6. PROJECT DESCRIPTION: LNG PLANT

This chapter describes the liquefied natural gas (LNG) plant components and ancillary facilities and their construction, operation and decommissioning, with the exception of the following components:

- All sections of the feed gas pipeline including the mainland section, the tunnelled section under Port Curtis, the Curtis Island section until it reaches the gas inlet station at the LNG plant, the tunnel launch and reception sites and the tunnel spoil disposal areas. These elements are addressed in Chapter 7, Project Description: Feed Gas Pipeline.
- All marine dredging (LNG jetty, materials offloading facilities, personnel jetty, and mainland launch sites) and dredge spoil disposal activities, which are described in Chapter 8, Project Description: Dredging.

The project description reflects the current design status of the project and will be further refined during the front end engineering design (FEED) and detailed design stages, which may result in further changes to the project description.

6.1 Overview

The scope of the proposed staged development, along with details of those options still under consideration, and the proposed development site are described in this section.

6.1.1 Project Components

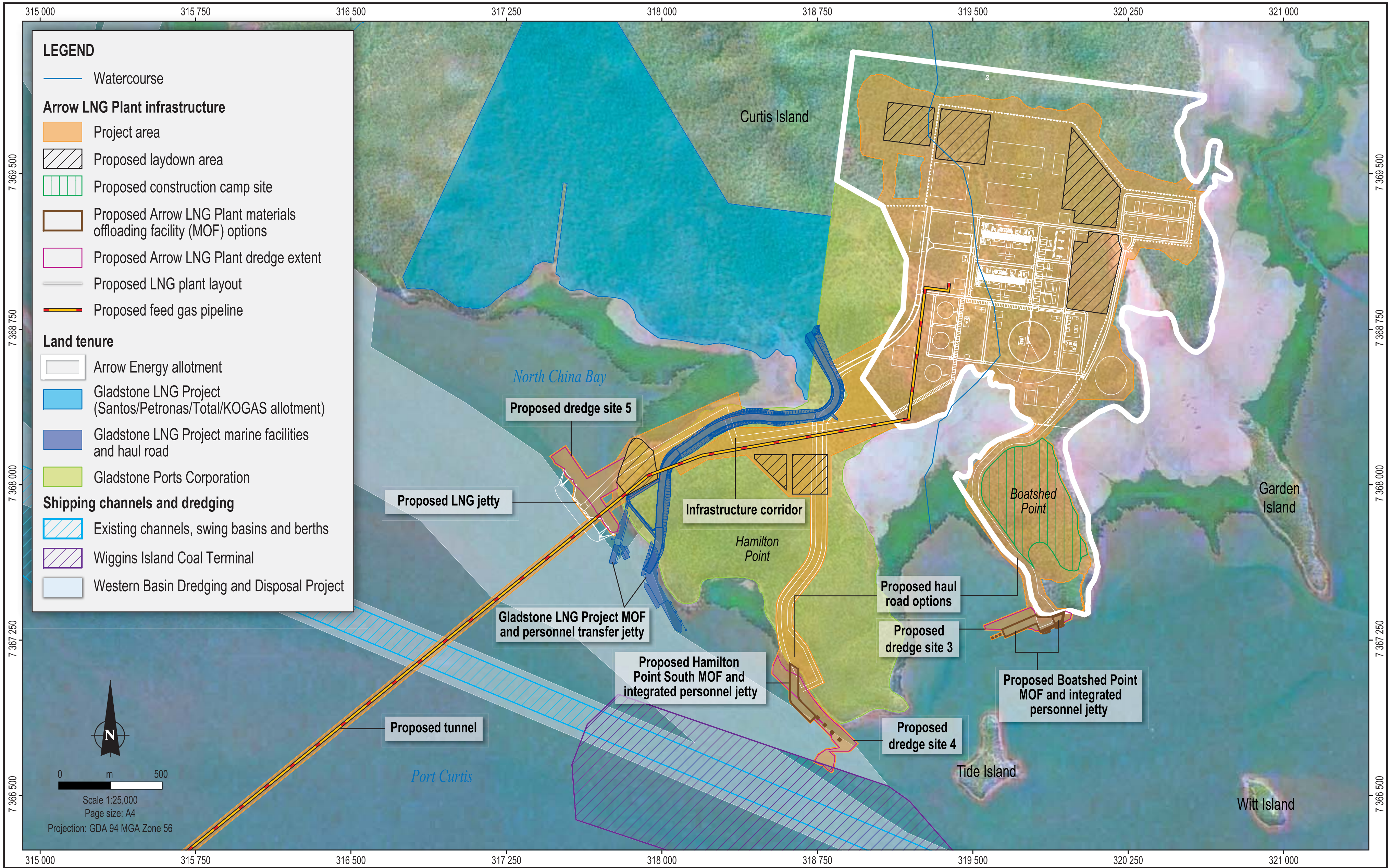
The LNG facility comprises the following main components:

- The plant to process the gas into LNG (the LNG plant) with associated utilities and ancillary facilities.
- A trestle jetty (the LNG jetty) with an LNG berth to facilitate loading and export of LNG.
- A facilities corridor between the LNG plant and the LNG jetty.
- A mainland launch site from which materials and personnel will be transported to Curtis Island.
- A materials offloading facility (MOF) to receive materials, equipment and construction machinery delivered by barge, and an associated personnel jetty.
- A 2,500-person, temporary construction camp on Curtis Island, and mainland temporary workers accommodation facility (TWAF).

Chapter 5, Assessment of Alternatives, describes the options evaluated for the mainland launch site, MOF and personnel jetty, and mainland TWAF. In all instances, several options were recommended for further investigation. They are listed below and shown in Figure 1.2 and Figure 6.1. Arrow Energy’s preference for an option based on its current understanding is indicated. In addition, Arrow Energy is investigating alternative power supply options for the LNG plant. The options under consideration are also listed below.

Mainland Launch Sites

The two sites being investigated are launch site 1 near the mouth of the Calliope River and launch site 4N at the northern extent of the Western Basin Reclamation Area. The preferred site is launch site 1.



Source:
Place names and watercourses from DME.
Proposed LNG plant layout, ancillary facilities and marine infrastructure from Arrow Energy.
Proposed feed gas pipeline, project area and land tenure proponents from Coffey Environments.
Western Basin Dredging Master Plan and Disposal Project from Gladstone Ports Corporation.
Imagery from SPOT (2004-2007).

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LNG plant and ancillary facilities

Figure No: 6.1

Temporary Workers Accommodation Facilities (TWAF)

If the need arises, a TWAF will be established on the mainland. The two sites still under consideration are TWAF 7 on the former Gladstone Power Station No 7 fly-ash pond adjacent to Gladstone, and TWAF 8, which is located northwest of Fishermans Landing, at the northeast corner of Forest Road and Calliope–Targinie Road. The current preferred site is TWAF 8.

MOF and Personnel Jetty

The MOF and personnel jetty will be co-located and three locations have been investigated. Boatshed Point and Hamilton Point South are greenfield sites. The third option is GLNG's Hamilton Point MOF, over which Arrow Energy is investigating a sharing arrangement with GLNG. Arrow Energy's current preference is for a stand-alone facility on Boatshed Point.

LNG Plant Power

Four alternatives to provide power to the LNG plant and utilities are under consideration: an all mechanical drive option, an all electrical drive and import option, and either partial or full import of utility power from the grid.

6.1.2 Development Stages

The LNG plant will be developed in two stages, with an ultimate capacity of four LNG trains producing up to 18 million tonnes per annum (Mtpa) of LNG. Each LNG train will have a nominal capacity of 4 Mtpa.

Stage 1 (trains 1 and 2) involves construction and operation of the first two of the four LNG trains and all associated utilities and ancillary facilities (i.e., equipment and facilities that support one or more of the LNG processing trains and the plant utilities). The LNG plant area will be designed to accommodate up to four LNG trains. The site preparation in Stage 1 will be such that only limited site preparation will be required during future expansion for trains 3 and 4.

LNG trains 3 and 4 will be constructed in Stage 2, bringing the LNG plant to its ultimate capacity of up to 18 Mtpa. Additional utilities and ancillary infrastructure required to service trains 3 and 4 include:

- An additional cold flare.
- Power generation units and emergency power generators.
- A third LNG storage tank.

First gas from train 1 is planned for 2017, with train 2 to enter operation approximately 6 to 12 months later. Market conditions will determine the timing of Stage 2, with a similar offset expected between trains 3 and 4 going into operation.

6.1.3 Locality and Site Topography

The LNG plant site is located on Curtis Island in the Curtis Island Industry Precinct of the Gladstone State Development Area, approximately 6 km north of Gladstone (see Figure 1.2). It is the southernmost site of the four sites allocated for LNG development but, unlike the other sites, it does not share a common boundary with another LNG development. The site abuts the Curtis Island Corridor Sub-precinct to the west, Curtis Island Environmental Management Precinct to the north, and the Queensland coast to the south and east (Figure 6.2).

The 284 ha site comprises three parcels of land and an unused government road, which Arrow Energy, as the adjoining landowner, has received approval from the Queensland Government to purchase. The combined area of the plant and associated facilities will be between 304 and 345 ha, depending on the final site of the marine facilities.

Source:
Place names and watercourses from DME.
Proposed LNG plant layout, ancillary facilities and marine infrastructure from Arrow Energy.
Proposed feed gas pipeline and project area from Coffey Environments.
Gladstone State Development Area from DIP.
Imagery from SPOT (2004-2007).

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Gladstone State Development Area
Curtis Island precincts

Figure No: 6.2

Located southeast of Ship Hill, the site consists of undulating terrain with gently sloping valleys between the north south aligned ridges that extend east of Ship Hill. Isolated hillocks occur to the west of the site. The valleys drain to the coast at North China Bay, and to the east and west of Boatshed Point, where coastal mudflats and mangroves occupy the shoreline. Ephemeral watercourses drain the four catchments straddled by the site (Plates 6.1 and 6.2).

Open woodland covers most of the site, with more dense riparian vegetation extending along the ephemeral watercourses. Small patches of vegetation have been cleared around old stockyards and outstation buildings. The four-wheel-drive access track from Southend to Hamilton Point passes through the site. Site relief is 50 m, with the valley floors rising 10 to 20 m above sea level.

6.2 LNG Plant

The four-train LNG plant occupies the majority of the site. The LNG trains are located in the centre of the site in order to maintain the required safety buffers for the operating plant, LNG and refrigerant storage tanks, and the flare.

Figure 6.3 shows the layout of the LNG plant, which comprises the LNG trains (where liquefaction occurs), LNG and refrigerant storage tanks, LNG loading lines to transfer LNG from the LNG storage tanks to a LNG carrier, seawater inlet for desalination and stormwater outlet pipelines, water and wastewater treatment, a 110-m-high flare stack, power generation, administrative buildings, laboratory, workshops, fire station and security guard house. If an all electrical option is adopted, a 275-kV switchyard will be located adjacent to the western boundary of the site. The LNG trains will be constructed south to north, and the LNG storage tanks north to south to allow for future expansion including trains 3 and 4 and a third LNG storage tank.

Marine infrastructure required to construct and operate the LNG plant includes the LNG jetty located in North China Bay off the northwest corner of Hamilton Point, and the MOF and personnel jetty located at Boatshed Point or Hamilton Point South. The LNG jetty will be connected to the LNG plant by an infrastructure corridor that contains the rundown pipelines, the feed gas pipeline and an access road. Depending on the ultimate configuration of the proposed tunnel under Port Curtis that will carry the feed gas pipeline, the corridor could also carry utilities, electricity supply and telecommunications cables. A haul road will connect the MOF and personnel jetty to the LNG plant site.

Additional infrastructure required to construct the LNG plant includes a construction camp located on Boatshed Point, a concrete batching plant, laydown areas and a quarantine area where all materials sourced offshore and shipped directly to the site will be inspected and, if necessary, treated before being transported to the site. Plate 6.3 shows Sakhalin Energy’s LNG plant on the southern coast of Sakhalin Island, Russia, that has a very similar design to the proposed plant.

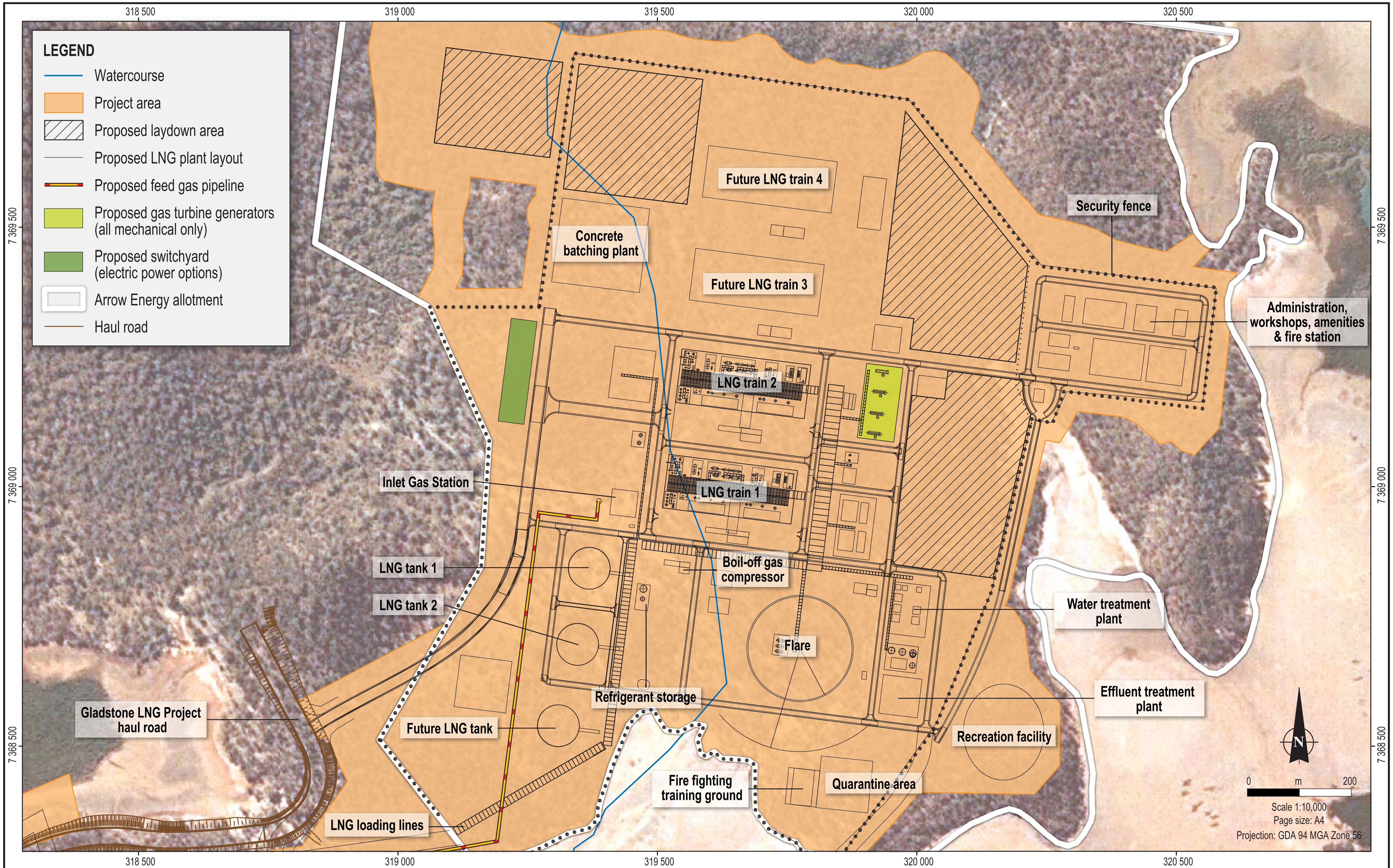
The LNG plant will use Royal Dutch Shell PLC’s mixed refrigerant process to convert natural (feed) gas delivered from coal seam gas fields in the Surat and Bowen basins to LNG. The process involves the removal of impurities from the gas before it is cooled to liquid (liquefaction) using refrigerants. A simplified schematic of the LNG process is shown in Figure 6.4.

Although similar, the liquefaction process varies depending on the powering option adopted for the LNG plant – all mechanical drive or all electrical power. Figures 6.5 and 6.6 show simplified process flow diagrams for the plant for the mechanical drive and electrical power options respectively. The following sections describe the processes, noting where they are common to both powering options.

Plate 6.1
View north over Boatshed Point to LNG plant site and Ship Hill

Plate 6.2
View south over LNG plant site to Port Curtis and Gladstone

Plate 6.3
Sakhalin Energy's LNG plant on the southern coast of Sakhalin Island, Russia



Source:
Watercourses from DME.
Proposed LNG plant layout from Arrow Energy.
Project area and feed gas pipeline from Coffey Environments.
Imagery from SPOT (2004-2007).

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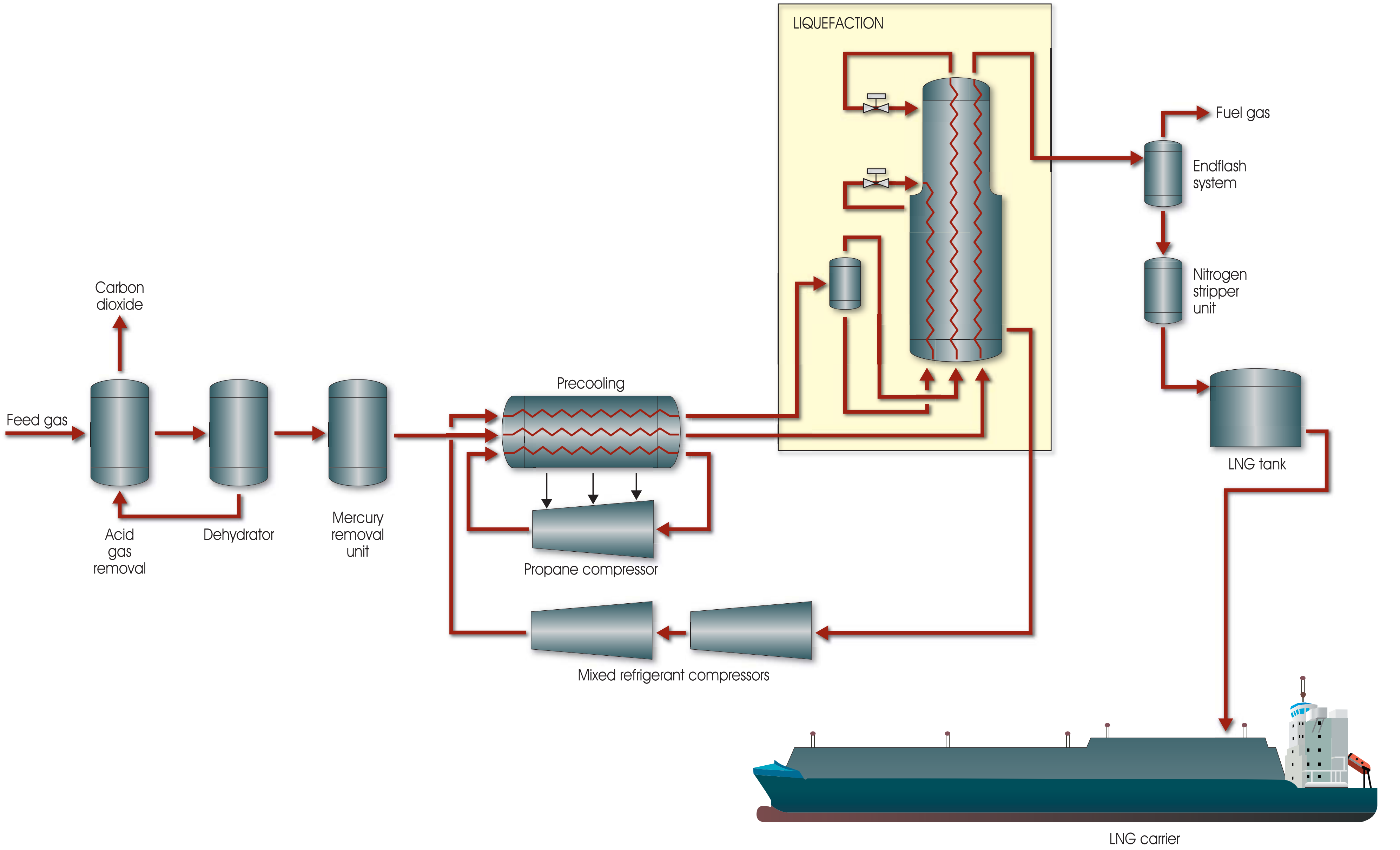
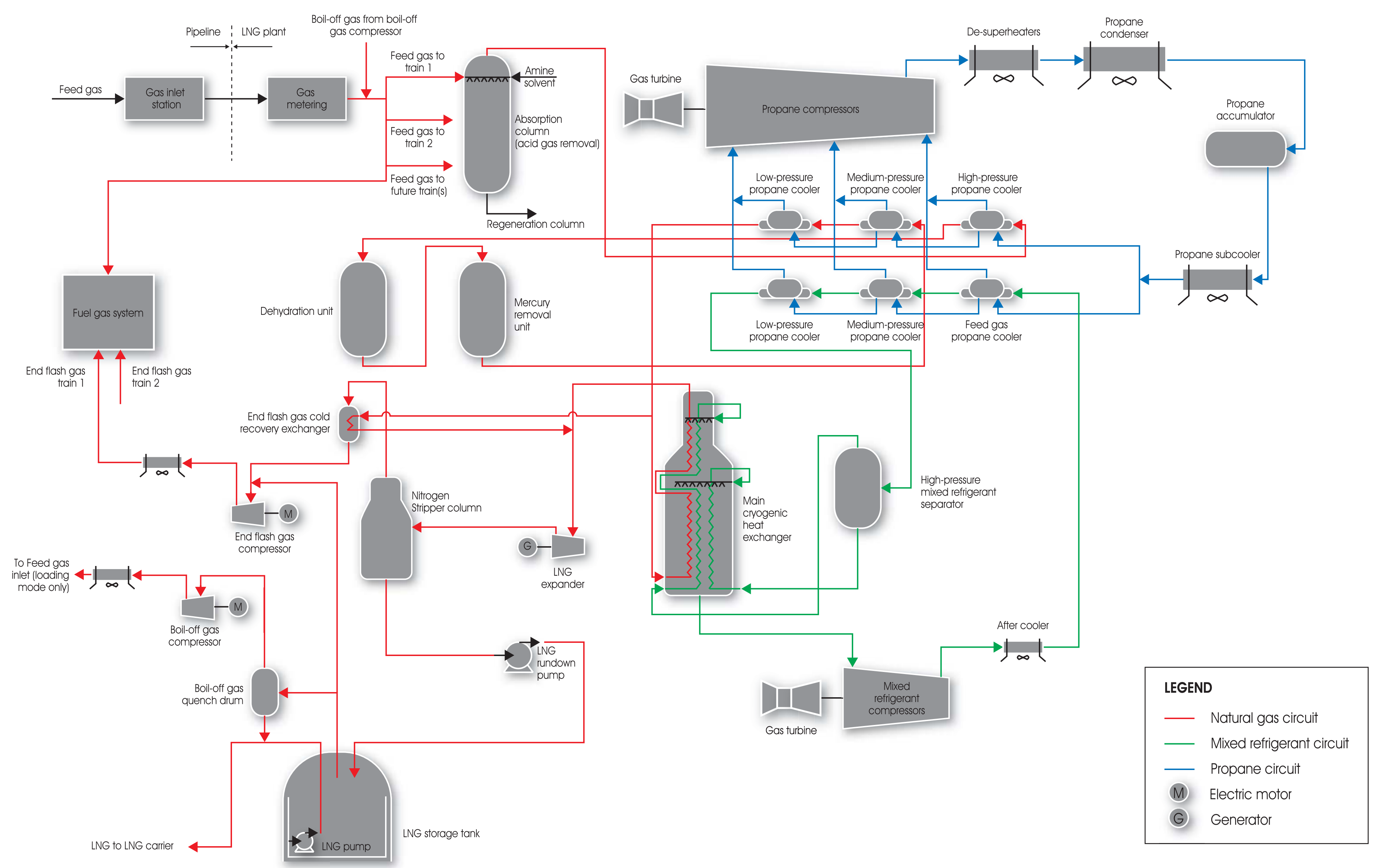
LNG plant layout

Figure No: 6.3



Source: Arrow Energy	coffey environments	Job No: 7033	Arrow Energy	arrow energy go further	LNG process schematic	Figure No: 6.4
		File Name: 7033_07_F06.04_HB	Arrow LNG Plant			



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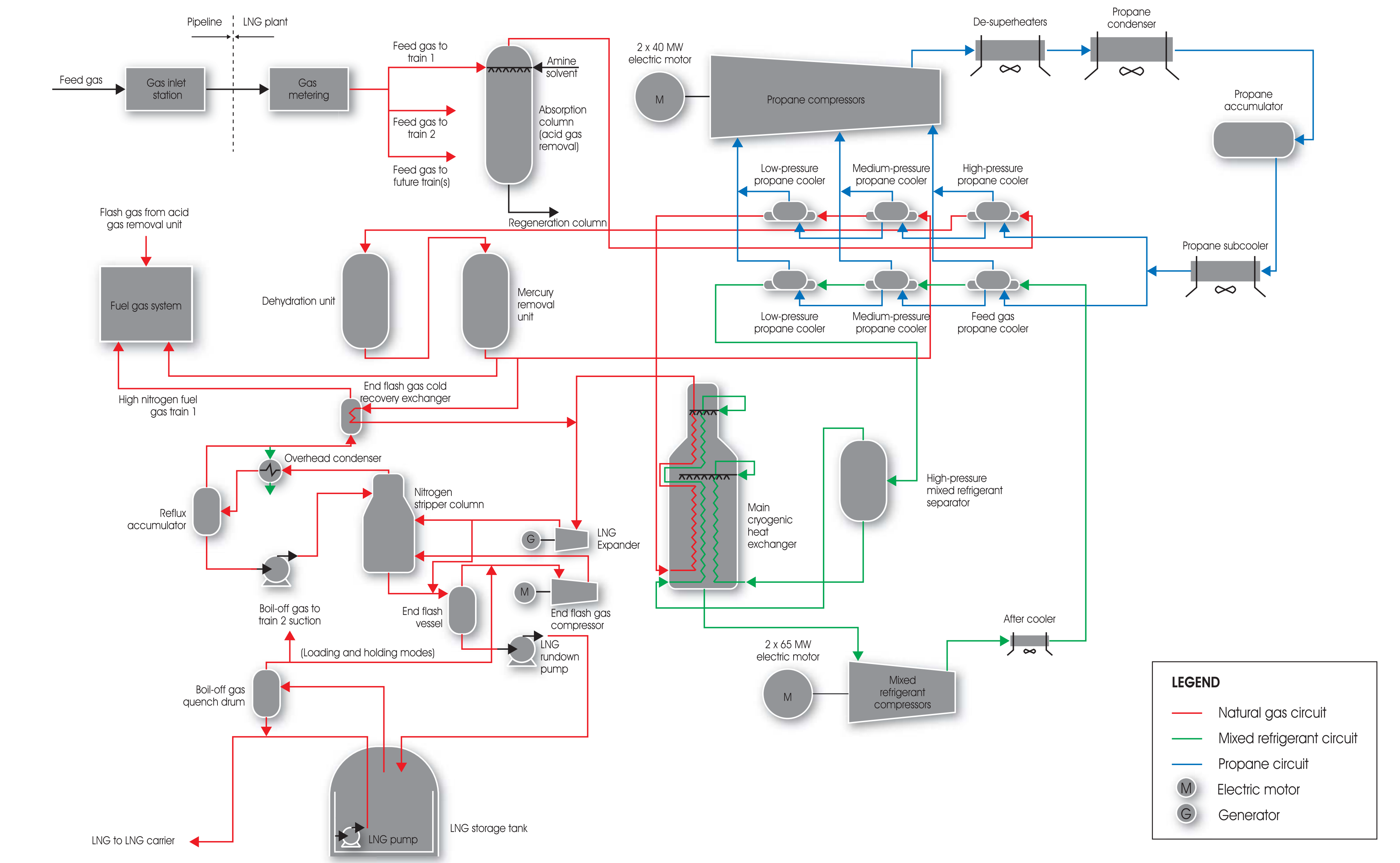
Simplified process flow diagram - mechanical drive option

Figure No: 6.5



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File Name: 7033_07_F06.06_FT

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Simplified process flow diagram - all electrical power option

Figure No: 6.6

6.2.1 Feed Gas Processing

The gas inlet station at the LNG plant will receive a semi-dehydrated natural gas from the feed gas pipeline at a pressure of 7.3 MPa and a temperature of between 12.4°C and 33°C. Natural gas is received by the LNG plant at the entrance to the gas inlet (metering) station where it then flows to the LNG trains. Each train includes processes to remove impurities from the feed gas, including acid gas (CO_2 and small quantities of H_2S), any residual moisture and mercury. These processes are described below.

Acid Gas Removal System

Removal of acid gases is the first process of the LNG train. Impurities in a gas stream, such as carbon dioxide (CO_2), are collectively referred to as acid gases. In this project, the acid gases will be mainly comprised of CO_2. An amine solvent (amine mixed with water) will be used to remove acid gas, as follows.

Acid Gas Removal. Feed gas from the metering station is piped to the amine absorption column where amine solvent is used to strip acid gases. The amine solvent is introduced into the absorption column near the top and flows down the column against the rising gas, so that the freshest solvent contacts the cleanest gas first. The solvent will progressively absorb the acid gases as it flows down the column. The treated feed gas will flow from the top of the absorption column to the natural gas circuit of the propane/mixed refrigerant liquefaction process.

Solvent Regeneration. The amine solvent containing the absorbed acid gases drains to the bottom of the absorption column where it is recovered and piped to the regeneration column. Solvent will be regenerated using hot water as a heating medium for reuse in the system, and acid gas containing small amounts of methane will be vented to the atmosphere.

Amine Storage. An amine storage tank will contain a mixture of fresh amine and demineralised water. The tank will have sufficient capacity to hold the normal make-up inventory plus all the solvent in the acid gas removal system, should the system need to be drained during a process upset or for maintenance.

Dehydration System

Gas leaving the acid gas removal system will be saturated with water. The dehydration system will dry the gas to prevent ice (hydrates) forming in the downstream liquefaction unit.

A propane refrigerant will cool the feed gas to 16°C (approximately 3°C above the hydrate formation temperature) and condense most of the water vapour, which will be directed to the acid gas removal system as make-up water. Molecular sieve driers will then adsorb the remaining water in the feed gas onto an inert zeolite (clay) bed.

Regeneration (drying of the molecular sieve adsorbent) will be achieved by cycling the molecular sieves through a heating and cooling process. The water released during regeneration will be used as make-up water for the acid gas removal system.

The molecular sieve adsorbent typically has a life of three years. The spent adsorbent will be analysed to confirm that no controlled substance (special wastes, restricted substances, metals, sulfur, nitrogen compounds) has adhered to the adsorbent before it is disposed of as a non-restricted waste.

Mercury Removal System

Elemental mercury, even very low traces, can corrode aluminium. As some of the equipment, including the cryogenic heat exchangers, in the liquefaction section of the LNG train is made of aluminium, elemental mercury must be removed to prevent damage.

Gas from the dehydration system will pass through a mercury removal system, which consists of a guard bed of absorbent non-regenerative, sulphur impregnated, activated carbon. The bed will chemically fix elemental mercury as a non-volatile mercury sulfide.

When the absorbent becomes saturated (expected to be in approximately 10 years), it will be sent off site for mercury recovery and recycling, and incineration of the stripped carbon. Management of non-restricted and restricted wastes generated during LNG plant operations is described in Chapter 31, Waste Management.

6.2.2 Liquefaction

The liquefaction process is based on the same principle as a household refrigerator in that it cools the feed gas to below the methane boiling point of approximately minus 163°C. At this temperature, the gas becomes a liquid with 1/600th of its original volume. The liquefaction process involves three main circuits: the natural gas circuit, the propane circuit and the mixed refrigerant circuit. These processes are described below for both the all mechanical drive and all electrical power options.

Mechanical Drive Liquefaction Process

In this process, gas turbines will be used to power the refrigerant compressors. A simplified process for these circuits is shown in Figure 6.5 and described below.

Natural Gas Circuit

The wet gas from the acid gas removal system will be precooled to 16°C in the high-pressure propane cooler. Water will be removed from the cooled gas in the dehydration unit and mercury removed in the mercury removal unit. The dry gas will be further cooled in the medium-pressure and low-pressure propane coolers, and will then flow to the main cryogenic heat exchanger.

A side stream of the dry gas will bypass the main cryogenic heat exchanger and will be liquefied in the end flash gas cold recovery exchanger. This side stream will recombine with the LNG stream downstream of the main cryogenic heat exchanger.

The main cryogenic heat exchanger is similar to the evaporator plate inside a refrigerator. It will provide a sufficiently large surface area to efficiently transfer heat from the feed gas to the refrigerant. In the main cryogenic heat exchanger, the feed gas will be further cooled, condensed and sub cooled by the refrigerant stream from the mixed refrigerant circuit. The cold natural gas will exit the main cryogenic heat exchanger at minus 155°C as LNG.

The LNG will then be routed through the LNG expander, and the pressure reduced. It will then be flashed into the top of the nitrogen stripper column where the LNG nitrogen content will be reduced to below one molar percent.

The flashing process will lose some of the LNG as a gas. This gas will be routed to the end flash gas cold recovery exchanger and used to liquefy the dry gas side stream. The gas will then be compressed in the end flash gas compressor and sent as fuel to the high-pressure fuel gas system to power the gas turbines for utility power and the refrigerant compressors.

LNG exiting the nitrogen stripper column will be pumped to the LNG tanks for storage. During storage, boil-off gas will be routed to the end flash gas compressor for use in the high pressure fuel gas system. During loading of LNG onto LNG carriers, boil-off gas will be routed to the boil-off gas quench drum then compressed, cooled and sent to the feed gas inlet for reprocessing.

Propane Circuit

The propane circuit will precool both the feed gas (described above) and the mixed refrigerant (see below) to a temperature of minus 33°C. The propane refrigerant will be compressed and superheated by two centrifugal propane compressors (see Figure 6.5), before being passed through two air-cooled de-superheaters and a single air-cooled propane condenser, where it will be liquefied.

The liquefied propane will be sent to the propane accumulator then further cooled in the propane subcooler. The propane will then be routed to propane coolers within the natural gas circuit and mixed refrigerant circuit to precool the gas and mixed refrigerant respectively.

Propane sent to the natural gas precooling circuit will initially pass through a high pressure propane cooler where it will cool the wet gas, which has passed through the acid gas removal system. Propane, which is vaporised during this process, will be sent to the propane compressors and the remaining liquefied propane will be sent to the medium-pressure propane cooler to further precool gas, which has passed through the dehydration and mercury removal units.

Vaporised propane will be sent to the propane compressors and the liquefied fraction will be routed to the low-pressure propane cooler for additional gas precooling. The propane will then be returned to the propane compressors for reuse.

Liquefied propane sent to the mixed refrigeration circuit will pass through a mixed refrigerant, high-pressure propane cooler, a mixed refrigerant, medium pressure propane cooler then a mixed refrigerant low pressure propane cooler to precool mixed refrigerant in a three stage process. Vaporised propane will be returned to the propane compressors at each stage and all remaining propane will be returned to the compressors after the last stage.

Mixed Refrigerant Circuit

Mixed refrigerant is used to liquefy and subcool the feed gas and convert it to LNG through cooling in the main cryogenic heat exchanger. This process is described below.

Mixed refrigerant vapour will leave the bottom of the main cryogenic heat exchanger and be compressed by two parallel, mixed refrigerant compressors and pass through two parallel after coolers. The combined vapour will then pass through the three propane coolers (mixed refrigerant, high pressure propane cooler, mixed refrigerant, medium pressure propane cooler and mixed refrigerant, low pressure propane cooler) where the vapour will be precooled and partially liquefied.

The precooled mixed refrigerant will be separated into vapour (light mixed refrigerant) and liquid (heavy mixed refrigerant) streams in the high-pressure, mixed refrigerant separator. Each stream will be fed into the main cryogenic heat exchanger.

The light mixed refrigerant will be cooled, condensed then vaporised in the low pressure shell of the main cryogenic heat exchanger. The heavy mixed refrigerant will be subcooled then vaporised in the low pressure shell of the main cryogenic heat exchanger, where it will mix with the light mixed refrigerant. The vaporised mixed refrigerants will liquefy the natural gas and convert it to LNG.

All Electrical Liquefaction Process

In the all electrical power option, electricity imported to site from the Queensland electricity grid will be used to power electric motors to drive the refrigerant compressors.

The all electrical process is largely similar to the mechanical drive process, particularly within the propane and mixed refrigerant circuits. The simplified process for these circuits is shown in Figure 6.6 and differences between the mechanical drive and all electrical processes are described below.

Natural Gas Circuit

The most significant differences between the all mechanical drive and all electrical power options are found in the natural gas circuit.

As for the mechanical drive circuit, wet gas from the acid gas removal system will be precooled to 16°C in the feed gas propane cooler then routed through the dehydration unit to dry the gas. Mercury will then be removed in the mercury removal units. After exiting the mercury removal unit, a side stream will be routed directly to the high-pressure fuel gas system, and another side stream routed to the end flash gas cold recovery exchanger where it is liquefied. The majority of the gas exiting the mercury removal unit will be further cooled in the medium-pressure and low-pressure propane coolers then routed to the main cryogenic heat exchanger.

Liquefaction is accomplished within the main cryogenic heat exchanger in the same method as for the mechanical drive option. LNG exiting the main cryogenic heat exchanger will be routed to the LNG expander then to the nitrogen stripper column. Before entering the nitrogen stripper column, a side stream of LNG will be sent to the nitrogen stripper column LNG outlet stream to regulate the nitrogen content of this outlet stream.

LNG sent to the nitrogen stripper column will have the nitrogen content reduced to below one molar percent. Some LNG will be converted to a nitrogen rich (up to 90 molar percent) gas during this process. This gas will pass through an overhead condenser to the reflux accumulator where the condensate will be pumped back to the nitrogen stripper column and the gas sent to the end flash gas cold recovery exchanger for reprocessing or use in the fuel gas system.

LNG exiting the nitrogen stripper column will combine with the LNG side stream and be flashed into the end flash vessel. Gas produced in the end flash vessel will be combined with boil-off gas and sent to the end flash gas compressor then to the nitrogen stripper column where it will be used in the nitrogen stripping process.

LNG exiting the end flash vessel will be pumped to the LNG tanks for storage. Boil-off gas formed during storage will be routed to the boil-off gas quench drum then combined with gas produced in the end flash vessel for use in the nitrogen stripper column.

Boil-off gas formed during LNG carrier loading will be treated in the same manner as that formed during storage.

Propane Circuit

The propane precooling compressor will be the same as that used in the all mechanical drive option, but will instead be powered by two 40 MW electric drive motors. Apart from this change, the propane circuit is the same as for the all mechanical drive option.

Mixed Refrigerant Circuit

The only difference between the all electrical and all mechanical drive options is that, in this case, the mixed refrigerant compressors will be driven by two 65 MW electric drive motors and not driven by gas turbines.

6.3 LNG Plant Utilities

The LNG plant utilities comprise various systems that store or produce inputs required by the plant as follows:

- Power generation and distribution systems.
- Water systems (freshwater, potable and service water, and demineralised water).
- Cooling water system.
- Heating system.
- Fuel gas system.
- Instrument and tool air system.
- Nitrogen system.

6.3.1 LNG Plant Power

Onsite gas turbine generators or power taken from the Queensland electricity grid (grid power) will supply electricity to the LNG plant, utilities and ancillary facilities. The option to drive the refrigerant compressors with electric motors instead of gas turbines results in four configurations for LNG plant power. The power configuration options are shown in Figure 6.7 and described below.

Base Case – Mechanical Drive

The mechanical drive option will use 100 MW gas turbines to mechanically drive the LNG train refrigerant compressors and 30 MW gas turbine generators to generate electricity to power the site utilities. Coal seam gas and end flash gas (produced in the liquefaction process) will be used to fuel the gas turbines and gas turbine generators.

During construction, electricity will be provided by diesel generators, because the gas turbines will not be operational and grid power will not be used.

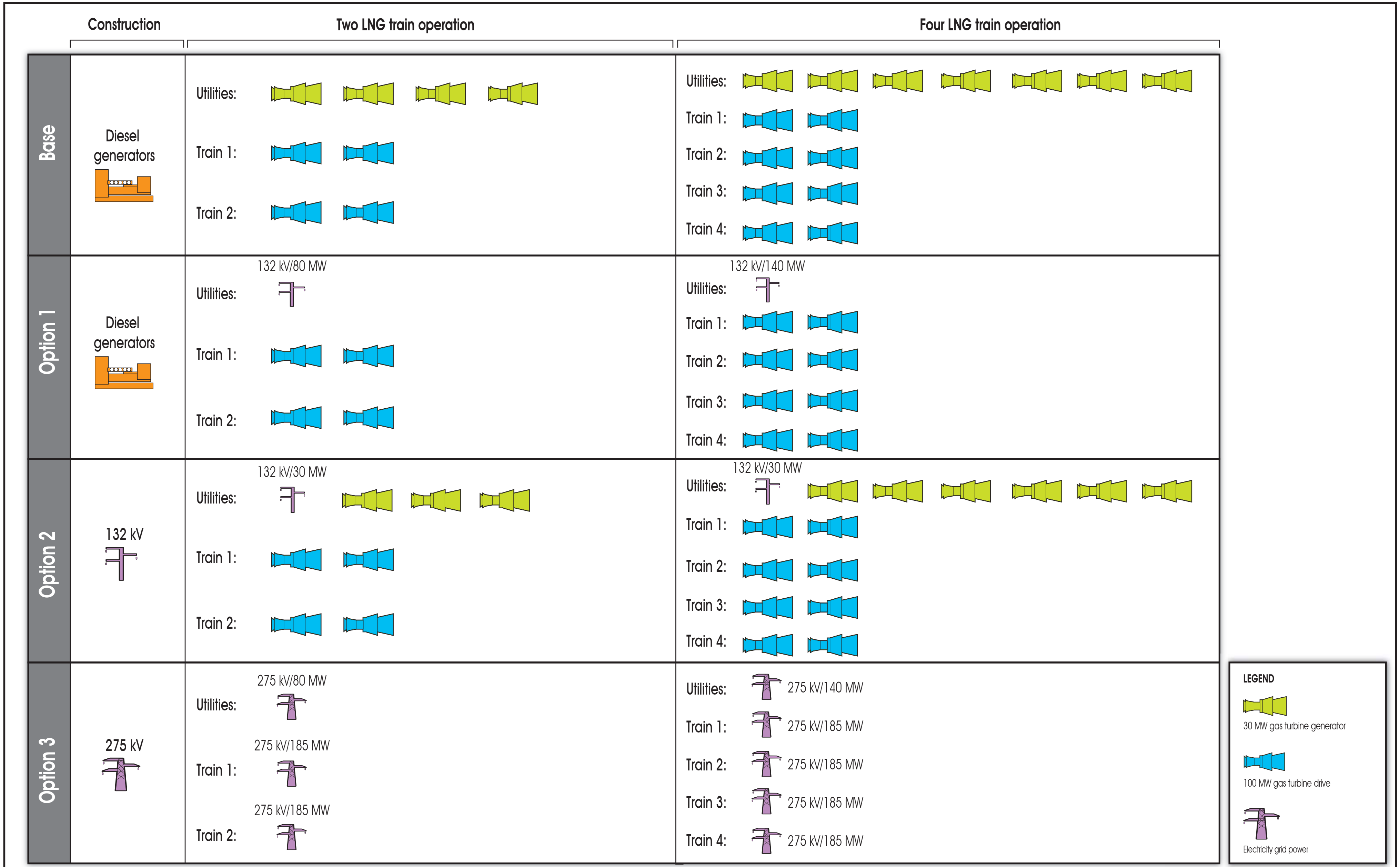
In the first stage, four 100 MW gas turbines will be installed to drive the refrigerant compressors i.e., two gas turbines per train. Electricity for site utilities will be generated by four 30 MW gas turbine generators. This configuration allows for sparing capacity in power generation.

When the LNG plant is expanded to four trains, each additional train will require two 100 MW gas turbines to drive refrigerant compressors, bringing the total number of 100 MW gas turbines to eight. Due to the project sparing philosophy, an additional three 30 MW gas turbine generators will be installed to power site utilities, resulting in a total of seven gas turbine generators.

Option 1 – Mechanical and Electrical Configuration A

The gas turbine generators are replaced with grid power in this option. A 132 kV transmission line (overhead and underground) will supply grid power to the LNG plant, utilities and ancillary facilities via a switchyard constructed adjacent to the western boundary of the site.

The transmission line to be installed and operated by a transmission network service provider will connect to the electricity grid near Port Curtis Way, and run overhead to the tunnel launch shaft, where it will transition to underground electricity cables that will run through the tunnel to the LNG



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LNG plant power options

Figure No: 6.7

plant site. Alternatively, the underground electricity cables will be installed in a separate duct installed by horizontal directional drilling under Port Curtis from near the tunnel launch shaft or another site nominated by the transmission network service provider.

Initially, 80 MW will be required to service trains 1 and 2, with 140 MW required to service all four trains. Gas turbines will drive the refrigerant compressors, with two 100 MW gas turbines required for each train.

Construction power will be provided by diesel generators.

Option 2 – Mechanical and Electrical Configuration B

In this option, electricity supply for construction is provided by grid power, which is then used in operations to replace one gas turbine generator.

A 132 kV transmission line will be installed in a duct installed by horizontal directional drilling under Port Curtis from a site nominated by the transmission network service provider. The electricity cables will run underground to the LNG plant site.

The 30 MW of electricity required for construction will replace the output of one 30 MW gas turbine generator during operations. Three 30 MW gas turbine generators will be required for the first two trains, increasing to six for four trains.

Two 100 MW gas turbines will be required to drive the refrigerant compressors for each train.

Option 3 – All Electrical

Construction and operation power requirements will be provided by grid power in this option. A 275 kV transmission line to be installed and operated by a transmission network service provider will supply power to the LNG plant site from a suitable connection to the Queensland electricity grid near Gladstone.

The high voltage electricity cables will run underground to the LNG plant site from the duct installed by horizontal directional drilling under Port Curtis from a site nominated by the transmission network service provider. A switchyard established adjacent to the western boundary of the site will distribute electricity at various voltages to the LNG plant, utilities and ancillary facilities.

The transmission line will provide 30 MW of grid power for construction, and up to 450 MW for the initial development. Power demand will increase to 880 MW for four trains. Electric motors will drive the refrigerant compressors. Diesel generators will provide power for safe shutdown of the plant in an emergency.

Adoption of an all electrical option necessitates changes to the liquefaction process and infrastructure, as waste heat is no longer available from the gas turbines, and the fuel gas specification is not as stringent. Changes required for the all electrical option are:

- Installation of gas fired furnaces to supply process heat to replace heat that would have been obtained from gas turbine exhaust stacks.
- Modification of the nitrogen stripper column and associated equipment to bring the LNG within specification with respect to nitrogen content.
- Modifications to the fuel gas balance, which would only need to provide process heat and not drive gas turbines for mechanical and electrical power.
- Removal of chilled water because cooling of gas turbine inlet air would no longer be required.

Power Distribution System

Power at various voltages will be distributed throughout the LNG plant site, marine facilities and construction camp from a substation located adjacent to the gas turbine generators, or from the switchyard constructed under options using grid power.

Two 2-MW emergency diesel generators will provide backup power, and batteries will provide uninterruptible back-up power for the following:

- Critical instrumentation and provision of instrument air.
- Controls.
- Telecommunication systems.
- Fire and gas detection.
- Emergency shutdown systems.
- Emergency lighting.

6.3.2 Water Supply

Water of varying quality is required for use in the LNG plant. Seawater drawn from Port Curtis and treated in a desalinisation plant will generate freshwater that will be used and further treated to provide high quality water for plant processes and human consumption. The water supply systems are shown in Figure 6.8 and described below.

Arrow Energy is also considering an alternative option of importing fresh water supplied by Gladstone Area Water Board (GAWB) from the mainland, and export of domestic sewage, grey water and effluent from LNG operations to Gladstone Regional Council's sewerage system. Arrow Energy is working with GAWB, the council and other LNG proponents to review the feasibility of this option.

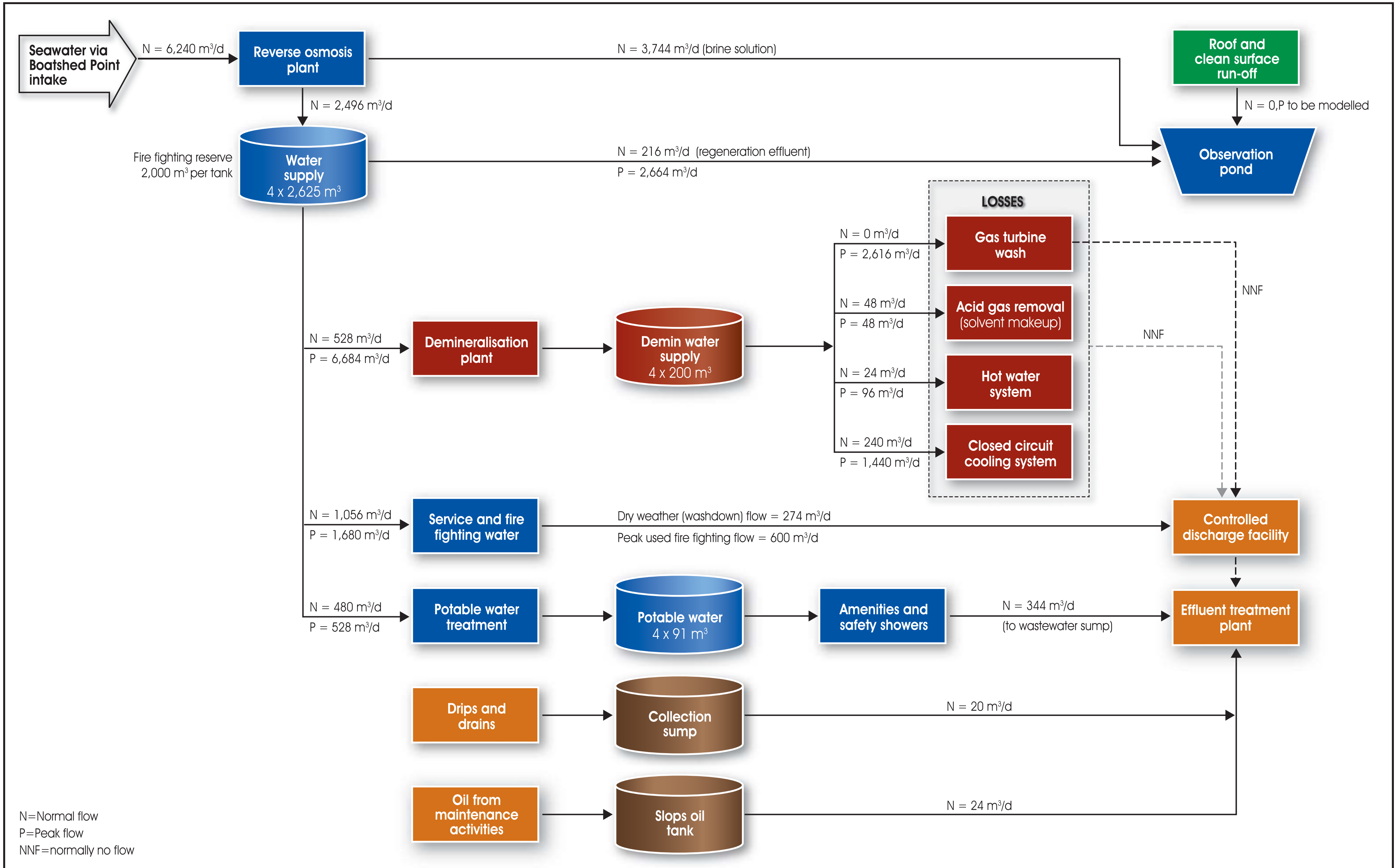
Freshwater System

Seawater desalination by reverse osmosis will supply fresh water during operations. Average salinities in Port Curtis of about 32 g/L are expected to enable a freshwater recovery rate of approximately 40%. The normal seawater demand for two LNG trains is estimated to be 3,120 m^3/day, increasing to 6,240 m^3/day for four LNG trains.

The desalination system will be located within the LNG plant east of the flare. The proposed seawater intake will be integrated with the quay structure of the Boatshed Point MOF, with sufficient separation from the brine outfall to avoid recycling of brine. The brine outfall will be located on the eastern side of Boatshed Point at a depth of approximately 12 m.

The desalination process will involve:

- Solids removal. Seawater will be dosed with ferric chloride (flocculant) and cationic polymer (coagulant) and the solids filtered out.
- Biocide. Intake seawater will be chlorinated to inhibit biological growths from obstructing the intake system.
- Chlorine removal. Membranes are sensitive to oxidising chemicals (such as chlorine) so the biocidal chlorine will be scavenged by sodium metabisulfite before the treated seawater enters the reverse osmosis system.
- Membrane descaling. Salts can precipitate and reduce membrane efficiency, so a proprietary antiscalant may be added to the intake water.



Source: Coffey Environments and Arrow Energy

coffey environments	Job No: 7033	Arrow Energy	arrow energy go further	Conceptual water management (operation) - water supply
	File Name: 7033_07_F06.08_HB	Arrow LNG Plant		Figure No: 6.8

- Final polishing. The treated water stream will be polished before storage in 2,625 m^3 storage tanks. A firefighting reserve of 2,000 m^3 will be maintained in each storage tank.

The brine solution produced in the reverse osmosis plant will, with the seawater intake filter backwash and membrane rinse water (which may contain traces of the chemical additives) be sent to the observation pond for settling and, if necessary, treatment before discharge.

Demineralised Water System

Freshwater from the reverse osmosis plant will be further treated in an ion exchanger to produce demineralised water, which will be stored in four 200 m^3 storage tanks. The demineralised water will be used to:

- Wash the blades of the gas turbines.
- Provide make-up water and wash water for the acid gas removal system.
- Provide make-up water for the hot water system.
- Provide make-up water to the closed-circuit cooling system.

Demineralised water used in these processes is typically treated as losses, as there is normally no flow or discharge from the cleaning or make-up activities. The peak flows indicated in Figure 6.8 occur on initial commissioning of the system and following major maintenance as liquefaction processing is re-established.

Service and Fire Fighting Water System

Service water is required for washing down plant, aprons and hardstanding areas. The normal demand for four trains is 1,056 m^3/d, with a peak demand of 1,680 m^3/d. The peak discharge from fire fighting activities is estimated at 600 m^3/d, while the normal discharge from washdown is estimated at 274 m^3/d. Wastewater is directed to the controlled discharge facility where it is treated before discharge to the sea near Boatshed Point.

Potable Water System

Freshwater will be treated to potable standards in a water treatment plant. A nominal capacity of 480 m^3/d is estimated to meet the operational requirement of 300 L/day per person. Treated water will be stored in four 91 m^3 tanks prior to distribution through the potable water reticulation system.

6.3.3 Cooling Water System

Process heat from the LNG plant utilities' units will be dissipated through fin-fan coolers via a closed-circuit cooling water system, with cooling water sourced from the demineralised water system. A dedicated cooling system will be provided for each of the gas turbines in the mechanical drive option. Closed-circuit cooling systems will also be required for the instrument air system and nitrogen system for both the mechanical drive and electric power options.

6.3.4 Hot Water System

Hot water provides the heat source in the acid gas removal unit and feed gas pre heater. In the all mechanical drive option, waste heat recovery units on the propane compressor, gas turbine drive exhausts heat demineralised water to 180°C for use in the acid gas removal unit. Under the all electrical power option, gas fired furnaces are used to heat the demineralised water. Each LNG train will have a hot water system.

6.3.5 Fuel Gas System

The fuel gas system will supply high-pressure fuel at 6.5 MPa to the gas turbines that will drive the refrigerant compressors and electricity generators under the all mechanical drive option. Under the all electrical power option, fuel gas will be used in gas fired furnaces to heat water for use in the acid gas removal unit. During LNG train start up, an electric heater (powered by the fuel-gas generators) will provide superheat to the high-pressure fuel gas.

6.3.6 Instrument and Tool Air System

The instrument and tool air system will supply compressed air for instrumentation, pneumatic tools and utilities, and to the nitrogen system. Compressor packages, sized to handle current and future requirements, will provide compressed air via a distribution system to the various facilities and processing units. The air required for the plant instrumentation will be approximately 7,296 Nm^3/hr of dry compressed air. The instrument air dryer packages will emit wet air to the atmosphere.

6.3.7 Nitrogen System

Nitrogen gas is required for the following process and maintenance purposes:

- To purge equipment on start up and shutdown.
- As make-up for refrigerant circuits.
- To maintain inert atmospheres, e.g., blanket gas in hydrocarbon storage tanks.
- To purge miscellaneous analytical equipment.
- To purge LNG carrier loading arms after use.

The nitrogen generation package will produce approximately 880 Nm^3/hr of nitrogen.

Nitrogen is used to remove oxygen (atmospheric air) from LNG train piping and processing units prior to introducing feed gas. During maintenance shutdowns, vessel and piping systems will be purged with nitrogen gas to remove hydrocarbons in the system, prior to opening the system for inspection or maintenance.

Liquid nitrogen will be brought to site by road tankers if the nitrogen production unit is shut down for maintenance.

6.4 LNG Plant Ancillary Facilities

LNG plant ancillary facilities refer to equipment and facilities that support the LNG processing trains and the LNG plant utilities. The LNG plant ancillary facilities are:

- LNG storage, loading and boil-off gas system.
- Flare system.
- Wastewater treatment system.
- Fire protection system.
- Diesel storage and distribution system.
- Refrigerant storage and make-up system.
- Waste management system.

6.4.1 LNG Storage, Loading and Boil-off Gas System

The LNG storage, loading and boil-off gas system provides the facilities needed to store and transfer LNG to LNG carriers, and to capture and process gas that forms as LNG warms in storage and handling. Boil-off gas occurs when heat is transferred to the LNG through contact with tank and pipe walls, and through friction during pumping.

Two low-pressure full containment or membrane LNG storage tanks, with a capacity of 120,000 m^3 to 180,000 m^3 will be constructed in Stage 1. Depending on the required final storage capacity, a similarly sized third LNG tank may be required for the Stage 2 development, when LNG trains 3 and 4 will be constructed and brought into operation.

The LNG storage tanks will operate at a temperature of minus 163°C and stand 40 to 45 m high. The LNG tanks will be filled and discharged from the top, to reduce the risk of a leak through side openings. A full containment tank comprises a free-standing 9%-nickel-steel container (primary containment) specifically designed for cryogenic temperatures and a secondary containment comprising a self-supporting, reinforced concrete tank fitted with a concrete dome roof to contain boil-off gas. A membrane tank comprises a reinforced concrete tank to which is attached an inner membrane of 9%-nickel-steel. The membrane is typically corrugated to allow for expansion and compression of the liner during filling and dispatching.

Boil-off compressors will control the pressure in the storage tanks. When outside of the boil-off gas control range, other process control and safety systems will be used to protect the tanks. Some of these include:

- Vacuum breakers on the tanks, which will open to control the maximum vacuum in the tank.
- Dry, high-pressure feed gas from the LNG plant, which will be introduced into the tank on low-pressure control to prevent the maximum allowable vacuum being exceeded.
- The staging control of the boil-off compressors, which will keep the pressure in the storage tank at the desired operating pressure range.
- The tank venting control valve, which will open on high pressure, sending tank vapour to the flare.

LNG loading operations will include storage tank product-level measurements, loading arm connection, product transfer activation from the central control room, monitoring of loading rates and confirmation of product transfer close.

LNG can be pumped up to a rate of 12,000 m^3/hour through the LNG loading lines to the LNG carrier. A vapour return line will send vapour generated at the jetty during the loading to the LNG storage tanks to replace the liquid volume being loaded. This gas is fed to the boil-off gas compressors, with no flaring during normal operating conditions.

When the LNG loading system is not operational, a small quantity of LNG will be circulated through the insulated loading lines to maintain cryogenic temperatures.

The area around the LNG storage tanks will not be paved, but covered with granular material. Adequate provisions will be made for access and laydown to allow maintenance of the cryogenic pumps.

6.4.2 Flare System

The cold (dry), hot (wet) and low-pressure flares will provide for the safe disposal of hydrocarbon fluids (gases and liquids) from pressure safety valves and blowdown valves during process upsets, emergencies, maintenance activities and shutdown conditions. It is likely that some flaring will occur during commissioning and start-up; however, it is not anticipated that flaring will be necessary during routine operations.

Flares are sized to accommodate what is expected to be the largest single event requiring gas release. For an LNG plant, this is typically the discharge from a blocked refrigerant compressor.

The flares will be designed to provide smokeless flaring over a maximum range of operation. The flare headers will be continuously purged with low-pressure fuel gas at a rate of 50 to 100 m^3/hour to prevent ingress of air (oxygen).

The flare stack will comprise five flares and one spare flare. The stack will be a steel structure and stand between 100 and 130 m high. The flares and their purpose are described below.

Cold Dry Flare

Two cold flares (one for trains 1 and 2, and an additional one for trains 3 and 4) will dispose of moisture-free vapour hydrocarbons from relief valves, vents and drains throughout the processing units. The cold flare will be sized to handle relief and blowdown streams from the liquefaction and refrigeration systems. The gas will flow through the cold flare knock-out drum, where the drained hydrocarbon liquids will be collected. Liquids will be stored in the knock-out drum until they vaporise, and are then flared.

Warm Wet Flare

One warm wet flare will collect vapours that are susceptible to freezing (and hence not compatible with the cold, dry gas flare). The warm wet flare will be sized to handle blowdown streams from the inlet gas station, the inlet gas treatment systems and the fuel gas system.

LNG Storage and Loading Flare

One LNG storage and loading flare will provide pressure relief for the LNG storage and loading system, and the boil-off gas system. A dedicated flare is required for these systems, as the LNG storage tanks are not able to handle back-pressures from the cold flare.

Operational Flare

One operational flare will dispose of operational releases during start-up of the LNG plant. Flow through the flare will be staged through a number of burners to ensure smokeless operation.

6.4.3 Wastewater Treatment System

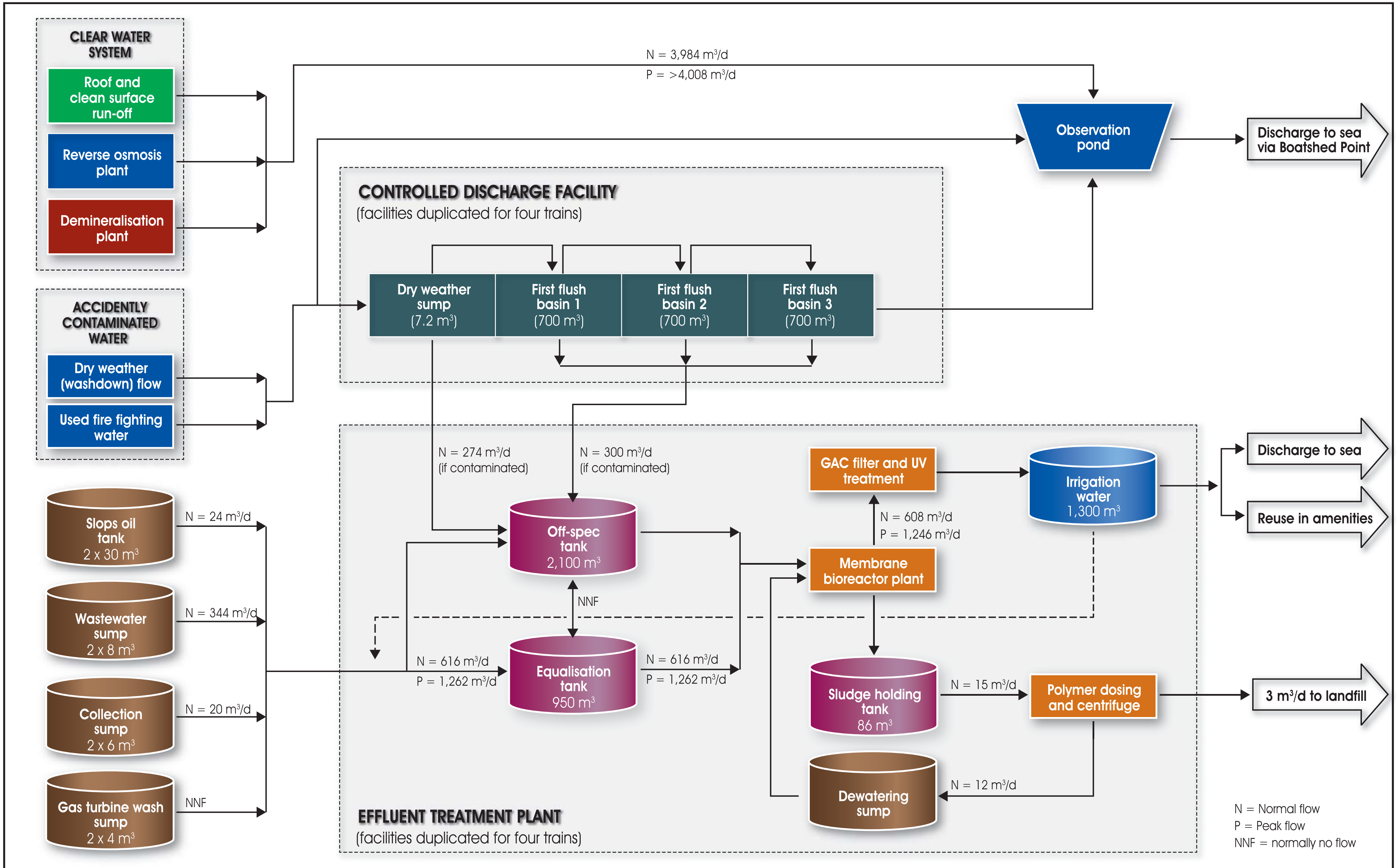
The LNG plant and associated facilities will generate various kinds of wastewater, including clear water (from roof and clean surface runoff, reverse osmosis plant brine and demineralisation plant effluent), contaminated water (from equipment washdown and used firefighting water), chemically contaminated water (from the slops oil tanks, wastewater sumps, collection sumps and gas turbine wash sumps) and sewage. The management of stormwater is described in Chapter 13, Surface Water Hydrology and Water Quality and in Appendix 6, Stormwater Quality Impact Assessment. These wastewater streams will be treated prior to discharge. Figure 6.9 shows the treatment facilities, which are described below.

Clear Water System

The clear water system will consist of liquid waste streams that do not require treatment. These waste streams will be discharged to Port Curtis and include:

- Brine from the reverse osmosis plant.
- Demineralisation plant effluent.
- Stormwater from clean catchment areas and roof runoff.

All discharges will be tested and treated to meet water quality criteria as required prior to discharge to Port Curtis via the outfall pipe and diffuser located at Boatshed Point. Marine water quality monitoring will be conducted periodically to ascertain water quality both inside and outside an established mixing zone in Port Curtis.



Source: Coffey Environments and Arrow Energy

coffey environments	Job No: 7033	Arrow Energy	arrow energy go further	Conceptual water management (operation) - effluent treatment and disposal	Figure No: 6.9
	File Name: 7033_07_F06.09_HB	Arrow LNG Plant			

Controlled Discharge Facility

The controlled discharge facility will collect and treat all potentially contaminated or contaminated runoff. Used fire fighting water, potentially contaminated stormwater flow and dry weather flows will be routed to the controlled discharge facility where water quality will be analysed using continuous monitoring equipment. If the runoff is not contaminated, it will be sent to the observation pond and mixed with clear water before discharge to Port Curtis. If the runoff water is unsuitable for discharge, it will be diverted to the effluent treatment plant for treatment prior to discharge.

Effluent Treatment Plant

The effluent treatment plant will be a tertiary treatment facility designed to treat wastewater to a quality suitable for re use in amenities or irrigation, or discharge to Port Curtis. The effluent treatment plant will be established early in the construction phase of the project and will include the following components:

- Main equalisation tank and off-specification tank.
- Membrane bioreactor package.
- Granular activated carbon filter package.
- Ultraviolet (UV) disinfection package.
- Chemical dosing package.
- Sludge dewatering facilities.

Sewage will be mixed with other process water streams in the equalisation tank. Intermittent flow generated from the gas turbine wash water, the slops oil tank bottom water and the contaminated controlled discharge facility water will be routed to either the main equalisation tank or the off-specification tank.

The mixed effluent will be filtered in the membrane bioreactor plant to produce clarified effluent, which will be passed through a granular activated carbon filter for total suspended solids removal followed by UV treatment. This clean effluent will be sent to the 1,300 m^3 irrigation water tank for storage prior to use as irrigation water, toilet flushing water and make-up water in the effluent treatment plant. In exceptional conditions, such as excessive wet weather, excess treated effluent (beyond design capacity) will be discharged to the marine environment through the brine outfall pipe at Boatshed Point.

Excess sludge from the membrane bioreactor plant will be pumped to the sludge holding tank and dewatered in a centrifugal system to produce a thick sludge cake for offsite disposal as a biosolid. Sludge dewatering liquid will be diverted back to the membrane bioreactor plant for additional treatment.

Treated effluent will be re used in accordance with the Queensland water recycling guidelines (EPA, 2005).

6.4.4 Fire Protection System

The fire protection system will provide full firefighting capabilities, with firewater ring mains incorporated into the LNG plant and marine facilities. Passive fire protection measures will also be provided (such as fire retardant paint) and will complement the fire protection system described below.

Fire hydrants will be located so that at least two hose streams can reach any point in the facilities areas. Water spray systems will be installed to cover potential sources of flammable liquid release in the process and storage areas.

Firewater storage capacity will allow two hours of maximum firewater requirements with 100% backup. Provision will be made for an additional backup firewater system with water from barges at the LNG jetty. The pumps and the ring main system will provide a minimum pressure of 10 bar at the most remote location of the site.

A high expansion foam system may be incorporated into the fire protection system for flammable liquid storage (i.e., diesel tanks). Selection of the foam system is yet to be made and will consider potential environmental implications of the options identified.

6.4.5 Diesel Storage and Distribution System

The LNG plant will include a system for receipt, storage and distribution of diesel fuel for use in the emergency diesel generators, diesel driven fire protection system, and the emergency instrument air compressor.

Diesel will be stored in two approximately 25 m^3 tanks in the LNG plant, which will allow the emergency diesel generators, diesel driven fire protection system and the emergency instrument air compressor to run concurrently and continuously for a 24 hour period.

The diesel storage tanks will also supply the filling station for refuelling plant, equipment and vehicles. Inventory levels in the tanks will not be allowed to fall below levels required for emergency operations.

6.4.6 Refrigerant Storage and Distribution System

The refrigerant process uses light hydrocarbons for the liquefaction of natural gas. The light hydrocarbons will be stored in tanks outside the processing unit area. For the operation of LNG trains 1 and 2, approximately 450 m^3 and 2,100 m^3 of ethylene and propane respectively will be held in the storage tanks located adjacent to the LNG storage tanks. This storage capacity will increase by 50% with the operation of trains 3 and 4.

Ethylene will be stored in semi-pressurised, semi-refrigerated spherical tanks, and fully pressurised spheres will be used to store propane. The storage spheres will be placed on concrete aprons that will drain any spills a safe distance from the facility, where they will be allowed to evaporate.

Transfer pumps will supply make-up refrigerant to each LNG train. The system will be designed to store one complete inventory of refrigerant for a two train operation; with additional capacity for another complete one LNG train inventory should the circuit require draining. If operational requirements trigger the need for additional light hydrocarbons, they will be imported in ISO-conforming containers.

6.4.7 Waste Management System

A number of waste streams will be generated during construction and operation of the LNG plant.

Waste streams generated during construction include:

- Waste oil and grease from servicing vehicles, plant and equipment.
- Air, oil and fuel filters from vehicles, plant and equipment.
- Brake linings and hydraulic hoses from servicing vehicles, plant and equipment.
- Spent batteries (wet and dry).
- Packaging, scrap metal, and metal and plastic drums.
- Concrete waste.
- Paints and solvents.

- Abrasive dust and waste powder from grit blasting and grinding.
- Waste paper, cardboard and polystyrene packaging.
- Domestic waste and sewage.

During operation and maintenance, additional wastes generated include:

- Glass waste from broken light fittings, screens and windows.
- Oily wastes from processing units.
- Waste activated carbon containing mercury sulfide.
- Waste zeolite.
- Waste silica gel filters.
- Spent filtered and absorptive pastes.

Other waste types include:

- Acid gas (CO_2) will be disposed via the exhaust stacks of the refrigerant gas turbines for the mechanical drive option, and via gas-fired furnaces for the all electrical option or to atmosphere.
- Emissions to air during construction will include dust from earthworks, together with exhaust emissions from construction vehicles and earthmoving equipment. During operations, emissions to air will occur from gas fired equipment (for the mechanical drive option), the utilities, LNG carriers, tugs and project vehicles. These emissions are described in Chapter 21, Air Quality.
- Domestic sewage, grey water and effluent from LNG operations (i.e., wastewater, oil from the boil-off gas compressor, flare knock-out water and gas turbine wash water) will be sent to the effluent treatment plant. These waste streams will be treated for re use in amenities and for irrigation. Arrow Energy is considering an alternative option of importing fresh water from GAWB on the mainland, and export of domestic sewage, grey water and effluent from LNG operations to the Gladstone Regional Council's sewerage system. Arrow Energy is currently working with GAWB, the council and other LNG proponents to review the feasibility of this option.
- Used fire fighting water, any contaminated stormwater flow, and dry weather flows will be routed to a controlled discharge facility where water quality will be analysed. Contaminated water will be directed to the effluent treatment plant, and uncontaminated water will discharged to the sea via an observation pond.
- Management of dredge material from capital and maintenance dredging is described in Chapter 8, Project Description: Dredging, and Chapter 16, Marine Water Quality and Sediment.

Waste management strategies to be adopted by the project are described in Chapter 31, Waste Management, and address waste avoidance and mitigation, recycling and re use, treatment and disposal, restricted waste management, waste storage, transportation and monitoring.

6.4.8 Infrastructure Corridor

The LNG plant will be connected to the LNG jetty via a 1,500 m long infrastructure corridor (Figure 6.10) located in the Curtis Island Corridor Sub-precinct (see Figure 6.2). The infrastructure corridor will carry the LNG rundown lines, fire fighting water supply lines, feed gas pipeline and an access road for maintenance purposes.

The corridor may also carry utilities including water supply and sewerage mains, and electricity supply and telecommunications cables. The inclusion of these services in the corridor will depend on the ultimate configuration of the proposed tunnel under Port Curtis, and arrangements with third-party service providers who will, in most instances, own and operate the infrastructure.

The infrastructure corridor will run from the LNG plant boundary westward to approximately halfway to the LNG jetty where it will turn north and pass through a culvert underneath the Gladstone LNG Project haul road. The culvert will be designed to bear the weight of modules travelling along the haul road. The infrastructure corridor then runs parallel to the haul road, west to the coast and LNG jetty.

Bunding of the LNG loading lines will not be required as LNG is volatile and will vaporise when exposed to the atmosphere. The jetty abutments and LNG loading lines will be protected by revetment walls in the section north of the haul road, where the infrastructure corridor will be established, in part, on reclaimed land.

6.5 LNG Jetty and Mooring Facilities

The LNG jetty will be constructed off the northwestern corner of Hamilton Point at the southern end of North China Bay (see Figure 6.1 and Figure 6.10).

Located on the edge of the berth pocket dredged as part of the Western Basin Dredging and Disposal Project, the jetty will be some 200 to 250 m long. The trestle structure will support the LNG loading and vapour return lines, utilities including fire-fighting water supply, jetty head platform on which the loading arms are located, and a 4 m wide roadway capable of carrying a 50 t mobile crane, heavy trucks, ambulances and pedestrian traffic. Marine operations and facilities buildings, including offices, customs services and storage facilities, will be located immediately onshore of the jetty.

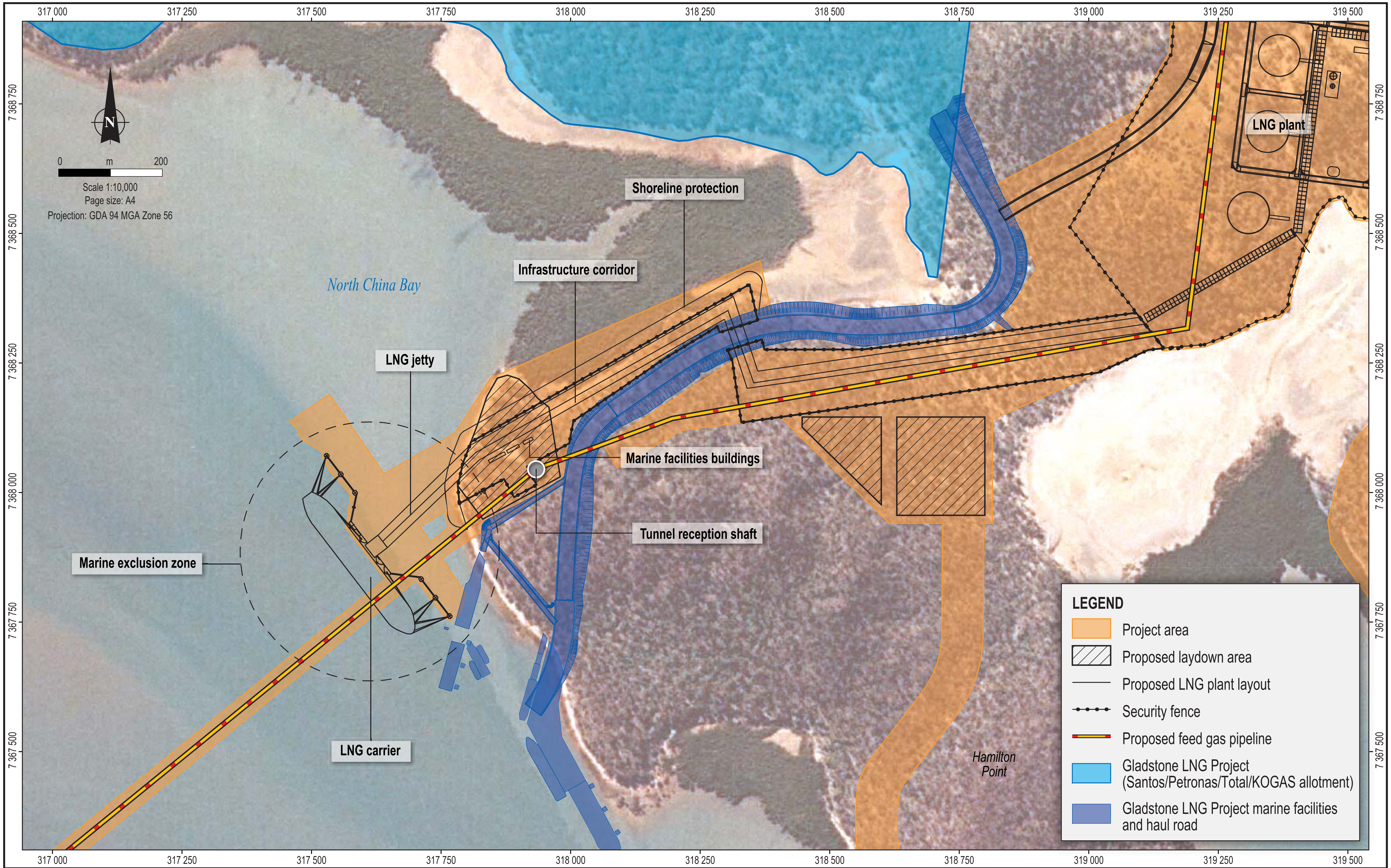
Constructed as a trestle on subsea piles embedded into the seafloor, the LNG jetty will be designed to ensure that wave-slamming forces will not affect the underside of the loading platform deck. The jetty will be designed to comply with AS 4997-2005 guidelines for the design of maritime structures. Cold flash protection will be applied to those sections of the jetty and loading platform that might be exposed to LNG spills to protect the steel structure from metal fatigue from excessive temperature variation (ambient to cryogenic).

6.5.1 Berth

The berth will be constructed at the seaward end of the LNG jetty trestle. The berth concept consists of two breasting dolphins and three mooring dolphins installed on each side of the LNG loading platform. These structures will be supported on piles, and access to the dolphins will be provided by catwalks.

The berth will be able to accommodate 145,000 to 215,000 m^3 LNG carriers with an unladen draught of 10.8 m and a fully laden draught of 12.2 m. The berth pocket provides for an under-keel clearance of 1.2 m for laden carriers.

The shipping access channel will be 200 m wide and incorporate a swing basin in front of the berth that will have a minimum diameter of two times the overall length of the longest LNG carrier, i.e., approximately 600 m.



Source:
Place names from DME.
Proposed LNG plant layout, ancillary facilities and marine infrastructure from Arrow Energy.
Proposed feed gas pipeline and project area from Coffey Environments.
Imagery from SPOT (2004-2007).

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Arrow Energy

Arrow LNG Plant

arrow energy go further

Infrastructure corridor and LNG jetty

Figure No: 6.10

6.5.2 Loading Platform

The loading platform will support the loading equipment, including:

- Four 16 inch loading arms (two liquid loading, one vapour return and one dual purpose liquid loading/vapour return) and associated pipework support systems. The loading arms will be fitted with an emergency shutdown system and powered emergency release couplings.
- Surge drum.
- Ship-to-shore access gangway.
- Staircases, ladders, walkways and handrails.
- Jetty operator cubicle.
- A fire fighting system, including monitors and detection systems.
- Area lighting to allow 24 hour operation.
- Catwalk access to adjoining breasting and mooring dolphins.

The facility will enable loading of a LNG carrier in approximately 24 hours.

6.5.3 Mooring Structures and Mooring Load Monitoring System

The mooring structures either side of the loading platform will be lit and equipped with the following:

- Guard rails.
- Quick release mooring hooks.
- Capstan and controls.
- System to monitor the load on each mooring connection.
- Line chafing guards.
- Ladder access from water.

6.5.4 Operations and Metocean Monitoring System

The marine facilities will be equipped with a marine operations and metocean monitoring system that will display wind speed and direction, sea level and tides, and current speed and direction in real time.

6.5.5 Navigation and Berthing Aids

LNG carriers entering the Port of Gladstone will be under the control of the Harbour Master and one or more pilots. Pilots will carry portable navaids which will show vessel position and track throughout the harbour transit. Buoys and lights will delineate the shipping channels.

The LNG jetty will be equipped with a docking laser system to assist with docking of the LNG carriers. Meteorological information will also be received electronically on a regular basis and will include data on wind (speed and direction), tidal current (speed and direction), and tide height.

Extensive marine simulations have been completed to prove the safe operations of the LNG carriers transiting, berthing and un-berthing at the LNG jetty.

6.6 Mainland Launch Site

A mainland launch site is required to transfer materials and personnel to and from Curtis Island. The requirements for this site vary between construction and operation; consequently, it is possible to establish a temporary launch site for construction followed by a permanent facility for operations. Arrow Energy's preference is to consolidate construction and operations requirements at a permanent site. A pioneer launch site may be required until the mainland launch site is operational for construction. It will be located in an existing facility in the marina area.

The facility will provide for the storage, loading and unloading of aggregate and materials, and the transfer of materials, aggregate, vehicles, plant and equipment, and personnel to and from Curtis Island. Approximately 16 ha of land is required during construction, reducing to approximately 4 ha of land in operations.

During construction, the land based infrastructure will typically comprise:

- A guardhouse.
- Warehousing.
- Laydown and staging areas.
- A stockpile and bulk materials storage and handling area.
- Car and bus parking.
- A ferry terminal with appropriate seating and restrooms.

During operations, the land based infrastructure may be downsized to:

- A guardhouse.
- Warehousing connected to heating, ventilation and air conditioning.
- A laydown and staging area.
- Car and bus parking.
- A ferry terminal with adequate seating and restrooms for operations personnel.

The marine infrastructure required for construction and operations is the same, and comprises:

- A fast passenger ferry jetty. The jetty will consist of a floating pontoon structure restrained by vertical steel piles and connected to the shore via a prefabricated steel gangway. The jetty will allow for berthing of two vessels to maximise passenger transfer efficiency.
- A combined roll-on, roll-off passenger (RoPax) and dumb barge berth. Where space exists, separate berths will be constructed as this will improve the efficiency of loading and unloading. A link span drawbridge will allow loading and unloading of vehicles and plant on the RoPax ferries. The dumb barge wharf will comprise a concrete deck supported by concrete piles driven into the river bed or seafloor, depending on the site.

All buildings will be connected to mains water, electricity, sewer, and telecommunications networks. However, if this is not feasible, alternatives such as water tanks, sewage package treatment plants and diesel generators for electricity supply will be installed.

Two mainland launch sites are under consideration – launch site 1 and launch site 4N (see Figure 1.2). Conceptual layouts of these sites are shown in Figure 6.11 and Figure 6.12, and described below, along with possible access arrangements.

6.6.1 Launch Site 1

Launch site 1 will be situated on former Gladstone Power Station ash ponds adjacent to the RG Tanna Coal Terminal and Calliope River, 2.2 km upstream of its mouth. The site has some 800 m of frontage to the Calliope River, enabling the RoPax jetty, dumb barge wharf and fast passenger ferry jetty to be separated.

The RoPax ferry berth will be an extension of the dumb barge berth, allowing independent loading and off-loading operations at the two facilities. The fast passenger ferry jetty will be located further upstream as dredging is not required at this facility due to the shallow draughts of the vessels.

A 100 m wide channel with a minimum depth of 5 m LAT is required to provide access to the facility under all tide conditions. This will necessitate dredging the bar at the entrance to the river, and the river bed to upstream of the dumb barge wharf where a swing basin will be established. Some 900,000 m^3 of material needs to be dredged, and it is anticipated the material will be disposed to the Western Basin Reclamation Area, which has received approval and is being constructed.

Two possible access routes to the site are being investigated, one from Bryan Jordon Drive and the other from the Gladstone–Mount Larcom Road. In both instances, existing access tracks and haul roads will require upgrading and sealing to provide all-weather access to the site. The access route from Gladstone–Mount Larcom Road is preferred because it does not involve a railway crossing, which imposes height restrictions and raises safety concerns.

The conceptual layout results in some 19 ha required for construction, with approximately 8 ha for operations.

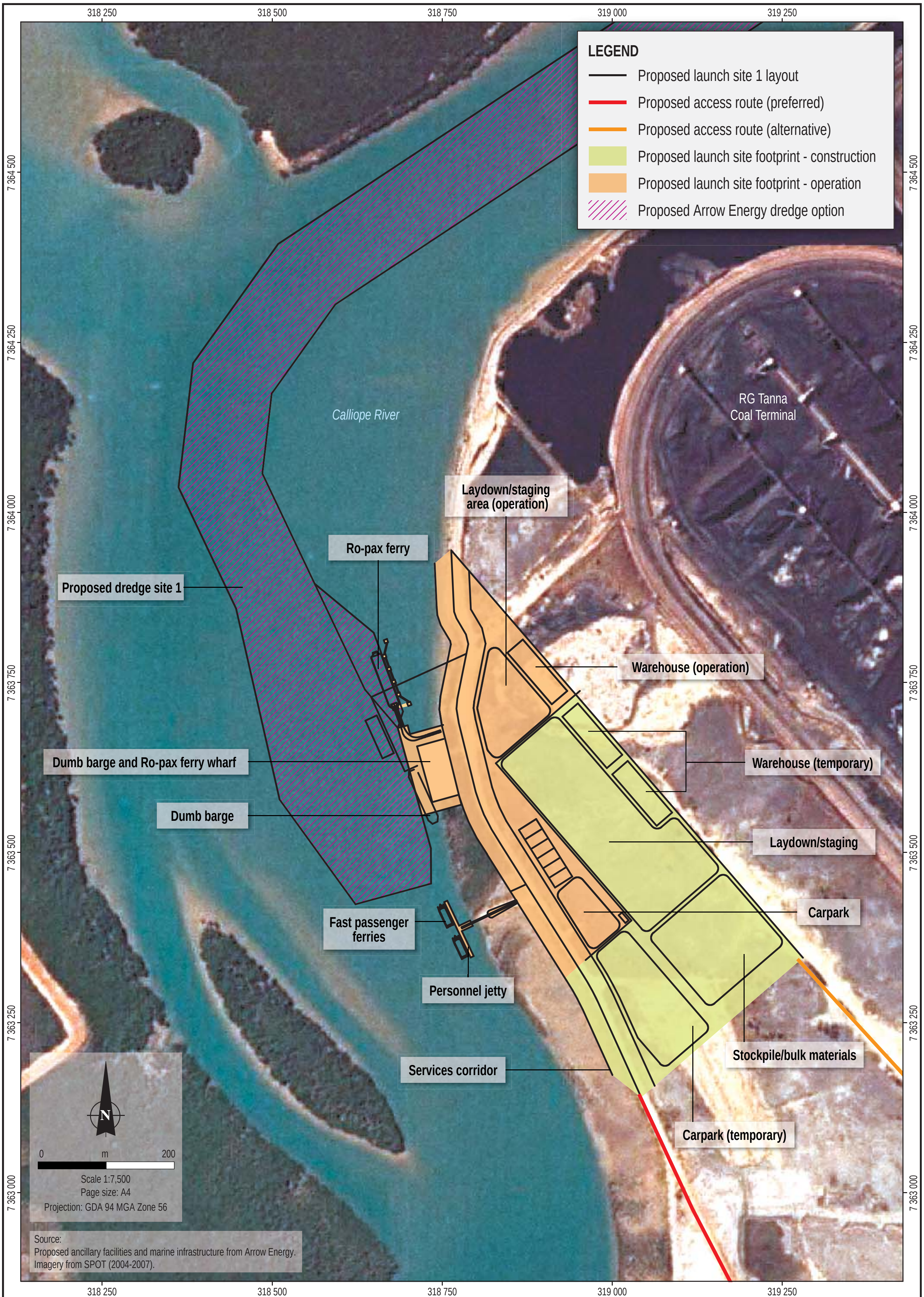
6.6.2 Launch Site 4N

Launch site 4N will be located at the northern tip of the Western Basin Reclamation Area. The Western Basin Reclamation Area is scheduled for completion by the end of 2013, at which time the site would be available to Arrow Energy. The reclaimed land would require a period of settlement, stabilisation or both to enable it to be developed for the required purpose. Minor dredging is required to create berth pockets that connect to the main shipping channel.

The reduced frontage (approximately 250 m) of this site necessitates the RoPax jetty to be integrated with the dumb barge wharf, which would be located immediately north of the fast passenger ferry jetty. This arrangement precludes simultaneous loading and unloading of RoPax ferries and dumb barges, the logistical effects of which will need to be managed through scheduling of vessel movements.

The site will be accessed via a road and services corridor to be established on the reclamation area engineered containment wall from either Landing Road or Forest Road. Depending on the access route, between 2.2 and 3.5 km of road may need to be constructed.

The constrained site limits the available land, resulting in the conceptual layout providing 17.5 ha for construction and 3.4 ha for operations. This site has been nominated by Gladstone Ports Corporation as land available for future LNG operations.



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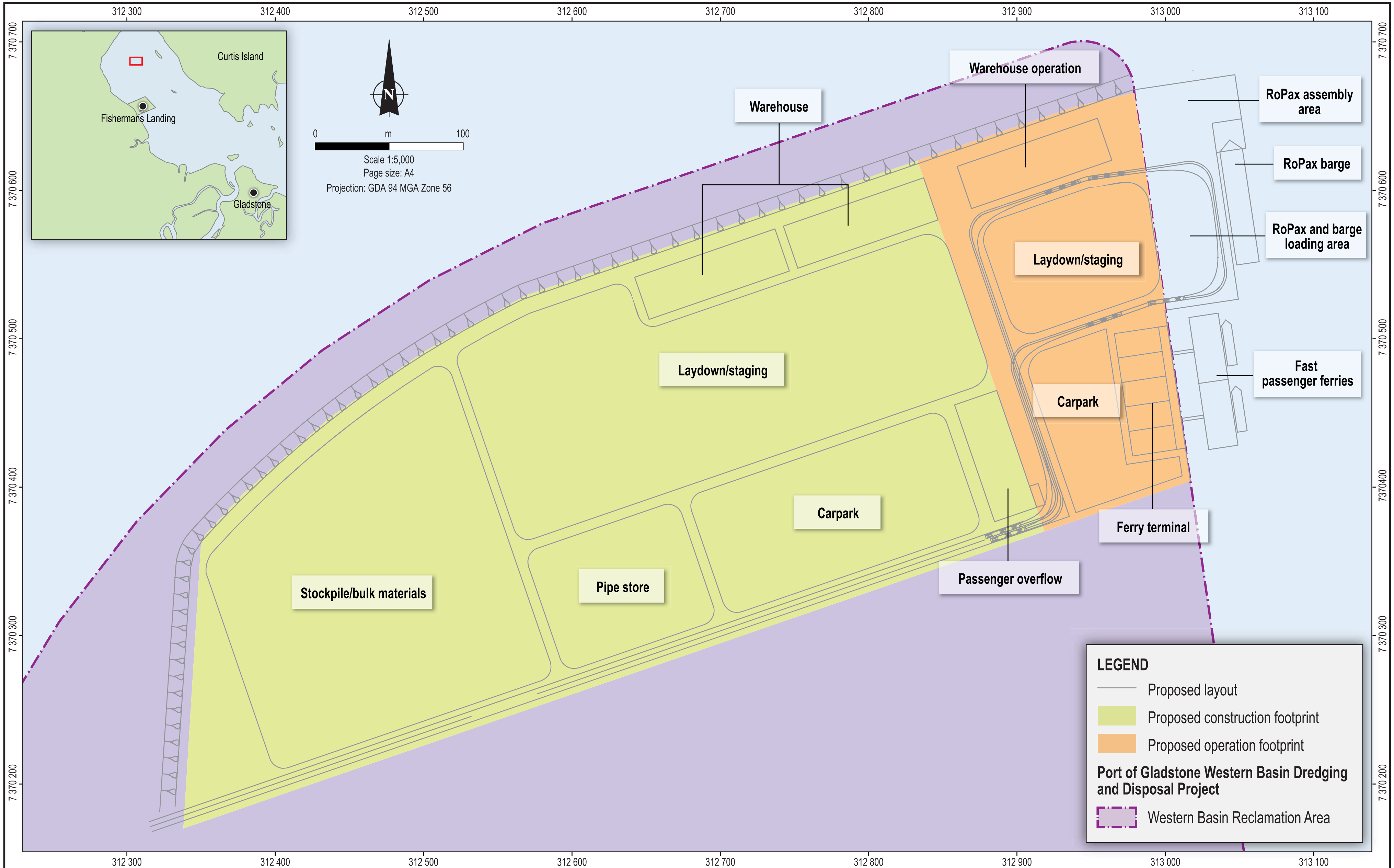
Arrow Energy

Arrow LNG Plant

arrow energy go further

Launch site 1 general arrangement

Figure No: 6.11



Source:
Proposed ancillary facilities and marine infrastructure from Arrow Energy.
Western Basin Reclamation Area from Gladstone Ports Corporation.

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Launch site 4N general arrangement

Figure No: 6.12

6.7 Materials Offloading Facility and Personnel Jetty

A MOF and co-located personnel jetty will be established to support construction and operations. The MOF will allow roll-on, roll-off or lift-on, lift-off vessels to dock and offload preassembled modules, equipment, supplies and construction materials. The personnel jetty will receive the fast passenger and RoPax ferries for worker transfers to and from the mainland.

The MOF will be a sheet piled structure. It will be backfilled with imported rock, gravel and clean fill that will remain available after construction for the full life of the project to support ongoing operation and maintenance and the decommissioning phase. The personnel jetty will be incorporated into the MOF. A haul road to carry over-dimensional loads and heavy and light vehicles will connect the MOF and personnel jetty with the LNG plant and construction camp.

If the MOF and personnel jetty are located at Boatshed Point, a pedestrian access path will be built between the personnel jetty and the construction camp along the eastern shore of Boatshed Point. The path will provide separate access from the vehicle road and an alternative means of egress from the construction camp in the event of an emergency.

The options identified for the MOF and personnel jetty locations are discussed in Chapter 5, Assessment of Alternatives. The three sites currently being investigated, and assessed as part of this EIS, include (see Figure 6.1):

- **Boatshed Point.** The preferred site is located at the southwest point of Boatshed Point. The associated haul road will be routed along the western shore of Boatshed Point (abutting the construction camp to the east) and will enter the LNG plant site at the southern boundary. The quarantine area, through which all imported materials will be processed, will be located adjacent to the southern boundary of the LNG plant adjacent to the haul road. Dredging is required to construct and operate the MOF, which will be located on the edge of deep water off Boatshed Point. Up to 50,000 m^3 of material would need to be dredged.
- **Hamilton Point South.** An alternative site is located at the southwest tip of Hamilton Point. The quarantine area will be located west of the LNG plant near the LNG storage tanks. The haul road will cross the saddle between the hills of Hamilton Point and intersect and share a small section of the Gladstone LNG Project (GLNG Project) haul road before entering the LNG plant near the LNG storage tanks. Submerged rock outcrops, beach and other coarse material would be dredged to facilitate construction and operation of the MOF and integrated personnel jetty. Up to 50,000 m^3 of material would need to be dredged.
- **GLNG MOF Hamilton Point.** A MOF, personnel jetty and haul road are being constructed at the northwest corner of Hamilton Point (south of the LNG jetty site) as part of the GLNG Project. A quarantine area and batching plant are integrated with the facilities. Arrow Energy is investigating the shared use of this facility. The impacts of construction and operation of this MOF and the associated haul road were assessed as part of the GLNG Project and are therefore not assessed in this EIS.

During the initial construction phase (up to 12 to 18 months), use will be made of an existing pioneer MOF on Curtis Island to bring equipment and people to the proposed LNG plant site. Arrow Energy is seeking an agreement with GLNG to utilise the pioneer MOF that has been constructed by GLNG at the northeast corner of Hamilton Point.

6.8 Design Philosophy

The principal design objective is an LNG facility that is safe and meets environmental, regulatory, constructability and operability requirements. An understanding of the risks associated with constructing, operating and maintaining an LNG plant and ancillary facilities is fundamental to the design process to ensure worker and community safety. Where possible, other community concerns will be addressed through design. Arrow Energy’s approach to the assessment of risk with respect to design and its response to community concerns, particularly those related to amenity, are described in this section.

6.8.1 Safety

Safety in design (or inherent safety principles) for the project will be determined using a multi-phased approach, from concept design through to detailed (final) design, construction and commissioning, operation and lastly, decommissioning.

The first phase (identify, select and pre-FEED) covered the project up to the end of the pre-FEED phase. The Concept Design HSE Case was prepared during this phase, providing an overview and status of HSE risks and activities for the project. The preliminary Quantitative Risk Assessment (QRA) for the LNG plant was also prepared during this phase and informed the conceptual layout of the LNG plant, utilities and ancillary facilities shown in Figure 6.3.

The second (FEED) phase involves updating the registers and documentation prepared in the concept design phase (such as the QRA) as the LNG Plant design and site layout is further refined. The emergency response plan, including medical emergency response, will also be developed in this phase.

The third (construction/commissioning) phase involves managing, during construction, non-routine tasks, hazardous activities (such as confined space entry) by performing appropriate risk assessments, developing detailed method statements, and executed under the permit to work system appropriate for the activities.

The fourth (operational) phase includes implementation of the HSE management system, HSE performance reviews, and technical HSE reviews. Non-routine operational activities and maintenance activities will be executed under the operations phase safe system of work (permit to work) system.

The fifth (decommissioning) phase includes the preparation of detailed HSE plans for decommissioning, including a hazard identification exercise(s) and health hazard risk reviews.

6.8.2 Visual Amenity

Located at the southern end of Curtis Island, the Arrow LNG plant will be visible from islands in Port Curtis (particularly Tide, Witt and Diamantina islands), Southend and Gladstone, particularly Auckland Point and other elevated areas of the city. Ship Hill provides a backdrop to the facility when viewed from Gladstone and the islands, and will assist in ameliorating the form and shape of the facility in the landscape. View Hill largely screens the facility from view from Southend.

The conceptual design of the LNG plant design has taken into consideration the visibility of the facility from the nominated sites and communities. The LNG plant and ancillary facilities will be constructed on several benches or terraces that will lower the height of various structures and buildings in the landscape, reducing the overall visibility of the facility. The LNG trains and associated utilities and ancillary infrastructure will be located on a bench with a nominal elevation of 14 m AHD. The higher structures, including the LNG storage tanks and flare, will be located on a lower bench at 11 m AHD. The administration buildings, workshops, fire station and construction laydown areas located to the east of the LNG trains will be located on a bench at an elevation of 14 m AHD.

Boatshed Point is a prominent feature of the southern coast of Curtis Island. The construction camp will be located on the point, as this is the only site that provides the required separation from the operating plant, particularly the LNG trains and flare. The conceptual design protects the headland of Boatshed Point, thus screening the majority of the camp from view. The 40 m relief of Boatshed Point offers a further opportunity to reduce the overall appearance and visibility of the camp through development of the camp on a bench at 15 to 20 m AHD.

6.9 Construction Schedule and Workforce

The indicative program for construction of the LNG facility and construction workforce requirements is described in this section, along with the proposed accommodation arrangements for the workforce.

6.9.1 Construction Schedule

Construction of the tunnel to convey the feed gas pipeline, and possibly other services to the LNG plant on Curtis Island will commence approximately one year before construction commences on the LNG plant and ancillary infrastructure. This is due to the long lead time required to procure a tunnel boring machine (these machines are bespoke designs) and the 30 to 33 month timeframe required to bore, line and fit out the tunnel. The detailed description of the tunnel construction is provided in Chapter 7, Project Description: Feed Gas Pipeline.

The first train will take approximately 44 months to construct, commission and bring into operation, with the first LNG cargo targeted for 2017. Construction of the second train will commence approximately one year after the start of construction for train 1, with the first LNG cargo from train 2 occurring in late 2018 or early 2019 (see Figure 1.3).

Initial construction activities will involve the establishment of barge landing facilities on Boatshed Point to facilitate the establishment of a pioneer camp on the island. At the same time, construction will commence on the mainland launch site and TWAF. The latter will provide accommodation capacity as the pioneer camp on the island is expanded to a full service construction camp. The construction camp will be incrementally expanded to its full capacity as the workforce ramps up over the first two years of construction.

Vegetation clearing and bulk earthworks will be undertaken simultaneously with construction of the MOF and personnel jetty. Access to the island during this period will be provided by barges and medium-sized personnel ferries operating through the temporary landing facility on Boatshed Point.

Completion of the MOF and personnel jetty will enable the establishment of a concrete batching plant and other infrastructure required to support construction of the LNG plant. Civil works, including foundations, will be followed by structural steel work. Major components of the LNG trains and ancillary infrastructure will be delivered to site as modules, with other infrastructure (such as the LNG storage tanks, main cryogenic heat exchanger, large processing columns and buildings) stick built.

Structural steelwork and assembly of LNG train modules will be followed by pipe work and installation of mechanical equipment, including gas turbines, electric motors and compressors. Electrical and instrumentation is the final major scope of work before the plant is commissioned.

Rehabilitation of temporary work sites will occur during and after commissioning, as appropriate, as some sites will be required for completion of train 2 and the construction of future trains.

To minimise noise disturbance to sensitive receptors, construction activities will typically occur between 7.00 a.m. and 7.00 p.m. However, occasionally activities will be performed at night, e.g., when modules arrive on vessels and during large concrete pours.

6.9.2 Construction Workforce

The peak workforce required to construct trains 1 and 2 is estimated at 3,500 persons, consisting of 3,000 construction workers, 350 engineering, procurement and construction (EPC) management personnel, and 150 Arrow Energy employees. In addition, up to 100 persons will be required to construct the tunnel, 75 persons to install the feed gas pipeline, and for dredging activities 20 to 40 people. The workforce required to construct trains 3 and 4 is projected to peak at 2,330 persons (2,000 construction workers, 250 EPC personnel and 80 Arrow Energy employees). The workforce histogram for development of all four trains is shown in Figure 6.13, which assumes a nominal five year period between stages 1 and 2.

Analysis of the workforce mix of previous major projects in the Gladstone region, along with the forecast workforce requirements of the other LNG developments, indicates that between 5% and 20% of the 3,000 construction workers could be sourced from the local community. The timing of the other LNG developments will strongly influence the ultimate make-up of the workforce.

Workers not sourced locally will be engaged on a single status, fly-in, fly-out contract with their contracted pick-up and set-down location being a capital city or other major city. Their contract conditions will require that they live in the construction camp or TWAF.

EPC management workforce and Arrow Energy employees not sourced locally will relocate to Gladstone and live in the community in existing residential properties, if available, and company-facilitated communal accommodation facilities. It is assumed that 5% of the EPC management workforce and 10% of Arrow Energy employees would be sourced from Gladstone. Of those non-resident employees, it is assumed that 10% of the EPC management workforce and 40% of Arrow Energy employees would be engaged on family status, with the remainder engaged on a single status. Single status employees would be accommodated in company facilitated communal accommodation.

The local content of the construction workforce is expected to be higher during early works when local subcontractors are expected to be able to provide the required civil construction and trades skills. During this period, 200 to 300 fly-in, fly-out workers would be required to establish the pioneer camp. They would be housed on the mainland in construction camp facilities provided by third parties or, if unavailable, in other forms of temporary accommodation facilitated by the project.

6.9.3 Construction Workforce Accommodation

The construction workforce, with the exception of the EPC management workforce and Arrow Energy employees, will be accommodated in either the construction camp at Boatshed Point on Curtis Island or in the TWAF on the mainland.

Construction Camp

Up to 2,500 people will be housed at the construction camp. Its establishment will be preceded by a 250-bed pioneer camp at the same locality. The pioneer camp will evolve into the full service camp by expansion in 200- to 250-bed stages every six to eight weeks until the bed numbers reach 2,500.

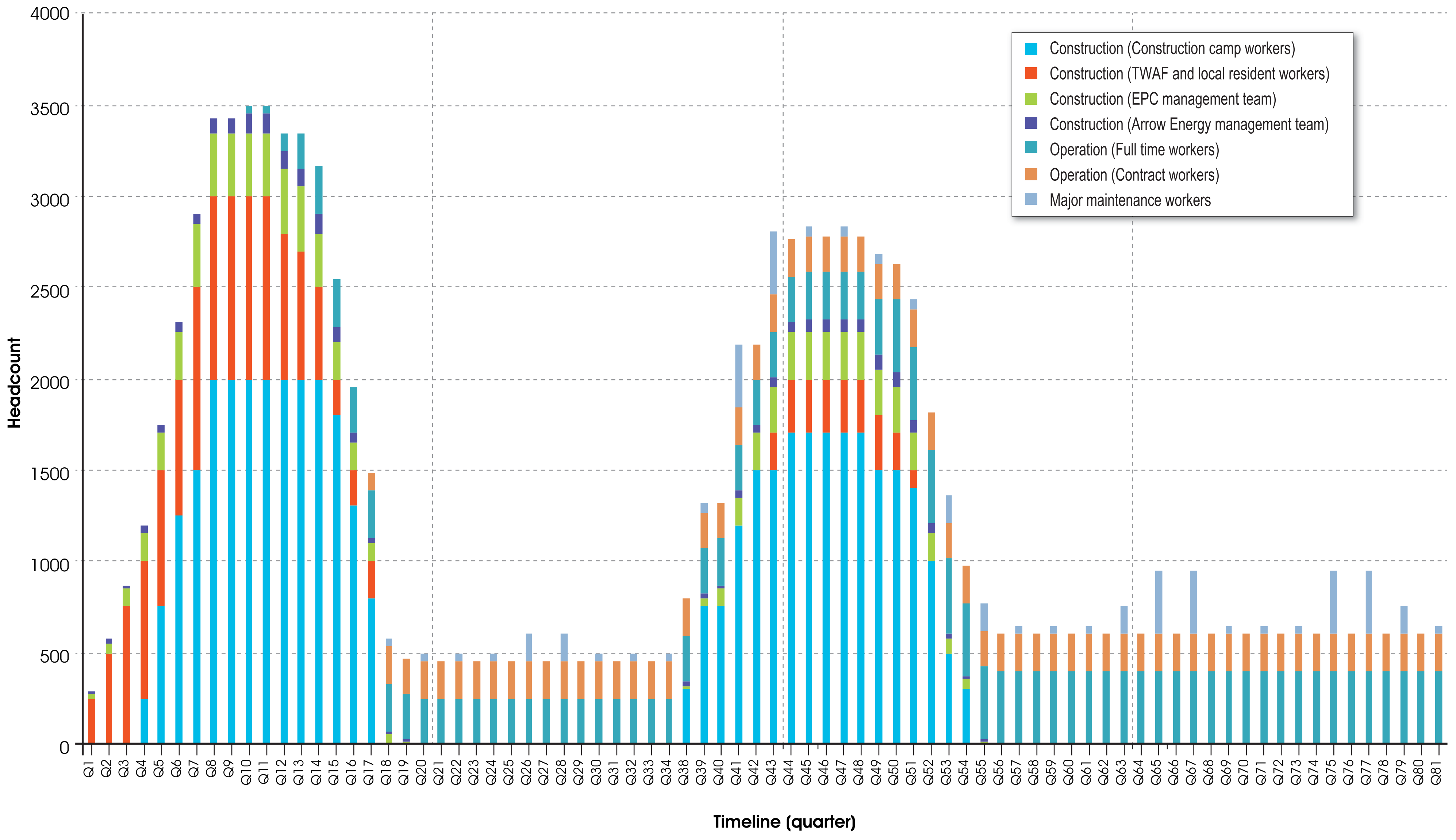

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Figure No: 6.13

The construction camp will be located on Boatshed Point. Vehicle and pedestrian access from the MOF and personnel jetty will be via the haul road and the walking track around the east shore of Boatshed Point respectively (see Figure 1.2).

A conceptual layout of the construction camp on the approximately 20 ha site is shown in Figure 6.14. The construction camp layout will be designed to address site-specific conditions, including topography, remnant vegetation, threatened species, and access. The camp will provide accommodation, services and messing, with facilities including:

- Mess, laundry, social and recreational facilities.
- Convenience store with banks and post office.
- Medical facilities.
- Facilities management office.
- Waste disposal collection points and provisions for the handling of solid waste.
- Provisions for surface water and stormwater runoff/drainage.
- Security facilities, including access gates, fencing and guardhouse.
- Telecommunication systems, including telephone, television, radio and internet.
- Fire-fighting services and alarm systems.
- Road and pedestrian network to and from personnel jetty and construction areas.
- Parking area for buses that will transfer workers to and from the personnel jetty and work sites.
- Emergency assembly points and emergency escape routes.

Due to land constraints, the recreation facility will be located northeast of the construction camp and east of the water and effluent treatment plants on the adjacent headland. Access to the facility will be afforded by a dedicated walking track so workers can avoid having to use the adjacent haul road. A helicopter landing area for emergency evacuations might be integrated with the recreational facility, unless a shared facility is established in consultation with the other LNG developments.

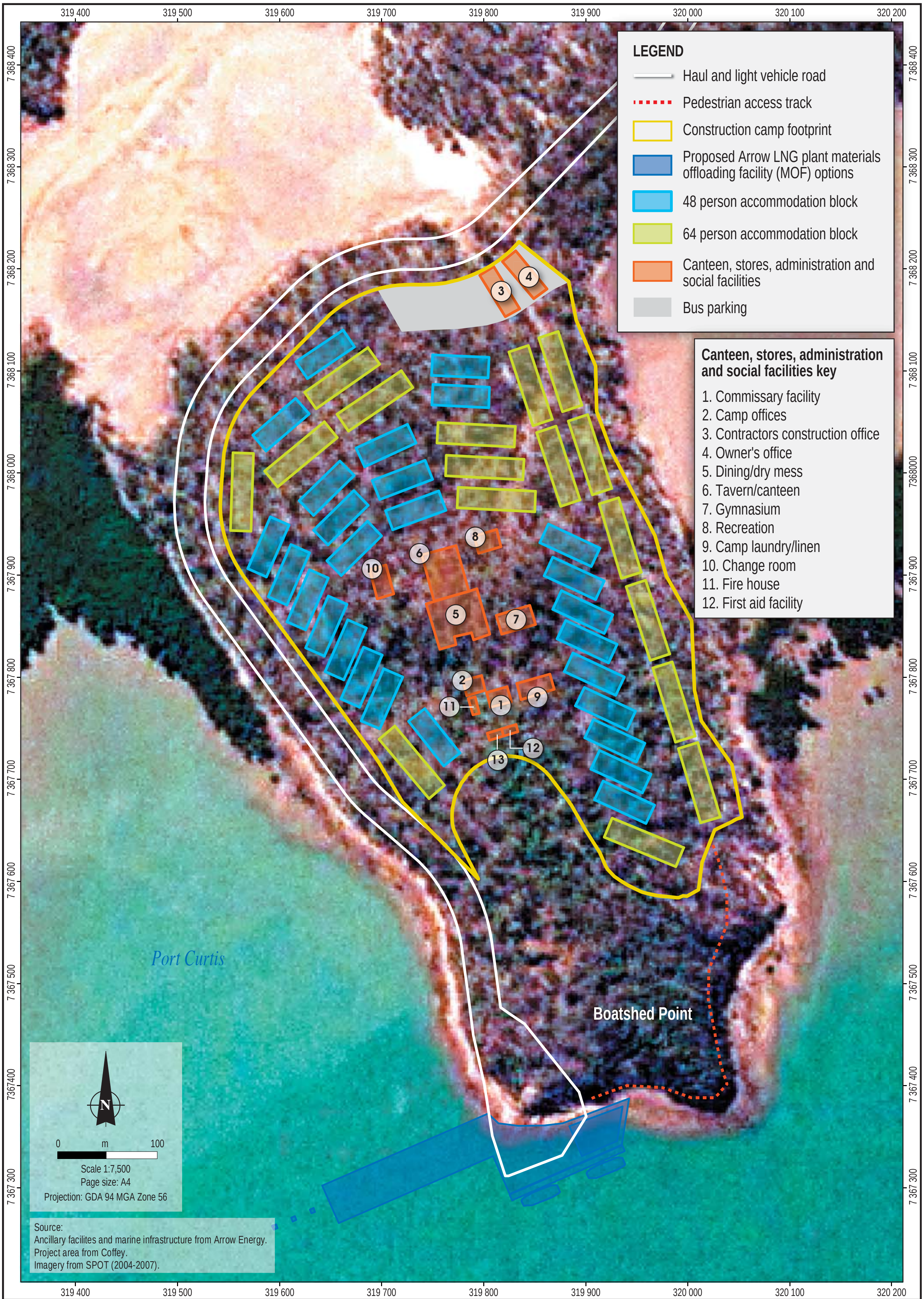
Camp power will be supplied by diesel generators or from electricity imported from the Queensland electricity grid. Sewage will initially be collected and trucked out until a package treatment plant is commissioned (after approximately 6 to 12 months after the establishment of the pioneer camp), at which time treated sewage will be discharged to Port Curtis via an outfall offshore of Boatshed Point.

The kitchen facilities will be sized to serve breakfast and dinner for up to 2,500 people in 90 minutes, including the preparation of crib lunches.

The construction camp will have a design life of approximately five years, i.e., the expected construction time for completion of trains 1 and 2 (Stage 1). Following the completion of Stage 1, consideration will be given to decommissioning the camp or maintaining the camp for the Stage 2 construction phase, depending on expected timing. Following completion of all construction phases, the construction camp will be decommissioned and the site stabilised, reinstated and rehabilitated to a self-sustaining landform.

Temporary Workers' Accommodation Facility

The TWAF will provide accommodation for fly-in, fly-out workers as an overflow camp if the construction camp has reached full capacity. The camp will also provide accommodation for workers associated with mainland based activities, e.g., pipeline and tunnel construction.



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Approximately 25 ha is required for the TWAF. The sites under consideration (TWAF 7 and TWAF 8) have ample space to accommodate the facility and laydown areas for temporary storage of construction materials. A conceptual arrangement of the facility is shown in Figure 6.15. The layout of the TWAF and associated laydown areas will be designed to address site-specific conditions including topography, remnant vegetation and access.

The TWAF will be designed to accommodate 1,000 people and will consist of the following components:

- Accommodation units.
- Mess, laundry, social and recreational facilities.
- Basic medical facilities.
- Management office.
- Waste disposal collection points and provisions for the handling of solid waste.
- Sewage treatment. Sewage at TWAF 7 will be directed to a sewer pump station at the site boundary then pumped to the nearest sewer main or sewerage treatment plant. A package treatment plant will be installed at TWAF 8 as it is located outside the existing sewerage network.
- Provisions for the collection and treatment (if necessary) of surface runoff and stormwater drainage to ensure water quality in adjacent watercourses is protected. Runoff and stormwater discharges from TWAF 7 and TWAF 8 will discharge to Auckland Creek and Targinie Creek, respectively.
- Security facilities including access gates, fencing and guardhouse.
- Telecommunication systems including telephone, television, radio and internet.
- Fire fighting services and alarm systems.
- Upgraded roads connecting the site to the main road network. TWAF 7 will be accessed via the existing causeway from Blain Drive, with TWAF 8 accessed from Forest Road (laydown areas) and Calliope–Targinie Road (accommodation facilities and services). The access points for TWAF 8 may be consolidated; however, protection of the wildlife corridor in riparian vegetation along Targinie Creek is a primary objective of development of this site.
- Parking area for buses which will transfer workers from the facility to and from the mainland launch site, and to and from the airport at completion/start of their rotation.
- Emergency assembly points and emergency escape routes.
- Electricity supply via a mains electricity connection.
- Water supply via a connection to treated mains water for TWAF 7. TWAF 8 is outside the existing water supply network and options for alternative potable water supply will be investigated (i.e., a 5-km-long pipeline to the nearest raw water main near the intersection of Forest and Landing roads or trucked-in water).

Not to scale

LEGEND

1 - Kitchen and dining room
2 - Covered assembly area
3 - Linen store
4 - Common amenities
5 - Recreation building (1 of 2)
6 - Recreation building (2 of 2)
7 - Gymnasium
8 - Swimming pool
9 - Outdoor recreation
10 - Housekeeping stores
11 - Accommodation block
12 - Laundry
13 - BBQ shelter
14 - Tavern/canteen
15 - Camp management
16 - Convenience store
17 - Maintenance/equipment storage
18 - First aid
19 - Bus parking
20 - Carpark

Source: Coffey Environments and Arrow Energy

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Conceptual temporary workers accommodation facility layout

Figure No: 6.15

The facility will have a similar lifespan to the main construction camp on the island. Its future – removal or reuse – will be determined near the end of Arrow Energy's need for the camp. As the facility will be strategically located in the vicinity of other future developments, it might have value to another party.

6.10 Early Works

Construction activities undertaken as part of early works will include:

- Site preparation and watercourse diversion.
- Installation of the security fencing and manned security gates.
- Construction of surface water system and temporary sedimentation ponds.
- Construction of a fuel storage and distribution facility for fuel supply to construction equipment.
- Establishment of the concrete batching plant.
- Construction of the MOF and personnel jetty.
- Construction of the mainland launch site.
- Construction of the mainland and island accommodation facilities.

These activities are described in the following sections.

6.10.1 Site Preparation

Site preparation will involve:

- Vegetation clearance and storage.
- Topsoil removal and storage.
- Installation of a surface water drainage system.
- Bulk earthworks.

Bulk earthworks and site drainage works for the four train development will be undertaken as part of the initial development. This will take advantage of the presence of construction equipment on site during Stage 1 construction, reduce dust in the vicinity of operating plant, and provide additional laydown area.

Vegetation Clearance and Storage

Areas required for construction of the LNG plant plus a 30 m wide firebreak will be cleared. Where possible, millable timber will be harvested, stockpiled and transported to the mainland for re use. Timber not recovered as wood product will be mulched and stockpiled for use in soil stabilisation and rehabilitation works. These long-term stockpiles will be located in areas to avoid rehandling. Bulldozers, timber harvesting machines, an excavator with a grab, and a mobile wood chipper will be employed to undertake these works.

Topsoil Removal and Storage

Topsoil is generally defined as the top layer of fertile soil, including organic plant matter that is not woody vegetation. Following vegetation clearance, topsoil will be progressively stripped and stockpiled in spoil areas on the site. Topsoil stockpiles will be planted with sterile grasses to reduce erosion from wind and rain to preserve, as much as possible, the organic matter. Topsoil will be respread over the final surfaces of areas designated for rehabilitation and landscaping to support regrowth. Topsoil removal will be undertaken using self-loading scrapers or graders, front-end loaders and trucks.

Installation of Surface Water Drainage System

A site surface water drainage system will be constructed to reduce the potential during construction for soil erosion and discharge of sediment-laden water to local drainage lines creeks and the marine environment.

The surface water drainage system will divert clean surface water runoff away from disturbed areas. The LNG plant will be constructed across several catchments requiring the diversion of the ephemeral watercourse that drains the largest catchment. The proposed diversion will also intercept flows from tributaries and side gullies of the ephemeral watercourse. Consequently, two diversions are required, one diverting the watercourse itself and intercepting side gullies to the west, and the other intercepting tributaries and side gullies to the east.

Two options are being investigated for the proposed diversion. The first option involves the construction of diversion channels west and east around the LNG plant bench. The western diversion channel would discharge to the existing ephemeral watercourse that drains the adjoining catchment and discharges to North China Bay. The eastern diversion channel would discharge to Port Curtis northeast of the LNG plant administration and workshops complex.

The second option involves integrating the diversion channels with the toe drains that will intercept runoff from the LNG plant bench batters. The toe drains extend west and east around the LNG plant bench. The western toe drain discharges to Port Curtis in the embayment west of Boatshed Point. The eastern toe drain discharges to Port Curtis northeast of the administration and workshops complex, at the same point as the dedicated diversion channel. The preferred option will be determined during FEED.

Sediment-laden water from disturbed areas will initially be diverted to temporary sedimentation ponds and later to a controlled discharge facility that will store the first 30 minutes of surface water runoff for settlement and treatment prior to discharge. Surface water flows occurring after 30 minutes will be discharged directly to Port Curtis.

Bulk Earthworks

Major earthworks (earthmoving and levelling activities) will establish the benches on which the LNG plant, utilities and ancillary infrastructure and Boatshed Point construction camp will be constructed. The haul road to the MOF and personnel jetty, the quarantine area and the infrastructure corridor formation that will carry the LNG rundown lines will also be excavated and formed.

Cut and fill volumes are estimated at approximately 4,700,000 m^3 and 4,200,000 m^3 respectively. Excavated cut material will be used for fill where suitable. This will result in approximately 43,000 m^3 of surplus material that will be used in landscaping mounds and other such landforms. Cut material comprises approximately 1,700,000 m^3 of weathered rock and 700,000 m^3 of fresh rock. The latter will be used, where possible, for the production of aggregate for road base and concrete production, reducing the overall quantity that needs to be imported from the mainland. This supply will be augmented with 100,000 m^3 of imported aggregate and rock for shore protection. Areas requiring undercut to remove poor soils will be backfilled with appropriate quality fill as needed. Areas will be trimmed to final grade and compacted on completion of major earthworks.

Bulk earthworks and stream diversion works will be undertaken using bulldozers, scrapers, excavators, haul trucks, front end loaders, backhoes, graders and compacters/rollers, which will be serviced by refuelling tankers and maintenance trucks. Water trucks, water sprays or dust suppressants will be used as necessary to manage dust. Water trucks will draw water from the temporary sedimentation ponds. Personnel will be bussed to and from the mobile plant depot.

Some drilling and blasting is required to remove weathered rock at the LNG plant site and marine areas. This will involve the use of drilling rigs and barge mounted drilling rigs. Explosives will be transported in explosive transport vehicles or tender vessels.

Security Fencing

On completion of bulk earthworks, the site will be fenced and secure access points established at Boatshed Point and the intersection of the access road and GLNG haul road. All access will be controlled through these points, which will include manned security gates.

6.10.2 Road Construction

Site roads including the 30 m wide haul road and narrower internal roads (approximately 5 m wide) will be constructed of a sub base of crushed rock on which road base, a finer aggregate, will be placed and compacted to form a safe, stable and durable driving surface. The surface will be able to bear the required loads, which will include up to 4,500 t modules. Internal roads will be bitumen sealed. Road markings, signs, safety barriers, lighting and other ancillary works will complete the road works.

The quarantine area, which is linked to the haul road, will be constructed in a similar manner and will comprise a crushed rock pad. Surface water runoff will be collected and stored in a retention pond to ensure any foreign material and organisms are contained to that site for appropriate treatment, including disinfection.

6.10.3 Concrete Batching Plant and Diesel Storage

A concrete batching plant will be established on site (see Figure 6.3) to provide concrete for civil works and foundations. In addition to the aggregate produced on site and imported, 140,000 m^3 of sand and 100,000 m^3 of cement will be sourced locally and imported to the island.

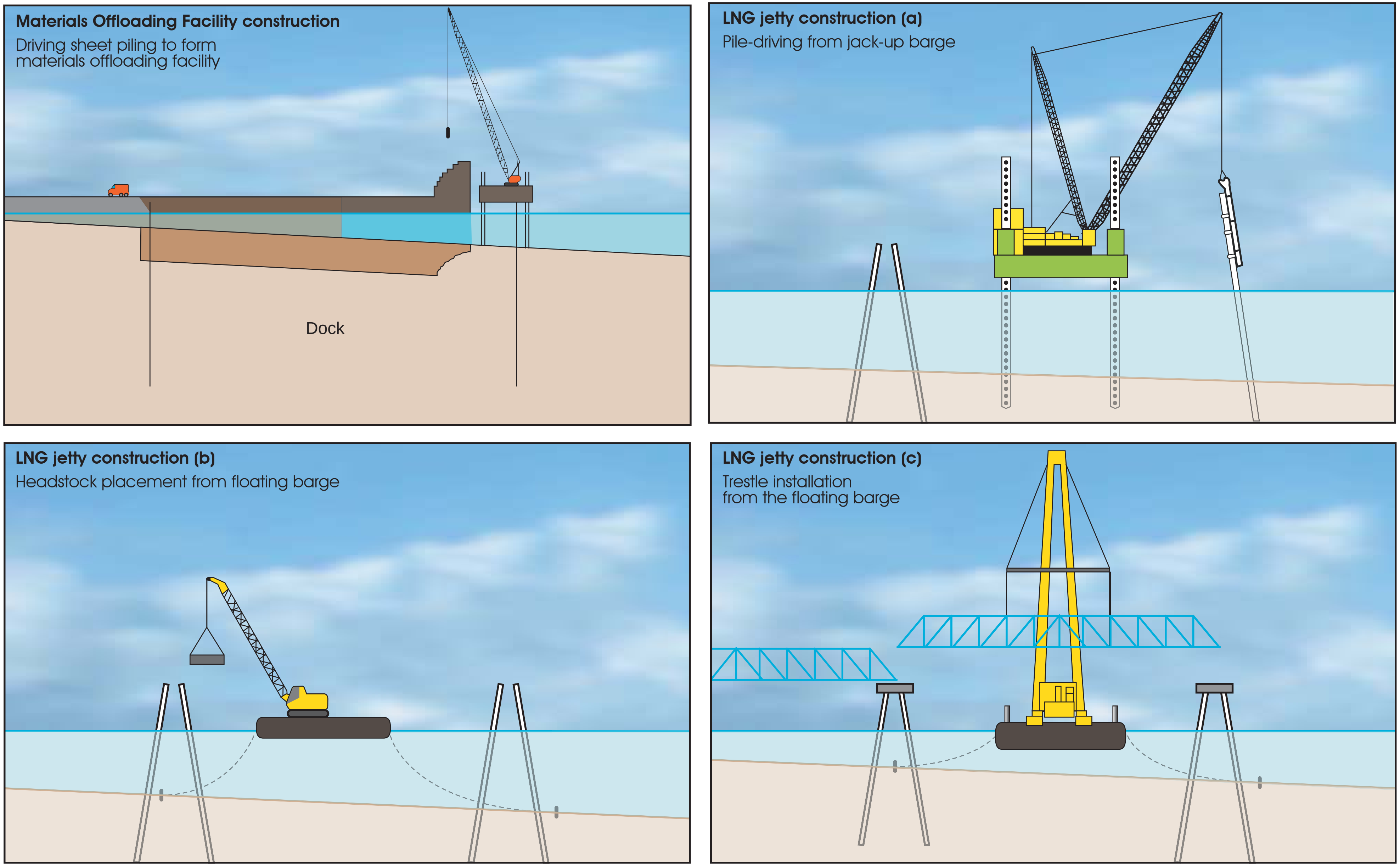
A fuel storage and distribution depot will be established on the island to provide fuel during construction. A 150 m^3 diesel storage tank and associated transfer pumps will provide low-sulfur diesel fuel, where practicable, to various users. Diesel filter coalescers will be provided to ensure particulates and water are removed. Diesel fuel day tanks will be strategically located throughout the facility, near clusters of users to enhance distribution. All tanks will have appropriately designed secondary containment.

6.10.4 Materials Offloading Facility and Personnel Jetty Construction

The MOF will be a sheet-piled structure, backfilled with rock, gravel and clean fill. The sheet piles will be brought to site via barge. Conventional pile-drivers (impact or vibratory) mounted on a barge will be used to drive sheet piles into the seafloor (Figure 6.16). The area will then be pumped out and filled by end-tipped and compacted material, surfaced with crushed rock and topped with concrete beams to form the working surface.

Where not integrated with the MOF, the personnel jetty will consist of a sheet-piled wharf from which a catwalk will extend to a floating dock held in place by piles. A conventional pile-driving rig mounted on a barge will be used to drive the sheet piles and piles. Cranes mounted on a work barge will complete the structure by lifting into position preassembled sections of the structure delivered to the site by towed barges.

Construction of the MOF and personnel jetty is expected to take about 18 months.



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Materials offloading facility and LNG jetty construction

Figure No: 6.16

Dredging required to construct the MOF and personnel jetty and to provide adequate depth for operation is discussed in Section 8.4.2, Materials Offloading Facility and Passenger Jetty.

6.10.5 Mainland Launch Site

Construction of the mainland launch site will require soil stabilisation regardless of the site. Dredge spoil and fly ash will need to be treated with lime or other stabilising materials before being compacted and able to achieve a bearing capacity suitable for the proposed infrastructure and materials.

The marine facilities will be constructed in a similar manner to the MOF and personnel jetty, as they are equivalent facilities on the mainland. Buildings, workshops and carparks will be constructed using conventional construction equipment and methods.

6.10.6 Accommodation Facilities

The main construction camp and temporary workers accommodation facility will be constructed using similar methods. Site preparation will be as described above. Accommodation units and other buildings will be prefabricated of modularised wood around a metal frame and stressed membrane structure. They will be transported to site by barge (main construction camp) and road transport. The buildings will be lifted off the trucks by a crane, set into place on prepared foundations, tied down and connected to services including electricity, water, sewage and telecommunications.

Connections to municipal and water authority infrastructure will be undertaken by contractors engaged by those organisations, and will form part of their water and wastewater networks. Extensions to electricity supply lines will be undertaken by approved contractors. Maintenance responsibility for the power line will depend on whether it is deemed a private line or forms part of the wider distribution network.

6.11 LNG Plant, Storage Tanks and Jetty Construction

Construction of the LNG facility will comprise stick-build and modular methods. Major structures, including the LNG storage tanks and jetty, will be stick built. The LNG trains will be predominantly constructed using preassembled modules fabricated offshore and shipped to the MOF for transport to the LNG plant site via the quarantine facility. Stick-build methods will be used to connect the modules, complete pipe work, install mechanical equipment that will be delivered as units, and build the services and ancillary infrastructure. The following sections provide an overview of the construction activities required to build the LNG plant, storage tanks and jetty.

6.11.1 LNG Plant Construction

Following site preparation, the following activities will be undertaken to construct the LNG plant:

Civil Works

Foundations for the major components will be constructed in this phase of work. Piling will be used to provide a stable foundation for the acid gas removal absorption column and flare stack. Site drainage systems, water and effluent treatment plants, and buildings and workshops will complete the scope of the civil works.

Structural Steel and Pipe Work

Structural steel and pipe work will be installed once the foundations are in place using cranes. Most structural steel and pipe work needed for the construction of the LNG trains and ancillary facilities will be delivered to the site as preassembled modules. Heavy lift cranes will be used to lift the modules into place. Mobile cranes will support the stick-built activities.

Equipment Setting

Mechanical equipment, processing columns and refrigerant storage tanks arriving throughout construction will require setting onto their foundations. After delivery to the MOF, heavy-haul transporters will deliver the items of equipment directly to the foundations or to a laydown area. Large cranes will lift (and transport) the items of equipment into their permanent positions where they will be bolted to the foundations. Most equipment will be assembled in modules, which will be set directly onto foundations.

Welding and Radiography

Once the structural steel and equipment erection has taken place, the piping assembles will be welded together. Crews will perform tie-in welds, weld inspection and repair, coating, coating inspections and coating repairs. Welds will predominantly be inspected by radiography. Other inspection methods (e.g., magnetic particle, ultrasonic testing) may also be employed.

Electrical and Instrumentation Installation

Once equipment has been set and the piping assembled into position, finishing works will include electrical and instrumentation installation. This will include some cables and the earthing grid will be installed underground within the camp and buildings and some plant areas.

Insulation and Application of Coating Materials

Equipment, piping and structural steel, where appropriate, will be coated in the field, if not coated by the suppliers. If major vessels are not insulated prior to delivery, they will be insulated in the horizontal position at the appropriate laydown area before lifting into position. Insulation of piping will follow-pressure testing, along with touch-up painting and fireproofing.

6.11.2 LNG Storage Tanks

Construction of the LNG storage tanks will be carried out in parallel with LNG train construction.

The LNG storage tanks will be founded on a mass concrete slab that will incorporate a settlement monitoring system. The reinforced concrete outer containment tank walls will be constructed in situ using slip-forming construction methods to ensure a monolithic watertight structure. Prestressed steel tendons will be inserted horizontally and vertically through the walls to enable post-tensioning of the structure.

The LNG storage tank roof will be constructed at ground level inside the storage tank walls then lifted into position by compressed air. Bridging sections will then be inserted between the main body of the roof and the outer cylindrical wall, in order to lock the roof in place. Tank filling and LNG carrier loading systems will be installed on top of the tanks.

The primary containment tank or membrane will undergo hydrostatic testing at the completion of construction. Town water, seawater or fresh water (from the reverse osmosis plant) will be used for hydrostatic testing and will be maintained in the tanks for at least 48 hours. Biocides and oxygen scavengers may be used to ensure organic deposits, which might cause corrosion, do not occur. Biocides and oxygen scavengers are typically applied at rates that ensure their decay to safe levels prior to discharge. Hydrostatic test water will be tested and, if necessary, treated before discharge to the sea. The primary containment tank or membrane will be thoroughly cleaned with fresh water following the hydrostatic test and dried before being precooled with a small volume of LNG.

6.11.3 LNG Jetty Construction

Dredging will be required to enable construction of the LNG jetty, as plant and equipment mounted on work barges will be used to undertake the various activities described below. The dredging method to be employed is described in Section 8.4.3, LNG Jetty.

LNG Jetty Construction

The trestle will be formed with piles driven into the seafloor by excavators mounted on jack-up barges or floating cranes (see Figure 6.16, frame (a)) with conventional hydraulic or diesel hammers. The type, strength and length of piles will be determined by the results of geotechnical investigations.

Piling will be undertaken using soft-start procedures that produce a sequential build-up of warning pulses before full power is delivered to the pile-driving head. This will give marine mammals and fish an opportunity to clear the area.

A barge-mounted crane (see Figure 6.16, frame (b)) will then place precast headstocks on the apex of the piles, where they will be fixed and welded into position. This will minimise the amount of in situ construction work to be completed over the water. The barge-mounted crane will then lift the trestle sections into position (see Figure 6.16, frame (c)).

Export Berth Construction

The LNG export berth will be built at the seaward end of the main LNG jetty trestle once the trestle is complete. The breasting and mooring dolphins will also be built at this time (see Figure 6.10). An excavator mounted on a jack-up barge or floating crane will drive piles for the berth and dolphin piles using soft-start procedures.

The floating crane or a temporary tower crane erected on the first completed dolphin will install precast headstock systems, decking and catwalks. The tower or floating crane will then complete the remainder of the export berth construction. On completion, the tower crane (if utilised) would be available to assist with the installation of mechanical and electrical works, as well as the LNG loading arms and associated export berth utilities.

Jetty Road and Auxiliaries

Access to the LNG jetty will be provided by a conventional two lane roadway that will be constructed of crushed rock with a bitumen seal. The vehicle roadway that will provide access along the jetty to the loading platform will be constructed of precast concrete road panels lifted into place by a mobile all-terrain crane near the shore then by a floating or barge-mounted crane.

Curbs and crash barriers will be cast in situ and will protect the rundown lines and jetty utilities and services from accidental impact. Construction will be completed with installation of safety handrails and lighting.

Topside Equipment and Electrical and Piping Works

Topside equipment that will be installed using a mobile crane operating from the roadway or a floating crane includes:

- Loading arms.
- Pipe racks.
- Transformer station.
- Pumps.
- Control room building.
- Fenders.

- Mooring hooks.

The efficiency and safety of installation of the infrastructure will determine whether a mobile crane or floating crane is used. The floating crane will avoid the need to first offload materials to shore, then transport them back along the trestle – a reduction in double-handling and the construction hazard of moving heavy equipment along the trestle.

Air, water, nitrogen, fire water and power will all be installed on the LNG jetty. Most of the piping will be pre-installed on the trestle sections, while some, including electrical systems, will be installed following the completion of the roadway.

6.12 Rehabilitation

Rehabilitation will be undertaken progressively to reduce prolonged exposure of soils. Batters and embankments will be rehabilitated and revegetated as soon as practicable after excavation and final shaping. Sterile grasses and mulch will be used to stabilise batters and embankments.

Long-term stockpiles will be protected from erosion through the installation of erosion control structures and, where appropriate, revegetated with sterile grasses.

Following construction and start up, the site will be cleaned, and temporary work sites no longer required for future development will be rehabilitated. This will involve the removal of construction waste materials, surplus material and scrap, temporary buildings, construction equipment and the remediation of any contamination. Areas no longer required for construction or support services will be reinstated and revegetated, initially with sterile grasses then with perennial grasses. This will establish a stable landform and cover that satisfies safety and plant security requirements.

Where possible, revegetation will use endemic species propagated from seed collected at the site prior to vegetation clearing. Ecosystems and threatened flora protected from construction activities (e.g., semi-evergreen vine thicket and Cupaniopsis spp. at Boatshed Point) will be monitored for weed invasion. Weed control will be undertaken if infestations are detected.

Areas that will remain exposed until construction of trains 3 and 4 (e.g., laydown areas, LNG train bench and quarantine area) will be stabilised to ensure the exposed soils do not erode. Surface water and stormwater runoff collection and discharge systems will be regularly inspected to ensure they are functioning effectively, including ensuring that there is adequate capacity in settling and retention ponds to contain and control the discharge of runoff in a storm event.

Rehabilitation will be regularly inspected and remedial works undertaken to address any failed or failing works or revegetation.

6.13 Construction Shipping and Ferry Movements

Personnel, provisions, materials and modules will need to be transported to Curtis Island, and personnel and waste transported from the island to the mainland. Further details of vessels movements are provided in Chapter 28, Traffic and Transport.

6.13.1 Modules and Major Components

Modules and major components (gas turbines, cryogenic heater exchanger, acid gas removal absorption column and refrigerant storage spheres) will be shipped to the MOF at Boatshed Point on purpose-built, heavy-cargo ships that will have lifting capacity or rely on shore-based heavy-lift cranes to load and unload the modules. Alternatively, the ships might be roll-on, roll-off vessels where the module or major component mounted on a heavy haulage transporter would drive on and off the ship.

6.13.2 Aggregate, Materials and Waste

Aggregate and bulk materials will be transferred to the island from the mainland launch site by tug-assisted dumb barges, or in trucks ferried to and from the island on the RoPax ferries. Aggregate and bulk materials will be delivered to Curtis Island using 5,000 to 6,000 t barges.

Provisions will be delivered to the island in delivery trucks, vans and refrigerated transporters ferried to and from the island on the RoPax ferries.

Waste will be transferred from the island to the mainland and on to approved disposal facilities in containers or waste collection trucks that will be ferried to and from the island on the RoPax ferries.

6.13.3 Personnel

Personnel transfer in the early stages of the project (until the mainland launch site facility is fully commissioned) will be carried out from a location on the mainland, most likely from existing facilities at Gladstone Marina or Auckland Point. Temporary landing facilities at Boatshed Point on Curtis Island will be used until the mainland launch site and the MOF and personnel jetty are completed and brought into operation.

Workers living on the mainland or in the mainland TWAF will require transport to and from Curtis Island on a daily basis. In addition to these daily commuters, fly-in, fly-out workers (who will be accommodated in the Boatshed Point construction camp) will require transfer to and from the camp at the start and end of their rosters, respectively.

It is anticipated that transfer of fly-in, fly-out workers will be performed outside peak hours and thus will not influence the sizing of the facilities (mainland launch site, personnel jetty and ferries).

A combination of fast passenger ferries and RoPax ferries will carry passengers between the mainland launch site and Boatshed Point. The fast passenger ferries will have a capacity of approximately 250 persons and the RoPax ferries will have a capacity of approximately 200 persons and a number of vehicles.

Ferries will commence operations at approximately 5.30 a.m. each day with the last return trip from the island expected to arrive at the mainland launch site at approximately 10.30 p.m. Ferries will operate on a regular basis, with peak ferry movements corresponding to shift changes. The total number of daily return ferry trips will be about 50.

Ferry trips will take on average 15 to 20 minutes one way, with a 20 minute turnaround at each marine terminal. At construction roster changes, two ferries will operate across the harbour to ship personnel to and from Curtis Island.

The ferries will be moored alongside the marine facilities (either mainland launch site or Boatshed Point) when not in operation. Storm anchorage will be provided by harbour authorities.

The exact routes to be taken by the ferries will be confirmed once the location of the mainland launch site is confirmed and they will comply with any navigation restrictions imposed by the Gladstone Harbour Master.

6.14 Operations and Maintenance

The LNG plant will be operated 24 hours a day, with planned maintenance shutdowns scheduled and coordinated to achieve a plant availability of 94.5% or 345 days per year for the all mechanical option, and an availability of 96.4% or 352 days per year for the all electrical drive option. The design life of the plant is 25 years. Regular maintenance and refurbishment are expected to extend the life of the plant beyond that timeframe.

LNG production will entail:

- Commissioning of the LNG plant, utilities and ancillary infrastructure.
- Operation of the LNG processing and loading equipment, and supporting power, water supply, fuel gas and nitrogen systems.
- Management and operation of the marine infrastructure including the mainland launch site, MOF and personnel jetty and LNG jetty.
- Waste and wastewater management.
- Management of security.
- Management of road and vessel traffic to and from the LNG plant.
- Dealing with unplanned events or upset conditions, e.g., liquids in the gas pipeline, interruptions to gas supply, the late arrival of an LNG carrier, or a fault in a processing unit.

6.14.1 Commissioning

Commissioning will involve bringing into operation LNG plant processes one stage at a time until full operation is established. Once full operation is established, the output of the plant will be progressively brought to full capacity to ensure all systems are functioning and able to operate at maximum output.

Initial commissioning activities will involve testing power generation facilities (mechanical drive using gas turbines) and will occur up to one year before planned start up of the plant. This will require the feed gas pipeline to have been commissioned and ready for service.

The LNG trains require 25% to 30% of the maximum feed gas supply for initial start up. Minimal flows during commissioning reduce the amount of gas that needs to be flared during start up activities. ALARP principles will be adopted in reducing flared gas during start up.

Cooling down the LNG process units, storage tanks and LNG rundown lines is a key commissioning activity. An imported LNG cargo will be used to cool the tanks, vessels and pipe work. The cooling process will be carefully integrated with plant start up to ensure key infrastructure is not subject to thermal stresses and shocks from sudden exposure to cryogenic temperatures.

Refrigerant fluids (ethylene and propane) will be imported on a just-in-time basis to reduce their time in the storage spheres to minimise losses. The refrigerant circuits will be brought on line sequentially or in parallel, depending on the start up philosophy.

6.14.2 Staffing

The operations workforce will comprise four main groups:

- LNG facility operations, maintenance, laboratory, security and safety.

- Administration, finance, human resources and business support services.
- Community relations.
- Engineering – mechanical, civil, electrical and instrumentation, training, information technology and building services.

Operations and maintenance personnel will be located at the LNG facility, the mainland launch site and Gladstone office (which will accommodate community relations staff).

Operation of trains 1 and 2 will require a workforce of 450 personnel comprising 250 Arrow Energy employees and 200 contractors. This will increase to 600 personnel on completion of trains 3 and 4 when the peak operations workforce will comprise 350 Arrow Energy staff and 250 contractors.

It is expected 30% of the Arrow Energy staff will be from Gladstone and its hinterland. Of the non-local Arrow Energy staff, it is assumed that 70% will be family status and move into the community (if they are not already resident) as a consequence of their involvement in the construction phase. Contractors will comprise resident and fly-in, fly-out workers, with 40% of contractors from Gladstone and its hinterland. All non-local contractors will be engaged as single-status workers.

LNG facility operations staff will work rostered work shifts on a 24 hour basis. Administration, business support and community relations staff will work an eight hour day, Monday to Friday.

All operations staff and contractors will commute daily to and from the island via the mainland launch site and personnel jetty, with ferry services scheduled around the shift roster.

6.14.3 Maintenance

Planned minor and major maintenance will be undertaken on the LNG plant. Minor maintenance will be carried out on gas turbines (mechanical drive options) every two years. Major maintenance of LNG trains will occur every five to six years.

Plant data and equipment performance monitoring systems will collect and plot data, monitor critical rotating equipment, and process data so that it can be accessed locally and remotely for troubleshooting and preventative maintenance.

Where possible, common equipment will be considered across the LNG plant (e.g., gas turbines, valves and instrumentation), to minimise spares holdings and personnel competency requirements.

Pipe work, valves, and processing units will be designed so that sections of the LNG plant can be isolated for maintenance work. Vents and drains will allow for safe and effective depressurising, draining, and purging of equipment.

Planned minor maintenance works will require up to 200 fly-in, fly-out workers for several weeks. Major maintenance shutdowns will employ 300 to 500 fly-in, fly-out workers for the duration of the scheduled maintenance activities, possibly months. Contractors engaged for these programs will work 10 hours a day, 7 days a week until the scheduled scope of work is completed.

It is expected that maintenance contractors will be accommodated in the community or in the TWAF, if it is still in operation.

6.14.4 LNG Plant Control and Monitoring

The control and supervisory systems will be designed as distributed systems to provide the appropriate level of control and monitoring of key processes, with overall control and redundancy vested in the central control room. The distributed system will include field auxiliary rooms, which will be located on the process modules of each LNG train, at the utilities and common facilities area, adjacent to the LNG storage tanks, at the gas inlet station (for pipeline leak detection), at the LNG jetty and at the effluent plant treatment area.

The LNG plant will be designed for fully automated operation, with control and monitoring systems programmed to automatically respond to plant upsets and emergencies. The principal objective of these systems will be to isolate the affected part of the facility and turn down or shut down that part of the plant in an orderly manner, thereby avoiding metal fatigue and other structural stresses on plant and equipment. In upset or emergency conditions, inventory (feed gas, refrigerant and LNG) will be diverted to the flare.

6.14.5 Operations Shipping and Ferry Movements

Shipping and ferry movements in operations will comprise the arrival, loading and departure of LNG carriers, ferries transferring staff and materials to and from the island daily, and barges or ships transporting refrigerant or major items of plant and equipment to the MOF as part of major outages.

LNG Cargo

The number of LNG carriers required to export LNG will vary depending on the size of the carrier, which, at the time of writing, is still under consideration. Table 6.1 details the number of LNG carriers required for the initial and final development.

Table 6.1 LNG carrier movements

LNG Carrier Nominal Capacity	Two LNG Trains		Four LNG Trains	
	LNG Carriers per Week	LNG Carriers per Year	LNG Carriers per Week	LNG Carriers per Year
145,000 m^3	2 to 3	120	4 to 5	240
215,000 m^3	1 to 2	88	3 to 4	176

Each LNG carrier will be escorted by four tugs, with two tugs active and two tugs on standby. Two escort class tugs will meet the LNG carriers at the fairway buoy and escort them through the Gladstone shipping channels to the LNG loading berth. The two harbour tugs will be on hand at Auckland Point and will assist with berthing. The turnaround time for a LNG carrier is approximately 24 hours.

The Gladstone Harbour Master will control LNG carrier movements in the Port of Gladstone until the carriers dock, when Arrow Energy will assume control of the loading, security and safety of the carrier at berth. LNG carriers will require pilotage from the fairway buoy.

LNG carrier and other ship movements will be separated by 30 minutes. This will ensure that a carrier could slow to a stop and not collide with another ship in the event of a loss of power. A 250 m exclusion zone will extend forward and aft of a LNG carrier when it is operating in the shipping channels. The exclusion zone will be reduced to a 250 m radius circle centred on the LNG loading manifold when the LNG carrier is moored at the berth for loading (see Figure 6.10). All non-project vessels will be prohibited from entering the exclusion zones or performing any operations within this zone, including fishing and other recreational activities.

Information sessions will be held to explain the need, and the procedures, for enforcing the exclusion zones. Marker buoys will be used to indicate and enforce the 250 m exclusion zones around the LNG jetty (during LNG carrier loading) and the MOF (during materials offloading). At other times, visual surveillance, warning sirens and patrol boats (if necessary) will be used to alert boats encroaching on the exclusion zone and, if necessary, escort them a safe distance away.

Materials and Equipment

Other shipping requirements during operations will include one propane tanker in the first year then periodic deliveries of fuel, lubricants, equipment and plant required for maintenance activities. Materials and equipment will be transferred to the MOF on Curtis Island from the mainland launch site on RoPax ferries or shipped directly to the MOF. Normal quarantine and customs procedures will apply to materials and equipment shipped from overseas. Waste will be transferred to the mainland in containers or waste collection trucks that will be transported by RoPax ferries.

Personnel

During LNG trains 1 and 2 operations, each shift will consist of 150 workers. This will increase to 195 workers when all four trains in operation. A single, fast passenger ferry or RoPax ferry will service each shift change, with trip and turnaround times the same as those during construction.

6.15 Decommissioning

A decommissioning and final rehabilitation plan will be prepared and approved by the relevant authority at least 12 months prior to the planned closure of the LNG plant. The plan will adopt standards and good industry practices applicable at that time. It will prescribe performance criteria and a warranty period that will include inspection and monitoring to ensure the desired outcome – a stable self-sustaining landform – is achieved.

6.15.1 Decommissioning of LNG Plant

The LNG plant will be decommissioned in accordance with the decommissioning plan. Current expectations are that equipment that can be salvaged will be reused or resold. Where feasible, material that cannot be used for its original purpose will be recycled or scrapped. The aim will be to minimise the amount of waste requiring disposal.

Prior to removal, equipment will be depressurised, purged and flushed of hydrocarbons and other products to prevent uncontrolled releases of hazardous materials, potentially leading to an explosion or site contamination.

A contaminated land site assessment, commensurate with the level of risk, will be undertaken prior to site reinstatement works to ensure any contamination is not disturbed and spread throughout the site. If any contamination is discovered, a remediation program consistent with applicable Queensland standards will be prepared and implemented.

Foundations will be excavated and removed, or demolished to at least 1 m below the intended final surface. The site will be reshaped to a stable landform that, where practical, reflects the natural contours and landforms of the adjacent land. Where practical, drainage lines will be reinstated. All drainage lines will be designed and constructed to perform within the normal variation expected of watercourses on Curtis Island. The site will be revegetated with endemic species using seed collected from, or adjacent to, the site, where practicable.

The overall aim of decommissioning will be to obtain agreement from the Queensland Government that the site has been decommissioned to agreed standards, and that the site poses negligible risk to public safety and the environment, and fulfils community expectations.

6.15.2 Decommissioning of Marine Facilities

The LNG jetty and loading facilities are expected to be decommissioned in a similar fashion to the LNG plant, should a future use for these facilities not be identified. The LNG jetty will be dismantled and the piles cut off at the seafloor. The structure and piles will be removed as scrap. Debris from the concrete deck and building foundations will be removed for disposal on land.

The MOF and shore protection works at the LNG jetty will be left in place. Local benthic habitat and associated flora and fauna will have adapted to the presence of these structures over the operational life of the project. In addition, the removal of these facilities is a major undertaking and would result in a greater environmental disturbance than leaving them in place.

Demolition of the mainland launch site will only occur if another use was not identified.