18 HAZARD AND RISK

This chapter provides an update to the Queensland Curtis LNG (QCLNG) Project's draft environmental impact statement (EIS) *Volume 5, Chapter 18: Hazard and Risk,* and the key issues from the public submissions that relate to this chapter. *Table 5.18.1* outlines issues raised in the public consultation process undertaken by QGC, with a response from QGC alongside.

Table 5.18.1 Response to Submissions on draft EIS

Issue Raised	QCLNG Response	Submission No
Cumulative impact on the shipping channels from all LNG facilities and existing users should be considered with regard to risk of collision, explosion or some form of deliberate harm and that these risk profiles should be calculated on a worst case scenario.	BG Group shipping will comply with international standards including Society of International Gas Tanker and Terminal Operators (SIGTTO), and Oil Companies International Maritime Forum (OCIMF). These standards provide guidance for the safe loading and transport of LNG across the world. The channels are being designed according to Permanent Association of Navigation Congresses (PIANC) and International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) recommendations and tested by extensive marine simulation. All large ships are under the control of a trained local Gladstone pilot. LNG ships will utilise "Escort Class" tugs throughout the channel transit. Initially, passing between LNG ships and other large ships will not be permitted. Should future port capacity requirements make passing necessary, passing procedure will be developed and controlled by the harbourmaster. The Gladstone Port Harbourmaster will be approving each ship to enter the port and the circumstances under which all ships can enter and leave the port. The harbourmaster's role is to ensure that safety zones and shipping exclusion zones are adhered to during transport of all types of material including LNG. QGC and BG Group shipping are working with the harbourmaster to ensure that all standards are met and that all parties are aware of any risks relevant to shipping and that the appropriate contingency planning is undertaken to minimise any human health impacts or environmental harm. For further detail on risks relating to explosion and deliberate harm, refer to responses to the Issues Raised in the next two rows below.	2
Calculated risk profiles based on worst case scenarios for shipping incidents and plant incidents should be published in the EIS. Not summary information.	Summary information only can be provided for security reasons. However, the draft EIS and the supplementary EIS have provided updated risk profiles for further consideration by assessing authorities and the general public. It should be noted that QGC has provided these documents to the Queensland Government for assessment and advice.	2

Issue Raised	QCLNG Response	Submission No
LNG plant and LNG ships pose a significant terrorist threat to Gladstone and Queensland. The draft EIS has not impact-assessed the risk of terrorism and possible impacts to the local community.	Deliberate harm which includes an act of terrorism has been excluded from the quantitative risk assessments (QRA). Federal and state agencies in Australia are responsible for assessing threats on critical infrastructure. An assessment at Gladstone found that the introduction of the liquefied natural gas industry to the port would not change existing threat levels. The International Ship and Port Facility Security Code (ISPS Code) (included as amendments to the *Safety of Life at Sea Convention, 1974* (SOLAS Convention) to which Australia is a party) requires a security plan for the vessel and another plan for the port. The security response will escalate according to the ISPS maritime threat level set by the Australian authorities.	2
The EIS needs to assess the shipping aspects of the EIS with regard to the SIGTTO standards to determine if the proposed LNG and shipping requirements will be in compliance with these standards. The EIS should assess if the QCLNG Project will meet its duty of care requirements for public safety as detailed in these standards.	BG Group is a member and a board member of SIGTTO. BG Group has been a key driver to developing and improving these standards. BG Group shipping, terminals and infrastructure will comply with those standards that are relevant. Where these standards are not appropriate, other internationally recognised standards (such as PIANC, IALA, OCIMF, as applicable) will be applied.	2, 6
The worst case scenario should be based on two tanks failing which would spread methane and LNG in an 7 mile radius covering Gladstone has not been assessed by the EIS.	The submission referring to a 7 mile radius is based on newspaper reporting of a report relating to a LNG terminal in the United States, and is not directly applicable to the QCLNG Project. Notwithstanding, QCLNG considers that a 7 mile spread of LNG and methane without encountering an ignition source is not credible, and thermal hazards associated with fire from a catastrophic tank failure would occur within a much smaller radius. Further, the double hull vessel construction means that in the unlikely event of grounding of an LNG vessel in Gladstone Harbour, bottom penetration would not reach the LNG cargo tank and result in loss of containment.	2
It has been requested that the QCLNG Project relocates the LNG plant and shipping activities to a remote location such as Port Alma.	Port Alma was included as a candidate's site within the site selection process, and was rejected on the basis of a range of factors, including safety issues relating to shipping. Key factors included: • Port Alma has insufficient land for a 3 train LNG plant that is easily accessible to LNG shipping, and has insufficient marine area for a clear 600 m diameter swing basin • Port Alma is a low lying site requiring large amounts of fill and with high potential for flooding and inundation • Use of Port Alma entails unworkable transit procedures for safety zones around the major existing import and export trade of ammonium nitrate.	2

Issue Raised	QCLNG Response	Submission No
QGC should follow US Government practices regarding shipping details and hazard zones, QGC should advise the Gladstone people of the terrorist implications and risks and in addition provide advice to the Gladstone people of worst case risk scenario and consequences i.e. number of deaths and locations; medical treatment plans, emergency response plans.	BG Group has a number of shipping terminals in the US, where these standards are applicable and where these standards are higher than other local standards, BG Group employs these standards. The quantitative risk assessment for the LNG Facility includes assessment of consequences of catastrophic failure. However, risks (likelihood) of deliberate harm which includes an act of terrorism has been excluded from the risk assessments, as Federal and state agencies in Australia are responsible for assessing threats including threats of deliberate harm on critical infrastructure such as the QCLNG Facility and shipping operations. An assessment conducted at Gladstone by these agencies found that the introduction of the LNG Industry would not change the existing threat levels.	2
The draft EIS has not considered the state Government's ''duty of care'' to protect Queenslanders from potential terrorist attacks. The Project would introduce a new level of risk to attract terrorist acts.	The Federal and state government agencies in Australia responsible for assessing threats on critical infrastructure have conducted an assessment at Gladstone and found that the introduction of the LNG industry to the port would not change existing threat levels.	2
Any cost/benefit analysis must consider the cost of supplying emergency services including emergency medical services in the event of a terrorist incident or an emergency incident that would have an impact on the local population.	Impacts of LNG operations and incidents were considered as part of the social impact assessment and the hazard and risk assessment outlined in *Volume 5, Chapter 18*. QGC will provide primary health care and medical services for QGC staff and contractors and will assist in the co-ordination of any emergency response required for QGC and local residents on Curtis Island and the mainland. QGC health, safety, security and environment (HSSE) and medical staff will be required to develop emergency response plans with local emergency services which would include emergency planning for any impacts from deliberate harm. The emergency response required for any attacks of deliberate harm would be of national and state interest and thus, the Queensland Government's Department of Emergency Services would play a lead role in facilitating any large-scale emergency response required.	2
It is important to link the Emergency Response Plan with the local Disaster Management Plan.	QGC will provide its Emergency Response Plan to local hospitals and emergency services for consultation and inclusion to any other plans that state or local authorities may have. QGC is committed to supporting local and state disaster management plans and programs. Emergency response plans will include a program of drills and exercises which will be conducted as appropriate in conjunction with emergency service providers.	8
Detail required as to the difference between risk area for propane and LNG shipping.	Propane spiking of LNG is no longer included within the Project description, and therefore bulk shipments of propane are no longer required (smaller volumes of propane, transported and stored in ISO containers, will still be used on site as a refrigerant in the liquefaction process).	21

Issue Raised	QCLNG Response	Submission No
Provide information on the handling procedures for both these types of vessels and how they differ and if there are any safety issues between the two types of vessels.	Additional processes regarding safety and security of LNG vessels are being developed with the Gladstone harbourmaster. Propane spiking of LNG is no longer included within the Project, and therefore no bulk LPG ships will operate at the QCLNG facilities.	25
LNG shipping provides a hazard and risk to the community: probability of catastrophic risk if there is a failure or shipping incident.	BG Group is a member and a board member of SIGTTO. BG Group has been a key driver to developing and improving these standards. BG Group shipping, terminals and infrastructure will comply with those standards that are relevant. Where these standards are not appropriate, other internationally recognised standards will be applied.	2, 6, 31

18.1 MANAGING RISKS AND HAZARDS

The LNG industry involves hazardous operations as described in *Volume 5, Chapter 18* of the draft EIS. However, it was clear from the submissions received that there were some concerns that the LNG industry posed an additional risk to health and safety for the Gladstone community.

QGC with BG Group has ensured that the highest level of technical excellence is applied to the design and operations of both the QCLNG Project and the export of LNG to the market. QGC has engaged independent third party experts to undertake risk assessments for the LNG Facility and the loading of LNG onto its carriers. QRAs have been submitted to the Queensland Hazardous Industries Chemical Branch (HICB) for assessment.

In general, quantitative risk assessment is a highly complex and technical field. QGC has developed a ‘‘plain English’’ description of how quantitative risk assessments are applied. This document, ‘‘Quantitative Risk Assessment Explained’’, is now available to the public and provides advice relating to:

- how QGC manages risks and hazards
- a description of how quantitative risk assessment has evolved and how it is used
- how it is applied to the oil and gas industry
- provides a description of imposed risk versus voluntary risk
- details how risk is calculated
- how consequences are determined
- how deliberate harm is managed and determined
- how strategies are developed to ensure communities are safe.

With regard to keeping communities safe, this complicated process produces a simple and direct result: either a risk is acceptable, or it is not.

In determining if a risk is acceptable or not, standards of risk which projects like the QCLNG Project must meet are defined by regulators and by industry engineering and operating standards. Engineering standards for the LNG Facility, LNG carriers and LNG terminals have all been developed with risk and with impacts from deliberate harm being considered. International safety and security standards have also been utilised, and are represented in standards, materials of construction to be used, safety devices and the development of a range of security and safety plans that must be developed to obtain relevant government approvals.

The risk contours that are described in *Volume 5, Chapter 18* of the draft EIS and are further defined in this chapter determine where a plant and its operations can go to ensure that existing residential areas do not fall within these contours. New residential developments would not be permitted to be developed within these contours either. However, QGC understands that these contours may provide a level of comfort to some people and not others. Additional safety features include, but are not limited to:

- safety briefings for community members, visitors and staff
- sensors through the plant that are monitored by computer in the main control room and reported to a number of staff for action should an alarm be triggered
- detailed safety management plans focused on both QGC workers, Curtis Island residents and the wider Gladstone community
- shipping procedures and safety zones, currently under discussion with the Gladstone harbourmaster.

Furthermore, regulators require that industrial developments present a fatality risk to the residential public no greater than a one-in-a-million chance in a year. Any development that poses a significantly greater risk than this to the public for any aspect of its activities is not allowed to proceed and the proponent must find ways to make it safer. QGC does not have any operations that provide a fatality risk greater than a one-in-a million chance in a year to the residential public.

Finally, QGC and BG Group shipping have been party to the assessments conducted by the state and commonwealth agencies on the assessment and management of risks from deliberate harm, or terrorism. The details cannot be made public for obvious reasons. The assessment at Gladstone has found that the introduction of the LNG industry to the port would not change the existing threat levels.

BG Group, with QGC, is committed to ensuring that its operations do not pose an unnecessary risk to local communities. Should any community member wish to speak with QGC representatives regarding these risk assessments or the design and operations of the QCLNG Project, QGC or BG Group will make the appropriate person available to discuss any concerns.

The following section details the amendments to the baseline risk assessments and identifies any changes to risk profiles or impacts as a result of further refining of the LNG Facility or operations.

18.2 AMENDMENTS TO BASELINE AND UPDATE OF IMPACTS

The draft EIS described the hazard identification and risk assessment process for the LNG Facility and LNG shipping (*Volume 5, Chapter 18, Section 18.4* of the draft EIS). Quantitative risk assessment outcomes specific to the LNG Facility and shiploading operations were described in *Section 18.4.2* and *Section 18.4.3* of the draft EIS respectively. These risk assessments have been revised to take into account changes to the Project description (as described in *Volume 2, Chapter 9* of this sEIS), and in particular:

- LNG loading jetty has been moved further south from what was described in the draft EIS, with the new location providing approximately 600 m between the manifold and southern plant boundary
- the QCLNG Project no longer proposes spiking of LNG with propane prior to export, and consequently the bulk propane storage tank shown in the draft EIS has been removed from the design along with ancillary equipment associated with bulk unloading and storage of propane at the site. Bulk LPG carriers to deliver propane for LNG spiking are no longer required
- tanks and other infrastructure in proximity to the foreshore moved further east
- reduction in LNG tank capacity from 160,000 m^3 (as assumed in the QRA for the draft EIS) to 140,000 m^3 for the revised QRA.

18.2.1 LNG Facility QRA

The QRA methodology undertaken for the sEIS was generally as described in the draft EIS (*Volume 5, Chapter 18, Section 18.4.2*), amended as appropriate to reflect process and design changes as outlined above. A summary of risk quantification outcomes of the QRA[1] is provided below.

18.2.1.1 Risk Quantification

As stated in the draft EIS, the risk posed by hazardous materials is often expressed as the product of the probability of occurrence of a hazardous event and the consequences of that event. In order to quantify the risk associated with hazardous fluids, it is necessary to quantify the probabilities of accidents that would release the fluids into the environment, and the consequences of such releases. The release frequencies and potential

1 Quest Consultants Inc 2009. Preliminary Quantitative Risk Analysis for the BG Queensland Curtis LNG Liquefaction Facility. Revision E, November 17, 2009

consequences must then be combined using a methodology that accounts for the influence of weather conditions and other pertinent factors.

Where applicable, impact levels used were based on *Hazardous Industry Planning Advisory Paper No. 10 – Land Use Safety Planning* (2007) (HIPAP10). This guidance document is published by the New South Wales Department of Planning, and is a combination of two earlier guidance documents referred to as HIPAP4 and HIPAP6. The risk acceptability criteria set forth in the HIPAP documents have been adopted for use by Queensland[2].

Toxic Exposure Impacts

The QCLNG Facility does not process, produce, store, import, or export any acutely toxic materials. Thus, there are no potential toxic impacts associated with releases from the LNG terminal.

Heat Radiation Impacts

A wide range of release scenarios and their associated radiant impacts were developed, and a composite vulnerability zone for radiant impact was prepared, with impacts assessed as defined by HIPAP (*Table 5.18.2*). It should be noted that these vulnerability zones do not provide any information about the frequency or probability of an event, nor do they specify the unique area impacted by any one fire event in the terminal. Due to these limitations, vulnerability zones do not represent any measure of the risk posed by the terminal with the composite vulnerability zone developed following the evaluation of thousands of unique release and fire events. Each unique event has a small probability of occurrence.

Composite vulnerability zones at or above the radiant flux level of 4.7 kW/m^2 (see *Table 5.18.2*) are fully contained within the LNG Facility boundary to the south, east and north (apart from along the pipeline corridor), extending only beyond the site boundary into marine areas.

The maximum radiant impact distances calculated for catastrophic events, including:

- BLEVE (Boiling Liquid, Expanding Vapour Explosion) of propane (refrigerant) storage vessel
- BLEVE of an ethylene (refrigerant) storage vessel
- catastrophic failure of full containment LNG storage tank (with a calculated probability of occurrence of 1 in 100 million years)

for radiant flux level of 4.7 kW/m^2 (see *Table 5.18.2*) are fully contained within the LNG Facility boundary to the south, east and north.

2 DES (2002), Queensland Department of Emergency Services, Chemical Hazards and Emergency Management Services unit. http://www.emergency.qld.gov.au/chem/publications/pdf/Interim_Risk_Objectives_for_MHFs.pdf

Table 5.18.2 HIPAP Defined Radiant Impact Levels

Radiant Flux Level (kW/m^2)	Defined Impact per HIPAP10
1.2	Received from the sun at noon in summer.
2.1	Minimum to cause pain after one minute
4.7	Will cause pain in 15-20 seconds and injury after 30 seconds exposure (at least second-degree burns will result). *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. After long exposure, the temperature of wood rises to a point where it can be readily ignited by a naked flame. Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure.
23.0	Likely fatality for extended exposure and chance for fatality for instantaneous exposure. Spontaneous ignition of wood after long exposure. Unprotected steel will reach thermal stress temperatures which can cause failures. Pressure vessel needs to be relieved or failure will occur. *This flux level not to be exceeded at adjacent industrial areas more than 50 x 10^{-6} per year.*
35	Cellulosic material will pilot ignite within one minute's exposure. Significant chance of fatality for people exposed instantaneously

Explosion Overpressure Impacts

When a flammable vapour cloud that is contained or partially contained in a congested area of the LNG terminal reaches an ignition source, it has the potential to generate some amount of overpressure depending on the reactivity of the material and the degree of congestion in the area. There are several locations (each denoted as a potential explosion site, or PES) in the LNG Facility where damaging explosion overpressures could be generated, as well as many potential combinations of fuel reactivity and volume filled for each PES.

Vulnerability zones, as defined by the HIPAP10 overpressure endpoints, were calculated as composite vulnerability zones for all 17 PESs identified for this study. All calculated overpressure levels as defined by HIPAP10 for defined overpressure impact levels for the LNG Facility fall within the onshore boundary.

Fatality and Injury Risks

The risk an individual is potentially exposed to by events that originate in the LNG Facility can be represented numerically. This measure represents the probability of an individual being exposed to a fatal hazard during a year-long period.

Table 5.18.3 Risk Level Terminology and Numerical Values

Numerical Value	Shorthand Notation	Chance Per Year of Fatality
1.0×10^{-3}/year	10^{-3}	One chance in 1,000 of being killed per year
1.0×10^{-4}/year	10^{-4}	One chance in 10,000 of being killed per year
1.0×10^{-5}/year	10^{-5}	One chance in 100,000 of being killed per year
1.0×10^{-6}/year	10^{-6}	One chance in 1,000,000 of being killed per year
1.0×10^{-7}/year	10^{-7}	One chance in 10,000,000 of being killed per year
1.0×10^{-8}/year	10^{-8}	One chance in 100,000,000 of being killed per year

HIPAP10 uses the following definitions of acceptable and unacceptable risk limits for new industrial installations located near residential developments:

- Risk levels lower than 1.0×10^{-6} per year are defined as acceptable for residential areas.
- Risk levels greater than 1.0×10^{-6} per year are defined as unacceptable for residential areas.

The HIPAP10 guidelines also define risk acceptability as a function of both the numerical risk value and the population at risk. Different acceptability criteria are defined based upon the composition of the potentially exposed population, and are summarised in *Table 5.18.4* below.

Table 5.18.4 HIPAP Suggested Individual Fatality Risk Criteria

Land Use	Suggested Criteria (risk in a million per year)
Hospitals schools, child-care facilities, old-age housing	0.5 (expressed as 0.5 x 10^{-6}/yr)
Residential, hotels, motels, tourist resorts	1.0 (expressed as 1.0 x 10^{-6}/yr)
Commercial developments including retail centres, offices and entertainment centres	5.0 (expressed as 5.0 x 10^{-6}/yr)
Sporting complexes and active open space	10 (expressed as 10.0 x 10^{-6}/yr)
Industrial	50.0 (expressed as 50.0 x 10^{-6}/yr)

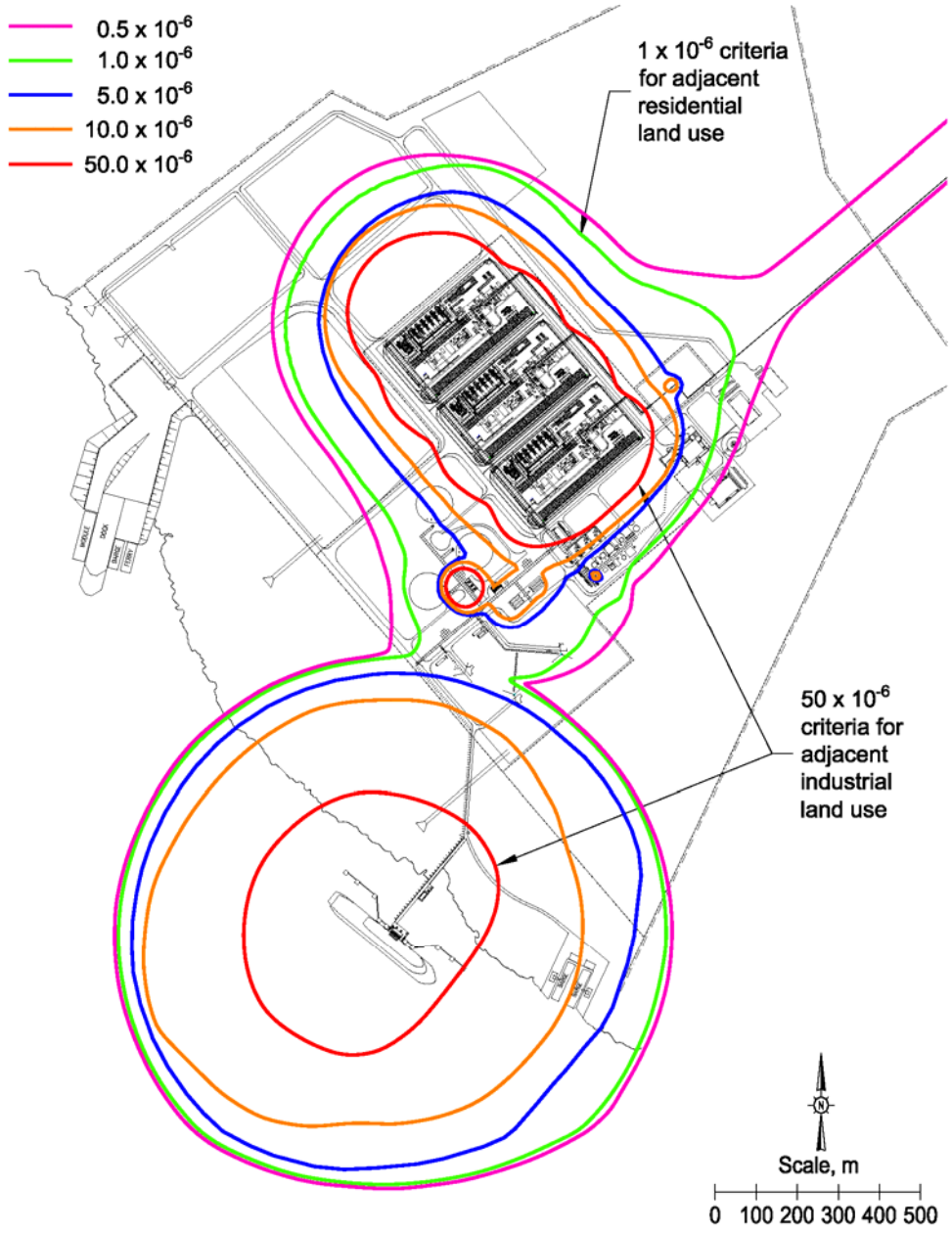
Figure 5.18.1 presents the risk contours (to the levels defined in the HIPAP guidelines) for the LNG Facility. Each contour illustrates the annual risk to persons in the area of the terminal as a function of their location, based on fatal exposure to any of the hazards associated with all releases originating within the liquefaction units, the associated natural gas inlet pipeline, product and refrigerant storage, the product export lines leading to the marine loading dock, and the LNG ship loading operations. For example, the contour labelled 10^{-6} in *Figure 5.18.1* represents one chance in one million per year of being exposed to a fatal hazard from any of the possible releases of flammable material from the terminal. Because the risk contours are based on annual data, this level of risk is dependent on an individual being in the location where the 10^{-6} contour is shown 24 hours per day, 365 days per year.

From *Figure 5.18.1* it can be seen that:

- Except for areas along the incoming gas pipeline, none of the risk contours for the land-based portion of the facility extend into areas beyond the facility property line.
- In the areas along the pipeline on Curtis Island affected by the 0.5 x 10^{-6} risk level (risk level applicable to hospitals schools, child-care facilities, old-age housing as per HIPAP guidelines presented in *Table 5.18.4 above)*, there are no public developments.
- Due to the offshore portions of the facility (surrounding the marine loading/unloading area), risk levels higher than 10 x 10^{-6} (and all lower levels) extend beyond the facility property lines at the southeast corner of the site, but there is no impact to public areas.
- There is no potential impact to future neighbouring industrial sites due to the fact that the 50 x 10^{-6} risk contour does not extend beyond a property line that can be built upon (i.e., the 50 x 10^{-6} risk contour only extends beyond the property boundary along the seaward side of the Facility).

In summary, all the HIPAP risk criteria are satisfied by the layout and design of the LNG Facility. This is due to the low level of risk associated with terminals of this scale and design as well as the location of the terminal in an uninhabited area away from any residential development.

Figure 5.18.1 Risk Contours for the QCLNG Facility - HIPAP Risk Levels (Fatality Risk per Year)



Note: The contours shown consider the risks associated with shiploading infrastructure on the LNG Jetty, but do not include actual shiploading operations. Risk levels associated with shiploading are described separately

18.2.2 Shipping Risk Assessment – Berthing and Ship Loading

In addition to the LNG Facility QRA described above (which includes product lines to the LNG jetty and ship loading operations), Lloyd's Register has updated the marine QRA assessing the LNG carrier berthing/unberthing and

cargo transfer operations[3]. As described in the draft EIS, this QRA includes hazard identification, consequence analysis, frequency and likelihood analysis, and risk analysis and assessment.

Overall, the the likelihood and consequences a range of accident scenarios associated with the loading of LNG have been estimated quantitatively and the risks compared to the land use planning criteria in use in Queensland. The risks associated with the berth loading and unloading meet the injury risk criterion of 50×10^{-6} at residential areas (based on 4.7 kW/m^2 heat radiation injury risk criteria from HIPAP 4[4]). The risks also meet the fatality risk criteria of 0.5×10^{-6} at sensitive land uses, 1×10^{-6} at residential areas, 10×10^{-6} at commercial areas and 50×10^{-6} at neighbouring industrial facilities.

18.3 CONCLUSION

In conclusion, BG Group is a world leader in natural gas and has successfully developed and managed liquefied natural gas (LNG) facilities in the United States, Trinidad and Tobago, Egypt and Wales without major incident.

The BG Group has played and continues to play a key role in developing international standards for the LNG industry, including shipping. BG Group has ensured that security measures to be implemented as part of the QCLNG Project meet local, national and international standards and BG Group's global security and safety policies, procedures and protocols. In particular, the BG Group is a signatory to the SIGGTO standards and ensures that all of its operations meet these and other international standard as appropriate.

QGC with BG Group has ensured that the highest level of technical excellence is applied to the design and operations of both the QCLNG Project and the export of LNG to the market. QGC has engaged independent third party experts to undertake risk assessments for the LNG Facility and the loading of LNG onto its carriers. QRAs have been submitted to the Queensland Hazardous Industries Chemical Branch (HICB) for assessment.

To this end, the BG Group and QGC conclude that the development of the QCLNG Project on Curtis Island does not increase the existing public safety risk level to the people of Gladstone and surrounding region.

3 Lloyd's Register, 2009. LNG Carrier Loading & LPG Carrier Unloading Safety: Quantitative Risk Assessment of LNG/LPG Carriers at Berth at Gladstone Port . unpublished report for BG LNG Services, Report # HOU/MCS/Q09-002 Rev. 6, October 2009

4 NSW Department of Urban Affairs and Planning (1992). Hazardous Industry Planning Advisory Paper No. 4, 'Risk Criteria for Land Use Safety Planning'