# Australia Pacific LNG Project

## Volume 4: LNG Facility

## Chapter 22: Hazard and Risk

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# 22. Hazard and risk

## 22.1 Introduction

### 22.1.1 Purpose

This chapter responds to section 6 of the environmental impact statement (EIS) terms of reference for the Australia Pacific LNG Project (the Project) and addresses potential hazards and risks resulting from construction, operation and decommissioning of the liquefied natural gas (LNG) facility, as well as, the health, safety and environmental values of existing community and on site personnel during construction, operation and decommissioning of the LNG facility.

When identifying potential hazard and risks and in the development and implementation of mitigation measures for the Project, Australia Pacific LNG is guided by the Australia Pacific LNG sustainability principles. Of Australia Pacific LNG's 12 sustainability principles, key principles that relate to hazard and risk are:

- Adhering to an overriding duty to safety, ensuring operations are carried out in a safe manner and empowering employees and contractors to place safety considerations above all other priorities
- Minimising adverse environmental impacts and enhancing environmental benefits associated with Australia Pacific LNG's activities, products or services; conserving, protecting, and enhancing where the opportunity exists, the biodiversity values and water resources in its operational areas
- Identifying, assessing, managing, monitoring and reviewing risks to Australia Pacific LNG's workforce, its property, the environment and the communities affected by its activities.

### 22.1.2 History of LNG plants

Worldwide, LNG facilities have an excellent safety history. This includes the processing plants, marine terminals and LNG shipping. LNG has been produced and transported for over 50 years in increasing quantities. The excellent safety record is due mainly to competent, technically trained professionals, a thorough and detailed LNG design process, multiple risk studies for LNG plant design, controlled construction and operation and decommissioning, stringent regulatory bodies and regulations. There have been a small number of significant events worldwide, hence the on-going requirements for stringent design, construction, and operation and decommissioning. Supporting this are the requirements of the *Dangerous Goods Safety Management Act 2001*, (DGSM Act) as well as a number of Australian and international standards.

Table 22.1 contains a list of LNG incidents in the past 30 years.

Each proposed LNG train is similar in size and design to the Darwin LNG plant (operated by Australian Pacific LNG's joint venture partner ConocoPhillips) as well as other LNG facilities worldwide. During the last 50 plus years, the safety record of these similar LNG facilities has been excellent. The design, construction and operation of these facilities to industry and government design codes have contributed to this safety record.

In the 30 years of modern tank design, full containment LNG tanks using nine percent nickel steel inner linings and an outer shell consisting of pre-stressed, reinforced concrete walls and concrete roof as proposed for this LNG facility, have never suffered a serious failure (Centre for Liquefied Natural Gas 2008b).

Over the last 50 years, LNG ships have covered more than 205 million kilometres without a major accident (Centre for Liquefied Natural Gas 2008a) and with no collisions, fires, explosions or hull failures resulting in a loss of containment in ports or at sea. According to the Sandia National Laboratories Report (Centre for Liquefied Natural Gas 2008a), only eight marine incidents worldwide have resulted in accidental LNG spillage. None of the spills resulted from a failure or breach of a containment system. LNG carrier spills have never resulted in loss of life (Centre for Energy Economics (CEE) n.d.).

### 22.1.3 ConocoPhillips' approach to process safety

ConocoPhillips is a joint venture partner in Australia Pacific LNG holding a 50% stake, and operates the Darwin LNG plant. As such ConocoPhillips' approach to process safety is discussed in this section.

The ConocoPhillips approach to process safety is imbedded within the elements of ConocoPhillips' health, safety and environment management system (HSEMS).

ConocoPhillips' HSEMS requires the systematic identification, prioritisation and control of operational health, safety and environmental risks on a continual basis. Its scope covers the broader aspects of plant, programs and procedures, people, management of change and their interactions.

The ConocoPhillips HSEMS is a framework to protect people, assets and the environment as shown in Figure 22.1.


**Figure 22.1 HSEMS framework**

**Table 22.1 LNG incidents over the past 30 years**

| Incident date | Ship/facility | Name location ship | Status | Injuries/fatalities | Ship/property damage | LNG release | Release comment |
|---|---|---|---|---|---|---|---|
| 1979 | Columbia Gas LNG terminal | Cove Point, Maryland, US | NA | 1 killed, 1 seriously injured | Yes | Yes | An explosion occurred within an electrical substation. LNG leaked through LNG pump electrical penetration seal, vaporized, passed through 200 feet of underground electrical conduit, and entered the substation. Since natural gas was never expected in this building, there were no gas detectors installed in the building. The normal arcing contacts of a circuit breaker ignited the natural gas-air mixture, resulting in an explosion. Building codes pertaining to the equipment and systems downstream of the pump seal were subsequently changed |
| 1979 | Mostefa Ben-Boulaid | | Unloading | No | Yes | Yes | Valve leakage. Deck fractures |
| 1979 | Pollenger | Distrigas terminal, Everett, Massachusetts | Unloading | No | Yes | Yes | Valve leakage. Tank cover plate fractures |
| 1979 | El Paso Paul Kayser | | At sea | No | Yes | No | Stranded. Severe damage to bottom, ballast tanks, motors water damaged, bottom of containment system. The LNG membrane tanks remained undamaged |
| 1980 | LNG Libra | | At sea | No | Yes | No | Shaft moved against rudder. Tail shaft fractured |
| 1980 | LNG Taurus | | In port | No | Yes | No | Stranded. Ballast tanks all flooded and listing. Extensive bottom damage |

| Incident date | Ship/facility | Name location ship | Status | Injuries/fatalities | Ship/property damage | LNG release | Release comment |
|---|---|---|---|---|---|---|---|
| 1984 | Melrose | | At Sea | No | Yes | No | Fire in engine room. No structural damage |
| 1985 | Gradinia | | In port | No | Not Reported | No | Steering gear failure. No details of damage reported |
| 1985 | Isabella | | Unloading | No | Yes | Yes | Cargo valve failure. Cargo overflow. Deck fractures |
| 1989 | Tellier | | Loading | No | Yes | No | Broke moorings. Hull and deck failures |
| 1989 | LNG Peakshaving facility | Thurley, United Kingdom | Unloading | Yes | Yes | Yes | While cooling down vaporizers in preparation for sending out natural gas, low-point drain valves were opened. One of these valves was not closed when pumps were started and LNG entered the vaporizers. LNG was released into the atmosphere and the resulting vapour cloud ignited, causing a flash fire that burned two operators |
| 1990 | Bachir Chihani | | At sea | No | Yes | No | Sustained structural cracks allegedly caused by stressing and fatigue in inner hull |
| 1992 | LNG Peakshaving facility | Baltimore,MD, US | NA | No | Yes | Yes | A relief valve on LNG piping failed to open and released LNG into the LNG tank containment for over 10 hours, resulting in loss of over 25,000 gallons into the LNG tank containment. The LNG also caused embrittlement fractures on the outer shell of the LNG tank. The tank was taken out of service and repaired |
| 1993 | Indonesian liquefaction facility | Indonesia | NA | No | NA | NA | LNG leak from open run-down line during a pipe modification project. LNG entered an underground concrete storm sewer system and underwent a |

| Incident date | Ship/facility | Name location ship | Status | Injuries/fatalities | Ship/property damage | LNG release | Release comment |
|---|---|---|---|---|---|---|---|
| | | | | | | | rapid vapour expansion that overpressured and ruptured the sewer pipes. Storm sewer system substantially damaged |
| 2002 | LNG ship Norman Lady | East of the Strait of Gibraltar | At sea | No | Yes | No | Collision with a U.S. Navy nuclear-powered attack submarine, the U.S.S Oklahoma City. In ballast condition. Ship suffered a leakage of seawater into the double bottom dry tank area |
| 2004 | Skikda | Algeria | NA | 27 killed<br>56 injured<br>(The casualties are mainly due to the blast, few casualties due to fire) | NA | NA | On January 2004: No wind, semi-confined area (cold boxes, boiler, control room on 3 sides). The fire completely destroyed the train although it did not damage the loading facilities or three large LNG storage tanks also located at the terminal. Complete details are pending until completion of ongoing accident investigation |
| 2006 | Train 2 facility | Port Fortin, Trinidad, Caracas | NA | 1 injured | No | Yes | Atlantic LNG reported that an accident occurred at its Train 2 facility at Point Fortin, Trinidad when a temporary eight inch isolation plug was blown by built-up pressure. The Train 2 facility had been shut down due to the detection of a gas release from a two-inch pipeline. The release of natural gas was brought under control, and personnel returned. While the company was carrying out repairs the plug blew injuring one worker. It had been filled with inert gas to facilitate repairs |

Source: (Centre for Energy Economics (CEE) n.d .).

The HSEMS is comprised of 15 individual elements. The elements are interrelated and the implementation of each element is essential for the effective functioning of the system as a whole. The 15 elements are integrated into a continuous improvement cycle with phases of plan, do, assess and adjust. Each phase includes one or more key elements illustrated in Figure 22.2 and listed as following:

1. Policy and leadership
2. Risk assessment
3. Legal requirements and standards of operation
4. Strategic planning, goals and objectives
5. Structure and responsibility
6. Programs and procedures
7. Assets and operations integrity
8. Emergency preparedness
9. Awareness, training and competence
10. Non-conformance, investigation and corrective action
11. Communications
12. Document control and records
13. Measuring and monitoring
14. Audits
15. Review.

The HSEMS will be fully developed during the detailed design phase before the commissioning period. This will be included in the safety report to be provided to Hazardous Industries and Chemical Branch (HICB) which is a unit within Workplace Health and Safety Queensland in accordance with the DSGM Act.

A Contractor HSEMS will also be developed for the construction phase. Note that Bechtel (the proposed construction contractor for the LNG facility) also built the Darwin LNG plant and so has well developed systems which align with ConocoPhillips' HSEMS.

Process safety refers to the control of process hazards in a facility with the potential to impact people, property or the environment. Process safety is the prevention, control and mitigation of unintentional releases of hazardous material or energy from primary containment. In simpler terms process safety is the prevention and mitigation of losses of containment that have the potential to become serious incidents (fires, explosions, severe to fatal injuries, etc.)

ConocoPhillips achieves process safety through unwavering management support and safeguarding their operations from catastrophic incidents by maintaining and enhancing existing systems and controls.

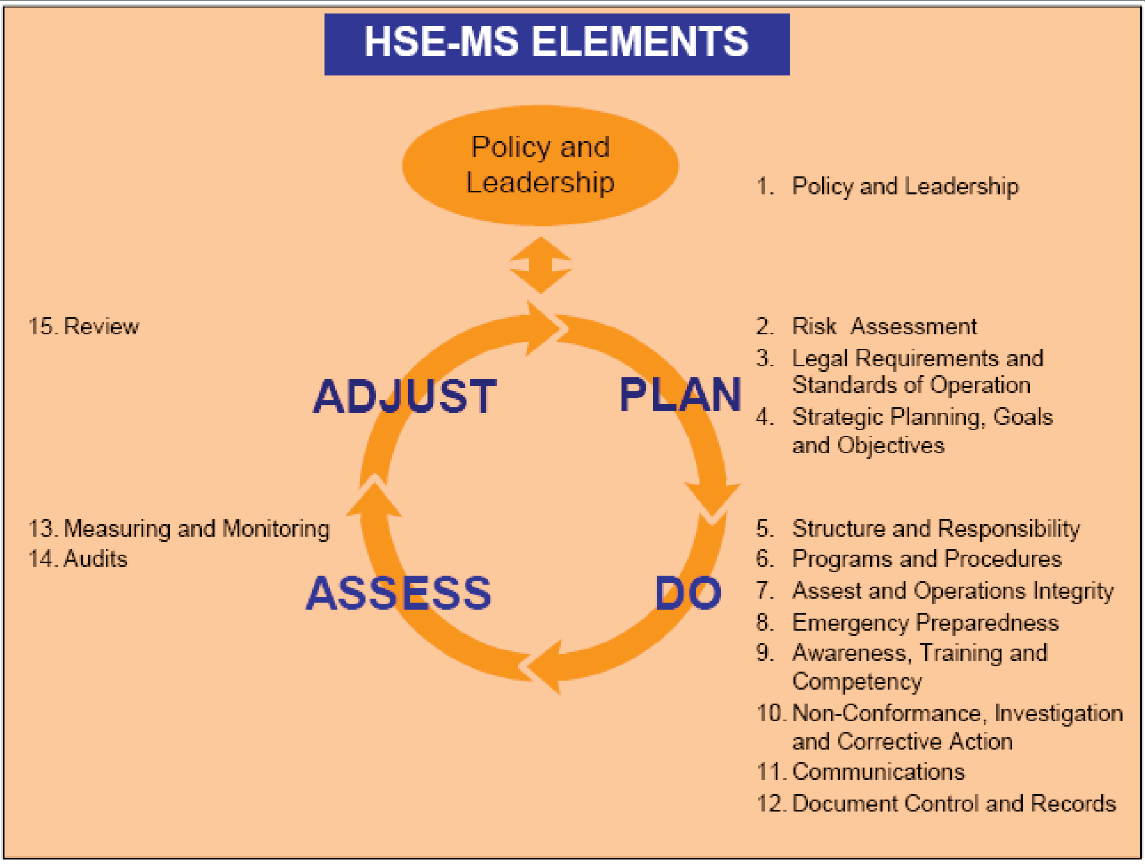


**Figure 22.2 HSEMS elements**

ConocoPhillips continually works to ensure the following existing systems and controls are effective:

- Health, safety and environment excellence (HSEMS and HSEMS excellence assessment tool)
- Operations excellence (asset & operating integrity, reliability, defect elimination, etc.)
- Design and engineering standards
- Maintenance of assets
- Auditing and reporting process safety metrics
- Risk management including root cause failure identification and implementation of corrective action plans
- Training and competency
- Management of change
- Contractor management

The activities, processes and procedures driven by the HSEMS help ConocoPhillips improve process safety performance. These are shown in the containment model described in Figure 22.3.


**Figure 22.3  The containment model**

## *Key HSE programs*

### Design and engineering

Design and engineering is the basis for sustaining technical integrity of all engineered equipment and systems to ensure the assets remain fit for purpose throughout their life cycle. It creates and preserves the asset basis of design and the technical limits for safe operation through:

- Design to project standards based on good engineering practices
- Management of change over the life cycle - addressing asset hardware and control system software
- Continuous improvement application of process safety principles, loss prevention and engineering best practice
- Inspection, test and maintenance management programs
- Technical competence of ConocoPhillips' personnel.

### Operating integrity

Operating integrity is assured by means of programs and procedures to control any activity or combination of activities involved in the acceptance, production, processing, transportation and storage of hydrocarbons and/or hazardous chemicals in the operational phase of an asset. It includes the operating, maintenance and technical competence of personnel.

### Asset integrity

Asset integrity is assured by means of programs and procedures to manage the condition of pipework, pressure vessels, tanks and their protective devices.

#### Detection

Detection of a process safety incident is achieved by means of engineered safeguards and associated procedures, and/or through observation by personnel on site. Equipment may include gas detectors, fire detectors and process alarms.

#### Control and mitigation

Control and mitigation of a process safety incident's ability to escalate is achieved by means of installed equipment and associated procedures. Equipment may include process control systems, flare and vent systems and emergency isolation valves.

In the event of escalation to a major accident, mitigation of the consequences to personnel will be achieved by effective systems for the provision of escape, evacuation and rescue. This could be through provision of installed equipment and associated procedures such as provision of muster points, evacuation equipment and emergency response teams.

## 22.1.4 Legislative framework

Legislation relevant to hazards and risks associated with the LNG facility are described in this section.

### *Queensland legislation*

#### Transport Infrastructure Act

The *Transport Infrastructure Act 1994* (TI Act) is operated in conjunction with the *Transport Planning and Coordination Act 1994* and the *Transport Operations (Road Use Management) Act* 1995. The TI Act aims to provide a regime for the effective integrated planning and efficient management of a system of transport infrastructure.

It is likely the Project will require approvals under the TI Act pertaining to transportation of oversized loads of plant, equipment and materials. These approvals will be obtained on an as-needs basis during the course of the Project's future design and construction phases when the necessary design and construction information required for the permit applications is available.

#### Transport Planning and Coordination Act

The objectives of the *Transport Planning and Coordination Act 1994* are to improve the economic, trade and regional development performance of Queensland, and the quality of life of Queenslanders, by achieving overall transport effectiveness and efficiency through strategic planning and management of transport resources. Any activities associated with the development of the Project that may impact on a public passenger service, active transport system or works on a local government road may require approval under this Act.

#### Petroleum and Gas (Production and Safety) Act

The *Petroleum and Gas (Production and Safety) Act 2004* (PAG Act) regulates petroleum and natural gas in Queensland. It aims to facilitate and regulate the carrying out of responsible petroleum activities and the development of a safe, efficient and viable petroleum and fuel gas industry. It aims to achieve this in a way that minimises land use conflicts and encourages responsible land use management (among other measures).

The safety obligations contained in the PAG Act apply to an operating plant as defined in the Act. However, since this LNG facility is likely to be classified as a major hazard facility (MHF) under the

DGSM Act, it is an operating plant under the PAG Act only to the extent to which the DGSM Act does not apply to the facility.

#### Dangerous Goods Safety Management Act

The DGSM Act sets out the obligations and requirements relating to the storage and handling of dangerous goods and combustible liquids and the safe operation of MHFs in Queensland. Dangerous goods are defined with reference to the Australian Code for the Transport of Dangerous Goods by Road and Rail.

The *Dangerous Goods Safety Management Regulation 2001* sets out specific obligations for people who manufacture, import, supply, store or handle stated dangerous goods or combustible liquids; or supply or install equipment for storing or handling those materials.

The DGSM Act and regulation are concerned with protecting against harm or injury to people or damage to property or the environment arising from an explosion, fire, harmful reaction or the evolution of flammable, corrosive or toxic vapours involving dangerous goods; or the escape, spillage or leakage of any dangerous goods. This regulation also defines the criteria by which a facility would be classified as a MHF.

The LNG facility is likely to be classified as a MHF due to the stored quantities of LNG exceeding the prescribed quantity of 200 tonnes.

The DGSM Act requirements for a MHF include a safety management system, safety report and emergency management plan.

#### Workplace Health and Safety Act

The *Workplace Health and Safety Act 1995* establishes a framework for preventing or minimising workers' exposure to risks by, among other things, imposing safety obligations on certain persons and establishing benchmarks for industry through the making of regulations and codes of practice. This Act applies to the construction, operation and commissioning of the proposed facilities.

#### Fire and Rescue Service Act

The *Fire and Rescue Service Act 1990 and Fire and Rescue Service Regulation 2001* requires the operator to establish effective relationships with the Queensland Fire and Rescue Service to provide for the prevention of and response to fires and certain other incidents endangering persons, property or the environment and/or for related purposes or activities.

### *Australian Government legislation*

#### Airports Act

The *Airports Act 1996* (Airports Act) regulates the development and operation of airports in Australia, whilst the regulating body, civil aviation safety authority (CASA), regulates operating procedures in the vicinity of aerodromes in Australia. Part 12 of the *Airports Act and the Airports (Protection of Airspace) Regulation 1996* establish a framework for the protection of airspace at and around airports.

Any activity that intrudes into protected airspace of an airport is a controlled activity that requires approval. These activities include tall stack sources and buoyant plumes from industrial facilities. The CASA advisory circular 139-05(0) (2004) defines the criteria and methodology under which the stack emissions are assessed for hazards to aviation safety.

#### Maritime Transport and Offshore Facilities Securities Act

The *Maritime Transport and Offshore Facilities Securities Act 2003* establishes a security framework that enables maritime industry participants to develop individual security plans that are relevant to their particular circumstances and specific risks. Relevantly, the Act applies to Australian ports, port facilities, and port service providers that serve security regulated ships, and Australia's offshore facilities. The act requires development, implementation and management of an maritime security plan. As Australia Pacific LNG will be a port facility operator within a security regulated port, under the *Maritime Transport and Offshore Facilities Securities Act 2003* it is required to submit a maritime security plan for review and approval.

### State planning policies

In addition to and parallel with the legislation, certain state planning policies (SPP) are referenced for developments and are described below.

#### SPP 1/03 Mitigating the adverse impacts of flood, bushfire and landslide

SPP 1/03 requires that developments will minimise the potential adverse impacts of flood, bushfire and landslide on people, property, economic activity and the environment.  The SPP has effect when development applications are assessed, when planning schemes are made or amended and when land is designated for community infrastructure

#### SPP 1/02 Development in the vicinity of certain airports and aviation facilities

SPP 1/02 sets out the State’s interest concerning development in the vicinity of those airports and aviation facilities considered essential for the State’s transport infrastructure or the national defence system.  The SPP addresses control of development and land use in the vicinity of aeronautical installations and provides guidance to local authorities on how this issue will be addressed when carrying out their planning duties.

### Australian and international standards

There are a number of Australian and international standards, guidelines and codes of practice that apply to the LNG facility with regard to design, construction and operations central to minimising hazards and risks. In general, the Australian standards will apply. Where equipment has been designed and constructed overseas, the appropriate international standard will apply, unless there is a significant variation from the Australian standard. In addition, there are international standards and recommended practices which are applicable where there are no equivalent Australian standard or guidelines.

The major document that is applied internationally for LNG plants is the American standard NFPA 59A – Standard for the production, storage, and handling of liquefied natural gas (NFPA 59A). This standard covers the design, location, construction, maintenance and operation of all LNG facilities. There is no specific Australian standard covering LNG plant design. The American standard NFPA 58 – Liquefied petroleum gas code, will also be used for the design of any LPG storage and handling facilities.

The major Australian standards associated with hazard and risk minimisation for the LNG industry include:

### AS 1940 - The storage and handling of flammable and combustible liquids

AS 1940 provides the requirements and recommendations for the design, construction and operation of installations where flammable or combustible liquids are stored and handled. Separate sections provide the requirements for storage of liquids in tanks, as well as, fire protection and emergency management.

### AS/NZS ISO 31000 Risk management – principles and guidelines

AS/NZS ISO 31000 provides a framework for evaluating relative risks. This has recently superseded AS/NZS 4360 but the overall approach remains consistent. Other relevant Australian standards are presented in Table 22.2

**Table 22.2 Other Australian standards**

| Standard | Title |
|---|---|
| AS1170.2 | Structural design actions: wind actions |
| AS1170.4 | Structural design actions: earthquake design actions in Australia |
| AS1210 | Pressure vessels |
| AS2885 | Pipelines—gas and liquid petroleum |
| AS3846 | The handling and transport of dangerous cargoes in port areas |
| AS3961 | The storage and handling of liquefied natural gas |
| AS4801 | Occupational health and safety management systems |
| AS4997 | Guidelines for the design of marine structures |
| AS/NZS 60079.10 | Explosive atmospheres - classification of areas - explosive gas atmospheres |
| AS IEC61511 | Functional safety – safety instrumented systems for the process industry sector |

There are also industry recommended practices from the American Petroleum Industry (API) that will be utilised during the design, construction and operation of the LNG facility. These are detailed in Table 22.3.

**Table 22.3 API recommended practices**

| Recommended practice | Title |
|---|---|
| API RP 520 | Sizing, selection, and installation of pressure-relieving devices in refineries |
| API RP 521 | Pressure-relieving and depressuring systems |
| API 620 | Design and construction of large, welded, low pressure tanks |
| API RP 752 | Management of hazards associated with location of process plant buildings |
| API RP 753 | Management of hazards associated with location of process plant portable buildings |
| API RP 2000 | Venting atmospheric and low pressure storage tanks: non refrigerated and refrigerated |

### 22.1.5 Risk management

The methodology for the risk assessment documented in this chapter was that used by ConocoPhillips for its global operations and developments. The approach is consistent with the methodology used for the EIS (refer to Volume 1 Chapter 4) and with AS/NZS ISO 31000. However, the consequence and likelihood descriptors and risk matrix is different from the Project standard outlined in Volume 1 Chapter 4. The specific risk matrix used by ConocoPhillips was adopted so that ConocoPhillips can compare these risks with those associated with other ConocoPhillips LNG facilities (refer Section 22.3.1). The risk management approach is systematic and ongoing during the life of the facility.

## 22.2 Project description

Australia Pacific LNG's LNG facility is intended to be developed in stages to a nominal capacity of approximately 18 million tonnes per annum (Mtpa) of LNG. The ultimate configuration of the LNG facility is yet to be determined, but is currently expected to comprise four LNG trains, each nominally producing 4.5Mtpa of LNG. Initially, it is proposed to construct two liquefaction process trains (LNG trains). The timing of construction of subsequent trains will depend on the LNG market and gas field development.

The LNG facility will utilise ConocoPhillips' Optimized Cascade® process which is a proven and reliable process well suited to a CSG application. The Darwin LNG facility, which was developed by ConocoPhillips and its joint venture partners, utilises this technology and is of similar design to that being planned by Australia Pacific LNG for this development. Each LNG train will utilise six turbines to drive the primary refrigeration compressors.

Liquid petroleum gas (LPG) may be imported to the facility and added to the LNG product to meet the market specifications for heating value.

The establishment of the LNG facility will require the construction of wharf and jetty structures to enable the loading of the LNG vessels. A materials offloading facility (MOF) which includes a ferry terminal is also required to enable the transfer of personnel, materials and heavy equipment to the project site for construction and operation.

The LNG facility components considered in the risk assessment were:

- LNG processing facilities (4 x 4.5Mtpa LNG trains)
- LNG storage and loading
- LPG unloading and storage
- Utilities and support facilities
- LPG and LNG shipping.

For a detailed project description refer to Volume 4 Chapter 3. Relevant aspects of the LNG process description are discussed below.

### 22.2.1 LNG plant process description

The facilities between the gas inlet to the LNG plant and the LNG ship loading line are illustrated in Figure 22.4 and include:

- Processing facilities:
  - Inlet facility including pig receiving, inlet separator and metering

– Acid gas ($CO_2$ and $H_2S$) removal unit
– Dehydration
– Mercury removal
– Refrigeration and liquefaction, with nitrogen rejection.

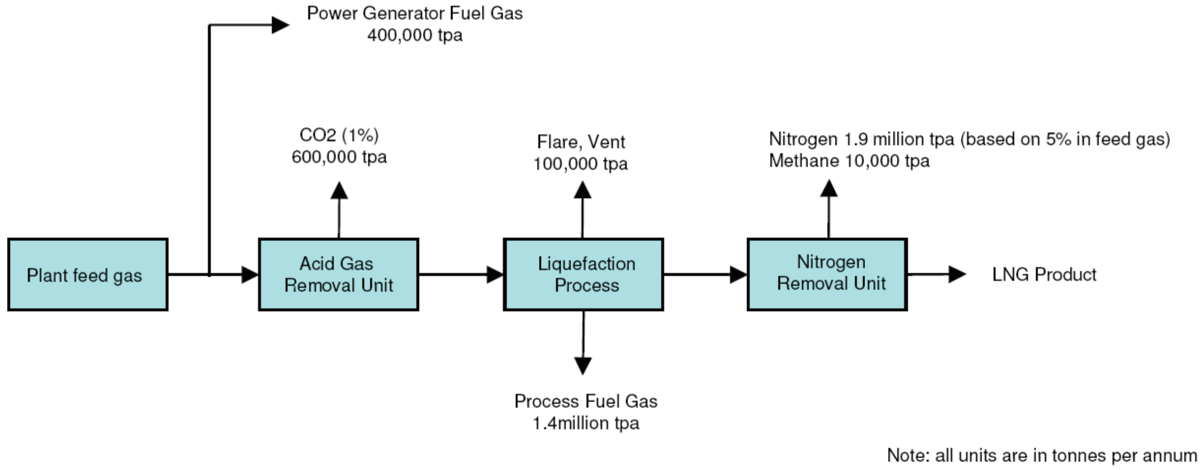


**Figure 22.4 LNG production process**

- Utilities and support facilities
  – LNG storage tanks (3)
  – LNG loading and boil off gas compressors connected to a jetty loading line, and loading arms and vapour return for LNG export by LNG tankers
  – LPG storage tanks (2) with vapour recovery connected to a jetty off-loading line and off-loading arms to receive LPG
  – LPG spiking, if required
  – LNG ship loading
  – Hot oil and fuel gas systems and waste heat recovery
  – Fuel gas system
  – Power generation and distribution
  – Water systems - fresh water sourcing will be determined as a front end engineering and design (FEED) study
  – Effluent treatment
  – Flares- process gas, wet /dry gas and marine
  – Refrigerant storage.

The feed gas to the LNG facility is primarily methane, with lower concentrations of ethane, nitrogen and carbon dioxide. Trace contaminants are expected to include water, mercury, and hydrogen sulphide. Mercury removal beds are included in the design to protect equipment from potential exposure to mercury.

A preliminary site layout for four LNG trains at the Laird Point site with ship berthing east of North Passage Island is shown in Figure 22.5.


**Figure 22.5 Indicative site plan for the LNG facility**

### *Process selection*

The safe design of the LNG facility, in order to prevent major accidents from occurring, has been a primary consideration of Australia Pacific LNG. The safety aspects of LNG operations are the subject of worldwide cooperation, and a number of groups have been set up to exchange information and the establishment of internationally recognised standards. Present day LNG facilities are, after many years of experience, constructed, operated and maintained to the highest standards of safety and reliability.

The principles of safe design and operation of LNG facilities are consolidated into published standards and codes of practice, of which the main reference document is NFPA 59A.

For the main liquefaction section ConocoPhillips' Optimized Cascade® process was selected as it has:

- Very high operating availability and flexibility
- High thermal efficiency
- Ease of start-up, shutdown and operation
- Improvements based on more than 40 years operating experience.

### *LNG and LPG storage*

Two LNG storage tanks, each with a capacity of approximately 160,000m$^3$, a diameter of approximately 80m and a height of approximately 35m, will store the LNG product from Trains 1 and 2. A further tank of similar capacity will be constructed with Trains 3 and 4 to provide additional storage. Each tank will be a full containment type with double-wall construction, with an inner wall being of low temperature steel and the outer wall of reinforced concrete. These LNG storage tanks will be designed to meet requirements of NFPA 59A and relevant Australian standards.

Each LNG storage tank will be equipped with loading pumps, level gauges, level transmitters, relief valves, vents, temperature elements, and other basic instrumentation.

One full-containment, refrigerated LPG storage tank with a capacity of 100,000m$^3$, a diameter of approximately 80m and a height of 30m, will be provided to receive shipments of LPG into the facility. This tank will be a full containment type with double-wall construction, with an inner wall being of low temperature steel and the outer wall of reinforced concrete.

In order to meet the heating value requirements of some LNG customers, it may be necessary to increase the energy content of the LNG by adding LPG. The LPG required for this action will be imported by sea, unloaded at the product loading facility and transferred to a second LPG storage tank. This additional LPG tank will also be a full-containment type with a capacity of 28,000m$^3$. LPG from this tank will be routed though a treatment system and then to a cryogenic chiller system to the super cooled LPG storage tank. The super cooled LPG is mixed with the LNG product. Vapour from the LPG storage tank will be compressed and re-condensed during normal operations. Only during emergency and upset conditions will these vapours be directed to the marine flare for disposal.

Both LPG storage tanks will be designed to meet requirements established in the relevant Australian and international standards. Each LPG storage tank will be equipped with transfer pumps, level gauges, level transmitters, relief valves, vents, temperature elements, and other basic instrumentation.

### *Ship loading and unloading*

Initially, there will be one ship loading facility allowing loading of one LNG ship. The LNG product from the storage tanks will be pumped to this loading facility, designed for Trains 1 and 2. A second jetty will be installed during Train 3 expansion. The initial berth will be used for LNG loading and LPG unloading. The second berth will be used for LNG loading only.

The jetty will be served by one LNG loading line, three LNG loading arms, two LPG unloading arms and one LNG vapour return loading arm. The LNG product is pumped from the tanks to the dock via the loading line, and transferred to the ship via the LNG loading arms. The vapour return arm handles displaced gas from the ship's tank, flashed gas, and vaporised gas from heat gain during ship loading. This gas is returned to the LNG tanks via a separate gas line. The second jetty will be served by one LNG loading line, three LNG loading arms and one LNG vapour return loading arm. No LPG unloading is expected from the second berth.

The composite gas from the LNG tanks and from the ship loading system are compressed in boil-off gas compressors as required and returned to the open cycle methane refrigerant systems. With all boil-off gas compressors in operation, excess gas that may be produced during ship loading can be handled without flaring. A marine flare is provided to handle the gas released during boil-off gas compressor malfunction and low pressure vent down of associated jetty pipework during maintenance work if a warm ship comes to port.

### LNG and LPG shipping

LNG will be transported by specially designed ships. With two trains in operation at approximately 4.5Mtpa production rate for each train, LNG ships will arrive approximately every three to four days for loading and export. Turnaround time for ships will be approximately 24 hours, with a product loading duration of approximately 14 hours.

The LNG tankers will likely have a draught of 11.5m and be from 260 to 290m in length with a carrying capacity of 125,000 to 165,000$m^3$. However, it is possible that LNG tankers with a capacity of up to 220,000$m^3$ may also be used. These vessels have a draught of up to 12m with a length of 315m. The design of the berthing and loading facilities is suitable for these large ships as well as the smaller 125,000$m^3$ ships as required.

The LPG ships are expected to have a capacity of 20,000$m^3$ to 80,000$m^3$ of LPG, similar to what is currently experienced in Gladstone Harbour. There will be one LPG loading arm. The expected number of LPG ship deliveries per year is about 40 (based on 80,000$m^3$ ship capacity and four LNG train LNG operation).

With four trains in production, LNG ships will arrive every one to two days for loading and export. Estimated shipping schedule is between 20 to 40 ships per year based on four LNG trains operation. Requirements for the safe transit of LNG and LPG within Port Curtis will be defined by Maritime Safety Queensland (MSQ) and the Gladstone Port Corporation (GPC). Pilotage will be compulsory for LNG and LPG vessels using Gladstone Harbour.

### Plant utility system

In addition to the main process facilities, there are several utility systems required. These are detailed below.

### Hot oil system

The hot oil system is a closed loop circulation system provided to service the heating requirements for the following units:

- Feed gas preheater
- Acid gas removal unit regenerator reboiler
- Acid gas removal unit solvent reclaimer
- Fuel gas heater
- Defrost gas heater.

Waste heat recovery will be used for heating the hot oil and molecular sieve regeneration gas. The system includes two hot oil heaters, pumps and a surge drum. Therminol “55” or equivalent heating oil is used as heating medium. Heaters are gas fired.

### Fuel gas system

The fuel gas system is separated into three pressure levels:

- High pressure fuel gas at approximately 4,000 Kilopascals (kPa) for the liquefaction gas turbine drivers
- Medium pressure compressor turbine fuel gas at ~2,500kPa for the power block gas turbine drivers
- Low pressure fuel gas at ~350kPa for the fired heaters, incinerator and flare pilots.

### Nitrogen

Nitrogen is used as blanket gas for storage tanks, purge gas for the cold boxes, loading arm swivel joint purges, compressor gas seals and buffer, and as purge gas required for repair and maintenance services and for other general purposes. Nitrogen gas is supplied to the plant from a nitrogen generation package. This is a membrane type unit that uses dry feed air from the plant instrument air system to supply nitrogen at approximately 800kPa. The package is designed with a maximum throughput of approximately 500 standard cubic metre per hour (SCMH) nitrogen with 96% to 98.5% purity.

A secondary liquid nitrogen system serves as a back-up to the membrane unit. This liquid nitrogen package is designed to furnish gaseous nitrogen (one Train's requirement), for a period of seven days of normal operation, at the rate of 500SCMH, without the membrane unit.

### Power generation system

Electrical power will be self-generated based on a peak electrical load during ship loading operations. The power generation system will supply electricity for LNG processing and the common utility and marine areas, such as the jetty and materials offloading facility. A low sulphur diesel powered generator will be provided for "black start" and emergency backup power requirements.

Power for the four train facility will be provided by 13 Solar Titan 130 gas turbine generator sets for the four LNG trains. The number and manufacturer of the generators are preliminary and will be finalised during the FEED phase of the Project. However, Australia Pacific LNG is still optimising the turbine configuration including the potential use of 14 turbines. The Solar Titan 130 generators are ISO rated at 15 MW each. Power generators will be equipped with dry low $NO_x$ technology and aero-derivative turbine drivers equipped with dry, low emission technology.

Uninterruptible power supply systems will be provided to supply the distributed control systems, emergency shutdown system, and other equipment requiring uninterruptible power. Uninterruptible power supply systems will be sized to accommodate the process control loads plus 20% spare capacity.

The emergency electrical power supply will consist of diesel generators. The emergency generators will supply power to loads during power system outages and will provide power to black start the gas turbine generators when required.

### Flare systems

The flare system for Train 1 and 2 will include three separate flare systems:

- Wet gas flare
- Dry gas flare

- Marine flare.

The wet gas flare is designed to handle warm hydrocarbon streams that may be saturated with water vapour and/or contain free liquid hydrocarbons and water. The second flare system is the dry gas flare which is designed to handle cryogenic hydrocarbons, both vapour and liquid. Current base case design is to have both burner headers located in the same enclosure. Each flare is equipped with a utility-type flare tip and an integral purge gas reduction seal and each is provided with an electronic ignition system. A second ground flare for wet and dry gas flare systems will be required for Trains 3 and 4 expansions.

The third flare system, the marine flare, is located near the LNG ship loading area and is provided to handle the flashed LNG vapours during loading of LNG product to the ship.

The worst case upset conditions are used to size the valves and flares. The worst case scenario for the wet gas flare was based on a blocked feed gas condition with the full flow of 18 million metric standard cubic metres per day of gas to the LNG facility. The marine flare is sized on the basis of the displaced gas and flashed gas during the ship loading.

#### *Fire water system*

The fire water system will have a self-sufficient fire protection system to control or extinguish a fire within the facility, designed on the single fire philosophy. The primary fire protection system is the firewater system. Sufficient capacity has been reserved in the service water storage tank for fire fighting. This reserved capacity allows the capability of fighting two sequential two hour fires. The tanks' volume and total pumping capacity also allow for fighting two concurrent two hour fire on the jetty. Firewater is pumped from the firewater tanks through a ring-main distribution system to hydrants, monitors, and hose stations.

Two electric, motor-driven jockey pumps are provided to pressurise the firewater system. Four main firewater pumps will be provided for Train 1 and 2, three 50% diesel firewater pumps and one motor firewater pump. These pumps will be sufficient for future Train 3 and 4 therefore no additional fire water pumps will be required. Two pumps are capable of covering the largest design fire in one process plant. One pump on each system is designated as the primary pump and backup pumps will auto-start if the primary pumps cannot maintain fire fighting system pressure. Once a week, the system is tested to assure that it is fully functional and there are no leaks in the distribution system. An extensive underground distribution system in each train is connected to above ground hydrants, monitors, and hose stations to provide fire protection coverage to the process areas, storage areas, and the jetties.

Additionally, a combination dry chemical/foam fire truck will also be provided for use by the facility emergency response team.

## 22.3 Hazard identification and risk assessment

### 22.3.1 Risk assessment methodology

Throughout the hazard study program, a consistent risk assessment process was followed, using ConocoPhillips' corporate risk ranking matrix illustrated in Table 22.4.

For each hazard identified, an assessment was made of the likelihood of the hazard occurring. Five levels of likelihood were used, as shown in Table 22.4, ranging from several / continuous to very unlikely.

For each potential hazard, five categories of consequences were then considered. No significant effect would include minor first-aid level injuries or no conceivable injury or health impact. For business interruption, the time that the system or LNG facility would be unavailable or off-line was the primary factor considered. Loss of total production for a month would be a major interruption, for example. Environmental impact was also considered, with consequences ranging from no measurable effect to significant / long term. In considering environmental impact, an assessment was made of the public's expectation and response associated with the event, as well as the estimate of the actual impact.

This risk matrix will be used throughout all future hazard studies and additional safety related studies to maintain consistency in approach.

**Table 22.4 Risk ranking matrix**

| Risk ranking matrix | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Category** | | | **Consequences / impact** | | | | |
| Personnel | | | Multiple fatalities | Single fatality | Severe injury | Lost time accident | No significant effect |
| Property damage / business interruption | | | Major | Significant | Moderate | Minor | Negligible |
| Environmental | | | Significant / long term | Significant / short term | Minor / long term | Minor / short term | Not measurable |
| **Likelihood** | | | | | | | |
| | No. per facility lifetime | Annual frequency | (1) Very high | (2) High | (3) Medium | (4) Low | (5) Insignificant |
| 1 | Several / continuous | > 0.1 | Redesign (1) | Redesign (2) | H (5) | W (9) | C (19) |
| 2 | Single | 0.1 - 0.01 | Redesign (3) | H (4) | H (7) | W (12) | C (20) |
| 3 | Likely | 0.01 – 0.001 | H (6) | H (8) | W (11) | C (14) | C (21) |
| 4 | Unlikely | 0.001 – 0.0001 | W (10) | W (13) | C (15) | C (16) | C (23) |
| 5 | Very unlikely | < 0.0001 | W (16) | W (18) | C (22) | C (24) | C 25) |

**Key**

| | |
|---|---|
| H (5) | First Line: HAZID type – Resign = do not proceed; H = HAZOP; W = what if; C = checklist<br>Second Line: risk level – Lower number = higher risk |

### 22.3.2 Hazard management

There are inherent hazards associated with the construction and operation of process plants, including those that contain hydrocarbons. Designing and operating a safe plant is the basis for reducing these hazards. The design of the LNG facility will adhere to all industry and government standards and guidelines, but will also draw on ConocoPhillips' vast experience in LNG over the last 40 years (Kenai Alaska has been operating since 1969) to reduce the hazards of operating the LNG facility to as low as reasonably practicable.

For hydrocarbon inventories, the potential consequences of a loss of containment range from dispersion of the resulting vapours without ignition, flash fires, fireballs, explosion and torch fires. The primary philosophy inherent in the design to mitigate these risks has the following components:

- Design integrity to minimise loss of containment events. Examples include the use of full containment type LNG storage tanks with double-wall construction as proposed, which are reliable and have never lost liquid containment (Centre for Liquefied Natural Gas 2008b). Engineering design and construction quality control standards ensure that the fabricated pipe and plant are of a high standard
- Early detection of leaks, using a plant-wide gas detection system
- Advanced process control and emergency shutdown systems, which reduce the potential for process upsets to propagate or escalate to a major event
- Emergency depressuring system, designed to rapidly dump inventory from a compromised section of the plant and dispose of it safely via the flare system
- Use of passive fire protection, such as fire proofing of critical structural steel to reduce the probability of failure under fire conditions, thus limiting escalation
- Use of active fire protection systems, such as water monitors and fire hoses. Manual fire fighting is designed around minimal personnel on site and aimed at containing any fire through cooling of adjacent structures and inventories and use of emergency depressuring systems, rather than aggressive fire fighting to extinguish fires.

In designing the LNG facility, various methods will be used to ensure a comprehensive and systematic approach to hazard identification, risk assessment and control. The methods used include:

- Review of historical operation of LNG facilities worldwide
- Specific technical studies on instrumented control and protective systems
- A series of hazard studies, including HAZOP, throughout design development
- Detailed fire hazard analyses.

Wherever hazards are identified in the above methods, the associated risk level will be determined using ConocoPhillips' risk ranking matrix, shown in Table 22.4. Risks will be reduced to as low as reasonably practicable (ALARP). The approach taken will be consistent with the overall hierarchy of controls, described as:

- Elimination – what design changes can be made to eliminate the hazard at the source? Most preferred solution
- Substitution – what change can be made to the process to substitute the hazard with a lower-risk hazard, or non-hazardous material/system? Next preferred option

- Engineering – if elimination and substitution are inadequate, what engineered controls can be built in or added on to control the risk to an acceptable level?
- Administration – what controls of a procedural or administrative nature can be implemented, for example to keep people away from the hazard?
- Protection – can protective equipment be provided that protects people or the environment from the hazard, once the hazard is realised? This is the least preferred option

Often a particular hazard requires more than one strategy from the above list of controls in order to reduce the risk to ALARP.

During construction and operation the HSEMS will be utilised to ensure an ongoing safe project. The HSEMS is discussed in Section 22.5.

### 22.3.3 LNG facility

#### *Hazardous materials*

The nature of this LNG facility is such that there will be three hazardous materials (as defined in the Dangerous Goods Safety Management Regulation 2001) of sufficient volume on site which may have the potential for off-site consequences.

These are:

- CSG in either the gaseous or cryogenic state
- LPG, if required
- Refrigerants.

These materials are further described in Table 22.5.

Substances listed in Table 22.5 are the predominant substances to be produced or transported to and stored on site. A complete list of all hazardous substances that will be held and utilised on site will be identified during detailed design of the LNG facility. Additional chemicals to be used may include compressor lubricants and as well as chemicals used in the water purification process (reverse osmosis).

Safeguards for the transport, storage, use, handling and on-site movement of hazardous substances will be as per material safety data sheets (MSDS) and applicable design codes. The need, capacity and standards of bunding of storage areas will be determined during detailed design in accordance with the appropriate Australian standards.

**Table 22.5 Preliminary list of proposed hazardous materials stored and handled on site**

| Hazardous materials | Concentration (raw materials) | Concentration (operation/ storage) | UN Number* | Shipping name | Approximate usage rate# | Estimated maximum inventory# |
|---|---|---|---|---|---|---|
| Natural gas (Methane) | 100% | Up to 100% | 1972 | Natural gas, LNG | | 480,000$m^3$ of LNG |
| LPG | 100% | 100% | 1075 | LPG | 1,600,000$m^3$ pa | 130,000$m^3$ |
| Ethylene | 100% | Up to 100% | 1962 | Ethylene | 440$m^3$ pa | 430$m^3$ (Note 1) |
| Propane | 100% | Up to 100% | 1978 | Propane | 630$m^3$ pa | 1,200$m^3$ (Note 1) |
| Activated N-Methyldiethanolamine (aMDEA) | +99% | 90% | | Actived N-Methyldiethanolamine | 6$m^3$ pa | 96$m^3$ (Note 1) |
| Nitrogen | 100% | 96% - 98.5% | 1066 | Nitrogen, Compressed | - | 320$m^3$ liquid (Note 2)<br>2,300$Sm^3$ vapour |

*Source: *Dangerous Goods Safety Management Regulation 2001*

#Source: Bechtel (2009)

Note 1 – Inventory per LNG train.

Note 2 – A nitrogen generation unit (including a nitrogen receiver) is required for storage tank blanket gas and to purge the swivel joints of the LNG loading arms during loading.

### Hazard identification

At this preliminary stage of design, hazard identification is restricted to generalised hazards and risks associated with LNG facilities based on common and known hazards of the proposed facilities.

A systematic hazard identification (HAZID) and environmental hazard identification (ENVID) study for the LNG facility was conducted on 4 and 5 August, 2009. The study considered a wide range of potential hazards and environmental problems that could occur during the LNG facility's operation. Due to the preliminary nature of the design, most process systems were not evaluated in a detailed manner. The HAZID/ENVID results were divided into four categories: operations, environmental, external hazards, and layout issues. Hazard identification studies in the next phase of design will be expanded to capture construction and decommissioning issues after more details on methodology have been finalised. The following section lists typical hazards.

### Construction hazards

Construction hazards would be similar those of any industrial construction site and would include:

- Transport – heavy vehicles, pedestrians and ferries and barges
- Fuel spills – fuel and oil spills, leaks and potential fires
- Hazardous materials/ substances/chemicals – personal injury (eye damage, burns)
- Heavy lift cranes – an incident during a heavy or difficult lift  causing equipment damage or injury
- Poor weather – cyclones, storms, winds or heat causing damage or injury and potential flooding
- Slips, trips and falls – injury
- Working at heights – injury
- Confined space entry, excavation and trenching
- Continual working with dust
- Hearing impacts prolonged noise exposure
- Electrical work – injury, fires.

The construction contractor will implement their core HSEMS and associated procedures. Their site specific construction HSE plan, work instructions, and permits to work will be bridged to be aligned with ConocoPhillips' HSEMS.

### Operational hazards

Operational hazards potentially associated with operation of LNG facilities include:

- Jet fire
- Pool fire
- Flash fire
- Vapour cloud explosion
- Boiling liquid expanding vapour explosions

- Hot and cold temperatures of equipment
- Release of cryogenic liquids leading to severe burns due to very low temperatures
- Asphyxiation
- Transport – heavy vehicles, pedestrians and ferries and barges
- Hazardous materials – personal injury (eye damage, burns).

The LNG facility will process, handle and store large inventories of CSG, LNG and LPG, together with ethylene, and propane. The potential hazards associated with uncontrolled releases of flammable hydrocarbons are readily apparent, the principal types being vapour clouds and fires, thermal radiation or flame impingement from jet or pool fires, vapour cloud explosions and boiling liquid expanding vapour explosions.

A release of hydrocarbon such as CSG, LNG, LPG, or refrigerant may form a vapour cloud that disperses in the atmosphere. A portion of the cloud would likely be flammable, giving rise to the possibility of ignition.

Ignition of a gas or liquid release can produce a jet or pool fire resulting in damage to unprotected plant equipment, and personnel hazards from thermal radiation exposure.

There have been no confirmed occurrences of vapour cloud explosions initiated from LNG in any operating LNG facility, although a negligible risk of such an event does exist. If ignition of the flammable cloud is delayed, there is the potential for a vapour cloud explosion. For a significant vapour cloud explosion to occur, the flammable cloud needs to be in a highly congested or confined area of the plant. Vapour cloud explosions can cause significant damage to equipment and high levels of personnel hazards as a result of blast overpressure.

If the flammable cloud does not ignite, there is the potential for asphyxiation due to the displacement of air.

A boiling liquid expanding vapour explosion is the term used to describe the catastrophic failure of a pressure vessel containing a flammable liquid above its atmospheric boiling point. If vessel rupture occurs as a result of vessel wall weakening due to fire, the violent liquid flashing and ignition results in a fireball.

Thermal radiation damage to equipment resulting from a boiling liquid expanding vapour explosion is generally minimal, but personnel hazards can occur outside the extent of the fireball. Projection of vessel fragments tends to be highly directional, and the likelihood of damage at any given location would be low. There are no recorded incidences of any boiling liquid expanding vapour explosions involving LNG having occurred on LNG facilities. Due to the low operating pressure, near atmospheric and cryogenic temperatures of an LNG tank contents, a boiling liquid expanding vapour explosion type event is not achievable.

### *Aviation safety*

An assessment of the vertical velocities associated with stack exhaust plumes at the proposed LNG facility was carried out, based on the guidelines for aviation safety published by the CASA.

Based on the assessment for normal LNG facility operations the following was identified:

- There is a potential for the average plume vertical velocity to exceed 4.3m/s up to a maximum height of approximately 850 metres above ground level at a maximum downwind distance of approximately 166m. The maximum height is dominated by the merged plume from the gas turbine compressors

- The merged plume from the gas turbine compressors is likely to cause the vertical velocity to be greater than 4.3 m/s at and above 400m (surface above which planes can fly) for approximately 28 hours per year or 0.32% of the time
- Of all the plumes considered for normal operations, the highest critical height for the 0.1 percentile is approximately 550 metres above ground level (merged gas turbine compressors).

During non-normal LNG facility operations for upset event such as flaring may occur. Extremely conservative scenarios were modelled, for example 100% flare capacity was modelled when, from experience from Darwin LNG it is usual for the flare to operate at 20% capacity. The conservative modelling indicated the following:

- A plume from the marine flare (stack not ground flare) would have a vertical velocity greater than 4.3 m/s above the height of 400m for approximately 28 hours per year or 0.38% of the time, when assumed operation for every hour of the year
- The ground flare, which will typically operate if emergency depressurisation of the plant is required, is likely to generate a plume with vertical velocities above 4.3 m/s above the 400m.

Discussions between Australia Pacific LNG, the Gladstone Airport and CASA will be required to determine an appropriate course of action to alert Gladstone Airport should a flare event occur. Further discussion on aviation safety is located in Volume 4 Chapter 13.

### *Decommissioning hazards*

The hazards associated with decommissioning will essentially be the same as those for construction.

There is the potential for contaminated soil resulting from liquid spills. However, the hydrocarbon product to be processed will be predominantly gaseous and is a clean service with no hydrocarbon liquid present at atmospheric temperature and pressure.

Additionally, there is secondary containment around all hazardous liquids including the main process area and utilities such as lubrication oils, diesel fuel and aMDEA. This results in a low probability of soil contamination. However, a soil contamination survey will be conducted to determine if there has been any inadvertent contamination.

During decommissioning, there will be a permit to work system in place and procedures to ensure equipment is purged of all hydrocarbons and other contaminants before being taken out of service.

### *Environmental hazards*

A preliminary ENVID has been undertaken to identify key environmental issues. Issues addressed in the study included hazardous materials releases, waste disposal, and regulatory compliance. The EIS further investigates these issues as well as other environmental issues identified through additional studies. These items are addressed in other chapter of this EIS.

### *External hazards*

External hazards include occurrences such as cyclones, earthquakes, tsunamis, lightning, bushfires, and wildlife. These general concerns will be evaluated during facility design and may require specific studies to be performed. In all cases risks associated with these events are considered to be greatly minimised through adherence to relevant standards and codes for the design, construction and operation of the LNG facility. Studies on the effects of cyclones, tsunamis and earthquakes as well as potential impacts associated with climate change/adaptation have been completed.

### Transport and traffic hazards

Potential transport and traffic hazards associated with the construction, operation and decommissioning of the LNG facility will include increased road, marine and air traffic and spillages of oils, fuels, chemicals or other contaminated liquid.

The potential hazard and risk aspects of road transport and traffic will be managed across the Project with a traffic management plan that will address road design, vehicle design, behaviour management of drivers and pedestrians, and emergency response.

Traffic and transport impacts and their management are further outlined in Volume 4 Chapter 17.

### Plant layout

Where hazards can not be designed out, their risks will be reduced to ALARP. A mitigation to avoid knock on effects within the facility is to allow adequate spacing between equipment. Plant layout has been based on previous detailed studies of other LNG facilities and the referenced technical standards. Bunding will be used to limit the spread of any liquid leaks that might occur and reduce the size of pool fires in the event that these leaks ignite.

### Preliminary hazard analysis

Based on the above high level hazard identification, a preliminary quantitative risk assessment (QRA) was undertaken to model and review potential hazards associated with the LNG facility and its effect on the surrounding industry and environment.  This modelling provides a standardised methodology to compare potential safety risks against community standards and expectations. This modelling was performed by a specialist consultant using industry developed and approved methods recognized as best practice in Australian Legislation.

This preliminary QRA provides a preliminary assessment of the risk contours around the LNG facility.

Inputs to the preliminary QRA were preliminary design data, historical statistical frequency of accidental releases, ignition probability data, meteorological data, and a set of scenario and consequence modelling assumptions.

During the completion of the detailed design of the LNG facility an updated, a detailed Quantitative Risk Assessment will be conducted to assist in ensuring facility risk contours are maintained or even reduced further than represented in Figure 22.6.

During the detailed design phase, additional hazard and risk mitigation efforts will be undertaken including:

- Constructability Reviews
- Hazard and Operability Study (HAZOP)
- HSE management system development and implementation, including:
  - Systematic Risk Assessment (SRA) as per the Queensland guidelines for Major Hazard Facilities

- detailed Safety Report for approval by the Authorities, prior to operation of the facility (including site operating procedures, training, pre-start-up safety review and audit and reporting provisions)
- Detailed emergency response plans and procedures.

The studies undertaken will meet the requirements for a SRA, using the methodology outlined in Guidelines for Major Hazard Facilities - Systematic Risk Assessment 2008, developed by the Department of Employment and Industrial Relations. This analysis undertakes the subsequent steps of risk assessment and risk management following the HAZID. These hazards will be reviewed for their risk to health and safety and in addition risks to the adjacent natural environment.

Construction hazards will be reviewed during the detailed design phase.

### *Fatality and injury risk contours*

Fatality risk contours have been developed for the operation of the LNG facility including loading of LNG and unloading of LPG. Fatality risk contours represent distances from the LNG facility at a particular risk level. Risk is measured as the likelihood (or frequency) of an individual suffering a fatality. This risk is based on a person being exposed at that location 24 hours per day, 365 days per year. The likelihood units are per annum; however the risk of fatality is extremely low, such that data is expressed as per million years (or number of fatalities x $10^{-6}$ per year Table 22.3).

The Fatality Individual Risk criteria applied was taken from Interim Risk Objectives: A Guide for Assessing Major Hazard Facility (MHF) and Possible MHF Development Applications 2002 developed by the Department of Employment and Industrial Relations. This document refers to the risk criteria proposed by the New South Wales (NSW) Department of Urban Affairs and Planning in its Hazardous Industry Planning Advisory Paper No. 4, 2008 (HIPAP4) titled Risk Criteria for Land Used Safety Planning. HIPAP4 is widely used as a default publication for Queensland facilities. The individual fatality risk criteria required for the various land uses are provided in Table 22.3.

**Table 22.6 Fatality risk criteria based on HIPAP4**

| Land use | Fatality individual risk | Contour shown in (Figure 22.6) |
|---|---|---|
| Hospitals, schools, child-care facilities, old age housing or such “sensitive developments”. | 0.5 x $10^{-6}$ per year | Green |
| Residential, hotels, motels, tourist resorts. | 1 x $10^{-6}$ per year | Cyan |
| Commercial developments including retail centres, offices and entertainment centres. | 5 x $10^{-6}$ per year | Blue |
| Sporting complexes and active open spaces. | 10 x $10^{-6}$ per year | Orange |
| Industrial. | 50 x $10^{-6}$ per year | Red |

Inputs to the preliminary fatality risk contour assessment consist of Project design data, historical statistical frequency of accidental releases, ignition probability data, and a set of scenario and consequence modelling assumptions (refer Figure 22.6). The assessment combines the consequence and likelihood of each potential incident with all other modelled scenarios and predicts probability of fatality distances from each component of the LNG facility. The output of the assessment is a set of risk contours which can be used to compare with the risk criteria or the acceptability of risk.

It should be noted that the fatality contours are not significantly impacted by the LNG and LPG storage tanks due to the extremely low likelihood of incidents occurring with double containment tanks.

As the adjacent land to the facility is zoned for industrial use only, the major criteria is 50 x $10^{-6}$ per year (shown as red contour in Figure 22.6). The risk contour for the residential criteria (1 x $10^{-6}$ per year shown as cyan) is within the property boundary of the LNG facility site and hence, the level of estimated individual fatality risk at residential communities such as South End and Gladstone is well below the risk criteria.

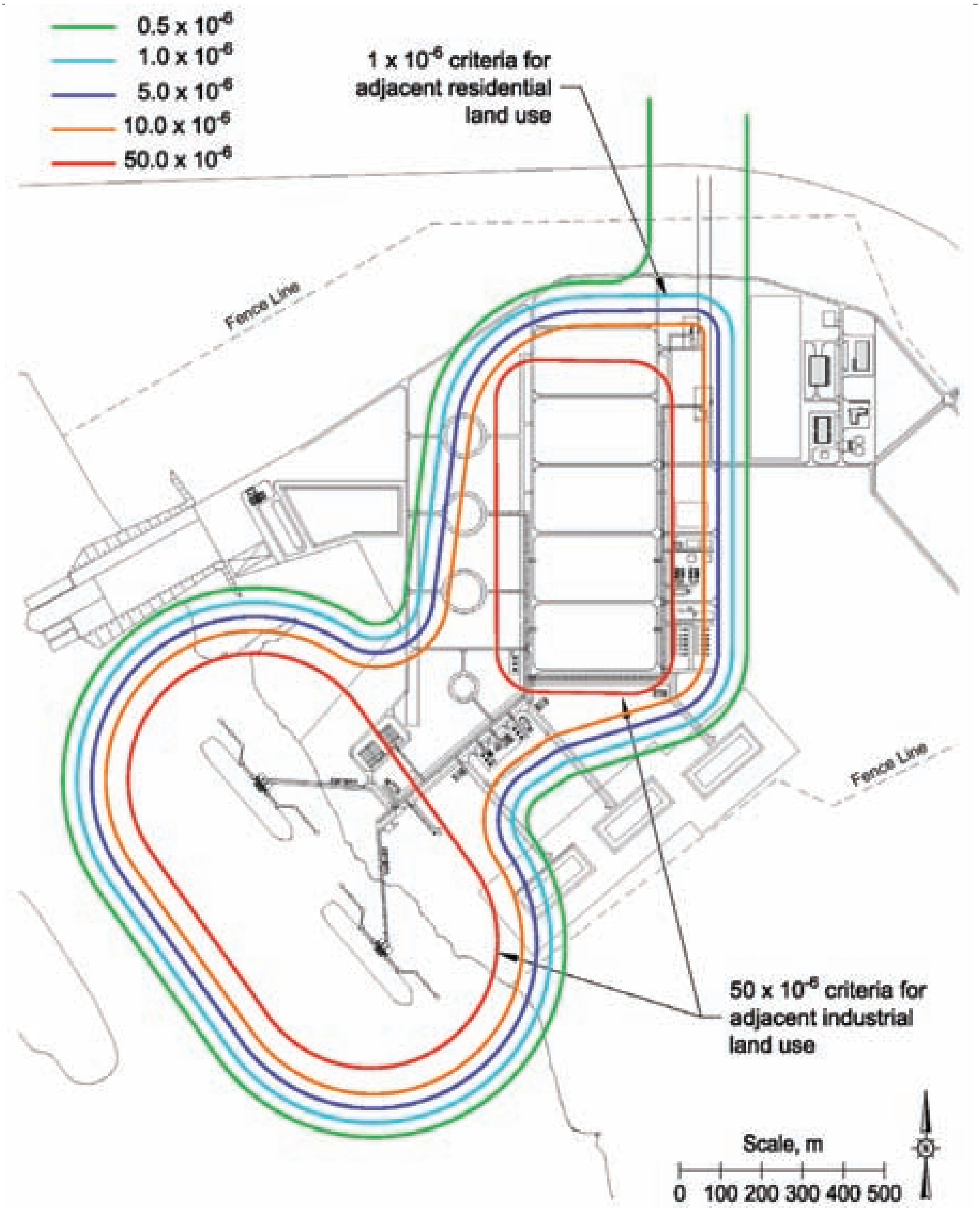


**Figure 22.6 Fatality risk contours**

Additionally, the administration buildings and temporary accommodation facilities of this project (top right hand corner of Figure 22.6) and other projects on Curtis Island remain well outside of the residential contour of $1x10^{-6}$ per year.

The temporary accommodation facility will be occupied while the plant is operational as the construction of further trains will occur after the initial trains are commissioned. The temporary accommodation facility has been located a sufficient distance from the plant such that it is outside any harmful heat radiation or overpressure zones, which are discussed later in this section. This is also the case for accommodation facilities for other LNG projects on Curtis Island.

NFPA 59A sets internationally recognised safety and property risk standards. These are similar to the Queensland standards.

Preliminary injury risk contours have not been modelled because the detailed design has not been completed and there is insufficient information to model injury risk. However preliminary modelling for fatalities suggests that injury contours would remain on the site. The relevant fire radiation distances and overpressure distances remain within the facility property boundary or the adjacent marine area as discussed below. As these are calculated for all credible scenarios without reference to their likelihood, the injury risk contours will be smaller than these.

### *Consequence analysis - LNG release and fire radiation impacts*

Further preliminary investigations were undertaken to assess the potential impact or consequence from a worst credible event. This consequence modelling examines a range of potential incidents based on worst case scenarios with no account taken of the low probability of these scenarios. The scenarios modelled were included in the preliminary fatality risk contour assessment as described above.

Many of the scenarios examined in the modelling are very unlikely events, and all would require the failure of multiple levels of commonly used safety devices as well as a major failure of the safety management systems. A conservative approach was taken in developing the scenarios.

Additionally, NFPA 59A has a requirement to estimate potential hazards resulting from releases of LNG. The hazards include flammable vapour clouds (flash fire) and thermal radiation. The potential effects of these hazards were evaluated to ensure that they do not adversely affect areas outside of the LNG facility's property line. The results of calculations required by NFPA 59A are referred to as exclusion distances – the calculation results in a distance that a given hazard, as specified by the code, could extend in the downwind direction. This information is used by local authorities to ensure public access in these exclusion zones is limited or prevented.

NFPA 59A requires the calculation of vapour dispersion exclusion distances using a vapour dispersion model that incorporates the physical factors of LNG vapour dispersion, including wind speed, humidity, atmospheric stability, surface roughness, gravity spreading, and heat transfer.

NFPA 59A specifies the use of 50% of the lower flammable limit (½ LFL) as the vapour dispersion hazard of concern for the design spills. The LFL was also included as a flammable dispersion endpoint. The ½ LFL zone is contained well within the LNG facility boundaries.

NFPA 59A also requires that thermal radiation exclusion distances resulting from releases of LNG, be calculated, using a model that accounts for impoundment configuration, wind speed, humidity, and atmospheric temperature.

Fire radiation zones at or above the radiant flux level of 4.7kW/m² (refer Table 22.7) are fully contained within the boundary of the facility with the exception of extending into marine areas around the loading jetty but as this is not over land it isn't modelled under NFPA 59A. Refer to the calculated fire radius data in Table 22.8.

The radius of the exclusion zone around the loading jetty has been agreed with other LNG proponents, GPC, and MSQ and is set at 250m.

Hazardous Industry Planning Advisory Paper No. 10 (HIPAP10) states that 4.7kW/m² is not to be exceeded at adjacent residential areas more than 50 x $10^{-6}$ per year while NFPA 59A states 5kW/m² is the maximum flux at the nearest point outside the property line used for outdoor assembly groups of 50 or more persons.

**Table 22.7 HIPAP10 defined radiant impact levels**

| Radiant Flux Level (kW/m²) | Defined impact per HIPAP10 |
|---|---|
| 1.2 | Received from the sun at noon in summer |
| 4.7 | Will cause pain in 15-20 seconds and injury after 30 seconds exposure (at least second-degree burns will result)<br>This flux level not to be exceeded at adjacent residential areas more than 50 x $10^{-6}$ per year |
| 12.6 | Significant chance of fatality for extended exposure. High chance of injury<br>After long exposure, the temperature of wood rises to a point where it can be readily ignited by a naked flame<br>Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure |
| 23 | Likely fatality for extended exposure and chance for fatality for instantaneous exposure<br>Spontaneous ignition of wood after long exposure<br>Unprotected steel will reach thermal stress temperatures which can cause failures<br>Pressure vessel needs to be relieved or failure will occur<br>This flux level not to be exceeded at adjacent industrial areas more than 50 x $10^{-6}$ per year |

Table 22.8 presents the predicted fire radiation exclusion distances for the LNG pool fire scenarios considered in the preliminary QRA. These scenarios may potentially be initiated by spillages and subsequent ignition of LNG.

**Table 22.8 Preliminary LNG pool fire radius**

| Fire scenario | Maximum downwind Distance (m) from Centre of Impoundment to Thermal Radiation Endpoint | | |
|---|---|---|---|
| | 23 kW/m² | 12.6 kW/m² | 4.7 kW/m² |
| Liquefaction area impoundment fire | 29 | 33 | 42 |
| Fully-involved LNG storage tank impoundment fire | 185 | 240 | 350 |
| LNG fire within loading platform bunded area | 51 | 57 | 75 |

The data in the table shows that predicted fire radiation is within the property boundary of the LNG facility site and hence, both the HIPAP10 and NFPA 59A criteria for fire radiation are met. Estimated fire radiation levels at residential communities such as South End and Gladstone are well below the fire radiation criteria.

Potential consequences in adjacent marine areas are managed through exclusion zones and procedures. Australia Pacific LNG continues to actively consult with the GPC, MSQ and other LNG facility proponents on this matter.

NFPA 59A contains several requirements pertaining to layout and spacing that are to be applied to the equipment within the LNG facility.

One requirement of NPFA 59A (Section 5.3.4.2) is that full containment storage tanks with outer concrete shells shall be located far enough apart that a tank top fire in one tank will not expose the concrete shell of any other tank to a heat flux that causes a loss of structural integrity.

NFPA 59A (2009) includes Annex E which provides a risk-based methodology to satisfy the siting provisions, and is intended to ensure that the LNG facility does not pose an unacceptable risk to its surroundings. The semi-quantitative risk-based approach is implemented through a risk matrix that assigns the following categories: acceptable, not acceptable, and acceptable with review (and the potential incorporation of safeguards/mitigation), through the use of seven frequency classifications and five consequence classifications.

Australia Pacific LNG intends to follow the chapter 5 in NFPA 59A requirements for siting and the layout of the LNG facility. This approach takes the following form:

- The event in question is a fire over the whole surface of the liquid contained in the tank, assuming the roof is completely lost, as required by 5.3.4.2 (1)(b). There have been no catastrophic failures of LNG containment tanks since 1944, when a tank built from inappropriate material suffered brittle failure
- TNO (Netherlands safety organisation) (1999) estimates the failure rate (defined as a release to environment) of a full-containment, concrete, cryogenic storage tank to be $1 \times 10^{-8}$ per year. In addition, the event of concern is escalation of the fire to a second tank due to a full tank top fire. The probability of the escalation would be less than one, resulting in an event frequency of less than $1 \times 10^{-8}$ per year.

Employing the NFPA 59 risk based approach the spacing between LNG storage tanks of approximately 100 metres (shell to shell) between each of the three tanks is appropriate.

### *Toxic gas infiltration*

Because there are no acutely toxic materials present in the incoming gas, nor in other process gasses, then no significant toxic gas release scenarios have been identified which could affect the overall LNG facility site.

### *Vapour cloud explosion overpressure impacts*

While the likelihood is very low, the following addresses consequence analysis as required by the TOR. Vapour cloud explosion calculations were accomplished with a consequence modelling package. For vapour cloud explosion calculations, the model uses estimation of flame speeds and is based on experimental data involving vapour cloud explosions, and is related to the amount of confinement and/or obstruction present in the volume occupied by the vapour cloud.

Using previous experience in release and dispersion modelling as a basis, the volumes to be considered for explosions were selected following evaluation of the potential mass of flammable gas in a dispersing plume. For each confined or congested volume identified, there exists at least one release that can fill the volume with a flammable mixture. Many of the potential liquefied gas releases at the LNG facility could extend into several congested locations. Thus, the source of the flammable gas in a congested area may not be specific to a release that originated in that area (i.e., a flammable cloud could drift into an area from a source other than that location).

The explosion overpressure endpoints used in this analysis were taken from API RP 753 Management of Hazards Associated with Location of Process Plant Portable Buildings 1st Ed, 2007and API RP 752 Management of Hazards Associated With Location of Process Plant Buildings, 2nd Ed, 2003.  Although API RP 752 does not explicitly define any overpressure endpoints to be evaluated, it provides a table of expected damage levels for different building types. The endpoints and a general description of their impacts are presented in Table 22.9.

**Table 22.9  Overpressure endpoint and associated building damage**

| Source | Overpressure level kPa | Description |
|---|---|---|
| API RP 753 | 4.1 | Portable buildings are damaged in localised areas. Individual components on walls facing the blast sustain up to major damage. Other walls and the roof sustain up to moderate damage. Window breakage and falling overhead items are expected. |
| | 6.2 | Portable buildings damage is widespread, but structural collapse is not expected. Wall components facing the blast sustain major damage and may fail. Wall and roof components not facing the blast sustain up to major damage. Window breakage and falling overhead items are expected |
| | 6.9 | Partial collapse of unreinforced masonry walls and; failure of non-loadbearing walls on steel or concrete frame buildings |
| | 13.8 | Wood-frame trailers collapse; significant damage to most “ordinary” buildings |
| | 20.7 | Unreinforced masonry buildings destroyed; steel-frame buildings frame collapse |
| | 34.5 | Total destruction for most buildings; reinforced buildings damaged |

Eleven facility areas where a large area of potential equipment congestion exists were chosen for the explosion scenarios summarised in Table 22.10. Scenarios 1 to 8 can possibly occur in each liquefaction train; Scenario 9 can possibly occur for each gas turbine generator, Scenario 10 can possibly occur in the refrigerant storage area (two tank groupings), and Scenario 11 can possibly occur (two equipment groups) just north of the utility substation.

**Table 22.10 Vapour cloud explosion accident scenarios**

| Scenario | Description of obstructed location | Volume ($m^3$) |
|---|---|---|
| 1 | Refrigeration compressor shelter: ½ of the volume below the compressor deck | 7,995 |
| 2 | Refrigeration compressor shelter: 1/10 of the volume below the compressor deck | 1,600 |
| 3 | Refrigeration compressor shelter: 1/10 of the volume above the compressor deck | 1,600 |
| 4 | Acid gas removal area | 1,090 |
| 5 | Gas dehydration/mercury removal area | 2,635 |
| 6 | Hot oil area | 795 |
| 7 | Refrigeration structure | 1,210 |
| 8 | Refrigeration main pipe rack | 3,135 |
| 9 | Power generation | 270 |
| 10 | Refrigerant storage | 3,480 |
| 11 | Utility area | 1,760 |

The overpressure distances for the 11 explosion scenarios are listed below in Table 22.11. Based on the current facility plot plan, the overpressure developed by each of these scenarios is less than 4.1kPa at all proposed permanent buildings with the exception of the northern marine terminal building. This is located within the 6.9kPa vulnerability zone which may result from an explosion in the refrigerant storage area. This building will be of a suitable type such that it can withstand the 6.9kPa overpressure from such an explosion.

**Table 22.11 Vapour cloud explosion overpressure distances**

| Scenario number | Maximum distance[1] (m) to overpressure endpoint | | | | | |
|---|---|---|---|---|---|---|
| | 35kPa | 21kPa | 14kPa | 7kPa | 6.2kPa | 4.1kPa |
| 1 | 35 | 70 | 105 | 190 | 210 | 300 |
| 2 | 45 | 65 | 95 | 165 | 180 | 255 |
| 3 | 20 | 40 | 60 | 110 | 120 | 175 |
| 4 | 40 | 60 | 80 | 145 | 160 | 225 |
| 5 | 50 | 80 | 110 | 195 | 215 | 300 |
| 6 | 35 | 50 | 75 | 130 | 145 | 200 |
| 7 | 40 | 60 | 85 | 150 | 165 | 230 |
| 8 | 55 | 85 | 115 | 205 | 225 | 320 |
| 9 | [2] | [2] | 10 | 15 | 20 | 30 |
| 10 | 25 | 45 | 65 | 125 | 140 | 205 |
| 11 | [2] | [2] | 15 | 30 | 35 | 55 |

[1] Distance from centre of obstructed volume

[2] Overpressure endpoint not achieved by this scenario, overpressure above 2 psi not achieved

These overpressure distances remain within the facility's property boundaries or the adjacent marine exclusion zone.

### *Key findings and conclusions*

The fundamental aim is to achieve a goal of zero accidental releases and zero incidents: it is not in the best interest of Australia Pacific LNG for such incidents to occur. This is why Australia Pacific LNG utilises a comprehensive engineering design that incorporates risk identification and mitigation based on the hazards that could conceivably arise. Mitigation will be achieved through the use of recognised standards, proper material selection, attention to design, high quality fabrication, and comprehensive testing and commissioning procedures, with the application of adequate safety factors. This will be reinforced by strict adherence to established operating and maintenance procedures, incorporated into a formalised safety management program.

The preliminary QRA and consequence modelling of risk, overpressure and radiation contours shows that risks to the public are within the acceptable criteria outside the property boundaries. International requirements set by NFPA 59A have also been met.

## 22.3.4 LNG and LPG transport – berthing and ship load/unloading

### *Hazard identification*

The scope of the berthing and loading/unloading operations assessed included:

- Final berthing and initial un-berthing manoeuvres of the LNG and/or LPG carriers (movement through the Gladstone port is discussed in Section 22.3.5)
- LNG loading and LPG unloading operations that occur while the carriers are at the berth.

On shore incidents that can be associated with loading/unloading activities are considered as part the LNG facility operation (refer to Section 22.3.3).

For the purpose of this assessment, potential incidents evaluated were:

- Release of LNG and/or LPG (liquid or vapour) from a transfer arm failure
- Release of LNG and/or LPG (liquid or vapour) from pipe work on the jetty due damage resulting from incorrect operation, failure or impact
- Release of LNG and/or LPG (liquid or vapour) due to damage to the carrier hull while berthing or when at berth (impact from other marine craft).

The resulting potential consequences from the above incidents include jet fire, pool fire, flash fire, vapour cloud explosion, asphyxiation, exposure to cryogenic liquid and rapid phase change overpressure. Vapour cloud explosion and rapid phase change overpressure (overpressure resulting from rapid change of phase, and thus expansion, from liquid to vapour) were not considered credible due to the lack of confinement within the marine loading area that is necessary for creating overpressure conditions.

Jet and pool fires have the potential for heat radiation to cause damage to equipment or injury while a flash fire, burn back of a vapour cloud to its source, would cause injury to individuals within an ignited cloud. LNG and/or LPG is at very low temperatures at atmospheric pressures and would cause severe cryogenic burns if it came in contact with exposed skin.

### Preliminary hazard analysis

This section summarises the potential hazards associated with berthing and ship loading/unloading.

The design of the loading/unloading jetty will reduce the likelihood of potential risks.

The two berth options (Option 1b and Option 2a) differ in regard to potential impacts to shipping safety. Australia Pacific LNG has conducted a navigational simulation study to assess the ease of marine access associated with Option 2a and Option 1b (BMT SeaTech 2009). While the study concluded that it was possible to access berths for both Option 2a and Option 1b, a key finding from the study was as follows:

> “The scenarios simulated, covering a range of moderate and extreme wind and current conditions proved to be more difficult with layout Option 1b than the equivalent for layout Option 2a. This result is primarily due to the ‘double bend’ in the approach channel as designed for Option 1b, which forces the pilot to align the ship in the channel in a non-optimum position due to the need to consider the position for the next bend and ultimately the position and vessel speed when entering the turning basin. Also of importance to this result is that the currents in proximity to the turning basin are stronger in Option 1b than the equivalent location for Option 2a.”

It was also concluded that as marine access is “easier” for Option 2a than for Option 1b and the overall risk of collision with the facility is lower.

Loading arm failures have the potential for high volume releases however industry standard designs reduce the volume of LNG and/or LPG that could be released. Leak detection systems on the jetty and concentrated around the loading arm if activated will initiate the emergency shut down system.

The couplings used on the loading arms, to connect to the carrier piping, will be of a break away type. This means that the coupling connection cannot be broken without the valve on either side of the coupling being closed. If the loading hose is broken, the coupling valve will automatically close to reduce the volume of the release.

The piping on the jetty will be protected from damage by vehicles on the jetty or by the carriers during berthing. Isolation valves for the jetty piping will be located to minimise the inventory of LNG and/or LPG available for any potential release.

The likelihood of a loss of containment of a carrier during berthing or while at berth is very low. Modern LNG and LPG carriers are made with a double hull design and the impact speed required to breach the cargo tanks is approximately 8 knots for 30,000 tonne vessel and 7 knots for a 60,000 tonne vessel. It is almost impossible for a small vessel to rupture the cargo tanks. Collision of the carrier with the jetty is at such a low speed there is no chance of cargo tank rupture.

The risk of a significant incident from impact with the fuel tanks of an LNG ship is low due to the controls in place (tugs, pilot) when the ship is within the port.

### Key findings and conclusions

The results of the preliminary hazard analysis are shown in the risk contours in Figure 22.6.

The likelihood of a loss of containment as a result of a carrier hitting the jetty is very low, due to the speeds required and the design of the ships. Additionally, the use of four tugs for ship berthing further reduces the probability of a carrier hitting the jetty and losing containment.

The main hazard at the ship berthing and loading facility is a release during the loading or unloading of a ship. The mitigation against these releases is the use of a leak detection system and break away hose couplings, which isolate once the connection is broken.

### 22.3.5 LNG transport – transit of Port of Gladstone

Lloyd's Register North America Inc. (2009) has carried out a risk assessment for LNG and LPG tankers transiting Gladstone Port to and from the proposed berths at Laird Point.

A summary of the Lloyd's Register risk assessment and key findings is provided below.

An assessment of potential impacts on marine flora and fauna arising from shipping is described in Volume 4 Chapter 10.

#### *Shipping in Gladstone Port*

Nearly 1,400 ships carrying overseas and coastal cargoes called at the Gladstone Port in 2007-2008 (Gladstone Ports Corporation 2008). The ships comprised bulk carriers; multi-purpose vessels; tankers; break bulk vessels; and LPG carriers. The largest ships to use the port include a 231,850 tonne vessel (Bureau of Transport Economics 2001).

A review of Australian Transport Safety Bureau incident report databases shows there have been six incidents of note in Gladstone Port since 2002. These are summarised in Table 22.12.

**Table 22.12 Incidents in the Gladstone Port**

| Year | Accident | Ship | Summarised description |
|---|---|---|---|
| 2002 | Grounding | La Pampa (bulk carrier) | Steering problems led to grounding after tugs were released. Tugs could not attend to vessel in time to prevent grounding. No damage to hull |
| 2005 | Injury | River Embley (bulk carrier) | Crew were performing maintenance work while at anchor off Gladstone when hot water spray leaked under pressure. Trying to escape the spray, a crew member fell and injured himself |
| 2005 | Fatality | On board Probo Panda (registered as a products, oil, bulk, ore carrier) | Crew member suffered heart attack after electric shock while at anchor off Gladstone |
| 2006 | Collision | Collision between Global Peace (Bulk Carrier) and Tom Tough (Tug) | Collision occurred while Global Peace was berthing due to sudden loss of power on Tom Tough (unexpected engine shutdown) |
| 2007 | Grounding | Endeavour River (bulk carrier) | Ship grounded while attempting to berth at mid-tide. Even with two tugs present, the ship grounded due to tidal influence. The ship damaged a beacon near Auckland Channel. Five tugs could not refloat ship immediately, however, ship refloated successfully at high tide. Minor damage to hull |

| Year | Accident | Ship | Summarised description |
|---|---|---|---|
| 2007 | Grounding | Grain Harvester (bulk carrier) | Grain Harvester grounded near Gatcombe Channel (only two weeks after Endeavour River grounded and two miles away). Grain Harvester was loaded with coal on route from Hay Point to Brazil, stopping to re-fuel at Gladstone (i.e. did not originate at Gladstone) |

### *Proposed shipping by Australia Pacific LNG*

Initially, the LNG facility will consist of two LNG trains. There is a requirement for export of LNG product and possible importation of LPG. This corresponds to a maximum annual number of ship visits of approximately 140 LNG carriers and 20 LPG carriers based on 125,000m³ capacity for the LNG carriers and 80,000m³ capacity for the LPG carriers.

Ultimately, the plant will consist of four LNG trains, which will require a maximum annual number of ship visits of approximately 280 LNG carriers and 40 LPG carriers. The actual number of LNG carrier visits will likely be lower as larger capacity ships will be used where cost effective. The maximum capacity of LNG carriers planned for operation of the LNG facility is 220,000m³, which could reduce the LNG carrier visits by approximately 40%.

In addition to the LNG carriers, there will be a number of ferry movements required per day to bring personnel, equipment and material to the site for construction and operation and decommissioning activities and return personnel to Gladstone. A dedicated wharf will be constructed on the site to receive the personnel, equipment and material. During construction there will also be dredgers and barges required for deepening the channels and turning basin, and for construction of the dolphins and berths.

### *Hazard identification*

Lloyd's Register has carried out a HAZID for failures of equipment, people and processes for the ship transit. The purpose of a HAZID was to apply a rigorous format of examination in order to demonstrate that all credible scenarios and accidental events have been considered for operations in the LNG facility.

To satisfy the objectives, the scope of analysis covered loss of containment of LNG, LPG or other accidental discharges from a ship associated with the transit of the LNG and/or LPG ship through the port.

The HAZID covered the following areas of the transit:

- Anchorage (including approaching anchorage and anchoring in position)
- Pilot boarding – disembarkation
- South Channel (Inbound and outbound)
- Gatcombe (Inbound and outbound)
- Auckland Channel and Clinton Bypass Channel(Inbound and outbound)
- Approach to berth (Option 1b) and swinging vessel
- Berthing Vessel at (Option 1b) berth
- Approach to berth (Option 2a) and swinging vessel

- Berthing vessel at (Option 2a) berth
- Ferry movements to and from the site
- Un-berthing vessel and leaving berth.

Possible incidents include grounding, impact (with a fixed structure such as a berth) or dashing against / collision (with another vessel under way), and striking (another vessel that is not under way e.g. anchored or berthed).

The high level comparison with industry criteria determined that the channel width was less than recommended. However it is accepted that specific modelling of transit through the port can provide acceptable specific requirements for the existing channel width. Therefore a reduced channel width is considered acceptable given a scenario specific risk assessment and implementation of appropriate mitigation measures which is currently being undertaken by LNG proponents, GPC and MSQ. Such an assessment and demonstration of acceptability is being undertaken as part of the shipping simulation studies.

### *Results of HAZID*

Using the risk assessment approach outlined in Section 22.3.1 there were no high risks.

Planning includes the presence of two tugs in the outer channel and four tugs in the inner harbour during the transit through the port which provides a high degree of protection against equipment failures, such as propulsion and steering failures, as well as the need for unexpected manoeuvring due to navigation errors or obstacles in the channel. Without this high level of support, the risks of grounding, collision, striking or impact would be significantly higher.

The main issues raised for the LNG and LPG carriers were associated with the potential for equipment failure or human error to result in the LNG LPG carriers grounding or striking one of the ships berthed along the route through the harbour. The attendance of tugs provided a significant mitigation for the risks of such incidents.

The risk associated with the large number of people on each ferry coupled with the large number of movements and the presence of other vessels (both large commercial and small recreational vessels) was reviewed. Risk mitigation measures include the appropriate standards and licensing of ferry operations and ensuring ferry operators HSE plans are up to date and audited.

The medium risk scenarios identified in the HAZID are listed in detail in Table 22.13.

**Table 22.13 Medium risk incident scenarios**

| Scenario No. | Incident scenario description |
|---|---|
| 1 | Sinking of small boat, causing loss of life |
| 2 | Striking own escort tug, causing interruption of all LNG shipping due to limited specialised tug fleet |
| 3 | Collision with channel beacon |
| 4 | Collision with a small boat with limited instrumentation |
| 5 | Collision with small recreational boats |

| Scenario No. | Incident scenario description |
|---|---|
| 6 | LNG/LPG carrier collision with dredging vessels |
| 7 | Collision of Australia Pacific LNG ferry with small craft due to human error |
| 8 | Collision of Australia Pacific LNG ferry with the material offloading facility (wharf for loading/unloading people and equipment) |
| 9 | Collision of Australia Pacific LNG ferry with loading embarkation dock |
| 10 | Collision of Australia Pacific LNG ferry with dredging vessel |
| 11 | Mooring line parting (then springs back) causing fatalities |
| 12 | Hard grounding of Australia Pacific LNG ferry |
| 13 | Other large ship dashing against LNG/LPG carrier while at berth |
| 14 | Other large ship dashing against LNG/LPG berth |
| 15 | Collision of small craft with wharf trestle |

### *Likelihood of incident scenarios*

The likelihood of each of these scenarios was considered in more detail during the HAZID due to the significant consequences that could occur. The historical record of such incidents, both in Gladstone and internationally, has been used to develop the likelihood estimates.

The frequency of an incident in a wide river/narrow estuary port like Gladstone is estimated $1.84 \times 10^{-3}$ per vessel visit (Robinson and Lelland 1996). This incident frequency is based on information supplied by ports in Great Britain and covers 75% of the total commercial traffic in Great Britain. The type of incidents covered in the study were defined as “any untoward event within the jurisdiction of the port authority that caused (or might well have caused) either injury to people, or non-trivial damage to the fabric of the port or the ship, or non-trivial pollution.”

Although the incident rate given by the Great Britain data is low, it may over-estimate the likelihood of incidents involving LNG carriers. LNG carriers are generally better maintained and operated than other shipping, including passenger ships. According to the Canadian Gas Association (2005), gas carriers have the lowest detention rate (as a percentage of inspections) of all ship types. A lower detention rate indicates the vessel’s navigational systems, maintenance, and crew training are more likely to be in line with class, governmental, and other compliance requirements. In 2004, gas carrier detention rate was 1.95%, compared to 3.9% for passenger ships / ferries, and 5.9% for all ship types.

If the ratio of incident rates for LNG carrier to the incident rates for all ships is assumed to be proportional to the ratio of gas carrier to all ship detentions (1.95% divided by 5.9%).

A case could be made for the frequency of an incident in Gladstone to be up to one third lower than the incident rate for all ships.

### *Gladstone LNG Carrier incident likelihood estimates*

Using the features of the Gladstone Port and the methodology provided in the HAZID report (Lloyds Register, 2009), the incident frequencies were estimated as incidents per annum.

The features relevant to the estimation of LNG carrier incident frequencies are:

1. The approach length from Fairway Buoy to the Swing Basin is 7km. Each visit will require an entry and exit, so the total distance is 14 km
2. Smaller ships may use the shallower Golding channel at the same time and the LNG carrier use the deeper channel. This affects the potential for collision between these ships but the separation of the channels is assumed to reduce the collision likelihood by a factor of five. It is assumed that during each visit; up to two smaller ships use the Golding bypass channel while the LNG carrier is using the main channel
3. The potential for striking is based on the distance from the shipping channels and the locations where ships could be anchored or berthed. Based on the number of berths at Fisherman's Landing and proposed on Curtis Island, it is assumed that two ships at berth will be close to the LNG carrier every visit
4. The incident rates for LNG carriers are only a third of the rates for all ships based on the detention rates
5. Gladstone port is characterised as a wide estuary.

The incident estimates are provided in Table 22.14 and show that the frequency of impacts dominates all the other incidents.  The incidents are separated into collision (with another vessel under way), grounding, striking (another vessel that is not under way such as anchored or berthed), and impact (with a fixed structure such as a berth).

**Table 22.14  Estimate of incident frequencies for Gladstone Port**

| Collision per visit | Grounding per visit | Striking per visit | Impact per visit | TOTAL |
|---|---|---|---|---|
| $2.7 \times 10^{-5}$ | $2.1 \times 10^{-4}$ | $2.7 \times 10^{-6}$ | $5.6 \times 10^{-4}$ | $8.0 \times 10^{-4}$ |

The estimate for grounding is considered to be an upper bound of the actual grounding likelihood due to the following factors:

- The historical incidents of groundings of all ships has been close to this rate in Gladstone Port
- Port procedures and management systems have improved over the period that the historical data was collected and the addition of the LNG carrier services is expected to further improve port traffic safety procedures
- Ship instrumentation including radar and other position locating devices have improved significantly over the period that the historical data was collected.

The other factor that needs to be considered is the severity of the incident. The history of LNG shipping shows that releases of LNG are extremely rare and have only occurred during cargo loading; no releases of LNG have occurred during transit through ports (Colton 2009; Robinson 2007). One LNG carrier, the El Paso Paul Kayser grounded in 1979 at full speed on rocky seabed, causing extensive damage to its outer hull. However, even though the ship grounded at near maximum speed, due to the double hull construction, there was no loss of containment.

The majority of incidents will involve minimal or minor damage to the hull or equipment of the LNG carrier but the interior tanks will not be affected by such incidents.

### *Bunker fuel oil spill*

To prevent/minimise impacts from bunker fuel oil, bunker fuel oil will not be stored on site.

Most modern LNG and LPG carriers have single skinned bunker fuel tanks. The likelihood of grounding or collision rupturing the bunker oil tanks is minimal due to the controls in place (tugs, pilot) when within the port.

### Ballast water release

Ballast water potentially could be released from LNG and/or LPG carriers as a result of grounding or collision rupturing the ballast tanks. The likelihood of such an incident is low.

To minimise the likelihood of ballast water release, all ships are required to comply with the International Convention of Pollution from Ships (MARPOL) as established by International Maritime Organisation. Additionally, the Australian Quarantine Inspection Service enforce mandatory ballast water management requirements (Department of Agriculture, Fisheries and Forestry 2008) for vessels engaged in international shipping which will cover vessels associated with the LNG facility. This is to ensure that exotic species and sediments are not introduced into the Gladstone Port ecosystem from ballast water releases. Ballast water will be exchanged in international waters prior to entering the Great Barrier Reef Marine Park.

Additionally, ConocoPhillips as the Australia Pacific LNG operator of the LNG facility will have in place a corporate global marine vetting standard. This is a standard for vessel vetting and marine terminal clearance for vessels that load or unload at a facility operated by ConocoPhillips. This is to ensure prudent management of marine risk. Refer Volume 4 Chapter 10 for further information regarding potential impacts from ballast water release

### Key findings and conclusions

The Lloyd's Register review of the transit risks for Australia Pacific LNG activities at Gladstone Port considered the port layout and facilities against industry standards.

Based on this, the following conclusions are made:

- Port facilities and management at Gladstone Port is well established, with navigation features, support systems and redundancy all contributing towards a low risk of an incident during transit
- Key hazards include the passage through the Outer Channel, transit past other facilities at Auckland Point and other berths, and interaction between the LNG carriers and support vessels during transit. The use of four tugs and a pilot while in the port give sufficient control in managing the transit of the LNG carriers to/from the berth to reduce the likelihood of these hazards resulting in major incidents
- The route through the port meets industry criteria for channel draught, angles of turn and turning basin even for large beam LNG carriers. It should be noted that the largest vessels entering the port are not LNG carriers
- The use of a reduced channel width will require an assessment and demonstration of acceptability as part of the shipping simulation studies
- The quantitative assessment of all incidents (such as a collision, grounding, allision, capsizing, sinking, or exposure to specific hazardous conditions) occurring during the transit shows that the likelihood is extremely low, less than $2.1 \times 10^{-4}$ incidents per visit. The likelihood of an incident resulting in a release of LNG is much lower at $2.1 \times 10^{-6}$ (i.e. 0.0006 per year, based on 280 LNG movements per year)
- These additional risks from shipping will be mitigated by the use of four tugs and a pilot while in the inner harbour, the use of two tugs and a pilot while in the outer harbour and provide

sufficient control in managing the transit through the port to minimise the likelihood and consequence of incidents. These protocols will apply to all LNG facilities

- Pilots will be appropriately trained.

## 22.4 Cumulative risk

There are several projects similar to this LNG facility proposed for Curtis Island. Figure 22.7 illustrates the Australia Pacific LNG facility site and the location relationship to surrounding projects on Curtis Island, Fisherman's Landing and within the Western Basin. Further, the risk contours applicable for industrial and residential land use stay within the site boundary of the LNG facility as seen in Figure 22.6. Therefore the plant will have no impact on surrounding project facilities. This has been achieved by adequate selection of site layout and footprint.

The intra plant spacing is also sufficient such that there is no knock-on effect from incidents within the plant or with other facilities. The plant layout will be as per NPFA 59 to ensure correct spacing.

The site accommodation facilities are located outside the risk contours applicable for residential land use as well as outside the more stringent Hospitals and other sensitive developments land use contours.

MHFs in the Curtis Island industry precinct will be regulated by HICB, which requires that the design of the proposed LNG facilities is such that risk criteria are met at the respective site boundaries. The risk profiles for neighbouring facilities will therefore not impact on the risk criteria compliance at the boundary of the LNG facility. Additionally, emergency management plans will be in place to help reduce the impact of any incidents on Curtis Island such that surrounding facilities and personnel are not affected.

The process technology chosen for the Australia Pacific LNG facility is proven technology, used in many LNG facilities worldwide and with an excellent track record in terms of safety. The selected process has been used for LNG production for over 40 years. According to their EIS document, the neighbouring QGC facility will use ConocoPhillips' Optimized Cascade® process for liquefaction process as Australia Pacific LNG.

Other MHFs located in the Gladstone area have similar risk criteria. Hence with their greater distance from the proposed facility, there will be no cumulative effect.

A positive effect of additional and similar neighbouring industrial facilities is that there is the potential for mutual aid groups to be formed. That is, the various industrial facilities can pool resources to provide enhanced emergency response equipment and develop standard emergency management plans. The promotion of mutual aid groups will be ongoing throughout the development of the LNG facility.

The introduction of LNG shipping to Gladstone Port will increase the cumulative risk to shipping. These additional risks have been mitigated by the use of four tugs and a pilot while in port and provide sufficient control in managing the transit through the port to minimise the likelihood and consequence of incidents. These protocols will apply to all LNG facilities.

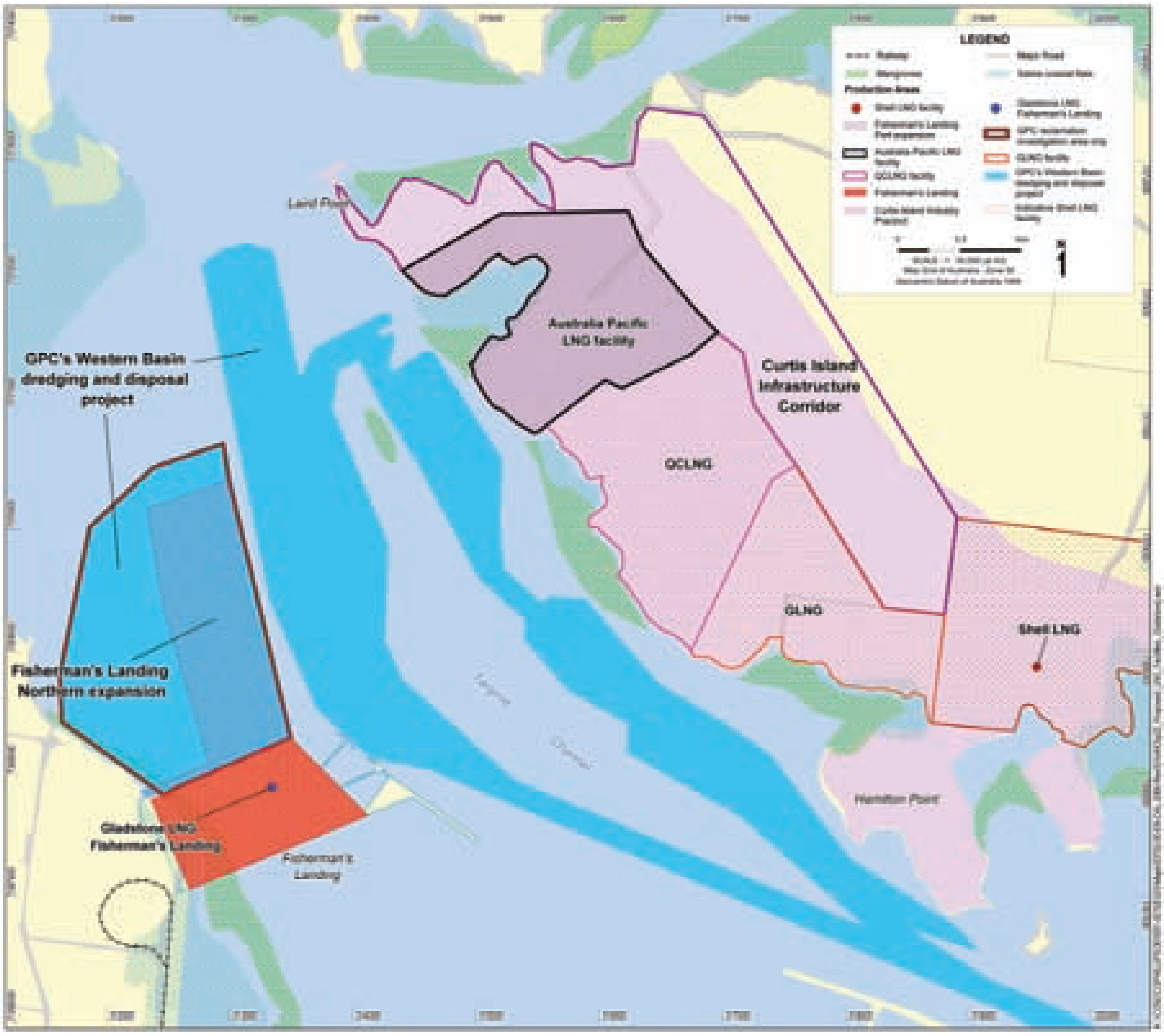


Figure 22.7 Australia Pacific LNG facility and surrounding project locations

## 22.5 Health, safety and environmental management

### 22.5.1 Construction

#### *Community*

It is expected that the level of potential health and safety risk to the community posed by the LNG facility will be minimal due to the distance to sensitive receptors. However, impacts may include air quality degradation due to dust and excessive noise during construction.

Mitigation measures to reduce these impacts include dust suppression activities, road watering, restriction of the duration of noise generating activities and appropriate management to ensure that a high standard of house keeping is maintained throughout the construction of the LNG facility. Further mitigation measures are detailed in Volume 4 Chapter 24.

### *Workplace*

Workplace health and safety will meet industry best standards, codes of practice and relevant statutory provisions, particularly, the *Workplace Health and Safety Act 1995.* Health and safety management will include:

- A Workplace health and safety policy
- Identification of risks associated with construction of the Project
- Assessment of the level of risk of each hazard
- Development of control measures to avoid or minimise the risk
- Implementation of corrective actions on an ongoing basis to avoid or minimise hazards, and
- Monitoring and review of the effectiveness of the control measures and corrective actions to maintain continual improvement.

The risks associated with the construction of the plant will be taken into consideration during detailed design and as part of commissioning planning.

The potential workplace health and safety risks and associated mitigation measures directly related to the construction phase of the Project are discussed in Table 22.15.

**Table 22.15 Potential workplace health and safety risks during construction**

| Potential health and safety risk | Mitigation measure during construction phase |
|---|---|
| Injuries from moving plant and vehicles | The construction contractor will implement a safety management plan. Measures to be adopted include: appropriate signage, reduced vehicle speed limits, designated roadways and walkways |
| Falls, slips and trips | The construction contractor will implement a safety management plan. Measures to be adopted include: appropriate signage and designated walkways |
| Working at heights - falls, slips and trips and/or equipment falling | The construction contractor will implement a safety management plan. Measures to be adopted include: Fall arrest and restraint equipment will be worn when working above two metres. |
| Working in confined spaces | The construction contractor will implement a safety management plan with confined space procedures complying with Australian Standards |
| Continual working with airborne contaminants (dust) | The construction contractor will implement a safety management plan and an environmental management plan. Measures to be adopted include: dust suppression, road watering, and appropriate vehicle and machine maintenance |
| Hearing impacts from prolonged noise exposure | The construction contractor will implement a safety management plan and an environmental management plan. Measures to be adopted include signage and PPE and specification of equipment that meets noise level requirements |

| Potential health and safety risk | Mitigation measure during construction phase |
|---|---|
| Injuries from hazardous substances/chemicals | The construction contractor will implement a safety management plan and an environmental management plan. Measures to be adopted include signage, Material Safety Data Sheets (MSDS) required for all chemicals, and PPE |
| Working with electricity | The construction contractor will implement a safety Management Plan with procedures complying with Australian Standards. |
| Heat exhaustion, dehydration and/or sunburn from continual working in the sun | The construction contractor will implement a safety management plan including measures to identify signs of heat stress and actions to avoid and treat. |

Table 22.16 provides a checklist to be covered in the development of the construction safety management plan to minimise health and safety risks.

**Table 22.16 Safety checklist**

| Safety action checklist | | |
|---|---|---|
| **Statutory acts and regulations** | **Personal protective equipment** | **Plant and equipment** |
| Health and safety objectives, targets and kPIs | Hazard assessment and risk management | Hazardous materials management |
| Sub-contractor management | Job hazard analysis | Health and safety issues/resolutions |
| Safety discipline | Induction's and new personnel | Health and safety auditing |
| Action plan register | Incident investigation and reporting | Competency and training, including induction |
| Communications including daily pre-start meetings | SMS planning and development and improvement | Communication and organisational learning |
| Emergency response | Safety procedures and safe work standards | Safety activity planner |

Decommissioning phase risks will be similar to construction phase risks.

### 22.5.2 Operation

Extensive hazard and risk assessment work addressing public and workplace safety, which has been carried out for this Project, is detailed in Volume 1 Chapter 4 and throughout the EIS.

#### *Community*

It is expected that the potential health and safety risks to the community due to noise and air quality will be minimal due to the distance to sensitive receptors as well as the low emission potential of the LNG facility. Cumulative impacts for noise and air have been assessed with impacts being well below relevant guideline goals, therefore eliminating, or at worst case minimising, the potential impacts to sensitive receptors during the operation of the LNG facility. The assessment for air quality is documented in Volume 4 Chapter 13 and noise emissions in Volume 4 Chapter 15.

### *Workplace*

Health and safety risk impacts associated personnel working onsite during the operational phase of the Project include those outlined in Table 22.17. These are a major driver for the design of the facility and on going management as per the COP systems and the HICB requirements, as detailed in the safety report referenced in Section 22.1.3.

**Table 22.17 Potential workplace health and safety risks during operations**

<table>
<tr><th>Potential health and safety risk</th><th>Mitigation measures</th></tr>
<tr><td>Fire and explosions resulting from the presence of combustible gases and liquids and ignition sources</td><td rowspan="5">Operation planning and management will be undertaken in accordance with regulatory requirements. Operational planning will include the following:<br>• Systematic risk assessments<br>• Emergency response plans and procedures<br>• Education and Training requirements<br>• Safety management plan<br>• Incident investigation, safety reporting<br>• Rehabilitation planning.</td></tr>
<tr><td>Contact with cold surfaces</td></tr>
<tr><td>Handling of hazardous materials and dangerous goods</td></tr>
<tr><td>Injuries due to working in confined spaces</td></tr>
<tr><td>Injuries from the impact of vehicles, plant and equipment</td></tr>
</table>

## 22.5.3 Environmental and natural

Environmental and natural disaster impacts associated with the construction and operational phases of the Project are addressed in along with corresponding mitigation measures (Table 22.18).

**Table 22.18 Potential environmental and natural disaster risks**

| Potential environmental and natural risk | Mitigation measures |
|---|---|
| Biting Insects, including mosquito and midge | Minimise areas of stagnant water or ponding of surface waters |
| Tsunami, cyclone, storm surge | Structural components of the LNG facility to be constructed in accordance with relevant Australian Standards. Develop an emergency response plan to include procedures and actions to be taken in the event that cyclone, tsunami warnings are issued. This will include immediate vessel departures, and controlled shut down of operations. Consideration of climate change/adaptation |

| Potential environmental and natural risk | Mitigation measures |
|---|---|
| Flooding: the site is traversed by a local creek system comprising three ephemeral tributaries that discharge from the site into Port Curtis approximately 1.3km south of Laird Point. The local creek catchment covers the proposed plant site and extends to the south-east, and comprises an area of 284ha. The proposed LNG plant site also extends onto tidal flats extending over an area of approximately 25ha between the mangroves at the mouth of the creek to near the bases of the hills. The flats are subject to occasional tidal inundation on higher spring tides. The maximum level for tidal inundation corresponds to highest astronomical tide (HAT) level which is RL 2.56m Australian Height Datum (AHD). The tidal flats and corridors 60-180m wide along the creek tributaries are prone to inundation in the 100 years ARI design flood event | It is proposed to fill the tidal flats and to construct a number of benches on the hillsides in order to provide flood-free platforms for the LNG plant and ancillary facilities. The proposed LNG plant is to be constructed in stages and will extend over an area of approximately 135ha. It is proposed to fill the tidal flats to RL 6m AHD and to construct a number of benches between RL 8m AHD and RL 35m AHD (refer Volume 4 Chapter 11). These levels will ensure that the plant footprint area is not likely to be affected by flooding from tides, storm surges or stormwater runoff<br><br>Mitigate peak flows (as a result of development of the proposed LNG facility) from the catchment before discharging into Port Curtis. Specifically, this relates to detention of gap flows between Q10 and Q100 ARI design storm events |
| Seismic event | Structural components of the LNG facility to be constructed in accordance with relevant Australian Standards (AS1170.4) |
| Spills of oils, fuels, chemicals and/or contaminated liquids. | Ensure all chemicals/oils are placed in a bunded area, ensure spill cannot contaminate surface and marine water and remediate the spill site as soon as possible with spill kits etc. See Volume 4 Chapter 24. Environmental management plan contains information on the surface water management plans for the Project. |
| Sedimentation and erosion particularly during clearing and earthworks | A sedimentation and erosion control plan will be developed for the site. The plan will develop management measures such as sedimentation fencing, check dams and sedimentation ponds. Volume 4 Chapter 5 provides further information on the soil and geology at the proposed site |
| Acid sulfate soils disturbance during construction | An acid sulfate soil management plan approved by the Department of Environment and Resource Management as required will be prepared and implemented |
| Landslide: Part of the site contains areas with slopes in excess of 15% and consequently these lands may constitute a landslide natural hazard management area. | The earthworks associated with the development will be designed to ensure such slopes are stable |

| Potential environmental and natural risk | Mitigation measures |
|---|---|
| Bushfires: the LNG plant site and surrounding area is rated as a medium bushfire hazard area by the Calliope Shire planning scheme 2007 | High or medium bushfire hazard will be managed through the design and the siting of buildings, including adequate firebreaks, providing access for fire-fighting/other emergency vehicles, and providing an adequate and accessible water supply for fire-fighting purposes<br>Periodic controlled burns of the surrounding areas<br>The LNG plant design incorporates firebreaks and a whole-of-site firewater storage and reticulation system. The plant also incorporates an emergency shut down system. Emergency shut down valves will be installed at critical points within the process, product lines to the LNG storage tanks, and the vessel loading lines. Gas detectors and fire detection systems will be installed at key areas in the LNG facility. Signals from the detection systems will either activate the appropriate emergency shut down valves or alert the operators so that they can take appropriate action |

### 22.5.4 Security

Impacts and injuries due to unauthorised access to the LNG facility are another potential impact to the localised community. Site security and access procedures for the construction and operation of the site will be developed further during detailed design, however, minimum security measures will include:

- 24 hour per day manned site during operation
- A fenced site
- A controlled single access point with individual electronic identity card access for personnel
- Restricted vehicular and public access
- Closed circuit television will be located at strategic locations within the LNG facility
- Development of marine security measures that will be documented in Maritime Security Plans prepared in accordance with the *Maritime Transport and Offshore Facilities Securities Act 2003*.

## 22.6 Emergency management

Australia Pacific LNG will maintain a state of emergency preparedness as a commitment to employees, contractors, customers, neighbours, communities and shareholders in providing a safe, healthy and environmentally responsible working environment.

While prevention must always be the first defence against any incident, Australia Pacific LNG will be prepared and fully capable of responding effectively to all incidents, regardless of how large or complex. The primary objective is to clearly define the framework and the tools that will facilitate the ability to respond to all incidents in the project risk portfolio.

This section outlines preliminary details of emergency plan development and proposed emergency management plans for the LNG facility's construction and operation and decommissioning.

APLNG will develop a full suite of crisis and emergency risk management/response plans and arrangements. These will be developed is accordance with NOSHC Control of Major Hazard Facilities National Standard [NOHSC:1014(2002)]and National Code of Practice [NOHSC:2016(1999)] and in accordance with DGSM Act for MHFs.

The emergency management plan also provides a standardised response and recovery protocol to prevent, minimise and mitigate injury and damage resulting from emergencies or disasters of manmade or natural origin.

Ultimately, this emergency management plan when implemented will allow for the effective management of emergency situations.

The Australia Pacific LNG emergency management plan will be adapted from ConocoPhillips' emergency management plans, given that ConocoPhillips is the operator of the Darwin LNG plant and is the proposed operator of the LNG facility. Linkages with the Origin organisation will also be part of the emergency plans as part of Australia Pacific LNG.

Detailed emergency response plans/procedures, including interfaces with other Curtis Island operators and government agencies as mutual aid arrangements and interoperability with State emergency agencies are critical, and participation in local and regional emergency management committees is essential

### 22.6.1 Emergency management planning

#### *Policy and principles*

Australia Pacific LNG is committed to implementing appropriate management strategies and processes that will identify and manage possible emergency and crisis events associated with all project activities. Australia Pacific LNG will therefore:

- Identify potential crisis scenarios associated with all activities and take appropriate action to prepare for these and other unforeseen events as part of our risk management process
- Prepare appropriate plans to manage emergency and crisis events that could affect the LNG facility
- Train key management staff in the principles of crisis and emergency management and undertake appropriate exercises to test and evaluate plans
- Regularly review emergency and crisis management plans to ensure that they remain relevant, robust and effective
- Work closely with the emergency services and other government organisations in the development and execution of response to emergency and crisis events
- Evaluate our response to exercises and incidents and identify lessons to be learned.

Consultation during the development of emergency management plans for construction, commissioning and operation and final decommissioning of the facility will be undertaken with (but not confined to) the following organisations:

- Port of Gladstone Harbour Master, MSQ
- Queensland Police
- Queensland Fire and Rescue Service

- Queensland Ambulance Service
- Gladstone Ports Corporation
- Queensland Department of Health
- Queensland Department of Community Safety
- Hazardous Industries and Chemical Branch Workplace Health and Safety Queensland (HICB)
- Commonwealth Department of Infrastructure, Transport, Regional Development and Local Government.

Issues to consider during the consultation and development of the emergency management plans include:

- Roles and responsibilities
- Emergency preparedness
- Access to site
- First response and available resources
- Evacuation procedures
- Communication and reporting.

The following are Australia Pacific LNG's response principles for incidents, emergencies, and/or crises at the LNG facility and are derived from ConocoPhillips' systems:

- Place the highest response priority on human health and safety
- After human health and safety, protecting the environment shall constitute the next highest response priority
- Over respond until the extent of the incident and/or crisis is understood. It is far easier and more acceptable to "ramp down" than to "ramp up" in the face of a deteriorating or misunderstood situation
- Respond quickly - there is only a short time within which to establish a credible response
- Apply the highest quality/intensity of technical and/or operational efforts to control the problems and normalise conditions
- Uphold commitments to ethical behaviour by communicating in an honest and forthright manner
- Protect the reputation and credibility of Australia Pacific LNG. The sincerity, honesty, and integrity of the Australia Pacific LNG must be maintained as a primary response objective.

### *Planning process – five primary phases*

#### Phase 1: Understand the situation

The first phase includes gathering, recording, analysing, and displaying situation, resource, and incident-potential information in a manner that will facilitate:

- Increased situational awareness of the magnitude, complexity, and potential impact of the incident

- The ability to determine the resources required to develop and implement an effective emergency action plan.

#### Phase 2: Establish incident objectives and strategy

The second phase includes formulating and prioritising measurable incident objectives and identifying an appropriate strategy. The incident objectives and strategy must conform to the legal obligations and management objectives of all affected agencies, and may need to include specific issues relevant to critical infrastructure.

Reasonable alternative strategies that will accomplish overall incident objectives are identified, analysed, and evaluated to determine the most appropriate strategy for the situation at hand. Evaluation criteria include public health and safety factors, estimated costs, and various environmental, legal, and political considerations.

#### Phase 3: Develop the plan

The third phase involves determining the tactical direction and the specific resources, reserves, and support requirements for implementing the selected strategies and tactics for the operational period.

Before the formal Planning Meetings, each member of the Command and General Staff are responsible for gathering certain information to support the proposed plan.

#### Phase 4: Prepare and disseminate the plan

The fourth phase involves preparing the plan in a format that is appropriate for the level of complexity of the incident. For the initial response, the format is a well-prepared outline for an oral briefing. For most incidents that will span multiple operational periods, the plan will be developed in writing.

#### Phase 5: Execute, evaluate, and revise the plan

The planning process includes the requirement to execute and evaluate planned activities and check the accuracy of information to be used in planning for subsequent operational periods. The general staff will regularly compare planned progress with actual progress. When deviations occur and when new information emerges, it will be included in the first step of the process used for modifying the current plan or developing the plan for the subsequent operational period.

### *Emergency management structure*

Australia Pacific LNG’s structure for emergency response is based on three levels of incident management. Each element has its own specific and mutually beneficial primary objectives, as follows:

#### Emergency response groups

These are the onsite response organisations responsible for physically responding to and controlling emergency situations that may develop on site. An emergency response plan is developed which identifies emergency response actions and the roles and responsibilities of the emergency response group (ERG) personnel.

The ERG’s primary objectives are to:

- Respond to and control emergencies
- Implement emergency response objectives and tactical plans

- Render personnel and facilities safe by the application of local resources
- Provide and maintain regular information updates to the incident management team (IMT).

#### Incident management team

The IMT under the leadership of the Incident Commander consists of tactical command, operational, planning, logistic, business Interruption and support personnel and are responsible for providing advice and logistical support for the ERG and managing the operational and technical aspects of the incident.

The IMT primary objectives are to:

- Provide immediate tactical support to the ERG
- Protect employees, contractors and members of the public from injury or illness as a result of an incident
- Liaise with appropriate support agencies to assist ERG members in emergency situations
- Minimise injury to people and damage to assets and the environment
- Provide and maintain regular information updates to the crisis management team (CMT).

#### Crisis management team

The CMT, under the leadership of the Crisis Manager, is responsible for the overall management of the incident from a strategic, legal, ethical and public information aspect.

The CMT primary objectives are to:

- Provide direct strategic guidance and support to the IMT as required
- Provide assistance and support to affected personnel and families
- Consider the strategic, legal and public image aspects of the incident
- Attend to all media issues
- Assure compliance with applicable regulatory requirements in an emergency situation.

## 22.6.2 Emergency response plans

### *Hydrocarbon spills*

#### Hazards associated with petroleum product and chemical spills

The welfare of all personnel attending the spill will be afforded the highest priority.

Some light petroleum products flash off or evaporate rapidly; hence a risk may exist of personnel coming into contact with hydrocarbon vapour. Some chemicals may release toxic fumes, particularly if they come into contact with other incompatible substances, resulting in a chemical reaction.

All persons should keep clear of gaseous areas until those areas are confirmed safe for entry. Personnel aboard vessels assisting with control or monitoring of the spill will be instructed not to allow any smoking and to stay upwind of the spill.

Prior to entering a potentially contaminated area, a job hazard analysis or job safety analysis will be conducted to determine whether a hazardous material response is required. Protective clothing must be provided to anyone who will be required to come into contact with, or be exposed to, petroleum hydrocarbons or chemicals during any clean-up operations.

The difficulties associated with clean-up activities during periods of high temperatures must be acknowledged when considering work rosters. Arrangements must include the provision of drinking water, and protection from the sun, and appropriate rest and food.

### Construction phase

During the construction phase, construction management will be responsible for providing training and/or orientation to employees or subcontractors that addresses the proper action regarding spills.

The most effective spillage control system is prevention. To ensure that the adequate quantity and type of spill response materials/equipment are readily available to address potential spills when the petroleum products arrive onsite, Australia Pacific LNG will evaluate the nature and frequency of various activities that pose the potential for spills/leaks. Based on these evaluations, Australia Pacific LNG will obtain the adequate spill response material and equipment prior to the petroleum products arriving on the project site.

All contractor vehicles (e.g., utility vehicles), heavy equipment (e.g., dozers, excavators), pumps, and generators will have spill kits that, at a minimum, will contain sufficient oil absorbent material to contain (e.g., oil absorbent boom) and cleanup any drips, leaks, or spills (e.g., ruptured hydraulic line) and plastic bags to contain any contaminated absorbents, soils, or wastes. Bags containing used cleanup material will be transported to the designated hazardous material/waste storage area for proper drumming, labelling, and classification prior to off-site disposal. Spill kits for equipment maintenance, fuel storage areas, and fuel trucks will also contain sufficient absorbent material to contain the quantity of the material stored in the stationary containers (e.g., tanks, drums, cylinders) and equipment to cleanup (e.g., shovel, broom) and store used absorbent material (e.g., 200 litre drum with metal banded lid).

### Minor spill to land

A minor spill will be identified by quantity of material released. In this case, up to 20 litres of oil/fuel material is released will be considered a minor spill.

The sequence of actions for a minor hydrocarbon spill to the ground is:

- Stop flow
- Notify site supervision
- Barricade area
- Pick up material
- Contain for disposal
- Dispose of material
- Notification of Site Environmental Coordinator (SEC).

### Major spill to land

A major spill will be identified by the quantity of material released. More than 20 litres of liquid material released to atmosphere/ground will be considered a major spill.

The sequence of actions for a major hydrocarbon spill to the ground is:

- Stop flow
- Notify site supervision
- Barricade area
- Notify site environmental coordinator
- Evaluate danger to workers and surrounding communities
- Develop action plan
- Reporting - Australia Pacific LNG will be responsible for making all official notifications to Governmental agencies (e.g. DERM, and GPC).

### Spill to water

A spill to water is usually considered more serious than a spill to the ground because of the tendency of the water to carry the pollutant over a large area. This being the case, any amount of fuel/oily material spilled to a body of water shall be considered a major spill.

The sequence of actions for a hydrocarbon spill to water is:

- Prevention by design
- Stop flow
- Prevent spread
- Notify site supervision
- Notify SEC
- Undertake corrective actions.

As with a major spill to the ground, all spill clean-up and mitigation for spills to water will be coordinated by the SEC. Because of larger affected areas, and the added dimension of the water as a conduit for the contamination, special equipment, and licensed contractors may be needed to remediate the area. Government agencies (eg. DERM, GPC) may have specific requirements that must be met to assure that the area is remediated.

### Marine collision

Shipping protocols will continue to be developed to minimise the likelihood of collisions (with another vessel underway), grounding, striking (another vessel not underway such as anchored or berthed), and impact (with a fixed structure such as a berth). An emergency plan will be developed in consultation with MSQ, GPC and emergency services to describe actions to be taken if any of these events occur. Actions will include notification to MSQ and emergency services as appropriate. Spills to water resulting from a marine collision will be dealt with as described above.

## *Cyclones*

The LNG facility is located in an area that is regularly subjected to cyclonic activity during the cyclone season. The cyclone season in the Queensland extends from January to March, however cyclones can occur outside of that period.

The path of a cyclone is often erratic and difficult to forecast accurately thereby requiring sufficient planning to prepare for the potential impact on the LNG facility.

A cyclone watch is issued if a cyclone or potential cyclone exists and there are strong indications that winds above gale force will affect coastal or island communities within 24 to 48 hours of issue. The message contains a brief estimate of the cyclone's location, intensity, severity category, and movement, and identifies the coastal area that could be affected. Watch messages are updated every six hours and issued to the public.

A cyclone warning is issued as soon as gales or stronger winds are expected to affect coastal or inland communities within 24 hours. It identifies the communities being threatened and contains the cyclone's name, its location, intensity (including maximum wind gusts, its severity, and its movement. Forecasts of heavy rainfall, flooding, and abnormally high tide are included where necessary.

#### Preparation plan – marine

Under current arrangements, the Bureau of Meteorology issues a tropical cyclone watch when a tropical low or a cyclone is located within the forecasting district, but not expected to bring gale force winds to the Gladstone area within the next 24 hours. This watch will be issued by radio and television stations. If this tropical cyclone watch is issued, the LNG Vessel Master will be contacted by the Terminal Representative and/or GPC to provide information of the cyclone watch status. There will be a similar requirement to contact any construction vessels within in the area.

If the vessel is in Gladstone Harbour at the time, the Harbour Master is required to secure the vessel for sea, have engines and crew on one hour notice and maintain a continuous radio watch.

If the cyclone is expected to cause gale force winds in the Gladstone area within the next 24 hours, the Bureau of Meteorology issues a tropical cyclone warning. Any significant changes or developments will be broadcasted in Flash warnings to attract attention. Updated warnings will be issued every three hours and repeatedly broadcasted. The Harbour Master will direct all port operations.

When a tropical cyclone warning has been issued, the LNG Vessel Master will be informed by the Terminal Representative and/or Gladstone Port Corporation and will be instructed to depart for sea beyond port limits. The LNG Vessel Master will manoeuvre to keep safe and clear from the cyclone outside the Port Limits until such time as the Port is re-opened by the Harbour Master.

#### Preparation plan – LNG facility

Prior to cyclone season the LNG facility site will be inspected and prepared for cyclone season to a level that will be determined during detailed design. An Australia Pacific LNG emergency response plan will be developed during detailed design and commissioning shall come into effect once a cyclone watch has been issued. The LNG facility has been designed to withstand the worst weather conditions likely to occur. Therefore it is intended that these facilities shall remain partially manned by operations personnel during cyclonic conditions.

A skeleton staff (critical manning) of essential personnel will be required to remain on site to maintain plant operation and the emergency shutdown system if required.

The minimum critical manning requirements for operation will be:

- Operations Supervisor
- Control Room Supervisor
- Operations Technician (Electrical)
- Operations Technician (Mechanical)

- Security personnel.

Once the critical manning levels have been determined essential personnel to meet the critical manning levels will be identified by the Shift Supervisor. Shift change and the projected path and timing of the cyclone will be taken into account when determining the identity of these essential personnel. Emergency facilities for these personnel will be provided.

During the cyclone watch period a plan of essential personnel will be developed by the Shift Supervisor. This plan will ensure that all nominated personnel have had sufficient time to prepare and secure their own homes.

Once all non essential personnel have been sent home from site the Operations Supervisor will take whatever actions are deemed necessary to protect the safety of personnel, plant and the environment.

### *Tropical storms*

In addition to cyclones, Gladstone is situated in an area that is subject to severe storms at any time of the year.

Dangers associated with severe storms are:

- Hail (diameter of 2 cm or more)
- Wind gusts (90 kph or greater)
- Flash floods
- Storm surge
- Storm tides
- Lightning.

In order to obtain advanced warning of severe storms, weather mapping systems are available which identify the location and approach of thunderstorms. This will enable accurate monitoring of the approaching storms to allow for loading operations to LNG carriers to be suspended within a safe time frame and also to suspend all outdoor activities involving personnel until the storm passes.

### *Fire*

A detailed plan for response to fire during construction works and facility operation will be developed during the construction and commissioning activities, typical fire management systems on similar sites include:

- Policies for smoking on site
- Procedures for obtaining hot work permits
- Educating the workforce about specific fire hazards and risks
- Supply and use of fire extinguishers. Hand-held extinguishers are provided for general use and trolley mounted extinguishers for larger fire risk areas and fuel storage
- Water truck with pump to fulfil limited fire fighting requirements
- Polices for storage and use of flammable materials
- Volunteer fire response team with appropriate training
- Drill and practice for first responders

- Coordination with local fire and rescue services brigade with jurisdiction
- Process plant fire would typically result in the entire facility, or individual unit being depressured and isolated to reduce the inventory of hydrocarbon.

Prior to these systems being incorporated into fire management plan, FEED and detailed design phases will implement a range of fire prevention and protection measures into the LNG facility design.

These measures would include:

- Passive fire protection, consisting of fire proofing equipment identified as being at risk of exposure to excessive heat flux during a fire
- Pool fire and boiling liquid expanding vapour explosion prevention by limiting pool size with collection and impoundment structures, controlling ignition sources and active fire protection (water monitors)
- Fire and gas detection systems throughout the facility for plant fire, gas and liquid spill detection
- Fire water systems designed to NFPA 59A and AS 2419
- LNG tank relief valve vent fire suppression
- Gas turbine fire protection
- Extinguishing systems activated by smoke and gas detectors.

As the design develops Australia Pacific LNG will examine potential fire scenarios and consider options for associated fire waste water management including such aspects as the potential toxicity of the fire waste water.

A general action plan for a fire during facility operations would be as below:

- Confirmed fire detection will result in a general site alarm accompanied by a PA/radio announcement
- Fixed fire extinguishing systems such as deluge or $CO_2$ would operate automatically in the event of confirmed fire detection
- On operation of the general site alarm, all personnel will proceed to the designated muster point.

As the design develops Australia Pacific LNG will examine potential fire scenarios and consider options for associated fire waste water management including such aspects as the potential toxicity of the fire waste water.

### *Medical emergency*

A detailed plan for response to any foreseeable medical emergency (including potential mass casualty events) during construction works and facility operation will be developed during the construction and commissioning activities and reviewed/updated for the operations phase. Typical medical emergency management systems on similar sites include:

- Industrial paramedics on site, or similarly trained personnel
- Senior first aiders within the workforce
- First-aid post/medical centre

- On-site ambulance(s)
- Trained personnel – such as for rescue of injured person from height
- Contracted doctors to provide advice over the phone
- Video-conference facilities in the medical centre to assist with remote diagnosis
- Formal channels to escalate site requirements – such as through the local Department of Health.

Similar medical emergency management systems will be provided for the Project. In addition, a helipad will be provided at Curtis Island for use in case of a medivac.

#### *Terrorist activities*

Detailed security planning will be undertaken in accordance with Queensland counter-terrorism and critical infrastructure protection policies. The LNG facility will included a number of security measures as discussed in the section 22.5.4.

Maritime security plans for the marine facilities and shipping activities will be developed in accordance with the *Maritime Transport and Offshore Facilities Securities Act* 2003.

#### *External threat*

The facility ERP will outline specific measures in case of a threat from external facilities such as an adjacent LNG facility, massive release of ammonia from the Orica facility on the mainland, etc as appropriate.

As the design develops such external threats will be considered and appropriate management measures provided (eg shelter in place procedures will be considered, and appropriate aspects incorporated in the design of accommodation areas and habitable structures, designated muster points provided with HVAC controls, etc.)

## 22.7 Conclusion

### 22.7.1 Assessment outcomes

The LNG facility will be storing approximately 480,000m³ (~250,000 tonnes) of LNG and hence is expected to be classified as an MHF. As an MHF Australia Pacific LNG will design, build and manage operations in accordance with the regulations for an MHF. It should be noted that the ConocoPhillips LNG plant in Darwin has been operating under MHF requirements since 2006 without significant incident.

The LNG facility will be located in the Gladstone State Development Area and within an industrial area. The off-site risks meet all the minimum requirements of a MHF in an industrial area. In particular, the $50 \times 10^{-6}$ individual fatality risk contour is well inside the site boundaries indicating a high level of compliance with the acceptability criteria set by HICB.

Consequence modelling and analysis has also been undertaken to consider the effects of a worst credible scenario (vapour cloud explosion and radiation). Even under this analysis the impacts of the modelled scenarios were contained within the site.

Likelihood analysis of shipping incidents in Gladstone Harbour was undertaken. Shipping risks have largely been mitigated by the proposed use of four tugs and a pilot while in the port. These will provide sufficient control in managing the transit through the port to minimise the likelihood and consequence of incidents. These protocols will apply to all LNG facilities.

Worldwide, LNG facilities have an excellent safety history. This includes the processing plants, marine terminals, and shipping. LNG has been produced and transported for over 50 years in increasing quantities. This safety record has been achieved by ongoing improvements in the design, construction, and operations of LNG facilities. Supporting this are the requirements of the DGSM Act, as well as a number of International and Australian standards.

### 22.7.2 Commitments

Australia Pacific LNG commits to the following:

- Continuing hazard and risk studies throughout the project life including HAZOPs, HAZIDs, constructability studies and operability studies
- Continue consultation with Civil Aviation Safety Authority and Gladstone Regional Council Airport Services to determine an appropriate course of action to manage any potential impact to aviation safety
- Communicate project health and safety practices and results of relevant monitoring through a range of channels such as Australia Pacific LNG's community centre, consultation sessions, media and meetings
- Developing a safety report to cover major hazard facility requirements during the project design phase and update as required during the operations phase.

## References

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