

# Public Safety

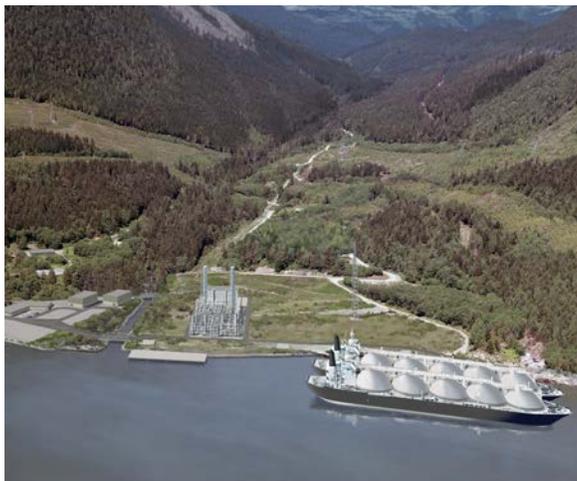
## DID YOU KNOW?

During operation, major accidents at LNG facilities are very rare. LNG is not explosive in an unconfined environment. Only two large explosions at LNG facilities are known to have occurred in the past 60 years. An explosion and fire in Ohio occurred in 1944 because of leaks from an LNG tank constructed from inappropriate material. In 2004, an explosion occurred in Algeria because of a steam boiler problem (boilers are not part of the Project design). Standards for modern LNG facilities have benefited from the lessons learned from these accidents, and include design requirements that avoid these accidents.

## DID YOU KNOW?

Natural gas in liquid form cannot burn or explode. This is because LNG does not contain oxygen, which is required for either of those reactions to occur. If LNG were to come in contact with the air, it would start to return to a gas. Since natural gas is less dense than air, it would evaporate into the atmosphere.

LNG does not persist in the environment. It is odourless, colourless, non-corrosive, and leaves no residue.



Woodfibre LNG Limited is of the view that safety is the number one priority, and that the Project will be developed in a manner that ensures the safe, shared use of Howe Sound.

**Section 11.0 Accidents and Malfunctions** of the Environmental Assessment Application assesses the effects of potential accidents and malfunctions resulting from the construction and operational phases of the Woodfibre LNG Project. The assessment is based on the Preliminary Quantitative Risk Assessment (QRA) conducted by Lloyd's Register Consulting, located in **Appendix 11-1** of the Application. The Preliminary QRA analyses the frequency and consequences of credible worse case scenarios, then provides additional recommendations and mitigation measures to be adopted within the design.

Woodfibre LNG Limited engaged Abbott Risk Consultants out of the United Kingdom to act as their independent expert reviewer to confirm and validate the assumptions in the Preliminary QRA model.

It is worth noting that the Preliminary QRA is the first step in assessing associated Project risk. A further detailed QRA and additional site specific safety studies will be undertaken as detailed design progresses to further identify potential hazards, assign mitigating measures, and to ensure any risk are as low as practically possible.

Thirteen accident and malfunction events were considered in the Application, and an additional six events of particular concern were addressed in a **Supplemental Report on Accidents and Malfunctions** at the request of the Environmental Assessment Office.

Events assessed included those resulting from:

- spills of hazardous materials
- failure of containment structures
- motor vehicle collisions
- marine vessel groundings, allisions or collisions
- inappropriate operation of machinery or equipment
- loss of containment of LNG
- unplanned facility shutdowns
- explosion or fire

With the implementation of effective Project design, management and contingency measures, none of the events were found to be categorized in the high or very high risk rating as defined within the Application. Furthermore, risks to the public were within the tolerable well below acceptable level of risk criteria regulated by the BC Oil and Gas Commission (OGC). The OGC will include a review of the QRA in the permit application review to confirm that the study and results meet the regulated requirements.

## PUBLIC RISK

Of all the accident and malfunction events considered, only four have the potential to interact with members of the public. The effects of the remaining events are contained inside the proposed facility boundary, which is inaccessible to the public. The four events that pose potential risk to the public include:

1. LNG release and flammable ignition from a potential loading arm failure.
2. LNG release and flammable ignition from a potential rupture of the floating LNG storage and offloading unit
3. A potential collision and loss of LNG containment between an LNG carrier and a passenger ferry
4. A potential collision and loss of LNG containment between an LNG carrier and a marine recreational vessel

### DID YOU KNOW?

Both Woodfibre LNG Limited and the LNG carriers will carry insurance, including coverage for any potential spills or discharge of pollutants, both marine and on-land. Woodfibre LNG Limited will ensure that LNG carriers destined for the Woodfibre LNG terminal will hold a valid contractual arrangement with the Western Canada Marine Response Corporation, under the Canada Shipping Act 2001 Part I – Pollution Prevention and Response.

For each event, a credible worst-case scenario was determined and assessed for potential effects to the public. By definition, a credible worst-case scenario is one where the likelihood of occurrence is low, but not out of the realm of possibility and severity of impact is high. For each of the four events listed above, the potential effects to the public resulting from a credible worst-case scenario are severe or lethal injury. However, the likelihood of occurrence is so rare that the overall risk to public safety in each event is extremely low.

### LNG release and flammable ignition from a potential loading arm failure

Once the Woodfibre LNG facility becomes operational, LNG will be transferred to LNG carriers via loading arms on the Floating Storage and Offloading (FSO) unit. A potential full loading arm rupture during offloading operations and release of LNG to Howe Sound could result in a subsequent pool or flash fire, provided the LNG vapour is within the flammable range and an ignition source is present. This would represent the credible worst-case scenario with potential affects to public safety.

Results from the Preliminary QRA show that the effects of this scenario have the potential to extend approximately 410m past the Project boundary. If a member of the public was present within this potential zone during this particular event the risk would be a fatality; however, the probability of this event occurring is one in every 1.75 million years. Given the low likelihood of the scenario and the Project site being located more than 5km from any residential development, public risk associated with a loading arm failure is considered to be very low.

### LNG release and flammable ignition from a potential rupture of the floating LNG storage and offloading unit

Before being transferred to LNG carriers, LNG will be stored on a permanently moored floating storage and offloading unit. A marine accident involving a large vessel and the floating storage and offloading unit has the potential to result in a loss of containment and LNG release to Howe Sound. Passing recreational and fishing vessels are too small to generate sufficient energy in the event of a collision to breach the robust double hull and LNG containment of the floating storage and offloading unit.

Additionally, LNG carriers are very unlikely to collide with the floating storage and offloading unit since they will be piloted by two BC Coastal Pilots and assisted by at least three tugboats when being slowly manoeuvred against the floating storage and offloading unit during mooring. Furthermore, a dedicated fendering system will be installed on the outer hull of the floating storage and offloading unit as an additional protection mechanism.

Other passing tankers or larger commercial vessels will avoid the Project's marine Control Zone, which exceeds the minimum clearance required between a passing vessel and moored vessel. Although a release from the floating storage and offloading unit could result in an injury or fatality to members of the public outside the facility boundaries, an LNG release to sea is expected to be unlikely and extremely low.

### A potential collision and loss of LNG containment between an LNG carrier and a passenger ferry

There have not been any historical events where a ship-to-ship collision with an LNG carrier has resulted in loss of containment. Historical data shows that although eight LNG carrier collisions were reported between 1971 and 2011, not a single one resulted in a release of LNG.

A release of LNG from an LNG carrier collision would only occur under a very specific set of circumstances. These circumstances require the colliding vessel to be at least 50,000 deadweight tonnes, travelling at a minimum of 12 knots, and the strike must occur at a 90-degree angle to the LNG Carrier in order to generate sufficient energy to penetrate the LNG carrier's double-hull and robust LNG containment system. The same set of specific circumstances is applicable for a potential rupture to occur within the floating storage and offloading unit.

## DID YOU KNOW?

The LNG carriers employed for the Project will be double-hulled ships specifically designed to handle liquefied natural gas at its  $-162^{\circ}\text{C}$  temperature, with state-of-the-art safety and security technology. LNG is not compressed but is always transported at atmospheric pressure.

Only outgoing carriers contain LNG. Consequently, a collision between two vessels carrying LNG will not occur in the marine corridor for the Project.

## DID YOU KNOW?

The Woodfibre LNG Project facility will be self-sufficient in terms of fire prevention and emergency response at the facility. The facility would have several elements of protection, including spill detection along with backup and emergency shutdown systems.

## DID YOU KNOW?

From 1964 to the end of 2012, close to 70,000 loaded cargos of LNG were shipped around the world without major incident both at port and at sea (International Group of Liquefied Natural Gas Importers, 2012). This means over 140,000 return journeys without a significant incident.

The largest vessel in the BC ferry fleet is not of sufficient size and would not be travelling at a speed required to breach the LNG carrier's double hull. The largest ferry transiting in Howe Sound is 13,600 deadweight tonnes and travels on a parallel path to the LNG carrier route (i.e., no potential for a collision at  $90^{\circ}$ ). This, combined with the fact that there has never been a release of LNG from a collision, suggests that the risk to public safety from a collision between a LNG carrier and passenger ferry is very low.

Although the conditions and existing vessel sizes transiting Howe Sound do not meet the requirements for a loss of containment, the effects associated with this scenario were considered. The potential effects to public safety depend on several factors. These factors include the amount of LNG released, whether and when the LNG ignites, and the proximity of ferry passengers to the release point. The released LNG would pool within the hull of the vessel and on the water surface, where it would spread and boil off, forming a vapour cloud that would disperse into the atmosphere. The vapour cloud would consist mostly of methane and since methane gas is lighter than air, it would disperse quickly to the upper atmosphere.

A zone of freezing and potential asphyxiation would extend approximately 120 m from the LNG carrier and to a height of 3 to 5 m above the seawater surface, which is not high enough to affect ferry passengers. The surface of the sea would rapidly cool, and if there were other vessels nearby, depending on the height of the vessel impacted, humans aboard vessels in the freezing zone could experience cryogenic burns and frostbite if LNG contacts their skin. The freezing zone is only applicable to the area above the water surface, with no effects experienced beneath the surface of the water.

LNG is only flammable in a very specific vapour range and requires an ignition source to combust and start a fire. In the event of a spill due to a collision, the friction and energy of the impact would most likely result in an immediate ignition of the vapour cloud. An immediate ignition limits the dispersion of an LNG vapour cloud and associated fire to the area immediately around the LNG carrier breach. Ignition of the LNG would cause a flash fire that would burn back to the source of the spill and then burn in a pool fire until the leak has stopped. The most significant impacts to public safety and property exist within 250m of such a spill.

In the less likely event that following a collision there is a delay in the ignition of the vapor cloud, a zone of impact larger than 250m could be created as the vapor cloud has more time to travel away from the immediate area around the LNG carrier breach. The results of the Quantitative Risk Assessment indicate that this extremely unlikely scenario could result in a vapour cloud that is still within its flammable range extending 408m from the LNG carrier breach.



## A potential collision and loss of LNG containment between an LNG carrier and a recreational vessel

The risk of a collision between an LNG carrier and a marine recreational vessel is very low as recreational vessel operators are expected to avoid being in close proximity to LNG carriers, and are required to adhere to current collision regulations that include a responsibility for vessel operators to avoid accidents, not impede the passage of large craft, and keep proper lookout to prevent accidents. In addition, LNG carriers are unlikely to collide with another vessel since they will be piloted by two BC Coastal Pilots and assisted by a minimum of three tugboats. Two tugboats will be positioned to the rear of the LNG carrier at either side and one tugboat will run lead (up to 500m in front) creating a dynamic safety zone around the LNG carrier.

LNG carriers will be traveling within designated shipping lanes; however, their size limits their capacity to change course in response to the presence of a recreational or commercial vessel in their path. A recreational vessel that is struck by a LNG carrier could experience several outcomes, including a change of course, capsizing and fragmentation of the recreational vessel from contact with the carrier. A collision between an LNG carrier and recreational vessel would not result in a breach of the carrier's hull and consequently would not result in a loss of containment since recreational vessels are not of sufficient size to generate the force required to rupture the double-hull of an LNG carrier.

### Mitigation measures

Woodfibre LNG Limited will implement several measures to minimize the likelihood of events that could negatively affect the public and to maximize the effectiveness of contingency measures in the unlikely circumstance that such an event occurs. Some of these mitigation measures include:

**Use of Modern LNG Carriers:** Woodfibre LNG Limited will require the use of modern LNG carriers that have design measures compliant with international regulations. These LNG carriers use double-hull and double-bottom configurations, forward collision bulkheads, double-wall bunker oil tanks, independent LNG cargo areas, LNG tanks separated from the engine room, and water sprayers on the decks and sides of the carrier to help control fires.

**Compliance with Canadian and International Regulations:** LNG carriers and other vessels associated with the Project will be required to comply with the Canada Shipping Act and associated regulations, the Pilotage Act and associated Pacific Pilotage Regulations for non-pleasure craft vessels over 350 gross tonnes transiting BC, as well as the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

**Use of Tugs and Experienced BC Coast Pilots:** All LNG carriers will use a minimum of three tugboats to assist LNG carriers and carriers will be boarded and guided by two experienced, licensed marine pilots who are intimately familiar with the local coastal conditions, navigational hazards, weather patterns, and maritime regulations governing shipping in BC.

**Adherence to Designated Speed and Shipping Lanes:** LNG carriers will be required to follow designated shipping routes. LNG carriers and other vessels will be required to reduce speeds to a maximum of 10 knots between the south end of Passage Island (entrance to Howe Sound) and the Project site. Upon reaching the immediate vicinity of the Project site, speed will be reduced to 6 knots.

**Implementation of Emergency Response Plan:** The Woodfibre LNG Project will include contingency measures in its Emergency Response Plan that consist of closing valves and securing hazardous material or LNG in its containment vessel to eliminate the source of the release.