# APPENDIX

# A

## CLIMATE LENS ASSESSMENT – GHG MITIGATION ASSESSMENT

Nova Scotia Department of Public Works (NSPW)

# NEW HIGHWAY 101 CAMBRIDGE INTERCHANGE AND CONNECTOR ROADS

## CLIMATE LENS ASSESSMENT - GHG MITIGATION ASSESSMENT

WSP REF.: 211-00242-00

May 10, 2022

wsp GOLDER

# NEW HIGHWAY 101 CAMBRIDGE INTERCHANGE AND CONNECTOR ROADS

## CLIMATE LENS ASSESSMENT - GHG MITIGATION ASSESSMENT

NOVA SCOTIA DEPARTMENT OF PUBLIC WORKS (NSPW)

FINAL VERSION

PROJECT NO.: 221-04152-00
DATE: MAY 10, 2022

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# 1 ATTESTATION FOR GHG MITGATION ASSESSMENT

We the undersigned attest that this Greenhouse Gas (GHG) Mitigation Assessment was undertaken using recognized assessment tools and approaches (i.e. ISO 14064-2: Specification with guidance at the project level for quantification, monitoring, and reporting of greenhouse gas emissions reductions or removal enhancements and, if chosen, the *GHG Protocol for Project Accounting*) and complies with the General Guidance and any relevant sector-specific technical guidance issued by Infrastructure Canada for use under the Climate Lens.

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*GHG Mitigation Assessments must be prepared, a qualified party (i.e., a professional engineer, or a GHG accounting professional with suitable GHG quantification training or expertise related to the project).

# 2 EXECUTIVE SUMMARY

The Nova Scotia Department of Public Works (NSPW) plans to initiate a new interchange (the "Project") on Highway 101 just west of the Annapolis Valley First Nation (AVFN) as a long-term goal to reduce traffic volumes on Trunk 1 in Coldbrook. The Project requires a Climate Lens Assessment (CLA) during the application/design phase of the Project for funding under the National Trade Corridors Fund (NTCF) application. The Climate Lens policy was developed under the Infrastructure Canada Investing in Canadian Plan to help address the climate change impacts and greenhouse gas (GHG) emissions of infrastructure projects in Canada. WSP was retained by NSPW to conduct a Greenhouse Gas Mitigation Assessment (GHGMA).

The GHGMA was conducted following Climate Lens guidance[1], which details the Project's GHG emissions inventory in 2030 and over the asset's lifespan, including both construction as well as operations and maintenance (O & M) phases. This report includes a list of GHG emissions sources, and the quantity of emissions anticipated to be released from each source during the asset's lifespan. The anticipated GHG emissions in the year 2030 and cumulatively over the anticipated Project lifespan for the baseline and two Project scenarios are shown in Table 2-1 below.

**Table 2-1: Net Reduction in GHG Emissions in 2030 and Cumulative Over 50-Year Lifespan**

| GHG Mitigation Assessment – Project Scenario A (Roundabout) | | | |
|---|---|---|---|
| **2030 GHG Results (tonnes of $CO_2e$)** | | **Lifetime GHG Results (tonnes of $CO_2e$)** | |
| Baseline Scenario Emissions in 2030 | 26,415 | Baseline Scenario Emissions, Lifetime (cumulative) | 688,064 |
| Estimated Project Emissions in 2030 | 25,611 | Estimated Project Emissions, Lifetime (cumulative) | 681,294 |
| **Net Emissions Change** | 804 | **Net Emissions Changes** | 6,770 |

GHG emissions included in the assessment consist of direct, on-site emissions (sometimes called Scope 1) and indirect, off-site emissions associated with purchased electricity consumption (sometimes called Scope 2). GHG emissions from mobile sources are the largest contributor for both the baseline scenario and project scenario. For the baseline case, 688,064 tonnes of $CO_2$-equivalent ($tCO_2e$) emissions are anticipated, spanning 33 years from 2023 to 2055. The Project is anticipated to emit 681,294 $tCO_2e$ over the same assessment period. In 2030, it is anticipated that 26,415 $tCO_2e$ will be emitted for the baseline case, and 25,611 $tCO_2e$ for the project scenario. The decreased GHG emissions from project scenario are due to vehicle idling times to provide smooth access to a variety of land uses.

For this Project, the total eligible amount of NTCF is 31,500,000 CAD, among which 50% is eligible for Federal funding. The GHG reduction cost for 2030 is 19,587 Federal contribution dollar per tonne of $CO_2e$

[1] Infrastructure Canada, Climate Lens – General Guidance, https://www.infrastructure.gc.ca/pub/other-autre/cl-occ-eng.html, accessed in April 2022

removed on a non-cumulative basis. For the Project lifespan, the GHG reduction cost is $4,653 Project dollar per tonne of $tCO_2e$ removed if the funding is approved.

This GHG Assessment has been developed in accordance with CAN/CSA-ISO Standard 14064-2:06 Greenhouse Gases – Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements. In addition, the team has consulted with the World Resource Institute (WRI)/ World Business Council for Sustainable Development (WBCSD) protocol: The GHG Protocol for Project Accounting and additional resources. The GHG assertions presented in this report have not undergone third-party verification.

# 3 PROJECT BACKGROUND

Highway 101 is a provincial (Nova Scotia) arterial highway and is a critical piece of infrastructure facilitating local, regional, and national economic activity. Trunk 1 runs parallel to Highway 101, intertwining throughout the province and acting as a local collector for small communities. Due to increased volumes on Trunk 1 in the Coldbrook and surrounding area, the NSPW is initiating a new interchange on Highway 101 just west of the AVFN (the “Project”) as a long-term goal to reduce traffic volumes.

The proposed Project involves the construction, maintenance and post-construction monitoring of the interchange along Highway 101, with two new connector roads. One connector south to Trunk 1 with a spur to the Michelin Tire plant and one north to Brooklyn Street. The new interchange is located between Coldbrook (Exit 14) and Berwick (Exit 15), near the AVFN reserve, which will provide the Band with a secondary access into the community. The south connector road travels 2 km to Trunk 1 near Waterville Mountain Road, and the north connector travels 1.5 km to Brooklyn Street. An active transport corridor, featuring a multi-use path, paralleling the south connector road is included as part of the project. The connector roads are designed as two-lane roads, with additional turning lanes for high volume access as necessary. Roundabouts are being implemented at both ramp terminals, and at the intersection with Trunk 1. The new interchange will reduce traffic volumes at Exit 14 and improve operations at the ramp terminals. It is estimated that the interchange will reduce traffic volumes on Trunk 1 by 20-25% compared to background conditions.

The Project requires a GHGMA for NTCF application per Climate Lens General Guidance. The Climate Lens policy was developed under the Investing in Canada Plan to help address the climate change impacts and GHG emissions of infrastructure projects in Canada.

# 4 METHODOLOGY

## 4.1 QUANTIFICATION PROTOCOL

Quantification of baseline and Project emissions adheres to the six principles for project GHG accounting set out in CAN/CSA-ISO Standard 14064-2[2] and The GHG Protocol for Project Accounting[3]. These include:

- **Relevance:** This GHGMA appropriately reflects the baseline and project case for the Project, and it serves the needs of its owners to communicate GHG emissions impacts of this development. Emissions factors and estimates used are sourced from Canada's National Inventory Report (NIR)[4] or Intergovernmental Panel on Climate Change (IPCC) sources, where possible, and are referenced in detail.
- **Completeness:** WSP has accounted for all significant GHG emission sources and activities within the chosen boundaries, referencing the Climate Lens guidance[1]. Any exclusion of emissions sources is disclosed and justified.
- **Consistency:** WSP has completed this assessment using consistent methodologies to enable meaningful comparisons of GHG emissions with other projects and over time. Methodological decisions are transparently documented.
- **Transparency:** WSP has produced this report in a factual and coherent manner. Any assumptions are stated, and calculation methodologies are referenced to ensure transparency.
- **Accuracy:** Quantification of the Project's anticipated baseline and Project emissions is made as accurate as possible, based on available data, emissions factors and estimation methodologies used, recognizing that uncertainties exist due to the early stage of Project development, and the limited emissions factors available for the relevant activities. Where there is uncertainty, a conservative approach has been taken and described.
- **Conservativeness:** Assumptions, estimations, and emissions and conversion factors are selected with the aim of avoiding under-estimating GHG emissions from the Project.

## 4.2 BOUNDARY OF THE ASSESSMENT

The boundary of the Project for the GHG assessment is defined as the activities associated with the construction and O&M of the Cambridge Interchange and Connector Roads. A detailed methodology

[2] ISO 14064-2: Specification with Guidance at the Project Level for Quantification, Monitoring, and Reporting of Greenhouse Gas Emission Reductions or Removal Enhancements

[3] World Business Council for Sustainable Development (WBCSD)/World Resources Institute (WRI) – The GHG Protocol for Project Accounting

[4] Environment and Climate Change Canada (ECCC), National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada, 2022

and parameters of the assessment including GHGs and emission scopes are summarized in the following sections.

## 4.3 PROJECT SCHEDULE AND LIFECYCLE

Based on the NTCF funding being approved in principle, construction is expected to occur in 2023 with an overall completion around end of 2025. Lifecycles for the road/highway structural assets have been projected at 75 years. For this project, the GHGMA emissions for construction were quantified for the period of 2023 to 2025; emissions for the O&M were quantified from 2026 to 2055 covering the 30-year project operation period as it is difficult to predict long-term traffic volume due to high data uncertainty. Emission sources include direct and indirect emissions during the construction and O & M phases.

## 4.4 GREENHOUSE GASES CONSIDERED

The assessment considers the seven gases and families of gases defined as GHGs under the United Nations IPCC:

- Carbon dioxide ($CO_2$);
- Methane ($CH_4$);
- Nitrous oxide ($N_2O$);
- Nitrogen Trifluoride ($NF_3$);
- Hydrofluorocarbons (HFCs – a family of gases);
- Fluorocarbons (PFCs – another family of gases) and
- Sulfur hexafluoride ($SF_6$).

The majority of the emissions are $CO_2$. Some amounts of $CH_4$ and $N_2O$ are anticipated and are quantified where an appropriate emission factor exists to quantify these. All are converted into tonnes of $CO_2$ equivalent ($tCO_2e$) using global warming potentials (GWP) sourced from the IPCC 4$^{th}$ Assessment Report as required for inventory reporting under the United Nations Framework Convention on Climate Change (UNFCCC) and by Section 46 (S.46) of the Canadian Environmental Protection Act for facility GHG reporting.

**Table 4-1: Global Warming Potential (100 year) for the Most Common GHG Species**

| Greenhouse Gas | Global Warming Potential (100 year) |
|---|---|
| Carbon dioxide ($CO_2$) | 1 |
| Methane ($CH_4$) | 25 |
| Nitrous oxide ($N_2O$) | 298 |

In some cases, available emissions factors are provided in units of $tCO_2e$, encompassing $CH_4$, $N_2O$, $SF_6$ emissions. Trace amounts of $NF_3$, HFCs, and PFCs are anticipated.

## 4.5 GHG ASSESSMENT SCENARIOS

For this Project, two assessment scenarios were evaluated. Namely, the baseline scenario and project scenario. The baseline scenario assumes that the Project does not exist. In the absence of the Project, the most likely business as usual case (BAU) is to maintain the current highway design, which could cause vehicle delays and bottlenecking at peak hours in the area. The Project case is to create a new, direct highway connection to the Cambridge area. The interchange will be located between Exit 14 (Coldbrook) and Exit 15 (Berwick) on Highway 101, approximately 8km west of Exit 14, and 6.5km east of Exit 15. The new interchange would save approximately 2 minutes per trip between Highway 101 Exit 14 and Waterville Mountain Road (Michelin) and 1 minute per trip between Highway 101 Exit 15 and Waterville Mountain Road.

For GHGMA, emissions from the baseline case and project case include activities associated with construction and O & M. Methods to quantify anticipated emissions associated with the Baseline /Project cases are described in the following sections.

## 4.6 EMISSION SCOPES

Anticipated emissions are quantified both for the construction phase and for the O&M phase over the lifespan of the asset. Sources of direct and energy indirect emissions are summarized in Table 4-2.

**Table 4-2: Assessment Boundary Emission Sources and Scopes**

| Source Scope | Construction Phase (2023-2025) | O &M Phase (2026-2055) |
|---|---|---|
| Scope 1 – Direct Emissions | Construction Activities (project scenario only) | → Mobile Emissions<br>→ O & M Emissions |
| Scope 2 – Energy Indirect Emissions | Electricity Consumption | Electricity Consumption |
| Scope 3 – Other Indirect Emissions | N/A | N/A |

## 4.7 EXCLUSIONS FROM THE ASSESSMENT

Fugitive emissions could result from the use of ozone depleting substances (ODS) and/or fire suppression equipment on-site, during construction and/or operations and maintenance. The ODS equipment could include heavy duty machinery and/or trucks equipped with air conditioners containing refrigerants, and fire suppression chemicals. Fugitive emissions could also result if electrical equipment containing sulfur hexafluoride ($SF_6$) is used on the project. Given the uncertainty about the types and details of refrigerant-containing equipment that could be used, fugitive emissions from loss of refrigerants were not quantified in this assessment.

Per Climate Lens[1] direction, upstream and downstream supply chain emissions were not quantified or assessed. Other supply chain emissions could exist for this type of project, include emissions resulting from manufacturing of construction materials (e.g., cement or steel), workers and staff commuting to site, and production and transportation of consumables, and upstream emissions associated with fuel and energy. Supply chain emissions are scope 3 emissions, which are the result of activities from assets not owned or controlled by the reporting organization but have indirect impacts to its' value chain. As per Climate lens guidance, the supply chain emissions are not required to be included in the GHGMA due to the complexities associated with both sourcing and quantifying these emissions. No emissions or emissions removals associated with this Project are anticipated to occur outside of Canada.

## 4.8 DATA COLLECTION AND CALCULATION PROCEDURES

GHG emissions anticipated for the Project were estimated based on currently available information or assumptions. WSP calculated the appropriate GHG emissions using Project activity data and emission factors by applying the following equation:

$$\text{GHG Emissions} = \text{Activity Data} \times \text{Emission Factor}$$

**Equation 1**

Activity data associated with construction and O & M activities were provided by the Project team or estimated based on the best available information. There are potential differences between projected and actual emissions which may arise due to actual materials used, activities undertaken during construction and O&M practices. For this study, the GHG emission factors were taken from various sources, such as the IPCC and the latest NIR[4].

## 4.9 ASSUMPTIONS

The Project is undergoing a design -bid- build process, some specific parameters are still being finalized at this time. As such, some assumptions were made to estimate some activities, yielding results that are potentially associated with greater uncertainty. If greater certainty is desired, the emission estimates may be revisited to incorporate new data following construction. The following sections detail assumptions and methods used for quantifying GHG emissions for the baseline and project scenarios.

With the implementation of the project, additional development is expected to occur in the area, which is expected to draw more traffic into the area. However, to directly compare project emissions with the baseline scenario, the traffic activity data used for the project GHG quantification is the same as the baseline scenario. Therefore, the increased traffic volumes resulting from additional commercial land use development are excluded in the GHGMA.

### *4.9.1 BASELINE SCENARIO*

The baseline scenario represents the BAU case. GHG emissions for the baseline case consists of the following components:

→ Mobile emissions; and

→ O & M emissions

GHG emissions were quantified on an annual basis. Detailed methodology is elaborated below.

#### 4.9.1.1 *MOBILE SOURCE EMISSIONS*

### TRAFFIC ACTIVITY

Annual vehicle travel activity information was based on a traffic study conducted at Highway 101 Cambridge Interchange in 2019[5]. Currently the section of Highway 101 between Exit 14 and Exit 15 has an Annual Average Daily Traffic (AADT) volume of 9,200 vehicles. To project future traffic volumes in the section, the following assumptions were made:

- An annual 1.5% of growth rate was applied for the forecasted traffic volume
- A factor of 12.5 was used to convert the peak AM and PM hour volumes to AADT.
- 66% of traffic is from the east and 34% of traffic is from the west
- Delayed traffic: 2 minutes per trip from the east and 1 minute per trip from the west. The delay times were treated as idling periods
- Traffic activity have incorporated planned development in the region (see Table 4-3) which is expected to occur even if the Project does not go ahead. For this GHGMA, additional future commercial development, including AVFN Highway commercial and Industrial Park at the interchange and connector roads are excluded for direct emission comparison between the baseline scenario and project scenario.

**Table 4-3: Future Traffic Projects for the Baseline and Project Scenarios**

| Time Horizon | Activity Description | Without Interchange |
|---|---|---|
| **2023** | Background growth | 9,685 |
| | 50 AVFN Residential Growth | 575 |
| | Michelin Expansion | 1,563 |
| | **Total** | **11,823** |
| **2033** | Background growth | 13,721 |
| | 100 AVFN Residential Growth | 1,113 |
| | Waterville Business Park | 2,170 |
| | **Total** | **17,004** |

- Included the impacts of zero emission vehicles (ZEVs) policy on future vehicle composition
- The estimated GHG emissions from the purchase of electricity was based on a variable grid intensity derived from Nova Scotia Integrated Resource Plan (IRP) Final Report Appendices[6]. Nova Scotia Power Inc. (NSPI) projected future grid intensity based on energy Plans.

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[5] Crandall Engineering Ltd., Highway 101 Cambridge Interchange Traffic Study, March 2, 2019
[6] Nova Scotia Power IRP Final Report Appendices, February 2020, https://irp.nspower.ca/files/key-documents/NS-Power-IRP-Appendices-A-N.pdf, accessed in March 2022

## VEHICLE TYPE COMPOSITION

Mobile emissions include vehicle travel along Highway 101 between Exit 14 and Exit 15, which includes GHG emissions during normal driving mode and idling mode. On road vehicles are divided into three categories according to vehicle weight based on the Canadian Vehicle Survey[7]. The vehicle type composition was obtained from Statistics Canada[8] using vehicle registration information in Nova Scotia. To consider truck movement from the Michelin Plant located nearby, the heavy-duty vehicle (HDV) type composition was adjusted to include 130 daily trucks to/from the Plant. It is expected that the planned expansion to the Michelin Plant will increase the number of trucks by 50% over the next 10-15 years.

Vehicle type composition for the baseline case is shown in Table 4-4.To quantify GHG emissions from fossil fuels, it was assumed that light-duty vehicles (LDV) use gasoline and medium-duty vehicles (MDV) and heavy-duty vehicles (HDV) use diesel as fuel supply.

**Table 4-4: Vehicle Type Composition**

| Vehicle Types | Description | Provincial Profile | Project Profile (2023) | Project Profile (2033) | Fuel Type |
|---|---|---|---|---|---|
| LDV | Vehicles <4,500 kg | 85.6% | 84.53% | 84.48% | Gasoline |
| MDV | Vehicles > 4,500 kg, < 15,000 kg | 3.0% | 2.97% | 2.97% | Diesel |
| HDV | Vehicles >15,000 kg | 11.4% | 12.50% | 12.55% | Diesel |
| **Total** | | **100.0%** | **100.0%** | **100.0%** | **-** |

## IMPACTS OF ZERO EMISSION VEHICLES

To estimate GHG emissions during the lifetime of the project, the zero emission vehicles (ZEVs) policy was incorporated. The Government of Canada is committed to mandating that all new light-duty cars and passenger trucks sold be zero-emission by 2035, with an interim sales target of at least 20% by 2026 and at least 60% by 2030[9]. The ZEV sales targets are expected to result in 5%, 16% and 40% of total LDVs being ZEVs on the road by 2026, 2030 and 2035. By 2050, all LDV will be all ZEVs, achieving a net-zero emissions target.

In addition, Canada is joining 15 nations to accelerate the shift towards zero emission MDVs and HDVs, targeting 30% new zero-emission MDVs and HDVs sales by 2030 and 100% new ZEV sales by 2040[10]. To consider the impact of ZEV policy on MDVs and HDVs, it was assumed that the same ZEV uptake percent

[7] Canadian Vehicle Survey, 2009 Summary Report, https://oee.nrcan.gc.ca/publications/statistics/cvs/2009/pdf/cvs09.pdf, accessed in June 2021

[8] Nova Scotia Vehicle Registrations, by Type of Vehicle, https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2310006701&pickMembers%5B0%5D=1.4&cubeTimeFrame.startYear=2019&cubeTimeFrame.endYear=2019&referencePeriods=20190101%2C20190101, accessed in April 2022

[9] Transport Canada, Canada's Zero-Emission Vehicle (ZEV) sales targets, https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles/canada-s-zero-emission-vehicle-zev-sales-targets, accessed in April 2022

[10] Electric Autonomy Canada, Canada signs global agreement targeting 100 per cent zero-emission truck and bus sales by 2040, https://electricautonomy.ca/2021/11/09/cop26-zero-emission-truck-bus-canada/, accessed in April 2022

for LDVs will apply to MDVs and HDVs but with 5-year delay due to the 5 years lag in achieving 100% sales target for MDVs and HDVs. A linear interpolation was used to estimate percentage of ZEVs on the road in each year as shown in Table 4-5.

**Table 4-5: ZEV Sales Policy on Vehicle**

| Year | ZEV on the road (LDVs) | ZEV on the road (MDVs & HDVs) |
|---|---|---|
| 2021 | 0.3% | 0% |
| 2022 | 1.24% | 0.5% |
| 2023 | 2.18% | 1.0% |
| 2024 | 3.12% | 1.5% |
| 2025 | 4.06% | 2.0% |
| 2026 | 5% | 2.5% |
| 2027 | 7.8% | 3.0% |
| 2028 | 10.5% | 3.5% |
| 2029 | 13.3% | 4.0% |
| 2030 | 16% | 4.5% |
| 2031 | 20.8% | 5% |
| 2032 | 25.6% | 7.8% |
| 2033 | 30.4% | 10.5% |
| 2034 | 35.2% | 13.3% |
| 2035 | 40% | 16% |
| 2036 | 44% | 20.8% |
| 2037 | 48% | 25.6% |
| 2038 | 52% | 30.4% |
| 2039 | 56% | 35.2% |
| 2040 | 60% | 40% |
| 2041 | 64% | 44.0% |
| 2042 | 68% | 48.0% |
| 2043 | 72% | 52.0% |
| 2044 | 76% | 56.0% |
| 2045 | 80% | 60.0% |
| 2046 | 84% | 64.0% |
| 2047 | 88% | 68.0% |
| 2048 | 92% | 72.0% |
| 2049 | 96% | 76.0% |
| 2050 | 100% | 80.0% |
| 2051 | 100% | 84.0% |
| 2052 | 100% | 88.0% |
| 2053 | 100% | 92.0% |
| 2054 | 100% | 96.0% |
| 2055 | 100% | 100% |

Based on the above ZEV policy and local traffic study, the anticipated traffic volume for the baseline scenario is shown in Table 4-6.

**Table 4-6: Annual Traffic Volume by Vehicle Types - Baseline Scenario**

| Year | Small ZEV Cars | Light-duty Gasoline Cars | Medium -duty ZEV trucks | Medium-duty Diesel Trucks | Large ZEV Trucks | Large-duty Diesel Trucks | Total Vehicles |
|---|---|---|---|---|---|---|---|
| 2023 | 79,519 | 3,568,128 | 1,282 | 126,918 | 5,395 | 534,075 | 4,315,317 |
| 2024 | 118,795 | 3,688,736 | 2,008 | 131,811 | 8,447 | 554,670 | 4,504,467 |
| 2025 | 161,087 | 3,806,570 | 2,789 | 136,658 | 11,736 | 575,062 | 4,693,902 |
| 2026 | 206,390 | 3,921,392 | 3,627 | 141,447 | 15,262 | 595,218 | 4,883,336 |
| 2027 | 332,313 | 3,955,594 | 4,522 | 146,180 | 19,025 | 615,137 | 5,072,771 |
| 2028 | 467,044 | 3,980,989 | 5,472 | 150,858 | 23,025 | 634,819 | 5,262,207 |
| 2029 | 610,581 | 3,997,577 | 6,479 | 155,479 | 27,262 | 654,264 | 5,451,642 |
| 2030 | 762,926 | 4,005,358 | 7,542 | 160,043 | 31,735 | 673,472 | 5,641,076 |
| 2031 | 1,025,110 | 3,903,299 | 8,661 | 164,552 | 36,445 | 692,444 | 5,830,511 |
| 2032 | 1,302,665 | 3,785,870 | 13,861 | 164,980 | 58,325 | 694,246 | 6,019,947 |
| 2033 | 1,593,973 | 3,649,359 | 19,350 | 164,931 | 81,773 | 697,011 | 6,206,397 |
| 2034 | 1,873,351 | 3,448,668 | 24,784 | 162,263 | 104,738 | 685,733 | 6,299,537 |
| 2035 | 2,160,754 | 3,241,130 | 30,377 | 159,477 | 128,374 | 673,959 | 6,394,071 |
| 2036 | 2,412,513 | 3,070,471 | 40,083 | 152,621 | 169,391 | 644,988 | 6,490,067 |
| 2037 | 2,671,352 | 2,893,964 | 50,074 | 145,524 | 211,612 | 614,996 | 6,587,522 |
| 2038 | 2,937,419 | 2,711,463 | 60,355 | 138,179 | 255,063 | 583,957 | 6,686,436 |
| 2039 | 3,210,862 | 2,522,820 | 70,934 | 130,581 | 299,769 | 551,846 | 6,786,812 |
| 2040 | 3,491,829 | 2,327,886 | 81,816 | 122,723 | 345,758 | 518,635 | 6,888,647 |
| 2041 | 3,780,666 | 2,126,624 | 91,352 | 116,264 | 386,056 | 491,344 | 6,992,306 |
| 2042 | 4,077,347 | 1,918,751 | 101,155 | 109,583 | 427,484 | 463,107 | 7,097,427 |
| 2043 | 4,382,021 | 1,704,119 | 111,230 | 102,672 | 470,062 | 433,903 | 7,204,007 |
| 2044 | 4,695,070 | 1,482,653 | 121,588 | 95,533 | 513,838 | 403,729 | 7,312,411 |
| 2045 | 5,016,432 | 1,254,108 | 132,230 | 88,153 | 558,812 | 372,541 | 7,422,276 |
| 2046 | 5,346,516 | 1,018,383 | 143,168 | 80,531 | 605,036 | 340,332 | 7,533,966 |
| 2047 | 5,685,233 | 775,258 | 154,401 | 72,658 | 652,506 | 307,061 | 7,647,117 |
| 2048 | 6,033,015 | 524,610 | 165,941 | 64,532 | 701,276 | 272,718 | 7,762,092 |
| 2049 | 6,389,753 | 266,239 | 177,787 | 56,143 | 751,340 | 237,264 | 7,878,526 |
| 2050 | 6,755,902 | 0 | 189,953 | 47,488 | 802,755 | 200,688 | 7,996,786 |
| 2051 | 6,857,353 | 0 | 202,446 | 38,561 | 855,551 | 162,961 | 8,116,872 |
| 2052 | 6,960,346 | 0 | 215,272 | 29,355 | 909,752 | 124,057 | 8,238,782 |
| 2053 | 7,064,880 | 0 | 228,437 | 19,864 | 965,389 | 83,946 | 8,362,516 |
| 2054 | 7,170,957 | 0 | 241,948 | 10,081 | 1,022,488 | 42,603 | 8,488,077 |
| 2055 | 7,278,575 | 0 | 255,811 | 0 | 1,081,075 | 0 | 8,615,461 |

## VEHICLE EMISSIONS DURING DRIVING

To estimate GHG emissions from vehicle driving, the vehicle kilometers travelled (VKT) by each vehicle type were estimated using road length multiplying by annual traffic volume along Highway 101 between Exit 14 and Exit 15.

Fuel consumption for vehicles while driving was assumed at 8.9 liters of gasoline per 100 kilometers (L/100 km) for LDVs based on Canada's average fuel efficiency [11]. Diesel consumption for MDVs and HDVs were estimated at 17.55 L/100 km and 40.55 L/100 km based on an energy consumption study for heavy duty vehicles[12]. Fuel consumption for MDVs were based on a Class 5 delivery truck and for HDVs were based on a Class 8 Port Drayage (semi-trailers). The difference in fuel efficiency between driving speed at 80km/h and 100km/h is insignificant[13] and was not included in the emission analysis. A summary of fuel usage for each type of vehicle during driving mode is shown in Table 4-7.

**Table 4-7: Vehicle Fuel Consumptions During Driving Mode - Baseline Scenario**

| Year | LDV Gasoline Consumption (L/yr) | MDV Diesel Consumption (L/yr) | HDV Diesel Consumption (L/yr) |
|---|---|---|---|
| 2023 | 4,763,451 | 334,175 | 3,248,851 |
| 2024 | 4,924,463 | 347,058 | 3,374,133 |
| 2025 | 5,081,771 | 359,820 | 3,498,180 |
| 2026 | 5,235,058 | 372,430 | 3,620,792 |
| 2027 | 5,280,718 | 384,892 | 3,741,962 |
| 2028 | 5,314,620 | 397,209 | 3,861,690 |
| 2029 | 5,336,765 | 409,376 | 3,979,977 |
| 2030 | 5,347,153 | 421,393 | 4,096,822 |
| 2031 | 5,210,904 | 433,265 | 4,212,231 |
| 2032 | 5,054,136 | 434,392 | 4,223,193 |
| 2033 | 4,871,894 | 434,263 | 4,240,013 |
| 2034 | 4,603,972 | 427,238 | 4,171,407 |
| 2035 | 4,326,909 | 419,903 | 4,099,784 |
| 2036 | 4,099,079 | 401,851 | 3,923,550 |
| 2037 | 3,863,442 | 383,165 | 3,741,104 |
| 2038 | 3,619,803 | 363,825 | 3,552,290 |
| 2039 | 3,367,965 | 343,820 | 3,356,954 |
| 2040 | 3,107,728 | 323,130 | 3,154,927 |
| 2041 | 2,839,043 | 306,123 | 2,988,912 |
| 2042 | 2,561,533 | 288,532 | 2,817,143 |

[11] Canada Energy Regulator, Market Snapshot: How does Canada Rank in terms of Vehicle Fuel Economy? https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2019/market-snapshot-how-does-canada-rank-in-terms-vehicle-fuel-economy.html, accessed in April 2022
[12] Gao et al., The Energy Consumption and Cost Savings of Truck Electrification for Heavy-Duty Vehicle Applications, https://www.osti.gov/pages/servlets/purl/1474495, accessed in April 2022
[13] MPG for Speed, https://www.mpgforspeed.com/, accessed in April 2022

| Year | LDV Gasoline Consumption (L/yr) | MDV Diesel Consumption (L/yr) | HDV Diesel Consumption (L/yr) |
|---|---|---|---|
| 2043 | 2,274,999 | 270,335 | 2,639,491 |
| 2044 | 1,979,342 | 251,538 | 2,455,938 |
| 2045 | 1,674,234 | 232,107 | 2,266,218 |
| 2046 | 1,359,541 | 212,038 | 2,070,286 |
| 2047 | 1,034,969 | 191,308 | 1,867,894 |
| 2048 | 700,354 | 169,913 | 1,658,981 |
| 2049 | 355,429 | 147,824 | 1,443,309 |
| 2050 | 0 | 125,036 | 1,220,812 |
| 2051 | 0 | 101,531 | 991,314 |
| 2052 | 0 | 77,292 | 754,656 |
| 2053 | 0 | 52,302 | 510,655 |
| 2054 | 0 | 26,543 | 259,160 |
| 2055 | 0 | 0 | 0 |

GHG emissions from fossil fuel combustion during driving mode were quantified using fuel usage multiplied by emission factors taken from Table A6.1-14 in Annex 6 of the NIR[4] as shown in Table 4-8 of the report.

**Table 4-8: Emission Factors for Mobile Sources**

| Vehicle and Fuel Type | Emission Factor (g/L) | | | |
|---|---|---|---|---|
| | $CO_2$ | $CH_4$ | $N_2O$ | $CO_2e$ |
| Light Duty Gasoline Vehicle – Oxidation Catalyst | 2,307.3 | 0.52 | 0.20 | 2,379.90 |
| Light Duty Diesel Vehicle - Moderate Control | 2,680.5 | 0.068 | 0.21 | 2,744.78 |
| Heavy Duty Diesel Vehicle - Moderate Control | 2,680.5 | 0.14 | 0.082 | 2,708.44 |

The following is an example calculation for $CO_2e$ emissions from gasoline vehicles while driving in 2023:

$CO_{2e}$=4,763,451 L/yr x 2,379.9 kg/GJ x tonne/1,000,000g = 11,337 tonne $CO_{2e}$

Although no GHG emissions were anticipated from ZEV mobile sources, there are GHG emissions associated with the electricity consumption for ZEV charging. Average electricity usage for ZEVs was estimated at 0.201 kwh/km for LDVs based on the electric vehicle database[14]. Average electricity consumption for MDVs were assumed at 0.81 kwh/km and 1.93 kwh/km for HDVs using information published in the energy consumption study for heavy duty vehicles[12]. The electricity consumption for MDV

[14] Electric Vehicle Database, https://ev-database.org/cheatsheet/energy-consumption-electric-car, accessed in April 2022

was based on a Class 5 delivery truck and for HDV was based on Class 8 Port Drayage. This approach is consistent with the same references used for fossil fuel usage. A summary of electricity usage for each type of vehicle is shown in Table 4-9.

**Table 4-9: Electricity Consumptions by Vehicle Types - Baseline Scenario**

| Year | LDV Electricity Consumption (kwh/yr) | MDV Electricity Consumption (kwh/yr) | HDV Electricity Consumption (kwh/yr) |
|---|---|---|---|
| 2023 | 15,983 | 15,534 | 155,882 |
| 2024 | 23,878 | 24,330 | 244,066 |
| 2025 | 32,378 | 33,794 | 339,097 |
| 2026 | 41,484 | 43,947 | 440,977 |
| 2027 | 66,795 | 54,792 | 549,704 |
| 2028 | 93,876 | 66,303 | 665,279 |
| 2029 | 122,727 | 78,504 | 787,702 |
| 2030 | 153,348 | 91,384 | 916,943 |
| 2031 | 206,047 | 104,943 | 1,053,033 |
| 2032 | 261,836 | 167,950 | 1,685,229 |
| 2033 | 320,389 | 234,459 | 2,362,729 |
| 2034 | 376,544 | 300,301 | 3,026,275 |
| 2035 | 434,312 | 368,070 | 3,709,208 |
| 2036 | 484,915 | 485,675 | 4,894,343 |
| 2037 | 536,942 | 606,734 | 6,114,266 |
| 2038 | 590,421 | 731,306 | 7,369,729 |
| 2039 | 645,383 | 859,489 | 8,661,454 |
| 2040 | 701,858 | 991,343 | 9,990,249 |
| 2041 | 759,914 | 1,106,888 | 11,154,610 |
| 2042 | 819,547 | 1,225,669 | 12,351,620 |
| 2043 | 880,786 | 1,347,745 | 13,581,859 |
| 2044 | 943,709 | 1,473,250 | 14,846,712 |
| 2045 | 1,008,303 | 1,602,196 | 16,146,180 |
| 2046 | 1,074,650 | 1,734,729 | 17,481,765 |
| 2047 | 1,142,732 | 1,870,837 | 18,853,352 |
| 2048 | 1,212,636 | 2,010,664 | 20,262,501 |
| 2049 | 1,284,340 | 2,154,199 | 21,709,038 |
| 2050 | 1,357,936 | 2,301,611 | 23,194,611 |
| 2051 | 1,378,328 | 2,452,985 | 24,720,086 |
| 2052 | 1,399,030 | 2,608,394 | 26,286,156 |
| 2053 | 1,420,041 | 2,767,911 | 27,893,718 |
| 2054 | 1,441,362 | 2,931,621 | 29,543,523 |
| 2055 | 1,462,994 | 3,099,595 | 31,236,322 |

To quantify GHG emissions from the purchased electricity, the amount of electricity was multiplied by Nova Scotia's grid emission intensity derived from IRP Final Report Appendices[15]. NSPI has conducted different model scenarios to explore environmental policy options, resource strategies, technology innovations, and potential futures for electricity demand and GHG emissions. Among different model scenarios, a reference scenario was used as a conservation approach for GHG emission quantification. Emission intensity for 2016 and 2050 were provided in Table 8 of the IRP appendices[6] at 0.609 and 0.362 kg CO2e/kWh, respectively. A linear decline in emission intensity between 2021 and 2050 was predicted for retirement of existing coal plants and new green powered facilities. As the NSPI grid intensity is available till 2050, to be conservative the intensity data after 2050 is assumed to be the same as 2050. The forecasted grid intensity is shown in Table 4-10.

**Table 4-10: Grid Emission Intensity**

| Year | NS Grid Intensity (kg $CO_2$eq/kwh) |
|---|---|
| 2023 | 0.476 |
| 2024 | 0.473 |
| 2025 | 0.470 |
| 2026 | 0.468 |
| 2027 | 0.465 |
| 2028 | 0.462 |
| 2029 | 0.460 |
| 2030 | 0.457 |
| 2031 | 0.452 |
| 2032 | 0.447 |
| 2033 | 0.443 |
| 2034 | 0.438 |
| 2035 | 0.433 |
| 2036 | 0.428 |
| 2037 | 0.424 |
| 2038 | 0.419 |
| 2039 | 0.414 |
| 2040 | 0.409 |
| 2041 | 0.405 |
| 2042 | 0.400 |
| 2043 | 0.395 |
| 2044 | 0.390 |
| 2045 | 0.386 |
| 2046 | 0.381 |
| 2047 | 0.376 |

[15] Nova Scotia Power IRP Final Report Appendices, February 2020, https://irp.nspower.ca/files/key-documents/NS-Power-IRP-Appendices-A-N.pdf, accessed in March 2022

| Year | NS Grid Intensity (kg $CO_2$eq/kwh) |
|---|---|
| 2048 | 0.371 |
| 2049 | 0.367 |
| 2050 | 0.362 |

The following is an example calculation for $CO_2$e emissions from light-duty ZEV in 2023:

$CO_{2e}$=15, 983 kWh/yr*0.476 kg/kWh*tonne/1,000 kg= 7.6 tonne $CO_{2e}$

## VEHICLE EMISSIONS DURING IDLING

To estimate the idling time due to traffic delay, it was assumed that there are 2 minutes per trip delay between Highway 101 Exit 14 and Waterville Mountain Road (Michelin) and 1 minute per trip delay between Highway 101 Exit 15 and Waterville Mountain Road. Idling emissions from ZEV are expected to be minimal (only power draw is due to lights as the motors shut down when the vehicles are stopped).

Fuel usage during idling for the LDV was estimated at 1.86 L/hr using the following information and assumptions:

- An idling passenger engine consumes 0.6 litres / hr per litre of engine displacement[16]
- The average passenger car has a 3.1 liter of engine displacement based on a 4-stroke compact car travelling locally[17]

The idling fuel consumption rate of 1.86 L/hr is consistent with the data reported in a published paper[18] at 0.5 gallon/hr, which is equivalent to 1.89 L/hr. The idling fuel consumption rate for the MDV and HDV were estimated at 1.1 gallon/hr and 1.51 gallon/hr, respectively[19], which is equivalent to 4.2 L/hr and 5.7 L/hr. Fuel consumption during idling mode was determined using the following equation:

$$\text{Fuel}_{\text{idling}} = Q_{vehicles} * \text{Fuel Rate}_{\text{idling}} * T_{idling} \quad \textbf{Equation 2}$$

Where:

| | |
|---|---|
| $\text{Fuel}_{\text{idling}}$: | Fuel consumed at the idling mode (L/year) |
| $Q_{\text{vehicles}}$: | Quantity of Fossil Fuel Vehicles (L/year) |
| $\text{Fuel Rate}_{\text{idling}}$: | Hourly fuel consumption rate at the idling mode (L/hr) |
| $T_{\text{idling}}$: | Vehicle idling time (hr/year) |

[16] Ecomobile, Don't let your engine idle, https://ecomobile.gouv.qc.ca/en/ecomobilite/tips/idling_engine.php, accessed in April 2022

[17] Lewis Poulin, Estimating Volumes of Air through Various Engines in an Urban Setting, Canadian Meteorological Center, https://collaboration.cmc.ec.gc.ca/science/rpn/SEM/dossiers/2006/seminaires/2006-04-07/AirVolumes_CMOSBULLETINSCMO_latest.pdf, accessed in April 2022

[18] South Carolina Department of Health and Environmental Control, Fact Sheet, Idling: Why It's Problem and What You Can Do, https://scdhec.gov/sites/default/files/Library/CR-010109.pdf, accessed in April 2022

[19] WorkTruck, Idle-Reduction Benefits Extend Beyond Fuel Savings, https://www.worktruckonline.com/279650/idle-reduction-benefits-extend-beyond-fuel-savings, accessed in June 2021

Table 4-11 summarizes annual vehicle idling time and fuel consumption by vehicle type for the baseline scenario.

**Table 4-11: Fuel Consumption During Idling Mode – Baseline Scenario**

| Year | LDV idling time (hr/yr) | MDV idling time (hr/yr) | HDV idling time (hr/yr) | LDV idling fuel (L/yr) | MDV idling fuel (L/yr) | LDV idling Fuel (L/yr) |
|---|---|---|---|---|---|---|
| 2023 | 98,718 | 3,511 | 14,776 | 183,616 | 14,621 | 84,460 |
| 2024 | 102,055 | 3,647 | 15,346 | 189,822 | 15,185 | 87,717 |
| 2025 | 105,315 | 3,781 | 15,910 | 195,886 | 15,744 | 90,942 |
| 2026 | 108,492 | 3,913 | 16,468 | 201,795 | 16,295 | 94,129 |
| 2027 | 109,438 | 4,044 | 17,019 | 203,555 | 16,841 | 97,279 |
| 2028 | 110,141 | 4,174 | 17,563 | 204,862 | 17,379 | 100,392 |
| 2029 | 110,600 | 4,302 | 18,101 | 205,715 | 17,912 | 103,467 |
| 2030 | 110,815 | 4,428 | 18,633 | 206,116 | 18,438 | 106,505 |
| 2031 | 107,991 | 4,553 | 19,158 | 200,864 | 18,957 | 109,505 |
| 2032 | 104,742 | 4,564 | 19,207 | 194,821 | 19,006 | 109,790 |
| 2033 | 100,966 | 4,563 | 19,284 | 187,796 | 19,001 | 110,227 |
| 2034 | 95,413 | 4,489 | 18,972 | 177,468 | 18,693 | 108,444 |
| 2035 | 89,671 | 4,412 | 18,646 | 166,789 | 18,372 | 106,582 |
| 2036 | 84,950 | 4,223 | 17,845 | 158,006 | 17,583 | 102,000 |
| 2037 | 80,066 | 4,026 | 17,015 | 148,923 | 16,765 | 97,257 |
| 2038 | 75,017 | 3,823 | 16,156 | 139,532 | 15,919 | 92,349 |
| 2039 | 69,798 | 3,613 | 15,268 | 129,824 | 15,043 | 87,270 |
| 2040 | 64,405 | 3,395 | 14,349 | 119,793 | 14,138 | 82,018 |
| 2041 | 58,837 | 3,217 | 13,594 | 109,436 | 13,394 | 77,703 |
| 2042 | 53,085 | 3,032 | 12,813 | 98,739 | 12,624 | 73,237 |
| 2043 | 47,147 | 2,841 | 12,005 | 87,694 | 11,828 | 68,619 |
| 2044 | 41,020 | 2,643 | 11,170 | 76,297 | 11,006 | 63,847 |
| 2045 | 34,697 | 2,439 | 10,307 | 64,536 | 10,156 | 58,915 |
| 2046 | 28,175 | 2,228 | 9,416 | 52,406 | 9,278 | 53,821 |
| 2047 | 21,449 | 2,010 | 8,495 | 39,895 | 8,371 | 48,560 |
| 2048 | 14,514 | 1,785 | 7,545 | 26,996 | 7,434 | 43,128 |
| 2049 | 7,366 | 1,553 | 6,564 | 13,701 | 6,468 | 37,522 |
| 2050 | 0 | 1,314 | 5,552 | 0 | 5,471 | 31,737 |
| 2051 | 0 | 1,067 | 4,509 | 0 | 4,442 | 25,771 |
| 2052 | 0 | 812 | 3,432 | 0 | 3,382 | 19,619 |
| 2053 | 0 | 550 | 2,323 | 0 | 2,288 | 13,276 |
| 2054 | 0 | 279 | 1,179 | 0 | 1,161 | 6,737 |
| 2055 | 0 | 0 | 0 | 0 | 0 | 0 |

GHG emissions from mobile sources during idling mode were quantified using fuel usage multiplied by emission factors taken from Annex 6 of the NIR[4] as shown in Table 4-8. The following is an example calculation for $CO_2$e emissions from LDV during idling in 2023:

$$CO_{2e} = 183{,}616 \frac{\mathrm{L}}{\mathrm{yr}} * 2{,}379.9 \frac{kg}{GJ} * \frac{tonne}{1{,}000{,}000g} = 437\ tonne\ CO_{2e}$$

#### 4.9.1.2 *ROAD O & M EMISSIONS*

Road O & M emissions involve the use of electricity or fuels for the lighting of the road, traffic lights and road surface de-icing. Emissions associated with maintenance activities include preventive and corrective actions related to the road surface. For the O&M of roads, GHG emission factors were taken from Table 3.1 of European Transport GHG report[20]. Table 4-12 summarizes emission factors used for estimating GHG emissions from road O & M operation activities.

**Table 4-12: Emission Factors and References for Road Maintenance Activities**

| Project Phase | Emission source | Emission factor |
|---|---|---|
| **Maintenance** | Maintenance - Preventive | 1.2 $tCO_2e/km$ |
| | Maintenance - Corrective | 3.9 $tCO_2e/km$ |
| **Total** | | **5.1 $tCO_2e/km$** |

The following is an example calculation of $CO_2$e emissions from O & M along Highway 101:

$$CO_{2e} = 5.1\ tonne \frac{CO_{2e}}{km} * 15\ km = 76.5\ tonne\ CO_{2e}$$

### 4.9.2 *PROJECT SCENARIOS*

The project scenarios represent the development of a new interchange on Highway 101 just west of the AVFN as a long-term solution to reduce traffic volumes on Trunk 1 in the Coldbrook and surrounding areas. GHG emissions for the project case consists of the following components:

- → Land clearing
- → Construction activity
- → Mobile sources; and
- → O & M Emissions

GHG emissions were quantified on an annual basis. Detailed methodology is elaborated below.

[20] EU Transport GHG: Routes to 2050 II, Final Report Appendix 2: The role of GHG emissions from infrastructure construction, vehicle manufacturing, and ELVs in overall transport sector emissions, April 2012

#### 4.9.2.1 *LAND CLEARING*

The Project will remove approximately 32 ha of green fields to create a new, direct highway connection to the Cambridge area. The green area covers different types of vegetation, such as forest, shrub and agriculture land. The impacted wetland area will be compensated in another area. Thus, emission changes due to wetlands are excluded for GHGMA.

$CO_2$ emissions due to clearing of green area were estimated using the following equation[21]:

$$CO_2 \text{ (tonne/year)} = A_{green} \times L_{biomass\ C} \times F_c \times 44/12$$

Where:

$A_{green}$ = Green Area (ha)

$L_{biomass\ C}$ = biomass carbon load (tonne C/ha/year

$F_c$ = carbon fraction of biomass

44/12 = molar ratio of $CO_2$ to carbon

Biomass carbon load for different types of green fields were obtained from Annex 3.5 of the NIR. Land use area change and biomass carbon load used for land clearing are shown in Table 4-13.

**Table 4-13: Parameters Used for Land Clearing**

| Land Type | Value | Unit | Area (ha) |
|---|---|---|---|
| Forest | 3.4 | Tonnes C/ha | 15.8 |
| Shrub | 1.6 | Tonnes C/ha | 2.4 |
| Agriculture | 0.77 | Tonnes C/ha | 13.6 |
| **Total** | - | - | **31.8** |

The following is an example of calculating $CO_2$ emissions from land clearing:

$$CO_2 = (\frac{3.4\ tonne\ C}{ha} * 15.8\ ha + \frac{1.6\ tonne\ C}{ha} * 2.4\ ha + \frac{0.77\ tonne\ C}{ha} * 13.6\ ha) * \frac{44\ tonne\ CO_2}{12\ tonne\ C}$$
$$= 249.5\ tonne\ CO_2$$

#### 4.9.2.2 *CONSTRUCTION EMISSIONS*

GHG emissions related to construction activities include the use of heavy equipment and electricity for site preparation, structure build up, and the installation of drainage systems. The project is still at the early application stage and a detailed design is not finalized. A detailed construction equipment list and energy

[21] Intergovernmental Panel on Climate Change (IPCC), Good Practice Guidance for Land Use, Land-Use Change and Forest, Chapter 3.2 Forest Land, https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/Chp3_2_Forest_Land.pdf, accessed in March 2021

usage demand is not yet available during the current phase of the Project. As a result, construction cost estimates are used as a proxy to calculate emissions.

Emissions from the construction phase were estimated based on cost estimates using an energy intensity index related to construction value. The GHG intensity data was taken from a US EPA study for reducing GHG emissions in the construction sector[22]. The US EPA study characterized the GHG emissions from various construction activities with a five-digit North American Industry Classification System (NAICS) of codes. The emission intensities for the construction industry were evaluated using metric tonnes of $CO_2$ equivalents per thousand 2002 US dollar (tCO2e/2002K USD). To convert 2002 USD to 2022 CAD, an exchange rate of 1.57, sourced from the Bank of Canada[23], was used to estimate the CAD in 2002. The 2002 CAD were then adjusted for inflation using the historical price index data from the inflation calculator for the Province of Nova Scotia[24] to obtain 2022 CAD. Emission parameters used to calculate anticipated construction emissions for Project Scenario are summarized in Table 4-14.

**Table 4-14: Emissions Intensities for Quantifying GHG Emissions from Construction Activity (2023-2025)**

| 2002 NAICS | Construction Description | Intensity | Intensity | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|
| | | $CO_{2}e$ tonne/ 2002k USD | $CO_{2}e$ tonne/ 2022k CAD | Cost (2022 CAD) | | |
| 23731 | Highway, street, and bridge construction | 0.49 | 0.210 | 5,800,000 | 14,760,000 | 10,550,000 |
| 23891 | Site preparation contractors | 0.36 | 0.154 | 200,000 | | |
| **Total** | | | | **6,000,000** | **14,760,000** | **10,550,000** |

The following is an example calculation for $CO_{2}e$ emissions from site clearing:

$$CO_{2e} = 0.154 \frac{tonne\ CO_{2e}}{2021k\ CAD} * 2,,000\ (2021k\ CAD) = 31\ tonne\ CO_{2e}$$

### 4.9.2.3 *MOBILE SOURCE EMISSIONS*

The methodology for quantifying GHG emissions from the Project vehicle driving mode are identical to the baseline scenario (section 4.9.1.1). No traffic delay is expected for the Project scenario due to the construction of the new interchange for traffic improvement. Thus, no vehicle idling emissions are included for the project scenario.

### 4.9.2.4 *ROAD O & M EMISSIONS*

The methodology for quantifying GHG emissions from road O & M activity is the same as the baseline scenario described in Section 4.9.1.2 of this report. Road distance for O & M was estimated at 20 kms to account for additional connectors due to the creation of new interchanges.

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[22] US EPA, Potential for Reducing Greenhouse Gas Emissions in the Construction Sector, 2009

[23] Government of Canada, Historical Noon and Closing Rates, https://www.bankofcanada.ca/rates/exchange/legacy-noon-and-closing-rates/, accessed in March 2022

[24] Inflation Calculator, https://inflationcalculator.ca/2021-cpi-and-inflation-rates-for-nova-scotia/, accessed in June 2021

# 5 ESTIMATED BASELINE EMISSIONS

## 5.1 MOBILE EMISSIONS

Baseline GHG emissions from mobile sources using fossil fuels (idling and driving activities) are shown in Table 5-1.

**Table 5-1: Baseline Mobile Emissions – Fossil Fuels**

| Year | Emissions (tonnes $CO_2e$) | | | | | | |
|---|---|---|---|---|---|---|---|
| | LDV - Driving | MDV - Driving | HDV - Driving | LDV - Idling | MDV - Idling | HDV - Idling | Total Fuel Emissions |
| 2023 | 11,337 | 917 | 8,799 | 437 | 40 | 228.8 | 21,759 |
| 2024 | 11,720 | 953 | 9,139 | 452 | 42 | 237.6 | 22,542 |
| 2025 | 12,094 | 988 | 9,475 | 466 | 43 | 246.3 | 23,312 |
| 2026 | 12,459 | 1,022 | 9,807 | 480 | 45 | 254.9 | 24,068 |
| 2027 | 12,568 | 1,056 | 10,135 | 484 | 46 | 263.5 | 24,553 |
| 2028 | 12,648 | 1,090 | 10,459 | 488 | 48 | 271.9 | 25,005 |
| 2029 | 12,701 | 1,124 | 10,780 | 490 | 49 | 280.2 | 25,423 |
| 2030 | 12,726 | 1,157 | 11,096 | 491 | 51 | 288.5 | 25,808 |
| 2031 | 12,401 | 1,189 | 11,409 | 478 | 52 | 296.6 | 25,826 |
| 2032 | 12,028 | 1,192 | 11,438 | 464 | 52 | 297.4 | 25,472 |
| 2033 | 11,595 | 1,192 | 11,484 | 447 | 52 | 298.5 | 25,068 |
| 2034 | 10,957 | 1,173 | 11,298 | 422 | 51 | 293.7 | 24,195 |
| 2035 | 10,298 | 1,153 | 11,104 | 397 | 50 | 288.7 | 23,290 |
| 2036 | 9,755 | 1,103 | 10,627 | 376 | 48 | 276.3 | 22,186 |
| 2037 | 9,195 | 1,052 | 10,133 | 354 | 46 | 263.4 | 21,043 |
| 2038 | 8,615 | 999 | 9,621 | 332 | 44 | 250.1 | 19,860 |
| 2039 | 8,015 | 944 | 9,092 | 309 | 41 | 236.4 | 18,638 |
| 2040 | 7,396 | 887 | 8,545 | 285 | 39 | 222.1 | 17,374 |
| 2041 | 6,757 | 840 | 8,095 | 260 | 37 | 210.5 | 16,200 |
| 2042 | 6,096 | 792 | 7,630 | 235 | 35 | 198.4 | 14,986 |
| 2043 | 5,414 | 742 | 7,149 | 209 | 32 | 185.8 | 13,732 |
| 2044 | 4,711 | 690 | 6,652 | 182 | 30 | 172.9 | 12,438 |
| 2045 | 3,985 | 637 | 6,138 | 154 | 28 | 159.6 | 11,101 |
| 2046 | 3,236 | 582 | 5,607 | 125 | 25 | 145.8 | 9,721 |
| 2047 | 2,463 | 525 | 5,059 | 95 | 23 | 131.5 | 8,297 |
| 2048 | 1,667 | 466 | 4,493 | 64 | 20 | 116.8 | 6,828 |
| 2049 | 846 | 406 | 3,909 | 33 | 18 | 101.6 | 5,313 |
| 2050 | 0 | 343 | 3,306 | 0 | 15 | 86.0 | 3,751 |
| 2051 | 0 | 279 | 2,685 | 0 | 12 | 69.8 | 3,046 |
| 2052 | 0 | 212 | 2,044 | 0 | 9 | 53.1 | 2,319 |
| 2053 | 0 | 144 | 1,383 | 0 | 6 | 36.0 | 1,569 |
| 2054 | 0 | 73 | 702 | 0 | 3 | 18.2 | 796 |
| 2055 | 0 | 0 | 0 | 0 | 0 | 0.0 | 0 |

Baseline GHG emissions from ZEVs are shown in Table 5-2.

**Table 5-2: Baseline ZEV Emissions**

| Year | Emissions (tonnes $CO_2e$) | | | |
|---|---|---|---|---|
| | Light-duty ZEV emissions | Medium-duty ZEV emissions | Heavy-duty ZEV emissions | Total Electricity emissions |
| 2023 | 7.6 | 7.4 | 74.2 | 89.2 |
| 2024 | 11.3 | 11.5 | 115.5 | 138.3 |
| 2025 | 15.2 | 15.9 | 159.5 | 190.7 |
| 2026 | 19.4 | 20.6 | 206.3 | 246.2 |
| 2027 | 31.1 | 25.5 | 255.6 | 312.2 |
| 2028 | 43.4 | 30.7 | 307.6 | 381.6 |
| 2029 | 56.4 | 36.1 | 362.0 | 454.5 |
| 2030 | 70.1 | 41.7 | 418.9 | 530.7 |
| 2031 | 93.2 | 47.4 | 476.1 | 616.7 |
| 2032 | 117.1 | 75.1 | 753.9 | 946.2 |
| 2033 | 141.8 | 103.8 | 1,045.8 | 1,291.4 |
| 2034 | 164.9 | 131.5 | 1,325.1 | 1,621.5 |
| 2035 | 188.1 | 159.4 | 1,606.6 | 1,954.1 |
| 2036 | 207.7 | 208.1 | 2,096.7 | 2,512.5 |
| 2037 | 227.5 | 257.0 | 2,590.3 | 3,074.8 |
| 2038 | 247.3 | 306.3 | 3,087.2 | 3,640.9 |
| 2039 | 267.3 | 356.0 | 3,587.2 | 4,210.5 |
| 2040 | 287.4 | 405.9 | 4,090.2 | 4,783.4 |
| 2041 | 307.5 | 447.9 | 4,514.0 | 5,269.5 |
| 2042 | 327.8 | 490.2 | 4,939.9 | 5,757.8 |
| 2043 | 348.1 | 532.6 | 5,367.5 | 6,248.2 |
| 2044 | 368.5 | 575.2 | 5,796.9 | 6,740.6 |
| 2045 | 388.9 | 618.0 | 6,227.7 | 7,234.6 |
| 2046 | 409.4 | 660.9 | 6,660.0 | 7,730.3 |
| 2047 | 429.9 | 703.9 | 7,093.1 | 8,226.9 |
| 2048 | 450.5 | 746.9 | 7,527.2 | 8,724.6 |
| 2049 | 471.0 | 790.0 | 7,961.6 | 9,222.7 |
| 2050 | 491.6 | 833.2 | 8,396.4 | 9,721.2 |
| 2051 | 499.0 | 888.0 | 8,948.7 | 10,335.6 |
| 2052 | 506.4 | 944.2 | 9,515.6 | 10,966.3 |
| 2053 | 514.1 | 1,002.0 | 10,097.5 | 11,613.6 |
| 2054 | 521.8 | 1,061.2 | 10,694.8 | 12,277.8 |
| 2055 | 529.6 | 1,122.1 | 11,307.5 | 12,959.2 |

Total emissions from mobile sources for the baseline scenario are shown in Table 5-3.

## Table 5-3: Baseline Mobile Emissions

| Year | Emissions (tonnes $CO_2e$) | | |
|---|---|---|---|
| | Total Fuel Emissions | Total Electricity Emissions | Total mobile Emissions |
| 2023 | 21,759 | 89.2 | 21,848.1 |
| 2024 | 22,542 | 138.3 | 22,680.3 |
| 2025 | 23,312 | 190.7 | 23,502.7 |
| 2026 | 24,068 | 246.2 | 24,314.0 |
| 2027 | 24,553 | 312.2 | 24,865.2 |
| 2028 | 25,005 | 381.6 | 25,386.4 |
| 2029 | 25,423 | 454.5 | 25,877.6 |
| 2030 | 25,808 | 530.7 | 26,338.6 |
| 2031 | 25,826 | 616.7 | 26,442.5 |
| 2032 | 25,472 | 946.2 | 26,418.2 |
| 2033 | 25,068 | 1,291.4 | 26,359.4 |
| 2034 | 24,195 | 1,621.5 | 25,816.5 |
| 2035 | 23,290 | 1,954.1 | 25,244.3 |
| 2036 | 22,186 | 2,512.5 | 24,698.1 |
| 2037 | 21,043 | 3,074.8 | 24,117.5 |
| 2038 | 19,860 | 3,640.9 | 23,501.3 |
| 2039 | 18,638 | 4,210.5 | 22,848.4 |
| 2040 | 17,374 | 4,783.4 | 22,157.4 |
| 2041 | 16,200 | 5,269.5 | 21,469.3 |
| 2042 | 14,986 | 5,757.8 | 20,744.0 |
| 2043 | 13,732 | 6,248.2 | 19,980.4 |
| 2044 | 12,438 | 6,740.6 | 19,178.2 |
| 2045 | 11,101 | 7,234.6 | 18,335.2 |
| 2046 | 9,721 | 7,730.3 | 17,451.0 |
| 2047 | 8,297 | 8,226.9 | 16,523.6 |
| 2048 | 6,828 | 8,724.6 | 15,552.5 |
| 2049 | 5,313 | 9,222.7 | 14,535.4 |
| 2050 | 3,751 | 9,721.2 | 13,471.9 |
| 2051 | 3,046 | 10,335.6 | 13,381.2 |
| 2052 | 2,319 | 10,966.3 | 13,284.8 |
| 2053 | 1,569 | 11,613.6 | 13,182.4 |
| 2054 | 796 | 12,277.8 | 13,074.0 |
| 2055 | 0 | 12,959.2 | 12,959.2 |

## 5.2 ROAD O & M EMISSIONS

Annual road GHG emissions from the O & M phases are shown in Table 5-4. The GHG emission factors used for estimating GHG emissions from O & M of road surfaces are consistent with a study published by Dimoula et al[25], who reported 1 to 5 tonne $CO_2$e/km of emissions related to preventive and corrective road maintenance activities.

**Table 5-4: Road O&M Emissions – Baseline Scenario**

| O & M | Annual O & M Emissions (tonne $CO_2$e/yr) |
|---|---|
| Maintenance activates for road preventive and corrective actions | 18.0 |
| Operation stage for lighting and traffic system & de-icing | 58.5 |
| **Total** | **76.5** |

## 5.3 BASELINE ANNUAL AND CUMULATIVE EMISSIONS

Annual and cumulative GHG emissions for the baseline case are shown in Table 5-5.

**Table 5-5: Baseline Annual and Cumulative Emissions**

| Calendar Year | GHG Emissions (tonnes of $CO_2$e) | | | |
|---|---|---|---|---|
| | Mobile | O&M | Total | Cumulative Emissions |
| 2023 | 21,848 | 76.5 | 21,925 | 21,925 |
| 2024 | 22,680 | 76.5 | 22,757 | 44,681 |
| 2025 | 23,503 | 76.5 | 23,579 | 68,261 |
| 2026 | 24,314 | 76.5 | 24,390 | 92,651 |
| 2027 | 24,865 | 76.5 | 24,942 | 117,593 |
| 2028 | 25,386 | 76.5 | 25,463 | 143,056 |
| 2029 | 25,878 | 76.5 | 25,954 | 169,010 |
| 2030 | 26,339 | 76.5 | 26,415 | 195,425 |
| 2031 | 26,443 | 76.5 | 26,519 | 221,944 |
| 2032 | 26,418 | 76.5 | 26,495 | 248,439 |
| 2033 | 26,359 | 76.5 | 26,436 | 274,875 |

[25] Dimoula, et al., A holistic Approach for Estimating Carbon Emissions of Road and Rail Transport System, Aerosol and Air Quality Research, 16: 61-68, 2016

| Calendar Year | GHG Emissions (tonnes of $CO_2e$) | | | |
|---|---|---|---|---|
| | Mobile | O&M | Total | Cumulative Emissions |
| 2034 | 25,817 | 76.5 | 25,893 | 300,768 |
| 2035 | 25,244 | 76.5 | 25,321 | 326,088 |
| 2036 | 24,698 | 76.5 | 24,775 | 350,863 |
| 2037 | 24,118 | 76.5 | 24,194 | 375,057 |
| 2038 | 23,501 | 76.5 | 23,578 | 398,635 |
| 2039 | 22,848 | 76.5 | 22,925 | 421,560 |
| 2040 | 22,157 | 76.5 | 22,234 | 443,794 |
| 2041 | 21,469 | 76.5 | 21,546 | 465,339 |
| 2042 | 20,744 | 76.5 | 20,821 | 486,160 |
| 2043 | 19,980 | 76.5 | 20,057 | 506,217 |
| 2044 | 19,178 | 76.5 | 19,255 | 525,471 |
| 2045 | 18,335 | 76.5 | 18,412 | 543,883 |
| 2046 | 17,451 | 76.5 | 17,528 | 561,411 |
| 2047 | 16,524 | 76.5 | 16,600 | 578,011 |
| 2048 | 15,552 | 76.5 | 15,629 | 593,640 |
| 2049 | 14,535 | 76.5 | 14,612 | 608,252 |
| 2050 | 13,472 | 76.5 | 13,548 | 621,800 |
| 2051 | 13,381 | 76.5 | 13,458 | 635,258 |
| 2052 | 13,285 | 76.5 | 13,361 | 648,619 |
| 2053 | 13,182 | 76.5 | 13,259 | 661,878 |
| 2054 | 13,074 | 76.5 | 13,150 | 675,028 |
| 2055 | 12,959 | 76.5 | 13,036 | 688,064 |

# 6 ESTIMATED PROJECT EMISSIONS

## 6.1 LAND CLEARING

Total $CO_2$ emissions from land clearing were estimated at 250 tonne $CO_2e$ /year using the method described in Section 4.9.2.1 as shown in Table 6-1.

**Table 6-1: Project Land Clearing Emissions**

| Land Type | $CO_2$ Emissions (tonnes) |
|---|---|
| Forest | 197.35 |
| Shrub | 13.85 |
| Agriculture | 38.34 |
| **Total** | **249.5** |

## 6.2 CONSTRUCTION

GHG emissions during the project construction phase are estimated at 6,596 tonnes $CO_2e$. A breakdown of construction emissions is shown in Table 6-2.

**Table 6-2: Project Construction Emissions (2023-2025)**

| 2002 NAICS | Construction Description | 2023 | 2024 | 2025 |
|---|---|---|---|---|
| | | Emissions (tonnes $CO_2e$) | | |
| 23731 | Highway and road construction | 1,219 | 3,102 | 2,217 |
| 23891 | Site preparation | 31 | - | - |
| **Total** | | **1,250** | **3,102** | **2,217** |

## 6.3 MOBILE EMISSIONS

Project mobile emissions using fossil fuels are shown in Table 6-3. During three construction periods, mobile emissions are identical to the baseline case since no improvement was made. After 2026, GHG emissions are reduced, which are mainly attributed to energy saving from vehicle idling time.

**Table 6-3: Project Mobile Emissions – Fossil Fuel**

| Year | Emissions (tonnes $CO_2e$) | | | | | | |
|---|---|---|---|---|---|---|---|
| | LDV - Driving | MDV - Driving | HDV - Driving | LDV - Idling | MDV - Idling | HDV - Idling | Total Fuel Emissions |
| 2023 | 11,337 | 917 | 8,799 | 437 | 40 | 228.8 | 21,759 |
| 2024 | 11,720 | 953 | 9,139 | 452 | 42 | 237.6 | 22,542 |
| 2025 | 12,094 | 988 | 9,475 | 466 | 43 | 246.3 | 23,312 |
| 2026 | 12,459 | 1,022 | 9,807 | | | | 23,288 |
| 2027 | 12,568 | 1,056 | 10,135 | | | | 23,759 |
| 2028 | 12,648 | 1,090 | 10,459 | | | | 24,198 |
| 2029 | 12,701 | 1,124 | 10,780 | | | | 24,604 |
| 2030 | 12,726 | 1,157 | 11,096 | | | | 24,978 |
| 2031 | 12,401 | 1,189 | 11,409 | | | | 24,999 |
| 2032 | 12,028 | 1,192 | 11,438 | | | | 24,659 |
| 2033 | 11,595 | 1,192 | 11,484 | | | | 24,270 |
| 2034 | 10,957 | 1,173 | 11,298 | | | | 23,428 |
| 2035 | 10,298 | 1,153 | 11,104 | | | | 22,554 |
| 2036 | 9,755 | 1,103 | 10,627 | | | | 21,485 |
| 2037 | 9,195 | 1,052 | 10,133 | | | | 20,379 |
| 2038 | 8,615 | 999 | 9,621 | | | | 19,235 |
| 2039 | 8,015 | 944 | 9,092 | | | | 18,051 |
| 2040 | 7,396 | 887 | 8,545 | | | | 16,828 |

| Year | Emissions (tonnes $CO_2e$) | | | | | | |
|---|---|---|---|---|---|---|---|
| | LDV - Driving | MDV - Driving | HDV - Driving | LDV - Idling | MDV - Idling | HDV - Idling | Total Fuel Emissions |
| 2041 | 6,757 | 840 | 8,095 | | | | 15,692 |
| 2042 | 6,096 | 792 | 7,630 | | | | 14,518 |
| 2043 | 5,414 | 742 | 7,149 | | | | 13,305 |
| 2044 | 4,711 | 690 | 6,652 | | | | 12,053 |
| 2045 | 3,985 | 637 | 6,138 | | | | 10,759 |
| 2046 | 3,236 | 582 | 5,607 | | | | 9,425 |
| 2047 | 2,463 | 525 | 5,059 | | | | 8,047 |
| 2048 | 1,667 | 466 | 4,493 | | | | 6,626 |
| 2049 | 846 | 406 | 3,909 | | | | 5,161 |
| 2050 | 0 | 343 | 3,306 | | | | 3,650 |
| 2051 | 0 | 279 | 2,685 | | | | 2,964 |
| 2052 | 0 | 212 | 2,044 | | | | 2,256 |
| 2053 | 0 | 144 | 1,383 | | | | 1,527 |
| 2054 | 0 | 73 | 702 | | | | 775 |
| 2055 | 0 | 0 | 0 | | | | 0 |

Project GHG emissions from ZEV are the same as the baseline case as shown in Table 5-2. Total Project Mobile sources are shown in Table 6-4.

### Table 6-4: Project Mobile Emissions

| Year | Emissions (tonnes $CO_2e$) | | |
|---|---|---|---|
| | Total Fuel Emissions | Total Electricity Emissions | Total mobile Emissions |
| 2023 | 21,759 | 89.2 | 21,848 |
| 2024 | 22,542 | 138.3 | 22,680 |
| 2025 | 23,312 | 190.7 | 23,503 |
| 2026 | 23,288 | 246.2 | 23,534 |
| 2027 | 23,759 | 312.2 | 24,071 |
| 2028 | 24,198 | 381.6 | 24,579 |
| 2029 | 24,604 | 454.5 | 25,059 |
| 2030 | 24,978 | 530.7 | 25,509 |
| 2031 | 24,999 | 616.7 | 25,616 |
| 2032 | 24,659 | 946.2 | 25,605 |
| 2033 | 24,270 | 1,291.4 | 25,562 |
| 2034 | 23,428 | 1,621.5 | 25,049 |
| 2035 | 22,554 | 1,954.1 | 24,508 |
| 2036 | 21,485 | 2,512.5 | 23,998 |
| 2037 | 20,379 | 3,074.8 | 23,454 |
| 2038 | 19,235 | 3,640.9 | 22,875 |
| 2039 | 18,051 | 4,210.5 | 22,262 |
| 2040 | 16,828 | 4,783.4 | 21,611 |

| Year | Emissions (tonnes $CO_2e$) | | |
|---|---|---|---|
| | Total Fuel Emissions | Total Electricity Emissions | Total mobile Emissions |
| 2041 | 15,692 | 5,269.5 | 20,962 |
| 2042 | 14,518 | 5,757.8 | 20,276 |
| 2043 | 13,305 | 6,248.2 | 19,553 |
| 2044 | 12,053 | 6,740.6 | 18,793 |
| 2045 | 10,759 | 7,234.6 | 17,994 |
| 2046 | 9,425 | 7,730.3 | 17,155 |
| 2047 | 8,047 | 8,226.9 | 16,274 |
| 2048 | 6,626 | 8,724.6 | 15,351 |
| 2049 | 5,161 | 9,222.7 | 14,383 |
| 2050 | 3,650 | 9,721.2 | 13,371 |
| 2051 | 2,964 | 10,335.6 | 13,299 |
| 2052 | 2,256 | 10,966.3 | 13,222 |
| 2053 | 1,527 | 11,613.6 | 13,140 |
| 2054 | 775 | 12,277.8 | 13,053 |
| 2055 | 0 | 12,959.2 | 12,959 |

## 6.4 ROAD O & M EMISSIONS

Project road O & M emissions are shown in Table 6-5.

**Table 6-5: Road O&M Emissions – Project Scenario**

| O & M | Annual O & M Emissions (tonne $CO_2e$/yr) |
|---|---|
| Maintenance activates for road preventive and corrective actions | 24 |
| Operation stage for lighting and traffic system & de-icing | 78 |
| **Total** | **102** |

## 6.5 PROJECT ANNUAL AND CUMULATIVE EMISSIONS

Annual and cumulative GHG emissions for the Project scenario are shown in Table 6-6.

**Table 6-6: Annual and Cumulative Emissions - Project Scenario**

| Project Case | Calendar Year | | GHG Emissions (tonnes of $CO_2e$) | | | | |
|---|---|---|---|---|---|---|---|
| | | Land Clear | Construction | Mobile | O&M | Total | Cumulative Emissions |
| Construction Year 1 | 2023 | 250 | 1,250 | 21,848 | 102 | 23,450 | 23,450 |
| Construction Year 2 | 2024 | - | 3,102 | 22,680 | 102 | 25,884 | 49,334 |
| Construction Year 3 | 2025 | - | 2,217 | 23,503 | 102 | 25,822 | 75,156 |
| O & M Year 1 | 2026 | - | - | 23,534 | 102 | 23,636 | 98,792 |
| O & M Year 2 | 2027 | - | - | 24,071 | 102 | 24,173 | 122,965 |
| O & M Year 3 | 2028 | - | - | 24,579 | 102 | 24,681 | 147,646 |
| O & M Year 4 | 2029 | - | - | 25,059 | 102 | 25,161 | 172,807 |
| O & M Year 5 | 2030 | - | - | 25,509 | 102 | 25,611 | 198,418 |
| O & M Year 6 | 2031 | - | - | 25,616 | 102 | 25,718 | 224,136 |
| O & M Year 7 | 2032 | - | - | 25,605 | 102 | 25,707 | 249,843 |
| O & M Year 8 | 2033 | - | - | 25,562 | 102 | 25,664 | 275,507 |
| O & M Year 9 | 2034 | - | - | 25,049 | 102 | 25,151 | 300,658 |
| O & M Year 10 | 2035 | - | - | 24,508 | 102 | 24,610 | 325,268 |
| O & M Year 11 | 2036 | - | - | 23,998 | 102 | 24,100 | 349,368 |
| O & M Year 12 | 2037 | - | - | 23,454 | 102 | 23,556 | 372,923 |
| O & M Year 13 | 2038 | - | - | 22,875 | 102 | 22,977 | 395,901 |
| O & M Year 14 | 2039 | - | - | 22,262 | 102 | 22,364 | 418,264 |
| O & M Year 15 | 2040 | - | - | 21,611 | 102 | 21,713 | 439,978 |
| O & M Year 16 | 2041 | - | - | 20,962 | 102 | 21,064 | 461,041 |
| O & M Year 17 | 2042 | - | - | 20,276 | 102 | 20,378 | 481,419 |
| O & M Year 18 | 2043 | - | - | 19,553 | 102 | 19,655 | 501,075 |
| O & M Year 19 | 2044 | - | - | 18,793 | 102 | 18,895 | 519,970 |
| O & M Year 20 | 2045 | - | - | 17,994 | 102 | 18,096 | 538,066 |
| O & M Year 21 | 2046 | - | - | 17,155 | 102 | 17,257 | 555,323 |
| O & M Year 22 | 2047 | - | - | 16,274 | 102 | 16,376 | 571,700 |
| O & M Year 23 | 2048 | - | - | 15,351 | 102 | 15,453 | 587,153 |
| O & M Year 24 | 2049 | - | - | 14,383 | 102 | 14,485 | 601,638 |
| O & M Year 25 | 2050 | - | - | 13,371 | 102 | 13,473 | 615,111 |
| O & M Year 26 | 2051 | - | - | 13,299 | 102 | 13,401 | 628,512 |
| O & M Year 27 | 2052 | - | - | 13,222 | 102 | 13,324 | 641,836 |
| O & M Year 28 | 2053 | - | - | 13,140 | 102 | 13,242 | 655,079 |
| O & M Year 29 | 2054 | - | - | 13,053 | 102 | 13,155 | 668,233 |
| O & M Year 30 | 2055 | - | - | 12,959 | 102 | 13,061 | 681,294 |

# 7 ESTIMATED NET DECREASE IN EMISSIONS

The project is expected to reduce GHG emissions from vehicle idling operation due to 2 minutes per vehicle trip saving between Highway 101 Exit 14 and Waterville Mountain Road (Michelin) and 1 minute per vehicle trip between Highway 101 Exit 15 and Waterville Mountain Road. Annual GHG emissions are expected to decline every year due to the implementation of ZEV policy for both baseline scenario and project scenario. Annual and cumulative emission changes for the baseline and project scenario in Table 7-1.

**Table 7-1: Annual and Cumulative Baseline/Project Emissions**

| Calendar Year | GHG Emissions (tonnes of $CO_2e$) | | | |
|---|---|---|---|---|
| | Baseline | Project | Net Emission Changes | Cumulative Changes |
| 2023 | 21,925 | 23,450 | 1,525 | 1,525 |
| 2024 | 22,757 | 25,884 | 3,128 | 4,653 |
| 2025 | 23,579 | 25,822 | 2,243 | 6,895 |
| 2026 | 24,390 | 23,636 | -754 | 6,141 |
| 2027 | 24,942 | 24,173 | -769 | 5,372 |
| 2028 | 25,463 | 24,681 | -782 | 4,591 |
| 2029 | 25,954 | 25,161 | -793 | 3,797 |
| 2030 | 26,415 | 25,611 | -804 | 2,993 |
| 2031 | 26,519 | 25,718 | -801 | 2,192 |
| 2032 | 26,495 | 25,707 | -788 | 1,404 |
| 2033 | 26,436 | 25,664 | -772 | 632 |
| 2034 | 25,893 | 25,151 | -742 | -110 |
| 2035 | 25,321 | 24,610 | -711 | -820 |
| 2036 | 24,775 | 24,100 | -675 | -1,495 |
| 2037 | 24,194 | 23,556 | -638 | -2,134 |
| 2038 | 23,578 | 22,977 | -600 | -2,734 |
| 2039 | 22,925 | 22,364 | -561 | -3,295 |
| 2040 | 22,234 | 21,713 | -521 | -3,816 |
| 2041 | 21,546 | 21,064 | -482 | -4,298 |
| 2042 | 20,821 | 20,378 | -442 | -4,741 |
| 2043 | 20,057 | 19,655 | -402 | -5,142 |
| 2044 | 19,255 | 18,895 | -359 | -5,501 |
| 2045 | 18,412 | 18,096 | -316 | -5,817 |
| 2046 | 17,528 | 17,257 | -270 | -6,087 |
| 2047 | 16,600 | 16,376 | -224 | -6,311 |
| 2048 | 15,629 | 15,453 | -176 | -6,487 |
| 2049 | 14,612 | 14,485 | -126 | -6,614 |
| 2050 | 13,548 | 13,473 | -75 | -6,689 |

| Calendar Year | GHG Emissions (tonnes of $CO_2e$) | | | |
|---|---|---|---|---|
| | Baseline | Project | Net Emission Changes | Cumulative Changes |
| 2051 | 13,458 | 13,401 | -56 | -6,746 |
| 2052 | 13,361 | 13,324 | -37 | -6,783 |
| 2053 | 13,259 | 13,242 | -17 | -6,799 |
| 2054 | 13,150 | 13,155 | 4 | -6,795 |
| 2055 | 13,036 | 13,061 | 26 | -6,770 |

# 8 ESTIMATED COST-PER-TONNE

For this Project, the total eligible amount of NTCF is 31,500,000 CAD, among which 50% is eligible for Federal funding. The GHG reduction cost for 2030 is 19,587 Federal contribution dollar per tonne of $CO_2e$ removed on a non-cumulative basis. For the Project lifespan, the GHG reduction cost is $4,653 Project dollar per tonne of $tCO_2e$ removed if the funding is approved.

# 9 CONCLUSION

GHG emissions from mobile emissions represent the largest source of GHG emissions for the baseline scenario and the project scenario. This Project is anticipated to result in 804 tonnes of $CO_2e$ reduction in 2030 (non-cumulative basis). For the Project lifespan, GHG reduction of 6,770 $tCO_2e$ relative to the baseline scenario are anticipated. The reduced GHG emissions from the project scenario are due to improved traffic movement in the study area. The baseline/project emissions changes are summarized in Table 9-1 below.

For this Project, the total eligible amount of NTCF is 31,500,000 CAD, among which 50% is eligible for Federal funding. The GHG reduction cost for 2030 is 19,587 Federal contribution dollar per tonne of $CO_2e$ removed on a non-cumulative basis. For the Project lifespan, the GHG reduction cost is $4,653 Project dollar per tonne of $tCO_2e$ removed if the funding is approved.

**Table 9-1: Net Reduction in GHG Emissions in 2030 and Cumulative Over 30-Year Lifespan**

| GHG Mitigation Assessment – Scenario A | | | |
|---|---|---|---|
| 2030 GHG Results (tonnes of $CO_2e$) | | Lifetime GHG Results (tonnes of $CO_2e$) | |
| Baseline Scenario Emissions in 2030 | 26,415 | Baseline Scenario Emissions, Lifetime (cumulative) | 688,064 |
| Estimated Project Emissions in 2030 | 25,611 | Estimated Project Emissions, Lifetime (cumulative) | 681,294 |
| Net Emissions Reduction | 804 | Net Emissions Reduction | 6,770 |
| GHG Reduction Cost for 2030 – non-cumulative basis ($/$tCO_2e$) | $19,587 | GHG Reduction Cost for Project Lifespan ($/t $CO_2e$) | $4,653 |

# A REPORTING INFORMATION

| No. | ISO14064-2: 2019 Section 6.2 Describe the Project | Declaration |
|---|---|---|
| **A** | Project title, purpose(s) and objectives; | Climate Lens GHG Mitigation Assessment – New Highway 101 Cambridge Interchange and Connector Roads<br><br>The purpose and objectives of the project are to reduce traffic volumes at Exit 14 and improve operations at the ramp terminals. |
| **B** | Type of GHG project; including descriptions of how the project will achieve GHG emission reductions and/or removal enhancements and specific GHGs targeted; | The Project will reduce vehicle idling time due to the improved traffic movement after the new interchange is created, thus resulting in a decrease of GHG emissions. |
| **C** | Project location, including organizational, geographic and physical location information, allowing the unique identification and delineation of the specific extent of the project; | The Project is located on the western side of Nova Scotia, in the Annapolis Valley. The proposed interchange is located on Highway 101 just west of the Annapolis Valley First Nation, near Cambridge Station, between Coldbrook (Exit 14) and Berwick (Exit 15). |
| **D** | Conditions prior to project initiation; | Currently no direct access from Highway 101 to the Waterville Michelin Tire Plant (at Waterville Mountain Road) is available, causing delays and bottlenecking during peak hours at the eastbound off-ramp at Exit 14. |
| **E** | Project technologies, products, services and the expected level of activity; | The project would save approximately 2 minutes per trip between Highway 101 Exit 14 and Waterville Mountain Road (Michelin) and 1 minute per trip between Highway 101 Exit 15 and Waterville Mountain Road due to improved traffic movement. Construction is scheduled for the three-year period 2023 to 2025. For this analysis, the GHG mitigation assessment was conducted till 2055 to include the impacts of ZEV policy on mobile emissions. |
| **F** | Aggregated GHG emissions reductions and removal enhancements, stated in tonnes of $CO_2e$, likely to occur from the GHG project; | The project will reduce 6,770 tonnes of GHG emissions from vehicle idling over project lifespan. |
| **G** | Identification of risks that could substantially affect the project's GHG emissions reductions or removal enhancements and; if applicable, any measures to manage those risks. | Potential risks that could result in significant differences between anticipated and actual emissions include changes to Project construction, operations and/or maintenance activities. |

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| **H** | Roles and responsibilities, including contact information of the project proponent and other project participants, including the intended users, and roles and contact information for relevant regulator(s) and/or administrators of any GHG programme(s) to which the GHG project subscribes; | This GHG Mitigation Assessment has been completed as part of the Project's Climate Lens submission.<br>Further inquiries can be directed to the following contact:<br>Hong Zhang<br>WSP Canada Inc. (Prime Consultant)<br>Senior Environmental Engineer<br>840 Howe Street, Suite 1000<br>Vancouver, V6Z 2M1 Canada<br>Hong.Zhang@wsp.com<br>(604) 601-6780 |
| **I** | A summary of environmental impact assessment when such an assessment is required by applicable legislation or regulation; | Not applicable. |
| **J** | Relevant outcomes from stakeholder consultations and mechanisms for on-going communication; | Not applicable. |
| **K** | A chronological plan or actual dates and justification for the following:<br>1) the date of initiating project activities;<br>2) GHG baseline time period;<br>3) Date of terminating the project;<br>4) Frequency of monitoring and reporting and the project period, including relevant project activities in each step of the GHG project cycle, as applicable;<br>5) Frequency of verification and validation, as applicable | At this time, it is anticipated that construction will begin in 2023 with an overall completion by end of 2025. Operations will commence in 2026. Dates for these and other Project and monitoring activities will be refined or further defined in the future. |