APPENDIX M

Climate Change Analysis

REPORT

De Havilland Field Project

Climate Change Analysis

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Table of Contents

TABLES

1.0 INTRODUCTION

2150038 Alberta Inc. (The Proponent) is proposing development of the De Havilland Field Project (the Project) on farmland in Wheatland County, Alberta. The proposed Project site is located approximately 14 km west of the town of Strathmore and 20 km east of the City of Calgary. The Project site is bordered by TransCanada Highway 1, approximately 800 m north of the perimeter, by Range Road 264 along the eastern side, by Range Road 265 along the western side, and by Township Road 240 along the southern border. The proposed site occupies approximately 600 hectares of existing farmland, divided into three lots: an airstrip on the southern lot (Cell 1) and two commercial/industrial areas on the eastern and northern lots (Cell 2 and Cell 3, respectively). The Project location and preliminary site details are show in Figures 1 and 2 of the Initial Project Description.

IAA guidelines require proponents to consider climate change based on the Strategic Assessment of Climate Change (SACC) (Government of Canada 2020) which includes:

- How operation of the proposed Project may affect climate change (i.e., the Project's contribution to climate through the emission of Greenhouse Gases [GHGs]); and,
- How potential changes in climate may affect the proposed Project, including supporting and/or ancillary facilities and infrastructure, (i.e., the resilience of the Project to climate change).

As such, to inform the IAA Initial Project Description, a Greenhouse Gas Assessment, as well as a Climate Change Resilience Assessment has been conducted for the Project. The Greenhouse Gas Assessment includes an estimate of the net GHG emissions associated with the Project which are based on the available Project information. To assess the potential impact, the estimated net GHG emissions are compared to the provincial and federal GHG inventories. The Greenhouse Gas Assessment has been summarized in Section 2.0 which includes a description of the methodology, data, assumptions, and emission factors used for GHG estimation.

The Climate Change Resilience Assessment employs a risk management approach based on the conceptual Project design. The assessment anticipates future climatic conditions for the Project region, and how climate change related disruptions or impacts may affect the Project. Given that the design is at the conceptual stage, a qualitative screening level risk assessment approach was conducted based on the preliminary design information. The Climate Change Resilience Assessment is consistent with Infrastructure Canada's *Climate Lens - General Guidance* (Infrastructure Canada 2019) and the SACC (Government of Canada 2020). The Climate Change Resiliency Assessment is summarized in Section 3.0.

2.0 GREENHOUSE GAS ASSESSMENT

Climate change is defined as change in global or regional climate patterns, primarily attributed to increased atmospheric concentrations of greenhouse gases (GHGs) (Government of Canada 2021a). GHGs have the potential to affect future climate as they contribute to the greenhouse effect by absorbing infrared radiation in the atmosphere, increasing temperature, and changing weather patterns (Government of Canada 2015). Therefore, assessing GHGs is the most effective method for estimating a project's effect on climate change. The Project would emit GHGs throughout all phases, with sources that produce carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). This section presents the net GHG emissions associated with the Project based on the available Project information.

2.1 Methodology

The GHG estimation approach has adhered to the following principles:

- **Relevance**: The data and GHG quantification procedures most applicable to the Project have been selected. Emissions factors were mainly sourced from Canada's Greenhouse Gas Quantification Requirements (ECCC 2020) and Canada's GHG National Inventory Report (NIR) for 1990-2020 (NIR Report) (ECCC 2022a, 2022b, 2022c). Emission factors used are referenced in Section 1.3.
- **Completeness**: Significant GHG emission sources and activities within the chosen boundaries have been accounted for.
- **Consistency**: The GHG estimation has been conducted by consistently applying data, methods, criteria, and assumptions to enable meaningful comparisons of GHG emissions between the Baseline case and the Project case.
- **Accuracy**: The GHG emissions have been quantified in a manner that reduces uncertainty to the extent practical by using the best available Project-specific input data, published emissions factors, and estimation methodologies.
- **Transparency**: Assumptions, methods, calculations, and associated uncertainties have been presented in this section in a factual manner.
- **Conservativeness**: It is recognized that uncertainties exist due to the Project's early design stage. Where there were uncertainties, the values that would result in a conservative estimate of potential emissions were used.
- The calculated GHG emissions described herein are based on conservative estimates and may overestimate the actual emissions. GHG impact assessment and reporting requirements should be based on actual annual emission totals and not those reported in this document.

2.1.1 Criteria and Indicators

The criteria and indicators selected for the estimation of Project effects on GHGs, and the rationale for their selection, are provided in Table 1.

Table 1: Greenhouse Gases Criteria and Indicators

Criteria	Rationale	Indicators
Greenhouse gases (GHGs)	▪ Greenhouse gases contribute to climate change. ▪ Federal and provincial concerns with GHG emissions and climate change.	▪ Predicted GHG emissions of CO_2. ▪ Predicted GHG emissions of N_2O. ▪ Predicted GHG emissions of CH_4.

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

GHG emissions include the following compounds: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs). Consideration of these GHG emissions is required as part of the Draft Technical Guide Related to the Strategic Assessment of Climate Change (SACC) (Government of Canada 2021b). However, GHG emissions from this Project are expected to be limited to those of CO_2, CH_4, and N_2O, as no sources are present that are anticipated to emit SF_6, PFCs, or HFCs.

- **GHG emissions of CO_2**: the quantity of CO_2 expressed in carbon dioxide equivalent (CO_2e) reflects federal and provincial commitments to GHG emissions and climate change. Emissions of CO_2 are expressed on an annual basis in tonnes of CO_2e per year (t CO_2e/yr).
- **GHG emissions of CH_4**: the quantity of CH_4 expressed in CO_2e reflects federal and provincial commitments to GHG emissions and climate change. Emissions of CH_4 are expressed on an annual basis in t CO_2e/yr.
- **GHG emissions of N_2O**: the quantity of N_2O expressed in CO_2e reflects federal and provincial commitments to GHG emissions and climate change. Emissions of N_2O are expressed on an annual basis in t CO_2e/yr.

2.1.2 GHG Emissions Scope

The Draft Technical Guide for the SACC (Government of Canada 2021b) requires proponents to calculate net GHG emissions based on the following equation:

Net GHG Emissions = Direct GHG Emissions + Acquired Energy GHG Emissions – CO_2 Captured and Stored – Avoided domestic GHG Emissions – Offset Credits.

Where:

- The Direct GHG Emissions (Scope 1) = emissions occurring from sources that are owned or controlled by a proponent (e.g., generators, boilers, vehicles, process, and fugitive emissions) (WRI and WBCSD 2013).
- The Acquired domestic GHG Emissions (Scope 2) = emissions from the generation of purchased electricity, heating, and cooling consumed by the proponent (WRI and WBCSD 2013).
- CO_2 Captured and Stored = emissions that are generated by the Project and permanently stored in a storage Project.
- Avoided domestic GHG Emissions = emissions that are reduced or eliminated in Canada as a result of the Project.
- Offset Credits = emission reductions or removals generated from activities that are additional to what would have occurred in the absence of the offset Project.

Consistent with the Draft Technical Guide for the SACC, the net GHG emissions for the Project have been calculated based on the sum of Direct GHG emissions (Scope 1) and Acquired Energy GHG Emissions (Scope 2) as summarized in Table 2. Considering the Project is in the preliminary design phase the emissions associated with avoided GHG emissions, CO_2 that would be captured and stored and with purchase of offset credits, were set to zero tonnes of carbon dioxide equivalent (0 t CO_2e), as a measure of conservatism.

Table 2: GHG Emission Sources for the Project

Emission Scope	Project Case
Direct GHG Emissions (Scope 1)	▪ Diesel combustion from construction equipment ▪ Natural gas combustion (building heating) ▪ Natural gas combustion from the emergency generator ▪ Natural gas combustion for the Ready-Mix Concrete Plant ▪ Jet fuel combustion from flight landings and take-offs (LTOs)
Acquired domestic GHG Emissions (Scope 2)	▪ Purchased electricity for buildings ▪ Purchased electricity for the Ready-Mix Concrete Plant
CO_2 Captured and Stored, avoided domestic GHG Emissions, Offset Credits	▪ Assumed to be 0 t CO_2e throughout the Project

Note: These GHG Emission scopes are consistent with the Draft Technical Guide for the SACC (Government of Canada 2021b).

Quantified project GHG emissions include emissions from the construction and operation of the Project. The Project is being built to operate indefinitely; for the purpose of this study a 100-year lifetime has been assumed. The following assumptions have been made regarding the lifespan of the Project:

- The construction of the buildings will take place over 10 years, from 2024 to 2033.
- The construction of aerodrome will be completed by the end of 2024. It is assumed that the construction of the aerodrome will take one year.
- The operational phase of the Project is considered to be 100 years, from 2026 to 2127. It is assumed that the buildings will become operational in phases as summarized in Table 3. The GHG emissions for heating and electricity consumptions are calculated based on the assumption that first phase of buildings will come online in 2026, the second phase in 2032, and third phase of buildings will come online in 2042.
- A Decommissioning and abandonment phase for the Project has not been anticipated, therefore GHG emissions for the decommissioning phase have not been calculated. If a decommissioning phase is planned for the Project in future, the emissions during decommissioning are anticipated to similar to the emissions during construction phase. It is expected that the decommissioning phase will be use similar equipment for removal of infrastructure as is did for construction.

Table 3: Calculated Floor Build Out Area (Interim and Full)

Year	Project Area			
	Southwest	East	Northwest	Total
Opening Day (2026)	1,590,884 sq. ft.	0.0 sq. ft.	0.0 sq. ft.	1,590,884 sq. ft.
Interim (2032)	1,590,884 sq. ft.	1,542,024 sq. ft.	2,873,392 sq. ft.	6,006,300 sq. ft.
Long-Term (2042)	5,302,948 sq. ft.	1,542,024 sq. ft.	2,873,392 sq. ft.	9,718,364 sq. ft.

Source: Data for interim and full build out area taken from the De Havilland Field, Transportation Impact Assessment, Final, Prepared for De Havilland Field on September 22, 2022 (Bunt and Associates 2022).

Note: If the East and Northwest areas end up being leased out, and The Proponent does not have financial control over them, the emissions from these plots would be Scope 3 emissions, and outside of this scope of assessment.

2.1.3 Data Collection Procedures and Assumptions

The GHG estimation for the Project is consistent with the relevant sections of ISO 14064-2:2006 and Canadian guidance documents related to the quantification of GHGs, i.e., Canada's National GHG Reporting Program and Canada's National GHG Inventory. Emissions of CO_2, CH_4, and N_2O were quantified. The data collection procedures and assumptions that were applied to the Project are summarized in Table 4.

Table 4: Data Collection Procedures and Assumptions

Emission Source	Description
Construction Phase	
Construction Equipment	■ GHG emissions from mobile equipment were calculated based on hours of operation, rated equipment horsepower, load factor, and emission factors for the mobile equipment. ■ Equipment, hours of operation and horsepower is based on an estimate in the early stages of the design process. ■ It was assumed that all mobile equipment is fueled by diesel. ■ The hours of operation were estimated based on the following assumptions: 10 hours per day, 20 days per month, 11.5 months in total. The construction of the Project will take place from 2024 to 2032. However, most of the buildings will be constructed by the year 2033 and therefore the GHG emissions from construction are calculated for the years 2024 to 2033. It was assumed that construction of the aerodrome will be completed by the end of 2024.
Land Clearing	■ Land clearing data for cropland, pastureland, waterbodies, and wetland was provided by the Proponent ■ It is assumed that GHG emissions from conversion of industrial land and yard site to Project land would be negligible. Hence, GHG emissions from this land-use change have not been estimated. ■ In the 2019 and 2020 field assessments, it was identified that ephemeral wetlands were largely seeded to the annual crops. Therefore, GHG emissions from ephemeral wetland land clearing were included in land clearing GHG emissions. ■ GHG emissions from pastureland were included in cropland clearing GHG emissions.
Ready-Mix Concrete Plant	■ The facility would have a ready-mix concrete plant with a production capacity of 50 cubic meters per hour during the construction phase of the Project. ■ It is assumed that this plant would be operational from 2024-2033. ■ It is assumed that the plant will operate on grid electricity with an estimated usage of 26.01 MJ/m^3 of concrete produced (Karla Vazquez-Calle et al. 2022). ■ It is assumed that natural gas heaters would be used for heating the plant with fuel consumption of 4.25 mm BTU/hour. ■ The plant is assumed to operate 12 hours/day, 7 days/week, 365 days/year.
■ **Operations Phase**	
Electricity Consumption	■ It is assumed that the electricity and cooling for the facility would be provided through the grid. ■ For the current aviation facility, which is located at Calgary airport, the Proponent provided monthly electricity consumption for July, August, and September 2022. The average electricity consumption for the three months was used to estimate the electricity consumption for the period 2026 to 2127. ■ Electricity consumption is calculated for Southwest, East, and Northwest areas. However, if East and Northwest areas are leased out, and the Proponent does not have financial control over them, the emissions from these plots would be Scope 3 emissions and should be removed from the total net emissions.
Natural Gas Consumption	■ It was assumed that the facilities would be heated using natural gas. ■ Typically, warehouses require 8004 BtU of natural gas per square foot annually for heating (Friendly Power 2020). This was used to calculate the heating emissions for the period of 2026 to 2127. ■ Natural Gas consumption is calculated for Southwest, East, and Northwest areas. However, if East and Northwest areas are leased out, and the Proponent does not have financial control over them, the emissions from these plots would be Scope 3 emissions and should be removed from the total net emissions.
Emergency Generators	■ It was assumed the facility will have a 500-kW emergency natural gas generator operating for 12 hours per year (one hour per month). ■ Using the fuel consumption of a standard natural gas generator of this size and the assumption on the annual hours of operation. The annual natural gas usage was calculated from 2026 to 2127.
LTO Emissions from Flights	■ It is assumed that there would be one LTO/ day from the Project site. ■ Currently, there would be four types of planes that would be manufactured at the site, with each daily flight being one of these four types of planes.

2.2 Emissions Calculations

2.2.1 Natural Gas Combustion (Heating- Scope 1)

For the Proponent facilities, it was assumed that the buildings will be heated using natural gas. The emission factors for CO_2, CH_4, and N_2O were taken from Environmental Protection Agency's (EPA) GHG Emissions Factor's Hub (EPA 2022); these are summarized in Table 5. Parameters for a sample emission calculation for natural gas combustion for the year 2026 for Southwest Facility Build-Out Area for CO_2 are shown in Table 6.

Table 5: Natural Gas Combustion Emission Factor

Value	CO_2 (kg/mmBTU)	CH_4 (g/mmBTU)	N_2O (g/mmBTU)
Natural Gas Emission Factor[(a)]	53.06	1.0	0.1

(a) Emission factors provided in Emissions Factor Hub (EPA 2022)

CO_2 = carbon dioxide; CH_4 = methane; N_2O = nitrous oxide; kg/MMBtu = kilogram per million British Thermal Unit; g/MMBtu = gram per million British Thermal Unit.

Table 6: Parameters for a Sample CO_2 Emission Calculation for Natural Gas Combustion for the Year 2026 for Southwest Facility Build-Out Area

Notation	Parameter	Unit	Value	Reference
Site Specific Input Parameters				
Natural Gas Consumption for Baseline Building	2026 Estimated Consumption	MMBtu	12,733	Calculated based on typical natural gas consumption per square foot per year for warehouses (Friendly Power 2020)
Default Parameters				
EF	CO_2 Emission Factor	kg/MMBtu	53.06	Emissions Factor Hub (EPA 2022)
UC	Unit Conversion	kg/tonne	1,000	—

MMBtu = million British thermal units; kg/MMBtu = kilogram per million British Thermal Unit; tonne/g = tonne per kilogram.

$$Annual\ CO_2\ Emissions\ (tonnes) = natural\ gas\ consumption \times\ EF \times UC$$

$$Annual\ CO_2\ Emissions\ (tonnes) = 12{,}733\ MMBtu \times \frac{53.06\ kg}{MMBtu} \times \frac{tonnes}{1{,}000\ kg}$$

$$Annual\ CO_2\ Emissions\ (tonnes) = \frac{676\ tonnes}{year}$$

2.2.2 Electricity Consumption (Scope 2)

The indirect GHG emissions (Scope 2) from electricity consumption were calculated using the electricity consumption intensity values for Alberta provided by ECCC (ECCC 2017). The electricity consumption GHG emissions intensity values for 2026 through 2127 are provided in Table 7 (ECCC 2017). It was assumed the GHG emissions intensity will remain the same after 2032. Parameters for the CO_2e emissions calculation for electricity consumption for the year 2026 for Southwest Facility Build-Out Area are provided in Table 8.

Table 7: Electricity Consumption GHG Emissions Intensity

Year	GHG Emissions Intensity for Alberta for Grid Based Electricity[(a)(b)] (CO_2e tonnes /MWh)
2024	0.47
2025	0.44
2026	0.43
2027	0.40
2028	0.40
2029	0.39
2030	0.38
2031	0.28
2032 to 2127	0.27

(a) GHG emissions intensity value for Alberta for grid-based electricity provided by ECCC (ECCC 2017).

(b) It is assumed that the grid intensity would remain same from 2032 till the end of the Project.

CO_2e = carbon dioxide equivalents; tonne/MWh = tonne per megawatt-hour.

Table 8: Parameters for CO_2e Emissions Calculation for Electricity Consumption for the Year 2026 for Southwest Facility Build-Out Area

Notation	Parameter	Unit	Value	Reference
Site Specific Input Parameters				
Electricity Consumed	2026 Estimated Consumption	kWh	7,457,729	Calculated based on the average monthly consumption over July, August, September of 2022 from existing building at Calgary airport.
Calculated Parameters				
Emission Intensity	CO_2e Emission Intensity for Alberta	tonne CO_2e / MWh	0.40	Provided by ECCC (2017)
Default Parameters				
UC1	Unit Conversion	MWh/kWh	0.001	—

kWh = kilowatt-hour; CO_2e = carbon dioxide equivalents; MWh = megawatt-hour; MWh/kWh = Megawatt-hour per kilowatt-hour.

$$Annual\ CO_2e\ Emissions\ (tonnes) = Annual\ Electricity\ Consumed\ \times CO_2e\ Emission\ Intensity\ \times UC1$$

$$Annual\ CO_2e\ Emissions\ (tonnes) = \frac{7{,}457{,}729\ kWh}{yr} \times \frac{0.40\ tonne\ CO_2e}{MWh} \times \frac{MWh}{10^3 kWh}$$

$$Annual\ CO_2e\ Emissions\ (tonnes) = \frac{2{,}983\ tonnes}{yr}$$

2.2.3 Emergency Generators (Scope 1)

It is assumed the emergency natural gas generator will be operational for 12 hours each year (at least one hour each month) and will use natural gas as the fuel source. The emission factors for CO_2 are taken from Table A6.1-1 (Alberta region) and emission factors for CH_4, and N_2O are taken from Table A6.1-3 of National Inventory Report (NIR) 1990-2020, Part 2 (ECCC 2022b).

Parameters for a sample CO_2 emissions calculation for diesel combustion within the emergency generator for 2026 are provided in Table 9.

Table 9: Parameters for a Sample CO_2 Emission Calculation for Emergency Natural Gas Generator for the Year 2026

Notation	Parameter	Unit	Value	Reference
Site Specific Input Parameters				
Hour	Emergency diesel generator operational hours	hours/year	12	Assumed 1 hour of operation per month
Fuel Consumption Rate (FCR)	Natural gas consumption rate at 100% load	m^3/h	166	Generac, 2019
Default Parameters				
EF	CO_2 Emission Factor	g/m^3	1,962	Table A6.1-1 of National Inventory Report (NIR) 1990-2020, Part 2 for Alberta region (ECCC 2022b).
UC	Unit Conversion	g/tonne	1,000,000	—

gal/h = gallon per hour; kg/kl = kilogram per kilolitre; tonne/kg = tonne per kilogram.

$$Annual\ CO_2\ Emissions\ = hour \times\ FCR \times EF \times UC$$

$$Annual\ CO_2\ Emissions\ = \frac{12\ hours}{year} \times \frac{166 m^3}{hour} \times \frac{1{,}962\ g}{m^3} \times \frac{tonnes}{1{,}000{,}000\ g}$$

$$Annual\ CO_2\ Emissions\ = \frac{4\ tonnes}{year}$$

2.2.4 LTO Emissions (Scope 1)

Currently, there would be four types of airplanes that would be manufactured at the site which include Twin Otter, Water Bomber (DL 515), Water Bomber (DL 415), and Dash 8. It is assumed that there would only be one Landing and Take Off (LTO) cycle from the Project facility per day. The GHG emissions from LTOs were calculated using the CO_2 emission factors provided in ICAO CO_2 Standards Thresholds, Final Report (Eastern Research Group, Inc. 2015). As Twin Otter, DL 515, and DL 415 have similar engine sizes, it is assumed that the CO_2 EF for Twin Otter can also be applied to DL 515 and DL 415. As Dash 8 has a larger engine size, CO_2 EF for Dash 8 has been taken from Table 2 of Good Practice Guidance and Uncertainty Management in National GHG Inventories (Kristin Rydpal, n.d.). For using a conservative approach, emissions from Dash 8 have been used for the GHG estimation.

Parameters for a sample CO_2 emissions calculation for LTO from the Dash 8 for 2026 are provided in Table 10.

Table 10: Parameters for a Sample CO_2 Emission Calculation for the Dash 8 for 2026

Notation	Parameter	Unit	Value	Reference
Site Specific Input Parameters				
LTO	LTO cycles for Twin Otter	LTO/year	365	Data provided in De Havilland Field_IPD_Information_Requests
Default Parameters				
ER	CO_2 Emission Rate	lbs/LTO	5,908	CO_2 EF taken from Table 2-5 (De Havilland Twin Otter DHC-6, PT6A27), U.S. ICAO CO_2 Standards Thresholds, Final Report (Eastern Research Group, Inc. 2015).
UC	Unit Conversion	lbs/tonnes	0.00453592	—

$$Annual\ CO_2\ Emissions = LTO\ Cycles \times CO2\ ER \times UC$$

$$Annual\ CO_2\ Emissions = 365 \times 5{,}908 \times 0.00453592$$

$$Annual\ CO_2\ Emissions = \frac{978\ tonnes}{year}$$

2.2.5 Construction Emissions (Scope 1)

Emission factors for CO_2, CH_4, and N_2O were taken from Table A6.1-5 in the Canada's NIR Part 2 (ECCC 2022b). Construction emissions for buildings and for aerodrome are calculated separately. It is assumed that the construction of aerodrome will be completed in 11.5 months in the year 2024, while the construction on buildings would be done in phases from the year 2024 to 2033. The GHG emission factors for on-road emissions are based on fuel consumption. Therefore, the total fuel consumption was estimated for each vehicle type. A list of vehicles and hours of operation were estimated based on the duration of the Project construction phase (Appendix A). Emission factors for construction vehicles are provided in Table 11. Parameters for a sample CO_2 emission calculation for diesel combustion for 2024 for a Belly Scraper are shown in Table 12.

Table 11: Construction Vehicle Emission Factors

Value	CO_2	CH_4	N_2O
EF[(a)] (g/L)	2,681	0.078	0.022

(a) Emission factors are for 4-stroke gasoline engines from Table A6.1-5 in the Canada's NIR Part 2 (ECCC 2022b).

CO_2 = carbon dioxide; CH_4 = methane, N_2O = nitrous oxide; g/L = gram per litre.

Table 12: Parameters for Sample CO_2 Emissions (tonnes/year) for Belly Scrapper

Notation	Parameter	Unit	Value	Reference
Site Specific Input Parameters (for Diesel Excavator)				
hp	Vehicle horsepower	Hp	490	Assumption based on a CAT 637 Belly Scrapper
hour	Construction hours per year	Hours/year	3,120	Assumed 10 hours per day, 6 days per week, 12 months per year.
Default Parameters				
LF	Load factor	—	0.59	Compression Ignition Load Factors -- Median Life, Annual Activity, and Load Factor Values for Nonroad engine Emissions Modeling – Report No. NR-005d
BSFC	Brake-specific fuel consumption	lb/hp-hr	0.367	Exhaust and Crankcase Emission Factors (USEPA 2002)
EF	CO_2 Emission Factor	g/L	2,681	Canada's NIR Part 2, Table A6.1-14 (ECCC 2022b)
ρ	Diesel Density	kg/m^3	860	Canada's Greenhouse Gas Quantification Requirements (ECCC 2019)
UC1	Unit Conversion	lb/kg	2.20462	—
UC2	Unit Conversion	L/m^3	1,000	—
UC3	Unit Conversion	tonne/kg	10^{-6}	—

hp = horsepower; lb/hp-hr = pound per horsepower hour; g/L = gram per litre; kg/m^3 = kilogram per cubic metre; lb/kg = pound per kilogram; L/m^3 = litre per cubic metre; tonne/kg = tonne per kilogram.

$$Construction\ CO_2\ Emissions\ (tonnes) = \frac{(hp\ \times hour\ \times LF\ \times BSFC)}{UC1 \times \rho} \times UC2 \times EF\ \times UC3$$

$$Construction\ CO_2\ Emissions\ (tonnes) = 490\ hp \times 3{,}120\ hours \times 0.59 \times \frac{0.367\ lb}{hp - h} \times \frac{kg}{2.20462\ lb} \times \frac{m^3}{860\ kg} \times \frac{1{,}000\ L}{m^3} \times \frac{2{,}681 g\ CO_2}{L} \times \frac{1\ tonne}{10^6\ g}$$

$$Construction\ CO_2\ Emissions\ (tonnes) = 468\ tonnes$$

2.2.6 Land-Use Change

Carbon dioxide emissions from land-use change 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 2006 Intergovernmental Panel on Climate Change (IPCC) Volume 4, Chapter 2 (IPCC 2006). The land area cleared is primarily classified as cropland, with some non-forest area classified as wetland. The calculation of the total carbon stored annually, and therefore lost 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, presented in Equation 2 (IPCC 2006). CH_4 from annual sink loss have been calculated using Equation 7.12 from Chapter 7 of the IPCC 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories (IPCC 2019). The calculation methodology is consistent with methodology provided in the IPCC 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories (IPCC 2019) and the Draft Technical Guide for the SACC (Government of Canada 2021b).

Parameters for a sample CO_2 emission calculation for carbon sink loss from wetland clearing are provided in Table 13, while parameters for a sample CO_2 emission calculation for loss of carbon from disturbance are provided in Table 14.

Equation 1 – Annual CO_2 Emissions from the Removal of Carbon Sinks

Table 13: Parameters for Sample CO_2 Emissions (tonnes/year) for Carbon Sink Loss from Wetland Clearing

Notation	Parameter	Unit	Value	Reference
Site Specific Input Parameters				
A	Total area that would be cleared	ha	63	From Trace Associates 2020, included as Appendix F to the Initial Project Description
Default Parameters				
G_W	Average annual above-ground biomass growth	tonne dm ha^{-1} yr^{-1}	0.40	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).
R	Ratio of below-ground to above-ground biomass	n/a	0.39	Table 4.4 of IPCC 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories, Vol 4, Chapter 4.
CF	Carbon fraction of dry matter	tonne C	0.47	Section 6.3.1 of IPCC 2006 Vol 4, Chapter 6. Default value for herbaceous biomass (No refinement in 2019)
UC1	Unit conversion	C/CO_2	3.67	—

$$CO_2 = \Delta C \times 3.67$$

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

$$CO_2 = 63 \times 0.40 \times (1 + 0.39) \times 0.47 \times 3.67$$

$$CO_2\ Emissions = 60 \frac{tonnes}{year}$$

Where:

ΔC = annual carbon stored due to biomass growth by vegetation type and climatic zone

A = Total area that would be cleared

G_W = Average annual above-ground biomass growth

R = Ratio of below-ground to above-ground biomass

CF = Carbon fraction of dry matter

CO_2 = annual mass of CO_2 emissions from the removal of carbon sinks

3.67 = Unit conversion from C to CO_2 (i.e., 44/12)

The one-time loss of carbon from disturbances which includes removal of vegetation and associated burning will be calculated based on Equation 2.14 in Section 2.3.1.1.A.2 of the 2006 IPCC Volume 4, Chapter 2 (IPCC 2006; see Equation 3 below). The SACC defines this as the carbon stock change resulting in direct GHG emissions. The calculation methodology is consistent with methodology provided in the IPCC 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories (IPCC 2019) and the Draft Technical Guide Related to the Strategic Assessment of Climate Change (SACC) (Government of Canada 2021).

Equation 2 – One-Time Loss of Carbon from Land Disturbance – Living Biomass

Table 14: Parameters for Sample CO_2 Emissions (tonnes/year) from Loss of Carbon from Disturbance (Wetland Clearing) (One-time Emissions)

Notation	Parameter	Unit	Value	Reference
Site Specific Input Parameters				
A	Total area that would be cleared	ha	63	From Trace Associates 2020, included as Appendix F to the Initial Project Description
fd	Fraction of biomass lost	n/a	1	n/a
Default Parameters				
G_W	Average annual above-ground biomass growth	tonne dm ha^{-1}	50	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).
R	Ratio of below-ground to above-ground biomass	n/a	0.39	Table 4.4 of IPCC 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories, Vol 4, Chapter 4.
CF	Carbon fraction of dry matter	Tonne C	0.47	Section 6.3.1 of IPCC 2006 Vol 4, Chapter 6. Default value for herbaceous biomass (No refinement in 2019)
UC1	Unit conversion	C/CO_2	3.67	—

$$CO_2 = L \times 3.67$$

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

$$CO_2 = 63 \times 50 \times (1 + 0.39) \times 0.47 \times 3.67$$

$$CO2\ Emissions = 7{,}514 \frac{tonnes}{year}$$

Where:

L = annual loss of carbon due to disturbances

A = Total area that would be cleared

fd = Fraction of biomass lost

B_W = Average annual above-ground biomass of land area affected by disturbance

R = Ratio of below-ground to above-ground biomass

CF = Carbon fraction of dry matter

CO_2 = one-time mass of CO_2 emissions from the loss of carbon due to disturbances assumed to all take place in one year (annual)

3.67 = Unit conversion from C to CO_2 (i.e., 44/12)

Equation 3 – One-Time Loss of Carbon from Land Disturbance – Dead Organic Matter (DOM)

The direct emissions from DOM have not been calculated as the project footprint does not include any forested land. DOM emissions are only calculated for any forested land that is being cleared.

Equation 4 – One-Time Loss of Carbon from Land Disturbance – Soil Organic Matter

$$\Delta C_{soils} = \Delta C_{mineral} - L_{organic} + \Delta C_{inorganic}$$

Where:

ΔC_{soils} = annual change in carbon stocks in soils, tonnes C yr^{-1}

$\Delta C_{Mineral}$ = annual change in organic carbon stocks in mineral soils, tonnes C yr^{-1}

$L_{Organic}$ = annual loss of carbon from drained organic soils, tonnes C yr^{-1}

$\Delta C_{Inorganic}$ = annual change in inorganic carbon stocks from soils, tonnes C yr^{-1} (assume 0 unless using a Tier 3 approach)

NOTE: $L_{Organic}$ is assumed to be 0, under the assumption that all soil is mineral soil.

$$\Delta C_{Mineral} = \frac{(SOC_o - SOC_{(o-T)})}{D}$$

$$SOC = \sum_{c,s,f} (SOC_{REF_{c,s,f}} \times F_{LU} \times F_{MG} \times F_I \times A)$$

Where:

$\Delta C_{Mineral}$ = annual change in organic carbon stocks in mineral soils, tonnes C yr^{-1}

SOC_0 = soil organic carbon stock in the last year of an inventory time period, tonnes C

$SOC_{(0-T)}$ = soil organic carbon stock in the beginning of an inventory time period, tonnes C

SOC_0 and $SOC_{(0-T)}$ are calculated using the SOC equation in the box where the reference carbon stocks and stock exchange factors are assigned according to land use and management activities and corresponding areas at each of the points in time (time = 0, and time = 0-T)

T = number of years over a single inventory period

D = Time dependant of stock change factors which in the default time period for transition between equilibrium SOC values, yr.

c = represents the climate zones, s the soil types, and i the set of management systems that are present in a country

SOC_{REF} = the reference carbon stock, tonnes C ha^{-1}

F_{LU} = Stock change factor for land use systems or sub-system for a particular land-use, dimensionless

F_{MG} = stock change factor for management regime, dimensionless

F_I = stock change factor for input of organic matter, dimensionless

A = land area of the stratum being estimated, ha

Note: The default stock change factor (F) according to the SACC is 0.8 for paving.

Note: No land claim recrimination or remediation will be undertaken thus F_{MG} F_I are not applicable.

2.3 Project Emissions

- The GHG emissions for the construction and operations of the Project have been estimated and summarized in Table 15. It is assumed that construction of the buildings will take place over 10 years, from 2024 to 2033, while the construction of aerodrome will take place over one year and be completed by the end of 2024. Therefore, emissions associated with construction are highest for the year 2024, as the estimate includes emissions from construction of aerodrome as well as buildings. The construction emissions from 2025 to 2033 are a result of construction of the buildings only.

- For the operations phase, it is assumed that buildings will come online in phases. The first phase of buildings will come online in 2026, the second phase in 2032, while the third phase of buildings will come online in 2042. As such, annual emissions from heating and electricity consumption are increasing in the years 2032 and 2042, as new buildings come online (see Table 3 for the calculated floor build out area associated with each phase).

The total GHG emissions for the highest operational annual emissions were estimated to be 17,899 tCO_2e/year, starting from the year 2042 (all buildings operational or the third phase). However, a part of these emissions, approximately 1,876 t CO_2e, are accounted for at the current facility at the Calgary airport and would be displaced from the airport to the Project site. The total GHG emissions over the lifetime of the Project (2024-2127) were estimated to be 1,757,013 tCO_2e. A part of these emissions, approximately 193,921 t CO_2e would be displaced from the Calgary airport to the Project site.

In addition to Table 15, direct emissions from land-use change (i.e., land clearing) are further detailed in Table 16. In accordance with the SACC technical guidance, emissions have been calculated for land-use change which includes impact to living biomass and impact to soil organic matter. Emissions associated with impact on dead organic matter have not been calculated as no forested land would be impacted by the project. It is assumed that these emissions are associated with the construction in 2024.

Annual emissions associated with the loss of carbon sequestration from carbon sinks are further detailed in Table 17.

A comparison of the estimated annual GHG emission from the highest emission year (2024) to the federal and provincial totals is provided in Table 18. Although the construction is temporary, we used the emissions from construction, rather than operations, in the comparison for conservatism. The estimated annual GHG emissions from the Project represent 0.01% of the provincial total and 0.0039% of the Canada-wide total. A comparison to the global GHG emissions total was not completed as GHG emissions from the Project represent a negligible fraction of global GHG emissions.

A comparison of the annual project GHG emissions to Canada’s 2030 targets has also been conducted to identify the impact of the Project on Canada’s GHG reduction target. Canada aims to reduce it’s GHG emissions by approximately 40-45% compared to the 2005 levels (ECCC 2022a) by 2030. The total estimated GHG emissions from the Project represent less than 0.006% of the Canada’s 2030 GHG emissions target.

Table 15: GHG Emissions (Scope 1 and Scope 2 over the Project lifespan)

Year	Direct GHG Emissions (Scope 1)																				Acquired Energy GHG Emissions (Scope 2)		Emissions Associated with Land Use Change		Annual Total Emissions (tonnes CO_2e)
	On-Site Mobile Equipment				Concrete Plant: Stationary Combustion				Building Heating: Stationary Combustion				Emergency Generators: Stationary Combustion				LTO Emissions				Concrete Plant Electricity Consumption	Building Electricity Consumption	Land Use Change (Direct Emissions)	Loss of Carbon Sink	
	CO_2	CH_4	N_2O	CO_2e	CO_2	CH_4	N_2O	CO_2e	CO_2	CH_4	N_2O	CO_2e	CO_2	CH_4	N_2O	CO_2e	CO_2	CH_4	N_2O	CO_2e	CO_2e	CO_2e	CO_2e	CO_2e	
2024	7,061	0	0.1	7,083	988	0.02	0.002	989	0	0.00	0.00	0	0	0	0	0	0	0	0	0	744	**0**	17,160	0	**25,976**
2025	3,555	0	0	3,566	988	0.02	0.002	989	0	0.00	0.00	0	0	0	0	0	0	0	0	0	696	0	0	0	**5,252**
2026	3,555	0	0	3,566	988	0.02	0.002	989	676	0.01	0.00	676	3.91	0.00	0.00	3.93	978	—	—	978	681	3,207	0	0	**10,101**
2027	3,555	0	0	3,566	988	0.02	0.002	989	676	0.01	0.00	676	3.91	0.00	0.00	3.93	978	—	—	978	633	2,983	0	487	**10,316**
2028	3,555	0	0	3,566	988	0.02	0.002	989	676	0.01	0.00	676	3.91	0.00	0.00	3.93	978	—	—	978	633	2,983	0	487	**10,316**
2029	3,555	0	0	3,566	988	0.02	0.002	989	676	0.01	0.00	676	3.91	0.00	0.00	3.93	978	—	—	978	617	2,909	0	487	**10,226**
2030	3,555	0	0	3,566	988	0.02	0.002	989	676	0.01	0.00	676	3.91	0.00	0.00	3.93	978	—	—	978	601	2,834	0	487	**10,135**
2031	3,555	0	0	3,566	988	0.02	0.002	989	676	0.01	0.00	676	3.91	0.00	0.00	3.93	978	—	—	978	443	2,088	0	487	**9,231**
2032	3,555	0	0	3,566	988	0.02	0.002	989	2,551	0.05	0.00	2,551	3.91	0.00	0.00	3.93	978	—	—	978	427	7,602	0	487	**16,605**
2033	3,555	0	0	3,566	988	0.02	0.002	989	2,551	0.05	0.00	2,551	3.91	0.00	0.00	3.93	978	—	—	978	427	7,602	0	487	**16,605**
2034	0	0	0.0	0	0	0	0	0	2,551	0.05	0.00	2,551	3.91	0.00	0.00	3.93	978	—	—	978	0	7,602	0	487	**11,622**
2035	0	0	0.0	0	0	0	0	0	2,551	0.05	0.00	2,551	3.91	0.00	0.00	3.93	978	—	—	978	0	7,602	0	487	**11,622**
2036	0	0	0	0	0	0	0	0	2,551	0.05	0.00	2,551	3.91	0.00	0.00	3.93	978	—	—	978	0	7,602	0	487	**11,622**
2037	0	0	0	0	0	0	0	0	2,551	0.05	0.00	2,551	3.91	0.00	0.00	3.93	978	—	—	978	0	7,602	0	487	**11,622**
2038	0	0	0	0	0	0	0	0	2,551	0.05	0.00	2,551	3.91	0.00	0.00	3.93	978	—	—	978	0	7,602	0	487	**11,622**
2039	0	0	0	0	0	0	0	0	2,551	0.05	0.00	2,551	3.91	0.00	0.00	3.93	978	—	—	978	0	7,602	0	487	**11,622**
2040	0	0	0	0	0	0	0	0	2,551	0.05	0.00	2,551	3.91	0.00	0.00	3.93	978	—	—	978	0	7,602	0	487	**11,622**
2041	0	0	0	0	0	0	0	0	2,551	0.05	0.00	2,551	3.91	0.00	0.00	3.93	978	—	—	978	0	7,602	0	487	**11,622**
2042-2127	0	0	0	0	0	0	0	0	4,127	0.08	0.01	4,129	3.91	0.00	0.00	3.93	978	—	—	978	0	12,301	0	487	**17,899**
Total Emissions by Source and GHG (tonnes)	**39,059**	**1**	**0**	**39,181**	**9,877**	**0**	**0**	**9,887**	**384,511**	**7**	**1**	**384,677**	**399**	**0**	**0**	**401**	**99,776**	**—**	**—**	**99,776**	**5,904**	**1,150,874**	**17,160**	**49,152**	**1,757,013**
Percent of Total Project Emissions (%)	**2.2%**				**0.6%**				**21.9%**				**0.0%**				**5.7%**				**0.3%**	**65.5%**	**1.0%**	**2.8%**	**100%**

(a) Bold values indicate the year with the highest total emissions during construction and operations Phase. These values will be used in the residual effects analysis to compare the Project emissions to baseline conditions.

(b) It is assumed that the emissions from Year 2042 are reflective of annual emissions until the end of the Project.

(c) A part of these emissions are accounted for at the current facility at the Calgary airport. These emissions will be displaced from the Calgary airport to the Project site, upon completion of Project construction.

(d) If East and Northwest areas are leased out, and the Proponent does not have financial control over them, the emissions from these plots would be Scope 3 emissions and would be removed from the net emissions.

(e) — indicate either no emissions, or emissions have not been calculated.

(f) Decommissioning and abandonment phase for the Project is not anticipated, therefore no greenhouse gas emissions have not been calculated for those phases. If a decommissioning phase is planned for the Project in future, the emissions during the decommissioning phase will be similar to the emissions during construction phase, as the decommissioning phase will be use of equipment for removal of infrastructure.

Table 16: Direct Emissions from Land-Use Change

Source	Emissions (CO_2e tonnes)
Living Biomass	9,114
Soil Organic Matter	8,046
Total	**17,160**

Note: It is assumed that these emissions will occur in the year 2024.

Table 17: Annual Impact from Carbon Sink Loss

Ecozone	Annual Emissions (CO_2e tonnes/year)
Cropland and Pasture Land	427
Boreal Plain - Wetland	60
Total	**487**

Table 18: Comparison to Provincial and Federal Totals

Source	Emissions (CO_2e tonnes/year)
Project GHG Emissions (Maximum Annual Emissions)	25,976
Alberta-wide GHG Emissions[(a)] (2020)	256,000,000
Canada-wide GHG Emissions[(a)] (2020)	672,000,000
Canada 2030 Target Emissions[(b)]	408,000,000
Comparison to Alberta 2020 Total	**0.01%**
Comparison to Canada-wide 2020 Total	**0.0039%**
Comparison to Canada's 2030 Targets	**0.0064%**

(a) Federal and Provincial total emissions taken for the year 2020 from NIR 1990-2020, Part 1, Table 2-2 (ECCC 2022a). Federal and Provincial GHG Emissions have been converted from kilotonne to tonnes.
(b) For conservatism, these emissions were calculated based on a 45% reduction compared to 2005 levels (rather than 40%).

Based on Table 15, 65.5% of total GHG emissions are associated with purchase of grid electricity for heating and cooling, and additional 21.9% of the total GHG emissions are associated with use of natural gas furnaces for heating of the buildings. Heating, cooling, and electricity consumption represent the highest GHG emission sources for the Project.

2.4 Mitigation Measures and Net-Zero Plan

The Project is currently in the conceptual design phase. Preliminary mitigation measures to reduce GHG emissions during construction and operations are provided below.

During the construction phase, the following mitigation measures will be implemented:

- Stationary and mobile equipment will adhere to applicable federal emission standards, where applicable, and will be regularly maintained to increase efficiency of the vehicles and reduce emissions.

- Project traffic will be managed to optimize travel routes and minimize travel on public routes.
- Project traffic will adhere to posted speed limits on public roads and reduced speed limits will be implemented on Project specific access roads, as needed. Reducing speed will reduce emissions.
- HVAC equipment will adhere to the *Canadian Building Code* and meet energy efficiency requirements.
- Air operations will adhere to the *Canadian Aviation Regulations*.
- Tier 4 vehicles, which have the strictest emissions standards, will be used to the extent possible and will be considered an asset during the procurement process, but not required.

The following mitigation measures may be implemented during the operations phase to reduce the GHG emissions:

- The facility will include addition of energy efficient infrastructure, as possible.
- Consideration will be taken for the use of ground-source heat pumps to reduce emissions associated with heating and implementing solar panels that will help reduce emissions from electricity consumption and cooling.
- The Draft Technical Guide for the SACC (Government of Canada 2021b) requires proponents to develop a net-zero plan as part of the environmental assessment for projects with a lifespan beyond 2050. The Project's operational life span extends to 2127. Currently, the Project is in the planning phase, which does not require development of a net-zero plan. If the Project is subject to an impact assessment, a net-zero plan would be developed for any activities that would take place beyond 2050. The net-zero plan would include identification of Best Available Technology/ Best Environmental Practices (BAT/ BEP) measures to reduce direct GHG emissions from building heating. As mentioned above, consideration of alternatives to natural gas such as ground-source heat pumps will be taken. Similarly, BAT/BEP measures will be identified to reduce indirect GHG emissions from electricity consumption such as installation of solar panels. Additionally, a technical feasibility assessment and financial feasibility assessment will be conducted for the selected measures, to identify the measures for implementation.

2.5 Greenhouse Gas Assessment Summary

Based on the GHG estimation, it has been assessed that the Project would lead to an estimated **17,899 tCO_2e** of GHG emissions during the year with the highest total emissions (for operational period), and the total GHG emissions from the Project (2024 to 2126) are estimated to be **1,757,013 tCO_2e.** A part of the GHG emissions have already been accounted for at the Calgary airport (approximately 149,530 t CO_2e over the Project lifetime). The total estimated GHG emissions from the Project are approximately 0.007% of the provincial total and 0.003% of the Canada-wide total. The Project is not likely to have a notable contribution above the uncertainty associated with the respective totals. The Project GHG emissions are also not likely to affect Canada's ability to reach the national emission reduction targets or Canada's alignment to transition to a low carbon economy and the net-zero targets, given the alternative options being considered to develop a sustainable and energy efficient facility.

3.0 CLIMATE CHANGE RESILIENCE ASSESSMENT

The Climate Change Resilience Assessment employs a risk management approach based on Infrastructure Canada's *Climate Lens - General Guidance* document (Infrastructure Canada 2019). The assessment anticipates future climatic conditions for the Project region, and how climate change related disruptions or impacts may affect the conceptual Project design. Given the information provided by the Proponent, a qualitative screening level risk assessment approach was conducted based on available conceptual design information. The assessment considers the lifespan of the Project including construction and operations, as there are currently no plans to close or decommission the site.

3.1 Methodology

The following approach has been used for the climate change resilience assessment:

- **Future Climate Projections:** A summary of the future climate projections for the Project location are provided based on information available from readily accessible climate data portals and literature.
- **Climate-Infrastructure Interactions:** Identification of potential climate-infrastructure interactions based on the Project description.
- **Risk Ranking:** Risk ratings of either negligible, low, medium, high, or extreme, based on the likelihood of an event occurring and the consequence, were assigned to each potential climate-infrastructure interaction for the Project.
- **Climate Resilience Measures:** Identification of existing resilience measures based on the available design parameters.
- **Summary and Continual Improvement:** Summary of how the available information could be used into the ongoing continual improvement process and risk management strategies at the site.

3.2 Project Infrastructure Considered

The Climate Change Resilience Assessment considers the construction, operations, and decommissioning phases of the Project. Construction is going to be completed in phases. Phase 1 of construction is anticipated to begin in 2024, while other phases of construction will be developed over the next 10 to 15 years. Operations is expected to begin in 2026 and last indefinitely, overlapping with some of the Project construction phase. There is no plan to decommission the Project.

Each phase of construction would not be long enough to have notable effects from climate change outside of the seasonal variation. The overall length of the construction phase could be impacted by climate change. However, this would be still likely be small compared with seasonal variations and could be addressed through planning and operation policies. Aside from a temporary ready-mix concrete plant which will be on site throughout the duration of construction, the construction phase will not be considered in this assessment. The infrastructure that has been considered for climate change resilience assessment from the operations phase has been summarized in Table 19.

Table 19: Infrastructure Considered for Climate Change Resiliency Assessment

Infrastructure	Description
Ready Mix Concrete Plant	■ A temporary ready-mix concrete plant with the production capacity of 50 cubic meter per hour during the construction phase of the Project.
Buildings	■ All buildings that would be constructed as a part of the Project such as the warehouse, the control tower, the fleet museum, manufacturing facilities, fire house, offices, as well as potential buildings on the lots to be leased to third parties (such as convenience stores or hotels).
Runway/Airstrips	A runway of 2,041 metres, with daily flights.
Roads	All internal and external road system that provides access to the Project.
Parking Lot	This includes various parking lots in the manufacturing facilities area.
Stormwater Management Systems	■ The Project has considered different approaches for stormwater management such as evaporation, irrigation, mechanical evaporation, and construction of storm-water management system. The climate change resilience assessment considers the impact of climate change on irrigation systems and on storm-water management system options.
Wastewater Treatment Plants	■ The Project has considered different approaches for sanitary water treatment such as construction of a new wastewater treatment facility on Project site or construction of a connection system with one of the existing wastewater treatment facilities. The climate change resilience assessment considers the impact of climate change on a new wastewater treatment facility and the associated effects on the Project site. The impact on the connection system option has not been considered as it is assumed that the connection pipes would be covered and would be located underground.
Water Supply	■ The Project has considered three different methods for water distribution such as recycling and reuse of stormwater for non-potable purposes, receive flows from surrounding water works systems, or diversion from Bow River. All three alternatives have been considered in the climate change resilience assessment.

Note: Currently, the Project site has nineteen active wells and a range of pipelines in the Project area. These wells and pipelines are not a part of the Project and have not been considered for the assessment.

3.3 Future Climate Projections

The IPCC is generally considered to be the definitive source of information related to past and future climate change as well as climate science. The IPCC is a United Nations body dedicated to providing an objective, scientific assessment of climate change information, and the potential natural, political, economic, and human impacts of climate change. The IPCC periodically releases Assessment Reports, each of which provides the current state of climate change science, where there is agreement within the scientific community. IPCC released the Fifth Assessment Report (AR5) 2013 followed by the Sixth Assessment Report (AR6) which was released in 2021. The AR6 is the most current and complete synthesis of information regarding climate change at the time of this assessment and includes general global and regional trends.

When projecting future climate conditions, there needs to be a consideration of different emission scenarios which are based on assumptions about future GHG emissions and atmospheric compound concentrations. In AR5 (IPCC 2013) these emission scenarios are termed as Representative Concentration Pathways (RCPs) and describe changing climatic conditions until 2100. AR5 defines four scenarios: RCP 2.6 (low emissions), RCP 4.5, RCP 6.0, and RCP 8.5 (high emissions). These four RCPs have been described more fully by van Vuuren et al. (2011) in their paper titled "*The Representative Concentration Pathways: An Overview"* and are summarized in Table 20.

Table 20: Characterization of Representative Concentration Pathways

Name	Radiative Forcing in 2100	Characterization
RCP 8.5 (high emissions scenario)	8.5 W/m^2	Increasing greenhouse gas emissions over time, with no stabilization, representative of scenarios leading to high greenhouse gas concentration levels.
RCP 6.0	6.0 W/m^2	Without additional efforts to constraint emissions (baseline scenarios).
RCP 4.5	4.5 W/m^2	Total radiative forcing is stabilized shortly after 2100, without overshoot. This is achieved through a reduction in greenhouse gases over time through climate policy.
RCP 2.6 (low emissions scenario)	2.6 W/m^2	"Peak and decline" scenario where the radiative forcing first reaches 3.1 W/m^2 by mid-century and returns to 2.6 W/m^2 by 2100. This is achieved through a substantial reduction in greenhouse gases over time through stringent climate policy.

Source: Summarized from van Vuuren et al. 2011.

RCP = representative concentration pathway; W/m^2 = Watts per square metre.

Compared to the IPCC AR5, a wider range of scenarios are provided in AR6, covering an updated set of pathways for future climate to unfold. These scenarios, called Shared Socioeconomic Pathways (SSPs), are summarized in Table 21. Where possible, the analogous pathway of the Special Report on Emissions Scenarios (SRES) from the AR5 are noted for each SSP from O'Neil, B.C. et al. (2014).

Table 21: Characterization of Shared Socioeconomic Pathways (SSPs) in IPCC Sixth Assessment Report

SSP	Radiative Forcing in 2100	Challenges	Global Temperature Change	Characterization
SSP1	1.9 W/m^2 2.6 W/m^2	Sustainability – Low for mitigation and adaptation	1.0°C – 2.4°C	Sustainable development proceeds at a reasonably high pace.
SSP2	4.5 W/m^2	Middle of the Road – Medium for mitigation and adaptation	2.1°C – 3.5°C	An intermediate case between SSP1 and SSP3. Analogous to RCP 4.5 scenario.
SSP3	7.0 W/m^2	Regional Rivalry – High for mitigation and adaptation	2.8°C – 4.6°C	Unmitigated emissions are high due to moderate economic growth.
SSP4	3.4 W/m^2 6.0 W/m^2	Inequality – High for adaptation, low for mitigation	—	A mixed world, with relatively rapid technological development in low carbon energy sources in key emitting regions, leading to relatively large mitigative capacity in places where it mattered most to global emissions.
SSP5	8.5 W/m^2	Fossil-fuelled Development – Low for mitigation, high for adaptation	3.3 – 5.7°C	In the absence of climate policies, energy demand is high and most of this demand is met with carbon-based fuels. Analogous to RCP 8.5 scenario.

Source: O'Neil et al. 2014.

Future climate change projections from peer-reviewed publicly available research for the Project region were used to describe changing climate trends. Specifically, data from the Government of Canada's *Changing Climate Report* (CCCR) (Bush, E. and Lemmen, D.S. 2019) and other provincial documents was used to describe trends at regional level. The data from these reports is based on IPCC'S AR5 data. Additionally, trends from the Government of Canada's most recent report, *Canada's Changing Climate Report, In Light of the Latest Global*

Science Assessment (Bush, E. et al 2022) were used to identify the general trends at a national level, as these trends are based on IPCC's latest AR6 data. However, this report does not provide detailed regional climate projections and therefore the CCCR still remains an authoritative source of information on regional climate trends (Bush, E. et al 2022). Trends from the Government of Canada's *Regional Perspectives Report: Prairie Provinces* (Sauchyn, D. et al. 2020) have been considered to provide regional level climate change projections. Lastly, regionally specific trends and projections have been gathered from both ClimateData.ca and Climate Atlas of Canada. This assessment focused on a variety of time horizons for the climate projections within the years 2021-2100, considering the 100-year lifespan of the Project. Time horizons are defined differently depending on the source of information; however, they usually fall into the categories of mid century, late century, or end of century. Due to the lifespan of this Project, some high-level projections beyond 2100 are described using information from IPCC AR6 report. High emission scenarios were focused of for conservatism. The selected climate hazards are described in Table 22.

Climate hazard projections have indicated increasing trends for both temperature and precipitation. Projections also indicate an increase in the frequency and severity of extreme events, heavy precipitation events, and increases in extreme temperatures. Further, extreme events such as inland flooding, wildfires, and storms have been projected to increase. A decrease in snowfall has been observed and is projected to continue to decrease.

Table 22: Climate Change Projections for the Project Region

Climate Hazard	Description	Trend	Current Climate	Future Climate Trend
Temperature	Mean Annual Temperatures	Increasing	■ In Canada, the mean annual temperatures have increased by 1.7ºC between 1948 and 2016 (Bush, E. and Lemmen, D.S. 2019). ■ In the Prairie provinces, the mean annual temperature has increased by 1.9ºC from 1948 to 2016, which is above the average national temperature increase (Bush, E. and Lemmen, D.S. 2019). ■ In Wheatland County Alberta, the annual average temperature between 1951-1980 was 3.3ºC, and between 1981-2010 it was 4.3ºC (ClimateData.ca 2022)	■ Globally, projected changes in near-surface air temperature show widespread warming by 2041-2060 and 2081-2100 (IPCC 2021). Beyond 2100, projections show that global temperature change is highly dependant on scenario, and under RCP 8.5, regional temperature changes 20ºC have been reported by multiple models (IPCC 2021). ■ For Canada, climate projections indicate that by the 2050s, the annual mean temperature will increase by 1.5ºC under RCP 2.6 scenario and by 2.3ºC under RCP 8.5 scenario, compared to the 1986-2005 baseline (Bush. E. and Lemmen, D.S. 2019). In Canada, the mean annual temperatures are projected to increase in the future (Bush E. et al 2022). ■ For the Prairie provinces, the mean annual temperature is projected to increase by 2.3ºC from 2031-2050 and by 6.5ºC from 2081-2100, compared with the 1986-2005 baseline, under RCP 8.5 scenario (Bush, E. and Lemmen, D.S. 2019). ■ For the region Wheatland County Alberta, under RCP 8.5 scenario, the annual average temperatures are projected to increase by 2.6ºC for the 2021-2050 period and 4.7ºC for the 2051-2080 period and 6.1ºC for the last 30 years of this century, compared to the 1951-1980 baseline values (ClimateData.ca 2022).
	Extreme Heat/ Extended Heat Waves	Increasing	■ In most regions in Canada, there has been an observed increase in the intensity and frequency of hot extremes (Bush, E. et al 2022). ■ In Southern Canada, the annual number of hot days (days with maximum temperature above 30ºC) have annually increased by 1 to 3 days from 1948-2016 period (Bush, E. and Lemmen, D.S. 2019). ■ For the region of Gleichen, which Wheatland County is in, the annual number of very hot days (+30ºC) were estimated to be 13 days between 1976-2005 (Climate Atlas of Canada 2019).	■ Extreme hot temperatures are projected to become more frequent and more intense in Canada (Bush, E. et al 2022). ■ For the Prairie provinces, the annual number of hot days are projected to increase by 7.2 from 2031-2050 and by 34.3 from 2081-2100 compared with the 1986-2005, under RCP 8.5 scenario (Bush, E. and Lemmen, D.S. 2019). ■ In the Prairie provinces, there is projected to be an increase is growing season for crops due to a longer period of warm weather (Sauchyn, D. et al. 2020). ■ For the region of Gleichen, which Wheatland County is in, the number of very hot days (+30ºC) are projected to increase by 14 days by 2021-2050 and by 34.2 days by 2051-2080, compared to the 1976-2005 baseline under RCP 8.5 (Climate Atlas of Canada 2019). ■ In Wheatland County, Alberta, under RCP 8.5, the hottest day is projected to be 35.1ºC, 36.6ºC, 39.8ºC, and 41.9ºC, in 2030, 2050, 2080, and 2100 respectively (ClimateData.ca 2022).
	Extended Cold Spells	Decreasing	■ In most regions in Canada, there has been an observed decrease in intensity and frequency of cold extremes (Bush, E. et al 2022). ■ In Canada, the number of cold days and nights has decreased between 1951 to 2010 and is projected to continue decreasing. Across Canada, frost days have decreased by more than 15 days and ice days have decreased by more than 10 days from 1948 to 2016 baseline (Bush, E. and Lemmen, D.S. 2019). ■ For the region of Gleichen, which Wheatland County is in, the annual number of winter days (-15ºC) were estimated to be 48.6 days between 1976-2005 (Climate Atlas of Canada 2019).	■ In Canada, it is projected that extreme cold days (i.e., days when daily minimum daytime temperatures are below the 10th percentile) will likely decrease in the future, as the annual number of extreme warm days and nights continue to increase (Lemmen, D.S. et al. 2014). ■ In the Prairie provinces, there will be far fewer cold days as the climate changes according to projections from climate models (Sauchyn, D. et al. 2020). ■ For the region of Gleichen, which Wheatland County is in, the annual number of winter days (-15ºC) were projected to decrease by 12.1 days by 2021-2050 and by 22.8 days by 2051-2080, compared to the 1976-2005 baseline (Climate Atlas of Canada 2019). ■ In Wheatland County, Alberta, the number of days with minimum temperature below -15ºC is projected to be 39 days in 2030, 36 days in 2050, 15 days in 2080, and 17 days in 2100 under RCP 8.5 (ClimateData.ca 2022).
	Freeze-Thaw Cycles	Increasing	■ In Canada, increasing temperatures have caused a shorter winter season, a large decrease in the number of frost days (days with daily minimum temperature of 0ºC or lower), and ice days (days with daily maximum temperature of 0ºC or lower) (Bush, E. and Lemmen, D.S. 2019). ■ For the region of Gleichen, which Wheatland County is in, the average length of the frost-free season was 128 days between 1976-2005 (Climate Atlas of Canada 2019).	■ In Canada, there is projected to be earlier ice break up in the spring by 10-25 days and a later fall freeze-up to 5-15 days due to warmer weather coming earlier in the spring and cold weather coming later in the fall (Bush, E. and Lemmen, D. 2019). ■ For the region of Gleichen, which Wheatland County is in, the length of the frost-free season is projected to increase by 17.8 days by 2021-2050, and 34 days by 2051-2080 under RCP 8.5 (Climate Atlas of Canada 2019). ■ In Wheatland County, Alberta, the number of days with a freeze thaw cycle, meaning the minimum temperature in below -1 ºC and the maximum temperature in above 0ºC, is projected to be 108 days in 2030, 92 days in 2050, 89 days in 2080, and 80 days in 2100 (ClimateData.ca 2022).

Table 22: Climate Change Projections for the Project Region

Climate Hazard	Description	Trend	Current Climate	Future Climate Trend
Precipitation	Mean Annual Precipitation	Increasing	■ In Canada normalized precipitation[1], averaged over the country, has increased by about 20% from 1948 to 2012 (Bush, E. and Lemmen, D.S. 2019). ■ In the Prairie provinces, mean annual precipitation has increased by 7% from 1948 to 2012 (Bush, E. and Lemmen, D.S. 2019). ■ In Wheatland County, Alberta, the average annual precipitation was 372 mm in the 1951-1980 period (Climatedata.ca 2022).	■ Globally, land precipitation is projected to increase in line with global surface air temperature under high emission scenarios beyond 2100 (IPCC 2021). ■ In Canada, projections indicate that by the 2050s the annual mean precipitation is projected to increase by 7.3% under the RCP 8.5 scenario, compared to the 1986-2005 baseline (Bush, E. and Lemmen, D.S. 2019). Annual and winter precipitation is projected to increase across Canada over the 21st century. However, reductions in summer rainfall are projected for parts of Southern Canada towards to late century (Bush, E. et al 2022). ■ In the Prairie provinces, mean annual precipitation is projected to increase by 6.5 % from 2031-2050 and by 15.3% from 2081-2100 under the RCP 8.5 scenario, compared to the 1986-2005 levels (Bush, E. and Lemmen, D.S. 2019). ■ In Wheatland County Alberta, there is projected to be in increase in average annual precipitation of 9% for the 2021-2050 period, and an increase of 10% for the 2051-2080 period, and a 12% increase for the last 30 years of this century (ClimateData.ca 2022).
	Frequency/ Amount of heavy rainfall events	Increasing	■ On a global scale, observations indicate an increase in extreme precipitation events associated with increase in temperatures. The median increase in extreme precipitation is observed to be about 7% per 1.0ºC increase in the global mean temperature, which is consistent with the increase in water holding capacity of the atmosphere due to warming (Bush, E. and Lemmen, D.S. 2019). ■ Excessively high precipitation has occurred in the Prairie provinces from the late 2000s to 2016 (Sauchyn, D. et al. 2020). ■ In Gleichen region, which Wheatland County is in, the mean maximum 1-day precipitation event between 1976-2005 was estimated at 32 mm (Climate Atlas of Canada 2019).	■ In Canada, extreme precipitation events are projected to become twice as frequent by 2050. Extreme precipitation with a return period of 20 years is projected to become a 1-in-10-year event by the 2050s under the RCP 8.5 scenario, compared to the 1986-2005 baseline (Bush, E. and Lemmen, D.S. 2019). A warmer temperature is projected to intensify very wet and very dry weather and climate events, with implications for flooding (Bush, E. et al 2022). ■ In the Prairie provinces, more frequent extreme precipitation events are projected (Sauchyn, D. et al. 2020). ■ In Wheatland County, Alberta, the maximum 1-day precipitation event is projected to be 28 mm, 30 mm, 30 mm, and 24 mm in 2030, 2050, 2080, and 2100 respectively (ClimateData.ca 2022).
	Snowfall	Decreasing	■ In Canada, the seasonal snow accumulation has decreased by 5-10% per decade since 1981 (Bush, E. and Lemmen, D.S. 2019). ■ In Western Canada from British Columbia to Manitoba, there has been an observed decline in days with heavy snowfall (Bush, E. and Lemmen, D.S. 2019). ■ In parts of Southern British Columbia and Alberta, there has been an observed decrease by several millimetres in highest 1-day snowfall event (Bush, E. and Lemmen, D.S. 2019). ■ Dissimilar to other Southern regions, spring snow cover has increased during 1981–2015 period, which could be due to natural variability (Bush, E. and Lemmen, D.S 2019).	■ In Canada, climate projections indicate that it is likely that seasonal snow accumulation will further decrease by the 2050s under all emission scenarios due to an increase in surface air temperatures (Bush, E, and Lemmen, D.S. 2019). Precipitation has increased in many parts of Canada, with a shift towards less snowfall and more rainfall (Bush, E. et al 2022). ■ In Canada, climate projections indicate general increases in rain-on-snow events from November to March for most of Canada by mid-century (2041–2070) for both medium (RCP 4.5) and high (RCP 8.5) emission scenarios (Bush, E. and Lemmen, D.S. 2019). ■ Longer snow-free periods are projected in the Prairie provinces (Sauchyn, D. et al. 2020).

[1] Normalized precipitation = the amount of precipitation divided by its long-term mean.

Table 22: Climate Change Projections for the Project Region

Climate Hazard	Description	Trend	Current Climate	Future Climate Trend
Extreme Weather Events	Storms (i.e., high wind, lightning, ice, hail)	Increasing	■ As climate warming has made more moisture available in the atmosphere, this additional moisture can lead to an increase in the intensity of extreme precipitation events that will vary between locations (Bush, E. and Lemmen, D.S. 2019). There is high confidence that the frequency and intensity of storm events are increasing globally (Palko, K.G. and Lemmen, D.S. 2017). Storm events can include high intensity winds, ice, snow, lightning, and thunderstorms. ■ In Canada since 1983,12 out of 20 of the most damaging weather events have happened in Alberta, including hail, lightning, windstorm, flooding, fire, and tornado events (Sauchyn, D. et al. 2020). Studies have shown that intensification of these events has been caused by climate change (Sauchyn, D. et al. 2020). ■ In Alberta, tornadoes are common, and May through September is considered tornado and hail season (Government of Alberta 2022a).	■ As climate warming makes more moisture available in the atmosphere, this additional moisture can lead to an increase in the intensity of extreme precipitation events that will vary between locations (Bush, E. and Lemmen, D.S. 2019). ■ Projections indicate an increased risk of extreme events including extreme precipitation in the Prairie provinces, which will exceed historical experiences (Sauchyn, D. et al. 2020). ■ In the Prairie provinces climate change is projected to increase frequency or intensity of extreme events including hail and windstorms (Sauchyn, D. et al. 2020). ■ In Alberta specifically, there is projected to be a potential increase in frequency and severity of individual extreme storms (Government of Alberta 2022b).
	Overland Flooding	Increasing	■ Overland flooding events in Canada have been observed to be influenced by many factors such as extreme precipitation, snowmelt, ice jams, or rain-on-snow events. However, there have been no observed spatially consistent trends related to overland flooding across Canada (Bush, E. and Lemmen, D.S. 2019). ■ The impacts of flooding in the Prairie provinces are unprecedented in recent years (Sauchyn, D. et al. 2020).	■ A warmer climate could intensify very wet and very dry climate events, that could increase inland flooding (Bush, E. et al 2022). ■ Climate models suggest an increased risk of flooding in the future in the Prairie provinces (Sauchyn, D. et al. 2020).
	Wildfires	Increasing	■ An increase in the frequency and intensity of high temperatures has led to an increase in conditions that increases the risk of extreme wildfire conditions (Bush, E. and Lemmen, D.S. 2019). ■ The impacts of wildfires in the Prairie provinces are unprecedented in recent years (Sauchyn, D. et al. 2020).	■ In Canada, projections indicate an increase in the frequency and intensity of extreme hot temperatures. An increase in extreme hot temperatures can increase wildfire risks for many regions of Canada (Bush, E. and Lemmen, D.S. 2019) (Bush, E. et al 2022). ■ Climate models suggest an increased risk of wildfires in the future in the Prairie provinces (Sauchyn, D. et al. 2020).

3.4 Climate-Infrastructure Interactions

Future climate projections indicate changes in temperature, precipitation, and extreme events, potentially interacting with different components of the Project during the operations phase. Table 23 identifies the potential climate events and change factors that may interact with the infrastructure components during the operations phase.

Table 23: Climate-Infrastructure Interactions Matrix

Infrastructure Component	Temperature			Precipitation		Extreme Weather Events		
	Extreme Heat	Extended Cold Spell	Freeze-Thaw Cycles	Frequency/ Amount of Heavy Rainfall Events	Changes in Snowfall	Storms (i.e., high wind, lightning, ice, hail)	Overland flooding	Wildfires
Ready Mix Concrete Plant	✓	✓		✓	✓		✓	✓
Buildings	✓	✓	✓	✓	✓	✓	✓	✓
Runway/ Airstrips	✓	✓	✓	✓	✓	✓	✓	✓
Roads	✓	✓	✓	✓	✓	✓	✓	✓
Parking Lot	✓		✓	✓	✓	✓	✓	✓
Stormwater Management System			✓	✓	✓		✓	
Wastewater Treatment Plants	✓			✓	✓		✓	
Water Supply	✓							✓

3.5 Risk Profile

A risk rating was assigned based on the likelihood of occurrence of a climate hazard and the consequence of the unwanted events caused by the climate hazard. Table 24 and Table 25 provide the criteria for the likelihood and consequence ratings that have been used to assign the risk ratings to each climate-infrastructure interaction. When considering the likelihood and consequence ratings, it is assumed that the current and planned adaptation measures are in place. The rating considers the likelihood and consequence that the projected change in climate will be outside of what was considered in the planning and design of the adaptation measure (e.g., design parameter or threshold).

Risk ratings were assigned to all identified climate-infrastructure interactions using a scale from negligible risk to extreme risk, as described in Table 26, based on the Likelihood and Consequence criteria. Interactions that have negligible/ low risk have a very low/ low frequency of occurrence (likelihood) and are not considered to cause substantial impacts to the Project (consequence). Risks identified as having a medium or high or extreme rating are projected to occur more frequently and have more severe impacts to the Project. For example, extreme events (e.g., storms, extreme precipitation) have a lower probability of occurrence, however, the consequence of such an event is more substantial rendering it a medium to extreme high risk.

Table 24: Criteria Defining Likelihood of Occurrence of a Climate Hazard

Qualitative Descriptor	Description
Very Low	Not likely to occur during the entire Project's operational life. Not likely to increase in intensity or duration during the Project life.
Low	Likely to occur at least once during the entire Project's operational life. Likely to increase in intensity or duration in 25 to 50 years of the Project life.
Moderate	Likely to occur more than once during the Project's operational life. Likely to increase in intensity or duration in the coming 15 to 25 years of the Project life
High	Likely to occur at least once every decade throughout the Project's operational life. Likely to increase in intensity or duration in the next 1 to 10 years of the Project life.
Very High	Likely to occur at least once or more in every year of the Project's operation life. Will increase in intensity and duration annually from the start of the Project.

Table 25: Criteria Defining Consequence of Unwanted Events caused by the Climate Hazard

Qualitative Descriptor	Description
Insignificant	Likely to cause no impacts on the Project. No damage to infrastructure.
Minor	Likely to cause few to no impacts on the Project. Minimal damage or repair costs.
Moderate	Likely to cause disruptions to the facility, or manageable damage to the infrastructure, and repair costs would be higher than previously budgeted.
Major	Likely to cause impacts that would disrupt the facility operations leading to closures, or damaged infrastructure that would require replacement and high repair costs.
Catastrophic	Likely to cause impacts that may require full replacement of infrastructure. Loss to property and access the emergency services.

Table 26: Risk Heat Map

Consequence	Catastrophic	Medium Risk	High Risk	High Risk	Extreme Risk	Extreme Risk
	Major	Low Risk	Medium Risk	High Risk	High Risk	Extreme Risk
	Moderate	Low Risk	Low Risk	Medium Risk	High Risk	High Risk
	Minor	Negligible Risk	Low Risk	Low Risk	Medium Risk	Medium Risk
	Insignificant	Negligible Risk	Negligible Risk	Low Risk	Low Risk	Low Risk
		Very Low	Low	Moderate	High	Very High
	Likelihood					

As discussed in the methodology, Table 27 identifies and describes the potential interactions between the Project components and the climate hazards listed previously. A description of the interaction is included, as well as the risk rating for each interaction with a rationale behind the level of risk for each. Each interaction identified was assigned a risk rating based on the criteria outlined above. The final column provides preliminary adaptation measures that will help address the identified risks.

Table 27: Risk Ranking and Planning Adaptation Measures

Component	Potential Interaction	Description of Interaction	Likelihood	Consequence	Current Assessment of Future Risk	Current and Planned Adaptation Measures
Ready Mix Concrete Plant	Yes	Concrete production could be negatively impacted by extreme temperatures.	Low	Moderate	Low	Operations policies and procedures will be put in place to reduce the impacts of extreme temperate events.
		The concrete plant could be susceptible to water damage due to increased precipitation and flooding events. This could cause temporary shutdowns.	Low	Moderate	Low	Operations and maintenance policies and procedures will be put in place to reduce the impacts of extreme precipitation events.
		The concrete plant could be vulnerable to extreme weather events including high winds, tornadoes, and wildfires that may cause structural damage to the systems.	Low	Moderate	Low	Operations and maintenance policies and procedures will be put in place to reduce the impacts of extreme events.
Building (including windows, roof, HVAC, insulation, foundation, and other structural elements)	Yes	Extreme temperatures changes, including extreme heat and extended cold spells could overwhelm the capacity of the HVAC systems of the buildings needed to support the facility demands, causing thermal discomfort. Extended cold spells can lead to cold air leakage from windows and other building infrastructure, causing heating problems. The freeze-thaw cycles may interact with the building structure and insulation causing freeze weathering. Increasing freeze-thaw cycles can cause physical damage to the roofs, decreasing their life expectancy.	Moderate	Minor	Low	The buildings will be designed to maintain an indoor air temperature of -16ºC to 27ºC for indoor comfort based on Appendix C of the National Building Code of Canada 2020, Volume 1 (Canadian Commission on Building and Fire Codes 2020). Changes in future climate will be considered as a part of the building design. Operations and maintenance policies and procedures will be put in place to reduce the impacts of extreme events. The policies and procedures will address current climate risks and will be reviewed and updated as needed to address future climate risks.
		Increasing extreme precipitation events including high intensity rainfall and associated storm events may result in structural damage of building including roofs, windows, and other exterior elements. Increased rainfall and snow melt can lead to water retention on the roof and can cause potential run-off into the walls. Increased rain-on-snow events may result in structural damage to the roof.	Moderate	Moderate	Medium	The buildings will comply with Appendix C of the National Building Code of Canada 2020, Volume 1 (Canadian Commission on Building and Fire Codes 2020). Based on this, the building would be designed for an annual total precipitation load of 1475 mm (Canadian Commission on Building and Fire Codes 2020). The building would also be designed for 123 mm one day rain for 1/50-year events (Canadian Commission on Building and Fire Codes 2020). Changes in future climate will be considered as a part of the building design. The buildings are likely to be exposed to increased snow loads (from rain-on-snow events). Snow loads will be considered in the building design based on Appendix C of the National Building Code of Canada 2020, Volume 1 (Canadian Commission on Building and Fire Codes 2020). Changes in future climate will be considered as a part of the building design. Operations and maintenance policies and procedures will be put in place to reduce the impacts of storm events. The policies and procedures will address current climate risks and will be reviewed and updated as needed to address future climate risks.
		The building may be vulnerable to extreme weather events including high winds that may cause structural damage to the roofs. High wind-speed events can put additional load on the building structure including roofs and windows. High winds along with cold spells, can cause air leakage through windows, causing heating problems.	Moderate	Major	High	Buildings are currently designed to comply with the Appendix C of the National Building Code of Canada 2020, Volume 1 (Canadian Commission on Building and Fire Codes 2020). Future design will consider the impacts of extreme climate events (e.g., flooding, snow loads, high winds) on the building. The building is likely to be exposed to high winds. Wind loads of 0.46kPa for 1/10-yr events and of 0.59kPa for 1/50-yr events would be considered in the building design based on Appendix C of the National Building Code of Canada 2020, Volume 1 (Canadian Commission on Building and Fire Codes 2020), to address impacts of high winds. Changes in future climate will be considered as a part of the building design. Operations and maintenance policies and procedures will be put in place to reduce the impacts of extreme events. The policies and procedures will address current climate risks and will be reviewed and updated as needed to address future climate risks. The Project would have emergency preparedness and response plans in place during extreme weather events.

Table 27: Risk Ranking and Planning Adaptation Measures

Component	Potential Interaction	Description of Interaction	Likelihood	Consequence	Current Assessment of Future Risk	Current and Planned Adaptation Measures
Runway/Airstrips	Yes	Airstrips and apron may be vulnerable to the effects of extreme heat as it might cause pavement softening. Extreme cold and freeze thaw cycles may have an affect on airstrips and apron causing cracks or potholes due to temperature fluctuations.	Moderate	Moderate	Medium	The runway/ airstrips for the Project would be designed in accordance with the TP312: Aerodrome Standards and Recommended Practices – Land Aerodromes (Transport Canada 2015). Operations and maintenance policies and procedures will be put in place to reduce the impacts of extreme temperatures.
		Increasing extreme precipitation events including high intensity rainfalls and storms may cause flooding on the airstrip and apron, limiting the access to the site. Heavy snowfall events could impact the airstrip and restrict access to the site.	Moderate	Moderate	Medium	The runway/ airstrips for the Project would be designed in accordance with the TP312: Aerodrome Standards and Recommended Practices – Land Aerodromes (Transport Canada 2015). Operations and maintenance policies and procedures will be put in place to reduce the impacts of extreme precipitation events.
		Extreme weather events including high winds and storms may lead to accumulation of debris on the airstrip and apron, affecting access to the facility. Wildfires might cause debris on the airstrip.	Moderate	Moderate	Medium	The runway/ airstrips for the Project would be designed in accordance with the TP312: Aerodrome Standards and Recommended Practices – Land Aerodromes (Transport Canada 2015). Operations and maintenance policies and procedures will be put in place to reduce the impacts of extreme events.
		In addition to increased freeze-thaw cycles, extreme weather (including extreme temperatures and precipitation) can impact the ability for flights to occur as required.	Moderate	Moderate	Medium	Operations and maintenance policies and procedures will be put in place to reduce the impacts of extreme events.
Roads	Yes	Roads may be vulnerable to the effects of extreme heat as it might cause pavement softening. Extreme cold and freeze thaw cycles may affect the roads causing cracks or potholes due to temperature fluctuations.	Moderate	Minor	Low	Operations and maintenance policies and procedures will be put in place to reduce the impacts of extreme temperature on Project controlled roads. The policies and procedures will address current climate risks and will be reviewed and updated as needed to address future climate risks.
		Increase precipitation could cause road washouts, limiting access to the site. Heavy snowfall events could restrict access to the site.	Moderate	Minor	Low	Operations and maintenance policies and procedures will be put in place to reduce the impacts of extreme precipitation on Project controlled roads. The policies and procedures will address current climate risks and will be reviewed and updated as needed to address future climate risks.
		Extreme weather events including high winds and storms may lead to accumulation of debris on the roads, affecting access to the facility. Wildfires may affect access to the site via roads.	Low	Minor	Low	Operations and maintenance policies and procedures will be put in place to reduce the impacts of extreme weather events on Project controlled roads. The policies and procedures will address current climate risks and will be reviewed and updated as needed to address future climate risks.
Parking lot	Yes	The parking lot may be vulnerable to the impacts of extreme heat as it might cause fading and deterioration of the parking surface. Extreme cold and freeze thaw cycles can have an impact of the parking lot causing cracks or potholes due to temperature fluctuations.	Moderate	Minor	Low	Operations and maintenance policies and procedures will be put in place to reduce the impacts of extreme events and maintain access to parking areas. The policies and procedures will address current climate risks and will be reviewed and updated as needed to address future climate risks.
		Increasing extreme precipitation events including high intensity rainfalls and storms can cause flooding in the parking lot, limiting the access to the site. Heavy snowfall events can cause structural damage to the parking lots.	Moderate	Minor	Low	Site drainage will be designed to reduce the consequence of extreme precipitation events. Changes in future climate will be considered as a part of the design. Operations and maintenance policies and procedures will be put in place to reduce the impacts of extreme precipitation events.
		Extreme weather events including high winds and storms may lead to accumulation of debris on the parking lot, impacting access to the facility.	Low	Minor	Low	Operations and maintenance policies will be put in place to reduce the impacts of extreme weather events on parking lots. The policies and procedures will address current climate risks and will be reviewed and updated as needed to address future climate risks.

Table 27: Risk Ranking and Planning Adaptation Measures

Component	Potential Interaction	Description of Interaction	Likelihood	Consequence	Current Assessment of Future Risk	Current and Planned Adaptation Measures
Stormwater Management System	Yes	Extreme heat and drought-like conditions might impact on-site water availability impacting the amount of water that would be available for irrigation.	Moderate	Moderate	Medium	Operations and maintenance policies will be put in place to reduce the impacts of temperature changes and drought. The policies and procedures will address current climate risks and will be reviewed and updated as needed to address future climate risks.
		Heavy precipitation events may affect cause overflow and structural damage to water management infrastructure and containment structures.	Moderate	Major	High	Operations and maintenance policies will be put in place to reduce the impacts of extreme precipitation events. The policies and procedures will address current climate risks and will be reviewed and updated as needed to address future climate risks.
		Freeze-thaw cycles can impact drainage of stormwater due to snow melting and freezing over drains.	Low	Minor	Low	Operations and maintenance policies will be put in place to reduce the impacts of extreme precipitation events. The policies and procedures will address current climate risks and will be reviewed and updated as needed to address future climate risks.
Sanitary Wastewater Treatment Facility	Yes	Extreme heat and increasing temperatures may affect the sewage treatment facilities by affecting the water availability, water quality and causing odour issues. Increasing cold spells may cause water main breaks causing treatment challenges. Increasing freeze-thaw cycles may cause physical damage to the pipes and sewage treatment facility's infrastructure.	Low	Minor	Low	Operations and maintenance policies will be put in place to reduce the impacts of temperature changes. The policies and procedures will address current climate risks and will be reviewed and updated as needed to address future climate risks.
		Increased precipitation may cause increased load on the sewage treatment facilities, may lead to increased probability of sewer flooding, overflow, and spills.	Low	Major	Medium	Operations and maintenance policies will be put in place to reduce the impacts of extreme precipitation events. The policies and procedures will address current climate risks and will be reviewed and updated as needed to address future climate risks.
		Sewage treatment facilities may be vulnerable to the effects of wildfires.	Low	Major	Medium	Operations and maintenance policies will be put in place to reduce the impacts of extreme precipitation events. The policies and procedures will address current climate risks and will be reviewed and updated as needed to address future climate risks.
Water Supply	Yes	Extreme heat and an increase in drought-like conditions could reduce on-site water availability either from the regional water systems or from the stormwater management systems. This could impact the on-site operations.	Moderate	Moderate	Medium	Operations and maintenance policies will be put in place to reduce the impacts of temperature changes. The policies and procedures will address current climate risks and will be reviewed and updated as needed to address future climate risks.

3.6 Climate Resilience Summary

A range of climate change events have been identified to impact the Project infrastructure. Some of these climate events include extreme precipitation, extreme temperatures, high winds, storms, and changes in snowfall. These extreme impacts may also impact Project activities during operations and resulting in delays, disruptions, or complete shutdowns of operations.

Although the Project is currently at the conceptual design stage, the following measures will be incorporated increase the overall resilience:

- Building codes and standards will be used in the design of the Project to address the impact of extreme events, including the National Building Code of Canada 2020, Volume 1 (Canadian Commission on Building and Fire Codes 2020).
- Operations and Maintenance policies and procedures will be followed that indirectly address current climate risks and will be reviewed and updated as needed.

However, further development of resilience measures to mitigate climate risks to the Project should be considered at the detailed design stage of the Project for medium and high-risk interactions identified in Table 27. Some of the following standards can be considered to increase resilience of the facility at the detailed design stage:

- *Climate-Resilient Buildings and Core Public Infrastructure: An Assessment of the Impact of Climate Change on Climate Design Data in Canada* (Cannon, A.J. et al 2020) provides an assessment of how climate design data relevant to the users of the National Building Code of Canada might change as the climate continues to warm. The document provides recommendations on using the IPCC AR5 data in the design of infrastructure. For example, for the mean annual temperatures, the document recommends using warming level associated with the RCP 8.5 scenario for the 50-year horizon in the design data.
- *The CSA A440. 4:19 Window, door, and skylight installation* (CSA 2019) standard's Annex H introduces information on consideration of climate change during installation of windows and doors.
- *The CSA S520:22. Design and construction of low-rise residential and small buildings to resist high wind* (CSA 2022) standard provides guidance for design and construction of new buildings to develop resistance to high wind speeds up to an EF-2 level (tornado-level wind speed).
- *The CSA A123.26:21. Performance requirements for climate resilience of low slope membrane roofing systems* (CSA 2021) standard provides requirements for low slope membrane roofing systems based on climate severity and resilience requirements.

Although the mitigation measures would have the potential to reduce climate risks, the measures need to be monitored for their performance through an ongoing monitoring and surveillance process. As a part of the continual improvement process, climate risks and opportunities could be integrated in Project's monitoring and surveillance activities. A Climate Adaptation Framework could be developed for the Project that forms the basis documenting the ongoing monitoring and continual improvement related to climate change, as well as to outline the decision-making process for when action needs to be taken to improve climate resilience.

The adaptive management plan could be updated through an ongoing process over the lifetime of the Project. The results from the monitoring programs could be integrated to test the effectiveness of resilience and mitigation actions and manage the unexpected outcomes. The Climate Adaptation Framework could be used to support future climate risk assessments for the Project and provide operational and financial decision-making support.

4.0 CLOSURE

The information in this report was prepared using published data and information, technical journals, articles, and assumptions based on professional judgment and experience. We trust the above meets your present requirements. If you have any questions or comments, please contact the undersigned.

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