Project description 4

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4 Project description

4.1 Project overview

Santos GLNG intends to further develop its Queensland gas resources by expanding its existing, previously approved gas supply business.

The GFD Project extends the approved GLNG Project's gas fields, and will involve the construction, operation, decommissioning and rehabilitation of wells and the associated supporting infrastructure needed to provide additional gas over more than 30 years.

The GFD Project will continue to progressively develop the Arcadia, Fairview, Roma and Scotia gas fields across 35 Santos GLNG petroleum tenures in the Surat and Bowen basins, and associated supporting infrastructure in these tenures and adjacent areas. The GFD Project area is illustrated in Figure 4-1.

4.1.1 GLNG Project

Santos GLNG has existing approvals for the exploration, and in some cases production, of gas from coal seams in the petroleum tenure making up the Arcadia, Fairview, and Roma gas fields.

To develop gas supply for LNG export markets, Santos GLNG completed an EIS for the GLNG Project in 2009 (2009 EIS), and received approval from the State and Commonwealth governments in 2010.

The GLNG Project involves the construction and operation of 2,650 exploration and production wells and supporting infrastructure across 6,887 km^2 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.

Production wells and associated gathering lines, transmission pipelines, gas compression and water management facilities, the Gladstone gas transmission pipeline and a two-train LNG facility are currently under construction. The approved gas field development component of the GLNG Project is summarised in Table 4-1 and illustrated in Figure 4-2.

Table 4-1 GLNG Project approved gas field development

Project components	Approved units
Wells	2,650 wells
Gathering lines / transmission pipelines	Approximately 2,000 km
Nodal gas compression facilities	Up to 150 facilities
Hub gas compression facilities	Up to 12 centralised facilities
Water management facilities	Up to 5 desalination treatment facilities (each processing 10 megalitres (ML/day)
Access roads	Approximately 6,800 km

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

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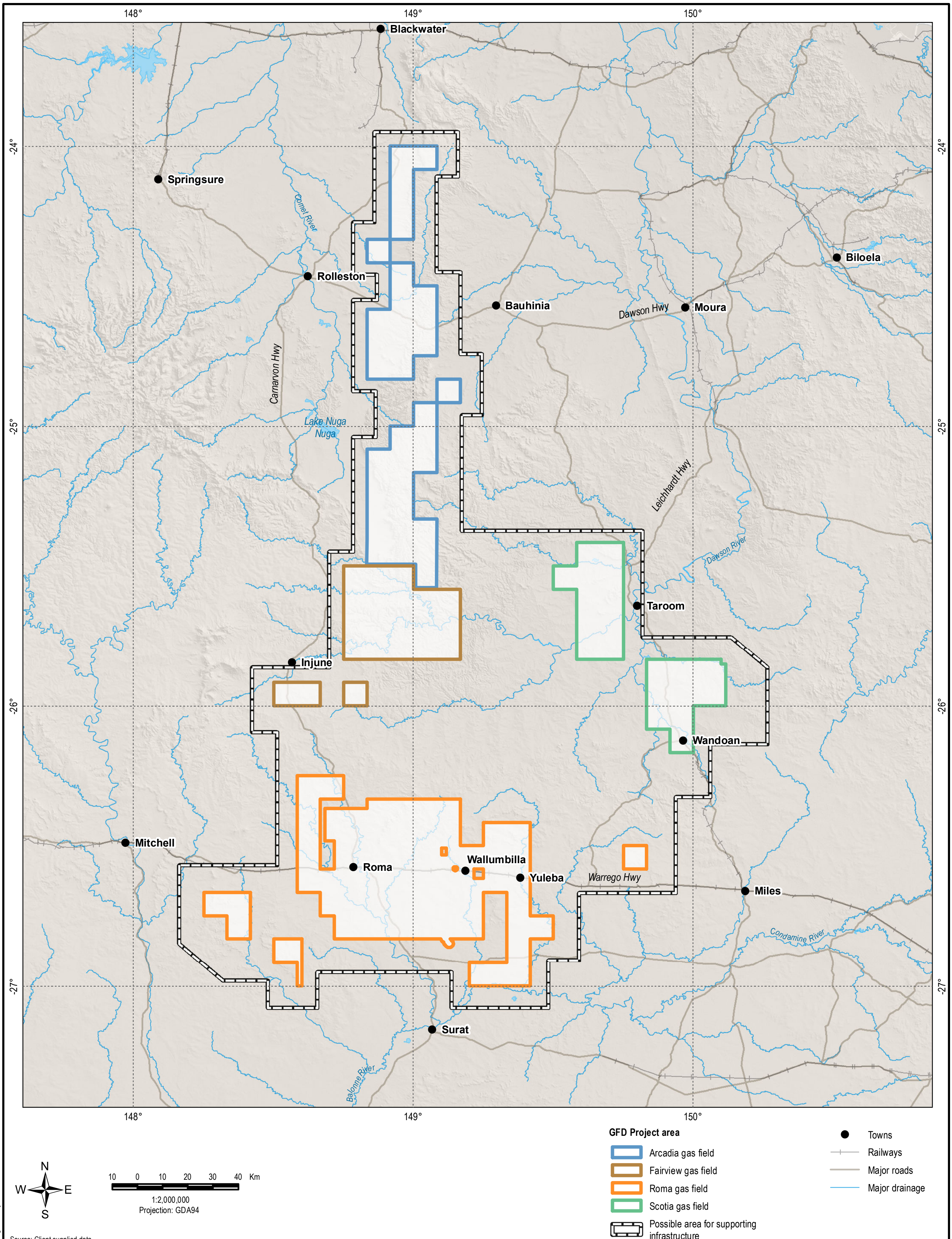

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Santos GLNG Project

GFD PROJECT EIS

GFD PROJECT AREA

URS

PROJECT DESCRIPTION

Figure: **4-1**

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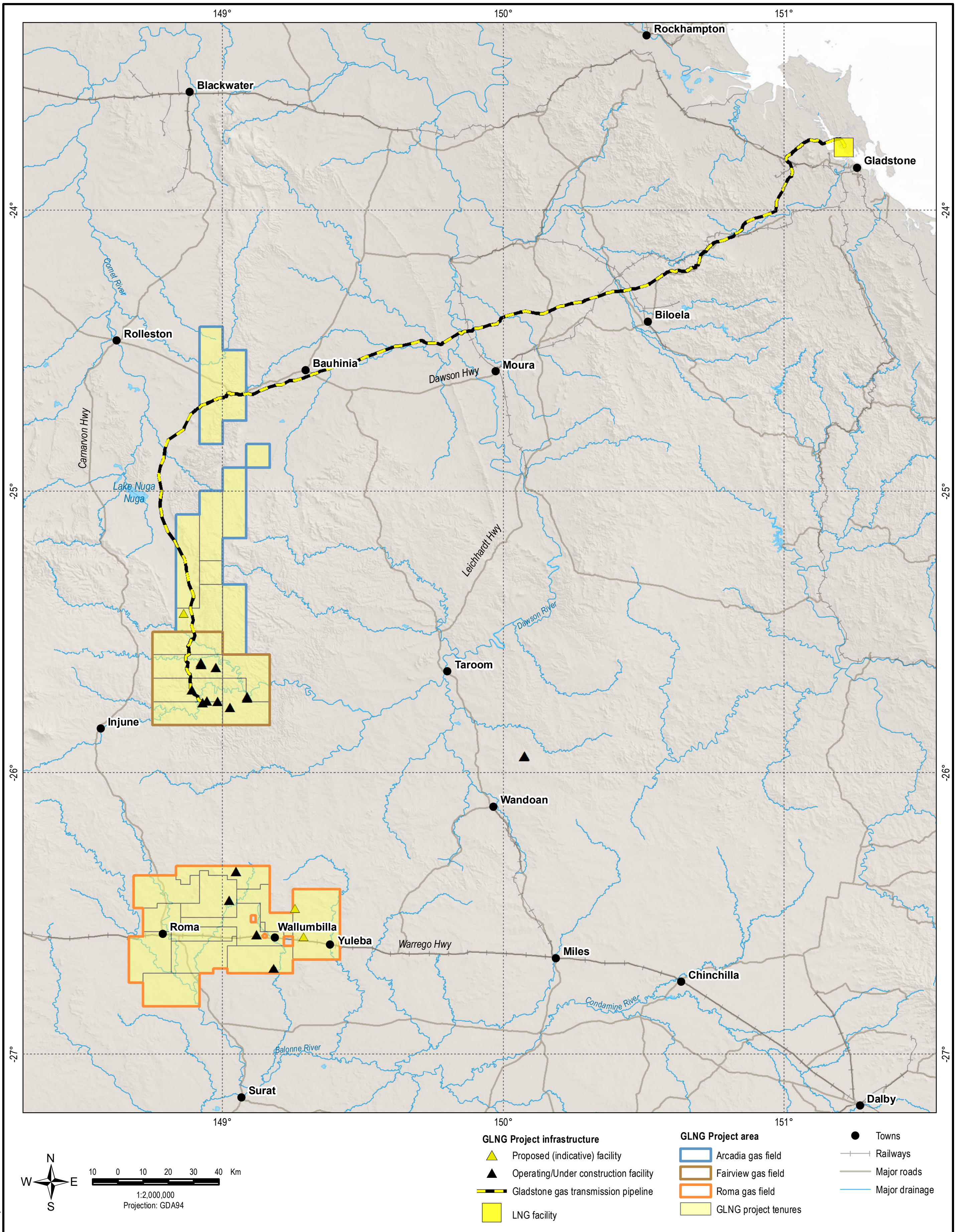

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Santos GLNG Project

GFD PROJECT EIS

APPROVED GLNG PROJECT INFRASTRUCTURE

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PROJECT DESCRIPTION

Figure: **4-2**

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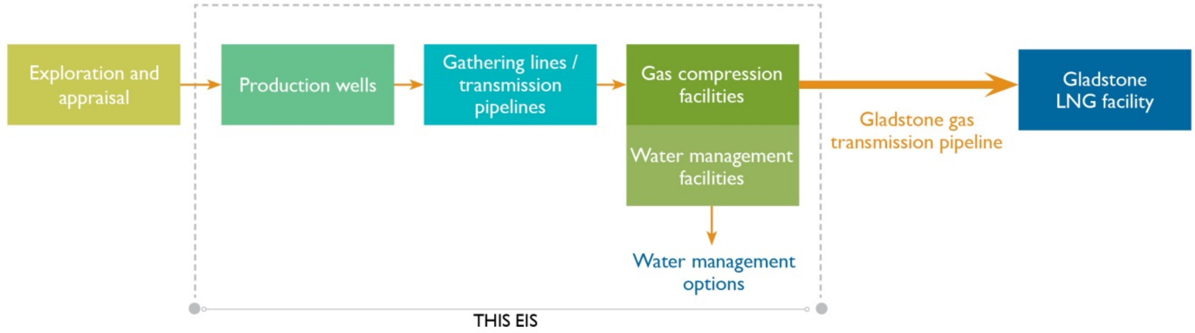
4.1.2 Proposed GFD Project

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 seeks approval to expand the GLNG Project's gas fields from 6,887 km^2 to 10,676 km^2 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. The downstream components of the existing GLNG Project (i.e. the Gladstone gas transmission pipeline and LNG facility) have sufficient approved capacity to accommodate the additional gas generated by the GFD Project.

The GFD Project components subject to assessment in this EIS process are shown in Figure 4-3.

Figure 4-3 GFD Project components relevant to this EIS



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
- 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 and 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. The process of ongoing field development is described in Section 5: Assessment framework.

For the purposes of transparency the 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. Section 1.6.7 of Section 1: Introduction details the EIS approvals process and ongoing approvals process required for the GFD Project.

Where practicable, the GFD Project will utilise existing or already approved infrastructure (e.g. accommodation camps, gas compression and water management facilities) from the GLNG Project or other separately approved developments. The GFD Project may also involve sourcing gas from third-party suppliers, as well as the sharing or co-location of gas field and associated facilities with third parties.

For assessment purposes, this EIS takes a “maximum development scenario” to develop the gas resources and therefore assumes minimal use of existing infrastructure. The maximum development scenario or “EIS assessment scenario” is outlined in Table 4-2.

Table 4-2 GFD Project potential gas field development (EIS assessment scenario)

Project components	Potential units
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) per 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 ML/day)
Access roads	As needed

The GFD Project field layout concept that makes up the EIS assessment scenario is illustrated in Figure 4-4.

4.2 Location

The GFD Project will be located across an area covering 10,676 km^2 of the Bowen and Surat basins. The Bowen Basin occupies about 160,000 km^2 of eastern central Queensland while the Surat Basin covers 300,000 km^2 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.

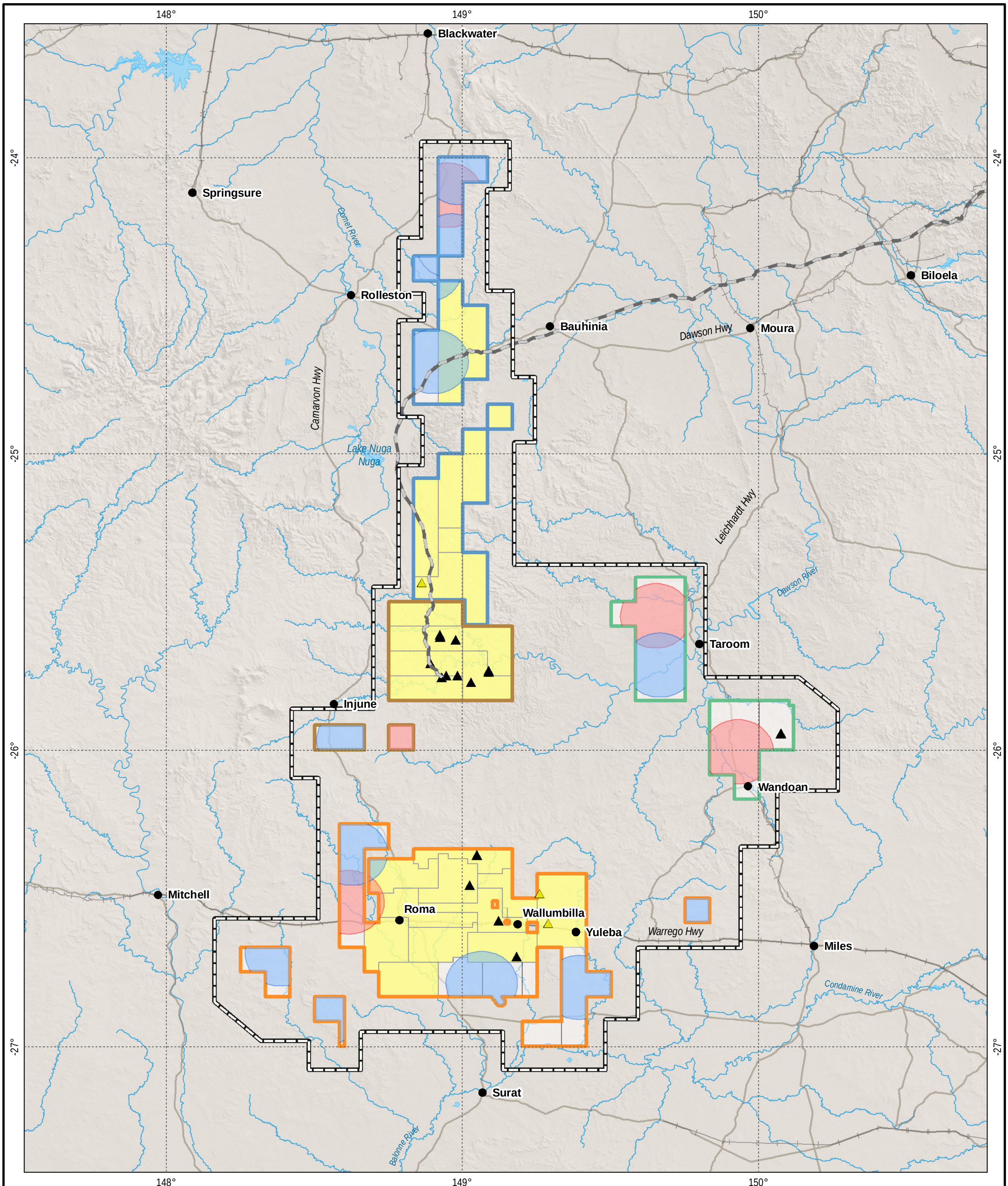
4.2.1 Land and petroleum tenures

The land tenures underlying the GFD Project area include freehold, leasehold, and Crown land (including various reserves, national parks and State forests), with the predominant tenure being freehold. A detailed description of land tenure is included in Section 8: Land use and tenure.

Santos GLNG has the necessary petroleum tenures to authorise gas field development activities including authorities to prospect (ATPs) for exploration and appraisal activities, and petroleum leases (PLs) for advanced appraisal and production activities. Petroleum tenures allow certain petroleum activities (i.e. gas production) to occur along with existing land tenures.

The GFD Project area comprises 35 petroleum tenements including 11 ATPs and 24 PLs as listed in Table 4-3. For operational purposes, Santos GLNG has divided petroleum tenure into four separate gas fields – Arcadia, Fairview, Roma and Scotia gas fields, shown on Figure 4-5. This EIS assessment was undertaken in early 2014 and the tenures shown in Table 4-3 and Figure 4-5 were representative at that time. The EAs which are located in Appendix Y-A of this EIS are those representative of October 2014.

Section 1.6.7 of Section 1: Introduction provides detail around the EIS and post-EIS approval process for the GFD Project.



GLNG Project infrastructure
- Proposed (indicative) facility
- Operating/Under construction facility
- Gladstone gas transmission pipeline
- GLNG Project tenures

GFD Project infrastructure*
- Potential gas compression and water management facility
- Potential gas compression facility

Indicative infrastructure locations - to be located within this area. For assessment purposes only.

GFD Project area
- Arcadia gas field
- Fairview gas field
- Roma gas field
- Scotia gas field
- Possible area for supporting infrastructure

- Towns
- Railways
- Major roads
- Major drainage

N W E S

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Santos GLNG Project

GFD PROJECT EIS

GFD PROJECT AREA AND PRIMARY INFRASTRUCTURE

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PROJECT DESCRIPTION

Figure: **4-4**

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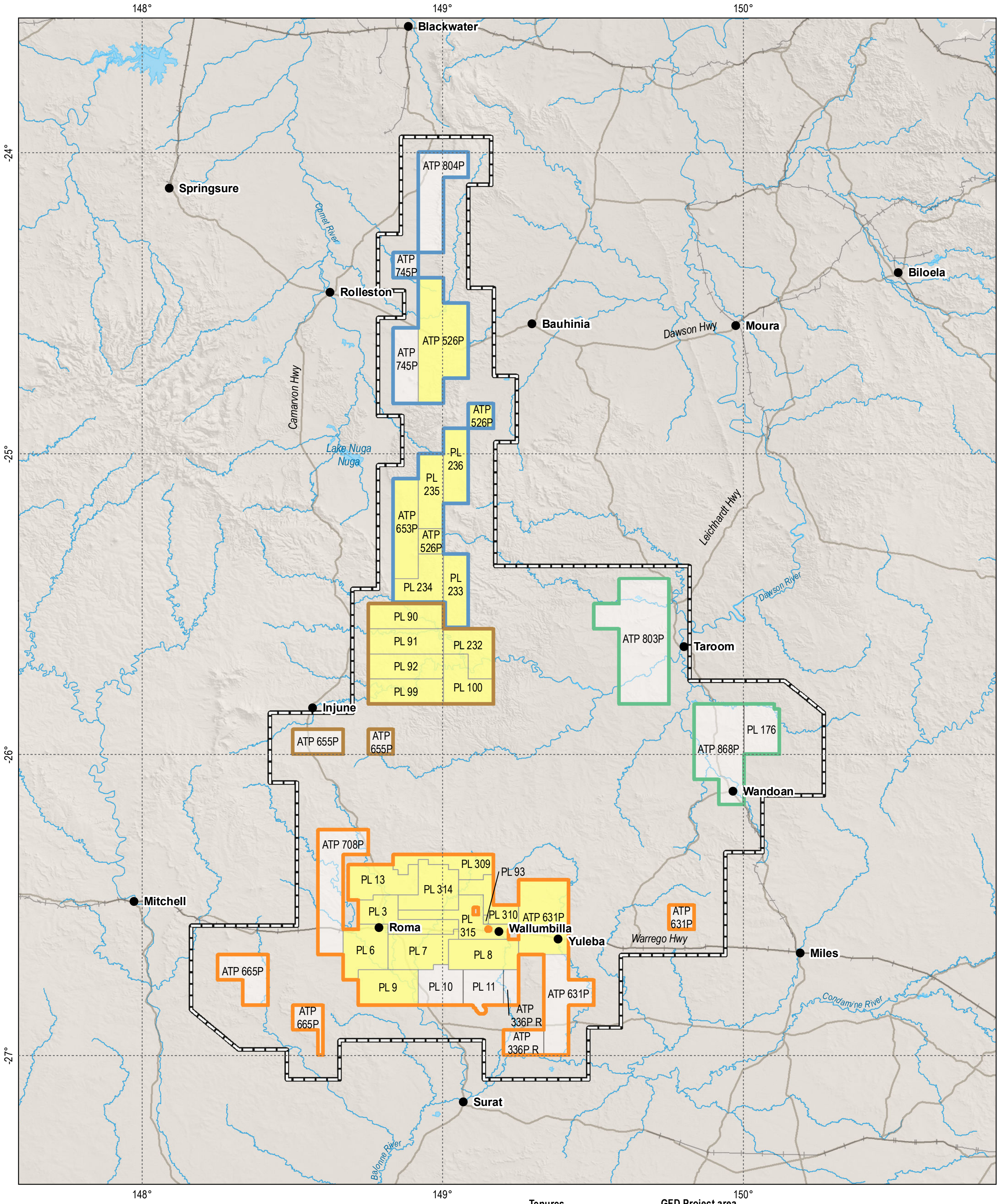

Tenures

- GLNG Project
- GFD Project

GFD Project area

- Arcadia gas field
- Fairview gas field
- Roma gas field
- Scotia gas field
- Possible area for supporting infrastructure

- Towns
- Railways
- Major roads
- Major drainage

N / E / S / W

10 0 10 20 30 40 Km

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Santos GLNG Project

GFD PROJECT EIS

GFD PROJECT PETROLEUM TENURES

URS

PROJECT DESCRIPTION

Figure: 4-5

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Table 4-3 Petroleum tenure forming the GFD Project area

Gas field (number of tenements)	Tenure				Area (km²)
	Petroleum lease (PL)/ Petroleum lease application (PLA)		Authority to prospect (ATP)		
	GLNG Project	Additional for GFD Project	GLNG Project	Additional for GFD Project	
Arcadia (8 tenements)	PL 233 PL 234 PL 235 PL 236	PLA 420 PLA 421 PLA 440	ATP 526P (5 parts) ATP 653P (1 part)	ATP 745P (2 parts) ATP 804P (1 part)	2,726
Fairview (7 tenements)	PL 90 PL 91 PL 92 PL 99 PL 100 PL 232			ATP 655P (2 parts)	1,962
Roma (17 tenements)	PL 3 (313) PL 6 (316) PL 7 (317) PL 8 (318) PL 9 (319) PL 13 (322) PL 93 (323) PL 309 PL 310 PL 314 PL 315	PL 10 (320) PL 11 (321) PLA 281 PLA 282		ATP 336P (2 parts) ATP 631P (2 parts) ATP 665P (2 parts) ATP 708P (1 part)	4,383
Scotia (3 tenements)		PL 176		ATP 803P (1 part) ATP 868P (1 part)	1,605
Total (35 tenements)	21 PLs	3 PLs	2 ATPs	9 ATPs	10,676

4.2.2 Off-tenure infrastructure

The location of gas field infrastructure is primarily influenced by the size of the gas resource and environmental constraints within an area. While major surface infrastructure such as wells and gas compression and water management facilities will be located within petroleum tenure, off-tenure infrastructure is also required and may include gas and water transmission pipelines, groundwater monitoring bores, as well as roads and power lines needed to connect gas field activities to each other and to nearby infrastructure and services. The area that off-tenure infrastructure may be located on is shown on Figure 4-5 as the possible area for supporting infrastructure.

Where Santos GLNG is responsible for developing off-tenure infrastructure it will seek the necessary development approvals separate to this EIS.

For the purposes of transparency the 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.

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Details on the approval requirements for off-tenure infrastructure are provided in Section 2: Project approvals.

Descriptions of the potential off-tenure infrastructure and construction methods associated with the connecting infrastructure such as power lines, transmission pipelines and communications are provided in section 4.6.

The EIS does not supply location details of where pipelines traverse transport corridor crossings as that detail is not available at this stage of field planning.

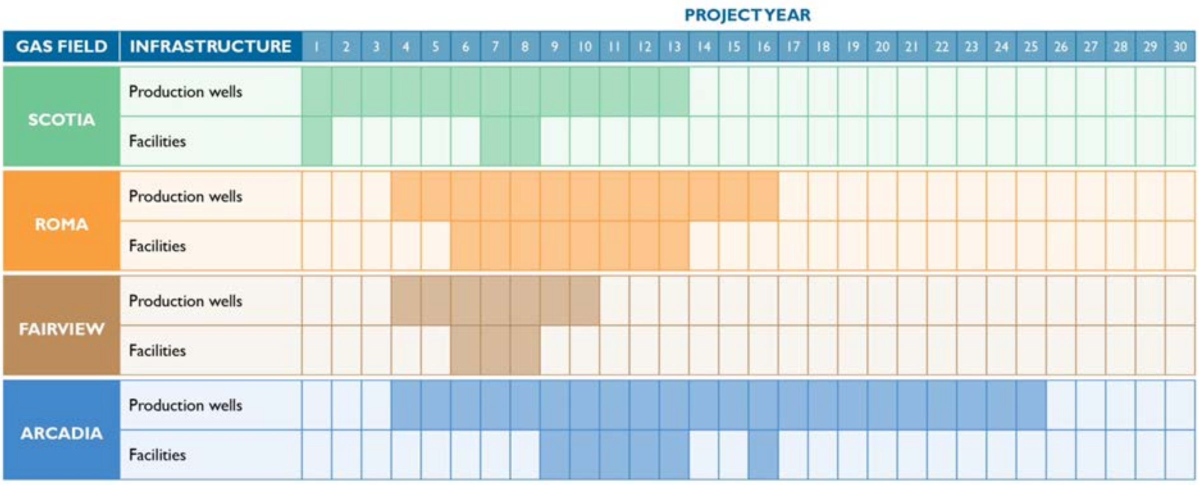
4.3 Proposed timing

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 scenario based on the maximum development case was developed at the approval of the ToR. 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 is outlined in Figure 4-6. This schedule provides an overall field development scenario for the purpose of assessment in this EIS.

Figure 4-6 Potential GFD Project development schedule for maximum development scenario



4.4 Construction phase

Construction activities generally involved in producing gas from coal seams are described in section 3.3.3 of Section 3: Natural gas from coal seams. This section describes the specific methods and equipment that will be used to construct the infrastructure for the GFD Project.

An outline of the various components of the GFD Project and the associated construction methods including disturbance footprints is provided in Table 4-4. Further detail on the process followed to locate GFD Project components and an estimate of maximum disturbance areas is provided in Section 5: Assessment framework.

The GFD Project will use the construction methods outlined in Table 4-4 and described in the following sections. The number and size of construction equipment to be used will vary according to the construction activity being undertaken and is likely to include a combination of dozers, graders, excavators, trucks, cranes, drilling rigs, rollers, front end loaders, scaffolding, welders and hand-held equipment.

Construction transport and workforce requirements are detailed in Section 11: Traffic and transport and Section 21: Social, respectively.

Table 4-4 GFD Project components' construction method, typical footprint and timeframes

Infrastructure components	Description	Construction method	Construction footprint	Construction timeframes
Well lease	• Drill rig • Chemical and fuel storage • Gas generator • Water storage • Mud pit (where required or a tank is used) • Flare and flare sump • Production well(s) • In-well pump • Gas/water separator (if required) • Metering facilities • Fencing and signage where appropriate.	Onsite construction using rotary or air lift drill.	Single well lease: 1.5 ha Multi-well lease: 2.5 ha.	Civil works: 30-60 days Drilling: 24 hours per day, 10-30 days per well Completions: 150 days Commissioning: 60 days.
Access tracks and roads	Graded or gravel roads, aligned to existing fences and tracks where practicable.	Onsite construction.	1.5-3 ha per km.	Civil works: 30-60 days
Gas and water gathering lines	• HDPE[1] (or other) pipeline, aligned to existing fences and access tracks, where practical • Signage.	Laid on ground, or buried in open cut/trench, with trenchless (directional) drilling for crossing sensitive areas.	1- 2.5 ha per km.	Up to 4 days per 500 m to clear, trench and bury line; plus up to 14 days for installation of vents, drains, manifolds, etc.
Gas and water transmission pipelines	• Steel (or other) pipeline, aligned to existing fences and access tracks, where practical • Medium to high pressure flow of water or gas • Signage.	Buried in open cut/trench or with trenchless (directional drilling) methods.	2.5-5 ha per km.	Up to 5 days per 500 m for surveying, clearing and supplies; 2 days per 2 km for trenching, laying and burying; plus 1-7 days for hydrotesting.

Infrastructure components	Description	Construction method	Construction footprint	Construction timeframes
Hub gas compression facilities	Centralised facility that compresses gas to the pressure required for transmission via the Gladstone gas transmission pipeline (or third party transmission pipeline) and, if required, treat gas to supply specifications. It comprises: • Relocatable modular units • Hub gas compression units • Gas turbine alternators to provide power • Water separator and oily water treatment • Triethylene glycol (TEG) dehydrator packages including reflux columns and TEG regenerative boilers • Emergency flare (able to burn 10 TJ/hour) • Backup diesel generator and diesel storage • Air compressors, pipework and transmission valving • Minor utilities like nitrogen generator for turbine seals • Control room, instrumentation and control systems • Office, workshops and equipment storeroom • Access roads/tracks.	Assembly of prefabricated modular units onsite.	20-40 ha each.	2-3 years
Nodal gas compression facilities	Field facility that compresses gas collected in the gas gathering lines to pressure for transmission or second stage (hub) compression. It comprises: • Relocatable modular units • Rotary screw compressors • Reciprocating engines to provide power, if not connected to grid • TEG dehydrator packages including reflux columns and TEG regenerative boilers • Air compressors, pipework and transmission valving • Control room, instrumentation and control systems • Access roads and tracks.	Assembly of prefabricated modular units onsite.	2-8 ha each.	1-2 years
Water management facilities	• Water storage • Filtration units • Desalination treatment units e.g. reverse osmosis and/or ion exchange • Chemical balancing unit e.g. water amendment facility • Above ground valving and pipework.	Combination of site constructed structures (i.e. dams) and modular treatment units prefabricated offsite.	5-10 ha each.	180 days +

Infrastructure components	Description	Construction method	Construction footprint	Construction timeframes
Water storage	Structures (tanks up to 15.5 ML, and dams up to 350 ML) for storage of coal seam water.	Onsite construction.	Tanks: Up to 1 ha each Large dams: 5-16 ha each.	Tanks: 30 days Large dams: 180 days +
Fluid (brine) storage	Regulated structures (up to 350 ML dams) for storage of fluid (brine).	Onsite construction	Large dams: 5-16 ha each.	Large dams: 180 days +
Camps	• Temporary or permanent accommodation facilities — Drill camps — Construction camps — Permanent camps • Modular in design and form, easily relocatable • Water supply • Sewage treatment facilities • Access roads.	Assembly of prefabricated modular units onsite.	1-20 ha each.	Large temporary camp (i.e. 400 persons): 6-9 months Permanent camp (i.e. 80 persons): 6-9 months
Laydown and storage yards	Cleared, graded area for temporary storage of materials, plant and equipment.	Onsite construction	5-40 ha each.	Up to 7 days
Borrow pits	Small area excavated to recover materials (e.g. soil, gravel).	Onsite construction.	5-50 ha each.	Up to 7 days

[1] High density polyethylene

4.4.1 Wells

Production wells

The construction and completion of production wells is a major component of gas field development. The wells are designed to maximise gas recovery, while at the same time minimising impact on the environment and protecting groundwater resources.

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 constructed to maximise gas recovery. 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.

Well construction involves extensive pre-planning and the use of custom drilling rigs, tools, equipment and materials. For each well, a site-specific drilling plan is developed taking into account the geological and environmental conditions.

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.

Underground gas storage and injection wells

Santos GLNG is currently storing gas underground in the Roma gas field to enable the management of the response to increases and decreases in gas supply or demand. Underground gas storage involves injection of gas into depleted conventional gas reservoirs. Potentially, underground gas storage and injection wells will also be used for gas extracted as part the GFD Project. The facilities required for gas storage and injection of gas will be similar to the types of infrastructure required for gas extraction – wells, gathering lines and compression facilities. However, the underground gas storage and injection wells will operate at a higher pressure than the wells used for gas extraction.

Fluid injection wells

One of the ways Santos GLNG currently manages brine/ concentrate from desalination treatment facilities (fluid) associated with the GLNG Project is by injecting the fluid into deep, saline fractured basement rock formations. The wells used for this activity are known as 'fluid injection wells. Where practicable, fluid injection wells will also be used to manage the GFD Project's fluid. Fluid injection wells will comprise similar surface facilities to that established for production wells, plus associated storage tanks and treatment facilities (e.g. sterilisation and de-oxygenation units, treatment chemicals, pressure pumps and control systems). Other options for dealing with the fluids are discussed in section 4.5.4.2.

Monitoring bores

Monitoring bores enable ongoing quality and pressure monitoring of the various water aquifers above and below the coal seam, including aquifers used for agricultural, industrial and domestic use within the gas fields. Where there is no existing bore suitable to use for monitoring, a new bore may need to be drilled. Depending on the depth and well design, a truck-mounted drilling rig may be used to complete the drilling (typically up to ten days) and development work (two to four days).

4.4.1.1 Well lease establishment

Production wells, monitoring bores, underground gas storage and injection wells, and fluid injection wells will be constructed on a similar well lease area (described in Table 4-4).

A well lease (the area cleared for each well) will be developed to accommodate the necessary drilling and completion equipment and support services as described in section 3.3.3 of Section 3: Natural gas from coal seams.

An example of a Santos GLNG well lease layout under construction is given in Plate 4-1 and shows the key equipment and support services brought onto a well lease such as:

- Drill rig and associated equipment
- Gas generator
- Chemical and fuel storage
- Mud pit or tank for drilling fluids
- Flare and flare sump for disposal of gas during drilling and appraisal process
- Water storage (tank or small dam) for initial water supply and coal seam water during construction.

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.

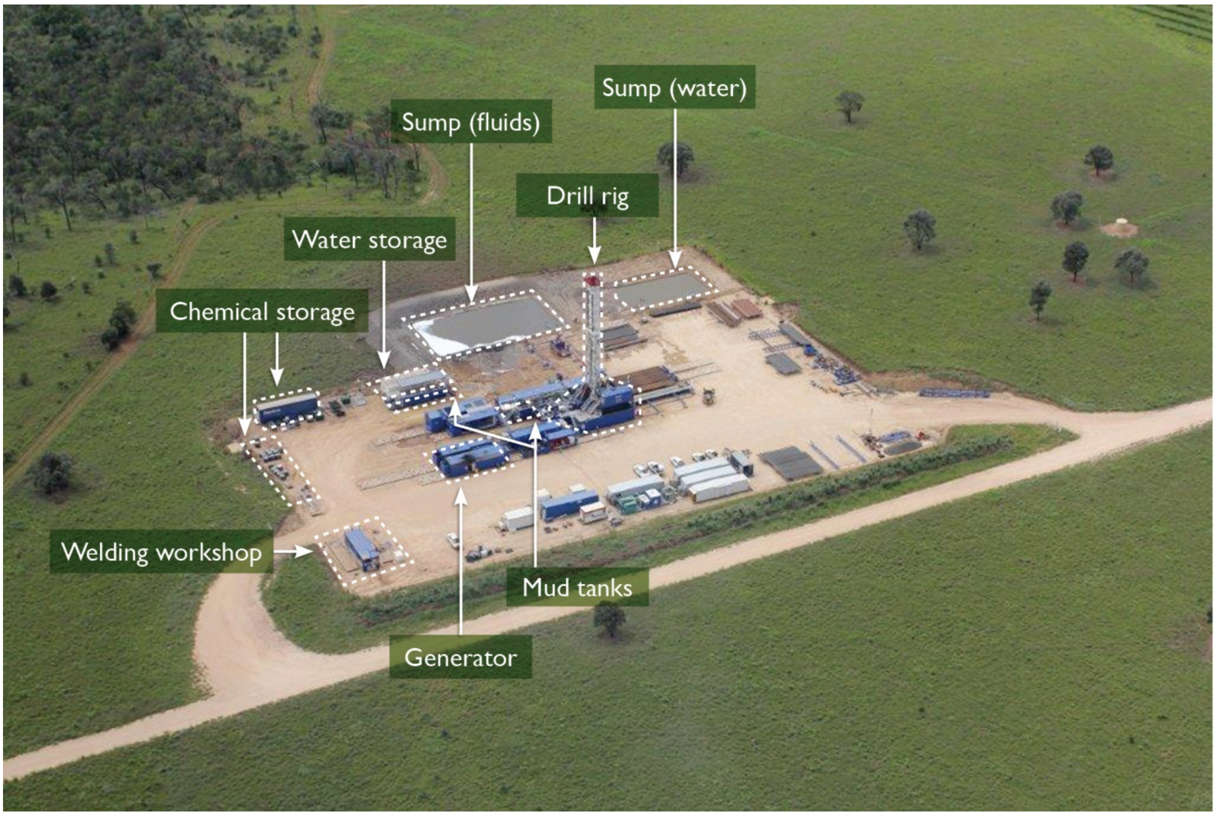


Plate 4-1 Example Santos GLNG well lease during construction

4.4.1.2 Drilling, casing and cementing

Methods for construction of production wells, monitoring bores, underground gas storage and fluid injection wells will be similar. During construction of wells, drilling will be carried out on a 24-hour basis for approximately 1-3 weeks per well. The time to complete each well is dependent on the depth of the well, the geology of the area and the type of rig used.

Drilling a vertical well involves a variety of drilling techniques to reach the target formation, including rotary or air techniques. For production wells, directional drilling can be applied to direct the well onto a horizontal plane to run along the coal seam or to increase the contact area of a well in contact with coal seam. This practice requires fewer wells and will decrease the surface footprint of the overall GFD Project.

Drilling fluids are circulated down the borehole during drilling to lubricate and cool the drill bit and remove drill cuttings from the bore. Drilling fluid and cuttings are collected in surface tanks or in pits and are removed from the well lease area for reuse, recycling or disposal.

Through multiple cycles of drilling, installing casing and cementing casing, the well is isolated from surrounding aquifers. Santos GLNG will test and prove the integrity of the well casing before gas extraction commences. The casing of the part of the well in the coal seam is perforated using jet perforating guns to create the flow of gas from the well to the surface. To produce gas from a well, the well head is installed and completed with an in-well pump and surface facilities.

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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. Examples of stimulation are described in section 3.3.5 of Section 3: Natural gas from coal seams and a detailed risk assessment is provided in Appendix AE-F: Hydraulic fracturing risk assessment. 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.

4.4.2 Gathering lines and transmission pipelines

To transport the gas and/or water from the production wells to the gas compression facilities/water management facilities, Santos GLNG will utilise 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.

4.4.2.1 Gathering lines

Gas and water gathering lines will be high-density polyethylene (HDPE) pipe of between 100 millimetres (mm) and 1,000 mm in diameter and will be buried; however, water gathering lines may be laid on the ground where appropriate. Gas gathering lines will be designed and constructed to comply with *Australian Standards AS2885 – Pipelines Gas and Liquid Petroleum*, *Code of Practice for constructing and abandoning coal seam gas wells and associated bores in Queensland* (Department of Natural Resources and Mines, 2013), and the *Australian Pipeline Industry Association (APIA) Code of Environmental Practice* (2013). Construction of buried gas gathering lines is shown in Plate 4-2.

Plate 4-2 Laying transmission pipeline in Fairview

4.4.2.2 Transmission pipelines

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 collect gas from nodal gas compression facilities (where present) within the gas fields and transport it under pressure to centralised hub gas compression facilities and into the Gladstone gas transmission pipeline or third party transmission pipelines. Similarly, water transmission pipelines may be constructed to transfer water to and from water management facilities or third parties.

Route selection for transmission pipeline corridors will be based on the final locations of the major facilities, as well as the constraints described in Section 5: Assessment framework. Where practicable, they will be co-located with other linear infrastructure.

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.

The following tasks will be involved in the construction of transmission pipelines:

- Construct access tracks, using existing roads where practicable, in consultation with landholders
- Survey the proposed pipeline alignment usually adjacent to existing access tracks or fence lines
- Clear vegetation and obstacles, grade and stockpile topsoil at the edge of the right of way
- Deliver lengths of pipe to site from laydown areas along the pipeline route
- Excavate a pipeline trench, with the subsoil stockpiled adjacent to the trench
- Lay the pipe alongside the trench. Steel pipes require bending and welding into lengths (up to one kilometre long strings) as required by route and terrain; welds must be inspected and tested
- Lower pipe into trench (using side boom tractors for heavy pipe strings) and weld strings together
- Backfill and compact the trench
- Hydrostatically or pneumatically test the pipeline for strength and leaks
- Re-contour and rehabilitate the right of way including removal of construction material
- Install signage along the alignment in line with Australian Standards.

Watercourse crossings for pipelines will be constructed using a range of techniques and activities suited to the local conditions, including:

- Open cut
- Flow diversion
- Isolation (through the construction of a temporary coffer dam)
- Trenchless (horizontal directional drilling or micro-tunnelling for large flowing watercourses).

Pipelines are integrity pressure-tested with water or air prior to commissioning. Hydrostatic testing involves filling the pipelines with water and applying higher than normal operating pressures. Water for the hydrostatic testing is normally obtained from existing sources in proximity to where the testing will occur.

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.

4.4.3 Gas compression and treatment facilities

Standalone nodal gas compression facilities will be installed in the field 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 will 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.

Construction of an existing GLNG Project hub gas compression facility in the Fairview gas field is shown on Plate 4-3.

Plate 4-3 Construction of collocated water treatment and gas compression facility at Fairview

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 activities will require the use of heavy earthmoving and lifting equipment and will involve:

- Clearing vegetation
- Grading the area, including placement of gravel subgrade for construction activities
- Installing underground utilities and infrastructure
- Constructing footings and foundations for buildings and shelters
- Placing modular structures and equipment
- Constructing non-modular buildings (if required)
- Installing piping, electrical equipment, controls, and instrumentation
- Testing and commissioning of equipment
- Paving or gravelling of work areas
- Power generation.

Buildings at these facilities will include a control room, offices, workshop, storerooms and, in some cases, emergency accommodation. Support infrastructure and facilities during construction will include:

- Construction camps
- Laydown yards for the storage of materials and equipment
- Concrete batching plants (at remote facilities)
- Water supply for construction activities and dust suppression activities
- Sanitation facilities at both construction camps and construction sites
- Upgrades to existing roads, or the construction of new roads to support the transportation of heavy modular equipment, piping, materials, and workers
- Diesel generators to provide electricity.

Commissioning will be undertaken in accordance with industry standards including hydrostatic testing, and the breaking in of pumps and compressors.

4.4.4 Water management facilities

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 extracted 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 for the GFD Project. However, the GFD Project may also require the construction of new water management facilities. This may include infrastructure such as gathering lines and transmission pipelines as described in section 4.4.2, as well as the following:

- Water storages including tanks and dams
- Water treatment facilities (refer to Plate 4-4) that can perform:
  - 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 ration and pH/residual alkalinity of the water
  - Temperature and ionic balance adjustment
  - Filtration removing suspended solids (lowering turbidity) and nutrients
  - Sterilisation to remove bacteria
  - De-oxygenation
  - Desalination facility (e.g. reverse osmosis, ion exchange)
  - Water amendment facility, which uses chemical dosing to amend pH and ionic balance of the water prior to use
  - Blending of separate water streams to achieve a target water quality
  - Water storage prior to or post-treatment.
- Fluid storage for the concentrated waste produced by desalination.

Commissioning will be undertaken in accordance with industry standards. Water management activities are discussed in section 4.5.4.

Plate 4-4 Water amendment facility

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4.4.4.1 Water storage

Coal seam water will have total dissolved solids ranging from 100 milligrams per litre (mg/L) (fresh water) to over 10,000 mg/L (brackish). Where water must be stored, dams and/or tanks will be constructed to store water prior to entering water management facilities (at the well lease or in central locations) or following treatment These dams will be earthen, constructed from material sourced locally and have capacities of up to 350 ML. Tanks will 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 Queensland Department of Environment and Heritage Protection's (EHP) *Manual for assessing hazard categories and hydraulic performance of dams* (EHP, 2012). Tanks will be designed to the relevant Australian Standards.

Dam construction activities may include a range of conventional earthworks activities including excavation and lining shown in Plate 4-5. Design and construction activities may involve the following:

- Placement and testing of clay and/or liner materials to achieve the required hydraulic performance
- Leak detection sump and pipe work
- Transfer pump and associated pipework
- Escape areas for animals on dam slopes
- Emergency spillways lined with geotextile
- Erosion control blanket over topsoil on batters.

Plate 4-5 Laying liner during construction of water storage structure

4.4.4.2 Water treatment facilities

As the GFD Project's water management facilities will be modular, they will be factory-fabricated and transported to the GFD Project area. The modules will be assembled and then the piping, electrical controls and instrumentation wiring will be installed.

Where desalination treatment (e.g. reverse osmosis or ion exchange) is required, these facilities will be generally designed and constructed with incremental capacities of 5 ML per day per module. Relocatable modules will have a smaller capacity up to 2 ML per day. A number of modules will be co-located to provide the required design capacity for each treatment facility. Desalination will sometimes be co-located with a water amendment facility and include water storage such as modular tanks combined with dams. Other alternative technologies may be identified during the GFD Project evaluation and design process.

4.4.4.3 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 (brine) stream with dissolved salt content of around 20-60 grams per litre. Depending on the salt content it can be classified as 'brine'. The storage will be constructed as fully engineered, purpose-built dams of up to 350 ML constructed in accordance with the *Manual for assessing hazard categories and hydraulic performance of dams* (EHP, 2012).

4.5 Operations phase

Following completion of construction activities, disturbed areas will be rehabilitated to reduce the extent of disturbance to the operations footprint of the facility and/or activity. The operations footprint of various GFD Project components is given in Table 4-5. The area of the operations footprint will be considerably less than those needed during construction (Table 4-4).

The locations, size and timing of each of the GFD Project's operational components will be confirmed as part of the ongoing field development process and presented in plans of operations as described in Section 5: Assessment framework. Operations transport and workforce requirements are detailed in Section 11: Traffic and transport and Section 21: Social, respectively.

Table 4-5 GFD Project components' operations footprint and inspection timeframes

Project component	Operations footprint	Inspection timeframes
Well lease	Single well lease: 0.3 ha Multi-well lease: 0.5 ha	Ongoing, averaging 5 visits to pumps over the life of the well
Access tracks and roads	0.8-1.5 ha per km	Ongoing
Gas and water gathering lines	None (right of way maintained)	Quarterly checks, as required
Gas and water transmission pipelines	None (right of way maintained)	Ongoing
Hub gas compression facilities	10-15 ha each	Ongoing (onsite or remote control)
Nodal gas compression facilities	1-4 ha each	Ongoing (onsite or remote control)
Water management facilities	2-5 ha each	Ongoing (onsite or remote control)
Water storage	Up to 0.5 ha per tank 3-8 ha each for large dams	Annual inspection by suitably qualified and experienced person (in accordance with regulatory approvals) and routine inspections or telemetry-based monitoring of water levels.
Fluid (brine) storage	Up to 8 ha each for large dams	
Camps	0.5-10 ha each	Ongoing, up to 52 weeks per year

4.5.1 Wells

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, gas from the wells will begin to become free flowing with reservoir pressures driving the gas flow to the surface. Production wells are expected to operate for up to 30 years.

Examples of a Santos GLNG single-well lease and multi-well lease during operations phase are shown in Plate 4-6 and Plate 4-7.

Plate 4-6 Operational single-well lease

Plate 4-7 Operational multi-well lease

Production wells can be monitored and controlled remotely. Information on production pressures and rates will be transmitted via radio telemetry or fibre optic cable to enable production to be controlled from remote sites, including from the Santos GLNG Operational Centre in Brisbane and regional operations centres. Rapid changes in pressure can be detected and can lead to automatic cut off at the well head.

Wells and well lease equipment will be routinely inspected and maintained as required. Well workover (the major servicing of a well) is expected to occur several times over the life of the well. Specialised workover drilling rigs will re-enter the well as necessary to perform pump repairs, remove blockages, isolate intervals or deepen the well.

4.5.2 Gathering lines and transmission pipelines

4.5.2.1 Gathering lines

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 Australian Standards.

Gas lines will include water condensate drains at low points in the terrain. These allow water that condensates within the line to be removed to prevent build up in the pipe and will be automatically or manually operated. Water pipelines include vents at high points in the terrain for removal of the small amounts of gas that might be dissolved in the water. Drains and vents will be inspected as part of routine field maintenance activities.

4.5.2.2 Transmission pipelines

Transmission pipelines for gas and water will be operated and maintained similarly to the gathering lines, except that they will be operating at higher pressure. There will be signage to identify the locations of the transmission pipelines as shown in Plate 4-8.

Pipeline location marker posts and inspection points for integrity testing will be installed along the length of the transmission pipelines. Marker posts are important for both landholders and pipeline maintenance personnel to identify the location of buried pipelines. An easement will remain over the pipeline once constructed. Pipeline operators may need to access the easement to conduct visual inspections, integrity testing and other operational duties from time to time.

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.

Plate 4-8 Pipeline above-ground signage

4.5.3 Gas compression and treatment facilities

Gas collected from the field will pass through nodal gas compression facilities and hub gas compression facilities to meet specifications for transmission and supply to market. Where wells are near the hub gas compression facility, both stages of compression will be conducted within the same facility (i.e. to bring gas up to pressure required for transmission to market). Some gas supplied to the gas compression facilities may be extracted from underground gas storage.

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

Gas compression facilities will be operated on a continuous basis and will be fully automated. 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.

Routine inspections and maintenance will be conducted on equipment at the facilities. This will comprise a combination of scheduled inspection and maintenance of select equipment and, in some instances, full shutdown with more extensive maintenance.

An existing compression facility, which may be representative of future nodal compression facilities, located in the Fairview gas field is illustrated in Plate 4-9.

Plate 4-9 Existing nodal gas compression and treatment facility at Fairview gas field

4.5.4 Water management facilities

The GFD Project water management facilities will accommodate a dynamic water management process designed to provide fit-for-purpose water for the intended use.

Water management facilities will operate 24 hours a day, with short periods of shutdown to facilitate scheduled maintenance. Routine inspections and maintenance will be conducted.

4.5.4.1 Coal seam water management

The GFD Project coal seam water management strategy (Appendix Z) is to manage coal seam water in accordance with the relevant regulatory framework. The strategy is sufficiently flexible to accommodate changes in policy, technology and field conditions, based on a rigorous evaluation and decision-making framework as alternative technologies may be identified during the GFD Project design and implementation process.

The regulatory framework includes the Queensland *Coal seam gas water management policy 2012* (EHP, 2013). The policy sets out the following management hierarchy under the *Environmental Protection Act 1994* (Qld) for prioritising management and use of coal seam water:

- Priority 1 – coal seam water is used for a purpose that is beneficial to one or more of the following: the environment, existing or new water users, and existing or new water-dependent industries.
- Priority 2 – after feasible beneficial use options have been considered, treating and disposing coal seam water in a way that firstly avoids, and then minimises and mitigates, impacts on environmental values.

In addition, the 'making good' requirements of the *Water Act 2000* (Qld) may require operators to consider the feasibility of using coal seam water to meet obligations for provision of water to mitigate impacts that may result from a coal seam operation on bores.

The GLNG Project already has an approved plan in place for existing operations. The strategy for the GFD Project will build upon the experience and understanding of the 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. The overall water production characteristics can be forecast with reasonable certainty to enable effective management of the water.

The quality of coal seam water determines the potential treatment requirements for its proposed use. Not all water extracted from coal seams requires treatment before use. Due to the lifecycle impacts (particularly energy) of some treatment processes it is preferable to minimise the amount of treatment wherever possible.

Treatment of coal seam water will be undertaken to provide water of appropriate quality for the proposed use. Where a change in water quality is needed to meet the required water quality of intended uses, this will primarily be achieved through one or a combination of the following approaches:

- Desalination using reverse osmosis to separate a portion the total dissolved solids and other constituents into a concentrated waste stream and produce a better quality permeate stream
- Amendment using chemical dosing to lower the sodium adsorption ratio and pH/residual alkalinity of coal seam water
- Temperature and ionic balance adjustment
- Filtration removing suspended solids (lowering the turbidity), bio-toxic elements and nutrients that can lead to algal blooms from the water
- 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, the intended uses and their water quality requirements according to relevant approvals.

Due to the geographic extent of gas production activities Santos GLNG will adopt a range of water management options to achieve outcomes in accordance with the regulatory framework.

The coal seam water management strategy for the GFD Project has adopted the policy's management hierarchy where by:

Priority 1 – Beneficial use

Coal seam water should be used for a purpose that is beneficial to existing users including GFD Project requirements and to meet "make good" obligations, new water users, and / or existing or new water-dependant industries. Management solutions will be determined based on an evaluation framework that includes full lifecycle assessments of potential benefits and liabilities associated with each option or suite of options. The objective of the framework is to identify feasible options which maximise beneficial use and minimise environmental impacts.

Priority 2 – Disposal

After feasible beneficial use options have been considered, coal seam water will be disposed of in a way that firstly avoids, and then minimises and mitigates, impacts on environmental values.

Options for managing water include utilising extracted water for make good arrangements, operational use, substitution of water allocation, depleted coal seam water injection, aquifer injection, providing water for landholder activities or other regional users, surface water release, and evaporation of water in accordance with EHP guidelines.

4.5.4.2 Fluid (brine) management

Where desalination (e.g. reverse osmosis) is required a fluid (RO concentrate or brine) is generated that will require appropriate management and subsequent disposal in accordance with regulatory requirements.

The Queensland *Coal Seam Gas Water Management Policy 2012* (EHP, 2013) sets out the following management hierarchy for prioritising management of brine (saline waste):

- Priority 1 – brine or salt residues are treated to create useable products wherever feasible.
- Priority 2 – after assessing the feasibility of treating the brine or solid salt residues to create useable and saleable products, disposing of the brine and salt residues in accordance with strict standards that protect the environment.

The options available for utilisation for the GFD Project can be divided into two categories; commercial salt recovery and brine or salt disposal.

Commercial salt recovery

The commercial viability of selling salt product produced by Santos GLNG's activities is based on a number of factors, including technical considerations, environmental impacts, market proximity and other economic factors. Currently, this option is not considered practicable for Santos GLNG, because of the significant energy intensity, cost and low commercial volumes of salt. Commercial salt beneficial use options may become more economic where economies of scale can be employed.

Fluid or salt disposal

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.

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.

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 utilised, each with advantages and challenges to feasibility including thermal evaporation. These technologies have differing energy intensity, environmental footprint, technical complexity, operability and economics.

4.6 Supporting infrastructure

In addition to the gas and water extraction, transmission, compression and management facilities, other infrastructure will be required to support the construction and operation of the gas fields including:

- Accommodation facilities, including sewage treatment, for construction and operational staff
- Access roads
- Fuel storage, workshops and maintenance areas
- Laydown, stockpile and/or storage areas
- Borrow pits and quarries
- External infrastructure such as transport, energy supply, water supply and communications.

Most of the supporting infrastructure will be constructed within the GFD Project's tenure, but some may also be located off-tenure in the area designated for possible supporting infrastructure (see Figure 4-1).

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.

4.6.1 Accommodation facilities

Local residents employed on the GFD Project will already have local housing in the 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 sites.

4.6.1.1 Camps

To accommodate the projected maximum workforce generated during the construction and operations phases, Santos GLNG will develop camps within the GFD Project area to supplement the existing accommodation, services and amenities. Field development planning processes will be used to determine the size and locations of these camps.

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

- Small temporary camps (also called drill camps) will be modular and relocatable facilities, less than 1 ha in area, and will provide basic amenities for up to 20 people for short-term activities such as drilling or installation of gathering lines. To support the drill camps, water tanks and modular sewage treatment plants will be provided.
- Larger semi-permanent camps will be built to support construction of large facilities (e.g. hub compression facilities). They will have an area of about 20 ha and will 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 (two to three 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. Example layouts of existing GLNG Project construction (semi-permanent) and operations (permanent) camps are shown in Plate 4-10 and Plate 4-11 respectively. Camps for the GFD Project will be similar to these.

Plate 4-10 GLNG Project semi-permanent construction camp layout

Plate 4-11 GLNG Project operations camp layout

4.6.1.2 Sewage treatment

Relevant approvals will be obtained to install and operate sewage treatment facilities at the camps. At the drill camps, small plants will be used as the number of site personnel will be fewer than 20 people. Effluent will be treated and released or transported offsite to approved waste disposal facilities. At the construction sites and laydown yards, portable amenities will be provided and wastewater will be transported offsite. At the semi-permanent construction camps and permanent operations camps, the sewage treatment facilities will be designed and installed to store, treat and dispose to required standards.

4.6.2 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 (e.g. gas compression facilities, accommodation camps, etc.). 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. In requires, this would be undertaken in consultation with landholders.

A typical access road used by the GLNG Project is shown in Plate 4-12.

Plate 4-12 Existing access road for the GLNG Project

The construction activities associated with roads and access tracks will include:

- Upgrading and/or widening of existing roads and tracks (clearing and grubbing) where required
- Excavation and filling
- Preparation of sub grade
- Installation of drainage, such as culverts and floodways
- Progressive rehabilitation of the clearing width down to the formation width of the road.

4.6.3 Fuel storage, workshops and maintenance areas

A component of the GFD Project construction and operations activities will be the fuelling, maintenance, inspection and testing of equipment. Facilities for these activities will be established at major construction and operations centres including laydown areas, stockpile and storage areas, accommodation camps, and hub gas compression and water management facilities.

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.

4.6.4 Laydown, stockpile and storage areas

General construction, maintenance and laydown yards will be established to support construction activities. These laydown yards will vary in size from less than 0.5 ha (drill camp laydown yards) to 25 ha (yards supporting development of a major gas compression facility).

The laydown, stockpile and storage areas will be used for storage of materials and equipment necessary for construction activities. These will be temporary facilities only used during the construction phase and will be located close to construction sites.

Where required, Santos GLNG will construct prefabricated offices, sanitation facilities and, in some cases, temporary warehouses for the storage of weather sensitive materials and equipment.

During operations, a smaller number of laydown, stockpile and storage areas will be required to support ongoing operations activities. An equipment store will be located within the gas compression facilities to house critical spare parts.

An existing GLNG Project laydown area is shown in Plate 4-13.

Plate 4-13 GLNG Project laydown area

4.6.5 Borrow pits and quarries

Borrow pits 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 will be determined as the needs arise. Similarly, Santos GLNG is not able to estimate the quantity that will be required for the development of the GFD Project at this time; however, Santos GLNG will comply with regulatory requirements in sourcing material.

At present, it is proposed that any Santos GLNG constructed borrow pits will be located in the gas fields. Alternatively materials may be sourced from third parties, who are appropriately licensed, including State-owned quarries.

Borrow pit sites will be selected on the basis of the need for construction materials, the suitability of the sites to provide these materials, and the sites' proximity to the main areas of construction. Normal earthmoving equipment (trucks, dozers, etc.) will be used for excavation activities and mechanical screens used as necessary to screen and grade materials. Santos GLNG does not anticipate that blasting will be required to source fill materials; however, if required, Santos GLNG will obtain and comply with the relevant approvals.

The 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.

4.6.6 External infrastructure requirements

The GFD Project will need to use external infrastructure such as transportation networks, water supply, electricity and communications infrastructure, which are described below.

4.6.6.1 Transportation

Transport of the non-local construction workforce will be mainly fly-in/fly-out via Roma, Emerald and other regional airports. The construction workforce will be transported by bus from the airport to the accommodation camps, which will be close to work sites. Assessment of workforce movements and accommodation aspects is provided in Appendix M: Traffic and transport and Appendix V: Social respectively.

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 material will be sourced within the GFD Project area or from third parties. Access to various sites 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.

A detailed assessment of the GFD Project's traffic impacts is provided in Appendix M: Traffic and transport.

4.6.6.2 Water supply and storage

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.

Water of appropriate quality will be used for construction and dust suppression activities. Potable water for the drill camps will be trucked and stored in water tanks. Potable water for the construction and operations camps will be provided by bores constructed into sandstone aquifers in the area. Operations water supply for maintenance activities and emergency services will be provided from water produced through gas extraction activities. This will require the construction of water storage dams or tanks at the facilities.

The 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.

4.6.6.3 Stormwater

Stormwater systems will be installed at each of the major facilities and accommodation camps to manage stormwater runoff and will be designed to minimise environmental risks and impacts on receiving waters. Retention basins and sediment ponds will be used as necessary to manage stormwater runoff to ensure that it is discharged at an acceptable quality. Erosion and sediment control systems will be installed as necessary including up-slope runoff diversions, designed channels and energy dissipation structures. All chemical and fuel storage areas will be bunded in accordance with relevant Australian standards.

4.6.6.4 Energy supply

Santos GLNG anticipates that the GFD Project's electrical demand will be to 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 for the GFD Project. Santos GLNG and/or third parties will seek additional approvals as required, in the event that grid-based power generation is selected.

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 above-ground 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.

Regardless of the power source options selected, power will be reticulated throughout the GFD Project area via a combination of above and below-ground power lines co-located with other infrastructure such as water and gas gathering lines, transmission pipelines or access roads where practicable.

An example of Santos GLNG power lines during construction and operations are shown in Plate 4-14.

Plate 4-14 GLNG Project power lines during construction and operations

4.6.6.5 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 m^2 each. Power to most telecommunications facilities (repeater stations) will be provided via batteries and solar panels.

Construction activities for telemetry and telecommunication towers will be limited to site clearing, pouring of concrete pads and foundations, and construction of a standard kitset tower. Generally, telecommunication cables will be co-located with existing or proposed facilities, gathering lines or transmission pipelines, or associated with power reticulation infrastructure.

4.7 Decommissioning and 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 involve the restoration of landform and vegetation to an agreed land use. Decommissioning and rehabilitation activities will:

- Comply with regulatory requirements and industry best practice at the time
- Meet stakeholder expectations
- Safely remove, reuse, recycle or appropriately dispose of above-ground infrastructure
- Transfer ownership of infrastructure (e.g. dams and roads) to the landholders or local authorities where authorised by regulatory authorities and an appropriate agreement has been signed
- Rehabilitate to a stable final landform and acceptable final land use (as specified by the regulator or agreed with the landholder)
- Minimise potential for adverse environmental impacts.

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 abandoned.

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).

A description of decommissioning and rehabilitation strategies for GFD Project components is discussed below, with a detailed discussion provided in Section 25: Decommissioning and rehabilitation.

4.7.1 Production wells

Once construction of production wells is complete, partial rehabilitation of the well lease will commence including management of drilling muds and spoil, backfilling and compaction of the mud pit (if used) and flare sump, and removal of water storage facilities. Rehabilitation significantly reduces the area of disturbance around the well (refer to Table 4-4 and Table 4-5). The areas surrounding the well will be graded and revegetated to control erosion.

Decommissioning of wells will occur on an ongoing basis as production within a gas field is exhausted. Wells at the end of their lifecycle will initially be capped to provide for their potential future use for other petroleum resources in the area. Only after determining the absence of future needs will plugging and abandonment be conducted. Plugging and abandonment of wells will be in accordance with regulatory requirements and the Queensland Government's *Code of Practice for constructing and abandoning coal seam gas wells and associated bores in Queensland* (Department of Natural Resources and Mines, 2013).

General guidelines for final well abandonment are outlined below:

- Placement of a surface cement plug in accordance with current procedures
- Removal of well surface equipment (e.g. generators, separators, tanks, metering skid, etc.) to a central storage facility for potential reuse
- Removal of well casing and tubing to below ground level
- Removal of casing risers, flow loops, or other pipe work attached to the wellhead but not part of downstream production flow-line for storage or disposal
- Cut-off and abandonment of screw piles associated with well lease foundations
- Backfilling excavations resulting from drilling, workover or production operations
- Marking the well lease in accordance with regulatory requirements

- Transferring to third parties remaining well bores (e.g. water bores) where appropriate regulatory authority exists, ensuring the recipient of infrastructure is properly instructed in the safe operating methods and appropriate maintenance of equipment
- Documenting and maintaining procedures and well work records in a permanent file.

4.7.2 Gathering lines and transmission pipelines

Gathering lines and transmission pipelines will be decommissioned at the end of gas production. As the pipeline corridors will have been rehabilitated at the end of the construction phase, buried pipelines will be decommissioned and left in place to minimise further disturbance. Surface gathering lines will be removed for reuse or disposal.

It is anticipated that pipelines will be decommissioned in situ. Buried gathering lines and transmission pipelines will be decommissioned in situ in accordance with the regulatory requirements, including the Queensland Government's *Code of Practice for constructing and abandoning coal seam gas wells and associated bores in Queensland* (Department of Natural Resources and Mines, 2013), and *AS2566 Buried flexible pipelines* and *AS285 Gas and liquid petroleum,* and the Australian Pipeline Industry Association Code current at that time. Decommissioning will include activities such as isolating, draining and/or purging with inert gas (usually nitrogen) or flushing with water, if required.

Where steel pipelines pass under a railway line or major highway, the pipelines will be cut and filled with a stable material (e.g. concrete) to prevent potential future subsidence due to corrosion or breakage. Long sections of transmission pipeline may be cut and capped to prevent the pipe from acting as a conduit for water and sediment transport.

Following decommissioning of the pipeline, pipeline marker signs will be removed and reused (depending on condition) and the right of way will be rehabilitated. Other above-ground structures associated with the transmission pipelines will be removed, and recycled or disposed.

4.7.3 Gas compression and water management facilities

Decommissioning of gas compression and water management facilities will aim to maximise beneficial reuse of equipment and materials wherever possible; this includes the transfer of infrastructure to landholders and local authorities if acceptable to the regulatory authorities and a written agreement is in place between the parties.

Those structures that are portable will be disassembled and removed intact from the area for reuse or disposal. If disassembly is not possible, such as for large structures, the buildings will be demolished after the removal of fuel, lubricants, chemicals, waste and recyclable materials.

The modular components of the gas compression facilities and the water management facilities will be decommissioned with the process equipment transferred to other areas for reuse or the equipment sold or scrapped.

Following removal of structures, concrete pads and foundations of buildings will be demolished where practicable, the concrete crushed and the steel reinforcing segregated for recycling. This may or may not include the removal of the concrete foundations. The crushed concrete will be reused where possible. Demolition activities will include the complete removal of surface infrastructure, with piping cut off and capped below ground.

Water storage decommissioning will involve the removal of water, accumulated sediment and spill detection systems; and partial or complete removal of liners (if used). Based on the chemical characteristics of the stored water, the water may be beneficially reused, further processed through water treatment facilities, or removed for treatment and disposal. Sampling of soils under the liner will identify if impacted soils need to be removed. Waste materials will be transported for disposal at a licensed facility. The dam walls will be recontoured and a stable landform established, after which topsoil will be spread and the area seeded to facilitate revegetation.

4.7.4 Supporting infrastructure

Supporting infrastructure may be transferred to the landholder or local authority, where authorised by regulatory authorities and an appropriate agreement has been signed.

In instances where infrastructure cannot be transferred, supporting surface infrastructure will be decommissioned in a manner similar to that of gas compression and water management facilities described in section 4.7.3; those structures that can be disassembled and removed intact will be, with the remainder demolished and then removed for recycling or disposal. The concrete foundations or asphalt (for access tracks) will be demolished and removed for recycling or disposal and the underlying land graded, stabilised and rehabilitated.

In the case of sub-surface infrastructure, Santos GLNG will safely abandon assets in situ such as electrical and communication lines in a similar manner to gathering lines and transmission pipelines (section 4.7.2) in accordance with the relevant and current codes and standards.