Woodfibre LNG Project

PLANNED AND EMERGENCY FLARING
Supplemental Report to the Application for an Environmental Assessment Certificate

June 2015

Woodfibre LNG Limited
1020 – 1075 W Georgia St.
Vancouver, BC V6E 3C9

Woodfibre LNG

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1.0 INTRODUCTION

Woodfibre LNG Limited is proposing the development and operation of a liquefied natural gas (LNG) production facility with marine storage and off-loading (Project) near Squamish, British Columbia. The Application for an Environmental Assessment Certificate (Application) for the Project is currently under review and a request has been received to provide additional information regarding the flaring associated with the Project and its potential for environmental effects.

To address the information request and assess potential effects, this memo follows the approach described in the following steps:

- Description of the Project components related to flaring
- Description of the potential flaring events
- Identification of potential interactions with intermediate components (IC) and valued components (VC) selected for the Project
- Assessment of residual effects to VCs, including mitigation measures

The information in this memo is based on the preliminary design information, and supplements the information and activities presented in **Section 2.2** of the Application. As the design of the Project progresses, the updated information will be included in the submissions to the Oil and Gas Commission (OGC) as part of the application for an LNG Facility Permit under the *LNG Facility Regulation*.

2.0 DESCRIPTION OF EVENTS

2.1 DESCRIPTION OF FLARING COMPONENTS

Flaring systems are used in LNG facilities to prevent the accumulation of natural gas and protect plant components from overpressure. The flaring system will allow for the safe disposal of waste gases when vented or burned during maintenance and emergency situations without exceeding permissible exposure limits for heat radiation and substances hazardous to health. In British Columbia, the height and location of the flare stack must be designed to meet OGC and Canadian Standards Association (CSA) standards for LNG projects, including safety and heat dispersion. The preliminary design for the flare stack for the Project consists of a derrick structure with an overall height of approximately 130 m above sea level. It will be located on the north side of Mill Creek at the northwestern end of the Project, and will be sufficiently separated from other Project components for safety and regulatory purposes. The specific area around the flare stack to be kept clear of vegetation and process components will be determined during final Project design. The location of the flare stack within the Project area is shown in **Appendix 1**.

Emergency and controlled releases of hydrocarbons shall be directed to the flare which is a designed to safely dispose these releases. The flare has pilot lights which enable ignition of hydrocarbon releases to ensure total combustion of the hydrocarbons exiting the flare. These pilot lights are typically 300 mm to 600 mm in height and located at the top of the flare tip with shrouding so as not to be directly visible, although at night will emit a visible glow. An example schematic of a flare system is shown in **Appendix 2**, illustrating the gas sources and types. Natural gas burns very cleanly and typically there will be no smoke associated with flaring. In the event there is combustion of heavier hydrocarbons, particularly during an emergency event, some black smoke may be produced for a very limited period of time.

2.2 DESCRIPTION OF POTENTIAL FLARING EVENTS

The flare system is designed to safely reduce the gas pressure at the plant during emergency shutdowns as well as during operational controlled situations. Controlled flaring shall include maintenance, loading of LNG carriers, unplanned shutdowns and also minor process upsets. Once Project construction is completed, flaring will occur under controlled conditions during introduction of hydrocarbons for start-up and commissioning of plant and equipment. Information is provided below regarding each of the flaring scenarios. Overall, it is anticipated that flaring will occur less than 3% of the time.

- **Normal Operation:** Flaring will not occur during normal plant operation. However pilot lights shall remain continuously lit, this is to ensure total combustion of hydrocarbons if released.
- **Planned Shutdowns:** Planned flaring for LNG facility maintenance is typically expected to occur approximately once per year. For planned flaring, the timing and volume of flaring can be controlled. Under this scenario, flaring will occur during the daylight hours over the period of up to one day, with flares up to 4 m above the flare stack.
- **Loading of LNG Carriers:** Depending on the temperature of incoming LNG carrier storage tanks, intermittent flaring may result during initial ship loading, this is to assure control of systems

pressure. Such flaring is anticipated each month, and would require a 30 m flare for approximately 20 to 30 minutes.

- **Unplanned Shutdowns:** Flaring may also occur during an unplanned shutdown (e.g., process upsets or trips). Based on experience with operational LNG facilities, there may be as many as four trips annually. During an unplanned shutdown, there may be a full flare of 50 to 60 m in height above the flare stack, lasting up to five minutes. Depending on the type of the operational trip, it may be possible to hold the natural gas or recirculate the natural gas in the system while resolving the cause of the trip. In these cases, gas may be held or recirculated for up to one day without needing to flare, providing an opportunity to control the timing of the flare – for example to postpone to daylight hours.
- **Emergency Events:** In an emergency event, it may be necessary to immediately depressurize the entire LNG facility, resulting in a full flare of approximately 50 m to 60 m in height above the flare stack for up to 10 minutes. Based on experience with operational LNG facilities, Woodfibre LNG Limited's operational goal is to limit the frequency of such emergency events to less than once every five years.
- **Start-up and Commissioning:** Start-up and commissioning occurs only when feed gas is introduced at the beginning of facility operation. During the approximately three to four week start-up and commissioning period, which occurs only once during the lifespan of a project, equipment will be tested for safety and reliability, and some of the tests will require full flares. It is anticipated that there will be intermittent flaring periods lasting up to three or four days at any one time during the month-long stat-up and commissioning and start-up phases.

2.3 REGULATORY REQUIREMENTS AND GUIDELINES

Woodfibre LNG Limited will acquire all permits required by law to build and operate the Project. As part of the permitting phase of the Project, Woodfibre LNG Limited will consult with the relevant regulatory agencies to fully define permitting requirements. Legislation and guidelines relevant to flare stacks and flaring include:

- *Oil and Gas Activities Act and LNG Facility Regulation*
- *Flaring and Venting Reduction Guideline (OGC 2013)*
- *British Columbia Noise Control Best Practices Guideline (OGC 2009)*
- *CSA Z276 – LNG – Production, storage and handling (CSA 2011)*
- *American Petroleum Institute Standard 521* Pressure Relieving and Depressurising Systems
- *Canadian Aviation Regulations – Obstructions to Aviation, Obstruction Clearance Permit*

2.4 THERMAL RADIATION CALCULATIONS

Allowable thermal radiation levels are established in the *LNG Facility Regulation*, Schedule 1, section 4(3). These allowable thermal radiation levels are presented in **Table 1** and **Table 2**. As part of obtaining a Facility Permit for the Project, Woodfibre LNG Limited will be required to demonstrate that the Project complies with these set thermal radiation levels.

Table 1 Allowable Thermal Radiation Flux[1] Inside Facility Boundaries

Column 1	Column 2	
Targets Inside Boundary	Maximum Thermal Radiation Flux (kW/m^2)	
	Normal Flow Rate[1]	Accidental Flow Rate[2]
Peak within sterile area	5	9
Outer edges of restricted area	N/A	5
Roads and open areas	3	5
Tanks, other than LNG storage tanks, and process equipment	1.5	5
Control rooms, maintenance workshops, laboratories, warehouses and other occupied structures within the LNG facility	1.5	5
Administrative buildings	1.5	5

[1] normal flow rate results from all operating modes within the LNG facility design intent

[2] accidental flow rate is the highest flow rate that results from an uncontrolled or unplanned event and is the sum of combined flow rates from all possible uncontrolled or unplanned scenarios that may occur simultaneously

Table 2 Allowable Thermal Radiation Flux[1] Outside Facility Boundaries

Column 1	Column 2	
Targets Outside Boundary	Maximum Thermal Radiation Flux (kW/m^2)	
	Normal Flow Rate[1]	Accidental Flow Rate[2]
Remote area	3	5
Critical area[3]	1.5	1.5
Other areas	1.5	3

The American Petroleum Institute defines recommended design thermal radiation for personnel (**Table 3**). These thermal radiation levels are provided as context for the Project-specific thermal radiation calculations presented later in this section.

[1] Excluding solar radiation

Table 3 Recommended Design Thermal Radiation for Personnel

Permissible design level K kW/m^2 (Btu/h·ft^2)	Conditions
9,46 (3 000)	Maximum radiant heat intensity at any location where urgent emergency action by personnel is required. When personnel enter or work in an area with the potential for radiant heat intensity greater than 6,31 kW/m^2 (2 000 Btu/h·ft^2), then radiation shielding and/or special protective apparel (e.g. a fire approach suit) should be considered. **SAFETY PRECAUTION — It is important to recognize that personnel with appropriate clothing [a] cannot tolerate thermal radiation at 6,31 kW/m^2 (2 000 Btu/h·ft^2) for more than a few seconds.**
6,31 (2 000)	Maximum radiant heat intensity in areas where emergency actions lasting up to 30 s can be required by personnel without shielding but with appropriate clothing [a]
4,73 (1 500)	Maximum radiant heat intensity in areas where emergency actions lasting 2 min to 3 min can be required by personnel without shielding but with appropriate clothing [a]
1,58 (500)	Maximum radiant heat intensity at any location where personnel with appropriate clothing [a] can be continuously exposed

[a] Appropriate clothing consists of hard hat, long-sleeved shirts with cuffs buttoned, work gloves, long-legged pants and work shoes. Appropriate clothing minimizes direct skin exposure to thermal radiation.

The calculations presented herein assess credible radiation and dispersion scenarios for flaring. These calculations identify the radiation characteristics from the lit flares (during normal operation and emergency flaring scenarios). The worst-case accidental load on the flare has been considered to pose the worst-case credible radiation hazards, with all releases from a single release point at the flare tip.

The calculations are presented as figures showing thermal ratiation contours. For normal operation flows, Figures 1 to 3 show the 1.5 kW/m^2, 3 kW/m^2, and 5 kW/m^2 radiation contours. For accidental (emergency) flows, Figures 4 to 6 show the 3 kW/m^2, 5 kW/m^2, and 9 kW/m^2 thermal radiation contours. All figures are looking at a profile of the flare tower with the top of that tower at 130 m on the y-axis.

Additional calculations and dispersion modelling with respect to thermal radiation from the flare will be undertaken during detail design to assess the effects to personnel and equipment within the facility boundaries and outside the facility boundaries.

Figure 1 Radiation Contours for 1.5 kW/m^2 under Normal Operation

Figure 2 Radiation Contours for 3.0 kW/m^2 under Normal Operation

Figure 3 Radiation Contours for 5.0 kW/m^2 under Normal Operation

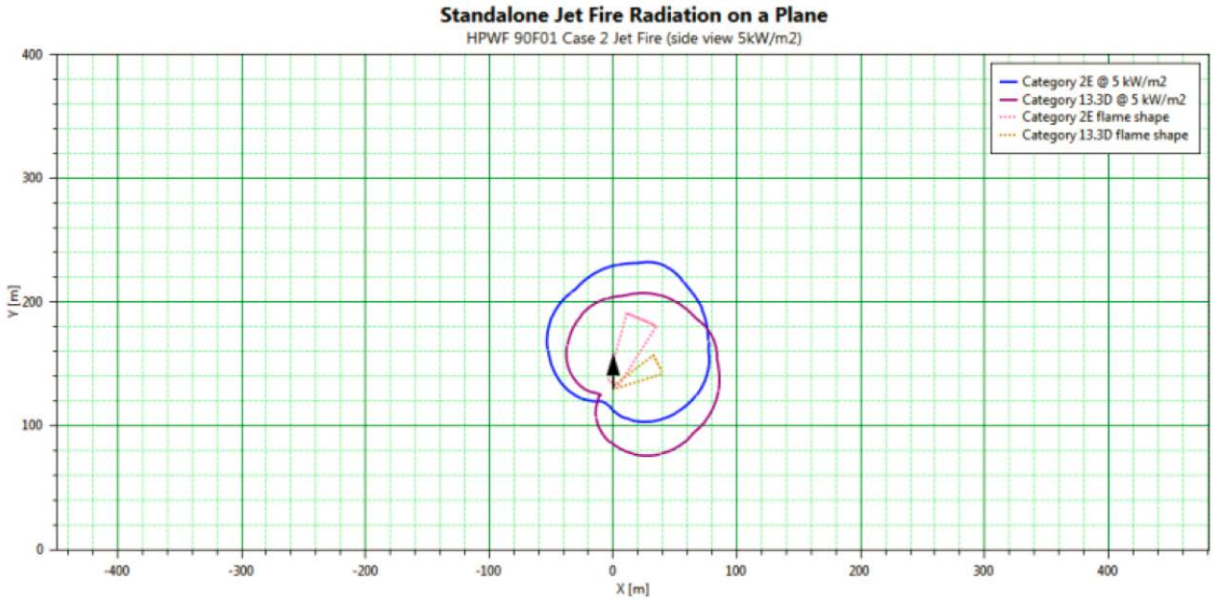


Figure 4 Radiation Cuntours for 3.0 kW/m^2 under Emergency Operations

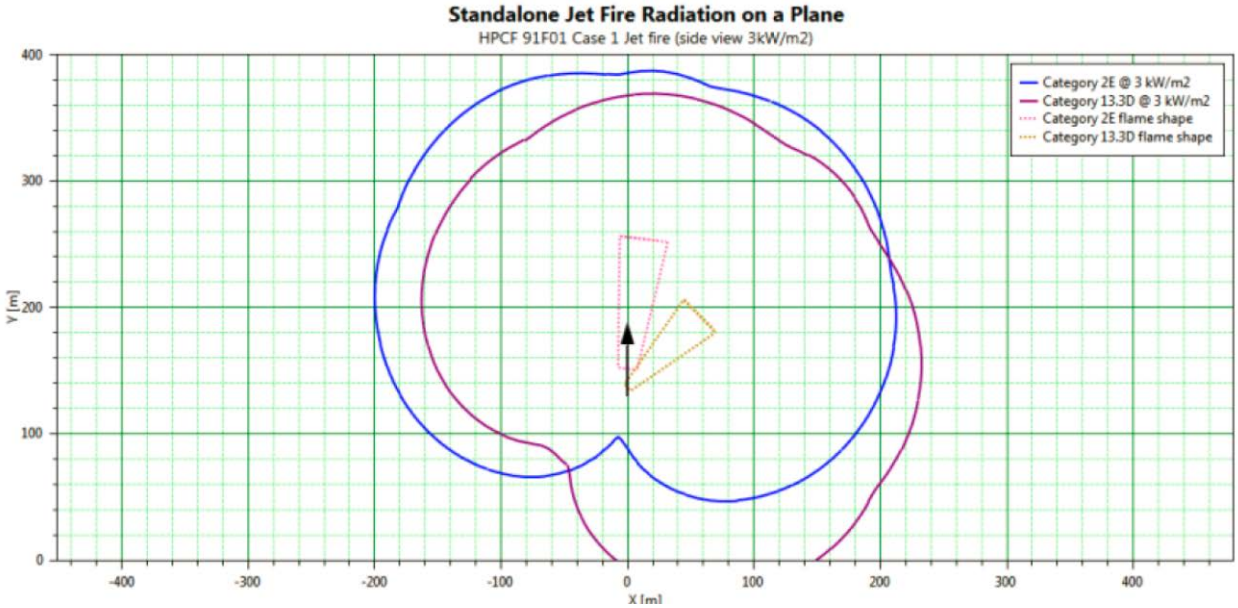


Figure 5 Radiation Contours for 5.0 kW/m^2 under Emergency Operations

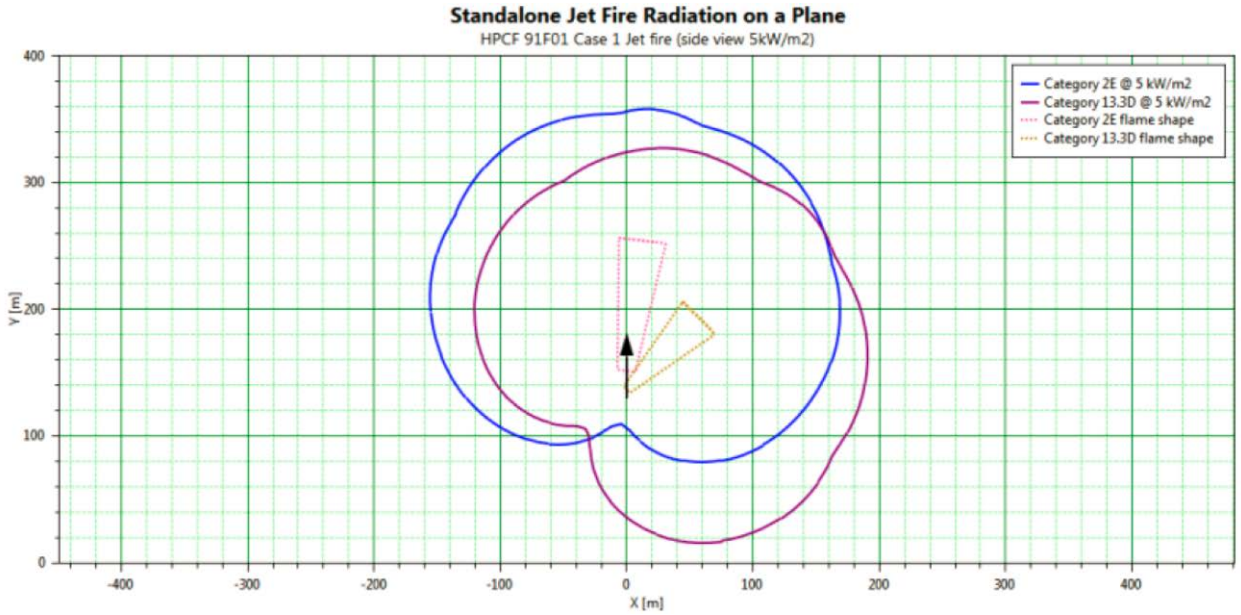
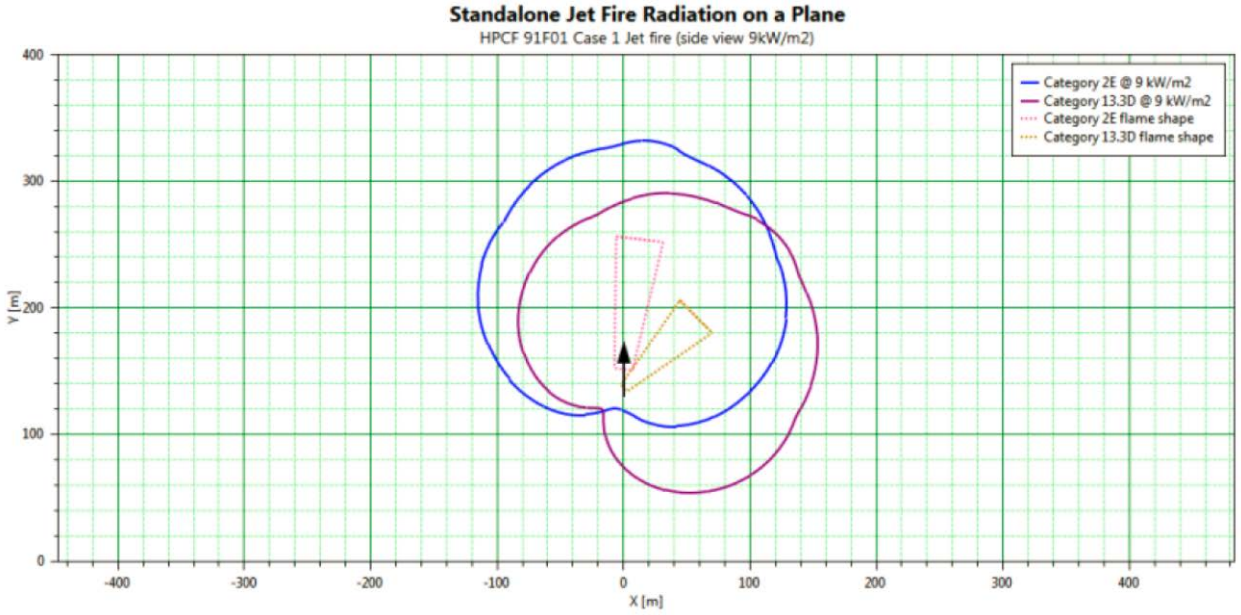


Figure 6 Radiation Contours for 9.0 kW/m^2 under Emergency Operations



3.0 POTENTIAL INTERACTIONS WITH VALUED COMPONENTS

There is a potential for interactions of VCs with the flare stack and flaring during the operation phase of the Project, including commissioning. No interactions are anticipated for construction and decommissioning. The potential for an adverse interaction between an activity associated with the flare stack and flaring and a VC is presented in **Table 4**. Potential interactions identified with an “X” in the table are carried forward for further discussion.

Table 4 Potential Interactions between Project Flaring Activity and Valued Components

Activity	Light	Sound	Atmospheric Environment (air quality)	Greenhouse Gas Management	Avifauna	At-Risk Bats	Marine Birds	Transportation (aeronautical)[2]	Visual Resources	Public Health
Normal Operation										
Pilot light								X		
Emissions			X	X						X
Planned Shutdowns										
Flare					X	X	X	X	X	
Emissions			X	X						X
Loading of LNG Carriers										
Flare	X	X			X	X	X	X	X	
Emissions			X	X	X	X	X			X
Unplanned Shutdowns										
Flare	X	X			X	X	X	X	X	
Emissions			X	X	X	X	X			X
Emergency events										
Flare	X	X			X	X	X	X	X	
Emissions			X	X	X	X	X			X
Start-up and Commissioning										
Flare	X	X			X	X	X	X	X	
Emissions			X	X	X	X	X			X

[2] Aeronautical transportation has been included in the interactions table for the purposes of this memo; however, it is not a VC in the Application.

Potential adverse interactions of flaring with ICs and VCs were identified as listed below and are discussed in the following sections:

- Changes to light and sound
- Effects to air quality, and greenhouse gas emissions, and public health
- Direct mortality effects from the flare stack and flaring (heat radiation) to avifauna, at-risk bats and marine birds
- Effects to aeronautical navigation
- Effects to visual quality from light, mainly at night

4.0 GENERAL MITIGATION

Design measures to reduce the potential effects associated with flaring were described in the Application, including **Section 2.2 Description of the Proposed Project** and **Section 11.0 Accidents and Malfunctions**. Additional information regarding design measures associated with flaring is presented below.

The Project incorporates design elements and controls to maximize the safety of the facility and limit the potential for unplanned flaring. For example, Woodfibre LNG Limited's decision to use electric drive reduces the frequency of flaring due to the reliability of the energy supply.

The Project design includes protection from operational malfunctions (e.g., overpressures, temperature exceedances), human operator error, and risks associated with routine maintenance activities. Furthermore, the Project design will include protection barriers (e.g., high- and low-temperature alarms, level and pressure controls, trip limits) to safely shut down equipment so Project operation occurs within allowable and safe operational ranges. Detectors for combustible gas, fire, smoke, and heat, as well as manual call points will be installed throughout the facility to trigger an alarm in the case of an emergency, and to allow for an immediate and safe shutdown of the facility if a predetermined threshold limit is reached.

In accordance with industry standards and requirements, equipment will undergo regular maintenance and inspection, personnel qualifications will be maintained, and associated documentation will be reviewed and updated on a regular basis.

5.0 ATMOSPHERIC ENVIRONMENT (AIR QUALITY), GREENHOUSE GAS MANAGEMENT, AND PUBLIC HEALTH

Effects to air quality, greenhouse gas (GHG) management, and public health from air emissions are not considered further in this memo as these interactions were addressed in detail in the Application (**Section 5.2 Atmospheric Environment**, **Section 5.3 Greenhouse Gas Emissions**, and **Section 9.2.2 Human Health Risk Assessment**).

For air quality, Project interactions for normal operation (with pilot lights) and upset conditions (with flaring and generators) were determined by quantifying emission rates from onsite activities (**Table 5.2-13** in the Application). The residual effects during normal operations were below air quality criteria. Based on the modelling, the upset conditions were considered limited in nature, and only normal operations residual effects were carried through to the assessment of significance and cumulative effects. The effects to air quality are therefore as described in **Section 5.2** of the Application.

The process flares were one of the GHG emissions sources considered as part of the Application (**Table 5.3-14**). The effects to GHG management are therefore as described in **Section 5.3** of the Application.

The results of the air quality modelling were carried forward into the Human Health Risk Assessment (**Section 9.2** of the Application). Accordingly, flaring is already considered and the effects to public health are as described in **Section 9.2.2** of the Application.

6.0 LIGHT

Flaring was excluded from the assessment because it was not considered to be typical operations (i.e., occurs less than 3% of the time). However, it is acknowledged that flaring could present a temporary and intermittent effect during Project operation.

Measures that will help to mitigate the changes to light associated with flaring include providing notification of planned flaring events and scheduling planned flaring events for daylight hours. Because flaring may be required for safety, these measures can only be implemented for planned events.

7.0 ATMOSPHERIC SOUND

Sound associated with the flare was included in the Application (**Table 5.4-9**). Accordingly, flaring is already considered and the effects to atmospheric sound are as described in Section 5.4 of the Application. The mitigation measures in the Application provide for scheduling of high noise emitting maintenance during the day, notification of residents, and a feedback mechanism for community input, which are in line with guidance for daytime planned flaring and flaring notifications. Because flaring may be required for safety reasons, these measures can only be implemented for planned events.

8.0 AVIFAUNA, MARINE BIRDS, AND BATS

8.1 POTENTIAL EFFECTS

There is a potential adverse interaction for avifauna, marine birds, and at-risk bats during flaring events from the flare stack and flare related to lighting and the flare itself. The potential effects to the avifauna, at-risk bats and marine birds VCs will be dependent on the anticipated presence of the VCs during the event, the timing and duration of the flare, and the distance from the flare in which physical parameters such as heat radiation and light would affect the VCs.

8.1.1 Potential Effects to Avifauna and Marine Birds

Passerine and marine birds are known to be attracted to artificial light sources in otherwise dark environments (Montevecchi et al. 2006). These disruptions in behavior are known to affect the ability of birds to navigate properly (potentially impairing migration), have detrimental energetic consequences, and potentially result in direct mortalities (Reed et al. 1985, Montevecchi et al. 2006, Poot et al. 2008, Rodriguez and Rodriguez 2009, CBC News 2013, Rich and Longcore 2013, Ronconi et al. 2015). The energetic costs of distracted or disoriented migration can be life-threatening, but consequent mortalities can be difficult to document or quantify. Although most documented cases of artificial lighting affecting birds are associated with the emission of light from light fixtures, flares from stacks have also been implicated (Bjorge 1987, CBC News 2013). The most recent known example of effects from flaring resulted in the mortality of an estimated 7,500 migrating birds (mostly passerine) when they flew into, or close-to, a continuous gas flare on the Bay of Fundy coast of New Brunswick, Canada (CBC News 2013). Focal groups occurring in the LAA known to migrate or be active at night that could potentially be affected by Project flaring include passerines, waterfowl, diving birds (e.g., grebes and loons), and owls.

The risk of bird mortalities associated with exposure to flaring is likely to be higher during seasonal migrations, or associated with juveniles (Rich and Longcore 2013). As indicated in **Sections 5.12.3.2** and **5.17.3.2** of the Application, the risk of mortalities increases under inclement weather, such as rainy, foggy or overcast conditions, when nocturnally migrating birds are more likely to adjust flight patterns (e.g., reduce flight altitude) (Rich and Longcore 2013). Adverse effects to birds from exposure to flaring are also possible during daylight hours if a bird flies too close to an exposed flame; however, the likelihood of this occurring is judged to be less than during nocturnal hours when the flame is more visible and has a greater likelihood of altering a bird's behaviour through attraction.

8.1.2 Potential Effects to Bats

Bats are known to forage in artificially lit environments that attract insect prey (Schnitzler et al. 1987, Rydell 1991, 1992, Acharya and Fenton 1999). Artificial lighting and flaring associated with the Project could promote localized concentrations on insect prey and consequently draw foraging bats close to the facility. Eight species of echolocating bats, two of which are of conservation concern (i.e., little brown

myotis (*Myotis lucifugus*) and Keen's myotis (*Myotis keenii*)), were detected in the LAA (see **Section 5.13** of the Application). Since the documented species use echolocation to detect prey when flying, which also assists in avoiding obstacles, the likelihood of direct mortality associated with collisions with Project infrastructure is considered low. The risk of mortality from singeing or burning by bats flying too close to an exposed flare, if the flare causes insects to congregate in larger than normal concentrations, is possible and considered greater.

8.1.3 Potential Effects on Species of Conservation Concern

Species of conservation concern with small or unstable populations can be vulnerable to changes in mortality rates (Shaffer 1981, Longcore et al. 2013). Project-induced mortality of species can have medium or long-term effects on regional populations if the mortality rate exceeds the rate at which natural recruitment could replace individuals within a population (Shaffer 1981, Longcore et al. 2013). Bird and bat species of conservation concern confirmed or possibly occurring within the LAA are:

- Sooty grouse (*Dendragapus fuliginosus*)
- Great blue heron (*Ardea herodias fannini*)
- Marbled murrelet (*Brachyramphus marmoratus*)
- Northern goshawk (*Accipiter gentilis laingi*)
- Western screech-owl (*Megascops kennicottii kennicottii*)
- Band-tailed pigeon (*Patagioenas fasciata*)
- Barn swallow (*Hirundo rustica*)
- Common nighthawk (*Chordeiles minor*)
- Olive-sided flycatcher (*Contopus cooperi*)
- Little brown myotis (*Myotis lucifugus*)
- Keen's myotis (*Myotis keenii*)

Bald eagle is also present, and is one of 57 priority terrestrial avian species included under Environment Canada's Bird Conservation Strategy, part of a pan-North American bird conservation strategy. Marbled murrelet critical habitat identified in a Recovery Strategy (Environment Canada 2014) was subsequently determined through supplemental field work to contain limited foraging and nesting habitat within the Project area and RAA (**Appendix 5.1-1** of the Application).Therefore, the likelihood of this species being present and potentially affected by flaring is considered low.

The species of concern are likely to be at the same risk of Project-related mortality as other species, with the exception of sooty grouse. Sooty grouse typically forage and nest on the ground. When foraging or roosting in trees, they can fly steeply from the ground into trees, hop from branch to branch, or fly between trees. They generally only fly short distances for foraging, roosting, during courtship, or when flushed (Zwickel and Bendell 2005). Given their affinity to the ground and their typically low, short flights, it is unlikely that sooty grouse will interact with any flaring activities.

8.2 PROPOSED MITIGATION

As discussed, the focus of this memo addresses potential effects resulting from flaring; however, implementation of measures to mitigate effects associated with artificial lighting are applicable (see **Section 5.5.3.2** of the Application) and are expected to reduce potential effects of flaring on all species of birds and bats. To further mitigate the potential for effects from flaring on birds and bats the proposed mitigation in the Application has been revised and is presented below:

- The LNG plant will not flare during normal operations.
- Operational conditions that allow controlled flaring will be done when practicable during daylight hours.
- Initial cool down and loading of LNG carriers shall be done during daylight hours whenever possible.
- Should mortalities occur, Woodfibre LNG Limited facility staff will regularly monitor site conditions and report mortalities or incidents to the Woodfibre LNG Limited environmental manager and management, who will include the information in the Wildlife Management Plan (M5.12-1) reporting.
- Prior to commissioning, Woodfibre LNG Limited, in consultation with agencies for the Wildlife Management Plan, will develop a mitigation and monitoring plan as part of the Wildlife Management Plan that will include:
    - Site monitoring of flaring during commissioning, scheduled maintenance, LNG carrier loading, and emergency events for one calendar year, to gain clarity on the effects.
    - Build a historical record of bird and bat interactions with the flare stack and flame.
    - Regular reporting of interactions and any recorded mortalities as a component of reporting in the Wildlife Management Plan
    - The development and implementation of measures, such as hazing techniques, to scare wildlife away from a flaring stack, if determined to be necessary

8.3 RESIDUAL EFFECTS

Limited research has been conducted to document the extent of potential effects of flaring on birds and bats in coastal BC and the effectiveness of mitigations. However, given the anticipated infrequent occurrence and short duration (outside of start-up and commissioning) of anticipated flaring events, and the low likelihood of emergency flare events occurring under a combination of conditions (i.e., during nighttime hours, within a migratory period under foggy or precipitation conditions) that could increase the potential for a large mortality event, effects to birds and bats are anticipated to be minor. Proposed mitigations are expected to further reduce the potential for mortality. Additionally, Woodfibre LNG Limited has committed to report bird and bat mortalities to verify the effectiveness of proposed lighting mitigations and institute an adaptive management plan to address potential unanticipated effects. As such, flaring associated with the Project is not expected to influence the sustainability of regional bird or bat populations and is determined to be not significant. Given limited research is available to document the

extent of mortality associated with the flare tower and flaring and the effectiveness of the mitigation, confidence in the significance prediction is considered moderate.

9.0 TRANSPORTATION (AERONAUTICAL)

The potential aeronautical effects of the Project were not identified during the VC selection process for an assessment as a VC in the Application; however, based on anticipated permitting requirements pursuant to the *Canadian Aviation Regulations*, supplemental information is included in this memo. A permit from Transport Canada for the operation of the helicopter pad at the Project site may also be required.

A potential interaction between flaring events and air transportation was noted in the interactions table. Interactions are related to the height of the flare stack, the potential visibility of a glow from the shrouded pilot light, and the flare itself during flaring events. The helicopter landing site has been located at the far south end of the Project area, approximately 1 km from the flare stack. Interactions between VCs and aeronautical lighting on the flare stack are addressed in the Application (**Sections 5.12 Avifauna, 5.13 At-risk Bats and 5.17 Marine Birds**).

The closest airport to the Project site is Squamish Airport (YSE), approximately 14 km to the north (about 8 km north of downtown Squamish). The District of Squamish is responsible for maintenance of the airport. Many of the services and facilities are the result of private club activities and donations. Activities at this airport include charter services, private aircraft, flying clubs, and other commercial activities; however, there is no regularly scheduled air service. Given the proximity of the Project to a large urban centre, there are numerous other facilities in the region, listed in **Appendix 3**.

There are various commercial and private flights in Howe Sound for sightseeing tours, chartered flights, emergency services, utilities services, film services, and general sightseeing and air time. Air traffic in the Sound consists of float planes, helicopters, small commercial and private planes. Companies operating in the area include:

- Sea to Sky Air (based out of Squamish Airport)
- Harbour Air (includes Whistler Air)
- Black Tusk Helicopter Inc.
- Glacier Air (based out of Squamish Airport)
- Blackcomb Aviation (bases in Squamish, Whistler, Vancouver, Pemberton and other locations)

Woodfibre LNG Limited will apply for permits for the flare stack as required by Transport Canada, and implement Transport Canada permitting requirements, including lighting of the flare stack. Woodfibre LNG Limited will also work with NAV Canada to assess and mitigate the potential effects of the flare stack on the air navigation system. In addition to working with federal agencies, Woodfibre LNG Limited will post

information regarding planned flaring events on their website and conduct active outreach with the local aircraft operators aimed at promoting safe air navigation around the LNG facility. With the implementation of the mitigation measures described, significant adverse effects to aeronautical transportation are not considered likely.

Introductory letters will be sent to the Squamish Airport, Sea to Sky Air, Harbour Air, Black Tusk Helicopter Inc., Glacier Air, and Blackcomb Aviation in June 2015. These letters will introduce the Project, including the flare stack, outline the communication methods proposed to contact aircraft companies prior to planned flaring, and request the opportunity to meet with the local aviation companies should they have any questions or concerns.

10.0 VISUAL RESOURCES

Flaring was excluded from the visual quality assessment because it was not considered to be typical operations (i.e., occurs less than 3% of the time), although it is acknowledged flaring could present a temporary and intermittent effect during operations. Viewing of the Project area can occur over a range of conditions and from a number of locations, but effects are characterized for those conditions most representative of viewing opportunities and continuous activities. The exclusion of an interaction depends on the character and extent of the activity. For example, the intermittent and brief visibility of marine traffic to the Project site is acknowledged as potentially creating a visual impact. However, relative to the short viewing duration and small visible extent/scale of this activity relative to the overall Project site and existing landscape context, this occurrence is expected to contribute minimally to the overall visual impact and not be representative of the typical viewing conditions that an observer would encounter when viewing the Project.

Further consideration of flaring events based on the supplemental information on flare height and duration presented herein does not affect the assessment of the visual effects, as the percentage of the time that the flare is visible remains low and is not representative of typical viewing conditions. Residual effects are likely to be not significant.

11.0 SUMMARY OF RESIDUAL EFFECTS

The residual effects of flaring included in the assessments for atmospheric environment (air quality), GHG management, sound, light visual resources and human health in the Application are not changed as a result of this review or the supplemental information presented herein.

Supplemental information on aeronautical transportation has been provided, and WLNG will work with Transport Canada regarding permitting for the lighting for the flare stack and updates to charts as required or deemed necessary. WLNG will also notify stakeholders of planned flaring through the Woodfibrelng.ca web site. Following implementation of permitting requirements, significant adverse residual effects to air transport are not considered likely.

With the proposed mitigation, flaring associated with the Project is not expected to influence the sustainability of regional bird or bat populations and is determined to be not significant. Given limited research is available to document the extent of mortality associated with the flare tower and flaring and the effectiveness of the mitigation, confidence in the significance prediction is considered moderate. A monitoring program for potential morality from flaring is proposed as a component of the Wildlife Management Plan.

12.0 REFERENCES

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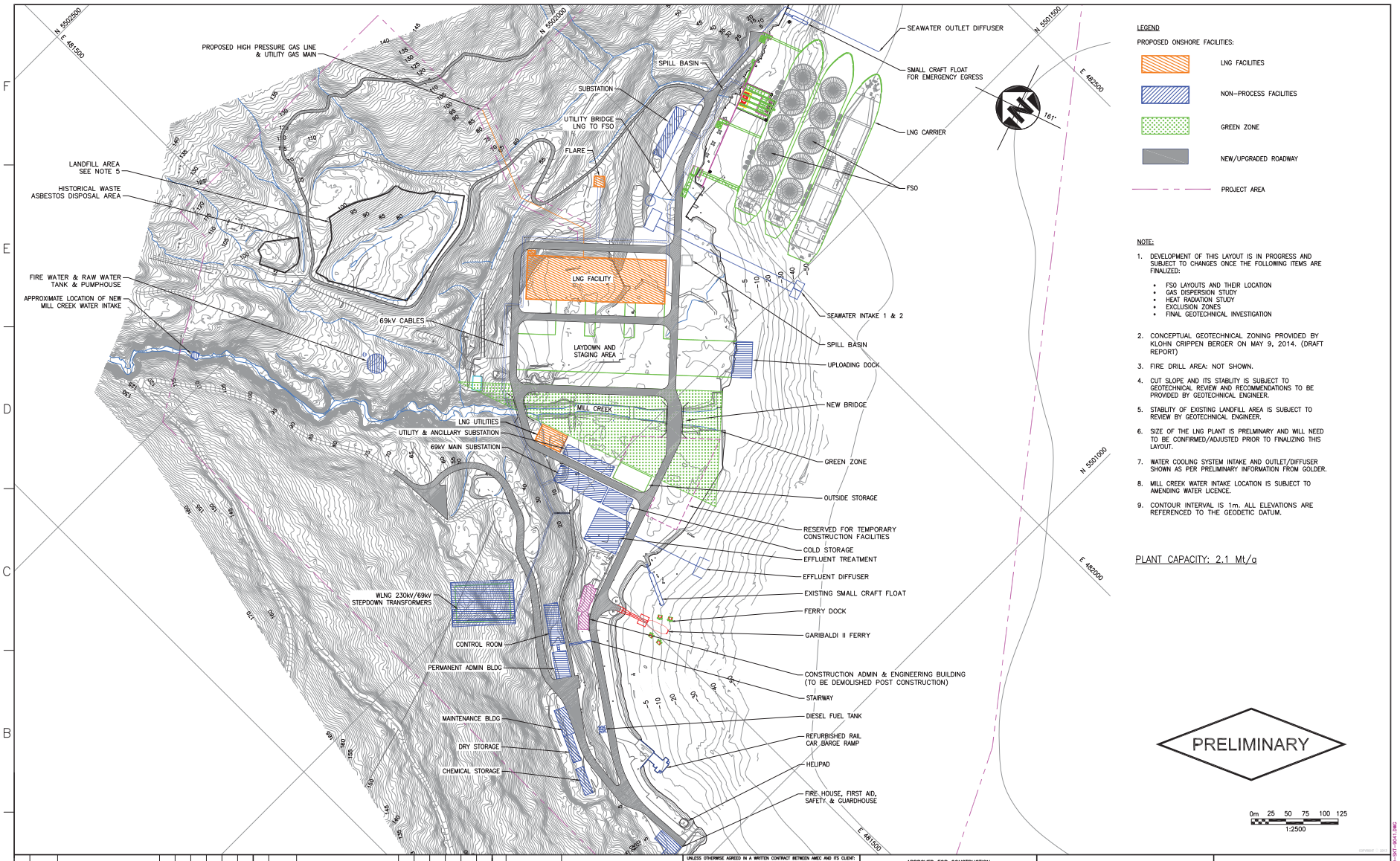
APPENDIX 1

Project Layout



LEGEND

PROPOSED ONSHORE FACILITIES:

- LNG FACILITIES
- NON-PROCESS FACILITIES
- GREEN ZONE
- NEW/UPGRADED ROADWAY
- PROJECT AREA

NOTE:

1. DEVELOPMENT OF THIS LAYOUT IS IN PROGRESS AND SUBJECT TO CHANGES ONCE THE FOLLOWING ITEMS ARE FINALIZED:
   - FSO LAYOUTS AND THEIR LOCATION
   - GAS DISPERSION STUDY
   - HEAT RADIATION STUDY
   - EXCLUSION ZONES
   - FINAL GEOTECHNICAL INVESTIGATION
2. CONCEPTUAL GEOTECHNICAL ZONING PROVIDED BY KLOHN CRIPPEN BERGER ON MAY 9, 2014. (DRAFT REPORT)
3. FIRE DRILL AREA: NOT SHOWN.
4. CUT SLOPE AND ITS STABLITY IS SUBJECT TO GEOTECHNICAL REVIEW AND RECOMMENDATIONS TO BE PROVIDED BY GEOTECHNICAL ENGINEER.
5. STABLITY OF EXISTING LANDFILL AREA IS SUBJECT TO REVIEW BY GEOTECHNICAL ENGINEER.
6. SIZE OF THE LNG PLANT IS PRELMINARY AND WILL NEED TO BE CONFIRMED/ADJUSTED PRIOR TO FINALIZING THIS LAYOUT.
7. WATER COOLING SYSTEM INTAKE AND OUTLET/DIFFUSER SHOWN AS PER PRELIMINARY INFORMATION FROM GOLDER.
8. MILL CREEK WATER INTAKE LOCATION IS SUBJECT TO AMENDING WATER LICENCE.
9. CONTOUR INTERVAL IS 1m. ALL ELEVATIONS ARE REFERENCED TO THE GEODETIC DATUM.

PLANT CAPACITY: 2.1 Mt/a

PRELIMINARY

0m 25 50 75 100 125
1:2500

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP
A			MK				

REF	NUMBER	TITLE
-	REFERENCES	

STAMP/SEAL

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR. DEPARTMENT MGR. PROJECT MGR.

PROJECT PHASE

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
176258		DES	P.B.	24JUN14
SCALE	PACKAGE CODE	DRN	M.K.	24JUN14
1:2500		CHK		
		APP		

Woodfibre LNG

amec

SUBJECT

CIVIL
PLAN
GENERAL ARRANGEMENT

AREA

CLIENT DWG. NO. FIGURE E-1

DRAWING NO. 176258-2000-DD10-SKT-9041 REV. A

SAVED: 24-Jun-14 2:29 PM PLOTTED: 24-Jun-14 3:03 PM USER: KRAMER, MARK H

DGN FILE: P:\CAD\CIVIL\MISC\176258-2000-DD10-SKT-9041.DWG

APPENDIX 2

Flare Stack Schematic

Sourced from:

Woodfibre LNG Flare Study Report, 2014.

Prepared by: Solaris Management Consultants Inc.

Pg. 15, Figure 4.

A schematic of the flare system is shown in Figure 4. The four flares will be assembled in a common structure.

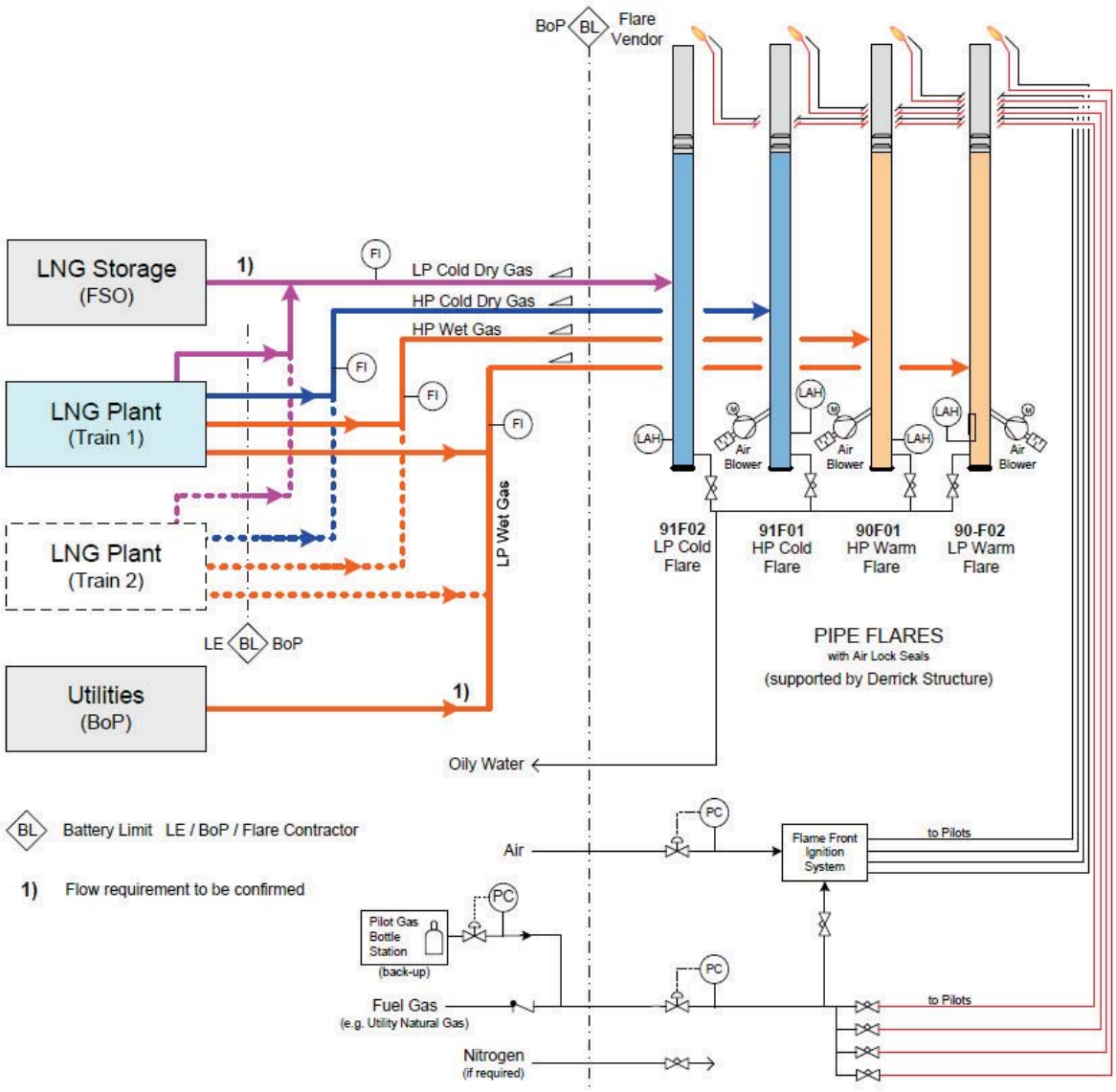


Figure 4: Schematic of Flare System [1]

The Elevated Flare Data Sheet [1] contains several flaring scenarios for each flare. The highest flow rate is selected as the governing case for each flare, with the intention of calculating the highest flare height to meet the safe thermal radiation level.

APPENDIX 3
Airport Facilities

AIR TRAFFIC IN HOWE SOUND

Several types of aircraft operate in Howe Sound. There are various commercial and private pilots that fly in Howe Sound for sightseeing tours, chartered flights, emergency services, utilities services, film services, and general sightseeing and air time. Air traffic in the Sound consists of float planes, helicopters, small commercial and private planes. Airports and helipads in and around Howe Sound are listed in **Table 3-1** and **Table 3-2** respectively.

Some of the companies operating in the area:

- **Sea to Sky Air** (based out of Squamish Airport)
  - Sightseeing tours
  - Chartered Flights
  - Flight training services
- **Harbour Air (Includes Whistler Air)**
  - Seaplane tours
  - Private charters
  - Regular scheduled commercial flights, including a route between Whistler and Vancouver, flying twice daily between May 2nd and September 6th (departing Vancouver at 9 am and 11:40 am, and departing Whistler at 12:45 pm and 6pm)
- **Black Tusk Helicopter Inc**.
  - Tourism (heli-skiing, heli-adventures)
  - Industry services
  - Chartered flights
- **Glacier Air** (based out of Squamish Airport)
  - Helicopter and airplane tours
  - Sightseeing tours
  - Mountain flight training
  - Private chartered flights
- **Blackcomb Aviation** (bases in Squamish, Whistler, Vancouver, Pemberton and other locations)
  - Helicopter and jet chartered flights
  - Executive travel
  - Tourism (sightseeing, heli skiing, alpine recreation drop-off)
  - Film services
  - Utility services
  - Emergency services

Table 3-1 Airports in and around Howe Sound

Airport Name	Approximate Distance from Site	Type/Details
Squamish Municipal Airport	14 km north	• Charter services, private aircraft, flying clubs, water access for float planes and other commercial activities • No regularly scheduled air service
Sunshine Coast Regional Airport	41 km southwest	• Formerly the Sechelt-Gibson's Airport • Charter services, private aircraft and flying clubs • No regularly scheduled air service
Sechelt Water Aerodrome	42 km southwest	• Airport listed as closed in 2007 by Nav Canada's Canada Water Aerodrome Supplement • Sechelt Inlet/Porpoise Bay still used by private airline operators
Vancouver Harbour Flight Centre	43 km southeast	• Scheduled commercial and chartered floatplane service
Vancouver International Airport	51 km south	• Managed by the Vancouver Airport Authority • Scheduled commercial airline service by 68 commercial carriers, in addition to smaller airline scheduled services and charter services, helicopter operations, sport fishing and aerospace facilities operated as Airport South
Vancouver International Water Aerodrome	54 km south	• Operated as part of Airport South from the public seaplane facility • Scheduled commercial and chartered floatplane service
Whistler Airport	57 km northeast	• Scheduled and charter floatplane services from May to September
Pitt Meadows Airport	63 km southeast	• Scheduled commercial, charter, skydiving, and tourism airline services • Flying clubs, flight training and helicopter chartering
Pitt Meadows Water Aerodrome	64 km southeast	• Part of the Pitt Meadows Airport, servicing floatplanes
Boundary Bay Airport	67 km southeast	• Managed by Alpha Aviation on behalf of the Corporation of Delta • Scheduled commercial airline service, chartered flights and flight training. Flying clubs
Delta Heritage Air Park	69 km southeast	• An uncontrolled aerodrome managed by the Delta Heritage Air Park Committee. • Flying clubs and private aircraft owners.
Surrey/King George Airpark	71 km southeast	• Likely privately owned, Limited publicly available information.
Langley Regional Airport	77 km southeast	• Scheduled commercial airline service, charters, flight training, and flying clubs.
Tipella Airport	78 km east	• Likely unmanaged community/public runway. Limited publicly available information.
Pemberton Airport	79 km northeast	• No towers or navigational assistance, • Managed by the Pemberton Regional Airport Authority • Users typically fire and rescue, commercial activity companies, private, local aircraft, flying clubs and helicopter companies
Nanaimo Airport	80 km southwest	• Scheduled commercial airline service and chartered flights

Airport Name	Approximate Distance from Site	Type/Details
Powell River Airport	91 km west	• Scheduled commercial airline service and chartered flights
Taxeda/Gillies Bay Airport	91 km west	• Scheduled commercial airline service and chartered flights
Abbotsford International Airport	95 km southeast	• Scheduled commercial airline service

Table 3-2 Helipads in and around Howe Sound

Helipad Name	Approximate Distance from Site	Type/Details
Squamish General Hospital Helipad	8 km northeast	Hospital service
Blackcomb Helicopters	61 km northeast	Commercial flights
Whistler Health Care Center Helipad	54 km northeast	Hospital service and charter helicopter service.
Vancouver/ Harbour (Public) Heliport	41 km southeast	Scheduled commercial airline service
Vancouver (Children and Women's Health Centre) Heliport	46 km southeast	Hospital service
Vancouver (General Hospital) Heliport	44 km southeast	Hospital service
Vancouver (Vancouver Film Studies) Heliport	46 km southeast	Charter, film and executive services
Global BC Heliport	50 km southeast	Private news service