other energy projects in the Surat Basin had not been adequately addressed in the EIS. In the SREIS, Arrow strengthened an existing commitment to facilitate pathways for student to gain employment on graduation and included a new committed to implement policies and programs to maintain the wellbeing of project personnel. With these changes, Arrow argued that the suite of mitigation actions in revised SIMP (Attachment 3, SREIS) were sufficient to address potential impacts associated with anti-social behaviour and fly-in, fly-out and bus-in, bus-out workforces.

4.17.5.3 Community values, lifestyle and connections

Submitters raised numerous concerns regarding the potential impacts of the project on community values and lifestyles. Various submissions stated that the EIS had not:

- Adequately accounted for the underrepresentation of small agricultural communities given recent council amalgamations or adequately considered issues and impacts relevant to the rural population outside the study area's towns.
- Given adequate consideration to the social fabric of communities and community social issues such as the fragmentation of pastoral and agricultural land, the pace of change and effects on community harmony.
- Given adequate consideration to the potential for: change in the character and values of the community; dilution of the rural heritage of the community with an influx of new residents who may not be from a rural background and may not be employed in rural occupations and; potential for further socio-economic divisions between urban and rural populations.
- Adequately addressed potential loss of social connection to the land/agricultural production.
- Given adequate consideration to the impact on everyday life of landholders and the loss of privacy, tranquility and lifestyle.

Arrow responded to these issues in the SREIS and argued they had been adequately addressed in the EIS and SIMP and made no amendments to the SREIS.

The former Department of Communities, Child Safety and Disability Services (DCCSDS) recommended that Arrow consider cultural awareness training for overseas workers and requested further information on how such initiatives would be delivered. In response, Arrow reiterated their commitment in the EIS to provide information and Australian cultural awareness briefing for overseas workers and their families and provided further detail on this initiative in sections 2.1, 2.5 and 2.7 of the SREIS SIMP (Attachment 3).

Former DCCSDS commented that mitigation measures in the SIMP did not include indigenous engagement activities such as support for indigenous students or specific strategies to mitigate potential impacts (such as reduction in accommodation for low income and vulnerable people) on local Indigenous people despite them being identified as a group at significant risk in the SIMP(Table 7-10). In response, Arrow advised it had provided updated data in the SREIS around persons identifying as Indigenous within the project development area. It had also updated and provided additional commitments in the SIMP in the SREIS to enhance project opportunities to Indigenous communities and students. This included a commitment to implement actions within Arrow's Aboriginal and Torres Strait Islander Reconciliation Action Plan (RAP) relating to educational opportunities for Indigenous students.

4.17.5.4 Employment, skills and business

A number of issues were raised in the submissions regarding the assessment and impact of the project on employment, skills and business. Key issues are discussed below.

- **Skills shortage**—Submitters raised concern that the EIS had not adequately considered or addressed the existing skills shortage in the agricultural industry. Difficulty with the recruitment of local workers in the Wandoan and Taroom area due to low unemployment rates was flagged by a submitter as an example. The ability for Arrow to achieve their commitment to use suitably qualified and experienced persons in the present skills shortage was also raised as an issue. The former DEEDI encouraged Arrow to consider providing local business with opportunities to be skilled up to undertake decommissioning of wells and facilities. Arrow contended in the SREIS, that issues relating to the deepening the existing skills shortage and competition for labour in the region had been adequately described and assessed and mitigation measures provided in the EIS. They included an additional commitment to undertake regular reviews of non-project related labour requirements and current skills sets for the study area by engaging with state agencies and other skills bodies to facilitate the development of training strategies.
- **Workforce estimates**—Submitters, including former DEEDI and Department of Housing and Public Works (DHPW) requested further clarification and justification of the estimated workforce figures for locally source construction work (target of 20%) and operational workers (50% predicted to reside in the region). Arrow presented new workforce requirements in the SREIS due to the revised workforce figures presented in the SREIS. They argued that figures adopted for the proportion of local workforce were appropriate and based on Arrow's construction workforce modelling and the known skill shortages in resource-oriented professions and construction trades (EIS Chapter 22, Social, Section 22.6.3). They stated that workforce estimates would continue to be refined through project planning and be informed by local conditions.
- **Training**—Former DEEDI requested more detail on strategies to increase the regional skills base over the life of the project such as employment of apprentices and trainees. In response, Arrow amended several commitments in the EIS (C342, C338, C339 and C338) to enhance employment and training programs such as initiatives for local school leavers, apprenticeships, scholarships, vocational training, support for work readiness programs and pre-trade training (SREIS Attachment 3, Social Impact Management Plan, Section 2.5).
- **Indigenous employment and training**—Former DEEDI, DATMSIMA and former DCCSDS commented that commitments by Arrow and its contractors to employing, educating and training Indigenous Australians, including local Indigenous worker percentage targets, were inadequate and requested further information on the Indigenous Participation Plan. In response, Arrow updated the SIMP of the SREIS (Section 2.4, Attachment 3) to detail a range of measures to provide project employment and education and training opportunities to Indigenous people and communities and two new commitments were included.
- **Local industry impact**—Former DEEDI, Millmerran Commerce and Progress and individual submitters raised concern about the potential impacts of the project on the local agricultural industry and other local businesses due to staff retention, skills shortages and wage competition. They requested more tangible measures be provided to assist employees and mitigate adverse impacts on local agricultural industry and other local businesses. To address these concerns, Arrow included a new commitment to undertake regular reviews of non-project related labour requirements and current skills sets for the study area by engaging with state agencies and other skills bodies to facilitate the development of training strategies.

Former DEEDI requested Arrow to develop a Local Industry Participation Plan in consultation with them to address how they will procure and engage local and regional businesses. However, since the EIS was release, DSDIP has remove the LIPP requirement and confirmed that Arrow can comply with this request through the development of an Australian Industry Participation Plan (AIPP). To address this, Arrow included a new committed in the SREIS to implement the Australian Industry Participation Plan (AIPP), which would provide detailed information about the strategies and approaches to be undertaken by Arrow to: encourage contractors to source local goods and services where possible, encourage business to consider Indigenous procurement to maximise Indigenous employment opportunities, engage with key business bodies regarding appropriate opportunities for local businesses to supply goods and services to the project. In addition to these measures, Arrow committed to use the Industry Capability Network database for potential suppliers in the area and development and maintenance of a business vendor register.

4.17.5.5 Landuse and property

Key issues raised by submitters on the social impacts of the project from disturbance to landuse and properties included:

- The EIS had not adequately considered the loss of social connection to the land/agricultural production.
- The EIS had not given adequate consideration to the impact on everyday life of landholders and the loss of privacy, tranquillity and lifestyle.
- The EIS had not considered the social impacts of the project on different types of agricultural operations.

Arrow argued that these issues had been adequately addressed in the EIS and SIMP and no amendments were made to the SREIS SIA and SIMP as a result.

DCSCS, TRC and landholders commented that the EIS ratings assigned to the 'loss of social connection to land/agriculture production' impact (in Table 22.11) were underrated and did not adequately reflect the potential severity of the impacts on family farming businesses and the flow on effects. Arrow provided further justification of these ratings and argued that ratings in the EIS were appropriate in the SREIS, but did not amend any of the significance ratings in Table 22.11 as a result.

Numerous landholders and submitters raised issues about the approach of using single landholder compensation agreements to manage impacts of the project on properties. Concerns included:

- The high degree of uncertainty surrounding the project, compensation agreements and impacts on individual properties.
- The fairness of using confidential agreements and the need for one party to yield to another in the negotiations.
- The effectiveness of compensation agreements in protecting agricultural lands
- The inability of compensation agreements to estimate the loss of production caused by the inconvenience of roads and production wells on property and intensive cropping.
- Loss of privacy and safety issues arising from unknown people having access to individual landholders properties e.g. safety issues surrounding drilling operations and strangers (workers and contractors) working in close proximity to children. In response to this issue, Arrow commented that site access including planned activities and the notification required would be negotiated with landholders and agreed upon by both parties as part of conduct and compensation agreements.
- The wider social implications and fairness of this approach.

While Arrow provided an individual response to each of issues in the SREIS, no specific resolution was provided as the response simply reiterated the management of impacts on individual properties would be managed through compensation agreements which would need to be agreed on by both parties.

Numerous landholders and submitters requested clarification and further information on the compensation process. Questions included whether the agreements would be conducted with individual landholders or landholders as a group, the depth of information that would be made available to landholders on activities proposed to be conducted on their properties, the penalties or implications for a gas company in the event that it does not comply with land access agreements, how they intended to 'add value', the level of notification Arrow would provide the landholder before entry onto properties and what statutory conditions would be put in place to ensure compliance with land access arrangements. Arrow answered these questions and clarified the compensation process in the SREIS.

Submitters raised concern about the potential for infrastructure on neighbouring properties to causes adverse impacts on a connecting property. They questioned: what compensation can be sought by the adjacent landholder if this scenario was to occur; who would be financially liable; and who would be responsible for rectifying any environmental damage? In response, Arrow outlined their process of Area Wide Planning which incorporates negotiations with individual landholders into an integrated plan across neighbours and catchment areas. This would assist in balancing individual needs of landholders with the needs of neighbouring properties and the broader agricultural community. Area Wide Planning considers the potential impacts of CSG infrastructure on neighbouring properties including overland flow.

4.17.5.6 Community infrastructure and services

Key issues raised by submitters on the social impacts of the project on community support services are discussed below.

- **General**—DCSCS and TRC commented that the EIS ratings assigned to the increased demand on medical and health facilities, increased demand on emergency services and reduction of accommodation availability for low income or vulnerable groups (in Table 22.11 of the EIS) were underrated. Arrow provided further justification of these ratings and argued that ratings in the EIS were appropriate in the SREIS and did not amend any of the significance ratings in Table 22.11 as a result.
  Submitters raised general concerns about the impacts of the project on: the ability to attract and retain service provider workers (e.g. police, teachers, doctors) due to increased living costs as a result of the project;

increased demand on recreational facilities; and increased demands on school and childcare centres. Arrow was satisfied that they had adequately assessed these impacts in the SIA and that commitments in the SIMP were sufficient to address the predicted impacts of the project at this stage of the project timeline. No amendments were made to the SREIS SIA and SIMP.

- **Social services**—Former DCCSDS argued that the EIS had not adequately assessed the impacts of the project on community services for disadvantaged and low income groups and impacted landholders (i.e. family support services, counselling, domestic and family violence) or outlined adequate strategies in the SIMP to mitigate such impacts. They requested further consultation with former DCCSDS and NGO sector in the development of mitigation measures and stressed the need for any strategies to complement, rather than duplicate current services funded by other proponents of resource projects. TRC expressed similar concerns to former DCCSDS about the inadequacy of the EIS to assess impacts of the project on social and community support services and facilities specifically in the TRC area and requested detailed mitigation strategies targeted for the TRC area. In response, Arrow included a new commitment in the SIMP to implement policies and programs to maintain the wellbeing of project personnel such as the provision of welfare and recreation facilities in TWAF's, counselling service for all workers, Arrow policies including OHS Policy, Drug, Alcohol and Contraband Policy, Duty to Stop Work Policy and Fit for Duty Policy, restrictions on working hours to reduce worker fatigue and provision of nutritionally balanced food to all personnel living within TWAFs in line with guidance issued by Queensland Health. However, this commitment only related to project personnel and project facilities (i.e. TWAF) and did not address concerns raised by submitters about the wider impact of the project on community services. Arrow stated that approximately 15% of the potential new residents are predicted to relocate to Toowoomba (114 persons including workers and their families) and did not consider this would have a significant impact on services to the regional centre. No commitment or strategies were put forward by Arrow in the SREIS to address support or counselling services for landholders affected by the project.
- **Health services**—Former DEEDI, QH and private submitters raised concern that the EIS had not adequately considered impacts of the construction workforce on individual and community health and associated services such as pressures on medical care facilities, deterioration of roads, driver fatigues. QH and TRC requested further information on the provision of non-emergency medical services for project workers, consultants and their families considering the scarce community regional health services. TRC provided the example of Dalby where local medical services had not kept pace with the growth and as a result it can take weeks to make an appointment for even a serious medical condition. Former DEEDI, QH and TRC argued that strategies in the SIMP aimed at addressing such impacts were inadequate, vague or non-committal (i.e. only 'where possible') and lacked detail on how and where strategies would be implemented and monitored. In response, Arrow reiterated their commitment to continue to support the Surat Gas Aero Medical Service in the region (co-funded by other resource projects) which provides 150 free hours to Queensland Health for community based aero medical recovery services and their commitment to provide authorities with forecasts of workforce numbers and projected families. No additional changes were made to the SREIS.
- **Emergency services**—Numerous submitters (Millmerran Commerce and Progress Inc.) commented that the EIS had not adequately assessed the impact of the project on emergency services or provided adequate strategies to ensure emergency services to existing residents and business can be maintained and sufficient coverage for new operational areas and activities can be achieved. Submissions requested Arrow conduct a detailed investigation of existing emergency resources for each of the proposed operational regions and propose detailed strategies for each region to address additional demands as a result of project. Arrow was satisfied that commitments C242 in the SIMP to develop emergency response plans in consultation with emergency services organisations and commitment C373 to continue financial contributions towards the Surat Gas Aero Medical Service in the region, were sufficient to address these concerns at this stage of the project timeline (i.e. EIS stage).
- **Infrastructure**—Former DEEDI, TRC and WDRC commented that there was insufficient detail in the EIS on where significant project infrastructure would be located and where populations are expected to increase. Consequently, the impacts of the project on local and regional municipal infrastructure and services, was not adequately assessed and specific mitigation actions not provided. For example, TRC was concerned about the impact of water usage, waste removal and sewage treatment from the TWAF camps on local rural water, sewerage and waste facilities and services particularly in the Cecil Plains and Millmerran areas. Arrow replied that they had revised workforce numbers in the SREIS and presented the potential sites for four production facilities and a temporary workers accommodation facility in the SREIS. No additional information on the impacts on infrastructure services was provided in the SRES. Arrow commented that the capacity of existing services and any upgrades required to service the TWAF would be a key consideration in the feasibility of connection to these services. Where unavailable or not feasible, on-site package water and sewage treatment and power generation would be required. Arrow committed to work with regional councils in relation to management of project waste and discuss all requirements, including options and the payment of user fees, prior to construction.
- **Communication facilities**—Submitters raised concern about the impact of the project on existing communication services. Arrow responded that it would assess the capability of existing telecommunications

networks and work with telecommunications providers to make appropriate infrastructure available for the project, without disrupting existing services.
- **Consultation**—DCCCS requested that the NGO sector be adequately represented in on-going stakeholder consultation activities with councils and the Consultative Committee to ensure data and information on any impacts of the project on social infrastructure is adequately communicated and effectively dealt with in a timely manners. Arrow did not respond to these issues in the SREIS.

4.17.5.7 Housing and accommodation availability and affordability.

Numerous submitters included former DEEDI and TRC raised concerns and requested further assessment of the direct and indirect impacts of the project on local housing markets, accommodation shortages and increased property values and rent, including details on the spatial breakdown of impacts for different towns and local government areas. They also argued that the EIS had not provided adequate measures to address:

- Housing availability given that accommodation shortages are already an issue in the region (including towns such as Dalby and Chinchilla, Cecil Plains and Millmerran) and there are no provisions in the EIS to construct new accommodation for operations staff and family.
- Housing assistance and support programs and accommodation for low to moderate income families and vulnerable groups to support access to rental housing in their community or region and homelessness and crisis accommodation.
- Impacts on the rental market such as consideration to not use private rental market in key locations of the project footprint where vacancy rates fall below 3% for families.

In response, Arrow updated commitments aimed at managing the project's impact on cost of living and housing affordability (SREIS Attachment 3, SIMP, Section 2.1). These include commitments to develop an Operations Accommodation Strategy 12 months prior to the commencement of operations and a Construction Workforce Accommodation Strategy three months after Financial Investment Decision. Arrow also confirmed commitments to continue to support government reviews on housing availability and affordability and on impacts on low-income groups, and contribute with community and affordable housing schemes.

Former DEEDI requested Arrow provide more details of the housing 'rent to buy' scheme and explore the possibility of an accommodation subsidy or other support mechanisms for workers relocating into the region. Arrow committed to develop a Construction Workforce Accommodation Strategy and an Operations Accommodation Strategy which considers, among other measures, a 'rent to buy' scheme and contribution to a government sponsored community and affordable housing initiative.

The DHPW requested further information on the main stakeholder groups/ organisations for continued and on-going consultation concerning Housing and Accommodation Availability and Affordability Strategy. Arrow clarified Arrows intent to participate as a member in the Western Downs Housing Trust Reference Group.

Submissions commented that the accommodation situation needs to be continually monitored through the project as situations can rapidly changing on a month by month basis.

Following review of the SREIS, former DEEDI made the following comments:

- Reiterated that Arrow commit to not accessing private rental market were vacancy rate are below 3% and seek other alternative housing options including provision of new housing stock or workers camps. Such a commitment would be consistent with mitigation and management strategies included in Arrow LNG Facility Project.
- Commented that the proponent had not made any further information on how they intended to provide accommodation for workers who would be constructing camps. They recommended that a commitment to an early works accommodation plan consistent with Arrow LNG Facility Project should be provided 4 months prior to the commencement of any construction of workers camps. The plan should provide details of the options being considered; include consultation with key stakeholders including local governments; and cover the period from construction commencement of camps until final decommissioning of the camps.
- Arrow should clarify their commitment to provide housing for workers if the need is identified.

4.17.5.8 Health, safety and environment

Numerous submitters contended that the EIS had not given adequate or genuine consideration for landholder concerns and increased community anxiety regarding the impacts of the project on health, safety, water availability and environmental (including potential groundwater impacts). In particular, QH and TRC advised that the EIS had not adequately addressed mental health impacts such as anxiety and depression to landholders directly impacted by the project and to others within the community (not Arrow staff) who are indirectly impacted by the project e.g., through cost of living, housing availability, rental market prices, etc. They commented that the only mitigation action addressing mental health impacts for landholders in the EIS was access to Arrow's land access officers who are not trained metal health professionals. Arrow was satisfied that the EIS had addressed these issues within their control and statutory responsibilities and committed to provide information about its activities to relevant government agencies to assist planning for increased demand and the provision of additional support services if existing services are inadequate.

QH commented that the EIS has not adequately considered management of alcohol and tobacco and/or other drugs at accommodation camps or provide sufficient information on food selection and preparation (*Food Act 2006*) for onsite workers and worker camps. Arrow provided further information in the SREIS on food preparation at workers' accommodation facilities and commitments to develop relevant policies and codes of conduct relating to public and worker's health and safety in line with appropriate legislation.

4.17.6 Conclusion and recommendations

The EIS documents have adequately met the requirements of the TOR in relation to social impacts. The EIS documents have adequately described, at a project scale, the exiting social environment of the project development area, provided qualitative predictions on the impacts of the project and outlined broad strategies to minimise social impacts of the project. Successful mitigation of impacts will be dependent on Arrow applying the commitments outlined in the EIS documents (with amendments) including conducting localised social assessments and developing and implementing more detailed mitigation strategies that are adaptive to changing social conditions over the life of the project.

It is recommended that the SIMP is amended to address the following matters, in consultation with relevant local and state government departments, non-government organisations and communities:

- Assess impacts and include mitigation strategies to address the decommissioning phase of the project.
- Specify if strategies in individual Action Plans have been endorsed/agree-upon by key stakeholders/agencies or indicate progress on any consultation or negotiations.
- Include strategies to mitigate impacts of the project on community services for disadvantaged and low income groups (i.e. family support services, counselling, domestic and family violence).
- Provisions for support and counselling services for landholders and communities affected by the project.
- Update mitigation actions to address impacts on non-emergency medical services for project workers, consultants and their families in consultation with QH and relevant local government.
- Include the NGO sector in on-going stakeholder consultation activities with councils and the Consultative Committee to assist the sharing of key social data.
- Provide and update mitigation strategies that address housing assistance and support programs and accommodation for low to moderate income families and vulnerable groups.
- Include monitoring provisions to ensure management actions are responsive to changing social environment.

4.17.6.1 DSDIP recommendations

The following recommendations made by DSDIP following a review of the SREIS should be addressed.

- Arrow consider the new policy directions, *Managing the Impacts of Major Projects in Resource Communities* and *Regional And Resource Town Action Plan*' (available on the DSDIP website) to assist in negotiating and agreeing mitigation and management strategies
- Arrow commit to the development of an Early Works Accommodation Plan consistent with Arrow LNG Facility Project provided 4 months prior to the commencement of any construction of workers camps. The plan is to: provide detail of the options being considered; include consultation with key stakeholders including local governments; and cover the period from construction commencement of camps until final decommissioning of the camps.
- Arrow commit to not accessing private rental market where vacancy rate are below 3% and seek other alternative housing options including provision of new housing stock or workers camps. Such a commitment would be consistent with mitigation and management strategies included in Arrow LNG Facility Project.
- Arrow commits to provide housing for workers if the need is identified.
- Arrow commit to full adoption of the QRC Code of conduct for Local Content.
- Arrow to provide an annual report to the Director General during construction and for two years following the commencement of operations. The report must describe:
  - The actions and adaptable management strategies to avoid manage; mitigate project related impacts on local and regional housing markets.
  - The actions to enhance local employment, training and development opportunities
  - The actions to avoid, manage or mitigate project related impacts on local community services, social infrastructure and community safety and well being
  - The actions to inform the community about projects impacts and show that community concerns about projects impacts have been taken into account.

4.17.6.2 Queensland Health recommendations

The following recommendations made by QH following their review of the SREIS should be addressed.

- In accordance with the Health (Drugs and Poisons) Regulation 1996, Arrow to ensure that the necessary approvals from Queensland Health are obtained if workforce accommodation camps / mining operations employ a person who may need to possess, obtain, administer or supply a scheduled drugs and poisons.
- “Healthy” food be made available and sought from local suppliers (as per an endorsed procurement policy) to help improve the health and well-being of the workers and minimise the prevalence of chronic diseases.
- Each accommodation camp should be designed to either be a smoke free environment, or provide for a single smoking area that is located in such a location that it will not impact on other residents at the camp, and;
- The proponent develop an Alcohol Management Plan to encourage safe and responsible consumption of alcohol, taking into account the Australian guidelines to Reduce Health Risks From Drinking Alcohol.

4.17.6.3 Recommendations on commitments

This assessment has reviewed the commitments in the EIS documents and endorses commitments made by Arrow regarding social impacts of the project and recommends their implementation.

Specific commitments relevant to social impacts include:

- Population and Demographic Profile – C333; C334; C335; C347; C336; C337; C338; C349; C553.
- Employment, Skills and Business – C339 to C363; C551; C552; C554; C555; C556.
- Land Use and Property – C364; C365; C369; C370; C371; C081; C501.
- Community Values and Lifestyles – C366; C367; C395; C499.
- Community Infrastructure and Services – C372; C373; C374; C387; C389; C366; C376; C377; C550.
- Housing and Accommodation Availability and Affordability – C378; C321; C322; C379 to C386; C548
- Health, Safety and Environment – C389; C077; C390; C391 to C395.

A complete list of Arrow’s commitments is provided in Appendix 3.

4.18 Indigenous cultural heritage

Chapter 23 of the EIS provided a description of the Indigenous cultural heritage values within the project development area and assessed the potential for these values to be affected by direct and indirect impacts of the project. Appendix Q, of the EIS, Aboriginal Cultural Heritage Impact Assessment, presented a detailed assessment of the project's Indigenous cultural heritage impacts. Matters concerns employment impacts and opportunities for Indigenous workers are addressed in 4.17 of this assessment report.

4.18.1 Methodology

A desktop review of existing and historical documents and a qualitative risk assessment was used to identify existing indigenous cultural heritage values, assess the likelihood of harm to cultural heritage sites from the project and assess the consequence of those impacts on indigenous cultural heritage values. No field surveys were conducted.

4.18.2 Existing environment

Registered native title applications over or in the vicinity of the project development area at the time the EIS was submitted included, the Iman People #2, Mandandanji People and the Bigambul People.

The EIS identified the following indigenous cultural heritage values:

- Known indigenous cultural heritage values throughout the project development area including a large number of objects and significant Aboriginal areas of both scientific and cultural significance including those identified on the Register of the National Estate (Barakula State Forest, Chinchilla Sands Local Fossil Fauna Site and Lake Broadwater Conservation Park), the Queensland Indigenous Cultural Heritage Database (372 sites with Aboriginal Cultural Heritage Values) and the Queensland Cultural Heritage Information Management System (3 sites with Aboriginal Cultural Heritage Values).
- A high likelihood of unknown indigenous cultural heritage sites and values being present across the project development area. An assessment of areas in the project development area most likely to contain unknown indigenous cultural heritage values based on the extent of previous Indigenous activity in the area, landscape features and level of landscape disturbance was presented in the EIS. Area's most likely to contain indigenous cultural heritage values were those near water courses, forests and ridges and escarpments that have not been cleared for agricultural use.

4.18.3 Impacts

Table 23.5 of the EIS summarised the pre-mitigated and residual impacts of the project on non-Indigenous cultural heritage. The EIS stated that without the implementation of appropriate management controls, the project, particularly clearing activities and ground disturbance, had the potential to impact on Indigenous cultural heritage values through:

- encroachment upon or disturbance of known or unknown places of cultural heritage to Indigenous persons and/or
- accidental destruction, damage or disturbance of physical objects.

4.18.4 Avoidance and mitigation measures

The EIS outlined a cultural heritage management strategy to avoid impacts on, or reduce the likelihood or consequence of known or unknown Indigenous cultural heritage within the project development area and comply with the *Aboriginal Cultural Heritage Act 2003* (ACH Act). The EIS outlined a series of commitments to minimise impacts on Indigenous cultural heritage (see Table X.1). These included:

- Avoid impacts on cultural heritage values where possible by:
  - Avoiding, through site-selection, locations of Indigenous cultural heritage values that are currently known, including but not limited to, the Chinchilla Sands fossil site and Lake Broadwater Conservation Park and avoid sites with Indigenous cultural heritage that become known throughout the course of the project development.
  - Where development occurs in the vicinity of known Indigenous cultural heritage sites, implement mitigation measures (such as flagging of agreed buffer zones around sites) to prevent accidental destruction, damage or disturbance of objects of physical heritage in the landscape.
- Avoid impacts on unknown cultural heritage values where possible and minimise the potential for accidental disturbance to previously unknown sites through:

  - Proactive implementation of the cultural heritage arrangement within the Indigenous Landuse Agreements (ILUA) or Cultural Heritage Management Plan (CHMP) where clearing and ground disturbance works are proposed.
  - Incorporating cultural heritage awareness into site induction procedures, including information on heritage values of the region, legal obligations and implementation of a ‘chance finds' procedure.
- Where it is not physically possible to avoid Indigenous cultural heritage, necessary disturbance would be conducted in accordance with the agreements with Aboriginal/endorsed parties. Any loss would be offset by a program of mitigation that would collect and preserve the data a site may hold for future research purposes.

In the SREIS, Arrow reports that it has been negotiating two ILUA for areas overlapping the project development area. At the time of the SREIS, negotiations for the Western Downs Unclaimed Area agreement had been completed and Arrow had lodged this agreement with the National Native Title Tribunal for registration. Negotiations between Arrow and the Bigambul People were continuing for the proposed Bigambul ILUA.

In parallel with ongoing ILUA negotiations, the EIS documents propose the development of CHMPs to ensure compliance with the cultural heritage duty of care if ILUA negotiations cannot be completed in accordance with the project timeframe or a Native Title Party is not registered. The EIS documents propose two types of CHMP to fit with the project’s staggered approach to field development:

- a staged ‘process CHMP’ model that will be directly tied to the staggered approach being planned for field development; and
- a ‘site management CHMP’ model for exploration and pilot wells when work is required in areas in advance of a process CHMP.

Arrow committed to issuing notices for CHMPs approximately three years in advance of its intention to develop any particular section of a tenement. For sections where this schedule is less than this period of time, Arrow committed to issue the requisite notices in a timely fashion such that the notification and development periods stipulated in the ACH Act for development of a CHMP are met.

4.18.5 Submissions

Submitters identified a number of issues in the EIS relating to Indigenous cultural heritage matters which Arrow deferred to be addressed in individual ILUA or CHMP:

- Former DEEDI recommended that Arrow engage cultural heritage monitors and the Condamine Alliance identified the importance of adequate monitoring to ensure compliance with Indigenous Cultural Heritage policies and protocols. Arrow responded that any engagement of cultural heritage monitors would be detailed in individual ILUAs. Further, they committed to incorporate management and monitoring protocols in CHMPs (or equivalent agreements) and cultural heritage awareness into site induction procedures (C409).
- Several submitters expressed concern that Arrow’s consultation with Indigenous parties had been too restrictive i.e. limited to current Indigenous parties and had not included registered native title parties that continue to constitute the Aboriginal party as per section 34 and 35 of the ACH Act including the Barunggam People and Western Wakka Wakka People. Arrow responded that voluntary consultation with Traditional Owners within its footprint had been conducted as part of the EIS process and reported that future consultation with Aboriginal parties would include giving notice of the development of CHMPs or equivalent agreements in accordance with the *Aboriginal Cultural Heritage Act 2003*.

The former DERM commented that the EIS had not adequately identified or considered impacts on any cultural or spiritual values associated with the groundwater systems and rivers. They requested that the SREIS detail the analysis and investigation undertaken to assess cultural and spiritual values associated with groundwater systems and groundwater dependent ecosystems. Arrow did not address this issue in the SREIS other than reiterating that CHMPs or equivalent agreements would be developed in accordance with the provisions of the *Aboriginal Cultural Heritage Act 2003* [C396].

4.18.6 Conclusion and recommendations

The EIS has adequately met the requirements of the TOR in relation to Indigenous cultural heritage. It adequately described, at a project scale, existing Indigenous cultural heritage values and broadly considered areas most likely to contain unknown non-Indigenous cultural heritage values. The EIS provided qualitative predictions on the impacts of the project on Indigenous cultural heritage values, outlined frameworks for undertaking more detailed site-specific assessments of values and included broad strategies to reduce the potential for adverse impacts on known and unknown Indigenous cultural heritage sites.

To avoid impacts on, or reduce the likelihood or consequence of known or unknown Indigenous cultural heritage within the project development area and to comply with the *Aboriginal Cultural Heritage Act 2003* (ACH Act), it is recommended that Arrow:

- Implement commitments outlined in Table 24 with recommended changes.
- Assess the cultural and spiritual values associated with groundwater systems and groundwater dependent ecosystems and consider any identified values in the development and implementation of the Cultural Heritage Management Plan and other relevant documents/procedures e.g. ‘chance finds’ and site induction procedures.
- Endeavour to, as far as possible, engage with all traditional owner groups associated with the project’s development area including previously registered native title parties.

It is also noted that Arrow has developed a Reconciliation Action Plan for 2013 – 2014 which supports initiatives to protect indigenous cultural heritage as well as supporting employment, training, education and business opportunities for Aboriginal and Torres Strait Islander people.

Table 24 Indigenous cultural heritage commitments and recommended changes

Commitment	Comment
Prepare CHMPs or equivalent agreements in accordance with the provisions of the ACH Act. [C396]	Amend to: 1. Include engagement with all traditional owner groups associated with the project’s development area including previously registered native title parties. 2. Consider any cultural and spiritual values associated with groundwater systems and groundwater dependent ecosystems.
Complete comprehensive initial cultural heritage assessments where disturbance is proposed (noting that this will be staged in line with proposed development schedules), with direct input from relevant Aboriginal parties. [C397]	Include cultural and spiritual values associated with groundwater systems and groundwater dependent ecosystems
Assess the results of the initial cultural heritage assessments in collaboration with the Aboriginal parties and develop a program for the management of all significant Aboriginal areas and objects to be affected by the project. Include management measures required prior to construction and those required throughout the life of the project. [C398]	
Commission high-order constraints papers from Aboriginal parties to identify places of Aboriginal cultural heritage significance. Ensure avoidance of these places is considered during detailed design. Ensure that operations gives effect to the avoidance principle as enunciated in the ACH Act. [C399]	Address the cultural and spiritual values associated with groundwater systems and groundwater dependent ecosystems and consider any identified values in the development and implementation of the Cultural Heritage Management Plan and other relevant documents/procedures e.g. ‘chance finds’ and site induction procedures.
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). [C400]	
Obtain all necessary permits and approvals prior to the commencement of works. [C401]	
Ensure site inductions provide cultural heritage awareness for places and objects (to avoid) and the appropriate procedures to	

Commitment	Comment
follow should there be any new discoveries. [C402]	
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. [C402]	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. [C402]
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. [C402]	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. [C402]
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. [C402]	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. [C402]

4.19 Non-Indigenous cultural heritage

Chapter 24 of the EIS provided a description of the non-Indigenous cultural heritage values within the project development area and assessed the potential for these values to be affected by direct and indirect impacts associated with the project. Appendix R, of the EIS, Non-Indigenous Heritage Impact Assessment, presented a detailed assessment of the project's cultural heritage impacts.

4.19.1 Assessment methodology

The non-Indigenous cultural heritage assessment in the EIS comprised of a desktop study, consultation and a field survey. A desktop review of existing and historical documentation was undertaken to identify sites of significance. Field surveys were conducted over the period from October through to December 2009 (focusing on the northern project development area), and again from January to March 2010 (centred in the southern part of the project development area). They targeted areas and regions with a strong likelihood of comprising heritage sites, guided by the results of the desktop study and consultation. A qualitative risk assessment was used to assess the likelihood of harm to cultural heritage sites from construction, operation and decommissioning activities, and the consequence of those impacts on non-Indigenous cultural heritage values.

4.19.2 Existing environment

The EIS identified known sites of non-Indigenous cultural heritage across the project development area comprising memorials, monuments, and the remains of historical events and activities that are typically associated with early European settlement. These included:

- No sites of world heritage or national significance; however, the Boonaraga Cactoblastis Memorial Hall (Plate 24.1) is said to have national listing qualities and the Dalby War Memorial and Memorial Park (Plate 24.2) was formerly recorded on the Register of National Estate (until being transferred to the Queensland Heritage Register).
- Nine sites with state heritage value, three of these being registered with the National Trust of Queensland and seven of these being registered with the National Trust of Queensland.
- 142 regionally known sites identified through fieldwork and consultation (60 sites), review of heritage reports (33 sites) and by Western Downs Regional Councillor and information from the Chinchilla local community (49 sites). These sites are not currently listed on any registers but hold historical interest to the local community. Some of the sites identified possess attributes that are of state significance and would warrant their inclusion on the Queensland Heritage Register.
- A likelihood of unknown non-Indigenous cultural heritage sites and values such as artefact sites from grazing and agricultural industries of local heritage value being present across the project development area. The EIS identified areas with moderate to high likelihood of containing unknown non-Indigenous cultural heritage values along major transport routes (particularly the railway lines), stock routes and old stagecoach routes, as well as river corridors and vermin fences.

4.19.3 Impacts

Table 24.4 of the EIS summarised the pre-mitgated and residual impacts of the project on non-Indigenous cultural heritage. The EIS stated that without the implementation of appropriate management controls, the project, has the potential to impact upon non-Indigenous cultural values as a result of:

- Damage or disturbance to sites or artefacts, or encroachment upon places of non-Indigenous cultural heritage during construction, operations and decommissioning.
- Accidental disturbance if construction crews are not aware of a site's or artefact's location.

4.19.4 Avoidance and mitigation measures

The EIS outlined avoidance, mitigation and management measures to reduce the potential for adverse impacts on non-Indigenous cultural heritage sites (both known and unknown). This included a suite of commitments by Arrow including preconstruction clearing surveys of sites , the development of a cultural heritage management plan including a chance finds procedure prior to commencement of ground disturbance works, notifying the relevant administering authority if any cultural heritage sites or items of significance are uncovered during construction.

4.19.5 Submissions

Submitters identified a number of issues in the EIS relating to non-Indigenous cultural heritage matters which Arrow responded to in the SREIS. Several submitters raised concerns that the non-Indigenous cultural heritage assessment only addressed European built heritage and did not adequately address non-built heritage sites relating to the history of the project development area. In response, Arrow acknowledged the importance of these sites to the community but stated that to-date, no non built heritage sites had been identified within the project area despite wide consultation with regional councils, local historic societies and archives during the assessment including asking landholders about heritage items that may occur in their properties.

4.19.6 Conclusion and recommendations

The EIS has largely met the requirements of the TOR in relation to non-Indigenous cultural heritage. It adequately described, at a project scale, existing non-Indigenous cultural heritage values and broadly considered areas most likely to contain unknown non-Indigenous cultural heritage values. The EIS provided qualitative predictions on the impacts of the project on non-Indigenous cultural heritage values, outlined frameworks for undertaking more detailed site-specific assessment of Indigenous cultural heritage values and included broad strategies to reduce the potential for adverse impacts on known and unknown non-Indigenous cultural heritage sites.

It is recommended that Arrow:

- Implement commitments outlined in Appendix 3 concerning cultural heritage.
- Develop a cultural heritage management plan prior to commencement of ground disturbance works that will mitigate and manage potential impacts on non-Indigenous cultural heritage sites - should be amended to make it explicit that non-built heritage sites relating to the history of the project development area are included.
- Consult with the community and landholders regarding the occurrence of non-built heritage sites relating to the history of the project development area and consider such values in the development and implementation of the Cultural Heritage Management Plan, ‘chance finds’ and site induction procedures and other mitigation tools aimed at minimising impacts on the project on non-Indigenous heritage values.

4.20 Hazard and risk

Chapter 25 Hazard and Risk of the EIS described the potential hazards associated construction, operation and decommissioning phases of the project, provided an assessment of their risks to people and property and outlined avoidance, mitigation and management measures. Detailed information on the hazard and risk assessment for the project was included as Appendix S, Preliminary Hazard and Risk Assessment geology, landform and soils. Updates to hazard and risk as a result of changes to the project in the SREIS was provided in Chapter 15, SREIS and a supplementary Preliminary Hazard and Risk Assessment included in Appendix 12 of the SREIS.

4.20.1 Assessment methodology

The preliminary hazard and risk assessment was completed in accordance with ISO 31000:2009 Risk Management – Principles and Guidelines (Standards Australia, 2009a), both qualitatively and quantitatively. The assessment considered risks to people and property, including the public, in the vicinity of the proposed project facilities.

The risk assessment process involved identification of the possible hazards, the causes or initiating factors of the hazardous event, the consequences of the event and the associated risks of those consequences occurring. The overall risk assessment comprised of three components: a hazard identification process, a quantitative risk assessment and a qualitative risk assessment.

The assessment of potential hazards and risks associated with the project infrastructure included consideration of CSG production wells, gathering systems and production facilities. Production facilities are assumed to comprise a combination of gas compression facilities, water treatment facilities and power generation.

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.
- Vapour cloud explosion of gas in a confined space.

A complementary qualitative risk assessment, which considered credible incident scenarios, addressed project activities and processes, such as driving, the storage and handling of chemicals and fuel, construction methods and operating procedures.

The supplementary preliminary hazard and risk assessment involved a review of project description changes and assessment of changes to the installations, materials, safeguards or systems proposed at the time of writing the preliminary hazard and risk assessment that could potentially influence the assumptions or conclusions made in the EIS.

4.20.2 Existing environment

The EIS described the environment and community that may be affected by the proposed project activities. The project development area has a widely dispersed population, except for townships such as Dalby, Chinchilla, Cecil Plains, Wandoan and Goondiwindi. The EIS stated that the dispersed population, large amount of open land and the widely distributed extent of the CSG resource supports the development of facilities in locations that maintain distance from centres of population and residential locations. This, and the inherent flexibility in the location of project infrastructure, contributes to the safety of people and property through adequate separation. Hot summers and prolonged cycle of drought and drought-breaking rains mean that the project development area may be affected by bushfires as well as floods.

4.20.3 Impacts

Coal seam gas 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 workforce.

A summary of the risk assessment, including credible hazard scenarios, possible causes and avoidance, mitigation and management measures was presented in Tables 25.10 to 25.13 of the EIS. Hazard scenarios and mitigations were grouped in terms of:

- Gas or pressure release and/or fire and explosion.
- External events such as bushfire and flooding.
- The storage and handling of hazardous materials.
- The personal safety of the project workforce.

The majority of the residual risks were assessed as either low or medium. A high residual risk was associated with road accidents involving project vehicles.

The supplementary preliminary hazard and risk assessment (Chapter 15 of the EIS and Appendix 12 of the SREIS) considered changes to the project description to confirm the buffer distances required to meet established risk criteria for both production wells and facilities. The addition of multi-well pads required some of the hazard scenarios outlined in the qualitative risk assessment to be updated. Some additional control measures were identified to manage these hazards and risks. No new hazards or risks were identified as a consequence of the project description changes and no changes are required to the consequences, likelihood or residual risk ratings detailed in the preliminary hazard and risk assessment. Overall, only minor changes have occurred to the hazards and risks identified in the preliminary hazard and risk assessment in the EIS resulting from the project description changes associated with the CGPF and production wells.

4.20.4 Avoidance and mitigation measures

Arrow outlined numerous avoidance, mitigation and management measures to minimise the potential risks to employees, the community, property and the environment from project activities (Tables 25.10 to 25.13 of the EIS). The EIS outlined a tiered management of safety hazards to be implemented through the application of site and technology selection, engineering controls, followed by procedural and behavioural controls. Main elements included:

- Site selection and engineering controls:
  - Selection of locations for project infrastructure to fully consider and allow for the minimum buffer zones indicated by the quantitative risk assessment. [C419]
  - Implementation of engineering control measures for the design, construction and operation of facilities in accordance with relevant Australian and international standards and industry codes of practice. 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.
- Procedural and behavioural controls:
  - Implementation of Arrow's health, safety and environment management system designed to manage hazard and risk through policy, standards and procedural controls. An integrated risk management plan would be built into the system and become a core component of normal operations.
  - Development and implementation of emergency response plans in consultation with emergency services organisations that includes a list of required equipment, training and other resources, and foreseeable emergency and crisis situations (including escapes, blowouts, gas fire, bushfire, critical equipment failure, trapped or missing people, flooding, cyclones, power failure, security incidents and threats, and transport incidents) [C424]
- Specific controls:
  - Development and implementation of specific controls to minimise risks specifically associated with the operation of CSG developments associated flood, bushfire, landslide, hazardous material and wildlife.

4.20.5 Submissions

Submissions on the EIS raised a range of issues relating to hazard and risk which Arrow responded to in the SREIS. The SREIS stated the issues covered the following topics: bushfires, flooding and landslides; controlled burning and farming practices; disease; emergency response; explosion risk; gas leaks; incident reporting; legislation; occupational health and safety; project infrastructure; and risk assessment.

DCS considers that Arrow provided appropriate responses in the SREIS to issues raised by the Queensland Fire and Rescue Service (QFRS) and the Queensland Ambulance Service (QAS). This includes but is not limited to a commitment from Arrow to address such issues as overcoming restrictions on site communications coverage and the interaction of Arrow and emergency services personnel and resource provision during emergency incidents. It was noted that Arrow commits to consultation with QFRS and QAS during Arrow's emergency management planning exercises where issues raised will be addressed

As a result of project changes and submissions on the EIS, Arrow provided seven updated and three new management measures (commitments) relevant to hazard and risk in the SREIS (Table 15.6 of the SREIS. The full list of commitments is included in Appendix 3.

4.20.6 Conclusion and recommendations

The EIS has adequately met the requirements of the TOR in relation to hazard impacts. The EIS has provided, at a project scale, a summary of the potential hazards associated with the project during the construction, operation and decommissioning phases of the project and conducted a broad assessment of their risks to people and property.

The DCS request that they be engaged in emergency management planning as early as possible in the detailed project design and layout.

In comments on the SREIS, DCS stressed the need for the siting of work areas and camps to have at least one emergency evaluation route that remains passable for emergency evacuations up to and including the 1:100 year flood recurrence interval event. If this cannot be achieved, there should be at least one emergency evacuation route that remains passable for emergency evacuations up to and including the 1 in 100 year event, or premises are located in an area where there is sufficient flood warning time to enable safe evacuation, or a safe refuge is available.

It is recommended that Arrow implement commitments concerning hazard and risk outlined in Tables 25.10 to 25.13 of the EIS with amendments and new commitments proposed in Table 15.6 of the SREIS. A full list of Arrow's commitments is available in Appendix 3.

4.21 Waste management

EIS Chapter 26, Waste Management identified the waste streams expected to be generated by the projects activities, provided an assessment of the potential impacts of generated waste and outlined management options for waste minimisation and disposal. A revised CSG Water and Salt Management Strategy were provided in SREIS Attachment 5 and changes to the strategy since the EIS was published were summarised in SREIS Chapter 3, Project Description.

The EIS stated that uncontrolled and controlled releases of waste associated with the projects' activities could potentially impact on land, air quality, ecology, water resources, visual amenity and health and safety. These impacts are discussed in the relevant sections of this assessment report.

This section of the assessment report assesses the adequacy of the EIS documents in addressing the waste management principles of the waste hierarchy as set out under the *Waste Reduction and Recycling Act 2011* (WRR Act). Specific consideration is given to sewage, drilling fluid, hydrostatic test water, and CSG water management including brine and water containment systems.

4.21.1 Assessment methodology

The waste assessment comprised a desktop study to identify:

- potential waste streams associated with the project's construction, operations and decommissioning activities (based on information from Arrow's existing operations);
- likely impacts associated with waste streams; and
- management options for waste minimisation and disposal.

4.21.2 Waste characterisation and quantification

Project activities expected to generate waste were outlined in EIS Chapter 5, Project Description, and updated in the SREIS, Chapter 3.

- EIS Chapter 26 provided an indicative list of potential wastes to be generated by the project, outlined the characteristics of the wastes (e.g. regulated, organic, recyclable or inert waste), estimated quantities, and proposed methods of disposal and management (Table 26.2, EIS Chapter 26). Waste products ranged from benign wastes such as soil, cleared vegetation, paper and cardboard, unused building materials and domestic wastes, to regulated wastes such as chemicals, oils and greases and crystallised salt. Estimates of the quantities of waste potentially generated by the project were not updated for the revised project description presented in SREIS Chapter 3.

The quantities of key wastes predicted to be generated by the project in large amounts over the life of the project are summarised in Table 25. The predicted quantities are based on estimates provided in Table 26.2 of EIS Chapter 26 and revised CSG water production estimates provided in SREIS Chapter 3. The EIS stated that quantities of the following wastes could not be determined at this stage of the assessment process due to the uncertainty of the final project design:

- Greywater and stormwater, contaminated stormwater runoff, domestic waste, CSG water filters and filter media, and electrical cables associated with construction and operational activities.
- Waste associated with decommissioning of the project including: electrical cables, fencing, gas pipelines, production wellheads, pumps, sewerage treatment plant and tanks and storage tanks.
- Following review of the SREIS, WDRC noted that the quantities of 'domestic' waste to be disposed of in each local government area were not provided in EIS Table 26 or the SREIS and requested that Arrow provide this information for each WDRC landfill facility.

The EIS documents state that the project would produce an average of 13 GL/a of CSG water, with peak production of 34 GL/a, and total production of 510 GL over a 40 year period. The CSG water would be extracted from the Walloon Coal Measures and would be classified as a regulated waste under the EP Act if has an electrical conductivity of greater than 1,000 mg/L and a pH between 6 – 10.5[14]. CSG water generated by the project would contain dissolved salts (3000–8000mg/L), suspended solids, ions (calcium, magnesium, potassium, fluoride, bromine, silicon and sulfate), trace metals and nutrients (SREIS Attachment 5, Coal Seam Gas Water and Salt Management Strategy).

[14] Based on EP Regulation

The EIS documents stated that chemicals that can potentially bioaccumulate within the environment would not be present in any of the project water discharges i.e. hydrotest water, sewage, CSG water and stormwater runoff. However, it did not specify whether chemicals with the potential to bioaccumulate would be used in the project and if so, how they would be managed.

Table 25 Indicative quantities of key project wastes (source: EIS Table 26.2, SREIS Table 3.1).

Waste	Quantity*
Well construction waste - Drill cuttings, drilling fluid additives, residual muds, contaminated soil	65,000m^3 - 487,500m^3 over project life Calculation based on 10 m^3 – 75 m^3 waste per well (EIS) x 6,500 wells (SREIS)
Hydrostatic test water	1,500 ML - 2,000 ML over project life Calculation based on 100 ML per gas field x 15–20 gas fields (as per estimates in EIS)
Construction oil and grease	Well construction – undefined (25 drums/year) Gas and water gathering systems – 450 kg/day Field compression - 50 L per facility CGPF - 170 L per facility CGPF with water treatment - 200 L per facility
Construction cleaning acids	Field compression - 100 L per facility CGPF - 300 L per facility CGPF with water treatment - 600 L per facility
Operations oil and grease	Engines - 750 L every 3,000 hours Compressors - 20 L/day Entrained oil – max. 30 tonne per year
Triethylene glycol	10 m^3 for each CGPF
Reverse osmosis facility treatment chemicals	Undefined (less than 1000 L per facility
Sewage	Field compression facility - 6 ML per year CGPF - 12 ML per year
Sewage sludge	CGPF with water treatment – 12 ML per year
CSG water	510 GL over project life Calculation based on SREIS estimate of 13 GL average annual production over 40 years
Crystallised salt	approx. 2.8 million tonne over project life Calculation based on SREIS estimate of 72,000 tonne annual average x 40 years
Salt precipitation waste product	approx. 288,000t over project life Calculation based on 7,200 t annual average

4.21.3 Avoidance and mitigation measures

Avoidance, mitigation and management of potential waste impacts from the project would be achieved primarily through implementation of a waste hierarchy as outlined in Figure 26.1 of the EIS.

4.21.3.1 General waste management

Arrow committed to apply the following hierarchy of management options to all waste generated during the project activities:

- Source reduction: avoid, eliminate, change or reduce practices that result in the generation of wastes.
- Reuse: reuse waste materials that are in their original form.
- Recycling: where possible, send waste to appropriate facilities to convert waste into other usable materials.

- Treatment and disposal: render wastes safe by neutralisation or other treatment methods and dispose of waste products that can no longer be reused or recycled either through landfill or incineration.

EHP is satisfied that the general waste management approaches outlined in the EIS documents are generally consistent with the management principles of the waste hierarchy as set out in the WRR Act. However, the following inadequacies are noted:

- The inclusion of an 'energy recovery' option in the waste hierarchy presented in EIS Figure 26.1 is supported. However, the EIS provided no further discussion on this matter and energy recovery measures, or examples of where energy recovery could be achieved, were not proposed.
- The EIS did not adequately consider reuse and recycling options for a number of wastes including: used oils, used chemicals, empty drums/ containers, hard waste, general waste from workers' accommodation areas, hydrostatic test water, scrap swarf (high definition polyethylene filings), unused materials or off-cuts, crystallised salt, salt precipitation waste product and CSG water.
- While the EIS documents recognised that the marketability of waste was the primary driver for recycling and stated that the project would maximise marketable volumes of recyclable waste (such as oil, metals and lead acid batteries) to local and regional business, no measures or initiatives to achieve this were proposed.

The EIS stated that general waste would be segregated, treated if necessary and stored on site prior to disposal. Segregation would include the separation of regulated and non-regulated waste, and separation of reusable and recyclable from other waste. Solid waste segregation would be achieved by the allocation of bins for different waste streams. Appropriate domestic waste disposal facilities would be provided at designated work sites to assist in segregation of waste. Onsite waste storage areas would be developed in accordance with industry practice and relevant waste management regulations. Liquid waste would be stored and periodically removed for disposal or recycling. Waste that could not be reused or recycled would be disposed of at appropriately licensed facilities.

A number of submitters, including local governments and the Hall Group, raised concerns that the impacts of the project on local and regional waste storage and disposal facilities had not been adequately addressed. WDRC requested further information on the specific impacts to WDRC facilities. Queensland Health reinforced these concerns, noting that the number of similar projects currently proposed in the area would potentially impact on local and regional waste storage and disposal sites. The submission by Queensland Health indicated that this increase in waste may significantly reduce the lifespan of landfills, affect the ability of local residents to utilise the facilities, and may have human health implications due to increased illegal dumping and/or stockpiling of waste. Queensland Health recommended that the proponent assess the project's impact on local and regional waste storage and disposal facilities, such as transfer stations and landfills. In response, Arrow stated that it would work with local governments on the management of waste associated with the project and discuss their requirements prior to construction. This would occur sequentially as the production drainage areas are developed.

The SREIS Strategic EMP included a range of general and specific mitigation measures to manage waste during the project phases. These included:

- Develop and implement emergency response and spill response procedures to reduce impacts that could occur as a result of releases of hazardous materials or loss of containment of storage equipment.
- 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).
- Develop onsite waste storage areas in accordance with industry practice and relevant waste management regulations.
- Procure materials in bulk where practicable to minimise containers and movement of material.
- Provide training in the principles of the waste hierarchy to personnel handling wastes on a regular basis.
- Quantify the type, severity and extent of soil or groundwater contamination and remediate or manage in accordance with the Queensland Government's Guideline for contaminated land professionals
- Carry out waste audits and reporting for waste generating activities to:
  - Provide waste data to enable continuous improvement of waste avoidance, reduction and management measures throughout the project life.
  - Assess whether action is required to meet waste objectives and management.
  - Assess the adequacy of proposed mitigation measures and identify where mitigation measures need revision or additional measures.
  - Monitor potential environmental impacts to enable positive action to be implemented in case of incidents or accident related to waste activities.
  - Provide actual waste management results by comparing predicated impacts and mitigation measures.
- Store liquid waste (other than CSG water and sewage) and periodically remove such waste for disposal or recycling.
- Dispose of waste that cannot be reused or recycled at appropriately licensed facilities.

- Store putrescible solid waste in covered containers to prevent odours, public health hazards and access by fauna.
- Contain all waste fluids and muds resulting from drilling activities in properly lined dams or storage tanks for in-situ treatment or disposal.
- Determine the reuse of waste largely by the salvage value of the material, and provide for onsite segregation and storage. The following possible reuse options were listed:
  - Reuse of cleared vegetation for mulch and soil erosion control.
  - Reuse of brine for production of potentially saleable salt products and implementing salt crystallisation.
  - Segregation of wastewater streams, i.e., contaminated stormwater, waste waters and CSG water.
  - Reuse of treated waste water for dust suppression, construction activities or irrigation.
  - Reuse of treated CSG water for town water supply, where of appropriate quality.
  - Reuse of hydrostatic test water.
  - Reuse of treated water for agricultural use, industrial use, potable water supply or injection into aquifers.
  - Treatment and reuse of solid wastes, such as drilling muds and cuttings, as soil conditioners, road base or construction material where practicable.
- Use onsite waste treatment for such purposes as sewage, CSG water and other specified wastes. Sewage would be treated in packaged sewage treatment plants.
- Sewage treatment plants would be located at production facilities and include settlement, digestion, aeration, clarification and disinfection equipment.
- Handle, store and dispose of regulated wastes in accordance with relevant standards and the Environmental Protection (Waste Management) Regulation 2000.
- Comply with Queensland Government waste tracking requirements.
- Segregate general waste, treat it if necessary and store it onsite prior to disposal.

4.21.3.2 Sewage

Sewerage treatment facilities would be required and installed at accommodation sites. Arrow committed to connecting operations phase wastewater and sewerage systems to existing sewerage systems where locally present. Alternatively, wastewater treatment or reuse systems would be installed in accordance with AS/NZS 1547:2000, On-site Domestic Wastewater Management (Standards Australia, 2000), relevant guidelines for managing sewerage infrastructure to reduce overflows and environmental impacts, and the Queensland water recycling guidelines (DERM, 2005).

The former DERM requested further information on the methods for treated effluent disposal including the location of any infrastructure and land disposal sites. Arrow provided no further information on how treated effluent would be managed in the SREIS but committed to not releasing any water to land during the construction and operation phases of the project. Arrow stated that sufficient information on sewage treatment and disposal (in accordance with the EHP guideline ‘Application requirements for petroleum activities’; EHP, 2013c), would be provided with an application for an EA or EA amendment.

4.21.3.3 Contaminated soils

The EIS classified soils contaminated by CSG water as a regulated waste under the EP Act. The EIS proposed that soil contaminated by CSG water would be buried on-site or disposed of in an off-site landfill. Burial of soil contaminated by CSG water on-site is not an appropriate disposal strategy for a regulated waste which must be disposed of at a licensed facility. EHP advised that soil contaminated by CSG water may not necessarily be considered a regulated waste. EHP would condition Arrow in the EA to have contingency plans to deal with any unauthorised discharge of CSG water and also requirements for notification should an event occur. It would be Arrow’s responsibility to remediate any harm caused and this would be enforced through compliance action if required.

The former DERM submission on the EIS identified salt contamination of soils as a significant issue that had not been adequately addressed. In response, Arrow referred to commitments to develop and implement emergency response and spill response procedures, to excavate any saline material during rehabilitation of coal seam water dams and brine dams, and to select the most appropriate waste management measure (e.g. treat for reuse or dispose of in a registered landfill). EHP advised that soils contaminated by CSG water must be assessed and appropriately managed in accordance with the EP Act.

4.21.3.4 Drilling fluid

The EIS estimated that 200,000L of drilling fluid (also known as mud or drill mud) would be used to lubricate and cool the drill bit and flush out the drill cuttings drill a production well. Drilling waste was classified as a regulated waste under the EP Act (Table 26.2, EIS Chapter 26, Waste management) and Arrow stated that its preference was to use an inert, water-based drilling fluid largely comprised of fresh water and 2 - 3% salt, to increase the mud weight and prevent natural clay in the formation from swelling. The EIS proposed that the following additives would be used in the drilling fluid (based on the composition of drilling fluids used in Arrow's current activities): clay stabilisers (calcium chloride, calcium chloride anhydrous and potassium chloride), cement additive (bentonite and calcium sulphate), disinfectant (biocide), viscosifier (FS2000, XCD polymer and NIF 20 liquid), foaming agent (Tuff-Foam Ultra) and fluid loss prevention (Tuff- Loss). Drilling fluid would be collected at the surface either in small pits or, where wells are constructed on intensively farmed land, in surface tanks. The drilling fluid would be either removed from site for disposal at a licensed facility or stored in purpose-built containment structures on the property and recycled where possible.

WDRC raised concerns in their submission on the EIS about the volume of mud used in the drilling of the wells. Arrow responded that the volume of muds used in the drilling of the wells would be continually monitored and at the completion of drilling, the muds would be stored in surface containers for potential recycling and re-use during the drilling of other wells.

Following review of the SREIS, QMDC commented that a number of matters pertaining to the potential contamination of land from drilling fluids remained outstanding. They argued that the EIS had not adequately quantified the volume of treated or untreated drilling fluids to be generated by the project, defined disposal and management strategies for drilling fluids including the location of proposed disposal sites; or adequately defined risks associated with the use and disposal of drilling fluid.

EHP considers that the drilling fluid additives have not been adequately described in terms of their potential toxicity, or assessed for potential for environmental harm associated with their use. EHP advised that waste drilling fluids and/or cuttings would be considered a regulated waste if they contained any of the items (or residues of any of items) listed in Schedule 7 of the EP Regulation, e.g. alkaline solutions, solvents or oils. On-site disposal of drill fluid would only be possible for drill cuttings/muds that have low toxicity, are easily biodegradable and have little impact on the environment.

Arrow has committed to provide sufficient information on drilling fluid additives and an assessment of their impacts on environmental values in accordance with the EHP Guideline 'Application requirements for petroleum activities' (EHP, 2013c) in support of an application for an EA or EA amendment.

4.21.3.5 Hydrostatic test water

The use, composition, management and disposal of hydrostatic test water were discussed in EIS chapter 15, SREIS chapter 3, and the SREIS Attachment 2, Strategic Environmental Management Plan. Submissions on the EIS expressed concern that insufficient information had been provided on hydrostatic testing, including storage, disposal, reuse, and associated risks. This was highlighted in the EIS submission from the former DERM, which stated that the Environmental Management Plan referred to hydrostatic test water but did not include adequate detail on potential sources, additives, storage or disposal.

Arrow provided further explanation on the hydrostatic testing process in the SREIS, and reiterated the commitment to prepare and implement a hydrostatic testing procedure prior to commencement of hydrostatic testing activities. While SREIS Chapter 3, Project description, provided additional information on typical water sources for hydrostatic test water such as property dams or local watercourses, no specific sites were defined. The SREIS included a recommendation that hydrostatic test water be treated with biocides and oxygen scavengers which can be neutralised, are biodegradable, and do not bio-accumulate in the soil, but no further information was provided.

The SREIS stated that hydrostatic test water may be recycled for secondary uses (in line with relevant statutory water quality guidelines), and indicated the hydrostatic test water could be discharged but provided no further information. Hydrostatic test water may be discharged to land or water if authorised under an EA.

Specific details on quantities, storage and disposal of hydrostatic test water and potential risks to environmental values consistent with the EHP Guideline 'Application requirements for petroleum activities', would need to be provided by Arrow in support of an application for an EA or EA amendment. Arrow stated that consultation with landholders and relevant regulatory authorities would occur prior to sourcing and disposing of hydrostatic test water.

4.21.3.6 CSG water management

Management strategy

EIS Attachment 9, Coal Seam Gas Water Management Strategy, presented a high level overview of options under consideration for the treatment and disposal of CSG water. Figure 7 outlines a conceptual overview of potential CSG water and brine management for the project. The EIS did not commit to a specific option, but treatment using reverse osmosis technology was stated to be the preferred option.

The EIS, Chapter 5, Project Description, proposed six integrated gas and water processing facilities at conceptual locations. SREIS Chapter 3, Project Description, presented a revised project description involving only two water treatment facilities - a northern facility co-located with CGPF2 north of Miles to treat approximately 35 ML/d of water, and a southern facility co-located with CGPF9 near Cecil Plans to treat approximately 90 ML/d. Infrastructure proposed for the treatment and storage of CSG water included feedwater and treated water storage dams, reverse osmosis water treatment plants and brine storage dams. A distribution network for beneficial use of treated water, and brine treatment facilities, may also be developed. Project water management would require raw (untreated) water dams with possible capacity from 450 ML to 1,050 ML, and treated water dams with a possible capacity from 900 ML to 4,200 ML. In addition, brine dams with an overall capacity of approximately 90 ML to 2,880 ML would be needed.

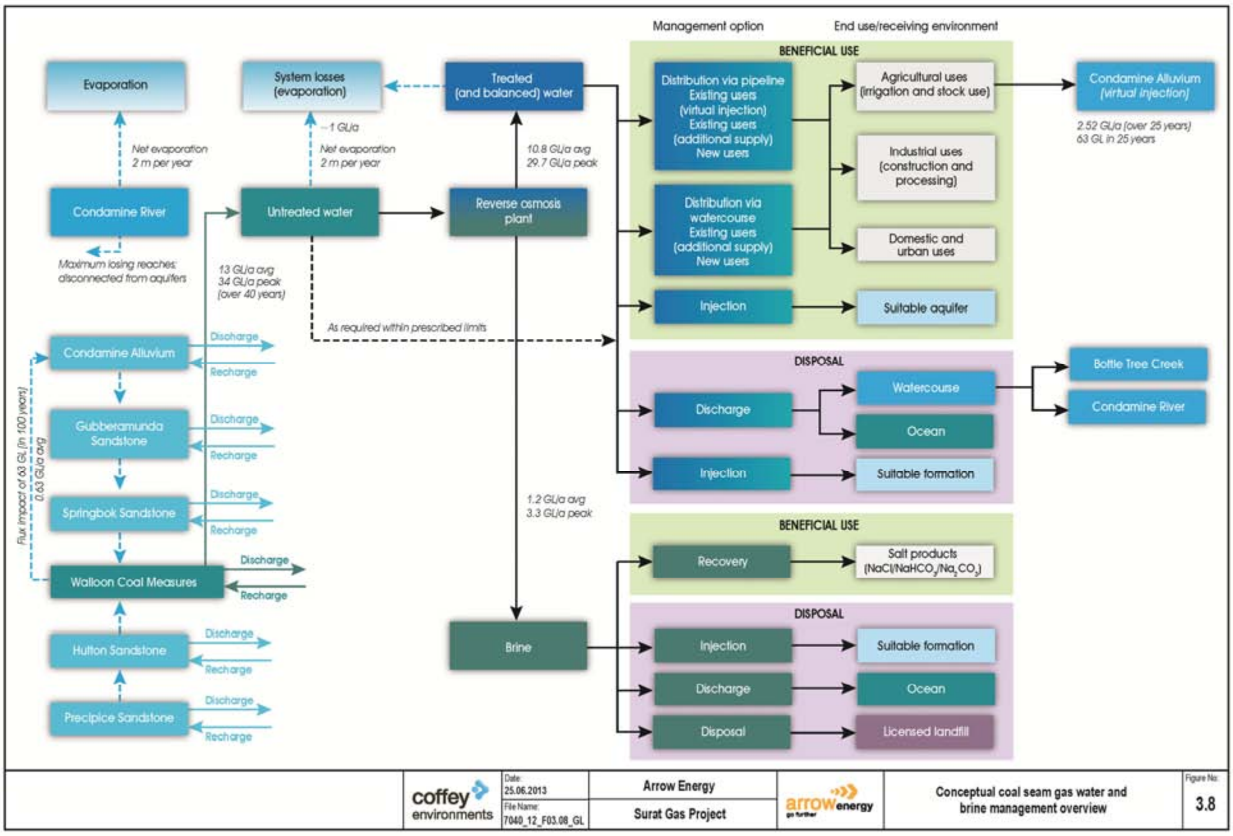


Figure 7 Conceptual overview of potential CSG water and brine management for the project (source: SREIS, Figure 3.8, Chapter 3, Project description).

SREIS, Attachment 5, Coal Seam Gas Water and Management Strategy, provided an updated list of options for the disposal of treated CSG water, brine and salt, including:

- beneficial use of treated CSG water by third parties
- re-injection of treated CSG water into a suitable aquifer
- disposal of treated CSG water to Bottle Tree Creek and the Condamine River
- disposal of treated CSG water to sea
- salt recovery from the brine and production of marketable salt products
- brine injection into a suitable formation

- disposal of brine to sea
- disposal of salt to landfill.

The proposal to discharge treated and untreated CSG water to surface waters adjacent the proposed treatment facilities is discussed in sections 4.10 Surface water and 4.11 Aquatic ecology of this assessment report.

Beneficial use of CSG water (treated and untreated) was proposed as the preferred management option, which could include its distribution for substitution and augmentation of existing groundwater allocations (irrigation and stock use), industrial uses, potable town water supply, and injection into depleted groundwater aquifers. The proposal to maximise beneficial use of CSG water, with quality appropriate for the intended use, is consistent with the second and third principles of the WRR Act waste hierarchy. However, an estimate of the volume or percentage of water to be directed to beneficial use was not provided. Distribution of CSG water for beneficial use via pipeline or watercourse was proposed but no further details were provided, other than in relation to proposed discharge to watercourses. Beneficial use approvals under the EP Act would be required.

SREIS, Attachment 5 stated that injection of treated CSG water into aquifers in the Surat Basin was currently not an option as no appropriate regulatory framework was in place and injection trials for the Precipice Sandstone had not yet been approved by EHP. Any approval of injection required completion of injection trials which were expected to take a significant amount of time. A large number of submissions on the EIS raised concerns with the adequacy of assessment of the feasibility and potential impacts of injection of CSG water or brine from treatment facilities, into groundwater aquifers. In response, Arrow referred to the regulatory framework relating to injection and the ongoing trials.

The EIS included commitments relevant to this matter in addition to make-good commitments consistent with the Water Act. Arrow proposed to verify the preferred water management strategy by modelling the effectiveness of substitution (‘virtual injection’) and injection (if conducted) in offsetting depressurisation impacts in the Condamine Alluvium.

Arrow proposed to supply of 2.5 GL/yr over 25 years for substitution in an intensively developed location within the greater Condamine Alluvium to the west of Dalby. The area was selected because maximum CSG related drawdowns were predicted for this part of the Condamine Alluvium, and it was assumed that sufficient existing entitlement holders would agree to substitution in order to offset Arrow’s proportion of the predicted flux impacts (63 GL) for the calibrated OGIA groundwater model.

A number of submissions on the EIS considered that insufficient detail had been provided on the beneficial use of CSG water, particularly for irrigation, and the potential for contamination of land and water. In response, Arrow referred to the requirements of the Queensland Government’s Coal Seam Gas Water Management Policy, and stated that CSG water management would be developed further through detailed engineering design and that selected management options would be detailed in the CSG water management plan. Arrow also highlighted that it intended to demonstrate the beneficial use of CSG water and the integration of CSG infrastructure with farming operations on its own properties. Statutory information requirements for management CSG water would be provided in accordance with the EHP Guideline 'Application requirements for petroleum activities' to support an application for an EA or EA amendment.

In comments on the SREIS, EHP, DSITIA and DNRM noted that Arrow has developed the Theten Property as a demonstration project for beneficial use of co-produced water. They noted that Arrow has relied on ANZECC guideline values for water and soil conditions when considering use of treated CSG water for irrigation. DNRM highlighted uncertainty associated with ANZECC guideline values and recommended caution when considering the application of the water quality guidelines for specific uses of the water. In particular, DNRM advised that the ANZECC guidelines do not fully consider all aspects of the risks to the environment (e.g. increasing salinity risk) and recommended that Arrow examine all risks inherent in applying large volumes of CSG water to land and in demonstrating that the activities would not cause environmental harm now or in the future. Advice from DAFF reinforced this concern, noting that the chemical composition of water can affect the long-term health of soils and livestock (e.g. high levels of fluoride can cause bone brittleness and fertility issues in cattle).

A number of submitters requested further information on the means by which treated water would be made available to substitute for existing entitlements, water quality requirements, and equity and legal issues relating to substitution. Arrow clarified that distribution of water to existing users (for substitution of their existing groundwater allocations from the Condamine Alluvium and/or as additional supply), or to new users, would require the development of water supply agreements between Arrow and each of the third party users. Arrow would deliver agreed volumes of CSG water, at an agreed quality, under a water supply agreement with third parties, and in accordance with regulatory requirements.

Submissions on the EIS raised concerns that use of CSG water for dust suppression on roads, tracks and construction sites could adversely affect soils due to the high salt/sodium content. In response, Arrow referred to the commitment that, where used for dust suppression on roads or for construction and operations activities, CSG water quality would be in accordance with relevant approvals.

The SREIS (chapter 3, Table 3.1 and Figure 3.8) proposed the discharge of CSG water to Bottle Tree Creek and the Condamine River during times where:

- it could not be beneficially used
- significant weather events occur
- operational upset conditions necessitated discharge
- the structural and operational integrity of dams was at risk.

Section 9.2.1 of SREIS chapter 9, Surface Water, stated that the two proposed water treatment facilities would discharge CSG water to nearby watercourses under both normal operations and emergency situations in order to manage variations in seasonal conditions and as a means of distribution to existing and new water users for beneficial use and injection to a suitable aquifer. These discharges were proposed to occur as required and within limits to be determined by subsequent investigations in support of an application for an environmental authority. No information on the potential volume or quality of CSG water to be discharged was provided. The SREIS proposed site-specific assessments to determine the appropriate discharge regime to minimise impact on the environment. This matter is further discussed in section 4.10 Surface water and 4.11 Ecology of this assessment report.

Advice provided DNRM based on review of the SREIS indicated that the impacts of the proposal to discharge CSG water that was not able to be beneficially used would need further consideration as substitution of irrigation water would not provide a continuous use option due to the seasonality of irrigation demand, and because irrigation demand would not account for the full volume of co-produced water. DNRM stated that use of water for substitution may not be possible for five months each year.

EHP review of SREIS Attachment 5, Coal Seam Gas Water and Salt Management Strategy, highlighted the following concerns with proposed CSG water management:

- The strategy described the regulatory framework for CSG water management and the management options being considered by Arrow, but did not make a commitment to prioritise management options in accordance with management hierarchy in the CSG Water Management Policy (EHP, December 2012) or provide project specific details about CSG water management.
- The strategy did not provide project specific details about the management of CSG water as required by s126 of the EP Act.

Brine and salt management

SREIS Chapter 3, Project description estimated that a total of 48GL of brine would be generated through reverse osmosis treatment of CSG water over the life of the project. This was based on an average generation of 1.2GL/a brine over a 40 year period, with 3.3GL/a being produced during peak times. The brine would be stored in four brine storage dams associated with the two water treatment facilities, located on the CGPF2 and CGPF9 properties. The EIS provided a commitment to ensuring sufficient capacity was available to store brine until such time when permanent disposal options became operational. Under the Queensland Government CSG Water Management Policy, CSG water evaporation dams are not considered to be an acceptable management strategy. In response to submissions on this issue, Arrow stated that evaporation dams would not be used as a method of brine disposal.

A number of options for brine management and disposal were considered in SREIS Attachment 5:

- Injection of brine into suitable aquifers was discounted as no suitable target formations were identified that would have a water quality low enough to take the brine.
- Disposal of brine via a pipeline to an undefined ocean discharge location was stated as an option. Feasibility of this option was not evaluated although initial studies were reported to have commenced.
- The preferred option for brine treatment was stated to be selective salt recovery to produce marketable salt products as a beneficial use. Arrow is reported to be investigating viable options for the beneficial use of brine. Selective salt precipitation trials have been undertaken by Arrow to: define the chemical composition of the brine; identify methods to enhance precipitation; and to identify viable processes to transform the brine into commercial products such as salt or soda ash. If salt recovery was to be undertaken, a salt recovery plant would be required, either as a joint-industry facility or a facility owned by the proponent. No further information was provided in the EIS documents on the potential location of such a facility, timing of commencement of operation, or the quantity of brine from the project that may be treated.

Submissions on the EIS raised concerns about the potential impact of brine spillage in transit, and with road safety and maintenance issues associated with increased truck movements. Particular concerns were raised about the logistics and long distances involved in trucking brine waste to a regulated waste facility at Swanbank. In response, Arrow provided a commitment to not dispose of brine (as a salt concentrate) to the regulated waste facility at Swanbank. Further, it was stated that disposal of brine and salt to a licensed landfill would only be pursued if beneficial use options were determined to be economically or logistically unfeasible. Arrow expected that other suitably licensed landfill sites would be developed in response to the demand created by the CSG industry and these sites would be available to accept brine produced in the project. SREIS chapter 3 stated that brine would have to be trucked from the planned water treatment facilities at CGPF2 and CGPF9 to a suitably-licensed facility.

CSG water and brine containment systems

SREIS Attachment 5, Coal Seam Gas Water and Management Strategy provided a description of dams required to provide operational storage or water balance capacity to ensure the containment of CSG water and brine, including:

- Aggregation dams to contain untreated CSG water from the gathering network and provide a buffer to accommodate variations in CSG water production and treated water flows.
- Treated water dams to contain treated CSG water and provide a buffer to balance treated water output and beneficial use demand.
- Utility dams to contain waste lubricants and chemicals used in water treatment and gas compression systems.
- Brine dams to contain brine produced during the reverse osmosis water treatment process.

The storage dams would be located with CGPF2 and CGPF9, although specific locations were not defined. Dams associated with exploration activities were considered temporary and due to distance, and associated cost, would not be connected to water gathering pipelines and treatment facilities.

The ranges of dam sizes being investigated for each water treatment facility were provided as follows (SREIS chapter 3):

- Raw (untreated) water aggregation dams - approximately 450ML - 1050ML each.
- Treated water dams - approximately 900ML - 4200ML each.
- Brine dams - approximately 45ML - 1440ML total capacity.

A number of submissions, including the submission by the former DERM, raised concerns about the potential for containment system failure, including loss of integrity due to flooding, overflow, and the risk of contamination of land and waters. The former DERM specifically requested that management of water levels in storage dams (raw and treated) provide for water to be drawn down in spring and early summer (particularly years when above average rainfall is predicted i.e. associated with a La Nina event), in order to minimise emergency discharge or dam failure. In response, Arrow referred to the commitment to design, construct, and monitor new dams in accordance with the requirements of the most recent version of EHP's Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (C141; DERM 2011) and highlighted design requirements in this document aimed at preventing overflow during heavy rainfall events and potential seepage to groundwater systems. Arrow did not commit to any specific operational measures.

The detailed design for water treatment facilities and associated infrastructure was not provided but a number of commitments addressed management actions to limit the risk of dam failure, overflow, and salt contamination. These included:

- dams for CSG water and brine not to be located on intensively farmed land
- dams to be designed and constructed by suitably qualified and experienced persons
- the design and size of dams to account for predicted flood conditions
- subsurface investigations to be undertaken to characterise the soil and groundwater conditions beneath and surrounding dams
- incorporation of an impervious lining in dams
- the installation of leak detection monitoring wells around brine dams
- development and implementation of emergency and spill response procedures
- brine and CSG water storage dams to be located on properties owned or leased by Arrow.

4.21.4 Conclusion

The EIS documents have adequately met the TOR requirements in relation to general waste management. The overall commitment and effort to apply and implement waste management principles in accordance with applicable legislation has been adequately demonstrated for waste other than CSG water. The waste hierarchy has been appropriately identified, generally adopted for identified waste streams, and reflected in generic and specific management measures. However, more specific and detailed waste management measures need to be developed to ensure that the waste hierarchy would be effectively implemented.

As feasibility studies for the management options identified to meet the CSG Water Management Policy priorities have either not been carried out or are incomplete, the policy requirements have not been adequately addressed. The SREIS acknowledged the limitations of the CSG water management assessment and committed to further investigating beneficial use and disposal options.

Arrow committed to provide required information on waste management as outlined in EHP Guideline 'Application requirements for petroleum activities' in support of an application for an EA or EA amendment.

4.21.5 Recommendations

Approvals under the EP Act

The following information on waste management is required as part of an EA, or EA amendment, application:

- An assessment of 'energy recovery' as an option in the waste management hierarchy.
- Measures to maximise use of marketable volumes of recyclable waste by local and regional businesses.
- Detailed information on reuse or disposal of treated effluent.

Section 126 of the EP Act requires specific details about the management of CSG water to be provided in support of an application for an EA, or EA amendment, including:

- The quantity of CSG water expected to be generated
- The expected flow rate of generated CSG water
- The quality of the CSG water including expected changes in water quality
- The proposed management of CSG water
- Measurable criteria for monitoring and assessing the effectiveness of the management
- Corrective actions to be implemented should compliance with the measurable criteria not be achieved.

In addition, any applications that include a request for beneficial reuse of CSG water should include the information required to assess and condition the BUA. Details of requirements are set out in the EHP Guideline 'Application requirements for petroleum activities (EM705)' section 3.7 Waste.

For local governments

Details of the project's requirements for local and regional waste storage and disposal facilities (i.e. transfer stations and landfills) should be provided to all affected local governments well before the project construction begins.

General conditions

The commitments made by Arrow (listed in Appendix 3 of this assessment report) are appropriate for the management of waste generated by the project and should be implemented. Table 26 Arrow commitments – recommended changes, provides recommendations on changes to a number of specific commitments concerning waste management for the project. The commitments identified should be amended as recommended.

Table 26 Arrow commitments – recommended changes

	Commitment	Recommended Amendment
C058	Arrow will apply the following hierarchy of management options to all waste generated during the project activities: • Source reduction: avoid, eliminate, change or reduce practices that result in the generation of wastes. • Reuse: reuse waste materials that are in their original form. • Recycling: where possible, send waste to appropriate facilities to convert waste into other usable materials. • Treatment and disposal: render wastes safe by neutralisation or other treatment methods and dispose of waste products that can no longer be reused or recycled either through landfilling or incineration.	Details of how this hierarchy will be applied to major waste streams should be provided as a component of the information required with an application for an EA or amendment to an EA.
C202	Contain coal seam gas water in dams for treatment through reverse osmosis.	Preferable that CSG water is treated directly and not stored.
C210	Have in place a system for the collection and proper disposal of any contaminants that move beyond the bounds of the containment system of brine dams.	Brine dams should be designed and constructed to minimise the risk of any movement of contaminants. Relevant monitoring systems should be installed with all brine dams.
C411	Contain all waste fluids and muds resulting from drilling activities in properly lined dams or storage tanks for in situ treatment or disposal.	Drilling fluids should be stored in above-ground tanks where drilling occurs on intensively farmed land.

	Commitment	Recommended Amendment
C469	Use onsite waste treatment for such purposes as sewage, coal seam gas water and other specified wastes. Sewage will be treated in packaged sewage treatment plants. Sewage treatment plants will be located at production facilities and include settlement, digestion, aeration, clarification and disinfection equipment.	Details of any proposed discharge from waste treatment should be provided to EHP.
C492	Design the storage capacity of coal seam gas water and brine dams to be sufficient to manage waste liquids until such time that permanent disposal options are operational.	Storage dams will not be designed for evaporation of CSG water or for permanent storage of brine
C495	Comply with Queensland Government waste tracking requirements.	Applies to regulated waste
C539	Maintain and update a water balance model that includes but is not limited to: • Monitoring of volume and quality of coal seam gas water produced and treated. • Monitoring of disposition volumes of treated and untreated coal seam gas water. • Monitoring of the volume of brine and its by-products used beneficially or disposed to landfill.	Regulated under the EA and other approvals.

5 Matters of National Environmental Significance

5.1 Introduction

This section of the report addresses the requirements of the Queensland Government‘s assessment as specified by Schedule 1 of the bilateral agreement between the Australian Government and the Queensland Government relating to environmental assessment, section 59 of the Environmental Protection Act 1994 (EP Act) and Section 9 of the EP Regulation.

This section provides an evaluation of the potential impacts of the project on MNES determined by the Australian Government to be controlling provisions under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and should be read in conjunction with Attachment 1 MNES of the Supplementary Report to the Surat Gas Project EIS (SREIS) which supersedes Attachment 3 MNES of the EIS and addresses the controlled action Referral No. EPBC 2010/5344.

5.2 Controlling provisions

On 2 February 2010, Arrow Energy Pty Ltd (Arrow) referred the Surat Gas Project (EPBC 2010/5344) to the Australian Government Minister for the former DSEWPaC, now the Department of Environment (DOE) (hereafter referred to as the Australian Government Environment Minister) for a determination as to whether the project would constitute a ‘controlled action’ with respect to potential impacts on MNES under sections 75 and 87 of the EPBC Act.

On 26 March 2010, the delegate of the Australian Government Environment Minister determined the project to be a ‘controlled action’ pursuant to section 75 of the EPBC Act. The relevant controlling provisions for the project were determined as being:

- sections 18 and 18A (listed threatened species and communities)
- sections 20 and 20A (listed migratory species).

Revisions have been made to the schedules of the EPBC Act for a number of species relevant to the project since the project was declared a controlled action. The MNES assessment for the project is not affected by additions to the lists of species, or up-listing of a threatened species status, made after the Australian Government Environment Minister decided the project was a controlled action. Where a species has been removed from the list, no assessment is required under the EPBC Act. However, these species have been included in the MNES assessment by the proponent and are described in Attachment 1 of the SREIS.

Changes made to the threatened species list since March 2010 relevant to the project are as follows:

- Koala (*Phascolarctos cinereus*) populations in Queensland, New South Wales and the Australian Capital Territory are now listed as vulnerable under the EPBC Act (previously not listed).
- King blue grass (*Dicanthium queenslandicum*) status listed as endangered (previously vulnerable).
- Brigalow scaly-foot (*Paradelma orientalis*) removed from the list (previously vulnerable)
- Wardell’s wattle (*Acacia wardellii*) removed from the list (previously vulnerable)
- Australian painted snipe (*Rostratula australis*) status listed as endangered (previously vulnerable).

Coal seam gas and large coal mining developments with the potential to have a ‘significant impact’ on water resources now require referral to and possibly approval from the Commonwealth Environment Minister under the EPBC Act. Under the transitional arrangements for commencement of the amendments to the Act, the project was assessed as to whether the new water trigger would apply. On 24 September 2013, the Commonwealth Minister for the Environment made a proposed decision that the water trigger applied to the project, On 17 October 2013 the Commonwealth Minister for the Environment made a final decision that the water trigger apply to the project.

This assessment of impacts on matters of MNES Chapter does not include an assessment of impacts on water resources. However, a comprehensive assessment of impacts on water from a State perspective is provided in section 4.9 and 4.10 of this assessment report. More detailed information on water is available in the EIS documents. EHP is of the view that there will not be an unacceptable impact on water resources.

5.3 Assessment process

The project is being assessed under Part 1 of Chapter 3 of the EP Act and the EP Regulation, in accordance with the bilateral agreement between the Australian Government and the Queensland Government (the bilateral agreement). The controlled action will be considered for approval under section 133 of the EPBC Act once the Australian Government Environment Minister has received this EIS Assessment Report from the delegate under the EP Act.

Potential impacts on MNES have been assessed throughout the EIS process for the project and addressed specifically as a consolidated report in SREIS Attachment 1. However, as the SREIS was prepared prior to notification that water resources was a controlling provision, it has not been addressed in the SREIS Attachment 1. Water resources were, however, addressed in the SREIS in Chapters 8 Groundwater; 9 Surface Water; 10 Aquatic Ecology; Attachment 4 Commitments Update; and Appendices 4 to 8.

DOE has been consulted on the evaluation of potential impacts and the adequacy of information with respect to potential impacts and mitigation measures on MNES throughout the EIS process and during the preparation of this report, in accordance with the bilateral agreement.

The Australian Government has established an Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC). The IESC provides scientific advice to decision-makers on the impact that CSG and large coal mining development that may impact on Australia's water resources. The project EIS was referred to the IESC on 14 January 2013 by DOE. The IESC's advice to the department dated 20February 2013 was published on its website in March 2013. The SREIS was also referred jointly by DOE and EHP to the IESC for their advice in August 2013. The Australian Government Environment Minister will consider the IESC's advice for the project in making a decision on whether or not to approve the project under the EPBC Act.

The evaluation of potential impacts on MNES presented in this report is based on information contained in the EIS, SREIS and a response by Arrow to an information request from EHP on impacts on MNES (Attachment 1). Also considered was advice from DOE in relation to the adequacy of the SREIS and particularly the adequacy of SREIS Attachment 1 (MNES).

5.4 Description of the proposed action

Arrow is seeking approval to construct, operate and decommission the project, located approximately 160km west of Brisbane in Queensland's Surat Basin. The project would form an expansion to Arrow's existing operations in the Surat Basin to cater to growing demand for gas in the Australian and global liquefied natural gas market.

Arrow is a wholly owned subsidiary of Arrow Energy Holdings Pty Ltd, a 50:50 joint venture between a subsidiary of Royal Dutch Shell plc and a subsidiary of PetroChina Company Limited (PetroChina). The EIS stated that the company has interests in more than 65,000km2 of petroleum tenures, mostly within Queensland's Surat and Bowen basins but also in the Clarence-Moreton, Coastal Tertiary, Ipswich, Styx and Nagoorin Graben basins. Arrow currently operates existing gas fields, facilities and infrastructure in an area near Dalby, and supplies gas to the domestic market for power generation and other domestic uses.

The proposed project is located approximately 160km west of Brisbane and would extend in an arc from Wandoan in the north to south west of Millmerran, covering an area of 6,100km2 (See Figure 1). Project infrastructure, including up to 6,500 CSG production wells and production facilities (including both water treatment and power generation facilities where applicable), would be located throughout the project development area but not in towns. However, facilities supporting the petroleum development activities, such as depots, stores and offices, may be located in or adjacent to towns.

The gas resources for the project lie within the Walloon Coal Measures of the Surat Basin. The Walloon Coal Measures are characterised by carbonaceous mudstone, siltstone, minor sandstone and coal; and include the Juandah Coal Measures, Tangalooma Sandstone, Taroom Coal Measures, and Durabilla Formation. Of these four formations, the Juandah and the Taroom coal measures, which generally range in depth from 150 to 750m below ground surface across the project development area, are targeted by Arrow for exploration and production.

Coal seam gas refers to the methane gas lining the open fractures between the coal and the inside of pores within the coal. Coal seams store both gas and water, with the water, which is under pressure from the weight of overlying material, holding the gas in place. When the water pressure is reduced by pumping from a coal seam, the gas is released and flows to the surface through the well. Gas and water are separated below ground in the well, with water being transferred to centralised collection and treatment points and the gas being piped to production facilities where it is dried, compressed and piped to market.

Coal seam gas production typically requires the extraction of large quantities of groundwater to depressurise coal seams to allow the gas to flow. Arrow has indicated that six months of dewatering is typically required to allow gas flow, and 18 months of dewatering is required to reach peak gas production from a well, although it could take several years depending on the characteristics of the coal seam. Average CSG water production was estimated to average 13GL/a over the life of the project, with peak production estimated at 34GL/a. Water quality from the Walloon Coal Measures can vary considerably but is typically high in salinity and other dissolved solids and requires management and treatment consistent with the Queensland Government Coal Seam Gas Water Management Policy (EHP, December 2012).

The project is proposed to be developed in eleven sequentially numbered drainage areas corresponding to the gas reserves that would supply a central gas processing facility (CGPF). Eight of these drainage areas are proposed to be developed initially (drainage areas 1, 2, 5, 7, 8, 9, 10 and 11), with a further three drainage areas having potential to be developed subject to favourable gas reserves and future market conditions. Each drainage basin would incorporate gas production wells, a CSG water gathering network, a low-pressure gas gathering network and a CGPF. Up to six field compression facilities may also be required, typically located between gas production wells and the CGPFs. Two CSG water treatment facilities are proposed to be co-located with the CGPFs in drainage area 2 and drainage area 9. Six temporary worker accommodation facilities (TWAFs), each to accommodate between 450 and 1,050 personnel, are proposed to be located within the same properties as the nearest CGPF.

Additional infrastructure would include:

- Medium-pressure gas pipelines to transport gas between field compression facilities and central gas processing facilities.
- High-pressure gas pipelines to transport gas from central gas processing facilities to the sales gas pipeline.
- Electricity transmission infrastructure drawing electricity from the grid via third-party substations or from gas-powered electricity generation equipment co-located with production facilities.

The SREIS Chapter 3 states that about 6,500 production wells would be drilled over the 35 year expected life of the project. Wells would be drilled from both single-well pads and multi-well pads comprised of up to 12 wells, spaced approximately 8m apart. A likely configuration of the multi-well pads would be one central vertical production well, with the remainder of the wells being deviated (directionally drilled) production wells.

The updated Coal Seam Gas Water and Salt Management Strategy (SREIS Attachment 5) states that CSG water would be discharged from each water treatment facility to a nearby watercourse as required and within prescribed quantity and quality limits. Discharge to watercourses is proposed as a management option to address the uncertainty of a range of other CSG water management options including distribution to existing and new water users for beneficial use and injection into a suitable groundwater aquifer.

The selection of equipment and design of facilities is stated to be subject to ongoing review to maximise efficiency and meet specific gas field development requirements. Disturbance area estimates provided for specific project infrastructure include:

- low pressure gas gathering line corridors - 20m wide
- medium pressure gas gathering line corridors - 25m wide
- single gas well pads - 100m by 100m
- multi-well pads - 200 by 100m
- field compression facilities - 100m by 50m
- CGPF - 350m by 520m
- CSG water treatment facilities - 202ha
- 132-kV overhead transmission lines corridors - up to 60m
- 275-kV overhead transmission lines - up to 120m
- TWAFs - 500m by 500m.

5.5 Places affected by the proposed action

The development area for the project is as shown in Figure 1 of this report. Project related infrastructure could be located anywhere within the development area. However, Arrow has yet to determine the exact locations of production wells, gas processing facilities, water treatment facilities, temporary workers accommodation, and other project infrastructure.

The EIS presented conceptual designs and potential areas for development for the purposes of identifying, describing and assessing the likely impacts. The SREIS presented a significantly reduced development area and revised conceptual design, including identification of the properties on which each of five CGPFs (of a potential eight CGPFs), two proposed water treatment facilities (reduced from six), and one TWAF (of a potential six TWAFs) are proposed to be located, although the actual location of infrastructure within these properties was not defined.

The EIS outlined the following key factors as influencing location of project components:

- ongoing exploratory drilling and pilot well programs to define viable gas reserves
- consultation with landholders
- environmental and social impact management
- economic and commercial risks that influence the extent and rate of field development
- ongoing refinement of the field development plan over the life of the project
- development of new technologies, standards and practices.

Specific locations for project infrastructure are proposed to be defined as engineering and other studies and consultation progress throughout the life of the project. The EIS presented a planning and management process based on technical studies and defined constraints (referred to as an “environmental framework”) to be used by Arrow to inform site selection and manage the potential impacts of development. This planning approach would also inform locations of infrastructure that would minimise impacts on MNES, particularly habitat.

5.6 Assessment method

As the actual location of all project facilities and infrastructure were not defined, the potential impacts of the project on MNES were described as being indicative of the scale of impacts that were likely to occur. The EIS documents described the likely typical impacts of project activities and outlined an internal process, known as the environmental framework approach, developed by Arrow to avoid and manage the impacts of CSG development where the location of infrastructure becomes known progressively over the life of the project. The environmental framework approach would include environmental controls and constraints that reflect the sensitivity or vulnerability of environmental values at a particular location. Constraints mapping, informed by the EIS documents findings, was proposed to guide the selection of sites and infrastructure routes to avoid and minimise impacts, and was used in conjunction with a conceptual development layout (that included an optimised and grid layout for parts of the project development area) to inform the estimates of potential impacts to MNES.

Under the proposed environmental framework approach, Arrow would rely on preconstruction and pre-approval surveys to confirm the ecological assessment for a specific site, to provide a basis for site-specific management measures required to avoid or minimise impacts, and to define the actual impacts on MNES which would then be used to determine offset requirements.

The DOE submission on the EIS requested more detail about when preconstruction surveys would be undertaken, proposed methodology, and how these surveys would inform the location of infrastructure and therefore determine the measures needed to avoid and mitigate and offset impacts. In response, Arrow referred to the management approach presented SREIS Chapter 11, Terrestrial Ecology, Section 11.5 and stated that field verification of vegetation communities and habitat features would be undertaken prior to preconstruction clearance surveys to determine the level of survey effort required, appropriate to each species as outlined in species dossiers within SREIS, Attachment 1, Appendix C. The SREIS also presented the results of ecological assessments (equivalent to the preconstruction surveys) in five areas proposed for the location of major project infrastructure as a demonstration of the staged assessment approach, although further surveys would be required when the actual location of infrastructure within these areas is defined.

The methodology for impact assessment for terrestrial ecology was outlined in EIS Chapter 17 , SREIS Attachment 1, and detailed in EIS Appendix K, Terrestrial Ecology Impact Assessment, including:

- Assignment of a level of confidence to habitat mapping for flora and fauna species, noting that this was based on an assumption that the mapping of regional ecosystems in the project development area was correct.
- Desktop investigations and targeted field assessment.
- Qualitative assessment of impacts to define sensitivity of habitats, local flora populations and fauna populations
- Qualitative sensitivity assessment and ranking.
- Impact magnitude ranking.
- Impact significance assessment and ranking, based on sensitivity and impact magnitude ratings.

The methodology for impact assessment for aquatic ecology followed a similar approach to that outlined in SREIS Attachment 1, Chapter 16 of the EIS, and detailed in the Section 3.5 of SREIS Appendix 8, Supplementary Aquatic Ecology Assessment.

5.6.1 Threatened ecological community and threatened species habitat

The area of TECs and threatened species habitat within the project development area was estimated based on existing regional ecosystem mapping published by the Queensland government, and on revised mapping for parts of the project development area based on surveys conducted for the EIS documents. The accuracy of the estimates was limited by the uncertain accuracy of the regional ecosystem mapping used (except where determined by field survey), inclusion of more than one regional ecosystem in mapped polygons (which would require field survey to resolve), and by assumptions made in correlating TECs and species habitat with regional ecosystems.

5.7 Mitigation measures

Table 27 MNES Potential impacts and Mitigation measures summarises the general measures proposed as commitments by Arrow to avoid or minimise impacts to TECs and threatened species.

Table 27 MNES Potential Impacts and Mitigation measures (source: SREIS Attachment 1 Section 8)

Potential Impacts	Mitigation measures
Clearing and fragmentation	Avoid direct impacts to critically endangered TECs and aim to avoid impacts to other TECs and the core habitat of threatened species (C217, C218, C240) with reference also to the 'environmental framework approach'. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C245, C246, C250) with consideration of the preconstruction clearance surveys. (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of terrestrial habitat	Fell trees away from existing stands where practicable (C241) and avoid damaging standing trees not identified for removal (C242). Retain woody debris, logs and rocks for use in rehabilitation of fauna corridors and to provide fauna refuge. (C238) Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472). Erosion and sediment and control measures (C034, C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Standard industry noise suppression techniques. (C254) Reduce light spill resulting from project activities to reduce disturbance to nocturnal fauna. (C255) Prohibit unauthorised collection of flora products. (C256) Reinstate self-supporting drainage lines (C251) and maintain natural surface water flows (C221) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Degradation of aquatic habitat	Avoid watercourses and riparian areas, minimise crossing width and disturbance, and co-locate crossings, where practicable (C185, C186, C191, C194) Buffer development from Broadwater Conservation Park and the high bank of watercourses (undefined width) (C156, C157) Erosion management at water discharge locations (C066, C561) and generally (C024, C034, C261, C505, C507) Stockpile cleared vegetation away from watercourses (C197) Manage herbicide use (C199) Develop and implement emergency response and spill response procedures (C036, C037)
Weed and pest fauna invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193)

Potential Impacts	Mitigation measures
	Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)
Injury to fauna	Manage food waste to limit fauna access (C212, C258) Design dams to limit fauna access (C243) and allow for fauna escape (C214) Manage risk to fauna from open trenches (C233, C500) Retain habitat trees where practicable (C234) and manage clearing of habitat trees (C235, C236, C237, C473) Speed restrictions (undefined) (C260) Manage overhead powerline risk to migratory birds (C562)

In addition to the general measures listed above, the following species specific measures were proposed:

- *Macrozamia machinii*:
  - Record the location of any newly identified populations of Machin's macrozamia (Macrozamia machinii) and confidentially notify relevant authorities. (C563)
- *Microcarpaea agonis:*
  - Develop a site-specific management plan to reduce changes to wetland habitat hydrology, including water quality, in areas of ground-truthed populations of Microcarpaea agonis adjacent to work sites. (C558).
  - Restrict access to any ground-truthed populations of Microcarpaea agonis identified adjacent to work sites. (C559).

In addition to the general measures listed above, a specific measure was proposed to protect migratory species through avoiding construction activities in waterbodies frequented by migratory species. (C225)

Concerning protection of the Murray cod, goodoo (Maccullochella peelii peelii), EHP considers that although the spread and introduction of 'exotic' species (i.e. exotic fish) is identified as a potential impact there are no mitigating measures relating to monitoring for the spread or introduction of these species and what action is required if they are found. There is only one measure relevant to controlling release of CSG water which has been included in this table (C561) but this may not be effective in relation to maintaining natural flow regimes to prevent spread of exotic fish.

A detailed assessment of project impacts on individual listed threatened species and communities is available in Appendix 5 to this assessment report.

5.8 Estimates of disturbance area for TECs and threatened species habitat

In the absence of defined locations for project infrastructure, Arrow provided estimates of the potential maximum disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. Estimates of the total potential disturbance areas represent the sum of:

- For core habitat known, the disturbance area comprised the total area of core habitat intersected by the conceptual field layout.
- For core habitat possible, the disturbance area comprised 10% of the core habitat possible intersected by the conceptual field layout. In effect, this method is the same as upgrading 10% of the core habitat potential to core habitat known.
- For general habitat, the disturbance area comprised 2% of the general habitat intersected by the conceptual field layout. The estimate of 2% reflects the extent of actual disturbance (wells, gathering lines, access tracks and production facilities) of the entire project.

It should be noted that the estimated disturbance area for each habitat class assumes complete clearance of identified parcels of habitat, not just the actual footprint of habitat encountered by the conceptual field layout for the location of CGPF, water treatment facilities and TWAFs. The accuracy of the disturbance area estimated for the entire project development area was limited by the uncertain accuracy of habitat mapping derived from regional ecosystem mapping, and particularly by the lack of site-specific information on the potential layout of all works and infrastructure required by the project. However, as the base mapping of habitat (RE mapping) is considered to be an overestimate due to the assignment of habitat types to Regional Ecosystems (REs) (the whole RE is treated as habitat) and the extent of disturbance considers that any intersection with the conceptual field layout would result in the complete clearing of identified parcels of habitat for major infrastructure, EHP is of the view that the estimates provided are conservative and could be considered ‘worst case’. Furthermore, it is considered that this conservatism would take into account impact areas associated with degradation of the condition of the remaining areas of habitat due to edge effects, etc. DoE is of the view that the estimates do not necessarily represent a worst case estimate for whole of project impacts to all listed threatened species and communities. DoE will consider Arrow’s approach in its assessment of impacts.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments. For this reason, EHP considers that a conservative approach in the estimation of maximum disturbance areas for threatened species and ecological communities is also considered appropriate.

5.8.1 Listed threatened ecological communities

The following Table 28 TEC Estimates of Impact Area provides a summary of the known or potentially occurring threatened ecological communities within the project development area, their estimated extent, and the estimated maximum disturbance area for the total project. The general advice in relation to the accuracy of mapping and estimates of disturbance area should be considered.

Table 28 TEC Estimates of Impact Area (source: Arrow Energy Pty Ltd EPBC 2010/5344 Response to request for information, 2013)

Ecological Community	EPBC Act Status	Area of Community Within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Brigalow (*Acacia harpophylla* dominant and co-dominant)	endangered	7,387	106
Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland	critically endangered	678	0
Coolibah - Black box woodlands of the Darling Riverine Plains and Brigalow Belt South Bioregions	endangered	206	8
White box – Yellow box – Blakely’s Red gum grassy woodland	critically endangered	260	0
Semi – evergreen vine thickets of the Brigalow Belt and Nandewar Bioregions	endangered	35	0
Weeping Myall Woodlands	endangered	<1	<1

Specific advice on each TEC is included in Appendix 5 to this report.

5.8.2 Listed threatened flora species

The following Table 29 Threatened Flora Species Estimates of Impact Area provides a summary of the known or potentially occurring threatened flora species, the estimated extent of their habitat within the project development area, and the estimated maximum habitat disturbance area for the total project. The general advice in relation to the accuracy of mapping and estimates of impact should be considered.

Table 29 Listed Threatened Flora Species Estimates of Impact Area (source: Arrow Energy Pty Ltd EPBC 2010/5344 Response to request for information, 2013)

Common Name	Scientific Name	EPBC Act Status	Estimated Extent of Habitat and Maximum Area of Potential Disturbance (ha)					
			Core Habitat Known		Core Habitat Possible		General Habitat	
			Extent	Impact	Extent	Impact	Extent	Impact
Austral toadflax	*Thesium australe*	vulnerable	77	0	9,798	16	7,472	11
Belson's panic	*Homopholis belsonii*	vulnerable	0	0	8,802	14	101,715	41
Cobar greenhood orchid	*Pterostylis cobarensis*	vulnerable	0	0	121,901	217	0	0
Curly-bark wattle	*Acacia curranii*	vulnerable	0	0	73,351	121	1,264	10
Finger panic grass	*Digitaria porrecta*	endangered	622	14	10,809	16	6,943	10
Hando’s wattle	*Acacia handonis*	vulnerable	0	0	73,521	121	1,302	10
Tara wattle	*Acacia lauta*	vulnerable	0	0	43,028	99	6,348	4
Lobed blue-grass	*Bothriochloa biloba*	vulnerable	371	5	20,146	30	12,210	18
Machin’s macrozamia	*Macrozamia machinii*	vulnerable	1,379	0	24,432	0	0	0
Kogan wax flower	*Philotheca sporadica*	vulnerable	655	0	32,380	48	76,712	44
unnamed mint-bush	*Prostanthera* sp. (Dunmore)	vulnerable	1,179	0	39,553	38	0	0
Small-leaved denhamia	*Denhamia parvifolia*	vulnerable	0	0	2,348	5	0	0
Xerothamnella	*Xerothamnella herbacea*	endangered	55	0	7,768	11	336	0
Hawkweed	*Picris evae*	vulnerable	0	0	5,314	12	5,361	10

Common Name	Scientific Name	EPBC Act Status	Estimated Extent of Habitat and Maximum Area of Potential Disturbance (ha)					
			Core Habitat Known		Core Habitat Possible		General Habitat	
			Extent	Impact	Extent	Impact	Extent	Impact
No common name	*Microcarpaea agonis*	endangered	0	0	0	0	2226	NA[15]
Austral cornflower, native thistle	*Rhaponticum australe*	vulnerable	0	0	9,661	16	6,313	8
Gurulmundi fringe-myrtle	*Calytrix gurulmundensis*	vulnerable	0	0	60,538	12	360	4
Ooline, scrub myrtle	*Cadellia pentastylis*	vulnerable	0	0	2,672	0	1,423	0
Shiny-leaved ironbark	*Eucalyptus virens*	vulnerable	0	0	3,318	17	4,360	1
King blue-grass	*Dichanthium queenslandicum*	endangered	0	0	10,856	16	7,472	11
Queensland western white gum	*Eucalyptus argophloia*	vulnerable	0	0	4,028	1	0	0
*Wardell's wattle	*Acacia wardellii*	vulnerable	0	0	28,828	57	19,803	22

*delisted

Specific advice on each the following key species is included in Appendix 5 of this report:

- Curly-bark wattle *Acacia curranii*
- Hando's wattle *Acacia handonis*
- Lobed blue-grass *Bothriochloa biloba*
- Kogan wax flower *Philotheca sporadica*
- Unnamed mint-bush *Prostanthera* sp. (Dunmore)
- Small-leaved denhamia *Denhamia parvifolia*
- Gurulmundi fringe-myrtle *Calytrix gurulmundensis*
- Ooline, scrub myrtle *Cadellia pentastylis*
- Finger panic grass *Digitaria porrecta*

A detailed species dossier, including information on threats, impacts and mitigation and management measures for each flora species identified in Table 5.3 is available in the SEIS at Attachment 5 Appendix C MNES Community and Species Profile Dossiers.

EHP notes that the Australian government will require offsets for residual impacts in accordance with the EPBC Act Environmental Offsets Policy.

EHP is of the view that the project will not result in an unacceptable impact on EPBC listed threatened flora species.

[15] Likely no impact – wetland species.

5.8.3 Listed threatened fauna species

The following Table 30 Threatened Fauna Species Estimates of Impact provides a summary of the known or potentially occurring threatened fauna species, the estimated extent of their habitat within the project development area, and the estimated maximum habitat disturbance area for the total project. The general advice in relation to the accuracy of mapping and estimates of impact should be considered.

Table 30 Listed Threatened Fauna Species Estimates of Impact Area (source: Arrow Energy Pty Ltd EPBC 2010/5344 Response to request for information, 2013)

Common Name	Scientific Name	EPBC Act Status	Estimated Extent of Habitat and Maximum Area of Potential Disturbance (ha)					
			Core Habitat Known		Core Habitat Possible		General Habitat	
			Extent	Impact	Extent	Impact	Extent	Impact
Birds								
Australian painted snipe1	*Rostratula australis*	endangered migratory	255	0	225	0.5	1,373	0.5
Regent honeyeater	*Anthochaera phrygia*	endangered	57	0	5,255	2	24,926	16
Squatter pigeon (southern)	*Geophaps scripta scripta*	vulnerable	17,576	471	144,623	279	46,037	24
Mammals								
South-eastern long-eared bat	*Nyctophilus corbeni*	vulnerable	14,268	520	182,570	356	0	0
Fish								
Murray cod, goodoo	*Maccullochella peelii peelii*	vulnerable	0	0	0	0	0	0
Reptiles								
Dunmall's snake	*Furina dunmalli*	vulnerable	0	0	210,400	440	0	0
Five-clawed worm-skink	*Anomalopus mackayi*	vulnerable	0	0	14,299	56	0	0
Collared delma	*Delma torquata*	vulnerable	604	0	4,927	9	67,998	30
Darling Downs earless dragon (grassland earless dragon)	*Tympanocryptis cf. tetraporophora*	endangered	0	0	10,916	55	0	0
Fitzroy River turtle, Fitzroy tortoise, Fitzroy turtle	*Rheodytes leukops*	vulnerable	0	0	0	0	0	0
Yakka skink	*Egernia rugosa*	vulnerable	0	0	22,569	31	197,449	90

Specific advice on each the following species is included in Appendix 5 of this report:

- South-eastern long-eared bat *Nyctophilus corbeni*
- Murray cod, goodoo *Maccullochella peelii peelii*

• Dunmall's snake	*Furina dunmalli*
• Five-clawed worm-skink	*Anomalopus mackayi*
• Fitzroy River turtle, Fitzroy tortoise, Fitzroy turtle	*Rheodytes leukops*

A detailed species dossier, including information on threats, impacts and mitigation and management measures for each fauna species identified in table 5.3 is available in the SEIS at Attachment 1 Matters of National Environmental Significance.

EHP notes that the Australian government will require offsets for residual impacts in accordance with the EPBC Act Environmental Offsets Policy.

EHP is of the view that the project will not result in an unacceptable impact on EPBC listed threatened fauna species.

5.8.4 Migratory species

The following table provides a summary of the EPBC Act listed migratory species known or potentially occurring within the project development area. Thirty-five listed migratory bird species have been recorded in or near the project development area.

Seven migratory species were recorded during field surveys;

- White-bellied sea-eagle
- White-throated needletail
- Great egret
- Rainbow bee-eater
- Spectacled monarch
- Rufous faintail
- Lathams snipe.

Nearly half of the migratory species known to occur within the project development area are shorebird species, typical of estuarine habitats. These species are present in Australia during the northern hemisphere winter, although small numbers may occur during the rest of the year. These species may occur at Lake Broadwater and other permanent and semi-permanent watercourses, which are likely to provide suitable habitat for listed migratory species. Away from Lake Broadwater, the likelihood of important populations of any listed migratory species being present within the project development area has been assessed by the proponent as low or very low.

Estimates of the area of migratory species habitat and maximum habitat disturbance area were not provided, although painted snipe and regent honeyeater are also threatened species for which disturbance estimates were provided and a detailed species analysis is included in the SEIS for these species.

Arrow advised that many migratory species potentially present in the study area are generalist species and it is not possible to isolate a particular habitat type of importance to such species. No important populations of listed migratory species were identified although Lake Broadwater was stated to be likely to provide suitable habitat for many threatened flora and fauna species and may support important populations of migratory species. EHP would limit CSG activities within a protection zone around the Lake Broadwater Conservation Park to ensure there were no adverse impacts from CSG activites on the values of the Conservation Park. Typically protection zones are in the range of 200 to 300 metres for CSG activities. The SEIS did not include specific mapping of the habitat of migratory species. Profiles of migratory species potentially affected by the project and the key existing threats to the species are provided in Appendix 5 of this report.

6 Environmental management plan

EIS Attachment 5 presented an Environmental Management Plan intended to meet the requirements of section 5 of the TOR, and section 310D of the *Environment Protection Act 1994*. The SREIS presented a revised Strategic Environmental Management Plan (SREIS Attachment 2) in partial response to a number of deficiencies identified by DERM (now EHP) and other submissions to the EIS, particularly in relation to:

- the location of infrastructure and particularly major infrastructure such as gas processing plants, water treatment plants, and quarries;
- spatial analysis of impacts including cumulative impacts
- constraints mapping and application of constraints to avoid and mitigate impacts
- management of CSG water
- management of potential impacts to cropping land
- rehabilitation
- monitoring.

In response to submissions, Arrow clarified that the Strategic Environmental Management Plan was a preliminary document and did not contain all the site-specific information required to support an application for an environmental authority, or amendment to an environmental authority, for all of the project components. Arrow further stated that statutory information requirements, including details relating to section 310D of the EP Act, would be provided in accordance with the EHP Guideline "Application requirements for petroleum activities" to accompany the application for an environmental authority or amendment.

Following review of the SREIS, EHP noted that, while environmental management plans are no longer required under the amended EP Act (as also identified in the SREIS), the content and structure of the Strategic Environmental Management Plan would be partly transferable into a document suitable for submission with an application for an environmental authority. EHP recommended that Arrow ensure that the information provided with the application meets the requirements of sections 125 and 126 of the EP Act.

7 Recommendations about the suitability of the project

In this EIS process the information compiled by Arrow about the environmental values of the proposed project development area, and the potential impacts on those values from project activities, has been scrutinised by representatives of state and local government, industry and members of the public through an open, public review process. The proponent has also met the EIS process requirements including notification, responding to comments and submissions as required by Chapter 3 of the EP Act.

The EIS adequately complied with the TOR and has outlined a range of mitigation measures to avoid or minimise environmental impacts. While the majority of issues were covered satisfactorily in the EIS and in the proponent's responses to the submissions and revised documents, a number of issues have not been fully resolved. These have been clearly outlined in the relevant sections of this assessment report.

EHP has considered the submitted EIS, all submissions and the EP Act standard criteria. The project is assessed as being suitable to proceed on the basis of any subsequent environmental authorities being conditioned suitably to implement the specific environmental protection commitments set out in the EIS documentation and as described in this report. Consequently, the project is considered suitable to proceed to the next stage of the approval process noting that the recommendations of this assessment report should be fully implemented.

8 Recommendations and outstanding matters

This assessment concludes that the EIS documents and assessment process has adequately complied with the requirements of the EIS process in the EP Act. The requirements of the terms of reference have been adequately met and the EIS documents have outlined a range of mitigation measures to avoid or minimise environmental impacts. While the majority of impacts and issues were covered satisfactorily in the EIS and in the proponent's responses to the submissions and revised documents, a number of issues have not been fully resolved. These have been clearly outlined in the relevant sections of this assessment report and are discussed for each of the key areas of the project assessed in the EIS documents.

Due to the nature of the project, specific locations for project infrastructure and activities have not been selected and the delivery of the project will be progressive over a 40 year period. This provided particular challenges for this assessment. In dealing with this, Arrow used a 'constraints approach' to direct site selection as part of an overall 'environmental framework' for avoiding, minimising, mitigating and managing environmental impacts due to the project.

EHP considers the approach taken by Arrow in the EIS to address impacts is suitable for the nature of the project. Generally the commitments made in the EIS are supported and if implemented, would result in an acceptable level of environmental impact.

The lack of certainty about the preferred location of infrastructure means that a number of the recommendations are concerned with Arrow providing this information to obtain the necessary approvals required for delivery of the project, particularly those approvals needed under the *Environmental Protection Act 1994, Petroleum and Gas (Production and Safety) Act 2004,* Water Act, and the *Environment Protection and Biodiversity Conservation Act 1999 (Cwth).*

Details of outstanding matters are provided in each section of this report.

The following is a summary of the main findings and outstanding matters.

8.1 Air quality

The EIS documents demonstrated that with the appropriate locating of project facilities and infrastructure and with the implementation of site-specific mitigation measures at some locations that the project impacts would meet or be within acceptable limits defined in the Environmental Protection (Air) Policy 2008.

In the more closely settled locations in the project development area, the setback distance needed to achieve acceptable contaminant levels at sensitive receptors is likely to pose a significant constraint to the siting of these facilities. This is more relevant to the siting of central gas processing facilities (and associated water treatment plants) which are the main sources of air emissions particularly if onsite power generation is undertaken. If these facilities are proposed to be located closer to sensitive receptors than the distances indicated in the EIS, a detailed assessment would be required that demonstrated that EPP (Air) quality standards could be achieved.

EHP would impose relevant air emission conditions (including the control and management of nuisance odour) on the project.

8.2 Greenhouse gas emissions and climatic adaptations

The EIS documents reported that there would be potential for impacts to the Earth's atmosphere from the greenhouse gas emissions from the project's activities. While the mitigation measures proposed in the EIS documents are supported, it is recommended that a number of Arrow's commitments be reworded and strengthened to ensure that a reduction in greenhouse gas emissions occurs by the timely uptake of greenhouse emissions programs and initiatives.

In order to ensure that the project is fully prepared for the effects of climate change it is recommended that the climate change adaptation strategy commitments stated in the EIS documents be fully implemented.

8.3 Geology, landform and soils

A number of commitments to avoid, minimise and manage impacts on landform and soils in particular were provided in EIS. The EIS outlined how the project would be configured to avoid quality and problem soils by informed site selection as well minimising the disturbance foot print by the use of improved well development technology (directional drilling, multiwell pads). Arrow committed to work with landholders to ensure the location of project infrastructure minimised adverse impacts on soils, overland flow and erosion.

This assessment recommends that Arrow make good its commitment to undertake initiatives to provide greater certainty regarding the restoration and rehabilitation of vertosols impacted by compaction.

Detailed measures for management of risks associated with accidental release or spills that could cause contamination or degradation of soils, would need to be included in management plans to be developed as part of the approvals for the delivery of the project.

DNRM advised that additional information would be needed to meet the application requirements under the SCL Act particularly regarding the re-instatement of soils impacted by disturbance and/or compaction or that was gravelled and used as access tracks and padded areas.

The assessment report recommended that all relevant commitments in the EIS documentation should be implemented by Arrow (once appropriate changes identified in the assessment report have been made) and fully integrated in the proposed project plans, operational plans and rehabilitation plans that would be needed to obtain the necessary approvals for the project to proceed.

8.4 Agriculture

EHP considers that the EIS documents have adequately identified the agricultural values of the project development area and the overall impacts that would occur on agricultural land should the project proceed. Measures are proposed that would minimise and manage those impacts.

As a result, this assessment considers that the EIS documents have adequately described the potential impacts of the project and their implications for grazing land and for some aspects of dry land cropping land. Mitigation measures – planned siting of infrastructure that minimises impacts on intensively farmed land and disruption of agricultural activities (‘environmental framework’) and appropriate management measures (outlined in commitments) – were provided in the EIS documents to avoid, minimise and manage impacts on agriculture.

Commitments to locate central gas processing facilities, water treatment facilities, brine and water storage ponds and other major project facilities off intensively farmed land are supported.

The assessment report acknowledges that due to lack of information about the location of project infrastructure and facilities, site-specific impacts at a property or farm scale could not be determined. These matters will need to be dealt with within the approvals process for CSG activities under the EP Act, Water Act, P&G Act and relevant policies and guidelines.

Arrow would need to address the following outstanding matters:

- For intensively farmed land, that Arrow’s commitment that the company would not develop on intensively farmed areas until it had satisfactorily addressed concerns’ (SREIS Chapter 19, Table 19.10 Issue R10011) should be addressed.
- All commitments made in the EIS concerning agriculture, including recommended amendments by DAFF and changes and additions to the commitments identified in this assessment report, should be implemented and where possible, incorporated in any approvals required.
- Additional (site-specific) information would need to be provided to DNRM for it to assess impacts on SCL. This would need to include information that demonstrated that SCL was avoided and where impacted, that successful reinstatement, particularly of gravelled access tracks and infrastructure padded areas could be achieved and that the original natural ground level could be restored.
- Implement the measures proposed in the SREIS to achieve ‘co-existence’ with agriculture. It should be noted that until the proposed Darling Downs Regional Plan is finalised, it is not known whether the proposed measures will meet the requirements of the plan.

Arrow would also need to implement its commitments on biosecurity (once they had been updated consistent with the advice from DAFF), particularly those relevant to control the movement of weeds, adverse impacts on barrier (pest) fences, management of agricultural chemicals and impacts on forestry land.

8.5 Groundwater

The Office of Groundwater Impact Assessment consider that the EIS has adequately described the projected impacts of the project on the groundwater aquifers in the project development area and that these impacts would be within the levels determined to be acceptable. Mitigation and monitoring activities have also been described, however detailed groundwater monitoring plans will need to be developed and implemented as directed by OGIA.

In particular, projected impacts on the groundwater of the Condamine Alluvium have been identified as being within acceptable levels. While it is acknowledged that the modelled estimates of impacts on groundwater aquifers in the EIS are conservative, there remains some uncertainty regarding impacts due to a lack of definitive understanding of the interconnectivity between the groundwater in the Walloon Coal Measures and the Condamine Alluvium. Better information on this interaction is being collected in research projects currently underway.

Approvals required under the Water Act that would include requirements to ‘make good’ on impairment of private bore water supplies within the cumulative management area.

8.6 Surface water

The EIS documents have demonstrated that project infrastructure can be located to minimise impacts on waterways and overland flow paths and to avoid or minimise the risk of flooding.

Commitments are made not to divert overland flow, to control erosion, to protect water quality and to minimise contamination of surface waters.

Local changes to overland flow and flooding resulting from project activities remain uncertain due to the lack of certainty in the location of project infrastructure and qualified commitments to location and design. While the commitments regarding the siting of project infrastructure and management measures outline a general approach to minimise this risk, specific and measurable/auditable measures need to be developed. Notably, these measures will need to describe how, and to what extent, connectivity of surface water flow would be maintained.

The proposed project included the discharge treated or untreated CSG water to waterways at two of the sites. While a number of studies were undertaken to determine the preferred location of the facilities and discharge points, including a geomorphic assessment, overland flow and flooding EHP, DSITIA or NRM have indicated that various aspects of the proposal require attention before an approval could be given for the discharge. Arrow would need to provide information on water quality (background and discharge), in stream ecology, in stream flows, proposed discharge regimes (timing and quantities), and potential geomorphic impacts.

Proposed stream discharges may also require applications to amend The Basin Plan (Cwth) (for discharges to the Condamine River system in the Murray Darling Basin) and/or the Water Resource (Condamine and Balonne) Plan 2004 and associated Resource Operations Plan (ROP) under the Water Act.

The EIS documents have demonstrated that using the a geomorphic assessment of the five properties which include the preferred locations for several of the central gas processing facilities and water treatment plants as well location of stream discharge points, can be located to avoid or minimise impacts due to flooding, in stream impacts.

8.7 Aquatic ecology

The EIS documents provided a qualitative assessment of potential impacts of the project, estimates of mitigation of impact through implementation of stated measures, and estimates of the residual impact on specific aquatic ecology values.

Detailed measures for management of risks associated with accidental releases or spills, and for weed and pest management, were proposed to be included in management plans to be developed as part of the approvals for the delivery of the project.

The proposed discharge of treated and untreated CSG water to watercourses would require additional detailed information to support an application to EHP under the EP Act, including information on the assessment of potential cumulative impact on water quality.

Environmental offsets were not proposed as the actual offset area requirements will not be determined until pre-construction surveys are completed and the actual location of infrastructure is defined. A draft strategy outlining a proposed approach to meet environmental offset obligations under Queensland and Commonwealth legislation was provided.

More detailed technical information will be required to support applications for an environmental authority. Key requirements of relevance to aquatic ecology:

- Exact location of water discharge/release points with description including environmental values of the release point and reasoning for site selection based on risk assessment of impacts to environmental values.
- Source of release water including quantity and quality.

- Proposed monitoring program including parameters, frequency and locations supported by program review procedures to ascertain effectiveness of the program.

DAFF requires that any works in watercourses would need to meet standards of the self-assessable codes, but if not a development approval will be required, and consultation with DAFF can help determine the fish passage requirements for such approval.

8.8 Terrestrial ecology

The EIS documents provided a qualitative assessment of potential impacts of the project, estimates of mitigation of impact through implementation of stated measures, and estimates of the residual impact on specific terrestrial ecology values.

Values of terrestrial ecology were identified at a project scale and confirmed in areas where detailed ground surveys have been completed. Estimates of the area of disturbance to ecological communities and threatened species habitat have been provided but the accuracy is uncertain due to uncertainties in the regional ecosystem mapping and the conceptual nature of the proposed project infrastructure layout that was used to identify impacts.

Commitments are made to undertake detailed site surveys to assist in the determining the location of project infrastructure and in establishing the actual impacts that would occur.

A number of commitments regarding inspection and monitoring related to protection of terrestrial biodiversity values were provided but key features for monitoring details of the species, habitat, or other features will need to be specified. This information should be included in a species management plan that would include species specific measures for protection and mitigation of impact.

Detailed measures for management of risks associated with weed and pest management, were proposed to be included in management plans to be developed after the EIS process.

Arrow has made a number of commitments relating to rehabilitation including site planning, preparation and management requirements in accordance with an approved plan (to be prepared).

Specific environmental offsets were not proposed as Arrow’s draft offset strategy proposes to determine the actual offset area requirements once pre-construction surveys are completed and the actual location of infrastructure is defined. A draft offset strategy was provided that outlines a staged delivery of offsets consistent with environmental offset obligations under Queensland and Commonwealth legislation and policy.

Additional information that would be needed in an application for an environmental authority incudes site-specific impacts, mitigation and management measures, and proposed offsets.

8.9 Landscape and visual amenity

The EIS documents identified potential project impacts on landscape and visual amenity values and a suite of mitigation measures were proposed. While the proposed mitigation measures are supported, there are a number of outstanding matters that would need to be addressed by Arrow prior to project commencing.

This assessment report recommends that:

- Arrow prepare and implement a Landscape and Visual Amenity Management Plan for the planning and design, construction, operation and decommissioning phases of the project, detailing measures to minimise visual impacts on landscape.
- When siting facilities, a landscape planner and/or landscape architect should be engaged to assist with minimising adverse impacts on the landscape and visual amenity.
- Construction sites should be landscaped following completion of construction to improve the visual amenity of the new plant site.
- Infrastructure should be designed with a low profile, shape and colour to maximise visual integration with the local surroundings.

Specific detailed mitigation measures should be developed to address potential impacts to landscape and visual amenity from proposed water and brine treatment facilities including raw and treated water dams and brine storage ponds.

8.10 Roads and transport

TMR advised that it is satisfied with some of Arrow’s intentions to update the road impact assessment, draft road use management plans, and to provide suitable mitigation measures. However, further consultation, information and specific action are required regarding a number of significant issues prior to the project proceeding, including:

- Information on the proposed upgrading of the State-controlled road network to ensure the ongoing safety efficiency and existing conditions of state-controlled roads and local roads is in accordance with the objectives and provisions of the relevant legislation including the *Transport Infrastructure Act 1994*, the *Transport Operations (Road-use Management) Act 1995* and TMR policies and guidelines (e.g. GARID).
- Once traffic information based on the final design and construction of the project, including traffic generation, is available, finalised road impact assessment (RIA), road-use management plan (RMP) and any traffic management plan(s) (TMP) are to be provided to clearly identify any necessary improvement works, rehabilitation and maintenance and road-use management strategies to mitigate the impacts of project traffic.

TMR stressed the need for these issues to be dealt with well before (9 months or earlier) impacts are likely to occur. The proponent should continue to engage with TMR, local governments and other interested and affected parties to identify and resolve the outstanding issues.

8.11 Noise and vibration

The EIS documents have adequately described, at a project scale, the exiting noise environment of the project, the projected impacts of the project and that with appropriate siting and separation distances between sensitive receptors and project facilities and (where necessary) the use of appropriate attenuation techniques, noise levels within statutory and WHO recommended levels can be achieved.

Several outstanding matters, mainly dealing with the site-specific impacts are identified in this assessment report would need to be addressed by Arrow. These matters include the preparation and implementation of a noise management and monitoring strategy that includes proactive as well as reactive management strategies.

Application/s for an environmental authority or amendment to an environmental authority under the EP Act for petroleum activities within the project areas must provide:

- Site-specific noise and vibration assessments for each proposed infrastructure location.
- Site-specific identification of sensitive receptors and potential impacts on sensitive receptors.

8.12 Economics

The EIS documents have adequately described, at a project scale, the exiting economic environment of the project development area, provided qualitative and some quantitative predictions on the impacts of the project and outlined broad strategies to minimise any negative economic impacts of the project.

The EIS outlines a strategy for individual compensation arrangements for primary producers for any impacts of the project on productivity. The cost-benefit analysis for the project did not consider the costs to be paid by Arrow to landholders to compensate for economic impacts. The economic impact of the project on individual landholders, farming sectors or regions or the agricultural industry as a whole has not been quantified.

Successful mitigation of impacts will be dependent on Arrow applying the commitments. It is recommended that Arrow address the follow matters, in consultation with relevant local and state government departments, non-government organisations and communities:

Consult with each affected Darling Downs local government area regarding:

- More detailed analysis of the economic impacts on their jurisdiction.
- Infrastructure requirements and costs.
- Their capacity to assist with ongoing project planning.

8.13 Social

The EIS documents have adequately described, at a project scale, the exiting social environment of the project development area, provided qualitative predictions on the impacts of the project and outlined broad strategies to minimise social impacts of the project. Successful mitigation of impacts will be dependent on Arrow applying the commitments outlined in the EIS documents including conducting localised social assessments and developing and implementing more detailed mitigation strategies that are adaptive to changing social conditions over the life of the project.

Before the project commences, Arrow would need to address the following matters, in consultation with relevant local and state government departments, non-government organisations and communities concerning social issues:

- Assess impacts and include mitigation strategies to address the decommissioning phase of the project.

- Specify if strategies in individual Action Plans have been endorsed/agree-upon by key stakeholders/agencies or indicate progress on any consultation or negotiations.
- Include strategies to mitigate impacts of the project on community services for disadvantaged and low income groups (i.e. family support services, counselling, domestic and family violence).
- Provisions for support and counselling services for landholders and communities affected by the project.
- Update mitigation actions to address impacts on non-emergency medical services for project workers, consultants and their families in consultation with QH and relevant local government.
- Include the NGO sector in on-going stakeholder consultation activities with councils and the Consultative Committee to assist the sharing of key social data.
- Provide and update mitigation strategies that address housing assistance and support programs and accommodation for low to moderate income families and vulnerable groups.
- Include monitoring provisions to ensure management actions are responsive to changing social environment.

In addition, DSDIP requires Arrow would need to:

- Consider the new policy directions, Managing the Impacts of Major Projects in Resource Communities and Regional And Resource Town Action Plan' to assist in negotiating and agreeing mitigation and management strategies
- Develop an Early Works Accommodation Plan 4 months prior to the commencement of any construction of workers camps. The plan is to: provide detail of the options being considered; include consultation with key stakeholders including local governments; and cover the period from construction commencement of camps until final decommissioning of the camps.
- Arrow commit to not accessing private rental market where vacancy rate are below 3% and seek other alternative housing options including provision of new housing stock or workers camps.
- Arrow commits to provide housing for workers if the need is identified.
- Arrow commit to full adoption of the QRC Code of conduct for Local Content.
- Arrow to provide an annual report to the Director General during construction and for two years following the commencement of operations.

8.14 Indigenous cultural heritage

The EIS documents have adequately described, at a project scale, existing Indigenous cultural heritage values and broadly considered areas most likely to contain unknown non-Indigenous cultural heritage values. The EIS provided qualitative predictions on the impacts of the project on Indigenous cultural heritage values, outlined frameworks for undertaking more detailed site-specific assessments of values and included broad strategies to reduce the potential for adverse impacts on known and unknown Indigenous cultural heritage sites.

Arrow would need to comply with the relevant requirements of the *Aboriginal Cultural Heritage Act 2003* (ACH Act).

8.15 Non-Indigenous cultural heritage

The EIS documents adequately described, at a project scale, existing non-Indigenous cultural heritage values and broadly considered areas most likely to contain unknown non-Indigenous cultural heritage values. The EIS provided qualitative predictions on the impacts of the project on non-Indigenous cultural heritage values, outlined frameworks for undertaking more detailed site-specific assessment of Indigenous cultural heritage values and included broad strategies to reduce the potential for adverse impacts on known and unknown non-Indigenous cultural heritage sites.

In addition to the Arrow's commitments regarding cultural heritage, Arrow would need to consult with the community and landholders regarding the occurrence of non-built heritage sites relating to the history of the project development area and consider such values in the development and implementation of the Cultural Heritage Management Plan, 'chance finds' and site induction procedures and other mitigation tools aimed at minimising impacts on the project on non-Indigenous heritage values.

8.16 Hazard and risk

The EIS documents have provided, at a project scale, a summary of the potential hazards associated with the project during the construction, operation and decommissioning phases of the project and conducted a broad assessment of their risks to people and property. Arrow's commitments (with minor changes) were considered adequate to manage to the hazards and risks posed by the project.

8.17 Waste management

The overall commitment and effort to apply and implement waste management principles in accordance with applicable legislation has been adequately demonstrated, for waste other than CSG water. The waste hierarchy has been appropriately identified, generally been adopted for identified waste streams and has been supported by generic and specific management/mitigation measures.

In the EIS documents, Arrow investigated number of options for management of CSG water, particularly substitution and discharge to watercourses. Arrow will need to provide a detailed CSG water management plan consistent with CSG Water Management Policy priorities to support any applications for approval under the EP Act and the Water Act.

Arrow would also need to provide detailed information on reuse or disposal of treated effluent associated with the major project facilities, particularly the temporary construction camps.

In addition, the information to be included with the EA application must describe:

- How the proposed management of brine and/or salt from CSG water management activities would be consistent with the prioritisation hierarchy in the CSG Water Management Policy.
- Where the proposed management of CSG water, brine and/or salt are not consistent with the CSG Water Management Policy – the reason for managing the waste in a way that is inconsistent with the policy.

Regarding the proposed discharge of treated and untreated CSG water discharge, a comprehensive proposal, addressing the matters identified in this assessment report would need to be provided with any application for an EA.

It should be noted that it is possible that the proximity of Arrow's proposed treated CSG water discharge points to the intakes of town water supply schemes will necessitate close attention to the requirements of the *Water Supply (Safety and Reliability) Act 2008.*

8.18 Matters of national environmental significance

The EIS documents have provided, at a project scale, an identification of the values of MNES matters potentially impacted by the project, the likelihood and magnitude of the potential impacts and outlined a number of measures to avoid, minimise and manage potential impacts due to the project during the construction, operation and decommissioning phases. These measures were encapsulated in Arrow commitments which, if implemented would be considered adequate. Should the project proceed, then these commitments should be implemented.

In addition, and complementary to these commitments, Arrow should also undertake the following:

- Where impacts on suitable habitat for MNES species cannot be avoided, undertake preclearance surveys targeted at MNES species that could be present based on the suitability of habitat.
- Arrow has committed to preclearance surveys prior to construction. DOE recommends that these surveys be undertaken in accordance with DOE survey guidelines and practice methodologies.
- Concerning protection of the Murray cod, goodoo (*Maccullochella peelii peelii*), Arrow should support programs that monitor the populations of exotic fish in Murray cod habitat (particularly in streams where Arrow proposes to discharge CSG water). Support should also be provided for any remedial action plans relevant to those streams.
- DOE requires an offset strategy, consistent with the EPBC Act Offsets Policy and Offsets Assessment Guide), before the assessment process is completed.

8.19 Approvals

Key approvals required for the project include:

- *Petroleum and Gas (Production and Safety) Act 2004* – obtaining the necessary petroleum leases to carry out the project.
- *Environmental Protection Act 1994* - A comprehensive list of the information requirements for an EA application is provided in Appendix 4. Further details are available in the EHP guideline EM705.
- *Water Act 2000* – approvals for take and interfer with water; approvals for the supply of CSG water outside of the purposes allowed for in the P&G Act.
- *Environmental Protection and Biodiversity Conservation Act 1999*: Approval is required and Section 5 of this assessment report provides the information needed for a decision to be made under this Act.
- *Strategic Cropping Land Act 2011* - DNRM has advised that site-specific information would be required to obtain a determination under the Act. The type and details of this information would be determined by the path Arrow would take to obtain approval, particularly whether validation of SCL was sought or if compliance with the code to achieve a compliance certificate or protection decision. It should also be noted that the SCL Act is currently under review.

9 Report Certification

The EIS process is completed when this EIS assessment report is approved by the delegate for the chief executive and given to Arrow Energy Pty Ltd.

	25 October 2013
Signature	Date

Lindsay Delzoppo
Director, Statewide Environmental Assessments
Environmental Performance and Coordination
Environmental Services and Regulation Division
Department of Environment and Heritage Protection
Delegate of the chief executive
Environmental Protection Act 1994

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Appendix 1 Summary of changes to Queensland Government departments

Former departments	New department(s) (as of 3 April 2012)[1]
Department of Employment, Economic Development and Innovation	Department of State Development, Infrastructure and Planning Queensland Treasury and Trade Department of Agriculture, Fisheries and Forestry Department of Water Supply
Department of Environment and Resource Management	Department of Environment and Heritage Protection Department of Natural Resources and Mines Department of Energy and Water Supply Department of Science, Information Technology, Innovation and the Arts Department of National Parks, Recreation, Sport and Racing
Department of Education and Training	Department of Education, Training and Employment
Department of Local Government and Planning	Department of Local Government, Community Recovery and Resilience)
Department of Communities	Department of Communities, Child Safety and Disability Services
Department of Public Works	Department of Housing and Public Works
No changes: Department of Transport and Main Roads Department of Community Safety Queensland Police Service Queensland Health	
New departments:	Department of Housing and Public Works Department of Aboriginal and Torres Strait Islander and Multicultural Affairs Tourism, Major Events, Small Business and the Commonwealth Games

[1]Based on The Public Service Departmental Arrangements Notice (No.4) 2012, Queensland Government.

Appendix 2 Arrow's response to information request on MNES

coffey environments
SPECIALISTS IN ENVIRONMENTAL,
SOCIAL AND SAFETY PERFORMANCE

Memorandum

To	Paul Neilson	**Company**	Arrow Energy
From	Jessica Reid and Andrew Jensen	**Date**	10 September 2013
Project	7040 Surat Gas Project		
Subject	Arrow's revised response to comments made by DSEWPaC on the Surat Gas Project SREIS including maximum disturbance areas for MNES communities and species		

Arrow Energy Pty Ltd's (Arrow) response to the Department of Environment and Heritage Protection's (EHP) request for further information is provided to assist their decision on the Surat Gas Project under s.62 of the *Environment Protection Act 1974*.

Whilst specifically requested to respond to the issue entitled "EPBC listed species" Arrow has taken the opportunity to provide EHP with a response to each of the comments made by the Department of Sustainability, Environment, Water, Populations and Communities (DSWEPaC). These responses are provided in Table 1. This information is provided to reinforce the information provided in the EIS documents, and is provided to assist in understanding the information already presented.

We note that DSEWPaC has requested the potential impacts on EPBC Act listed species be quantified. Accordingly, the potential maximum area of disturbance has been determined using the core habitat known, core habitat possible and general habitat estimates. The total estimate of disturbance comprises the maximum area of potential impact for each EPBC Act listed species that may be impacted by project activities over the 35 year life of the project.

The background and rationale to Arrow's approach to estimate the potential area of disturbance of EPBC Act listed species and for ongoing identification of disturbance limits is detailed below.

Habitat Identification

Habitat mapping for threatened species was undertaken to inform the EIS, and was refined for the supplementary report to the Surat Gas Project EIS (SREIS). The habitat requirements of threatened species were assessed during desktop assessment and supplemented with the results of field surveys, to determine a series of mapping rules relevant to individual species listed under the EPBC Act.

In total, over 500,000 individual data fields were attributed with an indicator of EVNT species habitat value, based on the Biodiversity Assessment Mapping Methodology developed by the Environmental Protection Authority (EPA) 2002 (now known as EHP). Further information on the habitat mapping process is provided in SREIS Attachment 1, MNES, Appendix C.

Habitat for listed threatened species within the project development area has been categorised under the following four headings, with the total area applicable to each species presented in individual species dossiers in Attachment 1, MNES, Appendix C:

- **Core habitat known.** This category identifies habitat where a spatially accurate confirmed record of a particular species exists (e.g., Herbrecs or survey record). Core habitat known is attributed to the particular habitat polygon in which it occurs, based on either regional ecosystem (RE) mapping provided by EHP or high resolution habitat mapping developed for a specific purpose. Core habitat known also applies to a 1 km buffer around all spatially accurate (<400 m accuracy) species records.
- **Core habitat possible**. This category identifies habitat where previous records of a particular species are not known to occur within a given area or habitat, although specific habitat features are present which are known to be favoured by the species and the habitat occurs within the species known geographic range.
- **General habitat**. This category identifies areas where a species has not been recorded in a given location and habitat accounts for some of the features favoured by a particular species. The habitat occurs on the margins of a species known geographic range. Otherwise, the habitat is suitable for the species although has been subject to intensive survey and the species has not been recorded.
- **Absence suspected.** This category identifies areas where the species has not been recorded in a given location and habitat features are not suitable (or sub-optimal) for survival of a given species or population.

Core habitat possible is identified to allow preconstruction clearance surveys to assess those areas. The inherent inaccuracy in regional ecosystem mapping means that Arrow has been conservative in identifying core habitat known and core habitat possible. The preconstruction clearance surveys area tailored to allow species distribution to be accurately mapped.

Prioritising Avoidance Using the Environmental Framework

CSG development occurs incrementally and over large geographic areas. The nature of this development means that making accurate estimates of losses, and consequential estimates of potential areas of impact can be very difficult. Arrow developed the environmental framework approach to address the nature of CSG development and the uncertainties over the locations of activities many years in the future.

The framework includes a planning tool (constraints mapping) to guide site and route selection to avoid areas of sensitive environmental values. Staging offsets, described in the SREIS and a key avoidance objective, will ensure areas requiring offsetting will be avoided where possible.

The staged offset approach accounts for actual losses by managing unavoidable losses and incentivises the protection of identified environmental values.

Arrow will develop its offset requirements following the staged approach as preconstruction clearance surveys verify areas of core habitat known for listed species that are unable to be avoided.

Quantifying the Potential Area of Impact for MNES

The estimates of the maximum potential area of disturbance (Attachment A, Table A1 to Table A3) for EPBC listed species have been developed using Arrow's conceptual field development layer. This layer comprises:

- An advanced conceptual field layout for a portion of the project development area (where development planning has progressed to consider areas of avoidance and constraints to development).

- A generic grid layout over the remainder of the project development area (with no consideration of the environmental framework).

As an example of the conceptual field development layer's conservative estimate, disturbance for facilities is assumed to encompass an entire property when a processing and water treatment facility will only occupy a portion of a property. For example, an entire property may be over 1000 ha, however a processing and water facility will disturb 220 ha. This approach builds in further conservatism to the estimate of the maximum potential area of disturbance.

Arrow recognises that preconstruction clearance surveys may identify habitat of listed species in areas previously defined as either core habitat possible or general habitat. The estimated maximum potential area of disturbance therefore includes a provision for such instances. The estimate recognises the potential for these habitats to occur and accounts for:

- The accuracy of mapping associated with core habitat possible and general habitat.
- The likelihood of species being present in these areas.
- The conservatism already built into the core habitat known mapping.
- The ability to avoid.

Attachment A, Table A4 presents a list of potential species within the project development area for which no impacts are predicted to core habitat known, core habitat possible or general habitat.

Listed migratory species such as the rainbow bee-eater or the great egret are generalist species. Isolating a particular habitat type of importance to the species in question is not feasible. These species are wide ranging and associated with many different habitats. No important populations of listed migratory species were identified in the project development area.

Table 1 Response to comments made by EHP and DSEWPaC

Issue	Comment	Response
Variation of the action	As previously advised, DSEWPaC recommends that Arrow request a variation to the project as a result of changes in project scope (e.g. reduction in project area and number of wells proposed)…etc.	Noted.
Species discounted from assessment	We require more information on presence of suitable habitat for a number of EPBC fauna species that are discounted from the assessment of impacts on MNES (for e.g. the Ornamental Snake - it appears suitable habitat is present (such as gilgai) and surveying hasn't been undertaken to provide enough certainty that there will not be an impact on this species from the project). As a minimum, a discussion on presence of suitable habitat must be provided for all fauna species that are identified in the ERT Report.	Species identified in the Protected Matters Search (otherwise known as the ERT Report) are presented and assessed in the EIS documents. The Excluded Species list, contained within EIS Appendix K, Terrestrial Ecology Impact Assessment and SREIS Attachment 1, MNES, Section 5.5 (Species Discounted from Further Assessment) outlines the excluded fauna species and explains the reasoning behind exclusions, which include a lack of recent records and/or a lack of suitable habitat. Survey effort in accordance with guidelines under the EPBC Act was not undertaken for species excluded from assessment based on the lack of database records and absence of potential habitat.
Surveys	DSEWPaC notes that Arrow will undertake pre-clearance surveys prior to construction. Any conditions of approval are likely to require surveys to be undertaken in accordance with DSEWPaC survey guidelines and best practice methodologies (including those referred to and discussed in the MNES chapter where relevant).	Arrow acknowledges that conditions of approval will set the survey requirements to be undertaken prior to construction. Arrow has presented an overview of a survey method based on DSEWPaC survey guidelines and best practice methodologies. The proposed survey method also provides for desktop and field verification of vegetation communities and habitat features to be undertaken prior to preconstruction clearance surveys to determine the level of survey effort required, appropriate to each species (as outlined in species dossiers within SREIS Attachment 1, MNES, Appendix C). Details of survey requirements in accordance with EPBC Act guidelines are detailed within Appendix C of SREIS Attachment 1, Matters of National Environmental Significance.
Disturbance	DSEWPaC has previously advised Arrow that it is highly likely that maximum disturbance limits for MNES will be conditioned for should the project be approved.	Please refer to the introductory text of the response.
Ecological Communities	DSEWPaC notes Arrow's commitment to avoid Natural grasslands on basalt and fine textured alluvial plains of northern New South Wales and southern	Arrow has committed to avoid two critically endangered communities referenced in SREIS Attachment 1, MNES, based on the sensitivity of these communities and the significance of the potential impacts on them. The endangered Semi-evergreen vine thickets community (of the Brigalow Belt (North and South) and Nandewar

Issue	Comment	Response
	Queensland (critically endangered), White Box-Yellow Box-Blakely's Red Gum Grass Woodland and Derived Native Grassland (critically endangered) and Semi-evergreen vine-thicket (endangered). DSEWPaC anticipates that, should the project be approved, it is likely that conditions of approval would reflect a zero disturbance limit on communities that are identified as not being impacted in the SEIS.	bioregions) has been assigned a lower sensitivity, and therefore the significance of potential impacts on this community is lower than the two critically endangered communities. Arrow has not committed to complete avoidance of this community, although will aim to avoid it. Given the conceptual field development layer does not intersect the Semi-evergreen vine thickets community, a disturbance limit for this community has not been identified. As Arrow's field development evolves, implementation of the environmental framework will continue to prioritise the avoidance of sensitive communities through preconstruction clearance surveys. Should Arrow determine that clearance of the Semi-evergreen vine thickets community is required, an offset strategy will be developed in accordance with the staged approach detailed in SREIS Attachment 6, Section 10.
Ecological Communities	Similarly, the SEIS notes in respect of Weeping Myall that less than 1 ha will be impacted by the conceptual field layout (which Arrow notes is conservative) – this is also likely to be reflected as a disturbance limit in any conditions, similar to limits provided for other communities (e.g. 106.4 ha for Brigalow and 8.1 ha for Coolibah). DSEWPaC notes that 1 ha is a low level of estimated conservative disturbance for Weeping Myall; particularly given the community can be easily overlooked, is not represented in RE mapping and the SEIS identifies that habitat may occur more broadly in the project area. Consider revising this disturbance amount.	Arrow recognises that the Weeping Myall Woodlands community may occur elsewhere within the project development area despite the findings that indicate the main distribution of this community is located to the west of the project development area (between Roma and Blackall). Survey efforts, and literature and database reviews also failed to identify any other occurrences of this community within the project development area other than that mapped at survey area 7, although as this community is not represented in regional ecosystem mapping, other occurrences are recognised as likely to occur. The indicative area (0.8 ha) impacted by the conceptual field development layer was determined based on the most robust scientific methodology available, given the inherent uncertainties in mapping beyond the properties for which detailed mapping has occurred. Conservatism was also built in to the estimated area of disturbance, which included allowance for total clearance of the (1,630 ha) lot within the property defined by survey area 7 on which the facility would be built, despite the facility only requiring 10 ha.
Ecological Communities	The SEIS states that 11.7 ha of Coolibah-black box ecological community is known in survey area 7, but there is a disturbance limit of 8.1 ha for the whole project area prescribed in table 10.1. 8.1 ha is said to be a conservative estimate, but in the event that the community cannot be avoided in survey area 7, more than 8.1 ha will be impacted within just one small area of the entire project area.	Survey area 7 relates to the siting of a central gas processing facility on one of the identified lots associated with the property. Given the size of the property associated with survey area 7 is 3,465 ha and the facility requires and estimated maximum area of 10 ha the estimated disturbance area of 8 ha is considered to be conservative.

Issue	Comment	Response
EPBC Listed Species	DSEWPaC requires a table setting out disturbance limits for listed threatened species and migratory species (noting these are likely to be based on a conceptual field layout) for core habitat known, core habitat possible and general habitat for each species. As previously advised, quantification of impacts to EPBC listed species must be provided for the whole of the project. Maximum disturbance limits have not been provided in the MNES chapter for EPBC listed species. While Attachment 6 provides an estimate of impacts to core habitat known for some species, DSEWPaC requires maximum disturbance limits for all habitat onsite to fully understand project impacts. Disturbance limits must be clearly justified, and supported by a robust and scientific methodology.	The terrestrial ecology values of the project development area and the impacts to these values are as presented in the EIS. The sensitivity of the terrestrial ecology values has been refined based on a review of updated data and information, including higher resolution mapping of vegetation communities and habitat. Habitat requirements for listed species have been classified and mapped as ‘core habitat known’, ‘core habitat possible’ and ‘general habitat’. The findings of the field surveys on properties identified for development have confirmed the presence or possible presence of communities, populations and individuals of listed species. As explained in sections 1.1 to 1.3 above, a maximum potential area of impact for threatened EPBC Act listed species is presented in Attachment A, Table A2 and Table A3. Listed migratory species such as the rainbow bee-eater or the great egret are generalist species and it is not possible to isolate a particular habitat type of importance to the species in question. These species are wide-ranging and associated with many different habitats. No important populations of listed migratory species were identified. Standard mitigation measures relating to works near waterbodies would afford a level of protection to any migratory species temporarily utilising that resource. Arrow has also committed to the avoidance of Lake Broadwater. The maximum potential areas of impact identified in Attachment A, Table A2 and Table A3 4 further contribute to the understanding of the potential project impacts to listed EPBC Act communities and species.
General	DSEWPaC recommends an independent peer review of the methodology for habitat mapping and quantification of disturbance, but notes that this may not be possible for this project (but should be undertaken for Arrow’s Bowen Gas project).	Noted.
Translocation	Please note that DSEWPaC does not generally accept translocation of species as a mitigation measure unless it can be clearly demonstrated based on scientific evidence to be effective for an individual species. On this basis, translocation will not be considered to reduce the level of impact on an MNES unless supporting scientific evidence is clearly provided.	Translocation has been described in SREIS Part B, Chapter 21 as an example of available management options. It is acknowledged that the effectiveness of translocation as a management option is species dependent. The success of translocation for individual species has been considered and is described in SREIS Attachment 1 MNES, Appendix C (species profiles). The species profiles identify species for which translocation can be an effective management measure. The effectiveness of translocation is reflected in the assessment of the significance of residual impacts (which considers implementation of proposed management measures).

Issue	Comment	Response
Mitigation and Management Measures	DSEWPaC notes that “assuming habitat can be avoided” is not an adequate mitigation measure to reduce the level of impact to a listed species or community. This is consistent with our previous comments. While DSEWPaC supports avoiding MNES habitat where possible, there is no certainty that habitat will actually be avoided.	Arrow has committed to the avoidance of communities and species where the sensitivity of the community or species has been assessed to be at a level where impacts upon the community or species cannot be managed (SREIS Attachment 6, Draft Environmental Offsets Strategic Management Plan, Section 6.1). Where Arrow has committed to avoidance this is reflected in the assessment of significance of residual impacts. Where Arrow has committed to aim to avoid a community or species the assessment of significance of residual impacts does not assume that avoidance is fully implemented. Arrow has developed the environmental framework approach, which promotes avoidance through use of the constraints mapping tool at the site selection phase. Despite these measures, Arrow acknowledges that where avoidance is not possible for habitat associated with less sensitive species, Arrow will reduce the area of disturbance to the affected habitat through measures including reduction of the right of way and workspace requirements where safe to do so and through micro-siting or realignment of facilities and infrastructure where possible.
Mitigation and Management Measures	Offsets are referred to as a mitigation and/or management measure in the MNES chapter. Please note that an offset is not a mitigation or a management measure and does not reduce the level of impact on MNES. Rather, offsets compensate for residual significant impacts on MNES.	Acknowledged. The SREIS presented mitigation measures to reduce the level of impacts on MNES. Offsets will be applied once all avoidance, mitigation and management measures are applied, and impacts are still of significance. The two commitments that refer to offsets within SREIS Attachment 1, MNES (C219 and C239) reflect Arrow’s commitment to undertake any offsets required following legislative requirements and an approved strategy, but do not reflect any reduction in the level of residual impacts as assessed in the MNES attachment.
Significance Assessment	The assessment of significance for listed species and communities in the MNES Chapter appears to be completed only in respect of the five survey areas (2, 7, 8, 9 and F). As previously advised, impacts from the project in its entirety must be assessed and considered by the Minister when making a decision on whether or not to approve the action under the EPBC Act (and what conditions to attach to approval). While DSEWPaC is supportive of the further survey work and habitat analysis undertaken in the SEIS, the impacts from the whole project must be clearly assessed and presented.	The significance of impacts for listed species and communities across the entire project development area was assessed in the Surat Gas Project EIS. Specifically, as outlined in SREIS Appendix 9 Terrestrial Ecology Assessment, Section 4, additional fieldwork conducted as part of the SREIS validated the findings of the EIS, and afforded the opportunity to demonstrate the process of detailed mapping to occur as part of the preconstruction surveys. The assessment undertaken for the SREIS on the five known properties, demonstrated how the EPBC survey guidelines are applied at site level, and site-specific data is collected and used to inform the siting of project facilities and infrastructure across the project development area, once property locations are known and agreed with landowners.

Issue	Comment	Response
Significance Assessment	The conclusions reached in the species dossiers must be in respect of whole of project impacts. For a number of listed species, DSEWPaC is of the view that there will be a residual significant impact that would require offsetting.	As per row above.
Offsets	DSEWPaC notes that the aim of SEIS Attachment 6 (Draft Environmental Offsets Strategic Management Plan) is to facilitate discussion with EHP and DSEWPaC on suitable offsets for unavoidable losses of vegetation and habitat incurred in constructing the project.	Noted. Arrow wish to implement a staged approach to offsets as outlined in SREIS Attachment 6, Draft Environmental Offsets Strategic Management Plan, Section 10. The proposed approach to the provision of offsets for unavoidable losses attempts to reconcile the inherent inaccuracy in estimating the area of disturbance upfront and the need to set limits on the extent of the ecological communities and species that might be disturbed by the project activities to ensure the proposed development does not have a significant impact of terrestrial ecological values. A staged approach to the provision of offsets that accounts for actual losses would manage unavoidable losses and incentivise the avoidance of environmental values.
Offsets	In line with Arrow's preferred option, DSEWPaC will consider recommending a staged approach to offsetting. However, Arrow must clearly demonstrate that offsets (consistent with the EPBC Act offsets Policy) can be provided for predicted maximum disturbance limits, should they be reached. DSEWPaC would also recommend an initial upfront offset be required as this would ensure certainty and confidence that a conservation gain can be achieved and there is a strategy in place for delivering offsets before or at the time of impact to certain areas (for e.g. a proposed offset for the first development area (or alternatively the first five surveyed areas) that is clearly consistent with the EPBC Act Offsets Policy and Offsets Assessment Guide). We require detail on this initial upfront offset before the assessment process is finalised.	SREIS Attachment 6, Draft Environmental Offsets Strategic Management Plan, Table 9.1 provides a preliminary assessment of the availability of affected REs and threatened species habitat in the Brigalow Belt South bioregion. This assessment has been undertaken using GIS analysis of REs, regrowth mapping and threatened species habitat. The analysis involved the sequential application of filters to identify suitable patches/tracts of affected REs, and hence potentially viable offsets. Threatened species associated with each RE type (as discussed in SREIS Attachment 1, MNES, Appendix C) are detailed in SREIS Attachment 6, Table 8.1. SREIS Attachment 6, Table 9.1 presents an estimate of the total areas of regional ecosystems available within the bioregion as potential offset sites. The final column of Table 9.1 excludes areas of remnant vegetation consistent with the Queensland Biodiversity Offset Policy. This column reflects areas of regrowth vegetation associated with the particular RE type. The Queensland Biodiversity Offset Policy presents a set of offset rules detailing the requirements for offset sites, which includes a requirement that the offset must not be an area of high value regrowth. The area of regrowth vegetation available was not able to be further assessed to establish whether the vegetation meets these criteria.

ATTACHMENT A

Table A1 Estimated maximum area of potential disturbance for MNES communities in project development area

Name/Species	EPBC Act Status	Significance of Impacts (EIS and SREIS)	Area of Community Within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Threatened Ecological Communities (EPBC Act)				
Brigalow (*Acacia harpophylla* dominant and co-dominant)	E	Moderate	7,387	**106**
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar bioregions	E	Moderate	35	**0**
Weeping Myall Woodlands	E	Moderate	<1	**<1**
Coolibah – Black Box Woodlands of the Darling Riverine Plains and Brigalow Belt South bioregions	E	Low	206	**8**

Table A2 Estimated maximum area of potential disturbance for MNES species habitat in the project development area (species with core habitat known within the conceptual field development layer)

Name/Species	EPBC Act Status	Significance of Impacts (EIS and SREIS)	Area of Core Habitat Known Within Project Development Area (ha)*	Estimated Maximum Area of Potential Disturbance – Core Habitat Known (ha)	Area of Core Habitat Possible Within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance – Core Habitat Possible (ha)	Area of General Habitat Within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance – General Habitat (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Threatened Fauna Species (EPBC Act)									
Squatter pigeon *(Geophaps scripta scripta)*	V	Moderate	17,576	471	144,623	279	46,037	24	**774**
South-eastern long-eared bat *(Nyctophilus corbeni)*	V	Moderate	14,268	520	182,570	356	0	0	**876**
Brigalow scaly-foot *(Paradelma orientalis)*	V	Low	13,477	69	164,035	404	46,448	46	**519****
Threatened Flora Species (EPBC Act)									
Finger panic grass *(Digitaria porrecta)*	E	Moderate	622	14	10,809	16	6,943	10	**40**
Lobed blue grass *(Bothriochloa biloba)*	V	Moderate	371	5	20,146	30	12,210	18	**53**

* Values have been updated post SREIS in review of EHP V7.0 dataset + mature regrowth dataset + detailed mapping area. The resulting values presented are less than those presented in SREIS Attachment 6, Offsets.

** Species has since been delisted from EPBC Act therefore no offset liability under current legislation.

Table A3 Estimated maximum area of potential disturbance for MNES species habitat in the project development area (species with core habitat possible and general habitat within the conceptual field development layer)

Name/Species	EPBC Act Status	Significance of Impacts (EIS and SREIS)	Area of Core Habitat Known Within Project Development Area (ha)*	Estimated Maximum Area of Potential Disturbance – Core Habitat Known (ha)	Area of Core Habitat Possible Within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance – Core Habitat Possible (ha)	Area of General Habitat Within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance – General Habitat (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Threatened Fauna Species (EPBC Act)									
Australian painted snipe *(Rostratula australis)*	V	Moderate	255	0	225	0.5	1,373	0.5	**1**
Regent Honeyeater *(Anthochaera Phrygia)*	E	High	57	0	5,255	2	24,926	16	**18**
Collared delma *(Delma torquate)*	V	Major	604	0	4,927	9	67,998	30	**39**
Dunmall's snake *(Furina dunmalli)*	V	Low	0	0	210,400	440	0	0	**440**
Yakka skink *(Egernia rugosa)*	V	Moderate	0	0	22,569	31	197,449	90	**121**
Five-clawed worm skink *(Anomalopus mackayi)*	V	Major	0	0	14,299	56	0	0	**56**
Darling Downs earless dragon *(Tympanocryptis cf. tetraporophora)*	E	High	0	0	10,916	55	0	0	**55**

Table A3 Estimated maximum area of potential disturbance for MNES species habitat in the project development area (species with core habitat possible and general habitat within the conceptual field development layer) (cont'd)

Name/Species	EPBC Act Status	Significance of Impacts (EIS and SREIS)	Area of Core Habitat Known Within Project Development Area (ha)*	Estimated Maximum Area of Potential Disturbance – Core Habitat Known (ha)	Area of Core Habitat Possible Within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance – Core Habitat Possible (ha)	Area of General Habitat Within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance – General Habitat (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Threatened Flora Species (EPBC Act) (cont'd)									
Austral toadflax *(Thesium australe)*	V	Moderate	77	0	9,798	16	7,472	11	**27**
Belson's panic *(Homopholis belsonii)*	V	Moderate	0	0	8,802	14	101,715	41	**55**
Cobar greenhood orchid *(Pterostylis cobarensis)*	V	Moderate	0	0	121,901	217	0	0	**217**
Curly-bark wattle *(Acacia curranii)*	V	Moderate	0	0	73,351	121	1,264	10	**131**
Hando's wattle, Percy Grant wattle *(Acacia handonis)*	V	Moderate	0	0	73,521	121	1,302	10	**131**
Tara wattle *(Acacia lauta)*	V	Low	0	0	43,028	99	6,348	4	**103**
Kogan wax flower *(Philotheca sporadica)*	V	Moderate	655	0	32,380	48	76,712	44	**92**

Table A3 Estimated maximum area of potential disturbance for MNES species habitat in the project development area (species with core habitat possible and general habitat within the conceptual field development layer) (cont'd)

Name/Species	EPBC Act Status	Significance of Impacts (EIS and SREIS)	Area of Core Habitat Known Within Project Development Area (ha)*	Estimated Maximum Area of Potential Disturbance – Core Habitat Known (ha)	Area of Core Habitat Possible Within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance – Core Habitat Possible (ha)	Area of General Habitat Within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance – General Habitat (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Threatened Flora Species (EPBC Act) (cont'd)									
Xerothamnella *(Xerothamnella herbacea)*	E	Moderate	55	0	7,768	11	336	0	**11**
Hawkweed *(Picris evae)*	V	Low	0	0	5,314	12	5,361	10	**22**
Austral cornflower *(Rhaponticum australe)*	V	Low	0	0	9,661	16	6,313	8	**24**
Wardell's wattle *(Acacia wardellii)*	V	Moderate	0	0	28,828	57	19,803	22	**79****
Shiny-leaved ironbark *(Eucalyptus virens)*	V	Moderate	0	0	3,138	17	4,360	1	**18**
King blue grass *(Dichanthium queenslandicum)*	V	Moderate	0	0	10,856	16	7,472	11	**27**

Table A3 Estimated maximum area of potential disturbance for MNES species habitat in the project development area (species with core habitat possible and general habitat within the conceptual field development layer) (cont'd)

Name/Species	EPBC Act Status	Significance of Impacts (EIS and SREIS)	Area of Core Habitat Known Within Project Development Area (ha)*	Estimated Maximum Area of Potential Disturbance – Core Habitat Known (ha)	Area of Core Habitat Possible Within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance – Core Habitat Possible (ha)	Area of General Habitat Within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance – General Habitat (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Threatened Flora Species (EPBC Act) (cont'd)									
Gurulmundi fringe-myrtle *(Calytrix gurulmundensis)*	V	High	0	0	60,538	121	360	4	**125**
Small-leaved denhamia *(Denhamia parvifolia)*	V	High	0	0	2,348	5	0	0	**5**
An unnamed mint-busy (*Prostanthera sp. (Dunmore))*	V	High	1,179	0	39,553	38	0	0	**38**
Queensland white-gum *(Eucalyptus argophloia)*	V	Low	0	0	4,028	1	0	0	**1**

* Values have been updated post SREIS in review of EHP V7.0 dataset + mature regrowth dataset + detailed mapping area. The resulting values presented are less than those presented in SREIS Attachment 6, Offsets.

** Species has since been delisted from EPBC Act therefore no offset liability under current legislation.

Table A4 MNES species within the project development area with no predicted impact

Name/Species	EPBC Act Status	Significance of Impacts (EIS and SREIS)	Area of Core Habitat Known Within Project Development Area (ha)*	Estimated Maximum Area of Potential Disturbance – Core Habitat Known (ha)	Area of Core Habitat Possible Within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance – Core Habitat Possible (ha)	Area of General Habitat Within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance – General Habitat (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Threatened Fauna Species (EPBC Act)									
Fitzroy River turtle (*Rheodytes leucops)*	V	Moderate	0	0	0	0	0	0	**0**
Murray cod *(Maccullochella peelii peelii)*	V	Moderate	0	0	0	0	0	0	**0**
Threatened Flora Species (EPBC Act)									
Machin's macrozamia *(Macrozamia machinii)*	V	Major	1,379	0	24,432	0	0	0	**0**
Ooline *(Cadellia pentastylis)*	V	High	0	0	2,672	0	1,423	0	**0**

* Significance of impacts assessed in SREIS assume that the species is found in preconstruction clearance surveys and that the impacts cannot be avoided – these species have limited distribution in the project development area however and it is assumed that they can be avoided.

Appendix 3 Arrow's commitments in the EIS documents

Commitment Number	Commitment	Relevant Phase
C001	Conduct site-specific air quality modelling once site locations are known to demonstrate that project-related air emissions meet EPP (Air) objectives at the nearest sensitive receptor.	Planning and Design
C002	Select equipment with consideration for low emissions to air (NOx, SOx), high energy efficiency and fuel efficiency.	Planning and Design
C003	Design facilities to meet relevant EPP (Air) objectives at sensitive receptors.	Planning and Design
C004	Minimise fuel consumption of vehicles by optimising transport logistics.	Planning and Design Construction Operations Decommissioning
C005	Select gaskets, seals and vehicle exhaust systems that are suitable for the task.	Planning and Design
C006	Arrow will develop a greenhouse gas management plan that will take into account both biodiversity and economic values of carbon.	Planning and Design Operations
C007	Consider energy efficiency programs both locally and across the company that contribute to greenhouse gas emission reductions.	Planning and Design Operations
C008	Arrow will participate actively in any government-approved emissions trading scheme.	Planning and Design Operations
C009	Routinely monitor water quality in dams.	Inspection and Monitoring
C010	Consider supporting through corporate community involvement programs the development of energy efficiency initiatives in the areas where Arrow operates.	Planning and Design Operations
C011	Operate and maintain all engines, machinery equipment and pollution control mechanisms in accordance with manufacturers' recommendations.	Planning and Design Construction/Operations Decommissioning
C012	Implement dust suppression measures for roads and construction sites where there is a potential for dust to cause nuisance effects.	Construction/Operations Decommissioning
C013	Cover dust-generating materials prior to transportation on public roads.	Construction/Operations Decommissioning
C014	Consult with potentially affected landowners prior to undertaking activities.	Construction Decommissioning
C015	Clear areas progressively and implement rehabilitation as soon as practicable following construction and decommissioning activities.	Construction/Operations Decommissioning
C016	Prevent venting and flaring of gas as far as practicable and where safe to do so.	Construction Operations
C017	Manage odours so that they do not cause a nuisance or harm to sensitive receptors.	Construction/Operations
C018	Optimise gas-engine operation to maintain high efficiency levels to keep greenhouse gas and air emissions as low as practicable.	Construction/Operations Decommissioning
C019	Inspect and observe site locations for the presence of contamination prior to commencement of intrusive activities.	Planning and Design

Commitment Number	Commitment	Relevant Phase
C020	Minimise the disturbance footprint and vegetation clearing.	Planning and Design Construction/Operations and maintenance Decommissioning
C021	During the construction phase, minimise greenhouse gas emissions as much as reasonably practicable through selection of equipment and the commitment to clear areas progressively. Implement rehabilitation as soon as practicable following construction activities.	Construction
C022	Consider supporting gas industry initiatives that seek to improve technology or processes, such as contributions or sponsorship of research and development.	Planning and Design Operations
C024	Install and maintain diversion drains to divert clean surface runoff water around production facilities and away from construction areas.	Planning and Design Construction/Operations Decommissioning
C025	Select permanent infrastructure, equipment and materials to withstand future predicted increases in ambient air temperature with consideration for cost implications.	Planning and Design Construction
C026	Design and construct the production facilities in accordance with current Australian standards addressing climatic factors including wind, bushfires and floods.	Planning and Design Construction
C027	Develop preventive and responsive measures for bushfire management and flooding	Planning and Design Construction/Operations Decommissioning
C030	Participate in government or industry climate change programs.	Planning and Design Construction/Operations Decommissioning
C031	Arrow will manage its impacts to private roads and tracks and minimise dust generation, where appropriate, in consultation with relevant landowners and council.	Planning and Design Construction Operations Decommissioning
C032	Use existing roads and tracks, where practicable.	Planning and Design Construction/Operations Decommissioning
C033	Confine project traffic to designated roads and access tracks, where practicable.	Planning and Design Construction/Operations Decommissioning
C034	Develop an erosion and sediment control plan and install and maintain appropriate site-specific controls, established on the basis of the sensitivity of the surrounding environment.	Planning and Design Construction/Operations Decommissioning
C035	Apply appropriate international, Australian and industry standards and codes of practice for the handling of hazardous materials (such as chemicals, fuels and lubricants).	Planning and Design Construction/Operations Decommissioning
C036	Develop and implement emergency response and spill response procedures to reduce impacts that could occur as a result of releases of hazardous materials or loss of containment of storage equipment.	Planning and Design Construction/Operations Decommissioning

Commitment Number	Commitment	Relevant Phase
C037	Ensure appropriate spill response equipment, including containment and recovery equipment, is available on site, or can be mobilised to the impacted site within an acceptable response time and that relevant personnel are appropriately trained.	Planning and Design Construction/Operations Decommissioning
C038	Carry out corrective actions immediately upon the identification of any contamination of soil or groundwater that has occurred as a result of project activities.	Planning and Design Construction/Operations Decommissioning
C039	Assess contamination that may have occurred as a result of project activities in accordance with documented operating procedures. Appoint one or more suitably qualified and experienced contaminated land specialists.	Planning and Design Construction/Operations Decommissioning
C040	Undertake an environmental site assessment in response to the identification of contamination that may have occurred as a result of project activities.	Planning and Design Construction/Operations Decommissioning
C041	Avoid the Chinchilla Sands Local Fossil Fauna Site and educate project personnel on the importance of the site.	Planning and Design Construction/Operations Decommissioning
C042	Design infrastructure located in cracking clays to withstand the differential shrink-swell ground movement.	Planning and Design
C043	Complete excavation, remediation, characterisation and validation activities in response to the identification of contamination that may have occurred as a result of project activities.	Planning and Design Construction/Operations Decommissioning
C044	Incorporate construction methods and treatments to deal with reactive gilgai and cracking clays in infrastructure design.	Planning and Design
C045	Time construction works and access to sites to avoid wetter periods, where practicable.	Planning and Design
C046	Design and plan the project to avoid steep slopes and areas dissected by gully networks, where practicable. Where these are unavoidable, ensure the required infrastructure (e.g., roads) is appropriately designed for erosion control purposes.	Planning and Design
C047	Locate pipelines to avoid or reduce the impact on irrigation flow or current farming practices. If the ROW must cross actively farmed arable land, ensure soil cover above the pipeline is deep enough to allow normal cultivation practices to resume.	Planning and Design
C048	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).	Planning and Design Construction/Operations Decommissioning
C049	Avoid development on contaminated land through the completion of 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).	Planning and Design

Commitment Number	Commitment	Relevant Phase
C050	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).	Planning and Design
C051	Allocate bins for different waste streams to achieve solid waste segregation. Provide appropriate domestic waste disposal facilities at designated work sites to assist in segregation of waste.	Construction Operations Decommissioning
C052	Reduce flow concentration and gully creation by minimising disruption to natural overland flow paths through the re-establishment of natural surface drainage lines.	Construction
C053	Avoid disrupting overland natural flow paths and, where avoidance is not practicable, maintain connectivity of flow in watercourses.	Construction
C054	Do not disturb or remove flood banks and artificial levees except in consultation with parties benefitting from the structures and the relevant authorities.	Construction
C055	Avoid disturbance of contour banks and irrigation bays.	Construction
C056	Avoid mounding of soil along pipelines in irrigated paddocks, to the greatest extent practicable, allowing for settlement of backfill.	Construction
C057	Reduce the duration of exposure of soils to as low as reasonably practicable during pipeline construction.	Construction
C058	Arrow will apply the following hierarchy of management options to all waste generated during the project activities: • Source reduction: avoid, eliminate, change or reduce practices that result in the generation of wastes. • Reuse: reuse waste materials that are in their original form. • Recycling: where possible, send waste to appropriate facilities to convert waste into other usable materials. • Treatment and disposal: render wastes safe by neutralisation or other treatment methods and dispose of waste products that can no longer be reused or recycled either through landfilling or incineration.	Construction/Operations Decommissioning
C059	Avoid excessive watering of saline soils to reduce leaching of salts and rising groundwater.	Construction
C060	Avoid excessive watering of surface-crusting soils to reduce crust formation.	Construction
C061	Provide regular access points to pipeline construction ROWs to limit rutting and compaction of soils from vehicles travelling along the ROW.	Construction
C062	Strip, salvage and stockpile topsoil near the work site separately to subsoils (in consultation with landowners). Ensure topsoil stockpiles are designed in accordance with best practise principles and are protected from erosion by wind, rain and floods. Stockpile topsoil to a maximum height of 2.5 m to maintain fertility and if stored for extended periods, sow with appropriate vegetation to maintain organic matter and microbial activity.	Construction ~~Operations~~ Decommissioning

Commitment Number	Commitment	Relevant Phase
C063	Carry out ground investigations in soils prone to salinity prior to major earthworks to establish the depth at which saline conditions occur.	Construction
C064	Avoid disturbance of contaminated soil and groundwater when it is identified or observed during intrusive works.	Construction
C065	Manage contaminated soil or groundwater that cannot be avoided through physical investigation; manage quantification of the type, severity and extent of contamination; and remediate or manage in accordance with the Queensland Government's Guideline for contaminated land professionals (EHP, 2012a).	Construction/Operations Decommissioning
C066	Discharge water from project activities at a rate and location that will not cause or exacerbate erosion. Install erosion protection measures, including energy dissipation structures, at discharge outlets.	Planning and Design Construction/Operations Decommissioning
C067	Ensure coal seam gas water used on highly productive soils is of comparable water quality to that used for irrigation in the specific area.	Operations
C068	Ensure the use of coal seam gas water meets beneficial-use licence conditions where it is to be used on GQAL or strategic cropping land or within heritage-listed or indicative sites.	Operations
C070	Develop rehabilitation plans based on environmental sensitivities that address ground preparation requirements, natural and constructed drainage patterns, soil erodibility, contamination, slope steepness and length, rainfall frequency and intensity, potential flow magnitudes, vegetation cover, land use and landowner requirements.	Decommissioning
C071	Backfill and rehabilitate excavations, particularly pipeline trenches and drilling sumps. Conduct backfilling in a manner that will promote successful rehabilitation, including capping of exposed subsoil with topsoil and replacement of the land surface to preconstruction levels to reduce trench subsidence and concentration of flow. Mounding of soils to allow for settling may be required in some areas. However, in laser-levelled paddocks, this may not be practicable, and backfilling should be carried out in consultation with the landowner.	Decommissioning
C072	Remedy areas of differential settlement associated with buried infrastructure that interrupt the pre-existing surface water flow within intensively cultivated areas.	Decommissioning
C073	Excavate any saline material during rehabilitation of coal seam water dams or brine dams and select an appropriate option for management for the material (e.g., treat for reuse, or dispose of in a registered landfill).	Decommissioning
C074	Implement a decommissioning and rehabilitation plan in accordance with the dam design plan.	Decommissioning
C075	Comply with the provisions of the *Petroleum and Gas (Production and Safety) Act 2004* and the Land Access Code (DEEDI, 2010) prior to accessing private land. All appropriate agreements (with accompanying maps of the area of interest and detail on infrastructure development) will be in place prior to entry onto the land. Arrow will ensure all appropriate landowners are notified prior to access being required to allow stock to be moved and access routes to be cleared of machinery or materials.	Planning and Design Construction/Operations Decommissioning

Commitment Number	Commitment	Relevant Phase
C076	Avoid infrastructure and associated farm management areas of intensive farming operations, including piggeries, feedlots, vineyards, orchards, horticultural enterprises, poultry farms and small-lot plantations.	Planning and Design Construction/Operations Decommissioning
C077	Maintain the grievance process (complaint management system) for the community to register complaints, issues, comments and suggestions.	Planning and Design Construction/Operations Decommissioning
C078	Retain and regularly inspect erosion and sediment control structures until reinstated soils have been stabilised and sown. If any problems are encountered, implement corrective actions as soon as practicable.	Planning and Design Construction/Operations Decommissioning
C079	Arrow will enforce a no hydraulic fracturing (fraccing) policy in the project development area.	Planning and Design Construction/Operations Decommissioning
C080	Plan and integrate construction and operations activities with harvesting, spraying and withholding periods.	Planning and Design Construction/Operations Decommissioning
C081	Develop and implement a compensation framework to ‘add value’ rather than just compensating for impacts.	Planning and Design
C082	Develop coal seam gas development property plans to address key issues raised by landowners relating to potential impacts on intensively farmed land.	Planning and Design
C083	Investigate the opportunity to increase well spacing from 160 acres (65 ha) to 320 acres (129 ha) or greater to reduce the footprint on strategic cropping land.	Planning and Design
C084	Consult and agree with landowners on the appropriate location for infrastructure and access routes (to well sites and to and along pipelines). Clearly identify the outcome of the discussions on scaled plans of the property and clearly indicate agreed access routes using signs, temporary fencing, barricade tape or traffic control measures.	Planning and Design
C085	Study methods to reduce impacts and maintain the soil profile during gathering system pipeline construction by understanding the soil type, reducing pipe diameters, plowing (instead of trenching) and potentially burying deeper than the minimum standard.	Planning and Design
C086	Develop or facilitate the development of a method for assessing impacts on productivity (crop yields) that incorporates statistical analysis and appropriate control and sampling sites.	Planning and Design
C087	Investigate alternative drilling technologies, such as using directional drilling to access coal measures, reducing gathering system pipe diameters and drilling multiple wells from one drill pad to potentially reduce the footprint on strategic cropping land.	Planning and Design
C088	Consult with landowners on the most appropriate method to minimise disruption to cultivation paddocks (including the introduction of additional headlands) and loss of productive land in controlled-traffic paddocks. The following measures will be considered in reaching agreement: • Locate infrastructure (in order of preference) outside of cultivation areas, in headlands or at the corners of cultivated areas, adjacent to boundary fences or in areas of a paddock	Planning and Design

Commitment Number	Commitment	Relevant Phase
	with the lowest-quality soil. • Utilise existing access tracks and trafficked areas. • Locate new access tracks in headlands or adjacent to boundary fences. • Align gathering lines and new access tracks parallel to the direction of cultivation, soil conservation structures and controlled traffic runs and avoid perpendicular or lateral connections. • Lay out drill pads in accordance with landowner requirements, subject to safety requirements, to reduce the overall impact on cultivation, where practicable.	
C089	Develop construction methods and design access tracks in cultivation paddocks to maintain the existing hydrologic and hydraulic regime of the site and in a way that does not cause erosion.	Planning and Design
C090	Backfill soils in the reverse order of removal, and undertake backfilling progressively and regularly during pipeline construction.	Construction/Operations Decommissioning
C091	Ensure construction activities do not extend beyond the work site boundaries.	Construction/Operations Decommissioning
C092	Ensure dams for coal seam gas water and brine are not constructed on intensively farmed land.	Construction/Operations Decommissioning
C093	Install gates in fences of an appropriate standard to restrict access to authorised personnel, vehicles, plant and equipment.	Construction/Operations Decommissioning
C094	Ensure an Arrow representative is in attendance at the time of first entry to check contractors have the appropriate environmental management procedures and property-specific information.	Construction/Operations Decommissioning
C095	Maintain the integrity and efficiency of surface irrigation systems by adopting the following measures: • Locate infrastructure at or adjacent to the end of head ditches or tail drains and in a manner that does not significantly interfere with swept paths of boom irrigators to avoid severance or fragmentation of water delivery systems. • Locate wells, gathering lines and access tracks adjacent to boundary fences, where practicable. • Align gathering lines and access tracks perpendicular to the direction of head ditches and tail drains (i.e., parallel to the direction of surface flows and cultivation).	Construction/Operations Decommissioning
C096	Use surface tanks (not pits) to manage drilling muds on black soils when drilling production wells.	Construction/Operations Decommissioning
C097	Fence the exclusion zone of production wells.	Construction/Operations Decommissioning
C098	Inspect work sites and access routes for notifiable weeds and pest plants and animals prior to accessing the site; and if detected, manage in accordance with the Petroleum Industry – Minimising Pest Spread Advisory Guidelines, Queensland Department of Primary Industries and Fisheries, June 2008 (Biosecurity Queensland, 2008).	Construction/Operations Decommissioning

Commitment Number	Commitment	Relevant Phase
C099	Wash down vehicles and equipment that have potentially been in contact with weeds before entering new work sites.	Planning and Design Construction/Operations Decommissioning
C100	When operating on black soils, collect, contain and store drilling fluids and waste (solid and liquid) on site in appropriate storage tanks until recycled, treated (if necessary) or disposed of off-site.	Construction/Operations Decommissioning
C101	Stockpile drilling cuttings adjacent to the well or in containers and dispose of appropriately in consultation with the landowner.	Construction/Operations Decommissioning
C102	Store onsite materials in suitable containment systems constructed to industry standards and Australian standards (AS 1940-2004, The Storage and Handling of Flammable and Combustible Liquids (Standards Australia, 2004a), and AS 3780, The Storage and Handling of Corrosive Substances (Standards Australia, 2008b) at a minimum). Maintain quality control and quality assurance procedures to monitor volumes and quantities. Bund aboveground storage areas to contain spills.	Construction/Operations Decommissioning
C103	Manage soil contaminated by oil, fuel and grease in accordance with the project hydrocarbon management plan, which includes procedures for the excavation and removal to a licensed landfill or remediation at site. Where contamination has occurred, investigate and remediate in accordance with [16]National Environmental Protection (Assessment of site Contamination) Measure 1999.	Construction Operations Decommissioning
C104	Maintain a minimum separation, as agreed with the landowner, between animal enclosures and production wells and facilities.	Construction Operations Decommissioning
C105	Suspend works when rainfall or storm events produce onsite conditions that, if trafficked or worked, would compromise the effectiveness of erosion and sediment control structures, or would lead to rutting and compaction of soils or mixing or inversion of soil horizons.	Construction/Operations Decommissioning
C106	Stockpile cleared or mulched vegetation along the inside edge of the work sites (separate from soil stockpiles), to aid the control of runoff and ensure stockpiled vegetation does not pose a bushfire hazard.	Construction Operations Decommissioning
C170	Control sediment runoff from stockpiles.	Construction
C108	Construct batters and embankments of drill pads and production facility benches at appropriate slopes and protect from erosion.	Construction/Operations Decommissioning
C109	Stockpile imported fill for bedding of pipes adjacent to the trench and away from vegetation, topsoil and subsoil stockpiles.	Construction/Operations Decommissioning

Replaces existing Queensland draft guideline

Commitment Number	Commitment	Relevant Phase
C110	Remove excess imported fill and residual subsoil from the work site, and reuse or dispose of in accordance with landowner requirements.	Construction/Operations Decommissioning
C111	Maintain the operation and effectiveness of soil conservation structures by considering the following measures: • Avoid breaching, diversion or disturbance of contour banks, waterways and dams. • Avoid earthworks that affect waterway function. • Locate wells, access tracks and gathering lines downhill and parallel to soil conservation structures and avoid perpendicular or lateral connections. • Utilise existing access tracks and trafficked areas.	Construction/Operations Decommissioning
C112	Remove sediment fencing prior to cultivation and dispose of in accordance with landowner requirements or in accordance with the waste management plan of the Arrow HSEMS.	Construction/Operations Decommissioning
C113	Cap or fit wellhead equipment to wells at the completion of drilling to ensure no uncontrolled release of gas or water.	Construction/Operations Decommissioning
C115	Replace or rehabilitate all disturbed infrastructure to predisturbance condition.	Decommissioning
C116	Regrade work sites to original surface contours following reinstatement of soil.	Decommissioning
C117	Mulch vegetation and reuse in site rehabilitation.	Decommissioning
C118	Deep rip and cross rip all construction areas and temporary access tracks to a depth of at least 0.4 m. Repeat following topsoil reinstatement to promote infiltration and assist the re-establishment of connections between soil horizons.	Decommissioning
C119	Compact padding material and subsoils used to backfill pipeline trenches to reduce settling. Limit compaction to no deeper than 0.5 m below natural surface level.	Decommissioning
C120	Prepare a baseline assessment plan to establish benchmark data in registered third-party bores (where possible) prior to the commencement of Arrow extraction activities in accordance with the Water Act, including the preparation and implementation of a groundwater monitoring and investigation strategy.	Planning and Design
C121	Rehabilitate clean water diversions, down-gradient soil erosion control works and temporary sediment dams to preconstruction site levels prior to sowing with crops or pasture grasses.	Decommissioning
C122	Clean and reinstate (if necessary) erosion and sediment control structures prior to and following storm events and periodically during long periods of rain.	Decommissioning
C123	Visually inspect rehabilitated work sites for flow diversions and evidence of erosion associated with trench settling or incomplete reinstatement of surface contours. If any problems are encountered, implement corrective actions as soon as practicable.	Decommissioning
C124	Consider local biological, groundwater and surface water conditions when identifying sites for coal seam gas water dams and brine dams.	Planning and Design

Commitment Number	Commitment	Relevant Phase
C125	Consider local groundwater conditions when identifying sites for the installation of buried infrastructure (e.g., gathering lines).	Planning and Design
C126	Avoid unnecessary impervious surface coverings and reduce land footprint and vegetation clearing when designing facilities.	Planning and Design
C127	Undertake bore assessments of third-party bores (where possible) in accordance with the Water Act, including: • Having the Office of Groundwater Impact Assessment (the former Queensland Water Commission) for the Surat Cumulative Management Area identify bores requiring assessment. • Developing make-good agreements that include the outcome of bore assessments and implementation of make-good measures in the event that impaired capacity occurs.	Planning and Design
C128	Continue an investigative program that will help quantify the connectivity between the Condamine Alluvium and the Walloon Coal Measures. The program will involve: • Monitoring the effects of groundwater extraction in the Walloon Coal Measures on the Condamine Alluvium to estimate horizontal and vertical hydraulic conductivity between the alluvium and the Walloon Coal Measures. • An investigative drilling program that will provide greater definition of the interface between the two units and will evaluate the geological and hydrogeological properties of the material at the interface of the units. • Groundwater chemistry studies to characterise mixing and migration between the units. • Groundwater modelling, utilising the connectivity data obtained through investigative components of the program, to understand important processes in the system and predict potential impacts.	Planning and Design
C129	Continue a program of aquifer testing in dedicated groundwater monitoring bores to increase the predictability of aquifer properties and groundwater movement.	Planning and Design
C130	Collect relevant geological and hydrogeological data from existing and future production wells, monitoring bores and registered third-party bores (where possible) together with information collated collaboratively with other proponents and regulatory authorities.	Planning and Design
C131	Update and calibrate the geological model and the numerical groundwater model with relevant data on an ongoing basis, including: • Aquifer thicknesses and interfaces between formations. • Aquifer properties, e.g., porosity, permeability. • The location of sensitive areas, e.g., groundwater discharge springs. • Observed responses in monitoring bores that reflect aquifer behaviour during coal seam gas extraction.	Planning and Design
C132	Utilise the updated geological and numerical groundwater models to: • Make ongoing predictions regarding changes to groundwater levels and groundwater quality as the project develops. • Improve confidence in the understanding of the	Planning and Design

Commitment Number	Commitment	Relevant Phase
	sensitivity and resilience of the aquifers within the identified groundwater systems.	
C133	Perform groundwater modelling simulations to predict impacts on groundwater resources in overlying and underlying aquifers. This information will subsequently be used to evaluate the suitability of these resources for use in make-good measures.	Planning and Design
C134	Verify the preferred water management strategy by modelling the effectiveness of substitution ('virtual injection') and injection (if conducted) in offsetting depressurisation impacts in the Condamine Alluvium.	Planning and Design
C135	Consider injection of coal seam gas water or brine of a suitable quality (if proven technically feasible) into shallow or deep aquifers to offset depressurisation impacts in aquifers.	Operations
C136	Address the potential for surface deformation through participation by Arrow in a collaborative study with other proponents using historical and baseline data from the Advanced Land Observation Satellite covering a time-lapse period from January 2007 until January 2011. This will allow a detailed analysis of the region and will enable the analysis of the evolution of measured surface deformation in space and time. The assessment will correlate and calibrate data deliverables (calibrated global map and vector files for measurement points) from the Advanced Land Observation Satellite to show the mean deformation rate, identify areas of large-scale deformation and compare patterns with other information (e.g., geology, basin structure, extraction wells and injection data).	Planning and Design
C137	Construct all coal seam gas production infrastructure in accordance with the standards described in the P&G Act and regulations to that act.	Construction
C138	Construct, decommission or repair all monitoring bores in accordance with the minimum construction requirements for water bores in Australia (National Uniform Drillers Licencing Committee, 2012) and the minimum standards for the construction and reconditioning of water bores that intersect the sediments of artesian basins in Queensland (DERM, 2004).	Construction Operations Decommissioning
C139	Select drilling fluids to minimise potential groundwater impacts. Do not use oil-based drilling fluids.	Construction
C140	Ensure well drilling is monitored by a suitably qualified geologist to ensure aquifers are accurately identified for correct well construction.	Construction

Commitment Number	Commitment	Relevant Phase
C141	Develop the construction, design and monitoring requirements for new dams (either raw water, treated water or brine dams) and determine the hazard category of the dam in accordance with the requirements of the most recent version of Manual for Assessing Hazard Categories and Hydraulic Performance of Dams (EHP, 2012c). Construct the dams under the supervision of a suitably qualified and experienced person in accordance with the relevant DERM schedule of conditions relating to dam design, construction, inspection and mandatory reporting requirements.	Construction
C142	Manage potential impacts on identified spring complexes by: • Supporting the identification of specific aquifers that serve as a groundwater source for discharge springs. • Assessing springs that are predicted to be subject to unacceptable impacts through the source aquifer. • Developing monitoring and mitigation strategies to avoid or minimise unacceptable impacts.	Operations
C143	Implement a well integrity management system during commissioning and operation of production wells.	Operations
C144	Minimise impacts of groundwater depressurisation on sensitive areas (e.g., groundwater-dependent ecosystems).	Operations
C145	Develop a procedure for investigating the impaired capacity of third-party bores. The investigation will comprise (but not be limited to) the following phased investigation response: • Verify groundwater levels in the nominated bores and investigate groundwater levels and groundwater quality in compliance monitoring bores against established trigger thresholds. • Request bore information and groundwater data from affected parties. • Review and assess data. • Advise bore owners in writing of findings.	Operations
C146	If impaired capacity is confirmed (bore can no longer produce quality or quantity of groundwater for the authorised purpose, and the impact is due to coal seam gas activities), implement make-good measures in accordance with the Water Act.	Operations
C147	Include where possible make-good measures such as substitution of groundwater allocations of equal or better quality to maintain user supply, deepening of bores, modification of pumps, or supply of groundwater from an alternative source.	Operations
C148	Connect wastewater and sewerage systems to sewers where locally present. Alternatively, install wastewater treatment or reuse systems in accordance with AS/NZS 1547:2000, On-site Domestic Wastewater Management (Standards Australia, 2000); DERM guideline for managing sewerage infrastructure to reduce overflows and environmental impacts (DERM, 2010b); and Queensland water recycling guidelines (DERM, 2005).	Operations
C149	Store and manage all waste materials (domestic and industrial) in accordance with industry regulations and EHP conditions. Use licensed waste management contractors. Conduct audits of disposal facilities, disposal permits and onsite operations to ensure adherence to regulations.	Operations

Commitment Number	Commitment	Relevant Phase
C150	Construct, decommission or repair all coal seam gas production wells in accordance with the code of practice for constructing and abandoning coal seam gas wells in Queensland (DEEDI, 2011b), or relevant code at the time of construction, which details mandatory requirements for well installations, monitoring, management and eventual decommissioning. Should production wells be converted into monitoring bores, do so in accordance with relevant regulations.	Construction Operations Decommissioning
C151	When siting production facilities, avoid wetlands and consider the following: • Stream processes that may result in channel migration (either over time or as a result of project activities) and areas that are highly susceptible to erosion (i.e., dispersive soils). • Downstream values of nearby watercourses or wetlands. • Minimising changes to natural drainage lines and flow paths. • Flooding regimes and areas subject to inundation.	Planning and Design
C152	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.	Planning and Design
C153	Avoid permanent pools, chains of ponds, and alluvial islands, where practicable, when selecting watercourse crossing points.	Planning and Design
C154	Design coal seam gas water dams in accordance with relevant legislation, standards and guidelines.	Planning and Design
C155	Site facilities above the 1-in-100-year average flood recurrence interval, where practicable and design infrastructure taking into consideration overland flow and flooding regimes to reduce impacts on immediate and surrounding areas.	Planning and Design
C156	Manage potential impacts on Lake Broadwater Conservation Park (Category A ESA) through implementation of relevant buffers in accordance with legislative requirements at the time of development in this region.	Planning and Design
C157	Arrow will implement a buffer zone from the high bank of all watercourses to prevent development or clearance occurring within the buffer~~s~~ (other than construction of watercourse crossings for roads and~~,~~ pipelines, discharge infrastructure and associated stream monitoring equipment). Determine the buffer zone distance in accordance with the legislative requirements at the time of development or through preconstruction clearance surveys.	Planning and Design Construction
C158	Develop site-specific management plans for permanent and semi-permanent watercourse crossings detailing construction and environmental management requirements, including consideration of the scour potential of the watercourse.	Planning and Design
C159	Design culverts and drains to maintain flow and prevent headward erosion.	Planning and Design
C160	Consider the bank and stream bed stability when siting watercourse crossings and, where practicable, utilise existing stable crossings or locations where bedrock control exists to reduce the potential for erosion and generation of sediment.	Planning and Design

Commitment Number	Commitment	Relevant Phase
C161	Plan construction of watercourse crossings to occur during periods of low rainfall and low flow, when practicable.	Planning and Design
C162	Minimise potential impacts on surface waters through implementation of the following measures during construction of watercourse crossings: • Delay clearance of stream banks until the watercourse crossing is due to be constructed, to the greatest extent practicable. • Implement appropriate erosion and sediment control measures (e.g., silt fences, sediment basins and erosion berms) on watercourse approaches and banks and ensure prompt completion of construction.	Construction
C163	Check for flood warnings or subscribe to flood warning services where relevant during construction of watercourse crossings.	Construction
C164	Construct watercourse crossings in a manner that reduces sediment release to watercourses, stream bed scouring (e.g., the crossing location will be at low-velocity, straight sections, with the pipeline or road orientated as near to perpendicular to water flow as practicable), obstruction of water flows and disturbance of stream banks and riparian vegetation. Avoid, where practicable, the use of rock gabions, as they are unsuited to watercourses of the region.	Construction
C165	Stockpile watercourse bed material in the watercourse channel adjacent to the construction ROW only when the watercourse is dry, and site the stockpile to avoid impacts on riparian vegetation and in-stream features.	Construction
C166	Retain coarse alluvial material from watercourse crossings for backfill armouring over the finer unconsolidated material.	Construction
C167	Stabilise and maintain stream banks following watercourse crossings.	Construction
168	Develop and implement a hydrostatic testing procedure prior to commencement of hydrotest activities that includes but is not limited to the following measures: • Conduct consultation with landowners and relevant regulatory authorities prior to sourcing and disposing of hydrotest water. • Avoid or minimise harmful chemical additives and reuse hydrotest water on adjacent pipeline sections where practicable. • Ensure hydrotest water that is discharged or recycled for secondary uses meets relevant statutory water quality guidelines.	Construction
C169	Grade soil away from watercourses.	Construction
C170	Locate soil stockpiles away from watercourses and wetlands to reduce potential for sediment runoff to enter the watercourse or wetland.	Construction
C171	Develop and implement incident reporting, emergency response and corrective action systems or procedures. Include systems for reporting, investigation and communications of lessons learned.	Construction/Operations
C172	Segregate stormwater discharge from potential contaminant process areas.	Operations

Commitment Number	Commitment	Relevant Phase
C173	Inspect rehabilitated watercourse channels and banks following significant flow events and undertake remedial works as required.	Operations
C174	Maximise beneficial use of coal seam gas water.	Operations
C176	Where used for dust suppression on roads or for construction and operations activities coal seam gas water quality will be, in accordance with relevant permits and/or consents.	Construction/Operations
C177	Minimise the inventory of hazardous materials stored on site.	Operations
C178	Decommission infrastructure in such a manner that it will not adversely affect overland or flood flows and in accordance with relevant legislation and regulations.	Decommissioning
C179	Advise all relevant personnel of the location and extent of weed infestations in the vicinity of work areas and the risks involved in moving from one site or property to another.	Planning and Design Construction/Operations Decommissioning
C180	Do not wash down vehicles in watercourses.	Planning and Design Construction/Operations Decommissioning
C181	Avoid the use of vehicles and machinery in the vicinity of or within watercourses and riparian zones, wherever practicable.	Planning and Design Construction/Operations Decommissioning
C182	Locate self-contained portable toilet facilities at designated work sites at appropriate distances from watercourses, where they are accessible to all operations and maintenance personnel. Regularly maintain the facilities and dispose of sewage and greywater from toilet facilities via a chemical treatment system or transport to a municipal sewage treatment plant using a licensed contractor.	Planning and Design Construction Operations Decommissioning
C183	Where appropriate, design ground disturbance works to minimise the need for cut-and-fill earthworks.	Planning and Design
C184	Design watercourse crossings to enable passage of flows resulting from a 1-in-100-year average recurrence interval flood event, as a minimum.	Planning and Design
C185	Design the width of the pipeline ROWs to be narrower at watercourse crossings, where practicable.	Planning and Design
C186	Co-locate pipelines into one watercourse crossing corridor, where practicable.	Planning and Design
C187	Design washdown facilities to ensure that runoff is contained on site and does not transfer weed seeds, spores or infected soils to adjacent areas. Treat or dispose of washdown solids in a registered landfill.	Planning and Design

Commitment Number	Commitment	Relevant Phase
C188	Develop a declared weed and pest management plan in accordance with the Petroleum industry (including coal seam methane gas) minimising pest spread advisory guidelines (Biosecurity Queensland, 2008), or relevant legislation at the time. Undertake species-specific management for identified key weed species at risk of spread through project activities (mesquite, parthenium, African lovegrass and lippia). Increase weed control efforts in areas particularly sensitive to invasion. The pest management plan should include, as a minimum, training, management of pest spread, management of pest infestations, requirements for crossing and working around pest fences and monitoring the effectiveness of control measures.	Planning and Design
C189	Plan construction and maintenance activities to minimise movement of plant and equipment between properties or areas with weed infestations.	Planning and Design
C190	When sourcing maintenance materials, check materials such as bedding sand, topsoil and sand bags for weeds and plant materials or animal pathogens. Request a weed hygiene declaration form from the supplier where there is possible risk of contamination in products or materials.	Planning and Design Construction Operations Decommissioning
C191	Design gathering lines and tracks to avoid watercourses, drainage lines and riparian areas (particularly permanent watercourses or perennial aquatic habitat), where practicable.	Planning and Design
C192	Obtain all relevant permits required under the *Fisheries Act 1994* (Qld), including permits for construction of waterway barriers or disturbance of fish habitat.	Planning and Design
C193	Identify declared weeds during the preconstruction clearance survey.	Construction
C194	Avoid transport of equipment across watercourses unless an appropriate crossing that minimises disturbance to the watercourse bed and banks and to riparian vegetation is available.	Construction
C196	Design flumes used to construct watercourse crossings to a suitable size~~d~~ to maintain flows and enable fish passage. Protect the bed of the watercourse from scouring at the site of the downstream discharge of any flumes or pipes.	Construction
C197	Store stockpiled, cleared vegetation away from watercourses or drainage lines.	Construction
C198	If diversion of watercourse flows using pumps is required, screen the pump intakes with mesh to protect aquatic life.	Construction
C199	Limit the use of herbicides in the vicinity of watercourses or within riparian zones. Use non-toxic, non-persistent (i.e., biodegradable) herbicides to treat weeds, except on properties where organic or biodynamic farming is practised, for which the method of weed treatment is to be agreed with the landowner.	Operations
C200	Adhere to the following mitigations specific to Landscape Type I: forested steep hills, Captains Mountain (comprising Captains Mountain, Commodore Peak and Mt Domville): • Avoid locating production facilities adjacent to and on Captains Mountain. • Avoid locating production wells and gathering systems on the forested steep slopes and ridges of Captains Mountain.	Planning and Design Construction

Commitment Number	Commitment	Relevant Phase
	• Avoid ROWs perpendicular to the slope when locating production wells and gathering systems adjacent to the forested steep hills of Captains Mountain.	
C201	Develop and continually maintain the coal seam gas water management strategy throughout the project life to optimise the investigation and implementation of the potential coal seam gas water management options in alignment with the overall project development.	Planning and Design
C202	Contain coal seam gas water in dams for treatment through reverse osmosis.	Construction/Operations Decommissioning
C203	Demonstrate the requirement for disposal when beneficial uses are unavailable, including details of the control measures that will be implemented.	Operations
C204	Maintain water balance models for long-term planning and management of coal seam gas water. Review and update modelling in alignment with the production-forecasting schedule.	Planning and Design Construction/Operations Decommissioning
C205	Identify strategies to minimise coal seam gas water surface storage and to promote increased efficiency.	Planning and Design
C206	Subject each dam to separate approvals by the regulating authority. Each approval will require the incorporation of general and specific controls to avoid, mitigate or manage threats associated with flooding.	Planning and Design
C207	Implement the dam operating plan.	Inspection and Monitoring
C208	To reduce mosquito breeding in dams, dams and dam inner banks will be maintained so that they are as free of vegetation as practicable.	Construction/Operations
C209	Use an independent, suitably qualified, third party to certify that dams meet the dam design plan.	Planning and Design
C210	Have in place a system for the collection and proper disposal of any contaminants that move beyond the bounds of the containment system of brine dams.	Planning and Design
C211	Design and size dams to account for predicted flood conditions.	Planning and Design
C212	Inspect food scrap bins and exclusion fences to ensure they are properly operated and maintained.	Inspection and Monitoring
C213	Line banks of dam with an impervious lining.	Construction
C214	Design dams to have an egress (escape point) for wildlife.	Construction
C215	Establish overflow and operational controls in accordance with the dam operating plan.	Operations
C216	Inspect and maintain dam integrity.	Operations
C217	Avoid the following areas: • Wondul Range National Park and Lake Broadwater Conservation Park (Category A ESAs). • Chinchilla Sands Local Fossil Fauna Site. • 'Critically endangered' EPBC Act communities within the project development area (REs 11.3.21, 11.3.24, 11.8.2a) including three natural grassland road reserves (Dalby Kogan, Dalby St George and Dalby Cecil Plains).	Planning and Design

Commitment Number	Commitment	Relevant Phase
C218	Aim to avoid: • Additional national- and state-listed communities: Brigalow (REs 11.3.1, 11.4.3, 11.4.10, 11.9.5, 11.9.6), Semi-evergreen vine thickets (REs 11.9.4a, 11.8.3), Weeping Myall Woodlands, and Coolibah-Blackbox Woodlands (RE 11.3.3). • Category B ESAs. • Category C ESAs, including Gurulmundi State Forest, Binkey State Forest and Barakula State Forest. • Wyaga-Kindon Ooline populations. • Stock routes and state or bioregional wildlife corridors. • Essential and core habitat (supporting listed wildlife species). • State forests and resources reserves. • State-listed 'of concern' regional ecosystems.	Planning and Design
C219	Where avoidance is not possible, and significant residual impacts remain to threatened species and communities, implement an offset strategy approved by a relevant government agency and comply with reporting conditions of an offset plan.	Planning and Design
C220	Conduct preconstruction clearance surveys to identify any additional areas that may need to be avoided.	Planning and Design
C221	Design facilities to ensure natural surface water flows are not impounded, e.g., by installing culverts on roads and stormwater diversion ditches around production facilities.	Planning and Design
C222	Arrow will carry out waste audits and reporting for waste generating activities to: • Provide waste data to enable continuous improvement of waste avoidance, reduction and management measures throughout the project life. • Assess whether action is required to fulfil set waste objectives and management. • Assess the adequacy of proposed mitigation measures and identify where mitigation measures need revision or additional measures. • Monitor potential environmental impacts that will enable positive action to be implemented in case of incidents or accidents related to waste activities. • Provide actual waste management results by comparing predicted impacts and mitigation measures.	Construction Operations Decommissioning
C223	Develop fire plans for production facilities.	Planning and Design Operations
C224	Develop management procedures, inclusive of buffers where required, for threatened communities and species as and when project activities are identified as likely to have an impact on these values.	Planning and Design
C225	Avoid construction activities in waterbodies frequented by migratory species.	Planning and Design
C226	Store liquid waste generated (other than coal seam gas water and sewage) and periodically remove it for disposal or recycling.	Construction/Operations Decommissioning
C227	Manage potential impacts on Category A, B and C ESAs through implementation of buffers in accordance with legislative requirements at the time.	Construction

Commitment Number	Commitment	Relevant Phase
C228	Mark site boundaries clearly for site-specific sensitive areas that require avoidance.	Construction
C229	Inform relevant workers, including contract plant and machinery operators of the location of significant remnant vegetation and buffers and use qualified personnel to guide~~d~~ clearing activities.	Construction
C230	Demarcate buffers and inform workers and machinery operators of buffer locations when working within the vicinity of national- and state-listed species, communities and areas identified for avoidance.	Construction
C231	Reduce the width of construction ROW within areas of sensitivity to the greatest extent practicable without compromising the safety of workers.	Construction
C232	Conduct preconstruction clearance surveys and include as a minimum: • Vegetation mapping at a scale suitable for site-specific planning. • Identification of core habitats and listed species. • Identification of site-specific sensitive areas that require avoidance or buffer areas.	Construction
C233	Minimise the time a trench is left open. Construct exit points when construction is within 1 km of native vegetation, using appropriate material. Provide fauna refuges, such as sawdust-filled bags, regularly through areas of high fauna activity.	Construction
C234	Retain habitat trees, where practicable.	Construction
C235	Assess trees prior to felling for potential nesting hollows. If identified, fell trees in the presence of a qualified fauna spotter-catcher and roll them so that the hollows are facing upwards, allowing fauna to escape.	Construction
C236	Identify key koala trees (*Eucalyptus tereticornis* and *Eucalyptus populnea*), and visually inspect prior to clearing to ensure that they are free of koalas. If koalas are located, the tree should be retained until the animals have moved on, typically overnight.	Construction
C237	Use appropriately trained personnel or a spotter-catcher to capture injured wildlife, where possible. If further action is required, consult with a qualified vet to determine appropriate action.	Construction
C238	Retain woody debris, logs and rocks for use in rehabilitation spreading them over part or all of the corridor or, as a minimum, piled along the edge of the cleared corridor to provide refuge for crossing fauna.	Construction
C239	Translocate or propagate significant species where it is deemed necessary for use during rehabilitation or in offsets in accordance with relevant legislation.	Construction
C240	Construct production wells, gathering lines and access tracks within cleared areas, where practicable, with the aim of avoiding sensitive areas.	Construction
C241	Fell trees away from existing stands where practicable. Where trees unavoidably fall into a stand, leave trees in situ to emulate natural tree fall and provide habitat for ground-dwelling species, where practicable.	Construction

Commitment Number	Commitment	Relevant Phase
C242	Avoid damaging standing trees not identified for removal. Limit the scraping of standing tree trunks and breaking of limbs by equipment as far as practicable.	Construction
C243	Erect fauna-exclusion fences around project dams.	Construction
C244	Consider the preconstruction clearance survey baseline characterisation when rehabilitating project sites.	Decommissioning
C245	Implement site planning, preparation and management requirements in accordance with a developed and approved decommissioning and rehabilitation plan.	Decommissioning
C246	Decommission the pipeline corridors in a manner that minimises potential impacts on the environment.	Decommissioning
C247	Identify areas for rehabilitation.	Decommissioning
C248	Prioritise areas for rehabilitation based on the preconstruction clearance survey baseline characteristics.	Decommissioning
C250	Advise, through procedures and plans, on requirements for rehabilitation in identified areas that are no longer in use.	Decommissioning
C251	Reinstate self-supporting drainage lines.	Decommissioning
C252	Inspect rehabilitation areas after decommissioning for regrowth similar to the surrounding environment.	Decommissioning
C253	Select plant species for the purposes of rehabilitation that are specific to the original ecosystem and of local provenance, wherever practicable.	Decommissioning
C254	Implement noise control techniques in accordance with the project's noise and vibration commitments and standard industry noise suppression techniques.	Construction/Operations Decommissioning
C255	Reduce light spill resulting from project activities to reduce disturbance to nocturnal fauna.	Construction/Operations Decommissioning
C256	Prohibit disturbance or harassment of wildlife and the unauthorised collection of flora and forest products.	Construction/Operations Decommissioning
C257	Dispose of waste that cannot be reused or recycled at appropriately licensed facilities.	Construction/Operations Decommissioning
C258	Dispose of food scraps in large skips or bins that prevent animal access. Empty these storage devices regularly in a manner that does not involve disposal to onsite trenches or waste dumps.	Construction/Operations Decommissioning
C259	Train field personnel to identify key pest species and to maintain constant vigilance for weeds and pest fauna species throughout the project life to ensure early detection and intervention.	Construction/Operations Decommissioning
C260	Implement speed limits on project-controlled roads to reduce the potential for vehicle collisions with wildlife.	Construction/Operations Decommissioning
C261	Install and maintain appropriate sediment and erosion control structures at work sites.	Construction/Operations Decommissioning
C262	Use shrouded, downcast lighting to minimise spill and restrict it to the minimum required for safety and security. Design lighting in accordance with AS 4282-1997, Control of the Obtrusive Effects of Outdoor Lighting (Standards Australia, 1997).	Planning and Design

Commitment Number	Commitment	Relevant Phase
C263	Co-locate facilities where practicable and design infrastructure layouts to minimise the footprint (taking into consideration the elements that contribute to landscape character) to reduce visibility of the facilities.	Planning and Design
C264	Site each production facility in the landscape of lowest sensitivity, where practicable, such as next to existing industrial developments or existing coal seam gas facilities.	Planning and Design
C265	Avoid visually sensitive locations and landscapes when siting facilities, where practicable. Seek backdrops when siting facilities to protect the skyline in distant views. Avoid siting facilities within view of sensitive viewpoints, particularly the bird hide and camping area at Lake Broadwater, Captains Mountain, Jimbour House, the Cunningham Highway, towns, schools and private residences.	Planning and Design
C266	When siting production facilities, maintain the maximum distance practicable from, and ~~minimise~~ reduce visual disturbance to, the most sensitive visual receptors. Seek to maintain at least 500 m separation from sensitive viewpoints, particularly tourist trails, roads, residences and built-up areas.	Planning and Design
C267	Hide or screen production facilities using natural landscape features or planted native vegetation barriers, where appropriate. Avoid removal of mature trees and other woodland features that screen views to facilities. Establish screening barriers using endemic species in advance of construction of the facilities.	Planning and Design
C268	Integrate facilities into the landscape setting where screening is not practicable, considering building and structure colour, texture and lines. Use matt and low-glare finishes two shades darker than the prevalent shading of the site, having regard to sun angles throughout the day and year and to the harvesting of crops, where practicable. Consider camouflage paints or finishes in highly sensitive landscapes.	Planning and Design
C269	Consult with potentially impacted visual receptors (landowners and neighbours) in locating facilities. Seek to reduce the form and shape of facilities visible by landowners and residents.	Planning and Design
C270	Conduct planned maintenance flaring during daylight hours to minimise light spill, where practicable.	Planning and Design
C271	Where it is not practicable to screen or integrate a facility into the landscape, consider designing the facility to be a feature in the landscape, taking into consideration the form, texture and arrangement of buildings and structures.	Planning and Design
C272	When clearing vegetation, seek to avoid creating gaps in stands or patches and to avoid isolating parcels of remnant vegetation from more continuous tracts.	Planning and Design
C273	Plan the movement of equipment and materials during times of least visual impact (i.e., work day start and end), where practicable.	Construction
C274	Target dry weather periods when undertaking construction in sensitive landscape areas (e.g., waterway crossings), where feasible, to minimise visual impacts due to sedimentation and erosion.	Construction

Commitment Number	Commitment	Relevant Phase
C275	Locate topsoil and spoil mounds in visually unobtrusive locations, where practicable.	Construction
C276	Incorporate excess spoil from site excavations into bunding at the base of a planted vegetation screening barrier to increase the overall height of the barrier.	Construction
C277	Utilise landscape features and contours, where practicable, to integrate linear infrastructure (access tracks, gathering lines) into the landscape.	Construction
C278	Optimise the length and width of roads and tracks.	Construction
C279	Avoid roads traversing highly visible hills.	Construction
C280	Minimise construction time near sensitive visual receptors.	Construction
C281	Develop and implement waste management procedures in accordance with the Queensland Environmental Protection (Waste Management) Policy 2000.	Construction
C282	Maintain visual amenity controls used to reduce landscape and visual impacts. Replace lost trees or shrubs in screening barriers to ensure they establish and maintain an effective barrier.	Operations
C283	Remove surface infrastructure and reinstate disturbed areas as soon as practicable to predisturbance landscape characteristics or consult with landowners regarding reinstatement objectives.	Decommissioning
C284	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 council or the Department of Transport and Main Roads.	Planning and Design Operations Decommissioning
C285	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 DTMR (if a state road).	Planning and Design
C286	Undertake threshold assessments to determine whether upgrading of rail crossings is warranted.	Planning and Design
C287	Implement driver training and fatigue awareness for employees and contractors and incorporate journey management practices.	Planning and Design
C288	Implement an in-vehicle monitoring system for project vehicles.	Planning and Design
C289	Schedule roster changes to avoid peak traffic times.	Planning and Design
C290	Develop project logistics plans to provide safe movement of people and materials, as well as to minimise traffic volumes.	Planning and Design
C291	Develop journey management plans in consideration of high-risk roads.	Planning and Design
C292	Use heavy-vehicle routes that avoid unsuitable bridges.	Planning and Design
C293	Where assessed necessary, identify and implement improvement measures (e.g. protected turning lanes) for entry to permanent facilities to address road safety issues.	Construction

Commitment Number	Commitment	Relevant Phase
C294	Ensure access driveways to project facilities and infrastructure have appropriate sight distances.	Construction
C295	Implement traffic controls, including signage (e.g., reduced speed limits, warning signs) and restrictions of movements (e.g., no travel during school bus pick-up and drop-off times).	Construction Operations Decommissioning
C296	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 pull-over areas where necessary.	Construction Operations Decommissioning
C297	Make workers aware of school bus routes, as well as typical pick-up and drop-off times in the vicinity of the work sites.	Construction Operations Decommissioning
C298	Coordinate with relevant authorities (e.g., Queensland Police, Department of Transport and Main Roads and council) for movement of heavy or oversized loads.	Construction Operations Decommissioning
C299	Implement journey management plans.	Construction/Operations Decommissioning
C300	Manage project-related activities in the vicinity of existing stock routes in accordance with the Land Protection (Pest and Stock Route Management) Act.	Construction/Operations Decommissioning
C301	Where noise reduction devices are deemed necessary, ensure devices (such as mufflers, low-noise fans and possibly enclosures) are fitted and work correctly.	Planning and Design Construction/Operations Decommissioning
C302	Operate equipment and handle materials in a manner that does not cause unnecessary noise. (e.g., excessive revving or dropping materials).	Planning and Design Construction/Operations Decommissioning
C303	Develop site-specific monitoring programs for threatened species and communities based on the identified risk to the conservation or maintenance of a viable population.	Inspection and Monitoring
C304	Manage noise in accordance with the relevant permits and/or consents. Where night-time activities are planned (10 p.m. to 6 a.m.) and are likely to exceed the prescribed noise criteria, conduct prior consultation with affected parties.	Planning and Design Construction/Operations Decommissioning
C305	Consult with those who may be affected by increased noise levels due to construction activities with particular reference to the type and timing of works.	Planning and Design Construction/Operations Decommissioning
C306	Conduct risk-based assessment or potential vibration monitoring during any construction activity that occurs within 100 m of a sensitive receptor that might be subject to vibration.	Planning and Design Construction/Operations Decommissioning
307	Implement a grievance management system that responds to noise complaints. If necessary, undertake noise monitoring of construction activities to facilitate a response to the grievance.	Planning and Design Construction/Operations Decommissioning
C308	Routinely monitor integrity and amenity on project-related roads.	Inspection and Monitoring
C309	Preferential selection of sites in sparsely populated areas.	Planning and Design

Commitment Number	Commitment	Relevant Phase
C310	Site-specific, detailed noise modelling of production facilities and the application of acoustic treatments where the modelled noise from facilities exceeds the established noise criteria at one or more sensitive receptors. Consideration of intrinsically quieter equipment or design of acoustic treatments such as hospital-grade exhaust systems and mufflers, or barriers and equipment housing will be given.	Planning and Design
C311	Locate equipment associated with production wells and associated wellhead infrastructure at a distance of 200 m or more from a sensitive receptor.	Planning and Design
C312	Consider the following factors prior to any blasting operations being conducted: • The type of rock and stratigraphy being blasted and any associated faulting. • The distance of the blast site from sensitive receptors. • The type, size and number of charges used. • The depth and manner in which the charge is installed. • The meteorological conditions. • Methods of controlling blast noise and vibration, such as mats or smaller blasts.	Construction
C313	Where practicable, schedule planned flaring events (e.g., those preceding shut-down maintenance) for the period between 6 a.m. and 10 p.m.	Operations
C314	Monitor compliance with the project's road safety requirements through regular review of reports generated by the in-vehicle monitoring system.	Inspection and Monitoring
C315	Conduct regular safety inspections of project vehicles.	Inspection and Monitoring
C316	Encourage contractors engaged by the project to utilise Australian and Queensland Government skills and training programs where possible, including the Australian Apprenticeship Program. This should include providing information about and developing awareness of government incentives and programs among all contractors engaged and directing contractors to relevant agencies.	Construction Operations Decommissioning
C317	Implement monitoring and inspection of avoidance, mitigation and management measures to ensure the residual impacts continue to be negligible throughout the lifetime of the project.	Inspection and Monitoring
C318	If directed by the administering authority in response to a valid noise complaint, undertake noise monitoring in accordance with the DERM (2000) Noise Measurement Manual.	Inspection and Monitoring
C319	Continue to support programs such as the CSG/LNG Industry Training Program to develop coal seam gas industry skills in the local workforce.	Construction Operations Decommissioning
C320	Collaborate with state government, local councils, local industry, industry organisations, and coal seam gas 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 Surat Gas Project from other sectors.	Construction Operations Decommissioning
C321	Consider building construction worker TWAFs prior to construction of production facilities to minimise any impacts on property markets during early phase construction works.	Planning and Design

Commitment Number	Commitment	Relevant Phase
C322	Accommodate workers required to construct camps TWAFs in temporary accommodation wherever practicable.	Planning and Design
C323	The social impact management plan details the mitigation measures that will be implemented by Arrow through the life of the project.	Planning and Design
C324	Inspect known Indigenous sites identified as having the potential for being impacted by the project and subsequently acknowledged for avoidance, in accordance with the relevant approval and permit conditions including the cultural heritage management plan.	Inspection and Monitoring
C325	Inspect known non-Indigenous sites identified as having the potential for being impacted by the project and subsequently acknowledged for avoidance, in accordance with the relevant approval and permit conditions including the cultural heritage management plan.	Inspection and Monitoring
C326	Schedule inspections and develop a monitoring program to ensure that the safety management systems are functioning properly and that it is appropriate to the hazards identified.	Inspection and Monitoring
C327	Examine options for establishing a local cooperative service or a network or alliances to connect local businesses and enable collaboration in meeting service supply requirements of the coal seam gas industry.	Construction Operations Decommissioning
C328	Inform local council, economic development organisations, the Industry Capability Network and state government of goods and services required by the Surat Gas Project that are not currently available or underserviced from within the Darling Downs.	Construction Operations Decommissioning
C329	Where proponent-owned land is available and it is suitable and safe to do so, consider leasing to farmers to support agricultural production on that land.	Construction/Operations Decommissioning
C330	Store putrescible solid waste in covered containers to prevent odours, public health hazards and access by fauna.	Construction/Operations Decommissioning
C331	Collaborate with state government and local councils to assess the suitability of current planning arrangements to handle a likely increase in demand for industrial and commercial developments and to help them position themselves to reduce response times to planning applications, particularly as the number of planning applications is likely to increase.	Construction Operations Decommissioning
C332	Collaborate with the Queensland Government and other proponents of major projects being developed in the region to identify peak periods when one or more proponents will require common resources simultaneously, to allow adequate and appropriate planning.	Construction Operations Decommissioning
C333	Continue to provide state and local government departments responsible for educational, health and other social infrastructure with forecasts of workforce numbers and projected families to assist in their future service planning. Provide this information in an agreed format that will allow these departments to plan for cumulative population change.	Construction Operations Decommissioning

Commitment Number	Commitment	Relevant Phase
C334	Encourage local population growth where it is desired and planned for, enforcing the expectation that non-local operations employees will relocate to the project development area as there are no plans to establish fly-in, fly-out or drive-in, drive-out operations.	Operations
C335	Provide information and Australian cultural awareness briefing for overseas workers and their families on how to undertake day-to-day activities; for example, provide advice on banking and shopping.	Construction Operations
C336	Provide opportunities for qualified females and people from other underrepresented groups.	Construction/Operations Decommissioning
C337	Implement an Operations Workforce Policy preferring local residence for operations staff.	Operations
C338	Develop a policy identifying training pathways for students and school leavers to assist students in gaining employment upon graduation. The policy will be developed in consultation with Education Queensland. Where relevant training programs have been initiated by other project proponents, Arrow will consider coordinating support with these, where appropriate.	Construction Operations
C339	Provide training opportunities for Arrow employees including: • Vocational and trade training to allow employees the opportunity to gain nationally recognised qualifications. • Specialist training to ensure employee skills are up-to-date. • Graduate development program, which provides a planned development path for newly degree-qualified employees.	Construction Operations Decommissioning
C342	Provide opportunities for students and recent graduates, including: • Graduate development program, offering a planned development path for newly degree-qualified employees. • Scholarships to first-year university students who want to pursue a career in the coal seam gas industry. • Vacation employment for undergraduates in their penultimate year of study, with 12 weeks' paid employment within the company. • School-based training for year 11 and 12 students in Dalby and Moranbah who want to gain vocational qualifications at the Certificate II level.	Construction Operations
C346	Facilitate opportunities for workers to transition to other project phases (e.g., facility construction to facility operation).	Construction Operations Decommissioning
C347	Consider flexible shift hours and rosters to encourage participation of underemployed sectors (e.g., family-friendly shift arrangements for locally-based operations workforce).	Construction Operations Decommissioning
C348	Continue to ensure that equal opportunity policies are in place addressing ethnicity, gender or disability.	Construction/Operations Decommissioning
C349	Implement a hierarchy of preferred employment for employees and contractors based on home or source location, with the highest preference for those living within the study area.	Construction Operations Decommissioning
C350	Liaise with local employment and education or training institutions (e.g., Southern Queensland Institute of TAFE) on training and skills development programs, to identify workers within the region who have the ability to obtain qualifications	Planning and design Construction Operations

Commitment Number	Commitment	Relevant Phase
	based on recognition of prior learning.	
C351	Identify the range of skills required for the labour force and undertake a gap analysis against skills availability. Where gaps exist, in consultation with Energy Skills Queensland, Manufacturing Skills Queensland and Construction Skills Queensland, identify the method or strategy through which these skills gaps will be filled-(e.g.,training).	Planning and design
C352	Undertake regular review of labour requirements and current skills sets to ensure that training strategies meet these needs.	Construction Operations Decommissioning
C353	Continue to build on existing training and skills development programs, including apprenticeships, scholarships, vocational training, support for work readiness programs and pretrade training.	Construction Operations Decommissioning
C354	Participate in existing state and federal government employment and training programs (e.g., Critical Skills Investment Fund, Productivity Places Program, Indigenous Cadetship Support, Indigenous Employment Program, Skilling Queenslanders for Work Initiative).	Construction Operations Decommissioning
C355	Work with Skills Queensland to deliver work readiness and skills development training programs for vulnerable local people, such as the long-term unemployed or underskilled, to assist them to gain employment.	Construction Operations Decommissioning
C356	Notify local people of employment opportunities through recruitment websites, local advertising, local recruitment agencies and information sessions.	Construction/Operations Decommissioning
C358	Implement the Australian Industry Participation Plan (AIPP), which provides detailed information about the strategies and approaches to be undertaken by Arrow to: • Encourage contractors to source local goods and services where possible. • Encourage business to consider Indigenous procurement to maximise Indigenous employment opportunities. • Engage with key business bodies regarding appropriate opportunities for local businesses to supply goods and services to the project. The AIPP was developed in consultation with the state government and is consistent with the Queensland Resource Council (QRC) Code of Conduct.	Construction Operations Decommissioning
C359	Continue to use the Industry Capability Network database for potential suppliers in the area.	Construction/Operations Decommissioning
C360	Develop and maintain a business vendor register.	Construction/Operations Decommissioning
C361	Organise local supplier information sessions to inform business of Arrow's development plans, tender opportunities for local business and how to complete tender requirements.	Construction Operations Decommissioning
C362	Provide industry support organisations with the information that they require to assist local businesses to improve their skills base and respond to project needs.	Construction Operations Decommissioning

Commitment Number	Commitment	Relevant Phase
C363	Collaborate with the existing job referral services set up by other proponents to make available information on positions vacant in local businesses with similar trade or skills requirements. This will allow applicants to choose between industry and non-industry jobs.	Construction Operations Decommissioning
C364	Continue regular consultation with landowners and other stakeholders through mechanisms such as the Arrow Intensively Farmed Land Committee and the Surat Community Reference Group. The Arrow Intensively Farmed Land Committee considers opportunities to co-create a plan for coexistence between coal seam gas and farming. The Arrow Surat Community Reference Group provides a strong consultative forum for community and industry groups.	Construction Operations Decommissioning
C365	All project personnel will only access land ~~only~~ in accordance with DEEDI's (2010) Land Access Code, Section 24A of the Petroleum and Gas (Production and Safety) Act 2004 and Arrow's land access rules and protocols.	Construction Operations Decommissioning
C366	Consult with councils and the regional community consultative committee for their views on which social, community or recreational infrastructure in Western Downs region is being directly impacted by the project and the extent of this. Liaise with the relevant body to coordinate efforts across all proponents and identify opportunities that may potentially ease or mitigate impacts.	Construction Operations Decommissioning
C367	Arrow acknowledges it has a shared responsibility with government, and society more broadly, to help facilitate the development of strong and sustainable communities. It is committed to managing the residual social impacts of its activities that cannot be avoided or sufficiently minimised and to contributing to the social and economic wealth of the communities in which it operates through its social investment program. Arrow has already committed to the Brighter Futures Program, providing funding for community grants, sponsorships and partnership opportunities.	Construction Operations Decommissioning
C368	Encourage resident employees and contractors to integrate and become involved in their local communities (e.g., volunteer work, participation in clubs and organisations).	Construction Operations Decommissioning
C369	Engage with landowners to develop a strategy for minimising impacts on land and existing agricultural activities (e.g., through siting of project facilities).	Construction Operations Decommissioning
C370	Communicate with landowners at least three months before any activities take place on private property.	Construction/Operations Decommissioning
C371	Continue to provide Community Officers, Land Liaison Officers and the 1800 free-call number for people to ask questions or raise concerns about Arrow's activities. This includes the establishment of the Dalby Community Information Centre.	Construction Operations Decommissioning
C372	Provide medical assistance with opportunities to extend to wider communities, where possible.	Construction/Operations Decommissioning
C373	Arrow, in collaboration with Origin Energy, QGC and Santos, has funded since 2011 the Surat Gas Aero Medical Service in the region. The service is provided by CareFlight, one of only two fully integrated aero medical retrieval operations in the	Construction Operations Decommissioning

Commitment Number	Commitment	Relevant Phase
	world. CareFlight employs its own full time emergency doctors, paramedics and flight crews. The Aero Medical Retrieval Service provides 150 free hours to Queensland Health for community based aero medical recovery services. Arrow will continue to support this initiative.	
C374	Develop traffic management plans that include: • Preferred routes for travel and measures to reduce risk of accidents. • Road safety awareness initiatives for project personnel and local residents. • Procedure for notifying council and road authorities prior to any traffic disruptions or road closures. • Road management strategy to manage any increased road maintenance requirements imposed by the project.	Construction Operations Decommissioning
C375	Maintain a waste stream inventory identifying the type, classification, storage, transport and disposal requirements for the waste.	Inspection and Monitoring
C376	Continue to develop and implement Arrow's site-selection process for project facilities (such as integrated processing facilities and TWAFs) that considers the availability and capacity of existing utilities. Consult with councils and other utility providers during the project facility design process to understand existing capacity, and consider installing stand-alone utilities as required, to reduce demand on community utilities.	Planning and Design Construction
C377	Provide developer contribution and head works charges for infrastructure.	Construction/Operations Decommissioning
C378	Develop a Construction Workforce Accommodation Strategy three months after Financial Investment Decision (FID). The strategy will: • Include a commitment to provide high quality Temporary worker accommodation facility (TWAF) accommodation for all non-resident construction workers. • Identify the preferred approach for facilitating accommodation for construction workers who relocate to the local area for the project, based on the state of the market to meet project generated demand and required market interventions to reduce adverse impacts upon the community. • Identify opportunities to bring forward facilitation of housing intended for the operations workforce that can be used for the construction workforce. • Consider: – Continued participation in initiatives set out in the Major Resource Projects Housing Policy and the Western Downs Regional Council Affordability Strategy. – Supporting the intent of the Surat Basin Regional Planning Framework and working with State government, Councils, Economic Development Queensland, building industry, realtors and other project proponents to identify co-operative strategies that address cumulative housing impacts and to ensure that developable land is brought to market to meet demand.	Planning and Design Construction
C379	Prior to decommissioning the TWAFs, consider their use during the operations phase to ease housing demand in towns.	Construction Operations

Commitment Number	Commitment	Relevant Phase
C380	Continue to collaborate with other proponents in the region and identify opportunities to share temporary accommodation where possible for the construction and operations workforces.	Construction Operations
C381	Develop an Operations Accommodation Strategy 12 months prior to the commencement of operations. The strategy will identify the preferred approach for facilitating accommodation for the operational workforce based on the ability of the market to meet project generated demand and required market interventions to ~~minimise~~ reduce adverse impacts on the community as much as reasonably practicable. The strategy will consider: • Continued participation in initiatives set out in the Major Resource Projects Housing Policy and the Western Downs Regional Council Affordability Strategy • Support the intent of the Surat Basin Regional Planning Framework and work with state government, councils, building industry, realtors and other project proponents to identify co-operative strategies that address cumulative housing impacts and to ensure that developable land is brought to market to meet demand. • Providing incentives to private investors and developers of accommodation, such as through head leasing agreements or rental guarantees. • Contributing to a government-sponsored community and affordable housing initiative. • Housing 'rent to buy scheme' option for workers.	Operations Decommissioning
C382	Encourage workers relocating to the area to move to towns better suited to growth by: • Providing accommodation advice services for workers and their families. • Providing work shuttle buses between work site and towns with an employment pool (e.g., Toowoomba, Dalby, Cherbourg).	Construction Operations Decommissioning
C383	Support government reviews on housing availability and affordability and on impacts on low-income groups.	Construction/Operations Decommissioning
C384	Have visiting workers stay in TWAFs rather than in hotel or motel accommodation, where possible.	Construction/Operations Decommissioning
C385	Avoid reserving hotel and motel accommodation for long blocks of time without a demonstrable need.	Construction/Operations Decommissioning
C386	Inform the tourist body and other peak business bodies of anticipated time frames for peak temporary accommodation demand.	Construction/Operations Decommissioning
C388	Inspect waste storage locations to verify containment and segregation measures.	Inspection and Monitoring
C389	Maintain an emergency management plan that will cover joint emergency response planning in collaboration with emergency service providers.	Construction/Operations Decommissioning
C390	Proceed with implementation of the community engagement program and other measures to notify the community of project activities and to identify and address community issues.	Construction Operations Decommissioning
C391	Publicly release information on how environmental impacts are being offset by the project.	Construction/Operations Decommissioning

Commitment Number	Commitment	Relevant Phase
C392	Communicate progress of the project to the public and the regional community consultative committee as part of Arrow's annual sustainability reporting.	Construction/Operations Decommissioning
C393	Have Land Liaison Officers and Community Officers available to discuss landowner and residents' concerns.	Construction/Operations Decommissioning
C394	Develop and implement mitigation measures that address the potential impacts relating to air and noise emissions through environmental management plans.	Construction/Operations Decommissioning
C395	Enforce a workforce Code of Conduct including disciplinary procedures, and a policy on appropriate worker behaviour and interaction with the public.	Construction/Operations Decommissioning
C396	Prepare CHMPs or equivalent agreements in accordance with the provisions of the Aboriginal Cultural Heritage Act.	Planning and Design Construction/Operations
C397	Complete comprehensive initial cultural heritage assessments where disturbance is proposed (noting that this will be staged in line with proposed development schedules), with direct input from relevant Aboriginal parties.	Planning and Design Construction Operations
C398	Assess the results of the initial cultural heritage assessments in collaboration with the Aboriginal parties and develop a program for the management of all significant Aboriginal areas and objects to be affected by the project. Include management measures required prior to construction and those required throughout the life of the project.	Planning and Design Construction Operations
C399	Commission high-order constraints papers from Aboriginal parties to identify places of Aboriginal cultural heritage significance. Ensure avoidance of these places is considered during detailed design. Ensure that operations gives effect to the avoidance principle as enunciated in the Aboriginal Cultural Heritage Act.	Planning and Design Construction Operations
C400	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).	Planning and Design Construction Operations
C401	Obtain all necessary permits and approvals prior to the commencement of works.	Planning and Design Construction/Operations
C402	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.	Planning and Design Construction/Operations
C403	Avoid known cultural heritage sites, where practicable, through site selection.	Planning and Design Construction/Operations
C404	Develop a 'chance finds' procedure for the discovery of unknown sites during construction as part of the cultural heritage management plan. This should include a stop work requirement on initial discovery, appropriate reporting and recording, and such management measures as avoidance, salvage or destruction.	Planning and Design Construction Operations
C405	Develop a cultural heritage management plan prior to commencement of ground disturbance works that will mitigate and manage potential impacts on non-Indigenous cultural heritage sites.	Planning and Design Construction Operations

Commitment Number	Commitment	Relevant Phase
C406	Conduct preconstruction clearance surveys of sites to identify the presence of heritage sites.	Planning and Design Construction/Operations
C407	Develop site-specific cultural heritage management plans in consultation with the Department of Environment and Heritage Protection three months prior to construction, should project activities be planned within 100 m of listed heritage sites.	Planning and Design Construction Operations
C408	Consult with the local community regarding the management of threatened historic sites and places.	Planning and Design Construction/Operations
C409	Incorporate cultural heritage awareness into site induction procedures, including information on heritage values of the region, legal obligations and implementation of the 'chance finds' procedure.	Planning and Design Construction Operations
C410	Record and report unknown sites identified during construction as chance finds. The cultural heritage management plan will include all measures for managing the discovery of chance finds.	Planning and Design Construction Operations
C411	Contain all waste fluids and muds resulting from drilling activities in properly lined dams or storage tanks for in situ treatment or disposal.	Construction/Operations Decommissioning
C412	Notify the relevant administering authority if any cultural heritage sites or items of significance are uncovered during construction, in accordance with section 89 of the *Queensland Heritage Act 1992* (Qld).	Planning and Design Construction Operations
C413	Undertake archaeological assessment by a qualified heritage practitioner if cultural heritage sites or artefacts are uncovered during construction.	Planning and Design Construction/Operations
C414	Maintain a database of all sites where non-Indigenous cultural heritage is known or found during the course of investigations and works.	Planning and Design Construction/Operations
C415	Take particular care when working in areas where significant heritage places are located within 500 m of proposed wells, pipelines or other infrastructure.	Planning and Design Construction/Operations
C416	Prepare project safety management plans for the construction, operations and decommissioning of the infrastructure that form part of the present development.	Planning and Design
C417	Implement Arrow's health, safety and environmental management system for all activities and phases of development.	Planning and Design Construction
C418	Conduct appropriate safety reviews during design of new and modified facilities, including the use of hazard and risk assessment processes. Base safety reviews on well-recognised methodologies, e.g., hazard and operability studies and AS 2885 (Standards Australia, 2008a) risk assessment (safety management studies).	Planning and Design
C419	Select locations for project infrastructure with full consideration of and allowance for the minimum buffer zones indicated by the quantitative risk assessment.	Planning and Design
C420	Design and construct project infrastructure and facilities in accordance with applicable codes and standards.	Planning and Design
C421	Facilities will be designed with the ability to be shut down and be isolated in preparation for impending bushfires.	Planning and Design

Commitment Number	Commitment	Relevant Phase
C422	Design and install combustion sources (such as generators and gas-fired compressors) on Arrow facilities in accordance with engineering codes and standards, thus ensuring they will have safety mechanisms built-in.	Planning and Design
C423	Develop protocols for the control of construction activities during extreme fire danger periods.	Planning and Design
C424	Arrow will develop emergency response plans in consultation with emergency services organisations that includes a list of required equipment, training and other resources, and foreseeable emergency and crisis situations (including escapes of gas, blowouts, gas fire, bushfire, critical equipment failure, trapped or missing people, flooding, cyclones, power failure, security incidents and threats, and transport incidents). The plans should include safe evacuation procedures, communication protocols (internal and to emergency services, including the Petroleum and Gas Inspectorate), accounting for personnel and visitors, roles and responsibilities, and requirements for training.	Planning and Design Operations
C425	Design all pressured pipes and vessels in accordance with applicable codes of practice and Australian standards, as revised from time to time.	Planning and Design
C426	Install pressure transmitters that remotely monitor high- and low-pressure alarms.	Planning and Design
C427	Consider remote-control isolation on gas and water lines.	Planning and Design
C428	Design equipment to withstand considerable heat load, e.g., through use of heat-resistant (fire-safe) isolation valves on production facilities.	Planning and Design
C429	Design radiation exclusion zones around flares according to API standard.	Planning and Design
C430	Register pipelines and below-ground electrical services with Dial Before You Dig.	Planning and Design
C431	Reduce enclosed spaces where flammable gas may accumulate in accordance with relevant safety requirements.	Planning and Design
C432	Consider installing flow and pressure instrumentation to transmit upset conditions and plant shutdown valves status, where necessary.	Planning and Design
C433	Manage flooding risk through site location, drainage, etc., particularly for production facilities.	Planning and Design
C434	Design appropriate drainages for waste spills within buildings.	Planning and Design
C435	Apply dam safety guidelines, which will apply for all facilities forming part of the project development.	Planning and Design
C436	Consider the Australian Pipeline Industry Association Construction Health and Safety Guidelines (APIA, 2008) for pipeline construction and development of Construction Health and Safety Plan.	Construction
C437	Conduct pre-job safety meetings prior to the start of and during construction activities.	Construction

Commitment Number	Commitment	Relevant Phase
C438	Perform blowout of pipes and equipment, to remove construction debris, using well-established procedures and under strict controls, including those detailed in risk assessments.	Construction
C439	Develop an integrated risk management plan with consideration for relevant industry and Australian standards	Planning and Design Construction/Operations Decommissioning
C440	Install, inspect and service fire-fighting equipment in accordance with risk assessments and relevant legislation and standards.	Construction
C441	Implement transport-related safety programs, including driver training, journey management plans and preventive maintenance programs of vehicles.	Construction
C442	Develop and implement safety training programs for personnel and contractors, including induction training of new starters. Include supervision requirements for drilling and construction activities.	Construction Operations
C443	Conduct pressure testing and inspection of equipment and pipelines in accordance with relevant legislative requirements and standards.	Construction Operations
C444	Design, construct, maintain and rehabilitate the gathering system network in accordance with the APIA code of practice Upstream PE gathering networks CSG industry version 2, or relevant Australian standards, as revised from time to time.	Construction
C445	Install isolation valves on pipelines in accordance with relevant standards and industry practices.	Construction
C446	Commission fire-safety equipment in the early phase of the construction period.	Construction
C447	Fit all buildings and production facilities (CGPFs and field compression facilities) with smoke or fire alarms.	Construction
C448	Fit pumps with automatic pump shutdown or other safety devices to prevent leak in case of pumping against a blockage.	Construction
C449	Install fire and gas detection systems to shutdown compressors.	Construction
C450	Implement security controls, e.g., fencing and locked gates.	Construction/Operations
C451	Install lightning mast and earthing grid to minimise risk of lightning strike at production facilities.	Construction
C452	Machine guard all rotating equipment in accordance with Australian standards.	Construction
C453	Where necessary, automate emergency shutdown systems at production facilities and, if necessary, include remote monitoring and control.	Construction Operations

Commitment Number	Commitment	Relevant Phase
C454	Determine the reuse of waste largely by the salvage value of the material. Reuse requires onsite segregation and storage and will include the following measures: • Reuse of cleared vegetation for mulch and soil erosion control. • Reuse of brine for production of potentially saleable salt products and implementing salt crystallisation (see Chapter 5, Project Description, of the EIS for options relating to beneficial use of brine and coal seam gas water). • Segregation of wastewater streams, i.e., contaminated stormwater, waste waters and coal seam gas water. • Reuse of treated waste water for dust suppression, construction activities or irrigation. • Reuse of treated coal seam gas water for town water supply, where of appropriate quality. • Reuse of hydrotest water. • Reuse of treated water for agricultural use, industrial use, potable water supply or injection into aquifers. • Treatment and reuse of solid wastes, such as drilling muds and cuttings, where practicable.	Construction Operations Decommissioning
C455	Conduct systematic risk assessments (which include hazard identification, assessment, treatment and monitoring) in accordance with relevant legislation and standards during design, construction and operations.	Operations
C456	Implement a permit to work system that includes a job safety analysis process.	Operations
C457	Implement management of change processes, including protocols for communication of changes to appropriate levels of management.	Operations
C458	Implement internal and external (independent) hazard audit programs. Communicate results from audit to management.	Operations
C459	Barricade fall points and use personal fall-arrest equipment and wrist straps and lanyards to secure tools when working at heights.	Operations
C460	Use whip check or safety chain and tie downs (or equivalent) on all high-pressure lines and pressurised air hoses.	Operations
C461	Wear appropriate personal protective equipment on a site- and duty-specific basis.	Operations
C462	Where applicable, establish blowout preventer and other well control measures.	Operations
C463	Certify all equipment for drilling, where applicable.	Operations
C464	Ensure equipment and vehicle operators are licensed.	Operations
C465	Prepare a risk control action plan as part of the safety assessment process.	Operations
C466	Purge equipment of oxygen prior to introducing flammable gas.	Operations
C467	Purge equipment after shutdowns.	Operations

Commitment Number	Commitment	Relevant Phase
C468	Develop protocols for the control of operational activities during extreme fire danger periods, e.g., flaring or shutdowns.	Operations
C469	Use onsite waste treatment for such purposes as sewage, coal seam gas water and other specified wastes. Sewage will be treated in packaged sewage treatment plants. Sewage treatment plants will be located at production facilities and include settlement, digestion, aeration, clarification and disinfection equipment.	Construction Operations Decommissioning
C470	Consider non-static protective clothing for operations personnel.	Operations
C471	Establish lone-worker protocols and communication.	Operations
C472	Conduct regular patrols and inspections of pipeline easements, including status of signposting subsidence and of fire breaks.	Operations
C473	Review site-specific management plans before moving stockpiled logs and vegetation to ~~avoid~~ reduce potential for fauna mortality.	Decommissioning
C474	Automate the chemical dosage system for water treatment at integrated processing facilities.	Operations
C475	Consider the use of non-toxic gases for water treatment if gases are used.	Operations
C476	Ensure operator supervision for unloading of hazardous materials at production facilities.	Operations
C477	Provide escape ropes and ladders at strategic locations within a dam.	Operations
C478	Carry out routine monitoring of rehabilitated sites.	Inspection and Monitoring
C479	Use suitably trained and supervised staff or contractors to carry out depressurising and purging activities.	Operations
C480	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. The rules encompass the following controls: • All staff to work with a valid permit where required. • Gas tests to be conducted where required. • Verification of isolation prior to work commencing and use of specified life-protecting equipment. • Authorisation to be obtained prior to entering a confined space. • Authorisation to be obtained prior to overriding or disabling any critical safety equipment. • All persons to protect themselves against a fall when working at a height. • No walking under a suspended load. • No smoking outside designated areas. • No alcohol or drugs while working or driving. • No phones to be used while driving and speed limits not to be exceeded. • Seat belts to be worn at all times. Prescribed journey management plan to be followed.	Operations

Commitment Number	Commitment	Relevant Phase
C481	Train relevant personnel in the identification and avoidance of potentially hazardous wildlife. Use qualified spotter-catchers to move wildlife from project areas when encountered.	Operations
C482	Inspect and monitor the success of newly propagated or translocated listed species, in accordance with the approved translocation or management plan.	Inspection and Monitoring
C483	Vegetation surrounding production facilities and wellheads will be maintained in a manner that limits the amount of combustible material in the area. The size of the cleared area will be determined on a site-by-site basis with consideration of the site-specific risk of bushfire.	Operations
C484	Implement safety procedures to manage maintenance of wells including if necessary, isolation of infrastructure from gas flow.	Construction Operations
C485	Maintain facilities so that flammable and combustible material does not accumulate on site.	Operations
C486	Keep access tracks to well sites clear of dry grass and combustible material wherever practicable and where there is a higher risk of bushfire (to minimise the risk of dry grass being ignited by hot components of vehicles accessing the sites).	Operations
C487	Daily operations will be managed with consideration of the fire danger current at that time.	Operations
C488	Develop rig move plans.	Decommissioning
C489	Depressurise and degas all plant and equipment in flammable-gas use prior to decommissioning.	Decommissioning
C490	Develop onsite waste storage areas in accordance with industry practice and relevant waste management regulations.	Planning and Design
C491	Procure materials in bulk, where practicable, to minimise containers and movement of material.	Planning and Design
C492	Design the storage capacity of coal seam gas water and brine dams to be sufficient to manage waste liquids until such time that permanent disposal options are operational.	Planning and Design
C493	Maintain a waste tracking system.	Inspection and Monitoring
C494	Handle, store and dispose of regulated wastes in accordance with relevant standards and the Environmental Protection (Waste Management) Regulation 2000.	Construction Operations Decommissioning
C495	Comply with Queensland Government waste tracking requirements.	Construction/Operations Decommissioning
C496	Segregate general waste, treat it if necessary and store it onsite prior to disposal. Segregation will include the separation of liquid from solid waste, separation of regulated from non-regulated waste, and separation of reusable and recyclable from non-reusable and non-recyclable waste.	Construction Operations Decommissioning
C497	Use coal seam gas water of appropriate quality, for dust suppression on roads and for construction and operation activities to reduce impact on land use.	Planning and Design Construction/Operations Decommissioning

Commitment Number	Commitment	Relevant Phase
C498	Develop a strategy for the discharge of coal seam gas water to watercourses in accordance with relevant legislation. The strategy will incorporate a water quality monitoring program with locations upstream and downstream of the discharge point to inform site-specific water quality objectives. A detailed environmental flows assessment informed by water quality monitoring data and an aquatic ecology monitoring program will inform the discharge strategy. Periodic inspections of the physical form and hydrology of the watercourse are to be incorporated in the strategy to monitor geomorphic performance.	Planning and Design
C500	Inspect and manage open trenches in accordance with the following: • Inspect trenches for the presence of fauna daily (preferably in the morning), as well as immediately prior to closing a trench. • Have appropriately trained personnel remove any fauna from a trench to minimise stress to the animal and to avoid personal injury. • Record details of trapped fauna for inclusion in the EHP Wildnet database.	Inspection and Monitoring
C502	Provide training in the principles of the waste hierarchy to personnel handling wastes on a regular basis.	Inspection and Monitoring
C503	Prevent subsurface water flows and erosion along the backfilled trench by appropriate means, such as trench blocks and compaction of backfilled soils.	Construction/Operations Decommissioning
C504	Install groundwater monitoring bores near dams as a leak detection measure: • The number of monitoring bores and their location will take into account site-specific hydrogeology, preferential pathways and potential receptors of impacts. • Monitoring bores installed near dams will have groundwater levels and relevant water quality parameters monitored on a routine basis. • The number of monitoring bores or associated monitoring frequencies will be increased and further investigation will be triggered where impacts are identified.	Planning and Design Construction Inspection and Monitoring
C505	Inspect erosion and sediment control measures following significant rainfall events and carry out repairs and/or maintain as required to retain the effectiveness of the measures.	Inspection and Monitoring
C506	Inspect pipeline ROWs routinely until ground stabilisation and natural revegetation or pasture grasses or crops are established.	Inspection and Monitoring
C507	Visually inspect physical form and monitor hydrology, turbidity and pH upstream and downstream of crossings immediately prior to, during and after construction of watercourse crossings.	Inspection and Monitoring
C508	Routinely inspect for pest flora and evidence of pest fauna species within project disturbed areas.	Inspection and Monitoring
C509	Routinely monitor buffer zones and project footprint using satellite imagery.	Inspection and Monitoring
C510	Prepare groundwater monitoring reports in accordance with the P&G Act, EP Act and Water Act.	Inspection and Monitoring

Commitment Number	Commitment	Relevant Phase
C511	Monitoring and inspection of mitigation and management measures will be implemented to ensure that the calculated ground-level concentrations of relevant pollutants do not exceed EPP (Air) objectives throughout the lifetime of the project.	Inspection and Monitoring
C512	Assess the energy-efficiency opportunities and estimate greenhouse emissions associated with the project in accordance with regulatory requirements. Calculate annual greenhouse gas emissions from the project as required under the NGER Act and Energy Efficiency Opportunities program, as well as future carbon price mechanisms.	Inspection and Monitoring
C514	Monitor soil salinity in salinity prone areas prior to major earthworks.	Inspection and Monitoring
C515	Provide chemical monitoring of contaminated soils and groundwater in relevant monitoring bores.	Inspection and Monitoring
C516	Routinely inspect spill containment controls and spill response kits.	Inspection and Monitoring
C517	Visually inspect physical form downstream of watercourse discharge locations.	Inspection and Monitoring
C518	Conduct inspection and monitoring in accordance with relevant permits and/or consents	Inspection and Monitoring
C519	Monitor crop productivity or pasture health periodically to measure productivity on disturbed areas.	Inspection and Monitoring
C520	Review landowner grievances regularly, including status of project actions and close-outs.	Inspection and Monitoring
C521	Ensure methods used to monitor groundwater levels and quality, together with monitoring frequencies and parameters are in accordance with approved regulatory standards.	Inspection and Monitoring
C522	Develop a structured database to host groundwater data from the project (i.e., groundwater levels and groundwater quality).	Inspection and Monitoring
C524	Install an appropriate regional groundwater monitoring network	Inspection and Monitoring
C524 (cont'd)	• Monitor impacts in accordance with the Water Act and regulations. • Provide an 'early warning system' that identifies areas potentially impacted by project activities to allow early intervention.	Inspection and Monitoring
C525	Comply with inspection and monitoring requirements of the Surat Cumulative Management Area Underground Water Impact Report administered by the Queensland Government Office of Groundwater Impact Assessment	Inspection and Monitoring
C526	Visually inspect physical form and monitor hydrology, turbidity and pH upstream and downstream of central gas processing and integrated processing facility stormwater and coal seam gas water discharge points.	Inspection and Monitoring
C527	Routinely visually inspect physical form integrity and monitor hydrology, turbidity, total suspended solids, pH, dissolved metals and total petroleum hydrocarbons upstream and downstream of authorised locations where water is to be discharged directly to a watercourse.	Inspection and Monitoring
C528	Monitor dam levels.	Inspection and Monitoring

Commitment Number	Commitment	Relevant Phase
C529	Measure the volume and quality of coal seam gas water released to surface waters on a routine basis in accordance with legislative requirements and approved release limits.	Inspection and Monitoring
C530	Routinely measure the volume and quality of treated sewage effluent in accordance with regulatory requirements and approved release limits.	Inspection and Monitoring
C532	Have a suitably qualified person routinely monitor the integrity and available storage of dams.	Inspection and Monitoring
C533	Inspect areas of avoidance to ensure that boundaries are clearly marked prior to clearing activities.	Inspection and Monitoring
C534	Monitor clearing activities to ensure marked boundaries are adhered to.	Inspection and Monitoring
C535	Inspect marked areas after clearing activities to ensure areas of avoidance remain and that no unauthorised encroachment has occurred.	Inspection and Monitoring
C536	Supervise construction activities in sensitive areas to ensure appropriate methods (e.g., narrowing of ROW) are being implemented, where required.	Inspection and Monitoring
C537	Production wells will be designed and constructed so that the well is cased or concreted through aquifers other than the coal seam to prevent transmission of water and gas between strata.	Planning and Design Construction
C538	The State Planning Policy 1/03 for mitigating the adverse impact of flood, bushfire and landslide will be taken into regard.	Planning and Design Construction/Operations Decommissioning
C539	Maintain and update a water balance model that includes but is not limited to: • Monitoring of volume and quality of coal seam gas water produced and treated. • Monitoring of disposition volumes of treated and untreated coal seam gas water. • Monitoring of the volume of brine and its by-products used beneficially or disposed to landfill.	Inspection and Monitoring
C541	Salvage seed from threatened flora species unavoidably disturbed for use in rehabilitation as propagation material or natural regeneration.	Construction
C542	Stabilise and revegetate long-term stockpiles as soon as possible to reduce potential for erosion.	Construction Decommissioning
C544	Develop an Emergency Response and Well Control Contingency Response Plan.	Planning and Design
C545	Adopt appropriate safety procedures to manage simultaneous operations such as those activities undertaken at a multi-well pad.	Planning and Design Construction
C547	Design multi-well pads to address the risk of propagation of an incident to adjacent wells.	Planning and Design
C548	Arrow will consult with state and local government and community stakeholders to deliver the most appropriate program for providing affordable housing options in the region including continued participation in the Western Downs Housing Trust Reference Group.	Planning and Design Construction Operations
C549	Implement policies and programs to maintain the wellbeing of project personnel.	Planning and Design Construction/Operations

Commitment Number	Commitment	Relevant Phase
C550	Implement the Arrow Reconciliation Action Plan (RAP) which outlines Arrow's commitment to Indigenous Australians, working with Traditional Owners and negotiating Indigenous Land Use Agreements (ILUA's) around the four goals of: • Ensuring Arrow is culturally safe and culturally competent. • Recruiting and retaining Aboriginal and Torres Strait Islander staff • Connecting Aboriginal and Torres Strait Islander people with business and employment opportunities. • Supporting Aboriginal and Torres Strait Islander education.	Planning and Design Construction Operations
C551	Implement actions within Arrow's Aboriginal and Torres Strait Islander Reconciliation Action Plan (RAP) relating to educational opportunities for Indigenous students.	Planning and Design Construction/Operations
C552	Continue the Arrow Energy Whanu Binal project to provide assistance to Traditional Owners and other interested members of the Indigenous community to further develop business development, employment and training and workforce planning capacity and capability.	Planning and Design Construction Operations
C553	Provide cultural awareness training to Arrow employees and contractors within three months of employment or engagement by the company. Educate Arrow employees on cultural awareness as part of the induction program. Include the following as objectives for the awareness and training programs: • Staff and contractors effectively engage and work with Indigenous people, suppliers and communities. • Indigenous staff are understood, respected and retained in the organisation. • Arrow maintains positive relationships with Indigenous communities.	Planning and Design Construction Operations
C554	Continue to support the "Careers in Gas" website or other similar initiatives.	Planning and Design Construction/Operations
C555	Arrow Diversity Council to continue to work with industry groups that focus on increasing the engagement of women in the industry and developing pathways for women to work in non-traditional roles.	Planning and Design Construction Operations
C556	Undertake regular reviews of non-project related labour requirements and current skills sets for the study area by engaging with state agencies and other skills bodies to facilitate the development of training strategies.	Planning and Design Construction Operations
C557	Design infrastructure to avoid disturbance of state significant vegetation and other high value ecological corridors where practicable.	Planning and Design
C558	Develop a site-specific management plan to reduce changes to wetland habitat hydrology, including water quality, in areas of ground-truthed populations of *Microcarpaea agonis* adjacent to work sites.	Planning and Design
C559	Demarcate in order to restrict access to any ground-truthed populations of *Microcarpaea agonis* identified adjacent to work sites.	Construction Operations
C560	Consult with landowners downstream of discharge points on access requirements for vehicular and stock crossings of the affected watercourse reaches, and manage discharges to reduce disruption to existing access arrangements.	Planning and Design Construction Operations
C561	Identify reaches vulnerable to bank erosion from the discharge	Planning and Design

Commitment Number	Commitment	Relevant Phase
	of coal seam gas water and develop site-specific erosion control and management plans for vulnerable reaches.	Construction Operations
C562	Ensure Arrow's overhead distribution powerlines are visible when construction is planned in proximity to waterbodies frequented by an important population of listed migratory bird species.	Planning and Design Construction
C563	Record the location of any newly identified populations of Machin's macrozamia (*Macrozamia machinii*) and confidentially notify relevant authorities.	Planning and Design Construction Operations
C564	Arrow will continue to provide information to the Office of Groundwater Impact Assessment (OGIA), as required by the Underground Water Impact Report, to enable continual development and updates to the regional cumulative model administered by OGIA.	Planning and Design Construction Operations
C565	Arrow is committed to offsetting its component of modelled likely flux impacts to the Condamine Alluvium in the area of greatest predicted drawdown as a result of coal seam gas water extraction from the Walloon Coal Measures.	Planning and Design Construction Operations

Appendix 4 EHP information requirements for environmental authority

Applications for an Environmental Authority, *Environmental Protection Act 1994*

Requirements

EHP requires Arrow, prior to submitting an EA application to ensure that the application contains sufficiently detailed information about the project, the impacts and the proposed mitigation measures as a scale suitable for assessment of an EA application.

While there is a substantial body of information in the EIS documents relevant to an application for an environmental authority for carrying out petroleum activities, it would need to be modified and supplemented with additional detailed information in an application. The EA application would need to provide the detailed information about CSG management in accordance with s126 of the EP Act. Arrow should refer to Part 3 of the EHP guideline "Application requirements for petroleum activities" (EM705) in preparing an EA application.

In the EIS documents, Arrow has committed to providing the providing the following relevant information in its response to comments on the EIS. EHP requires Arrow to provide this information as part of its application under s126 of the EP Act.

Information to be provided includes:

- Location of major infrastructure, such as gas compression plants, water treatments plants and accommodation camps, and the potential impacts of these locations on environmental values.
- Site selection of infrastructure in consideration of:
  - impacts of disturbance on ESAs
  - impacts of power distribution infrastructure on Category C ESAs (State forests)
  - impacts of wells and gathering networks on terrestrial ecology (animal habitat and breeding places, protected plants)
  - application of the avoid, minimise, mitigate hierarchy for proposed disturbance
  - identification, through ground-truthing where possible, of regional ecosystems to be disturbed
  - identification of proposed disturbance to areas of high ecological significance including those protected under the NC Act, EPBC Act and wetlands.
- Site-specific CSG water management options including details of proposed beneficial use schemes or releases of watercourses.
- Site-specific details of the groundwater monitoring program including:
  - locations of monitoring wells, including those proposed as leak detection bores around dams
  - frequency of monitoring
  - quality parameters of concern that should be monitored.
- Consideration of residual impacts on State Significant Biodiversity Values under the Queensland Biodiversity Offsets Policy and potential provision of offsets.
- Site-specific noise and vibration assessment for each proposed infrastructure location.
- Details of the proposed management of sewage
- Details of the management practices proposed to prevent and minimise environmental harm caused by uncontrolled release of waste
- Site-specific air quality assessment for each proposed infrastructure location that describes point source and fugitive emissions.
- Consideration of bioaccumulation of chemicals in the environment from discharges of hydrotest water, sewage, CSG water and runoff
- Description of the minimisation and management of any waste generated by the activities, including details of the proposed reuse of soils, drill cutting, hydrostatic test water and waste or washout liquids.
- Generation and management of hydrostatic test water including quantity, source, quality and additives, storage and disposal.
- Details of the proposed ERAs to be included in the project.
- Details of the proposed notifiable activities to be included in the project.
- Specification of the existing and proposed infrastructure to allow EHP to consider the scale and intensity of the project.
- Details of CSG water management infrastructure including identification of beneficial use infrastructure for both CSG water and salt/brine.

- Details of a greenhouse gas management strategy including potential impacts of the project on state and national GHG inventories, best practice methods for minimisation of GHG emissions and commitments to continuous improvement of GHG emissions.
- Details of existing contaminated land parcels on the Environmental Management or Contaminated Land Registers, and identification of the notifiable activities and locations that will require listing on these registers.
- Details of land management strategies including soil and topsoil handling and management, and erosion and sediment control measures.
- Identification of sensitive receptors and potential impacts on sensitive receptors including land, water, air, noise, waste and visual amenity.
- Identification of flood plains and site selection of infrastructure with regard to minimisation of the impacts of flooding.
- Details of discharges/releases of water including:
    - exact location of release point with description including environmental values of the release point and reasoning for site selection based on risk assessment of impacts to environmental values
    - source of release water including quantity and quality
    - proposed monitoring program including parameters, frequency and locations with program review procedures to ascertain effectiveness of the program.
- Consideration of impacts on groundwater dependent ecosystems within the project footprint.
- Details of site-specific groundwater environmental values, potential impacts on groundwater environmental values and mitigation measures including groundwater monitoring programs for all major infrastructures.
- Details of rehabilitation plan including:
    - rehabilitation hierarchy for post-rehabilitation outcome/land use
    - rehabilitation methods including site preparation and revegetation activities
    - rehabilitation goals including establishing final land use in consultation with landholders and EHP, identifying analogue sites to measure rehabilitation success, indicators of rehabilitation success
    - monitoring program
    - progressive rehabilitation and timeframes for commencement of rehabilitation activities.

Appendix 5 Listed threatened ecological communities and species information for MNES

Listed threatened ecological communities (EPBC Act)

Brigalow (*Acacia harpophylla* dominant and co-dominant)

EPBC Act Status: Endangered

Recovery Plan: A recovery plan has not been prepared for the Brigalow (*Acacia harpophylla)* dominant and co-dominant ecological community.

The Brigalow ecological community is characterised by the presence of Brigalow (*Acacia harpophylla*) as one of the three most abundant tree species. Brigalow is usually dominant in the tree layer or co-dominant with other species such as *Casuarina cristata* (Belah), other species of Acacia, or species of Eucalyptus. Occasionally Belah, or species of Acacia or Eucalyptus may be more common than Brigalow within the broad matrix of Brigalow vegetation. The structure of the vegetation ranges from open forest to open woodland. The height of the tree layer varies from about 9 m in low rainfall areas (averaging around 500 mm per annum) to around 25 m in higher rainfall areas (averaging around 750 mm per annum). A prominent shrub layer is usually present.

Brigalow flowers spasmodically and seeds generally remain viable for less than a year with germination and establishment requiring good rainfall during what is traditionally the driest time of the year. Brigalow trees sucker easily from their roots and resprout after damage as long as the root stocks remain intact. Brigalow and many of the shrub and tree species associated with Brigalow are capable of re-sprouting after low to moderate intensity fire damage. Brigalow and Belah are tolerant of saline conditions and Brigalow is extremely drought tolerant.

Animal species associated with the Brigalow ecological community rely on a range of attributes in the vegetation for habitat. These include litter and woody debris on the forest floor (especially important for reptiles), tree hollows and pockets under the bark of large trees (roost sites for various birds and mammals, including bats), and mistletoes and other sources of nectar and fruit (food for birds, including Belah seed for the Vulnerable Glossy Black-cockatoo).

The Brigalow ecological community has undergone a severe decline in extent due to clearing for agricultural use. At the time of listing under the EPBC Act (April 2001), information supporting the nomination estimated an original extent of 7,324,560 hectares (7,020,360 ha in Queensland and 304,200 ha in New South Wales) with approximately 804,264 hectares (661,314 ha in Queensland and 142,950 ha in New South Wales) remaining (approximately 10% of original extent).

The following remnant and regrowth regional ecosystems (REs) associated with the Brigalow (*Acacia harpophylla)* dominant and co-dominant ecological community (Brigalow TEC), were identified as occurring within the project development area based on existing mapping (EHP 2012a, EHP2012b) and surveys for the EIS documents:

- RE11.3.1 (*Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains)
- RE11.4.3 (*Acacia harpophylla* and/or *Casuarina cristata* shrubby open forest on Cainozoic clay plains)
- RE11.9.5 (*Acacia harpophylla* and/or Casuarina cristata open forest on fine-grained sedimentary rocks)
- RE11.4.10 (*Eucalyptus populnea* or *Eucalyptus pilligaensis*, Acacia harpophylla, Casuarina cristata open forest to woodland on margins of Cainozoic clay plains)
- RE11.9.6 (*Acacia melvillei* ± *Acacia harpophylla* open forest on fine-grained sedimentary rocks)
- Mature regrowth habitats derived from regional ecosystems listed above
- Brigalow regrowth greater than 15 years old.

The extent and intensity of surveys carried out for the EIS was not adequate to accurately determine the extent of the Brigalow TEC within the entire project development area. Arrow stated that the size of the project development area made detailed survey for listed species and communities impractical and proposed to progressively determine the extent of MNES within the project development area through preconstruction surveys. Detailed information obtained from surveys conducted in areas identified for the potential location of major project infrastructure (survey areas 2, 7, 8, 9, F) was presented in the SREIS to demonstrate the proposed approach.

The Brigalow TEC typically occurs as fragmented remnants and regrowth in the project development area, often with a heavily disturbed ground layer due to cattle and sheep grazing. The extent of Brigalow TEC within the project development area was estimated as 7,387 ha based on publicly available mapping of regional ecosystems and mature regrowth, and on mapping undertaken for the EIS documents. For the purposes of the assessment of the whole of project impacts, the data and methods used to estimate the extent of Brigalow TEC within the project development area is adequate.

The project would directly impact the Brigalow TEC through clearing for facilities and infrastructure (e.g. gathering lines for water and gas, gas processing facilities, access tracks, roads), further fragmentation of remnants and associated species populations, and potential associated decline in the viability of remnants due to changes in ecosystem function (e.g. fragmentation and edge effects). Project activities may further degrade the condition of the Brigalow TEC and interfere with ecological function through dust deposition, lighting, noise, spread and invasion of pest flora and fauna species, changes to the fire regime, and changes to surface water flow and sedimentation.

Unmanaged activities in the vicinity of sensitive areas do have considerable potential to accelerate edge effects and affect the long term viability of the Brigalow TEC on a project scale. The Brigalow TEC is relatively robust and has considerable potential to regenerate naturally and recover from disturbance in the absence of intervening factors such as exotic species invasion.

Mitigation and management measures proposed by Arrow relevant to the Brigalow TEC are listed in Table 31.

Table 31 Impacts and mitigation measures relevant to the Brigalow (*Acacia harpophylla*) dominant and co-dominant ecological community

Potential Impacts	Mitigation measures
Clearing and fragmentation	Aim to avoid impacts to Brigalow TEC (C218, C240) with reference also to the 'environmental framework approach' outlined in the EIS Chapter 8. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys. (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of remnant Brigalow values	Fell trees away from existing stands where practicable (C241) and avoid damaging standing trees not identified for removal (C242). Retain woody debris, logs and rocks for use in rehabilitation of fauna corridors and to provide fauna refuge. (C238) Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472). Erosion and sediment and control measures (C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Standard industry noise suppression techniques. (C254) Reduce light spill resulting from project activities to reduce disturbance to nocturnal fauna. (C255) Prohibit disturbance or harassment of wildlife and the unauthorised collection of flora and forest products. (C256) Reinstate self-supporting drainage lines (C251) and maintain natural surface water flows (C221) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Weed and pest fauna invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188)

Potential Impacts	Mitigation measures
	Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)

Arrow estimated that the maximum potential disturbance area for the Brigalow TEC is about 106 ha out of the 7,387 ha mapped as existing within the project development area. In the absence of defined locations for project infrastructure, Arrow estimated the potential disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. The accuracy of the disturbance area estimated for the entire project development area was limited by the uncertain accuracy of published regional ecosystem and regrowth mapping, inclusion of more than one regional ecosystem in mapped polygons which would require field survey to resolve, and particularly by the lack of site-specific information on the potential layout of all works and infrastructure required by the project. Errors in published regional ecosystem mapping may affect the reliability of mapping of the Brigalow TEC and the estimate of disturbance area. Furthermore, the estimate of disturbance area was based on clearing and did not attempt to estimate the impact area associated with degradation of the condition of the remaining areas of Brigalow TEC.

Arrow claimed that, as this potential area of disturbance was based on unverified mapping of remnant vegetation, included the whole of the area of the Brigalow TEC on properties identified for possible location of infrastructure and not just the area that would be directly impacted, and was based on a project layout that had not been optimised to avoid the Brigalow TEC, the estimate of maximum potential disturbance is likely to be greater than the actual maximum disturbance.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments. For this reason, the conservative approach used in the estimation of maximum disturbance areas for threatened species and ecological communities is considered appropriate.

EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the Brigalow TEC. Given that there is considerable opportunity for the actual impact on the Brigalow TEC to be less than the 106 ha estimated, and that this represents a relatively small proportion of the remnant Brigalow TEC in the project area, EHP is of the view that this level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland (Natural Grasslands TEC)

EPBC Act Status: Critically Endangered

Recovery Plan: A draft national recovery plan has been prepared for the Natural Grasslands TEC.

Conservation Advice: Conservation advice for the Natural Grasslands TEC was approved by the Minister on: 15/12/08

The Natural Grasslands TEC includes tussock grasslands that are considered one of the most threatened ecosystems in Australia with less than 5% of the grassland remaining and remnants threatened by conversion of native pastures to improved pastures, cropping, and overgrazing by stock. In Queensland, the Natural Grasslands TEC corresponds most closely to the following regional ecosystems:

- 11.3.21 *Dichanthium sericeum* and/or *Astrebla* spp. Grassland on alluvial plains. Cracking clay soils
- 11.3.24 *Themeda avenacea* grassland on alluvial plains. Basalt derived soils.

The ecological community occurs on landforms that are typically flat to very low slopes (<5% or 1 degree) and mainly associated with fine textured, often cracking clay soils derived from either basalt or alluvium. Occurrence is mainly within the Brigalow Belt South bioregion but patches extend into the Nandewar, Sydney Basin and Darling

Riverine Plains bioregions. Three major but disjunct areas occur where climate, soils and landform are conducive to the development of tussock grasslands: the Darling Downs, the Liverpool Plains, and the Moree Plains.

The ecological community's appearance can vary seasonally with native wildflowers visible during spring, some wildflowers remaining dormant during dry seasons, and some species sensitive to particular disturbance regimes. Highly palatable or grazing-sensitive native species may disappear from sites that have been intensively or repeatedly grazed.

Field surveys for the EIS determined that naturally grassed areas in the project development area, with the exception of a few minor occurrences, are confined almost entirely to designated stock routes which have been largely protected from land clearing. The community is largely restricted to narrow linear fragments in the area between Cecil Plains and Dalby with scattered remnants to the north between Dalby and Chinchilla. Four sites were sampled on a seasonal basis consistent with EPBC listing advice to determine threshold condition. All remnants examined during field surveys were on heavy clay soils with vertic properties (gilgai).

The grasslands on the Dalby-Kogan Road exhibited high integrity consistent with the 'best quality' EPBC endangered classification. The Dalby-Cecil Plains Road grasslands were assessed as 'good quality' grasslands under the EPBC threshold criteria but exhibited a higher incidence of weeds.

One EVNT species *Solanum papaverifolium*, was recorded within the Dalby-Kogan Road grasslands habitats. Habitat was considered to be suitable for the potential occurrence of lobed blue grass (*Bothriochloa biloba*), finger panic grass (*Digitaria porrecta*), king blue grass (*Dichanthium queenslandicum*), plains picris (*Picris evae*), Australe cornflower (*Rhaponticum australe*), *Solanum stenopterum*, and Austral toadflax (*Thesium australe*).

The extent of Natural Grasslands TEC within the project development area was estimated as 678 ha based on publicly available mapping of regional ecosystems, and on mapping undertaken for the EIS documents. The publicly available regional ecosystem mapping used as the basis for estimating the extent of the Natural Grassland TEC in the project development area may not present an accurate spatial representation of the community and requires field survey confirmation. The extent and intensity of surveys carried out for the EIS may not be adequate to accurately confirm the full extent of the Natural Grasslands TEC within the entire project development area. Arrow stated that the size of the project development area made detailed survey for listed species and communities impractical and proposed to progressively determine the extent of MNES within the project development area through preconstruction surveys. For the purposes of the assessment of the whole of project impacts, the data and methods used to estimate the extent of Natural Grasslands TEC within the project development area is adequate.

Project activities and processes which could threaten the Natural Grasslands TEC include:

- Direct impacts due to vegetation clearing, earthworks and vehicle movement.
- Further fragmentation of remnants.
- Edge effects associated development within or near remnants including loss of native ground covers, exotic species invasion, changes to surface water flow and sedimentation.
- Salt scalding through saline groundwater discharge to land.
- Interference with ecological function through dust deposition, lighting, noise, spread and invasion of pest flora and fauna species, changes to the fire regime, and changes to surface water flow and sedimentation.

Arrow has committed to avoiding direct impacts to areas of Natural Grasslands TEC as the only feasible method to mitigate direct impacts, but recognised that a range of measures, including buffers, would be required to prevent indirect impacts as outlined in Table 32.

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Table 32 Impacts and mitigation measures relevant to the Natural Grasslands TEC

Potential Impacts	Mitigation measures
Clearing and fragmentation	Avoid habitat of Natural Grasslands TEC within the project development area, including three natural grassland road reserves (Dalby Kogan, Dalby St George and Dalby Cecil Plains) (C217) with reference also to the 'environmental framework approach' outlined in the EIS Chapter 8. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys. (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation. (C478, C482, C252)
Degradation of remnant Natural Grasslands TEC values	Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472). Erosion and sediment and control measures (C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Prohibit disturbance or harassment of wildlife and the unauthorised collection of flora and forest products. (C256) Reinstate self-supporting drainage lines (C251) and maintain natural surface water flows (C221) Bunding of storages to contain spills (C102) and emergency response and spill response procedures (C036) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Weed and pest fauna invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)

Arrow asserted that there would be no disturbance of the Natural Grassland TEC within the project development area based on planned avoidance of direct impacts, implementation of buffers (of undefined width), and implementation of general mitigation measures. The practicality of avoiding the Natural Grassland TEC throughout the development assumes that the extent of the community is generally consistent with estimates based on published regional ecosystem mapping and that the larger remnants have been confirmed by field survey. EHP considers this to be a reasonable assumption and that avoidance of impact is practicable.

Coolibah – Black Box Woodlands of the Darling Riverine Plains and Brigalow Belt South Bioregions

EPBC Status: Endangered

Recovery Plan: A recovery plan has not been prepared for the Coolibah – Black Box Woodlands of the Darling Riverine Plains and Brigalow Belt South Bioregions (Coolibah – Black Box Woodlands TEC)

Conservation Advice: Conservation advice for the Coolibah – Black Box Woodlands TEC was approved by the Minister on 10 February 2011

The Coolibah – Black Box Woodlands TEC are found on the grey, self-mulching clays of periodically waterlogged floodplains, swamp margins, ephemeral wetlands, and stream levees associated with the floodplains and drainage areas of the Darling Riverine Plains and the Brigalow Belt South bioregions. *Eucalyptus coolabah* subsp. *coolabah* (Coolibah) and/or *Eucalyptus largiflorens* (Black Box) are the dominant canopy species with a grassy understorey.

The ecological community provides valuable habitat for a wide range of vertebrate and invertebrate animal species. Characteristic habitat features of value to particular fauna include a grassy understorey with scattered fallen logs, woody debris from floods, areas of deep-cracking clay soils, patches of thick regenerating *Eucalyptus* saplings and large trees containing a diverse bark and foliage foraging resource and an abundance of small and large hollows. The fertile and relatively mesic environment of these woodlands provides essential resources for the persistence of fauna in the semi-arid region. The association of this ecological community with floodplains indicates its particular importance for birds both as woodland habitat and as nesting sites for colonial breeding waterbirds that rely on wetlands in addition to woodland habitats.

The Coolibah – Black Box Woodlands TEC ecological community is mapped as occurring within the project development area in the Chinchilla region as a subdominant component of a flood plain woodland mosaic containing regional ecosystems 11.3.25 (*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines) and 11.3.4 (*Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains). Field survey did not confirm the presence of the ecological community as mapped but a relatively extensive area (10 ha) and a number of smaller areas were identified in surveys at other locations.

The extent of Coolibah – Black Box Woodlands TEC within the project development area was estimated as 206 ha based on publicly available mapping of regional ecosystems and mature regrowth, and on mapping undertaken for the EIS documents. For the purposes of the assessment of the whole of project impacts, the data and methods used to estimate the extent of Coolibah – Black Box Woodlands TEC within the project development area were adequate.

Arrow stated that the size of the project development area made detailed survey for listed species and communities impractical and proposed to progressively determine the extent of MNES within the project development area through preconstruction surveys. Detailed information obtained from surveys conducted in areas identified for the potential location of major project infrastructure was presented in the SREIS to demonstrate the proposed approach.

The project could directly impact the Coolibah – Black Box Woodlands TEC through clearing for facilities and infrastructure (e.g. gathering lines for water and gas, gas processing facilities, access tracks, roads), further fragmentation of remnants and associated species populations, and potential associated decline in the viability of remnants due to changes in ecosystem function. Project activities may further degrade the condition of the Coolibah – Black Box Woodlands TEC and interfere with ecological function through dust deposition, lighting, noise, spread and invasion of pest flora and fauna species, changes to the fire regime, and changes to surface water flows and sedimentation. Changes to hydrology may decrease (or increase) the period of seasonal wetting and affect ground cover and canopy health.

Mitigation and management measures proposed by Arrow relevant to the Coolibah – Black Box Woodlands TEC are listed in Table 33.

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Table 33 Impacts and mitigation measures relevant to the Coolibah – Black Box Woodlands TEC

Potential Impacts	Mitigation measures
Clearing and fragmentation	Aim to avoid impacts to Coolibah – Black Box Woodlands TEC (C218, C240) with reference also to the 'environmental framework approach' outlined in the EIS Chapter 8. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys. (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of remnant Coolibah – Black Box Woodlands TEC values	Fell trees away from existing stands where practicable (C241) and avoid damaging standing trees not identified for removal (C242). Retain woody debris, logs and rocks for use in rehabilitation of fauna corridors and to provide fauna refuge. (C238) Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472). Erosion and sediment and control measures (C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Standard industry noise suppression techniques. (C254) Reduce light spill resulting from project activities to reduce disturbance to nocturnal fauna. (C255) Prohibit disturbance or harassment of wildlife and the unauthorised collection of flora and forest products. (C256) Reinstate self-supporting drainage lines (C251) and maintain natural surface water flows (C221) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Weed and pest fauna invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)

Arrow estimated the maximum potential disturbance area for Coolibah – Black Box Woodlands TEC as 8 ha out of the 206 ha estimated as existing within the project development area. In the absence of defined locations for project infrastructure, Arrow estimated the potential disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. The accuracy of the disturbance area estimated for the entire project development area was limited by the uncertain accuracy of published regional ecosystem and regrowth mapping, uncertain correlation of the community with occurrence in mapped regional ecosystems, inclusion of more than one regional ecosystem in mapped polygons which would require field survey to resolve, and particularly by the lack of site-specific information on the potential layout of all works and infrastructure required by the project. Errors in published regional ecosystem mapping may affect the reliability of mapping of the Coolibah – Black Box Woodlands TEC and the estimate of disturbance area. Furthermore, the estimate of disturbance area was based on clearing and did not attempt to estimate the impact area associated with degradation of the condition of the remaining areas of Coolibah – Black Box Woodlands TEC.

Arrow claimed that, as this potential area of disturbance was based on clearing the whole of the area of the Coolibah – Black Box Woodlands TEC on properties identified for possible location of infrastructure and not just the area that would be directly impacted, and was based on a project layout that had not been optimised to avoid the Coolibah – Black Box Woodlands TEC, the estimate of maximum potential disturbance is likely to be greater than the actual maximum disturbance.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments. For this reason, the conservative approach used in the estimation of maximum disturbance areas for threatened species and ecological communities is considered appropriate.

EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the Coolibah – Black Box Woodlands TEC. Given that there is considerable opportunity for the actual impact on the Coolibah – Black Box Woodlands TEC to be less than the 8 ha estimated, and that this represents a relatively small proportion of the potential remnant Coolibah – Black Box Woodlands TEC in the project area, EHP is of the view that this level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland

EPBC Status: Critically Endangered

Recovery Plan: A recovery plan has been prepared for the White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (Box-Gum Grassy Woodland).

Box-Gum Grassy Woodland can occur either as woodland or derived native grassland (i.e. grassy woodland where the tree overstorey has been removed). It is characterised by a species-rich understorey of native tussock grasses, herbs and scattered shrubs (where shrub cover comprises less than 30% cover), and a dominance or prior dominance of White Box (Eucalyptus albens) and/or Yellow Box (E. melliodora) and/or Blakely's Red Gum (E. blakelyi) trees. In the Nandewar bioregion, Grey Box (E. microcarpa or E moluccana) may also be dominant or co-dominant. In the woodland state, tree cover is generally discontinuous and of medium height with canopies that are clearly separated. Box-Gum Grassy Woodland provides habitat for a number of threatened species and actions to improve the long-term viability of this ecological community can also be expected to improve conservation outcomes for these species.

Box-Gum Grassy Woodland occurs along the western slopes and tablelands of the Great Dividing Range from southern Queensland through New South Wales and the Australian Capital Territory to Victoria. The ecological community once covered several million hectares but due to its occurrence on fertile soils it has been extensively cleared for agriculture. Intact remnants are extremely rare and only 405,000 ha are estimated to remain in various condition states. Clearing and fragmentation for urban, rural residential, agricultural and infrastructure development remain on-going threats, while degradation resulting from inappropriate management and weed invasion continues to erode the conservation value of remnant areas.

In Queensland, the Box-Gum Grassy Woodland is a component of a number of regional ecosystems (13.3.1, 13.3.4, 13.12.8, 13.12.9, 13.11.8 and 12.8.16). The ecological community forms a primary component of regional ecosystem 11.8.2a (*Eucalyptus tereticornis* + *Eucalyptus melliodora* woodland) mapped as occurring on steep basalt landforms in the Captains Mountain area to the south of Millmerran within the project development area. However, these sites could not be accessed during the field survey for the EIS to allow confirmation.

The extent and intensity of surveys carried out for the EIS was not adequate to accurately determine the extent of the Box-Gum Grassy Woodland within the entire project development area. Arrow stated that the size of the project development area made detailed survey for listed species and communities impractical and proposed to progressively determine the extent of MNES within the project development area through preconstruction surveys.

Detailed information obtained from surveys conducted in areas identified for the potential location of major project infrastructure (survey areas 2, 7, 8, 9, F) was presented in the SREIS to demonstrate the proposed approach.

The extent of Box-Gum Grassy Woodland within the project development area was estimated as 260 ha based on publicly available mapping of regional ecosystems and mature regrowth, and on mapping undertaken for the EIS documents. For the purposes of the assessment of the whole of project impacts, the data and methods used to estimate the extent of Box-Gum Grassy Woodland within the project development area was adequate.

The project could directly impact the Box-Gum Grassy Woodland through clearing (although access would be limited on the steep basalt escarpments and hill slopes where the community is known to occur), further fragmentation of remnants and associated species populations, and potential associated decline in the viability of remnants due to changes in ecosystem function (e.g. edge effects). Project activities may further degrade the condition of the Box-Gum Grassy Woodland and interfere with ecological function (e.g. edge effects) through dust deposition, lighting, noise, spread and invasion of pest flora and fauna species, changes to the fire regime, and changes to surface water flow and sedimentation.

Mitigation and management measures proposed by Arrow relevant to the Box-Gum Grassy Woodland are listed in Table 34.

Table 34 Impacts and mitigation measures relevant to Box-Gum Grassy Woodland

Potential Impacts	Mitigation measures
Clearing and fragmentation	Avoid impacts to Box-Gum Grassy Woodland (C217) with reference also to the ‘environmental framework approach’ outlined in the EIS Chapter 8. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys. (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of remnant Box-Gum Grassy Woodland values	Fell trees away from existing stands where practicable (C241) and avoid damaging standing trees not identified for removal (C242). Retain woody debris, logs and rocks for use in rehabilitation of fauna corridors and to provide fauna refuge. (C238) Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472). Erosion and sediment and control measures (C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Standard industry noise suppression techniques. (C254) Reduce light spill resulting from project activities to reduce disturbance to nocturnal fauna. (C255) Prohibit disturbance or harassment of wildlife and the unauthorised collection of flora and forest products. (C256) Reinstate self-supporting drainage lines (C251) and maintain natural surface water flows (C221) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)

Potential Impacts	Mitigation measures
Weed and pest fauna invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)

Arrow asserted that there would be no disturbance of the Box-Gum Grassy Woodland within the project development area based on planned avoidance of direct impacts and implementation of general mitigation measures. The practicality of avoiding the Box-Gum Grassy Woodland throughout the development assumes that the extent of the community is generally consistent with published regional ecosystem mapping and that remnants occur mainly on inaccessible terrain. EHP considers this to be a reasonable assumption and that avoidance of impact is practicable.

Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions

EPBC Act Status: Endangered

Recovery Plan: A national recovery plan has been prepared for the Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions (Semi-evergreen Vine Thickets TEC).

Semi-evergreen vine thicket is a form of dry seasonal subtropical rainforest characterised by trees with microphyll sized leaves (2.5–7.5cm long), frequent presence of swollen-stemmed “bottle trees” (*Brachychiton australis, B. rupestris*), with vines, twining or scrambling plants prominent. Remnant semi-evergreen vine thickets, often referred to as softwood scrub or bottle tree scrub are most common on undulating plains on fine-grained sedimentary rocks (frequently shale) and on basalt hills and plains. They also occur on coastal dunes, Quaternary alluvium, Tertiary clay plains, old loamy and sandy plains, or hills and lowlands on metamorphic rocks.

Semi-evergreen vine thickets are widely scattered within Queensland, New South Wales, the Northern Territory and Western Australia, having a common structure but considerable regional variation in floristic associations. The Semi-evergreen Vine Thickets TEC is distinct from related communities located in other bioregions in northern Australia.

Within the Brigalow Belt bioregions, semi-evergreen vine thickets have been fragmented, reduced in area and degraded through land clearing and agricultural/grazing practices. The Semi-evergreen Vine Thickets TEC originally covered almost 900,000ha and the total remnant extent in 2003 was less than 150,000ha (17%), with approximately 37,000ha in protected areas. Remnants often occur in small patches in areas of higher soil moisture.

Many of the tree species found in semi-evergreen vine thickets are able to resprout vegetatively after fire or disturbance, either from stems or roots, although many are sensitive to fire and especially hot or frequent fires. Many canopy and emergent tree species have wind-dispersed seed, while lower canopy and understorey species often have bird or bat dispersed fruit/seed.

The ecological community in Queensland comprises six regional ecosystems. Of these, based on published ecosystem mapping, only regional ecosystem 11.9.4a (Semi-evergreen vine thicket or *Acacia harpophylla* with a semi-evergreen vine thicket understorey on fine grained sedimentary rocks) and a single occurrence of RE11.8.3 (Semi-evergreen vine thicket on Cainozoic igneous rocks. Steep hillsides) occur within the project development area. Semi-evergreen Vine Thickets TEC may occur in association with small patches of Brigalow TEC.

The ecological community was not observed during field surveys for the EIS documents. However, the extent and intensity of surveys was not adequate to accurately determine the extent of the Semi-evergreen Vine Thickets TEC within the entire project development area. Arrow stated that the size of the project development area made detailed survey for listed species and communities impractical and proposed to progressively determine the extent of MNES within the project development area through preconstruction surveys.

The extent of Semi-evergreen Vine Thickets TEC within the project development area was estimated as 35 ha based on publicly available mapping of regional ecosystems and mature regrowth, and on mapping undertaken for the EIS documents. The natural patch size of the Semi-evergreen Vine Thickets TEC may be extremely small but the EPBC advice listing does not specify a minimum patch size. Isolated remnants of less than 2 ha are often not represented in regional ecosystem mapping (which formed the basis for mapping the extent of the ecological community) making it possible that the estimated extent is significantly less than actual. However, for the purposes of the assessment of the whole of project impacts, the data and methods used to estimate the extent of Semi-evergreen Vine Thickets TEC within the project development area is adequate.

Project activities and processes which could threaten the Semi-evergreen Vine Thickets TEC include:

- Direct impacts due to vegetation clearing particularly associated with exploration drilling.
- Edge effects associated with increased land use pressure, habitat and landscape fragmentation including loss of native ground covers, exotic species invasion and promotion of inappropriate fire regimes.

Mitigation and management measures proposed by Arrow relevant to the Semi-evergreen Vine Thickets TEC are listed in Table 35.

Table 35 Impacts and mitigation measures relevant to the Semi-evergreen Vine Thickets TEC

Potential Impacts	Mitigation measures
Clearing and fragmentation	Aim to avoid impacts to Semi-evergreen Vine Thickets TEC (C218, C240) with reference also to the 'environmental framework approach' outlined in the EIS Chapter 8. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys. (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of remnant Semi-evergreen Vine Thickets TEC values	Fell trees away from existing stands where practicable (C241) and avoid damaging standing trees not identified for removal (C242). Retain woody debris, logs and rocks for use in rehabilitation of fauna corridors and to provide fauna refuge. (C238) Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472). Erosion and sediment and control measures (C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Standard industry noise suppression techniques. (C254) Reduce light spill resulting from project activities to reduce disturbance to nocturnal fauna. (C255) Prohibit disturbance or harassment of wildlife and the unauthorised collection of flora and forest products. (C256) Reinstate self-supporting drainage lines (C251) and maintain natural surface water flows (C221) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Weed and pest fauna invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193)

Potential Impacts	Mitigation measures
	Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)

Arrow asserted that there would be no disturbance of the Semi-evergreen Vine Thickets TEC within the project development area based on implementation of general mitigation measures. The practicality of avoiding the Semi-evergreen Vine Thickets TEC throughout the development assumes that the extent of the community is generally consistent with estimates based on published regional ecosystem mapping, and that remnants are generally small areas and therefore able to be avoided. EHP considers this to be a reasonable assumption and that avoidance of impact is practicable.

Weeping Myall Woodlands

EPBC Status: Endangered

Recovery Plan: A recovery plan has not been prepared for the Weeping Myall Woodlands Ecological Community (Weeping Myall Woodlands TEC).

Conservation Advice: Conservation advice for the Weeping Myall Woodlands TEC was approved by the Minister on: 17/12/08.

The Weeping Myall Woodlands TEC occurs in a range of open woodlands to woodlands, generally 4-12 m high, in which Weeping Myall (*Acacia pendula*) trees are the sole or dominant overstorey species with a shrubby and/or grassy understorey. Other species may include: Western Rosewood (*Alectryon oleifolius subsp. elongatus*); Poplar Box (*Eucalyptus populnea*); or Black Box (*Eucalyptus largiflorens*) The ground layer includes a diversity of grasses and forbs, and varies in species composition and cover depending on grazing regimes and rainfall.

The Weeping Myall Woodlands TEC also provides important habitat for a range of animals such as the Superb Parrot (*Polytelis swainsonii*), Painted Honeyeater (*Grantiella picta*) and the Bush Stone-curlew (*Burhinus grallarius).*

Weeping Myall goes through regular cycles of senescence (aging and death) and regeneration, and is also susceptible to defoliation by Bag-shelter Moth (*Ochrogaster lunifer*) caterpillars and often lopped for domestic stock fodder.

The Weeping Myall Woodlands TEC generally occurs on flat areas, shallow depressions or gilgais on raised (relict) alluvial plains not associated with active drainage channels and rarely if ever flooded. Much of the former range of the ecological community has been cleared for dryland and irrigated cropping or has been significantly modified by heavy grazing. Most areas remaining in good condition are in little-grazed, uncropped sites such as road reserves and stock routes.

The Weeping Myall Woodlands TEC is known to occur in Queensland as small patches within regional ecosystems 11.3.2 (*Eucalyptus populnea* woodland on alluvial plains) and 11.3.28 (*Casuarina cristata* +/- *Eucalyptus coolabah* open woodland on alluvial plains), although the latter ecosystem is not known to occur within the project development area. The patchy distribution of the community makes mapping of the spatial extent difficult.

The Weeping Myall Woodlands TEC was found at only one survey location within the project development area in an area of 0.85 ha. Regional distribution mapping indicates the greatest likelihood for occurrence is in a band stretching from Roma to Blackall, west of the project development area indicating that any occurrences within the project development area are significant, representing the eastern limits of distribution. As the ecological community is not clearly correlated with regional ecosystem mapping, no attempt was made to estimate its extent within the project development area.

The extent and intensity of surveys carried out for the EIS was not adequate to accurately determine the extent of the Weeping Myall Woodlands TEC within the entire project development area. Arrow stated that the size of the project development area made detailed survey for listed species and communities impractical and proposed to progressively determine the extent of MNES within the project development area through preconstruction surveys. Detailed information obtained from surveys conducted in areas identified for the potential location of major project infrastructure (survey areas 2, 7, 8, 9, F) was presented in the SREIS to demonstrate the proposed approach.

The project would directly impact the Weeping Myall Woodlands TEC through clearing for facilities and infrastructure. Edge effects associated with increased land use pressure, habitat and landscape fragmentation including loss of native ground covers and exotic species invasion.

Mitigation and management measures proposed by Arrow relevant to the Weeping Myall Woodlands TEC are listed in Table 36.

Table 36 Impacts and mitigation measures relevant to the Weeping Myall Woodlands TEC

Potential Impacts	Mitigation measures
Clearing and fragmentation	Aim to avoid impacts to Weeping Myall Woodlands TEC (C218, C240) with reference also to the 'environmental framework approach' outlined in the EIS Chapter 8. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys. (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of remnant Weeping Myall Woodlands TEC values	Fell trees away from existing stands where practicable (C241) and avoid damaging standing trees not identified for removal (C242). Retain woody debris, logs and rocks for use in rehabilitation of fauna corridors and to provide fauna refuge. (C238) Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472). Erosion and sediment and control measures (C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Standard industry noise suppression techniques. (C254) Reduce light spill resulting from project activities to reduce disturbance to nocturnal fauna. (C255) Prohibit disturbance or harassment of wildlife and the unauthorised collection of flora and forest products. (C256) Reinstate self-supporting drainage lines (C251) and maintain natural surface water flows (C221) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Weed and pest fauna invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099)

Potential Impacts	Mitigation measures
	Inspections and weed hygiene declarations where there is risk of contamination. (C190)

Arrow estimated that the maximum potential disturbance area for the Weeping Myall Woodlands TEC would be less than 1ha (0.85ha) based on total clearance of the only known area of this community within the project development area. However, the actual extent of the community within the project development area is unknown as no indicative mapping is available and the survey effort was insufficient to determine extent. It is likely that any other occurrence of the Weeping Myall Woodlands TEC would be in relatively small areas that could be avoided by implementation of the stated mitigation measures. EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the Weeping Myall Woodlands TEC.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

Listed threatened flora species (EPBC Act)

Acacia curranii (Curly-bark wattle)

EPBC Act Status: Vulnerable

Conservation advice: Approved by the Minister / Delegate of the Minister on 1/10/2008

Recovery plan: Recovery Plan not required, included on the Not Commenced List (1/11/2009).

Acacia curranii is an erect or spreading multi-stemmed shrub, up to 3 m tall, with distinctive red curling (minni-ritchi) bark, long needle-like leaves, and flowers clustered into small yellow spikes. The typical life span of curly-bark wattle is unknown, but it is probably similar to many other shrubby *Acacia* species in being a moderately long-lived shrub of 10 to 30 years. It has been recorded flowering during August and September, with pods maturing several months later, and seeds with hard coats indicating a long period of seed viability in the soil. The response to fire by curly-bark wattle may vary depending on the intensity and timing of the burn and the seed is capable of post-fire germination.

Acacia curranii grows on sandy clay soils that are poorly drained on weathered sandstone. Plants are known to occur in shrubby heaths, dry sclerophyll forests and semi-arid woodlands where they can occur as widely scattered thickets in heathy scrub with emergent eucalypts.

The species has a disjunct distribution in western NSW and south-eastern Queensland, occurring in three areas each separated by several hundred kilometres. In Queensland the species occurs in two populations of approximately 200 individuals in the Gurulmundi area north of Miles. The three main populations of *Acacia curranii* are too broadly separated to facilitate gene flow between populations.

Acacia curranii occurs on the north-west boundary of the project development area, approximately 65 km north of Chinchilla, and further west towards and within Gurulmundi State Forest. Suitable habitat for the species extends across the northern portion of the project development area. The species was not detected during field surveys within the project development area but the survey effort was not adequate to confirm presence or absence. The extent of habitat within the project development area was estimated as:

- Core Habitat Known 0 ha
- Core Habitat Possible 73,351 ha
- General Habitat 1,264 ha

The accuracy of the habitat area estimates is limited by the uncertain accuracy of the regional ecosystem mapping used, inclusion of more than one regional ecosystem in mapped polygons which would require field survey to resolve, and by the assumptions made in correlating habitat with regional ecosystems.

Impacts to *Acacia curranii* associated with the proposed project related activities could include:

- Loss of individual plants through clearing
- Loss of habitat in the construction of project infrastructure
- Degradation of habitat by weed infestation or altered habitat structure (edge effects following clearing)

- Fragmentation of populations with potential for reduced pollen and seed dispersal.
- Changed fire regimes with potential to impact existing plants and affect recruitment success.

For the Gurulmundi population, removal of the shrubs through mechanical clearing, damage from feral animals, especially goats and rabbits, and inappropriate fire regimes are likely to be the most significant.

Without mitigation measures, project impacts to restricted areas of habitat may occur causing decline in local populations. The potential magnitude of unmitigated impact to the species is high as approximately 20% of the local population occurs within the project development area and an estimated 12% of the project development area contains core habitat possible. The only known core habitat for *Acacia curranii* in Queensland occurs within a 20km area, with part of this local population occurring on the north-western boundary of the project development area.

Arrow proposed to give priority to avoiding core habitat for *Acacia curranii* through design and site selection, and to implement a range of general mitigation measures summarised in Table 37.

Arrow has also applied a specific mitigation measure for the *Acacia curranii*:

- Salvage seed from threatened flora species unavoidably disturbed, for use in rehabilitation as propagation material or for natural regeneration.

Acacia curranii is known to regenerate from seed germination and is likely to be successfully rehabilitated, with plants maturing within several years.

Table 37 Impacts and mitigation measures relevant to *Acacia curranii* (Curly-bark wattle)

Potential Impacts	Mitigation measures
Clearing and fragmentation	Aim to avoid impacts to *Acacia curranii* and its core habitat (C218, C240) with reference also to the ‘environmental framework approach’ outlined in the EIS Chapter 8. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of habitat	Fell trees away from existing stands where practicable (C241) and avoid damaging standing trees not identified for removal (C242). Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472). Erosion and sediment and control measures (C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Prohibit unauthorised collection of flora products. (C256) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Weed invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations.

Potential Impacts	Mitigation measures
	(C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)

Table 38 shows Arrow's estimated the potential area of disturbance of *Acacia curranii* habitat within the project development area as a result of project related activities.

Table 38 Potential area of disturbance of *Acacia curranii* habitat

	Area within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Core Habitat Known	0	0
Core Habitat Possible	73,351	121
General Habitat	1,264	10

In the absence of defined locations for project infrastructure, Arrow provided estimates of the potential maximum disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. The accuracy of the disturbance area estimated for the entire project development area was also limited by the uncertain accuracy of habitat mapping derived from regional ecosystem mapping, and particularly by the lack of site-specific information on the potential layout of all works and infrastructure required by the project. Furthermore, the estimate of disturbance area was based on clearing and did not attempt to estimate the impact area associated with degradation of the condition of the remaining areas of *Acacia curranii* habitat.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments. For this reason, the conservative approach used in the estimation of maximum disturbance areas for threatened species and ecological communities is considered appropriate.

EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the habitat of *Acacia curranii*. The known populations are widely spaced and contain small numbers of individual plants indicating that there is considerable opportunity for avoidance of impact and for the actual impact on the habitat of *Acacia curranii* to be considerably less than the 131 ha estimated. The impact of wildfire on species populations within the project development area could be reduced by the access tracks and proposed fire management measures. EHP is of the view that the level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

Acacia handonis (Hando's wattle)

EPBC Act Status: Vulnerable

Recovery plan: Recovery Plan not required, included on the Not Commenced List (1/11/2009).

Conservation advice: Approved by the Minister / Delegate of the Minister on: 1/10/2008

Acacia handonis is a small resinous shrub of 1 to 2 m in height with spirally arranged phyllodes (leaves), bright yellow globular flowers, and pods are up to 4 cm long and 4 mm wide. The life span of *Acacia handonis* plants in the wild is unknown, but they live for about 10 years in cultivation. Plants flower in July, August and September. As a hard-seeded legume, the soil-stored seed reserves of Hando's wattle are likely to be long lived (i.e. > 10 years). The response to fire by *Acacia handonis* has not been well studied but significant regeneration from seed following burning is likely and a minor proportion of plants may survive a low intensity fire. The age at which *Acacia handonis* seedlings begin producing seed is unknown but important to determine to assist the management of the species.

Acacia handonis has only been collected on rocky ridges and slopes on sandstone-derived geology in eucalypt woodland and open forest. The descriptions of the habitat from which it has been collected are consistent with regional ecosystem 11.7.7 (*Eucalyptus fibrosa* subsp. *nubila* +/- *Corymbia* spp. +/- *Eucalyptus* spp. on lateritic duricrust) and regional ecosystem 11.7.6 (*Corymbia citriodora* or *Eucalyptus crebra* woodland on lateritic duricrust).

Acacia handonis has an extremely restricted occurrence, being known only from the Barakula State Forest, approximately 40 km north of Chinchilla, in three adjacent areas containing around 10,080 individuals (in 1994) over approximately 28 ha. All currently known populations occur in Barakula State Forest in a cluster approximately 25 km to the east of the project development area boundary. Populations of the species may occur within the northern part of the project development area in suitable habitat adjoining Barakula State Forest and in Gurulmundi State Forest.

The species was not detected during field surveys within the project development area but the survey effort was not adequate to confirm presence or absence. The extent of habitat within the project development area was estimated as:

- Core Habitat Known 0 ha
- Core Habitat Possible 73,521 ha
- General Habitat 1,302 ha

The accuracy of the habitat area estimates is limited by the uncertain accuracy of the regional ecosystem mapping used, inclusion of more than one regional ecosystem in mapped polygons which would require field survey to resolve, and by the assumptions made in correlating habitat with regional ecosystems.

Impacts to *Acacia handonis* associated with the proposed project related activities could include:

- Loss of individual plants through clearing
- Loss of habitat in the construction of project infrastructure
- Degradation of habitat by weed infestation or altered habitat structure (edge effects following clearing)
- Fragmentation of populations with potential for reduced pollen and seed dispersal.
- Changed fire regimes with potential to impact existing plants and affect recruitment success.

Without mitigation measures, project impacts to restricted areas of habitat may occur causing decline in local populations. Arrow proposed to give priority to avoiding core habitat for *Acacia handonis* through design and site selection, and to implement a range of general mitigation measures summarised in Table 39.

Table 39 Impacts and mitigation measures relevant to *Acacia handonis* (Hando's wattle)

Potential Impacts	Mitigation measures
Clearing and fragmentation	Aim to avoid impacts to *Acacia handonis* and its core habitat (C218, C240) with reference also to the 'environmental framework approach' outlined in the EIS Chapter 8. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of habitat	Fell trees away from existing stands where practicable (C241) and avoid damaging standing trees not identified for removal (C242). Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472). Erosion and sediment and control measures (C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Prohibit unauthorised collection of flora products. (C256) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Weed invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)

Table 40 shows Arrow's estimated potential area of disturbance of *Acacia handonis* habitat within the project development area as a result of project related activities.

Table 40 Potential area of disturbance of *Acacia handonis* habitat

	Area within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Core Habitat Known	0	0
Core Habitat Possible	73,521	121
General Habitat	1,302	10

In the absence of defined locations for project infrastructure, Arrow provided estimates of the potential maximum disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. The accuracy of the disturbance area estimated for the entire project development area was also limited by the uncertain accuracy of habitat mapping derived from regional ecosystem mapping, and particularly by the lack of site-specific information on the potential layout of all works and infrastructure required by the project. Furthermore, the estimate of disturbance area was based on clearing and did not attempt to estimate the impact area associated with degradation of the condition of the remaining areas of *Acacia handonis* habitat.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments. For this reason, the conservative approach used in the estimation of maximum disturbance areas for threatened species and ecological communities is considered appropriate.

EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the habitat of *Acacia handonis*. The known populations contain relatively small numbers of individual plants indicating that there is considerable opportunity for avoidance of impact and for the actual impact on the habitat of *Acacia handonis* to be considerably less than the 131 ha estimated. The species is reported to propagate readily from seed and is therefore likely to be able to be successfully rehabilitated. The impact of wildfire on species populations within the project development area could be reduced by the access tracks and proposed fire management measures, and ‘cool’ fires could be used to stimulate seed germination. EHP is of the view that the level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

Bothriochloa biloba (Lobed blue grass)

EPBC Act Status: Vulnerable

Recovery plan: A recovery plan has not been prepared for *Bothriochloa biloba*.

Conservation Advice: Approved by the Minister / Delegate of the Minister on: 3/07/2008

Bothriochloa biloba is an erect or decumbent, tufted perennial grass to 1 m high. The ligule (i.e. membrane at the base of the leaf against the stem) is fringed with hairs. The leaves are 3 to 5 mm wide with margins that are slightly rough. The flowering stalk is often branched at the nodes. The inflorescence (i.e. the flower and seed head) consists of 3 to 6 arms, each 4 to 10 cm long, which emerge from almost the same point, resembling fingers on a hand. Each arm of the flower/seed head has long white hairs (6.5 to 8 mm long), giving a silky look. The lemmas (i.e. the lower of two bracts enclosing each flower) that are awned (i.e. with bristles) are two-lobed.

Bothriochloa biloba is a perennial grass related to some of Australia’s most valuable pasture species, yet it may be fairly unpalatable to stock.

Bothriochloa biloba has been collected in flower, or with seed heads, between November and June. Compared with some other bothriochloa species, *Bothriochloa biloba* produces low levels of viable seed. This is mainly due to a high proportion of seed formation following a process called apomixes, where the seed are produced asexually without pollen from a second plant. Many of the *Bothriochloa biloba* seeds formed through the apomixes process do not mature into viable seed.

Bothriochloa biloba has a preference for heavier-textured brown or black clay soils but is often found in cleared alluvial sandy clay sites in the Darling Downs region. It has been collected in cleared eucalypt forests with derived non-remnant grasslands in alluvial areas, often on the edge of RE11.3.4; disturbed roadside habitats of the Condamine flood plain; Queensland blue grass (Dichanthium sericeum) grassland on heavy alluvium (RE11.3.21), as well as within road and rail reserves where heavy alluvium occurs.

Bothriochloa biloba was found during the in EIS surveys within the project development area in open grassy woodland dominated by Queensland blue gum (*Eucalyptus tereticornis*) on the flood plain of the Condamine River. The woodland structure of the habitat where the species was collected had been heavily disturbed by extensive timber extraction and heavy grazing pressure to the extent that the site was considered non-remnant.

The species is known from the Darling Downs district in south east Queensland, south along the western slopes of the Great Dividing Range into NSW to North Star, Warialda, Bingara and Merriwa. It has been recorded from Miles

(2 km south of Condamine River), in the locality of Cecil Plains, and; 10 km north, 14 km NE and 6 km east of Goondiwindi . A vouchered survey record was collected from 5 km north-northeast of Cecil Plains. The species is documented to be common within the bioregion and has been delisted in Queensland to least concern status. The Darling Downs represents the northern geographic limit of the species.

Bothriochloa biloba is known to occur within the project development area with three previous records located to the south of Miles and the Cecil Plains area. A collection during surveys 5 km north-northeast of Cecil Plains indicated that the species will occur relatively extensively on alluvial habitats associated with the Condamine River floodplain. *Bothriochloa biloba* has also been collected to the east of Goondiwindi, approximately 50 km to the south of the project development area.

Lobed bluegrass has potential to occur within all areas proposed for development. The extent of habitat within the project development area was estimated as:

- Core Habitat Known 371 ha
- Core Habitat Possible 20,146 ha
- General Habitat 12,210 ha

The accuracy of the habitat area estimates is limited by the uncertain accuracy of the regional ecosystem mapping used, inclusion of more than one regional ecosystem in mapped polygons which would require field survey to resolve, and by the assumptions made in correlating habitat with regional ecosystems.

Impacts to *Bothriochloa biloba* associated with the proposed project related activities could include:

- Habitat edge effects such as promoting conditions for invasion of weeds and exotic grasses which induce altered habitat structure along gathering lines, tracks and clearing zones.
- Direct loss of individuals during habitat clearing, and
- Direct loss of habitat through construction of facilities and development and maintenance of access tracks.

Without mitigation measures, project impacts to restricted areas of habitat may occur causing decline in local populations. Arrow has identified that it is likely that a number of discrete populations of the species occur in the project development area and that these populations are potentially important for preserving genetic diversity of the species.

Arrow proposed to give priority to avoiding core habitat for *Bothriochloa biloba* through design and site selection, and to implement a range of general mitigation measures summarised in Table 41.

Arrow has also proposed a number of mitigation measures specific to Lobed blue grass:

- Extend pre-clearance surveys into non-remnant areas, particularly derived grassland habitats associated with the Condamine River floodplain to allow sensitive placement of infrastructure in relation to lobed bluegrass populations; and
  Detailed search methods as applicable to herbs and graminoids should be applied.

Table 41 Impacts and mitigation measures relevant to *Bothriochloa biloba* (Lobed blue grass)

Potential Impacts	Mitigation measures
Clearing and fragmentation	Aim to avoid impacts to *Bothriochloa biloba* and its core habitat (C240) with reference also to the ‘environmental framework approach’ outlined in the EIS Chapter 8. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys (C244,

Potential Impacts	Mitigation measures
	C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of habitat	Erosion and sediment and control measures (C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Prohibit unauthorised collection of flora products. (C256) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Weed invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)

Table 42 shows Arrow's estimated the potential area of disturbance of *Bothriochloa biloba* habitat within the project development area as a result of project related activities.

Table 42 Potential area of disturbance of *Bothriochloa biloba* habitat

	Area within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Core Habitat Known	371	5
Core Habitat Possible	20,146	30
General Habitat	12,210	18

In the absence of defined locations for project infrastructure, Arrow provided estimates of the potential maximum disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. The accuracy of the disturbance area estimated for the entire project development area was also limited by the uncertain accuracy of habitat mapping derived from regional ecosystem mapping, and particularly by the lack of site-specific information on the potential layout of all works and infrastructure required by the project. Furthermore, the estimate of disturbance area was based on clearing and did not attempt to estimate the impact area associated with degradation of the condition of the remaining areas of *Bothriochloa biloba* habitat.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments. For this reason, the conservative approach used in the estimation of maximum disturbance areas for threatened species and ecological communities is considered appropriate.

EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the habitat of *Bothriochloa biloba*. Rehabilitation using translocation and propagation from seed is likely to be practicable provided that competing species are managed. EHP is of the view that the level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

Philotheca sporadica (Kogan waxflower)

EPBC Act Status: Vulnerable

Recovery plan: A species recovery plan has not been developed for Kogan waxflower.

Conservation advice: yes

Philotheca sporadica is a multi-stemmed, spreading shrub to 1.5m high. Upper branchlets are green, with dark corky areas developing sporadically along the stem with age. The leaves are only 1 to 4 mm long, hairless, glandular below and fairly terete and broadest in the upper half i.e. shaped like a club. The white flowers are solitary and occur on short stalks to 0.7 mm long at the end of branchlets.

Philotheca sporadica is a perennial shrub of unknown life span. It flowers from July to September with mature fruit in September. The species has been recorded from along roadsides, indicating that it has some ability to regenerate after disturbance. The response of the species to fire is unknown.

The majority of records are in low open forest and woodland of Aca*cia burrowii, Eucalyptus exserta, Eucalyptus crebra, Eucalyptus fibrosa subsp. nubila* and *Callitris glaucophylla*. The species occurs on residual hills that are remnants of laterised Cretaceous sandstones, where the soils are shallow, uniform sandy loams to clay loams of extremely low fertility and poor condition. Recorded locations coincide with regional ecosystems 11.7.4 (*Eucalyptus decorticans* and/or *Eucalyptus* spp., *Corymbia* spp., *Acacia* spp., *Lysicarpus angustifolius* on lateritic duricrust), 11.7.5 (Shrubland on natural scalds on deeply weathered coarse-grained sedimentary rocks), and 11.7.7 (*Eucalyptus fibrosa* subsp*. nubila +/- Corymbia spp. +/- Eucalyptus* spp. on lateritic duricrust)

Philotheca sporadica is endemic to south-east Queensland, from just north of Tara, to approximately 12 km east of Kogan. Known populations occur on road verges, freehold land, and within Braemar State Forest. The species is known to occur in a number of discrete population clusters on the western margin of the project development area, on the Beelbee Rd near Kogan, and approximately 5 km south of Wyaga Creek, representing approximately 25% of known populations. The survey effort for the EIS was not adequate to define occurrence of the species but additional populations may occur within the project development area in tracts of remnant vegetation and on disturbed roadsides on lateritic duricrusts. The extent of habitat within the project development area was estimated as:

- Core Habitat Known 655 ha
- Core Habitat Possible 32,380 ha
- General Habitat 76,712 ha

The accuracy of the habitat area estimates is limited by the uncertain accuracy of the regional ecosystem mapping used, inclusion of more than one regional ecosystem in mapped polygons which would require field survey to resolve, by the assumptions made in correlating habitat with regional ecosystems, and by potential occurrence of the species in non-remnant vegetation.

Impacts to *Philotheca sporadica* associated with the proposed project related activities could include:

- Loss of individual plants through clearing
- Loss of habitat in the construction of project infrastructure
- Degradation of habitat by weed infestation or altered habitat structure (edge effects following clearing)
- Fragmentation of populations with potential for reduced pollen and seed dispersal.
- Changed fire regimes with potential to impact existing plants and affect recruitment success.

There is considerable risk of broad scale impacts to this species during gas field development coupled with cumulative impacts of adjoining non-Arrow CSG developments. Roadside populations along Beelbee Road to the north and south of the Kogan Road are particularly susceptible to disturbance. Populations are all viable in the long-term and are important for preservation of genetic diversity, and as such are considered important populations.

Without mitigation measures, project impacts to restricted areas of habitat may occur causing decline in local populations. Arrow proposed to give priority to avoiding core habitat for *Philotheca sporadica* through design and site selection, and to implement a range of general mitigation measures summarised in Table 43.

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Arrow has also noted that where avoidance is not possible, the development of a threatened species management plan may be required to guide rehabilitation programs.

Table 43 Impacts and mitigation measures relevant to *Philotheca sporadica* (Kogan wax flower)

Potential Impacts	Mitigation measures
Clearing and fragmentation	Aim to avoid impacts to *Philotheca sporadica* and its core habitat (C218, C240) with reference also to the 'environmental framework approach' outlined in the EIS Chapter 8. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of habitat	Fell trees away from existing stands where practicable (C241) and avoid damaging standing trees not identified for removal (C242). Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472). Erosion and sediment and control measures (C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Prohibit unauthorised collection of flora products. (C256) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Weed invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)

Table 44 shows Arrow's estimated potential area of disturbance of *Philotheca sporadica* habitat within the project development area as a result of project related activities.

Table 44 Potential area of disturbance of *Philotheca sporadica* habitat

	Area within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Core Habitat Known	655	0
Core Habitat Possible	32,380	48
General Habitat	76,712	44

In the absence of defined locations for project infrastructure, Arrow provided estimates of the potential maximum disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. The accuracy of the disturbance area estimated for the entire project development area was also limited by the uncertain accuracy of habitat mapping derived from regional ecosystem mapping, and particularly by the lack of site-specific information on the potential layout of all works and infrastructure required by the project. Furthermore, the estimate of disturbance area was based on clearing and did not attempt to estimate the impact area associated with degradation of the condition of the remaining areas of *Philotheca sporadica* habitat.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments. For this reason, the conservative approach used in the estimation of maximum disturbance areas for threatened species and ecological communities is considered appropriate.

EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the habitat of *Philotheca sporadica*. The species is known to have some ability to regenerate after disturbance, and has been successfully translocated. The impact of wildfire on species populations within the project development area could be reduced by the access tracks and proposed fire management measures. EHP is of the view that the level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

Prostanthera sp. (Dunmore D.M. Gordon 8A)

EPBC Act Status: Vulnerable

Recovery plan: Recovery Plan for *Prostanthera sp*. (Dunmore D.M. Gordon 8A) is not required.

Conservation Advice: Approved by the Minister / Delegate of the Minister on: 1/10/2008

Low, upright, aromatic shrub, to 1 m tall but often only 50 cm tall. Leaves are with whorled, stalk-less (i.e., sessile), linear leaves 0.8 to 1.2 cm long, and up to 2 mm wide. The leaf margins are curved underneath back towards the midrib. Flowers are clustered into terminal racemes or panicles, two-lipped, mauve to purple-blue and about 8 mm long.

The life span of *Prostanthera* sp. (Dunmore D.M.Gordon 8A) is not known, other than being a perennial. Flowering plants have been documented in June, August and October. No other ecological information is known, other than habitat preferences.

Prostanthera sp. (Dunmore D.M.Gordon 8A) grows in sandy soils and on stony ridges, including amongst rocks (Wang 1996). Regional ecosystems likely to form habitats include, RE11.5.1; RE11.5.4; RE11.7.4; RE11.7.5. The species has not been recorded in regrowth or otherwise “non-remnant” vegetation.

Prostanthera sp. (Dunmore D.M.Gordon 8A) is only known from four locations in a small area west of Millmerran, southern Queensland with a total extent of occurrence of less than 100 km². One population occurs on private land and three within state forest, including one on the border with Wondul Range National Park. The distribution of the species coincides with relatively contiguous tracts of remnant vegetation and the occurrence in the project development area coincides with a broad north-south trending wildlife corridor

Prostanthera sp. (Dunmore D. M. Gordon 8A) is known to occur within the project development area boundary between Wondul Range National Park and Bulli State Forest. The species was not recorded during field surveys. The extent of habitat within the project development area was estimated as:

- Core Habitat Known 1,179 ha
- Core Habitat Possible 39,553 ha
- General Habitat 0 ha

The accuracy of the habitat area estimates is limited by the uncertain accuracy of the regional ecosystem mapping used, inclusion of more than one regional ecosystem in mapped polygons which would require field survey to resolve, and by the assumptions made in correlating habitat with regional ecosystems.

Impacts to *Prostanthera* sp. (Dunmore D. M. Gordon 8A) associated with the proposed project related activities could include:

- Loss of individual plants through clearing
- Loss of habitat in the construction of project infrastructure
- Altered and inappropriate fire regimes.
- Habitat edge effects such as weed infestation, altered habitat structure along gathering lines, tracks and clearing zones.

Without mitigation measures, project impacts to restricted areas of habitat or individual trees may occur causing decline in local populations. Arrow proposed to give priority to avoiding core habitat for *Prostanthera* sp. (Dunmore D. M. Gordon 8A) through design and site selection, and to implement a range of general mitigation measures summarised in Table 45.

Table 45 Impacts and mitigation measures relevant to *Prostanthera* sp.

Potential Impacts	Mitigation measures
Clearing and fragmentation	Aim to avoid impacts to *Prostanthera* sp. (Dunmore D. M. Gordon 8A) and its core habitat (C218, C240) with reference also to the 'environmental framework approach' outlined in the EIS Chapter 8. Where avoidance is not possible, and significant residual impacts remain to *Prostanthera* sp. (Dunmore D. M. Gordon 8A) implement and offset strategy approved by a relevant government agency and comply with reporting conditions of an offset plan. (C219) Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of habitat	Fell trees away from existing stands where practicable (C241) and avoid damaging standing trees not identified for removal (C242). Erosion and sediment and control measures (C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Prohibit unauthorised collection of flora products. (C256) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Weed invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)
Changes to fire regime	Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472).

Table 46 shows Arrow's estimated the potential area of disturbance of *Prostanthera* sp. (Dunmore D. M. Gordon 8A) habitat within the project development area as a result of project related activities.

Table 46 Potential area of disturbance of *Prostanthera* sp. habitat

	Area within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Core Habitat Known	1,179	0
Core Habitat Possible	39,553	38
General Habitat	0	0

In the absence of defined locations for project infrastructure, Arrow provided estimates of the potential maximum disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. The accuracy of the disturbance area estimated for the entire project development area was also limited by the uncertain accuracy of habitat mapping derived from regional ecosystem mapping, and particularly by the lack of site-specific information on the potential layout of all works and infrastructure required by the project. Furthermore, the estimate of disturbance area was based on clearing and did not attempt to estimate the impact area associated with degradation of the condition of the remaining areas of *Prostanthera* sp. (Dunmore D. M. Gordon 8A) habitat.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments. For this reason, the conservative approach used in the estimation of maximum disturbance areas for threatened species and ecological communities is considered appropriate.

EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the habitat of *Prostanthera* sp. (Dunmore D. M. Gordon 8A No information regarding seed germination and post-disturbance regeneration is available. The impact of wildfire on species populations within the project development area could be reduced by the access tracks and proposed fire management measures. EHP is of the view that the level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

Denhamia parvifolia (Small-leaved denhamia)

EPBC Act Status: Vulnerable

Recovery plan: A recovery plan has not been prepared for small-leaved denhamia

Conservation Advice: Approved by the Minister / Delegate on: 16/12/2008

Denhamia parvifolia is a shrub to 3 m with mottled, white bark and orange roots. The alternatively arranged leaves are 0.5-2 cm long, with smooth margins or a few fine teeth. The leaves are broadest in the middle or the upper half and are prominently veined and rigid. The pale yellow flowers are grouped into clusters. The fruit are yellowish capsules that split into three or four sections to expose a black seed covered in red fleshy "aril".

Denhamia parvifolia probably lives for at least a decade. Flowering occurs in September to October and fruits are mature in the wet season, December to March. The red fleshy aril covering of the seed is likely to encourage bird dispersal. There is no information regarding regeneration of small-leaved denhamia, and notes associated with collections do not record the presence of any seedlings. Other denhamia species found in semi-evergreen vine thickets of the Brigalow Belt grow readily from seed.

Denhamia parvifolia grows in semi-evergreen vine thickets, vine scrubs and brigalow-softwood communities (including non-remnant patches) on fertile, red brown sandy clay loam hillslopes and crests. The species is restricted to southern Queensland in an area extending from Eidsvold to Chinchilla and areas near Kingaroy and Mundubbera.

The species has been historically recorded within the project development area but occurrence is currently unknown. Suitable habitat exists throughout the project development area. The species was not detected during field surveys within the project development area but the survey effort was not adequate to confirm presence or absence. The extent of habitat within the project development area was estimated as:

- Core Habitat Known 0 ha
- Core Habitat Possible 2,348 ha
- General Habitat 0 ha

The accuracy of the habitat area estimates is limited by the uncertain accuracy of the regional ecosystem mapping used, occurrence of many small unmapped patches of suitable habitat, and by the uncertain occurrence of the species in suitable habitat.

Impacts to *Denhamia parvifolia* associated with the proposed project related activities could include:

- Loss of individual plants through clearing
- Loss of habitat in the construction of project infrastructure
- Degradation of habitat by weed infestation or altered habitat structure (edge effects following clearing)
- Further fragmentation of populations with potential for reduced pollen and seed dispersal.
- Increased frequency or intensity of fires leading to loss of plants, weed invasion, and reduced recruitment success.

Without mitigation measures, project impacts to restricted areas of habitat may occur causing decline in local populations. Arrow proposed to give priority to avoiding core habitat for *Denhamia parvifolia* through design and site selection, and to implement a range of general mitigation measures summarised in Table 47.

Table 47 Impacts and mitigation measures relevant to *Denhamia parvifolia* (small-leaved denhamia)

Potential Impacts	Mitigation measures
Clearing and fragmentation	Aim to avoid impacts to *Denhamia parvifolia* and its core habitat (C218, C240) with reference also to the 'environmental framework approach' outlined in the EIS Chapter 8. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of habitat	Fell trees away from existing stands where practicable (C241) and avoid damaging standing trees not identified for removal (C242). Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472). Erosion and sediment and control measures (C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Prohibit unauthorised collection of flora products. (C256) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Weed invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed

Potential Impacts	Mitigation measures
	infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)

Table 48 shows Arrow's estimated the potential area of disturbance of *Denhamia parvifolia* habitat within the project development area as a result of project related activities as follows:

Table 48 Potential area of disturbance of *Denhamia parvifolia* habitat

	Area within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Core Habitat Known	0	0
Core Habitat Possible	2,348	5
General Habitat	0	0

In the absence of defined locations for project infrastructure, Arrow provided estimates of the potential maximum disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. The accuracy of the disturbance area estimated for the entire project development area was also limited by the uncertain accuracy of habitat mapping derived from regional ecosystem mapping, potential occurrence of the species in small unmapped remnant and non-remnant patches, and by the lack of site-specific information on the potential layout of all works and infrastructure required by the project. Furthermore, the estimate of disturbance area was based on clearing and did not attempt to estimate the impact area associated with degradation of the condition of the remaining areas of *Denhamia parvifolia* habitat.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments. For this reason, the conservative approach used in the estimation of maximum disturbance areas for threatened species and ecological communities is considered appropriate.

EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the habitat of *Denhamia parvifolia*. Suitable habitat typically occurs in small fragmented patches containing small numbers of individual plants indicating that there is considerable opportunity for avoidance of impact and for the actual impact on the habitat of *Denhamia parvifolia* to be less than the 5 ha estimated. The impact of wildfire on species populations within the project development area could be reduced by the access tracks and proposed fire management measures. Other denhamia species are known to be easily propagated from seed. EHP is of the view that the level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

Calytrix gurulmundensis (Gurulmundi fringe myrtle)

EPBC Act Status: Vulnerable

Recovery plan: A recovery plan has not been prepared for Calytrix gurulmundensis.

Conservation Advice: Approved by the Minister / Delegate on 1/0/2008

Calytrix gurulmundensis is an attractive, well branched shrub to 2 m tall. The leaves are 4 to 11 mm long and up to 1 mm wide, alternate or crowded together, slightly 3-angled or flat with a point at the apex, and are aromatic when crushed. The flowers are tubular and clustered at the ends of branches, with narrow cream petals that are yellow at their base, and many long yellow stamens. The fruit are dry, with the sepals from the flowers remaining attached. The life span of *Calytrix gurulmundensis* is unknown, but it is likely to live for at least a decade. Flowers have been recorded from June to October.

The species is endemic to the Gurulmundi and Barakula areas north of Chinchilla and has been recorded growing in patches of shrubland on very shallow yellow sandy-clay soils on lateritic sandstone ridges. Associated vegetation is predominately eucalypt, acacia, casuarina dense shrublands with spinifex, and spinifex grassland with scattered shrubs consistent with regional ecosystem 11.7.5 (shrubland on natural scalds on deeply weathered coarse-grained sedimentary rocks). *Calytrix gurulmundensis* can be common in localised areas.

The response of the species to disturbances such as habitat fragmentation, changed fire regimes and edge effects requires further detailed study, and the potential effectiveness of translocation and rehabilitation methods is unknown.

The species has not been recorded within the project development area but may occur based on habitat suitability and known distribution range. The species is known from the Barakula and Gurulmundi State Forests to the east and west of the project development area respectively. Additional populations have the potential to occur in tracts of remnant vegetation and on disturbed roadsides on lateritic duricrusts. In the project development area, suitable habitat occurs near Gurulmundi and Barakula State Forests, and in the Binkey State Forest. The species was not detected during field surveys within the project development area but the survey effort was not adequate to confirm presence or absence. The extent of habitat within the project development area was estimated as:

- Core Habitat Known 0 ha
- Core Habitat Possible 60,538 ha
- General Habitat 360 ha

The accuracy of the habitat area estimates is limited by the uncertain accuracy of the regional ecosystem mapping used, inclusion of more than one regional ecosystem in mapped polygons which would require field survey to resolve, and by the assumptions made in correlating habitat with regional ecosystems.

Impacts to *Calytrix gurulmundensis* associated with the proposed project related activities could include:

- Loss of individual plants through clearing
- Loss of habitat in the construction of project infrastructure
- Degradation of habitat by weed infestation or altered habitat structure (edge effects following clearing)
- Fragmentation of populations with potential for reduced pollen and seed dispersal.
- Changed fire regimes with potential to impact existing plants and affect recruitment success.

Without mitigation measures, project impacts to restricted areas of habitat may occur causing decline in local populations. Arrow proposed to give priority to avoiding core habitat for *Calytrix gurulmundensis* through design and site selection, and to implement a range of general mitigation measures summarised in Table 49.

Table 49 Impacts and mitigation measures relevant to *Calytrix gurulmundensis* (Gurulmundi fringe myrtle)

Potential Impacts	Mitigation measures
Clearing and fragmentation	Aim to avoid impacts to *Calytrix gurulmundensis* and its core habitat (C218, C240) with reference also to the 'environmental framework approach' outlined in EIS Chapter 8. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of habitat	Fell trees away from existing stands where practicable (C241) and avoid damaging standing trees not identified for removal (C242). Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472). Erosion and sediment and control measures (C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Prohibit unauthorised collection of flora products. (C256) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Weed invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)

Table 50 shows Arrow's estimated the potential area of disturbance of *Calytrix gurulmundensis* habitat within the project development area as a result of project related activities.

Table 50 Potential area of disturbance of Calytrix gurulmundensis habitat

	Area within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Core Habitat Known	0	0
Core Habitat Possible	60,538	121
General Habitat	360	4

In the absence of defined locations for project infrastructure, Arrow provided estimates of the potential maximum disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. The accuracy of the disturbance area estimated for the entire project development area was also limited by the uncertain accuracy of habitat mapping derived from regional ecosystem mapping, and particularly by the lack of site-specific information on the potential layout of all works and infrastructure required by the project. Furthermore, the estimate of disturbance area was based on clearing and did not attempt to estimate the impact area associated with degradation of the condition of the remaining areas of *Calytrix gurulmundensis* habitat.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments. For this reason, the conservative approach used in the estimation of maximum disturbance areas for threatened species and ecological communities is considered appropriate.

EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the habitat of *Calytrix gurulmundensis*. The species is likely to occur in patches indicating that there is opportunity for avoidance of impact. There is a lack of detailed information on seed germination and response to fire, and the effectiveness of translocation and/or propagation and rehabilitation programs is unknown. The impact of wildfire on species populations within the project development area could be reduced by the access tracks and proposed fire management measures. EHP is of the view that the level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

Cadellia pentastylis (Ooline / Scrub Myrtle)

EPBC Act Status: Vulnerable

Recovery plan: A recovery plan has not been prepared for *Cadellia pentastylis*.

Conservation Advice: Approved by the Minister / Delegate of the Minister on: 1/10/2008

Cadellia pentastylis is a long lived tree, typically growing to 10 m but occasionally up to 25 m tall, with hard fissured bark, simple alternate leaves, white flowers 5 to 7 mm long, and fruit (drupes) 5 mm long clustered together. Flowering and fruiting of ooline is sporadic with flowering is concentrated in October to December, but can extend to April, with fruit recorded in November and December. Ooline is likely to be damaged, or killed, by intense fires although coppicing can occur if trees are damaged.

Cadellia pentastylis grows in semi-evergreen vine thickets, brigalow and occasionally in adjacent eucalypt woodland, where it maybe locally dominant in the canopy layer or occur as an emergent. It is also known to occur in cleared non-remnant areas such as grazing lands and electricity corridors. Ooline tends to grow on soils of low to medium fertility, often with sandy clay or clay consistencies such as clay plains, sandstone and residual ridges.

Cadellia pentastylis was known to occur on the western edge of the NSW north-west slopes, extending into Carnarvon Range, Blackwater and the Callide Valley, south and west of Rockhampton in Queensland. A large proportion of its habitat has been cleared for cropping or grazing. Remnant populations are now restricted to a few scattered sites and the species is conserved within the Tregole National Park, Sundown National Park, and Carnarvon Gorge National Park. It is also known from the area to the west of Gurulmundi State Forest.

The species may occur within the project development area and has been historically recorded within the south-western part of the project development area which may be the eastern limit of distribution. *Cadellia pentastylis* has been recorded as very common in brigalow open forest and fragmented softwood scrub vegetation in the Stones Country Resources Reserve in the west Gurulmundi area approximately 15 km west of the project development area, and the Moonie Range 25 km west of the project development area. The majority of *Cadellia pentastylis* habitat within the project development area has been cleared and the species was not detected during field surveys within the project development area. However, the survey effort was not adequate to confirm presence or absence of the species. The extent of habitat within the project development area was estimated as:

- Core Habitat Known 0 ha
- Core Habitat Possible 2,672 ha
- General Habitat 1,423 ha

The accuracy of the habitat area estimates is limited by the uncertain accuracy of the regional ecosystem mapping used, inclusion of more than one regional ecosystem in mapped polygons which would require field survey to resolve, and by the assumptions made in correlating habitat with regional ecosystems.

Impacts to *Cadellia pentastylis* associated with the proposed project related activities could include:

- Loss of individual plants through clearing
- Loss of habitat in the construction of project infrastructure
- Degradation of habitat by weed infestation or altered habitat structure (edge effects following clearing)
- Further fragmentation of populations with potential for reduced pollen and seed dispersal.
- Changed fire regimes with potential to impact existing plants and affect recruitment success.

Without mitigation measures, project impacts to restricted areas of habitat or individual trees may occur causing decline in local populations. Arrow proposed to give priority to avoiding core habitat for *Cadellia pentastylis* through design and site selection, and to implement a range of general mitigation measures summarised in Table 51.

Table 51 Impacts and mitigation measures relevant to *Cadellia pentastylis* (Ooline)

Potential Impacts	Mitigation measures
Clearing and fragmentation	Aim to avoid impacts to *Cadellia pentastylis* and its core habitat (C218, C240) with reference also to the 'environmental framework approach' outlined in the EIS Chapter 8. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of habitat	Fell trees away from existing stands where practicable (C241) and avoid damaging standing trees not identified for removal (C242). Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472). Erosion and sediment and control measures (C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Prohibit unauthorised collection of flora products. (C256) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Weed invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)

Table 52 shows Arrow's estimated the potential area of disturbance of *Cadellia pentastylis* habitat within the project development area as a result of project related activities.

Table 52 Potential area of disturbance of *Cadellia pentastylis* habitat

	Area within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Core Habitat Known	0	0
Core Habitat Possible	2,672	0
General Habitat	1423	0

In the absence of defined locations for project infrastructure, Arrow provided estimates of the potential maximum disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. The accuracy of the disturbance area estimated for the entire project development area was also limited by the uncertain accuracy of habitat mapping derived from regional ecosystem mapping, and particularly by the lack of site-specific information on the potential layout of all works and infrastructure required by the project. Furthermore, the estimate of disturbance area was based on clearing and did not attempt to estimate the impact area associated with degradation of the condition of the remaining areas of *Cadellia pentastylis* habitat.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments. For this reason, the conservative approach used in the estimation of maximum disturbance areas for threatened species and ecological communities is considered appropriate.

EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the habitat of *Cadellia pentastylis*. The impact of wildfire on species populations within the project development area could be reduced by the access tracks and proposed fire management measures. *Cadellia pentastylis* is known to be able to be propagated from seed although seed production is sporadic. EHP is of the view that the level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

Digitaria porrecta (Finger panic grass)

EPBC Act Status: Endangered

Recovery plan: A draft recovery plan has been prepared by Halford (1995b).

Conservation advice: yes

A perennial grass to 80 cm tall, which can spread along rhizomes. A perennial grass to 60 cm tall, which can spread along rhizomes. Leaves are flat, 6 to 15 cm long, 2 to 3 mm wide, with rough hairs along the middle. The inflorescence (i.e. seed head) is a wide, compound, panicle, similar in outline to a panicum grass seed head.

Digitaria porrecta is a spreading perennial that can reproduce vegetatively. Older clumps are reported to die in the centre, with the outer edges of the clump becoming separate plants. The species seeds from March to April. Seeds drop to the ground when mature, but appear to have a six month to one year dormancy prior to germinating. .

Digitaria porrecta grows in grasslands, woodlands and open forests with a grassy understory, on black soil plains of the Darling Downs, and lighter textured soils to the west. The species is most abundant in grassland, but is "relatively unspecific" in its habitat preference. It is not restricted to high quality native grasslands, but also grows along roadsides and can be found in highly disturbed sites (Goodland 2000). Finger panic grass been recorded inside the project development area, within roadside remnant grasslands on dark cracking clay plains (RE11.3.21); poplar box (*E. populnea*) open forest and woodland with grassy understorey, on dark cracking clay plain (RE11.3.2); and along disturbed railway reserves on dark cracking clay soils. The primary habitats for this species in the project development area are RE11.3.2, RE 11.3.21 and non-remnant derived grasslands.

Digitaria porrecta is known from four disjunct areas extending over 1000 km across New South Wales and Queensland. The Queensland distribution includes broad populations in the Nebo district; the Central Highlands between Springsure and Rolleston; and from Jandowae south to Warwick. In New South Wales, it is known from near Inverell, south to the Liverpool Plains near Coonabarabran and Werris Creek.

Digitaria porrecta was not recorded during field survey but is known to occur in the project development area near Dalby, and within a 25 km buffer surrounding the project development area. The two remnant habitats that *Digitaria porrecta* has been collected from within the study area are: RE 11.3.2 (*Eucalyptus populnea* woodland on alluvial plains); RE 11.3.21 (Queensland blue grass (*Dichanthium sericeum*) and/or mitchell grass (*Astrebla* spp.) grassland on alluvial plains with cracking clay soils). The extent of habitat within the project development area was estimated as:

- Core Habitat Known 622 ha
- Core Habitat Possible 10,809 ha
- General Habitat 6,943 ha

The accuracy of the habitat area estimates is limited by the uncertain accuracy of the regional ecosystem mapping used, inclusion of more than one regional ecosystem in mapped polygons which would require field survey to resolve, and by the assumptions made in correlating habitat with regional ecosystems.

Impacts to *Digitaria porrecta* associated with the proposed project related activities could include:

- Direct loss of individuals during habitat clearing.
- Competition from exotic species, such as coolatai grass (*Hyparrhenia hirta*), Guinea grass (*Megathyrsus maximus*), feathertop (*Pennisetum villosum*), and Johnson grass (*Sorghum halepense*).
- Inappropriate management of roadside grasslands (i.e. spraying, low slashing, heavy grazing) which promotes the spread of weeds and aggressive weedy grasses.
- Direct loss and degradation of habitat for construction of facilities and development and maintenance of access tracks.
- Habitat edge effects such as weed infestation, altered habitat structure along gathering lines, tracks and clearing zones.

A high proportion of the local populations are known from within areas that may potentially be disturbed by the project. Although approximately 3% of the project development area contains remnant ecosystems in which *Digitaria porrecta* may occur, this grass is primarily known from roadsides and disturbed areas. Therefore, potential habitat may be relatively extensive and difficult to predict, particularly within the Dalby district.

Without mitigation measures, project impacts to restricted areas of habitat or individual trees may occur causing decline in local populations. Arrow proposed to give priority to avoiding core habitat for *Digitaria porrecta* through design and site selection, and to implement a range of general mitigation measures summarised in Table 53.

Table 53 Impacts and mitigation measures relevant to *Digitaria porrecta* (finger panic grass)

Potential Impacts	Mitigation measures
Clearing and fragmentation	Where avoidance is not possible, and significant residual impacts remain to *Digitaria porrecta* implement and offset strategy approved by a relevant government agency and comply with reporting conditions of an offset plan. (C219) Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Aim to avoid impacts to *Digitaria porrecta* and its core habitat (C218, C217 and C240) with reference also to the ‘environmental framework approach. Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys (C244,

Potential Impacts	Mitigation measures
	C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of habitat	Erosion and sediment and control measures (C261) Confine project traffic to designated roads and access tracks, where practicable. (C033) Prohibit unauthorised collection of flora products. (C256) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Weed invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)

Table 54 shows Arrow's estimated the potential area of disturbance of *Digitaria porrecta* habitat within the project development area as a result of project related activities.

Table 54 Potential area of disturbance of *Digitaria porrecta* habitat

	Area within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Core Habitat Known	622	14
Core Habitat Possible	10,809	16
General Habitat	6,943	10

In the absence of defined locations for project infrastructure, Arrow provided estimates of the potential maximum disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. The accuracy of the disturbance area estimated for the entire project development area was also limited by the uncertain accuracy of habitat mapping derived from regional ecosystem mapping, and particularly by the lack of site specific information on the potential layout of all works and infrastructure required by the project. Furthermore, the estimate of disturbance area was based on clearing and did not attempt to estimate the impact area associated with degradation of the condition of the remaining areas of *Digitaria porrecta* habitat.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments. For this reason, the conservative approach used in the estimation of maximum disturbance areas for threatened species and ecological communities is considered appropriate.

EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the habitat of *Digitaria porrecta*. Rehabilitation using translocation and propagation from seed is likely to be practicable provided that competing species are managed. EHP is of the view that the level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

Listed threatened fauna species (EPBC Act)

Nyctophilus corbeni (South-eastern Long-eared bat)

EPBC Act Status: Vulnerable

Recovery plan: Recovery Plan required, included on the Commenced List (1/11/2009). Draft national recovery plan for the south-eastern long-eared bat *Nyctophilus corbeni*.

Conservation Advice: Yes.

The south-eastern long-eared bat is larger in size than other long-eared bats and has a broader skull and jaw. It has a head and body length of about 50-70 mm and a tail length of 35-50 mm. Weight varies between gender with females (14-21 g) heavier than males and males (11-15 g). Little is known about the ecology of this species and most of what is known comes from research outside of Queensland. Roosting has been recorded in hollows of live trees, cracks in tree limbs, occasionally under exfoliating bark and even within foliage. With broad, short wings, the south-eastern long-eared bat is highly manoeuvrable and well-adapted to its cluttered habitat. They fly close to vegetation, often through the canopy and can drop suddenly to almost ground level after prey. Individuals are known to fly more than seven km moving between roosts and foraging areas. Roosts may be changed frequently, with an average of 1.3 days in one study. Mating occurs in autumn and winter. Females are able to store spermatozoa until ovulation and conception in early spring. Two young are usually born in late October to November and lactation continues until January.

The south-eastern long-eared bat (*Nyctophilus corbeni*) is most common in box/ironbark/cypress pine woodland on sandy soils, though it also occurs in bulloak (*Allocasuarina luehmannii*), brigalow (*Acacia harpophylla*) and belah (*Casuarina cristata*) communities, dry sclerophyll forests with *Corymbia citriodora*, and semi-evergreen vine thickets. The species prefers areas with a distinct canopy and a dense understorey. Most records are from large tracts of vegetation (> 5000ha) , although the species can be recorded from smaller tracts of 600 ha.

The species is largely restricted to the Murray-Darling Basin, with its stronghold in the Pilliga forests of central New South Wales. In Queensland the species is mainly recorded in Brigalow Belt South, with records from less than 30 locations, extending eastwards to the Bunya Mountains National Park. The distributional limits in Queensland are uncertain. The species is found north to near Duaringa and the Dawson River area may be its northern range limit. However, the most northerly record of the species is from 80 km west of Taroom. Forearm length is used extensively in field identifications of *Nyctophilus* species and there is broad overlap between each species for each sex of *N. corbeni* and *N. gouldi*. Larger individuals of *N. gouldi* are the same general size as *N. corbeni*. It is unknown if possible misidentifications of the species have resulted in the uncertainty attached to its distribution.

There are eight records for the project development area: one from approximately 25 km north of Miles and six from an area approximately 30 km south-west of Millmerran. There are also two recent survey records, one from approximately 18 km north north-east of Miles. One individual was trapped during field surveys for the project, and this should be treated as an important population. The extent of habitat within the project development area was estimated as:

- Core Habitat Known 14,268 ha
- Core Habitat Possible 182,570 ha
- General Habitat 0 ha

The accuracy of the habitat area estimates is limited by the uncertain accuracy of the regional ecosystem mapping used, inclusion of more than one regional ecosystem in mapped polygons which would require field survey to resolve, and by the assumptions made in correlating habitat with regional ecosystems.

Impacts to south-eastern long-eared bat (*Nyctophilus corbeni*) associated with the proposed project related activities could include:

- Potential death or injury of roosting bats caused by diurnal clearing of roosts. Depending on the extent of clearing, displaced animals forced into nearby habitats are unlikely to persist due to increased competition with resident animals.
- The loss of foraging and roosting habitat due to the construction of infrastructure.
- Fragmentation of existing large, intact and contiguous habitats.
- Increased fire frequency associated with increased human activity and machinery.
- Increased watering points by the creation of surface ponds around gas wells. Flying insect abundance may also be increased around these waterbodies.

Arrow stated that the potential for cumulative impacts on this species remains uncertain although, if habitat is cleared, development activities will potentially reinforce the cumulative impact to the species incurred across a range of interacting projects. The species is highly mobile and may be tolerant of small-scale disturbance associated with activities. More substantial clearing of vegetation associated with larger infrastructure (e.g., power generation plants, groundwater dams, etc.) would have greater impacts. Rehabilitation upon decommissioning has the potential to establish native vegetation, which over time should progress toward a native vegetation community.

Without mitigation measures, project impacts to restricted areas of habitat or individual trees may occur causing decline in local populations. Arrow proposed to give priority to avoiding core habitat for south-eastern long-eared bat (*Nyctophilus corbeni*) through design and site selection, and to implement a range of general mitigation measures summarised in Table 55.

Table 55 Impacts and mitigation measures relevant to south-eastern long-eared bat (*Nyctophilus corbeni*)

Potential Impacts	Mitigation measures
Clearing and fragmentation	Aim to avoid impacts to south-eastern long-eared bat (*Nyctophilus corbeni*) and its core habitat (C218, C240) with reference also to the ‘environmental framework approach’ outlined in the EIS Chapter 8. Where avoidance is not possible, and significant residual impacts remain to threatened species and communities, implement an offset strategy approved by relevant government agency and comply with reporting conditions of an offset plan. (C219) Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys (C244, C248) and appropriate species (C253) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252)
Degradation of habitat	Fell trees away from existing stands where practicable (C241) and avoid damaging standing trees not identified for removal (C242). Confine project traffic to designated roads and access tracks, where practicable. (C033) Prohibit disturbance or harassment of wildlife. (C256, C255 and C254) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303)
Injury to wildlife	Assess trees prior to felling for potential nesting hollows. If identified, fell trees in the presence of a qualified fauna spotter-catcher and roll them so that the hollows are facing upwards, allowing fauna to escape. (C235) Retain habitat trees, where practicable. (C234)
Changed fire regimes	Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472).

Table 56 shows Arrow's estimated the potential area of disturbance of south-eastern long-eared bat (*Nyctophilus corbeni*) habitat within the project development area as a result of project related activities.

Table 56 Potential area of disturbance of south-eastern long-eared bat (*Nyctophilus corbeni*) habitat

	Area within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Core Habitat Known	14,268	520
Core Habitat Possible	182,570	356
General Habitat	0	0

In the absence of defined locations for project infrastructure, Arrow provided estimates of the potential maximum disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. The accuracy of the disturbance area estimated for the entire project development area was also limited by the uncertain accuracy of habitat mapping derived from regional ecosystem mapping, and particularly by the lack of site specific information on the potential layout of all works and infrastructure required by the project. Furthermore, the estimate of disturbance area was based on clearing and did not attempt to estimate the impact area associated with degradation of the condition of the remaining areas of south-eastern long-eared bat (*Nyctophilus corbeni*) habitat.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments. For this reason, the conservative approach used in the estimation of maximum disturbance areas for threatened species and ecological communities is considered appropriate.

EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the habitat of south-eastern long-eared bat (*Nyctophilus corbeni*). EHP is of the view that the level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy. Arrow has stated that any habitat offsets required should be connected to much larger contiguous tracks of vegetation to be successful.

Maccullochella peelii (Murray cod)

EPBC Act Status: Vulnerable

Recovery plan: A recovery plan has been prepared for *Maccullochella peelii*.

Conservation advice: Yes

Maccullochella peelii can grow up to 1.8 m long and weigh up to 113.5 kg, making it the largest freshwater fish found in Australia. Typically, *Maccullochella peelii* range from 50 cm to 70 cm in length and weighs less than 10 kg. The species can live up to 60 years and typically resides within a 10 km stretch of river over their lifetime.

When compared to other species, *Maccullochella peelii* has relatively low fertility.
The species reaches sexual maturing within four to five years of age and females produce around 10,000 eggs to 90,000 eggs depending on the weight of the fish. Spawning occurs from late spring to early summer, with breeding taking place just before annual high flow and flood events.

Maccullochella peelii is carnivorous and feeds on other fish, turtles, frogs, crustaceans and molluscs, but also has been known to eat terrestrial animals including snakes, birds, mice, and water dragons.

Maccullochella peelii is known to migrate approximately 40 to 120 km upstream to spawn, following a flood event. The species then moves downstream to the same territory where they occupied prior to spawning.

Maccullochella peelii occurs in a wide range of warm water habitats including slow flowing, turbid waters of lowland rivers and billabongs and upland streams with rocky substrates and high flowing, clear waters. The species prefers waterways which are up to 5 m deep, with submerged logs and boulders, undercut banks and overhanging vegetation. Consequently, it is often found in the main river channel and larger tributaries rather than floodplain channels.

Maccullochella peelii occurs within the waterways of the Murray-Darling Basin (MDB) within Queensland, New South Wales, Victoria and South Australia. Within Queensland it is found in the south western boarder lakes and rivers. There have been attempts to translocate the species outside its normal range. Within Queensland it has been previously introduced into the Cooper Creek and Burnett and Fitzroy River systems.

Murray Cod is known to occur within the portion of the project development area within the Murray-Darling Basin. The population is known to be endemic, although there is population supplementation from stocking groups. The species was recorded during surveys completed for the project. This population of Murray Cod is considered an 'important population', as per the definition provided by the EPBC Significant Impact Guidelines, as it forms part of the interconnected population of the broader Murray-Darling Basin, and is necessary for the species' long-term survival and recovery. The extent of habitat within the project development area was estimated as:

- Core Habitat Known 0 ha
- Core Habitat Possible 0 ha
- General Habitat 0 ha

Impacts to *Maccullochella peelii* associated with the proposed project related activities could include:

- Modification/loss of physical habitat (hydrological, physical macro-habitat and physical micro-habitat) and changes in water quality as a result of soil disturbance activities that occur across the catchment and discharge of CSG water
- Disruption of breeding cycles due to alterations in the natural flow regime resulting from the release of CSG water
- Facilitation of the spread and introduction of 'exotic' species known to pose a threat to the species from changes to the natural flow regime from the release of CSG water.

Arrow has identified that the project has the potential to decrease the frequency and duration of no-flow periods in watercourses subject to the discharge of CSG water, which has the potential to facilitate the establishment of harmful invasive species. The Murray cod currently exists within the vicinity of the project development area. From current knowledge, the population has declined from pre-settlement times but is in a state of recovery from prior disturbance. The project was identified as having a moderate residual impact with the potential to interfere with the species recovery.

There is also the potential for cumulative impacts from similar activities undertaken by other proponents (discharge of CSG water) to further exacerbate these impacts.

Without mitigation measures, project impacts to restricted areas of habitat may occur causing decline in local populations. Arrow proposed to give priority to avoiding core habitat for Murray cod through design and site selection, and to implement a range of general mitigation measures summarised in Table 57.

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Table 57 Impacts and mitigation measures relevant to *Maccullochella peelii* (Murray cod)

Potential Impacts	Mitigation measures
Clearing	Erosion and sediment and control measures (C261) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Clear areas progressively and implement rehabilitation as soon as practicable. (C015)
Degradation of aquatic habitat	Develop a strategy for the discharge of coal seam gas water to watercourses, informed by an environmental flows and water quality data, and aquatic ecology monitoring, and incorporating a water quality and geomorphology monitoring program, (C498) Confine project traffic to designated roads and access tracks, where practicable. (C033) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303) Minimise disturbance to watercourse bed and banks through appropriate designs (C191) (C196), obtaining relevant permits (C192) avoiding transport of equipment across watercourses (C194), minimising watercourse crossings (C152), storing stockpiles away from watercourse (C197), discharging water from project activities at a rate and location that will not cause or exacerbate erosion (C066), and developing erosion and sediment control (C034) If diversion of watercourse flows using pumps is required, screen the pump intakes with mesh to protect aquatic life. (C198) Plan construction of watercourse crossings to occur during periods of low rainfall and low flow, when practicable. (C161) and monitor water quality (C507) Identify reaches vulnerable to bank erosion from the discharge of coal seam gas water and develop site-specific erosion control and management plans for vulnerable reaches. (C561) Maintain water quality through management of sewage and greywater (C182) and developing and implementing emergency response and spill response procedures (C036) (C038) (C048) (C037) (C043). Backfill and rehabilitate excavations, particularly pipeline trenches and drilling sumps, to promote successful rehabilitation. (C071) Inspect erosion and sediment control measures following significant rainfall events and carry out repairs and/or maintain as required to retain the effectiveness of the measures. (C505) Arrow will implement a buffer zone from the high bank of all watercourses to prevent development or clearance occurring within the buffer~~s~~ (other than construction of watercourse crossings for roads and pipelines, discharge infrastructure and associated stream monitoring equipment). Determine the buffer zone distance in accordance with the legislative requirements at the time of development or through preconstruction clearance surveys. (C157) Design watercourse crossings to enable passage of flows resulting from a 1 in 100 year average recurrence interval flood event, as a minimum. (C184)

Table 58 shows Arrow's estimated the potential area of disturbance of *Maccullochella peelii* habitat within the project development area as a result of project related activities.

Table 58 Potential area of disturbance of *Maccullochella peelii* habitat

	Area within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Core Habitat Known	0	0
Core Habitat Possible	0	0
General Habitat	0	0

In the absence of defined locations for project infrastructure, Arrow provided estimates of the potential maximum disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. Furthermore, the estimate of disturbance area was based on direct impacts and did not attempt to estimate the impact area associated with degradation of *Maccullochella peelii* habitat.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments.

Although the spread and introduction of 'exotic' species (i.e. exotic fish) was identified as a potential impact, proposed mitigation measures do not specifically include monitoring for the spread or introduction of these species, and actions required numbers of such species increase as a result of project activities. Arrow has committed to development of a declared weed and pest species management plan which should include measures relating to exotic aquatic species. Mitigation measures relating to release of CSG water may not be effective in maintaining natural flow regimes to prevent spread or population increase of exotic fish. Arrow should support programs that monitor the populations of exotic fish in Murray cod habitat (particularly in streams where Arrow proposes to discharge coal seam water). Support should also be provided for any remedial action plans relevant to those streams where discharges from Arrow's operations are demonstrated to have an impact on these species.

Considering the above, EHP is of the view that the level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

Furina dunmalli (Dunmall's snake)

EPBC Act Status: Vulnerable

Recovery plan: A recovery plan has not been prepared for *Furina dunmalli*. This species is included in the *Draft Queensland Brigalow Belt Reptile Recovery Plan 2008 – 2012* (Richardson 2006).

Furina dunmalli is a nocturnal, cryptic, secretive species that is possibly genuinely scarce and very rarely encountered. The species has been found sheltering under fallen timber and ground litter and may use cracks in alluvial clay soils. Little is known of its ecology, but it reportedly preys on lizards and geckos. Nothing is known of its breeding biology other than that it lays eggs.

The species has been found in a wide range of habitats, including forests and woodlands dominated by brigalow (*Acacia harpophylla*) and other acacias (*A. burowii*, *A. deanii*, *A. leiocalyx*), cypress (*Callitris* spp.) or bulloak (*Allocasuarina luehmannii*) on black alluvial cracking clay and clay loams. It also occurs in spotted gum (*Corymbia citriodora*), ironbark (*Eucalyptus crebra* and *Eucalyptus melanophloia*), white cypress pine (*Callitris glaucophylla*) and bulloak open forest and woodland on sandstone-derived soils and there is a record from the edge of dry vine scrub. However, preferred habitat appears to be brigalow growing on cracking black clay and clay loams.

Furina dunmalli is confined to the Brigalow Belt bioregion of south-eastern Queensland and north-eastern New South Wales, occurring north to Clermont and near Rockhampton. Most records are from the Dalby-Tara area of the Darling Downs.

There is no known record (post 1979) of *Furina dunmalli* in the project development area. ' The extent of habitat within the project development area was estimated as:

- Core Habitat Known 0 ha
- Core Habitat Possible 210,400 ha
- General Habitat 0 ha

The accuracy of the habitat area estimates is limited by the uncertain accuracy of the regional ecosystem mapping used, inclusion of more than one regional ecosystem in mapped polygons which would require field survey to resolve, and by the assumptions made in correlating habitat with regional ecosystems.

Impacts to *Furina dunmalli* associated with the proposed project related activities could include:

- Death or injury of individuals during construction. Those displaced by clearing may face increased competition with nearby existing resident animals.
- Loss of habitat, which may reduce population extent.
- While the species is known to cross roads and tracks, it is not known if movement frequency is reduced by these structures. The construction of gas gathering lines and access tracks could affect movement.
- Increased mortality due to captured individuals in open trenches passing through or adjacent to existing habitats.
- Modified fire regimes from increased human activity can cause mortality and lead to long-term changes in vegetation/habitat structure.
- Edge effects, particularly weed invasion, may alter the ground surface structure of existing habitats, rendering large areas unsuitable.
- Drowning or other mortality in steep-sided, plastic-lined dams.

Deaths associated with vegetation clearing may be unavoidable if the species is present, and this impact cannot be completely mitigated. Arrow stated that the consequences of the loss of individuals from existing populations is unknown, but would depend on the number of animals removed. Controlling indirect impacts through rehabilitation, trench clearing and weed suppression will be beneficial and assist in reducing short-term and long-term impacts.

Without mitigation measures, project impacts to restricted areas of habitat may occur causing decline in local populations. Arrow proposed to give priority to avoiding core habitat for *Furina dunmalli* through design and site selection, and to implement a range of general mitigation measures summarised in Table 59.

Table 59 Impacts and mitigation measures relevant to *Furina dunmalli* (Dunmall's snake)

Potential Impacts	Mitigation measures
Clearing and fragmentation	Aim to avoid impacts to *Furina dunmalli* and its core habitat (C218, C240) with reference also to the 'environmental framework approach' outlined in the EIS Chapter 8. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252) Retain woody debris, logs and rocks for use in rehabilitation of fauna corridors and to provide fauna refuge. (C238)
Degradation of habitat	Fell trees away from existing stands where practicable (C241) and avoid damaging standing trees not identified for removal (C242). Confine project traffic to designated roads and access tracks, where practicable. (C033) Prohibit unauthorised disturbance or harassment of wildlife. (C256) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303) Implement noise control techniques (C254) and reduce light spill to nocturnal fauna (C255).
Weed invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188) Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations.

Potential Impacts	Mitigation measures
	(C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)
Indirect impacts (fauna)	Design dams to have an egress (escape point) for wildlife. (C214)
Injury to fauna	Minimise time a trench is left open. (C233) Minimise injury to fauna by using appropriately trained personnel or a spotter-catcher to capture injured wildlife (C237), erecting fauna-exclusion fences around dams (C243), implementing speed-limits ((C260), reviewing site-specific management plans before moving stockpiled logs and vegetation (C473), inspecting and managing open trenches appropriately (C500).
Changes to fire regime	Preventive and responsive measures for bushfire management (C027, C424, C483, C486, C487) including control of construction and operational activities during extreme fire danger periods (C423, C468), and regular patrols and inspections (C472).

Table 60 shows Arrow's estimated the potential area of disturbance of *Furina dunmalli* habitat within the project development area as a result of project related activities.

Table 60 Potential area of disturbance of *Furina dunmalli* habitat

	Area within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Core Habitat Known	0	0
Core Habitat Possible	210,400	440
General Habitat	0	0

In the absence of defined locations for project infrastructure, Arrow provided estimates of the potential maximum disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. The accuracy of the disturbance area estimated for the entire project development area was also limited by the uncertain accuracy of habitat mapping derived from regional ecosystem mapping, and particularly by the lack of site specific information on the potential layout of all works and infrastructure required by the project. Furthermore, the estimate of disturbance area was based on clearing and did not attempt to estimate the impact area associated with degradation of the condition of the remaining areas of *Furina dunmalli* habitat.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments. For this reason, the conservative approach used in the estimation of maximum disturbance areas for threatened species and ecological communities is considered appropriate.

EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the habitat of *Furina dunmalli*. The impact of wildfire on species populations within the project development area could be reduced by the access tracks and proposed fire management measures. EHP is of the view that the level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

Anomalopus mackayi (Five clawed worm-skink)

EPBC Act Status: Vulnerable

Recovery plan: This species is included in the *Draft Queensland Brigalow Belt Reptile Recovery Plan 2008 – 2012* (Richardson 2006).

Conservation Advice: Approved by the Minister / Delegate of the Minister on: 26/03/2008

Little is known of this species' biology, but it is adapted to burrowing and can be found under logs, rocks and in loose soil, under clumps of slashed grass and presumably in soil cracks. Nothing is known of its breeding biology, except that it is an egg-laying species. Its diet is assumed to consist of small arthropods (e.g., insects, spiders). Captive animals remained beneath the upper surfaces of soil during the day, emerging only to capture mealworms from the surface.

No movement data has been recorded. The species has not been recorded crossing roadways or tracks. However, related species are known to occasionally cross open artificial surfaces. This suggests that the species, while very reluctant, may cross open ground for short distances.

The five clawed worm-skink (*Anomalopus mackayi*) is found in open grasslands on heavy cracking soil in areas with closely spaced tussock grass that may be prone to inundation. Scattered eucalypts may be present or adjacent. It also occurs in open eucalypt woodland, cypress pine (*Callitris* spp.) woodland with a grassy groundcover and in grassland on loam or sandy soils. Suitable habitats on the Darling Downs remain a stronghold, particularly low (typically <40 cm) native grasslands with or without sparse trees and also derived native grasslands created by land clearing. In Queensland, the species is now largely confined to relict roadside verges.

The five clawed worm-skink (*Anomalopus mackayi*) has a small distribution, being confined to the eastern Darling Downs region of the southern Brigalow Belt in Queensland and the western slopes of the Great Dividing Range in north-east New South Wales. Its range appears to have contracted eastwards. Records in the past 20 years have come only from Oakey and the Dalby regions of Queensland, and from the Wallangra, Mungindi and Wee Waa regions of New South Wales. The Wallangra specimens link what were previously thought to be disjunct Queensland and New South Wales populations. Localities for museum specimens collected prior to 1970 include a number on the plains south and west of Moree, and as far west as Goodooga, New South Wales.

There are three records of five clawed worm-skink (*Anomalopus mackayi*) for the project development area: two from Dalby and one from approximately 19 km east of Cecil Plains. The extent of habitat within the project development area was estimated as:

- Core Habitat Known 0 ha
- Core Habitat Possible 14,299 ha
- General Habitat 0 ha

The accuracy of the habitat area estimates is limited by the uncertain accuracy of the regional ecosystem mapping used, inclusion of more than one regional ecosystem in mapped polygons which would require field survey to resolve, and by the assumptions made in correlating habitat with regional ecosystems.

Impacts to the five clawed worm-skink (*Anomalopus mackayi*) associated with the proposed project related activities could include:

- Death or injury of individuals during vegetation clearing. Depending on the extent of clearing, displaced animals forced into nearby habitats are unlikely to persist due to increased competition with resident animals.
- Loss of suitable habitat.
- Fragmentation and isolation of previous contiguous or connected populations by gas gathering lines and access tracks.
- Increased mortality due to captured individuals in open trenches passing through or adjacent to existing habitats.
- Increased surface water leaking from gas bores may alter the soil structure, closing ground cracks and facilitating weed or exotic grass growth.
- Edge effects, particularly weed invasion, which pose a significant threat to grasslands dominated by native species.

Remaining populations are restricted to minor fragments such as roadside reserves. Due to the minor extent and linear nature of these areas, even small clearing actions can have serious impacts. Remaining populations are highly important. Remnant grasslands are fragile communities and highly susceptible to disturbance and modification. Clearing, fragmentation, increased mortality due to trench deaths and weed invasion pose significant threats to the species and impacts could be major in the absence of mitigation measures.

Arrow proposed to give priority to avoiding core habitat for the five clawed worm-skink (*Anomalopus mackayi*) through design and site selection, and to implement a range of general mitigation measures summarised in Table 61.

Table 61 Impacts and mitigation measures relevant to five clawed worm-skink (*Anomalopus mackayi*)

Potential Impacts	Mitigation measures
Clearing and fragmentation	Aim to avoid impacts to five clawed worm-skink (*Anomalopus mackayi*) and its core habitat (C218, C240, C217) with reference also to the 'environmental framework approach' outlined in the EIS Chapter 8. Conduct preconstruction clearance surveys to identify areas to be avoided. (C220, C232) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Design infrastructure to avoid disturbance of high value ecological corridors where practicable. (C557) Mark site boundaries clearly for areas that require avoidance (C228, C533), inform workers and machinery operators of buffer locations (C230) and use qualified personnel to guide clearing activities. (C229) Clear areas progressively and implement rehabilitation as soon as practicable. (C015) Supervise construction activities in sensitive areas. (C534, C535, C536) Identify areas for rehabilitation (C247), and develop procedures and plans for rehabilitation (C250) with consideration of the preconstruction clearance surveys (C244, C248) and appropriate species and seed source wherever practicable (C253, C541) Monitoring of rehabilitation and propagated or translocated species. (C478, C482, C252) Retain woody debris, logs and rocks for use in rehabilitation of fauna corridors and to provide fauna refuge. (C238) Where avoidance is not possible, and significant residual impacts remain to threatened species and communities, implement an offset strategy approved by a relevant government agency and comply with reporting conditions of an offset policy. (C219)
Degradation of habitat	Develop site-specific monitoring programs for threatened species and communities based on the identified risk to the conservation or maintenance of a viable population. (C303) Install and maintain appropriate sediment and erosion control structures at work sites. (C261) Where used for dust suppression on roads or for construction and operations activities coal seam gas water quality will be in accordance with relevant permits and/or consents. (C176) Confine project traffic to designated roads and access tracks, where practicable. (C033) Decommission the pipeline corridors in a manner that minimises potential impacts on the environment. (C246)
Injury to fauna	Inspect and manage open trenches in accordance with the following (C500 and C233): ▪ Inspect trenches for the presence of fauna daily (preferably in the morning), as well as immediately prior to closing a trench. ▪ Have appropriately trained personnel remove any fauna from a trench to minimise stress to the animal and to avoid personal injury. ▪ Record details of trapped fauna for inclusion in the EHP Wildnet database. ▪ Minimise the time a trench is left open Review site-specific management plans before moving stockpiled logs and vegetation to reduce potential for fauna mortality. (C473)
Weed invasion and spread	Develop a declared weed and pest management plan in accordance with the Petroleum industry advisory guidelines. (C188)

Potential Impacts	Mitigation measures
	Identify declared weeds during preconstruction clearance surveys. (C193) Train field personnel to identify key pest species, in location and extent of weed infestations (C259), weed spread risks (C179), monitoring for weeds (C508). Minimise movement of equipment between properties or areas with weed infestations. (C189) Wash down of vehicles and equipment that have potentially been in contact with weeds before entering new work sites. (C099) Inspections and weed hygiene declarations where there is risk of contamination. (C190)

Table 62 shows Arrow's estimated the potential area of disturbance of five clawed worm-skink (*Anomalopus mackayi*) habitat within the project development area as a result of project related activities.

Table 62 Potential area of disturbance of five clawed worm-skink (*Anomalopus mackayi*) habitat

	Area within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Core Habitat Known	0	0
Core Habitat Possible	14,299	56
General Habitat	0	0

In the absence of defined locations for project infrastructure, Arrow provided estimates of the potential maximum disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. The accuracy of the disturbance area estimated for the entire project development area was also limited by the uncertain accuracy of habitat mapping derived from regional ecosystem mapping, and particularly by the lack of site specific information on the potential layout of all works and infrastructure required by the project. Furthermore, the estimate of disturbance area was based on clearing and did not attempt to estimate the impact area associated with degradation of the condition of the remaining areas of five clawed worm-skink (*Anomalopus mackayi*) habitat.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments. For this reason, the conservative approach used in the estimation of maximum disturbance areas for threatened species and ecological communities is considered appropriate.

EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the habitat of five clawed worm-skink (*Anomalopus mackayi*). The impact of wildfire on species populations within the project development area could be reduced by the access tracks and proposed fire management measures. EHP is of the view that the level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

Rheodytes leukops (Fitzroy River turtle / Fitzroy tortoise)

EPBC Act Status: Vulnerable

Recovery plan: A recovery plan has not been prepared for *Rheodytes leukops* but it is listed in *The Action Plan for Australian Reptiles*.

Conservation Advice: Approved by the Minister / Delegate of the Minister on: 3/07/2008

Rheodytes leukops grows to 25 cm (shell length) and the shell has a medium to dark brown colouring, with some dark spots and blotches on the top of the shell. On the underside surface, the shell is yellow or cream and the skin is an olive-grey colour. The neck of *Rheodytes leukops* is covered with 'large, pointed conical tubercles'. The turtle also has long forelimbs, each with five claws, and a large cloacal bursae.

Rheodytes leukops has adapted to breathe either using its lungs or its cloaca. The turtles are known as 'bottom-breathers' as they can respire by drawing water in and expelling it from the cloaca at a rate of 15-60 times per minute. This function allows the turtle to walk on the streambed and stay underwater without coming to the surface for days or weeks.

Rheodytes leukops is slow to reach sexual maturity, taking up to 15-20 years before reproduction can occur. Nesting takes place between September and October annually, with nests being located in river sandbanks 1-4 m above the water level. Females typically lay between 46-59 eggs annually in three to five clutches.

Rheodytes leukops has a highly diverse diet consisting of algae, macroinvertebrate larvae, macrophytes (including Vallisneria spp.), freshwater sponges, terrestrial insects, as well as terrestrial leaves and bark.

Rheodytes leukops is thought to have a limited home range (417-679 m), overlapping riffle zones. Turtles have been observed to be active mainly during late afternoon and at night, although they can be largely sedentary staying in the same location for several days.

Rheodytes leukops occurs in rivers with a rock, gravel or sand substrate, with deep pools that are connected by shallow riffle zones. Riffle zones are an important habitat for *Rheodytes leukops* due to the high dissolved oxygen levels in these zones and abundant food sources, including benthic macroinvertebrates and algae.

During the dry season this species retracts into large slow flowing pools and/or non-flowing permanent pools. The species prefers waterways with high water clarity and areas that contain large macrophyte beds, including Vallisneria spp. *Rheodytes leukops* has been identified as occurring in the Fitzroy, Connors, Dawson, Isaac and Mackenzie Rivers, as well as Windah Creek and Develin or Malborough Creek. Since being described in 1980, the distribution of *Rheodytes leukops* is not believed to have significantly changed.

Rheodytes leukops is only known to occur within the Fitzroy Basin, not the Murray-Darling Basin (within which the vast majority of the project development area is situated). A small portion of the project development area falls within the Dawson River catchment of the Fitzroy Basin.

No specimen of *Rheodytes leukops* has been recorded within the project development area. The species is noted as 'possibly' occurring within the small portion of the project development area located within the Dawson River catchment.

Targeted *Rheodytes leukops* surveys (including nesting bank inspection during the breeding season) were not carried out for the project and no individuals were collected by the routine turtle sampling methodologies employed.

Rheodytes leukops has previously been recorded within the Dawson River below The Orange Creek Weir; which is situated approximately 175 km downstream of the project development area. The extent of habitat within the project development area was estimated as:

- Core Habitat Known 0 ha
- Core Habitat Possible 0 ha
- General Habitat 0 ha

Impacts to *Rheodytes leukops* associated with the proposed project related activities could include:

- Modification/loss of physical habitat (hydrological, physical macro-habitat and physical micro-habitat) and changes to water quality as a result of soil disturbance activities that occur across the catchment.

Without mitigation measures, project impacts to restricted areas of habitat may occur causing decline in local populations. Arrow proposed to give priority to avoiding core habitat for *Rheodytes leukops* through design and site selection, and to implement a range of general mitigation measures summarised in Table 63.

Table 63 Impacts and mitigation measures relevant to *Rheodytes leukops* (Fitzroy River turtle)

Potential Impacts	Mitigation measures
Clearing	Erosion and sediment and control measures (C261) Develop management procedures when project activities are identified as likely to have an impact on threatened ecological communities or species habitat. (C224) Minimise the disturbance footprint and vegetation clearing. (C020, C231) Clear areas progressively and implement rehabilitation as soon as practicable. (C015)
Degradation of aquatic habitat	Confine project traffic to designated roads and access tracks, where practicable. (C033) Site-specific monitoring programs based on the identified risk to the conservation or maintenance of a viable population. (C303) Minimise disturbance to watercourse bed and banks through appropriate designs (C191) (C196), obtaining relevant permits (C192) avoiding transport of equipment across watercourses (C194), minimising watercourse crossings (C152), storing stockpiles away from watercourse (C197), discharging water from project activities at a rate and location that will not cause or exacerbate erosion (C066), and developing erosion and sediment control (C034) (C561). Maintain water quality through management of sewage and greywater (C182) and developing and implementing emergency response and spill response procedures (C036) (C038) (C048) (C037) (C043). Plan construction of watercourse crossings to occur during periods of low rainfall and low flow, when practicable. (C161) and monitor water quality (C507) Backfill and rehabilitate excavations, particularly pipeline trenches and drilling sumps, to promote successful rehabilitation. (C071) Inspect erosion and sediment control measures following significant rainfall events and carry out repairs and/or maintain as required to retain the effectiveness of the measures. (C505) Arrow will implement a buffer zone from the high bank of all watercourses to prevent development or clearance occurring within the buffer~~s~~ (other than construction of watercourse crossings for roads and pipelines, discharge infrastructure and associated stream monitoring equipment). Determine the buffer zone distance in accordance with the legislative requirements at the time of development or through preconstruction clearance surveys. (C157) Design watercourse crossings to enable passage of flows resulting from a 1 in 100 year average recurrence interval flood event, as a minimum. (C184)

Table 64 shows Arrow's estimated the potential area of disturbance of *Rheodytes leukops* habitat within the project development area as a result of project related activities.

Table 64 Potential area of disturbance of *Rheodytes leukops* habitat

	Area within Project Development Area (ha)	Estimated Maximum Area of Potential Disturbance (ha)
Core Habitat Known	0	0
Core Habitat Possible	0	0
General Habitat	0	0

In the absence of defined locations for project infrastructure, Arrow provided estimates of the potential maximum disturbance area based on conceptual field development which combined advanced field layout planning where available and a generic grid-layout for other areas. Furthermore, the estimate of disturbance area was based on direct impacts and did not attempt to estimate the impact area associated with degradation of the condition of *Rheodytes leukops* habitat.

Arrow maintained that the proposed management measures, which form the basis for the impact significance assessment in the EIS, would be effective based on available evidence from existing gas field developments and internal review but has not provided supporting evidence of the effectiveness of the measures in the existing Arrow gas field developments.

EHP considers that the method used to determine the maximum potential disturbance is acceptable and provides a reasonable assessment of the maximum likely impact of the project on the habitat of *Rheodytes leukops*. EHP is of the view that the level of impact is acceptable.

The Australian government will require offsets for residual impacts in accordance with the EPBC Act environmental offsets policy.

Ecology, habitat and distribution, threats and risks for migratory species (EPBC Act)

Table 65 Ecology, habitat and distribution, threats and risks for migratory species listed under the EPBC Act

Common Name	Scientific Name	Ecology	Habitat and distribution	Threats and risks
Migratory Terrestrial Bird Species				
Rainbow bee-eater	*Merops ornatus*	Feeds on flying insects. Ground nesting species.	Common; any habitat suitable for catching insects	Minimal; nest predation by cane toads
Rufous fantail	*Rhipidura rufifrons*	Forages in trees for small invertebrates	Moist habitats; gullies and watercourses	Loss and fragmentation of breeding habitat within migration routes
White-bellied sea-eagle	*Haliaeetus leucogaster*	Nest on cliffs and in large trees	Coast and along rivers and lakes	Illegally shot or poisoned
Eastern osprey	*Pandion cristatus*	Nest on cliffs and in large trees or structures	Coast and along rivers and lakes	Loss of breeding sites and nests; lack of fish
Oriental Cuckoo	*Cuculus optatus*	Present in Australia between September and May	Rainforest, open forest and woodland; recorded in gardens and plantations	Collisions with windows and lighthouses; killed by cats
Spectacled monarch	*Symposiarchus trivirgatus*	Forages in trees for small invertebrates	Moist habitats; gullies and watercourses	Loss and fragmentation of breeding habitat within migration routes
White-throated needletail	*Hirundapus caudacutus*	Aerial species may occasionally roost in trees.	Cities, forests and the ocean	Minimal; collision with man-made structures
Fork-tailed swift	*Apus pacificus*	Aerial species may occasionally roost in trees.	Cities, forests and the ocean	Minimal; collision with man-made structures
Australian reed warbler	*Acrocephalus australis*	Prefers dense vegetation along watercourses.	Dense swamp vegetation in and adjacent to wetlands	Loss of habitat due to development; has benefited from artificial waterbodies
Black-faced monarch	*Monarcha melanopsis*	Forages in trees for small invertebrates	Moist habitats; gullies and watercourses	Loss and fragmentation of breeding habitat within migration routes
Satin flycatcher	*Myiagra cyanoleuca*	Forages in trees for small invertebrates	Confined to east of the Great Dividing Range	Loss and fragmentation of breeding habitat within migration routes
Migratory Shorebird Species				
Latham's snipe, Japanese snipe	*Gallinago hardwickii*	Occurs in vegetation around wetlands	Grasslands, heath, woodland and forest	Reclamation of wetlands

Common Name	Scientific Name	Ecology	Habitat and distribution	Threats and risks
Curlew sandpiper	*Calidris ferruginea*	Occurs in coastal areas, particularly in the intertidal zone.	Freshwater and artificial waterbodies such as rivers, swamps, dams and sewage ponds	Wetland degradation, pollution, human disturbance and invasive plants
Marsh sandpiper, little greenshank	*Tringa stagnatilis*			
Wood sandpiper	*Tringa glareola*			
Sharp-tailed sandpiper	*Calidris acuminata*			
Bar-tailed godwit*	*Limosa lapponica*	Large wader and mainly carnivorous with a diet consisting of worms, molluscs, crustaceans, insects and some plant materials. They occupy the East Asian-Australasian Flyway. During the non-breeding season 88% of the East Asian-Australasian Flyway population occurs in Australia and New Zealand. Known to be in Australia from October–April.	Recorded in the coastal areas of all Australian states, mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays. It is rarely found on inland wetlands or in areas of short grass, such as farmland, paddocks and airstrips.	Threats common to most migratory shorebirds include: Habitat loss Habitat degradation Disturbance Direct mortality (human, pest species, air strike, etc.)
Black-tailed godwit*	*Limosa limosa*	Large wader and is omnivorous. For populations occurring in the East Asian Australasian Flyway, breeding probably occurs in the far-east Russia. Known to be in Australia from September–April.	Is found in all states and territories of Australia, but prefers coastal regions in sheltered bays, estuaries and lagoons with large intertidal mudflats or sandflats, or spits and banks of mud, sand or shell-grit. There are a few inland records, around shallow, freshwater and saline lakes, swamps, dams and bore-overflows, lagoons in sewage farms and saltworks.	The species is not globally threatened and has increased in some areas due to ability to adapt to man-made habitats. Threats common to most migratory shorebirds include: Habitat loss Habitat degradation Disturbance Direct mortality (human, pest species, air strike, etc.)
Pacific golden plover*	*Pluvialis fulva*	Medium-sized plover and often form flocks, usually of 20 to 50 birds. Breeds mostly in northern Siberia.	Within Australia, the Pacific golden plover is widespread in coastal regions, mostly along the east coast, and are especially widespread along	While there are no threats that apply specifically to Pacific golden plovers, there are a number of threats that will affect all migratory waders, including:

Common Name	Scientific Name	Ecology	Habitat and distribution	Threats and risks
		Mainly feed on molluscs, polychaete worms, insects and insect larvae, spiders and crustaceans. Known to be in Australia from September–April.	the Queensland and NSW coastlines on beaches, mudflats and sandflats, harbours, estuaries and lagoons, and also in evaporation ponds in saltworks. They are less often recorded in terrestrial habitats, usually wetlands such as fresh, brackish or saline lakes, grass in paddocks, crops or airstrips, or ploughed or recently burnt areas.	Pollution Human activity Introduced weeds on intertidal zones.
Common sandpiper*	*Actitis hypoleucos*	Small sandpiper is omnivorous and breeds in parts of Europe and Asia, and occasionally Africa. It is found singularly or in small groups, but will form flocks of up to 200 individuals prior to migration movements. Eats molluscs such as bivalves, crustaceans such as amphipods and crabs and a variety of insects. Known to be in Australia from July–April.	Found along all coastlines of Australia and in many areas inland, and is widespread in small numbers. The population when in Australia is concentrated in northern and western Australia. Utilises a wide range of coastal wetlands and some inland wetlands, with varying levels of salinity.	Human activity Habitat loss Reduction of quality and quantity of water Global warming.
Red-necked stint*	*Calidris ruficollis*	Is the smallest shorebird in Australia. It breeds in Siberia and sporadically in north and west Alaska. During the non-breeding season, over 80% of the global population resides in Australia. Known to be in Australia from September–April.	Distributed along most of the Australian coastline with large densities on the Victorian and Tasmanian coasts, mostly found in coastal areas, including in sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks, saltworks and sewage farms; saltmarsh; ephemeral or permanent shallow wetlands near the coast or inland, including lagoons, flooded paddocks or damp grasslands.	Habitat loss Habitat degradation Disturbance Direct mortality (human, pest species, air strike, etc.).
Little curlew	*Numenius minutus*	Prefer short, dry grasslands	Claypans, sporting fields, lawns, terrestrial wetlands and burnt woodlands	Loss and degradation of wetlands
Whimbrel*	*Numenius*	Medium sized curlew feeding mainly	Found on the intertidal mudflats of	Habitat loss

Common Name	Scientific Name	Ecology	Habitat and distribution	Threats and risks
	phaeopus	on large crabs, mantis shrimps and mudskippers. The whimbrel breeds in north and west Alaska and is a regular migrant to Australia and New Zealand. Known to be in Australia from September–April.	sheltered coasts, harbours, lagoons, estuaries and river deltas, often those with mangroves, but also open, unvegetated mudflats. It has been infrequently recorded using saline or brackish lakes near coastal areas. There are a small number of inland records from saline lakes and canegrass swamps.	Habitat degradation Disturbance Direct mortality (human, pest species, air strike, etc.).
Oriental plover	*Charadrius veredus*	Prefer short, dry grasslands	Claypans, sporting fields, lawns, terrestrial wetlands and burnt woodlands	No Immediate threats.
Ruff*	*Philomachus pugnax*	Medium sized wader, insectivorous throughout the breeding grounds. It breeds in Eurasia and north-west Alaska. Known to be in Australia from September–April.	Regular visitor to Australia, being recorded in all States and Territories, in generally fresh, brackish of saline wetlands with exposed mudflats at the edges. Also found in terrestrial wetlands including lakes, swamps, pools, lagoons, tidal rivers, swampy fields and flood lands.	Habitat loss Habitat degradation Disturbance Direct mortality (human, pest species, air strike, etc.)
Common greenshank, greenshank*	*Tringa nebularia*	A carnivorous, heavily built wader seen singly or in small to large flocks. It breeds in Eurasia. Of the East Asian-Australasian Flyway population approximately a third spends the non-breeding season in Australia. Known to be in Australia from September–April.	Found in a wide variety of inland wetlands and sheltered coastal habitats of varying salinity, permanent and ephemeral terrestrial wetlands, including swamps, lakes, dams, rivers, creeks, billabongs, artificial wetlands, including sewage farms and saltworks dams, inundated rice crops and bores. The edges of the wetlands used are generally of mud or clay, occasionally of sand, and may be bare or with emergent or fringing vegetation.	Habitat loss Silt, pollution, weeds or pest invasion Disturbance Introduced species
Migratory Wetland Bird Species				
Great egret, white	*Ardea modesta*	Occurs on rivers, estuaries	Tidal mudflats, man-made dams and	Destruction and modification of

Common Name	Scientific Name	Ecology	Habitat and distribution	Threats and risks
egret			wet pasture	freshwater habitats
White-winged black tern	*Chlidonias leucopterus*	Mostly coastal	Lakes, rivers and inland wetlands	Degradation of feeding areas
Glossy Ibis	*Plegadis falcinellus*	Prefer inland freshwater wetlands	Abundant aquatic flora	Foxes
Caspian tern	*Hydropogne caspia*	Mostly coastal	Lakes, rivers and inland wetlands	Degradation of feeding areas.
Australian cotton pygmy-goose**	*Nettapus coromandelianus albipennis*	Not listed under EPBC - SPRAT Are found on freshwater lakes, swamps and large water impoundments. They congregate in flocks on permanent water-bodies during the dry season.	Deep freshwater swamps, lagoons, dams with water-lilies and semi-emergent water plants.	Destruction and modification of freshwater habitats, in particular: Drainage of wetlands Weeds (particularly the water hyacinth)
Cattle egret	*Ardea ibis*	Foraging in pasture and crops	Grasslands and wetlands	Nestlings by cats

*not described in the EIS. Information from http://www.environment.gov.au/cgi-bin/sprat/public/publicshowmigratory.pl
**http://www.environment.gov.au/biodiversity/threatened/publications/action/birds2000/pubs/cotton-pygmy-goose.pdf

Appendix 6 References

ANZECC. 2000. Australian and New Zealand guidelines for fresh and marine water quality. Department of Sustainability, Environment, Water, Population and Communities, Australian Capital Territory.

Biosecurity Queensland, 2008. Petroleum Industry - Pest Spread Minimisation Advisory Guide, Biosecurity Queensland.

DAFF 2013. Code for self-assessable development: Temporary waterway barrier works. Department of Agriculture Fisheries and Forestry, April 2013.

DCCEE. 2008. National greenhouse and energy reporting (measurement) determination. Department of Climate Change and Energy Efficiency, Canberra, Australian Capital Territory.

DEEDI, 2010. Land Access Code. Department of Employment, Economic Development and Innovation, November 2010, Brisbane, Queensland.

DERM, 2004. Planning for noise control. Department of Environment and Resource Management, Brisbane, Queensland.

DERM. 2005. Queensland water recycling guidelines. Department of Environmental and Resource Management. Brisbane, Queensland.

DERM. 2010a. Coal seam gas water management policy. Department of Environment and Resource Management. Brisbane, Queensland.

DERM. 2010b. Framework for managing sewerage infrastructure to reduce overflows and environmental impacts. Department of Environment and Resource Management. Brisbane, Queensland.

DERM. 2011. Manual for assessing hazard categories and hydraulic performance of dams. Department of Environment and Resource Management. Brisbane, Queensland.

DLGP, 2003. Guidelines for Incorporating Runoff and Flow Coordination into Local Government Planning Schemes on the Condamine Floodplains. Department of Local Government and Planning. Brisbane, Queensland.

DMR, 2006, Guideline for Assessment of Road Impacts of Development. Brisbane, Queensland.

DNRM, 2012. Strategic Cropping Land Standard Conditions Code for Resource Activities, Department of Natural Resources and Mines

DSDIP, 2013a. Regional and resource town action plan. Department of State Development Infrastructure and Planning, Brisbane, Queensland, March 2013.

DSDIP, 2013b. Managing the impacts of major projects in resource communities. Department of State Development Infrastructure and Planning Brisbane, Queensland July 2013.

Isbell, R. F. 2002. The Australian Soil Classification. CSIRO Australia, Collingwood, Victoria.

EHP. 2012a. Guideline for contaminated land professionals. Department of Environment and Heritage Protection, Brisbane, Queensland.

EHP. 2012b. Guideline: Assessing qualified persons according to section 381, 395 and 410 of the *Environmental Protection Act 1994*. Department of Environment and Heritage Protection, Brisbane, Queensland.

EHP. 2012c. Manual for assessing hazard categories and hydraulic performance of dams, Department of Environment and Heritage Protection, Brisbane, Queensland.

EHP. 2013a. Guideline: Noise Assessment: Prescribing noise conditions for environmental authorities for petroleum activities. Department of Environment and Heritage Protection, Brisbane, Queensland.

EHP, 2013b. Integrated laws to manage water impacts. Department of Environment and Heritage Protection, Information Sheet, March 2013.

EHP. 2013c. Guideline: Application requirements for petroleum activities (EM705). Department of Environment and Heritage Protection, Brisbane, Queensland.

Standards Australia. 2000. AS/NZS 1547:2000. On-site domestic wastewater management. Prepared by Standards Australia Limited, Sydney, New South Wales.