

Executive summary

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Gas Field Development Project

Environmental Impact Statement

EXECUTIVE SUMMARY



GLNG is a Santos PETRONAS Total KOGAS venture.

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Coxon Creek, Wallumbilla North, Queensland.

1. Introduction

Santos GLNG is developing its approved Gladstone Liquefied Natural Gas (GLNG) Project, which will bring gas to market via the Gladstone gas transmission pipeline and the liquefied natural gas (LNG) facility at Curtis Island, Gladstone. The Gas Field Development (GFD) Project is planned by Santos GLNG to further develop its Queensland gas resources to provide additional gas to the GLNG Project.

The GFD Project will involve the construction, operation, decommissioning and rehabilitation of additional production wells and associated infrastructure in petroleum tenures held by Santos GLNG in the Surat and Bowen basins. It is anticipated that the life of the GFD Project will exceed 30 years.

The Coordinator General's Terms of Reference required that the GFD Project environmental impact statement (EIS) assess the maximum development scenario of 6,100 production wells and associated infrastructure.

It is important to note that based on factors such as market conditions, exploration results, and technological advancements, a more likely level of development would be approximately half of these activities over the next 30 years. Therefore, it is important to read this EIS with the understanding that only some of the potential impacts identified in this EIS are likely to occur.

This executive summary provides an overview of the GFD Project and the contents of this EIS. It also provides information on how to view or obtain a copy of the document and how to make a submission.

The GFD Project's regional location is illustrated in Figure 1–1.

Figure 1–1 GFD Project location



1.1 The proponent – Santos GLNG

The GFD Project will be delivered by the Santos GLNG joint venture, the same joint venture that is developing the GLNG Project. Joint venture participants include some of the world's largest gas producers, exporters and buyers, namely:

Santos Limited

Santos Limited is one of the largest gas operators in Australia, with interests across Australian petroleum provinces as well as across the Asia Pacific.

Santos Limited has been an LNG exporter to Asia since 2006 via the Darwin LNG Project, since 2014 via the PNG LNG Project, and from 2015 from the GLNG Project per the project schedule.

Petroliam Nasional Berhad (PETRONAS)

PETRONAS is a Malaysian oil and gas corporation ranked among FORTUNE Global 500's largest corporations in the world.

PETRONAS has extensive experience in LNG and is currently operating the world's largest integrated LNG facility in Bintulu, Sarawak.

Total S.A. (Total)

Total is the fifth largest publicly-traded integrated international oil and gas company and a world-class chemicals manufacturer.

Total is active in almost all LNG producing regions and LNG markets, with exploration and production activities in more than 40 countries.

Korea Gas Corporation (KOGAS)

KOGAS is a leading multinational energy company with exploration and production interests in 11 countries. KOGAS currently holds interests in and operates 3,022 kilometres (km) of pipelines across South Korea.

1.2 Santos GLNG operations

Santos GLNG has existing approvals for the exploration (such as authority to prospect permit) and production of gas from coal seams in the petroleum tenure making up the Arcadia, Fairview and Roma gas fields in southwest Queensland.

The GLNG Project involves the construction and operation of 2,650 exploration and production wells and supporting infrastructure across 6,887 square kilometres (km²) of the Arcadia, Fairview and Roma gas fields, plus a 420 km long gas transmission pipeline connected to a three-train LNG facility at Curtis Island, Gladstone. (However, only a two-train facility is currently under construction.) Santos GLNG published an EIS for the GLNG Project in 2009 (2009 EIS), which was approved and allowed Santos GLNG to then obtain the required environmental authorities to construct and operate the GLNG Project. The GLNG Project is currently under construction.

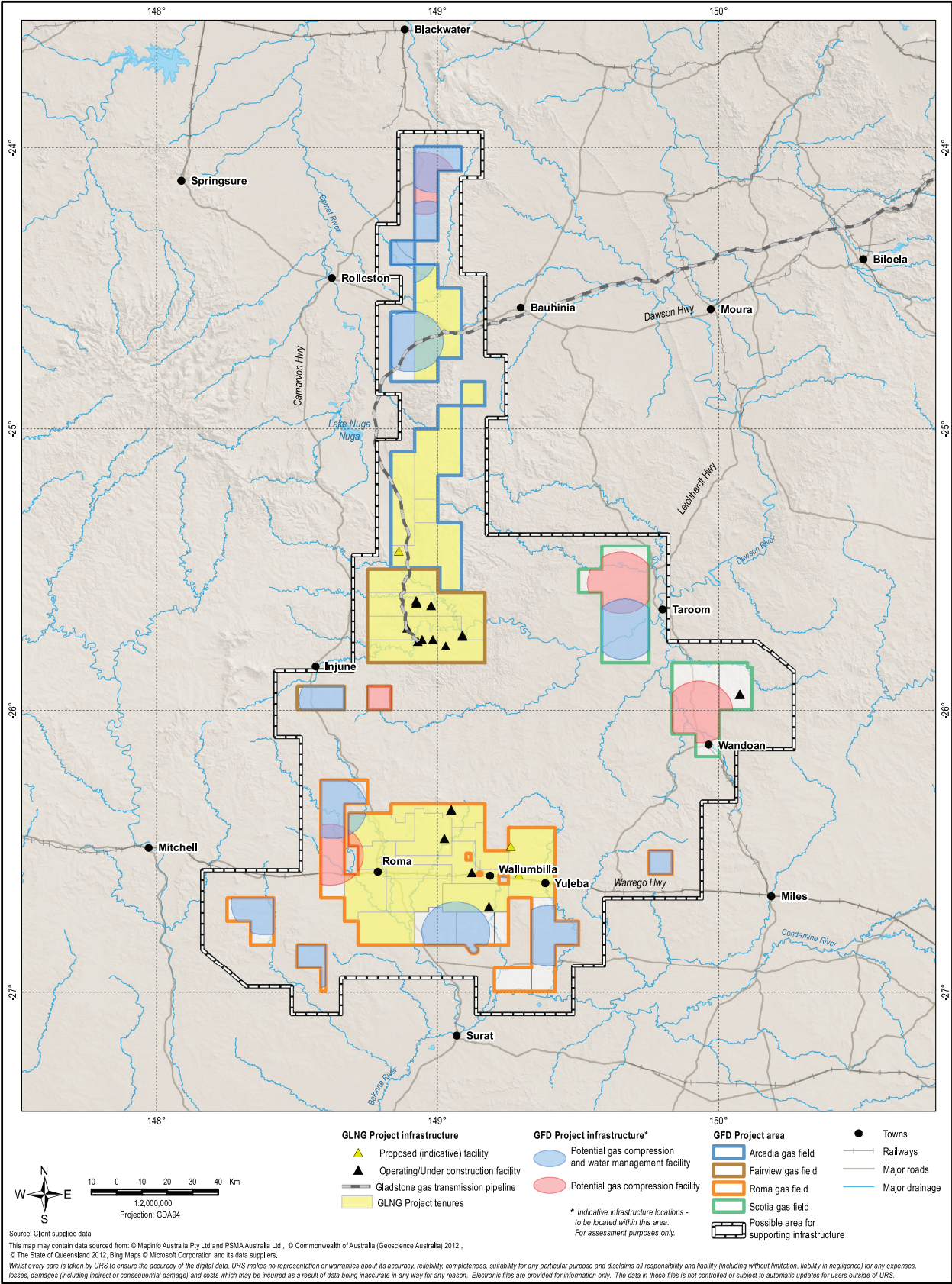
The 2009 EIS indicated that 2,650 wells would not be enough to support the gas supply needs for the approved LNG facility and that Santos GLNG would seek separate approval for additional production wells at a later stage: hence, the GFD Project.

The GFD Project will enable Santos GLNG to further develop its gas fields and expand production to meet supply demands of the approved GLNG Project's LNG facility and of third parties. The GFD Project builds on the infrastructure and area established for the GLNG Project as shown in Figure 1–2. The GFD Project will occupy much of the same area of the GLNG Project and will undertake the same activities.

Santos GLNG has been granted approvals and permits and has entered into land access agreements to develop the gas fields and associated infrastructure for the GLNG Project. Where they do not already exist, similar approvals, permits and agreements will be sought for the GFD Project.

As the GFD Project is an extension of the gas field component of the GLNG Project, there will be common infrastructure, resources, workforces and activities for both projects. Consequently, the management plans and strategies developed and implemented for the approved GLNG Project will be applied to the GFD Project following any revisions necessary, to ensure that environmental conditions, values and potential risks associated with the GFD Project are addressed.

Figure 1–2 GLNG Project and the GFD Project area and primary infrastructure



1.3 GFD Project overview

1.3.1 Project aims

The GFD Project is driven by the need to meet the gas supply needs of markets previously identified in the GLNG Project's EIS in 2009. The GFD Project will enable Santos GLNG to further develop its gas fields and expand production to meet supply needs of the approved GLNG Project's LNG facility and of third parties.

On a broader scale, the GFD Project will:

- Assist in meeting the increasing global need for more carbon-efficient energy
- Enhance the economic and employment benefits to the region, state and nation
- Support state and national policy directives.

1.3.2 Project alternatives

As the GFD Project's primary objective is to help meet the gas needs of the GLNG Project, the main alternative to the GFD Project would be to source gas from a third party (effectively the 'non project' alternative). The considerations and outcomes applicable to the 'non project' alternative as well as geographical location and timing alternatives are summarised in Table 1-1.

Beyond these primary alternative scenarios, there is always potential for technology and development processes to change based on technological and industrial improvements. Santos GLNG will make use of the best available technologies where practicable i.e. different technology will be adopted in different areas depending on geological and logistical requirements and technological developments.

1.3.3 Gas field development lifecycle

Like other natural gas and oil production, the commercial development of gas from coal seams occurs incrementally. The development cycle for a prospective area includes exploration, appraisal, production well and infrastructure construction, production operations, and then decommissioning and rehabilitation. A conceptual model of the field development process is illustrated in Figure 1-3. New information gained from ongoing exploration, appraisal and production activities is used to inform future field development planning.

Not all areas of a gas field are developed at the same time or to a maximum development scenario: as areas are expanded or new infrastructure developed, other declining areas are decommissioned. Where practicable, infrastructure such as gas compressors and water management facilities are relocated. Each production well has a finite life, after which time its gas supply will have been exhausted and it may be replaced by a new production well at a new location so that overall gas production can be maintained. Once wells have reached the end of their useful production, they are decommissioned, surface infrastructure removed and the area is rehabilitated. Rehabilitation occurs throughout the project lifecycle i.e. through exploration, construction and production, as well as after decommissioning. This results in an ongoing program of well development and decommissioning throughout the life of a project.

All of these activities require further specific approvals or agreements, such as environmental authorities or land access agreements, in addition to this GFD Project EIS.

Consultation on the subsequent approvals will be ongoing with the relevant administering authorities.

Figure 1-3 Ongoing field development process

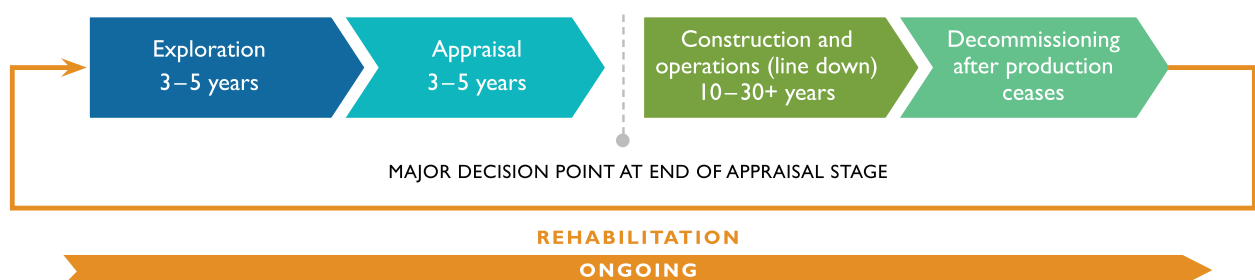


Table I-I Consideration of GFD Project alternatives

Alternative	Consideration	Outcome
Alternative gas supply – Non project	Gas could be sourced from third parties where commercial opportunities become available, and gas meets specifications for treatment and export.	Provision of gas from existing supplies could cause stress to the current supply and need balance. Santos GLNG does not consider the 'non project' alternative viable. A 'non project' alternative would not result in overall reduced environmental impact. The impact would simply occur elsewhere, and may in fact be more than the GFD Project, which can draw on existing infrastructure, resources and workforces.
Alternative locations	There are limited alternative project locations as the GFD Project is restricted to areas overlying viable coal seams within Santos GLNG's existing petroleum tenures. GFD Project infrastructure will be located following assessment of resource data and environmental constraints during the detailed design and field development stages. Where opportunities exist, existing approved facilities (Santos GLNG or third party) will be used, or infrastructure co-located within existing corridors or footprints to minimise potential impacts. Flexibility in location decisions can improve gas recovery and reduce potential environmental impacts.	Inflexibility in location decisions can lead to increased environmental impact and less efficient use of existing facilities and infrastructure. Santos GLNG does not consider alternative geographic locations to be a viable alternative.
Alternative timing	The timing of field development and associated activities depends on the progress of approved field development activities and the outcome of ongoing exploration, appraisal and production activities. Flexibility in timing can improve planning effectiveness, such as considering the ability to co-locate infrastructure, and allow changes that could reduce potential environmental impacts or increase gas recovery.	Inflexibility in timing can limit opportunities to reduce potential environmental impacts or increase gas recovery, and could impact the commercial viability of the GLNG Project, which will be reliant on the extraction of gas proposed by the GFD Project. Santos GLNG will program the timing of the development of the GFD Project to optimise productivity and gas recovery and to minimise environmental impact.

1.3.4 Project description

The GFD Project represents an incremental extension of the existing, approved gas field development activities of the GLNG Project over the next 30 years. The additional wells and associated infrastructure required for this extension make up the GFD Project.

The GFD Project will expand the GLNG Project's gas fields from 6,887 km² to 10,676 km² and develop up to an additional 6,100 production wells beyond the currently authorised 2,650 production wells, resulting in a maximum of up to 8,750 production wells.

This GFD Project will include the following components:

- Production wells
- Fluid injection wells, monitoring bores and potentially underground gas storage wells
- Gas and water gathering lines
- Gas and water transmission pipelines (within or between tenements and gas fields)
- Gas compression and treatment facilities
- Water storage and water management facilities
- Access roads and tracks
- Accommodation facilities and associated services (e.g. sewage treatment)
- Maintenance facilities, workshops, construction support, warehousing, and administration buildings
- Utilities such as water and power generation and supply (overhead and/or underground)
- Laydown, stockpile and storage areas
- Borrow pits and quarries
- Communications.

The final number, size and location of these components will be determined progressively over the life of the GFD Project. They will be influenced by the location, size and quality of the gas resources identified through ongoing field development planning processes, which include consideration of land access agreements negotiated with landholders, and environmental and cultural heritage values.

Where practicable, the GFD Project will use existing or already approved infrastructure (e.g. accommodation camps, gas compression and water management facilities) from the GLNG Project or other separately approved developments.

However, in order to model the maximum potential impacts, this EIS assumes a 'maximum development scenario' to develop the gas resources and minimal use of existing infrastructure.

For the purposes of transparency this EIS shows an area off-tenure that may be used for infrastructure such as pipelines and temporary camps (supporting infrastructure area). While not assessed specifically in this EIS, any infrastructure that may be located within this area would be subject to further approval processes separate to this EIS.

1.3.5 Potential timing for the maximum development scenario

Approved exploration and appraisal activities are currently underway across the GFD Project's petroleum tenure to improve understanding of the available gas resources. As the understanding of gas resources increases, investment decisions will be made about the scale, location and timing of the next stages of field development.

For the purposes of this EIS, a maximum development scenario was developed at the approval of the Terms of Reference. This scenario assumed that production from the wells and upgrading of the gas compression facilities in the Scotia gas field would commence in 2016, followed by the GFD Project wells in the Roma, Arcadia and Fairview gas fields in mid-2019. This schedule is indicative only and was used for the purpose of the impact assessment in this EIS.

The potential GFD Project schedule used in the maximum development scenario for this EIS is outlined in Figure 1–4.

1.3.6 Project location

The GFD Project will be located across an area covering 10,676 km² of the Bowen and Surat basins in southwest Queensland. The Bowen Basin occupies about 160,000 km² of eastern central Queensland while the Surat Basin covers 300,000 km² of central southern Queensland and extends into northern New South Wales.

The GFD Project area is located in the Banana Shire Council and Central Highlands, Maranoa and Western Downs regional council areas. The nearest towns include Bauhinia, Blackwater, Injune, Miles, Mitchell, Rolleston, Roma, Springsure, Surat, Taroom, Wallumbilla, Wandoan, and Yuleba. The project location is shown in Figure 1–5.

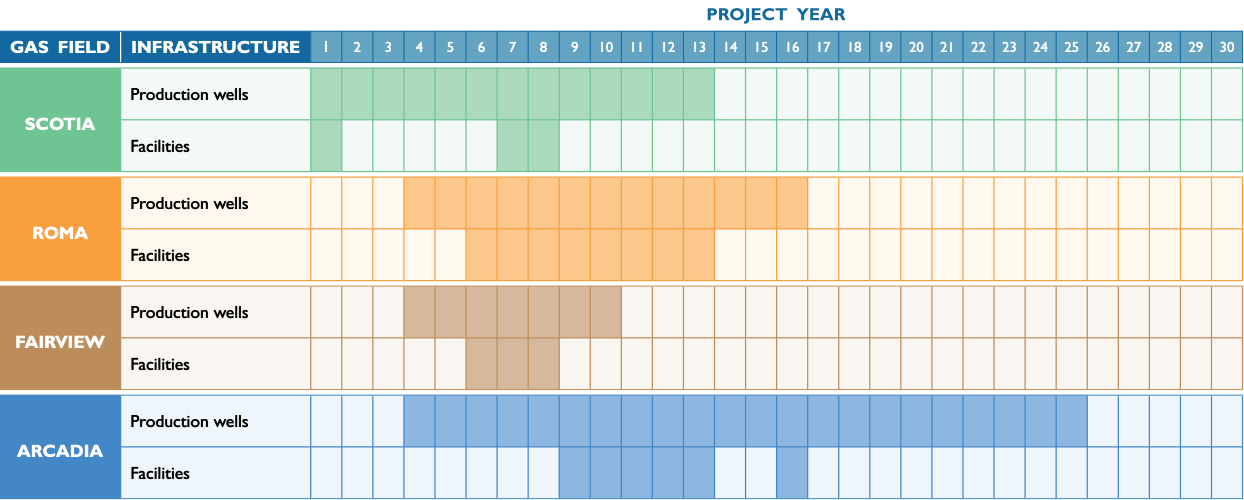
1.3.7 Related projects

There are three other projects converting coal seam gas to liquefied natural gas in Queensland that overlap with the GFD Project in terms of timing, location, resources and co-location opportunities. They are:

- Australia Pacific LNG (APLNG) Project
- Queensland Curtis LNG (QCLNG) Project
- Arrow Energy (Bowen and Surat) Gas Project.

Santos GLNG and APLNG signed a cooperation agreement in 2013, which will facilitate the shared use of infrastructure, particularly in the two projects' Surat Basin gas fields. This agreement will reduce the need for additional pipeline infrastructure for both projects. The potential for further integration of the GFD Project with other projects through the co-location of infrastructure will be considered as part of the field planning and design process and may further reduce the potential impacts identified in this EIS.

Figure 1-4 Potential GFD Project development schedule for the maximum development scenario

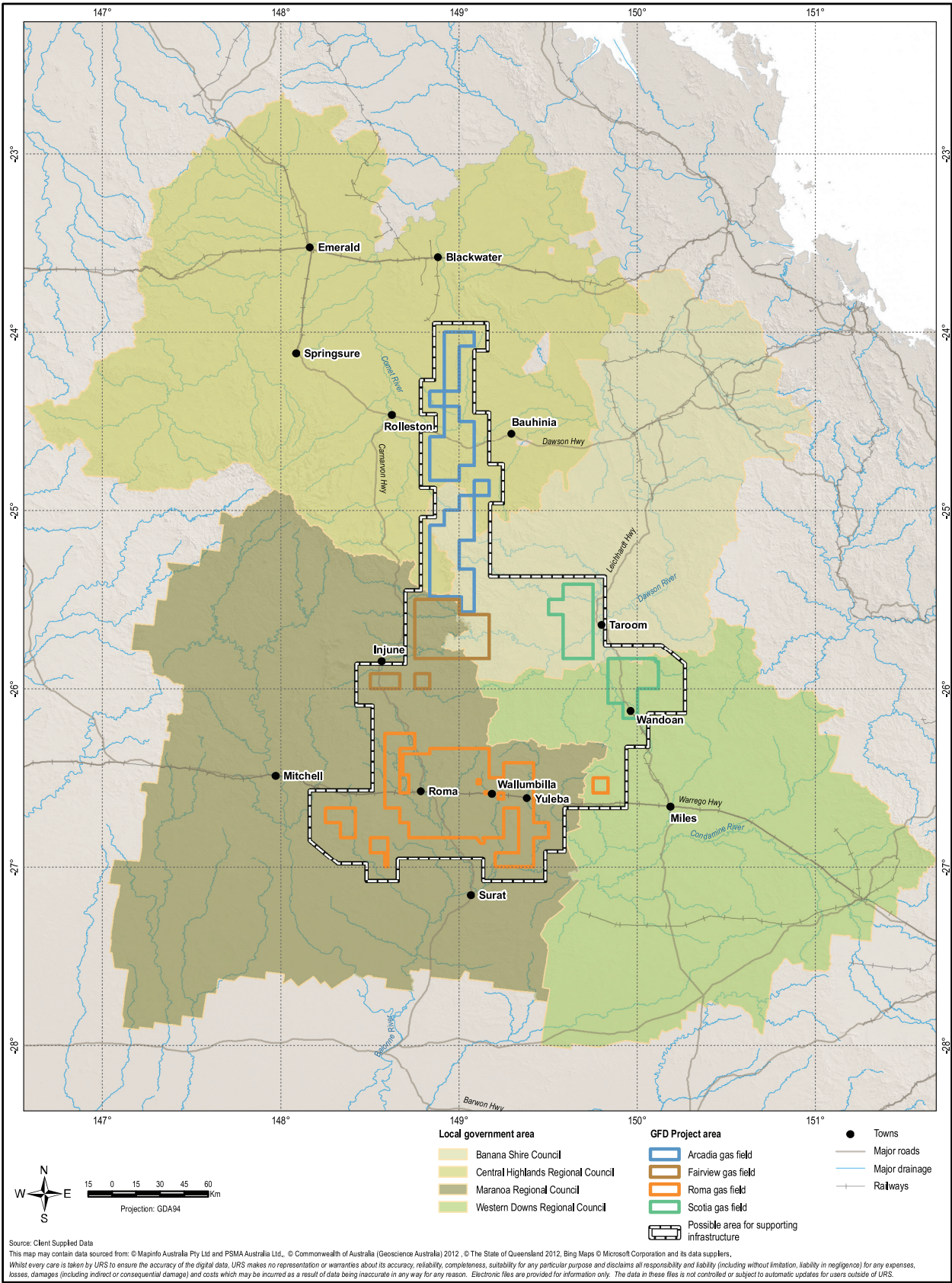


The potential for further integration of the GFD Project with other projects through the co-location of infrastructure will be considered as part of the field planning and design process and may further reduce the potential impacts identified in this EIS.



Santos GLNG's gas transmission pipeline under construction near Banana, Queensland, in mid-2013.

Figure I-5 GFD Project location





Cattle grazing at Coxon Creek, Wallumbilla North, Queensland.

2. Environmental impact statement

2.1 The EIS process

2.1.1 Legislative basis and schedule

At the state level, the GFD Project is being assessed in accordance with the requirements of Section 26 of the *State Development and Public Works Organisation Act 1971* (SDPWO Act) by the Coordinator-General's office. At the Commonwealth level, it is being assessed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The controlling provisions under the EPBC Act are:

- Wetlands of international importance
- Listed threatened species and communities
- Listed migratory species.

In October 2013, Santos GLNG was advised by the Commonwealth Department of the Environment that an additional controlling provision relating to the impact of coal seam gas development on water resources also applied to the GFD Project.

This EIS has been prepared and will be assessed in accordance with the Bilateral Agreement between the Commonwealth Government and the Queensland Government as a Class 2 Action under Part 4 of the SDPWO Act and the *State Development and Public Works Organisation Regulation 1999* (Qld).

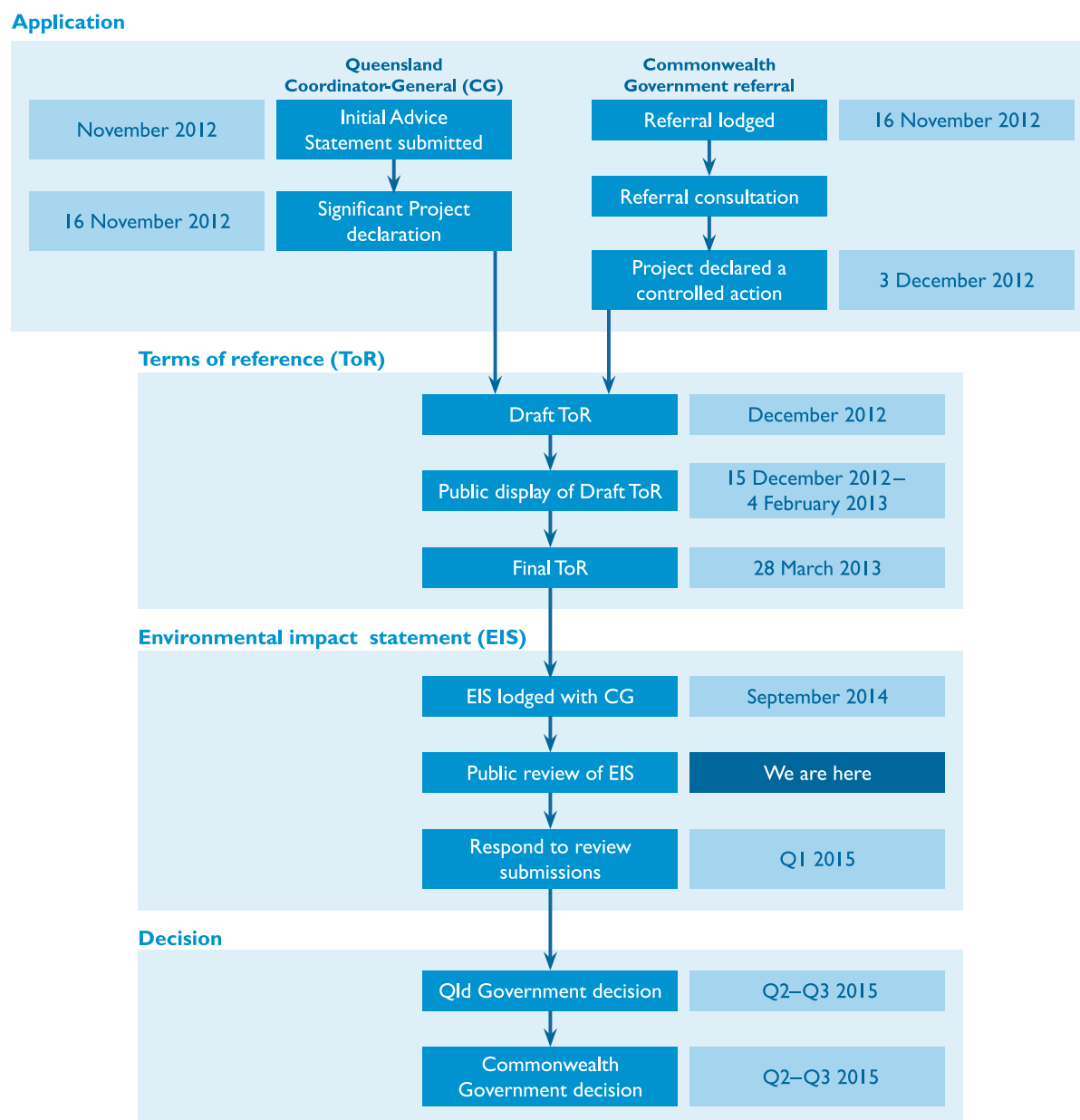
The Commonwealth Government has accredited the SDPWO Act process coordinated by the Queensland Coordinator-General for the purpose of assessment.

This EIS is currently at the public exhibition stage. Once the submissions and additional matters have been addressed, the Coordinator-General will prepare a report evaluating this EIS and other related material. The Coordinator-General's report will reach a conclusion about the environmental effects of the GFD Project and associated mitigation measures. The Coordinator-General's report will approve, approve with conditions, or not approve the GFD Project.

Similarly, the Commonwealth Department of the Environment will review this EIS and prepare its own assessment report for the Commonwealth Minister. The Minister will receive a copy of the Coordinator-General's assessment report and will take those findings into account when making a decision on the GFD Project, which will be to approve, approve with conditions, or not approve the GFD Project. The timeline for GFD Project is illustrated in Figure 2–1.

Approval of this EIS will trigger a number of subsequent approvals required for the GFD Project to proceed. Approvals will be required on tenure and off-tenure. Consultation on the subsequent approvals will be ongoing with the administering authorities.

Figure 2–1 Environmental impact statement schedule – expected dates



2.1.2 Aims

This EIS aims to be a comprehensive document that provides:

- Interested and affected stakeholders with a basis for understanding the GFD Project, existing environment, potential impacts and proposed management strategies.
- Regulatory agencies and advisory bodies with a framework for assessing the potential impacts of the GFD Project to assist in the development of conditions that would attach to an approval.
- Santos GLNG with a statement of commitments and actions to be implemented to manage potential adverse impacts from the construction, operations and decommissioning of the GFD Project.

2.1.3 Environmental impact statement structure

This EIS consists of a main report and supporting appendices. The main report provides a detailed description of the GFD Project, impact assessment, and proposed environmental management plan. The appendices contain detailed data, analyses and technical assessment to support the EIS and management plans that will be used to avoid, mitigate, manage and offset the GFD Project's impacts on the environment and communities. Figure 2–2 shows the structure of the EIS.

Figure 2–2 Environmental impact statement structure



2.1.4 Public exhibition and submissions

Santos GLNG has invited submissions on this EIS via notices in local, regional and state newspapers. Copies of this EIS have been made available for viewing at the locations outlined in Table 2–1.

Table 2–1 Environmental impact statement viewing locations

Location	Address
Biloela Library	Corner of Grevillea and Melton Streets, Biloela
Dalby Library	107 Drayton Street, Dalby
Emerald Library	44 Borilla Street, Emerald
Moura Library	McArthur Street, Moura
National Library of Australia	Parkes Place, Canberra, ACT
Roma Library	38–44 Hawthorne Street, Roma
Taroom Library	24 Yaldwyn Street
State Library of Queensland	Cultural Centre, Stanley Place, South Bank, Brisbane
Santos GLNG Roma Community Shopfront	80 McDowall Street, Roma
Santos GLNG Taroom Community Shopfront	37/39 Yaldwyn Street, Taroom

EIS documentation can also be obtained by:

- Downloading it from the Santos GLNG website at **www.santosglng.com**
- Requesting a USB by contacting:
 - Emailing community@santos.com
 - Telephoning 1800 761 113
 - Writing to Reply Paid, GLNG Community Engagement, GPO Box 1010, Brisbane QLD 4001.

All stakeholders are invited to make a submission on this EIS. An accepted submission will be one that:

- Is made in writing to the Coordinator-General
- Is received on or before the deadline for submissions
- States the name and address of each submitter
- Is signed by each submitter
- States the grounds of the submissions and the facts and circumstances relied on in support of the grounds.

Submissions must be made in writing and received before 22 December 2014 to:

EIS Project Manager – Santos GLNG Gas Field Development Project
Coordinated Project Delivery
PO Box 15517
City East Qld 4002

You can also make submissions online through the Queensland Governments Citizen Space at <https://haveyoursay.dsdp.qld.gov.au/coordinatorgeneral/gasfield>

Submissions received will be provided to Santos GLNG who may need to provide supplementary information to address specific matters raised in the submissions.

2.2 Public consultation process

Community engagement and participation is central to Santos GLNG's approach to the community. The key principles to Santos GLNG's community approach are outlined in Box 1.

Box 1 Community – key principles

Santos GLNG's vision is to be a valued and valuable member of the communities in which it operates. Santos GLNG is committed to sharing the benefits of its world-class natural gas business with the community. Santos GLNG has consulted extensively with the community in order to understand and manage the potential social impacts of its activities and will continue to do so using these four key principles:

- **Information and communication**
- **Community engagement and participation**
- **Actions align with values**
- **Mitigate and manage potential impacts.**

Santos GLNG has implemented a consultation plan to provide a framework for engaging with stakeholders, landholders, interest groups and the broader community for this EIS. The consultation plan identifies the stakeholders to be targeted, types and timing of consultation and communication activities, responsibilities and protocols, and reporting and feedback arrangements.

The consultation program for this EIS included a free-call (1800 number) service, community newsletters and factsheets, targeted stakeholder briefings, community information sessions, issues-based workshops and site tours. Feedback already obtained through the public consultation process has also been taken into consideration in this EIS. Some of this information has been used to develop mitigation and monitoring measures.

Santos GLNG will continue to consult with communities and other stakeholders as part of this EIS and engagement activities for the GLNG Project.



Rachel Bell and Jessica Pratt, from Santos GLNG's community team in Roma, Queensland.



Sunrise, southwest Queensland.

3. GFD Project components

3.1 GFD Project components relevant to this EIS

The exploration and appraisal of the GFD Project's gas fields is currently being undertaken under existing authority to prospect permits, which have a separate approval process. As such, this EIS is concerned with the construction, operation, and decommissioning and rehabilitation of the GFD Project components shown in Figure 3–1.

A schematic diagram of the interaction between the primary GFD Project components is shown in Figure 3–2.

In addition to these primary components, the GFD Project will require a range of supporting infrastructure including access roads and tracks; accommodation

facilities and associated services; maintenance facilities, workshops, construction support, warehousing, and administration buildings; utilities such as water and power generation and supply; laydown stockpile and storage ages; borrow pits and quarries; and communication facilities.

For assessment purposes, this EIS takes a 'maximum development scenario' to develop gas resources and therefore assumes minimal use of existing infrastructure. As such, the potential impacts identified in this EIS may overstate the actual impact that is experienced over the next 30 years. The EIS maximum development scenario is outlined in Table 3–1.

Figure 3–1 GFD Project components relevant to this environmental impact statement

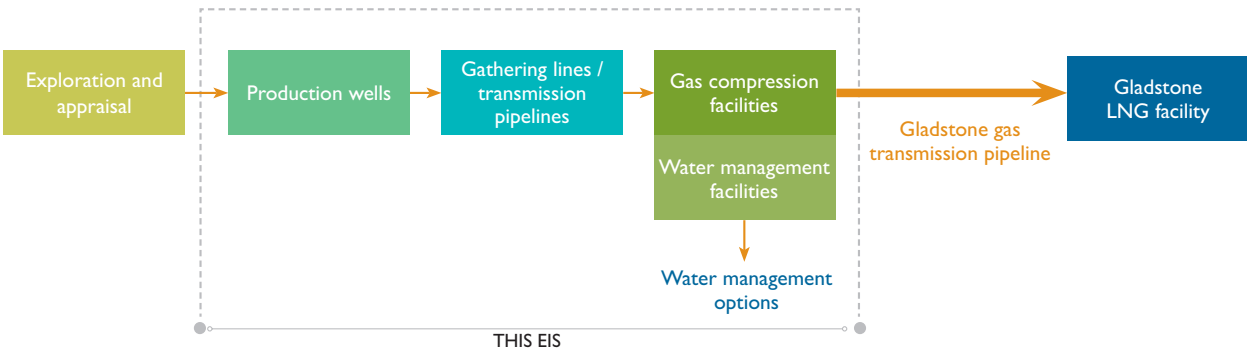


Figure 3–2 Schematic of gas gathering, transmission, compression and treatment

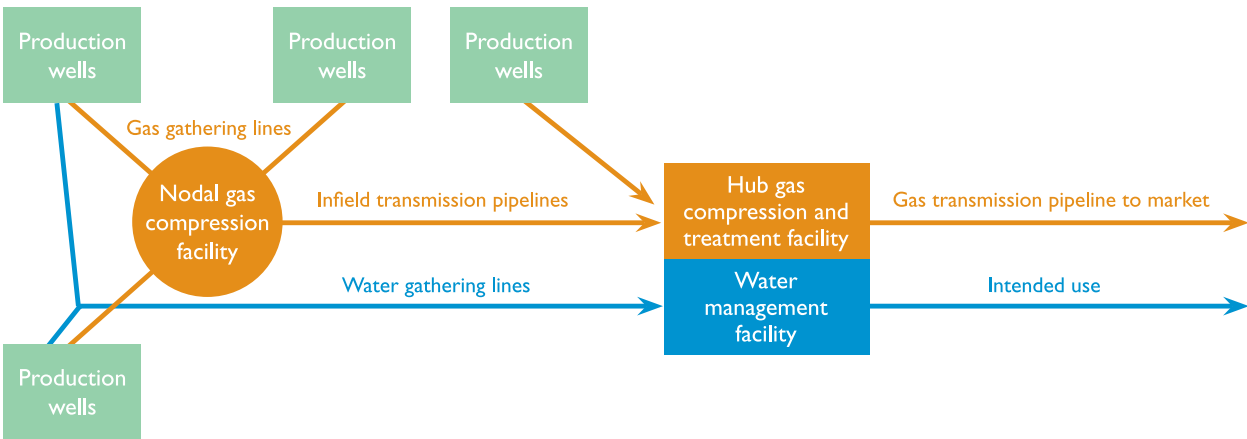


Table 3–I GFD Project potential gas field development (EIS maximum development scenario)

Project components	Potential units
Production wells	Up to 6,100 production wells
Gathering lines/transmission pipelines	Up to 6,000 km
Nodal gas compression facilities	Up to 5 facilities (each processing up to 80 terajoules (TJ) a day)
Hub gas compression facilities	Up to 10 facilities (each processing up to 240 TJ/day)
Water management facilities	Up to 15 facilities (each managing 5–20 megalitres/day)
Access roads	As needed

3.2 Production wells

3.2.1 Construction phase

Once the economic viability of the gas resource and the design and operational parameters are confirmed, appraisal wells may be converted to production wells. Additional production wells may also be installed. As the drilling and construction activities for appraisal wells are identical to those for production wells, their conversion is a simple process of installing permanent gas and water separation facilities and connections to water and gas gathering lines.

In addition to Santos GLNG's own design standards and robust safety procedures, risk is managed through compliance with the *Code of Practice for constructing and abandoning coal seam gas wells and associated bores in Queensland* (Department of Natural Resources and Mines, 2013). These measures result in long-term well integrity, containment of gas, and the protection of environmental values such as groundwater resources.

A well lease (the area cleared for a well) will be developed to accommodate the necessary drilling and completion equipment and support services. Where practicable, Santos GLNG will establish well leases with multiple wells (multi-well lease) to maximise gas recovery and reduce the number of well leases required. Although this may result in a larger area for each well lease, it will reduce the overall GFD Project footprint.

An example of a Santos GLNG well lease layout under construction is given in Plate 3–I.

3.2.2 Operations

Production wells become operational once they are connected to the gas and water gathering systems for delivery to the gas compression and water management facilities.

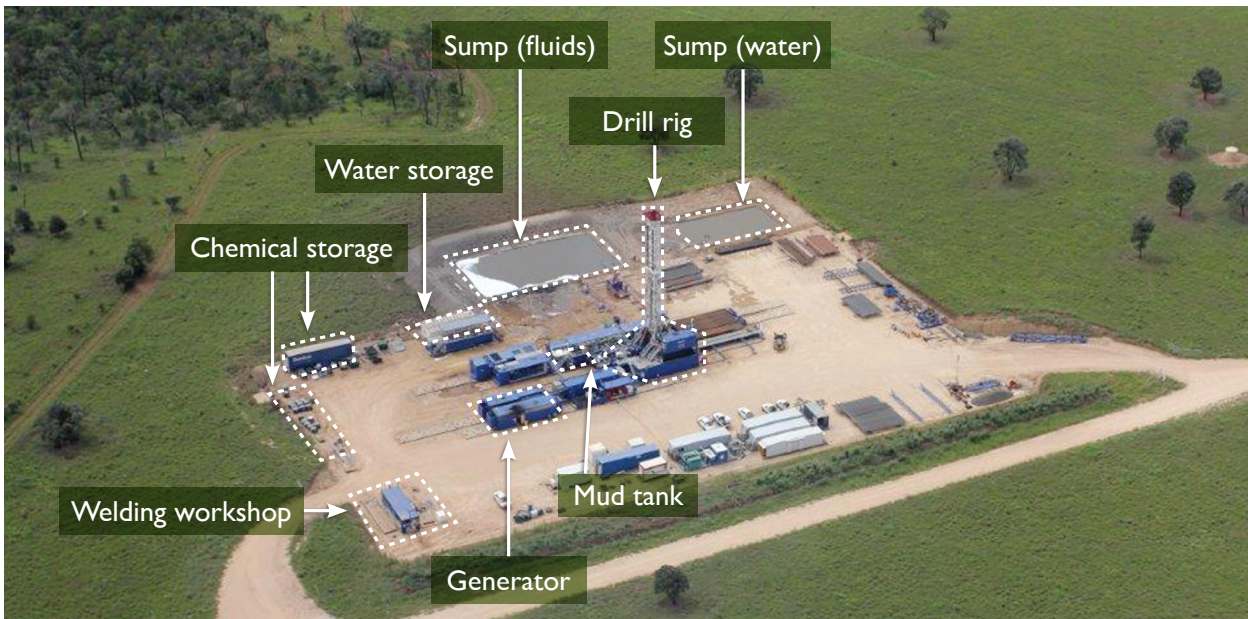
Initially, production wells will be fitted with pumps to extract water for the purpose of depressurising the coal seam. As water pressure declines in the coal seam, gas from the wells will begin to become free flowing with reservoir pressures driving the gas flow to the surface. Production wells can operate for up to 30 years.

Where required, well stimulation techniques (including hydraulic fracturing) will be used as part of the commissioning of a production well to improve the gas flow rate from the coal seam to the well head. Some wells may be subject to multiple stimulation events over their life. Santos GLNG is continually evaluating innovative techniques for enhancing gas production and minimising impacts. These techniques potentially include pneumatic techniques and fluid systems with lower concentrations of additives.



Ecology scout on Curtis Island, Gladstone, Queensland.

Plate 3–1 Example Santos GLNG well lease during construction



3.3 Gas gathering lines/transmission pipelines

3.3.1 Construction phase

To transport the gas and/or water from the production wells to the gas compression facilities/water management facilities, Santos GLNG will use existing gathering lines and transmission pipelines, where practicable. Alternatively, new gas and water gathering lines and transmission pipelines will be constructed.

Construction activities will be undertaken with a combination of conventional earthmoving equipment and specialist pipeline trenching and lifting equipment. The construction process for both gathering lines and transmission pipelines will generally be similar.

Gas and water gathering lines will be high-density polyethylene (HDPE) pipe of between 100 millimetres (mm) and 1,000 mm in diameter. Most lines will be buried, but some water gathering lines may be laid on the ground, where appropriate.

Transmission pipelines will be constructed to transfer gas under pressure from nodal or hub compression facilities and water from water management facilities within and between tenure. Gas transmission pipelines will be buried steel pipe with diameters ranging from 100 mm to 600 mm and will usually be less than 50 km in length. Water transmission pipelines will use a combination of HDPE, glass reinforced epoxy and steel piping up to 600 mm in diameter.

For the purposes of transparency, this EIS discusses infrastructure (such as pipelines) that may be located outside of Santos GLNG tenure within the possible area for supporting infrastructure. While not assessed specifically in this EIS, any infrastructure that may be located within this area would be subject to further approval processes separate to this EIS.

3.3.2 Operations

Operational activities in the gas and water gathering systems will be limited. The gas and water gathering lines are simple networks that will operate without the need for complex equipment or ongoing servicing. There will be signage to identify the locations of the gathering lines in accordance with requirements of relevant Australian Standards.

Transmission pipelines will be operated and maintained similarly to the gathering lines, except they will be operating at higher pressure. Pipeline location marker posts and inspection points for integrity testing will be installed along the length of the transmission pipelines. An easement will remain over the pipeline once constructed.

Regular inspection patrols and maintenance will be carried out along the transmission pipeline alignments to manage weeds, ensure woody vegetation is not encroaching on the pipeline centreline, check for subsidence or erosion, test and inspect valves, and conduct integrity testing.

3.4 Gas compression facilities

3.4.1 Construction phase

Standalone nodal gas compression facilities will be installed where required to compress gas to the pressure required for transmission across significant distances or to achieve entry pressure into the hub gas compression facilities. The nodal gas compression facilities will range in size and will have the capacity to compress up to 80 TJ/day per facility. In some cases, nodal gas compression facilities will be co-located with the hub gas compression facilities.

Centralised hub gas compression facilities will be developed in each of the gas fields (Arcadia, Fairview, Roma and Scotia) to increase the pressure of the gas prior to transmission. The hub gas compression facilities will range in size and have the capacity to compress up to 240 TJ/day per facility. Treatment at the hub gas compression facilities will include the removal of moisture and other impurities to meet supply specifications.

Gas compression facilities will be constructed using modular structures and processing units to minimise onsite construction activities, shorten the construction schedule, and limit the onsite construction workforce requirements.

Construction of an existing GLNG Project hub gas compression facility in the Fairview gas field is shown in Plate 3–2.

3.4.2 Operations

The compression process involves filtration, dehydration, compression and cooling – a relatively simple process due to low levels of other gas contaminants such as carbon dioxide or heavy hydrocarbons. A flare system will be used as a safety measure in the event of over pressurisation of gas or an emergency.

Gas compression facilities will be fully automated and operated on a continuous basis. They will be monitored for gas pressure, smoke, fire and gas quality.

Nodal gas compression facilities can be designed as unmanned facilities with routine maintenance and inspection. Hub gas compression facilities can be either unmanned or staffed during the day and remotely operated and monitored at night. Where the facilities are manned, the operators will generally live near the facility in operational camps.

3.5 Water management

3.5.1 Construction phase

The GFD Project water management facilities will accommodate a dynamic water management process designed to provide fit-for-purpose water for the intended use. Facilities to manage water produced from gas wells will be required across the four gas fields. Where practicable, Santos GLNG will utilise existing pipelines, water storage and water management facilities to assist in the management of water produced by the GFD Project. However, the GFD Project may also require the construction of new water management facilities. This will include facilities for water storage, water treatment and brine storage.

Water storage

Dams and/or tanks will be constructed to store water prior to entering water management facilities or following treatment. These dams will likely be earthen, constructed from material sourced locally and have capacities of up to 350 megalitres (ML). Tanks may be up to 15.5 ML in size, but would typically be 1–2 ML.

Dam construction will be undertaken in accordance with the requirements of i.e. the Queensland Department of Environment and Heritage Protection's (EHP) *Manual for assessing hazard categories and hydraulic performance of dams* (2012). Tanks will be designed to the relevant Australian standards.

Water treatment

Water treatment will be required where a change in water quality is needed to meet the required water quality of intended uses. Water treatment facilities will be modular and transported to site for assembly and the installation of piping, electrical controls and instrumentation wiring. Treatment will primarily be achieved through one or a combination of methods including:

- Desalination using reverse osmosis to separate a portion of the total dissolved solids and other constituents into a concentrated waste stream (fluid) and a permeate stream amendment using chemical dosing to lower the sodium adsorption ratio and pH/residual alkalinity
- Temperature and ionic balance adjustment.

Plate 3–2 Construction of a co-located water treatment and gas compression facility at Fairview



- Filtration removing suspended solids (lowering turbidity, bio-toxic elements and nutrients).
- Sterilisation to remove bacteria.
- De-oxygenation.
- Blending of separate water streams of differing quality to achieve a target water quality.

The appropriateness of these methods will be evaluated as information is refined regarding the expected water quality, its intended uses and their water quality requirements according to relevant approvals.

Fluid storage

The dissolved salts and metals removed from the coal seam water during desalination treatment will be concentrated into a low volume reject fluid stream. Depending on the salt content, this fluid may be classified as brine. The storage will be constructed as fully engineered, purpose-built dams of up to 350 ML in accordance with the *Manual for assessing hazard categories and hydraulic performance of dams* (EHP, 2012).

3.5.2 Operations

Coal seam water management

The GFD Project's coal seam water management strategy is to manage coal seam water in accordance with the relevant regulatory framework. The existing GLNG Project already has an approved plan in place for existing operations. The strategy for the GFD Project will build on the experience and understanding of operations to date. The strategy will be sufficiently flexible to accommodate changes in policy, technology and field conditions based on a rigorous evaluation and decision making framework.

The water quality and volumes extracted from coal seams will vary depending on the well location and the production plan. While the specific timing, quality and volume of coal seam water production for an individual well is not known with full certainty at the commencement of field development, the overall water production characteristics can be forecast to enable effective management of the water produced.

The coal seam water management strategy for the GFD Project has adopted the *Coal seam gas water management policy 2012* (EHP, 2013) management hierarchy where priority is placed on coal seam water being used beneficially by existing users. However, where this is not feasible, coal seam water will be disposed of in a way that avoids, mitigates and minimises impacts on environmental values.

Fluid (brine) management

Brine may be disposed of through deep well injection into suitable geological formations. This is already occurring in accordance with regulatory approvals for the GLNG Project.

Brine concentration options may be used to reduce the volume of brine requiring final management or to sufficiently concentrate brine to allow crystallisation of solid salt. Various technologies are available to be used, each with advantages and challenges to feasibility, including thermal evaporation. These technologies have differing energy intensity, environmental footprint, technical complexity, operability and economics. The transfer of brine or solid salt to a licensed waste management facility will only occur after other options have been assessed and considered unfeasible.

3.6 Supporting infrastructure

For the purposes of transparency, this EIS discusses supporting infrastructure that may be located off of Santos GLNG tenure within the possible area for supporting infrastructure. While not assessed specifically in this EIS, any infrastructure that may be located within this area would be subject to further approval processes separate to this EIS.

3.6.1 Accommodation facilities

Local residents employed on the GFD Project will already have housing in regional towns such as Roma, Wallumbilla, Taroom, Wandoan, Injune and Rolleston. Non-resident workers will be housed in purpose-built accommodation facilities (known as camps) close to work areas.

Camps will be modular structures that will accommodate one or two workers per unit. In general, camps will comprise three alternative forms:

- Small temporary camps will be modular and relocatable facilities, less than one hectare in area, and will provide basic amenities for up to 20 people for short-term activities such as drilling or installing gathering lines.
- Larger semi-permanent camps will be built to support the construction of large facilities (e.g. hub compression facilities). They will have an area of about 20 hectares, be adjacent to work areas and designed to provide more extensive services and facilities to larger workforces (about 400 people) for more long-term construction activities (2–3 years).
- Permanent operations camps will be designed to provide accommodation for operations personnel for the duration of the GFD Project and will accommodate about 80 people.

At a minimum, camps will include accommodation units, kitchen, dining, ablution and laundry facilities. At larger more permanent camps, facilities will also include water supply (bores, tanks and treatment), sewage treatment and disposal, power generation (if not connected to the grid supply) and back-up power generators, fuel and materials storage areas, recreational facilities, offices and car parking.

3.6.2 Access roads

Roads and access tracks will be required for construction and operations activities. Access roads will be built to allow servicing of well leases and access to other infrastructure. Wherever practicable, the GFD Project will use existing tracks, including existing access tracks and roads used by the GLNG Project, or already disturbed areas. Upgrades of existing access tracks and roads may be required to accommodate the construction and operations traffic associated with the GFD Project. Any upgrades to existing tracks and roads will be undertaken in consultation with landholders.



A Santos GLNG workforce camp, called Umo Yumba, near the Fairview field in Queensland.

3.6.3 Laydown, stockpile and storage areas

General construction, maintenance and laydown yards will be established to support construction activities. They will be used for storage of materials and equipment necessary for construction activities and will be located close to construction sites.

During operations, a smaller number of laydown, stockpile and storage areas will be required to support ongoing operations activities.

Construction and operations activities will include fuelling, maintenance, inspection and testing of equipment. The fuelling facilities will be constructed as modular tank and pump facilities and will be relocatable. About half of the fuel storage facilities will have capacities greater than 10,000 litres. Fuel storage will comply with appropriate Australian standards.

3.6.4 Borrow pits and quarries

Borrow pits and quarries will be required to source sand, gravel and other materials that are needed for the field development program. The locations and methods of extraction for each of the borrow pits and quarries will be determined as the needs arise. They will be located in the gas fields. Alternatively, materials will be sourced from third parties who are appropriately licensed.

Borrow pits will be used mainly during construction and most will be rehabilitated following the completion of this phase. A number of borrow pits may be retained to provide sand and gravel for ongoing road and site maintenance activities.



A water storage facility at Coxon Creek, Wallumbilla North, Queensland.

3.7 External infrastructure

For the purposes of transparency, this EIS discusses external infrastructure that may be located off of Santos GLNG tenure within the possible area for supporting infrastructure. While not assessed specifically in this EIS, any infrastructure that may be located within this area would be subject to further approval processes separate to this EIS.

3.7.1 Transportation

Transport for the non-resident construction workforce will be mainly fly in/fly out via Roma. The construction workforce will be transported by bus from the airport to the accommodation camps, which will be close to work sites.

Transportation of equipment, materials and supplies during the GFD Project's construction and operations phases will predominantly be undertaken by road. Materials will be delivered from Brisbane via Toowoomba; however, quarry and concrete materials will be sourced in the GFD Project area or from third parties. Access to various assets will be gained from main highways using existing state or local roads.

Rail transportation may be possible and will be considered in the planning stages. The use of ports will be required for the importation of equipment and construction materials.

3.7.2 Water supply

Water supply and storage will be needed for construction activities, dust suppression, vehicle wash down, accommodation camps, and operations and maintenance activities. Coal seam water will be prioritised to meet the GFD Project's construction, operations and rehabilitation requirements. Water sourced from local water bores or surface water will be used on-lease or off-lease in accordance with legislation and subsequent approvals, as required.

The potable water requirement for the construction workforce is anticipated to be between 0.2 and 0.4 ML/day (based on a construction workforce of 1,600 people). Operations workforce water requirements are anticipated to be around 0.04 ML/day (based on an operations workforce of 200 people).

Santos GLNG does not propose to rely on town water.

3.7.3 Energy

Santos GLNG anticipates that the GFD Project's electrical requirements will be in the order of 30 to 60 megawatts (MW) for each gas field.

Power for the gas field operations will be generated by gas-fired generators or serviced by grid connections, where available. The energy sources, including gas-fired power options, will be investigated during the field development phase of the GFD Project.

Where Santos GLNG is generating power, gas turbines (10–20 MW) will be installed at gas compression and water management facilities; however, power may also be supplied from reciprocating gas engines or via direct gas engines. Diesel generators (less than 2 MW each) will be used at temporary facilities with diesel stored in aboveground storage tanks and regularly delivered by tanker truck to site.

Where reticulated power is unavailable, gas-fired generators (up to 200 kilowatts capacity) will be provided at the well lease to power the pumps.

Where connection to the grid is the preferred option, a transmission network service provider may be engaged to construct transmission lines and other associated infrastructure to enable Santos GLNG to use electricity from the grid. In such cases, the major gas compression facilities will be used as the connection point for electricity that would subsequently be distributed to the remote facilities.

3.7.4 Communications

Communications services will include voice and data network services and telemetry services to the laydown and contractor yards, accommodation camps, well leases, gas compression and water management facilities.

Where available, the GFD Project will use existing communications services. Alternatively, Santos GLNG will look to extend the GLNG Project's fibre networks, or use satellite communications. Strategically located radio towers will be used for both data telemetry and voice radio services. Communications and telemetry towers will generally be located at elevated locations and will be constructed to a height not exceeding 10 m. These towers will generally have a ground disturbance of less than 25 m² each. Power to most telecommunications facilities (repeater stations) will be provided via batteries and solar panels.

3.8 Decommissioning & rehabilitation

To minimise the disturbance footprint of the GFD Project, decommissioning and rehabilitation will occur progressively in accordance with relevant approvals and regulatory requirements.

Decommissioning will involve the safe dismantling and removal of infrastructure and assets. Rehabilitation will restore the landform and vegetation to an agreed land use that meets stakeholder expectations. Santos GLNG will seek to transfer ownership of infrastructure (e.g. dams and roads) to landholders or local authorities where authorised by regulatory authorities and an appropriate agreement signed.

Rehabilitation will generally commence following construction activities and removal of short-term infrastructure (e.g. laydown yards) as operations activities cease, and as exhausted gas fields are decommissioned and rehabilitated.

Following decommissioning and rehabilitation, Santos GLNG will seek to surrender its environmental authorities. Surrender of environmental authorities will be undertaken in accordance with the relevant regulatory requirements, including preparation of a final rehabilitation report, and will include landholder signoff where necessary (i.e. where assets are to be transferred from Santos GLNG to the landholder).

3.9 Workforce

The following sections detail the potential workforce numbers for the construction and operations phases of the GFD Project. This workforce is reflective of the maximum development case developed for the purposes of impact assessment – the maximum development scenario.

Santos GLNG will work with the Department of Education, Training and Employment during the EIS consultation period and during field planning to provide further detail on workforce requirements, including occupational breakdown.

3.9.1 Construction workforce

The GFD Project's construction is expected to occur progressively from 2016 over the next 30 years. The construction phase workforce under the maximum development scenario is anticipated to reach its maximum in 2021 at around 1,980 full-time equivalent workers (FTEs) under the maximum development scenario. This will be generally maintained until 2025 when it will drop to an estimated 1,750 FTEs and continue to decline until 2038, when it will stabilise at around 70 until 2041. As can be seen in Figure 3–3 the majority of personnel are expected to be employed on the Roma gas field, followed by Arcadia and Scotia gas fields. Figure 3–3 demonstrates the sequential nature of the GFD Project where Arcadia gas field is expected to have the longest construction period and the Fairview gas field the shortest.

3.9.2 Operations, decommissioning and rehabilitation workforce

The operations workforce is expected to be at its maximum of more than 300 people in 2026 under the EIS maximum development scenario. As shown in Figure 3–4, the Roma gas field is expected to require the largest portion of the operations workforce between 2023 and 2034, while the Arcadia gas field is expected to require a smaller but consistent workforce across the life of the GFD Project.

The operations workforce also includes personnel engaged in decommissioning and rehabilitation activities, which will occur throughout the life of the GFD Project.

Workforce scheduling and rosters

Local workers generally work on a normal weekly roster of five days on two days off. Non-resident workers are anticipated to operate on a rotating three weeks on, one week off, fly-in fly-out/drive-in drive-out roster:

Workforce transport

Most non-resident workers arriving to the GFD Project area will fly in and out of an existing airport. From the airport, they will be transported to local accommodation camps in shuttle buses, with a smaller percentage using light vehicles (such as 4x4s). Some regionally based non-resident workers may drive-in and drive-out at the beginning and end of their shift. The remainder of the workforce will be locally sourced contractors or suppliers.



Horse grazing near Santos GLNG activity in southwest Queensland.

Figure 3–3 Potential construction workforce for the maximum development case (FTE)

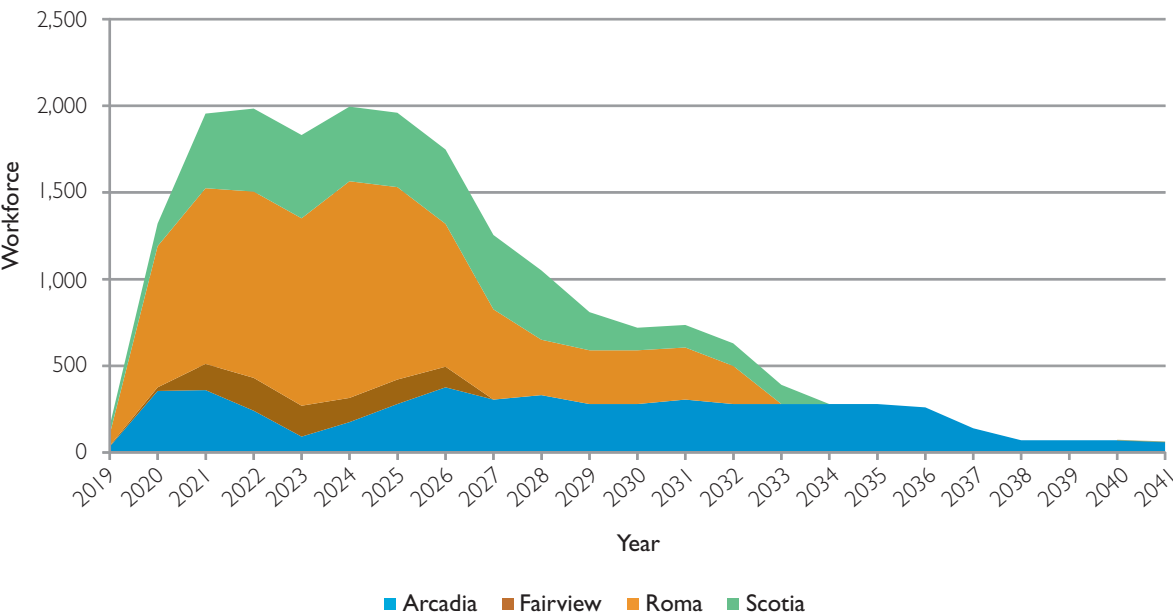
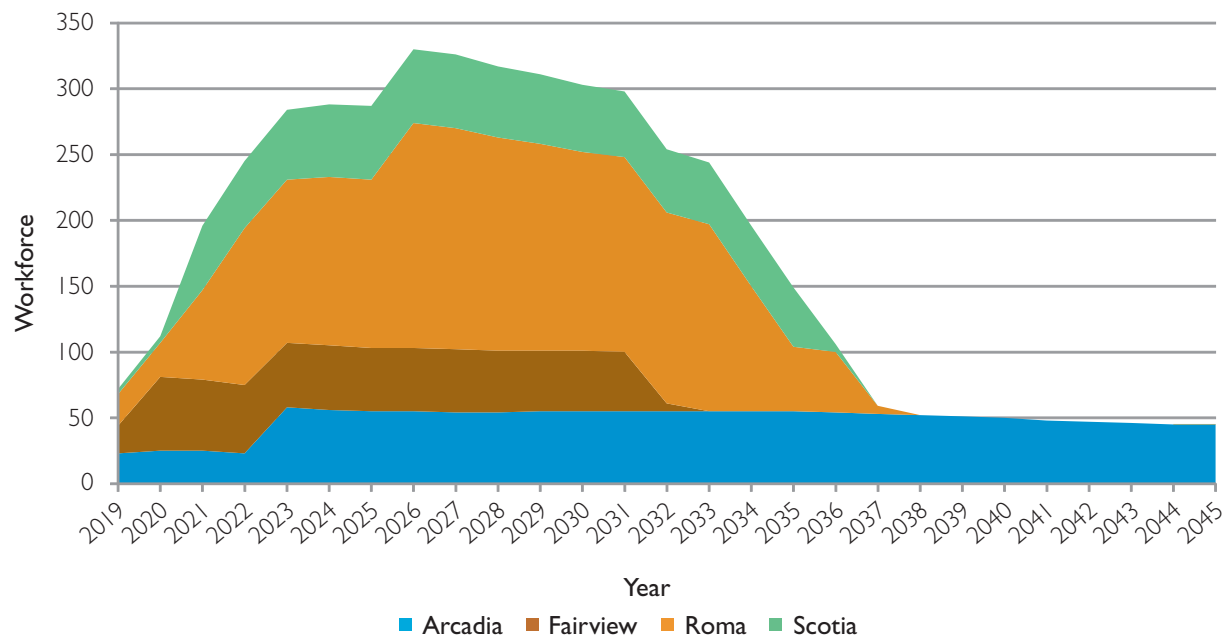


Figure 3–4 Potential operations workforce for the maximum development case (FTE)



Workforce sources

Based on current understanding of the local labour markets and Santos GLNG's experience with the GLNG Project, the source of the construction workforce is expected to be:

- Around 80% from outside of the GFD Project area and immediate region
- Around 15% from the region
- Around 5% from the local area.

The operations workforce is expected to have a greater level of local and regional workers. At present, the source of the operations workforce is expected to be:

- Around 50% from outside the GFD Project area and immediate region
- Around 30% from the region
- Around 20% from the local area.

The local area includes regional towns close to the GFD Project gas fields such as Roma, Wallumbilla, Taroom, Wandoan, Injune, Rolleston and Springsure.

Workforce accommodation

It is assumed that locally sourced workers employed on the GFD Project will already have local housing in regional towns such as Roma, Wallumbilla, Taroom, Wandoan, Injune, Rolleston and Springsure. Non-resident workers will be housed in purpose-built accommodation facilities (known as camps) close to GFD Project locations.

Based on the projected peak workforce generated during construction and operations phases, Santos GLNG will develop camps to supplement the existing accommodation, services and amenities that have already been developed for the approved GLNG Project workforce. Field development planning processes will be used to establish the required size and appropriate locations for these camps.



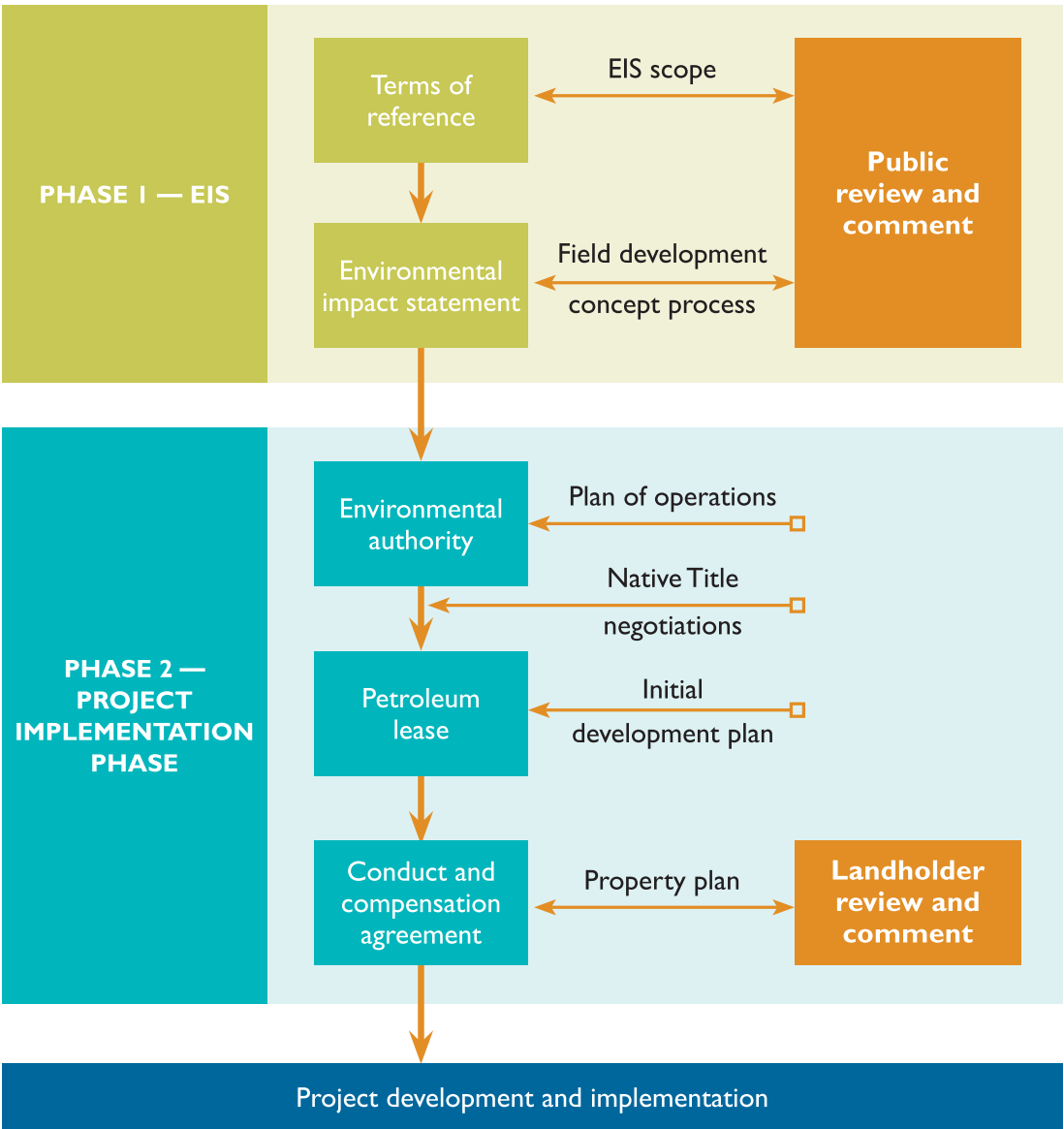
Santos GLNG Field Production Engineer Kyla Schliebs, during pipeline construction.

4. Assessment framework

The assessment framework used to assess potential impacts and develop mitigation strategies used in this EIS is consistent with the approach used in the approved GLNG Project. It is based on knowledge and system that have been previously assessed and approved by both the state and federal governments. This approach provides a high level of certainty about potential impacts by identifying those areas that are not amenable to development (i.e. no-go areas), or if they were to be developed, how development should proceed. This will occur by identifying constraints to development that exist within the GFD Project area and the environmental management controls that will be applied to the GFD Project's activities in these constrained areas.

A two-phased approach is necessary when designing and assessing the impact of gas field development projects, as the location, type and quantity of the primary infrastructure will be determined progressively over the GFD Project's life and are not known during the EIS stage. Phase 1 involves the preparation of the EIS and Phase 2 (which occurs after the EIS) involves applications for further regulatory approvals, such as environmental authorities and petroleum leases, as well as the development of detailed agreements with landholders. This approach is shown in Figure 4-1.

Figure 4-1 Two-phased assessment framework



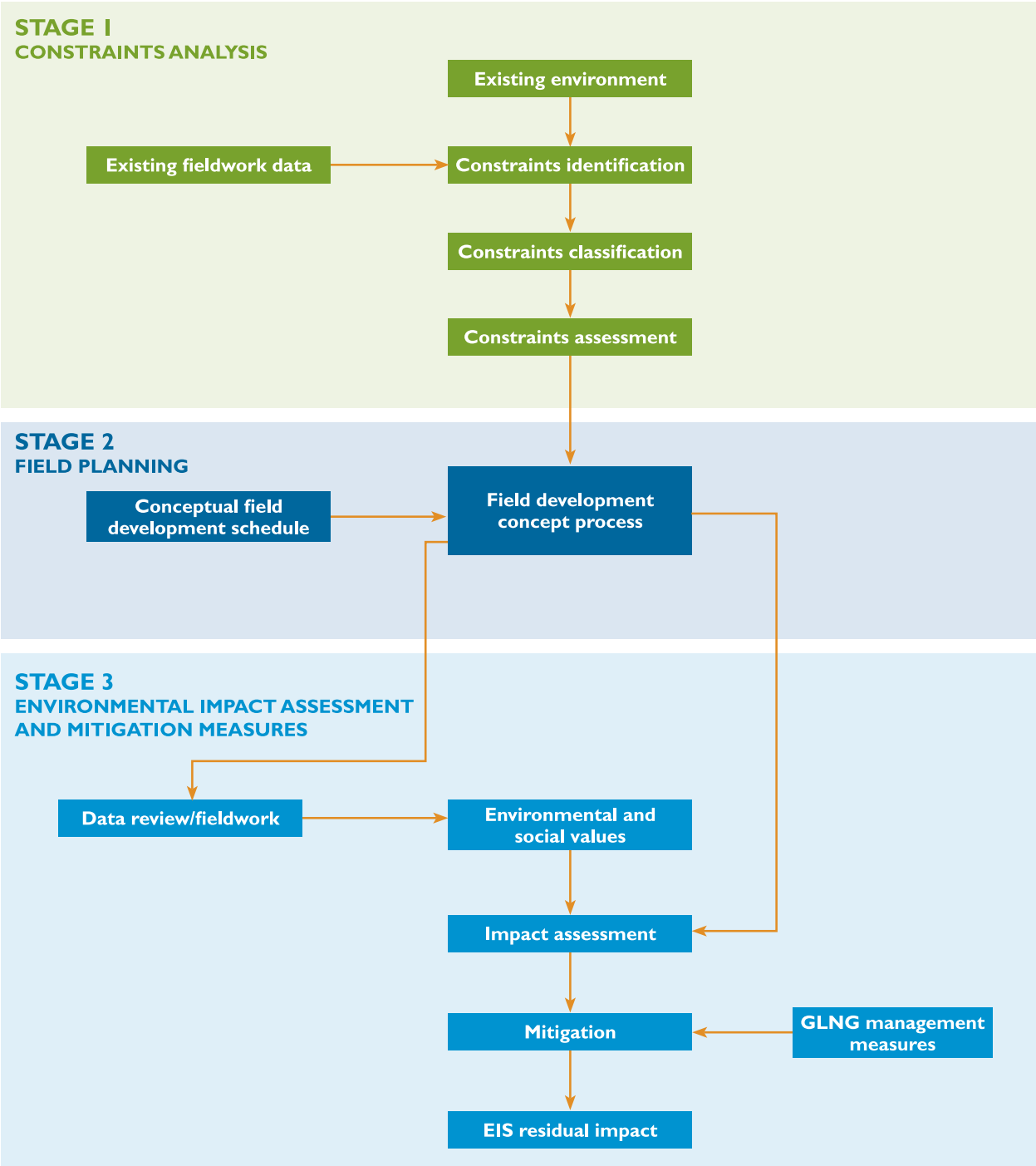
4.1 Phase 1 – Environmental impact statement

During Phase I (the subject of this EIS), the assessment of environmental, social and economic impacts was based on the predicted impacts at the project scale using a maximum development scenario. This means that the potential project development scenario has the maximum level of physical output and a corresponding maximum level of impact.

These impacts are well understood, given the experience of the GLNG Project, and are based on the GFD Project’s conceptual field development schedule and field development process.

The assessment methodology used for this EIS consisted of the three stages shown in Figure 4–2. A detailed description of each stage is given in the following subsections.

Figure 4–2 Environmental impact statement methodology flowchart



Stage 1 – Constraints analysis

Constraints analysis is a key component of the assessment framework and increases certainty about potential impacts by identifying those areas that are not amenable to development, or if they were to be developed, how development should proceed. This process, already in place for the approved GLNG Project, will be implemented through Santos GLNG's *Environmental protocol for constraints planning and field development (Constraints protocol)*. Santos GLNG has used existing fieldwork data from the GLNG Project together with data collected from fieldwork undertaken for the GFD Project to identify the constraints to the GFD Project.

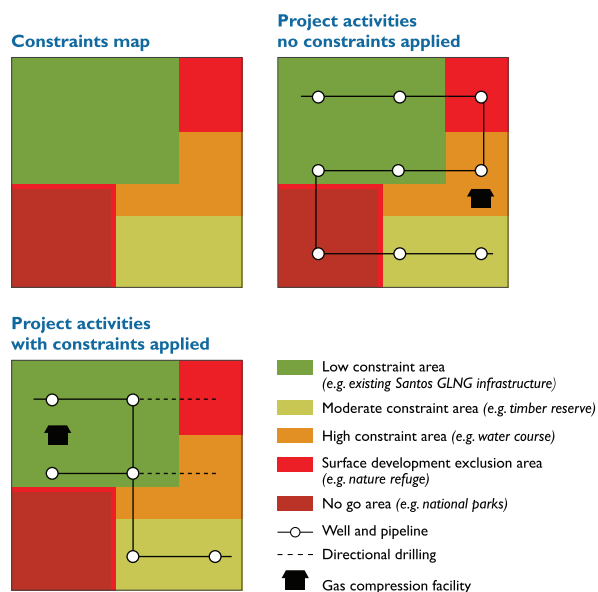
The analysis occurs by identifying the constraints to development that exist within the GFD Project area and the environmental management controls to be applied to project activities in these constrained areas. In this way, Santos GLNG can optimise environmental outcomes by avoiding sensitive receptors where practicable. Where avoidance is not practicable, Santos GLNG will use the management and mitigation measures that have already been approved and implemented for the GLNG Project.

Stage 2 – Field planning

For the purposes of this EIS, a conceptual field development schedule was prepared that indicates the number and type of activities that could be developed within the GFD Project area to extract the known available gas resources without consideration of constraints. Following this, a field development concept process was developed, which describes how the wells, pipelines, gas compression facilities and water management might be arranged to extract and process the gas, taking constraints into account. This process was used as the basis for impact assessment in this EIS as it indicates the likely maximum development case in terms of environmental impacts and the GFD Project's maximum disturbance footprint.

Figure 4–3 shows conceptually how the field development concept process will be applied.

Figure 4–3 Field development concept process



Stage 3 – Environmental impact assessment and mitigation measures

The impact assessment was based on the following process:

- The impacts that could potentially occur to the particular environmental values being assessed were identified.
- The potential impacts that could occur after the application of the constraints analysis were then identified as pre-mitigated impacts. These potential (pre-mitigated) impacts were then assessed using a methodology relevant to the environmental values being assessed (Table 4–1). The particular methodology used depended on the nature of the regulatory regime that applied to the particular environmental value, the sensitivity or vulnerability of the environmental value, the nature of the impacts, and how mitigation measures are applied.
- The pre-mitigated impacts were then managed by applying the relevant mitigation and management measures based on the existing plans and strategies contained within the approved environmental management framework that Santos GLNG has already implemented for the GLNG Project. This allowed the mitigated (residual) impacts to be identified.

There were three different impact assessment methodologies used in this EIS. The relevance of each methodology and the values to which they apply are summarised in Table 4–1.

Table 4–I Assessment methodologies

Methodology	Relevance	Values
Compliance assessment	Used where compliance with a known guideline or standard is required. Impacts are measured by the degree to which the GFD Project complies with published limits or thresholds or the extent of mitigation and management measures that need to be applied to comply.	• Air quality • Greenhouse gases • Noise and vibration.
Risk assessment	Used where the impact depends on how aspects or materials are managed. Impacts are measured by considering the likelihood and consequence of a potential impact to assess its level of risk.	• Climate • Cultural heritage • Hazard and risk • Land contamination • Social • Waste.
Significance assessment	Used where there are no quantitative guidelines, an impact will occur and it is the sensitivity or the vulnerability of the environmental value that is important. Impacts are measured by considering the sensitivity of the underlying environment and the magnitude of a potential impact to assess its level of significance.	• Ecology • Groundwater • Land use • Soils and geology • Surface water • Transportation • Visual amenity.



Ecology scouts on Curtis Island, Gladstone, Queensland.

4.2 Phase 2 – Project implementation

During Phase 2, the field development process will be ongoing as a continuation of the field planning process. The design of the GFD Project will be informed by the data gained during Phase 1, integrated into the field development process through the *Constraints protocol*. The GFD Project design will ultimately reflect environmental constraints, technical feasibility, cost, risk and adherence to applicable standards. This information will be used to support the applications for the additional approvals required subsequent to the EIS. These approvals include the following.

Environmental authority

An environmental authority is required by the *Environmental Protection Act 1994 (Qld)* before operations can commence. The application will include a description of all of the petroleum activities that are proposed, land on which the activities are to be carried out, and will be supported by the environmental assessment and management measures detailed in this EIS. Based on information developed during the field development process, Santos GLNG will develop a plan of operations which will detail how the environmental authority conditions are going to be met.

Petroleum lease

A petroleum lease is required before gas can be produced. Applications will be sought under the *Petroleum and Gas (Production and Safety) Act 2004 (P&G Act) (Qld)* and the *Petroleum Act 1923 (Qld)*. Santos GLNG will be submitted an initial development plan, which typically covers the first five years of a project's development, with the petroleum lease applications.

Conduct and compensation agreement

As required by the P&G Act, Santos GLNG will negotiate a conduct and compensation agreement (CCA) with landholders on whose land the petroleum activities will be carried out. These agreements will provide landholders with an opportunity to raise concerns specific to their property and to reach agreement with Santos GLNG on where, how and when development will occur on their property.



Cattle graze near a gas well on a property near Roma, Queensland.

5. Management framework

5.1 Environmental management hierarchy

The environmental management framework has been developed and successfully implemented for the approved GLNG Project and has been refined over the past four years. It includes the systems and procedures that will be applied to the GFD Project to achieve predictable and sustainable outcomes. An overview of the framework is given in Figure 5–1.

Figure 5–1 Overview of management framework



Emu in Arcadia Valley, Queensland.

5.2 Management framework components

5.2.1 Corporate values

Corporate values are the guiding principles that define how Santos GLNG's business is conducted. These values are the basis of Santos GLNG's commitment to operate with a view to its long-term sustainability.

5.2.2 Corporate policies

Santos GLNG has adopted the corporate policies and procedures that are applicable to the GFD Project as detailed in Table 5-1.

5.2.3 Corporate environment, health and safety management system

Santos GLNG has adopted the project-wide environment, health and safety management system that provides a structured framework for effective environmental, and health and safety practices across its activities and operations. The environment, health and safety management system is the basis for plans and procedures and will also apply to the proposed GFD Project.

5.2.4 Project-wide management plans

The management plans and strategies developed and implemented for the approved GLNG Project will be applied to the GFD Project following revisions as necessary to ensure that environmental conditions, values and potential risks associated with the GFD Project are adequately addressed. The management plans and strategies that will apply are listed below.

Draft environmental management plan

The *Draft environmental management plan* identifies the environmental values potentially affected by the GFD Project and proposes measures to manage the risks of potential adverse impact to these environmental values. The plan comprises:

- Environmental values potentially affected by the GFD Project
- Environmental management objectives and associated management measures
- Environmental monitoring and reporting
- Coal seam water management
- Proposed conditions.

GFD Project environmental protocol for constraints planning and field development

The *Constraints protocol* provides a framework to guide placement of infrastructure and adopts the following management principles:

- **Avoidance** – avoiding direct and indirect impacts
- **Minimisation** – minimise potential impacts
- **Mitigation** – implement mitigation and management measures
- **Remediation and rehabilitation** – actively remediate and rehabilitate impacted areas
- **Offset** – offset residual adverse impacts in accordance with regulatory requirements.

The *Constraints protocol* enables the systematic identification and assessment of environmental values and the application of development constraints to effectively avoid and/or manage environmental impacts.

Environmental monitoring and reporting

This document catalogues the environmental monitoring and reporting that will be undertaken for each area where this EIS has found monitoring to be required.

Contingency plan for emergency environmental incidents

The *Contingency plan* details the management practices in place within Santos GLNG to minimise environmental harm during an emergency environmental incident. The plan identifies potential incidents, and provides response actions, including escalation, communication, reporting and monitoring.

Erosion and sediment control management plan

The *Erosion and sediment control management plan* identifies erosion and sedimentation risk and provides an erosion and sediment control strategy that incorporates understanding of the risk inherent to local land resource characteristics. The plan is supported by the *Erosion and sediment control manual*, which provides erosion, sediment and drainage controls in line with best practice guidelines.

Table 5–1 Overview of corporate policies

Policy	Commitment
Environmental policy	The environmental policy commits the Santos GLNG to continuously seek to find new ways to minimise its environmental impact across the lifecycle of its activities.
Health and safety policy	The health and safety policy commits Santos GLNG to conducting business in a manner that prevents injury or illness to workers and the public.
Community policy	The community policy commits Santos GLNG to establishing and maintaining enduring and mutually-beneficial relationships with communities within which it operates.
Climate change policy	Climate change is a long-term issue, requiring urgent but informed action to stabilise atmospheric greenhouse gas concentrations. As a global stakeholder in the energy business, Santos GLNG recognises that one of their key social and environmental responsibilities is to pursue strategies that address the issue of climate change.
Aboriginal engagement policy	The Aboriginal engagement policy commits Santos GLNG to working with Aboriginal communities and creating beneficial relationships across all of its operations.

Chemical and fuel management plan

The *Chemical and fuel management plan* details the appropriate storage and handling practices for chemicals and fuels. The objectives of the plan are to:

- Facilitate compliance with relevant legislation, regulations and approvals
- Provide a framework for Santos GLNG to store and handle bulk chemicals and fuels in a way that minimises risk to the environment and human health
- Assess the potential risk of a chemical or fuel prior to its use
- Identify and implement appropriate mitigation measures.

Land release management plan

The *Land release management plan* addresses the management of releases of water to land in Santos GLNG’s gas fields, including:

- Coal seam water use for irrigation, construction and operations purposes
- Treated sewage effluent releases to land
- Use of treated sewage effluent for construction and operational purposes
- Low point drain water releases to land
- Hydrostatic test water releases to land.

The plan includes the principles, methods and controls to effectively manage and minimise the risk of environmental harm being caused by release of water to land.



Santos GLNG landholder adviser David Lobb at Coxon Creek, Wallumbilla North, Queensland.

Significant species management plan

The *Significant species management plan* provides an overview of the strategy, methods and controls implemented by Santos GLNG to manage adverse impacts to significant species and their habitats, and threatened ecological communities, listed under the EPBC Act. Specifically, the plan:

- Identifies and profiles significant species and threatened ecological communities that are present, or may occur, within the gas fields
- Identifies key threats to significant species and threatened ecological communities caused by activities within the gas fields
- Outlines general mitigation measures to be implemented by Santos GLNG to minimise the potential adverse impact of key threats to significant species and threatened ecological communities caused by Santos GLNG activities.

Fauna management plan

The *Fauna management plan* provides Santos GLNG's strategy to manage fauna during the construction and operations phases of the GFD Project. The plan:

- Identifies fauna species present within the gas fields
- Prioritises management of wildlife and livestock
- Provides mitigation measures to minimise impacts to fauna from Santos GLNG activities.

Pest and weed management plan

The management of pest and weed species will be undertaken in accordance with the *Pest and weed management plan*. The plan includes measures such as:

- Identification of pest and weed species and areas of infestation
- Avoidance of traversing and placing infrastructure in areas of known infestation
- Prevention of the spread of pest and weed species by implementing appropriate work practices and promotion of risk awareness
- Control of identified pest and weeds through containment, reduction or eradication as required by legislation.

Santos GLNG will review local government's pest and weed management plans and apply measures from these where it is appropriate.

Noise management plan

The *Noise management plan* identifies potential noise impacts from Santos GLNG activities and provides a strategy, methods and controls to:

- **Avoid** – plan the activity and engage with potentially affected stakeholders
- **Minimise** – implement noise mitigation measures to minimise noise impacts
- **Manage** – conduct monitoring, review mitigation methods and ensure compliance with Santos GLNG procedures.

Waste management plan

The *Waste management plan* details the strategy, methods and controls for managing waste generated by Santos GLNG activities. The plan identifies the types of wastes generated by Santos GLNG activities, and describes the waste management framework and how the waste management hierarchy is applied to generated waste.

Rehabilitation management plan

The *Rehabilitation management plan* outlines the rehabilitation objectives for GFD Project-related disturbances within the GFD Project area. This includes the phasing of rehabilitation to first achieve stabilisation and subsequently final rehabilitation for disturbances to land (i.e. ground surface).

The *Rehabilitation management plan*:

- Describes Santos GLNG's approach to rehabilitation
- Identifies key rehabilitation objectives and criteria to deem rehabilitation success
- Outlines general rehabilitation actions to be undertaken by Santos GLNG when rehabilitating a disturbance
- Provides an overview of monitoring and maintenance actions to be conducted on rehabilitated areas.

Decommissioning and abandonment management plan

The *Decommissioning and abandonment management plan* describes the management framework for when petroleum activities cease. The objectives of the plan are to:

- Undertake decommissioning of assets in a manner that complies with regulatory requirements and minimises the risk of environmental harm
- Undertake decommissioning activities in a manner that meets stakeholder expectations
- Leave a landform that is stable and compatible with intended post-closure land use
- Provide for the beneficial reuse of Santos GLNG infrastructure for third parties (e.g. landholders or local authorities) where an appropriate agreement has been signed by both parties and regulatory authorities are satisfied.

Hydraulic fracturing risk assessment: compendium of assessed fluid systems

The *Hydraulic fracturing risk assessment* synthesises the risk assessments completed on various hydraulic fracturing fluids and provides a framework for including new fluid systems within the risk assessment.

The report provides information on the geology and hydrogeology of the area, risk assessment methodologies (qualitative and quantitative) and current results. The appendices include risk assessments of different hydraulic fracturing fluids.

Stimulation impact monitoring plan

The plan was developed to provide a general description of the stimulation activities to be conducted by Santos GLNG, the regulatory requirements pertinent to stimulation monitoring, as well as the practices and procedures that comprise the monitoring program.



Water storage at Coxon Creek, Wallumbilla North, Queensland.

Land access

Santos GLNG has adopted an early engagement strategy where landholders who may be affected by GFD Project activities are able to discuss the potential location, timing and impacts of infrastructure on their property or business, and how Santos GLNG can help to minimise those impacts. This early engagement strategy has been developed in accordance with the *Land Access Code* (Department of Employment, Economic Development and Innovation, 2010).

Santos GLNG will negotiate a conduct and compensation agreement under the P&G Act with landholders on whose land the petroleum activities will be carried out. The locations of wells, gathering lines, and access tracks will be finalised in consultation with the landholder as part of the negotiations.

Offset strategy

Offsets are a mechanism to counterbalance any significant adverse residual impact, after the hierarchy of avoidance, minimisation, mitigation, remediation and rehabilitation measures have been implemented.

The Offset strategy is part of the management framework and will be further developed and implemented to meet regulatory requirements.

The purpose of the strategy is to:

- Summarise the Australian and Queensland Governments' offset requirements and policies
- Identify the environmental values that exist within the GFD Project area that after avoidance, minimisation, mitigation, remediation and rehabilitation measures may require offsetting
- Demonstrate how offsets are completed as part of the Santos GLNG Project
- Identify where existing Santos GLNG offset areas may be used for future additional offset required for the GFD Project
- Provide a description of Santos GLNG's staged offsets approach to provide potential offset delivery options and proposed method of delivery.

Social issues action plan

The *Social impact management plan* (SIMP) established for the GLNG Project will be implemented across the GFD Project. The plan outlines the roles, responsibilities and rights of Santos GLNG, the government, impacted communities and other stakeholders in relation to the GFD Project. In particular, it outlines the framework for community engagement, management strategies to avoid, mitigate or minimise potential impacts and to maximise opportunities and benefits arising throughout the life of the GFD Project, as well as a monitoring and reporting process.

The GLNG Project SIMP will be supplemented by issue action plans relating to the GFD Project that focus on the following key areas as agreed with the Coordinated Project Delivery Division of the Coordinator-General's office:

- Water and environment
- Community safety
- Social infrastructure
- Community wellbeing and liveability
- Local industry participation and training
- Aboriginal engagement and participation.

The SIMP is an operational document that is updated to reflect the ongoing needs of Santos GLNG and the communities it operates in.

Water resource management plan

The *Water resource management plan* has been developed to proactively detail how Santos GLNG manages and monitors potential adverse impacts to water resources which are defined as a matter of national environmental significance.

Hydraulic connectivity characterisation

The *Hydraulic connectivity characterisation* focuses on the hydraulic connectivity between the coal seam gas production coal beds and the overlying and underlying aquifers. This understanding is used to better estimate the potential impacts of coal seam gas water extraction on aquifers. The report describes the results of the hydraulic connectivity studies carried out and details ongoing studies.

Joint industry plan for an early warning system for the monitoring and protection of EPBC springs

The *Joint industry plan* has been collaboratively developed by Santos GLNG, Origin Energy and Queensland Gas Company (the Proponents).

The objectives of the joint industry plan are to:

- Summarise the monitoring requirements that have been requested of the Proponents in the *Surat Underground Water Impact Report for the Surat Cumulative Management Area* (Queensland Water Commission, 2012) and in the Proponents' approval conditions by the Department of the Environment
- Propose an early warning system monitoring network and escalating levels of triggers to manage springs listed under the EPBC Act from adverse impacts associated with coal seam water extraction
- Demonstrate that the Proponents will endeavour to identify potential adverse impact early and adequately respond to prevent adverse impact to springs listed under the EPBC Act
- Identify which Proponent is responsible for management actions for each spring
- Demonstrate the Proponents' commitments to meet the requirements of the EPBC Act approval.

Evaluation of prevention or mitigation options for Fairview Springs

The report provides an assessment of measures to prevent or mitigate potential impacts to three spring complexes within the Fairview gas field. The document details the currently implemented and planned monitoring of springs and groundwater systems to assess potential impacts to springs.

Ground deformation monitoring and management plan

The *Ground deformation monitoring and management plan* details how Santos GLNG monitors and manages the risk from subsidence across its tenure. The plan includes monitoring methodology, exceedance management and response, and reporting requirements.

Dawson River discharge receiving environmental monitoring program Fairview project area

The Receiving environmental monitoring program has been developed for the authorised Dawson River Release Scheme, an activity of the Santos GLNG Project. The program has been developed in accordance with environmental authority conditions (EPPG00928713) to monitor, identify and describe adverse impacts to the waters in the receiving environment resulting from the release of treated coal seam water.

5.2.5 Activity based procedures and processes

The established and effective work procedures that Santos GLNG has developed and implemented for the GLNG Project will also be used for the GFD Project. These procedures provide guidance to field and construction staff outlining the what, where and when to support the implementation of the management plans and strategies.

Work instructions will be prepared for operations staff and contractors working on a specific activity or at a specific location and provide detail of how the project-wide management plans and strategies are implemented at an asset level.



Santos GLNG's Julie Fletcher at the Fairview Hub 05 gas compressor station.



Countryside near Roma, Queensland.

6. Impact assessment

6.1 Climate

Climate hazards, such as extreme temperatures, bushfires, droughts and severe storms, can damage infrastructure and present a risk to the health and safety of the general population living in the region as well as the GFD Project workforce. As part of the EIS, the existing climate hazards in the GFD Project area and their potential to increase in intensity, duration and frequency based on published climate change modelling were identified. These are summarised as follows:

- The region's climate is classified as sub-tropical with hot summers that feature days of extreme heat (temperatures that exceed 35°C). The current climate change scenarios predict that by 2030 the number of very hot days will almost double across the GFD Project area.
- Similarly, different portions of the GFD Project area have a history of flooding. Although annual rainfall is expected to decline over the next 40 years, it is predicted that when rainfall events occur, they could be more intense, increasing the risk of flash flooding.

- Bushfire risk is evaluated by the presence of high density vegetation, strong winds and low humidity. Based on mapping by the Queensland Rural Fire Service, the risk of bushfires is considered to be low in the south of the GFD Project area. Further north, the risk is medium, with small pockets of high risk. The predicted decline in annual rainfall combined with hotter conditions is likely to increase bushfire risk across the region.
- Severe storms in Queensland occur primarily between September and March. Cyclone activity is limited in the region; however, 10 cyclones have crossed the GFD Project area in the past 100 years.
- Droughts are a known phenomenon across the GFD Project area and are predicted to increase in the future as annual rainfall declines.

Based on our current understanding of climate hazards in the GFD Project area, potential impacts to the GFD Project workforce and infrastructure from climate hazards are listed in Table 6–1.

Table 6–1 Potential impacts relevant to climate

Hazard	Potential impact
Extreme temperatures and heatwaves	• Heat-related health impacts • Increased energy demand • Heat-induced damage to infrastructure • Increased risk of bushfire • Increased invasive weed and pest species.
Increase in rainfall intensity and flooding	• Exceedance in capacity of water management facilities resulting in localised flooding and increased erosion risk • Degradation and failure of infrastructure.
More frequent droughts	• Water shortage • Increased dust • Soil shrinkage and movement • Less effective rehabilitation.
Increase in storm events and intensity of cyclones	• Increased damage to infrastructure • Increased workforce injuries • More frequent and prolonged interruptions to operations.

The potential climate impacts to GFD Project infrastructure and workforce were assessed according to the risk assessment methodology which considers the likelihood and consequence of potential impacts to determine their risks. The risks of these impacts occurring were then reassessed after the implementation of Santos GLNG's management framework, which is outlined in Box 2. After the application of management and mitigation measures, the residual risks have been assessed to be between very low and low. The exception is the medium residual risk of an increase in intensity and frequency of extreme storm events and cyclones causing increased damage to GFD Project infrastructure and loss of life or injury to workers travelling to the GFD Project area.



Countryside near Roma.

Box 2 Managing potential climate change impacts

Santos GLNG is committed to the following actions to mitigate the effects of climate change on the GFD Project infrastructure and workforce:

- **Avoid** – the location of infrastructure will consider the potential risks of atmospheric and climate factors.
- **Mitigate** – the following measures will consider the range of atmospheric and climatic factors:
 - Engineering design specifications
 - Inspection and maintenance programs
 - Procedures, control strategies and awareness training.
- **Manage** – the following management plans will also consider the risk of atmospheric and climatic factors:
 - *Bushfire management plan*
 - *Emergency response plan*
 - *Journey management plan*
 - *Pest and weed management plan*
 - *Rehabilitation management plan.*

6.2 Land use and tenure

The GFD Project area contains a range of land uses, including areas of agricultural production, resource extraction, Native Title, and protected areas with conservation and recreation values. Current land use values can be summarised as follows:

- Livestock grazing is the predominant land use within the GFD Project area, followed by dryland cropping.
- Resource extraction, including coal mining and gas exploration and production, is an established land use in the GFD Project area, particularly mining in the north which is situated over the southern end of the Bowen Basin, and gas production in the south in the Surat Basin.
- The GFD Project area contains active Native Title claims or determinations as well as state land where Native Title rights have not been extinguished and can still be made. Santos GLNG has entered into agreements with Native Title parties in order to develop the GLNG Project while taking into account the communal rights of Native Title parties across the GFD Project area.
- The GFD Project area includes a number of urban areas, from larger rural centres such as Roma and Injune to smaller localities including Taroom, Wandoan, Springsure, Wallumbilla, and Yuleba. In keeping with the areas of agricultural production across the GFD Project area, rural residences are present outside of the urban areas.
- The regional population is connected by a transport network, including road, rail and aviation facilities. The region is serviced by utilities that are typical for regional Australia, including water supply (for urban, industrial and agricultural uses), electricity distribution infrastructure, telecommunications, and gas production infrastructure.
- Forestry for millable timber and associated land uses is present throughout the GFD Project area. This land use is supported by a number of timber processing facilities.
- The GFD Project area contains a range of areas that hold conservation, tourism and recreational values by virtue of their undeveloped and in most instances, natural status. These include the Expedition (Limited Depth) National Park and Humboldt National Park in the north of the GFD Project area, and the Lake Murphy Conservation Park and Carraba Conservation Park within the Scotia gas field.



Overlooking the Roma saleyards.

Protected areas

The Central Queensland and Darling Downs regional plans have introduced provisions to manage competing state interests concerning the development of regional settlements, the agricultural sector and the resources sector. These are known as Priority Living Areas and Priority Agricultural Areas.

Priority Living Areas (PLAs) have been introduced to provide greater certainty of investment in the development of the region's towns and urban settlements by setting aside an area for town expansion and protecting it from incompatible resource development. They include the settlement area, rural residential areas associated with the settlement area, and a two kilometre buffer area around the settlement area.

The PLAs within and nearby the GFD Project area are listed in Table 6–2.

Priority Agricultural Areas (PAAs) identify high value, intensive agricultural areas. The regional plans also identify Priority Agricultural Land Uses which include cropping, horticulture, certain types of grazing, and a range of irrigated agricultural land uses. Land being used for a Priority Agricultural Land Use in a Priority Agricultural Area is given priority over any other land uses, including resources activity.

No declared water storage catchments are present within the GFD Project area.

The potential impacts of the GFD Project to underlying land use and tenure are listed in Table 6–3.

The potential impacts of the GFD Project on land use and tenure values were assessed using a significance assessment methodology, which considers the sensitivity of the underlying environment and the magnitude of a potential impact to assess its level of significance. After the application of Santos GLNG's management framework shown in Box 3, the residual significance is expected to be low to moderate.

The town planning aspects of the GFD Project were assessed using a compliance assessment, which is used where compliance with a known guideline or policy is required. The compliance assessment found that the GFD Project has a high level of compliance with relevant land use planning frameworks. This is reflective of demonstrated capability of Santos GLNG's management system to avoid, manage and mitigate the land use planning impacts of their activities in accordance with regulatory requirements.

Table 6–2 Priority Living Areas

GFD Project area	Outside of GFD Project area with the potential to be influenced by the GFD Project	
• Roma • Wallumbilla • Yuleba • Wandoan	• Miles • Mitchell • Injune • Blackwater	• Bluff • Surat • Taroom



Site access signage.

Table 6–3 Potential impacts relevant to land use

Land use	Potential impact
Agriculture and primary production	Reduction in the area of productive land, diminution in productivity, disturbance of soil structure, changes to surface water flows, weed and pest introduction, and disruption of landholder operations.
Forestry	Disruption to existing and potential operations, access restriction, and loss or premature harvesting of forestry resources.
Urban residential	Increase in population, stimulation of the local economy, and increased demand for retail, commercial and industrial uses. This may result in a shortage of accommodation facilities and appropriately zoned and serviced residential land.
Rural residential	Reduction in residential amenity due to noise and vibration, dust and lighting, and increased traffic on local roads.
Mining, petroleum and extractive resources	Restrictions to the exploration or extraction of other resources.
Conservation, tourism and recreation	Disturbance to vegetation and/or habitats so that the overall amenity may be reduced, affecting existing tourism and recreational values.
Transport infrastructure	Interference with the operations of transport infrastructure such as roads, rail, aerodromes and landing grounds, and stock routes.
Utilities and services	Interference with existing high voltage transmissions lines, gas pipelines, water pipelines or telecommunications facilities.

Box 3 Managing potential land use and tenure impacts

Santos GLNG is committed to managing the potential land use and tenure impacts of the GFD Project. Key measures to protect land use and tenure values include:

- Avoiding impacts where practicable by considering the land use constraints identified in the constraints planning processes to ensure that GFD Project infrastructure with potentially high or moderate impacts will be generally avoided in no-go and surface development exclusion areas, as well as in areas of high or moderate land use constraints.
- Engage with landholders, the community and other stakeholders to reduce potential land use and tenure impacts to successfully coexist with other land uses through the implementation of the land access and landholder engagement strategy and negotiation of conduct and compensation agreements.
- Mitigate and manage environmental impacts relevant to land use issues including soils, noise, dust and ecology through the *Decommissioning and abandonment management plan*, *Erosion and sediment control management plan*, *Fauna management plan*, *Noise management plan*, *Pest and weed management plan*, *Rehabilitation management plan*, *Road-use management plan*, *Significant species management plan*, and the *Social impact management plan*.

6.3 Land resources

6.3.1 Geology, topography and soils

The primary coal seams in the GFD Project area are the Jurassic age Walloon Coal Measures (Surat Basin) and the late Permian Bandanna Formation (Bowen Basin). These will be targeted by the GFD Project. No known sites of paleontological significance or geomorphological significance occur in the GFD Project area although fossil finds to date indicate there is potential for future fossil finds.

The topography of the GFD Project area includes areas that are characterised by low-relief undulating low hills that dominate in the east. Mesas feature at the border of the GFD Project tenements in the east, north and south-west. Alluvial plains are present across the GFD Project area with the most extensive associated with major watercourses and their tributaries, such as the Dawson River in the northeast, Comet River in the northwest, and Balonne River in the southwest.

Soils in the GFD Project area include uniform coarse textured (sandy) soils, uniform and gradational medium-textured (loamy) soils (in particular uniform loams), gravelly loams, red and yellow earths, and lateritic red earths. A number of soils that are considered to be 'problem' soils because they are either highly susceptible to erosion, have high salinity or are highly reactive occur throughout the GFD Project area. The GLNG Project EIS (URS, 2009) reported that substantial areas of land are subject to accelerated soil erosion, in particular areas of extensive surface sheet and rill erosion.

Reflective of the region's agricultural history, good quality agricultural land (GQAL) occurs in parts of the GFD Project area. Table 6–4 details the extent of agricultural land classes within the four gas fields and across the remainder of the GFD Project area.

The Regional Planning Interests Act 2014 (Qld) manages Queensland's best cropping land with regard to competing land uses, such as agriculture, mining and urban development. The Act uses trigger maps to identify a potential strategic cropping area which the Act declares to be an area of regional interest. If a resource activity is proposed within an area of regional interest and an exemption under the Act does not apply, a regional interest's development approval will be required. Table 6–5 details the extent of potential strategic cropping land within the GFD Project area and how much of it is in a protection area where greater restrictions apply.

Potential impacts to geology, soils and topography values that may occur as a result of the GFD Project include:

- Altered geological setting
- Change to landform
- Aquifer depressurisation resulting in subsidence
- Loss of soil resources
- Degradation of soil resources
- Restricted access to productive (agricultural or forestry) land
- Authorised release to soil

Table 6–4 Extent of agricultural land classes (ha)

Gas field	GQAL – Class A (cropping)	GQAL – Class B (arable, razing)	GQAL – Class C1 (grazing)	Class C2 (grazing)	Class C3 (grazing)
Arcadia	41,795	2,751	38,145	60,704	128,723
Fairview	13,096	9,445	23,278	86,699	29,627
Roma	53,817	277,028	82,486	58,101	0
Scotia	104,906	24,724	24,886	5,865	0
Remainder*	459,688	524,794	465,251	432,830	226,465
Total	673,302	838,742	634,046	644,199	384,815

*Additional land area within the possible area for supporting infrastructure outside of the gas fields

- Uncontrolled release to soil
- Damage to fossils.

The potential impacts to geology, topography and soils were assessed according to the significance assessment methodology, which considers the sensitivity of the underlying environment and the magnitude of a potential impact to assess its level of significance. The significance of the impacts was assessed after the implementation of Santos GLNG’s management framework, which is outlined in Box 4. After the application of management and mitigation measures, the significance of the residual impacts was found to be low to negligible.

Table 6–5 Distribution of strategic cropping areas (SCA) in the GFD Project area (ha)

Gas field	Total SCA trigger area
Arcadia	36,244
Fairview	12,576
Roma	34,451
Scotia	101,304
Remainder*	411,225
Total	595,799

*Additional land area within the possible area for supporting infrastructure boundary outside of the gas fields

Box 4 Managing potential geology, topography and soils impacts

Santos GLNG has an established management framework to ensure that geology, soils and topography values are protected throughout the life of the GFD Project.

This framework includes measures that are designed to mitigate and manage the potential for GFD Project activities to impact upon geology, topography and soils. The management plans that are applicable to geology, topography and soils impact include:

- *Constraints protocol*
- *Chemical and fuel management plan*
- *Contingency plan for emergency environmental incidents*
- *Erosion and sediment control management plan*
- *Decommissioning and abandonment management plan*
- *Ground deformation monitoring and management plan*
- *Hydraulic fracturing risk assessment compendium of assessed fluid systems*
- *Joint industry plan for an early warning system for the monitoring and protection of EPBC springs*
- *Land release management plan*
- *Rehabilitation management plan*
- *Water resource management plan.*

6.3.2 Resources and reserves

Santos GLNG's knowledge of the GFD Project's gas reserves is based on the exploration and appraisal activities that have been carried out to date. Ongoing exploration across the GFD Project area will continue to build Santos GLNG's confidence in total reserves. The estimate of Santos GLNG's reserves and contingent resources (excluding Santos Limited's portfolio and third party gas) for the GLNG Project is given in Table 6–6.

Potential impacts to resources and reserves within the GFD Project area include:

- Resource sterilisation
- The underdevelopment of resources.

Extraction of gas does not preclude the subsequent extraction of the coal. In fact, gas extraction is often required prior to coal extraction (particularly for underground mining) to reduce potential dangerous incidental mine gas concentrations to levels acceptable for mining. It is also of significant benefit for open cut mining as it reduces fugitive emission of methane. Coordinated coal and gas extraction can be mutually beneficial and commercially feasible.

The potential impacts to resources and reserves were assessed according to the significance assessment methodology, which considers the sensitivity of the underlying environment and the magnitude of a potential impact to assess its level of significance. As an experienced operator, Santos GLNG has demonstrated experience in managing resources and reserves as part of its operations. The measures Santos GLNG typically undertakes are outlined in Box 5. The significance of the residual impacts after the implementation of these measures is assessed to be low.

Box 5 Managing resources and reserves

When GFD Project infrastructure is located in areas of overlapping tenure with coal mining projects, the design and location of project infrastructure as well as the timing and rate of production may require consideration of future coal mining operations. In such a case, Santos GLNG will manage and minimise the risk of resource sterilisation and the underdevelopment of resources by entering into an agreement with the mining lease holder regarding the sequence of resource extraction. Alternatively, the Queensland Government has legislation in place to manage overlapping tenure.

Table 6–6 Santos GLNG share of gas from coal seam reserves and resources

Gas reserves and resources	Santos GLNG share (PJ)					
	2008	2009	2010	2011	2012	2013
1P (Proven)	1,167	1,232	1,432	1,789	1,797	1,844
2P (Probable)	3,246	4,003	5,009	5,268	5,376	5,406
2C (Contingent resources, best estimate)	2,647	2,769	3,732	3,277	1,638	1,374

6.3.3 Contaminated land

Land can be contaminated by a range of land uses and activities which are called 'notifiable activities' under Queensland legislation. Existing contamination in the GFD Project area could have resulted from previous activities associated with urban, industrial or agricultural land uses.

Land parcels where notifiable activities have been undertaken may be listed on the Environmental Management Register (EMR) or the Contaminated Land Register (CLR). These registers can only be searched by individual lot and plan. Given the large number of land parcels in the GFD Project area (7,817), it is not practical to search the EMR/CLR until the land parcels proposed for development are identified by the ongoing field development planning process. During field development planning, Santos GLNG will assess the risk associated with existing potential contamination and undertake CLR/EMR searches as required.

Key environmental values with the potential to be impacted by land contamination within the GFD Project area are listed below:

- Health and safety, being the life, health and wellbeing of people including the GFD Project workforce
- The natural environment, including soils and land, terrestrial ecology, water resources and aquatic ecology
- The productive capability of land, being its potential for use for agricultural, forestry or other uses for economic gain
- Sustainable use of natural resources.

The GFD Project has the potential to disturb existing contaminated land or introduce new contamination through GFD Project activities including petroleum, oil and chemical storage, abrasive blasting, and regulated waste storage and treatment. Disturbing existing contamination or introducing new contamination has the potential to contribute to human health risks, contaminate soil or groundwater resources, or reduce the productive capability of the land and the sustainable use of natural resources.

The potential for the GFD Project to disturb or introduce contamination was assessed according to the risk assessment methodology, which considers the likelihood and consequence of a potential impact to assess its risk. The risk of these impacts occurring was assessed after the implementation of Santos GLNG's management framework, which is outlined in Box 6. After the application of management and mitigation measures, the residual risks from contaminated land were found to be low to very low.



Countryside near Roma, Queensland.

Box 6 Managing the potential for contaminated land

Santos GLNG has an established contaminated land strategy that incorporates a number of standards from the project-wide Environmental Health and Safety Management System. Santos GLNG's contaminated land strategy aims to avoid disturbing contaminated land and minimise the potential to introduce contamination through the following steps:

- Avoid contaminated land during the field planning stage by undertaking preliminary assessments of the potential for the presence of contaminated land and avoiding it where practicable.
- Minimise the potential for Santos GLNG to contaminate land through compliance with the Environmental Health and Safety Management System, which includes standards for the design, installation and maintenance of structures associated with hazardous materials and activities. Santos GLNG has a number of management plans that are designed to minimise the risk of environmental harm occurring as a result of our activities. These include the:
 - *Chemical and fuel management plan*
 - *Contaminated site management plan*
 - *Decommissioning and abandonment plan*
 - *Emergency plan for emergency environmental incidents*
 - *Land release management plan*
 - *Waste management plan.*
- Where contamination is identified or occurs, report contamination and develop a contaminated site action plan to minimise the potential for environmental, land and human health impact according to *Environmental Hazard Standard 08 Contaminated sites*. Where an emergency environmental incident occurs, the *Contingency plan for emergency environmental incidents* details appropriate management practices to be undertaken.



Weed washdown facility, Clematis Dam.

6.4 Landscape and visual amenity

The landscape within the GFD Project area includes broad flat plains and river valleys, undulating hills, rugged ridges, narrow valleys and plateaux. Residents and visitors experience a rural landscape with a mix of broad long distance vistas, mountain ranges, natural forests and woodlands, rural roads and small townships. Oil and gas fields have operated in this area since the early 20th century and have become a part of the area's historical and visual landscape.

Visual impacts will be generated by GFD Project activities and the establishment of long-term or permanent infrastructure that creates a contrast in the landscape. The extent to which these activities and infrastructure alter the visual amenity of landscapes will depend on the sensitivity of receptors and the landscape. Certain landscapes have the ability to absorb introduced elements more readily than others. For example, a gas well situated on a flat grassy plain will be more visually apparent than a gas well situated within undulating and vegetated hills.

GFD Project activities that have the potential to impact visual amenity include:

- Clearing
- Construction/decommissioning (including earthworks)
- Traffic
- Night lighting (including lighting from vehicles)
- Operating activities (presence of component).

The impacts associated with each of these activities will be at their highest during construction then are expected to reduce. For example, the footprint required for each component during construction reduces (often considerably) during operation.

Similarly, night lighting is most often required during the construction phase, with the exception of certain infrastructure, such as accommodation facilities, which requires illumination during operations.

The potential impacts to landscape and visual amenity were assessed according to the significance assessment methodology, which considers the sensitivity of the underlying environment and the magnitude of a potential impact to assess its level of significance. However, in the case of landscape character and visual amenity, the sensitivity of the landscape and receptor values changes considerably across the GFD Project area, according to who the receptor is.

As a result of the varying sensitivity of both the existing landscape and receptor values, it is not possible to undertake a significance assessment when the sensitivity of underlying values remains static before and after mitigation. Rather, this impact assessment has assessed sensitivity based on the nature of GFD Project components, including:

- The frequency at which they occur within the landscape
- Their potential to alter the visual amenity values of a receptor.

The sensitivity criteria for the GFD Project components adopted for the visual impact assessment are outlined in Table 6–7.

The measures Santos GLNG will undertake to manage and mitigate the potential impacts to landscape and visual amenity values are outlined in Box 7. The significance of the residual impacts after the implementation these measures is assessed as being negligible to moderate, with the exception of overhead power lines, which are expected to have a high significance during the operations phase.

Table 6–7 Sensitivity criteria for GFD Project components

Sensitivity	Description
High	The GFD Project activity is clearly visible above ground, it is numerous, continuous and widespread and likely to intrude upon the visual amenity of a variety of receptors across a variety of landscapes e.g. overhead power lines.
Moderate	The GFD Project activity is visible, is numerous, replicated across large areas and may intrude upon the visual amenity of high sensitivity receptors across a variety of landscapes e.g. well lease.
Low	The GFD Project activity is visible but limited in number and is not replicated within view sheds of receptors.

Box 7 Managing potential landscape and visual amenity impacts

Santos GLNG has an effective management framework to avoid, mitigate and manage impacts on visual amenity through:

- Avoiding development on sensitive landscapes through the implementation of the *Constraints protocol*.
- Minimising disturbance in areas that are amenable to development such as the use of previously disturbed areas and common or adjacent easements as directed in *Environmental Hazard Standard 01 Biodiversity and land disturbance*. The length of disturbance will be reduced by implementing measures in the *Decommissioning and abandonment management plan*.
- Minimising and managing disturbance to rural residences by engaging with landholders to agree on infrastructure locations and the extent of visual mitigation necessary as per the *Land access* and landholder engagement strategy and the *Social impact management plan*.
- Mitigating the impact of temporary visual impacts, such as night-lighting through the *Draft environmental management plan* and traffic impacts through the *Road-use management plan*.

6.5 Traffic and transport

The GFD Project area is serviced by an extensive transport network including road, rail and aviation facilities that link the region internally and to surrounding regions. This transport network supports community connectivity and the regional economy.

Regional towns are connected by a network of highways and regional and rural roads, with rural access roads to isolated properties. Roads are used for local trips, tourism, heavy vehicle traffic moving bulk agricultural and extractive resources products and resource project inputs (such as fuel, equipment and materials), school buses, and vehicles transporting resources sector workforce.

The primary highway corridors include the Leichhardt Highway, Carnarvon Highway, Fitzroy Developmental Road, Warrego Highway and Dawson Highway. These state-controlled highways carry the highest traffic volumes in the region, with between 300 and 5,300 vehicles per day. Regional connecting roads have lower levels of traffic, at around 500 vehicles per day. Rural connecting roads, which may be sealed or unsealed, generally carry up to 350 vehicles per day.

The environmental values relevant to the traffic and transport aspects of the GFD Project are outlined below:

- **Efficiency** – the aspects of the road network that contribute to function and accessibility, which facilitate the efficient operation of the network.
- **Safety** – the aspects of the road network relating to the location and provision of physical infrastructure to ensure safe operation.
- **Amenity** – the sensory experience of those who are located near the road network such as communities or other land users.

The potential impacts of the GFD Project on the traffic and transport network were determined by the development and application of a traffic model to assess the impact of GFD Project traffic on the road network (highways, regional connecting roads, rural connecting roads and rural access roads) and to identify the mitigations required. Modelling of impacts on the traffic and transport is based on the EIS maximum development scenario.

The potential impacts included the following:

- **Pavement impacts.** Pavement rehabilitation is the reconstruction of a road pavement performed at the end of its structural life (approximately 20 years). An unplanned increase in traffic could result in rehabilitation works having to be performed sooner than forecast. A preliminary pavement impact assessment indicated that there are a number of state-controlled roads whose pavements could require additional maintenance or rehabilitation due to the impact of the GFD Project's traffic under the EIS maximum development scenario.
- **Intersection impacts.** A preliminary intersection assessment was performed to determine the potential impact the GFD Project would have on intersections within the GFD Project area as a result of existing traffic volumes and the anticipated GFD Project traffic under the EIS maximum development scenario.

The assessment indicated that the following intersections could potentially require upgrades due to GFD Project traffic:

- Leichhardt Highway/Dawson Highway
- Warrego Highway/Duke Street (Roma Southern Road)
- Warrego Highway/Leichhardt Highway
- Warrego Highway/Yuleba Surat Road.

- **Road link impacts.** This assessment involved reviewing the background traffic plus potential GFD Project traffic volumes to determine whether road links reach capacity earlier than they otherwise would due to the GFD Project traffic under the EIS maximum development scenario. This enables the 'bring forward' cost of road upgrade responsibility of the GFD Project to be determined. 'Bring forward' cost contributions apply to road sections where the GFD Project creates the need to bring forward upgrades by one year or more. The assessment showed that upgrades are not brought forward by more than a year for road links where the potential GFD Project traffic is significant. The only exception to this is the Warrego Highway between Oakey and Dalby. This section of road has had additional overtaking lanes constructed in the year 2013–2014 according to the Queensland Transport and Roads Investment Program, which occurred after assessment data was collected. As a result, it will meet the required formation to cater for both existing (background) and potential GFD Project traffic.
- **Environmental values impacts.** The potential impacts on environmental values consider a range of characteristics that may change on each functional road type (highway, regional connecting road, rural connecting road and rural access road) in response to development of the GFD Project. These potential impacts are summarised in Table 6–8.

Table 6–8 Potential impacts on environmental values – traffic and transport

Environmental value	Potential impact
Efficiency	Reduced efficiency related to increased traffic volumes and reduced standard of pavement and intersection control.
Safety	Reduced safety related to increased traffic volumes on bridges, cattle grids, rail crossings, school bus routes, traffic composition and driver fatigue controls.
Amenity	Reduced amenity related to stock route co-location, sensitivity of adjacent land uses, potential for dust nuisance and light glare issues.

The potential impacts to traffic and transport were assessed according to the significance assessment methodology, which considers the sensitivity of the underlying environment and the magnitude of a potential impact to assess its level of significance.

The measures Santos GLNG will undertake to manage and mitigate the potential impacts of the GFD Project to traffic and transport values are outlined in Box 8. The significance of the residual impacts after the implementation of these measures is assessed as being negligible for highways and moderate for regional connecting roads, rural connecting roads and rural access roads.

Box 8 Managing potential traffic and transport impacts

Santos GLNG has a demonstrated commitment to managing its impacts on the regional road network and has already contributed over \$50 million towards upgrading and maintaining roads impacted by the GLNG Project's traffic.

Santos GLNG will assist the Department of Transport and Main Roads with the costs associated with residual road impacts, as outlined within the *Guidelines for Assessment of Road Impacts of Development* (Department of Transport and Main Roads, 2006).

Santos GLNG's established traffic and road management framework to manage and mitigate its impacts on traffic and transport is primarily delivered through the *Road-use management plan* based on commitment to development. A number of other management plans provide measures to maintain the amenity and safety of the transport network and maintain the environment traffic will traverse including:

- *Emergency response plan*
- *Contingency plan for emergency environmental incidents*
- *Erosion and sediment control management plan*
- *Pest and weed management plan*
- *Social impact management plan*
- *Waste management plan.*

In addition, Santos GLNG has an established infrastructure agreement with infrastructure operators (such as the Department of Transport and Main Roads and relevant regional councils) regarding road impact mitigation.



Santos GLNG vehicle in Roma, Queensland.

6.6 Waste

In the GFD Project area, solid and liquid wastes are generated from domestic and commercial premises as well as agricultural, industrial and resource extraction activities. Regional councils provide waste collection, recycling and disposal facilities for residential and commercial properties. Commercially operated waste management facilities provide additional options for collection, treatment and disposal of solid and liquid wastes.

Environmental values with the potential to be impacted by waste generated from the construction, operations and decommissioning of the GFD Project include:

- Natural environment, including land, water resources, air quality, fauna and flora
- Productive capability of land i.e. its potential for use for agricultural, forestry or other uses
- Health and safety i.e. the life, health and wellbeing of people, including the GFD Project workers
- Sustainability of natural resources (e.g. construction materials, fuel, electricity, water)
- Available landfill capacity for waste disposal
- Visual amenity.

GFD Project activities will generate solid, liquid and gaseous wastes, which can be broadly classified as:

- **Regulated waste:** wastes that require specific controls or actions as defined by legislation. Listed, hazardous, regulated, controlled or trackable wastes typically have unique handling and disposal requirements in order to manage specific hazards associated with them.

- **General waste:** wastes not defined as regulated waste under legislation; general wastes comprise putrescible wastes (easily decomposed, recyclable by composting) and non-putrescible wastes (not easily decomposed, may be recyclable).

- **Recyclable waste:** waste types that are able to be reconditioned, reprocessed or reused.

These wastes will be generated during the various project stages as follows:

- **Construction.** The construction phase will be associated with the largest development footprint in terms of area, workforce, materials, plant and equipment and the largest waste volumes to be managed.

- **Operations.** Operational activities have reduced demand for workforce, material and transport when compared with construction. Consequently, the operation phase is expected to generate overall smaller volumes of waste to be managed.

- **Decommissioning and rehabilitation.** Prior to decommissioning each facility or area, accurate quantities of waste to be generated will be established along with details of their physical and chemical characteristics. It is expected that aboveground facilities and equipment will be either dismantled and removed for reuse on other Santos GLNG assets, or be sold, recycled or disposed of, depending on condition or demand.

Potential impacts to the identified environmental values and receptors may result from excessive waste generation from the inefficient use of resources, or from the improper management of wastes generated during the construction, operations, decommissioning and rehabilitation of the GFD Project. The potential impacts are outlined in Table 6–9.

Table 6–9 Waste-related potential impacts

Hazard	Potential impact
Waste generation	Excessive use of natural resources (disposed as waste)
	Waste to be disposed to landfill (additional to current levels)
Waste management	Uncontrolled release of waste (may cause contamination of land, surface or ground waters and dependent ecosystems)
	Controlled release of waste (may cause contamination of land, surface or ground waters and dependent ecosystems)
	Increase in vermin and pest populations.

The potential waste-related impacts were assessed according to the risk assessment methodology, which considers the likelihood and consequence of a potential impact to assess its risk.

The measures Santos GLNG will undertake to manage and mitigate the potential impacts of the GFD Project's wastes are outlined in Box 9. The residual risks that remain after the implementation of these measures was found to be very low to low.

Box 9 Waste management

Santos GLNG's management framework includes an established approach to managing waste associated with its activities that follows the waste management hierarchy. *Environment Hazard Standard EHS04 Waste* identifies the minimum acceptable performance standard for waste management processes and procedures, including waste generation, transportation, receiving, storage, recycling, treatment and/or disposal.

The standard follows a hierarchical approach that prioritises waste management strategies from the most preferable to least preferable as follows: avoid, reduce, reuse, recycle, recover; treat, and dispose. The *Waste management plan* details how these controls will be implemented for the GFD Project.

Other relevant management standards will also be used to manage wastes associated with the GFD Project's activities, including *Environment Hazard Standard EHS03 Produced (coal seam) water* and *Health and Safety Hazard Standard HSHS08 Chemical management*. In addition, the following plans will be implemented to manage the risks associated with waste for the GFD Project:

- *Constraints protocol*
- *Chemical and fuel management plan*
- *Coal seam water management strategy*
- *Decommissioning and abandonment management plan*
- *Erosion and sediment control management plan*
- *Land release management plan*
- *Pest and weed management.*

6.7 Surface water

The GFD Project is located across three catchments: the Dawson River catchment (located within the Fitzroy Basin), the Comet River catchment (located within the Fitzroy Basin) and the Condamine-Balonne River catchment (located within the Condamine-Balonne Basin). These catchments include watercourses, wetlands, springs and ecosystems dependent on groundwater. The GFD Project area and surface water study area sub-catchments are shown in Figure 6–1.

Watercourses in the GFD Project area are mostly ephemeral, meaning that they do not flow all year and generally only exist for short periods following rainfall. The exception to this is major watercourses such as the eastern portion of the Dawson River and parts of the Condamine River. A number of these water courses are recognised as having high ecological value under the *Environmental Protection Policy (Water) 2009* (Qld). These values which vary from low to high include:

- Aquatic ecosystems
- Irrigation
- Agriculture
- Stock water
- Aquaculture
- Human consumption
- Primary recreation
- Secondary recreation
- Visual appreciation
- Raw drinking water
- Industrial use
- Cultural and spiritual values.

In general, the following water uses are considered to be the most sensitive to human impacts within the GFD Project area:

- Livestock water
- Impound water (e.g. agricultural dams, emergency fire-fighting water supply)
- Domestic supply
- Water harvesting
- Industrial use
- Town water supply.

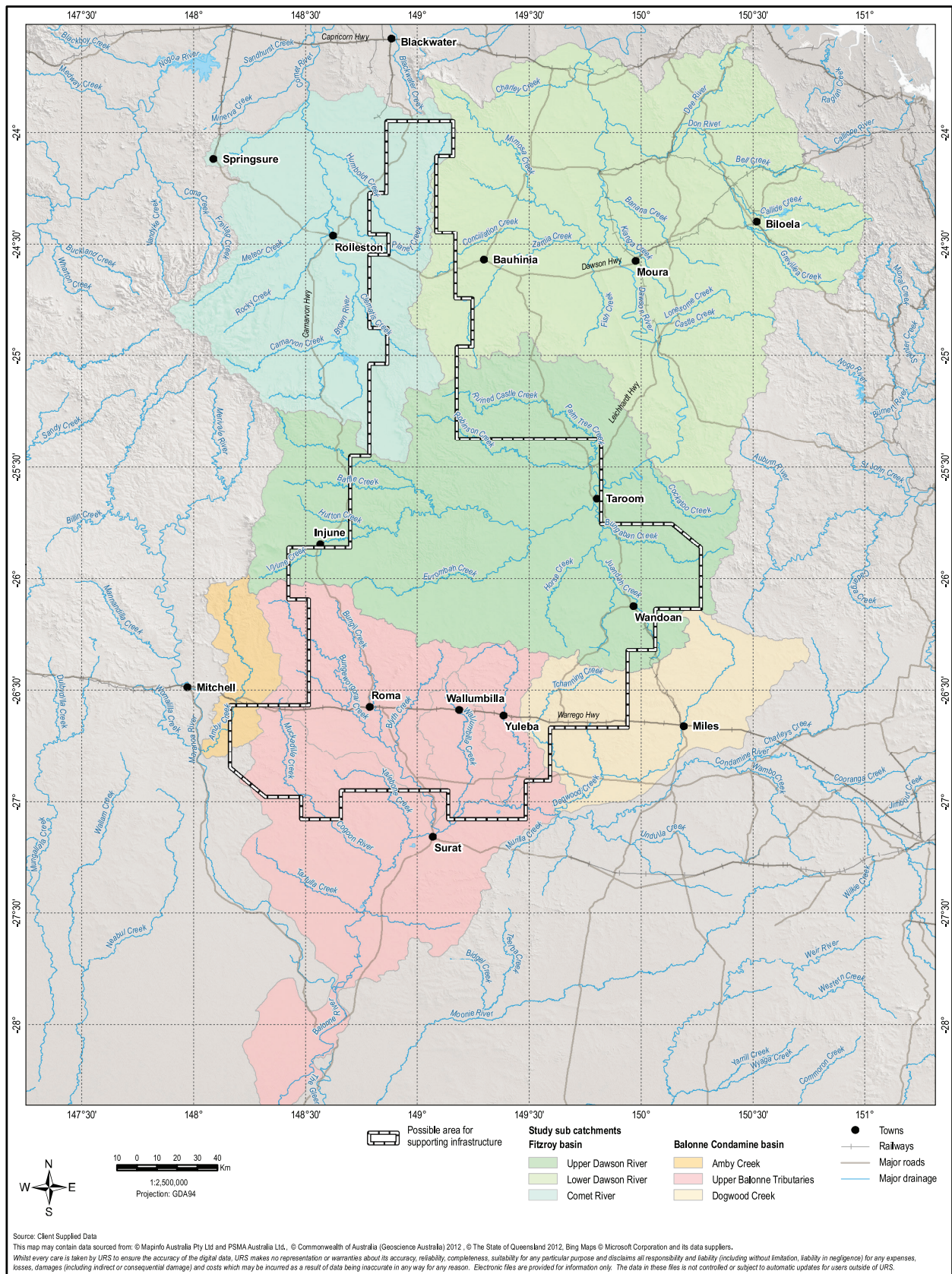
The surface water quality across the GFD Project area is varied. It is typical of a slightly to moderately disturbed environment with elevated heavy metals, ammonia and dissolved oxygen. Water is alkaline throughout the Comet and Upper Dawson River sub-catchments, neutral in the Upper Balonne River Tributaries and slightly acidic in Dogwood Creek. Electrical conductivity is highly variable with a clear relationship between low flow conditions and elevated electrical conductivity established across the GFD Project area.

Watercourses within the surface water study area exhibit a wide range of fluvial geomorphologic characteristics. Watercourses in the headwater catchments (i.e. where the water flow begins) are typically located in steep valleys. As the watercourses transition from steep headwater catchments, they typically become located in partially confined to unconfined valleys. Channels begin to show more lateral instability. Watercourses in the mid-catchment area show a higher level of impact from existing land use activities, such as vegetation clearance, grazing and cropping. The lower reaches of the sub-catchment watercourses are characterised by flat, low-relief terrain. Watercourses are located on broad alluvial floodplains and show a high degree of lateral instability.

Based on the fluvial geomorphology assessment, watercourses in the study area have the following characteristics:

- There is a range of flora and fauna that are dependent on the ephemeral watercourses.
- Stream banks along watercourses are strengthened by riparian vegetation (and associated habitat values for flora and fauna) and can influence and be influenced by stream flow hydraulics.
- Watercourses can be subject to periodic, high energy flood events that may cause rapid adjustments to channel morphology.

Figure 6–I GFD Project area and surface water study area sub-catchments



Potential surface water impacts that may occur as a result of the GFD Project include:

- Increased sedimentation within watercourses
- Decreased water quality due to increased erosion and related increase in suspended sediment load
- Decreased surface water quality due to increased concentrations of contaminants (i.e. adverse impact on surface water quality, primary and secondary toxicity to aquatic ecosystems)
- Altered surface water flow regime (i.e. risk to overland flow paths, riparian vegetation, terrestrial ecosystems, flow from watercourse springs/aquifers and environmental flow regimes)
- Altered geomorphic character (e.g. increased lateral instability, alteration of geomorphic units).

The potential impacts to surface water values were assessed according to the significance assessment methodology, which considers the sensitivity of the underlying environment and the magnitude of a potential impact to assess its level of significance.

The measures Santos GLNG will undertake to manage and mitigate the potential impacts to surface water values are outlined in Box 10. The significance of the residual impacts after the implementation of these measures is assessed as being low, except for a moderate significance applicable to surface water impact during construction and operations and altered surface water flows during construction.

Box 10 Managing potential surface water impacts

Santos GLNG is committed to managing potential impacts on surface water and has an established framework for avoiding, mitigating and managing these impacts. Santos GLNG will:

- Avoid impacts to wetlands of high ecological significance and wetlands of national importance and place a 200 meter buffer around these areas as per the *Constraints protocol*.
- Permit only low impact activities and activities associated with linear infrastructure within a 100 metre buffer of a water course as per the *Constraints protocol*.
- Manage and monitor potential adverse impacts to water resources through the *Water resource management plan*. This plan includes measures for ensuring that the quality of water (including coal seam water) generated via GFD Project activities is 'fit for purpose' and complies with relevant regulatory water quality requirements.
- Manage and minimise the risk of environmental harm being caused by the release of water to land by implementing the *Land release management plan*.
- Store and handle bulk chemicals, fuels and brine/solid salts in a way that minimises risk to the environment and human health as outlined in the *Chemical and fuel management plan*.
- Identify and control erosion and sediment risks as per the *Erosion and sediment control management plan*.
- Manage wastewater during the decommissioning phase and demolition activities by applying the *Decommissioning and abandonment management plan*.

In addition to this, Santos GLNG is committed to implementing a surface water monitoring program for the life of the GFD Project to assess the effectiveness of the management program.

6.8 Groundwater

Groundwater in the GFD Project area continues to be used extensively for stock, agricultural, domestic, town, and industry uses. Water is generally produced from a number of regional aquifers in the Great Artesian Basin (GAB) hydrogeological system and from locally important alluvial systems and volcanic rocks of the Surat Basin and the upper Bowen Basin. Water quality in most aquifers is generally fresh to brackish.

The Queensland Government has implemented a legislative regime to ensure the petroleum and gas industry develops in a responsible way. Under the regime, petroleum tenure holders have the right to extract groundwater in the process of petroleum and gas production, but are required to monitor and manage the impacts on springs and water supplies. This includes a requirement to 'make good' impairment of private bore supplies caused by the exercise of these rights.

Under this legislative regime, the Queensland Government (through the Office of Groundwater Impact Assessment (OGIA)) prepared the *Underground Water Impact Report (UWIR) for the Surat Cumulative Management Area (CMA)* (which includes the GFD Project area). The UWIR assessed the cumulative impacts of water extraction by oil and gas production on groundwater in the Surat CMA.

The assessment included numerical groundwater modelling to predict potential impacts of petroleum and gas production on groundwater pressure. This included the impacts of the currently approved Santos GLNG Project as well as the other approved coal seam gas projects in the Surat CMA. This assessment, which was undertaken in 2012, is referred to as 'the UWIR Scenario'. The OGIA ran the model again in 2013 and included the GFD Project and more development proposed by another proponent. This assessment is referred to as 'the EIS Scenario'.

The sensitive groundwater receptors in the GFD Project area are:

- Hydrogeological units used for domestic water supplies and stock watering, and to a lesser extent, agriculture, aquaculture and industrial purposes. Available data indicates that there are 872 registered landholder bores located within the GFD Project tenures.
- Springs, including spring vents (single point in the landscape where groundwater is discharged at the surface) and watercourse springs (a section of a watercourse where groundwater enters the stream through the streambed). There are 72 spring complexes (groups of spring vents located in close proximity to each) comprising 329 spring vents in the Surat CMA and 43 watercourse springs. There are 11 spring complexes (2 of which are matters of national environmental significance listed under the EPBC Act) and 11 watercourse springs in the GFD Project tenures.

The GFD Project tenures are located within the Comet and Dawson river sub-basins of the Fitzroy River Basin. The groundwater environmental values (EVs) adopted by the Queensland Government for these basins are summarised in Table 6–10.

A number of GFD Project activities have the potential to cause adverse impacts on the identified groundwater environmental values without adequate management controls in place.



Irrigation using treated water from coal seams.

Table 6–10 Environmental values of groundwater in the Comet, Dawson and Condamine-Balonne river basins

Environmental values	Comet River Sub-basin	Dawson River Sub-basin	Condamine-Balonne River Basin
Protection of aquatic ecosystem	✓	✓	✓
Secondary recreation (e.g. boating)*	✓	✓	✓
Visual (no contact) recreation*	✓	✓	✓
Drinking water supplies	✓	✓	✓
Crop irrigation	✓	✓	✓
Stock watering	✓	✓	✓
Farm supply/use	✓	✓	✓
Aquaculture (e.g. red claw, barramundi)	✓	✓	✓
Human consumers of aquatic food	✓	✓	✓
Industrial use (including manufacturing plants, power generation)	✓	✓	✓
Protection of cultural and spiritual activities	✓	✓	✓

*Primary, secondary and visual recreation contact have been included as EVs for groundwater due to groundwater contributions to surface water baseflow in some tenements.

The extraction of groundwater is an integral part of the production of gas from coal seams and has the potential to result in aquifer depressurisation and drawdown. Depressurisation is a reduction in groundwater pore pressure (pressure head) in a confined groundwater system due to extraction of groundwater. Drawdown is the change in groundwater level in a bore, or the change in water table elevation in an unconfined groundwater system, due to the extraction of groundwater.

The 2012 UWIR predicted that 528 landholder bores would be cumulatively impacted (potentially reducing supply to users) due to petroleum and gas development in Surat CMA under the UWIR Scenario. Under the EIS Scenario, an additional 73 private water bores in the Surat CMA, 48 of which are in the GFD Project tenures, are predicted to be impacted.

Of these 48, investigations have revealed:

- 66% (32) were observed to be in use by the landholder
- 23% (11) could not be located by the landholder; or else were not in use or were abandoned
- 10% (5) of private water bores have not yet been surveyed.

There are 45 spring complexes and 33 watercourse springs located within the Surat CMA that have been recognised as springs of interest. Modelling has shown that there is a risk of impact to 13 spring complexes (potentially affecting groundwater dependent ecosystems) and 19 watercourse springs (potentially reducing supply to downstream surface water users and/or aquatic ecosystems) under the EIS scenario. Among these, 8 spring complexes and 12 watercourse springs are located within or near GFD Project tenures.

Without adequate controls in place, other potential impacts from the GFD Project activities include:

- Subsidence caused by coal seam depressurisation resulting in ground surface displacement and altering surface water flow paths. However, modelling has predicted negligible impacts with maximum differential settlements at the surface of 0.06 m over a distance of 1.5 km for the Roma gas field, and 0.045 m over a distance of 3 km for the Arcadia and Fairview gas fields.
- Subsidence caused by coal seam depressurisation altering groundwater flow and aquifer storage.
- Gas wells will intersect multiple hydrogeological units and, although the likelihood is considered remote, there is the potential for localised depressurisation of aquifers to occur through creating a connection between previously isolated aquifers.
- A number of GFD Project activities have the potential to impact groundwater quality. These activities include:
 - Drilling and construction of wells
 - Extraction of groundwater for gas production
 - Hydraulic fracturing
 - Management of coal seam water
 - Brine management and injection
 - Beneficial use for irrigation or stock watering
 - Managed aquifer recharge
 - Shallow subsurface activities (e.g. borrow pits, buried pipelines and storage dams).
- Groundwater quality impacts from the above project activities can result in:
 - Degradation of the beneficial use of groundwater supplies
 - Loss or degradation of springs or other groundwater dependent ecosystems.

These potential impacts were assessed using quantitative and qualitative methodologies. The quantitative assessment was the modelling of the aquifer depressurisation impacts described above. Other impacts to groundwater values have been assessed qualitatively using the significance assessment methodology which considers the sensitivity of the underlying environment and the magnitude of a potential impact to assess its level of significance.

The measures Santos GLNG will undertake to manage and mitigate the potential impacts to groundwater values are outlined in Box 11.

The quantitative assessment of cumulative depressurisation impacts determined that the significance of the residual impacts after implementation of the management and mitigation measures was high for matters of national environmental significance springs (due to the high probability and duration of the impact and their high environmental sensitivity) and moderate for bores.

A separate significance assessment determined that the significance of the residual impacts after the implementation of the management and mitigation measures to be low, except for a moderate significance applicable to effects on groundwater dependent ecosystems fed by springs from aquifers affected by depressurisation or reduced water quality and to subsidence altering groundwater flow paths and aquifer storage during operations.

With the application of the management framework, the significance of the residual groundwater impacts of the GFD Project was found to be low to moderate. In addition, the numerical groundwater model used to assess the operation of production wells for the GFD Project combined with those of the other gas projects in the region found the significance of the cumulative depressurisation impacts to be high for springs (due to the high probability and duration of the impact and their high environmental sensitivity) and moderate for bores.



Reverse osmosis facility.

Santos GLNG is committed to managing potential impacts on groundwater and has an established framework for avoiding, mitigating and managing these impacts. Santos GLNG will:

- Apply the *Constraints protocol* to avoid or restrict development that may impact on springs.
- Comply with the commitments made in the UWIR for the Surat CMA, which include the completion of bore assessments and make good agreements with specified landholders, completion of baseline assessments of landholder bores, development of spring impact mitigation strategies, and undertaking groundwater and spring monitoring.
- Implement the commitments of the *Joint industry plan for the monitoring and protection of the EPBC springs*, which provides an early warning system and response plan for springs protected by the EPBC Act.
- Implement the *Coal seam water management strategy* to prioritise the beneficial use of coal seam water where practicable, while avoiding, minimising and mitigating environmental impacts.
- Implement the *Water resource management plan* to proactively manage and monitor potential adverse impacts to groundwater resources including springs and springs complexes. This plan specifically addresses how Santos GLNG will manage water resources across the life of the GFD Project. It includes the *Joint industry plan for the monitoring and protection of the EPBC springs*, which requires specialised studies on the GFD Project area and Santos GLNG activities that may impact groundwater including hydraulic fracturing and stimulation.
- Apply the hydraulic fracturing risk assessment to any fracturing fluids proposed to be used for the GFD Project.
- Implement the *Chemical and fuel management plan* to ensure the appropriate storage and handling practices of chemicals and fuels to minimise the risk of groundwater contamination.
- Construct all wells and bores to be in accordance with the *Code of practice for constructing and abandoning gas wells and associated bores in Queensland* (DNRM, 2013) and the *Code of practice for gas well head emissions detection and reporting* (DEEDI, 2011).
- Implement the monitoring program in accordance with the requirements of the environmental authority, the *Draft environmental management plan* and the *Water resource management plan*.

6.9 Air quality

Air quality that is conducive to human health, agricultural production and land use amenity is defined through the *Environmental Protection (Air) Policy 2008* (Qld). This policy stipulates air quality guidelines for a number of pollutants including nitrogen dioxide (NO₂), carbon monoxide (CO), and particulate matters (PM₁₀ and PM_{2.5}). The guidelines generally apply at the locations of sensitive receptors. The sensitive receptors that are expected to be relevant to the GFD Project are scattered rural dwellings, agricultural land and protected areas.

The air environment within the GFD Project area is predominantly influenced by dust from traffic on unsealed roads, wind erosion of bare soils from agricultural and resources activities, dust storms, and emissions from industrial activities such as power generation, quarries and resources projects. The background eight hour average CO and NO₂ concentrations are predicted to be well below guideline levels across the GFD Project area.

The activities associated with the air emission from the GFD Project are similar to those activities currently approved within the Arcadia, Fairview, Roma and Scotia gas fields. The GFD Project will result in an incremental increase in the quantity and geographical spread of such emissions. Potential impacts that may occur as a result of air emissions from the GFD Project are outlined in Table 6–11.

A qualitative assessment of potential impacts from dust emissions during construction, decommissioning and rehabilitation activities was undertaken. Dust emissions are primarily associated with the construction phase, and will reduce dramatically during operations. Minimal dust may occur during rehabilitation. The locations of the GFD Project's surface facilities will be selected in accordance with the *Constraints protocol*. Through this process, appropriate separation distances will be maintained between surface infrastructure and identified sensitive receptors to minimise impacts. Based on previous experience, it is considered that an appropriate separation distance is approximately 500 m. Where construction, decommissioning or rehabilitation activities are undertaken greater than 500 m from receptors, the risk of impacts from dust emissions is considered to be very low.

During operations, the major sources of air emissions will be from the hub and nodal gas compression facilities particularly where these facilities are not electrified. Modelling has predicted that the maximum downwind NO₂ concentrations will be below the relevant guidelines and will return to background levels within approximately 500 m of a non-electrified hub gas compression facility. An electrified facility is predicted to have around 75% less emissions and in turn 75% less NO₂ concentrations. Maximum downwind concentrations of NO₂ from a nodal gas compression facility will also be well below guideline values, but will not reach background levels until approximately 4 km because the emissions, although less than for the hub compression facility, have lower exit velocities.

Emissions of CO for a hub gas compression facility were also modelled to provide estimates of potential maximum downwind concentrations. This modelling showed that under worst case meteorological conditions, the eight-hour CO concentrations predicted downwind of the facility are far below the relevant guideline (less than 2%) and would not result in a significant increase above existing background levels.

Other sources of air emissions associated with the GFD Project operations phase such as vehicle movements, small gas-fired engines at wellheads, flaring at exploration wells etc., have a low potential for air quality impacts.

A compliance assessment methodology, which is used where compliance with a known guideline or standard is required, was used for air quality. The assessment concluded that where construction, demolition and rehabilitation works take place greater than 500 m from receptors, potential dust impacts will generally be low and compliant with the adopted air quality assessment objectives and unlikely to require specific mitigation and management. The assessment also concluded that maximum downwind NO₂ and CO concentrations from gas compression activities under normal operations and during flaring (commissioning and emergency) would comply with the relevant guidelines and will not require specific mitigation measures. Potential impacts on regional air quality are expected to be minimal with the GFD Project operations not a significant source contribution to regional NO₂ levels.

To further minimise the potential for air quality impacts at sensitive receptors, Santos GLNG will implement the management framework outlined in Box 12.

Table 6–11 Potential impacts to air quality environmental values

Environmental value	Potential impact
Health and wellbeing	Air emissions from the GFD Project contribute to an exceedance of one or more of the air quality objectives for NO ₂ , CO, PM ₁₀ or PM _{2.5} .
Health and biodiversity of ecosystems	Air emissions from the GFD Project contribute to an exceedance of the air quality objectives for NO ₂ .
Regional air quality	Acid deposition or acid rain caused by concentrations of SO _x or NO _x .
	Formation of photochemical smog caused by reaction of Volatile Organic Compounds

Box 12 Managing potential air quality impacts

The approach used to assess the potential impacts has been to model representative worst case and typical surface facilities. This allows Santos GLNG to identify any exceedances of compliance criteria and provide information on mitigation strategies such as separation distances from sensitive receptors, stack heights and/or emission exit velocities. As preferred locations for individual facilities are identified through the ongoing field development process, and details of the required size and number of engines and other fuel-burning equipment become known, more detailed modelling will be performed to enable a further refinement of any necessary mitigation measures (if relevant).

Santos GLNG has an established framework for planning and scheduling activities to manage and minimise air quality impacts. This framework revolves around the controls outlined in *Environment Hazard Standard EHS05 Air emissions*. In addition, the GFD Project will apply the following mitigation measures for air quality:

- Potential air emissions will be considered during planning of operations and activities. Appropriate internal and/or external environmental approvals will be obtained prior to construction for proposed activities that have potential to create air emissions.
- Operations, facilities and work activities will be conducted in a manner that minimises potential for pollution of air by release of emissions and in accordance with relevant environmental approvals, environmental authorities and management plans.
- Protocols and management plans to be implemented include:
 - Constraints protocol
 - Erosion and sediment control management plan
 - Chemical and fuel management plan
 - Chemical and fuel management plan
 - Decommissioning and abandonment management plan
 - Road-use management plan.

Monitoring of air emissions will be performed in accordance with the *Draft environmental management plan*. This will include monitoring in accordance with regulatory requirements.

6.10 Greenhouse gases

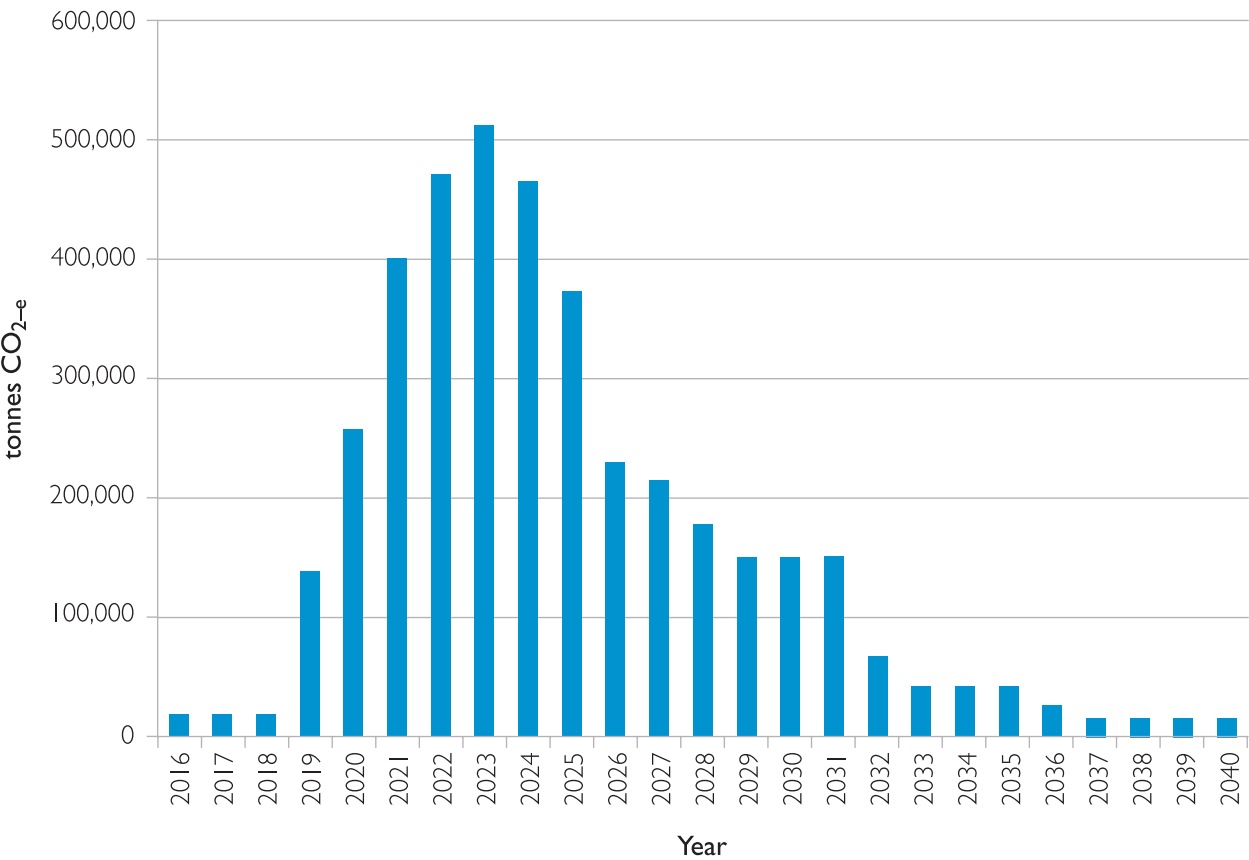
Global energy demand is expected to increase by 33% from 2010 to 2035 (International Energy Agency, 2011). Lower carbon energy sources such as natural gas and renewables can fuel this growth and reduce relative global greenhouse gas (GHG) emissions.

Santos GLNG's GHG emissions were addressed in the 2009 EIS and 2010 supplementary EIS for the GLNG Project. This assessment gave consideration to GHG emissions from the gas fields, pipelines, LNG facility on Curtis Island, shipping and product end-use associated with the GLNG Project. It estimated that the total annual GHG emissions would be up to 7.2 million tonnes of carbon dioxide equivalent (MtCO₂e). This total was based on the amount of gas necessary for the LNG facility to produce 10 Mt per annum of LNG. The estimated emissions were based on the volume of gas required to supply the LNG facility, rather than the number of wells required. Therefore, the GHG emissions associated with the operation of the GFD Project's production wells have already been accounted for in the 2009 EIS and the 2010 supplementary EIS.

While the GHG emissions from the operation of the GFD Project's wells has already been included in the previous EIS estimates, emissions from the construction and decommissioning of the GFD Project's production wells were not. These incremental GHG emissions will be generated by land clearing, fuel use for drilling and vehicles associated with construction, flaring from well completion and connection activities, and fuel use for decommissioning. Emissions from these sources are dependent on the number of wells constructed.

Figure 6–2 shows the lifetime incremental (construction) annual GHG emissions for the GFD Project over and above those already reported in the 2009 EIS and 2010 supplementary EIS.

Figure 6–2 GFD Project incremental annual greenhouse gas emissions (construction)



The incremental impact of the GHG emissions from the GFD Project has been assessed in terms of national and global emissions and its relative contribution to energy markets. Table 6–12 shows the annual total and incremental emissions from the GFD Project as a percentage of Australia's and Queensland's GHG emissions. The GFD Project emissions are based on the year of maximum emissions (2029) whereas the emissions for Australia and Queensland represent those from 2010/11.

Fugitive emissions

Fugitive emissions are minor intentional or unintentional GHG releases that occur during natural gas exploration, production and processing. Based on Santos Limited's reported 2011/12 emissions, minor unintentional releases are approximately 0.3% of total upstream emissions or 0.04% of total lifecycle emissions. Santos GLNG has a demonstrated commitment to understanding and managing fugitive emissions as outlined in Box 14.

Table 6–12 GFD Project emissions comparison to 2010/11 emissions

Sector	2010/11 emissions (million tonnes of carbon dioxide equivalent) ¹	Total GFD Project emissions as a percentage of the sector ² (%)	Incremental GFD Project emissions as a percentage of the sector ³ (%)
Queensland energy sector	99.5	2.4	0.16
Total Queensland	155.5	1.5	0.10
Australian energy sector	422.0	0.6	0.04
Total Australia	563.1	0.4	0.03

¹ Source: Adapted from Department of Climate Change and Energy Efficiency, 2013.

² Operations emissions for the 50% electrification scenario in 2029 already reported in the 2009 EIS and 2010 supplementary EIS plus the incremental emissions.

³ Construction and decommissioning emissions in 2029 not included in the 2009 EIS and 2010 supplementary EIS.

Box 13 Managing greenhouse gas emissions

Santos GLNG has a corporate climate change policy, which reflects a commitment to energy efficiency and reducing emissions across its operations, including the GFD Project. This policy includes commitments to:

- Continue to reduce the carbon intensity of its products by focusing on energy efficiency, technology development and embedding a carbon price in all activities
- Use energy more efficiently by identifying opportunities to implement energy efficiency projects and report their progress
- Examine the commercial development of low emission technologies, including storage solutions, which will contribute towards long-term emission reduction targets
- Pursue no flaring or venting of associated gas, unless there are no feasible alternatives
- Continue to publicly disclose GHG emissions profile and carefully examine forecast emissions
- Understand, manage and monitor climate change risk and develop appropriate adaptation strategies for Santos GLNG activities
- Assist governments and engage with other stakeholders on the design of effective and equitable climate change regulations and policy.

Santos Limited is taking a lead role in Australia to ensure that independent studies clarify the emissions from the coal seam gas industry by:

- Collaborating with other coal seam gas operators and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in a study to measure fugitive emissions from a sample of operations well leases throughout Queensland. To read the study, go to <http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/publications/csg-fugitive-emissions>.
- Assisting CSIRO to measure seepage and migration of natural gas from disbanded exploration wells and seeps that may occur naturally.
- Working with the University of Adelaide to establish the methodology and standard operating procedure to assess baseline emissions.

6.11 Noise and vibration

The existing acoustic environment of the GFD Project area is largely typical of a rural environment with low background noise levels that reduce during the evening and night time when bird, insect and road traffic activity is negligible. Existing ambient ground vibrations from industry, construction and heavy transport corridors are generally not perceptible at the majority of sensitive receptors, except at locations near mines and quarries.

The environmental values defined in the *Environmental Protection (Noise) Policy 2008* (EPP Noise) (Qld) aim to preserve or enhance qualities of the acoustic environment that protect human health and wellbeing (i.e. by ensuring suitable environments to sleep, study, learn, be involved in recreation, relaxation and conversation, and protect the amenity of the community), as well as the health and biodiversity of ecosystems.

Typical noise sources during construction would be activities associated with land clearing and earthworks, well drilling and completion, construction of gas compression and water treatment facilities, road and pipeline construction, and construction traffic. Operations noise sources will include compression facilities (both electrified and non-electrified), production wells, accommodation facilities and road traffic. Noise sources during decommissioning would be similar to those during operations.

Noise impacts were assessed using the compliance assessment methodology, which is used where compliance with a known guideline or criteria is required. The relevant criteria for noise are set out in the *Petroleum and Gas Noise Assessment guideline* (EHP, 2012) and have been adopted to achieve the acoustic quality objectives in the EPP Noise. Modelling was used to estimate the distances at which noise from typical GFD Project noise sources would comply with the criteria at sensitive receptors during the construction, operations and decommissioning phases.

Potential noise impacts could occur when the criteria are exceeded. They can be expected when the noise sensitive receptor is located closer to the noise source than the distance at which the relevant criterion is met without noise management or mitigation measures. The potential noise impacts on the environmental values that may occur as a result of the GFD Project are outlined in Table 6–13.

Noise modelling was undertaken to assess where noise emissions from the GFD Project may exceed acoustic criteria outlined within EPP Noise and other guidelines. The model and the values discussed in this EIS were established from baseline surveys conducted in 2008 as part of the EIS for the GLNG Project and in 2009 as part of the EIS for the Australia Pacific LNG Project (Savery and Associates, 2009).

Table 6–13 Potential noise impacts

Environmental value	Potential impact
Health and wellbeing	Noise and vibration emissions from the GFD Project could contribute to an exceedance of noise criteria, which may result in annoyance, stress, sleep disturbance and reduced wellbeing.
Fauna health and wellbeing	Noise emissions from the GFD Project could contribute to an exceedance of noise emissions greater than 65 dBA LAeq potentially disturbing native fauna.
Property	Vibration emissions from the GFD Project could contribute to an exceedance of vibration criteria, which may result in cosmetic damage.

The modelling indicates that the highest noise levels from the GFD Project will occur during construction and are associated with drilling activities. During operations, the highest noise levels associated will be emitted from hub gas compression facilities.

An assessment of the noise generated by the GFD Project's predicted traffic was also undertaken. Based on estimates of the GFD Project's traffic and existing traffic under the maximum development scenario, the noise criterion will be met on state-controlled roads as well as on council-controlled roads and access roads. The modelling has shown that an increase in traffic volumes of up to approximately 50% would meet the incremental change noise criterion for existing council-controlled roads.

There are no significant vibrations generated by the GFD Project and no significant impacts are expected.

This noise and vibration assessment has established the potential for noise impacts at various propagation distances associated with the major project activities and noise generating infrastructure. This information will be incorporated into the planning process for the GFD Project so that GFD Project's noise sources are located at distances from noise sensitive receptors, which are greater than those at which the relevant noise criteria will be met. If a risk of noise impact at a sensitive receptor above the relevant criteria is identified during planning and the separation distance cannot be increased, mitigation activities such as detailed modelling and/or physical, engineering or other mitigation controls will be implemented in consultation with the landholder. Noise management measures to be implemented for the GFD Project are summarised in Box 15.

Box 15 Managing potential noise impacts

Santos GLNG's management framework provides a range of mechanisms including the Constraints protocol, *Environment Hazard Standard EHS12 Noise emissions* and the *Noise management plan* for managing noise that may impact on the surrounding environment.

These standards and plans provide a framework for Santos GLNG to:

- Minimise noise emissions from Santos GLNG assets and activities
- Locate noise sources at distances from noise sensitive receptors that are sufficient to ensure that noise criteria are met
- Engage stakeholders including landholders and local communities in assisting Santos GLNG in the identification and management of noise emissions
- Monitor noise and take any necessary corrective action to ensure compliance with the applicable environmental authority noise limits when triggered by a noise complaint.

6.12 Terrestrial ecology

The GFD Project area is situated in the Brigalow Belt bioregion, which has experienced a long history of human disturbance mainly as a result of agricultural practices. As a result, at a regional level, most remaining areas of vegetation are now fragmented, occurring on the rockier hilly areas of ranges, as roadside vegetation, or as relatively small isolated remnants.

To establish the existing environmental values of the terrestrial ecology within the GFD Project terrestrial ecology study area (defined as the GFD Project area plus a 25 km buffer), information was compiled from desktop studies, aerial photographic surveys, predictive habitat modelling, targeted field surveys, the GLNG Project EIS (2009 EIS) and previous ecology surveys. The overall survey effort for the terrestrial ecology study area equates to over 1,700 days and has incorporated seasonal variations.

The GFD Project gas fields contains Category A, B and C environmentally sensitive areas as defined under the *Environmental Protection Act 1994* (Qld). The Category A areas are Expedition National Park, Humboldt National Park, Luke Murphy Conservation Park and the Carraba Conservation Park. The Category B environmentally sensitive areas include 'endangered' regional ecosystems (REs) and state forests are present as Category C environmentally sensitive areas.

The majority of the area of the GFD Project gas fields contains non-remnant vegetation. However, there are some extensive areas of remnant REs mapped (approximately 315,610 ha). There are 42 'endangered' and 53 'of concern' RE communities present. The most prevalent REs are:

- RE 11.3.2 (*Eucalyptus populnea* woodland on alluvial plains)
- RE 11.3.25 (*Eucalyptus tereticornis* or *Eucalyptus. camaldulensis* woodland fringing drainage lines)
- RE 11.9.5 (*Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks)
- RE 11.9.10 (*Eucalyptus populnea*, *Acacia harpophylla* open forest on fine-grained sedimentary rocks).

There are 79 conservation significant flora species that have been identified to potentially occur within the terrestrial ecology study area. Seventy-four of these are known to occur. Nine of these have been recorded during Santos GLNG Project's field assessments. Additionally, essential habitat for ten conservation significant flora species have been mapped in the

GFD Project terrestrial ecology study area and nine priority taxa flora species for the Brigalow Belt South bioregion (not listed in the EPBC Act and/or the *Nature Conservation Act 1992* (Qld) (NC Act)) are known to be present in the GFD Project gas fields.

Patches of 'endangered', 'of concern' and 'least concern' high value regrowth are also present throughout the GFD Project area.

There are 48 conservation significant fauna species that have been identified to potentially occur in the terrestrial ecology study area. Thirty-three of these are known to occur. The gas fields contain essential habitat for eight conservation significant fauna species, including the large-eared pied bat (*Chalinolobus dwyeri*), collared delma (*Delma torquata*), squatter pigeon (*Geophaps scripta*), Brigalow scaly-foot (*Paradelma orientalis*), Yakka skink (*Egernia rugosa*), Painted honeyeater (*Grantiella picta*), Imperial hairstreak (*Jalmenus eubulus*), and Greater long-eared bat (*Nyctophilus corbeni*).

Further information on terrestrial ecology aspects that relate to matters of national environmental significance are provided in Section 6.14.

Eight introduced flora species declared as pests were identified in the terrestrial ecology study area. The most abundant of these are *Lycium ferocissimum* (African boxthorn) and *Opuntia stricta* (Prickly pear). In addition, seven introduced fauna species declared as pests were identified in the terrestrial ecology study area.

The environmental values for terrestrial ecological identified for the GFD Project are:

- Endangered vegetation
- Of concern vegetation
- Essential habitat
- Conservation significant flora and fauna species
- Wetlands
- Category A, B and C environmentally sensitive areas
- EPBC Act Threatened ecological communities
- EPBC Act threatened and migratory fauna species
- EPBC Act threatened flora species.

Potential impacts to terrestrial ecology, environmentally sensitive areas and matters of national environmental significance that may occur as a result of the GFD Project include:

- Habitat loss from vegetation clearing/removal
- Fauna species injury or mortality from project activities
- Reduction in soil viability to support plant growth due to soil compaction
- Displacement of flora and fauna species by weed and pest species
- Reduction in the connectivity of biodiversity corridors
- Edge effects to habitat (e.g. weed invasion and reduction of biodiversity)
- Habitat fragmentation from vegetation clearing
- Barrier effects (e.g. loss of species' migration pathways)
- Disturbance to fauna and flora from noise, dust, and light

- Degradation of habitat from an increase in litter (waste).

The potential impacts to terrestrial ecology values were assessed according to the significance assessment methodology, which considers the sensitivity of the underlying environment and the magnitude of a potential impact to assess its level of significance.

The measures Santos GLNG will undertake to manage and mitigate the potential impacts to terrestrial ecology are outlined in Box 16. The significance of the residual impacts after the implementation of these measures was assessed as ranging from negligible to high.

The high significance residual impacts relate to construction phase clearing of any of the following:

- EPBC Act threatened flora or fauna species habitat
- Threatened ecological communities (Coolabah, Weeping myall, Semi-evergreen vine thicket)
- State forest and timber reserves
- High value regrowth flora
- Of concern REs or high value regrowth vegetation.

Box 16 Managing potential terrestrial ecology impacts

Santos GLNG has an established environmental management framework that has been proven to be effective in managing impacts on terrestrial flora and fauna. Santos GLNG is committed to implementing the following mitigation measures to manage potential terrestrial ecology, environmentally sensitive areas and matters of national environmental significance-related impacts:

- Apply the *Constraints protocol* to avoid impacts through restricting Santos GLNG activities in environmentally sensitive areas.
- Implement the following management plans:
 - *Decommissioning and abandonment management plan*
 - *Draft environmental management plan*
 - *Fauna management plan*
 - *Pest and weed management plan*
 - *Rehabilitation management plan*
 - *Significant species management plan.*
- Implement the Santos GLNG *Offset strategy* to offset residual adverse impacts in accordance with regulatory requirements.

6.13 Aquatic ecology

The GFD Project area is located across three catchments: the Dawson River catchment, the Comet River catchment, and the Condamine-Balonne River catchment. Aquatic habitats in the GFD Project area include watercourses, wetlands, springs and groundwater ecosystems.

Watercourses in the GFD Project area are mostly ephemeral, meaning that they do not flow all year and generally only exist for short periods following rainfall. Exceptions to this are the major watercourses such as the eastern portion of the Dawson River and parts of the Condamine River.

The aquatic habitat condition of waterways and wetlands in the GFD Project area has been assessed in the *State of the Rivers* surveys completed in the region. Numerous EIS studies and other monitoring programs (including those by Santos GLNG) have been undertaken in the region, as well as seasonal river health assessments of the Upper Dawson River. Additional field surveys were undertaken within the GFD Project area for this EIS, with a specific focus on the critically endangered Boggomoss snail.

The majority of watercourses within the GFD Project area are in a moderate to poor ecological condition. The decline of ecological conditions is a result of impacts associated with historic vegetation clearing, cattle grazing, river flow regulation and watercourse crossings for roads and other linear infrastructure.

Despite these impacts, watercourses in the GFD Project area continue to provide habitat for aquatic biota that is representative of the wider regional area, including aquatic plants, macroinvertebrates, fish, turtles and platypus.

Wetlands, deep watercourse pools and springs in the GFD Project area provide permanent aquatic habitat. The aquatic plants salt pipewort and artesian milfoil (both endangered) have been recorded at springs in the Dawson River catchment. The critically endangered Boggomoss snail was not identified within the study area, although it is known to occur within the Dawson River and Boggomoss Springs complex downstream of Taroom (Stanisic, 1996; BAAM, 2009; SKM, 2009; JKR, 2010).

Many wetlands and springs have been impacted by clearing, modification of drainage patterns, and cattle access; although some of these sensitive ecosystems are in good ecological condition and provide habitat for conservation significant species.

Watercourses, native aquatic flora and fauna occur in each of the tenements of the GFD Project. The distribution of the aquatic habitats across the GFD Project tenure is presented in Table 6–14.

Potential impacts to the aquatic environmental values that may result from construction, operations and decommissioning activities of the GFD Project include:

- Contamination (sediment) to water – may temporarily increase turbidity levels in the vicinity of the contamination source and downstream as the plume disperses
- Contamination (pollutants) to water – may temporarily increase toxicity (depending on the properties of the pollutant and rate of processes such as biodegradation) in the vicinity of the source and downstream as the plume disperses
- Altered flow regime – may disrupt seasonal patterns affecting dependent riparian vegetation and fauna, resulting in changes to species diversity
- Disturbance of stream channel and associated habitat (e.g. pools, riffles, etc.) – localised change may occur however change can generally be reversed by natural flows over time
- Loss of abundance and diversity of riparian vegetation and aquatic biota including groundwater dependent ecosystems – generally localised impact which may be long-term due to time required to restore pre-disturbance species composition/abundance.

The potential impacts to aquatic ecology values were assessed according to the significance assessment methodology, which considers the sensitivity of the underlying environment and the magnitude of a potential impact to assess its level of significance.

The measures Santos GLNG will undertake to manage and mitigate the potential impacts to aquatic ecology values are outlined in Box 17. The significance of the residual impacts after the implementation of these measures is assessed as being generally low. However, the residual impacts of contamination (pollutants) to water and the loss of abundance and diversity of riparian vegetation and aquatic biota during the construction phase have been assessed as moderate.

Table 6–14 Presence of aquatic environmental values per GFD Project tenure

Environmental values	Dawson River	Comet River	Condamine – Balonne River	Description
Aquatic habitat				
Wetlands	✓	✓	✓	Wetlands provide intermittent to perennial aquatic habitat and provide refugia for aquatic fauna. The Dawson River catchment is mapped as having high ecological value (referrable) wetlands in the Great Barrier Reef catchment – Lake Murphy Conservation Area. These wetlands contain species and regional ecosystems (REs) of conservation significance under both the EPBC Act and the NC Act. Wetlands within the Condamine-Balonne River catchment are classified as being of moderate conservation value although several wetlands near Roma are of high conservation value (DERM, 2011). The conservation value of wetlands in the Comet River catchment ranges from very low to very high although the majority are of moderate conservation value (DERM, 2009).
Springs	✓	✓	✓	Springs provide intermittent to perennial aquatic habitat. The Dawson River catchment includes eleven spring complexes within GFD Project gas fields. Of these, only two are considered part of an EPBC threatened ecological community (TEC). The EPBC Act-listed aquatic plant salt pipewort (<i>Eriocaulon carsonii</i>) has been recorded at the Lucky Last complex and the nearby Abyss complex (592) (Fensham et al., 2011). The presence of an EPBC Act-listed plant species does not necessarily mean the spring is part of the EPBC TEC. Ratings of spring condition vary within the catchment from very good to very poor. Livestock impacts are the main factor affecting condition ratings (Fensham et al., 2004). The Comet River catchment includes two spring complexes within the GFD Project gas fields. Neither complex corresponds to the EPBC Act-listed TEC. The Condamine-Balonne River catchment includes a single spring complex in the GFD Project gas fields. This complex does not support the EPBC listed TEC. Fensham et al. (2011) note that these spring wetlands have been destroyed by impoundment or excavation and therefore have been given a very low conservation rank.

Table 6–14 Presence of aquatic environmental values per GFD Project tenure continued

Environmental values	Dawson River	Comet River	Condamine – Balonne River	Description
Riverine regional ecosystems (RE)	✓	✗	✓	Riverine regional ecosystems within the Dawson River catchment are present on the following Santos GLNG tenures: • ATP 803 • ATP 868 • ATP 655. Riverine regional ecosystems within the Condamine-Balonne River are present on the following Santos GLNG tenures: • ATP 665 • PL 10 • ATP 708.
Waterholes	✗	✓	✓	Waterholes provide refugia for aquatic fauna.
Aquatic flora				
Listed threatened species	✓	✗	✓	Several aquatic flora species recorded in the catchments are listed under the EPBC Act and <i>Nature Conservation (Wildlife) Regulation</i>. Emergent aquatic plants are the most common form although submerged and floating species are also known from waterways near the GFD Project area. It is possible that the endangered salt pipewort (<i>Eriocaulon carsonii</i>) occurs in or near tenements in the Comet River catchment.
Non-indigenous species	✓	✓	✓	Non-indigenous species are those living in an area where they are not naturally found. A non-indigenous species can be a native Australian species or a non-native species (i.e. exotic).
Aquatic fauna				
Macro-invertebrates	✓	✓	✓	Macroinvertebrate richness was generally found to be higher in edge habitat than bed habitat. Plecoptera, Ephemeroptera and Tricoptera (PET) richness ranged from 0 to 4 at most locations and was generally indicative of poor to moderate habitat and water quality at the locations surveyed. Non-biting and phantom midge larvae (sub-family Chironominae, Tanypodinae and Chaoboridae), diving beetles (family Dytiscidae) and water bugs (family Corixidae) dominated the macroinvertebrate communities in Dawson River catchment (FRC Environmental, 2009b). Macrocrustaceans such as freshwater shrimp (family Atyidae), the freshwater prawn (<i>Macrobrachium australiense</i>) and the freshwater yabby (<i>Cherax destructor</i>) are known in the three catchments.

Table 6–14 Presence of aquatic environmental values per GFD Project tenure continued

Environmental values	Dawson River	Comet River	Condamine – Balonne River	Description
Fish – Listed threatened species	✗	✗	✓	Murray cod (<i>Maccullochella peelii peelii</i>) is listed as vulnerable under the EPBC Act.
Fish – Non-indigenous species	✓	✓	✓	Common carp (<i>Cyprinus carpio</i>) (Condamine-Balonne River catchment) and Mosquito fish (<i>Gambusia spp</i>) (all catchments) are declared noxious species under the <i>Fisheries Regulation 2008</i> (Qld).
Turtles	✓	✓	✓	The Fitzroy River Basin has a high conservation value with respect to freshwater turtles as there are many species endemic to the region. Six species have been recorded in the Fitzroy River Basin including the Fitzroy River turtle (<i>Rheodytes leukops</i>), which is a conservation significant species listed under the EPBC Act. Fitzroy River turtles were not recorded in the 2009 EIS surveys or subsequent surveys of the gas transmission pipeline (FRC Environmental, 2009a, 2012b).
Platypus	✓	✗	✗	Platypus (<i>Ornithorhynchus anatinus</i>) have been recorded in the region. However, no evidence of platypus was observed in the recent EIS surveys undertaken in the region and it is unlikely that they would inhabit ephemeral streams in the area. Platypus are present in Hutton Creek, a tributary of the Dawson River.
Boggomoss snail	✗	✗	✗	The Boggomoss Springs, which are located on the Dawson River downstream of the GFD Project area, support the EPBC Act critically endangered Boggomoss snail (<i>Adclarkia dawsonensis</i>). Extensive targeted surveys for the Boggomoss snail were undertaken as a part of this EIS within ATP803 and PL 176. Boggomoss snails were not found during these surveys.

✓ present; ✗ not present



Coxon Creek, Queensland.

Santos GLNG has an established framework for managing potential aquatic flora and fauna impacts that incorporates the following principles:

- Apply the *Constraints protocol* to avoid or constrain Santos GLNG activities in environmentally sensitive areas such as wetlands, lakes and watercourses.
- Minimise and mitigate potential impacts to aquatic flora and fauna values by identifying their presence and how GFD Project activities may impact on them and alter such activities accordingly.
- Implement the relevant management plans and strategies to minimise impacts to aquatic flora and fauna including:
 - *Chemical and fuel management plan*
 - *Contingency plan for emergency environmental incidents*
 - *Decommissioning and abandonment management plan*
 - *Draft environmental management plan*
 - *Erosion and sediment control management plan*
 - *Land release management plan*
 - *Pest and weed management plan*
 - *Receiving environment management plan*
 - *Rehabilitation management plan*
 - *Significance species management plan*
 - *Water resource management plan.*
- Implement the Santos GLNG *Offset strategy* to offset residual adverse impacts in accordance with regulatory requirements.
- Implement a monitoring program across the life of the GFD Project to assess the effectiveness of the management program.

6.14 Matters of national environmental significance

6.14.1 Water resources

Water resources in relation to coal seam gas projects are considered a matter of national environmental significance in accordance with the requirements of the EPBC Act.

The GFD Project tenure has a number of underlying aquifers that provide water supply for agriculture, industry and residents as well as sustaining springs and watercourses. The major aquifers are associated with the Great Artesian Basin (GAB), while the main productive water bearing formations in the GFD Project area are:

- Quaternary alluvial aquifer systems associated with the unconsolidated sediments of the Condamine-Balonne River, the Dawson River and the Comet River systems.
- Minor aquifers within Tertiary fractured basalt and sediments caps.
- Water bearing formations of the GAB, including the Clematis Sandstone, Precipice Sandstone, Hutton Sandstone, Springbok Sandstone, Gubberamunda Sandstone, Orallo Formation, Mooga Sandstone and Bungil Formation.

Extraction of groundwater in GFD Project tenure occurs via bores used for stock and domestic supply or agriculture, uncontrolled artesian bores, and petroleum and gas production. Registered bore data (OGIA, 2013) indicates that groundwater in GFD Project tenements is used for stock and domestic supply and to a lesser extent for urban water supply, agriculture (including irrigation and intensive stock watering) and industrial purposes. The Queensland Government has implemented a legislative regime to ensure the petroleum and gas industry develops in a responsible way. Under the regime, petroleum tenure holders have the right to extract groundwater in the process of petroleum and gas production, but are required to monitor and manage the impacts on springs and water supplies. This includes a requirement to 'make good' impairment of private bore supplies caused by the exercise of these rights.

Under this legislative regime, the Queensland Government (through the Office of Groundwater Impact Assessment (OGIA)) prepared an *Underground Water Impact Report (UWIR) for the Surat Cumulative Management Area (CMA)* (which includes the GFD

Project area). The UWIR assessed the cumulative impacts of water extraction by oil and gas production on groundwater in the Surat CMA. The assessment included numerical groundwater modelling to predict potential impacts of petroleum and gas production on groundwater pressure. This included the impacts of the currently approved Santos GLNG Project as well as the other approved coal seam gas projects in the Surat CMA. This assessment, which was undertaken in 2012, is referred to as 'the UWIR Scenario'. The OGIA ran the model again in 2013 and included the GFD Project and more development proposed by another proponent. This assessment is referred to as 'the EIS Scenario'.

The GFD Project area is located across three catchments: the Dawson River catchment, the Comet River catchment, and the Condamine-Balonne River catchment. Aquatic habitats in the GFD Project area include watercourses, wetlands, springs and groundwater ecosystems.

Watercourses in the GFD Project area mostly ephemeral, meaning that they do not flow all year and generally only exist for short periods following rainfall. The aquatic environmental values of watercourses within the GFD Project area are low to moderate and consistent with those of the wider catchments and a slightly to moderately disturbed ecosystem.

There are no Ramsar wetlands of international significance within the GFD Project area or in close proximity. The nearest Ramsar wetland is the Narran Lake Nature Reserve approximately 320 km downstream of the GFD Project area in the Condamine-Balonne River catchment.

Lake Murphy and part of the Palm Tree and Robinson Creek wetland complex located in the Lake Murphy Conservation Park (within GFD Project tenure ATP803) are listed as nationally important (Environment Australia, 2001). This area is mapped as having high ecological value (referrable) wetlands in the Great Barrier Reef catchments – Lake Murphy Conservation Area. These wetlands contain species and REs of conservation significance under both the EPBC Act and the NC Act.

A number of GFD Project activities have the potential to cause adverse impacts on the identified groundwater EVs without adequate management controls in place.

The extraction of groundwater is an integral part of the production of gas from coal seams and has the potential to result in aquifer depressurisation and drawdown. Depressurisation is a reduction in groundwater pore pressure (pressure head) in a confined groundwater system due to extraction of groundwater. Drawdown is the change in groundwater level in a bore, or the change in water table elevation in an unconfined groundwater system, due to the extraction of groundwater.

The 2012 UWIR predicted that 528 landholder bores would be cumulatively impacted (potentially reducing supply to users) due to petroleum and gas development in Surat CMA under the UWIR Scenario. Under the EIS Scenario, an additional 73 private water bores in the Surat CMA, 48 of which are in the GFD Project tenures, are predicted to be impacted.

Natural discharge from Great Artesian Basin aquifers may feed spring vents and watercourse springs. A spring vent is a single point in the landscape where groundwater is discharged at the surface. A group of spring vents located in close proximity to each other is called a spring complex.

Wetlands and springs in the GFD Project area provide permanent or semi-permanent aquatic habitat, and are therefore likely to support a greater diversity of aquatic flora and fauna than the ephemeral watercourses.

There are 45 spring complexes and 33 watercourse springs located within the Surat CMA that have been recognised as springs of interest. Modelling has shown that there is a risk of impact to 13 spring complexes (potentially affecting groundwater dependent ecosystems) and 19 watercourse springs (potentially reducing supply to downstream surface water users and/or aquatic ecosystems) under the EIS scenario. Among these, 8 spring complexes and 12 watercourse springs are located within or near GFD Project tenure.

The following four EPBC Act-listed aquatic ecology species and communities have the potential to occur within the GFD Project area:

- Fitzroy river turtle
- Murray cod
- Salt pipewort
- Community of native species dependent on natural discharge of groundwater from the Great Artesian Basin.

However, no near-threatened or threatened species of aquatic fauna have been recorded from the watercourses of the GFD Project area.

However, the watercourses in the Condamine-Balonne River Catchment may provide suitable breeding or dispersal habitat for Murray cod, and the Dawson River upstream of Taroom contains suitable habitat for the Fitzroy River Turtle, and may support this species. Salt pipewort has been recorded at springs in the Dawson River catchment. The critically endangered Boggomoss snail was not identified within the GFD Project area, but is known to occur within the Dawson River and the Boggomoss springs complex downstream of Taroom.

6.14.2 Terrestrial ecology

Six threatened ecological communities were identified as potentially occurring in the GFD Project area including:

- Brigalow (*Acacia harpophylla* dominant and co-dominant)
- Coolibah-Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions
- Natural Grasslands of the Queensland Central Highlands and the northern Fitzroy Basin
- Semi-evergreen vine thickets of the Brigalow Belt (north and south) and Nandewar Bioregions
- Community of native species dependent on natural discharge of groundwater from the Great Artesian Basin
- Weeping Myall Woodlands.

The presence of these communities was confirmed during field assessments, with the exception of the Natural Grasslands of the Queensland Central Highlands and the northern Fitzroy Basin, and Weeping Myall Woodlands.

Twenty-five EPBC Act-listed conservation significant flora species were identified as potentially occurring within the GFD Project terrestrial ecology study area. Of these, 20 species are known to occur. Only two of these (*Xerothamnella* and *Ooline*) have been recorded during the Santos GLNG field surveys.

Twenty-six EPBC listed conservation significant fauna species were identified as potentially occurring in the terrestrial ecology study area. This includes 11 birds, one fish, one gastropod, six reptiles and seven mammals. Of these, 14 are known to occur. Only five of these (Red goshawk, Squatter pigeon, Brush-tailed rock-wallaby, Koala and South-eastern long-eared bat) have been recorded during the Santos GLNG field surveys.

Twenty-three migratory species were identified as potentially occurring in the terrestrial ecology study area. Of these, 19 are known to occur. Only six of these

(Cattle egret, Fork-tailed swift, Rainbow bee-eater, Satin flycatcher, Spectacled monarch and Glossy ibis) have been recorded during the Santos GLNG field surveys. It is likely that the terrestrial ecology study area contains suitable habitat for other migratory species during locally favourable conditions or when episodic dry conditions prevail further inland.

6.14.3 Impacts and mitigation

Potential impacts to matters of national environmental significance that may occur as a result of the GFD Project include:

- Habitat loss from vegetation clearing/removal
- Fauna species injury or mortality from project activities
- Reduction in soil viability to support plant growth due to soil compaction
- Displacement of flora and fauna species by weed and pest species
- Reduction in the connectivity of biodiversity corridors
- Edge effects to habitat (e.g. weed invasion and reduction of biodiversity)
- Habitat fragmentation from vegetation clearing
- Barrier effects (e.g. loss of species' migration pathways)
- Disturbance to fauna and flora from noise, dust, and light
- Degradation of habitat from an increase in litter (waste)
- Increased sedimentation
- Erosion of stream banks
- Surface water contamination
- Altered surface water flow regime
- Altered geomorphic character
- Decline in groundwater levels/pressure in bores and reduced supply to groundwater users
- Reduced stream baseflow (watercourse spring flow) and loss or reduction of supply to downstream surface water users
- Subsidence, altering groundwater or surfacewater flow paths and aquifer storage
- Aquifer depressurisation leading to reduced spring flow or degradation of groundwater dependant ecosystems

- Altered water quality in aquifers leading to loss or degradation of ecosystems dependent on springs.

The potential impacts to matters of national environmental significance were assessed using quantitative and qualitative methodologies. Quantitative assessment involved the modelling of the aquifer depressurisation impacts (described above) and the prediction of disturbance areas for terrestrial ecology receptors using the Land Disturbance Probabilistic Calculation Model.

The other potential impacts were assessed according to the significance assessment methodology, which considers the sensitivity of the underlying environment and the magnitude of a potential impact to assess its level of significance.

The measures Santos GLNG will undertake to manage and mitigate the potential impacts to matters of national environmental significance are outlined in Box 18.

The quantitative assessment of cumulative depressurisation impacts determined that the significance of the residual impacts after implementation of the management and mitigation measures was high for matters of national environmental significance springs (due to the high probability and duration of the impact and their high environmental sensitivity) and moderate for bores.

The significance of the residual impacts after the implementation of these measures was assessed as ranging from negligible to high. The high significance residual impacts relate to construction phase clearing of any of the following:

- EPBC Act threatened flora or fauna species habitat
- Threatened ecological communities (Coolibah-black box woodlands, Weeping myall, Semi-evergreen vine thicket).



Santos GLNG has an established environmental management framework that has been proven to be effective in managing impacts on matters of national environmental significance. Santos GLNG is committed to implementing the following mitigation measures to manage potential impacts:

- Apply the *Constraints protocol* to avoid impacts through restricting Santos GLNG activities in environmentally sensitive areas. This includes placing EPBC Act-listed springs (plus a 200 metre buffer zone) and wetlands of national importance (plus a 200 metre buffer zone) in the no-go area.
- Comply with the commitments made in the UWIR for the Surat CMA, which include the completion of bore assessments and make good agreements with specified landholders, completion of baseline assessments of landholder bores, development of spring impact mitigation strategies, and undertaking groundwater and spring monitoring.
- Implement the commitments of the *Joint industry plan for the monitoring and protection of the EPBC springs*, which provides an early warning system and response plan for springs protected by the EPBC Act.
- Implement the *Coal seam water management strategy* to prioritise the beneficial use of coal seam water where practicable, while avoiding, minimising and mitigating environmental impacts.
- Implement the *Water resource management plan* to proactively manage and monitor potential adverse impacts to groundwater resources including springs and springs complexes. This plan specifically addresses how Santos GLNG will manage water resources across the life of the GFD Project. It includes the *Joint industry plan for the monitoring and protection of the EPBC Springs*, which requires specialised studies on the GFD Project area and Santos GLNG activities that may impact groundwater including hydraulic fracturing and stimulation.
- Apply the hydraulic fracturing risk assessment to any fracturing fluids proposed to be used for the GFD Project.
- Implement the *Chemical and fuel management plan* to ensure the appropriate storage and handling practices of chemicals and fuels to minimise the risk of groundwater contamination.
- Construct all wells and bores to be in accordance with the *Code of practice for constructing and abandoning gas wells and associated bores in Queensland* (DNRM, 2013) and the *Code of practice for gas well head emissions detection and reporting* (DEEDI, 2011).
- Implement the monitoring program in accordance with the requirements of the environmental authority, the *Draft environmental management plan* and the *Water resource management plan*.

- Implement the following management plans and strategies:
 - *Chemical and fuel management plan*
 - *Coal seam water management strategy*
 - *Decommissioning and abandonment management plan*
 - *Draft environmental management plan*
 - *Erosion and sediment control management plan*
 - *Fauna management plan*
 - *Hydraulic fracturing risk assessment*
 - *Joint industry plan for an early warning system for the monitoring and protection of EPBC springs*
 - *Land release management plan*
 - *Pest and weed management plan*
 - *Rehabilitation management plan*
 - *Significant species management plan*
 - *Stimulation impact monitoring plan*
 - *Water resource management plan.*
- Implement the Santos GLNG *Offset strategy* to offset residual adverse impacts in accordance with regulatory requirements.

6.15 Cultural heritage

The GFD Project area contains a variety of cultural heritage places, reflective of its Indigenous history and early European settlement. There are numerous areas and artefacts relevant to Indigenous peoples present which are protected under established cultural heritage management plans (CHMPs). Santos GLNG has developed an understanding of the Indigenous cultural heritage landscape of the GLNG Project area by conducting more than 1,000 inspections and/or surveys since 2009. These surveys have covered an area of more than 19,500 hectares and have been undertaken in accordance with Santos GLNG's existing CHMPs and cultural heritage clearance process.

With regard to non-indigenous cultural heritage, the GFD Project area played host to early European exploration in Queensland and thus contains places reflective of exploration, early settlement and European-Indigenous frontier interaction and conflict. The non-indigenous cultural heritage values were identified through a review of statutory and non-statutory registers and a review of cultural heritage surveys undertaken within the GFD Project area.

The search of registers and reports identified a wide range of non-indigenous cultural heritage sites throughout the GFD Project area, including:

- Explorers' campsites
- Contact places including massacre places and places showing evidence of Aboriginal and non-indigenous occupation
- Pastoral places including homestead complexes (including homesteads, cattle/sheep dips, meat houses, dairies, holding yards, shearing sheds, storage sheds and refuse dumps), fencing, bores, water storage ponds, bush camps, surveyors' marks and terracing
- Isolated graves and cemeteries
- Historical precincts within towns such as Roma, Surat, Wallumbilla, Old Yulebah and New Yulebah

- Roads, railways and stock routes and associated telegraph/telephone lines including old road alignments and roads which reflect specific phases of development (e.g. soldier settler roads), railways, sidings, stations and associated settlement and housing
- Forestry industry places
- Resources projects and quarrying places, including underground and open cut mines, wells and associated infrastructure
- Memorials both to early explorers and soldiers.

The cultural heritage values in the GFD Project area include:

- Known heritage places of national, state and local significance, as well as unassessed sites
- Unknown heritage places of national, state and local significance.

GFD Project activities have the potential to disturb or encroach on places of known cultural heritage significance, places of unknown cultural heritage significance, or significant cultural heritage landscapes.

In accordance with the *Aboriginal Cultural Heritage Act 2003* (Qld), where category A and B Aboriginal parties and areas covered by registered Aboriginal cultural heritage bodies exist, Santos GLNG has entered into CHMPs with the Aboriginal Parties. The philosophy behind these CHMPs is to avoid harm to cultural heritage in the first instance and, if that cannot be achieved, management strategies to minimise impacts will be adopted in consultation with the Aboriginal Party according to processes outlined in the relevant CHMP. There are eight existing CHMPs covering the GFD Project area.

The potential impacts to cultural heritage values in the GFD Project area were assessed according to the risk assessment methodology, which considers the likelihood and consequence of a potential impact to assess its risk. The measures Santos GLNG will undertake to manage and mitigate the potential impacts of the GFD Project on cultural heritage are outlined in Box 19. The residual risks that remain after the implementation of these measures vary from very low to medium.

Box 19 Managing potential cultural heritage impacts

Santos GLNG is committed to managing the potential cultural heritage impacts of the GFD Project. Key measures to achieve this across the life of the GFD Project include:

- **Constraints protocol** – which will be used to guide the location of GFD Project infrastructure to avoid places of cultural heritage significance.
- **Environmental hazard standard EHSI I Cultural heritage** – which provides a range of mechanisms to identify and avoid where practicable or otherwise minimise impacts on cultural heritage places. These mechanisms include awareness training, pre-clearance surveys, and procedures for discovery, clearances, monitoring and reporting.
- **Cultural heritage management plans** – the GFD Project will operate within the bounds of the plans developed with each relevant Aboriginal Party under the *Aboriginal Cultural Heritage Act 2003*.

6.16 Social

The GFD Project's gas fields are located across the four local government areas of Banana Shire Council, and the Central Highlands, Maranoa and Western Downs regional councils. Local towns include Taroom, Wandoan, Rolleston, Injune, Roma, Wallumbilla and Yuleba.

This region has historically had a strong rural industry base with grazing being the predominant land use. However, especially in the past decade, the region has experienced population and economic growth as a result of the development and expansion of the resources sector, particularly in relation to coal and gas production. The resources industry has partly offset subdued economic activity in the agricultural sector during periods of drought and low commodity prices. Recent gas field development has built upon the long history of gas production in the region, particularly in the vicinity of Roma.

The potential for social impacts to occur has been assessed within each gas field individually (Arcadia, Fairview, Roma and Scotia), as although the GFD Project will undertake the same activities within each field, the impacts will differ depending on the existing social conditions present within the host communities. However, Fairview and Roma gas fields have been assessed together, recognising that both these gas fields have considerable linkages between the same primary towns (Roma and Injune), which are both located in the Maranoa Regional Council area.

The existing social conditions and potential social impacts on the Indigenous and non-Indigenous communities have been assessed separately due to the considerable socio-economic and cultural differences between these communities in the GFD Project area.



Senior landholder compliance officer Katrina Macdonald.

The social impact assessment used a tiered geographic framework for the purpose of comparing social conditions and assessing the potential impacts within each of the GFD Project gas fields. The areas are:

- **Gas field locality** – includes the smallest number of Australian Bureau of Statistics' standard statistical area 1 (SA1) areas that cover each GFD Project gas field. It is the area most likely to be subject to direct impact by GFD Project activities. The key population areas that are contained within each gas field locality are detailed in Table 6–15.
- **Social catchment area** – includes the standard statistical area 2 (SA2) and/or local government area for each gas field. This is the area that is likely to experience second order impacts as it has dominant transport, communication, health and social infrastructure and social links to the communities within the gas field locality.

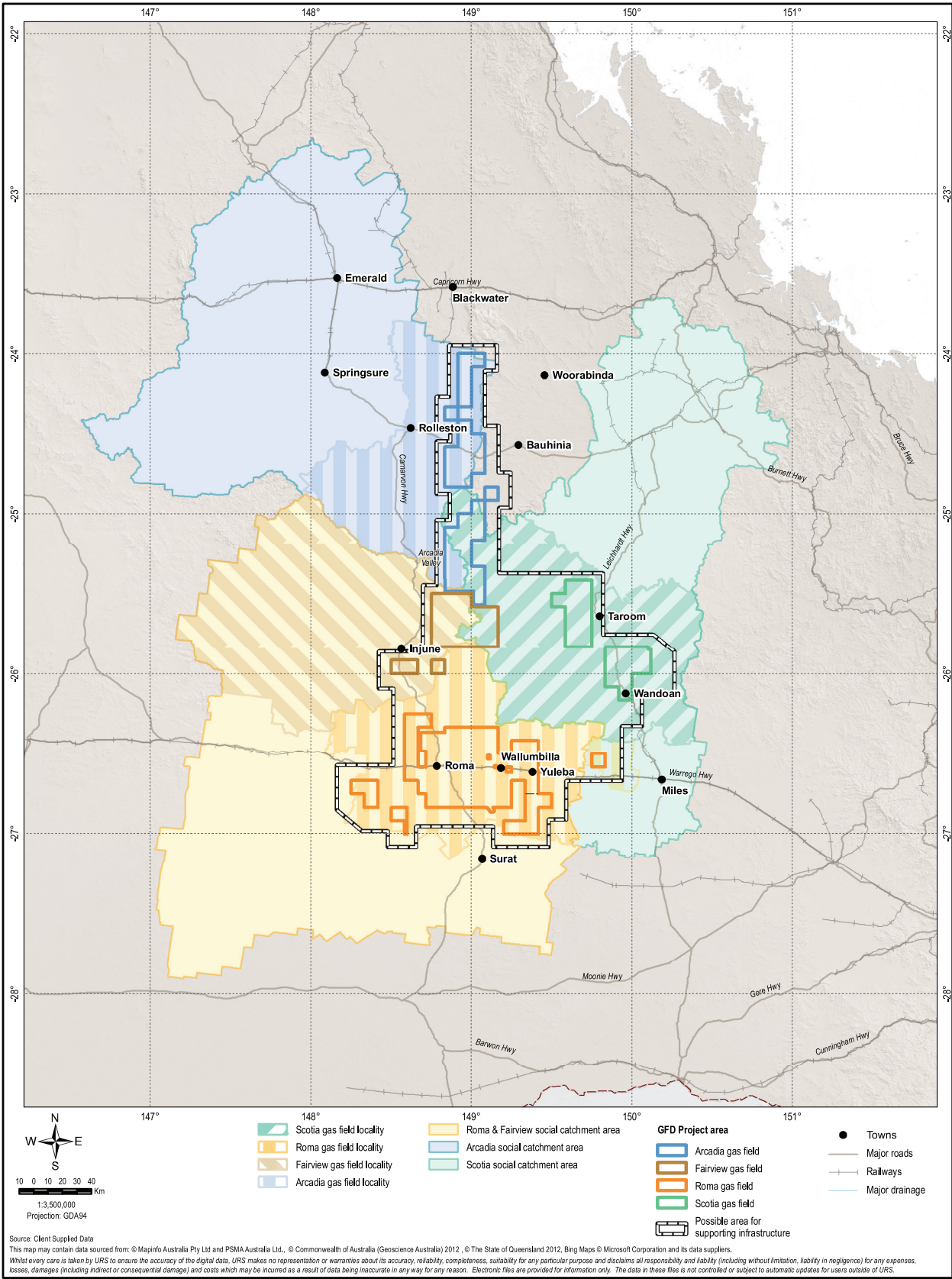
The social baseline established for the Indigenous community is inclusive of all social catchment areas and the town of Woorabinda.

These areas are based on areas defined in the Australian Bureau of Statistics Australian Standard Geographical Classification (ABS, 2012) and are shown on Figure 6–3.

Table 6–15 Key population centres – gas field localities

Gas field	Key population centre
Arcadia	• Rolleston • Springsure
Fairview	• Injune
Roma	• Roma • Wallumbilla
Scotia	• Taroom • Wandoan

Figure 6–3 Gas field social geography



6.16.1 Social values – non-indigenous

The social values and related indicators that have been considered for the non-indigenous community are outlined in Table 6–16.

The characteristics of these values within each gas field locality and social catchment area are discussed below.

Arcadia gas field

Liveable community

Springsure is the regional centre and its proximity to Emerald affords access to a higher level of services while retaining the small rural town pace of life. There is reasonable access to primary education services, although secondary education services are only available up to year 10. While infrastructure in Springsure is felt to be adequate, the more remote parts of the region express a high degree of concern for the state of infrastructure services, particularly roads. The region has an active sporting and cultural environment.

The demographic profile is characterised by an above average number of people in the working age group and lower than average in the teenage and 65+ age ranges. Men outnumber women in a number of age groups, particularly in the working age range.

Affordable lifestyle

While the cost of food and other essential items is manageable, housing costs in Springsure have undergone increases over the past four years, and the cost of housing in Rolleston has fluctuated with only modest increases. The area is generally characterised by a lower level of socioeconomic disadvantage than the Queensland average.

Recognisable community identity and spirit

The area has a high level of regional identity and community spirit, based on its proximity to the Carnarvon National Park, its development history, and its status as a support centre for highly productive agricultural enterprises. There are a range of social and cultural organisations and local events.

Capacity for sustainable economic activity

The area has traditionally had a dependence on agriculture with more recent diversification into mining. While unemployment is low, youth and young adult unemployment remains of concern. The region has an active business development infrastructure through the Central Highlands Development Corporation and a vibrant commercial centre in Emerald.

Roma and Fairview gas field

Liveable community

Roma acts as the regional hub for the communities within both gas fields and provides a range of education and health facilities. Infrastructure, while adequate in the past, has been placed under some strain with the growth of gas developments in the region. However, the negotiation of support from gas development companies and the Royalties for Regions and *Resource Towns Action Plan* are providing funding for regional roads and other infrastructure upgrades.

The region, and in particular Roma, is expected to grow moderately over the next 10 to 20 years as a result of gas development projects, with the median age expected to remain steady while the broader regional area ages.

The region provides adequate opportunity for sporting, recreational and cultural activity, with recent support from resource companies and major contractors improving this. Early childhood education may be an area requiring some strengthening.

Affordable lifestyle

Higher costs for food, clothing and footwear in the area have traditionally been offset by lower housing costs. Housing costs have grown over the past four years; however, the market is showing signs of stabilising.

Action to address land availability and housing affordability in both Roma and Injune should increase affordability over time. Median household income levels have risen in line with inflation over the past 10 years in the Roma area, but in regional areas income increases have been at around half the rate of inflation.

Recognisable community identity and spirit

The region has a high level of community identity derived from agricultural production. Nevertheless, the oil and gas industry has a long history in the Roma area and has been incorporated into community heritage promotion together with the history of early European settlers. Injune promotes its early settler and development heritage, as well as its proximity to significant natural landscape features such as the Carnarvon Ranges.

There is a substantial range of active community cultural and sporting organisations, and community celebrations, such as Roma's Easter in the Country festival. Supply response to increased demand on short-term accommodation facilities has ensured an ongoing capacity to accommodate visitors.

Table 6–16 Social values and indicators (non-indigenous)

Social value	Indicators
Liveable community	• Access to, and proximity of, quality services (health, education, aged care, childcare, retail) • Balanced demographic profile • Harmonious relationships, lack of conflict • Respect for law by community members • Adequate infrastructure that is well maintained (roads, airport, power, water & sewerage, telephone, internet) • Effective local governance • Opportunity for recreational, cultural and sporting pursuits • Safe social and physical environment.
Affordable lifestyle	• Cost of land and housing • Local government rates and service charges • Cost of food and other essential items.
Community identity and spirit	• Level of volunteering and availability of assistance • Local celebrations • Recognition, preservation and promotion of heritage • Capacity to accommodate visitors • Perceptions of being able to influence community destiny • Employment share by industry.
Capacity for sustainable economic activity	• Viability, vitality and diversity of local industry • Workforce participation and employment • Job creation and the retention of young people • Supportive business environment (e.g. availability of serviced industrial land, adequate zoning, provision of information on opportunities etc.) • On-going environmental integrity (e.g. surface and groundwater, land degradation) • Willingness of businesses to invest.

Capacity for sustainable economic activity

Gas industry development in the Roma and Fairview area is making a significant contribution to sustainable economic activity at a time when there is increasing uncertainty around the future of agricultural production. Gas industry development has driven investment in visitor accommodation facilities in Roma, and provided additional pathways to training and employment for school leavers wishing to pursue trade training.

Scotia gas field

Liveable community

Taroom, Miles and Wandoan are the primary towns in the Scotia gas field locality. These towns have good access to education up to year 10. Health services are generally adequate for the existing population level. These services, combined with access to an extensive array of cultural, recreational and sporting opportunities, indicate a high level of liveability, particularly for families with primary and lower-secondary age children.

As with most small rural centres, there is concern with regards to the maintenance of key community infrastructure, such as water and sewage treatment plants, aerodromes and roads. While there has been some increase in reported crime, the area would still be considered safe and law abiding with generally harmonious relationships between residents.

All towns have experienced a slightly higher level of population decline than the surrounding social catchment area over the past 10 years. However, population growth in the area is forecast to be positive over the next 20 years. As is typical in rural communities, there is an imbalance in the age profile with under-representation in the 15-40 age group with continued ageing of the population expected over the next 20 years. The working age population also has a higher proportion of men than women.

Affordable lifestyle

Within the area housing has historically been affordable, with lower levels of mortgage and rental costs than the state average. However, recent data indicate that there are developing potential housing pressures in Taroom and Wandoan.

Recognisable community identity and spirit

The area is noted for the production of cattle and grain. It supports a wide range of voluntary cultural and service organisations. Significant local celebrations include the Dawson River Festival (Taroom), the Juandah Heritage Day (Wandoan) and a number of race meetings, camp drafts and rodeos. While there was limited visitor accommodation in the past, resource development has stimulated the provision of additional accommodation.

Capacity for sustainable economic activity

Prior to the development of resources projects, the declining population and ageing workforce indicated vulnerability for future capacity to support sustainable economic activity. Long periods of drought have severely affected the viability of agricultural enterprises, restricting job creation and retention. Notwithstanding this, residents consider the ongoing viability of the region to be dependent on agriculture. New commercial opportunities for local businesses in areas such as catering, accommodation, security, fuel and general supplies and broader support services are beginning to appear in response to the development of gas fields and associated infrastructure in the area.



Roma Rugby Union Club.

6.16.2 Social values – Indigenous

While Indigenous people would identify in broad terms with the social values detailed for the non-indigenous communities, there are also different indicators for values reflecting Indigenous peoples' circumstances and experience as a distinct cultural group. Consequentially, the potential impacts on Indigenous communities across the GFD Project area are different. The assessment of impact on the Indigenous communities has been based on the social values and indicators listed in Table 6–17.

Liveable community

Within the Indigenous population, the people of Woorabinda experience more disadvantage when compared to Indigenous people living in other towns. The Indigenous community in general has a concern with the lack of culturally appropriate service delivery, particularly health services.

Affordable lifestyle

Addressing the inadequate state of housing for Indigenous people is acknowledged as a priority by communities and governments across Australia. There is a higher incidence of over-crowding and a lower level of home ownership compared to the non-indigenous population. While there is no development-induced elevated housing market demand in Woorabinda, the inability to afford external accommodation options and the low level of mobility of residents are likely to constrain their ability to access employment opportunities elsewhere.

Community identity and spirit

The recognition of Indigenous community history and culture has been advanced through resource development companies negotiating Indigenous land use agreements and cultural heritage management plans over wide geographic areas. Prior to this, the management of cultural heritage across the GFD Project area provided a limited focus on Indigenous interests.

Capacity for sustainable economic activity

Indigenous capacity for sustainable economic activity is limited, and severely constrained in Woorabinda. Some indication of change is evident in the north of the GFD Project area, with an increase in the number of Indigenous people working in the private sector (principally mining) over the last census period.

Table 6–17 Indigenous social values and indicators

Social value	Indicators
Liveable community	• Proximity and access to traditional country • Degree of satisfaction with the management of traditional country • Respectful and harmonious relationships with the non-indigenous community • Access to service delivery (in particular health and education) that acknowledges and respects culture • Harmonious intra-community relationships • Ability for extended family residence • Adequate infrastructure.
Affordable lifestyle	• Availability of adequate housing • Cost of housing • Cost of transport.
Community identity and spirit	• Historical recognition and protection of cultural heritage • Number and strength of Indigenous organisations • Status of reconciliation with non-indigenous community.
Capacity for sustainable economic activity	• Availability of employment opportunities • Indigenous workforce participation • Indigenous business start-ups and ownership • Level of education achievement, including retention to year 12 and post-school destination.



Mandandanji woman Tracy Landers with Santos GLNG's Rebecca Girle in Roma, Queensland.

6.16.3 Potential social impacts

The potential impacts on the social values for the Indigenous and non-indigenous communities in the GFD Project area are summarised in Table 6–18.

The potential social impacts of the GFD Project were assessed according to the risk assessment methodology, which considers the likelihood and consequence of a potential impact to assess its risk.

The measures Santos GLNG will undertake to manage and mitigate the potential social impacts of the GFD Project are outlined in Box 20. The residual risks that remain after the implementation of these measures vary from very low to medium.

Table 6–18 Potential social impacts

Social value	Potential impacts (non-indigenous)	Potential impacts (Indigenous)
Liveable community	• Workforce demand on public health facilities and services • Intra-community conflict • Construction and operations traffic on local roads and in the town areas • Presence of a younger, predominantly male workforce in social venues and general town areas • Demand on public physical infrastructure.	• Uncertainty with regard to environmental impact of GFD Project • Lack of cultural awareness of in-migrating construction and operations workforce • Tension between different segments of Indigenous populations over access to project benefits • Out-migration of elements of family groups due to inability to afford housing.
Affordable lifestyle	• Increased demand for housing • Increased wage pressures on local businesses.	• Increased housing costs.
Community identity and spirit	• Local employees working extended shift hours and rosters • Visible presence of gas industry workers in local community venues and the presence and scale of project facilities • High occupancy of short-term accommodation by project contractors, displacing visitors to communities • Out-migration of primary producers.	• Inadvertent interference with cultural heritage • Increased Indigenous employment presents staffing difficulties for Indigenous organisations • General level of development marginalises Indigenous presence in community • Resentment at perceived landholder benefit from the occupation of traditional land.
Capacity for sustainable economic activity	• Disruption to agricultural production through field operations • Construction activity deters local tourism and highway trade • Perception that gas extraction creates uncertainty around water availability for agriculture • Inward movement of larger enterprises to local area.	• High-paying, short-term construction work draws higher-level students from schooling • Unsupportive workplace environment for local Indigenous employees.

Box 20 Managing potential social impacts

Santos GLNG's approach to managing potential social impacts is detailed within the existing *Social impact management plan*, which has been established, implemented and refined for the GLNG Project.

The plan, which will be adopted for the GFD Project, outlines the framework for community engagement, strategies to avoid, manage or mitigate potential impacts, and ways to maximise opportunities and benefits arising throughout the life of the GFD Project.

The objectives of the plan are focused on the key areas of potential impact to communities in the GFD Project area including:

- Water and environment
 - Maximise the beneficial reuse of coal seam water where practicable and monitor potential adverse effects
 - Minimise harmful effects on land environments including actively preventing the spread of weeds and pests.
- Community safety
 - Minimise health and safety risks to Santos GLNG employees, contractors and the community including road safety risks
 - Minimise potential social dysfunction associated with the Santos GLNG workforce
 - Minimise the impact on regional social infrastructure.
- Community wellbeing and liveability
 - Minimise the impacts to landholders of gas field development activity
 - Support and enhance the liveability and wellbeing of regional communities where Santos GLNG operates.
- Local industry participation and training
 - Maximise the availability of skilled labour within regional communities
 - Maximise opportunities for local business and industry to participate in Santos GLNG projects.
- Aboriginal engagement and participation
 - Minimise the impact of our activities on Aboriginal communities
 - Minimise the potential for damage to culturally significant sites
 - Strive to achieve enduring and mutually beneficial relationships.

Santos GLNG has adopted an early engagement strategy where landholders that may be affected by GFD Project activities are able to discuss the potential location, timing and impacts of infrastructure on their property or business, and how Santos GLNG can help to minimise those impacts. Based on this, Santos GLNG will negotiate a Conduct and Compensation Agreement as required under the *Petroleum and Gas (Production and Safety) Act 2004* with landholders on whose land the petroleum activities will be carried out.

Other policies and plans to be implemented include:

- **Community policy** – provides overarching guidance on ensuring that Santos GLNG establishes and maintains enduring mutually beneficial relationships with the communities of which it is a part
- **Aboriginal engagement policy** – focuses on the elements of Native Title, cultural heritage, employment and training, enterprise development, community capacity and corporate social responsibility
- **Cultural heritage management plans** – provide for cultural heritage surveys and management measures for any potential or actual impacts to cultural heritage to ensure Indigenous cultural heritage is treated with appropriate respect.

6.17 Economics

The economies of the local government areas across the GFD Project area are highly reliant on resource production (mining and oil/gas) and agriculture. These primary industries are supported by a range of services, concentrated in the urban centres of Roma and Blackwater.

Modelling to understand the potential economic impacts of the GFD Project has been undertaken for the period 2013 to 2040 for three specific economic regions:

- **GFD Project area** – includes all of the Banana Shire Council and Central Highlands, Maranoa and Western Down regional council areas
- **Queensland** – includes the GFD Project area in the context of the rest of the state
- **Australia** – examines the impact of the GFD Project from a national perspective.

As the GFD Project follows an incremental field development process, the exact number, size and location of production wells, gas compression facilities and associated infrastructure (and how these are integrated within existing GLNG Project infrastructure) are yet to be determined. To reflect some of these uncertainties, the economic impact modelling undertaken specifically for this EIS has been conducted for two different production scenarios:

- Moderate scenario taking into account commercial sensitivities related to gas development that may result in a reduced well count and number of support facilities
- Maximum scenario based upon the development of all 6,100 wells for which approval is being sought.

The potential direct and flow-on economic benefits offered by the GFD Project result from:

- Capital investment in upstream gas production, processing facilities and other supporting infrastructure
- Export revenues generated from additional LNG production as the GFD Project supplies the existing LNG facility at Curtis Island in Gladstone
- Additional employment activity
- Increased fiscal receipts to the Queensland and Commonwealth Governments in the form of taxes and royalties.
- The economic analysis indicates that the GFD Project would have a significant positive impact on the regional, state and national economies.

Other economic impacts from the GFD Project could include:

- Increase in the non-resident workforce. This can potentially increase the level of economic activity in the area through raising the demand for basic goods and services. Where wages are repatriated to families and leisure time is spent away from the employment region, money is generally expended in other regions of Queensland and Australia.
- Increase in the cost of living within the GFD Project area. This can occur through increased property and rental costs. While price increases, especially for essential housing services, will impact the cost of living, the welfare implications are determined by other variables, such as economic growth, employment and investment. In this regard, cost of living pressures stem from strong investment, rising incomes and low unemployment, each of which are crucial factors underpinning community living standards.

- Increased participation opportunities for local industries. There will be considerable opportunities for local service industries to secure key elements of GFD Project work and ultimately gain from the technology transfer, skills development and commercial engagement processes.
- Increased demand for government infrastructure. Santos GLNG will work with government to manage economic impacts on infrastructure and other government functions generated by the GFD Project. This will include ongoing assessment of impacts to roads and ongoing assessment of social and community facilities through the social impact management plan.

A summary of the economic impacts (change to gross domestic product) is provided in Table 6–19. Results are presented as cumulative impacts, with the results for Queensland inclusive of the impacts across the GFD Project area and rest of Queensland, and the rest of Australia.

Table 6-20 summarises the employment impacts associated with the GFD Project. Again the results are cumulative for Queensland and Australia as described for Table 6–18.

The development of the GFD Project has the potential to generate substantial economic output and employment within the GFD Project area, Queensland and Australia. However, as discussed above, most large projects involve development challenges and there is potential for the GFD Project area to experience these. Santos GLNG's management framework includes mechanisms for managing economic impacts and increasing economic opportunities for communities as outlined in Box 21.

Box 21 Managing potential economic impacts continued.

Santos GLNG is committed to working with government, industry and the community to manage economic impacts. We are focused on addressing issues around workforce and housing through our *Social impact management plan* and on increasing local industry participation through adopting the Queensland Resources Council's *Code of Practice for Local Content*.



Santos GLNG housing under construction in Gladstone.

Table 6–19 Summary of the cumulative economic impacts

Economic region	Economic output (net present value, \$M)			
	2020	2030	2040	2013–2040
Moderate scenario				
GFD Project area	622	1,505	1,298	9,795
Queensland	740	1,952	1,519	12,059
Australia	729	1,748	961	10,951
Maximum scenario				
GFD Project area	1,114	2,392	2,931	16,882
Queensland	1,354	2,786	3,574	20,047
Australia	1,277	2,533	2,772	18,301

Note: Net present values have been calculated using a discount rate of 7%. Values are in real 2012–13 terms.

Table 6–20 Summary of the cumulative employment impacts

Economic region	Number of employees (FTE)				Employment average (FTE)
	2015	2020	2030	2040	2015–2040
Moderate scenario					
GFD Project area	386	1,456	369	537	616
Queensland	491	2,029	1,072	876	1,123
Australia	484	1,933	796	10,951	929
Maximum scenario					
GFD Project area	38	3,146	1,222	804	1,337
Queensland	986	4,368	2,063	1,916	2,182
Australia	688	4,171	1,772	1,324	1,904

FTE – full time equivalent

6.18 Health and safety

The overarching environmental values derived for the health and safety aspects of the GFD Project are the health, safety, wellbeing and general quality of life of communities, particularly vulnerable members of the community, as well as the GFD Project workforce. While there are many values that contribute to health and safety, for the purposes of the GFD Project relevant values include:

- Air quality that is conducive to human health and agricultural production
- Acoustic environment that is conducive to human health and agricultural production
- Water quality that is conducive to human health and agricultural production.
- Transport networks that are well maintained with the capacity for their traffic volume
- Health, safety and wellbeing of workers associated with the GFD Project.

The potential impacts to health and safety values from the GFD Project include the following:

- Exceedance of air quality objectives
- Exceedance of noise and vibration criteria
- Increased potential for traffic accidents
- Exceedance of water quality objectives

- Increased potential for industrial accidents
- Workplace health and safety
- Protecting the health and safety of the community and GFD Project workforce.

Potential impacts to health and safety were assessed according to the risk assessment methodology, which considers the likelihood and consequence of a potential impact to assess its risk. The measures Santos GLNG will undertake to manage and mitigate the potential impacts of the GFD Project on health and safety are outlined in Box 22. Once these measures are implemented, the residual health and safety risks associated with air quality, noise and vibration, and water quality impacts are low. Residual workplace health and safety risks vary from low to high with the high residual applicable during construction. There is also a high residual risk of potential for traffic incidents.

Santos GLNG has an established environment, health and safety management system for the GLNG Project that is designed to identify, mitigate and manage risks to the environment and health and safety.

These will be adopted for the GFD Project and will include environment, health and safety management standards and health and safety hazard standards that provide a systematic approach to applying the following health and safety principles:

- Elimination (e.g. by eliminating inventories of dangerous goods)
- Substitution (e.g. by using a less hazardous material in place of a more hazardous material)
- Engineering (e.g. compliance with internal and external standards)
- Isolation (e.g. erection of physical barriers)
- Administrative (e.g. emergency procedures)
- Protective (e.g. use of personal protective equipment).

In addition, Santos GLNG will apply the *Constraints protocol* to isolate sensitive receptors from those aspects of the GFD Project that have potential health and safety risks.

It will also apply the following management plans as necessary to further reduce health and safety risks:

- *Contingency plan for emergency environmental incidents*
- *Chemical and fuel management plan*
- *Coal seam water management strategy*
- *Land release management plan*
- *Noise management plan*
- *Waste management plan*
- *Road-use management plan*
- *Journey management plan*
- *Emergency response plan.*



Engineers Steve Allen and Kyla Schliebs.

6.19 Hazard and risk

The development of large projects introduces the potential for hazards and risks that did not previously exist in the environment. In the case of the GFD Project, hazards relate primarily to the accidental release of natural gas from GFD Project infrastructure. The hazardous scenarios with the potential to impact on people and property are:

- Release of natural gas from GFD Project infrastructure (e.g. wells, gathering lines, compression facilities)
- Release of natural gas from medium or high pressure transmission lines
- Damage to adjacent gas pipelines during construction of other GFD Project infrastructure
- Escalation of fire at diesel storage
- Catastrophic failure of water storage.

The potential consequences of the above hazardous scenarios were assessed as:

- A jet fire, when a pressurised gas leak is ignited immediately
- A fireball, when a gas leak from a pipeline rupture is ignited immediately
- A flash fire, when a gas leak does not ignite immediately, a vapour cloud will form. If it is ignited the vapour would burn rapidly and flash back to the release point as a jet fire
- A bund fire, in the event of escalation of a fire to stored diesel
- Flooding, from a catastrophic failure of water storage.

The environmental values relevant to hazard and risk relate to maintaining and protecting the health, safety and wellbeing of people, property and the wider environment in and surrounding the GFD Project area.

The risk assessment methodology used involved combining the potential off-site consequences of the above hazardous scenarios and their associated likelihoods and comparing them against agreed criteria. The risks of the hazardous events considered were assessed as follows:

- Risks associated with wells, gas compression facilities and gas gathering and gas transmission pipelines were assessed on a qualitative basis.

- Risks associated with gas gathering and gas transmission pipelines were further assessed on a quantitative basis which determined the risk as a function of distance from the gas gathering or gas transmission pipelines.

Risks have been presented as residual risks based on the adoption of existing processes and controls in the approved management and regulatory framework for the GLNG Project which will also be adopted for the GFD Project. This recognises that further planning, risk assessment, engineering design and risk mitigation controls and measures will be undertaken to ensure that risks from the GFD Project are reduced to levels that are as low as reasonably practicable (ALARP).

The risks to people have been assessed as follows:

- **Construction phase.** Construction and commissioning activities are unlikely to result in significant offsite impacts to people and will be adequately controlled by implementation of the Santos GLNG Environment, Health and Safety Management System, as well as construction management plans and procedures. The risks to people during construction of the gas gathering and transmission pipelines were assessed as medium i.e. the risks may be accepted as tolerable if they can be shown to be reduced to ALARP.
- **Operations phase.** The risks to people from the hazardous scenarios associated with wells and gas compression facilities were assessed as medium. For the gas gathering lines and medium pressure gas transmission pipelines the estimated risks of injury and fatality are below all relevant criteria, as is the case for high pressure transmission pipelines except for the criterion for sensitive land uses (e.g. hospitals, childcare facilities and old age housing), which will be met within 150 m of the pipeline.
- **Decommissioning phase.** As for construction, decommissioning will be relatively short-term. Decommissioning activities are unlikely to result in significant offsite impacts to people and should be adequately controlled by implementation of the Santos GLNG Environment, Health and Safety Management System, as well as decommissioning plans and procedures.

The risks to property from the hazardous scenarios assessed for wells and gas compression facilities were low for all project phases. Furthermore, risks from the construction, operations and decommissioning of the gathering lines and transmission pipelines were all below the relevant criteria for damage to property. However a medium property risk applies to water management facilities because of possible consequences in the unlikely event of catastrophic failure of a water storage dam.

In summary, the risk assessment found that after the application of Santos GLNG's management framework, which is outlined in Box 23, the residual risks to people are medium (because of the critical consequences in the event of a fatality) and to property are low except for the risk of a catastrophic failure of water storage which is medium.

Box 23 Managing hazard and risk

Santos GLNG's management framework includes a standard for managing health and safety risks which includes processes to systematically identify hazards, assess their risk and adopt control strategies to reduce risk to as low as reasonably practicable.

The hierarchy of controls detailed in the standard are:

- Elimination (e.g. by eliminating inventories of dangerous goods)
- Substitution (e.g. by using a less hazardous material in place of a more hazardous material)
- Engineering (e.g. compliance with internal and external standards)
- Isolation (e.g. erection of physical barriers)
- Administrative (e.g. emergency procedures)
- Protective (e.g. use of personal protective equipment).

In addition, Santos GLNG will apply the *Constraints protocol* to isolate those aspects of the GFD Project that have potential risks to people and property. It will also apply the following management plans as necessary to further reduce risks to people and property:

- *Contingency plan for emergency environmental incidents*
- *Chemical and fuel management plan*
- *Decommissioning and abandonment management plan*
- *Emergency response plan*
- *Social impact management plan*
- *Queensland incident management plan.*

6.20 Decommissioning and rehabilitation

Decommissioning and rehabilitation activities will occur throughout the life of GFD Project. They will be implemented for short-term or temporary construction related activities (such as temporary camps) as well as for long-term or more permanent infrastructure (such as compressor stations and water management facilities).

The objective of final rehabilitation is to achieve:

- A landform suitable for the intended ongoing land use (i.e. cropping or grazing)
- Another stable landform consistent with the surrounding or adjacent areas (i.e. native vegetation)
- Other agreed land use in consultation with the landholder and in accordance with regulatory requirements.

This approach to rehabilitation is consistent with the Santos GLNG Project, which is currently operating within the GFD Project area under approved environmental approval conditions.

Key rehabilitation and decommissioning activities to be undertaken include:

- Rehabilitation of construction works such as laydown yards and pipeline construction areas
- Decommissioning and rehabilitation of short-term infrastructure such as temporary camps
- Rehabilitation of production wells and associated infrastructure after depletion of gas supply
- Rehabilitation at the end of the GFD Project of remaining supporting infrastructure (such as water management facilities and compressor stations) prior to relinquishment of the petroleum tenure and environmental authority.

Decommissioning and rehabilitation will be considered successful when:

- The asset or disturbance location can be managed for its designated post-GFD Project land use without any greater management input than for other land in the area being used for a similar purpose
- Monitoring has shown the rehabilitation to have been successful and that a sustainable and stable landform has been achieved
- Written agreement has been attained by the land owner/holder and the administering authority as necessary (i.e. the surrender of the environmental authority).

The decommissioning and rehabilitation will facilitate the return of the land to a stable state, where either the former land use or another land use agreed by the landholder and/or regulatory agency can occur.

Risks imposed by the rehabilitated land use will not exceed the risks posed by the surrounding undisturbed land use. Prior to the handover of infrastructure to be retained for third party use, Santos GLNG will ensure the infrastructure is in sound working order. Following the application of Santos GLNG's management framework, which is outlined in Box 24, the residual decommissioning and rehabilitation impacts will be low.

Box 24 Managing decommissioning and rehabilitation

Santos GLNG is committed to implementing decommissioning and rehabilitation methodology to mitigate the potential impacts of the GFD Project.

These methodologies will be incorporated into the management framework for the GFD Project and supported by the following management plans, standards and protocols:

- *Decommissioning and abandonment management plan*
- *Environmental health and safety management standard 01 Land disturbance*
- *Environmental health and safety management standard 11.11 Decommissioning and abandonment*
- *Erosion and sediment control management plan*
- *Constraints protocol*
- *Rehabilitation management plan.*

6.2.1 Cumulative impacts

When numerous projects occur in a region they can cause cumulative impacts, which may differ from those of an individual project when considered in isolation. Cumulative impacts may be positive or negative, and their severity and duration will depend on the extent of the overlap of the projects' size and timing.

A cumulative impact assessment does not include existing projects, as they are considered part of the existing environment and have already been accounted for in the assessment of the GLNG Project's residual impacts. The projects considered as part of the cumulative impact assessment for the GFD Project are those that are proposed or under construction, but not yet fully operational. A list of projects that have been considered are shown in Figure 6–4.

The potential for impacts of the GFD Project to interact with those of other projects that are proposed or under construction is based on the similarity of project activities and their geographic proximity. As can be seen in Figure 6–4, the GFD Project's cumulative impact area includes three other gas projects in addition to a range of other resources, power and water projects. These can be expected to have similar impacts to those of the GFD Project. The combined impact of these projects will further extend the area of the land that is potentially affected by cumulative impacts.

The methodology used to assess the GFD Project's cumulative impacts consisted of the following tasks:

- Identify the residual impacts of the GFD Project using existing baseline conditions (these impacts have been described in detail in the relevant sections of this EIS)
- Identify the proposed or under construction projects to be considered in the cumulative impact assessment and their residual impacts
- Identify appropriate spatial boundaries for the analysis of cumulative impacts
- Identify appropriate temporal boundaries for the analysis of cumulative impacts
- Determine the relevance and significance of the cumulative impacts for each relevant environmental value
- Develop suitable mitigation measures for the significant cumulative impacts.

In assessing the significance of potential cumulative impacts, the extent of compliance with established standards or guidelines was used where the impacts could be expressed quantitatively. Where the impacts were expressed qualitatively, the probability, duration, and magnitude/intensity of the impacts were considered as well as the sensitivity and value of the receiving environmental conditions.

The cumulative impacts that remain after the application of mitigation and management measures have been assessed using the above methodology. As can be seen in Table 6–21, the assessment found that the residual cumulative impacts to environmental values within the GFD Project's cumulative area are predicted to have a low to medium significance.

The one exception to this was the significance of the residual cumulative impact for matters of national environmental significance springs, which was assessed as high (due to the probability and duration of the impact and the matters of national environmental significance springs' environmental sensitivity).



Fairview, Queensland.

Table 6–21 Residual cumulative significance

Environmental value	Residual cumulative significance
Land use and tenure	Low
Land resources	Low
Landscape and visual amenity	Low
Traffic and transport	Medium
Waste	Low
Surface water	Low
Groundwater (matters of national environmental significance springs)	High
Groundwater (bores)	Medium
Air quality	Low
Greenhouse gases	Low
Noise and vibration	Low
Terrestrial ecology (including matters of national environmental significance)	Medium
Aquatic ecology	Medium
Cultural heritage	Medium
Social	Low
Economics (benefits)	Medium



Fairview, Queensland.

Santos

GLNG Project

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