9 LNG COMPONENT OPERATIONS

9.1 OVERVIEW

This chapter, *Chapter 9*, discusses the operations of the LNG Component of the Queensland Curtis LNG (QCLNG) Project.

The LNG Component of the Project comprises development, construction and operation within the Curtis Island Industry Precinct of the Gladstone State Development Area (GSDA) of a LNG processing plant (LNG Facility) with production capacity up to 12 million tonnes per annum (mtpa), nominally comprising three LNG processing units or "trains" with 4 mtpa production capacity each.

The LNG Component comprises:

- gas pre-treatment, including inlet receiving and metering, gas pre-treatment facilities for the removal of water and impurities from the feed gas
- gas liquefaction units sized for nominal 4 mtpa production per train
- LNG storage, including three full containment LNG storage tanks with 160,000 m³ capacity each, a full containment propane storage tank with 100,000 m³ capacity for product spiking
- LNG loading / propane unloading facilities, including jetty and docking facilities
- utilities and supporting services which include a Pioneer Dock, Materials Offloading Facility (MOF), fuel and chemical storage and handling, fire protection and safety systems, flare / vent systems, process control, general utilities, etc.

The site boundary on Curtis Island covers approximately 268 hectares above the highest astronomical tide (HAT), with an additional proposed wet lease area (below HAT) of approximately 71 ha. Within this boundary, the Facility onshore footprint (above HAT) will occupy approximately 140 ha. An additional 25 ha is required for intertidal and marine facilities (including jetty, docking facilities, and MOF) and 29 ha for other shore disturbance related matters such as the placement of excess site strip material within the LNG Facility boundary (refer *Volume 2, Chapter 13*). This represents a total disturbance of 57.2 per cent of the site allocated for this development.

The LNG Facility has been designed for continuous 24-hour operation.

Table 2.9.1 shows the total area, disturbed and undisturbed, required for the LNG Component on Curtis Island.

Table 2.9.1 Indicative LNG Facility Site Area

	Indicative Disturbed Area[1]	Total Area (disturbed & undisturbed)
	LNG Facility Footprint[2]	
Area of LNG Facility above HAT	140 ha	268 ha
Proposed Wet Lease Area[3]	25 ha	71 ha
Total	165 ha	339 ha

Notes:

1: Indicative Disturbed Area is the area that it is currently anticipated will be disturbed by construction and operation of the LNG Component. This area may be refined slightly during further detailed design.

2: The LNG Facility footprint is the footprint within which physical construction and operations activities will be undertaken.

3: Activities within the proposed Wet Lease Area include bulk earthworks within the intertidal zone below HAT, and footprint of the Materials Offloading Facility (MOF) and LNG jetty.

A site layout plan is presented in *Figure 2.9.1* showing the boundary, the LNG Facility's onshore and marine footprint, the location of key facilities.

For the purposes of this Environmental Impact Statement, (EIS) the operation of the LNG Component is described under the headings:

- LNG Process
- LNG Loading/LPG Unloading Facilities
- Utilities and Supporting Services.

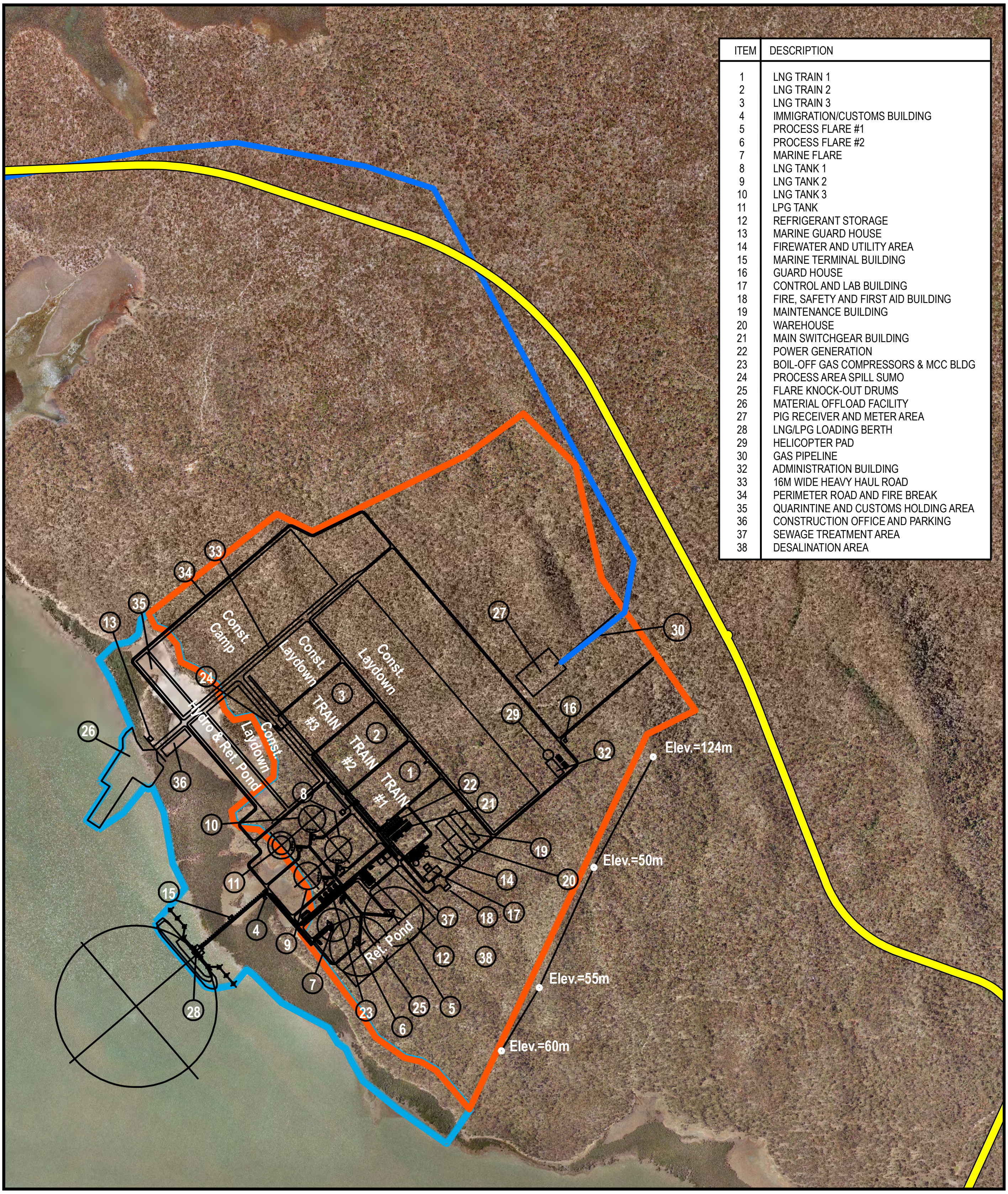
9.1.1.1 LNG Process Overview

The LNG process comprises gas pre-treatment, liquefaction and subsequent storage, as outlined below.

- **Gas pre-treatment.** Raw gas (or feed gas) from the Gas Field Component is piped to the LNG Facility where it is cleaned to remove any impurities.

  Gas received from the Pipeline is metered at the inlet to ensure there are no gas leaks throughout the Pipeline and for custody transfer.

- **Liquefaction.** The treated gas is cooled to about -162ºC through a cryogenic process undertaken in parallel processing units, or "trains", using the ConocoPhillips Optimized Cascade Process℠. At this low temperature the gas becomes a liquid. Essentially, liquefaction technology makes it more economical to safely store and transport natural gas.



Legend

- Proposed QCLNG Site Boundary
- Indicative Wet Lease Area
- QCLNG Footprint Plant Layout
- Possible Curtis Island Road/ Bridge Corridor
- Proposed Export Pipeline

Source Note:
Aerial Photo - Department of Infrastructure and Planning for QCLNG Project
Curtis Island Road Corridor - Connell Wagner

Projection: UTM MGA Zone 56
Datum: GDA 94

0 125 250 500 m

N

QUEENSLAND CURTIS LNG
A BG Group business

ERM
Environmental Resources Management Australia Pty Ltd

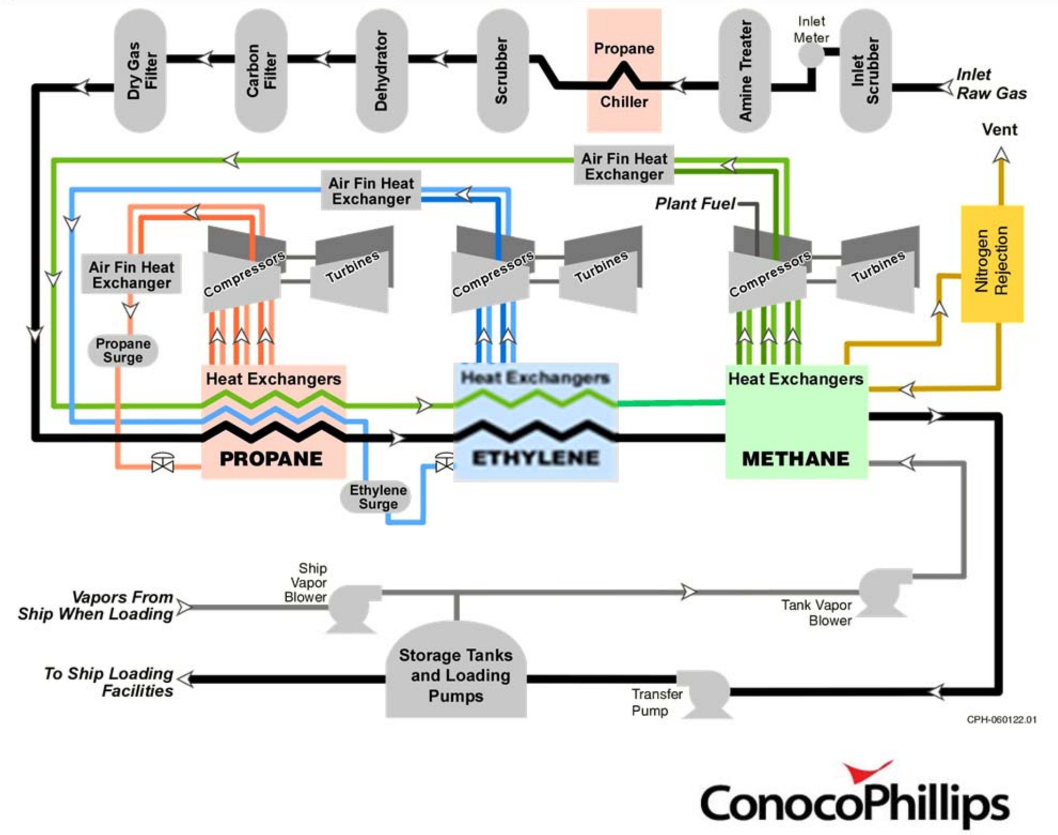
Project	Queensland Curtis LNG Project	Title	LNG Facility Layout
Client	QGC - A BG Group business		
Drawn JB	Volume 2 Figure 2.9.1		
Approved GB	File No: 0086165b_EIS_LFO_GIS001_F2.9.1		
Date 20.05.09	Revision 1		

9.1.1.2 *QGC plans to commission Train One in late 2013 and Train Two approximately six to 12 months later in early- to mid-2014. A third parallel train (covered by this EIS) is planned.*

As the LNG trains are progressively brought online, the LNG Facility will have annual production capacity of nominally 12 mtpa of LNG with the three producing trains. The average production capacity of each train is approximately 3.68 mtpa as it takes into consideration the expected average feed gas-flow rates and long-term availability of the processing equipment.

- **LNG storage:** Following the liquefaction process, the LNG is stored in specially designed, fully contained storage tanks. QGC proposes to initially construct two LNG storage tanks for Trains 1 and 2, each with capacity up to 180,000 m^3 (detailed design ongoing but preliminary design indicates tank size of between 160,000 m^3 and 180,000 m^3). A third tank of similar capacity will be constructed and commissioned when the third LNG train is built. One tank with capacity of approximately 100,000 m^3 may be used to store propane prior for use in spiking LNG, as propane may be required sometimes to spike LNG prior to export to achieve a higher heating value (HHV) to meet market/consumer demands for natural gas with a specific HHV. *Figure 2.9.2* provides a schematic overview of the LNG Optimised Cascade Liquefaction process.
- **LNG Loading/Propane Unloading Facilities,** including
  - a marine jetty consisting of a reinforced concrete loading platform and associated mooring dolphins, breasting dolphins, fabricated structural steel access catwalk, marine operations control building, vehicle parking (for Facility vehicles only), LNG loading facilities and propane unloading facilities.
  - an access trestle of reinforced concrete and fabricated structural steel, connecting the loading platform to onshore facilities and including an access road, footpath, pipe rack and pipework for LNG and propane transfer, and utilities including firewater systems, and vapour return system
  - a marine flare system for disposal of vapours from LNG ships under upset conditions where boil-off gas (BoG) compressors are not operating, and for venting of inert gases from vessels which arrive at the jetty direct from dry dock.

Figure 2.9.2 LNG Process Schematic[1]



- **Dredging works**, within the Port of Gladstone to allow all-tide access to/from the jetty for vessels to approximately 12 m loaded draft (capacity 180,000 m^3), with 10 per cent (1.2 m) under-keel clearance. The works will require:
  - dredging of a new channel and swing basin and
  - dredging to upgrade a number of existing channels..
- **Utilities and Supporting Services**, comprising
  - Flare / vent systems, including two process flares being a wet flare system for warm gases and blowdown and a dry flare system for the cold gases and blowdown, plus a marine flare for the disposal of vapours from upset conditions during loading of ships and venting of inert gases from vessels
  - control systems, power generation and associated utilities
  - a Materials Offloading Facility (MOF). The MOF will be used to facilitate personnel movement and for the offloading of large/heavy equipment shipped directly to the site. It will also permit waste removal services from the LNG Facility during the operation phase.

1 Figure copyright ConocoPhillips. Used with permission

- associated utilities and infrastructure such as compressed air, water treatment and distribution, nitrogen, refrigerant storage, miscellaneous storage (diesel fuel, lube oil etc.), power generation/distribution, fire protection and safety, stormwater management, waste management, telecommunications systems, sewage treatment plant (STP).
- common buildings including administration offices, maintenance and compressor control rooms, control centres, workshops, staff amenities, training rooms, first-aid facilities and communications centre. Also required are rest/refuge areas for temporary accommodation of personnel (approximately 30 beds) at peak times and as part of shift management.
- ferry terminals and staging areas on Gladstone mainland for personnel transit to and from the Facility by ferry and/or water taxi. This infrastructure will also allow for the ongoing transit of plant, materials and equipment to the LNG Facility and waste removal from the Facility. The terminals and staging areas will have roll-on roll-off capability to allow rapid embarkation/debarkation transport of trucks and mobile equipment.
- Auckland Point will be the primary ferry terminal and staging area for the construction phase of the Project, and is described in *Volume 2, Chapter 13*. For operations, the ferry terminal/staging is proposed along the shoreline behind the existing RG Tanna Coal Terminal, with access via Alf O'Rourke Drive.
- Final configuration of this infrastructure is subject to commercial arrangements with Gladstone Ports Corporation (GPC). An indicative location of the operations ferry terminal is shown in EIS *Volume 2, Chapter 4*, *Figure 2.4.2*.
- an administration building(s) in Gladstone City or surrounding mainland.

Operation of the LNG Facility is described in detail below. An indicative photomontage of the LNG Facility is provided in *Figure 2.9.3*.

9.2 LNG PROCESS

The section contains a detailed description of the LNG Facility design and process.

9.2.1 Pre-treatment

9.2.1.1 Inlet Receiving and Metering

CSG from the Pipeline will enter the LNG Facility via gas pipeline described in *Volume 2 Chapter 8*. It will be filtered to remove entrained pipeline debris, metered, and sent to the gas-treating section.

The feed gas is then heated via a feed gas heater (if required) to prevent hydrate formation when the gas pressure is reduced (i.e. on occasions when the inlet temperature is low). Typically, at the end of this process the gas is dry and contains no free water or hydrocarbon condensate.

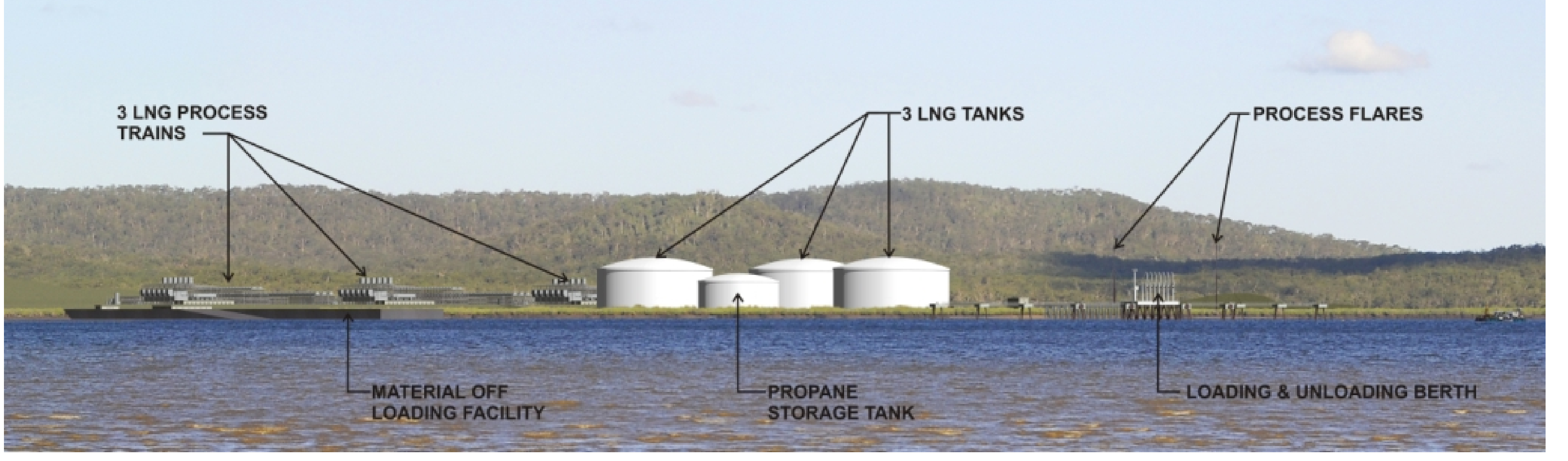
A pig receiver for the gas transmission line will be located within the LNG Facility boundary fence, and is provided for infrequent maintenance pigging operations. No routine pigging of the gas pipeline is required. The pigging facilities will perform the pigging operation without affecting operations at the LNG Facility. Appropriate safety systems (i.e. pig-catcher door interlocks with the gas pipeline isolation valves) will be installed.

9.2.1.2 Amine Regeneration

The LNG Facility requires the CO_2 content of the feed gas to be reduced to < 50 parts per million (ppm) prior to liquefaction, to prevent freezing during the cryogenic process. The amine regeneration unit is designed to remove CO_2 from the feed gas using a conventional Acid Gas Removal Unit with Diglycolamine (DGA) as a solvent. DGA absorbs CO_2 which is subsequently stripped from the solution and vented to the atmosphere.

No provisions have been made for removal of significant levels of hydrogen sulphide or other sulphur components in this LNG Facility as the feed gas has only trace concentrations. The gas is vented to the atmosphere without additional thermal oxidation.

Figure 2.9.3 Main components of the Queensland Curtis LNG Facility – Photomontage from Targinie Foreshore Viewpoint[2]



2 Environmental Resources Management Australia, 2009. *Queensland Curtis Island LNG Project - Landscape and Visual Impact Assessment*

9.2.1.3 *Dehydration and Mercury Removal*

Dehydration of feed gas is required to prevent freezing during the cryogenic process, and is undertaken by filtering it through a three-bed molecular sieve dryer. The gas is passed through a propane pre-cooler for cooling and condensation of some water and heavier hydrocarbons which may be present in trace concentrations. The dehydration unit has three beds, with two beds on 24-hour adsorption, one bed on 12 hours regeneration/standby with 3.5 hours heating. Fuel gas burner(s) can be used for heating. The QCLNG Project proposes to utilise Waste Heat Recovery (WHR) from the liquefaction process to enable the dehydration unit to operate with the burner required only on restart. This consequently reduces emissions and is best practice.

Mercury removal beds are upstream of the liquefaction process. The level of mercury within the feed gas is negligible, however, guard beds are included as part of the standard requirement of the licensed process as even small amounts of mercury are potentially damaging to the plant. The mercury removal beds will be replaced every five years, with the contaminated beds processed by specialist companies.

9.2.2 Liquefaction

ConocoPhillips Optimized Cascade Process^{SM} is a proven, stable and easy-to-operate method of liquefying natural gas. The gas is chilled and then liquefied through a series of chillers using propane, ethylene and methane as refrigerants. Through this process the gas is lowered to -162°C, the target temperature for LNG.

The liquefaction process is achieved in three stages using three refrigerants. Propane, ethylene and methane are used to sequentially chill the gas. Two or three levels of evaporating pressures are used for each of the refrigerants with multi-stage compressors. Thus the refrigerants are supplied at eight discrete temperature levels. Using these refrigeration levels, heat is removed from the gas at successively lower temperatures. The final refrigeration stage uses a methane cycle in combination with a pressure reduction stage to liquefy the gas. The low level heat removed by the methane cycle is transferred to the ethylene cycle, and the heat removed in the ethylene cycle is partially accomplished by air cooling and the rest transferred to the propane cycle. Final rejection of the heat from the propane system is accomplished through air cooling. The overall capacity of the liquefaction process is limited by the power available from the turbines driving the refrigeration compressors.

Nitrogen removed during the liquefaction process will be vented to the atmosphere via a cryogenic Nitrogen Rejection Unit (NRU). This unit is designed to prevent the build-up of nitrogen in the fuel gas and methane refrigerant systems.

9.2.3 LNG Storage

The LNG is pumped from the liquefaction system to one of three full containment tanks each with a capacity of approximately 160,000 to 180,000 m³ for storage on site. It is stored at slightly above atmospheric pressure.

The storage tanks will be equipped with in-tank pumps to transfer the LNG to ship-loading operations and BoG compressors for compressing composite gas vapours from the LNG tanks. Tanks are designed for a boil-off rate of less than 0.05 weight per cent of tank inventory per day. Tank vapours will comprise the flash gas, ship-loading return vapours and heat leak. Compressed BoG is returned to the methane refrigerant loop for cooling and subsequent re-liquefaction.

The LNG storage tanks chosen for the QCLNG Project are full containment tanks with a 9 per cent nickel-steel inner container and a pre-stressed concrete outer container. In normal service the inner, primary container will provide liquid containment and prevent ingress of LNG into the space between the primary and secondary containers.

The outer, secondary container is a self-supporting tank with a domed concrete roof. This is designed for vapour containment and to hold the thermal insulation of the primary container.

In case of leakage of the primary container, the design will ensure the safe containment of the gross liquid volume without liquid leakage or uncontrolled vapour release. The secondary container will remain structurally vapour tight.

Tanks are designed to resist earthquakes. Specifically, the tank system will be designed to maintain continuous operation during and after an operational basis earthquake (OBE) and to ensure no loss of containment capability during and after safe shutdown earthquake (SSE) events (for discussion of seismic risks applicable to the Facility, refer to *Volume 5, Chapter 4*).

The primary tank will be sized so that there is sufficient freeboard space to accommodate liquid sloshing during OBE and SSE events. The tanks will be designed to prevent damage to access ways inside the tank on and above the suspended deck.

The design of the LNG tanks will comply with the requirements of API 620 (American Petroleum Institute Standard 620: *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*), ACI 318 (American Concrete Institute Code 318: *Building Code Requirements for Structural Concrete*), NFPA 59A (National Fire Protection Association 59A: *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG))*, AS 3961 (Australian Standard 3961-2005: *The storage and handling of liquefied natural gas*). BoG will be returned to process for re-liquefaction, or may be flared / vented in case of emergency. Trip systems will be installed to prevent liquid overfill, with detailed design of the tanks to allow relief capacity in each tank equivalent to 100 per cent vaporisation of LNG, based on a filling rate to a single tank of 115 per cent of nameplate capacity of two LNG trains.

9.2.3.1 *Loss Prevention*

Loss prevention measures include:

- design of the tank roof to a classification of Zone 1 hazardous area
- installation of relief and vacuum breaker valves, with relief valves provided with a dry-powder snuffing system.

9.2.3.2 *Mechanical Handling*

Allowances will be made in the detailed tank design for mechanical handling devices to be installed on the main roof platform to lift the submerged pumps into and out of the pump wells and facilitate other maintenance work from the platform. Such allowances will include the installation of lifting structures for attachment of hoists etc. Similar mechanical handling will be provided for maintenance of pressure relief and vacuum relief valves.

The mechanical handling devices will be capable of lowering the pumps or valves to grade level. Hoists will be powered by ex-proof electric motors with two speeds and “inching” control.

For construction and maintenance purposes, a trolley beam for a two-man gondola will be installed inside the tank.

9.2.3.3 *Drying & Inerting*

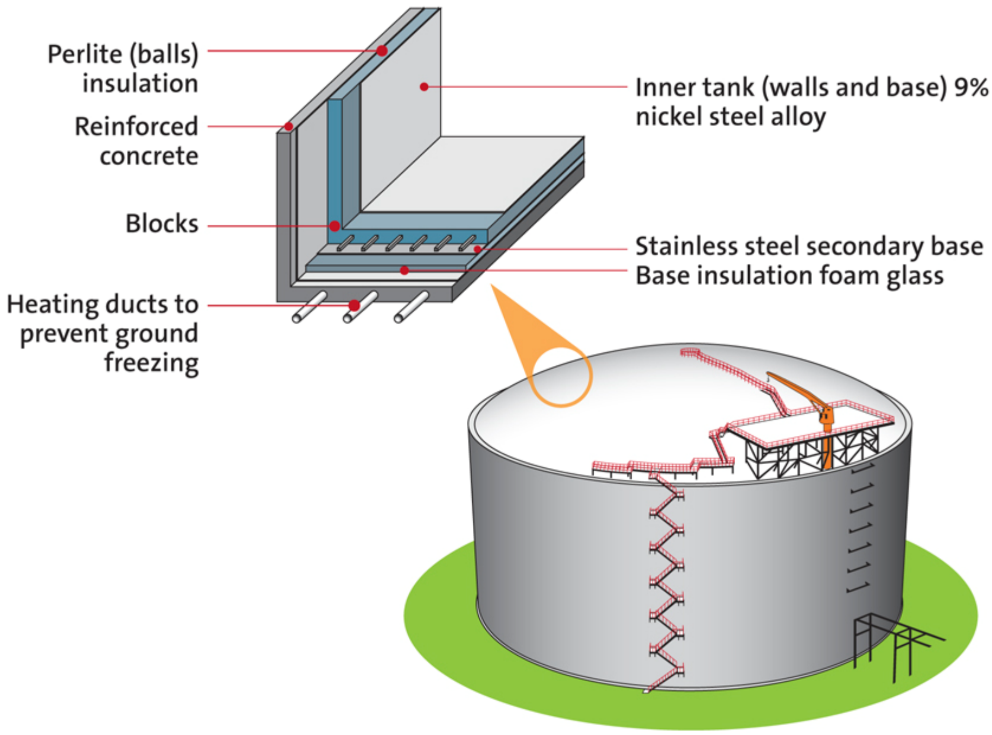
Inerting will be carried out with high-purity nitrogen. Initial drying may be carried out with air. *Figure 2.9.4* provides a tank cutaway which demonstrates the features of the proposed LNG storage tanks to be used for this LNG Facility.

9.2.3.4 *Propane Storage & Product Spiking*

A 100,000 m^3 capacity propane tank will store imported propane if “spiking” the LNG product to increase the higher heating value if a specific HHV is required by market demand.

Spiking consists of injecting propane into the LNG stream to raise the HHV to satisfy market and customer requirements. A vapour-recovery system will be provided for the propane tank.

Figure 2.9.4 LNG Tank Cutaway



The propane tank will also be designed as a full containment tank with a low temperature, carbon steel, primary container and a pre-stressed concrete outer container. Other requirements are the same as those for the LNG tanks as described above.

Propane will be unloaded from LPG tanker vessels at the jetty and pumped through a metering package to the propane storage tank. Vapours generated by heat leak through the storage tank, unloading lines and cool-down lines will be sent to the propane boil-off compressor. Vapour from the compressor discharge will be condensed and returned to the LNG storage tank.

For spiking of LNG with propane prior to ship loading, propane will be pumped from the propane storage tank into the LNG loading line.

9.2.4 LNG Loading/Propane Unloading Facilities

9.2.4.1 Jetty

The jetty is designed to accommodate unloading of 38,000 m^3 to 85,000 m^3 capacity LPG vessels (delivering propane) and loading of LNG vessels ranging from 125,000 m^3 to 220,000 m^3 in capacity. The maximum anticipated draught of loaded LNG vessels is 12 m and dredge depths will be set by the GPC to accommodate these vessels at all stages of tidal processes. A 10 per cent under-keel clearance margin at LAT will also be required. Some LPG vessels may have a slightly greater draught, but LPG access to the jetty will be relatively infrequent and all tide access is not required for these vessels.

Mooring dolphins will be located at the edge of the existing mangrove growth. The loading platform will be about 50 m further offshore. The trestle connecting the jetty to the onshore causeway will be approximately 170 m.

The trestle elevation is based on storm surge + tide + wave height + sea level, with allowance for sea-level rise and increased storm surge associated with potential climate change over the life of the Project (refer to *Volume 5, Chapter 2*). The loading platform will be a further 3.5 m above the trestle.

A marine terminal building will be located on shore, along the trestle for the berth operator and security control. The trestle will have a roadway with one-way vehicular access only.

A small boat landing will be provided adjacent to the service platform for line-handling boats, as an alternate means of departure from the jetty, and as an alternate means of access for the pilot boat.

Plan layout of the LNG jetty is shown in *Figure 2.9.5.* A conceptual cross-section of the jetty and loading platform is provided in *Figure 2.9.6*, which shows indicatively the type of LNG marine-loading facilities to be constructed for the QCLNG Project.

9.2.4.2 LNG Loading

The planned LNG production rate suggests that approximately 62 LNG vessels will be loaded per year, per LNG process train (i.e., approximately 186 LNG vessels per year with three trains operating, with some variation due to variation in ship capacity).

LNG will be pumped from the storage tank, through a cryogenic pipeline to the loading platform at the jetty head.

There will be four 16” (406 mm) diameter LNG cargo arms on the loading platform for a maximum LNG loading rate of 12,000 m^3 per hour (three liquid and one vapour). Q-flex vessels, with larger manifold connections, will require adaptors. There will be two propane-liquid unloading arms each with a 350 mm diameter.

A photograph of a LNG vessel loading at the Egyptian LNG facility, of which BG Group is a major shareholder, is provided in *Plate 2.9.1*.

Figure 2.9.5 Plan Layout of LNG Jetty

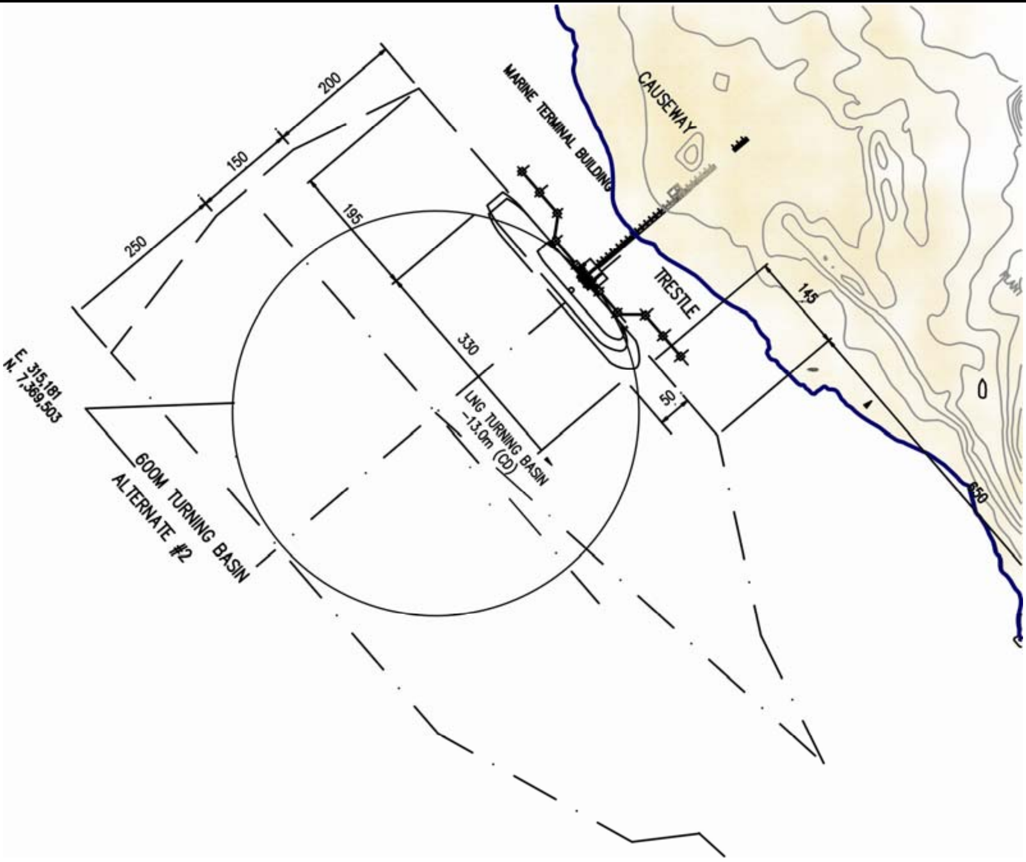
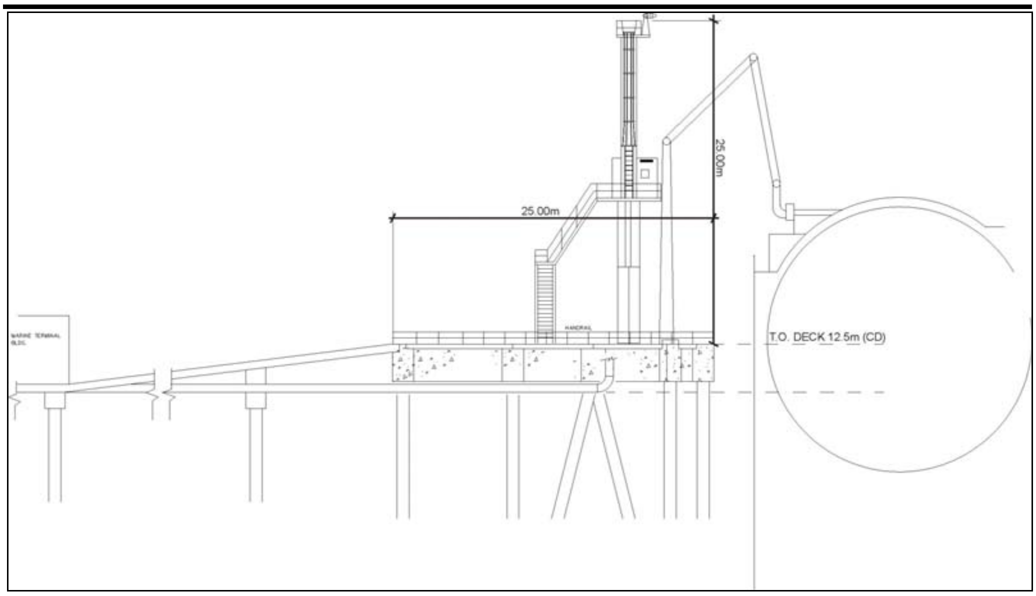


Figure 2.9.6 Representation of LNG Loading Facility[3]



3 Environmental Resources Management Australia, 2009. *Queensland Curtis Island LNG Project - Landscape and Visual Impact Assessment* (unpublished report)

Plate 2.9.1 LNG Vessel Loading at BG Egypt LNG Facility

9.2.4.3 Vapour Return from LNG Storage

A separate vapour recovery arm will handle the vapours produced by final flash (vapours generated where LNG is used to cool down a warm ship) into storage, heat leak, and ship-loading vapours and vaporised gas produced during loading line cool-down. This gas will be returned to shore through a separate pipeline.

There will be no flaring of BoG or ship vapour return in normal operation. The LNG Facility will receive recovered process vapours generated from the final flash into storage, heat leak, and ship-loading vapours.

Heat-leak rate is a function of the size of the LNG tank and the length/size of the loading lines and other system components. The process system will recover process vapours generated from both the final flash into storage and heat leak in holding mode. The design case for vapour recovery is based on recovery of both final tank flash plus ship-loading vapours.

Ships are assumed to arrive at the loading jetty with a heel (small volume) of LNG such that the compartments are at LNG temperature of ≈ -160°C. Warm cargo tanks (vessels arriving with LNG storage with temperature > -160°C, although these could be as warm as ambient) can be accommodated. However, a period of cool-down will be required before the ship can be loaded with LNG. Flaring or venting will only be required when:

- used for venting of ships arriving direct from dry dock (typically filled with inert gas such as CO_2)
- BoG compressors are in upset or maintenance mode.

9.2.5 Utilities and Supporting Services and Systems

9.2.5.1 Materials Offloading Facility (MOF)

A Materials Offloading Facility (MOF) will be constructed early in the Project and will remain throughout the life of the Project. It will form the primary entry and exit point for the LNG Facility throughout construction and operations, allowing for movement of personnel, equipment, supplies and materials.

Description of MOF construction is provided in *Volume 2, Chapter 13*. Conceptual layout of the MOF is shown in *Figure 2.9.7.*

9.2.5.2 Fuel and Chemical Storage and Handling

Miscellaneous storage will be provided on site for diesel, other fuels and other chemicals to be used by the LNG process or ancillary activities.

Spill prevention and containment will be undertaken by:

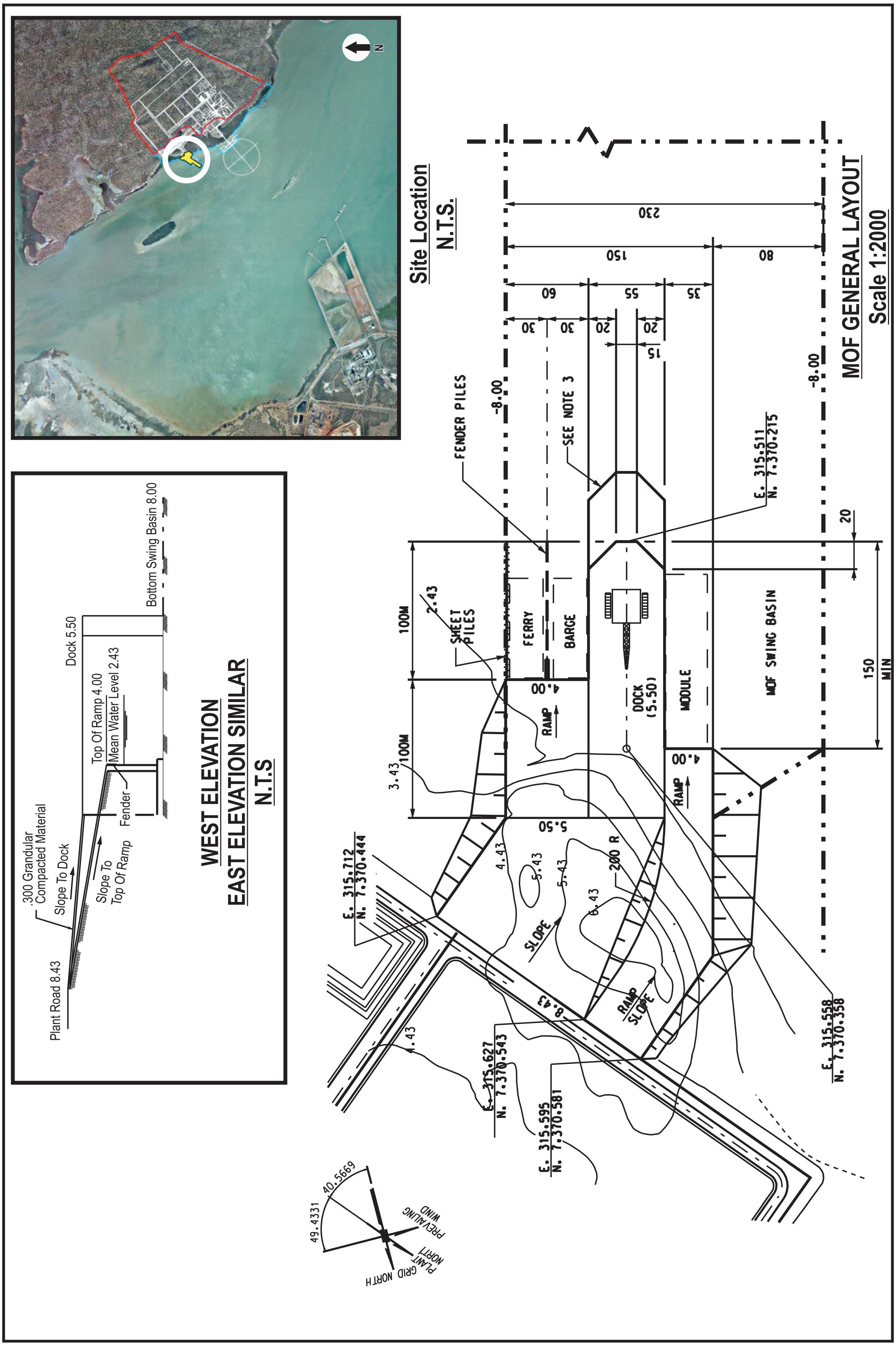
- **ensuring containment integrity.** All process piping will be welded where possible, with an emphasis on minimum flanged connections. Screwed piping will not be used in any service, including water, air or other utility services
- **secondary containment**. For storage areas, 110 per cent secondary containment will be provided for flammable, combustible or toxic materials, as required by the relevant Australian Standards, including but not limited to AS 3961 and AS 1940
- **drainage and collection**. Flammable liquid hydrocarbons process and storage areas will be provided with a drainage system designed to remove a spill as quickly as possible in order to minimise heat flux damage to equipment if an ignition occurs.

9.2.5.3 Fire Protection and Safety Systems

The LNG Facility layout will maximise the use of passive fire protection in the form of:

- equipment spacing
- fire-resistant insulation on steelwork
- minimising potential for leaks
- drainage of areas where liquid spills could occur away from critical equipment to containment sumps
- ensuring that there are no ignition sources within process or storage areas.

Active measures such as a fire and gas detection system, firewater system, and overpressure protection will be included in the design.



Source:
Bechtel Drawing No RO-000-00005.
Rev A: Marine Offloading Facility,
Configuration, Arrangement, Profile,
Curtis Island, Australia

Notes:
1. All dimensions and elevations are in metres
2. All elevations are in LAT format
3. To be determined for any vessel that will be self-powered and determined from traffic and logistics studies

QUEENSLAND CURTIS LNG A BG Group business	Project: Queensland Curtis LNG Project Client: QGC - A BG Group business	Title: Indicative Layout of the Materials Offloading Facility
ERM Environmental Resources Management Australia Pty Ltd	Drawn: JB — Volume 2 — Figure 2.9.7 Approved: DS — File No: 0086165b_EIS_LFC_CDR002_F2.9.7 Date: 05/05/09 — Revision 2	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.

Onshore LNG facilities will be serviced by a freshwater firewater system which includes a storage tank, pumps and a ring main distribution system to hydrants, monitors and hose stations.

A stand-alone firewater system (storage, pumping and distribution) will be provided for the LNG Facility and jetty. Jetty firewater demand, based on previous similar projects, is approximately 500 m^3/hr. A single steel main will connect the LNG Facility firewater pipeline grid to the jetty and will be sized to provide sufficient flow and pressures for the maximum demand case.

This configuration has been used on other similar projects, and meets NFPA 59A and AS 2419, and eliminates the need for a separate, seawater-based fire-quench system at the jetty.

Fire and gas detection systems include:

- LNG Facility fire detection
- gas detection
- spill detection.

These systems are briefly described below.

The LNG Facility fire detection system will be used throughout the areas including storage and jetty areas. It will be via a multi-spectrum, infra-red flame detection system. Detectors will be placed to cover areas where fires from flanges, valves and small-bore connections are considered possible.

A dry pilot system will detect fire around specific hazards, such as the refrigerant storage vessels, at the propane accumulator and at the jetty loading arms.

The proposed gas-detection system includes line-of-sight detectors. These will be the primary means of detecting flammable gas. Placed around the perimeter of the liquefaction area, under the compressor deck and around the gas turbine generators, the line-of-sight gas detectors will alarm only on activation. Once activated, an investigation from the operators to determine cause and appropriate action will be required.

Infra-red point gas detectors will be used at the air inlet to fired equipment and at building heating, ventilation and air-conditioning (HVAC) inlets. Detection will provide for an alarm to the Fire and Gas System (FGS) and allow for the shutdown of the equipment concerned.

Spill detection will be in the form of cold temperature detectors which will be located within trenches and sumps designed for cryogenic liquid spill collection. These detectors will also be located in the drainage path between major cryogenic liquid process inventories, such as the cold boxes and the collection trench. Cold temperature spill detectors will alarm only on activation and will require investigation from the operators to determine cause and any necessary appropriate action.

9.2.5.4 *Flare/Vent Systems*

During start-up, emergency or maintenance operations flaring or venting may be required to burn hydrocarbon releases and vent the burn-off gas. The pressure relief and flare system will be separated into three systems:

- a wet flare system (process flare) for warm gases and blowdown
- dry flare system (process flare) for cold gases and blowdown under upset conditions subsequent to the dehydration process
- marine cold service flare system for disposal of vapours from the LNG storage tank(s) and the LNG ship during start-up operations and upset condition when BoG compressors are in upset or maintenance mode.

A double flare stack will include both the wet and dry gas flare headers. The marine flare will have a separate stack.

The process and marine flares will operate with a permanent pilot light. Noise and emissions impacts arising from the operation of the process and marine flares are described in *Volume 5, Chapter 12 (Air Quality)*, *Chapter 13 (Noise and Vibration)*, and in *Volume 7 (Greenhouse Gas Management)* of this EIS.

Flaring/venting scenarios for the process and marine flares are summarised below. In addition to the scenarios outlined below, venting of CO_2 will also occur from the Amine Regeneration Unit as described in *Section 9.2.1.2*.

Process Flares

Process flares (wet flare and dry flare) will operate as follows:

Emergency flaring: In certain rare circumstances, this will represent the maximum flaring rate required to ensure the LNG Facility is brought to a steady-state controlled condition as soon as possible. Emergency flaring will only occur as a last resort when other pressure-containing safety devices have already been activated. The emergency pressure relief is expected to be very infrequent. The noise and emissions generated during emergency flaring will only last a few minutes.

Pressure blowdown: In the event of an overpressure, or detected fire or gas, it may be necessary to evacuate affected pressurised hydrocarbon inventories. The pressure blowdown will last approximately 15 minutes for affected areas, and the rate at which the gas is released will be similar to the peak emergency flaring case described above.

Maintenance Flaring: There will also be periods of planned maintenance, where a whole train will be depressurised. The amount of gas flared will be minimised by producing LNG to the storage tanks to the lowest possible pressure, before the gas is flared to the atmosphere. Depressurisation of a train will be controlled and have less of a noise and emissions impact than an emergency blowdown. LNG train depressurisation will take less than eight hours, plus additional time required to purge with inert gas to allow maintenance access.

Start-up flaring: During the start-up of an LNG train (at commencement of operations or following shutdown) it will be necessary to flare gas at certain points in the process to ensure the gas specifications are met at all points in the Facility. Within a five-day start-up there will be periodic inadvertent flaring, at lower flaring rates than for emergency or depressurisation.

Each train is anticipated to have a shutdown every three to four years.

Marine Flare

In addition to emergency situations, the marine flare may be utilised under the following conditions:

- when gas-free ships arrive from dry dock and vessel purging with methane commences (gas-up), the ship will vent CO2 from the forward vent mast during gas-up until the methane content is high enough to burn at the shore-side marine flare. When the methane content reaches 5 per cent, venting on board will stop and mixed CO2/methane vapour will be sent to the marine flare. While the occurrence of this will vary subject to vessel scheduling, indicatively this will occur for only one or two LNG vessels per annum
- when the LNG Facility is shut down, excess vapour from the LNG storage tanks will be diverted to the marine flare.

9.2.5.5 Safety, Shutdown and Depressurisation Systems

Safety, shutdown and depressurisation of the LNG Facility will be performed by the Safety Instrumented System (SIS) functions. The SIS will be fully independent and yet integrated with the Process Control System (PCS) and the Fire and Gas System (FGS) on a common network to form an Integrated Control and Safety System (ICSS).

Detailed design, configuration and construction/installation of the SIS will be undertaken in accordance with guidance contained within *Australian Standard AS 61508: Functional Safety of Electrical/Electronic/Programmable Electronic Safety Related Systems*.

The SIS will include components separate to each LNG process train as well as to ship-loading facilities and include a combination of automatic shutdown processes. The independent safety-instrumented system will be of high integrity, failsafe, fault tolerant, redundant design, and have a power back-up by the Facility's uninterruptible power supply (UPS).

In addition to the shutdown processes for each train and for ship loading, the six refrigeration compressors for each LNG process train will have their own separate and dedicated (vendor supplied) safety and fire and gas detection and shutdown system to protect the machines, which will satisfy the guidelines contained within the *AS 61508.*

9.2.5.6 *Hot Oil System*

A closed loop circulating hot oil system will provide process heating requirements for the Amine Regeneration Unit, feed gas heaters, amine reclaimer, regeneration boiler and make-up fuel gas heaters. The heat to the hot oil will be supplied by waste-heat recovery from the liquefaction units. The hot oil system is a closed system with no venting to the atmosphere.

9.2.5.7 *Compressed Air and Nitrogen Systems*

Each train will be equipped with a combined air system to supply compressed air for Facility utilities and instruments and feed air to the nitrogen generation system. The compressed air system will consist of screw-type air compressors using motors driven by fuel gas and equipped with an emergency diesel turbine-driven back-up.

Nitrogen will be used for blanket gas on LNG storage tanks, purge gas in cold boxes, swivel-loading arms and compressor seals, and as a purge gas during maintenance. Nitrogen will be supplied to the Facility by a standard nitrogen generation package unit (membrane type unit) at each train. A common membrane unit will act as a back-up to the LNG train dedicated nitrogen supply.

9.2.5.8 *LNG Process Control*

The Project control philosophy requires that process and utility operations on the QCLNG facilities be monitored from a Central Control Room (CCR). Equipment and facilities will be installed to allow any emergency or unusual event to be evaluated, monitored and managed from within the CCR.

Equipment installed in CCR should include environmental monitoring and a full communications suite to communicate both internally and externally. Major or critical items of the Facility will be capable of being started, controlled and stopped from the CCR. Local shutdown facilities will also be provided.

9.2.6 *LNG/LPG Shipping Activities*

A summary of shipping activities associated with LNG/LPG shipping is provided below. Further detail, including assessment of impacts on existing shipping activities in Gladstone Harbour, is provided in *Volume 5, Chapter 15* of this EIS.

LNG/LPG shipping activities during Project operation will include:

- regular transit of LNG tankers, with up to 62 LNG vessels per year to be loaded per operational LNG process train (approximately 186 vessels per year once three trains are operating). The number of LNG vessels will vary subject to the mix of vessels being used as well as the degree of spiking of LNG required (fewer ship loadings will be needed if no propane spiking of LNG is necessary)

- infrequent transit of ships carrying propane. The number of vessels will vary subject to commercial requirements as to HHV of LNG exported and therefore the amount of propane spiking required, and subject to size of vessels used, but will indicatively be five to seven LPG vessels per year once three trains are operational
- tug and pilot boat operation to support safe passage of LNG and LPG (propane) tankers
- ancillary activities.

Movement of LNG/LPG tankers through the Great Barrier Reef Marine Park (GBRMP) will be within approved shipping zones and conducted under Australian Maritime Safety Authority (AMSA) approved shipping operations.

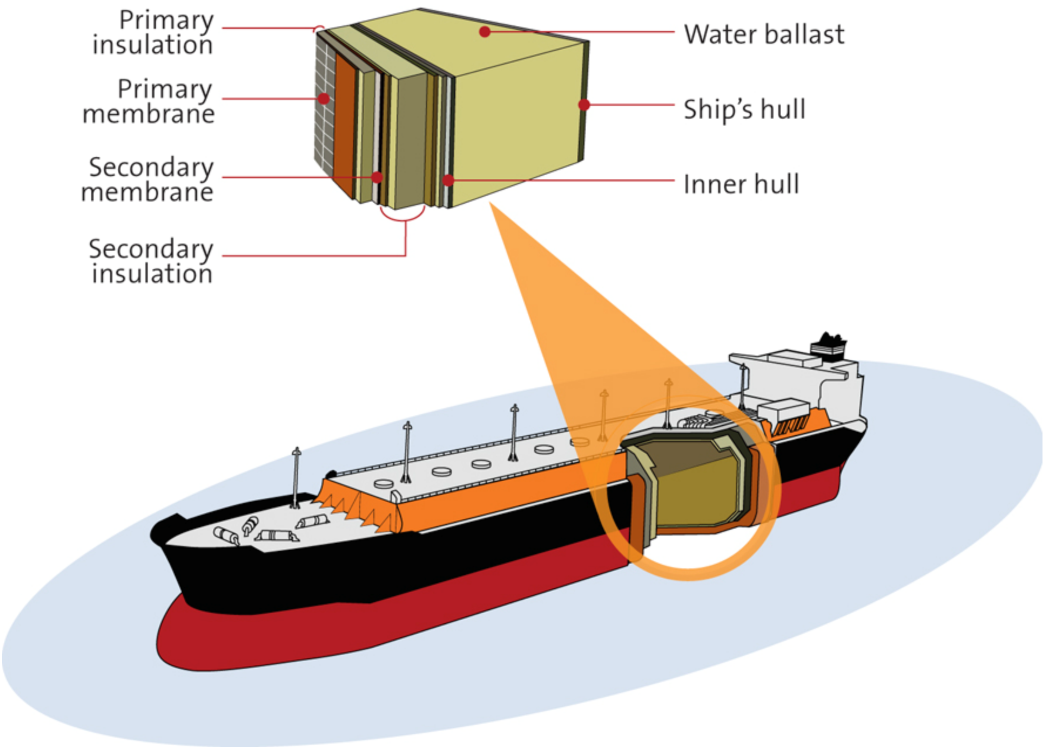
Typically shipping of LNG out of the Port of Gladstone will be undertaken by BG Group, with LNG ships being a combination of vessels owned by BG Group and vessels contracted by BG Group to carry cargo (on occasions throughout the Project life, vessels not contracted by BG Group may also be used). BG Group has a core fleet of nine LNG tanker ships. Seven ships are bareboat chartered of 145,000 m^3 cargo capacity and steam turbine propulsion. Two ships of 138,000 m^3 cargo capacity and steam turbine propulsion are long-term chartered. Four additional owned vessels of 170,000 m^3 cargo capacity are under construction for delivery commencing in 2010. These newly built vessels will be dual-fuel diesel-electric propulsion which is more efficient and produces fewer emissions.

BG Group contracts additional shipping as required on a short-, medium-, and long-term charter in order to capture business opportunities and maintain a balanced shipping position. The flexible charter fleet consists of seven to fifteen ships of various sizes, although additional vessels may be added to this fleet over the life of the Project.

All LNG vessels used will have double hulls and primary and secondary containment systems as shown in *Figure 2.9.8* which shows a schematic cutaway of an LNG vessel hull. Detailed discussion of hazards and risks associated with vessel transit and loading of LNG/unloading of propane is discussed in *Volume 5*.

A summary of proposed LNG shipping activities is included below. Further detail including assessment of impacts on existing users is included in *Volume 5, Chapter 15*. Assessment of potential impacts of LNG shipping on marine ecology both within the Port of Gladstone and within the bounds of the GBRMP is included in *Volume 5, Chapter 8.*

Figure 2.9.8 LNG Tankers



9.2.6.1 Navigational Arrangements

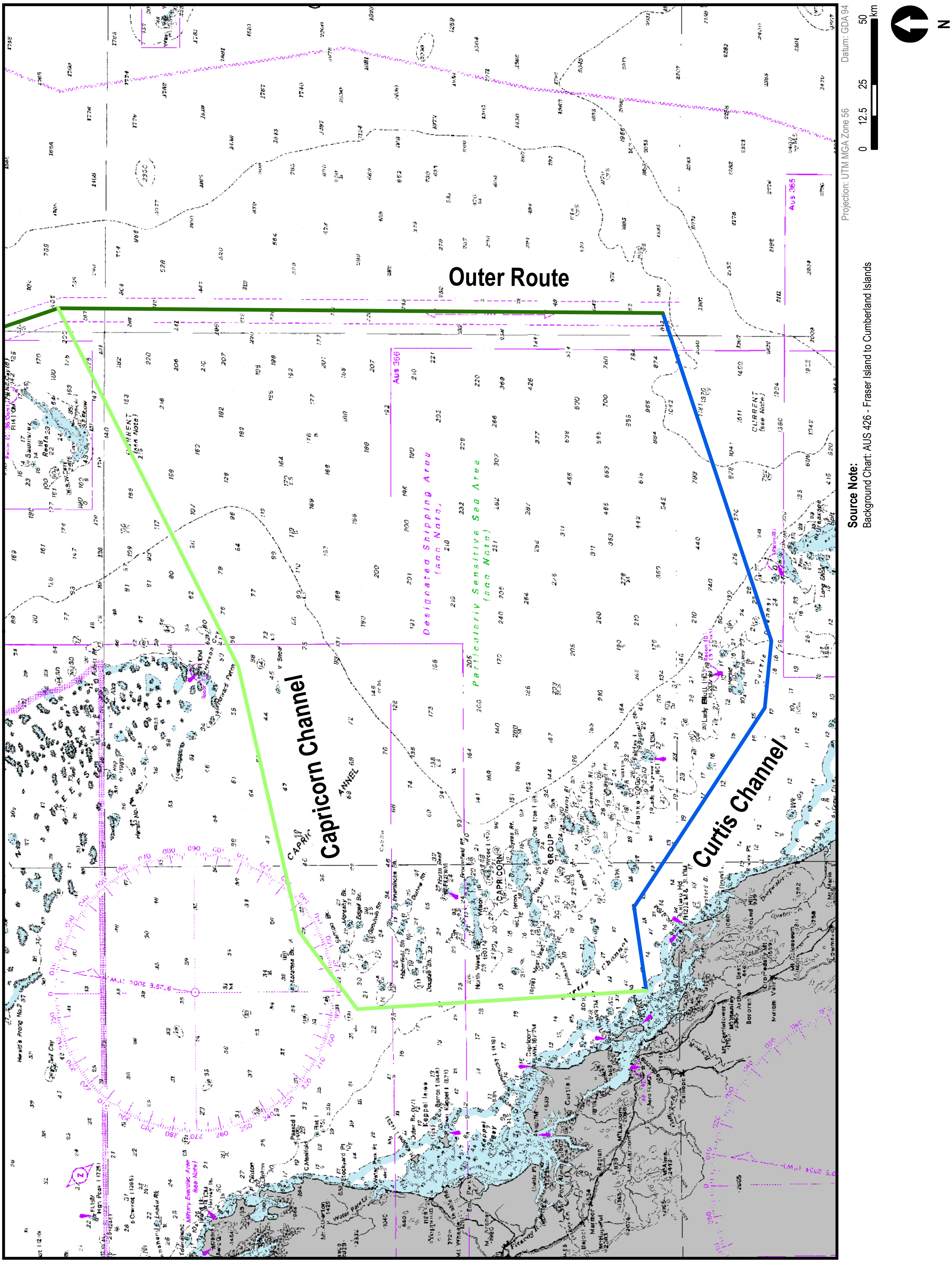
Outside Port of Gladstone

Shipping outside the bounds of the Port of Gladstone within Australian Territorial Waters will be undertaken within approved shipping channels. Within the bounds of the GBRMP shipping will be limited to the transit of ships through designated channels (Capricorn and Curtis Channels) to shipping channels outside GBRMP (refer to *Figure 2.9.9*).

Within Port of Gladstone

Within the Port of Gladstone shipping will be along existing shipping channels from the outer harbour to the Targinie Channel (refer to *Figure 2.9.10*). Some widening and/or deepening of these channels will be required. These requirements are detailed in *Volume 6* of this EIS.

From the Targinie Channel to the LNG Facility, a new Channel and Swing Basin will be required to accommodate the LNG vessels. Configuration of these proposed new channels is included in *Figure 2.9.11*.



QUEENSLAND CURTIS LNG A BG Group business	Project: Queensland Curtis LNG Project Client: QGC - A BG Group business	Title: **Proposed Shipping Routes outside of Port of Gladstone**
ERM Environmental Resources Management Australia Pty Ltd	Drawn: KP — **Volume 2** — **Figure 2.9.9** Approved: DS — File No: 0086165b_EIS_LFO_GIS009_F2.9.9 Date: 20.05.09 — Revision 1	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.

Inner-harbour channels will be required to be dredged to approximately 200 m width in accordance with Permanent International Association of Navigation Congresses (PIANC) recommended widths for 46-m beam ships. Marine simulations with Gladstone pilots have demonstrated that the Q-Flex (QF) size vessels can safely navigate the 200 m-wide channels. Escort tugs are planned throughout the inner and outer channel transit by LNG tankers (refer to *Volume 5, Chapter 15*).

Further details including depths and dredging requirements are addressed in *Volume 6*.

9.2.6.2 Shipping Buffer Zone within Port of Gladstone

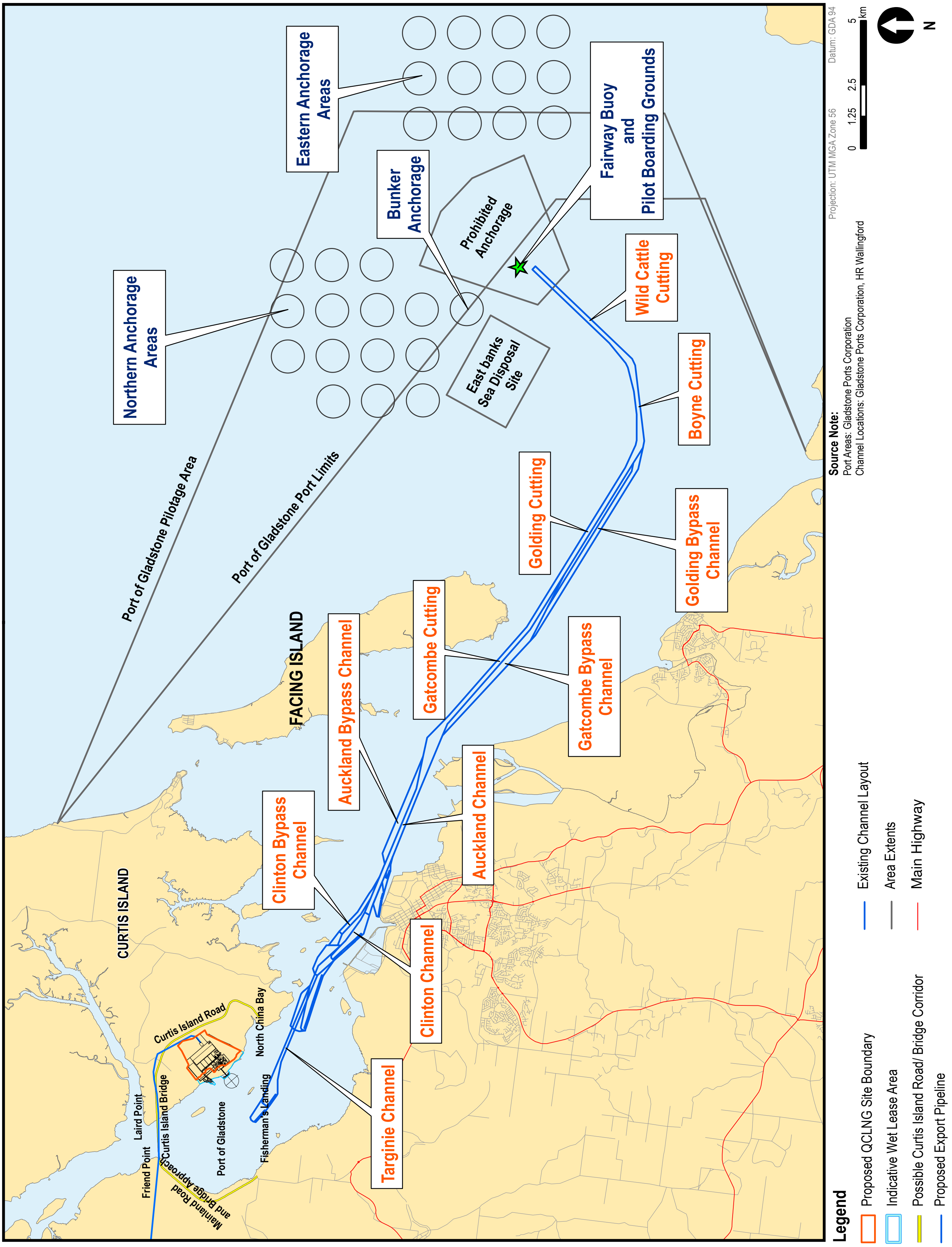
The Gladstone Harbourmaster currently requires one-hour separation for outbound Capesize bulkers, and 30 minutes for Panamax coal bulkers. Discussions with the Harbourmaster are ongoing, but the current proposed port rule is for a half-hour separation for LNG tankers at the beginning of the transit (i.e. outer areas of Gladstone Harbour), potentially increasing throughout the transit. A final determination regarding these requirements will be forthcoming from the Harbourmaster, but risk assessment of the transit indicates the likelihood of an incident leading to cargo release, and the potential impact on public safety, is sufficiently low that no additional LNG specific safety zones for navigation through the harbour will be required. Further detail on risk assessment undertaken is provided in *Volume 5, Chapter 18*.

The channel configuration allows a passing zone along the 7 m-depth parallel Golding Channel. Small ships going in the opposite direction will pass the LNG Carrier (LNGC) parallel to the Golding Channel.

At the berth, a 250 m safety zone (preliminary and to be refined in consultation with Gladstone Harbourmaster) from the manifold will be applied to exclude small boats and uncontrolled ignition sources during cargo operations. The safety zone will be patrolled by the standby tug while a ship is loading. As most LNG vessels are approximately 50 m across the beam, this zone will be in the order of 200 m from the side of the LNG ship. Temporary buoys will be deployed to demarcate this area.

While the berth is unoccupied, a 50 m safety zone will be applied to exclude small boats and uncontrolled ignition sources.

Anchorage for LNG vessels while awaiting transit through the Port of Gladstone to the LNG Facility will be within an extension to the bounds of the existing anchorage and pilot boarding area for the Port of Gladstone (refer *to Figure 2.9.10*). The existing anchorage area will be extended eastward to allow for an additional three anchorages. There will be no special safety zone at the anchorage for LNG vessels.



QUEENSLAND CURTIS LNG A BG Group business	Project: **Queensland Curtis LNG Project**		Title: **Existing Shipping Channels within the Port of Gladstone**
	Client: **QGC - A BG Group business**		
ERM Environmental Resources Management Australia Pty Ltd	Drawn: KP	**Volume 2** **Figure 2.9.10**	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.
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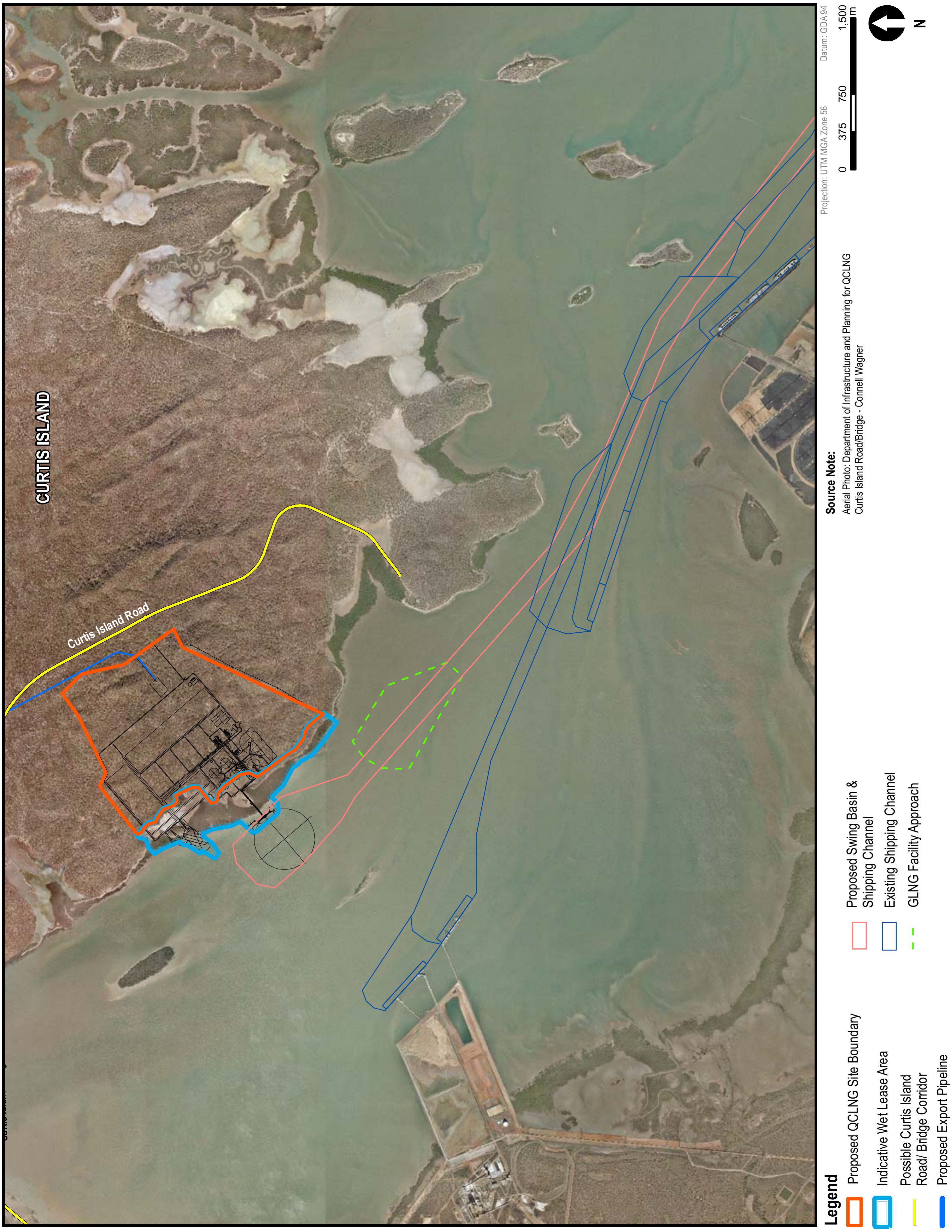

QUEENSLAND CURTIS LNG A BG Group business	Project: **Queensland Curtis LNG Project** Client: **QGC - A BG Group business**	Title: **Configuration of Proposed New Channel & Swing Basin: Targinie Channel to LNG Facility**

ERM Environmental Resources Management Australia Pty Ltd			
Drawn	JB	**Volume 2**	**Figure 2.9.11**
Approved	DS	File No: 0086165b_EIS_LFO_GIS004_F2.9.11	
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No extra security zones are currently planned in addition to those safety zones discussed above.

9.2.6.3 *Tugs and Navigation within Port of Gladstone*

Tugs

Port of Gladstone currently operates:

- two by 62-tonne bollard pull tugs
- one by 60-tonne bollard pull tug
- two by 47-tonne bollard pull tugs.

Simulations of LNG shipping within Gladstone Harbour have indicated that four tugs will be required per LNG ship and that these tugs will need the following capacities:

- two 62-tonne or equivalent capacity tugs sourced from existing tug fleet
- two 80-tonne bollard pull tugs which will be required in addition to the existing tug fleet. It should be noted that an additional 80-tonne tug will be required as a spare tug to allow for downtime and maintenance. QCG will work with and enter into appropriate commercial/contractual arrangements with the tug contractor and in consultation with GPC to ensure that adequate tug capacity is provided.

The two-80 tonne tugs will be escort tugs from the Fairway Buoy to the Gatcombe Channel. Shipping simulations have indicated that escort tugs will not be required to transit the harbour channels. However, they may be used in the event of engine or rudder failure.

Navigation Aids

Shipping simulations are ongoing to determine all navigational aids required for LNG vessels in Gladstone Harbour. A combination of new fixed and floating aids will be used. These will primarily be located on the proposed new channel north of Targinie Channel. Final configuration of these navigational aids is subject to the outcomes of final shipping simulations.

The Gladstone Harbourmaster and pilots have been involved in some of the simulations undertaken, and will be required to approve the navigation layout.

While aids to navigation on common channels (channels which may be utilised by other projects) are not yet finalised, *Figure 2.9.12* shows an indicative layout of navigation aids that have so far been specified for the Project Channel and Swing Basin.

A carry-on pilot positioning unit will be provided to marine pilots for precisely locating the vessel within the channels. The carry-on position unit will indicate the position, speed, and rate of turn of the vessel, independent of the ship's navigational systems. The vessel's progress will be monitored by radar and/or CCTV at the Gladstone Vessel Traffic Service (VTS). All vessels will have a minimum of one pilot on board through the Port of Gladstone commencing at the Fairway Buoy (or as otherwise directed by the Gladstone Harbourmaster).

Other Navigation Requirements

The following additional requirements will be put in place for all LNG/LPG vessels associated with the Project:

- An indicative upper limit on wind speed of 30 knots will apply to pilot boarding and berthing operations within the Port of Gladstone. This limit is currently being finalised in consultation with the Gladstone Harbourmaster.
- BG Operations Policy directs that transit of Gladstone Harbour and berthing will be undertaken in daylight for the first six months of operations, in order to ensure that pilots are familiar with LNG vessels and ship captains are familiar with the harbour. After six months, 24-hour access through the harbour to the berth is anticipated.
- Visibility controls on harbour transit and berthing will be specified by the Gladstone Harbourmaster.

9.2.6.4 Bunkering and Provisioning

Bunkering (refuelling) of LNG / LPG vessels may be undertaken within the Port of Gladstone as part of normal operations. If undertaken, it will be carried out by the port bunkering contractor at berth (i.e. alongside the LNG jetty). If undertaken, bunkering will not be carried out while LNG loading or propane unloading is being undertaken.

Food and other consumables may be loaded onto vessels direct from barges while a vessel is at the jetty, either before or after cargo-loading operations. Removal of solid wastes may also be undertaken. Solid wastes will be removed from a vessel by crane onto a waiting barge from where wastes will be disposed of by an appropriately licensed waste management contractor.

No sewage discharge is expected within the Port of Gladstone as part of normal operations. However, clean, deep ocean ballast water or treated ballast water will be routinely discharged simultaneously during cargo loading to maintain vessel stability at roughly similar loaded and ballast draughts.

9.3 LNG FACILITY MAINTENANCE

Details of planned maintenance will be further refined during detailed engineering. However, the objective of maintenance is to ensure maximum overall availability of the QCLNG Facilities at minimum cost while ensuring safe operating conditions.

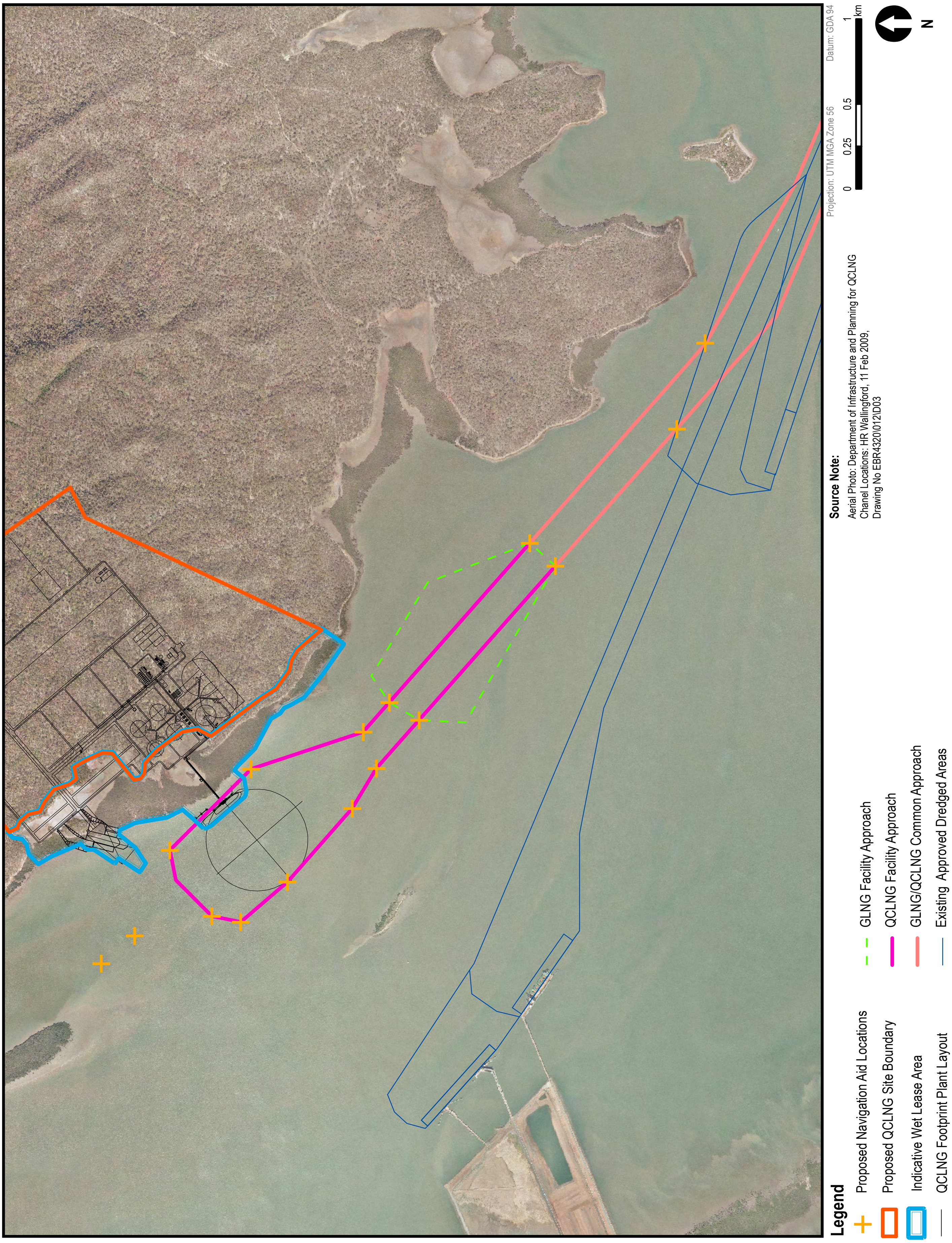
In general, the QCLNG Project maintenance philosophy ensures that equipment is maintained in accordance with manufacturer recommendations throughout the Facility's operational life, and promotes optimisation in terms of equipment availability and sparing.

Maintenance will be undertaken on the basis of:

Preventive maintenance, being either schedule-based (including routine maintenance) or condition-based.

- Schedule-based (or fixed time) maintenance and routine maintenance involves replacement of all equipment parts subject to normal wear and tear within regular, pre-determined intervals.
  - Common routine maintenance activities are lubrication, calibration, adjustment, minor leak repair, provision of fluids/greases and cleaning.
  - Maintenance campaigns and planned shutdowns will be dictated by the risk-based inspection process for statutory vessel inspections and re-certifications. Indicatively, major shutdowns will occur approximately every three years for each train and will require approximately 300 personnel.
  - Other maintenance campaigns will be required for turbine servicing and engine change-outs that may be outside these shutdown windows.
- Condition-based (or predictive) maintenance requires provision of measuring devices and condition-monitoring inspection routines to predict the effective need for maintenance before a failure occurs. This is achieved by permanently installed equipment (such as vibration measurement of heavy machinery) or with portable equipment on sequences defined by the behaviour of the equipment.
- Condition-based (or predictive) maintenance is applied to “capital” items such as gas turbines and main process compressors (i.e. liquefaction compressors) and highly critical items.

Corrective maintenance is carried out after fault recognition and is intended to enable an item to perform its required function.



QUEENSLAND CURTIS LNG A BG Group business	Project: Queensland Curtis LNG Project		Title: **Indicative Layout of Navigation Aids for QCLNG Channel and Swing Basin**
	Client: QGC - A BG Group business		
ERM Environmental Resources Management Australia Pty Ltd	Drawn: KP	Volume 2 — Figure 2.9.12	Disclaimer: Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only. ERM does not warrant the accuracy of any such Maps and Figures.
	Approved: DS	File No: 0086165b_EIS_LFO_GIS007_F2.9.12	
	Date: 20.05.09	Revision 1	

9.4 SITE BUILDINGS

9.4.1.1 *General*

The following permanent buildings will be included within the Facility:

- Control and Laboratory Building
- Administration Building
- Fire, Safety and First Aid Building
- Maintenance Building
- Warehouse
- Chemical Store
- BoG Compressor and Master Control Centre (MCC) Building
- Main Switchgear Building
- Marine Terminal Building
- Guard Houses

The following descriptions are provided for key non-process and process buildings.

9.4.1.2 *Control and Laboratory Building*

The Control Building will be a single-storey blast-resistant building. The building will include the control room, electrical room, battery (UPS) room, auxiliary room, computer/printer rooms, laboratory, training simulation room and telecommunications room.

The Laboratory will be located in the Control Building and will accommodate equipment and staff for process analysis requirements.

Space will be provided for operational staff, permit issue counter, waiting area, mess room/pantry, room for personal safety gear, smoking room, conference room, filing, library, female/male toilets and heating, ventilating and air conditioning (HVAC) room.

The operator consoles consist of a number of “multi-windows” computer workstations from which the operator can control the Facility and will be installed in the main control room.

A CCTV system will enable visual monitoring of specific Facility areas for general supervision and remote surveillance.

A separate station will be provided for fire and gas detection and protection.

The LNG trains console will have additional visual display units (VDUs) to allow an extra operator position during upsets, start-up and shutdown of one of the trains. The common facilities console will also have additional VDUs to allow an extra operator position during ship-loading operations.

The building will be supported by a steel or reinforced concrete frame and have steel cladding or prefabricated, reinforced concrete wall elements. The roof will be made of either monolithic, reinforced concrete or galvanised steel sheeting combined with a structural concrete layer on top of the sheeting..

A centralised HVAC system will be provided, with fresh air intake. A chilled water buffer vessel is required on the basis of the expectation that the temperature in the control room may rise significantly within half an hour in the event of an emergency.

9.4.1.3 Administration Building

The Administration Building will accommodate site administration staff, and include meeting/conference rooms, archives, toilets etc.

A centralised HVAC system will provide fresh-air intake.

9.4.1.4 Fire, Safety and First Aid Building

The Fire, Safety and First Aid Building will be located near to the Control Building and be sized to allow temporary occupation of emergency personnel during incidents. The following systems will be provided within the Emergency Control Centre:

- Facility radio
- Marine radio
- Aeronautical radio
- PA control
- Pager control
- Telephone - national/international/hotlines/short-dial
- CCTV monitor
- LAN connection points

Medical facilities will be located in the Administration Area.

The Fire Station will serve both the Facility and construction camps.

The Fire Station will contain necessary fire-fighting and safety equipment for dealing with all possible incidents on the Facility. Offices will be included for permanent fire/safety and security staff, as well as a small workshop and fire training ground.

A small, open compound for storage of road signs and other items will be adjacent to the building. Hose-washing and drying facilities and foam storage tanks will be provided. Covered shelter will be provided for two fire-fighting trucks and trailers.

9.4.1.5 Maintenance Building

The Maintenance Building will be equipped to cater for the maintenance needs of the Facility and house offices, toilet facilities, tool stores, instrument shop, electrical shop and plant rooms. All rooms/areas will have air-conditioning and forced ventilation.

The fitting shop will be provided with a transport rail system, embedded in the concrete floor.

Two 10-tonne overhead travelling cranes will be included in the mechanical workshop and one in the electrical workshop bay.

9.4.1.6 Warehouse

The Warehouse will be adjacent to the Maintenance Building and will house a bulk store, consumable and spare parts store, air-conditioned store, small items store, receiving/inspection and dispatch areas, offices and toilet facilities.

The Materials yard will consist of a fenced asphalt area located next to the materials Warehouse. Provisions will be made for an outside industrial gas cylinder store with roof, a scrap yard (concrete bays with low side wall and fencing) and a container receipt area.

Apart from the air-conditioned offices and cold store, all other rooms/areas will have forced ventilation. The building will consist of steel frames supported by a concrete foundation. The outside walls of the building will consist of double-sheeted, insulated metal cladding.

9.4.1.7 Chemical Store

A Chemical Store will be provided to accommodate drum storage, molecular sieves, heat transfer fluid, mercury removal absorbent, treatment chemicals, and other chemicals.

Design and operation of chemical stores will include requirements for bunding and handling of chemicals and potential spillage. The design will take into consideration ventilation, separation of chemicals stored, fire rating and fire-fighting requirements as per any applicable codes for general chemical storage.

9.4.1.8 BoG Compressor and MCC Building

A steel-framed structure with a roof but open-sided steel cladding will be used to provide protection for the BoG compressors and associated equipment.

The MCC Building will be separated from the BoG Compressor shelter and will be fully enclosed.

The MCC Building protects essential instrumentation for controlling the Facility operation.

The MCC Building will be provided with adequate ventilation and a centralised HVAC system, with fresh air intake and a split-unit, air-conditioning system.

9.4.1.9 Main Switchgear Building

The Main Switchgear Building protects essential instrumentation for controlling the Facility operation

9.4.1.10 Guard Houses

Guard Houses will be provided at the MOF and at the road entrance to the site if the road is eventually built.

9.5 SITE SECURITY

Proposed site security measures are summarised below. It is intended that a detailed security risk assessment will be undertaken for the site during the FEED process, and levels of security discussed and agreed with the national and state authorities and maritime security authorities. At this stage of design, the planned security philosophy incorporates the following baseline elements:

9.5.1.1 Perimeter Fence

The onshore terminal will be contained within a perimeter fence, and the shore-end of the jetty will be contained within a similar fence. Fencing is to be constructed of weld mesh or palisade, indicatively 2.9 m high and topped with razor wire. Outside the fence will be a clear zone (at least 5 m in width) to allow observation by CCTV and a roadway to allow for passage of security patrol vehicles.

A system will be installed on the jetty pile legs to prevent access to jetty topsides from the sea. Infra-red motion-detection cameras and automated monitoring software will be used to cover the entire dock and jetty topsides.

9.5.1.2 Access Gates

Access gates will be constructed to the same level of security as the fence. There will be at least one main and one alternative vehicle and pedestrian access gate.

Vehicle access will be of a double-gate, airlock system, and will be monitored by CCTV and manned by security guards (in the event that the bridge across The Narrows and associated access roads are not constructed, this measure may be deemed to be superfluous).

9.5.1.3 *Vehicle Access*

Arrangements for vehicular access will vary subject to the construction of the Curtis Island Bridge/Road and associated access roads, but in all scenarios vehicle access to operational areas of the site will be strictly limited to essential operational vehicles only.

Diesel, propane, ethylene, gasoline and bulk nitrogen will be delivered by ship, ferry or barge at the jetty and/or MOF. Storage, transport and handling will be in accordance with applicable Australian and Queensland standards.

9.5.1.4 *Personnel Access*

A personnel electronic identity card system will be used to control access for both terminal employees and visitors to the process and jetty areas. Access to all operational buildings on the site will be controlled by using a swipe-card reader.

Personnel emergency exit gates will be installed at various locations around the Facility to allow emergency egress. Gates/egress points will be monitored with motion-detection CCTV. All personnel accessing the process areas of the Facility will be required to adhere to the site Personal Protective Equipment (PPE) requirements including fire-retardant clothing.

9.5.1.5 *Site Security Control Area*

A security control area will be located within the main control room. The security control area will have access to CCTV screens monitoring the site, and ability to access and track the electronic identity swipe-card system. The security control area will have access to the site's public address (PA) system and internal telephone system, the Facility general alarm system, and the Facility two-way radio communication system.

9.5.1.6 *Intruder Detection Systems*

A Perimeter Intruder Detection System (PIDS) will be installed to cover the Facility and jetty compound. The system will be zoned and connected to a central alarm point in the security control area, with zones sufficiently defined to allow accurate location of any intrusion. A range of systems are being considered and include:

- electric power fence
- microwave beam
- buried cable intruder detection system

- fence-mounted two-wire optical fibre detector system.

9.6 WORKFORCE AND ACCOMMODATION

Details of operational workforce and proposed accommodation strategy are included in *Volume 2, Chapter 6*.

In summary, operational workforce is anticipated to consist of a total permanent workforce of approximately 162 workers including staff and contractors. This will include approximately 115 workers (operational, maintenance and security personnel) working at the LNG Facility. Although these will be split between:

- an eight-hour day shift (general staff)
- a 12-hour day shift (6am to 6pm for operations, maintenance and security personnel)
- night shift (6pm to 6am being primarily operations and security personnel, with maintenance as required).

Numbers of personnel on site will vary subject to maintenance requirements. Up to a further 50 personnel will be based on the mainland in Gladstone and include IT personnel, human resources, management and general administration.

A summary of operational workforce under normal operations is provided in *Table 2.9.2*.

Table 2.9.2: *Indicative Operational Workforce*

	LNG Facility (Curtis Island)	Mainland (Gladstone/ Brisbane)	Total Personnel
8-hour day shift	15	47	**62**
12-hour day shift	24 + approx. 20 contract as required	-	**24 + approx. 20 contract as required**
12-hour night shift	16	-	**16**
Off shift	40		**40**
Total (all shifts)	**115**	**47**	**162**

Shutdown of the LNG Facility will only occur during planned routine maintenance on Facility equipment or as a result of emergency shutdown. Major maintenance campaigns and planned shutdowns will occur approximately every three years and require approximately 300 personnel (in addition to normal operational personnel).

Other maintenance campaigns will be required for turbine servicing and engine change-outs. These will occur outside the shutdown windows. It is expected that most of these workers will be available in the local area or other parts of Queensland.

No permanent accommodation is planned on Curtis Island for the operations phase. Some refuge accommodation (approximately 30 beds) may be installed to allow for shift work during periods of high activity.

9.7 TRANSPORT REQUIREMENTS AND INFRASTRUCTURE

LNG/propane shipping is described separately in *Section 9.2.6.*

Logistical planning for the operations phase is based around a marine-only option, with operational and maintenance personnel working out of Gladstone daily, via a new land-based and marine terminal (refer *Figure 2.9.13*) to be located behind RG Tanna Coal Terminal at the end of Alf O'Rourke drive. The facility will be accessed via a new roundabout and will include a parking area and amenities building.

Regular vessel transit for normal operations will include:

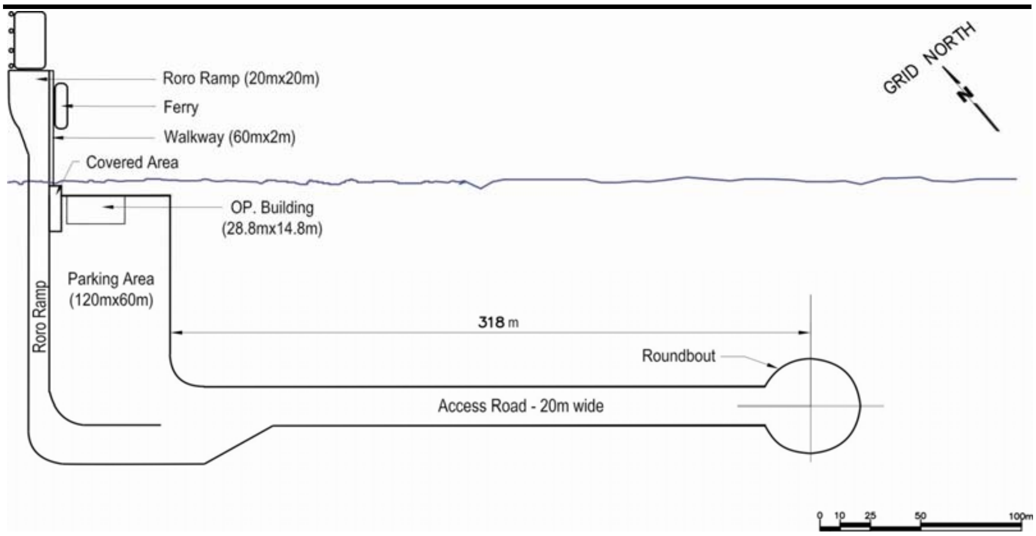
- water taxi at change of shift, plus additional movement of personnel on an as-needs basis throughout the day
- daily ferries carrying waste and supplies to and from the LNG Facility via the roll-on roll-off ramp.

9.8 ELECTRICITY/ENERGY

For each LNG train, six refrigeration compressor drivers will be used, being LM2500+G4s gas turbine generators equipped with dry, low Oxides of Nitrogen ($NO_{x)}$ emission systems.

In addition to refrigeration compressor drivers, electric power for the LNG Facility will be generated by two LM2500+G4 gas turbine generators equipped with dry, low Oxides of Nitrogen ($NO_{x)}$ emission systems. These will be sufficient for two and three trains. Preliminary generation requirements (to be refined further during detailed design) are for approximately 28 MW for Train One, plus an additional 20 MW for each of Train Two and Train Three. No interconnection with existing or future power generation sources outside the LNG Facility is anticipated.

Figure 2.9.13 Indicative Layout of Operations Terminal



These gas turbine generators will be augmented with a "black-start" diesel generator at the generator area, and with standby diesel generators at the Administration Building and at the Marine Terminal Building. The gas turbine generators will be fired from pipeline gas upon Facility start-up; but are fuelled from the Facility fuel-gas system once the Facility is in operation.

A standby LM2500+G4 gas turbine generator will also be in place to allow for continued power supply while maintenance on one of the generators is being undertaken.

The frequency and voltages implemented will be standard at 50 Hz and 415/240 volts. The electrical system will be designed and installed in accordance with AS/NZS Wiring Rules and other AS/NZS Standards, and with regard to applicable International Electrotechnical Commission standards when dealing with topics for which Australian Standards do not exist.

All substations will feature oil-filled transformers with cables feeding prefabricated switchgear assemblies. All transformers will be placed atop oil-retaining concrete foundations which can contain all of the transformer oil in an event of a tank leak. Where adequate space cannot be provided between transformers, a firewall will be installed between transformers.

Dual redundant UPS systems featuring redundant four-hour Valve Regulated Lead Acid (VLRA) batteries and redundant battery chargers will provide power to Distributed Control System (DCS) equipment installations and to control-room equipment, telecommunications equipment, security equipment, and strain-gauge marine monitoring equipment.

9.9 TELECOMMUNICATIONS

Details of telecommunications external to the LNG Facility are undergoing refinement, with options under consideration including:

- a fibre-optic cable co-located with the Pipeline from the mainland to the island;
- an overhead connection using 3750E to 3750E direction WIFI, served by the existing mobile phone network; and/or
- microwave system.

Consultation with the telecommunications provider is ongoing to ensure integration into existing systems.

9.10 WATER SUPPLY AND MANAGEMENT

Optimisation of water production and use, including opportunities for water recycling and reuse, will be pursued during the detailed design phase of the water systems for this Project.

Water for Facility operations will be sourced through use of a reverse osmosis (RO) desalination system to treat seawater to an appropriate quality. The desalinated water would be further treated to meet specific needs such as processed water and potable water. It is estimated that total site water usage during operations will be in the order of 38 m^3 per day for three trains.

Uptake of seawater for the RO system, and discharge of RO brine streams, will be located at the end of the MOF. Discussion of brine stream water volume and quality is provided in *Section 9.13 (Stormwater and Liquid Effluent Management)*, and *Volume 5, Chapters 8* and *11* describe dispersion modelling and assessment of impact of discharge on waters to Gladstone Harbour and on marine biota. *Figure 2.9.14* outlines the process for the water supply operations.

9.10.1.1 *Demineralised Water*

Demineralised water is required as make-up to the Acid Gas Removal Unit (AGRU), and for washing of the gas turbine compressor blades.

9.10.1.2 *Potable Water*

Utility water will be pumped from the utility water tank(s) to the potable water system. The potable water quality will comply with the requirements of the World Health Organisation *Guidelines for Drinking Water Quality*, 3rd edition, 2004 and *Australian Water Quality Guidelines for Fresh and Marine Waters*.

The potable water system will consist of a storage tank, filter system, hypochlorite injection set to provide free residual chlorine, and transfer pumps.

Dosing with salts for taste will be considered if the water is desalinated.

The potable water supply will be sized for a minimum 200 litres/day for each staff member on site.

9.10.1.3 Utility Water

Utility water will be stored in the utility water tank(s) with capacity for five days' usage of water. The utility water will be for users that do not require demineralised or potable quality water.

9.10.1.4 Fire water

The Facility layout will maximise the use of passive protection in the form of equipment spacing and drainage of possible liquid spillages away from critical equipment to containment sumps. However, active measures such as fire and gas detection, a fire-water system and overpressure protection will also be included in the design.

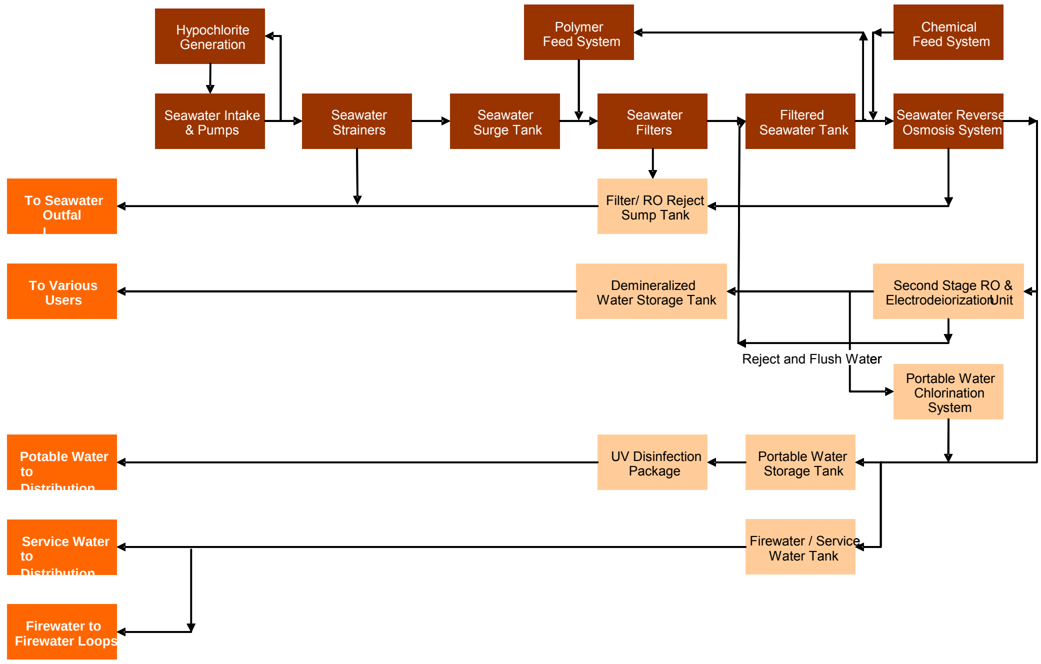
The fire protection and safety systems include:

- Fire water – underground distribution loop and above-ground system
- fire and gas detection systems – response to release of combustible, hazardous and/or low temperature gases and fires
- fire proofing – all major structural steel and insulated vessels in the liquefaction section that normally contain flammable or combustible hydrocarbon
- fire water tank
- fire water pumps – diesel driven.

9.10.1.5 Condensate

In addition to the water use outlined above, use of inlet air chilling in the LNG process will result in production of water as atmospheric condensate. Volumes of water condensed will be subject to a number of parameters including the ambient temperature, relative humidity, and the drop in temperature at the gas turbine compressor inlet. While the volume will vary with these conditions, an indicative estimate of condensate produced (based on 70 per cent relative humidity and 23^{0}C ambient temperature) is for approximately 150 m^3 per LNG train per day.

Figure 2.9.14 Water Systems for Operations



Quality of water produced as condensate would be dependent upon atmospheric constituents at the time of condensation, but would be roughly analogous to rainwater quality although quality cannot be guaranteed. The preliminary management strategy for the condensate water is for discharge to the sediment ponds for disposal through evaporation and overflow to Gladstone Harbour, although other potential uses of this water are still being assessed.

9.11 STORMWATER AND LIQUID EFFLUENT MANAGEMENT

Details of stormwater management are described in *Volume 5, Chapter 9*. A brief overview is provided below.

Sources of major liquid waste streams and their proposed management and disposal are described below.

- Clean stormwater run-off from uncontaminated parts of the site will be routed to two sedimentation ponds (indicative sizes 470 m x 65 m x 2.5 m deep, and 390 m x 75 m x 2.5 m deep). Excess stormwater (overflow from the ponds) will be discharged as a sheet flow to Gladstone Harbour.
- Sewage will be treated via an extended aeration-activated sewage treatment plant. Treated wastewater is further processed through tertiary filters and stored before it is pumped to an irrigation system or discharged to outfall.
- Excess water will be routed to sedimentation pond(s). Rejects from seawater desalination system will be routed to an outfall to the harbour.

- Processed wastewater and contaminated stormwater run-off from the Facility process will be routed to the corrugated plate interceptor (CPI) separator via process area spill containment sump and various stormwater lift stations for treatment. CPI effluent will be further treated in a dissolved air flotation unit and a tertiary filter and then routed to the irrigation system or routed to the sedimentation ponds.

Rainfall run-off from the hills outside the site boundary will be intercepted and diverted around the Facility footprint, and discharged direct to harbour.

Stormwater run-off from the diversion ditches and the overflow run-off from the sedimentation ponds will be discharged to Gladstone Harbour as sheet flow via riprap aprons.

The liquid effluent from the LNG Facility that will be discharged to outfall at the end of the MOF is detailed below in *Table 2.9.3*. Dispersion modelling of effluent discharges has been undertaken and an assessment of potential impacts on marine water quality and marine biota is included in *Volume 5, Chapters 8* and *11*.

More detailed site drainage plans will be developed during the FEED Stage-2 and EPC (Engineer-Procurement-Construction (EPC)) phases of the Project.

Table 2.9.3 Anticipated Operational Effluent Discharges and Quality

Stream Description	**Flow, m^3/hr**						**Estimated Characteristics**
	Average			**Maximum**			
No. of Trains	**1**	**2**	**3**	**1**	**2**	**3**	
Treated Process/ contaminated stormwater (Note 1)	2.5	3.5	5	44	70	100	pH: 6 to 7 BOD_5 : 10 to 20 mg/l TSS: 5 to 10 mg/l Oil: 5 to 15 mg/l
Desalination (RO) System Blowdown (Note 2)	10	15	20	26	40	50	pH: 6.5 to 7.5 units TDS: 55,500-60,000 mg/l $N+^-$: 17,000 mg/l Alkalinity: 170 mg/l Cl: 30,650 mg/l Mg++ : 2000 mg/l TSS: 0 mg/l SiO_2 : 16 mg/l
Treated sewage (Note 3)	1	2	2.5	1.5	2.5	3.5	pH: 6.5 to 7.5 BOD_5 : 10 to 20 mg/l Oil & Grease: 5 to 10 mg/l Total Nitrogen: 30 to 40 mg/l as N Total Kjeldahl Nitrogen: 1 to 5 mg/l Ammonia nitrogen: 1 to 5 mg/l Total Phosphorus: 5 to 10 mg/l TDS: 250 mg/l

Notes:

1. The average flows are based on dry weather flows and includes filter backwash water and reject stream from the EDI section of the RO plant. The maximum flows are based on wet weather flows (i.e. stormwater) and includes dry weather (normal) flows.
2. Based on First Pass RO Reject.
3. Based on an average population of 100 people (includes visitors and transient workers) and a maximum population of 150 people.

9.12 *SOLID AND SEMI-SOLID WASTE MANAGEMENT*

Waste streams anticipated to be generated during site operations are identified in *Volume 5, Chapter 17*, along with a description of proposed management procedures. Key waste streams addressed include:

- sewage and sanitary wastewater
- digested sewage sludge which will be periodically removed from site to mainland for disposal at an appropriate licensed facility such as a landfill or an incinerator
- solid wastes such as those from administration and office buildings, Facility area, amine and dehydration units, the sewage treatment plant, Coalescing Plate Interceptor (CPI) separator, Dissolved Air Flotation (DAF) unit and mercury adsorbent
- non-hazardous wastes such as waste lubricating oils, sanitary sludge, demineralisation sludge, cellulose and putrescible and non-putrescible waste.
- hazardous waste such as spent solvents, molecular sieve waste and oily sludge from the CPI separator float from the DAF unit.

It is anticipated that the above wastes will be removed from site and disposed of within the Gladstone region by a licensed waste contractor to a licensed waste facility. *Table 2.9.4* presents an indicative summary of the anticipated solid and semi-liquid wastes generated annually from the LNG Facility.

Table 2.9.4 Anticipated LNG Facility Solid Waste Generation

Waste product	Quantity (Kg/yr) Unless otherwise stated		
	1-Train	2-Trains	3-Trains
Waste Lubricating Oils	8,000	14,000	20,000
Spent Oils	1,000	1,700	2,500
Cellulose	1,000	1,500	2,500
Biological Sludge	4,000	5,000	6,000
Oily Sludge/Float	7,000	14,000	20,000
Spent Solvents	100	200	250
Ceramic Balls*	12,000	24,000	36,000
Molecular Sieve Waste*	116,400	232,800	349,200
Activated Carbon (Amine filter)	33,000**	66,000	99,000*
Trash	50,000	80,000	120,000
Waste Oil from Slop Oil Tank	20 m^3/year	35 m^3/year	50 m^3/year
Mercury Adsorbent	-3.	-3.	-2.

Notes:

1. Kg every 3 years
2. Waste-activated carbon quantities are based on reference plant data. These will be verified during the FEED phase.
3. Based on the design feed gas mercury concentration, adsorbent bed life is expected to last for the Facility design life.

9.13 NOISE EMISSIONS

9.13.1.1 Noise Sources

The principal source of noise emissions from the operating LNG Facility are anticipated to be the gas turbines used to drive compressors and generators, associated pipe work and the cooling fans used in the air coolers.

A table summarising the typical noise sources and indicative sound power and sound pressure levels for an LNG train is provided below in *Table 2.9.5*.

Table 2.9.5 Indicative List of Key Noise Sources from an LNG Train

Description	Sound Power Level For a Single Noise Source (dBA)	Sound Pressure Level at 1 m (dBA)
LNG TRAIN PROCESS AREA		
Coolers		
Propane Refrigerant Condenser	96	86
Low-Stage Methane Discharge Coolers	97	86
Inter-Stage Methane Discharge Coolers	98	87
High-Stage Methane Discharge Coolers	98	87
Ethylene Compressor Intercoolers	98	87
Ethylene Compressor Discharge Coolers	99	87
Regenerator Overhead Condenser	99	87
Lean Solvent Cooler	97	86
Regeneration Gas Cooler	99	87
Combustion Turbines		
Methane Compressor Turbine and Stack	118	85-95
Ethylene Compressor Turbine and Stack	118	85-95
Propane Compressor Turbine and Stack	118	85-95
Compressors		
LP Methane Compressor	104	85
MP Methane Compressor	99	85
HP Methane Compressor	95	85
Ethylene Compressor	105	85
Ethylene Compressor Gearbox	79	75
Propane Compressor	104	85
Propane Compressor Gearbox	80	75
Piping		
Pipelines outside the Compressor Deck	110	85-95

Description	*Sound Power Level* For a Single Noise Source (dBA)	*Sound Pressure Level at 1 m (dBA)*
Pipelines under the Compressor Deck	105	85-95
Recirculation pipelines	105	85-95
Misc. Equipment		
Regenerator Compressor	107	85-90
Instrument Air Compressor	105	85-90
Lean Solvent Booster Pump	105	85-90
Lean Solvent Charge Pump	113	85-90
LNG Transfer Pump	103	85-90
Gas Turbines Generators		
Gas Turbine Generators	112	85-90
OSBL AREA		
Compressors		
BoG compressor	116.5	87
Pumps		
Demineralised Water Pump	99.0	85
Service Water Pump	101.7	85
Potable Water Pump	101.1	85

A preliminary noise analysis for the LNG Facility has been completed to assess steady-state operational noise, using previous project data. This preliminary analysis modelled a nominal two-train and four-train Facility operating under steady-state conditions, with the following assumptions with regard noise mitigation measures in place. A number of mitigation measures have been recommended and will be adopted by QGC and subsequently incorporated into detailed design and construction of the Facility.

- Propane, ethylene and methane air coolers: The air coolers are specified with a sound power level limit of 99 dBA for each fan. The air cooler motors are specified with a sound pressure level of 82 dBA at 1 m. The air cooler drives are specified with a sound power level limit of 92 dBA.
- Gas Turbines: The gas turbines for refrigerant compressors and generators are specified with a sound pressure level limit of 85 dBA at 1 m everywhere from each sub-source. Each gas turbine exhaust is specified with a sound pressure level limit of 90 dBA at 1 m from the edge of the opening.
- Gearboxes for Propane and Ethylene Compressors: Standard equipment without any special noise treatment assumed.
- Refrigerant Compressors: Standard equipment without any special noise treatment assumed.
- Refrigerant Compressor Suction, Discharge and Recycle Piping: Refrigerant compressor suction, discharge and recycle piping have 100 mm thick Class B acoustic insulation.
- Control Valves: Control valves including anti-surge valves are required

with 85 dBA at 1 m from the valve and 1 m from the downstream piping.

- Gas Turbine Generator (GTG): Each GTG is specified with a sound pressure level limit of 85 dBA at 1 m from the generator enclosure.
- BoG Compressors: Standard equipment without any special noise treatment assumed.
- Regeneration Compressor: Standard equipment without any special noise treatment assumed.
- Instrument Air Compressors: Standard equipment without any special noise treatment assumed.

On this basis, the preliminary noise analysis (refer *Table 2.9.6)* gave the predicted noise levels at the Facility site boundary for a nominal four-train LNG Facility:

Table 2.9.6 Predicted Operational Noise Levels at Facility Boundary. Nominal Four-Train Facility

Facility Boundary	Predicated Operational Noise Levels (dBA)
West property line (coastline)	63 ~ 71 dBA
East property line	60 ~ 67 dBA
North property line	64 ~ 69 dBA
South property line	63 ~ 68 dBA

9.13.1.2 Sensitive Receptors

An assessment of impacts of Facility operational noise on sensitive receptors in the Gladstone region has been undertaken and is discussed in detail in *Volume 5, Chapter 13*. Sensitive receptors considered as part of this assessment are included in *Table 2.9.7*, with locations of these receptors shown in *Figure 2.9.15.*

Table 2.9.7 Noise–Sensitive Receptors Considered[4]

Noise Assessment Location	Address	Approximate Distance from Curtis Island LNG Site (km)
NAL 1	Jetty G/H, Gladstone Marina	8.5
NAL 2	Lot 2 Fisherman's Road, Yarwun	6.5
NAL 3	Turtle Street, South End, Curtis Island	11.5
NAL 4	71 Flinders Parade, Gladstone	10
NAL 5	Tide Island	5
NAL 6	12 Lord St, Gladstone	9.5
NAL 7	Smith St, Targinie	9

4 Environmental Resources Management Australia, 2009. *Queensland Curtis LNG Plant: Noise & Vibration Report* (unpublished report for BG International Group)

9.14 AIR EMISSIONS

Air emissions predicted to be generated during LNG Facility operations are described in detail, and impacts assessed in *Volume 5, Chapter 12.*

In assessing air quality and greenhouse impacts associated with the Project, a range of potential technologies were assessed to minimise emissions from the LNG Facility. A Best Available Techniques (BAT) assessment and justification was undertaken to identify air emissions associated with the LNG process, and review potential for reductions. Key outcomes included:

- adoption of waste heat-recovery (WHR) to reduce use of fuel gas burners associated with the dehydration and mercury removal component of the LNG process. Use of fuel gas burners would result in an estimated CO_2 emission of approximately 10,800 tonnes per annum per LNG train. The decision to use the WHR system will result in only approximately 365 tonnes CO_2 per annum being released
- a variety of refrigeration compressor drivers were considered for the Project. The aero-derivative LM2500+G4s with Dry Low Emissions (DLE) were selected in a 2x2x2 configuration for each LNG process train (total six compressor drivers per train). The main reasons for selection of this option were:
  - design NO_x emissions from the this configuration of LM2500+G4s + DLE to be as low as or lower than any of the other options considered in detail (although electric motor drives were rejected prior to detailed assessment due to limited reliability and proven technology data)
  - thermal efficiency was as great as or greater than any other option considered, with greater thermal efficiency indicating lower rates of greenhouse gas emissions arising from operation of the compression drivers.

Projection: UTM MGA Zone 56
Datum: GDA 94

0 1 2 4 km

N

Source Note:
StreetPro Australia - Pitney Bowes MapInfo
Environmental Resources Management Australia, 2009.
Queensland Curtis LNG Plant: Noise & Vibration Report
unpublished report for BG International Group,
draft report February 2009

Legend
- Proposed QCLNG Site Boundary
- QCLNG Footprint Plant Layout
- Possible Curtis Island Road/ Bridge Corridor
- Proposed Export Pipeline
- Ferry Terminal
- Main Highways
- Noise Assessment Locations
- Noise Monitoring Locations

QUEENSLAND CURTIS LNG
A BG Group business

ERM
Environmental Resources Management Australia Pty Ltd

Project	Queensland Curtis LNG Project	Title	Locations of Sensitive Receptors (Noise Assessment Locations)
Client	QGC - A BG Group business		
Drawn KP	Volume 2 Figure 2.9.15	Disclaimer:	
Approved DS	File No: 0086165b_EIS_LFO_GIS005_F2.9.15	Maps and Figures contained in this Report may be based on Third Party Data, may not to be to scale and are intended as Guides only.	
Date 05.05.09	Revision 2	ERM does not warrant the accuracy of any such Maps and Figures.	

The initial design of the Facility assumed use of 2x2x2 (per LNG train) Frame 5D Gas Turbine Drivers. Selection of the LM2500+G4s instead will result in a reduction of:

- annual NOx emissions from approximately 975 tpa per LNG train (for the base case of the Frame 5D) to approximately 580 tpa per LNG train
- annual CO2 emissions from approximately 1,020 mtpa per LNG train (for the Base Case of the Frame 5D) to approximately 730 mtpa per LNG train.

It should be noted that these changes will result in this Facility being one of the lowest greenhouse gas emitters in Australia and in the world. The LNG generated by this Facility will be done so with the lowest greenhouse gas footprint based on:

- optimisation of power generation, with a range of turbine configurations assessed for one, two and three-train operation. Aero-derivative LM2500+G4s with DLE were also selected for power generation, with two operating plus one spare (for two-train operation). For the third train, it is assumed that Inlet Air Chilling (IAC) has been applied (see below), allowing two operating LM2500+G4 units to run all three trains. Use of the LM2500+G4 is calculated to result in the lowest NOx and CO2 emissions of all the options considered.
- IAC on the main refrigeration turbines increase the LNG production for the same installed units. The efficiency of the liquefaction process increases. The LNG production is offset by an increased electrical load. However, the overall impact is more LNG production per total unit of installed power.

These outcomes have been integrated into the air quality and greenhouse gas assessments provided in *Volume 5, Chapter 12 and Volume 7* respectively.

9.15 ALTERNATIVES CONSIDERED

9.15.1 LNG Facility Site Selection Process

9.15.1.1 LNG Facility Siting Methodology

Site selection investigation was undertaken according to:

- an assessment of minimum site requirements
- BG Group's business, environmental and social principles and guidelines
- review of relevant government policies, input and direction
- detailed assessment of desktop information, database searches, Geographic Information Systems (GIS) analysis and limited field work.
- A multi-criteria analysis process was then applied for comparative purposes to inform site selection. The above mentioned criteria were applied in a two-staged process during the site selection process.

The first stage involved a regional screening assessment of potential LNG Facility locations within Queensland, considering available sites and any specific governmental preferences. The outcome of this first stage was the selection of the Gladstone area as the preferred location.

Table 2.9.8 details the sites considered during this initial screening. The initial screening site locations are identified on *Figure 2.9.16* and *Figure 2.9.17*.

The second stage involved a more detailed analysis of the available local sites in the Gladstone area to identify a preferred site for the LNG Facility.

A consolidated summary of key advantages/strengths and potential disadvantages/ weaknesses of each site identified in all the site selection studies (Stage 1 and Stage 2) is provided in *Table 2.9.8* and *Table 2.9.9.*

9.15.1.2 Minimum Site Requirements

QGC determined that the minimum essential requirements for the LNG Facility (including associated marine activities) were:

- 200 to 300 ha of land (existing or reclaimed) for all land-based infrastructure associated with the LNG Facility, including accessibility to the site during construction and long term operations
- the proposed 12 mtpa LNG Export Facility using the ConocoPhillips Optimized Cascade℠ LNG technology for liquefaction
- site geography allows space and location of full containment LNG storage tanks without costly civil site development costs. The LNG spill and thermal radiation containment zones defined by NFPA 59A code are required to be contained within the site perimeter design
- sufficient area for construction lay-down and a construction camp with capacity of up to 1,200 personnel
- appropriate deep water site for LNG marine loading and propane offloading facilities, including jetty, shipping channels and turning basin, allowing safe navigation access for LNG vessels up to 180,000 m^3 in capacity, with a minimum of 14 m depth water to provide sufficient under-keel clearance and channels up to 200 m wide and a turning basin diameter of approximately 600 m
- access to existing shipping channels and port facilities for construction and operation of the LNG facility including loading platform for berthing, mooring, LNG loading arms. Other associated facilities would include breasting dolphins, mooring dolphins, and navigational aids
- access for establishment of a construction dock/MOF to receive bulk materials, heavy equipment, pre-constructed process modules and labor/personnel for construction and operations
- understand overview of Australian/Queensland regulatory process and identify any key local and/or governmental drivers for approving projects in the region that may conflict with BG's standard policies and intentions for

the implementation of this Project

- identify any environmental and social performance sensitive areas and specifically show stoppers, including the potential existence of protected species, cultural heritage sites and any known community plans/serious objections.

STAGE 1 - Regional Location Selection and Analysis

A regional screening investigation was undertaken of sites between Brisbane and the north end of Curtis Island, off Gladstone.

The sites considered in the Stage 1 regional screening were:

1. Port of Brisbane
2. Port of Bundaberg
3. Hamilton Point, Gladstone
4. Boatshed Point (South Curtis Island), Gladstone
5. North China Bay (South Curtis Island), Gladstone
6. Laird Point (South Curtis Island), Gladstone
7. Facing Island, Gladstone
8. Friend Point (Kangaroo Island), Gladstone
9. South Trees Point (South Trees Island), Gladstone
10. Fisherman's Landing, Gladstone
11. Aldoga Locations (inland from Gladstone port)
12. Gladstone Pacific Nickel site, Gladstone
13. Port Alma (remote mainland but near North Curtis Island), Gladstone
14. Sea Hill, North Curtis Island

The regional screening process concluded that Gladstone and Bundaberg were the preferred areas to consider for the LNG Facility. These areas were chosen for the following key reasons:

- the availability of land within an industrial development area - Bundaberg land was marginally large enough to accommodate potential future growth of the project
- ease and safety of navigation access
- protected natural deepwater harbour - Bundaberg had significant maintenance dredging issues at the mouth of a river
- existing port/shipping infrastructure - relatively underdeveloped for Bundaberg
- relative proximity to the Gas Field Component - Gladstone was further away and required a difficult crossing of the harbour in the WHA

- no fundamentally prohibitive social or environmental issues - although each area was close to or within some type of environmentally protected zone.

The QCLNG Project is consistent with the Queensland Government's policy to develop and add value to Queensland resources. As a result of other government studies, Gladstone was the area identified by the Queensland government for an LNG Precinct. Additionally, the QCLNG Project offers the additional benefit of diversifying Queensland's economic base and establishing Gladstone as an energy hub in the Asia Pacific region.

9.15.1.3 Detailed Assessment of Desktop Information, Database Searches, Geographic Information Systems (GIS) Analysis and Limited Fieldwork

Site-selection investigations were undertaken by a multi-disciplinary team (i.e. engineering, marine, environmental, planning, social, etc) to:

- visit the sites and evaluate engineering and construction challenges to design, build and operate a 3 or 4 train LNG export facility
- meet with available local specialists in the area to gather current, historical and relevant engineering, marine and environmental data to allow the due diligence review of the sites for the purpose of selecting the best site
- provide an overview of the environmental and social issues associated with the potential sites for the LNG Facility and associated marine facilities
- identify any potential fatal flaws that may be associated with the sites under review, including site size and geotechnical challenges, marine access, environmental or social performance issues and other potential risks
- summarise potential risks and impacts associated with the potential sites
- provide a ranking of individual sites and identification of a preferred option
- provide an overview of the legislative and approvals framework associated with the Project components.

Environmental desktop information, database searches, GIS analysis and limited fieldwork identified issues and risks, including:

- regional ecological and cultural values – proximity to areas of listed international, Australian or state ecological or cultural significance
- terrestrial ecology – potential impacts on listed protected terrestrial flora and fauna in the vicinity of the sites
- migratory species – potential impacts on migratory species protected by Commonwealth or Queensland legislation, or by international treaty
- marine ecology – potential impacts on listed protected terrestrial flora and fauna in the vicinity of the sites
- marine facilities and shipping – potential for siltation, water turbidity, tidal reach and height, ship turning area
- land resources – issues relating to contaminated land, cultural heritage,

native title and hydrogeology

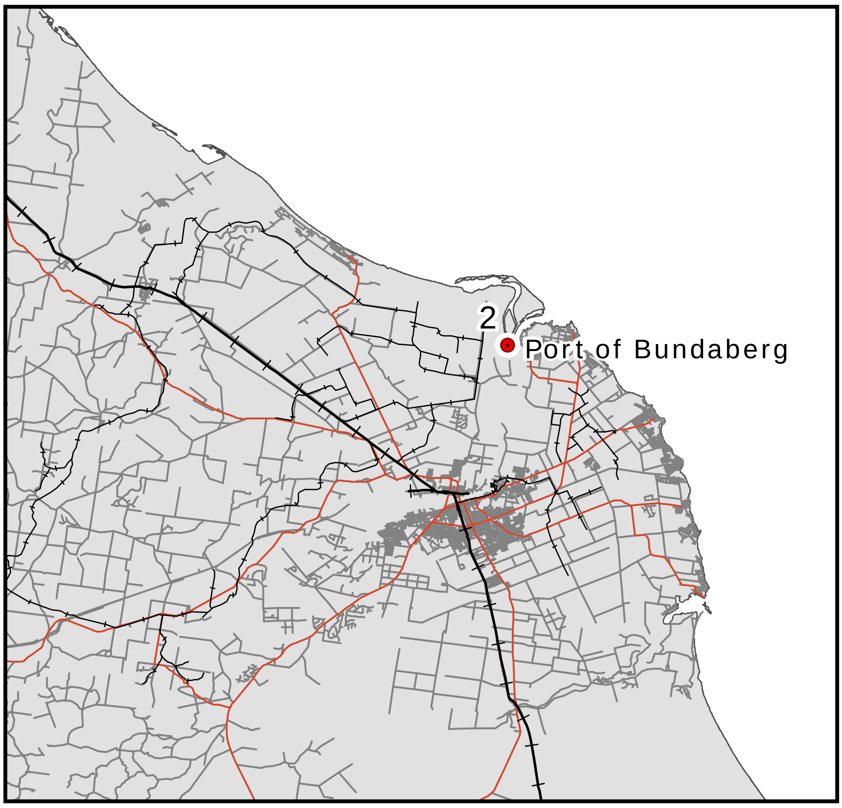
- infrastructure – issues relating to construction camp, proximity to infrastructure and feed gas supply, and export lines
- social baseline and community – summary of the socio-economic baseline for Gladstone and Bundaberg, and potential issues such as workforce availability and presence of community infrastructure, attitude towards industrial development
- other issues potentially impacting on site selection, including air quality, noise, and visual impacts.

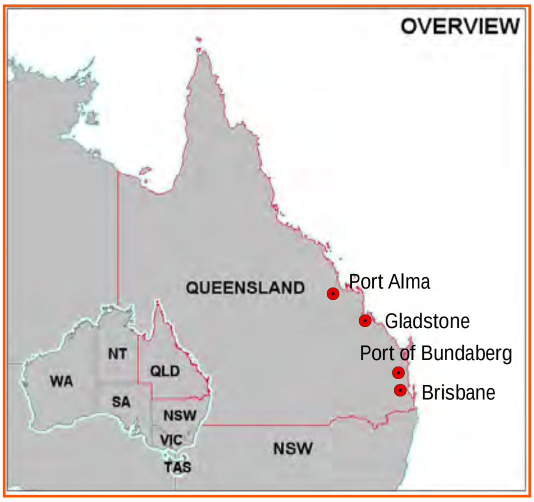
9.15.1.4 *STAGE 2 - Local Gladstone Site Selection and Analysis*

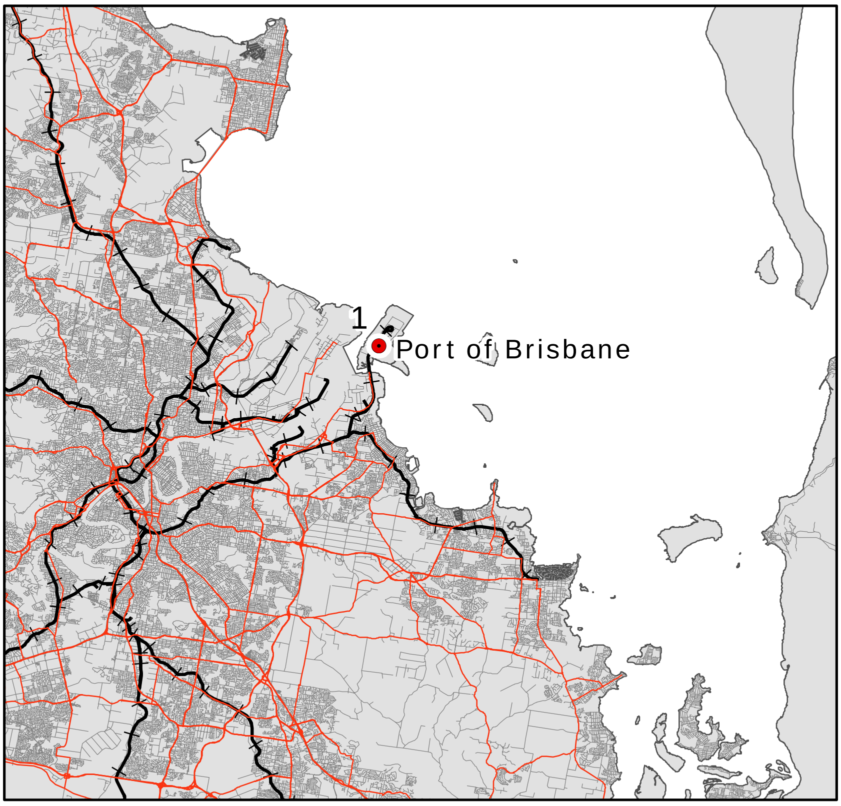
Based on the results of the initial regional screening investigation of Stage 1, sites in the Gladstone area became the focus of the more detailed site-selection investigations undertaken in Stage 2. The Port of Bundaberg site was retained as the only single out of Gladstone option remotely possible as an opportunity to balance the Gladstone review. In addition, several mainland Gladstone sites and South Trees Island (in the Gladstone harbour) were added to the list of sites for a more detailed site-selection study. This Stage 2 evaluation engaged three specialist contractors to combine engineering, marine and environmental analysis and input to determine a preferred site for the LNG Facility.

The sites considered in Stage 2 were:

1. North China Bay, Curtis Island, Gladstone
2. Laird Point, Curtis Island, Gladstone
3. Boatshed Point, Curtis Island, Gladstone
4. South Trees Point (South Trees Island), Gladstone
5. Port Alma, remote mainland but near North Curtis Island
6. Sea Hill, North Curtis Island
7. Mainland Gladstone - North side of Phillipies Landing Road
8. Mainland Gladstone - North of Cement Plant
9. Mainland Gladstone - Quarry Area
10. Mainland Gladstone - Intertidal area south of Fisherman's Landing
11. Mainland Gladstone – site for Gladstone Pacific Nickel (GPN) Project
12. Port Bundaberg







Site	Site Name
1	Port of Brisbane
2	Port of Bundaberg
3	Hamilton Point, South Curtis Island, Gladstone
4	Boatshed Point, South Curtis Island, Gladstone
5	North China Bay, South Curtis Island, Gladstone
6	Laird Point, South Curtis Island, Gladstone
7	Facing Island, Gladstone
8	Friend Point, Kangaroo Island, Gladstone
9	South Trees Point, South Trees Island
10	Fisherman's Landing
11	Aldoga Locations
12	Queensland Pacific Nickel Site, Gladstone
13	Port Alma
14	Sea Hill, North Curtis Island
15	North side of Phillipies Road, Gladstone
16	North of Cement Plant, Gladstone
17	Quarry Area, Gladstone
18	Intertidal Area south of Fisherman's Landing

Legend

- Potential LNG Site Locations
- Main Highway
- Local Roads
- Railway
- Light Railway
- Regional Screening
- Local Site Selection Stage
- Supplementary Site Selection

Source Note:
StreetPro Australia - Pitney Bowes MapInfo

Projection: UTM MGA Zone 56 Datum: GDA 94

0 3.75 7.5 15 km

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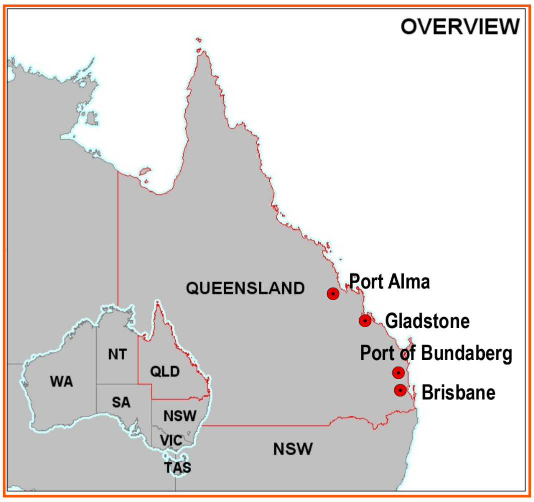
QUEENSLAND CURTIS LNG
A BG Group business

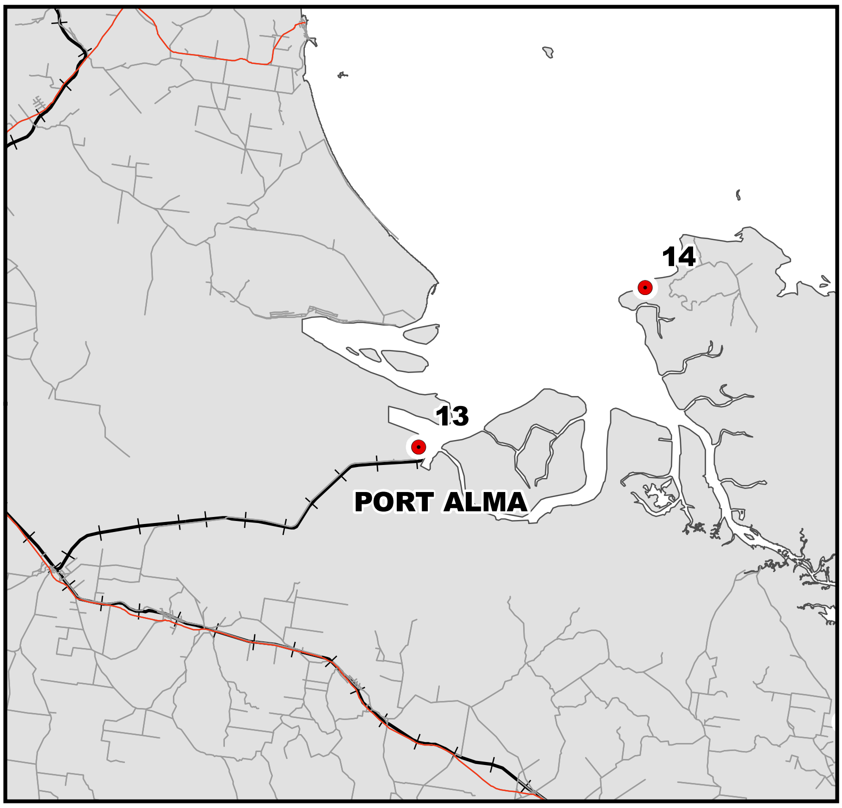
Project	Queensland Curtis LNG Project
Client	QGC - A BG Group business

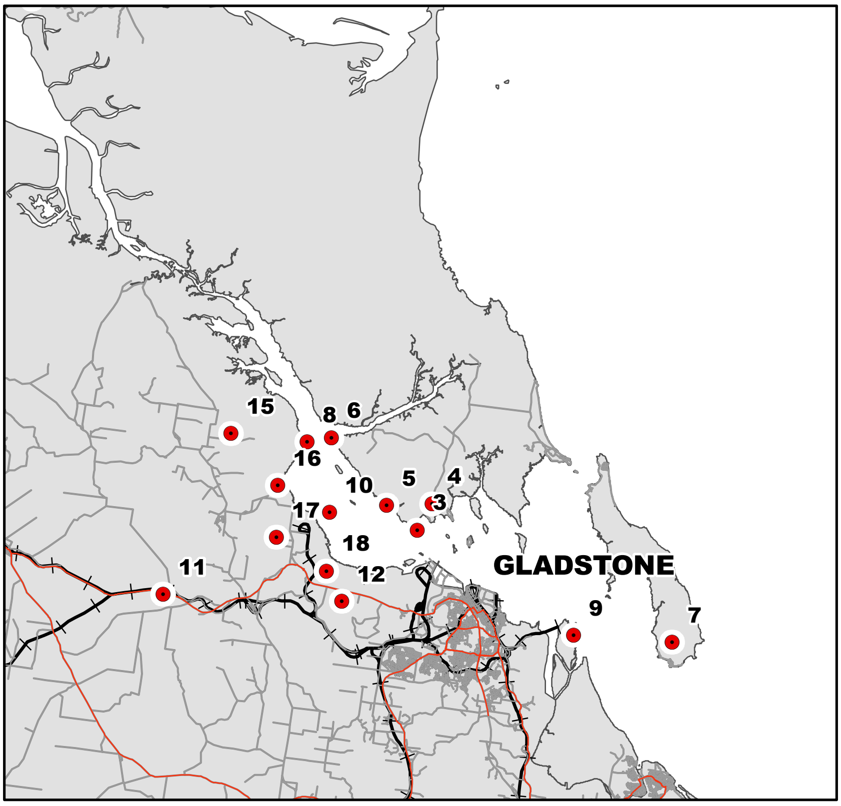
Title Potential LNG Sites
Port of Brisbane and Port of Bundaberg

ERM
Environmental Resources Management Australia Pty Ltd

Drawn	JB	Volume 2	Figure 2.9.16
Approved	GB	File No: 0086165b_EIS_LFO_GIS010_F2.9.16	
Date	27.05.09	Revision 0	







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Legend

- Potential LNG Sites
- Main Highway
- Local Roads
- Railway
- Regional Screening
- Local Site Selection Stage
- Supplementary Site Selection

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Project	**Queensland Curtis LNG Project**	Title	**Potential LNG Sites Gladstone and Port Alma**
Client	**QGC - A BG Group business**		
Drawn JB	**Volume 2** **Figure 2.9.17**		
Approved GB	File No: 0086165b_EIS_LFO_GIS011_F2.9.17		
Date 27.05.09	Revision 0		

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ERM does not warrant the accuracy of any such Maps and Figures.

Table 2.9.8 Sites considered at Stage 1 - Regional Screening

Site	Description	Comments
1. Port of Brisbane	The main port complex is located at the mouth of the Brisbane River, about 40 minutes from Brisbane CBD. Port of Brisbane is Queensland's largest general cargo port	The Port of Brisbane Corporation advised that a LNG development was inconsistent with the port strategy that is heavily focussed on growth in the container trade. Insufficient land was available in any event.
2. Port of Bundaberg	Bundaberg Port is located at the Burnett River mouth at Burnett Heads, approximately 10 km north of the City of Bundaberg. The site is a nearly flat sugar cane field located across the harbour from the existing sugar mill.	Insufficient land available for three LNG trains, narrow channel with high siltation rates (continuous maintenance dredging), no room for swing basin or a safety zone, close proximity to residential development, major capital dredging to deepen shipping approach channel extending to approximately 10 km offshore, potential conflicts in harbour with recreational craft, no marine infrastructure/port procedures.
3. Hamilton Point (South Curtis Island), Gladstone	Located on the south-west tip of Curtis Island in the Port of Gladstone.	The Gladstone Ports Corporation controls the site and intends to use the site for a common bulk loading terminal and therefore the site is not being offered for LNG development. A third party has an option on the site for LNG in the event the land use allocation is changed. The site is hilly and requires major cut/levelling costs, insufficient land for expansion desired.
4. Boatshed Point (South Curtis Island), Gladstone	Boatshed Point is the third site located on the southern end of Curtis Island in the Port of Gladstone.	Strong currents would seriously challenge or prevent the location of an LNG berth close to the Facility site. Proximity of residential receptors may result in undesirable noise and visual impacts from the LNG Facility.
5. North China Bay (South Curtis Island), Gladstone	Located on the south-west side of Curtis Island approximately halfway between Laird Point (at Graham Creek) and Hamilton Point	Adjacent to proposed Santos LNG project. Consistent with Queensland Government direction on location of LNG industry. Adequate land available with favorable site conditions compared with other assessed locations. Isolated location to nearest community receptors and least visual and noise impact from Gladstone City.
6. Laird Point (South Curtis Island), Gladstone	Located on Curtis Island north-west of the North China Bay location and south of Graham Creek	Use of site would require LNG carriers to traverse the full length of Gladstone Harbour, so implying the maximum dredging option for the Gladstone sites. Immediately bordering the GBRCMP habitat protection zone. Challenging geotechnical conditions requiring substantial volumes of fill. Long jetty required to reach shipping channels with associated impacts on

Site	Description	Comments
		recreational and boating access / amenity to The Narrows.
7. Facing Island, Gladstone	Large sand island to the east of Gladstone City and south of Curtis Island, forming a low lying but natural breakwater to the port of Gladstone Sites considered on the island were primarily grazing land.	Significant infrastructure required to establish construction and operation access. Pipeline access seen as problematic. Environmentally sensitive coastal area set aside as a community environmental protected area and therefore non-negotiable. Additional concern expressed that building may erode the narrow island and remove the natural breakwater effect for the Port. Least amount of dredging required. Inconsistent with precedent and direction of Gladstone State Development Area (GSDA) Development Scheme, Gladstone City planning scheme and GPC Strategic Plan (50-year horizon).
8. Friend Point, Kangaroo Island, Gladstone	To the north of Gladstone City in the southern section of The Narrows	Previously identified as a future airport site. Now identified within the GSDA as a "Restricted Development Precinct". The maximum dredging option for the Gladstone sites. Immediately bordering the GBRCMP habitat protection zone. Insufficient land and carried potentially significant cultural heritage issues. Challenging geotechnical conditions requiring substantial volumes of fill. Extensive sensitive intertidal/marine habitats which would be substantially impacted by industrial plant location. Relatively accessible for gas transmission pipeline.
9. South Trees Point, South Trees Island	On South Trees Island, at south-eastern entrance to Gladstone Harbour	Coastal wetlands site subject to tidal inundation that would require extensive mangrove clearing and reclamation/filling. This implies ecological impact and time delays. Adjacent to heavy industry which could be incompatible to co-location of a LNG Facility. Least amount of dredging. Difficult but possible road and pipeline access. Site is upwind of Gladstone City which was an expressed concern, contrary to long term vision for future industry to be located north (downwind) of main population.
10. Fisherman's Landing, Gladstone	A reclaimed land area on the shoreline of The Narrows waterway, located approximately 10 km north-west of Gladstone	Site not large enough and site committed to the LNG Limited proposed project. Requires second greatest amount of dredging of all sites.
11. Aldoga locations (various),	Located 10 km inland from Gladstone	Inland location would require a long cryogenic line, the cost of which would be prohibitive to development of the Project

Site	Description	Comments
West of Gladstone		Potential sites also restricted by oil shale leases which potentially compromise clear tenure for development of other long-term industrial infrastructure
12. Gladstone Pacific Nickel site, Gladstone	Located approximately 8 km west of the Gladstone CBD, at the intersection of Hanson and Reid Roads	Site committed to Gladstone Pacific Nickel Project (GNP) At the time of the regional screening the GNP EIS had not been determined, however the Project was granted Coordinator-General approval with conditions in January 2009 and the site is not available. In any event the site is setback from the harbour and would require an extended and expensive cryogenic line over land and a long jetty to access deep water in the harbour.
13. Port Alma, North Curtis Island	Located on the Fitzroy River delta and bounded by Casuarina and Raglan Creeks, and by the Fitzroy River to the north Approximately 42 km south of Rockhampton by road	Adjacent to an existing ammonium nitrate import and export facility which creates a safety risk for the development of an LNG facility and associated shipping. A remote location lacking port required and other infrastructure. Experiences serious tidal inundation and requires extensive site preparation remediation. Ship access would be more difficult and no space available for a swing basin. Extensive capital dredging required. Maintenance dredging required due to siltation during high rainfall / monsoonal events. Silts potentially affected by pesticides runoff from agricultural hinterland.
14. Sea Hill, North Curtis Island	Sea Hill is located on the north-west peninsula of Curtis Island, Keppel Bay	An environmentally-sensitive and remote location lacking port and other infrastructure. Access is problematic for personnel (no roads) and the pipeline. A product jetty would be exposed to direct north winds which offer 3+ m waves regularly thus lowering berthing availability. Major site clearing and levelling works required with major permanent alteration to coastal landscape.

Criteria considered and applied to the evaluation of each site included:

High Level (Most Critical Issues)

- deep water/dredging requirement and adequate turning area to accommodate a range of ship sizes
- safety issues - safe navigation access, sufficient land for QRA/code requirements and separation from population areas
- environmental constraints – cultural heritage, flood and inundation, acid sulphate soils, highly valued habitats, protected species and areas
- key resources area – land use conflicts /sterilising oil shale resource
- marine activities - potential of negative environmental impacts.

Medium Level

- available land area, limits of tank location, jetty trestle length, future expansion, other layout issues such as height above sea level
- noise and air quality, and impact on community health
- port-related infrastructure, control of large ships, sheltered berth
- adjacent industrial development and clear planning framework
- community support and attitude towards industrial development.

Low Level (Least Critical Issues)

- workforce availability and construction camp transport/logistics
- supporting municipal infrastructure
- visual impact
- flight paths
- local synergies.

A consolidated summary of key advantages/strengths and potential disadvantages/weaknesses of each site identified in all the site selection studies is provided in *Table 2.9.9.*

Table 2.9.9 Stage 2 - Advantages and Disadvantages of Alternative Gladstone Siting Options for the LNG Facility

Site	Advantages/Strengths	Disadvantages / Weaknesses
1. North China Bay, Curtis Island, Gladstone	• Sufficient land area and land for expansion potentially available • Contouring and terrain of site allows for a balanced cut and fill approach • Geotechnically suitable for Facility and tank construction • Noise and visual impacts on sensitive receivers are low • The site is part of the 'Curtis Island Industry Precinct' within the GSDA which was designated to provide for the establishment of LNG facilities • The adjacent LNG land use (GLNG project) provides potential opportunities for expansion • Close to existing Gladstone industrial workforce • Site has harbour front access and would require a short LNG loading jetty	• Access to island site requires additional logistical effort • Significant dredging requirement Minor area of endangered and of-concern regional ecosystem present Potential impact of fine particulates on operations if a coal bulk loading facility is established at Hamilton Point in future
2. Laird Point, Curtis Island, Gladstone	• Noise and visual impacts on sensitive receivers are low • The site is part of the ''Curtis Island Industry Precinct'' within the GSDA which was designated to provide for the establishment of LNG facilities • The adjacent LNG land use (GLNG project) provides potential opportunities to develop common user infrastructure	• Terrain of the site increased the need for cut and fill, and reduces the available land area • Extensive dredging requirement • Access to island site requires additional logistical effort; • The site is the furthest north in the Port of Gladstone and is near the crossing point selected for a future bridge and road from the mainland to Curtis Island, requiring a separation envelope • Limited housing availability and would require island-based construction camp • The marine LNG ship berth location requires a long on-shore jetty pipe rack
3. Boatshed Point, Curtis Island, Gladstone	• Close to existing Gladstone industrial workforce • Island location provides good security and an adequate safety buffer zone • The site is part of the ''Curtis Island	Substantial cut and fill will be required due to topographical characteristics requiring a greater level of civil engineering and site works • Significant dredging requirement • Access to island site requires additional logistical effort

Site	Advantages/Strengths	Disadvantages / Weaknesses
	Industry Precinct'' within the GSDA which was designated to provide for the establishment of LNG facilities • The adjacent LNG land use (GLNG project) provides potential opportunities to develop common user infrastructure	The strong currents south of the island prevent the location of a LNG ship berth close to the LNG Facility site, even though adequate depth might be made available through dredging In proximity to residential properties located on nearby islands Of-concern regional ecosystem present • Potential disturbance to nearby European cultural heritage place (Garden Island Environmental Park)
4. South Trees Point, South Trees Island, Gladstone	Existing road access Close to existing Gladstone industrial workforce • Coastal access • No "of concern" or "endangered" regional ecosystem is mapped at the site	• The site is a coastal wetland and requires extensive reclamation and piling to create a site suitable for construction of a LNG Facility • The site is subject to tidal inundation and at risk of flooding • Closer to main shipping channel, however this exposes the site to high vessel traffic and interaction The site impacts on Gladstone City air shed Industrial development in this location may face community opposition due to perceived air quality and health impacts
5. Sugar Cane Factory Land, Bundaberg	• Mainland site with existing road access • No "of concern" or "endangered" regional ecosystems mapped at the site Located outside the Great Barrier Reef World Heritage Area (GBRWHA)	Potential for impacts upon shorebird-feeding habitat and sea grasses. Limited land availability The existing site elevation needs to be increased to avoid potential storm flooding The Port Bundaberg city, sugar mill and residential development are within 1 km from the LNG facilities. There is the potential for major noise impacts, as well as significant visual impacts High sedimentation rates from the Burnett River result in high and unacceptable maintenance dredging requirements The impact of dredging operations on turtle nesting grounds is a significant issue. The coast to the immediate west and east is a sea turtle sensitive area and Mon Repos Conservation Park (approximately 14 km east of Port Bundaberg) is the site of the largest concentration of nesting turtles on eastern

Site	Advantages/Strengths	Disadvantages / Weaknesses
		mainland Australia
6. Port Alma	Sufficient land area available and potential for expansion Isolated location means noise and visual impacts on sensitive receivers are low	Existing road access, however this would require upgrading The site is a low-lying intertidal mud flat with high potential for flooding. The existing site elevation would need to be increased, requiring significant volumes of fill The site has insufficient marine area for the swing basin and would involve major costs for significant dredging and a long cryogenic product line and jetty Poor existing infrastructure and services The site is distant from available workforces and would require a construction camp in a climatically unpleasant location The shipping safety procedures associated with the existing use of the port for ammonium nitrate import/ export would place unacceptable restrictions on LNG shipping The adjacent ammonium nitrate loading prevents the establishment of an adequate safety buffer zone around the LNG Facility A LNG Facility may conflict with the existing use of nearby land for salt harvesting
7. Sea Hill (North Curtis Island)	• Partially geotechnically suitable for Facility and tank construction • Island location provides good security and an adequate safety buffer zone • Adequate ship turning area	Available land area limited by topography and environmental constraints Poor potential for future expansion Use of site would probably require levelling Sea Hill Access to remote island site requires additional logistical consideration Use of this site would require significant infrastructure investment on the island

Site	Advantages/Strengths	Disadvantages / Weaknesses
		and connecting roads on the mainland Would require significant dredging and spoils disposal program The exposed location may be subject to substantial wave penetration during northerly sea breezes and adverse weather conditions causing problems for the loading of LNG ships Non-existent port infrastructure The site is significantly removed from a skilled labour workforce, and associated support infrastructure, e.g. emergency response systems • Requires island-based construction camp or construction camp at Port Alma • Industrial development in this location is likely to face community opposition • Small fishing community in proximity to the site would incur noise and visual impacts Sensitive coastal environment, contains endangered regional ecosystems, is identified in essential habitat mapping and is an identified turtle-breeding area Site is outside of the GSDA and identified as a key coastal site in the Curtis Coast Regional Coastal Management Plan (CCRCMP) Industrial development in this location is contrary to the objectives of the CCRCMP A resort development is proposed at North Curtis Island which would conflict with LNG use
8. Mainland Gladstone - North side of Phillipies Landing Road, Gladstone Located approximately 14 km north-west of Gladstone CBD	Sufficient land area available and potential for expansion • Need for dredging reduced by GPC commitment to dredge to Fisherman's Landing • Mainland site with access to existing Gladstone industrial workforce	• Existing road access but would need to be upgraded for heavy vehicle access • Community opinion is potentially negative due to the site's proximity to Great Barrier Reef Marine Park (GBRMP) • Within Key Resource Area (oil shale) • Requires a long 4 km Jetty length, • Crosses GPC proposed spoil disposal area, and significant intertidal sensitive wetland area.

Site	Advantages/Strengths	Disadvantages / Weaknesses
	• Good access to a range of port-related infrastructure and services (eg: Customs, quarantine, pilots, tugs and towage, bunkering, emergency response, navigational aids, maintenance dredge program)	
9. Mainland Gladstone - North of Cement Plant, Gladstone Contiguous coastal lots west of Gladstone CBD and north of Cement Australia Plant at Serrant Road, Gladstone	• Need for dredging reduced by Gladstone Ports Corporation (GPC) commitment to dredge to Fisherman's Landing • Mainland site with access to existing Gladstone industrial workforce • Good access to a range of port-related infrastructure and services (eg: Customs, quarantine, pilots, tugs and towage, bunkering, emergency response, navigational aids, maintenance dredge program) • Site is located in an existing industrial area and community opinion is likely to be positive	• Insufficient land available for proposed LNG facility • Existing road access but would need to be upgraded for heavy vehicle access • Constrained by existing mining leases (oil shale) • Site is identified in essential habitat mapping • Site is adjacent to major shorebird feeding site • The LNG jetty would be adjacent to proposed new GPC berths north of Fisherman's Landing which may conflict with GPC plans • Site requires a +2 km trestle jetty that needs to traverse proposed dredge spoil disposal area
10. Mainland Gladstone - Quarry Area Disused quarry site located approximately 13 km west of Gladstone CBD Accessed via Landing Road, Gladstone.	• Need for dredging reduced by GPC commitment to dredge to Fisherman's Landing Sufficient land area available and potential for expansion Existing road access Mainland site with access to existing Gladstone industrial workforce	• Pipeline would have to traverse Key Resource Area (oil shale) and cross rail line and require a cryogenic pipeline of approximately 5 km, including a 3 km jetty • Site is potentially affected by Gladstone Airport flight path
11. Mainland Gladstone - Intertidal area south of Fisherman's Landing, Gladstone	• Sufficient land area available and potential for expansion • Need for dredging reduced by GPC commitment to dredge to Fisherman's Landing • Mainland site with access to existing Gladstone industrial workforce	• Site is located on intertidal flood plains so would need to be filled and piled • Geotechnical conditions are anticipated to be complex, with deep running unstable soils, not suitable for direct bearing • Existing road access but requiring extensive and costly upgrading • Site is identified in essential habitat mapping • Site is adjacent to major shorebird feeding site

Site	Advantages/Strengths	Disadvantages / Weaknesses
Located approximately 10 km west of Gladstone CBD	• Good access to a range of port-related infrastructure and services (eg: Customs, quarantine, pilots, tugs and towage, bunkering, emergency response, navigational aids, maintenance dredge program)	• Site is adjacent to the Orica Chemical Plant which produces an explosive material, presenting safety issues to the LNG Facility and the storage/loading of LNG • Site is potentially affected by Gladstone Airport flight path • requires long cryogenic line/jetty length of approximately 3-4 km
12. Mainland Gladstone – area designated for potential Gladstone Pacific Nickel Project Located approximately 8 km west of the Gladstone CBD, at the intersection of Hanson and Reid Roads	Sufficient land area available and potential for expansion Need for dredging reduced by GPC commitment to dredge to Fisherman's Landing • Mainland site with access to existing Gladstone industrial workforce • Good access to a range of port-related infrastructure and services (eg: Customs, quarantine, pilots, tugs and towage, bunkering, emergency response, navigational aids, maintenance dredge program)	• Site is partly located on intertidal flood plains so would need to be filled and piled • Geotechnical conditions are anticipated to be complex, with deep running unstable soils, not suitable for direct bearing • Existing road access but requiring extensive and costly upgrading • Site is adjacent to the Orica Chemical Plant which produces an explosive material, presenting safety issues to the LNG Facility and the storage/loading of LNG • The site is close to residential receptors of Gladstone City and the LNG Facility • Oxides of Nitrogen would add to the high power plant levels in the local area • The site contains dominant endangered regional ecosystems and is identified in essential habitat mapping • Site is potentially affected by Gladstone Airport flight path • Long jetty trestle length of approximately 4-5 km required • EIS for Gladstone Nickel Project approved with conditions in January 2009 and the site is not available

9.15.1.5 *Preferred Site Option*

Following the site-selection studies, North China Bay on Curtis Island in the Port of Gladstone was identified as the preferred location for the LNG Facility, for the reasons explained below.

Technical

The area from North China Bay to Laird Point has been designated as the ‘‘Curtis Island Industry Precinct’’ within the GSDA to provide for the establishment of LNG facilities.

Although remotely located on Curtis Island, the North China Bay site is amenable to ferrying labour, equipment and bulk materials to the site. The existing port infrastructure staffed with trained marine pilots made this an attractive port of entry.

The logistical challenges arising from the LNG Facility being sited on an island are also partially offset by the advantages this remoteness provides. The distance between the site and residential receptors reduces and minimises visual impact arising from the LNG Facility. The site also offers good security and can achieve the necessary buffer zones between the LNG Facility site and adjacent land uses.

Geotechnically, the North China Bay site is suitable for LNG tanks and liquefaction process units. This feature also provides for balanced cut and fill.

Capital dredging will be needed to both widen and deepen existing channels in Gladstone Harbour and to extend a new channel to the North China Bay site. However, a requirement for dredging was not considered a significant differential between the Curtis Island sites considered during the Stage 2 site selection process.

Commercial

All of the Gladstone sites, including North China Bay on Curtis Island, provides a range of commercial advantages including direct access of shipping channels to export markets such as Japan and China. A sheltered harbour means less expected bad weather days and increases the Projects ability to ship processed LNG with reliable certainty, thus increasing the success of the Project. The Gladstone Ports Corporation (GPC) and Maritime Safety Queensland have been consulted and have expressed support to ensure the port facilities and services (i.e. tug sizes/quantity) are upgraded to accommodate the technical shipping requirements for LNG.

Social

The location of North China Bay on Curtis Island has a minimum or negligible social impact on surrounding communities. The area is well away from neighbouring communities. The geographical location of the bay and the natural buffer zone it provides between the proposed site and existing residents ensures that social impacts will be minimised.

Environmental

The initial north China Bay site investigation indicated that impacts on protected flora and fauna species could be minimised. This site's remoteness also affords minimal impact on noise and visual amenity to the nearest receptors and the general Gladstone community. Impacts on Gladstone region air quality were found to be acceptable.

Government Policy

The Queensland Government has designated south-western Curtis Island as part of the Gladstone State Development Area

Further, the Queensland Government has long recognised Gladstone as Queensland's key industrial city. Successive Queensland Governments have invested heavily in Gladstone through the provision of infrastructure to support heavy industry. The Queensland and Australian Governments have encouraged and facilitated substantial levels of foreign investment in Gladstone, particularly from major trading partners such as Japan and China.

9.15.1.6 Location of Jetty/Berth and Turning Basin

The conceptual location for the jetty, turning basin and marine infrastructure was primarily motivated by navigational access requirements and technical requirements related to minimising the cryogenic pipeline through which LNG would be transferred from the storage tanks to waiting vessels. The final location and configuration of the turning basin will be subject to further analysis and optimisation to strike the best possible balance between all relevant factors, including dredge volumes.

GPC and Maritime Safety Queensland have been and will continue to be consulted throughout this process.

9.15.1.7 LNG Facility Site Access Alternatives

QGC has investigated two prime alternatives for LNG Facility site access: marine transport; or Curtis Island Bridge and Road.

QGCs preferred option is to transport personnel, equipment, materials and all associated items to and from the LNG Facility site during construction and operations by means of marine transport from Gladstone to Curtis Island.

However, at the time the EIS was undertaken, the Department of Infrastructure and Planning (DIP) was also investigating the development of a bridge and road linking the mainland to Curtis Island (i.e. the Curtis Island Bridge/Road). The Curtis Island Bridge/Road therefore presents a site access alternative which has been considered in this EIS.

Alternative 1 - Marine Transport

During the construction and operations phase the marine transport alternative would entail vessels transporting personnel, equipment, materials, waste and all associated items between the Gladstone mainland to the MOF on Curtis Island. Auckland Point will be the primary ferry terminal and staging area for the construction phase of the Project, from land leased from the GPC.

During operations, a ferry terminal/staging area is proposed along the shoreline behind the existing RG Tanna Wharf with access via Alf O'Rourke Drive. There is little difference in transit time between the marine and road transit option.

Alternative 2 - Curtis Island Bridge/Road

The development of the Curtis Island Bridge/Road would provide vehicular access to Curtis Island from the mainland north of Fisherman's Landing via a road bridge crossing The Narrows. This would allow personnel, equipment, materials and waste to be transported to and from the LNG Facility by road.

The proposal to develop a bridge and a road connecting the mainland and Curtis Island stemmed from the Gladstone Land Port Rail Road Infrastructure (GLPRRI) Study in 2007. This study was commissioned by the DIP to identify infrastructure required to service potential future development on Curtis Island; to define separation distances between infrastructure types; and to identify preferred routes for the establishment of infrastructure corridors linking the mainland to Curtis Island.

Following the GLPRRI Study, the Coordinator-General commissioned Connell Wagner to commence Concept Design investigations into the Curtis Island Bridge/Road (Connell Wagner, 2008a[5], 2008b[6], 2008c[7], 2008d[8], 2008e[9], 2008f[10]). These studies were commissioned on the basis that this infrastructure would be required to provide access to the QGC and Santos LNG facilities (the Gladstone LNG Project) on Curtis Island, particularly during the construction phase of these projects when the largest volumes of personnel, equipment and materials would need to be transported to and from the island.

The development of the Curtis Island Bridge/Road therefore presents a site

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5 Connell Wagner (2008a) **Executive Summary. Curtis Island Road/Bridge Concept Design.** Reference 36914-001, Revision 0. Prepared for the Department of the Coordinator-General. 12 December 2008.

6 Connell Wagner (2008b) **The Narrows Crossing – Options Analysis. Curtis Island Road/Bridge Concept Design**. Reference 36914-001. Revision 2. Prepared for the Department of the Coordinator-General. 12 December 2008.

7 Connell Wagner (2008c) **Bridge Planning Report. Curtis Island Road/Bridge Concept Design.** Reference 36914-001-05. Revision 1. Prepared for the Department of the Coordinator-General. 12 December 2008.

8 Connell Wagner (2008d) **Road Design Report. Curtis Island Road/Bridge Concept Design.** Reference 36914-001-03. Revision 1. Prepared for the Department of the Coordinator-General. 12 December 2008.

9 Connell Wagner (2008e) **Constructability Review Report. Curtis Island Road/Bridge Concept Design.** Reference 36914-001-04, Revision 0. Prepared for the Department of the Coordinator-General. 12 December 2008.

10 Connell Wagner (2008f) **Cost Estimate Report. Curtis Island Road/Bridge Concept Design.** Reference 36914-001-012. Revision 02. Prepared for the Department of the Coordinator-General. 12 December 2008.

access alternative for QGC and is described in more detail in the section that follows.

9.15.1.8 *Curtis Island Bridge/Road*

The Bridge would extend 1.5 km to 2 km from the southern end of Kangaroo Island (Friend Point) across The Narrows (a seawater channel) to Laird Point on Curtis Island, south of Graham Creek (refer to *Figure 2.9.18)*. The length between abutments would depend on the final adopted bridge alignment and location of the abutments.

The alignment for the Curtis Island Bridge lies in close proximity to the northern boundary of the Port of Gladstone and the southern boundary of the Great Barrier Reef Coast Marine Park. The alignment has considered GPC's plans for future land facilities associated with port development. Ongoing planning by GPC may require amendments to the alignment adopted for conceptual design.

The Mainland Road and Bridge Approach will connect to the northern end of Landing Road at a new three-way intersection of Landing Road–Mainland Road and Bridge Approach–Fisherman's Landing Port Access Road. The road will extend north along the foreshore for approximately 2.5 km before turning north-east across the tidal mudflats for a distance of approximately 2.5 km towards the southern end of Kangaroo Island at Friend Point (refer to *Figure 2.9.18*).

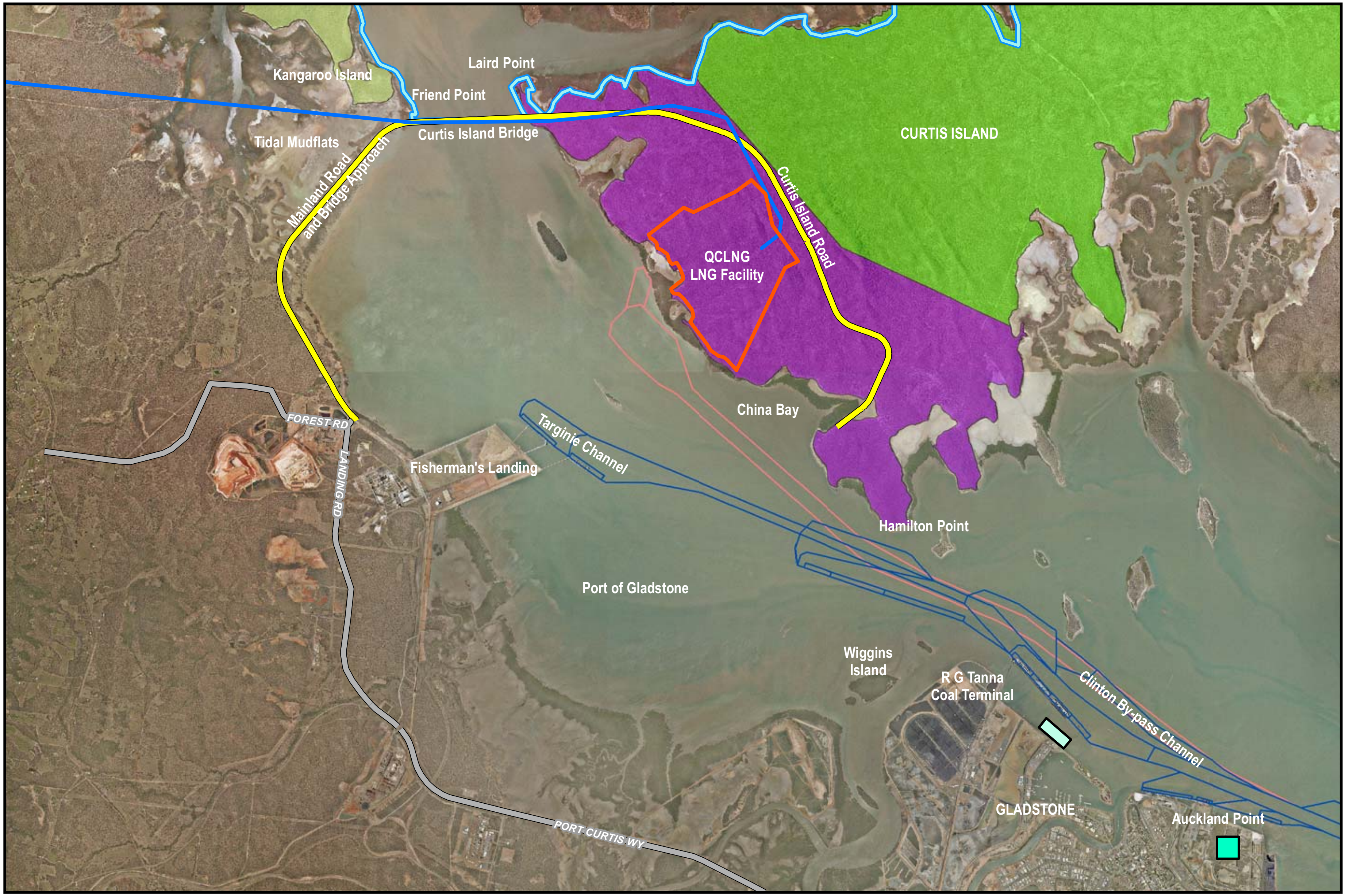
The road on Curtis Island will extend approximately 8.5 km from the eastern bridge abutment at Laird Point south of Graham Creek to the LNG Facility site. From the eastern abutment, the road will extend east and parallel to Graham Creek for approximately 2.5 km before turning south-east for approximately 5 km to Hamilton Point on the south-west corner of Curtis Island. The proposed new road will have a corridor width of approximately 50 m.

9.15.1.9 *Reason for the Selection of Marine Transport as the Preferred Alternative*

Marine transport was selected as the preferred option for the reasons stated below.

Early Site Access

No access will be available to Curtis Island for early works or during the first year or two of the Project construction activities. Therefore, an economical means of site access needed to be considered by the Project to support a reasonable EPC Schedule of work. Following a consideration of the marine versus road transport alternatives, QGC determined that marine transport is more attractive for economic, environmental and social reasons. The selection of the marine transport option as QGC's preferred alternative for accessing Curtis Island is supported by the following considerations.



Legend

- Proposed QCLNG Site Boundary
- Proposed Export Pipeline
- Possible Curtis Island Road/ Bridge Corridor
- GBRCMP Boundary
- Proposed Swing Basin & Shipping Channel
- Existing Shipping Channel
- Indicative Location of the Proposed Operations Phase Ferry Terminal
- Construction Phase Logistics Site

Curtis Island - Gladstone State Development Area

- Curtis Island Industry Precinct
- Environmental Management Precinct
- Restricted Development

Source Note:

Aerial Photo - Department of Infrastructure and Planning for QCLNG Project.
Curtis Island Road/Bridge Corridor - Connell Wagner.
Shipping Channels - HR Wallingford, Drawing EBR4320\012\D003-E

Projection: UTM MGA Zone 56 Datum: GDA 94

0 0.5 1 2 km

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QUEENSLAND CURTIS LNG
A BG Group business

Project: Queensland Curtis LNG Project
Client: QGC - A BG Group business
Drawn: JB Volume 2 Figure 2.9.18
Approved: FM File No: 0086165b_EIS_LFO_GIS012_F2.9.18
Date: 07.07.09 Revision 0

Title: **Location of the LNG Facility and Associated Infrastructure**

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ERM does not warrant the accuracy of any such Maps and Figures.

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Technical

The bridge would traverse geological conditions that may require more engineering and expense than is presently understood. The projected cost of a bridge to be provided by the Project was uneconomical. Its late availability in the schedule negated it's usefulness in achieving Project schedule objectives.

Commercial

It is likely that funding for the Curtis Island bridge and road would need to be provided by private proponents, most likely those intending to develop in the Curtis Island Industry Precinct. The cost of constructing and maintaining the Curtis Island Bridge/Road may therefore be subject to the both the timing of the first project to be developed in the Precinct, and ultimately the total number of proponents operating in the precinct. Therefore the cost to any single proponent is uncertain and difficult to determine at this stage.

In addition, the bridge and road is unlikely to be able to be constructed in time to be used as a means of transporting the peak construction workforce to and from the LNG Facility site, obviating its key benefit to the Project.

Bridge construction will require between six and 14 barges. This has the potential to result in schedule delays or cost escalations due to competition for barges between bridge construction and LNG Facility construction.

Current cost estimates for the Curtis Island Bridge/Road could escalate further due to the following costs which are as yet unspecified:

- additional studies, engineering and materials required to design and construct the bridge across the The Narrows
- management of acid sulphate soils for the section of the mainland approach road that crosses tidal mudflats
- management of cultural heritage and native title issues.

Following a cost-benefit analysis of the two alternatives, it is estimated that marine transport offers cost advantages when compared to the Curtis Island Bridge/Road option. This is underlined by the likelihood that the proposed schedule for the construction of the Curtis Island Bridge/Road has a high potential to be extended, thus negatively impacting one of the critical drivers for the Project.

Environmental and Social

The proposed Curtis Island Bridge is on the border of the State Great Barrier Reef Coast Marine Park. Additional government approvals would be required for the bridge construction if the final alignment extends into this park.

The Narrows is listed on the Australian Heritage Commission Register of National Estate and described as "an uncommon passage landscape and one of only five narrow tidal passages separating large continental islands from the mainland in Australia". It is also identified as an Area of State Significance (Scenic Coastal Landscape) within the Curtis Coast Regional Coastal

Management Plan with the desired coastal outcome being that "the landscape values and ecological integrity or mangroves, inlets and waterways are maintained" and that "infrastructure in areas of high visual quality does not obscure views to water or intrude on waterways".

The approaches to the bridge are in intertidal mudflat and mangrove areas and are likely to have acid sulfate or potential acid sulfate soils. In addition, Aboriginal cultural heritage and native title issues would also need to be addressed in order to develop the bridge and roads. The development of the bridge therefore faces considerable environmental and cultural heritage management issues due to its visual impact and its possible or perceived impact on the marine park.

For these reasons, the Bridge/Road Access to Curtis Island is not QGC's preferred option and is not proposed for the QCLNG Project.