Section 3 Project Description

3.1 Introduction

This section describes the proposed GLNG Project including its three major components. It describes the project in sufficient detail to enable the reader to gain an understanding of the project's construction and operation as well as its decommissioning.

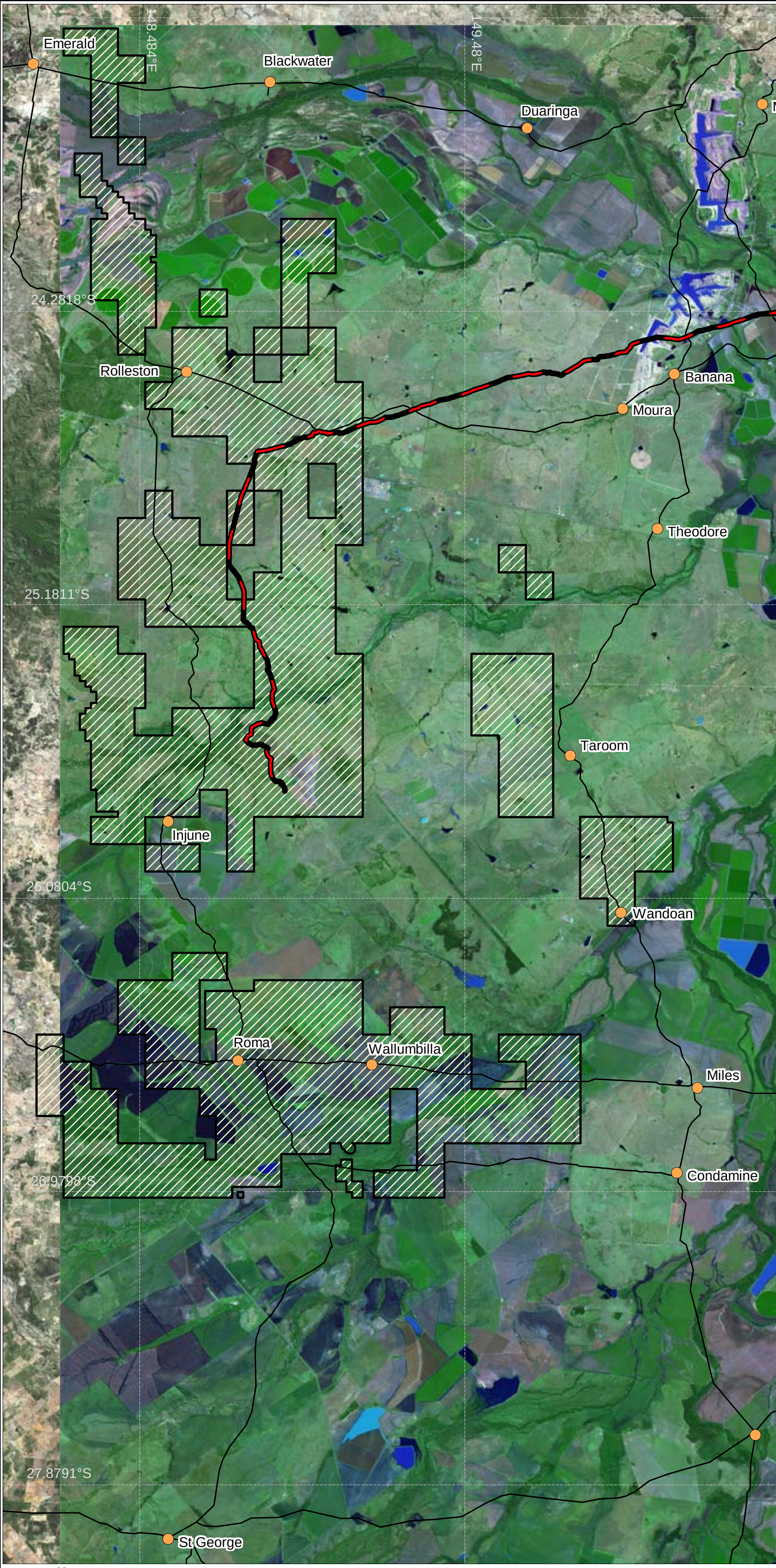
3.2 Project Components

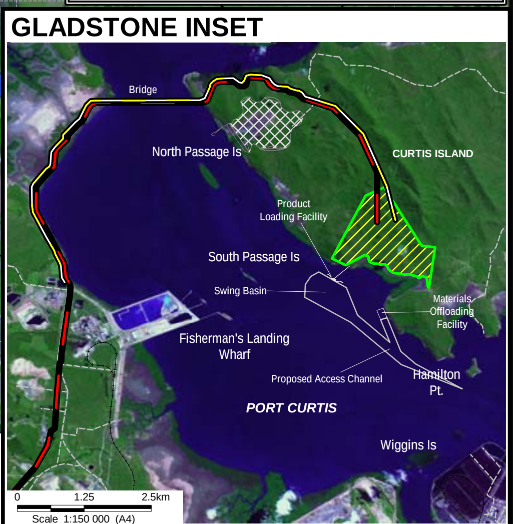
Santos is proposing to develop coal seam gas (CSG) resources (also known as coal bed methane) in the Surat and Bowen Basins in the area between Roma and Emerald in Queensland. The CSG fields will supply gas for a proposed liquefied natural gas (LNG) liquefaction and export facility (LNG facility) on Curtis Island, near Gladstone in Queensland. A high pressure gas transmission pipeline is proposed to be constructed to link the CSG fields to the LNG facility. These components are collectively referred as the Gladstone LNG Project (GLNG Project).

Figure 1.1.1 and Figure 3.2.1 illustrate the regional location of the project components.

Approvals are being sought for the following components of the GLNG Project:

- Production of approximately 5,300 petajoules (PJ) (140 billion m^3) from the CSG fields to supply the first stage of the LNG facility. This will involve the development of approximately 2,650 exploration and production wells. It is anticipated that about 1,200 wells will be established prior to 2015, with potential for 1,450 or more additional wells after 2015. Additional supporting infrastructure including field gathering lines, nodal compressor stations, centralised compression and water treatment facilities, accommodation facilities, power generation and water management facilities will also be installed.
- A 435 km long gas transmission pipeline for the delivery of the gas from the CSG fields to the LNG facility.
- An LNG facility of approximately 10 million tonnes per annum (Mtpa) capacity on Curtis Island. The LNG facility is proposed to be developed in three stages (called trains), the first of which will have a capacity of approximately 3 - 4 Mtpa. The LNG facility will consist of the following key elements (for which approvals will be sought):
  - A liquefaction facility which includes the on-shore gas liquefaction and storage facilities;
  - Marine facilities which will include a product loading facility (PLF) for loading LNG into ships for export, and a materials offloading facility (MOF) and haul road for the delivery of equipment, plant and materials to the LNG facility site;
  - A swing basin and an access channel from the existing Targinie Chanel in Port Curtis;
  - A dredge material placement facility at Laird Point; and
  - A maximum 2,000-person capacity accommodation facility on Curtis Island for construction workers.
- Access to the LNG facility from the mainland will occur by either of the following options:
  - The provision of road access to Curtis Island by way of a potential access road and bridge from the mainland crossing Port Curtis between Friend Point and Laird Point. Construction phase access to the site for at least Train 1 will be by barge and ferry as the access road and bridge will not be constructed by that time; or
  - Access to the site by barge or ferry for the life of the GLNG Project (for both construction and operation) if the access road and bridge is not constructed.





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Client	Project	Title
LNG	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT	**PROJECT COMPONENTS**
URS	Drawn: CA / Approved: JB / Date: 18-03-2009	Figure: **3.2.1** / Rev:E
	Job No: **4262 6220** / File No: 42626220-g-802e.wor	A4

3.3 Description of LNG

3.3.1 LNG Characteristics

LNG is natural gas which has been cooled by liquefaction to its liquid state at approximately -161°C and at atmospheric pressure. Liquefaction reduces the volume of the gas by approximately 600 times, thus enabling it to be economically transported around the world in specially designed ships. LNG is used for long distance transport of gas where traditional pipeline transportation systems operating at high pressure are not technically or economically feasible.

Some relevant properties of LNG include the following:

- It is mostly methane gas, typically with small concentrations of ethane, propane and butane. However, the Santos CSG is typically 95 % methane, 4 % nitrogen and 1 % carbon dioxide. The gas composition varies slightly from field to field and may change slightly over the life of the project.
- It is a cryogenic liquid (cooled to approximately -161°C) which is stored and transported at atmospheric pressure.
- In its vapour phase it is lighter than air at temperatures above -107°C.
- It is colourless, odourless, non-toxic and non-persistent in the environment.
- As a liquid it cannot explode or burn.
- It is stored and transported at atmospheric pressure.

3.3.2 Sources of Natural Gas

Natural gas for the LNG facility will be sourced from CSG fields located in Queensland in the vicinity of Roma to Emerald (see Figure 3.2.1). The characteristics of CSG are described below.

3.3.2.1 Storage

The characteristics of CSG reservoirs differ from conventional gas reservoirs. Unlike conventional gas reservoirs, coal is both the reservoir rock and the source rock for the gas. It is a heterogeneous and porous medium which is characterised by two distinct systems of different porosity: macropores and micropores. The macropores, also known as cleats, constitute the natural fractures common to all coal seams (see Figure 3.3.1).

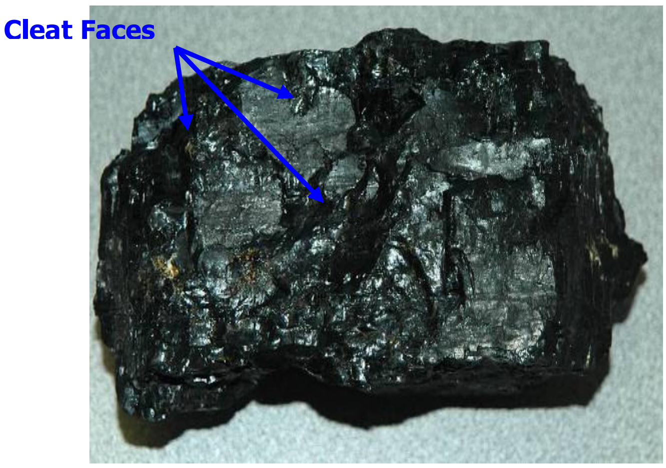


Figure 3.3.1 Coal Cleats

Micropores, or the matrix within the coal, contain the vast majority of the gas. This unique coal characteristic has resulted in classification of CSG as an unconventional gas resource.

As coal is formed, large quantities of methane-rich gas are generated and stored within the coal matrix. Because coal has such a large internal surface area, it can store large volumes of methane-rich gas, six or seven times as much gas as a conventional natural gas reservoir of equal rock volume can hold.

3.3.2.2 Production

In CSG and conventional reservoirs, both gas and water are produced. In a conventional oil or gas reservoir, the gas lies on top of the oil which, in turn, lies on top of water. A conventional well typically draws only from the top layer of oil or gas without necessarily extracting the lower water layers. With CSG, the coal cleats are filled with water and the gas is adsorbed in the coal matrix. Typically, water must be pumped from the coal seams to reduce reservoir pressure and enable the release of the gas. Once the pressure in the cleat system is lowered by pumping of the water, the gas will desorb from the matrix and flow into the cleat system and from there to the production well. As a result, peak gas production is not reached until after the water has been produced with water production reducing over time. This water is generally called associated water (or produced water). Given the large volume of gas adsorbed in the coal it generally takes a long time (up to 20 years) for the coal seam to deliver all its gas, thus resulting in long life wells. Figure 3.3.2 shows the difference in the rate of gas (methane) and associated water production over time between CSG and conventional wells.

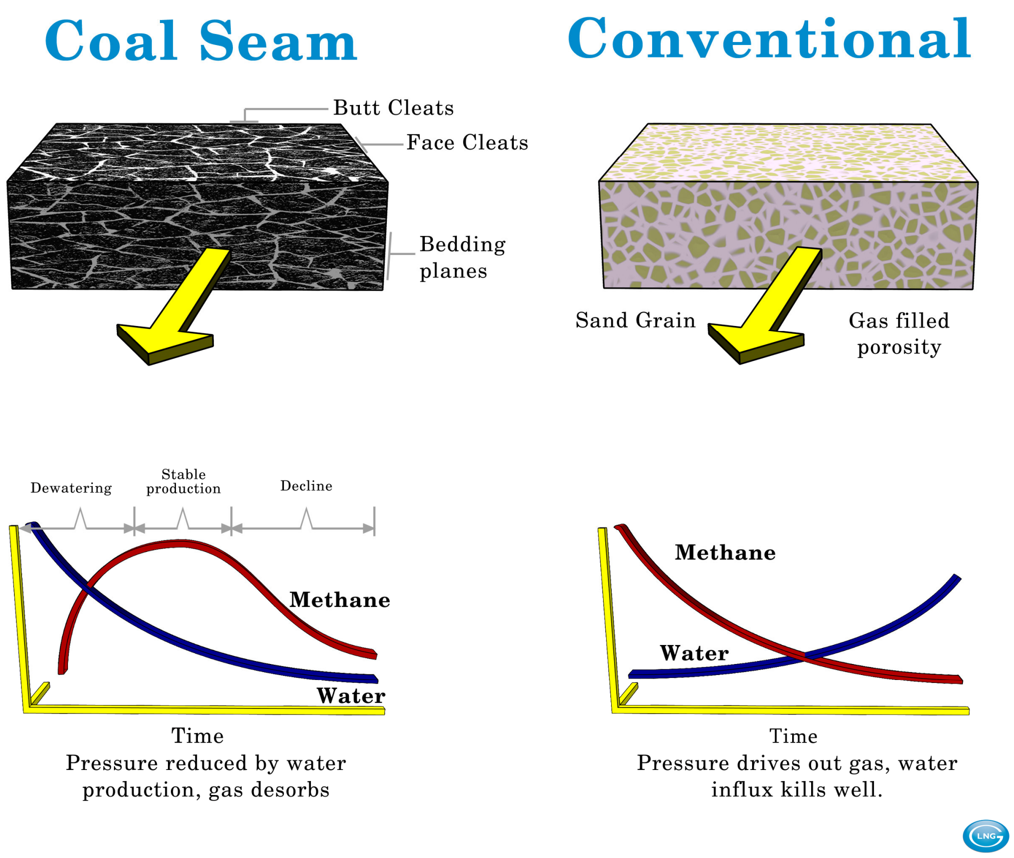


Figure 3.3.2 Coal Seam Gas vs. Conventional Gas

Much of the coal, and thus much of the gas, lies at readily accessible depths (500 – 1200 m below surface) making wells relatively quick to drill. With greater depth, increased pressure closes the fractures (cleats) in the coal, which reduces permeability and the ability of the gas to move through and out of the coal.

3.3.3 LNG Safety and Risks

As a liquid, the risk of LNG exploding or burning is extremely low. It is colourless, odourless, and non-toxic. It does not mix with water. If LNG liquid escapes from its storage containment to the environment, it begins warming immediately and begins turning into a vapour cloud. As the gas warms up to -107ºC from -161ºC (the temperature at which it is liquid at atmospheric pressure) the vapors become lighter than air and will rise into the atmosphere. Methane vapour is only flammable if it is within the concentration range of 5 - 15 % gas in air. If it is less than 5 % gas in air, there is not enough gas concentration in the oxygen to burn. If it is more than 15 % gas concentration in air, there is too much gas in the air and not enough oxygen for it to burn. The lighter-than-air property of methane actually makes it less hazardous than some other fuels, such as propane or butane, which are heavier than air and tend to settle closer to the ground. If spilt on water or land, LNG evaporates and dissipates into the air as it warms to ambient temperature without leaving any residue.

The safety, efficiency and stability of the proposed LNG facility operations will be achieved through the use of high level detection and safety systems and regular preventative maintenance. Security measures will include security patrols, protective enclosures, lighting and monitoring equipment. The site and plant layout will ensure that any site operational issues are contained within the site boundaries.

The gas is liquefied but is not under pressure either in the on-site storage tanks or while being transported in the LNG ships.

LNG facilities have an exemplary safety record. Since 1980, there have been no fatalities at LNG import and storage facilities around the world. During the industry's infancy, a serious accident occurred in Cleveland, Ohio at an LNG storage facility. The steel used in storage tanks must contain nickel to provide the appropriate properties to withstand the cold cryogenic conditions of LNG. The steel used in this early storage tank did not contain sufficient nickel, resulting in a crack and spill. That incident triggered major changes in LNG regulations, and the Cleveland facility would not meet today's safety standards. Modern tanks, which use 9 % nickel-steel, have never had a crack failure in their 35-year history (http://www.lngfacts.org/About-LNG/Facility-Safety.asp).

LNG ships are double-hulled ships and are specially designed to prevent leakage or rupture in an accident. Transportation of LNG by marine carriers has a long record of safe operation. In LNG's 40-plus year history of over 40,000 voyages, LNG carriers have travelled more than 100 million miles without a major incident. There have been no collisions, fires, explosions or hull failures resulting in a loss of containment for LNG ships in ports or at sea (Bainbridge, 2002). Over this period only eight marine incidents worldwide have resulted in accidental spillage of LNG and not one of the spills has been as a result of a failure or breach of a containment system. In the cases of the accidental spillages, no fires occurred and only minor structural damage was noted. Seven additional marine-related incidents have occurred with none resulting in release of cargo. No explosions or fatalities from a cargo spill have ever occurred aboard an LNG carrier (http://www.lngfacts.org/About-LNG/Carrier-Safety.asp).

Further details of the health, safety and risk aspects of the GLNG Project are given in Section 10.4.

3.4 Project Location

3.4.1 Regional Location

The project is located in Queensland, Australia. The CSG fields extend from south of Roma to Emerald in Queensland. The proposed LNG facility is located on Curtis Island near the coastal city of Gladstone. The gas transmission pipeline will connect the gas fields to the LNG facility.

Figure 1.1.1 illustrates the regional location of the project components. Figure 3.2.1 is a rectified aerial photograph illustrating the location of the project components.

For details of the project's real property descriptions, easements and local government boundaries refer to Sections 6.11, 7.11, 8.11 and Appendix I.

3.4.2 CSG Fields and Tenures

The development of the CSG fields will be undertaken pursuant to petroleum authorities granted under the *Petroleum and Gas (Production and Safety) Act 2004* and the *Petroleum Act 1923* administered by the Department of Mines and Energy. These authorities allow the holder to carry out petroleum (including coal seam gas) exploration, production and other incidental activities over other existing land tenures. The industry operates on a multiple-land use premise and works with local communities and landholders to ensure that while the gas reserves can be developed, other land uses can continue.

An authority to prospect (ATP) authorises the holder to carry out exploration and testing of petroleum reserves. This may include seismic surveys and exploration drilling.

Should the exploration investigations indicate the presence of gas in commercial quantities, the ATP holder may apply for a petroleum lease (PL) to develop the gas reserve. As well as exploration and testing, a PL also authorises petroleum production, processing, storage and other incidental activities including construction of operating plant, compressors, powerlines, roads, evaporation ponds and tanks, temporary camps and other temporary structures. Activities carried out under a PL are regulated by the conditions attached to the PL and the associated environmental authority issued under the *Environmental Protection Act 1994*, which is administered by the Environmental Protection Agency (EPA).

Exploration activities are primarily conducted under an ATP and production activities are conducted under a PL.

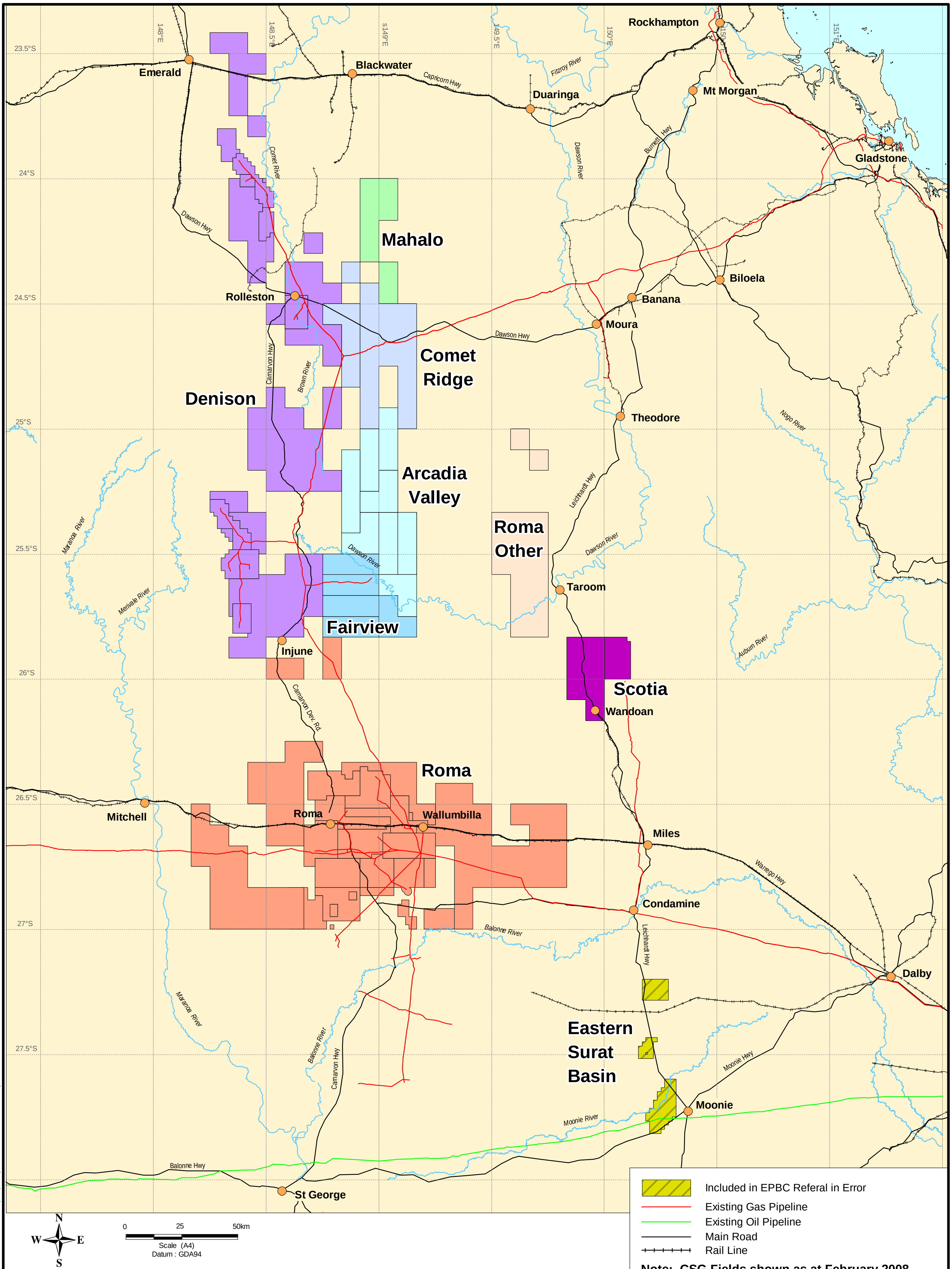
Figure 3.4.1 shows the extent of the petroleum authorities and names of the CSG fields as they existed in February 2008 which was when the EIS baseline studies commenced. Since that time the boundaries of some petroleum authorities have changed as some of the ATPs have been converted to PLs and some areas have been relinquished in accordance with the governing legislation. This is a normal part of managing CSG fields and it is possible that Santos may acquire additional gas acreage in the future.

Projections of future CSG production are difficult to make. Several variables complicate such forecasts, including new exploration or production techniques, increases or decreases in demand for natural gas/LNG, and price increases or decreases that may prompt larger or smaller production programs. For the GLNG Project a reasonably foreseeable development (RFD) scenario has been established to assess the degree of CSG development that can be reasonably expected to occur over a given period of time.

CSG field development to support the initial 3 – 4 Mtpa LNG facility (Train 1) is proposed to be located in the RFD area. The RFD area comprises tenements in the Roma (part), Fairview, Arcadia Valley and part of the Comet Ridge fields. The RFD tenements as they existed in February 2009 are listed in Table 3.4.1 and shown on Figure 3.4.2. Santos proposes to drill and complete enough development wells within the RFD area to supply approximately 5,300 PJ (140 billion m^3) of gas to Train 1. This will likely require up to 1,200 development wells prior to 2015 and up to 1,450 wells after 2015 (excluding exploration wells). The number of wells required to deliver this volume will be influenced by the results of exploration programs, production techniques and other factors. Due to the nature of the CSG industry, exploration results will influence the development plans.

Gas in quantities beyond 5,300 PJ required for the second and third trains of the LNG facility are likely to be supplied by a combination of the following:

- From the development of the wells discussed above.
- From the development of the future development area which includes tenements in the Mahalo, Denison, Scotia, Comet Ridge and Roma Other fields shown on Figure 3.4.2 and listed in Table 3.4.1.
- By utilising Santos' share of gas from tenements in which Santos has an interest but is not the operator. These tenements are listed in Table 3.4.1 and are shown in Figure 3.4.2 as "Other CSG Fields".
- From third parties.



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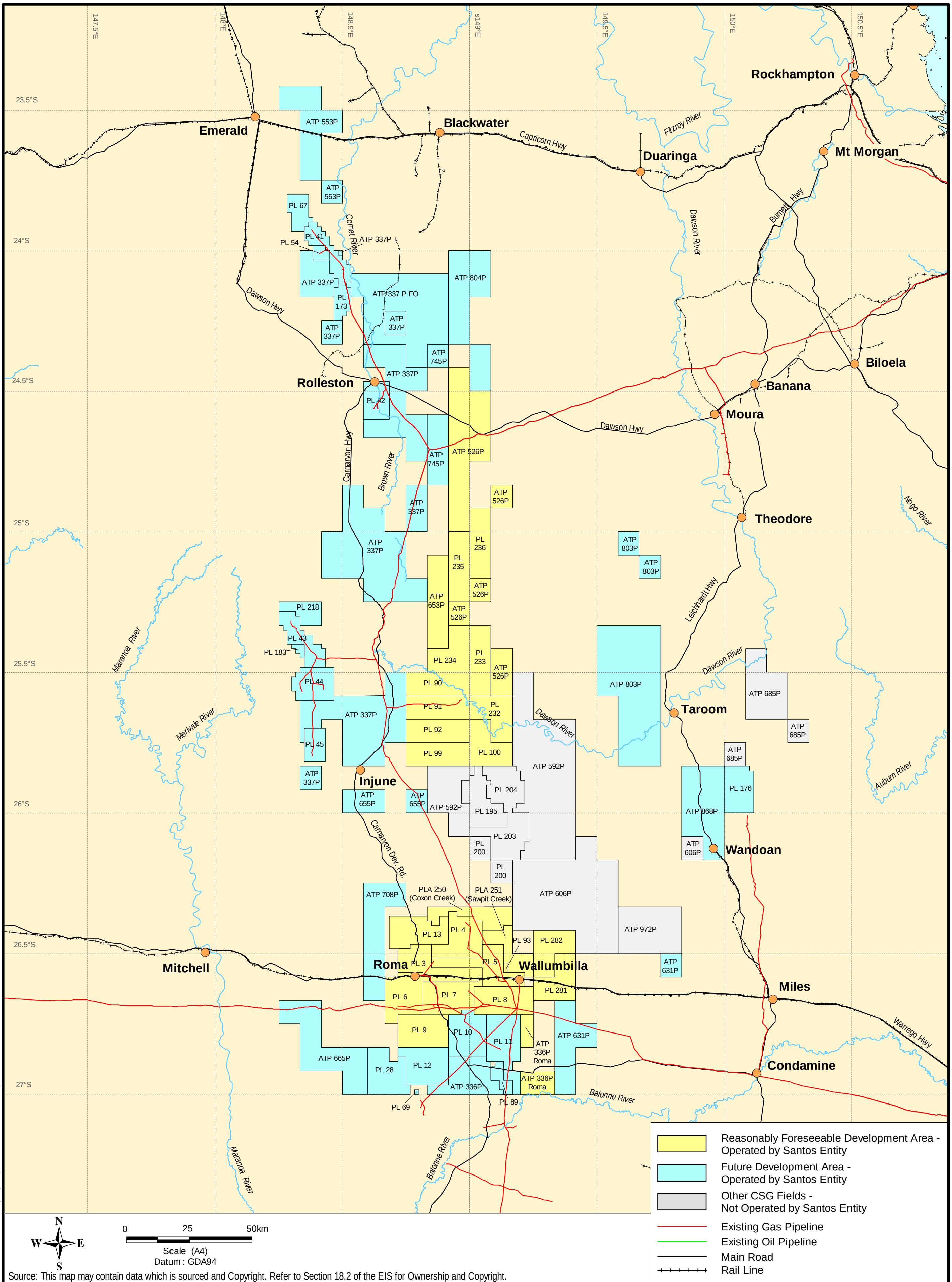
Client	Project	Title
LNG	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT	**LOCATION OF CSG FIELDS**
URS	Drawn: VH · Approved: JB · Date: 21-02-2009 Job No: **4262 6220** · File No: 42626220-g-803.wor	Figure: **3.4.1** · Rev:B · A4



Client	Project	Title
LNG / URS	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT	**CSG FIELD DEVELOPMENT AREAS JANUARY 2009**
	Drawn: VH · Approved: JB · Date: 18-03-2009	Figure: **3.4.2** · Rev:B
	Job No: **4262 6220** · File No: 42626220-g-803b.wor	A4

Table 3.4.1 Proposed CSG Fields for GLNG Project

Development Area	Area (km^2)	Petroleum Tenures		
		Petroleum Leases (PLs)	Authorities to Prospect (ATPs)	Pipeline Licenses (PPLs)
Reasonably Foreseeable Development Operated by Santos Entity	6,887	232 - 236	526P, 653P	
		90 – 92, 99, 100	526P, 653P	76, 92
		3 – 9, 13, 93, 250[1, 4], 251[1, 4], 281[1, 3], 282[1, 3]	336P (Part)	
Future Development Operated by Santos Entity	12,078	10-12, 28, 41[2], 42[2], 43[2], 44[2], 45[2], 54[2], 67[2], 69, 89, 173[2], 176, 183[2], 218[2]	336P (Part) 337P, 553P, 631P, 655P, 665P, 708P, 745P, 803P, 804P, 868P[1]	118
Other CSG Fields Not Operated by Santos Entity	5,091	195, 200, 203, 204	592P, 606P, 685P, 972P	10, 11

1 Under application at time of EIS preparation
2 Santos acts only as exploration operator under the applicable joint operating agreement. Another party to the agreement acts as production operator.
3 Previously part of ATP 631P
4 Previously part of ATP 336P

The timing and selection of the source of gas for the subsequent stages of the LNG facility cannot be fully determined at present as it will depend on future exploration activities and development plans. Santos is not seeking approval for the additional CSG development which may be required for the second and third stages of the LNG facility as part of this EIS. Further environmental assessment and approval processes beyond those contemplated in this EIS may apply for the extraction of the additional CSG required depending on the arrangements made for sourcing of the gas.

Although Santos' CSG tenures cover an area of approximately 24,000 km^2, the RFD area is expected to encompass only about 6,900 km^2 which equates to approximately 28 % of the total Santos tenure area. The balance consists of future development areas some of which are operated by a Santos entity (12,100 km^2) and some with operators other than a Santos entity (5,100 km^2).

It should be noted that the EPBC Act Referral 2008/4059 incorrectly included PL1(1), PL1(2), PL(3), PL17 and EPC 937. PL1, PL1(1), and PL1(2) are oil fields. PL17 is not intended to be used by Santos for the GLNG Project. EPC 937 is an exploration permit for coal. These tenements are not required for the GLNG Project and are not included as part of this assessment.

The PLs listed in Table 3.4.1 above have existing approvals (other than PLs 250, 251, 281 and 282 which are under application) in place that enable petroleum exploration and production activities (for both conventional gas and CSG). Santos will also be applying for additional PLs over all or part of the area of Santos' existing ATPs as set out in Table 3.4.1 to support the expansion of the CSG field production.

For details of the real property descriptions as well as petroleum and mining tenures within the CSG fields refer to Appendix I.

The CSG fields are within the following local government authority areas; Roma Regional Council, Central Highlands Regional Council, Banana Shire Council and Dalby Regional Council. Refer to Section 6.11 for details of the local planning schemes and features of national and state environmental significance.

3.4.3 Gas Transmission Pipeline Location

A high pressure gas transmission pipeline is proposed to link the CSG fields to the proposed LNG facility on Curtis Island. Initial studies assessed the potential impacts of the proposed gas transmission pipeline within a 5 km wide corridor although this was reduced to 100 m wide on Curtis Island. As these studies progressed, a preferred 30 m wide pipeline right-of-way (ROW) was identified for which detailed studies were undertaken. It is expected that the gas transmission pipeline will be constructed in this ROW.

Figure 3.4.3 shows the proposed alignment of the gas transmission pipeline corridor and Figure 3.4.4 shows the extent of freehold and leasehold land and conservation reserves traversed. Section 4 provides details of the vehicle routes to be used to access the ROW.

For details of the real property descriptions as well as the petroleum and mining tenures that are crossed by the proposed pipeline corridor refer to Appendix I.

The pipeline corridor will be within the following local authority areas: Roma Regional Council, Central Highlands Regional Council, Banana Shire Council, Dalby Regional Council and Gladstone Regional Council. Refer to Section 7.11 for details of the local planning schemes and features of national and state environmental significance along the gas transmission pipeline corridor.

3.4.4 LNG Facility Location

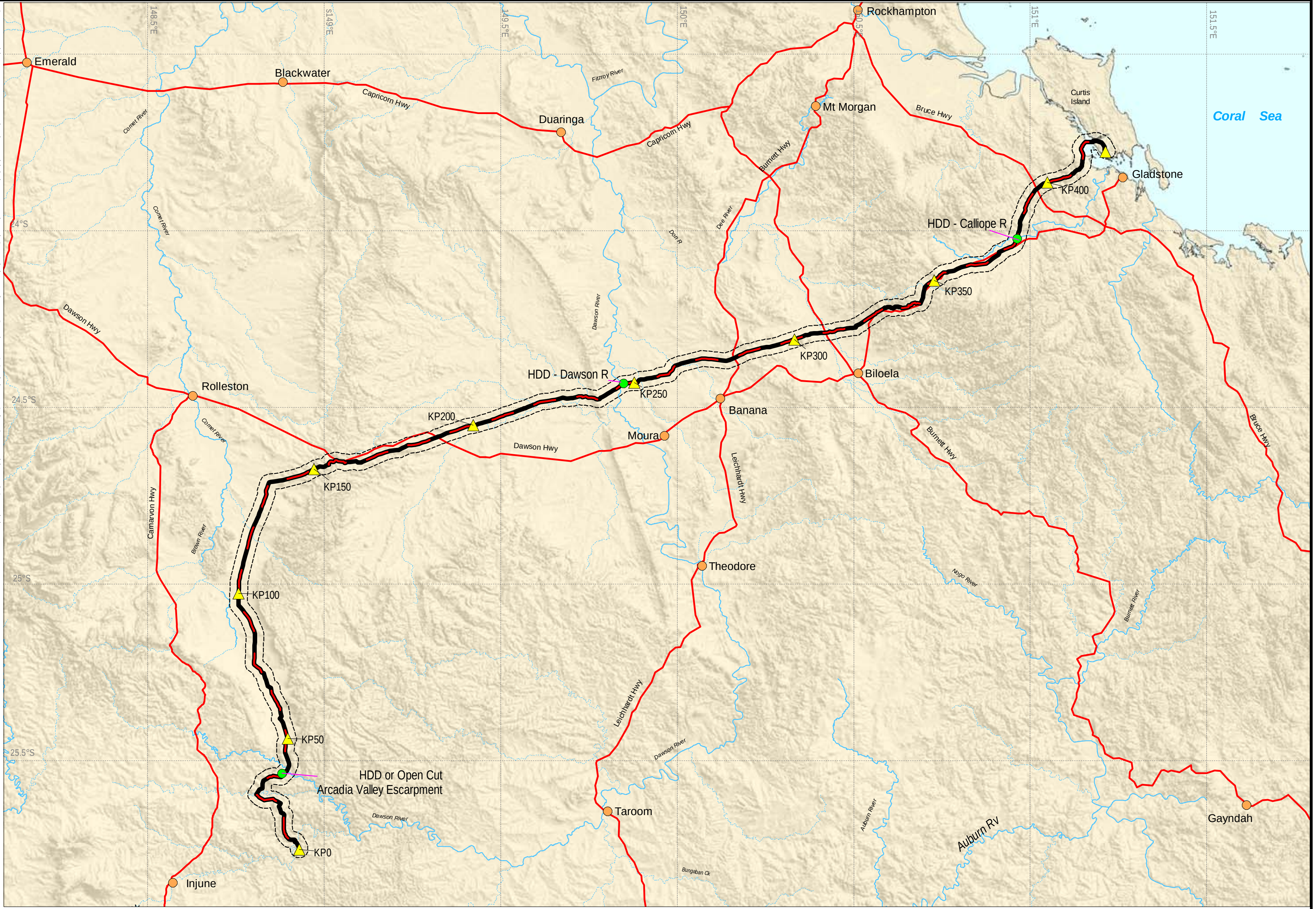
The proposed LNG facility is located within the Gladstone State Development Area (GSDA) at the south-west end of Curtis Island which is situated approximately 5 km north of Gladstone. Figure 3.4.5 shows the location of the LNG facility in the context of the Gladstone region and Figures 3.4.6 and 3.4.7 show the conceptual layout of the facility on the site.

The LNG facility site has a total area of approximately 190 ha and the footprint of the LNG facility will be approximately 40 ha for Train 1 and 100 ha for the 3 trains. It is located on freehold land. The real property description for the facility location is Lot 9 on DS220 and proposed Lots 7 and 10 on DS220. Details of the site's real property description are given in Section 8.11.

- The LNG facility will include the PLF and MOF as well as a heavy haul road for transferring plant, equipment and personnel from the MOF to the construction site. A construction accommodation facility will be provided on the site for the construction workforce, some of which may be kept on site as emergency accommodation in the event the bridge is not constructed.
- Access channels and a swing basin will be dredged to enable vessels to access the PLF and the MOF. The dredged material from this process is proposed to be placed on a dredge material placement facility to be constructed on Curtis Island at Laird Point. The area to be dredged is described in Section 8.7. The details of the location of the dredge material placement facility and the assessment of the related impacts are included in Section 8.17.
- Access to the LNG facility from the mainland will occur by either of the following options:
  - The provision of road access to Curtis Island by way of an access road and bridge from the mainland crossing Port Curtis between Friend Point and Laird Point. Construction phase access to the site for at least Train 1 will be likely by barge and ferry as the access road and bridge is unlikely to be available at that time; or
  - Access to the site by barge or ferry for the life of the GLNG Project (for both construction and operation) if the access road and bridge is not constructed. Both options are assessed in the EIS.

The LNG facility and associated infrastructure components are located in the Gladstone Regional Council area.

- Refer to Section 8.11 for details of the relevant regional and local planning schemes. Features of national and state environmental significance in the vicinity of the site are discussed in Section 8.4.



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Datum : GDA94

Gas Transmission Pipeline Corridor
Major Road
Major Drainage
Gas Transmission Pipeline
KP50 Kilometre Post Distance Marker (in Km)
Horizontal Directional Drilling Location

Client: URS / LNG

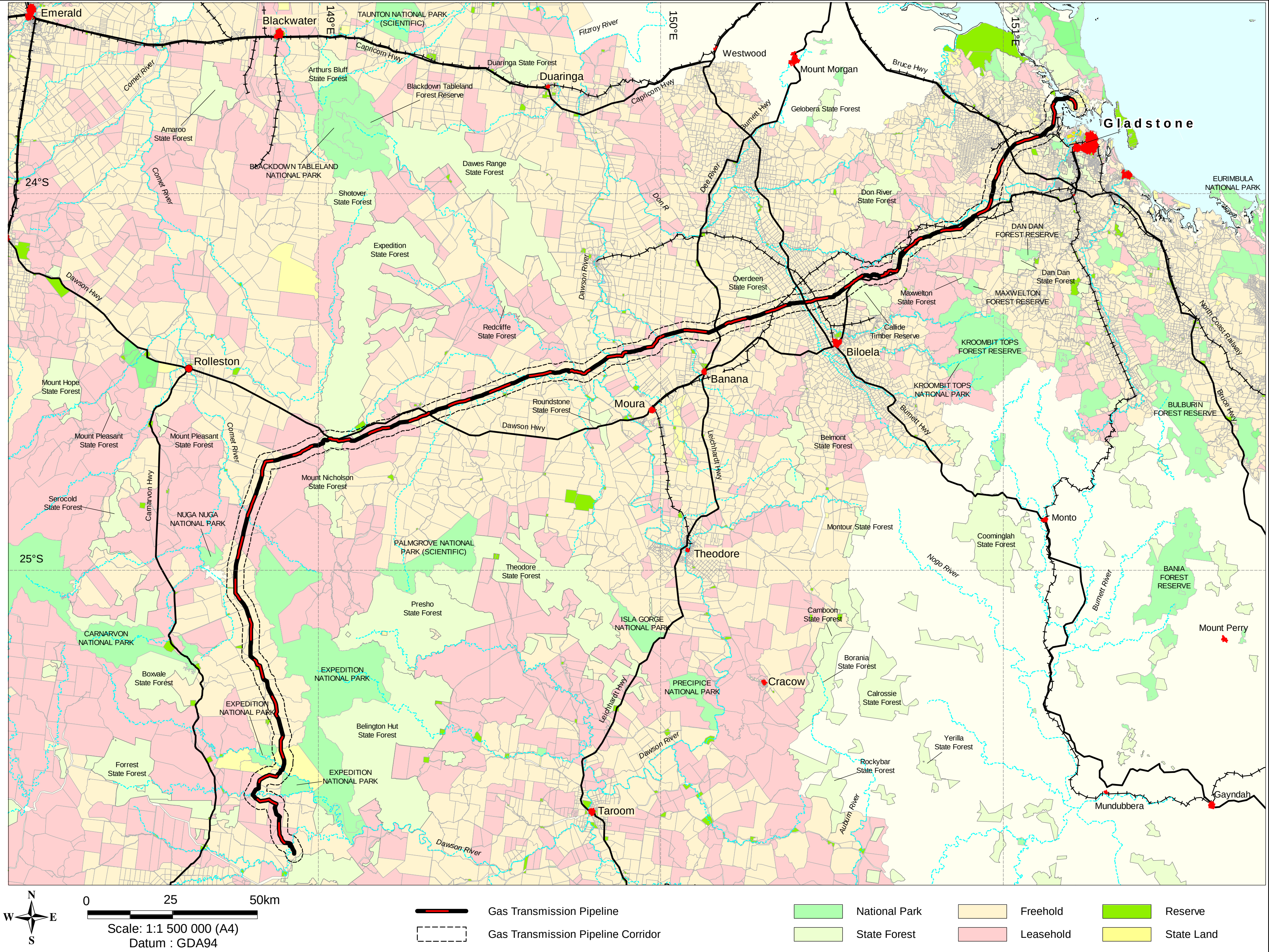
Project: GLADSTONE LNG PROJECT
ENVIRONMENTAL IMPACT STATEMENT

Title: GAS TRANSMISSION PIPELINE ALIGNMENT

Drawn: CA | Approved: JB | Date: 05-02-2009

Job No: 4262 6220 | File No: 42626220-g-806.wor

Figure: 3.4.3 | Rev: B | A4



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Client

URS

Project

GLADSTONE LNG PROJECT
ENVIRONMENTAL IMPACT STATEMENT

Drawn: CA | Approved: JB | Date: 23-02-2009

Job No: **4262 6220** | File No: 42626220-g-807.wor

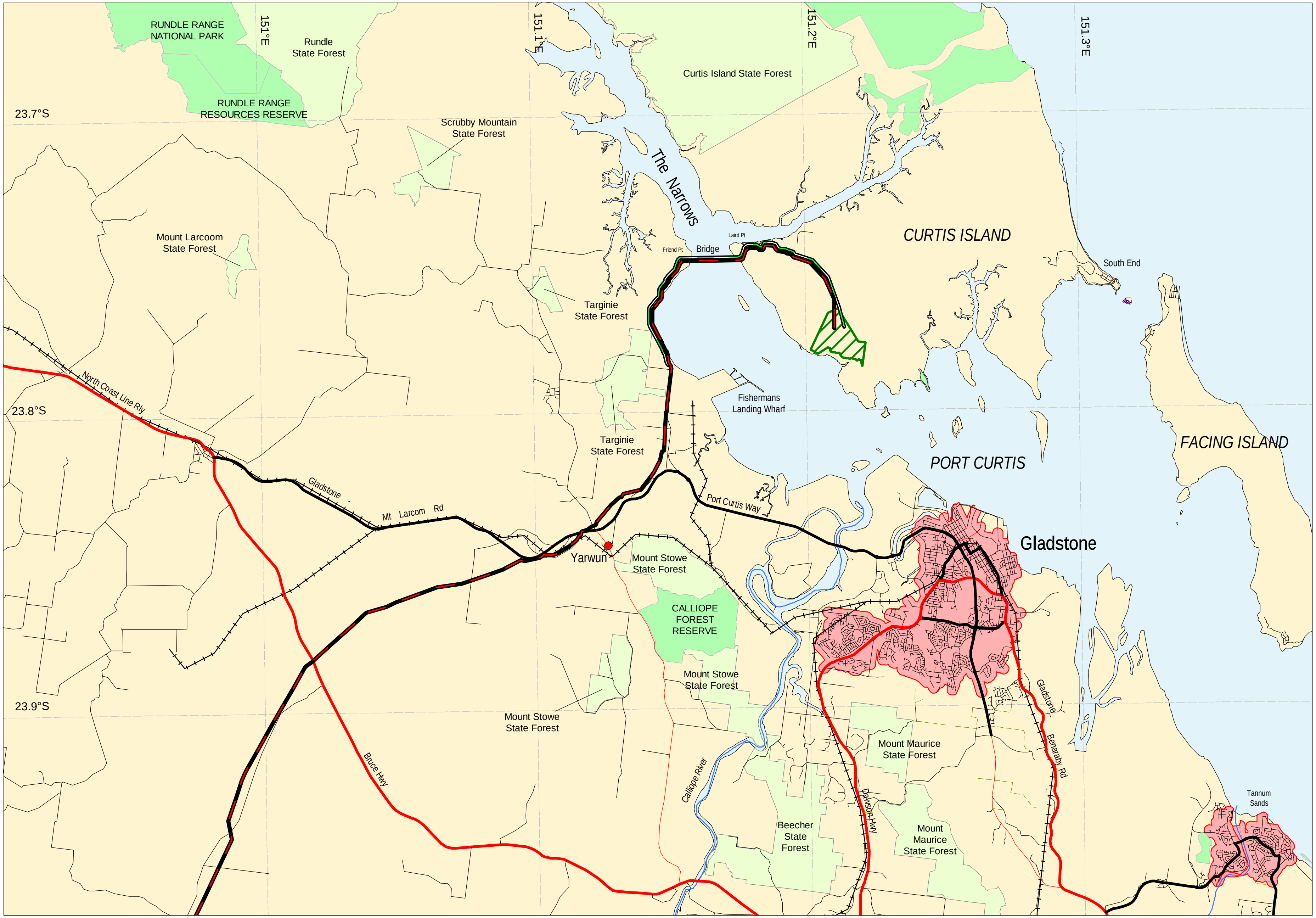
Title

GAS TRANSMISSION PIPELINE LAND TENURE

Figure: **3.4.4**

Rev:C

A4



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Datum: GDA94

LNG Facility Site	National Park
Gas Transmission Pipeline	State Forest
Potential LNG Facility Access Road	Urban Area

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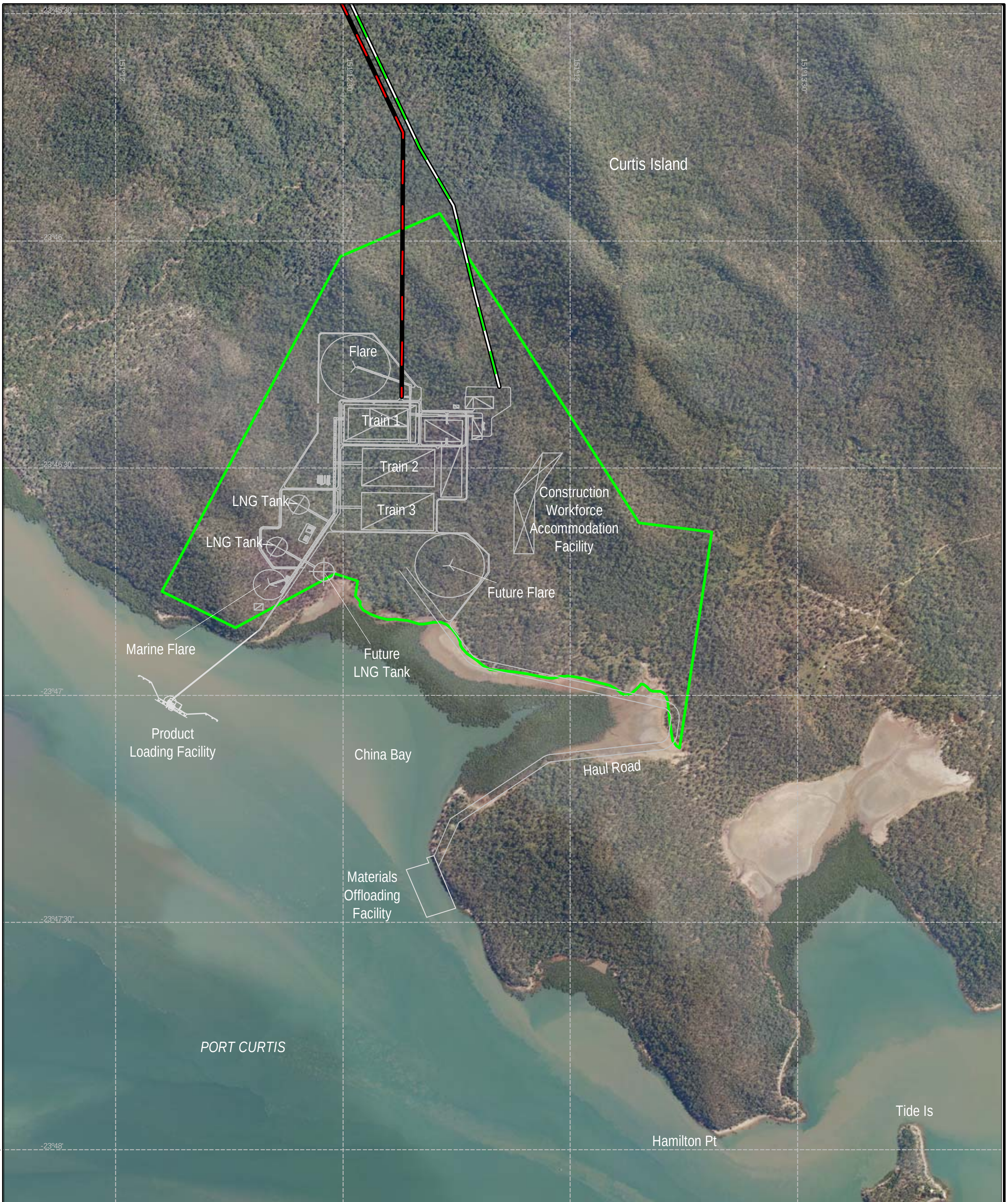
Client

Project
GLADSTONE LNG PROJECT
ENVIRONMENTAL IMPACT STATEMENT

Title
GLADSTONE REGION

Drawn: CA
Approved: JB
Date: 18-02-2009
Job No: **4262 6220**
File No: 42626220-g-808.wor
Figure: **3.4.5**
Rev:C
A4



Scale 1:20 000 (A4)
Datum : GDA94

Gas Transmission Pipeline
Potential LNG Facility Access Road
Site Boundary

Client	Project	Title
LNG / URS	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT	**LNG FACILITY SITE**
Drawn: CA / Approved: JB / Date: 18-03-2009	Job No: **4262 6220** / File No: 42626220-g-811.wor	Figure: **3.4.6** / Rev:D / A4

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Source 2: Copyright HR Wallingford Ltd 2009. All rights reserved. With regard to Product Loading Facility and Material Offloading Facility - These layouts are subject to alteration during detailed design development and ongoing consultation with the Gladstone Ports Corporation and the Gladstone Regional Harbour Master to ensure issues of navigation safety are appropriately addressed.

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Client	Project	Title
LNG / URS	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT	**LNG FACILITY ARTIST'S IMPRESSION**
	Drawn: LL · Approved: JB · Date: 18-03-2009	Figure: **3.4.7** · Rev. A
	Job No.: **4262 6220** · File No. 42626220-g-1045.cdr	A4

3.5 Project Schedule

As discussed in Section 3.2, the LNG facility is to be developed in three stages. Each stage is called a train. Construction of the first train (Train 1) including the marine facilities and capital dredging is proposed to commence in 2010 with construction taking approximately four years. During this period the gas transmission pipeline will also be constructed. This will take approximately two years.

The LNG facility operations are planned to commence in early 2014. Depending on demand, it is possible that construction of Train 2 could commence as early as 2011 and Train 3 in 2012, which will bring the LNG facility up to its ultimate capacity of 10 Mtpa. However the timing of these trains is dependant on market conditions, gas availability, labour availability and the economic climate and may vary from what is described in this EIS. It is possible that construction of Trains 1 and 2 and/or Trains 2 and 3 may overlap.

During this time development of the RFD area of the CSG fields will be ongoing up to the 5,300 PJ required for Train 1. As each production well will have an approximate life of 5 to 15 years it will be necessary to replace depleted wells with new ones. New wells will be developed at a rate that is sufficient to provide enough CSG for the annual LNG production.

The nominal life of the project is 25 years; however the project may remain in operation beyond this period.

The proposed project schedule is provided in Figure 3.5.1. Operations of all project components will continue well past the year 2022 that is shown in the figure.

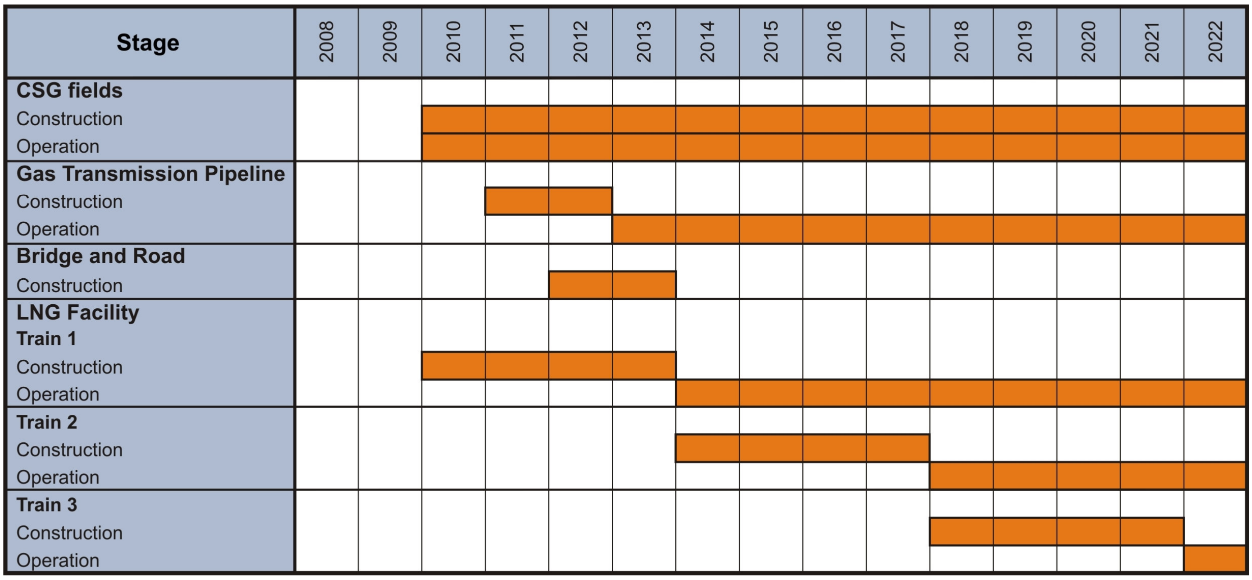


Figure 3.5.1 Project Schedule

3.6 CSG Fields

3.6.1 Existing CSG Fields

Santos has been conducting conventional oil and gas activities in the Surat Basin for many years and began CSG development in 2002. Over that time Santos has obtained a variety of petroleum tenures to permit its activities in the area. Details of these tenures are given in Section 3.4.2.

Exploration and gas production activities are currently being undertaken in the Scotia, Roma and Fairview fields. Exploration is also being undertaken in the Arcadia Valley field. The locations of these fields are shown in Figure 3.4.1.

Santos began exploration of the Scotia CSG fields in 1996 and commenced production in 2002. The Scotia plant compresses the gas for transmission to the Queensland gas market via the existing transmission pipeline network.

The Roma area was initially developed by Santos as a conventional gas field. However the CSG reserves from the shallower coals in the area are now being developed for CSG production.

Santos purchased the Fairview and Arcadia Valley assets in 2005 to add to their CSG portfolio. Santos has since progressed development of the Fairview field and has increased its reserves significantly.

Santos has a number of existing gas sales agreements and the work necessary for ongoing field development to service these agreements will continue under existing approvals already held and being sought by Santos.

3.6.2 GLNG Project Field Development

3.6.2.1 Nature of Field Development

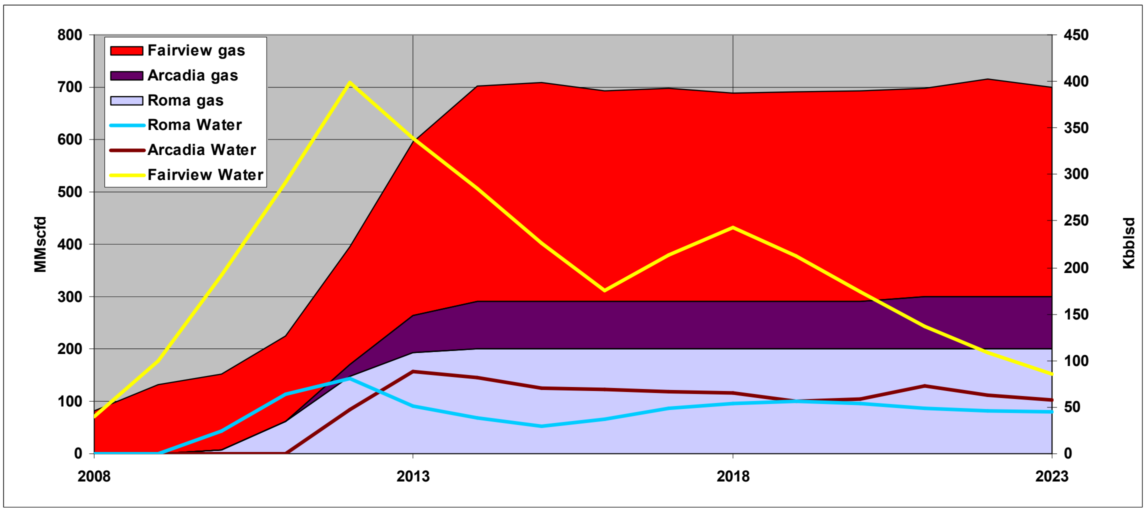
As part of the GLNG Project, existing field development will be expanded. Initially this expansion will be in the RFD area (see Section 3.4.2) which is expected to be sufficient to supply at least Train 1 of the LNG facility.

Field development in the RFD area will be more intense leading to 2014, which is the proposed start-up date of the first LNG train. This period will see gas production rates increase to feed enough CSG to produce 3 - 4 Mtpa of LNG. This will require new CGS wells and associated infrastructure to be developed.

The ramp up of RFD production is illustrated in Figure 3.6.1. During the ramp up, gas will be turned down at the well head (where practicable) and exported to domestic sales and/or stored in underground reservoirs in order to conserve any gas production in excess of sales amounts. The optimum level of gas storage is being evaluated and may assist in both storing gas ahead of the LNG facility start up and with supply to the facility during its early years of operation.

Ongoing field development will require new wells to be drilled to replace declining wells. This will cause the ongoing disturbance of small areas throughout the RFD area, which will see a rolling program of exploration and production activities. Close consultation with landholders, the local community, and the relevant regulatory bodies will form an integral part of the rolling development program.

In addition to well development, development in the RFD area will also include the construction of up to 12 centralised compression and water treatment facilities, and up to 150 nodal compressor stations. The nodal compressors will be low to intermediate pressure rotary screw compressors with gas/electric drivers to pump the gas and associated water to the centralised facilities. The centralised compression and water treatment facilities will treat and compress the gas prior to it entering the gas transmission pipeline. They will also treat the associated water. Further details on the centralised compression and water treatment facilities are given in Section 3.6.4.



MMscfd – million standard cubic feet per day
Kbblsd – thousand barrels per day

Figure 3.6.1 Ramp Up of CSG Production in the RFD Area

Other project infrastructure will include access roads, water management facilities, water and gas gathering lines (pipelines) and accommodation facilities.

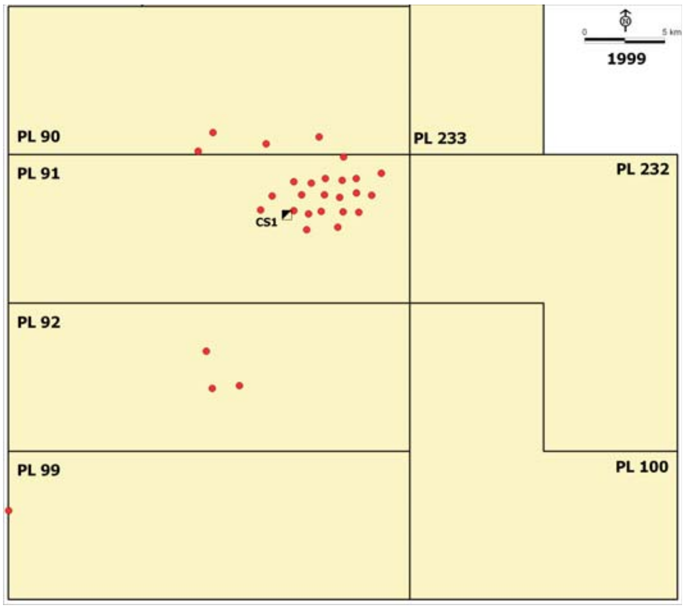
Because of the nature of the CSG exploration, the planning for field development, including the specific locations of exploration and development wells and associated infrastructure, is determined incrementally based on the outcome of ongoing exploration programs.

Initial development in any one area will begin with a small number of wells increasing over time (several years). In addition, the road network will expand to provide access to each well and water and gas gathering lines will be installed. Once sufficient wells are developed, nodal compressor stations will be established and the centralised compression and water treatment facilities developed. Figure 3.6.2 indicates the progressive nature of well development in the Fairview field from 1999 to 2009 to the present as well as the likely extent of future development. It shows a relatively small number of wells throughout the area and one compressor station (SC1) in 1999. This has increased over time so that by 2009 there are many more wells and four compressor stations. Access roads have been constructed to each of the wells although they are not shown on Figure 3.6.2. However they are shown on Figure 3.6.3 which is an aerial photograph of the same area showing the extent of development in 2008. The well sites and access roads are clearly visible in the vegetated areas where clearing has been necessary.

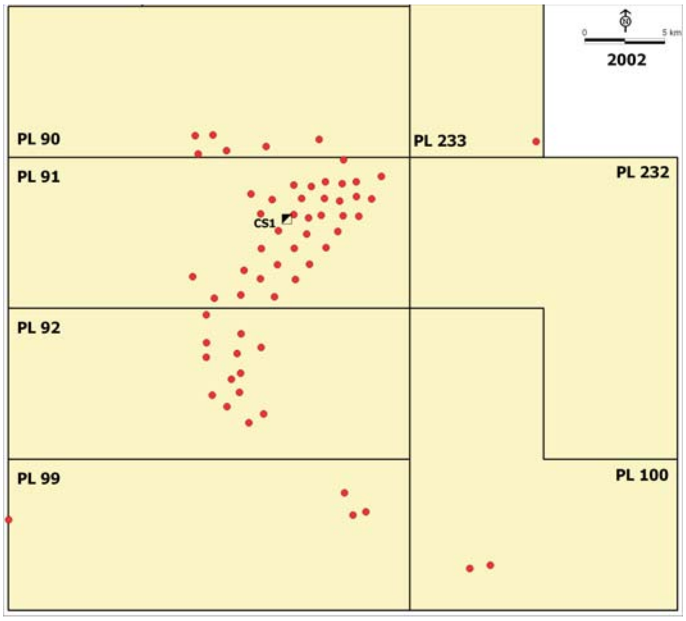
Table 3.6.1 summarises an indicative well development within the RFD area. However this is subject to change as more detailed exploration, planning and engineering is undertaken. It does not include any information about the potential expanded development area outside of the RFD area; the need for and extent of this will not be known for some years.

Table 3.6.1 Indicative Future Development of RFD Area

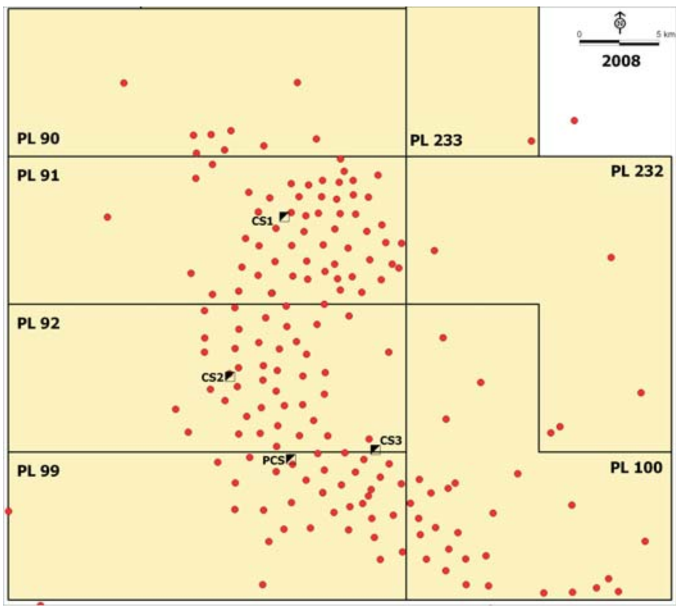
Activity	Location	Years					
		Existing to 2009	2010-2014	2015-2019	2020-2024	2025-2029	2030-2034
Wells Drilled (number)	Roma	110	386	336	336	206	36
	Fairview	205	325	198	121	0	0
	Arcadia Valley	0	137	121	133	0	0
	Total	**315**	**848**	**655**	**590**	**206**	**36**



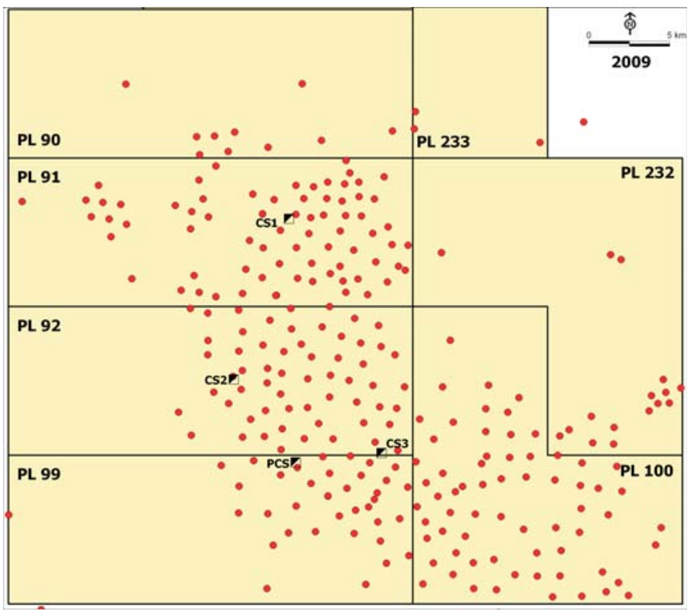
Field Development 1999



Field Development 2002



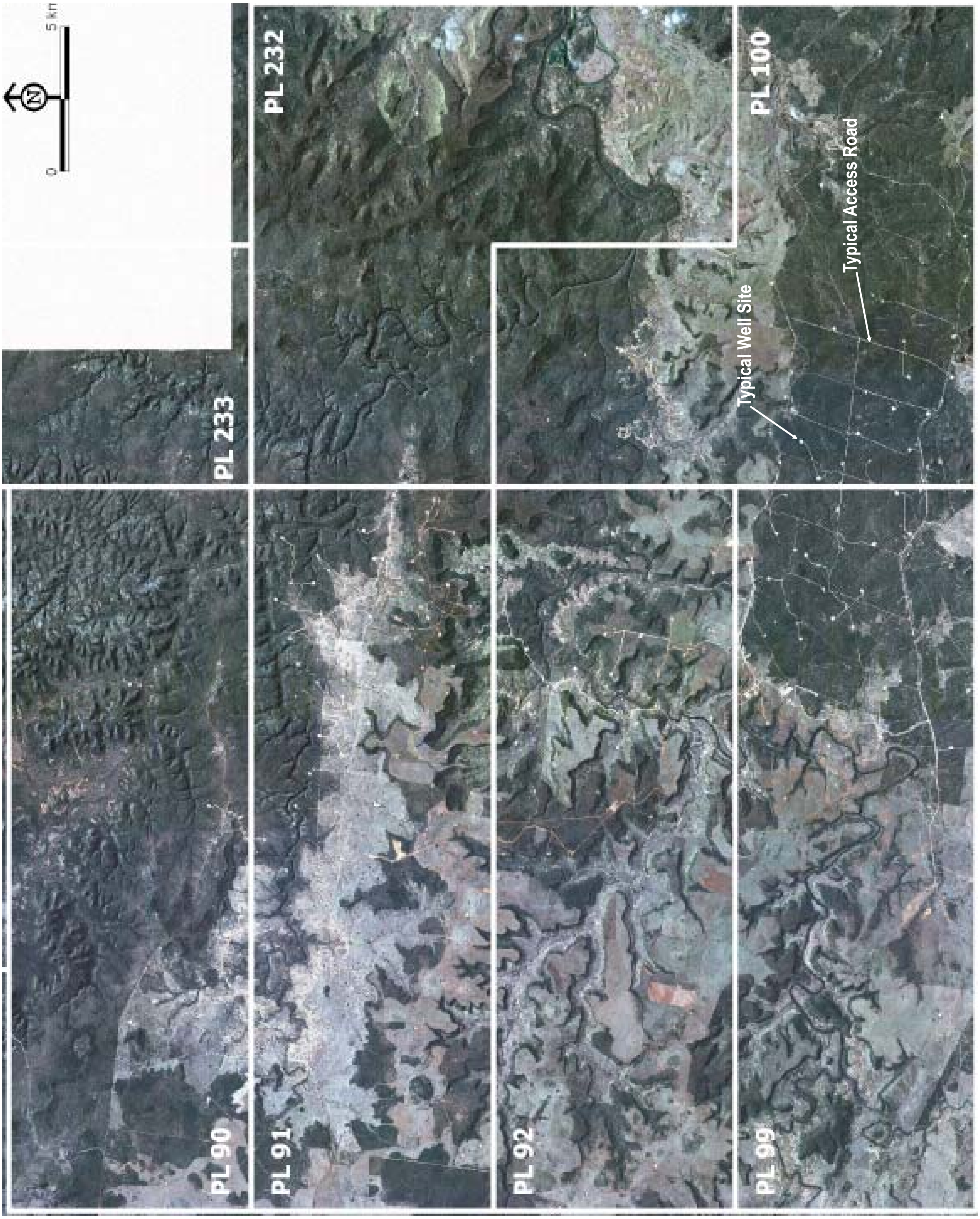
Field Development 2008



Field Development 2009

Source: This map may be sourced and Copyright. See Section 18.2 of the EIS for Ownership and Copyright.

Client	Project	Title
LNG / URS	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT	PROGRESSIVE FIELD DEVELOPMENT - FAIRVIEW
	Drawn: CA · Approved: JB · Date: 02-03-2009	Figure: 3.6.2 · Rev. A
	Job No.: 4262 6220 · File No. 42626220-g-1015.cdr	A4



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Client	Project	Title
LNG / URS	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT	**FAIRVIEW FIELD DEVELOPMENT - 2008**
	Drawn: CA / Approved: JB / Date: 04-03-2009	Figure: **3.6.3** / Rev. B
	Job No.: **4262 6220** / File No. 42626220-g-1016.cdr	A4

3.6.2.2 Impact Assessment Process for Field Development

Because of the large area of the CSG fields and the ongoing nature of exploration and gas production, the precise number and location of the wells and associated infrastructure, and the locations of the centralised compression and water treatment facilities, is not yet known and will evolve gradually over the life of the project. Consequently, it is not feasible to undertake conventional baseline studies and impact assessment and so, for the CSG fields component of the project, a two-phased approach has been adopted for its impact assessment.

The first phase of impact assessment (Phase 1) which has been reported within this EIS incorporates the following activities:

- Desktop assessment of the CSG fields. This assessment included the GCS fields as shown on Figure 3.4.1. This included the RFD area as well as the FD area. The purpose of the desktop assessment was to indentify regional environmental constraints over the whole area and to provide a focus for the subsequent reconnaissance field surveys. This desktop assessment included literature reviews, database searches, interpretation of relevant mapping layers and liaison with local community groups.
- Reconnaissance field surveys. The surveys were undertaken in the potentially sensitive locations in the RFD area that were identified from the desktop assessment. The purpose of the reconnaissance field surveys was to identify the environmental values likely to be affected by development of the RFD area.
- Assessment of likely impacts from typical project elements (e.g. wells, pipelines, nodal compressors, centralised compression and water treatment facilities, accommodation facilities and other related infrastructure). This was based on identified impacts and mitigation measures employed at the existing Santos CSG operations. The purpose of the assessment was to identify the impacts associated with the proposed development and to develop appropriate mitigation measures.
- Development of a protocol for the ongoing impact assessment of each project element to be undertaken as their specific nature and location becomes known over the life of the project.

The second phase (Phase 2) will be the implementation of the protocol for ongoing impact assessment of each project element once its nature and location becomes known over the life of the field development. The purpose of the protocols is to provide a robust framework for the management of each component of the CSG fields in a manner which minimises its impact on the environment. The protocols will be developed to:

- Identify the elements of the CSG fields development which have the potential to impact on the environment;
- Identify the sensitive features of the existing environment;
- Specify the site selection criteria to be applied according to the type and location of the development proposed;
- Outline the proposed timing and scope of field work required to enable the proposed development to be located in accordance with the relevant site selection criteria; and
- Identify mitigation measures which will be employed to minimise impact on the environment.

The protocols are set out in:

- The environmental management plans (EMPs);
- The mitigation measures in the EIS; and
- The management standards and hazard standards as set out in Santos' Environmental Health and Management System (EHSMS) (see Section 1.2.3.3).

The protocols will be managed through the existing Santos impact assessment process and will feed directly into their EHSMS.

3.6.3 CSG Fields Development Process

Development of the CSG fields may include a range of activities from geophysical investigations through to production and processing. Project phases include:

- Exploration - including geophysical surveys and drilling of exploration wells;
- Appraisal - drilling and testing of appraisal wells (also called pilot holes);
- Development, including:
  - Drilling and completion of production wells (wells drilled to enable gas production); and
  - Construction of centralised compression and water treatment facility, gas and water gathering networks, associated water management facilities and other related infrastructure.
- Production/Operation; and
- Rehabilitation and Decommissioning.

An overview of the typical field development stages and key activities is provided below in Figure 3.6.4. Within an ATP, exploration activities are undertaken and, based on the results, the value of the resources is appraised. This process can take 5+ years. Should the resource prove to be adequate, Santos may apply for a PL. Following the grant of the PL, a field development program will be implemented and production and operational wells developed. Depending on the productivity of the field, production could continue for 30 years or more. Eventually gas production will decline and the field will be decommissioned. This will include removal of the facilities and equipment and final rehabilitation of the area.

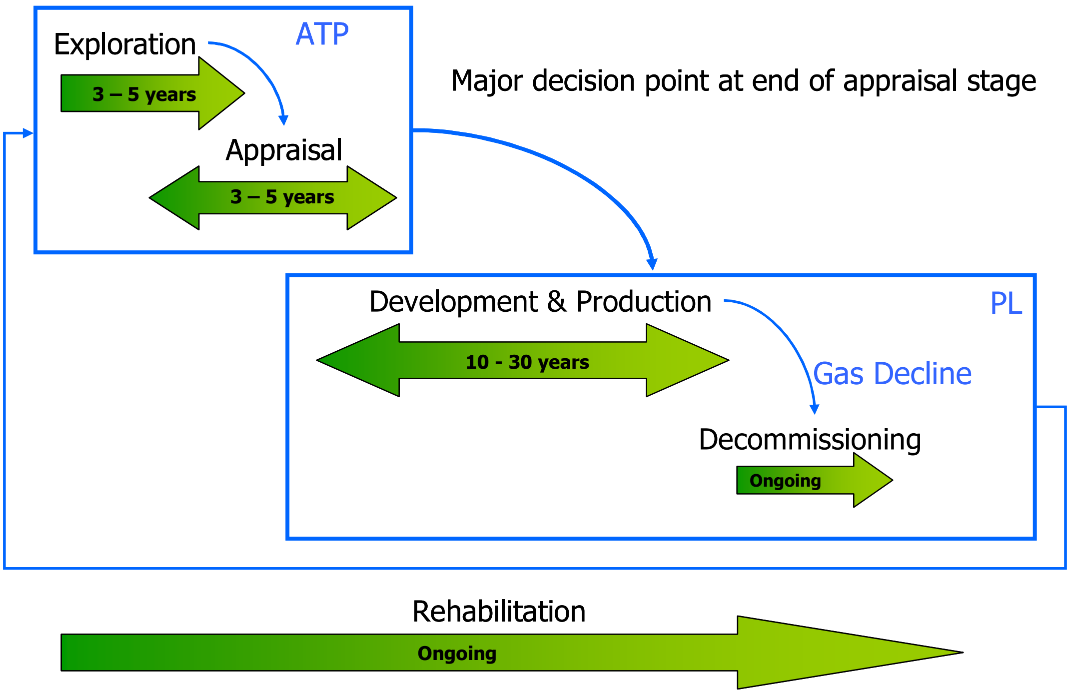


Figure 3.6.4 Overview of Field Development Stages

3.6.3.1 Exploration

Seismic and Other Geophysical Surveys

A seismic survey is a field geological assessment method that may be used during field exploration. The vibroseis method is the preferred method of data acquisition for seismic surveys. This method utilises a generator and vibrator pad and hydraulically transmits vibrations through a range of frequencies into the earth. However in areas where preservation of vegetation cover is important, the shot hole (dynamite) method is utilised.

Other geophysical surveys such as aeromagnetics and multi-transient electro-magnetics are under active consideration. An aeromagnetic survey involves towing a passive receiver behind a low-flying aeroplane and measuring the variation in the earth's naturally occurring magnetic field. These surveys are typically of short duration (1-2 weeks).

Corehole and Exploration Drilling

Corehole drilling is undertaken to collect solid coal and rock cores for testing. Holes are typically between 100 mm and 300 mm in diameter. Exploration wells are lined with steel casing which is pressure cemented into the side of the hole, both for safety reasons and to isolate any aquifers that are intersected.

When work is finished at a specific site, the hole is usually filled with cement and the area appropriately rehabilitated. An area of approximately 60 m x 60 m is usually required for drilling coreholes and exploration wells.

3.6.3.2 Appraisal

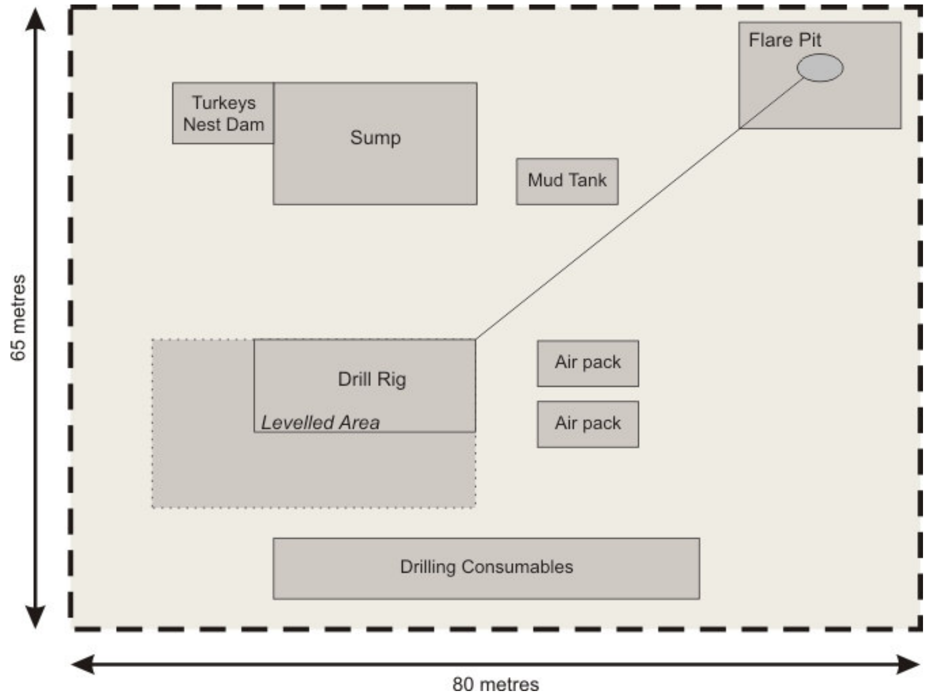
Appraisal Wells (Also called Pilot Wells)

Once a promising geological structure has been identified by the seismic surveys and/or core hole drilling, the presence of a resource and the thickness and internal pressure of a reservoir is confirmed by drilling an appraisal well. The location of a drill site (referred to as a drilling lease) depends on the characteristics of the underlying geological formations, soil, terrain and seasonal variations.

A drilling lease is developed at the chosen site to accommodate the necessary drilling equipment and support services. The largest drilling lease configuration for a single well could be up to 100 m x 110 m (11,000 m^2). However, depending upon the drilling rig type and specific site constraints, this area could potentially be reduced to approximately 65 m x 80 m (5,200 m^2). Apart from the drill rig and associated equipment, some of the major elements within the lease area include a flare and flare pit for disposal of the gas and associated water that is produced, a sump for the drilling fluids, and a turkeys nest dam for water supply. Figure 3.6.5 outlines the typical layout for a drilling lease. Options to drill multiple wells from a single drilling lease are being considered. These may result in a somewhat larger lease size but overall will considerably reduce the number of leases required and consequently reduce the overall project footprint.

Preparation of the lease includes:

- Clearing of surface vegetation and topsoil which are stockpiled for future rehabilitation;
- Levelling the ground surface for the drill rig;
- Fencing the site boundary of some sites;
- Construction of an earthen pit or sump to contain the cuttings removed from the well by water or air;
- Constructing a flare pit to contain the flare associated with the combustion of produced gas; and
- Installing a cellar (a 2 m^3 cube through which the drilling assembly passes) and surface conductor pipe.



Not drawn to scale

Figure 3.6.5 Schematic of Typical Appraisal Drilling Lease Layout

Drilling is on a 24 hour basis for approximately 1 - 3 weeks per well. The precise time to complete drilling is dependent on the depth of the well, the geology of the area and the rig used.

Once drilling commences, drilling fluid or mud is continuously circulated down the drill pipe and back to the surface where it is disposed of in a sump that is established on the well lease. The drilling fluid is used to balance underground hydrostatic pressure, cool the drill bit and flush out rock cuttings.

Gas flows from the well are measured to enable an assessment of the gas reserves to be made. The risk of an uncontrolled gas flow from the reservoir to the surface is greatly reduced by using blowout preventers – a series of hydraulically actuated steel rams that can close quickly around the drill string or casing to seal off a well. The gas that is produced is flared as it is not yet connected to a centralised compression and water treatment facility by a gas gathering system. Flaring reduces the global warming potential of the gas.

The typical drilling operation of an appraisal well is shown on Figure 3.6.6.

The drilling crew will be accommodated in on-site self-contained accommodation facilities which will include canteen facilities, communications, vehicle maintenance and parking areas, fuel handling and storage areas, and facilities for the collection, treatment and disposal of wastes. These accommodation facilities typically occupy an area of approximately 6,000 m^2 and are located away from the immediate area of the drilling rig in a centralised location so as to reduce the environmental footprint of the drilling program. If well leases are located in remote or difficult to access locations, small relocatable accommodation facilities may be established to service the drilling rig.

Depending on the surrounding land use, fencing may be placed around the well lease to exclude cattle and wildlife and as a safety precaution. As part of the site's rehabilitation, the fence will be removed.

After drilling and appraisal, the rig is dismantled and moved to the next site.

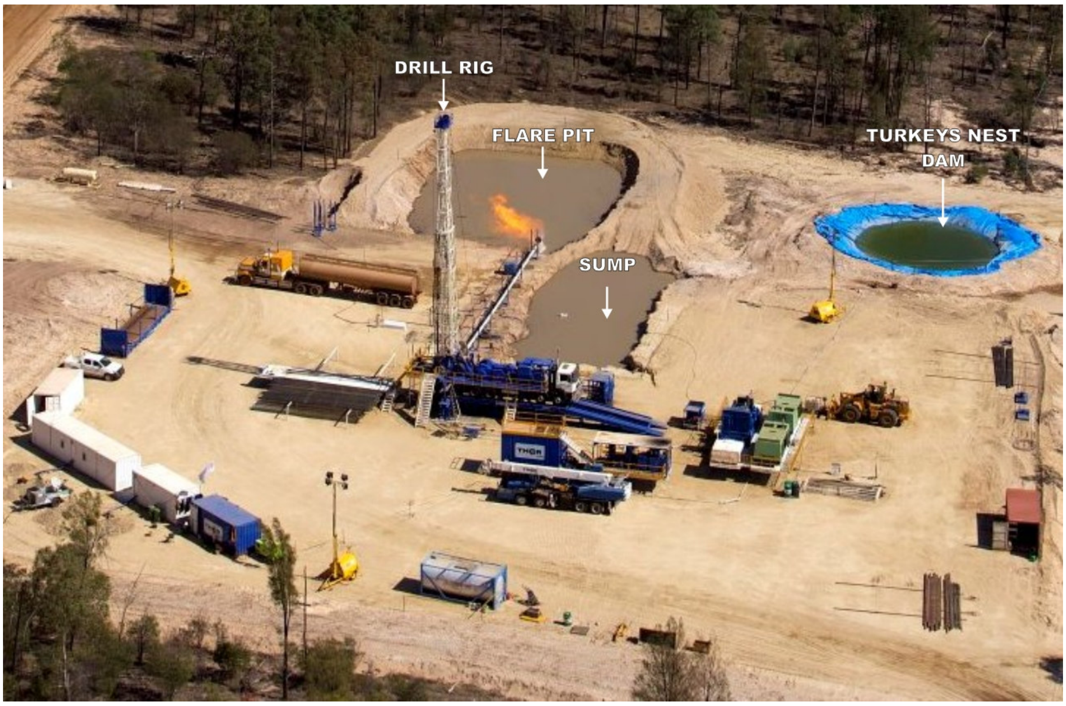


Figure 3.6.6 Typical Appraisal Drilling Operation

If the well does not contain any commercial gas reserves, it is plugged downhole with several cement plugs and a steel plate welded over the conductor pipe with the details of the well inscribed onto the plate. This will be negotiated with the landholder at the time of drilling. The site will then be fully rehabilitated by re-contouring and actively promoting vegetation regrowth. Disposal of drill cuttings will be by means of burial onsite.

Testing

If economic volumes of gas are identified, pilot testing will be carried out. This will typically comprise testing a series of up to five relatively close appraisal wells over time. The locations of wells are dependent on the underground gas resources and also on the characteristics of the coal seam. The coal seam can be thick, thin, highly permeable or tight – all of these factors determine the spacing of the wells. However, generally the wells are spaced about 1 km apart. The well locations will also be altered to avoid environmentally sensitive areas such as dams, watercourses, vegetation and existing infrastructure.

Water and gas from the pilot wells will be pumped from the coal seams for testing. The gas will be flared at each well and the water from the wells will be collected and pumped to a dam or other alternative such as tanks for management as described in Section 3.6.5.

3.6.3.3 Development and Production

Production and Operational Wells

Upon confirmation of the economic viability of the gas resource, the pilot wells will be converted to production wells to enable the gas to be produced. Each appraisal will be prepared for production before the drilling rig departs. At this stage, the blowout preventer will be replaced by a control valve assembly.

Wells are developed by placing a steel casing (or pipe) into completed sections of the borehole and cementing it into place. The casing provides structural support to maintain the integrity of the borehole and isolates formations above the coal seam from the well. A water pump is commonly inserted in the well to extract the associated water. As the water pressure is reduced in the coal seam the gas is released and flows through the well. This process is illustrated in Figure 3.6.7.

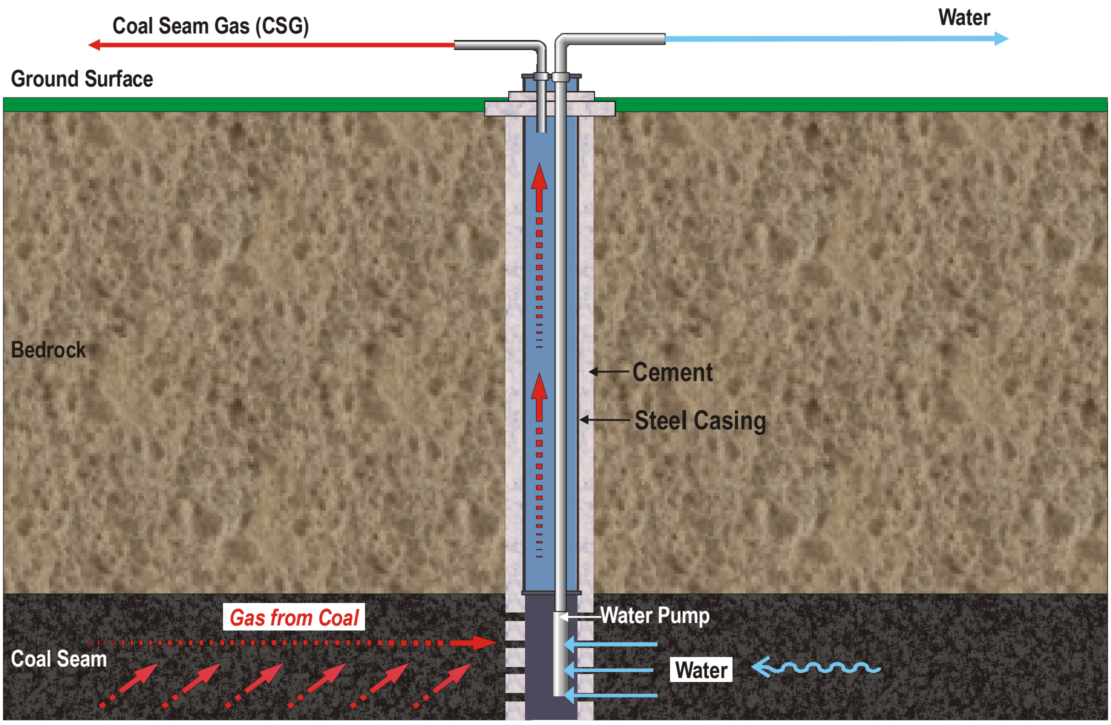


Figure 3.6.7 Typical Well Sections

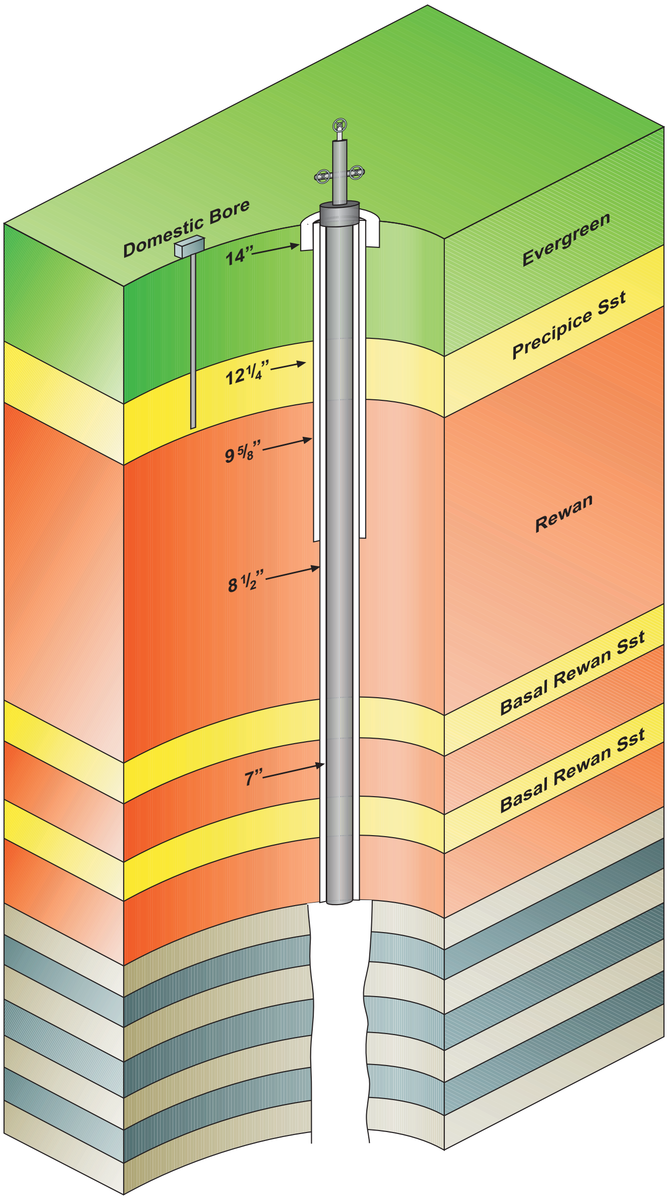
Figure 3.6.8 shows the geological strata that will be penetrated by a typical well in the Roma and Arcadia Valley fields.

The wells will become operational once they are connected to the gas and gathering systems for delivery to the centralised compression and water treatment facility. The wells will also be connected to water gathering systems for delivery of associated water management facilities. Once the wells become operational (operational wells), the appraisal and pilot facilities are removed and the wellhead assembly and lease area is reduced and rehabilitated as required. The surface facilities at an operational well typically include a well pump, gas or electric powered drivers for the pumps, separator (which separates associated water from the gas), metering facilities and a flare stack.

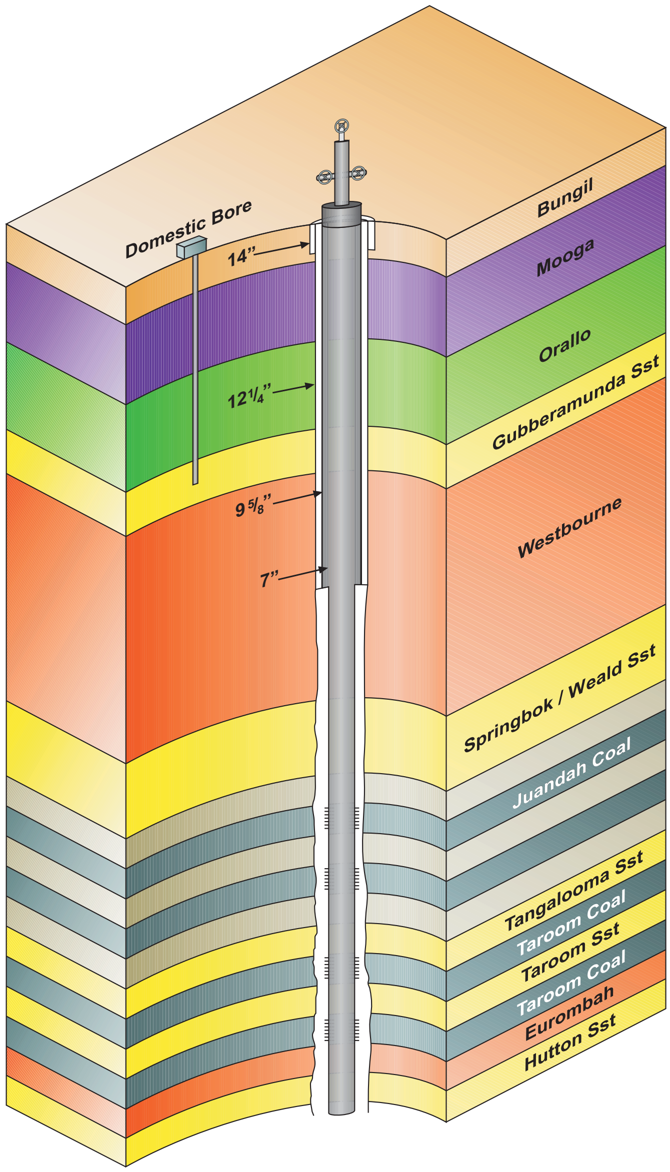
An operational well lease area is typically 0.1 ha. It is generally fenced to exclude stock and the surface rehabilitated and revegetated to control erosion. A typical wellhead for an operational well is shown in Figure 3.6.9.

Santos expects to drill and complete approximately 2,650 operational wells in the Roma, Fairview and Arcadia Valley fields within the RFD area to supply approximately 5,300 PJ of gas to the first train of the LNG facility (3 -4 Mtpa for 20+ years). Several development scenarios are being evaluated. Table 3.6.2 details the currently planned operational well development rate for the RFD area for the likely development scenario. More or fewer wells for Train 1 may be required depending on factors such as field performance and drilling techniques. Note that as the flow rate of wells decline, new wells will become operational to maintain the gas production rate. As such, the end of year cumulative number of wells drilled will be larger than the number of wells operating at that time but this will vary.

ARCADIA VALLEY



ROMA



Client	Project	Title
LNG / URS	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT	**TYPICAL GEOLOGICAL STRATA**
	Drawn: AA · Approved: JB · Date: 04-03-2009	Figure: **3.6.8** · Rev. B
	Job No.: **4262 6220** · File No. 42626220-g-991.cdr	A4

Figure 3.6.9 Typical Operational Well

Road access will be required to each operational well for construction, operational and maintenance purposes. Typically, operational and maintenance vehicular access to each well may be required approximately three times per week. Access will be via existing farm roads or tracks where practicable. Alternatively a new access built to local farm track standard will be constructed in consultation with the landholder. A typical well access track is shown in Figure 3.6.10.

Figure 3.6.10 Well Access Track

Table 3.6.2 Planned Operational Well Development Rate Reference

Year	Fairview		Roma		Arcadia Valley		Total	
	New Wells	Cumulative Wells Drilled	New Wells	Cumulative Wells Drilled	New Wells	Cumulative Wells Drilled	New Wells	Cumulative Wells Drilled
Pre-2009	0	139	0	73	0	0	0	212
2009	66	205	37	110	0	0	103	315
2010	102	307	82	192	0	0	184	499
2011	107	414	172	364	0	0	279	778
2012	48	462	84	448	52	52	184	962
2013	68	530	0	448	48	100	116	1,078
2014	0	530	48	496	37	137	85	1,163
2015-2019	198	728	336	832	121	258	655	1,818
2020-0224	121	849	336	1,168	133	391	590	2,408
2025-2029	0	849	206	1,374	0	391	206	2,614
2030-2032	0	849	36	1,410	0	391	36	2,650

Gas and Water Pipeline Gathering System

Once the gas reaches the surface, it will be pumped to a centralised compression and water treatment facility through a network of buried pipes. In some cases there may not be adequate pressure for the gas to flow to the centralised facility. If so, nodal compressor stations will be provided to pump the gas to the central facilities. The nodal stations will be low to intermediate rotary screw compressors with either a gas or electric driver. Approximately 150 of them will be required for the development of the RFD area.

Typically there are two pipeline systems installed in the CSG fields as described below:

- The first is the gas pipelines system (often called a gathering system) that is used to collect the gas from the wellheads on the leases and send it to the nodal compressor stations or the centralised compression and water treatment facilities. These pipelines can be steel, polyethylene or non-ferrous material and constructed in compliance with code requirements.
- The second system is the water pipelines. These are similar to the gas lines however they collect associated water from the leases and transport it to the relevant water management facility. The water pipelines can also be either steel or polyethylene depending on required pressures and generally will be buried in the same trenches as the gas pipelines where practical.

In order to minimise the disturbance footprint, pipelines will be located along existing roads and tracks or existing fence lines where practical. The current plan for the gas and water pipeline gathering system for the RFD area is that it will require in the order of 2,000 km of pipeline. The gathering system may be longer or shorter depending on ultimate field performance and development plan.

3.6.4 Centralised Compression and Water Treatment Facilities

The centralised compression and water treatment facilities will be located throughout the gas fields to minimise the length of the gathering pipelines and pumping requirements. The size and number of centralised compression and water treatment facilities will depend on the nature of the reservoirs, the number of wells and the volume and nature of associated water. It is currently estimated that approximately 12 new centralised compression and water treatment facilities will be required for the RFD area.

They will consist of the following major process items: filtration, compression, cooling and dehydration. Compressors will be either driven by gas internal combustion engines or electric motors pending the outcome of detailed efficiency, operability and reliability analysis.

Support infrastructure may include:

- Oily water treatment;
- Piping and fittings, and supports;
- Instrumentation and control systems;
- Utilities (instrument and fuel gas systems and generators);
- Flare system;
- Petroleum fuel tanks;
- Scraper station facilities; and
- Buildings (may include a control room, offices, a workshop, storerooms and emergency accommodation).

The estimated compound size is likely to be in the order of 250 m x 200 m.

An existing centralised compression and water treatment facility at the Fairview field is shown in Figure 3.6.11 and is typical of what can be expected throughout the RFD area. This is indicative only and does not necessarily reflect the final layout, nor the acoustic treatment that may be used.

Figure 3.6.11 Centralised Compression and Water Treatment Facility - Fairview

Gas will be transported from the centralised compression and water treatment facilities to the Gladstone LNG facility via the gas transmission pipeline.

3.6.5 Associated Water Management

The volume of associated water produced will vary from well to well and with the duration of well production. The volume of water produced from an individual well will reduce over time.

Figure 3.6.12 provides an overview of the volume of associated water expected from the RFD area over the life of the GLNG Project. It must be noted that the volumes identified in Figure 3.6.12 have a substantial range of uncertainty because of the significant subsurface uncertainty. Detailed volume estimates will be better defined during later stages of field development.

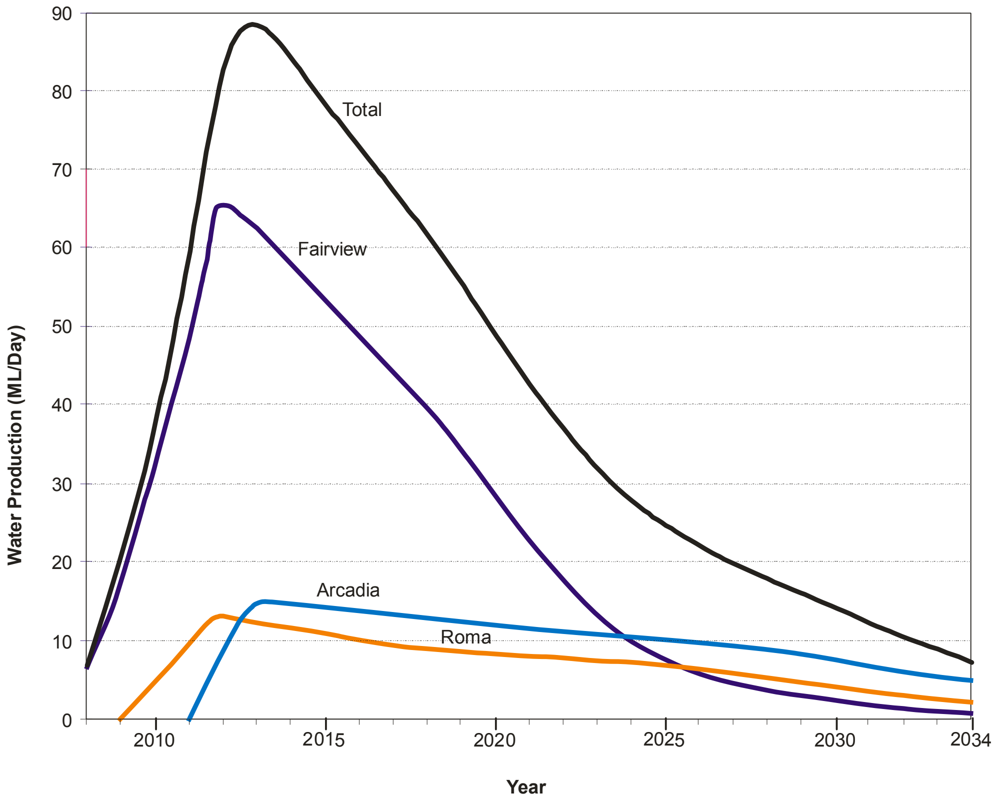


Figure 3.6.12 Estimated Associated Water Production from RFD Area

Figure 3.6.12 shows that the volume of associated water generated will be significant. Accordingly a sustainable and economically viable water management strategy has been developed and will form the basis of the project's associated water management plan once the field development plan is finalised.

The associated water will generally have elevated salt concentrations in the range 1,500 to 8,000 mg/L. Nevertheless it has potential for beneficial reuse and a range of management options are being developed that can be adapted to the variability in quality and quantity of the water across the fields and over time. A risk management approach has been used to develop a short list of water management options that will be combined in different proportions across the three fields.

The Queensland Environmental Protection Agency (EPA) has an operational policy for associated water which identifies a preference to re-inject associated water to groundwater, preferably to the coal seams from which the water originated. However, this approach will require the construction of very large areas of temporary water management ponds, which will have impacts similar to those of evaporation ponds, which are not permitted under current EPA policy.

The risk assessment undertaken by Santos has identified a range of options for associated water management. In order of preference, they include:

- Direct irrigation of salt tolerant crops (e.g. Chinchilla White Gum is already under irrigation at the Fairview field using water with salinity concentrations of up to 3,000 mg/L);

- Some localised stock watering as appropriate[1];
- Desalination, followed by supply of low salinity water to any of the following[2]:
  - Local landholders, on whose land the CSG fields are located. (Santos expects to supply at least half of its desalinated water to the local pasture industry. Most of this water can be expected to be applied to irrigation of fodder crops).
  - Local industry (possibly using rivers to transport desalinated water).
  - Local municipal purposes.
  - Environmental enhancement and/or provide increased public amenity (for example, maintain water levels in lakes in the region).

Figure 3.6.13 shows a schematic layout proposed for associated water management in a typical CSG field. Associated water will be collected from the CSG wells and retained in an associated water management pond. The water will then be transferred to a water treatment facility where it will be treated in a Reserve Osmosis (RO) plant (or equivalent). The treated water will be used by landholders or for beneficial re-use.

The RO plant will produce a waste stream of approximately 20 % of the input rate of the associated water. The waste steam is referred to as brine, even though it may only have salinity concentrations of around 15,000 - 20,000 mg/L. The brine will be contained in water management ponds. Detailed monitoring of groundwater pressures in response to the coal seam depressurisation will be undertaken to determine the feasibility of injection of the brine to coal seams or other suitable aquifers. An alternative is to reduce it to a solid form and encapsulate.

The extent of infrastructure and equipment to be provided to manage the associated water will vary according to the options selected and will be subject to more detailed design. Nevertheless the broad concept design parameters currently proposed include the following:

Water management ponds:

- Ponds used for containment of associated water or brine, will be constructed using a 300 mm compacted clay liner (or equivalent), overlain by a 2 mm HDPE liner. Sand drains will be constructed in the pond walls to provide a further measure of risk management.
- Water management pond size will vary from about 20 ML to 200 ML.
- Brine containment pond size will vary between 300 ML and 1000 ML, depending on the situation. The area of these ponds will be up to 16 ha (their typical operational depth will be up to 6 m).
- Water management ponds will also be constructed at the termini of pipelines constructed to transfer treated water to local landholders. These ponds are expected to be about 10 ML in capacity and will generally be earth lined ponds.

Pipelines:

- Water pipelines will typically be welded HDPE pipe, buried to at least 300 mm below the surface, but deeper in areas of surface traffic.

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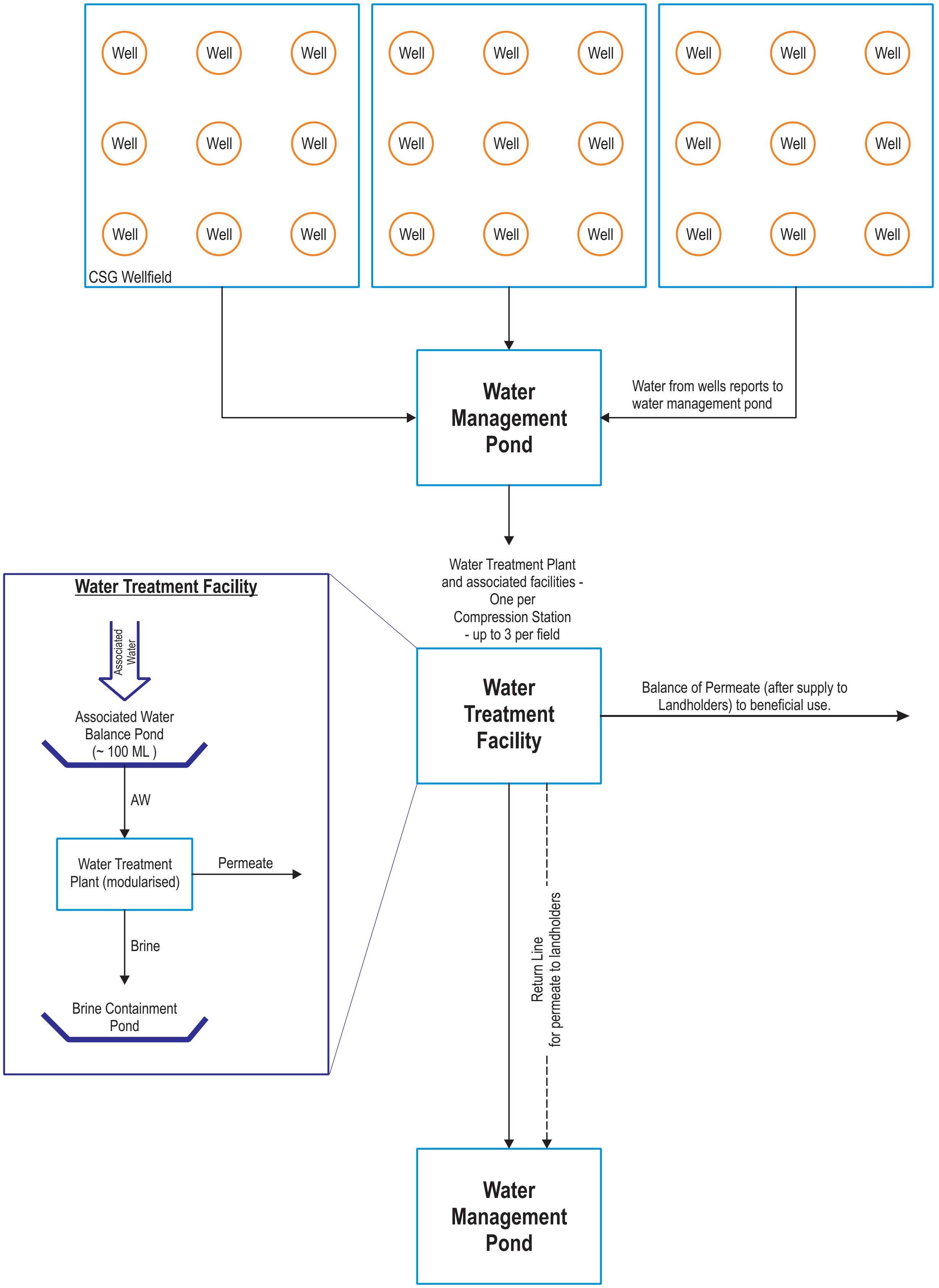
[1] Current legislation restricts the amount of water that may be applied to stock watering without a water licence.

[2] With the exception of the Fairview field, there is currently only a low demand for the direct application of associated water to salt tolerant species. Furthermore, the Roma and Arcadia Valley fields are not as suited to direct irrigation with associated water. Hence it is proposed to develop and use water management methods that rely on desalinating the water first, then applying the desalinated water to other beneficial uses.



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Client	Project	Title
LNG	GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT STATEMENT	SCHEMATIC WATER MANAGEMENT LAYOUT
URS	Drawn: CA · Approved: JB · Date: 03-03-2009 Job No.: 4262 6220 · File No. 42626220-g-1019.cdr	Figure: 3.6.13 · Rev. A · A4

Water treatment facilities:

- Water treatment will be by RO.
- Modular RO plants of about 2.5 ML/day capacity will be fabricated off site then mobilised to the field at a location preferably co-located with compressor stations. Up to five RO plants are expected to be required, with capacity up to 10 ML/d each.
- It is expected that waste heat from the compressor stations will be utilised to minimise the footprint of brine containment ponds by encouraging evaporation prior to discharge of the brine.

Figure 3.6.14 shows the existing water treatment facility at another Santos CSG field which is typical of what can be expected in the RFD area.

Figure 3.6.14 Pony Hills Water Treatment Facility

A detailed assessment of the proposed associated water management strategy is given in Section 6.7.

3.6.6 Support Activities and Infrastructure

3.6.6.1 Land Clearing and Road Construction

Land clearing and road construction will be required as part of the exploration, appraisal, development and operation activities. The extent of clearing and road construction will be dependent on the location and nature of the proposed CSG activity. Access roads are also required during operation to allow inspection of well sites and other supporting infrastructure. They will be placed in areas that best suit both the landholder and Santos. Roads are typically placed along fence lines to minimise disturbance. Where practicable, they are planned to avoid remnant vegetation, steep slopes, erosion prone soils and sensitive ecosystems.

The expected clearing requirement for wells and associated roads and facilities within the RFD area is approximately 2,500 km^2. This includes approximately 6,800 km of access roads which generally will be built to a low volume, unpaved, rural road standard in accordance with relevant local government requirements. This clearing will be widely dispersed over the area and will occur gradually over a 25+ year period. Rehabilitation of the disturbed areas will also occur gradually over the life of the project so that the total area cleared at any one time will be less than the above area.

3.6.6.2 Waste Management

During both construction and operational phases, careful consideration will be given to the choice of materials used so as to minimise the volume of waste going to landfill. Operational and construction solid wastes that cannot be recycled or re-used will be disposed of at various local authority waste disposal facilities. All waste movement will be tracked in accordance with the requirements of the *Environmental Protection (Waste Management) Regulation 2000 Schedule 2.*

Further details on waste management are provided in Section 5.

Associated water is also classified as a regulated waste under the *Environmental Protection Act 1994*. Further details of its proposed management strategies are given in Section 6.7.

3.6.6.3 Borrow Pits and Storage Areas

Borrow pits will be required to source gravel and other materials that are needed for the CSG development program. The locations and methods of extraction for each of the borrow pits will be determined as the need arises with the ongoing development of the CSG fields. Borrow pits are directly linked to the petroleum activities for this project and approvals will incorporated into the project's environmental authorities. Construction and lay down areas for equipment storage will also be required. Alternatively existing commercial sources for some of the relevant construction materials will be sought from existing operators. The nature and amount of material required will be assessed as the various field development plans are prepared.

3.6.6.4 Stormwater Drainage

Each worker accommodation facility will include a stormwater drainage system. These systems will be designed to collect runoff to prevent ponding or flooding. Stormwater runoff will be discharged at non-erosive velocities to the natural drainage system. Further discussion on stormwater management is given in Section 6.5.

3.6.6.5 Sewerage

It is anticipated that package sewage treatment facilities will be installed at the workforce accommodation facilities and the relevant approvals will be obtained by Santos in conjunction with the facilities' development approvals. Treated effluent will generally be disposed of by irrigation.

Where sewage effluent absorption beds and/or irrigation fields are used, they will be located and designed to ensure that:

- Sensitive areas are avoided;
- Soil erosion and soil structure damage is avoided;
- There is no surface ponding or runoff of effluent; and
- The quality of groundwater is not adversely affected.

Areas where treated sewage effluent is discharged to absorption beds or irrigation fields will be fenced and clearly marked with warning notices of the purpose of the area and not to use or drink the effluent.

Effluent treatment systems will be designed to include alternate measures for effluent storage and/or disposal, where conditions prevent the absorption of treated effluent to land (e.g. rain events). This may include wet weather storage or disposal off site. There will be no discharge of treated effluent from wet weather storage to any waters.

Further discussion on sewage treatment is given in Section 6.5.

3.6.6.6 Power

Power for the CSG fields operations is anticipated to be generated by CSG however, various alternatives energy sources, including potential gas fired power options, will be investigated during the field development phase for the project. GLNG will seek additional approvals, as required, in the event that these options were selected.

3.6.6.7 Telecommunications

Telecommunications services to be provided will include voice and data network services and telemetry services. Santos will use existing carrier services where available, otherwise alternative methods will be used such as:

- Santos' fibre network will be extended from existing facilities and installed parallel with piped gathering networks;
- Communications equipment will be accommodated in operational or administration buildings; and
- Satellite communications will be used in remote locations.

Telemetry services will be provided to facilitate the operation and monitoring of field production. Strategically located radio towers will be used for both data telemetry and voice radio services. These services will be connected to the data networks at operation or administration facilities.

3.6.7 Decommissioning and Rehabilitation

3.6.7.1 Objectives

After the gas supply from each well is exhausted (generally after 5 - 15 years of operation), the well site (lease) and associated facilities and infrastructure will be decommissioned, remediated and rehabilitated. The objectives will include a requirement to:

- Return disturbed areas to a stable condition similar to that of the surrounding area within an acceptable time frame or to an endpoint consistent with stakeholder requirements and expectations;
- Enable the effective transfer of operating areas to landholders compatible with post-closure land use;
- Minimise disturbance to drainage patterns and avoid contamination of soil, surface waters and shallow groundwater resources; and
- Minimise disturbance to native vegetation and native fauna.

In order to achieve these objectives, the following specific requirements will be adopted:

- **Stakeholder Consultation** - Santos will consult with the relevant stakeholders to enable the transfer of operating areas to the owners of the land;
- **Health and Safety** - During and at the completion of decommissioning and closure activities, all sites will be left in a tidy and safe condition with public and animal safety risks reduced to acceptable levels;
- **Environment** – Santos will comply, as a minimum, with relevant licenses and legislative conditions for the CSG project area and will ensure that post-closure activities have minimum impact on the environment;
- **Land Use** - Santos will undertake to return all sites to conditions consistent with pre-project land uses or alternative land uses determined in consultation with the landholders and regulatory agencies;

- **Decommissioning** - Santos will decommission, remove, make safe, and/or appropriately dispose of infrastructure, equipment and contaminated materials on/from all sites within the CSG fields in accordance with relevant laws and regulations unless otherwise agreed with the regulatory agencies. This will take into account the needs/concerns of the relevant landholders;
- **Site Assessment and Remediation** - Prior to closure, any ground contamination will be to a level where the risk to human health or the environment is as low as reasonably practicable, or otherwise agreed by stakeholders. Risk assessment will be undertaken in accordance with the regulatory requirements applicable at the time to determine the appropriate end-point criteria for specific contaminants and exposure scenarios relevant for the area;
- The decommissioning and rehabilitation strategy will comply with the EPA's requirements as set out in *Guideline 18: Rehabilitation Requirements for Mining Projects* (EPA, 2007) or other legislation relevant at the time; and
- An outline of the proposed decommissioning, remediation and rehabilitation activities is given below. Further details are provided in Section 6.16.

3.6.7.2 Decommissioning

The facilities within the CSG fields can be divided into the following categories of sites requiring decommissioning:

- **Seismic lines** – this category includes all historic seismic lines;
- **Wells and well sites** – this includes the wells, wellheads, well separators, flares, storage tanks and associated pipes and pumps;
- **Pipelines** – this includes the gathering networks connecting the wells to processing facilities and water management facilities and the transmission pipelines;
- **Processing and associated facilities** – includes compression and gas treatment facilities and where applicable, administration buildings, workshops, accommodation facilities and stores;
- **Water management facilities** – includes treatment plants, pipes, tanks as well as any water management ponds for the temporary storage of associated water;
- **Waste management areas** – includes waste storage facilities and soil remediation areas;
- **Roads and access tracks** – includes all access tracks and roads established as part of the project; and
- **Borrow pits and storage areas** – includes pipe stockpiles and construction materials.

3.6.7.3 Remediation

Potential contaminants associated with the operation of the CSG fields are expected to be predominantly hydrocarbons and salts (principally sodium chloride from the associated water).

Assessment of possible soil, surface water and groundwater contamination will be undertaken, specifically in:

- Locations where petroleum or chemical products were stored (e.g. tanks), pumped or handled;
- Waste management areas; and
- Sites that have been subject to historical oil and associated water spills or burial of wastes.

An assessment of additional areas may be required, such as historical spill sites and isolation valves.

Prior to closure of a CSG field, potential site contamination will be assessed to ensure it is at a level where risk to human health or the environment is as low as reasonably practicable, or otherwise agreed by stakeholders. Risk assessment will be undertaken in accordance with applicable Queensland regulatory requirements including the relevant EPA requirements and the National Environmental

Protection (Assessment of Contaminated Sites) Measure applicable at the time of closure to determine the appropriate end-point criteria for specific contaminants and exposure scenarios relevant for the area.

3.6.7.4 Rehabilitation

Progressive rehabilitation works will be undertaken throughout the life of the GLNG Project. The rehabilitation strategy will be flexible and will be amended from ongoing experience as new rehabilitation techniques are developed. This will include works such as revegetating cleared areas as soon as they as no longer required, and controlling runoff to minimise erosion.

The nature of the final site rehabilitation for disturbed areas may vary from area to area depending on the nature of the development in that area and the wishes of the local landholder and other relevant stakeholders. Generally, rehabilitation works will involve the following activities:

- Surface preparation and site contouring;
- Installation of drainage and appropriate erosion control structures if required; and
- Revegetation.

Any existing infrastructure that is useful to the landholder may be left and disturbed areas revegetated in accordance with future land-use.

3.6.8 Workforce

Table 3.6.3 presents an estimate of the total construction and operation workforce in the RFD area and Roma Centre from 2010 to 2034. Estimates every five years are provided beyond 2014 due to the uncertainty of development plans and the associated workforce numbers. It is based on two rosters working 14 days on 14 days off for 11 hours per day. Note that the numbers in Table 3.6.3 do not equate to the total workforce in the area at any given time. This will be significantly less as the workers will be on different schedules and work rotations.

Table 3.6.3 RFD Area Workforce

Area	2010	2011	2012	2013	2014	2019	2024	2029	2034
Construction									
Compressor Construction	20	50	60	20	15	0	0	0	0
Drilling	266	180	200	80	130	153	153	153	153
General Field Construction	500	700	700	700	600	31	31	31	31
Operations									
Roma Centre	29	39	45	53	57	59	60	62	62
Roma field	62	123	185	245	245	252	260	266	270
Fairview field	137	198	258	320	320	335	344	339	339
Arcadia Valley field	20	27	19	62	62	82	99	99	99
Total	**1,034**	**1,317**	**1,467**	**1,480**	**1,429**	**912**	**947**	**950**	**954**

For details of the occupational groupings and recruitment policies refer to Sections 6.14, 7.14 and 8.14.

Non-local field operational workers will live in a number of on-site accommodation facilities located at sites convenient to the various work areas. Generally the same accommodation facilities will be used by the exploration, drilling and construction workforce. At the end of their two-week rosters the field employees will fly-out to their places of origin (unless locally based). It is expected that the Roma Centre employees will live permanently in Roma or the surrounding area.

While fly-in/fly-out (FIFO) has been the past practice in the Fairview field, the actual workforce accommodation strategy to be employed for the GLNG Project will be dependent on the ultimate field development plan which emerges. It may be that in some field development scenarios a FIFO arrangement may be less optimal from an operational and community perspective than the use of a locally based workforce or a combination of the two.

The accommodation facilities will be self-contained modular structures, catering for one worker per unit. Each unit will include a private toilet, shower and sink. There will be a mess hall featuring kitchen/cafeteria dining hall and break area. The kitchen will be designed to the relevant standards set out by the *Health Act 1911.* Central recreational facilities will also be provided. Water supply, waste and sewerage treatment facilities will also be provided.

Where required, appropriate approvals and permits will be obtained for the accommodation facilities as part of the pre-construction planning activities (refer Section 6.11).

Figure 3.6.15 shows the layout of the existing accommodation facility at Fairview.

Figure 3.6.15 Fairview Accommodation Facility

3.7 Gas Transmission Pipeline

3.7.1 Location

The proposed gas transmission pipeline corridor is closely aligned with the existing Queensland Gas Pipeline (QGP) for much of its length with the exception of the section north of Injune where the corridor will run up the eastern side of the Arcadia Valley. The pipeline will approach Gladstone from the south-west, entering the Gladstone State Development Area (GSDA) and crossing Port Curtis between Friend Point and Laird Point to Curtis Island. The proposed alignment is shown on Figure 3.4.3. The length of this route is 435 km. There will be no linkages to any existing gas pipelines along the route.

3.7.1.1 Route Selection Criteria

The criteria used to determine the most appropriate route for the gas transmission pipeline were based on the Australian Pipeline Industry Association's *Code of Environmental Practice* (APIA, 2005) and Australian Standard AS2885. The following criteria were used in the selection of the pipeline route:

- Safety:
  - Relevant safety standards; and
  - Assessment of safety risks.

- Engineering:
  - Relevant engineering design, construction and operation standards;
  - Terrain, seismic and geotechnical constraints and hazards;
  - Co-location opportunities with existing infrastructure;
  - Climatic implications; and
  - Access requirements for construction and operation.
- Environmental (including social aspects):
  - Conservation of terrestrial and aquatic flora and fauna;
  - Protection of habitat and ecosystem integrity;
  - Protection of surface and ground water quality;
  - Maintenance of surface stability;
  - Potential for successful rehabilitation;
  - Air and noise pollution;
  - Management of historical and cultural heritage values;
  - Impacts on local residents, traditional owners, existing land uses and infrastructure;
  - Use of existing easements;
  - Zoning requirements; and
  - Protection of landscape values.
- Commercial:
  - Construction and operating costs.

Further details of the route selection process are given in Section 2.2.

3.7.1.2 Co-location Opportunities

As discussed in Section 3.7.1.1 above, one of the pipeline route selection criteria adopted for the project was to maximise opportunities for co-location with existing pipeline easements where practicable so that environmental and landholder impacts can be minimised.

The proposed gas transmission pipeline will be located adjacent to the existing QGP ROW for about 300 km of the corridor from south of Rolleston to Gladstone. This will minimise the area of land disturbed and will reduce the impact on existing land use and infrastructure. However there are sections along the corridor where due to landholder, land use, environmental or topographical constraints the proposed pipeline will by necessity deviate from the QGP ROW.

There are also co-location opportunities within the GSDA near Yarwun where there are a number of existing pipelines servicing local industries in the Materials Transport and Services Corridor Precinct.

However topographical constraints in the area are such that there is limited space available to accommodate the gas transmission pipeline.

Co-locating the gas transmission pipeline adjacent to powerlines or rail lines is constrained by the risk of induced currents being generated in the steel pipeline which could accelerate the rate of corrosion and hence increase the risk of pipe failure, or pose a safety risk to pipeline technicians. For this reason co-location along power or rail easements can only be considered if there are adequate separation distances from the electrical facilities and sufficient design measures are installed to protect the pipeline.

3.7.2 Gas Transmission Pipeline Components

3.7.2.1 Pipe

The gas transmission pipeline will be a buried, high pressure steel pipeline. It will be designed in accordance with the requirements of *AS 2885 Pipelines – Gas and Liquid Petroleum* and constructed in accordance with the Australian Pipeline Industry Association's *Code of Environmental Practice* (APIA, 2005). In accordance with AS 2885 the design considerations included:

- **Risk assessment** – route selection, land use conflict, future development, land stability, flooding etc; and
- **Pipeline design** – material selection, wall thickness, coating requirements, corrosion protection, burial depth, remote monitoring etc.

Preliminary engineering and design features of the pipeline are provided in Table 3.7.1. These may change with detailed design.

Table 3.7.1 Pipeline Engineering and Design Features

Design Element	Preliminary Specification
Length	435 km
Diameter	914 - 1070 mm
Wall Thickness	20 - 28 mm
Factory Coating	3.0 mm trilaminate coating or fusion bonded epoxy
Operational Pressure	6.5 - 15.3 MPa
Maximum Allowable Operating Pressure (MAOP)	15.3 MPag
Design Capacity	630 - 2,100 MMScfd[1]
Standard Construction ROW Width	30 m (narrowed in sensitive areas where practicable)
Corrosion Protection	External coating and impressed current cathodic protection, maintained and operated in accordance with AS2885 Part 3
Non Destructive Testing	100% radiography or ultrasonic inspection of welded joints. Hydrostatic pressure testing of completed pipeline to at least 1.25 times MAOP. This requirement may be relaxed during construction subject to agreement between Santos and the contractor pending receipt of exceptional inspection results.
Buried Marker Tape	Buried marker tape will be placed over the top of the fibre optic cable for the full route length in addition to marker tape for the pipeline at specific locations

[1] million standard cubic feet per day

The pipe joints will be internally lined but the welded joints will be left bare. The internal lining is applied for hydraulics purposes.

The gas transmission pipeline will be buried for its entire length and will be deep enough so that current land use activities will be able to continue after the pipe has been installed. Typical depths of cover are summarised in Table 3.7.2.

Table 3.7.2 Depth of Pipeline Cover

Location	Typical Depth of Cover
Normal Construction	750 mm
High Consequence Location Classes eg. cropping areas	1,200 mm
Road/ Rail Easement	1,500 mm
Crossings: - Water	1,200 - 2,000 mm
Crossings: - Services	Varied depth of cover dependent on depth of the service. Concrete slabs will be installed a minimum of 300 mm above the pipe between the services, with a nominal separation of 600 mm between the pipe and service. The pipeline minimum depth of cover for the construction type of the area shall be maintained.
Rock	Where continuous rock cannot be ripped, the provision of AS 2885.1-2007 Section 5.5.3 shall apply.

The above depths are minimum values and the cover at any location will be influenced by the local land use, watercourse crossing method (open cut or directional drilling), likelihood of external loads, risk of third party damage, and risk of erosion or scouring. In particular the cover at major stream crossings and other directionally drilled locations may be substantially greater than the typical depths given in Table 3.7.2.

3.7.2.2 Above Ground Facilities

Location of Above Ground Facilities

The number and location of above ground facilities has not been fully determined at this stage, but may include the facilities detailed in Table 3.7.3.

Table 3.7.3 Above Ground Facilities

Location[1]	Description of Above Ground Facilities
KP0	Start of Pipeline Launcher Trap Possible metering
KP 0 - 35	Gathering field connections (potentially below ground). Mainline Valve (MLV)
KP 35 - 70	Gathering field connections (potentially below ground). MLV
KP 70 – 110	Scraper Station MLV
KP 110 – 145	MLV
KP 145 – 180	MLV
KP 180 – 220	Scraper Station MLV
KP 220 - 255	MLV
KP 255 – 290	MLV
KP 290 - 330	Scraper Station MLV
KP 330 – 360	MLV
KP 360 – 390	MLV
KP 390 – 410	MLV
KP 410 - 435	MLV Scraper Station End of Pipeline Receiver Trap Isolation Valve Vent / Blowdown piping Typical end of line facilities assumed by LNG facility

[1] See Figure 3.4.3

Mainline Valves

A mainline valve (MLV) is a buried valve with an above-ground bypass valve and blowdown piping. MLVs are used for isolating sections of the pipeline and venting gas to enable maintenance activities or isolation in the event of an incident.

Approximately nine mainline valve stations will be located approximately equidistant along the gas transmission pipeline. They will be located within a fenced compound of approximately 20 m x 50 m. Typical equipment in the compound will be a solar panel with radio tower or satellite dish, and/or a small hut. The valves will be remotely operable with pressure and temperature telemetry and blowdown vent.

Further design work will determine where the mainline valve stations are required and the equipment needed at each location.

Scraper Stations

Scraper stations (also referred to as launcher and receiver stations) are used for inserting and removing in-line cleaning and inspection tools to enable cleaning, maintenance and ensuring pipeline integrity. Approximately four scraper stations will be required, which will necessitate additional land outside the ROW. The scraper stations could potentially be 80 m x 100 m in size. Equipment may include but not be limited to:

- Pipeline pig receiver;
- Pipeline pig launcher;
- Pipeline blowdown vent/flare;
- Isolation valves;
- Bypass facilities; and
- Control facilities.

Gas Receival Stations and Metering

A gas receival station will be constructed at the LNG facility on Curtis Island where the gas will leave the gas transmission pipeline. The gas receival station will consist of a station limit valve, scraper receiver, gas filters and flow control equipment together with metering.

The station will consist of the following major process equipment: filtration, water bath heating, pressure regulation and custody transfer metering. Pressure regulators will maintain a consistent delivery pressure to the LNG facility whilst heating will be used to overcome cooling effects from large pressure reductions.

Warning Signs

Pipeline warning signs will be provided in accordance with AS 2885. As a minimum, they will be located at the following locations:

- Both sides of public roads;
- Both sides of railways;
- Each property boundary (at internal fence lines as appropriate);
- Both sides of rivers;
- Vehicle tracks that are expected to be frequently used;
- Each change of direction;
- Utility crossings (buried or above ground);
- The landfall of submerged crossings or subsea pipelines, and will be visible from a distance of at least 100 m on the water side of the landfall; and
- On the fences of all above ground pipeline facilities.

Signs will be placed so that at least one will be visible at any location along the corridor, with a maximum allowable spacing of 500 m for rural areas and considerably closer for areas with higher population densities or increased activity. The signs will be either offset from the centreline or directly over the gas transmission pipeline (see Figure 3.7.4).

Where spaced to achieve adequate visibility or due to the 500 m maximum spacing, sign locations will be determined on site at time of construction.

Aerial pipeline markers will be installed along the pipelines and denote the chainage in kilometres from the start point. Aerial markers will be at 10 km intervals.

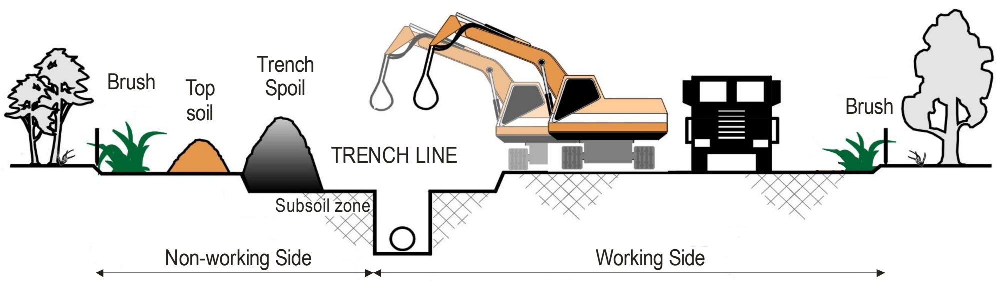
3.7.3 Construction

3.7.3.1 Construction Activities

A summary of the typical construction procedures and activities is provided below.

- Survey of the gas transmission pipeline route.
- **Provision of access tracks and temporary facilities**. Existing roads will be utilised as far as practicable to minimise disturbance to the surrounding areas. Access tracks will be positioned and constructed in consultation with landholders.
- **Clear and grade the ROW.** The gas transmission pipeline route will be marked, vegetation and other obstacles removed from the ROW, topsoil will be stripped stockpiled at the edge of the ROW. Temporary fencing and gates will also be installed to allow easy access between properties.
- **Pipe delivery.** Lengths of pipe are transported from Gladstone to specially constructed laydown locations at strategic points along the pipeline route.
- **Pipe stringing and bending.** The pipe will be laid out in preparation for welding and pipes bent as required by route and terrain.
- **Pipe welding.** The pipe will be welded into long lengths, typically up to 1000 m, called pipe strings.
- **Tie-ins.** The individual pipe strings will be welded together to form a continuous pipeline. Tie-ins will be carried out either above ground or 'in-the-trench'.
- **Trenching.** A pipeline trench will be excavated, with the subsoil stockpiled adjacent to the trench.
- **Pipe placement in the trench (lowering in and laying).** The trench spoil, where suitable, will be used as bedding and backfill for the pipeline. The pipe will then be lowered into the trench using side boom tractors and the trench backfilled and compacted. In addition, marker tape will be laid in the trench at designated areas.
- **Fibre optic cable (FOC).** Duct for a FOC to be used for communications along the pipeline will most probably be installed in the pipeline trench during the backfilling operation. Marker tape will be placed over the top of the duct. The actual FOC will be 'blown' through the duct at a later stage.
- **Hydrotesting.** The gas transmission pipeline will be cleaned and gauged prior to being hydrostatically tested for strength and leaks.
- **Rehabilitation.** Once construction is complete, rehabilitation will involve removal of construction material, surface re-contouring, fence repair/replacement, respreading of topsoil and vegetation and seeding/revegetation.

A conceptual cross section of a typical gas transmission pipeline construction operation is given in Figure 3.7.1.



Source: RLMS, 2007

Figure 3.7.1 Gas Transmission Pipeline Construction

Construction crews will advance at a typical rate of approximately 1 km per day but this can vary from 200 m to 3,000 m depending on terrain and weather. Construction crews will work 10 hours per day, 7 days per week, on rotation.

3.7.3.2 Construction Depots and Temporary Facilities

The locations of construction depots will be selected by the contractor prior to the commencement of construction activities. The sites may be co-located with construction workers accommodation facilities and will be relocated as the pipeline construction progresses. The construction contractor will select the number and location of depots. Due to the length of the gas transmission pipeline, it is likely that between six and ten will be required.

The construction depot will be primarily used for equipment storage, vehicle laydown, site office and administration facilities, and meeting points for crews prior to commencing work on the ROW.

Equipment stored at a construction depot may include:

- Construction equipment;
- Maintenance equipment; and
- Line pipe.

The location of the construction depots and temporary facilities will be based on logistical requirements, constraints of the pipeline route, environmental constraints, and outcomes of consultation with the relevant landholders and local authorities. Considerations will include ensuring that facilities are located as close to the ROW as possible as well as at a suitable distance from watercourses so they are not in threat of flood, and that locations do not require clearing of sensitive vegetation and can be managed in such a way as to ensure no long term land contamination issues. Brownfield sites will be preferred for depots and temporary facilities. All facilities will normally be located less than a one hour drive from the active construction site although this can vary according to conditions. Once this driving time increases beyond an hour, the construction depot and temporary facilities will be moved.

A pipeline licence will be sought under the *Petroleum and Gas (Production and Safety) Act 2004* to authorise the construction, operation and decommissioning of the pipeline and other incidental activities (refer Section 7.11).

3.7.3.3 Access

Equipment and personnel require regular access to the ROW and work sites during construction. Access will generally be via existing roads and tracks as well as the ROW. The gas transmission pipeline corridor has a network of existing public roads and farm or forestry tracks which may reduce the amount of disturbance required. Existing access roads and tracks will be used wherever practicable and all project-related movements will be restricted to existing public roads, approved access tracks and the ROW.

Access track design and planning will include consultation with relevant landholders and regulatory authorities to determine the exact location of the access, and if the access points are to be permanent or temporary. New access tracks will avoid environmentally sensitive areas and will be sited to minimise disturbance to landholders. All temporary access tracks will be rehabilitated in accordance with the statutory approvals and landholder requirements.

Existing fences transecting the ROW will be severed and replaced with temporary construction gates for the duration of construction activities, then reinstated. Upon completion, fences and gates may be left if requested by the landholder.

3.7.3.4 Clear and Grade

Graders and bulldozers will be used to clear vegetation and topsoil from the ROW ready for construction to commence. Vegetation and topsoil will be stockpiled separately on the ROW. Topsoil will typically be graded to a depth of 150 mm (unless otherwise agreed) over the full width of the ROW. Refer to Section 7.4 for details of vegetation clearing, its management and its use in rehabilitation and soil stabilisation.

The ROW width of 30 m allows the gas transmission pipeline to be constructed safely, pipeline traffic and impacts to be restricted to the ROW, and to provide adequate area to store topsoil. The easement will be narrowed in some areas where necessary (e.g. to minimise impacts on sensitive vegetation). The feasibility of narrowing the ROW is dependent on site-specific conditions, such as slope, soil type, sensitive ecosystems, construction requirements, presence of alternative access past the site, and safety considerations. In some areas extra workspace may be required in addition to the 30 m easement (e.g. for truck turnarounds or to accommodate spoil and vegetation stockpiles adjacent to constrained workspaces such as watercourse crossings).

Figure 3.7.2 shows a cleared ROW prior to the installation of the pipeline for the existing Santos pipeline from Comet Ridge to Wallumbilla.

Figure 3.7.2 Cleared Pipeline ROW

3.7.3.5 Trenching

After the ROW is cleared and the pipe is welded, a trench will be dug for the pipeline either by a trenching machine or excavator in accordance with the design burial depth. The required depths will be determined by the AS2885.1 risk assessment process and recorded on construction alignment sheets. Trench distances covered each day can vary from 200 m – 3,000 m or more dependent on terrain type, equipment and weather conditions.

The trench will be left open for as short a time and distance as possible. The trench will have ramps and other controls to allow fauna that accidentally fall into the trench to escape. Regular inspections of the trench will be conducted.

Trench spoil will be stockpiled on the ROW, usually on the non-working side. Trench spoil will be stockpiled separately to topsoil.

3.7.3.6 Blasting

There may be sections along the gas transmission pipeline's alignment where the presence of rock prevents the use of a trenching machine or excavator. In these areas controlled blasting may be required. Should this be necessary a detailed blasting plan will be prepared which will specify the proposed method of blasting, safety measures, drill pattern, charges, explosives, detonation methods and debris control. All blasting activities will be undertaken by appropriately qualified personnel in accordance with the requirements of the relevant legislation and standards. Before any blasting occurs, notice will be given to all construction crews, local landholders and other relevant parties.

3.7.3.7 Stringing and Bending

Steel pipe will be trucked to the construction site in approximately 12 m - 18 m lengths, which will be laid end-to-end along the ROW. The pipes will be placed on sandbags and raised on blocks of wood (timber skids) to protect the pipe from rolling sideways.

Where required, pipe lengths will be bent to match changes either in elevation or direction of the route. Pipes will not be strung on steep slopes without the necessary precautionary measures being implemented.

Radioactive isotopes may be used for the inspection of all pipeline welds in the following manner:

- The use of radioactive isotopes is a normal activity for cross-country pipelines and is used world-wide;
- Approximately 37,000 welds could be subject to X-ray inspection;
- The upstream and downstream facilities will also use X-ray inspection for many of their welds;
- The pipeline contractor will be licensed to handle, store and use the isotopes;
- Only qualified personnel will handle / use the isotopes;
- The isotopes will be stored in specially constructed and secure containers, strategically located along the pipeline route;
- The isotopes will deplete with use and time and when depleted will be disposed of in a correct manner by the contractor;
- All non-specialist personnel will be kept a safe distance from the isotopes at all times, particularly during usage; and
- The isotopes will be transported in secure containers that are designed to protect the general public and construction personnel from any radioactive exposure.

3.7.3.8 Welding, Radiography and Joint Coating

Pipes will be welded together in lengths of up to approximately 1000 m. Each weld will be inspected using x-ray or ultrasonic equipment as per AS 2885.2. This requirement may be relaxed during construction subject to agreement between Santos and the pipeline contractor pending receipt of exceptional inspection results. The area around the weld will be cleaned and then coated with a protective coating to prevent corrosion.

The isotopes will be transported in secure containers that are designed to protect the general public and construction personnel from any radioactive exposure.

3.7.3.9 Lowering-in and Backfill

Side booms (bulldozers with cranes) or excavators will be used to lower the welded pipe into the trench. A final coating integrity inspection will be performed as the pipeline is lowered into the trench. Where required, padding machines will be used to sift the excavated subsoil to remove coarse materials. This will be required to protect the pipe coating from coarse material during backfilling. The remaining fine material will be used to pad beneath and on top of the buried pipe. In some instances (e.g. where very rocky soils are encountered) imported sand or foam pillows may be used for padding. Imported padding may be sourced from local borrow pits with the appropriate approvals and the padding source inspected to ensure it is free of weed infestations. Figure 3.7.3 shows the lowering-in operation for an existing pipeline.

Duct for a fibre optic cable (FOC) to be used for communications along the pipeline will most probably be installed in the pipeline trench during the backfilling operation. Marker tape will be placed over the top of the duct. The actual FOC will be 'blown' through the duct at a later stage.

Trench spoil will be returned to the trench and compacted to minimise the likelihood of ground subsidence over the pipe. The length of trench open at any one time will be kept to a minimum. Santos will liaise with landholders to avoid stock access to the open trenches. Wildlife escape ramps will also be installed.

There may be a limited need for specialist backfill material or sand and gravel for construction materials. As this need arises local commercial quarry operations will be sought. The nature and extent of the materials required will be determined during the details design phase.

The ROW will be cleared and levelled and the pre-existing site drainage reinstated. The ROW will then be rehabilitated as discussed in Section 3.7.3.17. A typical ROW at completion of pipe laying is shown on Figure 3.7.4.

Figure 3.7.3 Lowering-in of Pipeline

Figure 3.7.4 Reinstated ROW

3.7.3.10 Pressure Testing

Pipeline integrity will be verified using hydrostatic testing in accordance with AS 2885.5. During hydrostatic testing, the pipeline will be capped with test manifolds, filled with water and pressurised to at least 1.25 times the maximum allowable operating pressure. A 24-hour leak test will then follow. Details on water sources and management are provided in Section 3.7.3.12.

Hydrotest water may be treated prior to testing with chemicals such as biocide, oxygen scavengers and corrosion inhibitors (depending on factors such as the quality of test water and the length of pipe tested).

3.7.3.11 Waste Management

Pipeline construction generates little waste, and usually includes pipe offcuts and timber skids, which are generally recycled. All waste materials will be removed from the work areas and disposed of at appropriately licensed facilities. Further details are provided in Section 5.3.2.

3.7.3.12 Water Supply and Management

It is anticipated that the key water uses during the pipeline's construction phase will be for:

- Construction activities such as dust suppression and soil compaction;
- Vehicle and plant wash down to prevent the spread of weeds;
- Assistance with horizontal directional drilling (HDD), as a component of drilling fluid, and the production of concrete;
- Hydrotesting of the pipelines; and
- Domestic uses at worker accommodation facilities.

The workers accommodation facilities, construction depots, and offices will require potable and non-potable water for domestic use during construction. It is estimated that the combined usage of domestic water during construction will be approximately 400 L/person/day.

During the commissioning phase, it is anticipated that large volumes of water will be required to undertake the pressure and leak tests (approximately 30 ML). Minimal water demands are anticipated during the operational phase, with limited personnel along the pipeline alignment.

Local water sources have been suggested for the hydrostatic testing to be undertaken during the commissioning phase, however due to the ephemeral nature of many of the watercourses within the region, it is assumed that local sources such as rivers will not be used.

It is proposed that hydrotest water used to pressure test the pipeline will be associated water from the CSG fields. It will be used to test short sections of the pipeline (5 - 50 km) at a time depending on differences in elevation. Upon completion of one section, the water will where possible be recycled and used for the next section. Otherwise the hydrotest water will be disposed of at appropriate locations in accordance with the relevant environmental authority conditions. Further details are provided in Section 7.5.

It is proposed that due to the limited local water supplies, other water demands for construction and operation will be imported to the site from local municipal supplies located along the length of the gas transmission pipeline.

If potable water services are not available, it will either be trucked to the site or raw water will be sourced locally and treated on site. Non-potable and raw water will be sourced from local surface water sources and bores under permit. Santos will ensure that all necessary permits are obtained.

3.7.3.13 Energy

Supply of power for the pipeline's construction as well as for the workers accommodation facilities will be from mobile diesel-fuelled generators. The anticipated power requirements are between approximately 650 to 800 kVA. The exact location and scale of the units will be determined during the detailed design phase of the project. All relevant approvals or permits will be sought as necessary.

3.7.3.14 Stormwater

Each worker accommodation facility will include a stormwater drainage system. These systems will be designed to collect runoff to prevent ponding or flooding. Stormwater runoff will be discharged at non-erosive velocities to the natural drainage system. Further discussion on stormwater management is given in Section 7.5.

3.7.3.15 Sewerage

It is anticipated that package sewage treatment facilities will be installed at the workforce accommodation facilities and the relevant approvals will be obtained by Santos in conjunction with the facilities' development approvals. Treated effluent will generally be disposed of by irrigation.

Where sewage effluent absorption beds and/or irrigation fields are used, they will be located and designed to ensure that:

- Sensitive areas are avoided;
- Soil erosion and soil structure damage is avoided;
- There is no surface ponding or runoff of effluent; and
- The quality of groundwater is not adversely affected.

Areas where treated sewage effluent is discharged to absorption beds or irrigation fields will be fenced and clearly marked with warning notices of the purpose of the area and not to use or drink the effluent.

Effluent treatment systems will be designed to include alternate measures for effluent storage and/or disposal, where conditions prevent the absorption of treated effluent to land (e.g. rain events). This may include wet weather storage or disposal off site. There will be no discharge of treated effluent from wet weather storage to any waters.

Further discussion on sewage treatment is given in Section 7.5.

3.7.3.16 Telecommunications

It is currently anticipated that that a FOC will be installed in the same trench as the gas transmission pipeline for its entire length, providing communications for the pipeline's supervisory control and data acquisition system.

Alternative communication systems for the gas transmission pipeline may include radio, satellite or phone networks, which could possibly require additional infrastructure installation given the remote location of the route and stations. This may include receivers and transmitters.

During operation, pipeline operators will utilise mobile phones, satellite phones or radio for voice communications.

3.7.3.17 Restoration and Rehabilitation

Restoration and rehabilitation of the ROW will be in accordance with the relevant project approvals.

As soon as practical after pipe laying and backfill, the easement will be cleared of all construction equipment and debris and re-contoured to match the surrounding landform and drainage patterns with erosion controls constructed where necessary. The separately stockpiled topsoil will then be respread evenly across the ROW and in accordance with any statutory and landholder requirements, any cleared vegetation may be placed across the easement to assist in soil retention and provision of seed stock. The respreading of topsoil and vegetation assist in stabilising the ground and in re-establishing vegetation growth.

To promote vegetation growth and to protect against erosion, the ROW surface will normally be lightly scarified prior to the respreading of topsoil. Reseeding or revegetation, using appropriate species (i.e. crops/pasture or indigenous native species) and in the appropriate season, may be undertaken to restore vegetation cover in consultation with the landholder and in accordance with any regulatory approvals for rehabilitation.

Figure 3.7.5 shows a rehabilitated pipeline ROW at the Roma CSG field.

Figure 3.7.5 Pipeline Rehabilitation at Roma CSG Field

3.7.3.18 Road Crossings

Road crossing construction methods are selected based on the road formation type. Crossing design and construction methods will vary according to the size and quantity of vehicles that use the road. The types of road crossing methods to be considered are summarised below, along with the relevant road types:

- **Open cut:** unformed and formed tracks, gravel roads and some bitumen roads;
- **Bored (cased or uncased):** some major highways and some bitumen roads; and
- **HDD (cased or uncased):** some major highways.

A list of major roads to be crossed by the gas transmission pipeline is given in Section 7.11.4.

3.7.3.19 Railway Crossings

Railway crossings will be either bored or directional drilled crossings. Unless requirements are otherwise agreed with Queensland Rail, rail crossings will be installed as follows:

- Minimum 2,000 mm cover to the top of track;
- Minimum 1,200 mm cover to the bottom of the table drain;
- Heavy wall pipe between the boundaries of the rail reserve;
- Pipeline warning signs on both sides of the rail reserve;
- Concrete slabs under any table drains, unless the depth of cover under the drain is greater than 2 m;
- Crossing at nominally 90 degrees unless otherwise specifically approved; and
- Casing pipe, if specified.

Prior to details being finalised, agreement will be sought from Queensland Rail (QR) with respect to crossing locations, design details, timing and safety considerations.

A list of railways to be crossed by the gas transmission pipeline is given in Section 7.11.4.

3.7.3.20 Watercourse Crossings

The initial crossing points for watercourses will be selected on the basis of the following criteria:

- Minimise the extent of clearing of riparian vegetation;
- Avoid permanent and semi-permanent waterholes;
- Avoid unstable and/or steep, incised banks; and
- Avoid bends in the channel and confluences with other channels.

The method for watercourse crossings will be confirmed during the detailed design phase of the project and will be based on further investigations and information which will include (but not be limited to):

- Watercourse width, depth and flow;
- Environmental sensitivity of the crossing;
- Downstream water values;
- Riverbank, geotechnical and stability concerns;
- Riverbed substrate composition;
- Hydrological data; and
- Economic concerns.

For all crossings the actual water flow in the watercourse will not be stopped or interrupted due to the crossing construction activities. Techniques such as flume pipes and/or diversions will be used to suit local conditions. Flume pipe crossings, for example, will also enable construction traffic to cross the watercourse uninterrupted and without adversely affecting water quality or flow.

Upon confirmation of the crossing method, detailed crossing plans will be developed and submitted to the relevant regulatory agencies as part of the permitting process.

The following construction methods will be evaluated where water crossings are encountered along the pipeline route.

Open Trench

The majority of watercourse crossings are expected to be constructed using standard open trenching construction. This technique is most suited to the dry or low flow conditions which will be preferred for the construction phase.

The trenching method will involve establishing a stable working platform either side of the watercourse to enable excavators to create the trench. The trench will not be completed through the banks until immediately prior to pipe installation. Tie-in points will be located on high ground well away from the banks.

Watercourse bed and bank material and trench spoil will be stockpiled separately, away from banks to reduce the likelihood of sedimentation from surface runoff. Pipe string welding and concrete coating will occur prior to placement in the trench.

The pipe will be concrete-coated at major crossings and areas of significant inundation for stability and/or protection requirements (as identified by risk assessment in compliance with AS2885.1) to protect the external coating and to prevent the pipe “floating” once in place. Minor crossings such as creeks and streams will not normally warrant or need concrete coated pipe.

To minimise the period of construction and subsequent environmental disturbance, it is proposed to complete watercourse crossings within the shortest period practicable.

Figure 3.7.6 shows creek rehabilitation at the Scotia CSG field complete with contour banks installed to divert water from pipeline route and minimise erosion.

Figure 3.7.6 Creek Rehabilitation at Scotia CSG Field

Open Trench with Flow Diversion

Flow diversion is a modification to the standard trenching method employed where higher water volumes and flows are present (typically up to 1,000 litres per second). Flow diversion techniques may include:

- Diverting the flow through a pipe to prevent siltation problems that may be created during trenching, lowering in and backfilling. This technique is not suitable for watercourses with broad channels, low gradients or permeable substrates.
- Pumping of water around the work area. This is appropriate for low gradient streams, with discharges less than 1,000 litres per second during construction. Barrier dykes or head walls are constructed above and below the trenched area and the work area pumped dry.
- Controlling water running into the creek from the surrounding catchment by contour banks to protect the creek banks from erosion.

Horizontal Directional Drilling

HDD is generally used to cross major watercourses where standard open cut methods are not feasible. HDD can also be used for infrastructure crossings as an alternative to boring. The feasibility of using HDD is limited by site conditions such as soil stability, slope, access, available workspace and the nature of subsurface strata. Detailed route survey and geotechnical investigations will be undertaken prior to all HDD operations.

HDD crossing are currently planned for the crossings of the Dawson and Calliope Rivers as well as possibly the Arcadia Valley escarpment.

The installation of the gas transmission pipeline by HDD will involve drilling a hole at a shallow angle beneath the surface through which the pipe will be threaded. Drilling will be conducted by a specially designed drill rig, operated by a specialist contractor. A variety of associated equipment and infrastructure will be required.

Although HDD may reduce above ground impacts, the technique introduces additional environmental considerations such as drill site sediment control, waste management, noise and increased duration of construction and workforce numbers. A site-specific management procedure will be prepared during later engineering studies and prior to drilling to address these issues.

Port Curtis Crossing

The gas transmission pipeline will cross Port Curtis between Friend Point and Laird Point. The preferred design for the crossing is for the gas transmission pipeline to be laid in a trench below the sea bed and backfilled with rock for protection, as indicated in the Figure 3.7.7 below.

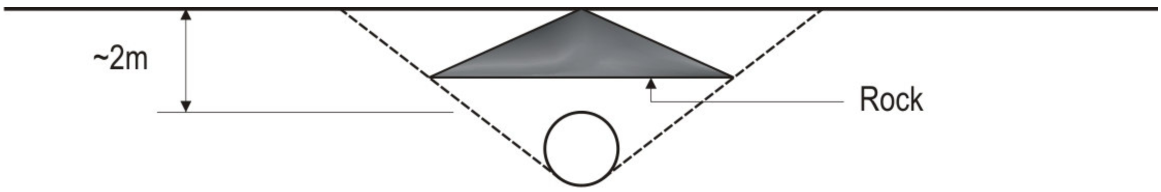


Figure 3.7.7 Gas Transmission Pipeline Trench

A trench will be dug to a depth of approximately 3 m with the excavated material loaded onto a barge for transfer to the proposed dredge material placement facility at Laird Point. Construction techniques to install the pipeline may include the following, however the final design will not be made until the FEED stage:

- **Lay barge** – progressively constructing / laying the pipeline; or
- **Floatation** – fabrication of the pipe string onshore and floating it to the crossing location before sinking it into position.

The layer of rocks placed over the top of the pipe will act:

- As additional buoyancy protection;
- As mechanical protection from vessels (e.g. anchors, hulls); and
- To limit scouring due to tidal flows.

The design of the Port Curtis crossing will include an allowance for the planned/possible installation of other similar pipelines in the immediate vicinity so that the integrity of the GLNG pipeline is not jeopardised by these other pipelines. The sizes and other details of these pipelines are currently unknown.

3.7.3.21 Infrastructure

The locations of the various types of infrastructure (e.g. roads, powerlines, railways, other pipelines) to be intersected by the construction of the gas transmission pipeline corridor are summarised in Section 7.11.

Discussions with the owners/custodians of the potentially affected infrastructure will be held to make arrangements for the construction of the gas transmission pipeline and the management of the existing infrastructure.

3.7.3.22 Materials and Equipment

The construction will most likely be executed by a main construction crew with one or two smaller crews completing the more difficult sections. Typical equipment to be used for the construction of the pipeline is outlined in Table 3.7.4.

Table 3.7.4 Gas Transmission Pipeline Construction Equipment

Equipment	
Wacker Packer Rammer	Low Loader Prime Mover
Dozer	Tanker
Blast Pot	Welding machine
Grader	2WD truck
Wheel Loader	Cruiser Tray Back
Excavator	Toyota Land Cruiser Wagon
Drill and Blast Rig	Flatbed Truck
Hydraulic Breaker from Excavator	Fitters Truck
Backhoe Loader	Tipper
Hydro Test Equipment	Tanker
Bending Machine	Challenger
Lined Bending Set	Truck HDD
Trencher	Tractor HDD
Holiday Detector	Bus Bare Hire 17 Seat
Vacuum Lift for Excavator	Fuel Truck
Roller Craddles	4 x 4 Truck
Padder	Cruiser Tray Back Camp based
Compressor	Land Cruiser Wagon Camp based
Side booms	Tipper Trucks
Generators	Facing Machines
Pumps	Rollers
Winches	Field Joint Coating Spread
Auger Bore Spread	Fitters Truck Camp based

Typical materials for construction include:

- Line pipe;
- Consumables (i.e. welding rods, grinding discs, etc);
- Field joint coating materials;
- Sand bags;
- Explosives (possibly);
- Slag/garnet for sand blasting;
- Marker posts; and
- Fuels and lubricants.

Materials will be stored as required at the construction depots, with the temporary facilities that follow the crews or at approved stockpile locations. All materials will be stored as per the applicable legislation and Australian standards. Slag will be contained either in canisters or bulk bags, any explosives required will be in dedicated magazines, consumables will be in site huts, diesel fuel will be in bunded steel tanks, and the remaining materials will be stored in compounds or stockpiles as required.

3.7.3.23 Transport

The major transport issue associated with the construction of the pipeline is the transport of pipe to the construction ROW (Section 4).

It is presently anticipated that pipes will be transported to Gladstone by sea from overseas sources. The final transport option will be determined in the detailed design phase of the project and will be dependent on the location of the pipeline supplier.

Once the gas transmission pipeline contractor has been appointed and details of the pipeline delivery and accommodation facility locations determined, a road use management plan will be prepared for the pipeline's construction. This plan will address all relevant issues including the standard of the roads proposed to be used, traffic volumes, access conditions, hours of operation, safety provisions, traffic impacts, dust control etc. This plan will be developed in consultation with the Department of Main Roads (DMR), relevant local authorities and landholders as appropriate. Operational traffic will be minimal.

As discussed in Section 2.2, the following two options (truck and rail) are being considered for the delivery of pipe from Gladstone to the pipeline ROW. As a decision as to which option will be used will not be made until the FEED, the traffic and noise impacts of each option have been assessed (see Sections 4 and 7.10 respectively):

- For the truck delivery option, trucks will be used to transport the pipe from Auckland Point to one of six or more laydown areas spaced roughly equidistant along the pipeline route. The laydown areas (approximately 5 ha) will consist of a hardstand area for pipe storage and associated facilities. Pipes will then be reloaded onto trucks for delivery to the pipeline construction areas. Delivery will be at an approximate rate of 65 - 70 truck loads per day (i.e. up to 140 truck movements per day). This will last for approximately six months. The primary delivery route will be along the Dawson Highway.
- For the rail delivery option, pipe will be loaded onto a train at Auckland Point and railed to one of three laydown areas along the pipeline route. One laydown area will be located at Moura and the other two at intermediate locations between Gladstone and Moura. A rail siding will be constructed at each laydown area and a hardstand and associated facilities developed for the unloading of pipe off the trains and loading it onto trucks for delivery to the pipeline construction areas. Delivery will be at a rate of approximately one train per day for approximately six months (i.e. two train movements per day). Each train will consist of approximately 67 cars. Laydown areas beyond Moura are likely to be the same as for the truck delivery option, i.e. 4 - 5 sites each of 5 ha.

State-Controlled Roads

It is currently proposed that pipe will be delivered from Gladstone to the construction site by truck along State-controlled roads. Trucks used for pipeline delivery will most likely be extendable semi-trailers and the pipes are likely to be transported in lengths of approximately 12 - 18 m.

Pipes will be transported directly to the ROW. Pipes will likely be transported to Gladstone by sea, and trucked by road to strategically placed stockpiles along the ROW or directly to the construction area for stringing.

Other heavy vehicle movement associated with the pipeline's construction will include transport of construction equipment to the ROW and mobilisation and demobilisation of the workers' accommodation facilities. Additional traffic on state-controlled roads will include the daily travel of the construction workforce to the construction location. The workforce will most likely travel in a combination of four-wheel drives and minibuses.

Refer to Section 4 for an assessment of the impact of pipe transportation on the road network.

Local Government-Controlled Roads and Private Tracks

Where practicable, construction traffic will access the ROW by existing local roads and private tracks. Prior to construction, an inspection of the access roads will be made in consultation with the relevant local authority to determine the state of the road, whether any upgrade is required, and to record the pre-construction condition of the road (e.g. written record, photographs). Santos will work with the relevant local authorities to agree the reinstatement condition necessary for each road. Santos will also work with landholders to develop agreements for any upgrade or reinstatement of private access tracks.

Truck movements on the ROW and on private tracks will take place in daylight hours as far as practical. Transport to and from the ROW will utilise local roads as far as possible, to minimise access via private tracks or extensive travel along the ROW.

Refer to Section 4 for an assessment of the impact of pipe transportation on the road network.

3.7.3.24 Weed Management

Santos is committed to reducing the risk of spreading weeds along the gas transmission pipeline corridor during its installation and operation. As part of this commitment, Santos will work with the local community, landholders and relevant state government agencies to provide an integrated weed management approach.

During field investigations a weed survey will be undertaken to identify all declared and environmental weeds along the ROW so that management strategies can be developed. Also, wash-down facilities (both permanent and temporary) will be installed to assist in weed control measures as required.

Further details of the proposed weed management strategy are given in Section 7.4.

3.7.3.25 Construction Workforce and Accommodation

A construction workforce of up to approximately 1,000 is anticipated during the construction of the gas transmission pipeline. They are expected to work 10 hours per day, 7 days per week with no night-time construction activity. Crews will typically work for four weeks followed by one week off on a rostered system. Section 7.14 details the anticipated occupational groups, recruitment polices and workforce numbers.

Due to the mainly rural nature of the region and the limited number of townships along the proposed gas transmission pipeline route, existing accommodation is not readily available. Hence dedicated workers' accommodation facilities will be required.

It is estimated that the pipeline construction will last approximately 21 months (start Q2 2011 and end Q1 2013). The first three months will involve mainly clear and grade activities, mobilisation and construction ramp-up. The main construction activities will take approximately 15 months with the last 3 months involving construction ramp-down, rehabilitation and commissioning. During the ramp-up and ramp-down periods the workforce will be approximately 500 but will increase to 1,000 during the main 15 month construction period.

The workforce will be accommodated in a series of main and satellite accommodation facilities. It is currently anticipated that there could be three main accommodation facilities located roughly equidistant along the pipeline but the final number will be confirmed during FEED. Facilities 1 and 2 will operate for half of the time and then facilities 2 and 3 will operate for the other half. There will be up to 500 workers accommodated in the two main accommodation facilities. In addition, two or more smaller satellite accommodation facilities will be located between the main facilities. They will operate one at a time and will accommodate up to 100 workers (note: the accommodation facilities will rarely be at full capacity, which allows workers to move between accommodation facilities as required during the project).

An additional 100-person accommodation facility will be provided near Friend Point for the pipeline crossing from Friend Point to Laird Point.

The exact locations of the accommodation facilities will be determined during the detailed construction planning phase. It is possible that an accommodation facility may be located on Curtis Island during construction of this section of the pipeline. Site selection criteria to be used in selecting the locations are discussed in Section 2.2. Santos will work closely with relevant government authorities in regard to this issue. It is expected that the accommodation facilities will be located within the pipeline licence area.

Key components of the workers accommodation facilities will include:

- Air conditioned demountable style accommodation units;
- Ablution units;
- Dining and cook houses;
- Offices;
- Cold room;
- Medical facilities;
- Recreational facilities;
- Laundromat;
- Generators;
- Sewage treatment plants;
- Fuel storage area;
- Waste collection facilities;
- Vehicle / equipment wash down facility;
- Car parks;
- Level earthwork pads; and
- Fencing and access roads.

Pets will be banned from all accommodation facilities and construction areas. Food wastes will be kept covered and then transported to the nearest local authority landfill for disposal.

Potable water for accommodation requirements will be sourced from local potable water supplies. All necessary permits will be sought from the relevant authority for the supply of water.

Sewage wastes will be treated in a mobile package sewage treatment plants. Treated plant effluent will be disposed of by irrigation in accordance with the relevant authority requirements.

3.7.4 Operations

3.7.4.1 Operational Activities

The operation of the proposed gas transmission pipeline will be in accordance with the relevant statutory approvals, Santos' Environment, Health and Safety Management System (EHSMS), AS 2885, and the Australian Pipeline Industry Association (APIA) *Code of Environmental Practice*.

The gas transmission pipeline will likely be operated from the LNG facility. Pipeline systems will be designed to operate with a minimum of operator attention using programmable logic control devices for system sequencing, alarm monitoring and control.

A routine operation and maintenance program will be implemented, which will include leak detection and external coating surveys, ground and/or aerial patrols, repair or replacement of faulty/damaged components, internal cleaning of the pipeline, corrosion monitoring and remediation, and easement and lease area maintenance. Aerial and/or ground inspections will include checking for encroachment activities close to the pipeline easement, discolouration of vegetation which can be an indicator of a gas leak, detection of erosion, monitoring of rehabilitation success and detection of weed species.

Monitoring of the cathodic protection system will be undertaken on a regular basis. The frequency of monitoring will be determined during the development of the detailed operating procedures.

Continued access to the ROW will be necessary for inspections and to follow-up issues identified from inspections. Low level remediation for erosion, subsidence and weeds is likely to be necessary, particularly during the first 12 months following construction.

More significant maintenance activities, such as dig-ups to address coating defects, are less likely to be required. Dig-ups involve the excavation of material from around the gas transmission pipeline (typically referred to as a bellhole) to allow sufficient room for personnel to safely undertake any remedial works that may be required. The excavation of material will be undertaken in accordance with management conditions for construction (that is, topsoil will be stockpiled separately from trench spoil, and the site will be restored as soon as practical following completion of maintenance works).

Prior to commencing extensive work, or where numerous sites are involved, operations personnel will consult with regulatory authorities as appropriate.

Regular consultation will be maintained with landholders whose properties are traversed by the gas transmission pipeline and a “dial-before-you-dig” system for excavation and locations initiated.

3.7.4.2 Operational Workforce

There will be 15 - 20 personnel required for operational and routine maintenance/surveillance activities. This will consist of 6 - 8 field-based maintenance and surveillance personnel, 4 panel operators, and the remainder being supervisors, engineers and managers. Most personnel will be located in Gladstone although there may be up to six located in towns along the gas transmission pipeline route.

3.7.5 Decommissioning

The gas transmission pipeline has a design life of 40 years. At project closure, it will be decommissioned or reused in consultation with regulatory authorities and other potential users.

In the event that the pipeline is no longer required, it will be decommissioned in accordance with the relevant statutory approvals, the legislative requirements of the day, AS2885 and the APIA Code of Environmental Practice (APIA, 2005). The most likely options are:

- **Mothballing** – this will involve depressurising the pipeline, capping and filling with an inert gas such as nitrogen and maintaining the cathodic protection system to prevent the pipe corroding.
- **Abandonment** – this could involve disconnecting the gas transmission pipeline from all above ground structures including the cathodic protection systems, purging the pipe of gas or other materials, placing plugs at predetermined intervals to inhibit groundwater flow, and removing all above ground facilities. The pipeline will then be abandoned to corrode in-situ. The pipeline may be filled with a stable material (e.g. concrete grout) at critical locations such as where it passes under a railway line or major highway to prevent subsidence.

3.8 LNG Facility

3.8.1 Location

The LNG facility will be located at the Hamilton Point West site adjacent to China Bay on Curtis Island. The location of the proposed site was selected based on a number of criteria including shipping access, geotechnical suitability, environmental suitability and proximity to infrastructure. The site’s location is shown on Figure 3.4.6. The overall size of the site is approximately 190 ha. The initial 3 - 4 Mtpa facility (Train 1) will have a footprint of about 40 ha increasing to 100 ha for the 10 Mtpa facility (Trains 1-3).

3.8.2 Construction

3.8.2.1 Site Access

The LNG facility on Curtis Island is intended to be accessed either by construction of a road and bridge from the mainland or by barge/ferry. Should it be built, the bridge will cross Port Curtis between Friend Point and Laird Point, and the access road will travel south to the eastern boundary of the LNG facility site. The bridge location and the route of the access road are shown on Figure 3.4.5.

If the bridge is built, it is not expected to be available until at least after the completion of the construction of Train 1. Hence during this period, construction material, equipment and personnel will be transferred from the mainland to Curtis Island by the barge/ferry operations. A temporary MOF will be built at the point where the LNG jetty crosses the shoreline. This jetty will be used to land equipment and materials during early works construction until the MOF and haul road have been constructed.

It is proposed that material and equipment that is barged to Curtis Island will leave from Auckland Point. Most of the imported equipment (approximately 80 %) will be unloaded at the MOF directly from export vessels. The balance of the imported equipment will be unloaded at Auckland Point and stored in a secured laydown area adjacent to the wharf. It will then be loaded on to contracted barges for transfer at the MOF on Curtis Island. This will require customs being located at the MOF.

It is proposed that all workforce ferries will also leave from Auckland Point. Santos will discuss with the Gladstone Ports Corporation (GPC) the need for any upgrading of facilities to enable this to occur. On Curtis Island, workers will embark and disembark at the MOF.

While the construction workers will be accommodated in a construction accommodation facility (CAF) on Curtis Island, they will still require transport to and from the mainland and this too will be by ferry. It is expected that the existing barge/ferry facilities will be augmented to provide the capacity required.

Construction traffic planning will be undertaken in conjunction with the DMR and the Gladstone Regional Council prior to any construction activities occurring. The traffic impacts associated with the construction activities are assessed in Section 4.

If the bridge is not built, site access for the construction of Trains 2 and 3 will utilise the transport methods described above. Construction workers for these stages will also be accommodated on Curtis Island.

3.8.2.2 LNG Facility Construction Activities

Site Preparation

Site preparation activities are expected to commence in mid 2010. The necessary earthmoving equipment will be mobilised to Curtis Island by landing craft type vessels possibly from Auckland Point. They will land at the proposed MOF area (which will not be constructed at this point) and travel to the facility site via existing trails. As part of early works this equipment will be used to construct the MOF and haul road.

An area will be designated for lay down and construction activities as well as site facilities. This area will be clearly identified and its boundaries flagged to ensure that construction activities do not extend beyond the designated construction area.

The designated construction area will be cleared of vegetation prior to earthworks commencing. Any valuable timber will be recovered where practical with the balanced reused as part of the site's landscaping program. Any cleared vegetation that remains will be disposed of in accordance with the requirements of the relevant statutory approval. Management strategies to be applied during the site clearing activities are discussed in Section 8.4.

Earthworks will begin with topsoil stripping, which will be stockpiled for later reuse in the site's landscaping program. The stockpile will be located so that it will not be disturbed during construction activities. Following this, the subsoil will be stripped for reuse in site earthworks and construction activities. On completion of soil stripping, rock removal down to design formation level will be undertaken by means of dozers fitted with ripper arms and excavators. This will be a cut and fill operation and the use of a mobile rock crushing plant maybe required. All surplus rock from the cut and fill areas will be utilised in the PLF, MOF area, haul roads and embankments. Any areas that require backfilling will be filled in layers of no more than 300 mm with each layer being compacted in accordance with the relevant design specifications.

Construction

Initial site development will begin with the construction contractor undertaking earthworks, preparing the site and providing temporary facilities for the construction workforce. The contractor will then provide site services including drainage, perimeter fencing, and internal roads. At the same time the construction worker accommodation facility will be established together with the necessary water supply and sewerage infrastructure. Water for construction will be either barged from the mainland or produced from a temporary desalination plant on site. Sewage will be treated onsite in accordance with the applicable regulatory standards and approvals and the environmental management plan (EMP).

Where possible, rock, sand and gravel required for construction materials will be sourced from the materials cut from the site levelling process. As discussed above, surplus rock from the site's cut and fill operation will be used in the PLF and MOF areas and haul road construction. Where there is a shortfall in the supply of construction materials they will be sought from commercial suppliers within the Gladstone region and will be transferred to the site by barge. The nature and amount of material required will be determined during FEED.

Once the site has been established, foundations will be dug, trimmed and poured and steelworks and pipe-racks erected. Work will also begin on fabrication of the LNG storage tanks as they will have one of the longest lead times of any of the facility's components. Mechanical erection will generally begin with the installation of heavy items and/or modules as they are delivered and proceed to lighter or higher mounted equipment such as interconnecting pipes and pumps. Electrical and instrumentation work will be undertaken once the major process equipment is installed.

Work will include construction of the following:

- Major foundations;
- LNG train facilities;
- LNG tanks;
- Gas turbine and compressors;
- Pipe racks;
- Power generation facilities;
- Sub stations;
- Effluent and water treatment plants;
- Flare;
- Utilities; and
- Administration buildings.

3.8.2.3 Product Loading Facility Construction Activities

It is currently proposed that the following construction methodology will be utilised.

Due to the relatively short length of the trestle required for the product unloading facility and the shallow water depths involved it is likely that construction of the trestle and berth structures will be carried out from two work fronts. One work front will commence onshore and work out towards the berth while the other work front will concentrate on the offshore infrastructure from the jetty head.

Near-shore Work Front

The access trestle work front will initially comprise working on dry land using conventional piling and construction equipment. Once the trestle is over water it will use 'hand over hand' techniques for the pile driving and setting of the crossheads (as shown in Figure 3.8.1). This technique requires the piles to be handled and pitched using a trestle-mounted crane which will operate from a driven section of the access trestle and pitch and drive the piles at a 24 m outreach. A second crane will follow on placing the permanent pile bent caps, precast roadway beams and deck. Any in-situ concrete required offshore will be transported using truck mixers on barges towed to the construction site and placed using concrete pumps from the barges or skips handled by the trestle-mounted cranes.

Figure 3.8.1 "Hand Over Hand" Construction Method

Offshore Work Front

It is expected that the loading platform, breasting dolphins and mooring dolphins will be constructed using either a jack-up barge or a floating crane barge capable of pitching and driving piles. Due to the currents in the area the more likely option is a jack-up barge. Figure 3.8.2 shows a typical jack-up barge. The jack-up barge may also be used to place any pre-cast deck elements such as the loading platform and the decks of the mooring and breasting dolphins as shown in Figure 3.8.3. In addition the same equipment will be used to install loading equipment and modules, piping and berth furniture.

Figure 3.8.2 Jack-Up Barge

Figure 3.8.3 Floating Crane Barge Placing Pile Caps for Mooring Dolphins

Dredging

Dredging will be required to construct suitable navigation channel access and ship swing basin. The approximate volume of dredged material for the berth pockets, swing basin and approach will be approximately 8,000,000 m^3. Further details on the proposed dredging are provided in Section 3.10.1.

Dredged material will be disposed of at a proposed dredge material placement facility south of Laird Point as discussed in Section 3.10.2.

3.8.2.4 Materials Offloading Facility Construction Activities

It is proposed that the MOF will be constructed off Hamilton Point and will be used to support onshore and offshore construction. The MOF design is currently being developed and is expected to include the following components:

- Three separate berths to accommodate a range of vessels for delivery of material, plant modules, construction equipment and workers;
- Wharf structures, mooring and breasting dolphins;
- Material, equipment and module laydown areas (including vehicle manoeuvring areas); and
- A quarantine area.

The MOF will be designed to accommodate up to 2,500 t modules unloaded from a roll-on/roll-off (Ro Ro) barge at the module berth as well as up to 800 t loads of heavy equipment at the general cargo berth. It will also be able to handle bulk construction materials and a range of vehicles and earth moving equipment.

The construction methodology of the MOF has not yet been determined, but could include a sheet-piled structure and piled foundations to support the necessary berthing and mooring structures. A conceptual layout for the MOF is shown on Figure 3.8.4. The layout is subject to alteration during detailed design and ongoing consultation with the GPC and the Gladstone Regional Harbour Master to ensure issues of navigation safety are appropriately addressed.

A haul road will be constructed from the MOF to the LNG facility to enable unloaded materials and personnel to be transferred to the construction site.

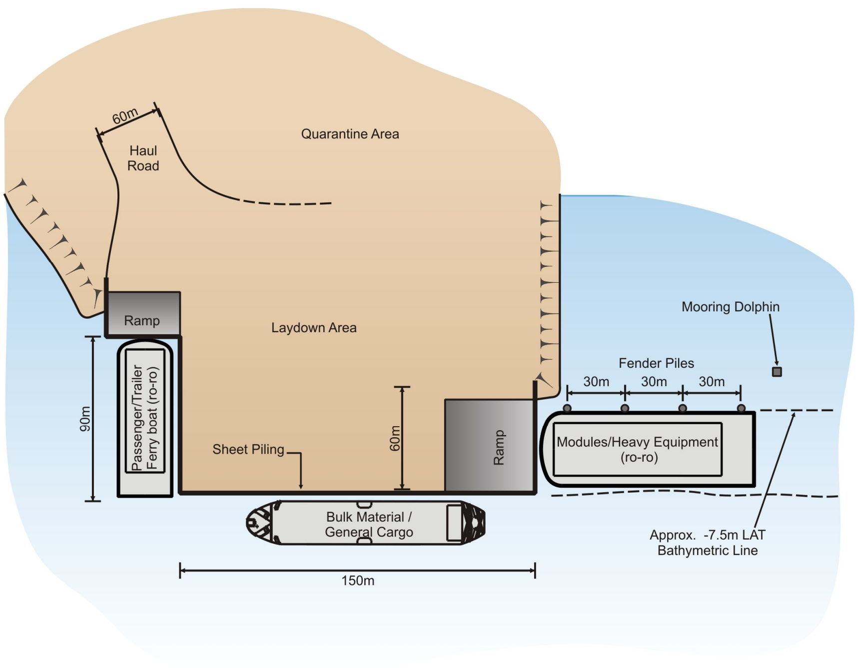


Figure 3.8.4 Materials Offloading Facility Concept

Prior to the construction of the MOF a temporary 'pioneer dock' will be established. This will allow vehicles, earth moving equipment and other machinery to be mobilised to commence the early site works.

3.8.2.5 Construction Equipment and Materials

Table 3.8.1 indicates the typical equipment that is expected to be transported to Curtis Island and utilised during the construction period.

Table 3.8.1 Typical Construction Equipment

Equipment Type	
Excavators	Maintenance workshop
Bulldozers	Fuel Depot
Graders	Compressors
Crushing Plant	Backhoe
Concrete Batch Plant	Ballast Equaliser
Transit Mixers	Ballast Tamper
Concrete Pumps	Compactor
Dump Trucks	Concrete mixer
Cranes	Concrete pump
Fork Lift Trucks	Concrete vibrator
Electricity Generators	Impact wrench
Lighting sets	Loader
Welding sets	Pile driver
Pumps (water)	Pneumatic Tool
Water tankers	Rail saw
Water tanks	Rock Drill
Temp Fire Pump	Roller
Desalination Unit	Saw
Sewer Treatment Plant	Scarifier
40 ft Flat Bed trailers	Scraper
Accommodation Block	Spike river
Dining Facility	Tie Cutter
Medical Centre	Tie inserter
Security & Training Centre	Tie Handler

As the situation is uncertain regarding the ability of the GLNG Project to access sufficient skilled manpower to construct Train 1 in the 2010 to 2014 timeframe, the use of pre-assembled modules (PAMs) is being considered. PAMs offer an alternative to the traditional stick-build method and will result in a reduction in the construction labour manpower requirements in Gladstone. At this stage it is uncertain as to which construction method (modular or stick-build) will be used. However for the purposes of the EIS, it has been assumed that the stick-build method will be used as this will result in greater quantities of resources required from the Gladstone area than will the PAM method.

Table 3.8.2 provides an indication of the materials that are expected to be transported to site and utilised during the construction period assuming the stick-build construction method is used. The quantity of construction materials for Train 1 will be greater than for Trains 2 and 3 due to the initial site development, and the construction of the accommodation facility, MOF, PLF, and control buildings during the construction of Train 1.

Table 3.8.2 Construction Materials

Items	Quantities	Units
Plant Equipment	320	items
Above-ground pipe	114,300	m
Underground Pipe	9,320	m
Building architectural	1.0	Ls
Concrete	37,330	m^3
Grout	73	m^3
Paving	1,740	m^3
Steel	42,225	tonnes
Instrumentation	2,790	each
AG Electrical	362,570	m
UG Electrical	14,400	m
Equipment FPR	1,465	m^2
Equipment Insulation	40,000	m^2
Pipe Insulation	81,825	m
Steel FPR	6,790	m^3
Paint	832,325	m^2

A number of heavy and indivisible loads of equipment and materials will be required to be transported to site. The exact numbers of heavy and indivisible loads is currently unknown, and is the subject of further work. These include materials and equipment for the following project components:

- Liquefaction;
- Process;
- Acid recovery;
- Power generation;
- Effluent treatment;
- Flare section;
- Boil off gas;
- Pipe rack;
- PLF; and
- Other utility systems.

3.8.2.6 Construction Water Supply

Raw Water

The total raw water demand for construction of Train 1 will be 45,600 m^3/year. This may be supplied by either a mobile desalination plant and/or bulk water delivered by tankers from the mainland. Storage tanks or bladders will be erected on site to receive raw water deliveries. This facility is expected to be located to the west of the northern side of the LNG storage tank, west of the storm water diversion channel. Therefore in the event of a tank (or bladder) failure, the lost water will discharge into the channel and not onto the construction area. Rainwater will also be collected where practicable.

Potable Water

Some of the raw water will be treated for potable uses. A centrally located bulk storage reservoir will be connected to the site by a pipeline distribution system.

Potable water will be stored and distributed to the worker accommodation facility, service buildings and contractors' offices by a buried pipeline system. The distribution system will include flow, volume, and pressure control valves to control output. The water supply will cater for residents' consumption, kitchen use and ablution needs throughout the construction site and for the duration of the project.

Non-Potable Water

The balance of the raw water will be treated for non-potable uses such as earthworks compaction, hydrotesting, fire fighting, washing down the equipment, and dust control.

For fire fighting purposes, two tanks of 1,000 m^3 capacity each are considered sufficient. These tanks shall also be tied into the facility's fire water system via a suitable firewater pump. This will give fire protection to the whole of the project area, and construction water where required via the permanent hydrants.

Table 3.8.3 details the estimated water consumption figures during the construction of the LNG facility and export facility.

Table 3.8.3 Construction - Estimated Water Consumption

Water Type	Estimated Hourly Demand (L/h)	Estimated Daily Demand (L/day)	Estimated Annual Demand (m^3/year)
Potable Water	1,300	31,200	11,400
Non-Potable Water	3,900	93,800	34,200
Fire Fighting	-	-	2,000
Dust Control	-	-	500
Hydrotesting	-	-	500
Total Raw Water	**5,200**	**125,000**	**45,600**

3.8.2.7 Construction Workforce and Accommodation

Construction of the LNG facility will take approximately four years. The construction workforce will peak at approximately 3,000 people for the stick-built option. If pre-assembled modules are used this may reduce to 2,000. Construction workers will work 10-hour days for 10 days and then have a 4-day leave period.

The construction workforce will be accommodated in an accommodation facility to be established on Curtis Island. This will include both local and non-local (distant) workers so as to avoid the significant time delay that will otherwise be incurred if workers had to travel by ferry to and from the site each day. All workers will be transported to and from Curtis Island by ferry. During their rostered time off, the non-local workers will return to their places of residence under a fly-in/fly-out arrangement. As not all workers will be on site at the same time, the capacity of the accommodation facility will be 2,000.

Further details on the construction workforce including shift details, roster arrangements, skills requirements, occupational groupings and recruitment procedures are given in Section 8.14.

Figure 3.8.5 shows the variation of worker numbers for the construction of each of the three trains.

If construction of Train 1 commenced in mid 2010, it is expected to be completed by late 2013. At this time it is possible that, depending on market conditions, construction of Train 2 will have commenced. The maximum construction workforce for this second stage will be approximately 1,800 as many of the facilities required for Train 2 will have already been built for Train 1. Figure 3.8.5 also shows the variation of construction worker numbers for Train 2. The Train 3 construction worker profile will be similar to that for Train 2.

It is possible that, given favourable market conditions, construction of Train 2 could commence before the completion of the Train 1 construction. Similarly, construction of Train 3 could start before the completion of Train 2 construction. In this event the total construction workforce would still be within the maxima given in Figure 3.8.5.

The accommodation facility on Curtis Island will be completely self-contained and will provide the housing, dining, logistics and recreation facilities for the residents. Worker access to areas on Curtis Island outside of the designated construction site will be restricted.

Key components of the workers accommodation facilities will include:

- Air conditioned demountable style accommodation units;
- Ablution units;
- Dining and kitchen facilities;
- Offices;
- Recreational facilities;
- Laundry;
- Medical facilities;
- Cold room;
- Waste collection facility;
- Car park; and
- Fencing and access roads.

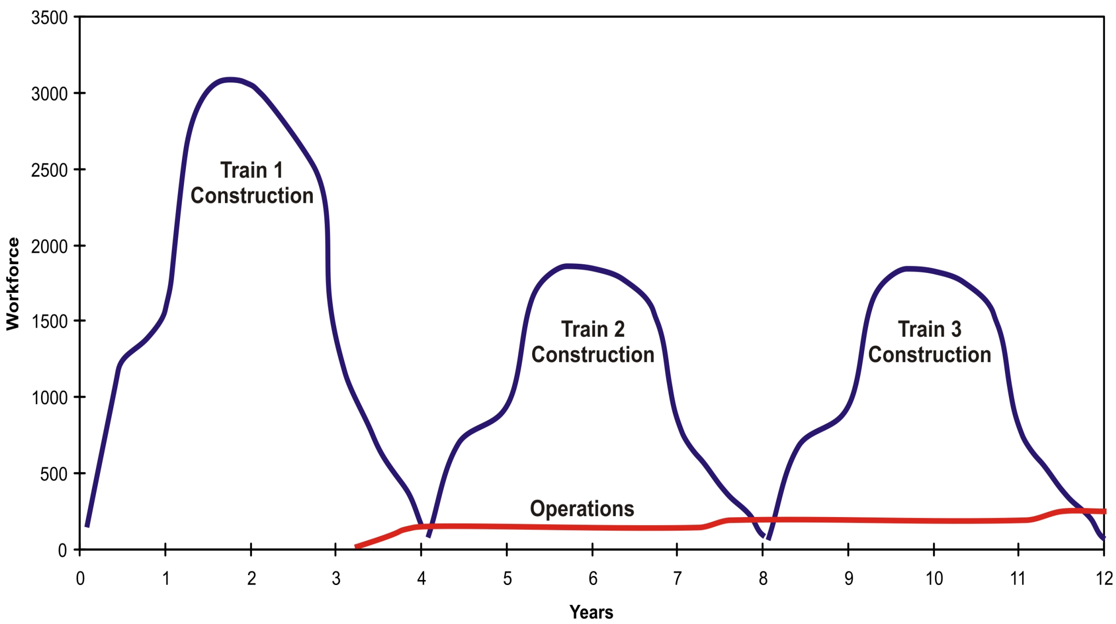


Figure 3.8.5 Construction Workforce

Pets will be banned from all accommodation facilities and construction areas. Food wastes will be kept covered and then transported to the nearest local authority landfill for disposal.

The accommodation strategy is further discussed in Section 8.14.

Should construction of any subsequent train not follow on directly from the construction of the previous train, consideration will be given to either mothballing or demobilising the construction workers accommodation facility during the interim period.

3.8.2.8 Sewerage

It is anticipated that package sewage treatment facilities will be installed at the construction workforce accommodation facility and that relevant approvals will be obtained by Santos in conjunction with the facilities' development approvals. Treated effluent will be loaded into tankers and barged to the mainland for disposal at an existing wastewater treatment plant. Santos will discuss this proposal with the Gladstone Regional Council.

3.8.3 Operation

3.8.3.1 LNG Production Technology

The purpose of the LNG facility is to liquefy CSG to facilitate its transport via tanker. The liquefaction technology uses a refrigeration process whereby the refrigerant is expanded and compressed in a closed loop system to achieve the cold temperatures needed for liquefaction. A number of liquefaction processes have been developed around the world, with the differences mainly confined to the types of refrigeration/ liquefaction technology employed.

For the GLNG Project, Santos considered two competing liquefaction processes - the ConocoPhillips (CoP) Optimised Cascade Process (OCP), and the Air Products Chemicals Incorporated (APCI) Propane Pre-cooled Mixed Refrigerant (C3MR) process. Both processes use similar gas treatment unit operations, and LNG storage and ship loading facilities. As described in Section 2.3.3, the key differences between the two processes are in the refrigeration technologies used to liquefy the purified gas. In late 2008, Santos decided to proceed into FEED with only the ConocoPhillips liquefaction process (OCP) and this section relates to that process.

Many of the project's impact assessments that are presented in the appendices were undertaken during 2008 prior to the selection of the OCP and included assessment of both technologies. The EIS sections however have addressed only the OCP technology.

The Phillips Petroleum Company developed the original OCP in the 1960s. The objective was to develop a liquefaction technology that permitted easy start-up and smooth operation for a wide range of feed gas conditions. This process was first used in 1969 at Phillips Petroleum's LNG facility at Kenai, Alaska. The facility was the first to ship LNG to Japan and has achieved uninterrupted supply to its Japanese customers since. This process uses three refrigerants – propane, ethylene and methane circuits - cascaded to provide maximum LNG production. Each circuit uses two 50 % compressors with common process equipment. The OCP can provide designs with high thermal efficiency and achieve designs optimized for project economics. The process utilizes proven technology and equipment, and has a wide range of operational flexibility. The plant provides low utility and reduced flaring requirements. Operating plants (and plants being implemented) using this technology include the Darwin LNG Plant as well as plants in Alaska, Trinidad, Egypt, Equatorial Guinea, Angola and Nigeria. At year end 2008, the LNG production capacity from plants utilising this technology was approximately 31 Mtpa.

Figure 3.8.6 shows a conceptual process flowchart of the OCP process.

Figure 3.8.6 shows the various process stages of gas receiving, treatment, liquefaction, storage and shipping. Note that the process flowchart is generic and not specific to the GLNG Project. During the FEED phase that will take place during 2009, the specific details of the plant technology will be developed.

Figures 3.4.6 and 3.4.7 show the layout of the LNG facility. The facility components forming part of the initial stage (Train 1) are shown together with those proposed for the subsequent stages (Trains 2 and 3).

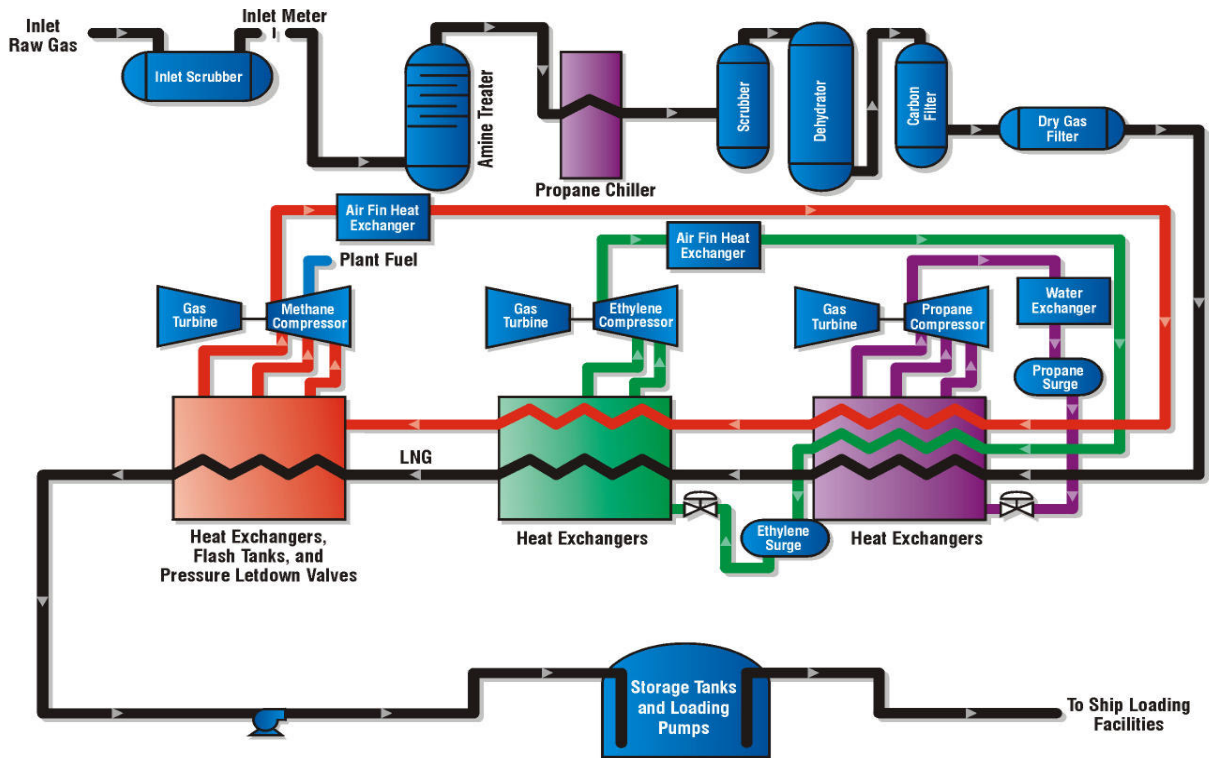


Figure 3.8.6 Conceptual Process Flowchart

Figure 3.8.7 shows the LNG facility that was recently constructed at Darwin. This facility uses the OCP process and is similar to what the GLNG LNG facility will look like. The figure clearly shows the liquefaction facility, the LNG storage tank and the product loading facility.

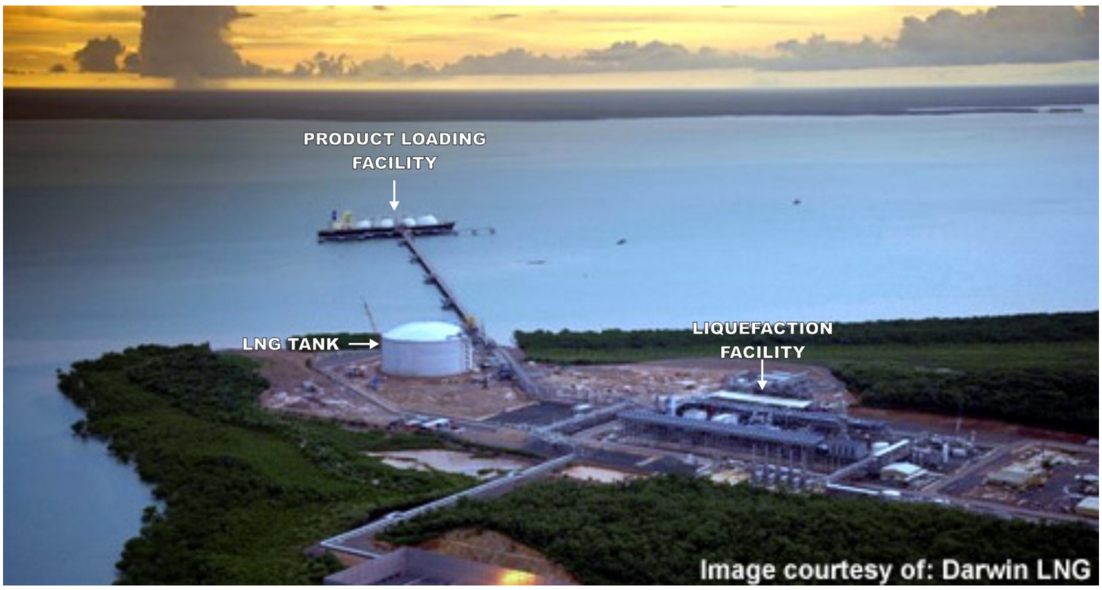


Figure 3.8.7 Darwin LNG Facility

3.8.3.2 Inlet Facilities

CSG will be transported to the LNG facility via the gas transmission pipeline. The gas has a high methane concentration with very few impurities, no heavy hydrocarbons or water. The typical composition of CSG is summarised in Table 3.8.4.

Table 3.8.4 Gas Composition

Constituents	Composition (%)		
	Start of Life	Average	End of Life
Methane	95.45	94.95	95.0
Ethane	0.03	0.03	0.03
Propane	0.02	0.02	0.02
Nitrogen	4.0	4.0	2.95
Carbon Dioxide	0.5	1.0	2.0

On entering the facility, gas from the transmission pipeline will first be routed through the inlet facility where it will pass through a pipeline gas heater and a pressure letdown station prior to entering an inlet separator. The pipeline gas heater will be necessary to avoid freezing and hydrate formation when the gas is depressurised (which results in a cooling of the gas due to the Joule Thompson effect).

Downstream of the inlet separator the gas will flow through a metering package. Metering facilities will be used to measure the amount of gas received for use in pipeline monitoring and possibly gas transfer accounting. The last step in the inlet facilities will be inlet filters which remove any contaminant particles entrained in the gas.

The inlet facility will also be equipped with a scraper receiving station which will be used to collect scrapers (internal pipeline cleaning equipment which is typically spherical in shape with an outside diameter equal to the pipeline's inside diameter) sent down pipelines for cleaning / monitoring purposes.

3.8.3.3 Gas Treatment

After the inlet facilities the gas will enter the gas treatment section to remove any impurities within the gas stream that are detrimental to the natural gas liquefaction process. These components are primarily carbon dioxide (CO_2) and water.

The first step in the gas treatment process will be the removal of CO_2 and trace sulfur-containing compounds (collectively called acid gas). If CO_2 is not removed, it will solidify (freeze) during the LNG liquefaction process plugging equipment and causing maintenance outages.

The feed gas which contains CO_2 and possibly trace sulfur containing compounds will enter the bottom of a CO_2 absorber where it will counter-currently contact an amine solution. This interaction will cause the acid gas from the feed gas to be absorbed into the amine solution via a physical and chemical process. The feed gas will then exit the top of the CO_2 absorber free from acid gas. The amine solution is then stripped of acid gas in a regenerator and directed to the acid gas vent stack for final disposal within regulatory limits.

After the gas leaves the amine treatment section it will be routed to a dehydration unit. As with CO_2, if water is not removed from the gas stream prior to liquefaction, it will freeze once temperatures are reduced and will plug equipment. The first stage of dehydration will be to chill the gas in order to condense and drop out a large percentage of the water.

After being chilled, the gas will then be routed through a three-bed molecular sieve system to remove the final traces of water to a dew point of approximately -70 ^{o}C. Three beds will be used, two in operation and one in regeneration/cool down or standby mode. Water collected will be sent to the wastewater treatment system.

The final gas treating step will use two sulfur impregnated carbon beds to remove trace amounts of mercury (if present) in the gas. While the CSG contains no measurable level of mercury, if a small amount is present and left entrained in the CSG, it could cause corrosion of the brazed aluminum heat exchangers located downstream in the process. The mercury removal beds will serve as a safeguard to help ensure the integrity of the downstream equipment. The beds will be designed to be in use for the design life of the plant.

3.8.3.4 Gas Liquefaction and Nitrogen Removal

The dry, mercury free gas will flow into the refrigeration and then liquefaction system where it will be liquefied to become the LNG product. In order to meet sales quality specification for LNG, nitrogen in the gas must be removed.

The nitrogen will be removed by letting down the pressure of the condensed feed gas. The vapour produced from this pressure letdown (fuel gas rich in nitrogen) will be compressed in a fuel gas compressor and used as plant fuel gas. The LNG, will then be within sales LNG specifications, and will be pumped to the LNG product storage tanks.

3.8.3.5 Gas Storage

LNG will be stored in double walled, full-containment storage tanks. For the eventual 10 Mpta development on the site, it is anticipated that three tanks, each with a storage capacity of between 125,000 and 200,000 m^3 will required. Each tank will be approximately 80 m diameter and 60 m high to the top of the dome. The individual tank and total LNG storage capacity will only be finalised following negotiation of the LNG sales and purchase agreements with LNG buyers. However for initial planning purposes, Santos has assumed this may total 420,000 m^3 for the 10 Mpta development.

Each tank will consist of an inner container of 9 % nickel-steel surrounded by insulation, contained within an outer wall. The inner container will hold the LNG product at its boiling point of -161 °C at a pressure slightly above atmospheric. In the unlikely case of inner tank failure, both the liquid and vapour will be contained within the outer tank.

The cross section of a typical full-containment LNG storage tank is provided in Figure 3.8.8.

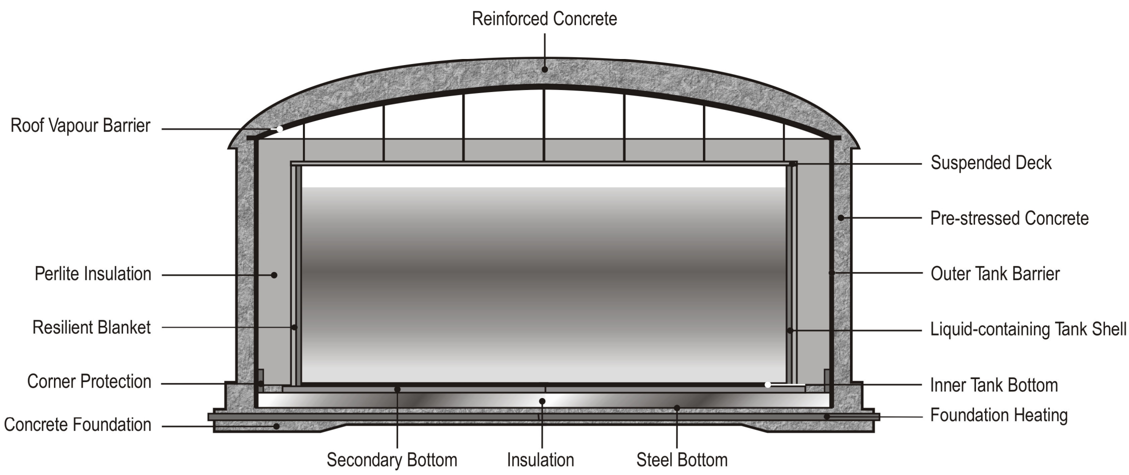


Figure 3.8.8 LNG Storage Tank Configuration

While no refrigeration is used to maintain the -161 °C temperature, the storage system will include a boil-off compressor for handling the vaporising LNG and product pumped for ship loading. This latter system will recover vapour produced in the storage tanks due to heat gain or displaced by liquid as the tanks are filled, and return it to the facility for fuel or re-liquefaction.

LNG will be held in the storage tanks until it is transferred to the PLF for loading into ships for export. The LNG will be pumped from the tanks via pipework connections through the tank roofs using in-tank pumps to avoid the need for any sidewall penetrations.

3.8.3.6 Product Loading Facility

The product loading facility (PLF) will include:

- Access trestle – approximately 300 m long piled structure over the water. The pipes on this trestle will connect the onshore plant to the offshore loading platforms;
- Loading platform with four loading arms for loading of LNG onto ships;
- Marine operations platform - for housing the marine terminal, which may be moved to onshore at a later stage in design;
- Building, electrical room, firewater pumps and stand-by generators, which may be moved to onshore at a later stage in design and the firewater supplied from an onshore tank; and
- Six mooring and four breasting dolphins.

The access trestle, loading platform and berthing dolphins will load LNG to specially designed LNG tankers for shipment to markets.The proposed layout of the trestle and berth structures is shown on Figure 3.8.9.

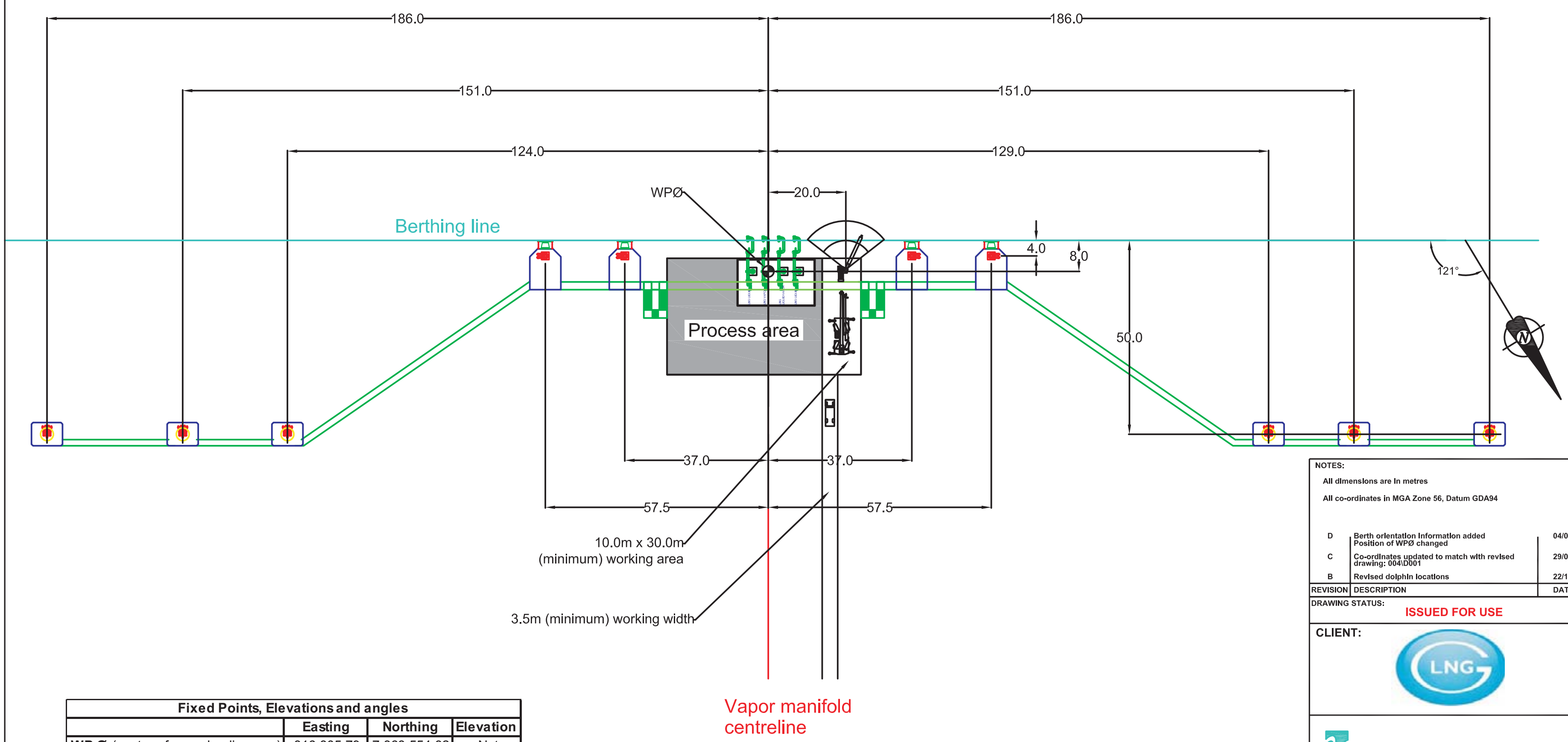
The current trestle design is for a tubular steel-piped structure which will carry a roadway and pipe rack out to the loading platform. Pipeline expansion loops will be provided at regular intervals and pipeline anchor points will be provided between expansion loops.

The final location, length and orientation of the loading trestle and platform will be determined during FEED and will:

- Provide safe and reliable access for marine vessels to service the site;
- Minimise the extent of dredging, to reduce level of environmental impact and dredging costs;
- Allow for adequate draft for the size of LNG tankers expected;
- Preserve the mangroves to the best extent possible;
- Account for the prevailing waves and currents; and
- Avoid disruption of other marine traffic.

LNG will be pumped from the storage tanks to the ships via a pipeline and PLF-mounted retractable loading arms that connect the pipeline to the ships' storage tanks. During ship loading, gas vapours will be produced as a result of heat gain throughout the process and the venting of the displaced vapour space within the ship as it is filled. Some of these vapours will be used to displace the LNG being removed from the storage tanks during loading and the remaining vapours will be routed to boil-off gas compressors and sent back to the LNG liquefaction section for use as fuel or re-liquefaction. In this way the release of fugitive gas emissions to the atmosphere will be minimised.

In the event that the vapour is produced at a higher rate than the boil off compressors can handle, the surplus vapours will be routed to a marine flare which will be located onshore at the end of the PLF.



Fixed Points, Elevations and angles			
	Easting	Northing	Elevation
WP Ø (centre of vapor loading arm)	316,805.79	7,368,554.32	Not specified
Top of mooring and breasting dolphin deck	.	.	+11.0m (LAT)
Berth alignment	121° N reletive to Grid (MGA zone 56 Datum GDA94)		

Scale 1:1,000 @ A3

NOTES:

All dimensions are in metres

All co-ordinates in MGA Zone 56, Datum GDA94

REVISION	DESCRIPTION	DATE
D	Berth orientation information added Position of WPØ changed	04/02/09
C	Co-ordinates updated to match with revised drawing: 004\D001	29/01/09
B	Revised dolphin locations	22/12/08

DRAWING STATUS: ISSUED FOR USE

CLIENT:

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PROJECT: Gladstone LNG

DRAWING TITLE: Product loading facilities
Fixed points, Elevations and Dimensions

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Client

Project: GLADSTONE LNG PROJECT
ENVIRONMENTAL IMPACT ASSESSMENT

Title: PRODUCT LOADING FACILITY
GENERAL ARRANGEMENT

Drawn: AA/CA | Approved: JB | Date: 10-03-2009

Job No.: 4262 6220 | File No. 42626220-g-1025.cdr

Figure: 3.8.9 | Rev. A | A4

3.8.3.7 Operational Workforce

The LNG facility will operate 24 hours per day 7 days per week. This will require four 20-person operation shifts for train 1. These shifts are likely to be 12 hour shifts, and may be on a 4 days on, 4 days off rotation. Should the potential bridge option not proceed, these workers may be shifted to a two week on, two week off rotation. Rotation lengths are yet to be determined and may be altered to meet changing project needs and parameters. It is expected that maintenance and administration will work week days for eight hours with weekends off.

The 3 - 4 Mtpa facility (Train 1) will have an operational on-site workforce of about 80 increasing to 130 for the 10 Mtpa facility (Trains 1-3).

Details of the operational workforce are shown in Table 3.8.5.

Table 3.8.5 Operational Workforce

Staff Type	Work Hours	No. Shifts	Train 1	Trains 1-2	Trains 1-3
Maintenance	Mon/Fri 0700-1600	1	30	40	50
Operations	7 days 0600-1800/1800-0600	4	20	30	40
Administration	Mon/Fri 0700-1600	1	30	35	40
Total on Site			**80**	**105**	**130**
Total Employed			**140**	**190**	**250**

Further details on the operational workforce including shift details, roster arrangements, skills requirements, occupational groupings and recruitment procedures are given in Section 8.14.

It is anticipated that all of the operational workforce will reside in Gladstone and surrounding areas and will be transported daily by ferry from Auckland Point to Curtis Island and back again.

3.8.3.8 LNG Facility Inputs and Outputs

Table 3.8.6 details the approximate annual consumption of hazardous materials during the operational phase of the LNG facility.

Table 3.8.6 Operational Materials and Chemicals

System	Chemical	Quantity		Units
		Train 1	Trains 1-3	
Amine System	Amine	10,000	30,000	kg
Amine System	Antifoam	400	1,200	kg
Turbine Cooling System	Ammonia	500	1,500	kg
Sewage Treatment:	TCCA - Chlorine Tablets	600	1,800	kg
Sewage Treatment:	Waste Water System Nalco 2490	2,000	6,000	kg
Potable Water System	Sodium Hypochlorite	1,000	3,000	kg
Demineralised Water System	Sodium Chloride (pellets)	4,500	13,500	kg
Demineralised Water System	Potassium Permanganate (crystals)	1,000	3,000	kg
Demineralised Water System	Sodium Meta Bisulfite	4,000	12,000	kg
Demineralised Water System	R.O. Scale Inhibitor	3,500	10,500	kg

System	Chemical	Quantity		Units
		Train 1	Trains 1-3	
Demineralised Water System	Ferric Sulphate	24,000	72,000	kg
Demineralised Water System	Sodium Hydroxide	12,000	36,000	kg
Nitrogen Generation	Liquid Nitrogen	412,500	1,237,500	m^3
Desalination	Coagulant	47,500	109,500	kg
Desalination	Sodium Sulphite (20%)	7,900	18,200	kg
Desalination	Sulphuric Acid (98%)	11,900	27,400	kg
Desalination	Antiscalant	3,150	7,300	kg
Remineralisation Unit	Calcium and Magnesium salts	4,400	10,200	kg
Seawater Dosing	Sodium hypochlorite (10%)	15,800	36,400	kg

3.8.3.9 Water Supply

Table 3.8.7 details the estimated water demand figures during the operation of the LNG facility for Train 1 and Trains 1-3. The water will be sourced from the sea and then desalinated to supply the various water types required as listed in Table 3.8.7.

Table 3.8.7 Operation - Estimated Water Demand

Water Type	Hourly (m^3)		Daily (m^3)		Annual (m^3)		Remarks
	Train 1	Trains 1-3	Train 1	Trains 1-3	Train 1	Trains 1-3	
Potable Water	10	17	228	408	83,000	150,000	For admin block and safety showers
Demineralised Water	7	19	156	456	57,000	166,000	For solvent dilution, cooling water makeup and turbine washing
Utility Water	1	1	11	33	4,000	12,000	General usage around site
Fire Water	1	3	23	69	8,300	25,000	
Total Water Use	**19**	**40**	**418**	**966**	**152,300**	**353,000**	
Sea Water for Desalination	78	179	1,870	4,303	682,000	1,570,000	The sea water intake will be greater that the volume of useable water produced. The balance will be discharged back to Port Curtis.

Sea Water

Sea water will be desalinated to provide water for the LNG facility. Sea water will be extracted using pumps located at the product loading wharf. Due to the biofouling nature of sea water, a sodium hypochlorite dosing system will be provided to suppress biological growth in the seawater pipework. Circular clarifiers will be used to remove any silt present and the settled sea water will be pumped to the desalination units.

The desalination units will use RO technology, with the required necessary pre-treatment. The brine reject from the membranes will be returned to sea as it is effectively concentrated seawater. RO permeate will be stored to provide the feedwater to the other plant water systems. The environmental effects of the brine discharge are discussed in Section 8.7.

Demineralised Water

Desalinated water will be fed to the demineralisation unit, which will use mixed bed ion exchange to produce the demineralised water. A storage tank and pumps will supply the various users, with a separate storage tank and pumps to provide gas turbine wash water.

Potable Water

Desalinated water will be fed to the remineralisation package. This will reinstate hardness and alkalinity in the water that was lost in the desalination process by adding lime or limestone. A small amount of sodium hypochlorite will be dosed to the outlet to disinfect the water and to provide a residual to keep the downstream system sterile. A downstream storage tank and pumps will supply the potable water to the safety showers and eyebaths around the plant, and to the control room and administration block.

Utility Water

Desalinated water will be of a high enough quality for most general purposes. A dedicated utility water tank and pumps will be fed from the desalinated water header.

Firewater

Desalinated water will be used as firewater and will be stored in a dedicated tank. Electric driven pumps with diesel backup will supply the system, with a jockey pump to maintain system pressure. The system may also be able to use a backup seawater supply.

3.8.3.10 Electricity

The total power requirement for the site during operations is expected to be 25 MW for Train 1 increasing to approximately 75 MW for Trains 1 - 3. This electricity will be generated by on-site gas turbine generators.

Emergency diesel generators with a capacity of 2 MW will be installed to provide electricity in the event of failure of the main electricity supply. The generators will support the following typical items of the plant:

- Uninterruptible power supply systems;
- Emergency lighting;
- Air conditioning in control rooms to maintain electronics;
- Gas turbine and compressor auxiliaries;
- Fire water pumps;
- Instrument air compressor;
- Flare system; and
- Common fuel gas heater.

3.8.3.11 Stormwater Drainage

Surface water at the site will be managed to minimise environmental risks and impacts on receiving waters from the facility's operations. Key considerations in designing the stormwater system were to:

- Minimise the potential for contaminants to be mobilised in off-site runoff; and
- Direct naturally occurring stormwater runoff around the site and away from process areas.

Due to the existing water courses running through the site, a series of diversion channels will be constructed around the perimeter. These channels will divert clean runoff from the surrounding hills and channel it around and away from the site and discharge it to China Bay.

Clean stormwater runoff from non-process areas of the site will be discharged via drains to the surrounding natural drainage system.

Potentially contaminated stormwater runoff from process areas will pass through an oil skimmer with the skimmed water/oil being routed to a corrugated plate interceptor (CPI) oil/water separator unit for removal of oil and grease and suspended solids. This waste stream could also include low volumes of utility water from cleaning operations or testing of fire fighting equipment as well as sump water.

The clean underflow drainage from the skimmer will pass through a "first flush" retention pond with flows in excess of the pond's capacity being bypassed and discharged to the natural drainage system. The "first flush" pond will be kept empty to ensure that it has adequate capacity for subsequent storm events. Retained pond water will be tested and, if suitable, will be discharged to the natural drainage system.

Contaminated (off-spec) water from the first flush pond or from the CPI separator (as well as sludge and slops from the CPI) will be transported offsite to an approved treatment and disposal facility.

Further details of the stormwater management system are given in Section 8.5.

3.8.3.12 Sewerage

It is anticipated that a package sewage treatment plant will be installed to treat sewage from the LNG facility and the relevant approvals will be obtained by Santos in conjunction with the facility's' development approvals. Treated effluent will be disposed of by irrigation.

Where sewage effluent absorption beds and/or irrigation fields are used, they will be located and designed to ensure that:

- Sensitive areas are avoided;
- Soil erosion and soil structure damage is avoided;
- There is no surface ponding or runoff of effluent; and
- The quality of groundwater is not adversely affected.

Areas where treated sewage effluent is discharged to absorption beds or irrigation fields will be fenced and clearly marked with warning notices of the purpose of the area and not to use or drink the effluent.

Effluent treatment systems will be designed to include alternate measures for effluent storage and/or disposal, where conditions prevent the absorption of treated effluent to land (e.g. rain events). This may include wet weather storage or disposal off site. There will be no discharge of treated effluent from wet weather storage to any waters.

Further discussion on sewage treatment is given in Section 8.5.

3.8.3.13 Telecommunications

The telecommunications system will be designed to provide voice and data communications within the facility, including marine areas, and to interface with the local service providers for public switched telephone network voice access. Data connectivity external to the facility will be developed during FEED. All telecommunications central equipment will be located in a dedicated telecommunications room in the main control building.

The site's telecommunications system will consist of:

- Fibre optic cabling to support voice and non-process data to user telecommunications outlets in work areas inside buildings throughout the facility; and
- A local area network for the transport of non-process-related data communications within the facility.

Unless otherwise specified, in general, the electrical systems shall conform in design, material and performance with the current issue and amendments of the relevant codes, standards, and regulations prevailing on the date of contract award.

Communications to on-site personnel will use one of several radio frequencies. One frequency will be exclusively allocated for use in emergencies.

3.8.3.14 Security

The GLNG Project will be designed and operated to protect all personnel from harm and all assets from damage or loss. Assets include physical and real property such as inventories, equipment, operational facilities, securities, and cash. Assets also include intangible property, such as sensitive and proprietary information. In addition all workplaces will be expected to be free of acts or threats of violence or harassment and employees will be encouraged to report any such incidents to management, human resources personnel or to corporate security.

A detailed security and threat assessment will be undertaken during the FEED stage and the results will form the basis for the level of security required and the security procedures that will be developed.

The GLNG Project will be a national asset and both federal and state governments will have a vital interest in the security of the LNG facility. Any requirements from the government on security shall be incorporated into the design or included in management systems and procedures whichever is appropriate.

Closed Circuit Television

Closed circuit television will be used to monitor selected zones of interest including, but not limited to, coverage of critical process, flare, tankage, marine loading, and LNG facility entrance/exit areas. Camera control will be available at the main guardhouse, main control room, and marine terminal building.

Exclusion Zones

A safety zone of 200 - 250 m radius (to be decided during FEED) is proposed to be imposed around the PLF. This is a common safety measure applied to most LNG facilities. Further details on the risks associated with the PLF are given in Section 10.

Access Control

The access control system will have proximity-based card access readers protecting gates, turnstiles, and doors in selected critical areas of the LNG facility. The system will offer colour photographic employee and visitor badges, and will be capable of permitting time, role, and area based physical access control. Based on internal physical layout and segregation of LNG facility areas, high-security turnstile(s) may be provided for the control of pedestrians into and out of sensitive areas. Motorized gate operators will be provided for the main gate, which will allow automated access and egress by authorised personnel.

Telephony

The telephony system will provide voice communications to buildings in the LNG facility. The system will be capable of connection to a local phone service provider. The system will offer an internal voicemail capability for all users, and will be compatible with standard analog facsimile and modem equipment.

Public Address and General Alarm

The public address and general alarm systems will be a manually initiated system of loudspeakers and beacons to provide one-way informational notices and warnings throughout all on-shore and marine areas of the LNG facility. An operator panel will be provided in the main control room and in the central equipment cabinet. Visual beacons will be placed to augment the use of loudspeakers in high noise areas.

Plant Radio

There will be a multi-channel analog land mobile radio system to provide wireless voice communications to all onshore and marine areas. The system will include a tower next to the main control building to support all plant and marine radio antennas.

Marine Radio

A marine radio system will be installed to provide a single frequency land-based station for communicating with approaching vessels out to 20 nautical miles. The antenna for this system will be mounted on the communications tower.

3.8.3.15 Maintenance

Throughout the operations phase there will be a regular program of maintenance shutdowns. These shutdowns could be partial or facility-wide and may occur once every few years. During these periods, maintenance contractors will be engaged to undertake the work which may last from some weeks. At these times temporary accommodation facilities for up to 250 people will be provided on Curtis Island in or adjacent to the construction workers accommodation facility site.

3.8.4 Rehabilitation and Decommissioning

3.8.4.1 Decommissioning

Decommissioning and rehabilitation of the LNG facility will be in accordance with the relevant statutory approvals, Santos EHMS requirements, and current best practice techniques available at the time of decommissioning.

Decommissioning of the LNG facility will involve flushing all process equipment and associated pipe work with water. This water will be disposed of as per the decommissioning plan developed in conjunction with the regulatory authorities.

Decommissioning procedures will largely involve the removal of equipment and structures which are of no further economic value, including where necessary, testing to establish whether any decontamination work is required and performance of such work. If applicable, any ponds will be decontaminated, filled and re-contoured to match the surrounding topography. The site will be re-contoured as necessary and revegetated to stabilise against erosion.

As the LNG facility will be located in the GSDA it is possible that the site and its infrastructure could be valuable either as a package or as individual elements to other industrial users. Proximity to the Gladstone harbour in an area with developed social and physical infrastructure and considerable energy and raw material resources suggests that the most probable decommissioning activity will be preparation of the site for alternative industrial uses.

The port facilities will be decommissioned in consultation with the GPC. Should project-related infrastructure require decommissioning, negotiations will be had with relevant stakeholders as to the benefits of retaining some of the infrastructure for future use (e.g. roads, hardstand etc). Infrastructure will only be left after decommissioning where formal agreements have been obtained from the relevant stakeholders for its use and maintenance/management.

Buildings and plant not agreed to remain on site will be demolished and disposed of to ensure the safety of the area. Building materials will be recycled where practicable. Equipment will either be removed and used at other Santos projects or auctioned. Hardstand (including concrete footings and foundations) not to be used in future projects will be removed and the area ripped, topsoiled and revegetated. The rehabilitated industrial/infrastructure areas will be regraded where necessary.

Power lines and power poles will be removed following closure if their continued use is not envisaged. Pads/footings will be removed from site. Site roads and tracks will either remain with the agreement of the relevant stakeholders or will be removed. Where roads are to be decommissioned, road base will be removed and the surface ripped, topsoiled and revegetated. Electrical infrastructure will be removed where reuse is not anticipated.

If sediment ponds are not to remain, these will be drained, filled, recontoured, topsoiled and revegetated. Any stormwater management ponds present at the time of decommissioning will be used to assist with the provision of water for rehabilitation, where necessary.

Rehabilitation and decommissioning plans will be developed in conjunction with regulatory agencies at least five years prior to decommissioning. At this time there will be a greater understanding of the relevant decommissioning standards and alternative land uses available for each of the decommissioned sites.

3.8.4.2 Contaminated Land

Potential exists for land to become contaminated as a result of any of the following:

- Malfunction of sewage treatment facilities;
- Poor management of general and regulated wastes; or
- Spills and/or leakage of hydrocarbons and other chemicals.

Sites contaminated by operational activities will be identified in the site management plan (including register and survey plan) which will be maintained for the life of the project. Identified contaminated areas will be included on the EPA's Environmental Management Register and Contaminated Land Register as appropriate. On decommissioning, Phase 1 and 2 contaminated land assessments will be conducted in potentially contaminated areas to standards prescribed by the *Environmental Protection Act 1994*. Contaminated areas will be assessed and areas that have elevated levels of contaminants will be remediated as they become available during the life of the project. Depending on the future land use, the top 0.5 m of soil at all fuel storage areas will be remediated. In addition, any hazardous materials and wastes will be removed from site or remediated. Remediation measures will be discussed with the EPA prior to commencement of remediation works. Refer to Section 8.3.4 for further details.

3.9 LNG Shipping

3.9.1 Ship Design

The LNG will be transported in ships specifically designed to handle its low temperature. LNG will be stored in non-pressurised cargo containment systems made up of primary and secondary containment all within the double hull of the ship. With a gap of at least 2 m between the outer hull and the cargo, these vessels are designed to protect the cargo and prevent leaks in the event of an accident. There are two main types of containment used for LNG storage on ships; Moss Rosenberg (spherical) and membrane. A photo of the spherical type visiting the Darwin LNG facility is shown in Figure 3.9.1.

Source: Darwin LNG

Figure 3.9.1 LNG Ship at Darwin LNG Facility

The following description and figure relates to the membrane containment systems.

The double hull design of the ships provides additional protection with ballast water typically occupying the space between the hulls. The LNG tanks will be double insulated to minimise the amount of gas boil off. These features are illustrated below in Figure 3.9.2.

The storage tanks onboard the LNG tankers will contain a complex system of inner structures that will absorb stress fluctuations resulting from wind, wave, cargo load and temperature changes. A longitudinal and lateral bulkhead will be integrated into the structure of each tank to help prevent agitating or wave movement of the LNG, especially while the ship is in a partially loaded condition. Gas that vaporises during shipment will typically be collected, compressed and used as fuel in the ship's propulsion system. Fuel requirements in excess of this natural vapourisation rate will normally be supplied by fuel oil.

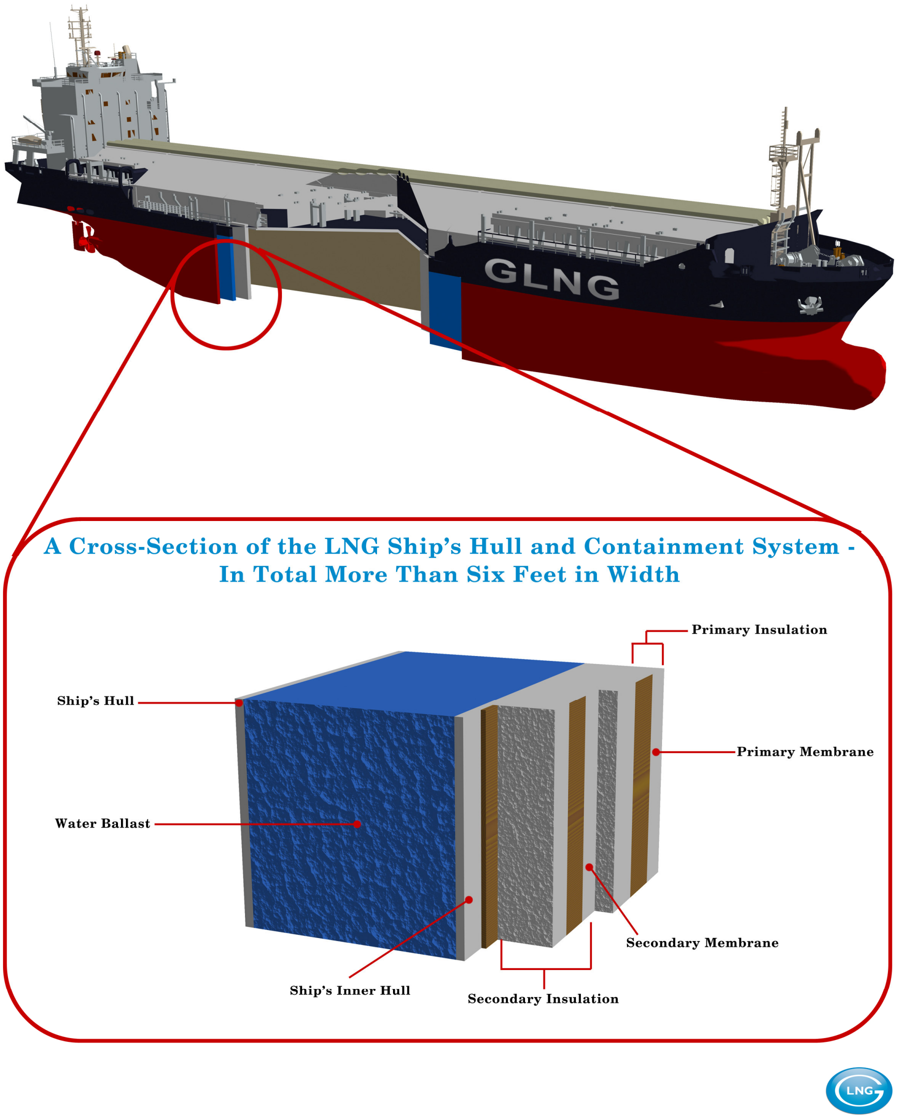


Figure 3.9.2 Double Hulled LNG Vessel

3.9.2 Ship Movements

The LNG tankers around the world vary in size. The ships that will be used to export the LNG from Gladstone will have a laden draught of up to 12.0 m, be up to 315 m in length, with a beam up to 50 m, and could contain from 130,000 m^3 to 217,000 m^3 of LNG. The largest LNG ships that currently exist (but are not planned for use at GLNG) have a 345 m length, 55 m beam and 12 m draft.

The proposed maintained depth of -13 mLAT for the proposed GLNG channel and swing basin will give all-tides access for the range of possible LNG vessels. The largest LNG carriers in existence would only be restricted by depth on a few very low tides each year (which would be acceptable if they are used). Hence there will be no need to deepen any of the proposed channels in the future, even if the LNG trade were to increase beyond expectations. The existing channels within the port are all deeper than -13 mLAT.

For comparison, at present the largest ships calling at the Port of Gladstone are Capesize class bulk carriers up to 220,000 dwt with lengths of 315 m and drafts of up to 18m. Hence the maximum draft of the largest expected LNG carrier (at approximately 12 m) is considerably less than that of the largest bulk carriers that currently dock at Gladstone. The largest bulk carriers are severely tidally restricted and can only depart on particularly high tides.

LNG tankers will enter Port Curtis and proceed along the main shipping channel to the loading berth. Turnaround time for vessels to enter and exit the port will be about 32 hours, of which product loading will take approximately 15 - 16 hours. Assuming 155,000 m^3 capacity ships, at the initial single train LNG production rate of 3 - 4 Mtpa, there will be approximately 50 ship loads exported each year, or about one ship per week. This rate will increase to 160 ships per year or about one ship every 2 days when the production rate increases to 10 Mtpa. Using larger ships will involve correspondingly fewer ship movements.

In the 2007/08 financial year (the latest year for which data are available), there were 1,368 ship visits to the port and the tonnage handled at Port of Gladstone was approximately 76 Mt. The GPC projections of trade volumes for the 2011/12 financial year show the tonnage handled at the port increasing to approximately 104 Mt. This represents an increase of 28 Mt (37 %) over a 4 year period. Assuming a proportional increase in the number of ship movements, the ship movements generated by the initial LNG facility (Train 1) will represent an approximate 3.6 % increase in ship movements in the port. Ship movements from Train 3 operations will be approximately 11.7 % of 2007/08 ship movements in the port.

The GPC and the Regional Harbour Master have been actively involved in a number of realtime navigation simulation sessions and workshops in relation to safety of the shipping to be generated by the GLNG Project. They have been actively involved in the design of navigation areas and the development of operational procedures. This close involvement will continue as the project moves to construction.

Details of the project's impacts on ship traffic are provided in Section 4.

3.10 Dredging and Dredged Material Management

3.10.1 Dredging

3.10.1.1 Product Loading Facility

To enable LNG vessels to access the PLF it will be necessary for an access channel to be dredged from the existing Targinie Channel in Port Curtis which is currently used to provide shipping access to the RG Tanna Terminal and is to be extended to provide access to the proposed Wiggins Island Terminal. The GLNG access channel will be 200 m wide and approximately 2 km long extending from the Targinie Channel to the LNG PLF. It will be dredged to a depth of -13.5 m below lowest astronomical tide (LAT). In addition, a swing basin will be dredged to -13.5 m LAT at the PLF to enable ships to manoeuvre safely.

The proposed dredging locations are shown on Figure 3.10.1.

Approximately 8 million m^3 of material will require dredging for the access channel and swing basin. The material to be dredged consists of a combination of clayey silts and sands together with approximately 240,000 m^3 of rocky material. Due to the characteristics of the material to be dredged and the presence of pockets of rock, the most technically suitable and cost effective dredging plant is a large or medium cutter suction dredge (CSD). It is most likely that a medium sized CSD will be used.

3.10.1.2 Materials Offloading Facility

Dredging may be required to ensure suitable barge and ferry access to the MOF. The volume of dredged material will be approximately 100,000 m^3.

Based on the currently available geotechnical information for the area, the characteristics of the material to be dredged for the MOF may be as follows:

- Soft silts and clay - 50 %;
- Sand and gravels – 40 %;

- Weak rock – 5 %; and
- Hard rock – 5 %.

Based on the assumed likely material, available water depths and the volume of material to be dredged, it is likely that the dredging will be carried out using a medium sized CSD. The CSD will pump dredged material to an onshore reception lagoon and settlement pond. The most suitable location for such works will be adjacent to the MOF haul road where control of the operation and the potential beneficial reuse of the material will be possible.

The size of the settlement pond will be dictated by both the quantity of discharge water and the length of time required to reduce the suspended solids content to the discharge conditions of the pond's environmental authority. The reception lagoons will be most likely constructed of imported rock fill together with sand and gravel, clay and lined with an impermeable membrane. The lagoons will be connected by pipeline and weir boxes in order that the discharge water can be transferred under gravity into the final settlement lagoon. The rate at which water moves from the reception pit into the settlement lagoon and back into the sea will be controlled by the weirs between the lagoons and preceding the final discharge pipe work.

The majority of the dredged material is expected to be suitable for engineering re-use, and thus will be used as fill material for the construction of the MOF and laydown area. However, due to the high content of soft clay in the material, it may not be possible to make use of all the material for engineering purposes (i.e. structural fill). This material will therefore remain in the reception lagoon where it will be stabilised and rehabilitated for use as landscaping. Alternatively it may be pumped to the proposed dredge material placement facility at Laird Point (see Section 3.10.2).

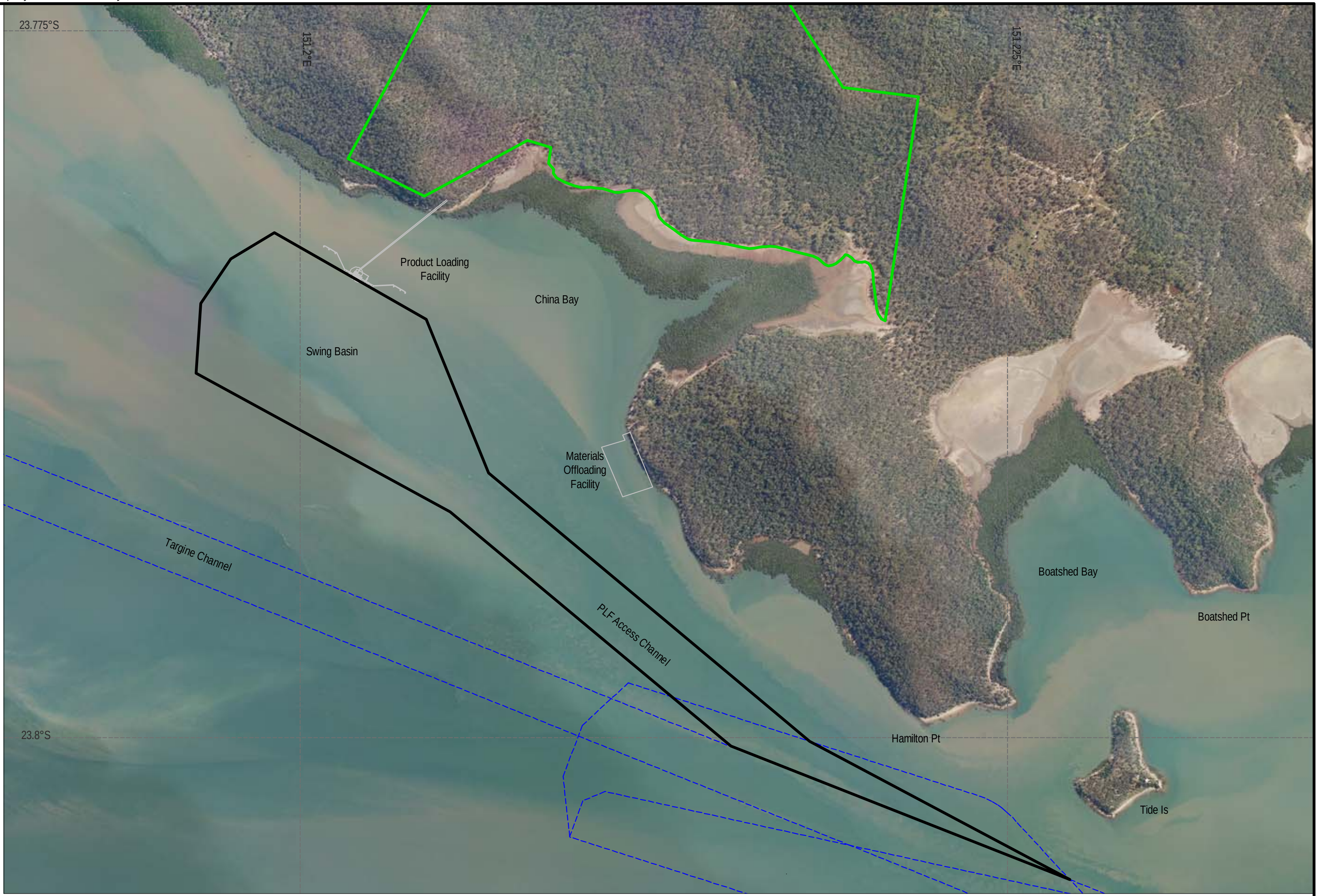
3.10.2 Marine Dredged Material Placement Facility

As discussed in section 2.3.9, the Queensland Government and the GPC are presently reviewing the dredged material management plan for Port Curtis to plan for the long term dredging and dredged material disposal that may be required to provide safe and efficient access to existing and proposed port facilities in the harbour for the foreseeable future. The plan considers dredging and dredged material disposal required for industrial and port related projects currently proposed for Gladstone. As part of the plan, the GPC is considering a single dredged material disposal area which will be large enough to accommodate the combined dredged material from all of these projects in a manner which is consistent with GPC's long term port development objectives.

The GPC and the Queensland Government propose to undertake an environmental assessment of the overall plan and to obtain the necessary approvals before adopting and implementing the plan. If the plan is approved, the dredging and the associated dredged material placement for the GLNG Project will be undertaken in accordance with the plan provided the timing of the approval is consistent with the GLNG Project requirements.

If for some reason the GPC's strategic dredging and disposal project is delayed or does not proceed, a plan specific to the GLNG Project has been prepared to manage the project's dredge material. This plan is to develop a dredge material placement facility south of Laird Point on Curtis Island.

Santos recognises that use of Laird Point as a dredged material placement facility would require approval by the Queensland Coordinator General for a material change of use of the site to allow for dredged material disposal. At the time of this EIS submission, Laird Point, while declared for LNG industry use, had not been formally acquired by a specific proponent for LNG industry use.



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Scale 1: 20 000 (A4)
Datum: GDA94

LNG Facility Site Boundary

Proposed Dredging

Existing Channel

Source 1: Copyright HR Wallingford Ltd 2009. All rights reserved. With regard to Product Loading Facility and Material Offloading Facility - These layouts are subject to alteration during detailed design development and ongoing consultation with the Gladstone Ports Corporation and the Gladstone Regional Harbour Master to ensure issues of navigation safety are appropriately addressed.

Source 2: This map may contain further data which is sourced and Copyright. Refer to Section 18.2 of the EIS for Ownership and Copyright.

Client

Project

GLADSTONE LNG PROJECT
ENVIRONMENTAL IMPACT STATEMENT

Title

ACCESS CHANNEL AND SWING BASIN

Drawn: CA | Approved: JB | Date: 06-03-2009

Job No: **4262 6220** | File No: 42626220-g-952.wor

Figure: **3.10.1**

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It is proposed to pump the dredged material to the placement facility directly from the dredge site. The pipeline between the dredge site and the facility will be in excess of 4 km and a pump booster station will be required. The pump station will be located on shore at Hamilton Point West. From there the pipeline to the dredge materials placement facility will be either offshore or onshore along the Curtis Island coast as shown on Figure 3.10.2. The dredged material will be stored in a retention facility formed by the construction of a rock-fill bund wall across the embayment to the south of Laird Point.

A decision as to whether the delivery pipeline will be located onshore or offshore will be made during FEED. The offshore option will avoid the need for land disturbance. The pipeline for the onshore option will be above ground and be able to be manoeuvred around any vegetation communities of conservation significance so as to minimise the extent of disturbance necessary.

Based on the initial conceptual design (Wallingford, 2009), the proposed dredge material placement facility will cover an area of approximately 120 ha, and will provide air space for approximately 13.2 million m^3 of dredged material. Bunds (embankments) will be constructed up to a height of 18 m (in two or more stages), with the dredged material being pumped into a series of internal ponds separated by bunds with strategically located weirs to allow the overflowing seawater to flow from one pond to the next. The dredged material will pass slowly through the ponds allowing the solid material (sand, silt etc) to settle out of the seawater. Following a period of controlled settlement and monitoring, the seawater will be discharged back into marine environment.

The placement facility will have a capacity of approximately 10.7 million m^3 of consolidated dredged material. Allowing for bulking of the dredge material this is more than adequate for the capital dredging of the swing basin and access channel. It could therefore also provide some capacity for ongoing maintenance dredging. In time however, maintenance dredging material will have to be placed in other dredge material placement facilities, the authority for which will be sought by GPC. Studies are ongoing to assess the likely rates of siltation in the swing basin and will inform likely future maintenance dredging volumes.

It is likely that initially a 10 m high bund will be constructed with 1:5 side slopes and a 4 m wide access track on top. It will be an engineered bund built with a sand and clay inner core and rock facing for protection against tidal and wave action. The foundation is yet to be designed but it is possible that the existing soft material will be excavated and a geotextile fabric used to provide foundation stability. It is expected that 90 % of the 400,000 m^3 (approximately) of construction materials required will be available from within the footprint of the facility. The balance of the construction materials will be transported by barge from the LNG facility construction site.

The initial bund height of 10 m will be similar to that at Fisherman's Landing. Any subsequent bund raising will be undertaken using the dredged material.

The construction equipment required will include excavators, dump trucks and dozers. They will be transported to the site by a barge that will be ramp equipped for unloading via a causeway which will also be used for unloading any construction materials barged from the LNG facility site. The causeway will most likely comprise a bund of suitable material placed over the existing salt flat out to the 0 m LAT (lowest astronomical tide) contour. The foundation is yet to be designed but it is expected that the existing soft material will be excavated and a geotextile fabric used to provide foundation stability. The causeway will be topped with a suitable wearing surface to enable the unloaded plant and equipment to be transported to the work areas.

A construction workforce of approximately 50 is expected for an 18-month construction period. They will be ferried from the mainland on a daily basis and have been assumed to be available from the existing Gladstone workforce.

The dredge material placement facility will be designed and managed to ensure that the quality of discharge water complies with the relevant environmental authority approval conditions. The impacts of the discharge are discussed in Section 8.7. Details of the facility and its water management system are provided in Section 8.17.

3.11 Access to Curtis Island

3.11.1 Dual Options

The Queensland CG, as the lead agent for a working group comprising the Department of Infrastructure and Planning (DIP), Gladstone Ports Corporation Limited (GPC), Santos and the BG Group/Queensland Gas Company (QGC) joint venture, has engaged consultants to prepare concept designs of a potential road and bridge that could provide access from the mainland to Curtis Island (Connell Wagner, 2008a and Connell Wagner, 2008b).

Access to the LNG facility from the mainland will occur by either of the following options:

- The provision of road access to Curtis Island by way of an access road and bridge from the mainland crossing Port Curtis between Friend Point and Laird Point. Construction phase access to the site for at least Train 1 will be by barge and ferry as the access road and bridge will not be available at that time; or
- Access to the site by barge or ferry for the life of the GLNG Project (for both construction and operation) if the access road and bridge is not constructed.

A decision on which option is to be adopted will be made during FEED when it is expected that greater clarity will be available on the likelihood and timing of the access road and bridge option. For the purposes of this EIS both options have been assessed.

3.11.2 Bridge and Access Road Option

3.11.2.1 Bridge

The preferred alignment for the bridge is shown on Figure 3.11.1.

This alignment has been adopted to achieve:

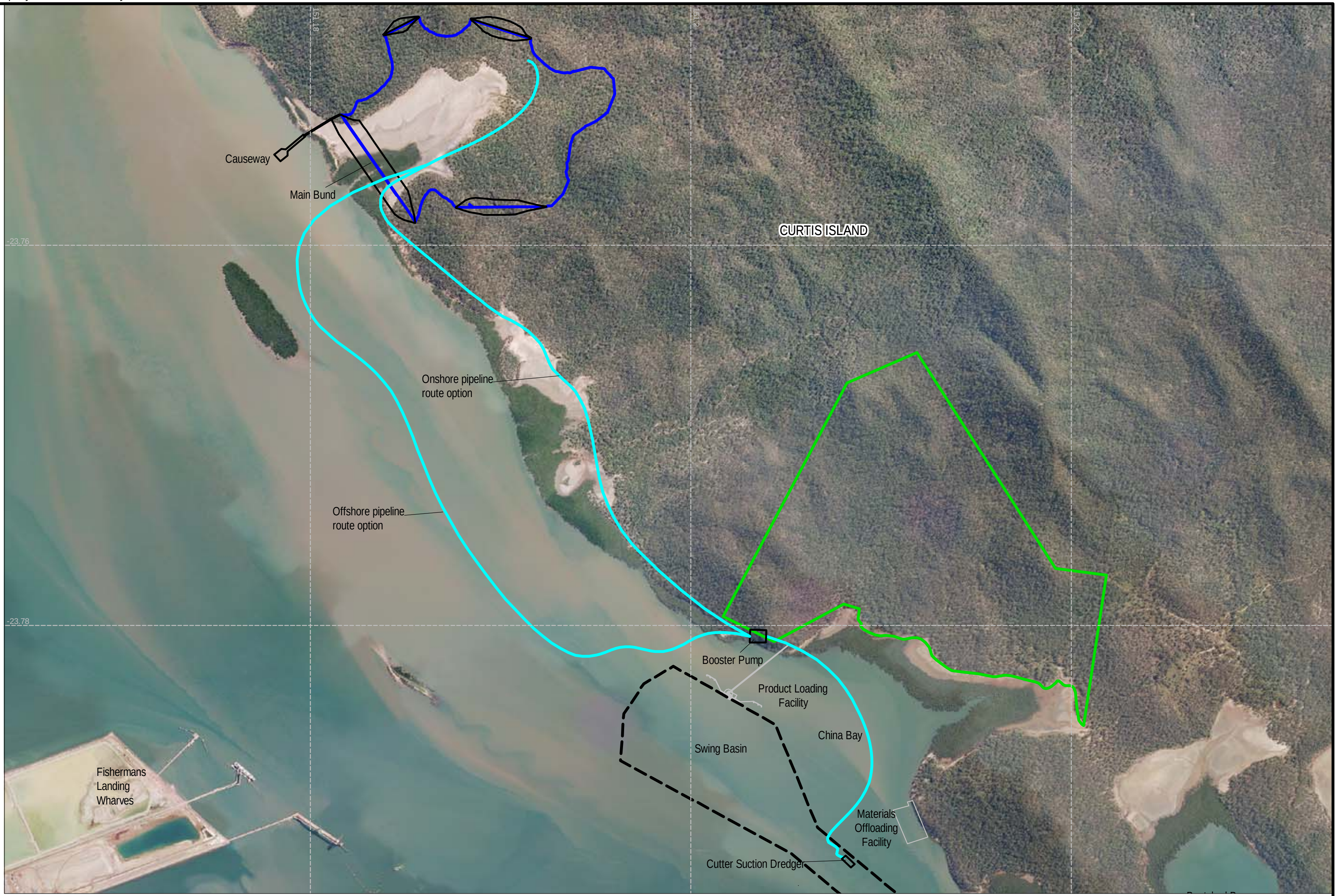
- Minimal impact on port development and potential land use on Curtis Island, by aligning the eastern approaches to the north of Laird Point;
- Minimal footprint over seagrass areas by aligning the western approaches as far north as possible and still achieve the following:
  - Straight horizontal alignment for bridge structure; and
  - Non-skewed bridge structure, i.e. bridge aligned perpendicular to tidal flow.

The western approach of the access road to the bridge is across the tidal area north of Landing Road to Friend Point. This is consistent with the draft Gladstone Land Port Rail Road Infrastructure Study in that it is aligned to the southern edge of the mudflats to:

- Minimise the length of the road element over the softer ground conditions; and
- Maximise the area of land on the northern side available for future port related activities.

The preferred route alignment for the bridge is partially within (eastern end) and partially outside (western end) the State Marine Park which extends to the north along The Narrows (Figure 3.11.1).

The bridge will have a two lane precast segmental box girder superstructure on cast in situ pier, pile cap and 1,500 mm diameter bored piles. The span between the piers will be 50 - 70 m and the total bridge length will be approximately 1.5 km. The bridge will have a vertical clearance of 20.5 m above highest astronomical tide level and 23.0 m above mid tide level with a horizontal clearance between piers of at least 30 m within the region of the main waterway channel. This clearance envelope has been adopted to allow for the movement of recreational vehicles between Port Curtis and The Narrows. Plan and elevation views of the bridge are given in Figure 3.11.2 with cross sections shown in Figure 3.11.3.



N W E S

0 500 1000m

Scale: 1:30,000 (A4)
Datum: GDA94

Dredge Delivery Line
Dredge Material Placement Facility
Proposed Dredging
LNG Facility Site Boundary

 With regard to Product Loading Facility and Material Offloading Facility - These layouts are subject to alteration during detailed design development and ongoing consultation with the Gladstone Ports Corporation and the Gladstone Regional Harbour Master to ensure issues of navigation safety are appropriately addressed.

Source: This map may contain data which is sourced and Copyright. Refer to Section 18.2 of the EIS for Ownership and Copyright.

Client

URS

Project
GLADSTONE LNG PROJECT
ENVIRONMENTAL IMPACT STATEMENT

Title
MARINE DREDGE MATERIAL PLACEMENT FACILITY

Drawn: RG | Approved: JB | Date: 16-03-2009

Job No: **4262 6220** | File No: 42626220-g-1017.wor

Figure: **3.10.2** | Rev:B | A4

The CG has indicated:

- The bridge will not be open to the public and will only connect with industrial developments in the GSDA's Curtis Island Industry Precinct. However public access may be allowed in emergency situations such as bushfires or cyclones.
- South End residents may be able to access the bridge and people that have moored in Graham's Creek may be permitted to access the mainland.

3.11.2.2 Access Road

The proposed Curtis Island access road will extend from the northern end of Landing Road at Fisherman's Landing along the coast above the high water mark for a distance of approximately 2.5 km, then north-east across the intertidal area from the mainland to the southern tip of Kangaroo Island (Friend Point) to the western end of the proposed bridge location. From the eastern end of the bridge the road will continue east along the southern side of Graham Creek for approximately 2.5 km then turn south-east to Hamilton Point along the western side of an existing ridgeline. The total length of the road will be approximately 15 km. Its proposed alignment is shown on Figure 3.11.4.

The primary function of the road will be to provide access from the mainland to the Curtis Island Industry Precinct for the movement of workers and freight for industry and port activities that may be developed in the Industry Precinct of the GSDA.

The concept design for the road is for a two-lane, two-way carriageway with limited, controlled access. Its design capacity will be 2,000 vehicles per day and the design speed will be 110 km/h. It will have two 3.5 m wide traffic lanes and 1.5 m wide shoulders. Details of the concept design are given in Connell Wagner (2008b).

The alignment of the western section of the proposed road has taken into consideration the following constraints:

- Avoidance of an existing mining lease;
- Minimising any impact on an existing mining lease application;
- Avoidance of areas proposed for future port development; and
- Minimisation of impacts on existing marine vegetation by using an alignment between two linear mangrove communities.

The in-situ materials over which the road embankment is to be built are such that the embankment can be constructed in staged lifts with periods allowed between lifts for settlement to occur. It will typically comprise a standard earth embankment built in accordance with the DMR Standard Specification MRS 11.04 General Earthworks. It is envisaged that the embankment can be built over a period of months. The proposed embankment and construction methodology is standard practice for road embankments and is expected to have minimal impact on the in-situ materials. However, the potential may exist for the embankment loading to create vertical heaving of the in-situ materials outside the footprint of the embankment, i.e. a bow wave effect, and this will be identified and addressed in the FEED phase.

In crossing the intertidal area the road will be placed on a fill embankment with a minimum development level of 5.5 m Australian Height Datum (AHD) to avoid tidal influences, wave set up, storm surge and possible sea level rises due to climate change. This is higher than the design levels for the Fisherman's Landing port development (4.0 to 4.5 m AHD) and for Landing Road over tidal areas (4.5 to 5.0 m AHD).

The natural surface level of the intertidal area is approximately RL 1.7 - 1.8 m AHD with a mean high water spring tide level of 1.56 m AHD and a highest astronomical tide level of 2.34 m AHD. Only extremely high tides flood this area and it is inundated from both directions (both from the east and west) at the same time. Investigations to date indicate that there are only negligible flows across this area during extreme high tides and the effect of building a road embankment on tidal flows will be minimal with little need, if any, for drainage through the embankment. This conclusion will be further assessed during the detailed design of the road.

URS

Client: LNG

Project: GLADSTONE LNG PROJECT ENVIRONMENTAL IMPACT ASSESSMENT

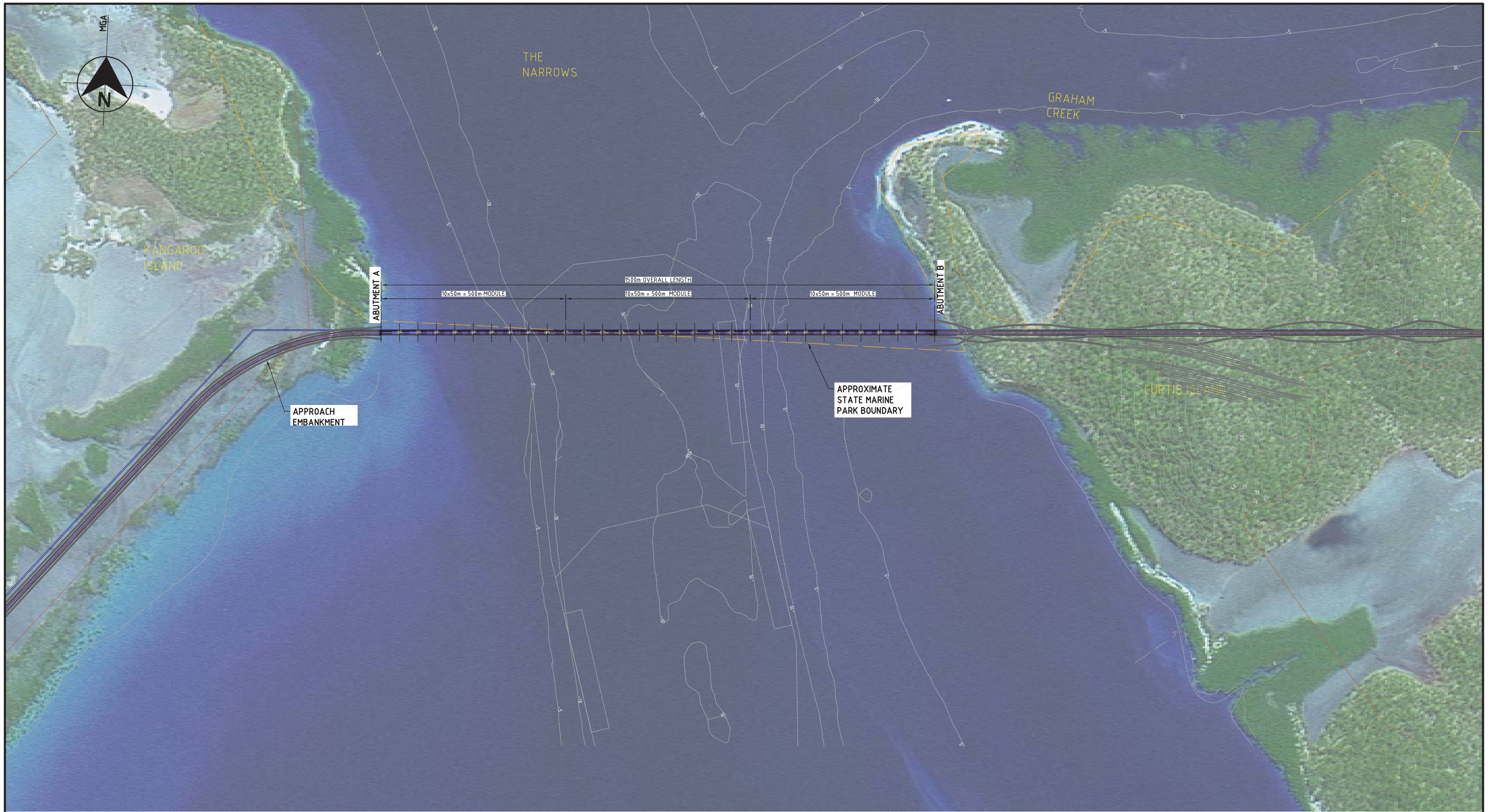
Title: PROPOSED BRIDGE ALIGNMENT

Drawn: AA | Approved: JB | Date: 06-03-2009

Job No.: 4262 6220 | File No. 42626220-g-949.cdr

Figure: 3.11.1

Rev. A | A4



PLAN
SCALE 1:5000

TIDAL PLANES
HAT 2.42m
AHD 0.00m
LAT -2.27m

100 0 100 200 300 400 500m
SCALE 1:5000

PRELIMINARY
NOT FOR CONSTRUCTION

Rev.	Date	Revision Details	Drn	Ver.	App.
03	11/12/08	BRIDGE SUBSTRUCTURE REVISED	JLP		
02	28/11/08	RAIL ALIGNMENT REMOVED	JLP		
01		BRIDGE PLANNING REPORT ISSUE	JLP		

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Client: Queensland Government — Department of Infrastructure and Planning

Project: CURTIS ISLAND ROAD / BRIDGE CONCEPT DESIGN

		Signed	Date
Drawn	JLP		
Designed	YPT		
Verified			
Approved			

Drawing Title: CURTIS ISLAND INFRASTRUCTURE CORRIDOR PREFERRED ALIGNMENT - 110km/hr - 50m SPAN GENERAL ARRANGEMENT SHEET 1 OF 3

Project No. 36914

Scale: 1:5000 | Sheet Size: A1

Drawing No. CI-CD-BR-B-GA-001 | Rev. 03

URS

Client

Project

GLADSTONE LNG PROJECT
ENVIRONMENTAL IMPACT ASSESSMENT

Title

BRIDGE PLAN
& ELEVATION

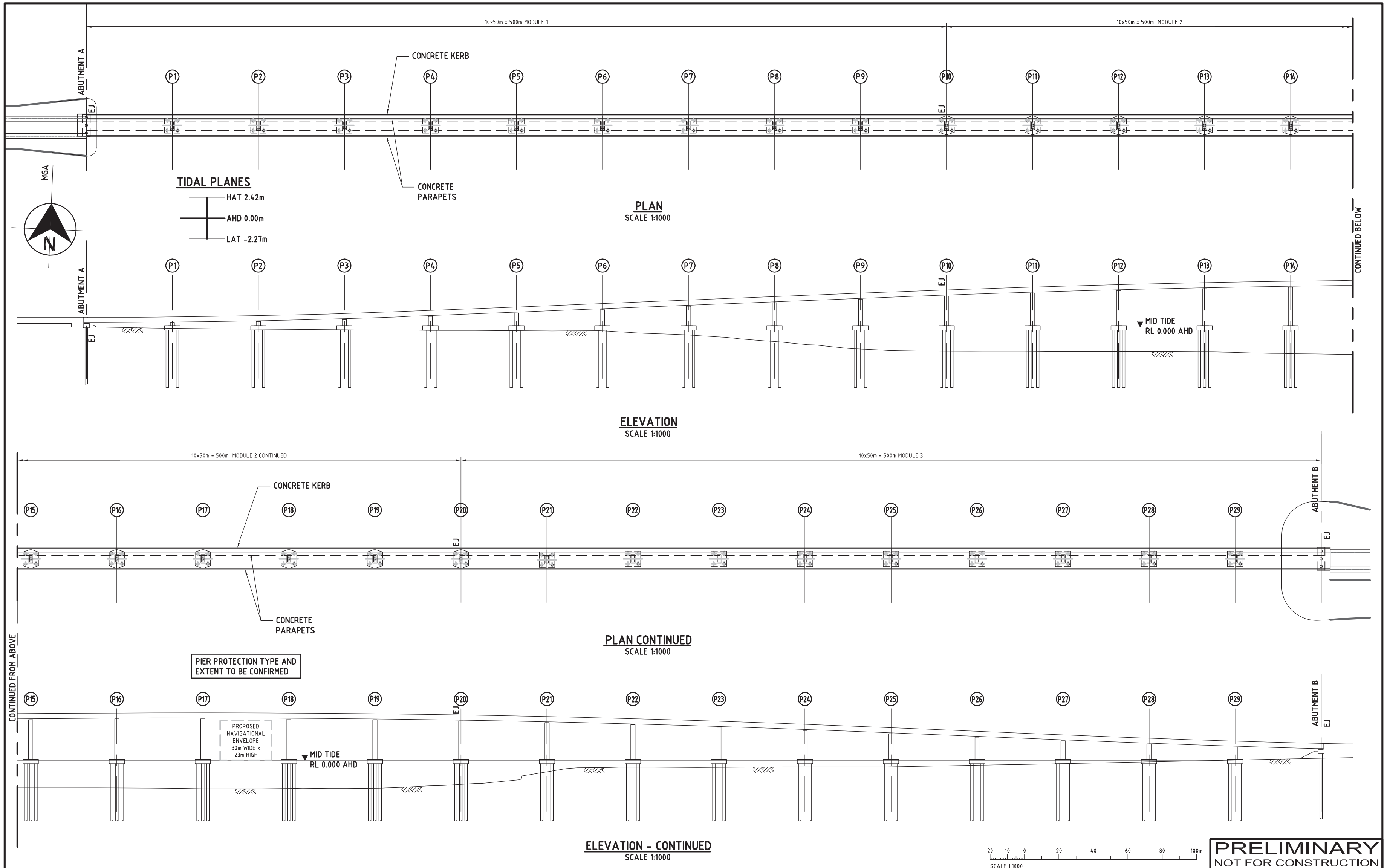
Drawn: AA | Approved: JB | Date: 06-03-2009

Job No.: 4262 6220 | File No. 42626220-g-950.cdr

Figure: 3.11.2

Rev. A

A4



PRELIMINARY
NOT FOR CONSTRUCTION

Rev.	Date	Revision Details	Drn	Ver.	App.
03	11/12/08	BRIDGE SUBSTRUCTURE REVISED	JLP		
02	28/11/08	VERTICAL ALIGNMENT REVISED	JLP		
01		BRIDGE PLANNING REPORT ISSUE	JLP		

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Client: Queensland Government
Department of Infrastructure and Planning

Project: CURTIS ISLAND ROAD / BRIDGE CONCEPT DESIGN

Drawn	JLP	Signed	Date
Designed	YPT	Signed	Date
Verified		Signed	Date
Approved		Signed	Date

Drawing Title:
CURTIS ISLAND INFRASTRUCTURE CORRIDOR
PREFERRED ALIGNMENT - 110km/hr - 50m SPAN
GENERAL ARRANGEMENT
SHEET 2 OF 3

Project No. 36914

Scale 1:1000 | Sheet Size A1

Drawing No. CI-CD-BR-B-GA-002 | Rev. 03

URS

Client: LNG

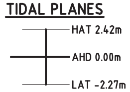
Project: GLADSTONE LNG PROJECT
ENVIRONMENTAL IMPACT ASSESSMENT

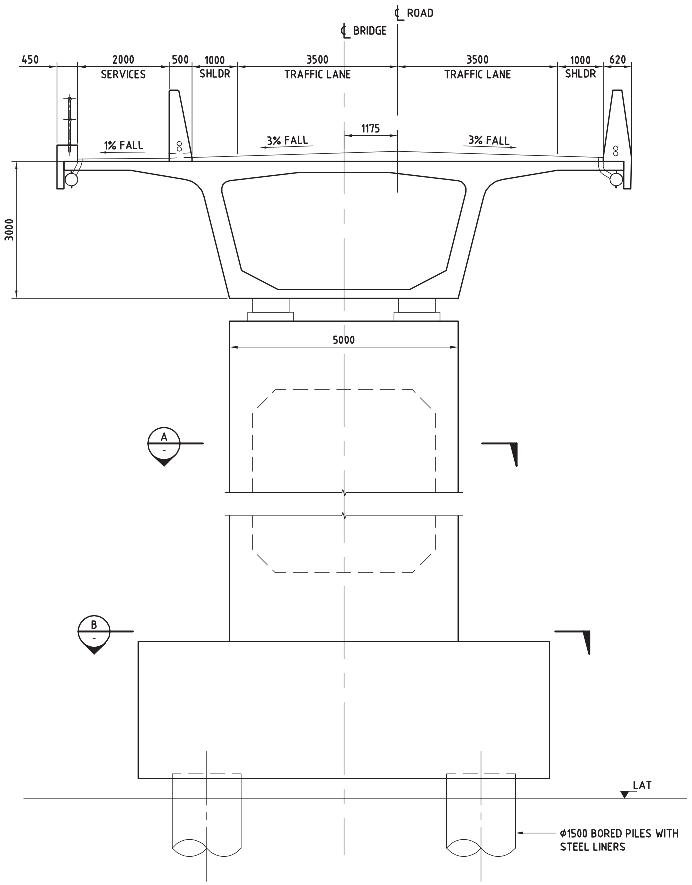
Title: BRIDGE CROSS SECTION

Drawn: AA | Approved: JB | Date: 06-03-2009

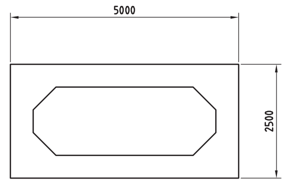
Job No.: 4262 6220 | File No. 42626220-g-951.cdr

Figure: 3.11.3 | Rev. A | A4

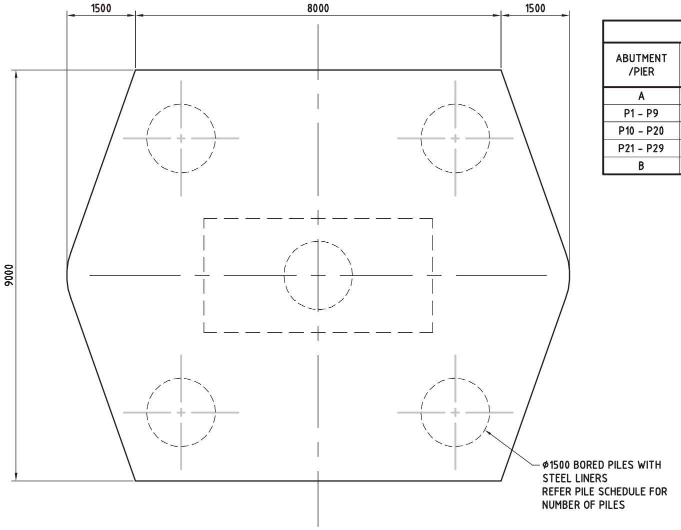




PIER - TYPICAL SECTION
SCALE 1:50



SECTION A
SCALE 1:50



SECTION B
SCALE 1:50

PILE SCHEDULE

ABUTMENT /PIER	NO. OF PILES	ESTIMATED LENGTH OF PILES (m)
A	3	35
P1 - P9	4	35
P10 - P20	5	50
P21 - P29	4	35
B	3	35

SCALE 1:50

PRELIMINARY
NOT FOR CONSTRUCTION

Rev.	Date	Revision Details	Drn	Ver.	App.
03	11/12/08	BRIDGE SUBSTRUCTURE REVISED	JLP		
02	28/11/08	ROAD CONFIGURATION REVISED	JLP		
01		BRIDGE PLANNING REPORT ISSUE	JLP		

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Client: Queensland Government
Department of Infrastructure and Planning

Project: CURTIS ISLAND ROAD / BRIDGE
CONCEPT DESIGN

Drawn: JLP | Designed: YPT | Verified | Approved

Drawing Title: CURTIS ISLAND INFRASTRUCTURE CORRIDOR
PREFERRED ALIGNMENT - 110km/hr - 50m SPAN
GENERAL ARRANGEMENT
SHEET 3 OF 3

Project No. 36914
Scale 1:50
Sheet Size A1
Drawing No. CI-CD-BR-B-GA-003
Rev. 03

3.11.3 3.11.3 Ferry/Barging Option

3.11.3.1 Ferry Operations

Ferries will be used to transfer construction workers from the mainland to Port Curtis during the construction of Train 1. In the event that the potential access road and bridge option does not proceed, the ferry operation will continue for the life of the GLNG Project. Should the access road and bridge be built at some later stage, it will then be used and the ferrying operation will cease.

A number of options exist to provide a ferry service for the project. These include:

- Use of the existing Curtis Ferry Service which operates two 150 passenger capacity ferries from the Gladstone Marina. These ferries have an operating speed of 10 knots.
- Use of a high speed "fast-cat" service using ferries with a passenger capacity of 300 - 400 and speeds of 15 - 25 knots. This will require the use of ferries not currently available in Gladstone.
- Placing the buses directly onto barges which will also be used for the transfer of construction equipment. The buses could then be used to transfer the workers directly to the construction workers accommodation facility.
- A combination of the above.

To estimate the number of ferry trips necessary for the construction phase, the following assumptions have been made:

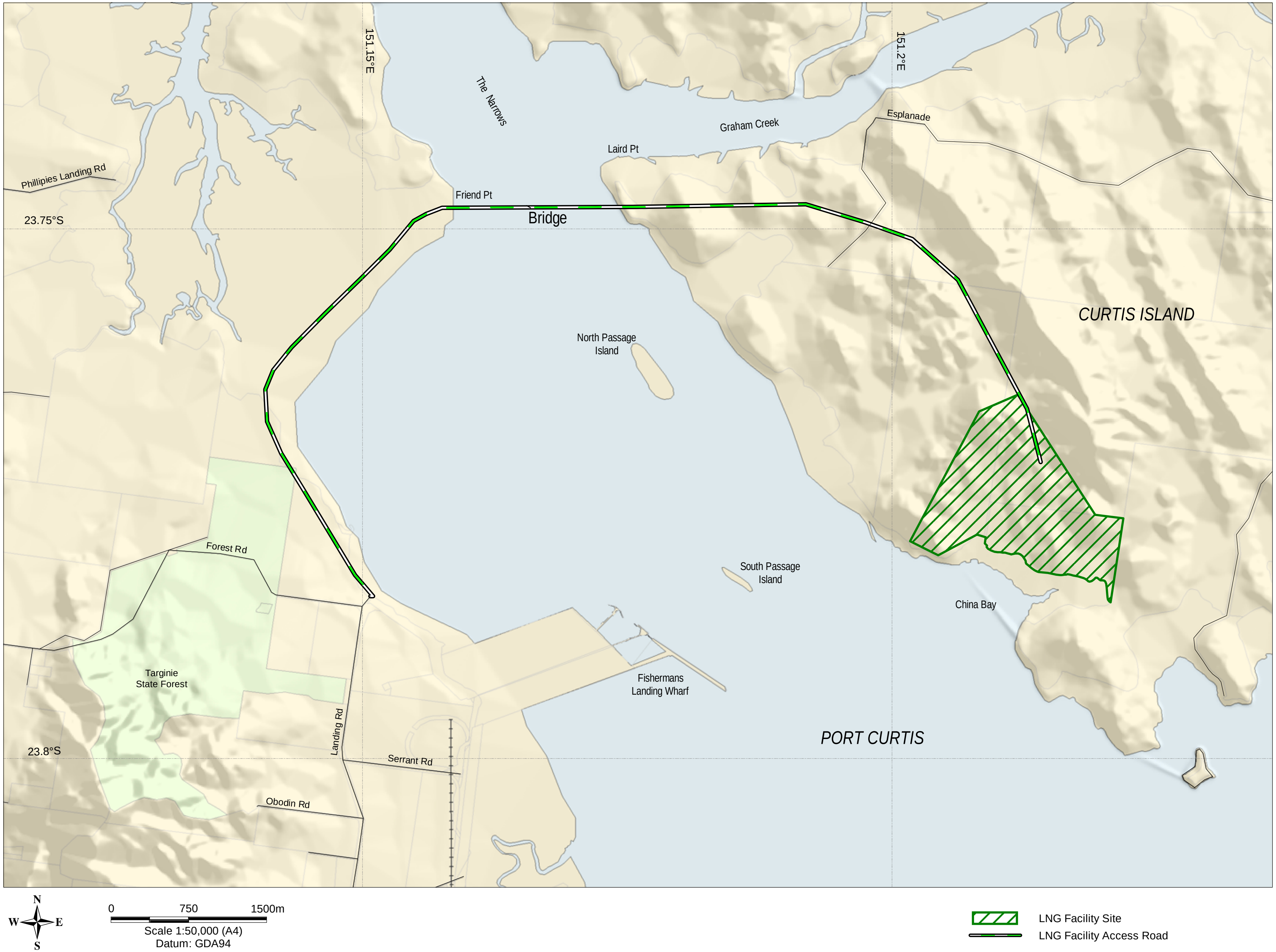
- All construction workers will live in the construction workers accommodation facility on Curtis Island;
- All construction workers will work for a 10-day period followed by a 4-day rostered-off period;
- Two thirds of the workforce will be working at any one time and the remaining one third will be on leave; and
- All ferry trips are back-loaded (i.e. all ferries delivering workers to the island will bring returning workers back).

On this basis, the Train 1 construction will require 21 ferry trips per 14-day work cycle. This equates to one to two ferry trips per day (1,500 trips in total during the whole construction phase). The construction of Trains 2 and 3 will require approximately one ferry trip per day (900 trips in total during each construction phase).

The above estimates of ferry movements have been based on the stick-built construction option. Should pre-assembled modules be used, there is unlikely to be any significant reduction in ferry movements although the capacity of the ferries could be reduced.

During the operations phase, the workforce will be accommodated on the mainland and will travel to Curtis Island on a daily basis. As discussed in Section 3.8.3.8, maintenance and administration workers will work week days for eight hours with weekends off. The operations workers will work 12-hour shifts which could be on a two-weeks-on/two-weeks-off roster. On this basis there could be up to four ferry trips per day depending on the final roster selection. Due to the smaller workforce, the capacity of the ferries used during operations will be much less than that proposed for the construction phase.

As discussed in Section 2.3.4.2, following an assessment of alternative sites and based on discussions with the GPC, the preferred site for the ferry terminal on the mainland is Auckland Point. It is proposed that some upgrades will be undertaken to provide adequate ferry docking and vehicle parking facilities. On Curtis Island, the ferry terminal will be at the MOF.



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Client

Project

GLADSTONE LNG PROJECT
ENVIRONMENTAL IMPACT STATEMENT

Drawn: CA | Approved: JB | Date: 06-03-2009

Job No: **4262 6220** | File No: 42626220-g-810.wor

Title

ACCESS ROAD LOCATION

Figure: **3.11.4**

Rev: A

A4

3.11.3.2 Barging Operations

During construction, barges will be used to transport construction materials from the mainland to Curtis Island. This will include aggregate, cement, piping, structural steel, electrical and instrumentation equipment, and machinery. The barges will be loaded at Auckland Point and offloaded at the MOF.

Stick-Built

For the stick-built option, there will be approximately 2,500 barge trips for Train 1 construction. The barges will carry trucks loaded with construction materials and a capacity of four trucks per barge has been assumed. Most of the barge traffic will occur during the peak 24 month period of the construction phase. If it was evenly spread over that time it will result in three to four barge trips per day. However there will be periods of peak construction activity when the daily barge traffic will be greater than this.

For the construction of Trains 2 and 3, approximately 1,200 barge movements will be required for each train. This is because the construction of subsequent trains will required less material than the initial construction. The daily barge movements for the construction of Trains 2 and 3 could be approximately half that for Train 1.

Pre-Assembled Modules

For the pre-assembled module option, there will be a significant reduction in the amount of construction materials and equipment that will need to be barged from the mainland. The actual reduction cannot be estimated until the extent of modular construction is determined during FEED, however it can be assumed that the barge traffic between Auckland Point and the MOF will reduce by one third to one half of that required for the stick-built option.

The local barge traffic will be replaced by barges and heavy lift vessels coming from domestic or overseas locations delivering the pre-assembled modules. It has been estimated that there could be approximately 10 heavy lift vessels trips and 30 barges trips required to delivered the pre-assembled modules spread over three years of the construction phase. The estimated number and size of modules to be delivered is shown in Table 3.11.1.

Table 3.11.1 Estimated Number and Size of Modules

Module	Number	Size (tonnes)
Process	32	700 - 2,500
Utilities	60	200 – 500
Jetty/piperack	25	100 - 300

The modules will be offloaded at the MOF onto self-propelled motorised transporters which will be designed to carry the heavy loads along the haul road to the construction site.

Under Australia's quarantine regulations, the GLNG Project will undertake cleaning of any imported equipment. To avoid the possibility of re-exporting due to contamination, offshore inspection by an appropriate AQIS or equivalent officer may be undertaken at the module construction site prior to shipment.