APPENDIX 6.8-A

Greenhouse Gas Calculation Methodology

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1.0 Greenhouse Gas Assessment Methodology

1.1 Introduction

This appendix supplements Section 6.8 Greenhouse Gas Emissions and documents the methods, data, and assumptions that were used to estimate greenhouse gas (GHG) emissions during the construction stage for the proposed Waasigan Transmission Line Project (Project).

Greenhouse gases (GHGs) are defined as gases that trap radiation, essentially heating the atmosphere. The most common GHGs are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone, perfluorocarbons, hydrofluorocarbons, and sulphur hexafluoride. Greenhouse gas emissions occur because of various natural and anthropogenic activities, with the combustion of fossil fuels being the most widely attributed anthropogenic source.

The calculated GHG emissions described herein are based on conservative estimates and may overestimate the actual emissions. GHG reporting requirements should be based on actual annual emission totals and not those reported in this document.

1.1.1 Identification of Greenhouse Gas Emission Sources

The GHG emissions were estimated for the Project's construction stage based on information provided by Hydro One Networks Inc. (Hydro One) or included in the Project description. This assessment of Project effects on GHG emissions considers effects that occur during the construction stage, as GHG emissions are anticipated to be largest during this stage of the Project. During construction the Project is estimated to emit CO_2, CH_4 and N_2O from the combustion of fossil fuels during operation of mobile equipment (vehicles, construction equipment and helicopters), electricity consumption, and effects of land clearing (loss of carbon sink).

Based on the Project description, activities that would result in GHG emissions within each Project phase are listed in Table 1.1-1.

Table 1.1-1: Greenhouse Gas Emissions Sources

GHG Emission Source	GHG Source	Emissions Scope
Fuel consumption	CO_2, CH_4, N_2O	Scope 1
Land-use Clearing	CO_2, CH_4	Scope 1
Electricity generation	CO_2	Scope 2

CO_2 = carbon dioxide; CH_4 = methane; N_2O = nitrous oxide; GHG = greenhouse gas

1.1.2 Greenhouse Gas Emission Estimate Framework

The emissions estimation methods described follow generally accepted practices for assessing GHGs for environmental assessments and, where applicable, Ontario regulatory reporting guidance documents, federal regulatory reporting guidance documents and other international guidance. Table 1.1-2 represents the relevant guidelines that form the basis of GHG emission estimates for the Project.

Table 1.1-2: Applicable Guidelines for Estimation of Greenhouse Gas Emissions

Guideline	Program	Sources	Date
Canada's Greenhouse Gas Quantification Requirements, Version 4.0	Greenhouse Gas Reporting Program	Environment and Climate Change Canada	December 2020
Ontario's Guideline for Considering Climate Change in the Environmental Assessment Process (Ontario Climate Change Guide)	Ontario *Environmental Assessment Act*	Ministry of the Environment, Conservation and Parks	October 2017
Ontario's Guideline for Quantification, Reporting and Verification of Greenhouse Gas Emissions	Greenhouse Gas Reporting Program	Ministry of Environment, Conservation and Parks	December 2022
Draft Technical Guidance on Reporting Greenhouse Gas Emissions	Strategic Assessment of Climate Change	Environment and Climate Change Canada	October 2022
The Greenhouse Gas Protocol/A Corporate Accounting and Reporting Standard	Multiple Programs (e.g., Global Reporting Initiative); International Organization for Standardization (14001).	World Business Council for Sustainable Development and World Resources Institute	February 2013 Amendment
Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories	United Nations Framework Convention on Climate Change National Greenhouse Gas Inventories Programme	Intergovernmental Panel on Climate Change	2006 & 2019 Refinement

1.1.3 Provincial and Federal Greenhouse Gas Quantification Requirements (2020)

Ontario Regulation (O. Reg.) 390/18 governs the documentation and reporting of GHG emissions in Ontario (MECP 2022a). *Guideline for Quantification, Reporting and Verification of Greenhouse Gas Emissions Reporting* (MECP 2022b; the O. Reg. 390/18 Guideline) provides the emission estimation methods that are required to be used under this reporting regulation. O. Reg. 390/18 refers to the Canada's Greenhouse Gas Quantification Requirement (the Greenhouse Gas Reporting Program [GHGRP] Guideline; ECCC 2020a) for methods to be used in estimating facilities emissions.

The GHGRP Guideline (ECCC 2020a) provides direction in determining if facilities are required to submit a GHG report to Environment and Climate Change Canada, an overview of the reporting process, and technical information related to GHG emissions estimations. Technical information includes GHG emission sources subject to reporting and information on emission estimation methodologies.

The GHGRP Guideline references GHG estimation methodologies from the United Nations Framework Convention on Climate Change and the Intergovernmental Panel on Climate Change (IPCC). The GHGRP Guideline states that "no specific estimation methods are prescribed" and that facilities should choose estimation methods that are most appropriate for their industry. However, the GHGRP Guideline is consistent with the guidelines adopted by the United Nations Framework Convention on Climate Change (UNFCCC) for preparing national GHG inventories.

1.1.4 The Greenhouse Gas Protocol

The World Business Council for Sustainable Development and the World Resources Institute have developed *The Greenhouse Gas Reporting Protocol: A Corporate Accounting and Reporting Standard* (GHG Protocol; World Resources Institute & World Business Council for Sustainable Development 2013), which provides guidance for preparing corporate GHG inventories as well as sector-specific and general calculation tools that can be used for estimating GHG emissions. The GHG Protocol has been adopted by the Global Reporting Initiative, which provides guidance on sustainability reporting for industry.

Following the GHG Protocol, emissions are classified as either direct or indirect. Direct emissions are those generated from sources that are owned by the proponent. Indirect emissions are those that result from activities of the operating proponent, but occur at sources owned by another proponent, such as electrical power consumption. For the purposes of accounting and reporting, these are typically classified as Scope 1, Scope 2, or Scope 3, and defined as Table 1.1-1.

The GHG Protocol requires reporting of Scope 1 (direct emissions from site) and Scope 2 (emissions from on-site energy consumption) emissions only. Scope 1 and Scope 2 emissions are typically the focus of most corporate inventories, though many organizations choose to account for other activities such as employee travel and downstream emissions from

waste. These sources are classified as Scope 3 (indirect) emissions and are reported as an option. The GHG inventory focuses on the emissions directly linked to the Project (i.e., Scope 1 and Scope 2 emissions).

1.1.5 Emissions Inventory Boundary

The definition of the inventory boundary, which frames the GHG emission sources that are included in the GHG emissions inventory for the Project, is based on the GHGRP and IPCC's Guidelines for National Greenhouse Gas Inventories. Table 1.1-3 outlines the GHG inventory boundaries of the guidelines and presents the source categories included in the Project GHG inventory.

Table 1.1-3: Emission Source Categories Included in the Greenhouse Gas Reporting Program, Ontario Climate Change Guide, Intergovernmental Panel on Climate Change, The Greenhouse Gas Protocol, and Assessed in the Application

Emission Source Category	GHGRP / O. Reg 390/18	Ontario Climate Change Guide	IPCC	GHG Protocol	Assessed in this GHG Assessment
Fuel Consumption (Scope 1)	Y	Y	Y	Y	Y
Land-Use Clearing (Scope 1)	N	Y	Y	N	Y
Electricity generation (Scope 2)	Y	Y	Y	Y	Y

GHGRP = Greenhouse Gas Reporting Program; O. Reg 390/18 = Ontario Regulation 390/18; IPCC = Intergovernmental Panel on Climate Change; GHG Protocol = *The Greenhouse Gas Reporting Protocol: A Corporate Accounting and Reporting Standard*; EIS = Environmental Impact Statement; Y = yes; N = no.

1.1.6 Greenhouse Gas Emissions Assessment Data Requirements

Table 1.1-4, below, documents the sources for all data used to estimate the GHG emissions.

Table 1.1-4: Greenhouse Gas Emissions Assessment Data Sources

Emission Source	Parameter	Value	Unit	Data Source
Electricity Consumption	• Annual electricity consumption • Emission intensity for Ontario grid (Consumption Intensity)	• 200 • 28	• MW/hr per camp/year • g CO2e / kWh	• Information provided by Valard Construction • NIR 1990-2020: GHG Sources and Sinks in Canada, Canada's Submission to the UNFCCC, Table A13-7, Part 3 for the year 2020 for Ontario. EF taken for consumption intensity (ECCC 2022c)
Fuel Consumption	• Total diesel consumption for phase 1 • Total diesel consumption for phase 2 • Total jet A fuel consumption for phase 1 • Total jet A fuel consumption for phase 2 • Total gasoline consumption for phase 1 • Total gasoline consumption for phase 2	• 3,391,050 • 2,117,500 • 1,099,800 • 665,000 • 1,420,575 • 1,050,000	• L • L • L • L • L • L	Information provided by Valard Construction
Fuel Consumption	• Total propane consumption for phase 1 • Total propane consumption for phase 2	• 2,640,000 • 2,520,000	• L • L	Information provided by Valard Construction

Emission Source	Parameter	Value	Unit	Data Source
Fuel Consumption	• Emission factor for diesel combustion (CO_2) • Emission factor for diesel combustion (CH_4) • Emission factor for diesel combustion (N_2O)	• 2,681 • 0.078 • 0.022	• g CO_2/L • g CH_4/L • g N_2O/L	Table A6.1-5 of NIR 1990-2020: GHG Sources and Sinks in Canada, Canada's Submission to the UNFCCC, Part 2 (ECCC 2022b)
Fuel Consumption	• Emission factor for jet A combustion (CO_2) • Emission factor for jet A combustion (CH4) • Emission factor for jet A combustion (N_2O)	• 2,560 • 0.026 • 0.031	• g CO_2/L • g CH_4/L • g N_2O/L	Table A6.1-5 (Kerosene, Construction) of NIR 1990-2020: GHG Sources and Sinks in Canada, Canada's Submission to the UNFCCC, Part 2 (ECCC 2022b)
Fuel Consumption	• Emission factor for gasoline combustion (CO_2) • Emission factor for gasoline combustion (CH_4) • Emission factor for gasoline combustion (N_2O)	• 2,307 • 0.140 • 0.022	• g CO_2/L • g CH_4/L • g N_2O/L	Table A6.1-14 (Tier 2, LDGVs) of NIR 1990-2020: GHG Sources and Sinks in Canada, Canada's Submission to the UNFCCC, Part 2 (ECCC 2022b)
Fuel Consumption	• Emission factor for propane combustion (CO_2) • Emission factor for propane combustion (CH_4)	• 1,515 • 0.024	• g CO_2/L • g CH_4/L	Table A6.1-4 (Emission Factors for Natural Gas Liquid, Propane, All Other Uses) of NIR. 1990-2020: GHG Sources and Sinks in Canada, Canada's Submission to the UNFCCC, Part 2 (ECCC 2022b)
Fuel Consumption	• Emission factor for propane combustion (N_2O)	• 0.108	• g N_2O/L	Table A6.1-4 (Emission Factors for Natural Gas Liquid, Propane, All Other Uses) of NIR. 1990-2020: GHG Sources and Sinks in Canada, Canada's Submission to

Emission Source	Parameter	Value	Unit	Data Source
				the UNFCCC, Part 2 (ECCC 2022b)
Land Change: Land Clearing Area	• Forest Land • Wetland	• 3,486 • 117	• ha • ha	Information based on data provided as part of the vegetation assessment for the final preferred route alignment (August 2023).
Land-use Change: Carbon Sink Loss (CO_2) - Boreal Plain: Forest (Coniferous/ Deciduous)	• Average annual above-ground biomass growth (Gw) • Ratio of below-ground to above-ground biomass (R) • Carbon fraction of dry matter (CF)	• 1 • 0.39 • 0.47	• tonne dm ha^{-1} yr^{-1} • n/a • tonne C	• Table 4.12 of IPCC 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories, Vol 4, Chapter 4. Boreal Coniferous Forest • Table 4.4 of IPCC 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories Vol 4, Chapter 4. Boreal forest with biomass density <75 tonnes/ha Table 4.3 of IPCC 2006 Vol 4, Chapter 4. Boreal forest with all parts (broad-leaves and conifers) (No Refinement in IPCC 2019)
Land-use Change: Carbon Sink Loss (CO_2) - Boreal Plain: Wetland	• Average annual above -ground biomass growth (Gw) • Ratio of below-ground to above-ground biomass (R)	• 0.40 • 4.0 • 0.47	• tonne dm ha^{-1} yr^{-1} • n/a • tonne C	• Table 4.12 of IPCC 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories Vol 4, Chapter 4. Default value from forest-type closest to non-forest vegetation is used (as per directions in Chapter 2). • Table 6.1 of IPCC Vol 4, Chapter 6. Boreal climate zone. (No Refinement in IPCC 2019)

Emission Source	Parameter	Value	Unit	Data Source
	• Carbon fraction of dry matter (CF)			• Section 6.3.1 of IPCC 2006 Vol 4, Chapter 6. Default value for herbaceous biomass. (No Refinement in IPCC 2019)
Land-use Change: Constant value	• Conversion factor C to CO_2	• 3.67	• n/a	• Ratio of molecular weight of CO_2 to C
Land-use Change: Carbon Sink Loss (CH_4) - Boreal Plain: Wetland	• Total annual flux of CH_4	• 183	• kg CH_4 ha-1 yr-1	• Table 7.12 of IPCC 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories Vol 4, Chapter 7.
	• Emission factor for other waterbody type	• 1	• n/a	• Equation 7.12 of IPCC 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories Vol 4, Chapter 7.
Land-use Change: Loss of Carbon from Disturbance (One Time Loss) – Boreal Plain Coniferous/ Deciduous	• Average above-ground biomass affected by disturbance (Bw)	• 62.9	• tonne dm ha^{-1}	• Table 4.7 of IPCC 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories Vol 4, Chapter 4. Boreal coniferous forest.
	• Ratio of below-ground to above-ground biomass (R)	• 0.39	• n/a	• Table 4.4 of IPCC 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories Vol 4, Chapter 4. Boreal forest with biomass density <75 tonnes/ha
	• Carbon fraction of dry matter (CF)	• 0.47	• tonne C	• Table 4.3 of IPCC 2006 Vol 4, Chapter 4. Boreal forest with all parts (broad-leaves and conifers). (No Refinement in IPCC 2019)
	• Fraction of biomass lost (fd)	• 1.0	• n/a	• Assumes all biomass is lost.

Emission Source	Parameter	Value	Unit	Data Source
Land-use Change: Loss of Carbon from Disturbance (One Time Loss) – Boreal Plain Wetland	• Average above-ground biomass affected by disturbance (Bw)	• 50.0	• tonne dm ha^{-1}	• Table 4.7 of IPCC 2006 Vol 4, Chapter 4. Default value from forest-type closest to non-forest vegetation is used (as per directions in Chapter 2).
	• Ratio of below-ground to above-ground biomass (R)	• 4.0	• n/a	• Table 6.1 of IPCC Vol 4, Chapter 6. Boreal climate zone.
	• Carbon fraction of dry matter (CF)	• 0.47	• tonne C	• Section 6.3.1 of IPCC 2006 Vol 4, Chapter 6. Default value for herbaceous biomass.
	• Fraction of biomass lost (fd)	• 1.0	• n/a	• Assumes all biomass is lost.
Global Warming Potentials	• Carbon dioxide	• 1	• CO_2	• IPCC AR5 (IPCC 2013)
	• Methane	• 28	• CH_4	• IPCC AR5 (IPCC 2013)
	• Nitrous Oxide	• 265	• N_2O	• IPCC AR5 (IPCC 2013)

a) Source: ECCC 2022a
b) Source: ECCC 2022b
c) Source: ECCC 2022c
d) Source: IPCC 2006
e) Source: IPCC 2019

1.1.7 Greenhouse Gas Emission Methodology

This subsection includes information on the methods used to calculate emissions from fuel consumption, land-use clearing and electricity generation.

1.1.7.1 Electricity Consumption

Emission rates of electricity consumption were calculated as follows:

Equation 1

$$ER = EF \times E_y \times 0.000001 \times 1000$$

Where,

ER = emission rate in tonnes CO_2e per year;

EF = the emission factor, in CO_2e per kWh, provided by NIR 1990-2020: GHG Sources and Sinks in Canada, Canada's Submission to the UNFCCC, Table A13-7, Part 3 (ECCC 2022c),

Ey = the energy consumed in MWh per year;

0.000001 = conversion factor from grams to tonnes;

1,000 = the conversion factor from MWh to KWh

1.1.8 Fuel Consumption

Emission rates of fuel consumption are calculated as follows.

Equation 2

$$ER = \sum (EF \times Fuel\ Usage \times UC1\ )$$

Where,

ER = emission rate in tonnes per year;

EF = emission factor in gCO_2/L, gCH_4/L, or gN_20/L, provided by NIR 1990-2020: GHG Sources and Sinks in Canada, Canada's Submission to the UNFCCC, Part 2 (ECCC 2022b); and

UC1 = unit conversion from g to tonnes.

1.1.8.1 Land Clearing

Carbon dioxide emissions from land clearing include the annual carbon sink loss and the one-time loss of carbon from land clearing activities. The emissions were calculated using the method described in the 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories (IPCC 2019). The land to be cleared includes forest, shrub, field, meadow, and barren, as well as wetland. For these calculations, the project footprint area has been classified

as boreal forest, as well as wetland per the IPCC definitions. The calculation of the total carbon stored annually, and therefore considered to be emitted annually with the removal of vegetation, was calculated based on Equation 2.9 and Equation 2.10 (Tier 1) in Section 2.3.1.1.A of the 2006 IPCC Volume 4, Chapter 2 (IPCC 2006). This is presented in Equation 3 below. It was conservatively assumed that all land cleared will be burned in the absence of a known percentage of burning (anticipated to be much less than 100%).

Equation 3

$$CO_2 = \Delta C \times 44/12 \; and$$

$$\Delta C = \sum A \times G_W \times (1 + R) \times CF$$

Where,

CO_2 = annual mass of CO_2 emissions from the removal of carbon sinks, in tonnes of CO_2 per year;

ΔC = annual carbon stored due to biomass growth by vegetation type and climatic zone, in tonnes of carbon per year;

A = area of land, in hectares;

GW = average annual above-ground biomass growth for a specific woody vegetation type, in tonnes of dry matter per hectare per year;

R = ratio of below-ground biomass to above-ground biomass for a specific vegetation type, in tonnes of dry matter below-ground biomass per tonne dry matter above-ground biomass;

CF = carbon fraction of dry matter, tonnes of carbon per tonne dry matter; and

44/12 = conversion factor carbon to CO_2

The calculation of the total CH_4 stored annually in the wetland, and therefore considered to be emitted annually with the removal of vegetation, was calculated based on Equation 7.12 (Tier 1) in Section 7.3.1.2 of the IPCC 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories, Chapter 7 (IPCC 2019). This is presented in Equation 4 below.

Equation 4

$$F_{CH4\ other} = \sum_{j=1}^{6} \sum_{w=1}^{3} \sum_{i=1}^{nother_{w,j}} (A_{j,w,i} * EF_{CH4,w} * \alpha_{j,w,i})$$

Where,

$F_{CH4\ other}$= Total annual flux of CH_4 from ponds and ditches in kg CH_4 per yr^{-1};

$A_{j,w,l}$ = Area of other waterbody 'l' of type 'w' in climate zone 'j' in hectares;

$A_{j,w,l}$ = Emission factor adjustment for trophic state other waterbody 'l' of type 'w' located in climate zone 'j'. Currently = 1 for all tiers. [dimensionless];

EF CH4,w = Emission factor for other waterbody of type 'w' in kg CH_4 ha -1 y-1]; Refer to Table 7.15

$nother_{w,j}$ = Number of other waterbodies of type 'w' in climate zone 'j'

i = Summation index for the number of other waterbodies of type 'w' in climate zone 'j'

j = Summation index for climate zones (j= 1-6)

w = Summation index for waterbody classes

The one-time loss of carbon from disturbances was calculated based on Equation 2.14 in Section 2.3.1.1.A.2 of the 2006 IPCC Volume 4, Chapter 2 (IPCC 2006). This is presented in Equation 5 below.

Equation 5

$$CO_2 = L \times 44/12\ and$$

$$L = \sum A \times B_W \times (1 + R) \times CF \times fd$$

Where,

CO_2 = annual mass of CO_2 emissions from the loss of carbon due to disturbances, in tonnes of CO_2 per year;

L = annual loss of carbon due to disturbances, in tonnes of carbon per year;

A = area affected by disturbances, in hectares per year;

B_W = average above-ground biomass of land area affected by disturbances, in tonnes of dry matter per hectare;

R = ratio of below-ground biomass to above-ground biomass, in tonnes of dry matter below-ground biomass per tonne dry matter above-ground biomass;

CF = carbon fraction of dry matter, tonnes of carbon per tonne dry matter;

fd = fraction of biomass lost in disturbance; and

44/12 = conversion factor carbon to CO_2.

1.1.9 Conservatism

Table 1.1-5, below, outlines assumptions and conservatisms used in the emission calculations. With these conservative assumptions it is unlikely that the emissions associated with the Project are underestimated.

Table 1.1-5: Greenhouse Gas Emissions Assessment Assumptions List

Source Area	Conservatism
Electricity consumption	The natural gas consumption for electricity generation was conservatively estimated using the maximum estimates rather than average estimates.
Fuel Consumption	The maximum volume of fuel to be consumed for building heating and each piece of construction equipment were used in the calculations.
Land-Use Clearing	It has been conservatively assumed that all vegetation cleared will be burned and therefore directly emitted to the atmosphere.

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