Technical Data Report—Greenhouse Gases

Ksi Lisims LNG – Natural Gas Liquefaction and Marine Terminal Project

August 2024

Prepared for:

KSI LISIMS LNG

Prepared by:

Stantec Consulting Ltd.

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

Executive Summary

The Nisg̱a'a Nation, Rockies LNG Limited Partnership (**Rockies LNG**) and Western LNG LLC (via its subsidiary, Western LNG) (each a Proponent and collectively referred to herein as the **Proponents**), are proposing to jointly develop an energy project, the Ksi Lisims LNG – Natural Gas Liquefaction and Marine Terminal Project (the **Project**), a floating liquefied natural gas (**FLNG**) production, storage and offloading facility, with supporting upland infrastructure and a marine terminal. The Project Site (the **Site**) is located at Wil Milit, British Columbia (**BC**), on the northern end of Pearse Island, approximately 15 kilometres (**km**) west of the Nisg̱a'a community of Gingolx.

This technical data report (**TDR**) presents technical data and analysis for the greenhouse gas (**GHG**) emissions that may occur because of the Project construction and operation. GHGs are substances that, once in the atmosphere, contribute to global climate change. These substances are released from the combustion of fossil fuels but can also occur from the combustion and decomposition of biogenic material (e.g., wood) and can be affected by land-use changes (such as removal of forested areas). The planned main energy source for the Project is electricity from the BC Hydro electrical grid, rather than on-Site electricity generation via natural gas combustion. However, if the connection to the electrical grid is delayed, on-Site generation will be required for, as currently identified, up to the initial five years of operation following construction. The GHG estimates are based on the currently available engineering design information for the Project, including expected throughputs, fuel use, and equipment design, for the construction, operation, and decommissioning of the Project.

Direct construction emissions occur from both on-road (e.g., pick-up trucks) and off-road (e.g., loaders) equipment. Off-road equipment also includes marine sources, such as tugboats. Portable diesel generators will be used to provide electricity during construction. Explosive combustion during blasting and concrete plant heating will also be present. The commissioning of the FLNGs will use either electricity from the BC Hydro grid or from combined cycle power generation barges (i.e., natural gas turbines), depending on timing of the availability of the electrical transmission line. Construction is expected to occur over the period of 2025 to 2028; approximately 83,902 tonnes (**t**) of carbon dioxide equivalent (**CO_2e**) to 237,134 t CO_2e of emissions are expected to be released over this period, including land-use change emissions, depending on the source of energy available for commissioning activities.

GHG emissions will also occur during construction associated with the construction of the transmission line. These emissions will be from combustion of diesel in off-road equipment. Approximately 1,338 t CO_2e may be released from transmission line construction.

The estimate of the land-clearing emissions associated with the transmission line construction is 66,968 t CO_2e.

Direct terrestrial GHG emissions during the operation phase, when the Project is connected to the electrical grid, occur mainly from the thermal oxidizers, which are required to safely destroy waste gas. However, if on-Site electricity generation is required, the temporary power barges would be the main emission sources. Other emission sources include the heat medium fired heaters and flares. The estimated direct GHG emissions from terrestrial emission sources during operation are approximately 187,575 t CO_2e per year when the Project uses grid supplied electricity and 1,831,576 t CO_2e per year if the Project generates electricity on-Site.

Liquefied natural gas carriers (**LNGC**) and natural gas liquids (**NGL**) product carriers will transit to and from the Project, LNGCs approximately 12.5 times per month and NGL carriers 1 time per month. For the assessment, it is assumed that one escort tugboat will be present while the vessels are transiting between Triple Island and the Site and three harbour tugboats will be present while the vessels are berthing. Because emissions associated with NGL carrier visits (carriers and tugboats) are estimated to represent less than 1% of the direct emissions associated with the Project, these emissions have been omitted from the inventory. The direct GHG emissions associated with transiting to the Site and berthing of the LNGCs, not including the escort and harbour tugboats, are approximately 30,182 t CO_2e per year. The direct GHG emissions associated with the escort and harbour tugboats are approximately 4,364 t CO_2e per year. Additional GHG emissions associated with the marine transport of material and personnel during operation are approximately 1,870 t CO_2e per year.

Considering both terrestrial and marine direct emission sources, the estimated total direct GHG emissions from emission sources during operation are approximately 223,990 t CO_2e per year when the Project uses grid supplied electricity and 1,867,992 t CO_2e per year if the Project generates electricity on-Site using power barges.

Indirect GHG emissions from electricity generation will occur from the use of electricity from BC Hydro. Although these emissions do not occur at the Site, GHG emissions occur at electricity generation facilities as a result of the generation required to supply electricity to the Site. The indirect GHG emissions associated with the Project are estimated at 28,645 t CO_2e per year when the Project uses electricity supplied by the grid as the grid is mainly hydroelectric generation. If electricity is generated on-Site, the emissions are considered direct and are noted above. There could potentially be indirect GHG emissions from electricity during the construction phase for commissioning activities if grid supplied electricity is available; approximately 3,370 t CO_2e may result from commissioning activities.

Overall, operation emissions (direct and indirect) are anticipated to be approximately 252,636 t CO_2e per year when electricity from the BC Hydro electrical grid is used and approximately 1,867,992 t CO_2e per year when electricity is generated on-Site using gas turbines.

Complete details on the emission sources likely to occur during the decommissioning phase are currently not available; however, it is expected that the emissions would be similar to or lower than GHG emissions during the construction phase as activities would be similar and improved, lower GHG emitting options for equipment should be readily available to support decommissioning as it is planned to occur approximately 30 years following start-up. As such, a conservative estimate of decommissioning phase emissions is 45,381 t CO_2e (based on construction emissions and excluding land-use change and commissioning).

A TDR addressing the following components can be found in Appendix 8B (Strategic Assessment of Climate Change (SACC)):

- Best available technologies and best environmental practices
- Upstream assessment
- Net-zero plan
- Climate resilience

Abbreviations

BC	British Columbia
BTU	British thermal unit
CH_4	methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
EA	Environmental Assessment
EF	emission factors
ECCC	Environment and Climate Change Canada
FLNG	floating liquefied natural gas production, storage and offloading facility
g	gram
GHG	greenhouse gas
GGIRCA	*Greenhouse Gas Industrial Reporting and Control Act*
GJ	gigajoule
GWh	gigawatt-hour
HFCs	hydrofluorocarbons
HHV	higher heating value
hp	horsepower
h	hour
IA	Impact assessment
IAA	*Impact Assessment Act*
IPCC	Intergovernmental Panel on Climate Change
kg	kilogram

km	kilometre
kW	kilowatt
kWh	kilowatt-hour
L	litre
lb/hp-hr	pounds per horsepower-hour
LNG	liquefied natural gas
LNGC	liquefied natural gas carrier
m^3	cubic metre
MJ	megajoule
mpg	miles per gallon
MW	megawatt
MWh	megawatt-hour
Nisga'a Treaty	Nisga'a Final Agreement
NIR	National Inventory Report
N_2O	nitrous oxide
NF_3	nitrogen trifluoride
NGL	natural gas liquids
the Project	Ksi Lisims LNG – Natural Gas Liquefaction and Marine Terminal
the Proponent	Rockies LNG Limited Partnership and Western LNG
PFCs	perfluorocarbons
SACC	Strategic Assessment of Climate Change
SF_6	sulphur hexafluoride
the Site	Project Site
SOC	soil organic carbon
t	tonne

TDR	technical data report
US EPA	United States Environmental Protection Agency
VC	valued component
WCI	Western Climate Initiative

Glossary

Carbon dioxide equivalent (CO_2e)	The CO_2e emissions are obtained by multiplying the emissions of a GHG by its global warming potential for a given time horizon. CO_2e is a metric to describe the combined effect that GHGs on the atmosphere.
Project Area	The area of the Project and includes District Lot 99 and marine waters extending approximately 500 m offshore.
Floating liquefied natural gas (FLNG) facility	A water-based liquefied natural gas production facility that is purpose-built to liquefy and store liquefied natural gas and transfer it to LNG carriers for global export.
Global warming potential	A measure of how much heat a greenhouse gas traps in the atmosphere relative to CO_2.
Greenhouse gas (GHG)	A GHG is defined as any gas in the atmosphere that absorbs and re-emits infrared radiation.
Liquefied natural gas (LNG)	Natural gas that has been cooled to approximately -162°C where the methane (CH_4) and other components condense from gas to liquid form. In its liquid state, natural gas takes up 1/600 of the space that the gaseous phase occupies.
LNG carrier	A marine cargo ship with specialized cryogenic tanks that are designed for transporting liquefied natural gas.
Natural gas	A naturally occurring hydrocarbon gas mixture consisting primarily of methane (typically >98%) plus varying amounts of ethane, propane, butanes, pentanes, higher molecular weight hydrocarbons, hydrogen sulfide, carbon dioxide, water vapor, and sometimes helium and nitrogen.

1.0 INTRODUCTION

The Nisga'a Nation, Rockies LNG Limited Partnership (**Rockies LNG**) and Western LNG LLC (via its subsidiary, Western LNG) (each a Proponent and collectively referred to herein as the **Proponents**), are proposing to jointly develop an energy project, the Ksi Lisims LNG – Natural Gas Liquefaction and Marine Terminal Project (the **Project**), a floating liquefied natural gas (**FLNG**) production, storage and offloading facility, with supporting upland infrastructure and a marine terminal. The Project Site (the **Site**) is located at Wil Milit, British Columbia (**BC**) on the northern end of Pearse Island, approximately 15 kilometres (**km**) west of the Nisga'a community of Gingolx. The Project is located on Category A fee simple land as defined in the Nisga'a Final Agreement (**Nisga'a Treaty**) and is adjacent to a proposed water lot located on the east side of the Site, in Portland Canal (**Error! Reference source not found.**).

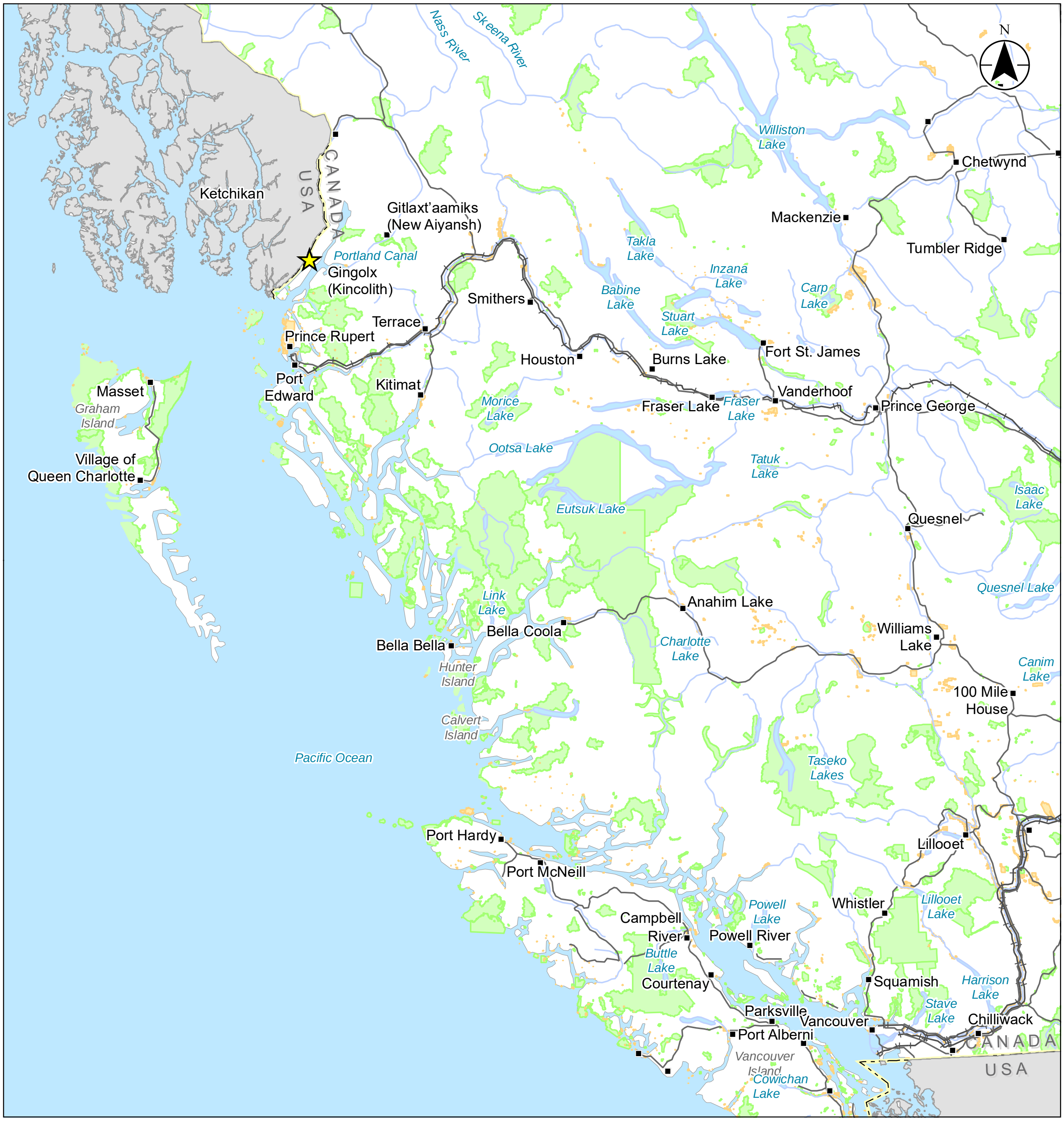
The Project is subject to an environmental assessment (**EA**) under the British Columbia *Environmental Assessment Act* and an impact assessment (**IA**) under the federal *Impact Assessment Act* (**IAA**). The Government of BC requested substitution of the provincial review process for the federal impact assessment process from the federal Minister of Environment and Climate Change Canada (**ECCC**). The federal Minister of ECCC approved the request for substitution. Given the location of the Project on Category A Lands owned by the Nisga'a Nation, the Application will also meet requirements of Chapter 10, paragraph 8 of the Nisga'a Treaty. Accordingly, the Application that focuses on a suite of valued components (**VCs**) has been prepared. VCs are components of the natural and human environment that are considered by the Proponents, public, Indigenous nations, scientists and other technical specialists, and government agencies involved in the assessment process to have scientific, ecological, economic, social, cultural, archaeological, historical, or other importance.

Information presented in this technical data report (**TDR**) has been obtained from the Proponents, existing literature, published technical data sources, engineering calculations, or from previous similar project experience.

The following information is presented within this TDR:

- Location of the study area (Section 2.0)
- Substances of interest (i.e., the specific greenhouse gases [**GHGs**] assessed for this Project [Section 3.0])
- Description of the methods used to estimate the quantities of GHG emissions (Section 4.0)
- Summary of estimated GHG emissions by Project phase (Section 5.0)

In addition to this TDR, the Proponents developed the Strategic Assessment of Climate Change (**SACC**) TDR (Appendix 8B) to address mitigation measures and the net-zero plan, carbon sinks, and upstream GHG assessment.



KSI LISIMS LNG

- ■ Populated Place
- ☆ Site
- Highway
- International Boundary
- Provincial Boundary
- Railway
- Watercourse
- Canada
- United States of America
- First Nations Reserve
- Provincial Park, Ecological Reserve, Protected Area, or Conservancy Area
- Waterbody

0 50 100 150 200 km

1:5,000,000 (at original document size of 8.5x11)

Notes
1. Coordinate System: NAD 1983 BC Environment Albers
2. Data Sources: DataBC, Government of British Columbia; Natural Resources Canada
3. NTS Map Sheets: 092A, 092B, 092C, 092D, 092E, 092F, 092G, 092H, 093E, 092M, 093A, 102N, 093I, 093J, 103F, 103G, 102H, 103B, 093F, 093G, 093H, 092J, 092K, 092L, 092N, 092O, 092P, 093B, 093C, 093D, 093K, 093L, 093N, 093O, 093P, 102B, 102C, 102F, 102G, 102A, 103H, 103I, 102I, 102J, 102K, 102O, 102P, 103A, 103C, 103E, 103J, 103P, 093M, 092I, 103K, 103L, 103O, 104A, 104B, 104C, 094B, 094C, 094D, 094A

Stantec

Project Location:
Pearse Island, BC

Project Number: 123221820
Prepared by TQUILICHINI on 20231016
Requested by EFLORY on 20231016
Checked by EFLORY on 20231016

Client/Project/Report
Ksi Lisims LNG
Natural Gas Liquefaction and Marine Terminal
GHG Technical Data Report

Figure No.
1-1

Title
Project Location

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2.0 STUDY AREA

The Project is located at Wil Milit, BC on the northern end of Pearse Island, approximately 15 km west of the Nisg̱a'a community of Gingolx in northern BC.

Because the environmental effects associated with GHG emissions are a global phenomenon, local and regional spatial boundaries are not used for the assessment of GHGs. This is based on GHGs mixing well and remaining in the atmosphere for some time, and then dispersing well away from their emission sources (i.e., effects are not localized) (Intergovernmental Panel on Climate Change [**IPCC**] 2013).

The GHG emissions from the marine movements of personnel and material from Gingolx (approximately 38 km roundtrip) and Prince Rupert or Port Edward, BC (approximately 220 km roundtrip) were estimated for the construction phase. Material and personnel movement beyond these origin points are not included in the Project scope. During the operation phase, GHG emissions were estimated for transiting liquefied natural gas carriers (**LNGCs**) in open water (from the 12 nautical mile Canadian territorial sea limit to the pilotage station at Triple Island, 336 km roundtrip) and LNGCs and tugboats transiting from the pilotage station at Triple Island to the Site (approximately 203 km roundtrip).

3.0 SUBSTANCES

A GHG can be any gas in the atmosphere that absorbs and re-emits infrared radiation, thereby acting as a thermal blanket for the planet that warms the lower levels of the atmosphere. GHGs can be released from both natural and anthropogenic (human activity) sources (IPCC 2013).

GHGs are estimated provincially and federally in Canada and are reported annually in the National Inventory Report (**NIR**) published by ECCC. The national GHG inventory includes the following gases: carbon dioxide (**CO_2**), methane (**CH_4**), nitrous oxide (**N_2O**), perfluorocarbons (**PFCs**), hydrofluorocarbons (**HFCs**), sulphur hexafluoride (**SF_6**), and nitrogen trifluoride (**NF_3**) (ECCC 2023). This assessment is considering the same set of GHGs as the NIR.

For this assessment, the GHGs that may be released during Project activities include mainly CO_2, CH_4, and N_2O. The GHGs that are not expected to be emitted by the Project in substantive quantities are PFC, HFC, and NF_3, as these gases are not known to be required for Project activities. The SF_6 will be used as an insulating medium for the high voltage gas insulated switchgear in the electrical system; however, if required to be used, these units are sealed and designed to not allow gases to escape. The units will also be equipped with a means to monitor for leaks. These gases are, therefore, excluded from further consideration in this assessment.

The emissions of each of the included GHGs are multiplied by their 100-year global warming potential as determined by the IPCC and are reported as carbon dioxide equivalent (**CO_2e**). The global warming potential of these GHGs align with the ones applied in the 2023 NIR (ECCC 2023):

- CO_2 = 1
- CH_4 = 25
- N_2O = 298

The total mass of CO_2e for the Project is calculated as:

$$CO_2e = (mass\ CO_2 * 1) + (mass\ CH_4 * 25) + (mass\ N_20 * 298)$$

4.0 METHODOLOGY

The methods used to estimate the GHG emissions from the Project are based on accounting and reporting principles of The GHG Protocol developed by the World Resource Institute and the World Business Council for Sustainable Development (2015). The GHG Protocol is an internationally accepted accounting and reporting standard for quantifying and reporting GHG emissions. The guiding principles of the Protocol are relevance, completeness, consistency, transparency, and accuracy.

The ECCC's SACC (ECCC 2020) was used to determine the net GHG emissions from the Project. The equation for net GHG emissions is:

$$Net\ GHG\ Emissions\ = Direct\ GHG\ Emissions\ + Aquired\ Energy\ GHG\ Emissions \\ - Avoided\ Domestic\ GHG\ Emissions - Offset\ Measures$$

Direct emissions refer to emission sources within the Project assessment scope. Those under control of the Proponents include those such as the thermal oxidizers or natural gas combustion heaters. Although not directly under the control of the Project as they will be owned and operated by third-parties, emissions from LNGCs, natural gas liquids (**NGL**) product vessels, tugboats, and water taxis are included as direct emissions as they are considered within the Project scope. Acquired energy emissions refer to GHG emissions generated to supply electricity to the Project (from connection to the BC Hydro electrical grid); these are also commonly referred to as indirect emissions. The Project does not include avoided domestic emissions (i.e., emissions in Canada that will no longer occur as a result of the Project). Offset measures (i.e., CO_2 captured and stored and retired offset credits) are not considered in this TDR but are discussed in the SACC TDR (Appendix 8B).

The following sections describe the specific quantification methods used to estimate direct and acquired energy GHG emissions from construction and operation emission sources.

4.1 CONSTRUCTION PHASE

The FLNG facilities themselves, as well as the floating temporary worker accommodation and temporary power generation barges, will be assembled overseas and emissions associated with their construction are not included in the scope of this assessment. Activities included in the scope of this assessment are the construction of the marine terminal, including the material off-load facility (**MOF**) and small craft berths and jetty, other support and utility buildings, operation workforce accommodation, helipad, water treatment plant, wastewater treatment plant, electrical substation, natural gas receiving station, back-up diesel power generation, roadways, utility corridors, and overburden storage areas, permanent marine mooring infrastructure, and two pile-supported jetties from shore to each FLNG facility. Construction is estimated to begin in 2025 and last approximately three to four years (subject to regulatory approval timelines).

The direct emissions associated with the construction activities listed above have been divided in the following categories:

Direct GHG emissions:

- Emissions from fuel combustion by off-road vehicles and equipment, including marine equipment
- Emissions from fuel combustion by on-road vehicles and equipment
- Emissions from fuel combustion for the concrete plant
- Emissions associated with blasting
- Emissions from fuel combustion in portable diesel-powered generators
- Emissions associated with land clearing activities
- Emissions associated with marine vessels used to transport the workforce and materials to and from the Site
- Emissions associated with ocean-going tugboats used to transport materials from overseas

Because power from BC Hydro connection may not be available until just prior to the operation phase, no indirect emissions from electrical use are included in the construction phase inventory. Electricity consumed during the construction phase would be from diesel gensets, which are included as direct emission sources.

The construction activity assumptions and details, such as type and number of equipment, load factors, total operating hours of construction equipment and fuel consumption, are based on input from the Proponents or published literature. The equipment list and operation schedules are based on the best information available at the time of the assessment. Construction emission estimates consider the full build-out of the Project. The methods and emission calculations for each category are explained in the following sections.

4.1.1 Off-road Construction Equipment

Off-road construction equipment includes the use of heavy machinery such as bulldozers, graders, and cranes. This category also includes marine equipment, such as self-propelled barges, ferries, or tugs. Diesel or marine diesel is the fuel typically used by off-road construction equipment; some smaller equipment may use gasoline or propane. The diesel gensets are also included in this category. Because the calculation approach differs between marine and non-marine equipment, the GHG emission estimation methodologies are described separately.

4.1.1.1 Non-Marine Construction Equipment

The non-marine construction equipment and their operational details used for the assessment are presented in Table 4.1–1. This equipment combusts diesel.

Table 4.1–1 Non-Marine Construction Equipment Details

Description	Number of Units	Engine Power (hp)	Model Year	Load Factor (fraction)	Operating Hours per Day (h/d)	Operating Days (total)	Utilization (%)	Brake-specific Fuel Consumption (lb/hp-hr)
Marine Terminal								
Piling Rigs (diesel hammer)	1	N/A	2019	0.43	10	427	75	-
Piling Rigs (vibratory hammer)	1	335	2019	0.43	10	427	75	0.367
Piling Rig (hydraulic power packs)	1	523	2019	0.43	10	427	75	0.367
600T Crane	1	919	2019	0.43	10	427	75	0.367
Hydraulic Crane (300-ton, traveler)	1	919	2019	0.43	10	427	75	0.367
Hydraulic Crane (150-ton, traveler)	1	536	2019	0.43	10	427	75	0.367
Terrestrial Construction								
Dozer (D8)	6	303	2019	0.59	10	631	75	0.367
Front-End Loader (FEL) (CAT966)	4	276	2019	0.59	10	618	75	0.367
Excavator (CAT374)	4	484	2019	0.59	10	618	75	0.367
Grader (Cat)	2	238	2019	0.59	10	896	75	0.367
Rock Crusher	2	200	2019	0.43	10	510	75	0.367
Skid Steer Loader	2	193	2019	0.59	10	1,108	75	0.367
Forklift (long reach)	3	74	2019	0.59	10	824	75	0.408
Hydraulic Crane (150 t)	2	536	2019	0.43	10	853	75	0.367
Hydraulic Crane (60 t)	2	450	2019	0.43	10	682	75	0.367
Crawler Crane (160 t)	2	331	2019	0.43	10	512	75	0.367
Generator (500 kW diesel)	4	670	2019	0.43	24	851	100	0.367
Generator (100 kW diesel)	5	134	2019	0.43	24	921	100	0.367
Self-Propelled Modular Transport	1	2,092	2019	0.59	10	513	75	0.367

Table 4.1–1 Non-Marine Construction Equipment Details

Description	Number of Units	Engine Power (hp)	Model Year	Load Factor (fraction)	Operating Hours per Day (h/d)	Operating Days (total)	Utilization (%)	Brake-specific Fuel Consumption (lb/hp-hr)
Light Plant	15	11	2019	0.43	16	853	100	0.408
Hydraulic Crane 180 ton for Cooler Rack	1	315	2019	0.43	10	937	75	0.367
Hydraulic Crane 180 ton for Pipe Racks	1	315	2019	0.43	10	937	75	0.367
Hydraulic Crane 300 ton for Pipe Racks	1	919	2019	0.43	10	937	75	0.367
Hydraulic Crane 180 ton for Buildings	1	315	2019	0.43	10	937	75	0.367
Crane 600 Ton	1	919	2019	0.43	10	937	75	0.367
Grid Roller Double Drum	1	130	2019	0.62	10	256	75	0.367
Vibrating Roller	1	129	2019	0.62	10	256	75	0.367
Smooth Roller Tandem	1	129	2019	0.62	10	256	75	0.367

NOTES:
hp horsepower
hr hour
lb pound
kW kilowatt
t tonne
- Not used

GHG emissions can readily be estimated based on anticipated fuel usage and available emission factors (**EF**s). The fuel usage was estimated using the following equation:

$$Fuel\ Consumption\ \left(\frac{L}{hr}\right)\ for\ Equipment\ Type = Engine\ Power\ (hp) * Load\ Factor(\%) * Brake\ Specific\ Fuel\ Consumption\ \left(\frac{lb}{hp*hr}\right) * Conversion\ \left(0.454\frac{kg}{lb}\right) \div Diesel\ Density\ \left(0.86\frac{kg}{L}\right) * Number\ of\ Units$$

For diesel-fueled equipment, brake-specific fuel consumptions were obtained from *Exhaust and Crankcase Emission Factors for Nonroad Compression-Ignition Engines in MOVES2014b* (US EPA 2018). Each equipment type was assigned a representative manufacturer and model with corresponding engine power. The equipment was assumed to be of the 2019 model year. The load factors are based on documentation from US EPA for nonroad engine emissions modelling for the equipment types (US EPA 2010). The diesel density of 0.86 kilograms per litre (kg/L) was selected as the average density of diesel.

The estimation of GHG emissions from diesel volume is shown in the following equation:

$$CO_2, CH_4, N_2O\ Emissions\ over\ Construction\ Period\ for\ Equipment\ Type\ (tonnes) = Total\ Operating\ time\ \ (hr) * Fuel\ Consumption\ \left(\frac{L}{hr}\right) * Utilization\ (\%) * \ Emission\ Factor\ \left(\frac{g}{L}\right) * Unit\ Conversion\ \left(\frac{1\ tonne}{10^6 g}\right)$$

The EFs used for off-road diesel equipment are presented in Table 4.1–2. These EFs are from the Western Climate Initiative (**WCI**) Final Essential Requirements of Mandatory Reporting (WCI 2012), which is required for reporting under the *Greenhouse Gas Industrial Reporting and Control Act* (**GGIRCA**) in BC.

Table 4.1–2 Diesel Offroad GHG Emission Factors

Fuel Type	CO_2 Emission Factor (g/L)	CH_4 Emission Factor (g/L)	N_2O Emission Factor (g/L)
Off-road Diesel Equipment	2,663	0.133	0.4

NOTES:
WCI (2012), Table 20-2
g gram
L Litre

The percent utilization considers the actual duration that an engine is expected to be running during each operating hour.

4.1.1.2 Marine Construction Equipment

The marine construction equipment and their operational details used for the assessment are presented in Table 4.1–3. The marine construction equipment combusts diesel. Equipment such as barges that do not combust fuel directly are excluded from the table.

Table 4.1–3 Marine Construction Equipment Details

Vessel	Number of Units	Engine Power (hp)	Load Factor (fraction)	Operating Hours per Day (h/d)	Operating Days (total)	Utilization (%)	Fuel Consumption (g/kWh)
Marine Terminal							
Safety Rescue Boat	1	250	0.45	10	427	100	213

NOTES:
US EPA (2022)
kWh – kilowatt-hour

Details on personnel and material movements during construction are presented in Table 4.1–4.

Table 4.1–4 Marine Personnel and Material Shipping Equipment Details

Vessel	Number of Round-trips	Engine Power (hp)	Load Factor (fraction)	Roundtrip Distance (km)	Fuel Consumption (g/kWh)
Personnel Shipping					
Water Taxi from Gingolx	344	250	0.45	38	213
Water Taxi from Prince Rupert	344	250	0.45	220	213
Material Shipping					
Tugboat from Gingolx	228	4,000	0.5	38	205
Tugboat from Prince Rupert	228	4,000	0.5	220	205
Ocean-going tugboat	20	2,984	0.5	270	205

NOTE:
US EPA (2022)

The GHG emissions from the operation of the LNGC and tugboats were estimated using the US EPA's *Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions* (US EPA 2022). The CO_2, CH_4, and N_2O estimation methodologies are presented in the following equation:

$$\begin{aligned} CO_2, CH_4, N_2O\ Emissions\ from\ Marine\ Engines \left(\frac{tonnes}{yr}\right) \\ = Emission\ Factor \left(\frac{g}{kWh}\right) * Engine\ Power \left(\frac{kW}{vessel}\right) * Operating\ Hours \left(\frac{hr}{d}\right) \\ * Duration \left(\frac{d}{Construction}\right) * \ Number\ of\ Vessels \left(\frac{vessel}{yr}\right) * Load\ Factor(\%) \\ * Unit\ Conversion \left(\frac{1\ tonne}{10^6}\right) * Utilization(\%) \end{aligned}$$

The GHG EFs for marine construction vessels are presented in Table 4.1–5.

Table 4.1–5 Marine Construction Vessels GHG Emission Factors

Vessel	CO_2 Emission Factor (g/kWh)	CH_4 Emission Factor (g/kWh)	N_2O Emission Factor (g/kWh)
Safety Rescue Boat	680	0.002	0.033
Tugboat (local shipping)	657	0.01	0.03
Tugboat (overseas shipping)	657	0.01	0.03
Water taxi (personnel)	680	0.001	0.033
NOTES: US EPA (2022) g/kWh = gram per kilowatt-hour			

The fuel consumption rate, load factors, and GHG EFs for each type of vessel were obtained from US EPA (2022).

4.1.2 On-Road Construction Equipment

On-road construction vehicles used for the construction of the Project include pick-up trucks and crew buses. On-road vehicle operation information is listed in Table 4.1–6. The on-road vehicles are assumed to be diesel-powered. The fuel consumption rates of on-road vehicles (in units of mile/gallon) were based on the fuel economy published by the Oak Ridge National Laboratory (2017). The trip length is based on information provided by the Proponents.

$$\mathit{Fuel\ Consumption\ by\ Vehicle\ Type}\left(\frac{L}{d}\right)$$
$$= \mathit{Road\ Length\ per\ Trip}\left(\frac{km}{trip}\right) * \mathit{Vehicle\ Trips}\left(\frac{total\ trips}{d}\right)$$
$$\div \left\{\left(\mathit{Fuel\ Consumption}\left(\frac{mile}{gallon}\right) * \mathit{Unit\ Conversion}\left(\frac{gallon}{3.7854\ L}\right)\right.\right.$$
$$\left.* \mathit{Unit\ Conversion}\left(\frac{1.609\ km}{mile}\right)\right\}$$

Table 4.1–6 On-road Equipment Details

Vessel	Road Length per Trip (km/trip)	Vehicle Trips (trips/h)	Operating Hours per Day	Duration (Days of Construction)	Fuel Consumption	
					Miles / gallon	L/100 km
Terrestrial Construction						
Dump Truck (CAT745)	1.5	4	10	597	2.5	94.1
Water Tank Truck	1.5	0.30	10	768	9	26.1
Truck (flat bed)	0.8	4	10	682	9	26.1
Concrete Pump Truck	0.8	1	10	682	12	19.6
Concrete Mixer Truck	0.8	1	10	1,360	5	47.1
Vacuum Truck	0.8	0.2	10	895	25	9.4
Pick-up Truck	1.5	4	10	954	20.4	11.5
Side by Side Utility Vehicle	0.8	8	10	852	33	7.1

NOTES:
Pick-up trucks are assumed to be half-ton.
Concrete Pump Truck is assumed to be an Alliance 47 m boom on a Mack truck.
Miles per gallon (**mpg**) from Oak Ridge National Laboratory (2017)

The estimation of GHG emissions from diesel is shown in the following equation:

$$CO_2, CH_4, N_2O\ \mathit{Emissions\ over\ Construction\ Period\ for\ Vehicle\ Type\ (tonnes)}$$
$$= \mathit{Duration}\left(\frac{d}{construction}\right) * \mathit{Fuel\ Consumption}\left(\frac{L}{d}\right) * \mathit{Emission\ Factor}\left(\frac{g}{L}\right)$$
$$* \mathit{Unit\ Conversion}\left(\frac{1\ tonne}{10^6 g}\right)$$

The EFs used for on-road diesel equipment are presented in Table 4.1–2 (above) and are from WCI (2012).

4.1.3 Blasting

Blasting during construction is expected to be limited and will use an ammonium nitrate/fuel oil (ANFO) explosive. CO_2 emissions can be generated from the combustion of the explosive. Emission factors for CH_4 and N_2O emissions are not available; these emissions are not considered substantive in comparison to CO_2. The estimation of CO_2 emissions from ANFO combustion is shown in the following equation:

$$CO_2\ Emissions\ Over\ Construction\ Period = ANFO\ Usage\left(\frac{kg}{hole}\right) * No.of\ Holes(hole) * CO_2Emission\ Factor\left(\frac{kg}{kg\ ANFO}\right)$$

The CO_2 emission factor used was 0.189 kg/kg (The Mining Association of Canada 2009).

4.1.4 Fuel Used for Concrete Plant

A 30 cubic metre (**m³**) per hour capacity concrete plant that uses propane for heating is planned to be used during construction. The amount of propane required was estimated based on an energy use of 31,000 British Thermal Unit (**BTU**) per cubic yard of concrete produced (US EPA 2013), which is approximately 43 megajoule (**MJ**) per m^3. With an assumed density of 2.4 t/m^3 of concrete and a default heating value of propane as 915,000 BTU per gallon, the required energy per hour of operation is 14 gallons per hour (64 L/h).

The GHG emissions from the operation of the concrete plant are estimated using the following equation:

$$CO_2, CH_4, N_2O\ Emissions\ over\ Construction\ Period\ for\ Concrete\ Plant\ (tonnes) = Duration\left(\frac{d}{construction}\right) * Fuel\ Consumption\ \left(\frac{L}{h}\right) * \ Emission\ Factor\ \left(\frac{g}{L}\right) * Unit\ Conversion\ \left(\frac{1\ tonne}{10^6 g}\right) * Operating\ Hours\left(\frac{h}{d}\right)$$

The EFs for propane combustion are presented in Table 4.1–7.

Table 4.1–7 Propane Combustion GHG Emission Factors

Fuel	CO_2 Emission Factor (g/L)	CH_4 Emission Factor (g/L)	N_2O Emission Factor (g/L)
Propane	1,510	0.024	0.108
NOTE: WCI (2012)			

4.1.5 Land-Use Change

Building the marine terminal and transmission line will require clearing of existing vegetation. This activity is one of the first to occur and is carried out during initial Site preparation, prior to many of the other construction activities. The total area that would be disturbed as part of the marine terminal is estimated to be 40 hectares (**ha**); of this approximately 26 ha of forest land would be converted to settlements and 14 ha of wetlands would be converted to settlements.

This assessment follows the SACC draft Technical Guide (ECCC 2021) and related IPCC methodologies (IPCC 2006, 2011, 2023a, 2023b). The emission calculation methods consider carbon stock changes before and after land conversion. The tier 2 method (Canada area-specific data) was used where available.

Converting forest land to settlements would result in carbon stock changes in biomass (i.e., vegetation) due to land clearing and in soil organic carbon (**SOC**) as a portion of the area would be paved or covered by the infrastructure. A conservative assumption was made that the carbon stock in the existing biomass that is not salvaged will be converted to CO_2 during the first year; some of this biomass is allowed to decay and some will be burned. Approximately 20% of the carbon in soil will be emitted to atmosphere as CO_2 over a 20-year period. Some disturbed areas will be allowed to revegetate either naturally or through grass seeding; other areas will remain as the settlement land-use type over the lifetime of the Project.

The wetlands area is assumed to be peatlands with nutrient rich peat deposits and a conservative assumption was made that all peat deposit carbons are converted to CO_2 for the conversion of wetlands to settlements.

Activity data on the area of land considered forest land and wetland were obtained through the Vegetation Resource Index (VRI) (BC Ministry of Forestry, Lands, Natural Resource Operations and Rural Development 2022). In addition, information on biomass density was derived from VRI data.

The emissions are calculated as:

$$\begin{aligned} &Decay\ Emissions\ (t\ CO_2) \\ &= Carbon\ stock\ change \left(\frac{tonnes\ of\ carbon}{year}\right) \times Molecular\ weight\ of\ CO_2 \left(\frac{tCO_2}{tmol}\right) \\ &\div Molecular\ weight\ of\ carbon \left(\frac{tonnes\ of\ carbon}{tmol}\right) \end{aligned}$$

$$\begin{aligned} &Burning\ Emissions\ (t\ CO_2) \\ &= Volume\ of\ Biomass\ Burned\ (m^3) \times Density\ of\ Biomass \left(\frac{t\ dry\ matter}{m^3}\right) \\ &\times Carbon\ fraction\ of\ dry\ matter \left(\frac{tonnes\ of\ carbon}{tonnes\ dry\ matter}\right) \times Conversion\ Factor \left(\frac{0.9\ t\ C}{1\ t\ C}\right) \\ &\times Molecular\ weight\ of\ CO_2 \left(\frac{tCO_2}{tmol}\right) \div Molecular\ weight\ of\ carbon \left(\frac{tonnes\ of\ carbon}{tmol}\right) \end{aligned}$$

$$Burning\ Emissions\ (t\ CH_4) = Volume\ of\ biomass\ burned\ (m^3) \times density\ of\ biomass\ \left(\frac{t\ dry\ matter}{m^3}\right) \times Carbon\ fraction\ of\ dry\ matter\ \left(\frac{tonnes\ of\ carbon}{tonnes\ dry\ matter}\right) \times Conversion\ factor\ \left(\frac{0.01\ t}{1\ t\ CH_4}\right) \times Molecular\ weight\ of\ CO_2\ \left(\frac{t\ CO_2}{tmol}\right) \div Molecular\ weight\ of\ CH_4\ \left(\frac{tonnes\ of\ CH_4}{tmol}\right)$$

$$Burning\ Emissions\ (t\ N_2O) = Mass\ of\ CO_2\ (t) \times Conversion\ factor\ \left(\frac{0.00017\ t\ N_2O}{1\ t\ CO_2}\right)$$

$$Carbon\ stock\ change\ for\ biomass\ \left(\frac{tonnes\ of\ carbon}{year}\right) = \left\{\left[Biomass, after\ \left(\frac{tonnes\ dry\ matter}{ha}\right) - Biomass, before\ \left(\frac{tonnes\ dry\ matter}{ha}\right)\right] \times Area\ of\ land\ converted\ (ha)\right\} \times Carbon\ fraction\ of\ dry\ matter\ \left(\frac{tonnes\ of\ carbon}{tonnes\ dry\ matter}\right)$$

$$Carbon\ stock\ change\ for\ SOC\ \left(\frac{tonnes\ of\ carbon}{year}\right) = \left[SOC, end\ of\ period\ \left(\frac{tonnes\ of\ carbon}{20\ years}\right) - SOC, beginning\ of\ period\ \left(\frac{tonnes\ of\ carbon}{20\ years}\right)\right] \div 20\ (years)$$

$$SOC, end\ or\ beginning\ of\ period\ \left(\frac{tonnes\ of\ carbon}{20\ years}\right) = Soil\ organic\ carbon\ content\ \left(\frac{tonnes\ of\ carbon}{ha \cdot 20\ years}\right) \times Stockchange\ factor\ (dimensionless) \times Area\ of\ land\ converted\ (ha)$$

$$Carbon\ stock\ change\ for\ wetlands\ \left(\frac{tonnes\ of\ carbon}{year}\right) = \left[Onsite\ peat\ deposits, after\ \left(\frac{tonnes\ carbon}{ha \cdot year}\right) - Onsite\ peat\ deposits, before\ \left(\frac{tonnes\ carbon}{ha \cdot year}\right)\right] \times Area\ of\ land\ converted\ (ha)$$

The following EFs and parameters were used in the emission calculation (Table 4.1–8).

Table 4.1–8 Land-Use Change Emission Factors and Parameters

Land Use Conversion	Carbon Stock	Parameters	Values	Units	Reference and Assumption
Forest Land to Settlements	Biomass	Biomass Before Conversion	238	t dry matter/ha	Canada Pacific Maritime (NRCan 1997)
		Carbon Fraction of Dry Matter	0.51	t C/t dry matter	Boreal and Temperate climate region, Conifers (IPCC 2023a)
		Volume of Biomass Burned	10,007	m^3	Estimated with VRI data (FLNRORD 2022)
		Volume of Biomass Salvaged	5,860	m^3	Estimated with VRI data (FLNRORD 2022)
		Volume of Biomass Allowed to Decay	3,907	m^3	Estimated with VRI data (FLNRORD 2022)
		Density of Dry Matter	0.8	t dry matter/m^3	Estimated with VRI data (FLNRORD 2022)
		Fraction of Carbon Converted to CO_2 when Burned	0.9	-	NIR (ECCC 2023)
		Fraction of Carbon Converted to CH_4 when Burned	0.01	-	NIR (ECCC 2023)
		N_2O Generated by Biomass Burning	0.00017	t N_2O/t CO_2	SACC (ECCC 2021)
	SOC	Soil Organic Carbon Content	117	t C/ha	Boreal climate region, Spodic soil (IPCC 2023b)[a]
		Stock Change Factor After Conversion	0.8	dimensionless	Settlement area is paved over or covered by the infrastructure (IPCC 2006)
Wetlands to Settlements	Peatlands	Nutrient Rich Peat	1.1	t C/ha/year	Boreal and Temperate climate region (IPCC 2011)

NOTE:
[a] Soil type is not known; spodic soil was selected for conservativeness.

4.1.6 Transmission Line

Construction of the transmission line will involve heavy construction equipment that combust diesel. To estimate GHG emission from transmission line construction, fuel use was estimated for a representative selection of equipment and operating detail and emission factors were applied. The estimation methodology used is the same as for non-marine construction equipment as described in Section 4.1.1.1.

The specific path of transmission line is not known. However, an estimate of GHG emissions from land-clearing activities will be made by scaling the Project land-clearing emissions by the ratio of the Project to transmission line corridor. For this estimate, the longest on-land portion of the transmission line (28.1 km) was estimated using GIS data and conservatively assuming a 45 m corridor.

4.1.7 Commissioning

Commissioning of the facility will occur immediately prior to the operation phase and is expected to take eight months. Depending on whether the connection to the BC Hydro electrical grid is ready, commissioning may use electricity either from the electrical grid or the power barges.

The methodology to estimate GHG emissions from the gas turbines can be found in Section 4.2.1 and Section 4.2.2. The methodology to estimate acquired GHG emissions from electricity can be found in Section 4.2.4.

4.2 OPERATION PHASE

The operation phase is anticipated to begin in late 2027 and is expected to continue for at least 30 years. Project design currently includes GHG emission sources for the operation phase including direct and indirect emissions from electricity.

During most of operation, the Project will use electricity from BC Hydro. This is considered to be the Base Case of the operation phase. However, it is possible that there may be a delay in the connection to the BC Hydro electrical grid. If this occurs, electricity will be generated on-Site in natural gas and steam turbines on temporary power barges for up to five years following the start of operation. The power barges will be purpose built for the Project. They will use the latest generation gas turbine technology, and a high efficiency steam combined cycle to achieve a heat rate comparable to the most efficient power generation facilities. Once the electrical connection is made to the BC Hydro grid, the temporary power barges will be decommissioned and removed from the Site.

Direct GHG emission sources are:

- Direct-fired process heaters (i.e., heat medium fired heaters)
- Thermal oxidizers
- Temporary power barges to produce power from Project feed gas until the transmission line is commissioned, if required

- Flares including:
  - Warm flares
  - Cold flares
- Marine operation including:
  - LNGCs
  - NGL product vessels
  - Tugboats (escort, harbour, or for material shipping)
  - Water taxis (personnel movements)

Indirect GHG emissions:

- Electricity consumption (acquired energy from the grid) when the BC Hydro connection is available

The Project is not expected to release a substantive amount of natural gas via voluntary venting or involuntarily via fugitive emissions. Specific mitigation related to venting and fugitive emissions are discussed in the SACC TDR (Appendix 8B) and include:

- Reduction of flanges and other emission points by using welded connections for hydrocarbon piping
- Specially designed valves that have lower leak rate from stems
- Capture, compression, and re-liquefaction of boil-off gas
- LDAR program using surveys

Due to the small number of NGL product carriers visiting each year, GHG emissions from this source are nominal and, therefore, have not been estimated.

The following subsections summarize the methods and assumptions used to estimate GHG emissions from normal operation activities for each source.

4.2.1 Combustion Methodology

Estimating the amount of CO_2 released from the combustion of a hydrocarbon fuel can be done using a mass balance approach. This approach assumes that the carbon present in the fuel is converted, to some degree, to CO_2. The degree of conversion is referred to as combustion efficiency, which can vary between equipment types.

Natural gas is predominantly made up of CH_4 which can be released to the atmosphere due to incomplete combustion. The combustion of petroleum fuels also results in the production of N_2O. The specific methodologies used are from the WCI (WCI 2012). These methodologies are the same as those required for reporting under the GGIRCA. For CO_2 emissions based on carbon content of the fuel, WCI.23 Equation 20-1 was applied. The carbon in the entrained CO_2 was not included in the Mole Fraction of

Hydrocarbon Constituents term; this entrained CO_2 was estimated separately (Section 4.2.2). For CH_4 emissions when a 100% combustion efficiency was assumed, WCI.24 Equation 20-12 was applied using estimated higher heating value (**HHV**) and EFs from WCI (2012). When a combustion efficiency of less than 100% was applied, CH_4 emissions were calculated using WCI.24 Equation 360-42 and the fuel-specific CH_4 content. The WCI.24 Equation 20-12 with estimated HHV and EFs from WCI (2012) was used to calculate N_2O emissions.

The emissions are calculated as per the equations shown below. For the CO_2 emission calculation, a molar volume conversion factor of 23.6449 m^3/kg-mole at standard conditions (15°C and 101.325 kPa) is applied. The plant availability factor is 94%. The estimated HHV for each fuel type is presented in Table 4.2–1 and the EFs are presented in the equipment detail tables below.

$$\mathit{WCI.\ 23\ Equation\ 20\text{-}1{:}\ CO_2\ Emissions\ from\ Combustion}\left(\frac{tonnes}{y}\right)$$
$$= Gas\ Rate\left(\frac{m^3}{hr}\right) * Hours\ \left(\frac{8760\ hr}{y}\right) * Plant\ Availability\ (94\%)$$
$$* Combustion\ Efficiency\ (\%)$$
$$* CO_2\ Emission\ factor\ from\ Combustion\ \left(\frac{kg}{m^3}\right) * Unit\ Conversion\ \left(\frac{1\ tonne}{10^3 kg}\right)$$

$$CO_2\ Emission\ Factor\ from\ Combustion\ \left(\frac{kg}{m^3}\right)$$
$$= \sum (Mole\ Fraction\ of\ Hydrocarbon\ Constituent$$
$$* Number\ of\ Carbon\ Atoms\ in\ the\ Hydrocarbon\ Constituent)$$
$$* \ Molecular\ Weight\ of\ Carbon\ \left(\frac{12.01\ kg\ C}{kg\text{-}mole}\right) \div Molar\ Volume\ Conversion\ Factor\left(\frac{23.6449\ m^3}{kg\text{-}mole}\right) * 3.664\ \frac{kg\ CO_2}{kg\ C}$$

$$WCI.24\ Equation\ 20\text{-}12{:}\ CH_4\ and\ N_2O\ Emissions\left(\frac{tonne}{y}\right)$$
$$= Gas\ Rate\left(\frac{m^3}{hr}\right) * Hours\ \left(\frac{8760\ hr}{yr}\right) * Fuel\text{-}specific\ HHV\ \left(\frac{GJ}{m^3}\right)$$
$$* Plant\ Availability\ (94\%) * \ Emission\ Factor\left(\frac{g}{GJ}\right) * Unit\ Conversion\ \left(\frac{1\ tonne}{10^6 g}\right)$$

$$WCI.24\ Equation\ 360\text{-}42:\ CH_4\ Emissions\left(\frac{tonne}{y}\right)$$
$$= Gas\ \ Rate\left(\frac{m^3}{hr}\right) * Hours\ \left(\frac{8760\ hr}{y}\right) * Plant\ Availability\ (94\%)$$
$$* CH_4\ Emmission\ Factor\ \left(\frac{kg}{m^3}\right) * Unit\ Conversion\left(\frac{1\ tonne}{1000\ kg}\right)$$
$$* \left(100\% - Combustion\ Efficiency(\%)\right)$$

$$CH_4\ Emission\ Factor\left(\frac{kg}{m^3}\right)$$
$$= Mole\ Fraction\ of\ Methane * \frac{Pressure\ (kPa) * Molecular\ Weight\ of\ Methane\left(\frac{16.043\ kg\ CH_4}{kg\text{-}mole}\right)}{Ideal\ Gas\ Constant\ \left(\frac{kJ}{kg\text{-}mol \cdot K}\right) * Temperature\ (K)}$$

The following table presents the gas compositions and the associated HHV used in this assessment as provided by the Proponents (see Table 4.2–1).

Table 4.2–1 Gas Analyses

Compound	Normalized Mole Fraction[a]			
	Design Feed Gas	Waste Gas	Flash Gas	Auxiliary Fuel
H_2O (water)	0	0.033	0.0065	0
H_2 (hydrogen)	0	0	0	0
He (helium)	0	0	0	0
N_2 (nitrogen)	0.004	0	0.0014	0.0004
CO_2 (carbon dioxide)	0.0033	0.958	0.0006	0.0001
H_2S (hydrogen sulphide)	0.000007	0.0006	0	0.000002
C1 (methane)	0.895	0.0066	0.879	0.901
C2 (ethane)	0.075	0.0013	0.0923	0.075
C3 (propane)	0.017	0.0003	0.0171	0.0172
I-C4 (isobutane)	0.0021	0	0.0011	0.0021
n-C4 (normal butane)	0.0025	0	0.0019	0.0025
I-C5 (isopentane)	0.00038	0	0.0002	0.0004
n-C5 (normal pentane)	0.00025	0	0.0002	0.0003
C6 (hexane)	0.00027	0	0.0001	0.0002
C7+ (heptane)	0	0	0	0
Benzene	0	0.0001	0	0
Total	1	1	1	1
HHV [b] (MJ/m^3)	41.0	0.39	41.3	41.3

NOTES:
[a] Provided by the Proponents
[b] HHV Higher heating value

4.2.2 Entrained CO_2 Methodology

Natural gas inherently contains a small amount of CO_2 (as shown in Table 4.2-1). When this gas is combusted, the CO_2 portion enters the atmosphere without any transformation. A mass balance approach was used to estimate the amount of CO_2 entrained in the combusted gases that was released to the atmosphere. The equation for calculating entrained CO_2 is provided.

$$CO_2\ Emissions\ from\ Entrained\ CO_2\ \left(\frac{tonnes}{y}\right)$$
$$= \sum Design\ Fuel\ Gas\ Rate \left(\frac{m^3}{hr}\right) * Hours\ \left(\frac{8760\ hr}{y}\right)$$
$$* Plant\ Availability\ (94\%) * Entrained\ CO_2\ Emission\ Factor\ \left(\frac{kg}{m^3}\right) * Unit\ Conversion\ \left(\frac{1\ tonne}{10^3 kg}\right)$$

$$Entrained\ CO_2 Emission\ Factor\ \left(\frac{kg}{m^3}\right)$$
$$= (Mole\ Fraction\ of\ Carbon\ Dioxide) *$$
$$* \ Molecular\ Weight\ of\ Carbon\ Dioxide\ \left(\frac{44.01\ kg\ CO_2}{kg\text{-}mole}\right) \div Molar\ Volume\ Conversion\ Factor\ \left(\frac{23.6449\ m^3}{kg\text{-}mole}\right)$$

For an LNG facility, CO_2 must be removed prior to the liquefaction process. The CO_2 and any sulphur compounds are scrubbed out of the process natural gas and become concentrated in a waste gas. The CO_2 portion of the waste gas is directly released from the thermal oxidizer, which is described in Section 4.2.3.2. Any hydrocarbons present are also converted to CO_2, as described in Section 4.2.1.

4.2.3 Equipment Details

4.2.3.1 Heat Medium Fired Heater

The heat medium fired heaters, used for process heating, combust natural gas. The Project has two heat medium fired heaters. The GHG emissions were estimated using the methodologies described in Section 4.2.1 and Section 4.2.2. The combustion efficiency and the CH_4 and N_2O EFs applied are presented in Table 4.2–2.

Table 4.2–2 Heat Medium Fired Heater GHG Details

Equipment	Fuel Type	Combustion Efficiency	Total Fuel Flow Rate (sm³/h)	CO_2 Emission Factor (combustion) (kg/m³)	CO_2 Emission Factor (entrained) (kg/m³)	CH_4 Emission Factor (g/GJ)	N_2O Emission Factor (g/GJ)
Heat Medium Fired Heaters	Design Fuel Gas	100%	3,953	2.08	0.614	0.966	0.861

NOTES:
Combustion and entrained CO_2 EFs are calculated from the equations in Section 4.2.1 and 4.2.2.
CH_4 and N_2O EFs from WCI (2012), Table 20-4
GJ Gigajoules

4.2.3.2 Thermal Oxidizer

Waste gas potentially containing reduced sulphur compounds is directed to the thermal oxidizer for conversion to sulphur dioxide. The waste gas also contains the CO_2 that is stripped out of the natural gas prior to the liquefaction process. In addition, a flash gas stream is directed to the thermal oxidizer to oxidize waste hydrocarbons, including CH_4, to CO_2. Because the HHV of the waste gas stream is low, an auxiliary fuel similar in composition to the feed natural gas is injected to the thermal oxidizer along with the waste gas to increase combustion efficiency. The Project has two thermal oxidizers.

The GHG emissions from the thermal oxidizers were estimated using the methodologies described in Section 4.2.1 and Section 4.2.2. The combustion efficiency, CO_2 EFs, CH_4 emission factor, and N_2O emission factor applied are presented in Table 4.2–3.

Because an N_2O emission factor specific to a thermal oxidizer could not be located in the literature, the N_2O emission factor for flaring, found in WCI (2012) was used. The flaring emission factor may underestimate the N_2O emissions from a thermal oxidizer, given that the thermal oxidizer operates at a higher temperature then a typical flare and N_2O emissions increase with temperature (up to approximately 1,200 K). The N_2O results are not expected to be substantively affected using the flaring emission factor.

Table 4.2–3 Thermal Oxidizer GHG Details

Equipment	Fuel Type	Combustion Efficiency	Total Fuel Flow Rate (sm^3/h)	CO_2 Emission Factor (combustion) (kg/m^3)	CO_2 Emission Factor (entrained) (kg/m^3)	CH_4 Emission Factor (kg/m^3)	N_2O Emission Factor (g/GJ)
Thermal Oxidizers	Auxiliary Fuel	99.9%	485	2.10	0.019	0.612	9.52×10^{-5}
	Waste Gas	99.9%	6,918	0.020	1.78	0.004	9.52×10^{-5}
	Flash Gas	99.9%	406	2.10	0.112	0.596	9.52×10^{-5}

NOTES:
Combustion and entrained CO_2 EFs are calculated from the equations in Section 4.2.1 and 4.2.2.
CH_4 EF is calculated from the equation in Section 4.2.1.
N_2O EF from WCI (2012), Equation 360-31

4.2.3.3 Temporary Power Barges (if required)

Power barges may be used during operation if the connection to the BC Hydro electrical grid is delayed. With a plant availability of 94%, the Project is anticipated to consume 4,700,000 megawatt-hours (**MWh**) of electricity per year.

The power barges will include both gas turbines and steam turbines in a combined cycle to produce the required electrical power requirements for the facility, as well as electrical power needed to operate the power barges and their attendant cooling equipment.

When the power barges are present, eight gas turbine generator sets would be normally operating, for a total net power of 603 MW. Stantec used the anticipated fuel consumption rate with the natural gas composition to determine the amount of CO_2 produced through combustion and the amount of CO_2 released that was already present in the natural gas. The fuel consumption rate was provided by the Proponents through a turbine manufacturer.

The GHG emissions from the power barges were estimated using the methodologies described in Section 4.2.1 and Section 4.2.2. The combustion efficiency, fuel flow rates, and emission factors applied are presented in Table 4.2–4.

Table 4.2–4 Power Barges GHG Details

Equipment	Fuel Type	Combustion Efficiency	Total Fuel Flow Rate (sm^3/h)	CO_2 Emission Factor (combustion) (kg/m^3)	CO_2 Emission Factor (entrained) (kg/m^3)	CH_4 Emission Factor (g/GJ)	N_2O Emission Factor (g/GJ)
Power Barges	Design Feed Gas	100%	95,033	2.08	0.614	0.966	0.861

NOTES:
Combustion and entrained CO_2 EFs are calculated from the equations in Section 4.2.1 and 4.2.2.
CH_4 and N_2O EFs from WCI (2012), Table 20-4.
Combustion efficiency of 100% is assumed.

4.2.3.4 Flares

There are three flare headers present on each FLNG with two flare stacks on each FLNG (i.e., six flares in total). Each flare has a continuous lit pilot so that in an emergency, process gas is directed to a flare that is ready for combustion. Stantec used the anticipated fuel consumption rate of the flare pilots and the natural gas composition to determine the amount of CO_2 produced through combustion and the amount of CO_2 released that was already present in the natural gas.

The GHG emissions from the normal (pilot) operation of the flares were estimated using the methodologies described in Section 4.2.1 and Section 4.2.2. The combustion efficiency, carbon content, CH_4 content, and N_2O emission factor applied are presented in Table 4.2–5.

Table 4.2–5 Flare Pilot GHG Details

Equipment	Fuel Type	Combustion Efficiency	Total Fuel Flow Rate (sm^3/h)	CO_2 Emission Factor (combustion) (kg/m^3)	CO_2 Emission Factor (entrained) (kg/m^3)	CH_4 Content (mole fraction)	N_2O Emission Factor (g/GJ)
Warm Flares	Auxiliary Fuel	98%	12.1	2.08	0.614	0.90	9.52×10^{-5}
High Pressure Cold Flares	Auxiliary Fuel	98%	12.1	2.08	0.614	0.90	9.52×10^{-5}
Low Pressure Cold Flares	Auxiliary Fuel	98%	12.1	2.08	0.614	0.90	9.52×10^{-5}

NOTE:
N_2O EF from WCI (2012), Equation 360-31

4.2.4 Acquired Energy (Electricity Consumption)

The Project is planned to have a connection to the BC Hydro electrical grid during operation. The anticipated electricity consumption of the Project is 4,700,000 MWh per year.

The use of electricity from the electrical grid does not generate GHG emissions directly at the Project. Instead, GHG emissions are released at the Site of electricity generation. These emissions are referred to as “indirect” or “acquired energy” emissions. The methodology used to estimate these emissions is from the draft Technical Guide (ECCC 2021):

$$Acquired\ Energy\ Emissions\ (tonnes\ CO_2e) = Electricity\ Use\ \left(\frac{MWh}{yr}\right) * Unit\ Conversion\ \left(\frac{1\ GWh}{1000\ MWh}\right) * Emission\ Factor\ \left(\frac{t\ CO_2e}{GWh}\right)$$

The government of BC has developed a methodology to estimate its electricity emission intensity factor (EEIF) for the integrated grid that the Project will be connected to. This methodology takes into account the generation of electricity within BC and also generation that takes place outside of BC but is consumed in BC. For the 2022 calendar year, the EEIF of the integrated grid was 11.5 t CO_2e/GWh (Government of British Columbia nd).

To consider the potential for the GHG intensity of electrical grids to change over time as fossil fuels are further phased out, more generation comes from renewable sources, and the push to net-zero, ECCC has established projected provincial EFs out to 2050 (ECCC 2022a). Stantec used the trend in emissions intensity described by ECCC for BC with the 2021 EEIF to approximate the change in electricity emission intensity over the lifetime of the Project. This approach assumes that the EEIF of 11.5 t CO_2e/GWh remains representative for the year 2028, when operation of the Project starts. Since the EEIF is expected to decrease over time, this assumption results in conservatively high acquired energy emissions. These EFs do not include the CO_2 from biogenic sources, which is in line with both BC and federal reporting guidance. Because the Project’s operation is expected to continue until at least the end of 2057, Stantec used the 2050 emission factor for the years 2051 through 2057. The EFs are presented in Table 4.2–6.

Table 4.2–6 Projected Electricity Consumption Emission Factors

Year	ECCC Projected Electricity Factor ($t\ CO_2e/GWh$)	Electricity Consumption Factors Used for Project ($t\ CO_2e/GWh$)
2028	1.1	11.5
2029	1.7	13.0
2030	1	7.67
2031 through 2033	0.9	6.90
2034 through 2038	0.8	6.13
2039 through 2057	0.7	5.37

NOTES:
ECCC (2022a)
Government of British Columbia (nd)
Projected EFs for 2051 through 2057 are not available. 2050 emission factor used for quantifying post 2050 emissions.
GWh Gigawatt-hour

The electricity consumption factors do not take into account that Canada has targeted to have a net-zero electricity grid by 2035 (ECCC 2022b). This is further considered in the SACC TDR (Appendix 8.0B).

4.2.5 Marine Operation

The LNGCs have two sets of engines: the main engines and the auxiliary engines. The engines typically burn marine diesel, but newer LNGC have the capability to burn boil-off gas (i.e., natural gas) as well. The assessment considered the combustion of marine diesel for propulsion and maneuvering while in transit and using natural gas while berthing, loading, or unberthing. The LNGCs also have a boiler onboard for water heating. Stantec assumed that the boiler uses marine diesel while the LNGC is transiting and natural gas when the vessel is berthing, loading, or unberthing.

The LNGC specifications used in the assessment are presented in Table 4.2–7.

Table 4.2–7 LNGC Specifications

Equipment	Fuel Type	Number and Size of Engines	Brake-Specific Fuel Consumption (g/kWh)		Transit Speed (knot)	Maximum Speed (knot)
			Diesel	LNG		
Main Engine	Marine Diesel/ Natural Gas	2 @ 15,600 kW	205	166	10	23.7
Auxiliary Engine	Marine Diesel/ Natural Gas	1 @ 8,020 kW	217	166	10	23.7
Boiler	Marine Diesel (in Portland Inlet), Natural Gas (at terminal)	1 @ 371 kW	300	-	-	-

NOTES:
US EPA (2022)
- Not relevant

For this assessment, it was assumed that each LNGC is accompanied by one escort tugboat while transiting between Triple Island and the Site and by three harbour tugboats while berthing or unberthing. The engine specifications of a RAstar 4000-DF tugboat were used for the escort tugboat and a RAstar 3800-DF specification was used for each harbour tugboat. Tugboats are also used to ship supplies to the Site during operation.

To estimate GHG emissions, it was assumed that the tugboat engines use marine diesel oil. The tugboat specifications used in the assessment are presented in Table 4.2–8.

Table 4.2–8 Tugboat Specifications

Equipment	Fuel Type	Number and Size of Engines	Brake-Specific Fuel Consumption (g/kWh)	Transit Speed (knot)
Escort Tugboat (Main Engine)	Marine Diesel	2 @ 3,000 kW	205	10
Harbour Tugboat (Main Engine)	Marine Diesel	2 @ 2,389 kW	213	-
Shipping Tugboat	Marine Diesel	1 @ 2,984 kW	205	10

NOTES:
US EPA (2022)
- Not relevant

Water taxis are small diesel ferries for personnel transport. Two routes are considered: from Gingolx to Site and from Prince Rupert to Site. The assessment assumes that the total trips are equally divided between the two routes. Each water taxi is assumed to have an engine output of 187 kW and travel at 11 knots. The brake-specific fuel consumption is 213 g/kWh (US EPA 2022).

The GHG emissions from the operation of the LNGC, tugboats, and water taxis were estimated using the US EPA's *Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions* (US EPA 2022). The CO_2, CH_4, and N_2O estimation methodologies are presented in the following equations.

$$
\begin{aligned}
&CO_2, CH_4, N_2O\ Emissions\ from\ Marine\ Engines\ During\ Transit\ \left(\frac{tonnes}{yr}\right) \\
&= Emission\ Factor\left(\frac{g}{kWh}\right) * Engine\ Power\left(\frac{kW}{vessel}\right) * Vessel\ Speed(knot) \\
&* Unit\ Conversion\left(\frac{1.852\ km/h}{1\ knot}\right) \div Distance(one\text{-}way\ trip\ km) \\
&* Number\ of\ Vessels\ \left(\frac{vessel}{yr}\right) * Load\ Factor(\%) * Unit\ Conversion\left(\frac{1\ tonne}{10^6}\right) \\
&* \frac{2\ movements}{one\text{-}way\ trip}
\end{aligned}
$$

$$
\begin{aligned}
&CO_2, CH_4, N_2O\ Emissions\ from\ Marine\ Engines\ at\ Terminal\left(\frac{tonnes}{yr}\right) \\
&= Emission\ Factor\left(\frac{g}{kWh}\right) * Engine\ Power\left(\frac{kW}{vessel}\right) \\
&* Hours\ Berthing\ or\ Unberthing\left(\frac{h}{vessel}\right) * Number\ of\ Vessels\ \left(\frac{vessel}{yr}\right) \\
&* Load\ Factor(\%) * Unit\ Conversion\left(\frac{1\ tonne}{10^6}\right)
\end{aligned}
$$

The load factor is calculated using the US EPA Port Guidance Equation 3.6:

$$
Load\ Factor = \left(\frac{Speed(knot)}{Max\ Speed(knot)}\right)^3 * Sea\ Margin(1.1)
$$

The boiler is assumed to have a load factor of 1. The sea margin is set as 1.1, which is indicated in US EPA (2022) to be relevant for coastal operation.

The EFs relevant for the LNGC, tugboat, and water taxi engines are presented in Table 4.2–9.

Table 4.2–9 Marine Vessel Emission Factors

Vessel	CO_2 Emission Factor (g/kWh)	CH_4 Emission Factor (g/kWh)	N_2O Emission Factor (g/kWh)
LNGC Main Engine – Portland Inlet	657	0.01	0.029
LNGC Auxiliary Engine – Terminal	696	0.008	0.029
LNGC Main Engine – Terminal	456	0.001	0.029
LNGC Auxiliary Engine – Terminal	456	0.001	0.029
LNGC Boiler – Portland Inlet	962	0.002	0.075
Tugboat (Escort)	657	0.01	0.029
Tugboat (Harbour)	679	0.0003	0.033
Tugboat (Shipping)	657	0.01	0.029
Water Taxi	679	0.002	0.033
NOTE: US EPA (2022)			

The GHG emissions associated with the boiler while the LNGC is berthing, loading, and unberthing were estimated using the WCI.23 and WCI.24 methodologies described in Section 4.2.1. The entrained CO_2 emissions were estimated as per the methodology described in Section 4.2.2.

4.2.5.1 Open Water

The LNGC approaches the Site via open water (i.e., between the 12 nautical mile Canadian territorial sea limit and the BC pilot station at Triple Island), then via the Portland Inlet. The one-way distance from the 12 nautical mile limit to the Triple Island pilot boarding station is approximately 167 km. At an assumed average speed of 14 knots (26 km/h), the LNGC travels for approximately 6.5 hours. The load factor for the LNGC is estimated to be 0.23 for the main engine and assumed to be 0.43 for the auxiliary engine while maneuvering.

During this portion of the trip, no tugboats are present. Based on current Project design, 150 LNGC vessels per year are expected for a total of 300 movements per year in open water.

4.2.5.2 Portland Inlet

While transiting between the BC pilot station at Triple Island and the Site, the LNGC is operating at approximately 10 knots (19 km/h). Based on a one-way transit distance of approximately 101 km, the LNGC and escort tugboat travel for approximately 5.5 hours in Portland Inlet. The load factor for the LNGC is estimated to be 0.08 for the main engine and assumed to be 0.43 for the auxiliary engine.

The tugboats are assumed to travel at the same speed as the LNGC auxiliary engine. A load factor of 0.33 was applied based on the travel speed (from US EPA 2022).

Based on current Project design, 150 LNGC per year are expected to travel through Portland Canal twice per visit (i.e., 300 movements per year). One tugboat is assumed to escort the LNGC through this route within (primarily) Portland Inlet each visit, for a total of 300 tugboat movements per year.

4.2.5.3 Terminal

Once near the terminal, the LNGCs begin berthing. It was assumed that an LNGC takes 2 hours to berth, 24 hours to complete loading, and 1 hour to unberth. The estimation of GHG emissions follows the methodology presented in Section 4.2.5.

The LNGC boiler operates at a higher load while the LNGC is loading. The LNGC boiler thermal efficiency and the CH_4 and N_2O EFs applied are presented in Table 4.2–10.

Table 4.2–10 LNGC Boiler (Loading) GHG Details

Equipment	Fuel Type	Thermal Efficiency	Fuel Flow Rate (sm^3/h)		CO_2 Emission Factor (combustion) (kg/m^3)	CO_2 Emission Factor (entrained) (kg/m^3)	CH_4 Emission Factor (g/GJ)	N_2O Emission Factor (g/GJ)
			Maneuvering	Loading				
LNGC Boiler	Design Fuel Gas	80%	44.3	358	2.08	0.614	0.966	0.861

NOTE:
CH_4 and N_2O EFs from WCI (2012), Table 20-4

While an LNGC is near the terminal, three harbour tugboats are expected to be present. Each tugboat is assumed to remain in escort positions for three hours per LNGC berthing, loading, and unberthing cycle.

4.3 DECOMISSIONING PHASE

Details on the GHG sources likely to occur during the decommissioning phase are not currently available. Overall, the sources present in the construction phase are also expected to be present in the decommissioning phase. This includes on- and off-road equipment and vessels and temporary diesel generators. GHG emissions associated with this phase are expected to be lower than during the construction phase as advancements in technologies such as electric heavy mobile equipment (that could be charged by the low GHG intensity BC grid electricity) should be available by that time. As such, a conservative estimate of decommissioning phase emissions is 45,381 t CO_2e (based on construction emissions and excluding land-use change and commissioning).

5.0 RESULTS

5.1 CONSTRUCTION PHASE

5.1.1 Off-road Non-marine Construction

The estimated GHG emissions from non-marine construction activities over the construction period are presented in Table 5.1–1.

Table 5.1–1 Off-road Non-marine Construction Emissions

Parameter	CO_2 (tonnes)	CH_4 (tonnes)	N_2O (tonnes)	CO_2e (tonnes)	CO_2e (tonnes/year)
Marine Terminal Construction					
Piling Rigs (diesel hammer)	384	0.02	0.06	401	100
Piling Rigs (vibratory hammer)	238	0.01	0.04	249	62.2
Piling Rig (hydraulic power packs)	371	0.02	0.06	388	97.1
600T Crane	652	0.03	0.10	682	170
Hydraulic Crane (300-ton, traveler)	652	0.03	0.10	682	170
Hydraulic Crane (150-ton, traveler)	381	0.02	0.06	398	99.6
Subtotal	**2,677**	**0.13**	**0.40**	**2,800**	**700**
Terrestrial Construction					
Dozer (D8)	2,615	0.13	0.39	2,735	684
Front-End Loader (FEL) (CAT966)	1,555	0.08	0.23	1,627	407
Excavator (CAT374)	2,727	0.14	0.41	2,853	713
Grader (Cat)	972	0.05	0.15	1,017	254
Rock Crusher	339	0.02	0.05	355	88.7
Skid Steer Loader	975	0.05	0.15	1,020	255
Forklift (long reach)	464	0.02	0.07	485	121
Hydraulic Crane (150 t)	1,520	0.08	0.23	1,590	398
Hydraulic Crane (60 t)	1,020	0.05	0.15	1,067	267
Crawler Crane (160 t)	563	0.03	0.08	589	147
Generator (500 kW diesel)	12,130	0.61	1.82	12,688	3,172

Table 5.1–1 Off-road Non-marine Construction Emissions

Parameter	CO_2 (tonnes)	CH_4 (tonnes)	N_2O (tonnes)	CO_2e (tonnes)	CO_2e (tonnes/year)
Generator (100 kW diesel)	3,283	0.16	0.49	3,434	859
Self-Propelled Modular Transport	2,447	0.12	0.37	2,560	640
Light Plant	541	0.03	0.08	566	141
Hydraulic Crane 180 ton for Cooler Rack	491	0.02	0.07	513	128
Hydraulic Crane 180 ton for Pipe Racks	491	0.02	0.07	513	128
Hydraulic Crane 300 ton for Pipe Racks	1,431	0.07	0.21	1,496	374
Hydraulic Crane 180 ton for Buildings	491	0.02	0.07	513	128
Crane 600 Ton	1,431	0.07	0.21	1,496	374
Grid Roller Double Drum	79.8	0.004	0.01	83.4	20.9
Vibrating Roller	79.4	0.004	0.01	83.0	20.8
Smooth Roller Tandem	79.4	0.004	0.01	83.0	20.8
Subtotal	35,725	1.78	5.37	37,368	9,342
Total	**38,402**	**1.92**	**5.77**	**40,169**	**10,042**

NOTE:
Totals may not add up due to rounding. Annual emissions are estimated using the total emissions over the phase and dividing by the number of construction years (4).

Total GHG emissions from non-marine construction activities are approximately 40,169 t CO_2e over the construction period (2025 to 2028), which is approximately 10,042 t CO_2e per year of construction.

5.1.2 Off-road Marine Construction

The estimated GHG emissions from marine construction activities over the construction period are presented in Table 5.1–2.

Table 5.1–2 Off-road Marine Construction Emissions

Parameter	CO_2 (tonnes)	CH_4 (tonnes)	N_2O (tonnes)	CO_2e (tonnes)	CO_2e (tonnes/year)
Marine Terminal					
Safety Rescue Boat	243	0.001	0.01	247	61.8
Total	**243**	**0.001**	**0.01**	**247**	**61.8**
NOTE: Totals may not add up due to rounding. Annual emissions are estimated using the total emissions over the phase and dividing by the number of construction years (4).					

Total GHG emissions from marine construction activities are approximately 247 t CO_2e over the construction period (2025 to 2028), which is approximately 61.8 t CO_2e per year of construction.

5.1.3 Marine Shipping

The estimated GHG emissions from marine shipping activities over the construction period are presented in Table 5.1–3.

Table 5.1–3 Marine Shipping Emissions

Parameter	CO_2 (tonnes)	CH_4 (tonnes)	N_2O (tonnes)	CO_2e (tonnes)	CO_2e (tonnes/year)
Personnel Shipping					
Water Taxi from Gingolx	36.5	0.0001	0.002	37.1	9.27
Water Taxi from Prince Rupert	212	0.001	0.01	215	53.7
Subtotal	**248**	**0.001**	**0.01**	**252**	**62.9**
Material Shipping					
Tugboat from Gingolx	535	0.008	0.02	542	136
Tugboat from Prince Rupert	2,811	0.04	0.12	2,849	712
Overseas Tugboat	666	0.01	0.03	674	169
Subtotal	**4,012**	**0.06**	**0.18**	**4,066**	**1,016**
Total	**4,260**	**0.06**	**0.19**	**4,318**	**1,080**
NOTE: Totals may not add up due to rounding. Annual emissions are estimated using the total emissions over the phase and dividing by the number of construction years (4).					

Estimated GHG emissions from marine shipping during construction are approximately 4,318 t CO_2e over the construction period (2025 to 2028), which is approximately 1,080 t CO_2e per year of construction.

5.1.4 On-road Construction Equipment

The estimated GHG emissions from on-road construction equipment over the construction period are presented in Table 5.1–4.

Table 5.1–4 On-road Construction Emissions

Parameter	CO_2 (tonnes)	CH_4 (tonnes)	N_2O (tonnes)	CO_2e (tonnes)	CO_2e (tonnes/year)
Terrestrial Construction					
Dump Truck (CAT745)	135	0.007	0.02	141	35.2
Water Tank Truck	3.61	0.0002	0.001	3.77	0.94
Truck (flat bed)	22.8	0.001	0.003	23.8	5.96
Concrete Pump Truck	5.13	0.0003	0.001	5.36	1.34
Concrete Mixer Truck	49.2	0.003	0.007	51.5	12.9
Vacuum Truck	0.54	0.00003	0.0001	0.56	0.14
Pick-up Truck	26.4	0.001	0.004	27.6	6.89
Side by Side Utility Vehicle	15.5	0.0008	0.002	16.3	4.06
Total	**258**	**0.01**	**0.04**	**270**	**67.4**

NOTE:
Totals may not add up due to rounding. Annual emissions are estimated using the total emissions over the phase and dividing by the number of construction years (4).

Total GHG emissions from on-road construction activities are approximately 270 t CO_2e over the construction period (2025 to 2028), which is approximately 67.4 t CO_2e per year of construction.

5.1.5 Blasting

The estimated GHG emissions from blasting over the construction period are presented in Table 5.1–5.

Table 5.1–5 Blasting Emissions

Parameter	CO_2 (tonnes)	CH_4 (tonnes)	N_2O (tonnes)	CO_2e (tonnes)	CO_2e (tonnes/year)
Terrestrial Construction	208	-	-	208	52.0
Total	**208**	**-**	**-**	**208**	**52.0**

NOTE:
Totals may not add up due to rounding. Annual emissions are estimated using the total emissions over the phase and dividing by the number of construction years (4).

Total GHG emissions from blasting activities are approximately 208 t CO_2e over the construction period (2025 to 2028).

5.1.6 Concrete Plant

The estimated GHG emissions from propane combustion associated with the concrete plant over the construction period are presented in Table 5.1–6.

Table 5.1–6 Concrete Plant Combustion Emissions

Parameter	CO_2 (tonnes)	CH_4 (tonnes)	N_2O (tonnes)	CO_2e (tonnes)	CO_2e (tonnes/year)
Terrestrial Construction	167	0.003	0.01	170	42.5
Total	**167**	**0.003**	**0.01**	**170**	**42.5**

NOTE:
Totals may not add up due to rounding. Annual emissions are estimated using the total emissions over the phase and dividing by the number of construction years (4).

Total GHG emissions from propane combustion at the concrete plant are approximately 170 t CO_2e over the construction period (2025 to 2028).

5.1.7 Land-Use Change

The estimated emissions from land-use change over 20 years are provided in Table 5.1–7.

Table 5.1–7 Land-Use Change Emissions

Land-use Conversion	Carbon Stock	Initial Carbon Stock (t C)	Change in Carbon Stock (t C/y)	Total Change in Carbon (t C)	CO_2 Emissions (Decay and Burning) (tonnes)	CH_4 and N_2O Emissions (Burning) (t CO_2e)
Forest Land to Settlements	Biomass (Living)	8,095	-8,095	-5,704	21,454	2,046
	Biomass (Dead)	1,432	-1,432	-1,432	5,249	-
	Soil Organic Carbon	609	-30.4	-609	2,233	-
Wetlands to Settlements	Biomass (Living)	15.7	-15.7	-15.7	57.7	-
	Biomass (Dead)	787	-787	-787	2,884	-
	Soil Organic Carbon	335	-16.7	-335	1,227	-
Total (over 20 years)					**35,151**	

NOTES:
Totals may not add up due to rounding.
Negative values for Change in Carbon Stock and Total Change in Carbon indicate releases of carbon. CO_2 Emissions to the atmosphere are positive.
Total Land-use Change emissions are conservatively included as emissions occurring within the construction phase.

Conservatively assuming that the emissions theoretically occurring over approximately 20 years occur over the three to four-year construction period, the annual GHG emissions from land use change during construction are 8,788 t CO_2/year.

5.1.8 Transmission Line

The estimated GHG emissions from transmission line construction are presented in Table 5.1–8.

Table 5.1–8 Transmission Line Construction

Parameter	CO_2 (tonnes)	CH_4 (tonnes)	N_2O (tonnes)	CO_2e (tonnes)
Transmission Line Construction	1,278	0.21	0.18	1,338
Total	**1,278**	**0.21**	**0.18**	**1,338**

The total GHG emissions from transmission line construction are approximately 1,338 t CO_2e.

The estimate of land-use change emissions associated with transmission line construction is 66,968 t CO_2e.

5.1.9 Commissioning

The estimated GHG emissions from commissioning activities are presented in Table 5.1–9.

Table 5.1–9 Commissioning Emissions

Parameter	CO_2 (tonnes)	CH_4 (tonnes)	N_2O (tonnes)	CO_2e (tonnes)	CO_2e (tonnes/year)
BC Hydro Acquired Energy	-	-	-	3,370	3,370
Power Barges	155,741	2.96	2.64	156,602	156,602

Approximately 3,370 t CO_2e of acquired emissions or approximately 156,602 t CO_2e of direct emissions are expected over the eight months of commissioning, depending upon the availability of the BC Hydro grid.

5.1.10 Summary

The GHG emissions that occur during the construction phase, including commissioning, are summarized in Table 5.1–10.

Table 5.1–10 Summary of Construction Phase Emissions

Equipment	CO_2 (tonnes)	CH_4 (tonnes)	N_2O (tonnes)	CO_2e (tonnes)	CO_2e (tonnes/ year)
Marine Terminal					
Off-road Non-marine	2,677	0.13	0.40	2,800	700
Off-road Marine	243	0.001	0.01	247	61.8
Subtotal	**2,921**	**0.13**	**0.41**	**3,048**	**762**
Terrestrial Construction					
Off-road Non-marine	35,725	1.78	5.37	37,368	9,342
On-road	258	0.01	0.04	270	67.4
Blasting	208	-	-	208	52.0
Concrete Plant	167	0.003	0.01	170	42.5
Land-use Change	33,105	54.5	2.29	35,351	8,788
Subtotal (including Land-use Change)	**69,462**	**56.3**	**7.71**	**73,167**	**18,292**

Table 5.1–10 Summary of Construction Phase Emissions

Equipment	CO_2 (tonnes)	CH_4 (tonnes)	N_2O (tonnes)	CO_2e (tonnes)	CO_2e (tonnes/ year)
Subtotal (excluding Land-use Change)	**36,357**	**1.80**	**5.42**	**38,016**	**9,504**
Shipping Materials					
Off-road Marine	4,012	0.06	0.18	4,066	1,016
Personnel Transport					
Off-road Marine	248	0.001	0.01	252	62.9
Commissioning					
BC Hydro Electricity	-	-	-	3,370	3,370
Power Barges	155,741	2.96	2.64	156,602	156,602
Total (BC Hydro, including Land-use Change)	**76,643**	**56.5**	**8.31**	**83,902**	**20,975**
Total (BC Hydro, excluding Land-use Change)	**43,538**	**2.00**	**6.02**	**48,751**	**12,188**
Total (Power Barges, including Land-use Change)	**232,384**	**59.5**	**11.0**	**237,134**	**59,284**
Total (Power Barges, excluding Land-use Change)	**199,279**	**4.96**	**8.66**	**201,983**	**50,496**

NOTE:
Totals may not add up due to rounding. Annual emissions are estimated using the total emissions over the phase and dividing by the number of construction years (4).

The total GHG emissions associated with the construction phase of the Project are estimated to range from 83,902 t CO_2e (using BC Hydro electricity for commissioning) to 237,134 t CO_2e (using power barges) when including emissions from land-use change and 48,751 t CO_2e (using BC Hydro electricity for commissioning) to 201,983 t CO_2e (using power barges) when excluding emissions from land-use change.

The annual GHG emissions associated with the Project construction phase are estimated to range from 20,975 t CO_2e/year (using BC Hydro electricity for commissioning) to 59,284 t CO_2e/year (using power barges) on an annual basis when including emissions from land-use change and 12,188 t CO_2e/year (using BC Hydro electricity for commissioning) to 50,496 t CO_2e/year (using power barges) on an annual basis when excluding emissions from land-use change.

5.2 OPERATION PHASE

5.2.1 Stationary Combustion

The stationary combustion sources include the heat medium fired heaters and the thermal oxidizers. If the BC Hydro grid is not available prior to operation, on-Site power generation will occur on temporary power barges.

The estimated annual GHG emissions from stationary combustion sources are presented in Table 5.2–1.

Table 5.2–1 Annual Stationary Combustion Emissions

Equipment	Combustion CO_2 (t/y)	Entrained CO_2 (t/y)	CH_4 (t/y)	N_2O (t/y)	CO_2e (t/y)
Heat Medium Fired Heaters	68,264	6.08	1.30	1.16	68,648
Thermal Oxidizers	16,510	101,590	4.69	0.03	118,226
Temporary Power Barges (8 units running, only if grid connection is delayed)	1,630,193	4,807	31.0	27.6	1,644,002
Total with on-Site generation	**1,714,967**	**106,403**	**37.0**	**28.8**	**1,830,876**
Total without on-Site generation	**84,774**	**101,596**	**5.99**	**1.19**	**186,874**
NOTE: Totals may not add up due to rounding.					

The stationary combustion emissions are approximately 186,874 t CO_2e per year when electricity is sourced from BC Hydro. If electricity is generated on-Site, approximately 1,830,876 t CO_2e per year is anticipated. The entrained CO_2 being released from the thermal oxidizer contributes approximately 55% to stationary combustion emissions, when gas turbines are not used.

5.2.2 Flares

GHG emissions from flares occur from the combustion of pilot gas on a routine basis. The flaring emissions are presented in Table 5.2–2.

Table 5.2–2 Annual Flaring Emissions (Pilot Gas)

Equipment	CO_2 (t/y)	CH_4 (t/y)	N_2O (t/y)	CO_2e (t/y)
Pilot Gas	609	3.65	0.001	700
Total	**609**	**3.65**	**0.001**	**700**

The flaring emissions are approximately 700 t CO_2e per year from pilot gas combustion.

5.2.3 Acquired Energy

The Project plans to use electricity from the BC Hydro electrical grid. Although GHG emissions are not directly emitted from the Project from the use of electricity, some GHGs are generated at the electricity generation source. As discussed in Section 5.1.8, if the electrical connection to the BC Hydro grid is available, grid electricity will be used for commissioning. Acquired energy emissions are presented over the period of 2027 (commissioning) to 2057 to show the forecasted change over time because of expected grid expansions over the lifetime of the Project. The estimated GHG emissions from the use of electricity are presented in Table 5.2–3.

Table 5.2–3 Acquired Energy Emissions (Including Potential Commissioning)

Year	Acquired Energy Emissions ($t\ CO_2e/y$)
2027	3,370
2028	41,400
2029	61,257
2030	36,033
2031	32,430
2032	32,430
2033	32,430
2034	28,827
2035	28,827
2036	28,827
2037	28,827
2038	28,827
2039	25,223
2040	25,223
2041	25,223
2042	25,223
2043	25,223
2044	25,223
2045	25,223
2046	25,223
2047	25,223
2048	25,223
2049	25,223
2050	25,223
2051	25,223

Table 5.2–3 Acquired Energy Emissions (Including Potential Commissioning)

Year	Acquired Energy Emissions ($t\ CO_2e/y$)
2052	25,223
2053	25,223
2054	25,223
2055	25,223
2056	25,223
2057	25,223
Total	859,357
Annual Average during Operation	28,645

NOTES:
Totals may not add up due to rounding.
Commissioning emissions are not included in the annual average.

When electricity from the BC Hydro electrical grid is used, the annual average GHG emissions from acquired energy use is approximately 28,645 t CO_2e per year.

5.2.4 Marine Operation

5.2.4.1 Open Water

While travelling in open water, the LNGCs will release GHG emissions from the combustion of marine diesel fuel. The estimated annual GHG emissions are presented in Table 5.2–4.

Table 5.2–4 Annual Marine (Open Water) Emissions

Equipment	CO_2 (t/y)	CH_4 (t/y)	N_2O (t/y)	CO_2e (t/y)
LNGCs	14,350	0.19	0.65	14,547
Total	**14,350**	**0.19**	**0.65**	**14,547**

NOTE:
Totals may not add up due to rounding.

The total emissions from LNGC in open water (i.e., between the 12 nautical mile Canadian territorial sea limit and the BC pilot station at Triple Island) are approximately 14,547 t CO_2e per year.

5.2.4.2 Portland Inlet

While transiting between the BC pilot station at Triple Island and the Site, the LNGCs and the escort tugboats will release GHG emissions from the combustion of marine diesel. The estimated annual GHG emissions are presented in Table 5.2–5.

Table 5.2–5 Annual Marine (Portland Inlet) Emissions

Equipment	CO_2 (t/y)	CH_4 (t/y)	N_2O (t/y)	CO_2e (t/y)
LNGCs	8,368	0.17	0.38	8,484
Escort Tugboats	2,111	0.03	0.09	2,140
Total	**10,479**	**0.20**	**0.47**	**10,624**
NOTE: Totals may not add up due to rounding.				

The total emissions from marine sources while transiting between the BC pilot station at Triple Island and the Site are approximately 10,624 t CO_2e per year.

5.2.4.3 Terminal

While berthing, loading, and unloading, each LNGC and three harbour tugboats will release GHG emissions from the combustion of marine diesel and natural gas. The estimated GHG emissions are presented in Table 5.2–6.

Table 5.2–6 Annual Marine (Terminal) Emissions

Equipment	CO_2 (t/y)	CH_4 (t/y)	N_2O (t/y)	CO_2e (t/y)
LNGCs	7,023	0.02	0.43	7,151
Harbour Tugboats	2,191	0.001	0.11	2,223
Total	**9,215**	**0.02**	**0.54**	**9,375**
NOTE: Totals may not add up due to rounding.				

The total emissions from marine sources while at the terminal are approximately 9,375 t CO_2e per year.

5.2.4.4 Material Shipping and Personnel Movements

Tugboats that are used to transport materials and water taxis that move personnel will release GHG emissions from the combustion of marine diesel. The estimated GHG emissions are presented in Table 5.2–6.

Table 5.2–7 Annual Marine Shipping and Personnel Movement Emissions

Equipment	CO_2 (t/y)	CH_4 (t/y)	N_2O (t/y)	CO_2e (t/y)
Material Shipping	1,657	0.03	0.07	1,680
Personnel Movements	188	0.001	0.009	191
Total	**1,845**	**0.03**	**0.08**	**1,870**
NOTE: Totals may not add up due to rounding.				

The total emissions from marine sources while at the terminal are approximately 1,870 t CO_2e per year.

5.2.5 Operation Summary

The GHG emissions that occur during the operation phase when the Project is connected to the BC Hydro electrical grid are summarized in Table 5.2–8. The GHG emissions that occur during the operation phase if the Project is not connected to the BC Hydro electrical grid are summarized in Table 5.2–9. The GHG emissions associated with the Alternative Case are expected to occur until the electrical connection is made (as late as 2032). Once connected, the BC Hydro Case emissions are expected to occur until the end of the Project operation phase. Actual GHG emissions from the Project during operation will be estimated according to BC legislation.

Table 5.2–8 Summary of Operation Phase Emissions (BC Hydro Case)

Equipment	CO_2 (t/y)	CH_4 (t/y)	N_2O (t/y)	CO_2e (t/y)
Stationary Combustion				
Heat Medium Fired Heaters	68,270	1.30	1.16	68,648
Thermal Oxidizers	118,100	4.69	0.03	118,226
Flaring				
Pilot Gas	609	3.65	0.001	700
Acquired Energy (Indirect)				
Electricity Use	-	-	-	28,645
Marine (Open Water)				
LNG Carriers	14,350	0.19	0.65	14,547

Table 5.2–8 Summary of Operation Phase Emissions (BC Hydro Case)

Equipment	CO_2 (t/y)	CH_4 (t/y)	N_2O (t/y)	CO_2e (t/y)
Marine (Portland Inlet)				
LNG Carriers	8,368	0.17	0.38	8,484
Escort Tugboats	2,111	0.03	0.09	2,140
Marine (Terminal)				
LNG Carriers	7,023	0.02	0.43	7,151
Harbour Tugboats	2,191	0.001	0.11	2,223
Marine (Material and Personnel Movements)				
Material Shipping	1,657	0.03	0.07	1,680
Personnel Movements	188	0.001	0.009	191
Total (Direct)	**222,868**	**10.1**	**2.93**	**222,990**
Total (Direct and Indirect)	**222,868**	**10.1**	**2.93**	**252,636**
NOTE: Totals may not add up due to rounding.				

The estimated direct and indirect on-Site GHG emissions from on-land emission sources (stationary combustion, flaring, acquired energy) are approximately 216,220 t CO_2e per year when the Project uses grid supplied electricity. GHG emissions from marine emission sources are approximately 36,416 t CO_2e per year. The total direct and indirect GHG emissions associated with the operation phase of the Project, when electricity from the BC Hydro electrical grid is used, are estimated to be 252,636 t CO_2e.

Table 5.2–9 Summary of Operation Phase Emissions (On-Site Generation)

Equipment	CO_2 (t/y)	CH_4 (t/y)	N_2O (t/y)	CO_2e (t/y)
Stationary Combustion				
Heat Medium Fired Heaters	68,270	1.30	1.16	68,648
Thermal Oxidizers	118,100	4.69	0.03	118,226
Temporary Power Barges (8 units running)	1,635,000	31.0	27.6	1,644,002
Flaring				
Pilot Gas	609	3.65	0.001	700
Marine (Open Water)				
LNG Carriers	14,350	0.19	0.65	14,547
Marine (Portland Inlet)				
LNG Carriers	8,368	0.17	0.38	8,484

Table 5.2–9 Summary of Operation Phase Emissions (On-Site Generation)

Equipment	CO_2 (t/y)	CH_4 (t/y)	N_2O (t/y)	CO_2e (t/y)
Escort Tugboats	2,111	0.03	0.09	2,140
Marine (Terminal)				
LNG Carriers	7,023	0.02	0.43	7,151
Harbour Tugboats	2,191	0.001	0.11	2,223
Marine (Material and Personnel Movements)				
Material Shipping	1,657	0.03	0.07	1,680
Personnel Movements	188	0.001	0.009	191
Total	**1,857,868**	**41.0**	**30.5**	**1,867,992**
NOTE: Totals may not add up due to rounding.				

The estimated annual direct on-Site GHG emissions from on-land emission sources (stationary combustion, flaring) are approximately 1,831,576 t CO_2e if the Project generates electricity on-Site during initial operating years. GHG emissions from marine emission sources are approximately 36,416 t CO_2e per year. The total annual direct GHG emissions associated with the operation phase of the Project, when electricity is generated on-Site, are estimated to be 1,867,992 t CO_2e.

5.3 DECOMMISIONING PHASE

Complete details on the emission sources likely to occur during the decommissioning phase are currently not available; however, it is expected that the emissions would be similar to or lower than GHG emissions during the construction phase. Activities would be similar and improved, lower GHG emitting options for equipment should be available to support decommissioning since it is planned to occur approximately 30 years following start-up. As such, a conservative estimate of decommissioning phase emissions is 45,381 t CO_2e (based on construction emissions excluding land-use change and commissioning).

5.4 UNCERTAINTY

The GHG emissions have been estimated using the best available information about Project design at the time of writing and using conservative assumptions where relevant. A change in the amount of hydrocarbon fuel combusted would have the greatest effect on the construction emissions and the emissions from the gas turbines. Because the direct CO_2 emissions from operation are estimated based on fuel carbon content, CO_2 emissions from fuel combustion have the lowest uncertainty. With respect to indirect emissions, the actual emissions intensity of the BC Hydro electrical grid in the future may be more or less than the assumed intensity used to estimate acquired emissions. The estimates of GHG emissions from land-clearing have a greater degree of uncertainty because the land area that is cleared may change as the Project is designed and because conservative assumptions were used to develop emissions estimates. The estimate of decommissioning emissions is based on construction phase emissions; actual emissions during decommissioning will depend on the source emissions characteristics used at the time of decommissioning.

6.0 CLOSURE

This TDR was prepared for the sole benefit of the Proponents for the Ksi Lisims LNG Project to estimate GHG emissions within the Project study areas for the Climate Change Valued Component.

Respectfully submitted,

Stantec Consulting Ltd.

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7.0 REFERENCES

7.1 LITERATURE CITED

(FLNRORD) BC Ministry of Forestry, Lands, Natural Resource Operations and Rural Development. 2022. Forest Vegetation Composite Polygons. Available online at: https://catalogue.data.gov.bc.ca/dataset/vri-2021-forest-vegetation-composite-polygons.

ECCC (Environment and Climate Change Canada). 2021. Technical Guide Related to the Strategic Assessment of Climate Change: Guidance on quantification of net GHG emissions, impact on carbon sinks, mitigation measures, net-zero plan and upstream GHG assessment. Draft. August 2021.

ECCC. 2022a. Canada's Greenhouse Gas Emissions Projections. From Environment and Climate Change Canada Data. Downloaded August 2, 2023. Available from: https://data.ec.gc.ca/data/substances/monitor/Canada-s-greenhouse-gas-emissions-projections/Current-Projections-Actuelles/Energy-Energie/Grid-O&G-Intensities-Intensites-Reseau-Delectricite-P&G/?lang=en.

ECCC. 2022b. Canada launches consultations on a Clean Electricity Standard to achieve a net-zero emissions grid by 2035. News release, March 15, 2022. Available at: https://www.canada.ca/en/environment-climate-change/news/2022/03/canada-launches-consultations-on-a-clean-electricity-standard-to-achieve-a-net-zero-emissions-grid-by-2035.html.

ECCC. 2023. National Inventory Report 1990-2021: Greenhouse Gas Sources and Sinks in Canada. Canada's Submission to the United Nations Framework Convention on Climate Change. Available at: https://unfccc.int/ghg-inventories-annex-i-parties/2023.

Government of British Columbia. *Greenhouse Gas Industrial Reporting and Control Act*.

Government of British Columbia. nd. Electricity emission intensity factors for grid-connected entities. Available online at: https://www2.gov.bc.ca/gov/content/environment/climate-change/industry/reporting/quantify/electricity. Accessed: January 22, 2023.

IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4: Agriculture, Forestry and Other Land Use. Chapter 7: Wetlands.

IPCC. 2011. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4: Agriculture, Forestry and Other Land Use. Chapter 7: Wetlands. Last updated August 2011.

IPCC. 2013. Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC. 2019. 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4: Agriculture, Forestry and Other Land Use. Chapter 3: Consistent Representation of Lands.

IPCC. 2023a. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4: Agriculture, Forestry and Other Land Use. Chapter 4: Forest Land. Last updated Jully 2023.

IPCC. 2023b. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4: Agriculture, Forestry and Other Land Use. Chapter 2: Generic Methodologies Applicable to Multiple Land-Use Categories. Last updated Jully 2023.

NRCan (Natural Resources Canada). 1997. Canada's Forest Biomass Resources: Deriving Estimates from Canada's Forest Inventory, Information Report BC-X-370 Pacific Forestry Centre, Victoria, BC. Canadian Forest Service.

Oak Ridge National Laboratory. 2017. 2016 Vehicle Technologies Market Report, ONRL/TM-2017/238. Prepared for the Vehicle Technologies Office, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy. Available at: https://info.ornl.gov/sites/publications/files/Pub74587.pdf.

The Mining Association of Canada. 2009. Energy and GHG Emissions Management Guidance Document – Final Version. July 2009.

US EPA. 2010. Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling, NR-005d, EPA-420-R-10-016, July 2010. Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi/P10081RV.PDF?Dockey=P10081RV.PDF.

US EPA. 2013. Saving Energy in Ready Mixed Concrete Production: An Energy Star® Quick Guide for Managing Energy, EPA-430-R-13-010, August 2013. Available at: https://www.energystar.gov/sites/default/files/buildings/tools/Concrete_Quick_Guide_09052013.pdf.

US EPA. 2018. Exhaust and Crankcase Emission Factors for Nonroad Compression-Ignition Engines in MOVES 2014b. Assessment and Standards Division, Office of Transportation and Air Quality. EPA-420-R-18-009. July 2018.

US EPA. 2022. Ports Emissions Inventory Guidance: Methodologies for Estimating Port-Related and Goods Movement Mobile Source Emissions, EPA-420-B-21-011, April 2022. Available at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1014J1S.pdf.

WCI. 2012. Final Essential Requirements of Mandatory Reporting: 2011 Amendments for Harmonization of Reporting in Canadian Jurisdictions. Amended February 10, 2012. Available at: https://www2.gov.BC.ca/assets/gov/environment/climate-change/ind/quantification/wci-2012.pdf.

World Resource Institute and World Business Council for Sustainable Development. 2015. The Greenhouse Gas Protocol. A Corporate Accounting and Reporting Standard. Revised Edition. Available at: https://ghgprotocol.org/corporate-standard.