Regional District of Nanaimo 2023 GPC BASIC+ Community Greenhouse Gas (GHG) Emissions Inventory Report

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Executive Summary

There is increasing evidence that global climate change resulting from emissions of carbon dioxide (CO_2) and other greenhouse gases (GHGs) is having a significant impact on the ecology of the planet. Delayed actions to respond to the effects of climate change are expected to have serious negative impacts on global economic growth and development.

Beyond the costs associated with delayed climate action, there are cost savings to be realized through efforts to improve energy efficiency, conserve energy, and reduce GHG emissions intensity. To make informed decisions on reducing energy use and GHG emissions at the community scale, community managers must have a good understanding of these sources, the activities that drive them, and their relative contribution to the total. This requires the completion of an energy and GHG emissions inventory. To allow for credible and meaningful reporting locally and internationally, the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (the GPC Protocol) was developed. The GPC Protocol has been adopted by the Global Covenant of Mayors—an agreement led by community networks to undertake a transparent and supportive approach to measure GHG emissions community-wide. The Global Covenant of Mayors and the Federation of Canadian Municipalities promotes the use of the GPC Protocol as a standardized way for municipalities to collect and report their actions on climate change.

This project set out to compile a detailed GHG inventory for the Regional District of Nanaimo (RDN) for the 2007 base year and the 2023 reporting year using the GPC Protocol. The RDN has historically relied on the Provincial 2007, 2010 and 2012 Community Energy and Emissions Inventories (CEEI) to baseline and track community GHG emissions. However, there have been some limitations to the CEEI which has resulted in the RDN preparing a GPC BASIC+ inventory. Following the requirements of the GPC Protocol, the GHG inventories considered emissions from all reporting Sectors, including Stationary Energy, Transportation, Waste, Industrial Process and Product Use (IPPU), and Agriculture, Forestry and Other Land Use (AFOLU). The purpose of this document is to describe the quantification methodologies used to calculate GHG emissions for the 2023 reporting year, and to present the RDN's 2023 community GHG emissions.

In 2023, the RDN's BASIC+ GHG emissions totaled 1,472,894 tonnes of carbon dioxide equivalent (tCO_2e). On an absolute basis, this is an 16.1% increase from the 2007 reporting year GHG emissions and a decline of 9.9% on a per capita basis. Due to limitations in how to quantify GHG emissions resulting from land use change (e.g., residential development) and ecosystem sequestration, these GHG emissions have been excluded from the RDNs GHG emissions inventory, but have been disclosed, until a more robust measurement methodology can be developed. At the request of the Nanaimo Airport all aviation GHG emissions have been excluded from the GHG emissions inventory until the airport quantifies and reports on these emissions.

A summary of the 2023 GHG emissions is presented in Table E-1 and Figure E-1.

Table E-1 BASIC+ 2007 Base & 2023 Reporting Year GHG Emissions

Sector	Sub-Sector	2007 GHG Emissions (tCO_2e)	2023 GHG Emissions (tCO_2e)
Stationary Energy	Residential Buildings	175,592	133,080
	Commercial & Institutional Buildings	88,577	85,737
	Manufacturing Industries & Construction	131,220	174,495
	Energy Industries	462	582
	Agriculture, Forestry & Fishing Activities	34,815	55,697
	Fugitive Emissions	583	1,151
Transportation	In-Boundary On-road Transportation	644,726	756,621
	Trans-Boundary On-road Transportation	88,904	114,327
	Waterborne Navigation	6,518	9,606
	Aviation	0	0
	Railway	1,248	1,630
	Off-road Transportation	24,215	35,781
Waste	Solid Waste	45,315	53,826
	Biological Treatment of Waste	394	4,015
	Incineration & Open Burning	126	160
	Wastewater Treatment & Discharge	1,965	3,097
IPPU	IPPU	20,388	38,817
AFOLU	Land-Use: Emissions Sequestered (Disclosure Only - Not Included In Total)	-304,136	-270,915
	Land-Use: Emissions Released (Disclosure Only - Not Included In Total)	9,322	9,322
	Livestock	3,818	4,184
	Non-CO2 Land Emission Sources	109	89
Change in GHG Emissions from Reporting year		**1,268,976**	**1,472,894**
Total Per Capita GHG Emissions (tCO_2e / Capita)		**8.9**	**8.0**
Change GHG Emissions Per Capita from 2007 Reporting year			**-9.9%**
Change in GHG Emissions from 2007 Reporting year			**16.1%**

Data in the table above is depicted in Figure E-1.

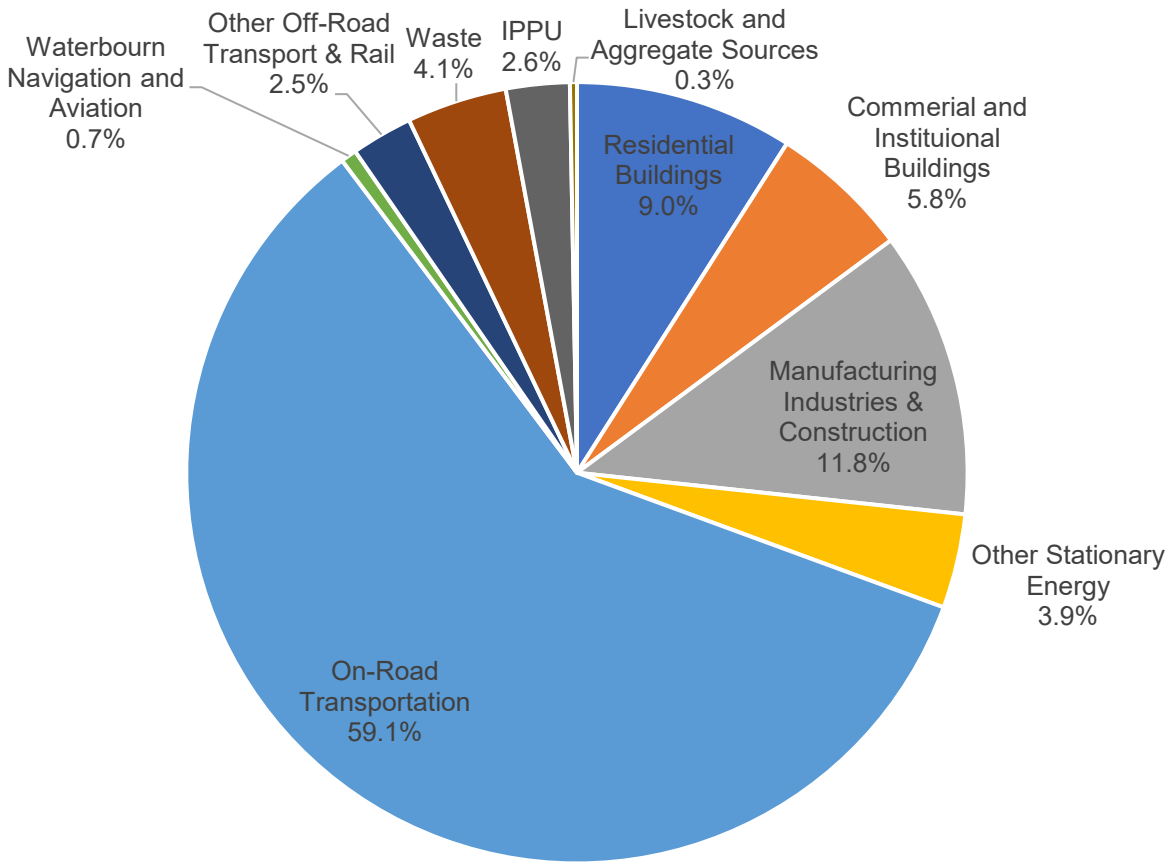

Figure E-1 RDN's 2023 BASIC+ GHG Emissions Profile (Excluding Land-Use)

Abbreviations

ACI	Annual Crop Inventory
AFOLU	Agriculture, Forestry, and Other Land Use
BC	British Columbia
C40	C40 Cities Climate Leadership Group
CH_4	Methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents
CEEI	Community Energy and Emissions Inventories
RDN	Regional District of Nanaimo
eMWh	megawatt hours equivalents
FCM	Federation of Canadian Municipalities
GDP	gross domestic product
GHG	greenhouse gas
GJ	Gigajoules
GPC	Global Protocol for Community-Scale Greenhouse Gas Emission Inventories
GWP	global warming potentials
HDV	Heavy Duty Vehicle
HFC	Hydrofluorocarbons
ICBC	Insurance Corporation of BC
ICLEI	International Council for Local Environmental Initiatives
IE	included elsewhere
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Process and Product Use
ISO	International Organization for Standardization

kg	Kilograms
kW	Kilowatt
kWh	kilowatt hours
L	Litres
LDT	Light Duty Truck
LDV	Light Duty Vehicle
MWh	megawatt hours
N_2O	nitrous oxides
NE	not estimated
NIR	National Inventory Report
NPRI	National Pollutant Release Inventory
NO	not occurring
ORVE	Off-Road Vehicle and Equipment
PCP	Partnership for Climate Protection
PFC	Perfluorocarbons
SC	Other Scope 3
SF_6	sulfur hexafluoride
T	Tonnes
VIA	Victoria International Airport
WIP	waste-in-place
WRI	World Resources Institute

Glossary

Air pollution	The presence of toxic chemicals or materials in the air, at levels that pose a human health risk.
Reporting year	This is the reference or starting year to which targets and GHG emissions projections are based.
BASIC	An inventory reporting level that includes all Scope 1 sources except from energy generation, imported waste, IPPU, and AFOLU, as well as all Scope 2 sources (GPC, 2014).
BASIC+	An inventory reporting level that covers all GPC BASIC sources, plus Scope 1 AFOLU and IPPU, and Scope 3 in the Stationary Energy and Transportation Sectors (GPC, 2014).
Biogenic emissions	Emissions produced by living organisms or biological processes, but not fossilized or from fossil sources (GPC, 2014).
Carbon dioxide equivalent (CO_2e)	The amount of carbon dioxide (CO_2) emissions that would cause the same integrated radiative forcing, over a given time horizon, as an emitted amount of a greenhouse gas (GHG) or a mixture of GHGs. The CO_2e emission is obtained by multiplying the emission of a GHG by its Global Warming Potential (GWP) for the given time horizon. For a mix of GHGs, it is obtained by summing the CO_2e emissions of each gas (IPCC 2014).
Climate change	Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2014).
Emission	The release of GHGs into the atmosphere (GPC, 2014).
Emission factor(s)	A factor that converts activity data into GHG emissions data (GPC, 2014).
Flaring	The burning of natural gas that cannot be used.
Fossil fuels	A hydrocarbon deposit derived from the accumulated remains of ancient plants and animals which is used as an energy source.
Fugitive emission	Emissions that are released during extraction, transformation, and transportation of primary fossil fuels. These GHG emissions are not combusted for energy.
Geographic boundary	A geographic boundary that identifies the spatial dimensions of the inventory's assessment boundary. This geographic boundary defines the physical perimeter separating in-boundary emissions from out-of-boundary and transboundary emissions (GPC, 2014).
Gigajoule (GJ)	A gigajoule (GJ), one billion joules, is a measure of energy. One GJ is about the same energy as: • Natural gas for 3-4 days of household use • The electricity used by a typical house in 10 days

Global warming	A gradual increase in the Earth's temperature which is attributed to the greenhouse effect caused by the release of greenhouse gas (GHG) emissions into the atmosphere.
Global warming potential (GWP)	An index measuring the radiative forcing following an emission of a unit mass of a given substance, accumulated over a chosen time horizon, relative to that of the reference substance, carbon dioxide (CO_2). The GWP thus represents the combined effect of the differing times these substances remain in the atmosphere and their effectiveness in causing radiative forcing. The Kyoto Protocol is based on global warming potentials over a 100-year period (IPCC 2014).
Greenhouse gas (GHG)	GHGs are the seven gases covered by the UNFCCC: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); sulphur hexafluoride (SF_6); and nitrogen trifluoride (NF_3) (GPC, 2014).
GHG intensity	The annual rate to which GHG emissions are released in the atmosphere, relative to a specific intensity.
Gross domestic product (GDP)	An economic measure of all goods and services produced in an economy.
In-boundary	Occurring within the established geographic boundary (GPC, 2014).
Reporting year	The year for which emissions are reported (GPC, 2014).
Scope 1	Emissions that physically occur within a community.
Scope 2	Emissions that occur from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross Community boundaries.
Scope 3	Emissions that occur outside a community but are driven by activities taking place within a community's boundaries.
Tonne of CO_2e	A tonne of greenhouse gases (GHGs) is the amount created when we consume: • 385 litres of gasoline (about 10 fill-ups) • Enough electricity for three homes for a year (38,000 kWh)
Transboundary GHG emissions	Emissions from sources that cross the geographic boundary (GPC, 2014). These include GHG emissions from on-road trips where the vehicle crosses municipal boundaries. For example, if travelling from Comox to Nanaimo, the on-road transportation GHG emissions in Nanaimo would be considered transboundary as the origin of the trip occurred in Comox.

1.0 INTRODUCTION

1.1 CLIMATE CHANGE AND GREENHOUSE GAS EMISSIONS

Since the industrial revolution, human activities such as burning fossil fuels, deforestation, agricultural practices, and other land use changes have resulted in the release of unnaturally large volumes of greenhouse gas (GHG) emissions into the Earth's atmosphere causing global climate systems to change. In its sixth assessment report, the Intergovernmental Panel on Climate Change (IPCC) concluded that "the scale of recent changes across the climate system as a whole and the present state of many aspects of the climate system are unprecedented over many centuries to many thousands of years."[1] To substantially reduce the risks and effects of climate change, and limit global warming to 1.5°C, scientists and policy makers have come to the agreement that global society must dramatically reduce greenhouse gas (GHG) emissions 50–60% by 2030, 80% by 2040, more than 90% by 2050 with the remaining emissions being offset or neutralized (e.g., direct air capture, reforestation, etc.) and be net negative in the second half of the century. Recognizing the importance and benefits to addressing climate change, many governments – including the Government of Canada and Province of British Columba, and the RDN as well as publicly traded organizations representing more than $23 trillion in market capitalization have now committed to these GHG reduction targets.[2]

1.2 COMMUNITIES AND GREENHOUSE GAS EMISSIONS

Communities are centers of communication, commerce, and culture. They are, however, also a significant and growing source of energy consumption and GHG emissions. On a global scale, communities are major players in GHG emissions. They are responsible for more than 70% of global energy-related carbon dioxide emissions and thus represent the single greatest opportunity for tackling climate change.

For a community to act on mitigating climate change and monitor its progress, it is crucial to have good quality GHG emissions data to build a GHG inventory. Such an inventory enables cities to understand the breakdown of their emissions and plan for effective climate action. The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC Protocol) seeks to support exactly that, by giving cities the standards and tools that are needed to measure the emissions, build more effective emissions reduction strategies, set measurable and more ambitious emission reduction goals, and to track their progress more accurately and comprehensively.

Until recently there has been no internationally recognized way to measure community-level emissions. Inventory methods that community managers have used to date around the globe vary significantly. This inconsistency has made comparisons between cities and over the years difficult. The GPC Protocol offers

[1] https://www.ipcc.ch/assessment-report/ar6/
[2] sciencebasedtargets.org/news/more-than-1000-companies-commit-to-science-based-emissions-reductions-in-line-with-1-5-c-climate-ambition

an internationally accepted, credible emissions accounting and reporting practice that will help communities to develop comparable GHG inventories.

1.3 VARIANCE FROM COMMUNITY ENERGY AND EMISSIONS INVENTORIES (CEEI)

The RDN has historically relied on annual Provincial Community Energy and Emissions Inventories (CEEI) to track community GHG emissions. Because the current CEEI does not fully meet the requirements of the GPC Protocol BASIC+ reporting requirements, the RDN has prepared its own GHG emissions inventory which relies on the CEEI data as well as external data sources. A high-level summary of the differences between the CEEI and GPC Protocol inventories are presented in Table 1.

Table 1 Summary of GHG Inventory Scope Differences

Reporting Sector	CEEI	GPC BASIC	GPC BASIC+
Residential Buildings	✓	✓	✓
Commercial And Institutional Buildings And Facilities	✓	✓	✓
Manufacturing Industries And Construction	✓	✓	✓
Energy Industries		✓	✓
Energy Generation Supplied To The Grid		✓	✓
Agriculture, Forestry And Fishing Activities		✓	✓
Non-Specified Sources		✓	✓
Fugitive Emissions From Mining, Processing, Storage, And Transportation Of Coal		✓	✓
Fugitive Emissions From Oil And Natural Gas Systems		✓	✓
On-Road Transportation	✓	✓	✓
Railways		✓	✓
Waterborne Navigation		✓	✓
Aviation		✓	✓
Off-Road Transportation	✓	✓	✓
Solid Waste	✓	✓	✓
Biological Waste	✓	✓	✓
Incinerated And Burned Waste		✓	✓
Wastewater		✓	✓
Emissions From Industrial Processes			✓
Emissions From Product Use			✓

Reporting Sector	CEEI	GPC BASIC	GPC BASIC+
Emissions From Livestock	✓		✓
Emissions From Land			✓
Emissions From Aggregate Sources And Non-CO_2 Emission Sources On Land	✓		✓

1.4 PURPOSE OF THIS DOCUMENT

The purpose of this document is to describe the quantification methodologies used by the RDN to calculate its BASIC+ GHG emissions for the 2007 base and 2023 reporting years. The focus of this report is on the 2023 reporting year. The RDN has elected to prepare a BASIC+ GHG emissions inventory to align with global best practices in community GHG emissions and to provide its members with the more comprehensive GHG emissions inventory database.

This document also supports the preparation of future community GHG emissions inventories, by:

- Defining GHG emissions data sources to be used for future inventory work
- Establishing quantification methods and assumptions.
- Evaluating the quality of the data sources and emission factors.
- Supporting consistent quantification of the inventory results over time.

2.0 GLOBAL PROTOCOL FOR COMMUNITY (GPC) SCALE EMISSION INVENTORIES PROTOCOL

2.1 OVERVIEW

The GPC Protocol is the result of a collaborative effort between the GHG Protocol at the World Resources Institute (WRI), C40 Cities Climate Leadership Group (C40), and ICLEI—Local Governments for Sustainability (ICLEI). The GPC Protocol is recognized as one of the first set of standardized global rules for cities to measure and publicly report community wide GHG emissions. It sets out requirements and provides guidance for calculating and reporting community wide GHG emissions, consistent with the 2006 IPCC guidelines on how to estimate GHG emissions (IPCC, 2006). Specifically, the GPC Protocol seeks to:

- Help cities develop a comprehensive and robust GHG inventory to support climate action planning.
- Help cities establish a reporting year GHG emissions inventory, set GHG reduction targets, and track performance.
- Ensure consistent and transparent measurement and reporting of GHG emissions between cities, following internationally recognized GHG accounting and reporting principles.
- Enable community wide GHG inventories to be aggregated at subnational and national levels.
- Demonstrate the important role that cities play in tackling climate change and facilitate insight through benchmarking—and aggregation—of comparable GHG data.

2.2 GPC PROTOCOL STRUCTURE

The GPC Protocol sets several assessment boundaries which identify the restrictions for gases, emission sources, geographic area, and time span covered by a GHG inventory:

- The GHG inventory is required to include all seven Kyoto Protocol GHGs occurring within the geographic boundary of a community. These include:
  - Carbon dioxide (CO_2)
  - Methane (CH_4)
  - Nitrous oxide (N_2O)
  - Hydrofluorocarbons (HFCs)
  - Perfluorocarbons (PFCs)
  - Sulfur hexafluoride (SF_6)
  - Nitrogen trifluoride (NF_3)
- The GHG emissions from community-wide activities must be organized and reporting under the following five Sectors, based on the selected reporting level:
  - Stationary Energy
  - Transportation
  - Waste
  - Industrial Processes and Product Use (IPPU)

- Agriculture, Forestry, and Other Land Use (AFOLU)

The GPC Protocol also requires that a community define an inventory boundary, identifying the geographic area, time span, gases, and emission sources.

Under the GPC Protocol, a community has the option of reporting GHG emissions under three different levels:

- Territorial - A City only reports on GHG emissions occurring within the city boundaries
- City-Induced – A City accounts for all GHG emissions as a result of activities that occur within Under the City-Induced framework, there are two levels of reporting available to cities - BASIC and BASIC+
  - **BASIC—**This level covers stationary energy and transportation GHG emissions that physically occur within a city (Scope 1) and those that occur from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross city boundaries (Scope 2). The BASIC level also includes waste GHG emissions that may occur outside of a city but are driven by activities taking place within a city's boundaries (Scope 3). The BASIC level aligns with the current GHG reporting requirements of most voluntary reporting programs for local governments.
  - **BASIC+—**This level covers the same scopes as BASIC and includes more in-depth and data dependent methodologies. Specifically, it expands the reporting scope to include Scope 1 emissions from Industrial Process and Product Use (IPPU), Agriculture, Forestry, and Other Land-Use (AFOLU), and Scope 3 GHG emissions from transboundary transportation. The sources covered in BASIC+ also align with sources required for national reporting in IPCC guidelines.

Activities taking place within a community can generate GHG emissions that occur inside a Community boundary as well as outside a Community boundary. To distinguish between these, the GPC Protocol groups emissions into three categories based on where they occur: Scope 1, Scope 2, or Scope 3 emissions. The GPC Protocol distinguishes between emissions that physically occur within a Community (Scope 1), from those that occur outside a Community but are driven by activities taking place within a Community's boundaries (Scope 3), from those that occur from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross community boundaries (Scope 2). Scope 1 emissions may also be termed "territorial" emissions, because they are produced solely within the territory defined by the geographic boundary (see Figure 1).

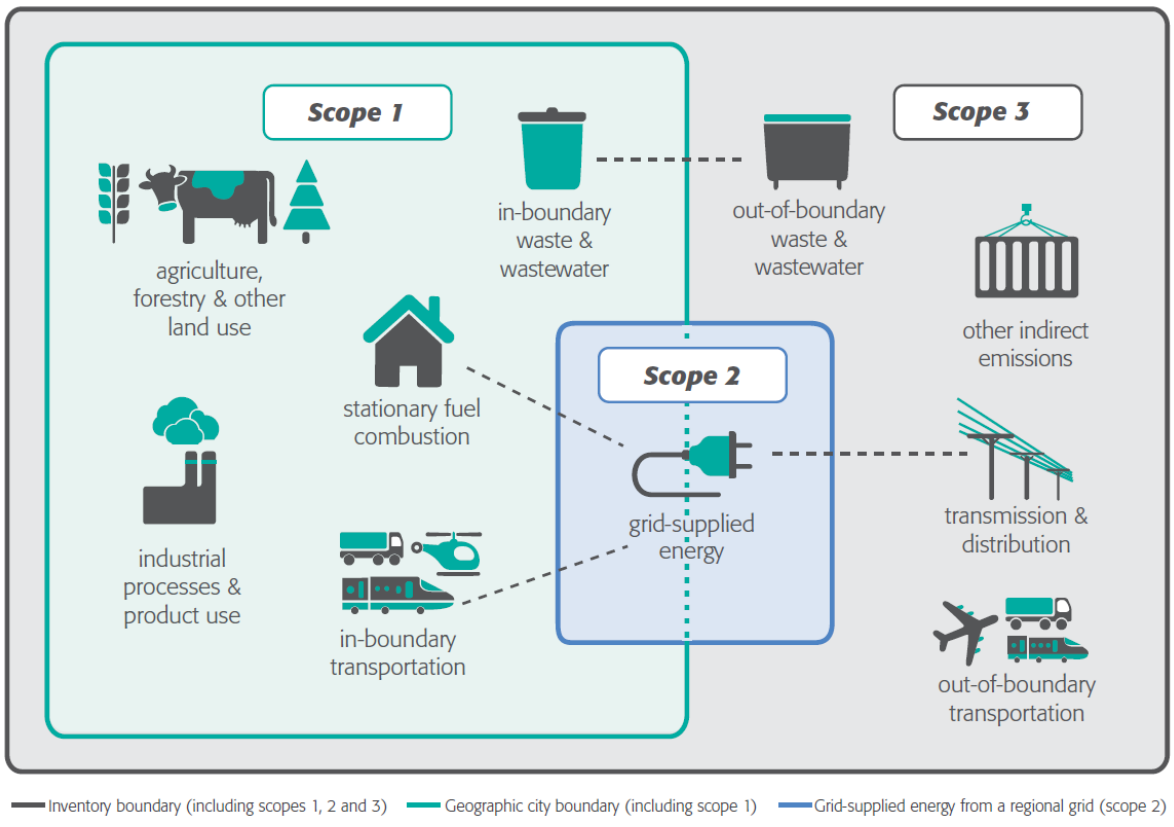

Figure 1 Sources and Boundaries of a Community's GHG Emissions (GPC 2014)

2.3 GHG EMISSION CATEGORIES

As noted previously, the GPC Protocol requires that different emission sources to be categorized into six main reporting Sectors. These high-level categories are described in more detail in Section 2.3.1 to Section 2.3.6. More information on how GHG emissions are captured within the GPC Protocol is available on the Greenhouse Gas Protocol website.

2.3.1 Stationary Energy

Stationary energy sources are typically one of the largest contributors to a community's GHG emissions. In general, these emissions come from fuel combustion and fugitive emissions. They include the emissions from energy to heat and cool residential, commercial, and industrial buildings, as well as the activities that occur within these residences and facilities. Emissions associated with distribution losses from grid-supplied electricity/steam/heating/cooling are also included, as are some fugitive emissions from sources such as coal piles, natural gas. They include the emissions from energy to heat and cool residential, commercial, and industrial buildings, as well as the activities that occur within the residences

and facilities. Emissions associated with distribution losses from grid-supplied electricity/steam/heating/cooling are also included, as are fugitive emissions from sources such as coal piles, natural gas pipelines, and related Off-road Transportation GHG emission sources.

The Stationary Energy Sector includes the following Sub-Sectors:

- Residential buildings
- Commercial and institutional buildings and facilities
- Agriculture, forestry, and fishing activities
- Manufacturing industries and construction
- Energy industries
- Energy generation supplied to the grid*
- Non-specific sources
- Fugitive emissions from mining, processing, storage, and transportation of coal
- Fugitive emissions from oil and natural gas systems

*Emissions related with electricity generation activities occurring within a community's boundaries are to be reported; however, the GHG emissions from these sources are not reported separately as they are accounted for elsewhere and to prevent double counting (GPC 2014).

Under the GPC Protocol, cities are to report off-road GHG emissions under the Off-road Transportation Sub-Sector if and only if the GHG emissions are occurring at transportation facilities (e.g., airports, harbors, bus terminals, train stations, etc.). Other off-road transportation GHG emissions that occur on industrial premises, construction sites, agriculture farms, forests, aquaculture farms, and military premises, etc., are to be reported under the most relevant Stationary Energy Sub-Sector (GPC, 2014). For example, GHG emissions from commercial building off-road construction equipment would be included in the Commercial And Institutional Buildings And Facilities Sub-Sector, whereas GHG emissions from residential lawn mowers would be reported under the Residential Buildings Sub-Sector.

2.3.2 Transportation

The GHGs released to the atmosphere to be reported in the Transportation Sector are those from combustion of fuels in journeys by on-road, railway, waterborne navigation, aviation, and off-road. GHG emissions are produced directly by the combustion of fuel, and indirectly using grid-supplied electricity. Unlike the Stationary Energy Sector, transit is mobile and can pose challenges in both accurately calculating GHG emissions and allocating them to a specific Sub-Sector. This is particularly true when it comes to transboundary transportation, which includes GHG emissions from trips that either start or finish within a community's boundaries (e.g., departing flight emissions from an airport outside a Community boundaries) (GPC, 2014). Transboundary GHG emissions are only required for GPC BASIC+ GHG reporting.

The Transportation Sector includes the following Sub-Sectors:

- On-road

- Railways
- Waterborne
- Aviation
- Off-road

As noted previously, cities are to report off-road GHG emissions under the Off-road Transportation Sub-Sector if and only if the GHG emissions are occurring at transportation facilities (e.g., airports, harbors, bus terminals, train stations, etc.). For example, off-road railway maintenance support equipment GHG emissions are reported under the Off-Road Transportation Sub-Sector.

2.3.3 Waste

Cities produce GHG emissions that arise from activities related to the disposal and management of solid waste. Waste does not directly consume energy, but releases GHG emissions because of decomposition, burning, incineration, and other management methods.

The Waste Sector includes the following Sub-Sectors:

- Solid waste disposal
- Biological treatment of waste
- Incineration and open burning
- Wastewater treatment and discharge

Under the GPC Protocol, the Waste Sector includes all GHG emissions that result from the treatment or decomposition of waste regardless of the source of the waste (e.g., another community's waste in a Community's landfill). However, the GHG emissions that are associated with waste from outside a Community's boundary that is treated or decomposes within a Community boundary are deemed to be "reporting only" emissions and do not contribute to the GHG inventory (GPC 2014).

Any GHG emissions that result from the combustion of waste or waste related gases to generate energy, such as a methane capture and energy generation system at a landfill, are reported under Stationary Energy Generation Supplied to The Grid Sub-Sector (GPC, 2014). Any waste related GHG emissions that are combusted but not related to energy generation are reported in the appropriate Waste Sub-Sector. Lastly, any waste GHG emissions that are released to the atmosphere are also captured in the appropriate Waste Sub-Sector.

2.3.4 Industrial Processes and Product Use (IPPU)

Emissions from this Sector are only required for BASIC+ GHG reporting under the GPC Protocol. This Sector encompasses GHG emissions produced from industrial processes that chemically or physically transform materials and using products by industry and end-consumers (e.g., refrigerants, foams, aerosol cans) (GPC, 2014).

The IPPU Sector includes the following Sub-Sectors:

- Industrial processes
- Product use

Any GHG emissions associated with energy use for industrial processes are not reported in the IPPU Sector; rather, they are reported under the appropriate Stationary Energy Sub-Sector.

2.3.5 Agriculture, Forestry, and Other Land Use (AFOLU)

Emissions from the AFOLU Sector are only required for BASIC+ GHG reporting. AFOLU GHG emissions are those that are captured or released because of land-management activities. These activities can range from the preservation of forested lands to the development of crop land. Specifically, this Sector includes GHG emissions from land-use change, manure management, livestock, and the direct and indirect release of nitrous oxides (N_2O) from soil management, rice cultivation, biomass burning, urea application, fertilizer, and manure application (GPC, 2014).

The AFOLU Sector is organized into the following Sub-Sectors:

- Livestock
- Land
- Aggregate sources and non-CO_2 emission sources on land

2.3.6 Other Scope 3 Emissions

Cities, by their size and connectivity, inevitably give rise to GHG emissions beyond their boundaries – often referred to as Other Scope 3 GHG emissions under the GPC Protocol. In the community context, Other Scope 3 GHG emissions include upstream GHG emissions, such as fuel extraction, production, and transportation GHG emissions, as well as cradle to-gate GHG emissions associated with the consumption of goods and services like food and drink, water, construction materials, and other goods and services that are estimated to make a material contribution to a city's GHG inventory. The GPC Protocol already includes the following Scope 3 emissions in other Sectors:

- On-road, waterborne, and aviation transboundary transportation
- Transmission and distribution losses associated with grid-supplied energy
- Solid waste disposal
- Biological treatment of solid waste
- Wastewater treatment and discharge

Cities may voluntarily report on Other Scope 3 emissions as they are estimated. In the case of the RDN, no other Scope 3 GHG emissions, other than those listed above, have been estimated.

2.4 ACCOUNTING AND REPORTING PRINCIPLES

All GHG inventories following the GPC Protocol are required to meet GHG accounting principles. Specifically, these inventories should be relevant, consistent from year to year, accurate and transparent about methodologies, assumptions, and data sources. The transparency of inventories is fundamental to the success of replication and assessment of the inventory by interested parties.

The GHG inventories must also properly account for key energy and GHG emission sinks, sources, and reservoirs (SSR) that are occurring within municipal boundaries. The SSRs are a convenient way to identify and categorize all the GHG emissions to determine if they should be included or excluded from a GHG inventory. A “Source” is something that releases GHG emissions to the atmosphere, such as a diesel generator. A “Sink” is a process or item that removes GHG from the atmosphere, such as photosynthesis and tree growth. Finally, a “Reservoir” is a process or item with the capability to store or accumulate a GHG removed from the atmosphere by a GHG sink, such as a wetland or a peat bog. By assessing and reporting on the applicable SSRs, users of the GHG inventory can have confidence that the inventory is complete and representative of the types and quantities of the GHGs being released within community limits.

2.5 BASE AND REPORTING YEAR RECALCULATIONS

As communities grow and expand, significant changes to the GHG emissions profile can alter materially thus making it difficult to meaningfully assess GHG emission trends and changes over time. The GPC Protocol has requirements on how to treat changes in a community’s GHG profile—this is presented in Table 2.

Table 2 GPC Protocol Recalculation Thresholds

Threshold	Example Change	Recalculation Needed	No Recalculation Needed
Changes in the assessment boundary	A local government is annexed in or removed from the administrative boundary	✓	
	Change in protocol reporting method (e.g., from BASIC to BASIC+, addition of GHGs reported, etc.)	✓	
	Shut down of a power plant		✓
	Building a new cement factory		✓
Changes in calculation methodology or improvements in data accuracy	Change in calculation methodology for landfilled municipal solid waste (MSW) that results in a material change in GHG emissions to that sector (i.e., +/-10%).	✓	
	Adoption of more accurate local emission factors, instead of a national average emission factor that results in a material change in GHG emissions (i.e., +/-10%).	✓	

Threshold	Example Change	Recalculation Needed	No Recalculation Needed
	Access to more accurate source data (e.g., vehicle registration data). Recalculation depends on the magnitude of the change in GHG emissions.	✓	✓
	Change in electricity emission factor due to energy efficiency improvement and growth of renewable energy utilization.		✓
Discovery of significant errors	Discovery of mistake in unit conversion in formula used.	✓	

2.6 DATA QUALITY

Data collection and the assessment of its quality is an integral component of compiling any GHG inventory. Like the IPCC, the GPC Protocol requires users to establish first whether a source exists, and then assess the data availability and quality. To support GHG reporting, the following notation keys are used.

- If the GHG sink, source or reservoir does not exist, a “NO” is used to indicate it is “not occurring”.
- If the GHG sink, source or reservoir does occur, and data is available, then the emissions are estimated. However, if the data is also included in another emissions source category or cannot be disaggregated, the notation key “IE” would be used to indicate “included elsewhere” to avoid double counting.
- When GHG emissions are occurring in the RDN, but data is not available, then the notation key “NE” would be used to indicate “not estimated”.

For GHG data that does exist, in accordance with the GPC Protocol, an assessment of quality is also made on emission factors and GHG estimation methodologies deployed. The GPC Protocol data quality assessment notation keys are summarized in Table 3.

Table 3 GPC Protocol Data Quality Assessment Notation Keys

Data Quality	Activity Data	Emission Factor
High (H)	Detailed activity data. Data accuracy is high.	Site-specific emission factors
Medium (M)	Modeled activity data using robust assumptions. Data accuracy is moderate.	More general emission factors
Low (L)	Highly modeled or uncertain activity data. Data accuracy is low / very poor.	Default emission factors

3.0 GHG ASSESSMENT BOUNDARIES

This section sets out the reporting boundaries of the RDN's GHG inventory.

3.1 SPATIAL BOUNDARIES

This GHG inventory is defined geographically by the RDN's jurisdictional boundaries. As shown in Figure 2, the RDN consists of 4 municipalities and 7 electoral areas. For the purposes of this report, only the RDN GHG emissions are presented. A breakdown of GHG emissions by each RDN municipality and electoral area has been presented in a separate report.

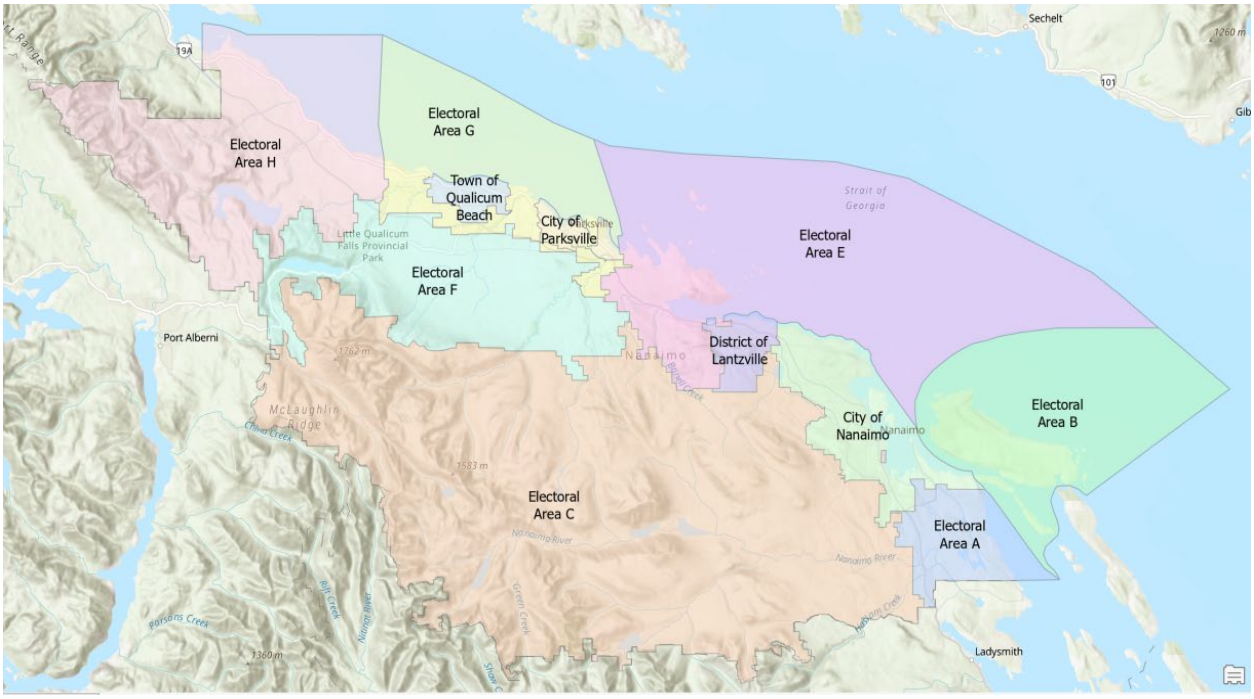

Figure 2 GHG Boundary

Additional GHG inventory related information is presented in Table 4.

Table 4 Inventory Information

Inventory Boundary	Community / District Information
Name of Community / District	Regional District of Nanaimo
Municipality / Electoral Area	• City of Nanaimo • City of Parksville • Town of Qualicum Beach

	• District of Lantzville • Electoral Area A • Electoral Area B • Electoral Area C • Electoral Area E • Electoral Area F • Electoral Area G • Electoral Area H
Country	Canada
Inventory Year	2023
Geographic Boundary	See Figure 2
Land Area (hectares)	312,706
Resident population	183,039 (Est.)
GDP (CAN$)	Unknown at time of reporting
Composition of Economy	Government; some commercial and industrial
Climate	Temperate, warm summer

3.2 TEMPORAL BOUNDARIES

3.2.1 GHG Inventory Updates

Since the release of the last GHG emissions inventory for the 2021 reporting period, there have been several updates to data sources which impact all inventories from 2007 to 2021. The most noteworthy is the Province of BC's release of updated (2007, 2010, 2012) and newly published (2008, 2009, 2011, 2013-2021) vehicle count data, VKT and fuel consumption data for all BC municipalities for use in the CEEIs.[3] As the vehicle count data is showing stability across all years and is expected to continue, and the Province has low uncertainty associated with it, this new data was incorporated into the 2007-2023 GHG emissions inventories which results in a change in base year GHG emissions for all RDN municipalities. The City of Nanaimo in partnership with the RDN engaged a consultant to complete a study on the potential for deep energy retrofits in residential buildings which involved an analysis of wood, propane, and heating oil consumption. The values from the study were incorporated into the 2021-2023 reporting year GHG inventories. The Province also updated wood and fuel oil GHG emission factors – these too were applied to all GHG inventories. While the change does not have a material impact on the 2007 base year, it does have a material impact on the 2012-2021 reporting years.

[3] 2021 Community Energy and Emissions Inventory data - Province of British Columbia (gov.bc.ca)

Table 5 presents the prior 2007 and the updated 2007 base year GHG emissions reported as tonnes of carbon dioxide equivalent (tCO_2e). The GHG emissions inventory baseline data for RDN members is presented in Appendix A.

Table 5 Original And Updated BASIC+ Base Year

Sector	GPC Protocol: 2007 GHG Base Year (tCO_2e)	Updated GPC Protocol: 2007 GHG Base Year (tCO_2e)
Residential Buildings	178,457	175,592
Commercial & Institutional Buildings	88,577	88,577
Manufacturing Industries & Construction	131,220	131,220
Energy Industries	462	462
Non-Specified Sources	-	-
Agriculture, Forestry & Fishing activities	34,815	34,815
Fugitive Emissions	583	583
In-Boundary On-road Transportation	680,030	644,726
Trans-Boundary On-road Transportation	93,773	88,904
Waterborne Navigation	6,518	6,518
Aviation	Not Estimated*	Not Estimated*
Railway	1,248	1,248
Off-road Transportation	24,215	24,215
Solid Waste	45,315	45,315
Biological Treatment of Waste	394	394
Incineration & Open Burning	126	126
Wastewater Treatment & Discharge	1,965	1,965
IPPU	20,388	20,388
Land-Use Change	(294,814)	(294,814)
Livestock	3,818	3,818
Non-CO_2 Land Emission Sources	109	109
Total Without Land Use GHG Emissions	**1,312,013**	**1,268,976**
Total With Land Use GHG Emissions	**1,017,198**	**974,162**

** At the request of the Nanaimo Airport all aviation GHG emissions have been excluded from the GHG emissions inventory until the airport quantifies and reports on these emissions.*

3.2.2 2023 GHG Boundary

This inventory covers all in-scope GHG emissions for the 2023 reporting year. Where 2023 data was not available, the most recent year's data have been used, and the timescale noted accordingly. These are as follows:

- **Global Warming Potentials (GWP).** The BC government has communicated that is adopting GWPs from the fifth IPCC report. On this basis, the RDN is applying GWPs from the fifth IPCC report.

- **Stationary Energy: Residential Buildings**. The 2021-2023 propane, heating oil and wood GHG emissions were estimated using the Nanaimo Region Deep Energy Retrofits Feasibility Study (Nanaimo, 2024) and heating degree days (HDD) published by Environment and Climate Change Canada. While the study focused on Nanaimo, the 2021 energy splits for the City was used to estimate the energy consumption for the other member municipalities.

- **Stationary Energy: Residential, Commercial and Institutional Buildings in Electoral Areas.** The 2022 and 2023 building natural gas data was not available for the Electoral Areas at the time of reporting but was available for the other RDN municipalities. To estimate the Electoral Areas natural gas usage for the 2022 and 2023 reporting years, the 2021 Electoral Areas natural gas values was grown based on the change in total natural gas use for the RDN non-Electoral Areas municipalities between the 2022 and 2023 reporting years.

- **Stationary Energy:** Other Off-Road. The ECCC 2024 NIR prepared for the Province of BC for the 2021 reporting year was used to estimate GHG emissions for:

    - Off-road agriculture and forestry GHG emissions
    - Off-road commercial and institutional GHG emissions
    - Off-road manufacturing, mining, and construction GHG emissions
    - Off-road residential GHG emissions
    - These GHG emissions were assigned to the RDN on a per capita basis.

- **Stationary Energy: Fugitives.** Fugitive emissions data was not available for the RDN. As such, the Victoria Capital Regional District's reported fugitive emissions per connection for the 2020 reporting year was used to derive 2007 and 2023 estimates.

- **Transportation: On-Road.** The 2023 vehicle registration data was not available at the time of reporting. To estimate the GHG emissions, the number of registered vehicles for the 2022 reporting year was grown using the reported population change between 2022 and 2023. Insurance Corporation of BC (ICBC) compiles data on an April 1 to March 31 basis, and thus the 2007 and 2023 on-road GHG emission estimates are based on the number of registrations from April 1 – March 31 and may not accurately represent the actual vehicle population for each given reporting year.

- **Transportation: Waterborne.** The number of recreational boats was estimated from the total number of pleasure craft and large vessels registered in the RDN as tracked by Transport Canada.

Recreational vessel fuel consumption rates are based on the study entitled "Marine Vessel Air Emissions in BC and Washington State Outside of the Greater Victoria Regional District (GVRD) and FVRD for the Year 2000". Cruise ship emissions are based on the number of reported vessels at the Nanaimo Port for the 2023 reporting year and the Greater Victoria Harbor Authority's 2018 estimate of GHG emissions per cruise ship. Deep vessel shipment GHG emissions are based on 2023 Nanaimo Port data and the Port of Vancouver's 2015 estimate of GHG emissions per tonne of cargo throughput.

- **Waste: Incineration & Opening Burning.** Open burning GHG emissions are estimated using 2015 data reported by the Comox Valley Regional District as not value has been publicly reported by the RDN. The GHG emissions are adjusted to 2007 and 2023 using population data and are assumed to only occur in the EA's.

- **AFOLU: Land-Use.** The land cover change analysis requires a consistent land-use category attribution and spatial data. Landsat spatial data was available for the 2005, 2010, 2015 and 2020 reporting years only. Since annual data is not available, the change between land cover data years (2005-2010, 2010-2015, 2015-2020) for all areas was averaged and may not represent actual changes in land-use each year.

The implications of using this data on the GHG emissions inventory is presented in Section 7.1.

3.3 GHG EMISSION SOURCES AND SCOPES

Table 6 summarizes the RDN's GHG emissions by source and GHG emission scope. Due to limitations in how to quantify GHG emissions resulting from land use change (e.g., residential development), these GHG emissions have been excluded from the RDN's 2007 and 2023 GHG emissions inventories, but have been disclosed, until a more robust measurement methodology can be developed.

Table 6 Summary of Emissions Scope and GPC Protocol Reporting Sector

GHG Emissions Scope	GPC Protocol Reporting Sector
Scope 1	The GHG emissions occurring from sources located within the RDN's limits: • Stationary fuel combustion: – Residential buildings – Commercial and institutional buildings and facilities – Manufacturing industries and construction – Energy industries – Energy generation supplied to the grid. – Agriculture, forestry and fishing activities – Fugitive emissions from oil and natural gas systems • Transportation: – On-road transportation – Railways – Waterborne navigation

GHG Emissions Scope	GPC Protocol Reporting Sector
	– Aviation (Not Estimated) – Off-road transportation • Waste: – Solid waste generated in the city. – Biological waste generated in the city. – Incinerated and burned waste generated in the city. – Wastewater generated in the city. – Solid waste generated outside the city. • Industrial processes and product use (IPPU): – Emissions from industrial processes occurring in the city boundary. • Agriculture, Forestry, and Other Land Use (AFOLU): – Land-use: emissions sequestered (*reported, but not included in the total*) – Livestock – Aggregate sources and non-CO_2 emission sources on land
Scope 2	The GHG emissions occurring from using grid-supplied electricity, heating and/or cooling within the RDN's boundary: • Stationary fuel combustion: – Residential buildings – Commercial and institutional buildings and facilities • Transportation: – On-road
Scope 3	Other GHG emissions occurring outside of the RDN's limits as a result of the RDN's activities: • Stationary Energy: – Residential buildings – Commercial and institutional buildings and facilities • Transportation: – On-Road: Transboundary

3.4 GHG REPORTING

Where relevant, the GPC Protocol recommends using methodologies that align with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The GHG inventory is required to include all seven Kyoto Protocol GHGs occurring within the geographic boundary of a community.

Each GHG listed above has a different global warming potential (GWP) due to its ability to absorb and re-emit infrared radiation. This chemical property is recognized by the GWP set out by the IPCC Fifth Assessment Report. A larger GWP value means the substance has a greater affinity to absorb and re-emit infrared radiation. The GWP of these GHGs are CO_2 = 1.0, CH_4 = 28, N_2O = 265 (IPCC, 2014).

Total GHG emissions are normally reported as CO_2e, whereby emissions of each of the GHGs are multiplied by their GWP and are reported as tonnes of CO_2e.

The GHG inventory results following the GPC Protocol reporting table format is presented in Section 5.0. The GPC Protocol reporting format is presented in Table 7 below which also indicates the reporting level (BASIC / BASIC+) for each source.

This report follows the GPC Basic + reporting scope.

Table 7 GPC Protocol Summary Table

GPC Protocol Reference Number	Reporting Level	Emissions Scope	GHG Emissions Source
I	**Stationary Energy Sources**		
I.1	**Residential Buildings**		
I.1.1	BASIC	1	Emissions from in-boundary fuel combustion
I.1.2	BASIC	2	Emissions from consumption of grid-supplied energy
I.1.3	BASIC+	3	Transmission and distribution losses from grid-supplied energy
I.2	**Commercial and Institutional Buildings/Facilities**		
I.2.1	BASIC	1	Emissions from in-boundary fuel combustion
I.2.2	BASIC	2	Emissions from consumption of grid-supplied energy
I.2.3	BASIC+	3	Transmission and distribution losses from grid-supplied energy
I.3	**Manufacturing Industry and Construction**		
I.3.1	BASIC	1	Emissions from in-boundary fuel combustion
I.3.2	BASIC	2	Emissions from consumption of grid-supplied energy
I.3.3	BASIC+	3	Transmission and distribution losses from grid-supplied energy
I.4	**Energy Industries**		
I.4.1	BASIC	1	Emissions from in-boundary production of energy used in auxiliary operations
I.4.3	BASIC+	3	Transmission and distribution losses from grid-supplied energy
I.5	**Agriculture, Forestry, and Fishing Activities**		
I.5.1	BASIC	1	Emissions from in-boundary fuel combustion
I.5.2	BASIC	2	Emissions from consumption of grid-supplied energy
I.5.3	BASIC+	3	Transmission and distribution losses from grid-supplied energy
I.7	**Fugitive Emissions from Mining, Processing, Storage, And Transportation of Coal**		
I.7.1	BASIC	1	In-boundary fugitive emissions
I.8	**Fugitive Emissions from Oil and Natural Gas Systems**		
I.8.1	BASIC	1	In-boundary fugitive emissions
II	**Transportation**		
II.1	**On-road Transportation**		
II.1.1	BASIC	1	Emissions from in-boundary transport

Table 7 GPC Protocol Summary Table

GPC Protocol Reference Number	Reporting Level	Emissions Scope	GHG Emissions Source
II.1.2	BASIC	2	Emissions from consumption of grid-supplied energy
II.1.3	BASIC+	3	Emissions from transboundary journeys
II.2	**Railways**		
II.2.1	BASIC	1	Emissions from in-boundary transport
II.2.2	BASIC	2	Emissions from consumption of grid-supplied energy
II.2.3	BASIC+	3	Emissions from transboundary journeys
II.3	**Waterborne Navigation**		
II.3.1	BASIC	1	Emissions from in-boundary transport
II.3.2	BASIC	2	Emissions from consumption of grid-supplied energy
II.3.3	BASIC	3	Emissions from transboundary journeys
II.4	**Aviation**		
II.4.1	BASIC	1	Emissions from in-boundary transport
II.4.2	BASIC	2	Emissions from consumption of grid-supplied energy
II.4.3	BASIC+	3	Emissions from transboundary journeys
II.5	**Off-road**		
II.5.1	BASIC	1	Emissions from in-boundary transport
II.5.2	BASIC	2	Emissions from consumption of grid-supplied energy
III	**Waste**		
III.1	**Solid Waste Disposal**		
III.1.1	BASIC	1	Emissions from waste generated and treated within the Community
III.1.2	BASIC	3	Emissions from waste generated within but treated outside of the Community
III.2	**Biological Treatment of Waste**		
III.2.1	BASIC	1	Emissions from waste generated and treated within the Community
III.2.2	BASIC	3	Emissions from waste generated within but treated outside of the Community
III.3	**Incineration and Open Burning**		
III.3.1	BASIC	1	Emissions from waste generated and treated within the Community
III.3.2	BASIC	3	Emissions from waste generated within but treated outside of the Community
III.4	**Wastewater Treatment and Discharge**		

Table 7 GPC Protocol Summary Table

GPC Protocol Reference Number	Reporting Level	Emissions Scope	GHG Emissions Source
III.4.1	BASIC	1	Emissions from wastewater generated and treated within the Community
III.4.2	BASIC	3	Emissions from wastewater generated within but treated outside of the Community
IV	**Industrial Processes and Product Use (IPPU)**		
IV.1	BASIC+	1	In-boundary emissions from industrial processes
IV.2	BASIC+	1	In-boundary emissions from product use
V	**Agriculture, Forestry, and Other Land Use (AFOLU)**		
V.1	BASIC+	1	In-boundary emissions from livestock
V.1	BASIC+	1	In-boundary emissions from land
V.1	BASIC+	1	In-boundary emissions from other agriculture
VI	**Other Scope 3 Emissions**		
VI.1	BASIC / BASIC+	3	Other indirect emissions

4.0 GHG METHODOLOGIES BY SOURCE CATEGORY

The following sections describe the reporting source category, assumptions, activity data applied, and quantification methodology. The results of the analysis are presented in Section 5.0.

4.1 STATIONARY ENERGY

4.1.1 Overview

Stationery energy sources are one of the largest contributors to the RDN's GHG emissions. For the District, the Stationary Energy Sector encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 1 Emissions:
  - Residential buildings
  - Commercial and institutional buildings and facilities
  - Manufacturing industries and construction
  - Energy industries
  - Energy generation supplied to the grid
  - Agriculture, forestry and fishing activities
  - Fugitive emissions from oil and natural gas systems
- Scope 2 Emissions:
  - Emissions From The Consumption Of Grid-Supplied Electricity, Steam, Heating, And Cooling.
- Scope 3 Emissions:
  - Transmission And Distribution Losses Of Electricity, Steam, Heating, And Cooling.

4.1.2 Activity Data

BC Hydro and Fortis BC provided the Province of BC 2023 electricity and natural gas consumption data itemized by community in MWh and GJ, respectively. Based on the utility provider descriptions of the data, each is categorized as follows:

- Residential Buildings based on the BC Hydro and Fortis BC descriptor: "Residential"
- Commercial and Institutional Buildings/Facilities based on BC Hydro and Fortis BC descriptor: "Commercial"

Fortis BC also provided the number of natural gas connections.

2007-2021 residential fuel oil, propane and wood GHG and energy use estimates were derived by the Province using the 2010 BC Hydro Conservation Potential Review. This data was used to estimate the 2022-2023 reporting year GHG emissions for all RDN members and assumes that the consumption of each fuel type increased directly with the number of annual heating degree days (HDD) for the RDN as reported by ECCC.

Fugitive emissions from the natural gas distribution network within the RDN is based on the Fortis fugitive emission factor for the 2020 reporting year for the Victoria Capital Regional District. This factor was used to estimate 2007-2023 fugitive emissions for residential natural gas use in the RDN and assumes a direct change with the number of reported natural gas connections (as reported by Fortis BC).

Harmac Pacific Operations reported their stationary combustion GHG emissions under the BC *Greenhouse Gas Industrial Reporting and Control Act.* This information was accessed though the Province of BC's website for industrial emissions and was reported under the Manufacturing Industries & Construction sub-sector.[4]

The Greater Nanaimo Pollution Control Centre captures biogas for reuse and flaring. The RDN landfill captures landfill fugitive gas and combusts it for energy generation and export to the BC electrical grid and flares the landfill gas captured, but not used. The biogas and landfill fugitive gas that is captured and used is reported in the Stationary Energy category and the remaining unused biogas / gas is flared and is reported under the Waste category. To support the quantification of these GHG emissions, the RDN provided the following data for each reporting year:

- Greater Nanaimo Pollution Control Centre biogas used.
- Greater Nanaimo Pollution Control Centre biogas flared.
- Average methane content of landfill gas
- Volume of landfill gas collected, flared, and combusted to generate electricity.

Residential, commercial, and institutional building related off-road GHG emissions (e.g., residential lawn-mowers) included in the Stationary Energy Sector are based on the 2024 NIR as prepared by Environment and Climate Change Canada. These emissions are pro-rated to the RDN on a per capita basis. Agriculture, forestry and fishing, and manufacturing industries and construction related off-road GHG emissions included in the Stationary Energy Sector are based on the 2024 NIR as prepared by Environment and Climate Change Canada. These emissions are pro-rated to the RDN on the number of employees (using Statistics Canada data) in each of the reported sectors within the region.

4.1.3 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2023 GHG emissions:

- The 2022 and 2023 building natural gas data was not available for the Electoral Areas at the time of reporting but was available for the other RDN municipalities. To estimate the Electoral Areas natural gas usage for the 2022 and 2023 reporting years, the 2021 Electoral Areas natural gas values was grown based on the change in total natural gas use for the RDN non-Electoral Areas municipalities between the 2022 and 2023 reporting years.
- The City of Nanaimo natural gas commercial data included industrial natural gas consumption (from the Pulp Mill). Using the industrial GHG emissions data as provided by the Province, it is estimated that for the 2007 and 2023 reporting year ~27% and ~21%, respectively, of the City of Nanaimo's

[4] Industrial facility greenhouse gas reporting - Province of British Columbia (gov.bc.ca)

natural gas consumption is related to industrial activity. These values were used to deduct industrial natural gas consumption from the commercial natural gas consumption volumes for Nanaimo and reported under the Manufacturing Industries & Construction Sub-sector.

- BC Hydro estimates that the combined energy losses- transmission and distribution- to be approximately 6.28% of supplied electricity. This value was used to calculate the Scope 3 emissions for each Stationary Energy Sub-Sector.
- Fortis BC provided the number of natural gas connections in the RDN, and the total fugitive emissions per connection for the 2020 reporting year at the Victoria Capital Regional District level. The 2020 value was used to derive 2007-2023 estimates.
- The 2021-2023 propane, heating oil and wood GHG emissions were estimated using the Nanaimo Region Deep Energy Retrofits Feasibility Study (Nanaimo, 2024) and heating degree days (HDD) published by Environment and Climate Change Canada. While the study focused on Nanaimo, the 2021 energy splits for the City was used to estimate the energy consumption for the other member municipalities.
- It was assumed that the high heat value (HHV) and the biogas efficiency factors as derived from the BC WCI.20-20 guidance are a reasonable reflection of the biogas being generated at the Greater Nanaimo Pollution Control Centre.

4.1.4 Data Quality Assessment

Table 8 presents the activity data quality assessment for the stationary energy sources.

Table 8 Stationary Energy Data Source Quality Assessment

Data	Quality Assessment Rating
Residential, Commercial and Industrial Electricity	High For Non-EA Members; Medium for EAs
Residential, Commercial and Industrial Natural Gas	High For Non-EA Members; Medium for EAs
Residential Heating Oil, Wood and Propane Energy Use	Medium-High
Industrial GHG Emissions Data: Harmac Pacific Operations	High
Agriculture, Forestry & Fishing Activity GHG Emissions	Low
Manufacturing Industries & Construction GHG Emissions	Low
Fugitive Emissions	Medium
Transmission, Distribution & Line Losses	Medium
Off-Road Transportation Emissions	Low
Biogas & Landfill Gas Volumes Utilized / Flared	High

4.1.5 Residential & Commercial Buildings GHG Calculation Methodology

Residential propane, heating oil and wood GHG emissions were estimated using the Nanaimo Region Deep Energy Retrofits Feasibility Study (Nanaimo, 2024) and heating degree days (HDD) published by Environment and Climate Change Canada. While the study focused on Nanaimo, the 2021 energy splits for the City was used to estimate the energy consumption for the other member municipalities; the change in HDD between the 2021-2023 reporting years was used to adjust the total consumption volumes for heating oil, propane and wood. The energy split that was applied to all RDN municipalities is as follows:

- Electricity: 53%
- Natural Gas: 31%
- Heating Oil: 5%
- Propane: 2%
- Wood: 8%

To calculate GHG emissions from electricity, natural gas, heating oil, propane, and wood, the total net annual energy values (where applicable, less transmission, distribution, and line losses of 6.28%) were multiplied by applicable emissions factors. These values were then multiplied by the pollutant's GWP to give total CO_2e emissions in tonnes.

These quantification methods are captured as follows:

$$\textbf{Energy}_{\text{Stationary Energy – Electricity}} = Electricity * (1 - Line\ Loss\ (\%))$$

$$\textbf{Energy}_{\text{Stationary Energy – Transmission, Distribution, and line Losses}} = Electricity * Line\ Loss\ (\%)$$

$$\textbf{Emissions}_{\text{Stationary Energy – Electricity}} = Fuel\ (MWh) * EF_{tCO2e}$$

$$\textbf{Emissions}_{\text{Stationary Energy – Natural Gas}} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

$$\textbf{Emissions}_{\text{Stationary Energy – Propane}} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

$$\textbf{Emissions}_{\text{Stationary Energy – Wood}} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

$$\textbf{Emissions}_{\text{Stationary Energy – Heating Oil}} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

The emission factors used in the 2023 reporting year are summarized in Table 9.

Table 9 Residential & Commercial Buildings Stationary Energy GHG Emission Factors

Emission Factor	Units	tCO_2e	Quality Assessment Rating
Electricity (BC Hydro)	tCO_2e / MWh	0.0113000	Medium
Natural Gas	tonne CO_2e / m^3	0.0018702	Medium
Propane	tonne CO_2e / L	0.0015443	Medium
Heating Oil	tonne CO_2e / GJ	0.0693592	Medium
Wood	tonne CO2e / kg	0.0003930	Medium

4.1.6 Industrial GHG Emissions

Harmac Pacific Operations reported their GHG emissions under the BC *Greenhouse Gas Industrial Reporting and Control Act.* This information was accessed though the Province of BC's website for industrial emissions. This reporting does not provide total energy use at these facilities and creates a risk of double counting.

Because emissions from Harmac natural gas use are already included in the inventory through the Fortis BC natural gas data (under Commercial), they need to be subtracted from the natural gas values reported by Fortis to more accurately represent where natural gas consumption occurs and to avoid double counting. As this value could not be obtained from Harmac, an estimate was derived using publicly available data. To derive the 2007 value, the prior 2007 CEEI data (which did not include the industrial consumption volumes) and updated 2007 community energy data (which does include the industrial consumption volumes) were compared and a change in values derived. The data set that included industrial consumption volumes showed 29% higher natural gas use, which is assumed to be solely for Harmac Pacific Operations. The 2007 value ended up being reduced to 21% in 2023 to account for increasing rates of residential natural gas use in the City of Nanaimo (as a result of an increase in the number of dwellings being constructed). The 2023 value was derived using a change in the number of residential housing counts between 2007 and 2023, the change in Harmac's reported GHG emissions, and the change in natural gas consumption.

4.1.7 Biogas & Flaring GHG Emissions

The Greater Nanaimo Pollution Control Centre captures biogas for reuse and flaring. The biogas that is used is reported as a Stationary Energy source as it is used to heat the Greater Nanaimo Pollution Control Centre. To quantify these GHG emissions, the BC WCI.20-20 high heat value (HHV) and the biogas efficiency factors are used – this methodology is as follows.

$$\textbf{Emissions}_{Biogas} = Biogas\ Volume_{m3} * Biogas\ HHV\ (0.0281)_{GJ/m3} * EF_{tCO2e}$$

The biogas combustion emission factor is presented in Table 10.

Table 10 Biogas Combustion GHG Emission Factor

Emission Factor	Units	Emission Factor	Quality Assessment Rating
Biogas	tCO_2e/GJ Biogas	0.00494	Medium

The biogas that is combusted for heating is reported under the Stationary Energy category; the flared biogas is reported under the Solid Waste category. This is in accordance with the GPC Protocol.

The RDN landfill captures fugitive landfill gas, combusts it for energy generation and export to the BC electrical grid, and flares the landfill gas captured but not used. The landfill gas that is combusted for export into the electrical grid, under the GPC Protocol, it is deemed a reporting only GHG emissions source and is not included in the GHG inventory. This is to avoid double counting GHG emissions with other cities and energy consumers. The landfill gas that is flared is reported under the Solid Waste category. Both methodologies assume a combustion efficiency of 99.7%. To quantify GHG emissions related to landfill fugitive gas combustion, the following methodology is deployed.

$$Emissions_{Fugitive\ Landfill\ Gas} = LFG\ Volume_{m3} * LFG\ Methane\ Content_{Percent} * Density\ of\ methane\ at\ 25^{o}C\ and\ 1.0\ Atmosphere * Combustion\ Efficiency * GWP_{CH4}$$

4.2 TRANSPORTATION

4.2.1 Overview

Transportation covers all GHG emissions from combustion of fuels in journeys by on-road, railways, waterborne navigation, aviation, and off-road. GHG emissions are produced directly by the combustion of fuel, and indirectly using grid-supplied electricity. For the RDN, the Transportation Sector encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 1 Emissions:
  - On-road: In Boundary
  - Waterborne
  - Aviation
  - Off-road
- Scope 2 Emissions:
  - Emissions from the consumption of grid-supplied electricity.
- Scope 3 Emissions:
  - On-road: Transboundary
  - Waterborne

- Aviation
- Off-road

4.2.2 Activity Data

The Province of BC provided 2007-2022 vehicle counts, VKT and fuel consumption data for the City of Nanaimo, City of Parksville, Town of Qualicum Beach, the District of Lantzville and the aggregated Electoral Areas.[5]

Google Insights Explorer provided an estimate of the change in the transportation GHG emissions and transboundary split for the Regional District and the City of Nanaimo for the 2018-2023 reporting years.[6]

The RDN provided transit fuel volumes and estimated kilometers travelled (VKT) for busses. This data was used to estimate GHG emissions from buses serving the RDN.

Transport Canada provided total domestic and international itinerant movements, by type of operation, airports with NAV CANADA flight service stations for the Nanaimo Airport. The Transport Canada Vessel Registration System provided the total number of registered waterborne vehicles for the reporting year. Historical data is not available.

Through their annual reports. the Nanaimo Port Authority provided the number of cruise ships serviced and total number of deep-sea ship traffic in their Port Authority Statistics.[7]

Through their annual reports[8], BC Ferries provided total fuel volumes consumed for all of BC Ferries operations and total passenger counts for Departure Bay and Duke Point.

The RDN provided total fuel consumption volumes consumed at the RDN landfill and an estimate of GHG emissions related to biosolids transportation. Other off-road transportation emissions are based on the 2024 NIR as prepared by Environment and Climate Change Canada. These GHG emissions are prorated on a per capita basis.

4.2.3 Assumptions and Disclosures

The following assumptions were made in the calculation of the Transportation Sector GHG emissions:

- On-Road:
  - The 2023 vehicle registration data was not available at the time of reporting. To estimate the GHG emissions, the number of registered vehicles for the 2022 reporting year was grown using the reported population change between 2022 and 2023. Insurance Corporation of BC (ICBC) compiles data on an April 1 to March 31 basis, and thus the 2007 and 2023 on-road GHG

[5] 2021 Community Energy and Emissions Inventory data - Province of British Columbia (gov.bc.ca)
[6] Nanaimo - Summary - Google Environmental Insights Explorer - Make Informed Decisions (sustainability.google)
[7] Cargo, Vessel and Passenger Volumes - 2013 to 2022 - Port of Nanaimo (npa.ca)
[8] Plans, Reports, Policies and Other Resources | BC Ferries

emission estimates are based on the number of registrations from April 1 – March 31 and may not accurately represent the actual vehicle population for each given reporting year.

- Aviation
  - At the request of the Nanaimo Airport all aviation GHG emissions have been excluded from the GHG emissions inventory until the airport quantifies and reports on these emissions.
- Waterborne Navigation
  - The number of recreational boats was estimated based on the number of total number of pleasure craft and large vessels registered in the RDN as tracked by Transport Canada. Recreational vessel fuel consumption rates are based on the study entitled “Marine Vessel Air Emissions in BC and Washington State Outside of the Greater Victoria Regional District (GVRD) and FVRD for the Year 2000”. These GHG emissions are prorated based on the each RDN member population relative to the RDN population.
  - BC Ferries GHG emissions were estimated and assigned to the RDN based on total annual passenger counts to Departure Bay and Duke Point. These assigned GHG emissions where then prorated to each RDN member population relative to the RDN population.
  - Cruise ship emissions are based on the Greater Victoria Harbor Authority’s 2018 estimate of GHG emissions per cruise ship and the count as reported by the Nanaimo Port Authority. These GHG emissions were assigned to the City of Nanaimo as they occur within Nanaimo’s municipal boundary.
  - Deep vessel shipment GHG emissions are based on the Port of Vancouver’s 2015 estimate of GHG emissions per cargo throughput and the count as reported by the Nanaimo Port Authority. These GHG emissions were assigned to the City of Nanaimo as they occur within Nanaimo’s municipal boundary.

4.2.4 Data Quality Assessment

Table 11 presents the activity data quality assessment for the transportation data sources.

Table 11 Transportation Data Quality Assessment

Data	Quality Assessment Rating
Split Between In-Boundary and Transboundary Traffic	Low
Vehicle Registry Data	High
Vehicle Kilometers Travelled (VKT) Data	Medium-Low
Vehicle Fuel Economy Data	Medium
Railway GHG Data	Low
Waterborne GHG Data	Low
Other Off-Road Transportation GHG Data	Low

4.2.5 Calculation Methodology

4.2.5.1 On-Road

The GPC Protocol identifies several methods for determining on-road emissions. The vehicle kilometers travelled (VKT) methodology was utilized to estimate the GHG emissions from on-road transportation (Scope 1) and transboundary transportation (Scope 3). The VKT uses the number and type of vehicles registered in a geopolitical boundary, the estimated fuel consumption rate of individual vehicles, and an estimate of the annual vehicle kilometres traveled (VKT) by various vehicle classes. To estimate the split between on-road in-boundary and transboundary traffic, data from the Google Insight Explorer was applied. The results of the survey as it applies to the RDN is presented in Table 12.

Table 12 RDN On-Road In-Boundary/Transboundary Split

Aspect	RDN	RDN Members
Estimated proportion of on-road in-boundary travel	86.9%	76.2%
Estimated proportion of on-road transboundary travel	13.1%	23.8%

To quantify the 2007 and 2023 reporting year on-road and transboundary GHG emissions, the following steps were taken:

1. Collect reported vehicle count data for all RDN members for the 2007-2022 reporting years.[9]
2. To estimate 2023 vehicle, count data for all RDN members, grow the 2022 vehicle count data using the change in population between 2022 and 2023.
3. Assign average provincially derived VKT and vehicle fuel consumption rates (Table 13).
4. Estimate total fuel use by vehicle classification (Table 14).
5. Summate and allocate estimated fuel use, by vehicle class using the applicable in-boundary and transboundary split.
6. Pro-rate the diesel fuel use from busses.
7. Summate and allocate estimated bus fuel use using the applicable in-boundary and transboundary split.

Table 13 Estimated VKT And Fuel Efficiencies by Vehicle Class For Reporting Year

Vehicle Classification	Estimated VKT / Year (Average)	Estimated Fuel Efficiency (L/100 km)
Diesel-HDV	56,421	29.3
Diesel-LDT	4,794	11.8
Diesel-LDV	11,881	6.6
Diesel-ORVE	Not Estimated	Not Estimated
Electric-HDV	18,509	1.6
Electric-LDT	9,932	3.0

[9] Community Energy and Emissions Inventory - Province of British Columbia (gov.bc.ca)

Vehicle Classification	Estimated VKT / Year (Average)	Estimated Fuel Efficiency (L/100 km)
Electric-LDV	5,524	1.0
Electric-ORVE	Not Estimated	Not Estimated
Gasoline-HDV	10,221	31.0
Gasoline-Hybrid-HDV	12,594	43.2
Gasoline-Hybrid-LDT	Not Estimated	8.0
Gasoline-Hybrid-LDV	22,302	5.7
Gasoline-Hybrid-ORVE	Not Estimated	Not Estimated
Gasoline-LDT	14,236	14.0
Gasoline-LDV	24,040	11.0
Gasoline-ORVE	Not Estimated	Not Estimated
Hydrogen-Hybrid-LDV	Not Estimated	Not Estimated
Hydrogen-LDV	13,205	5.3
Hydrogen-LDT	9,161	12.1
Motorcycle – Electric	3,022	16.6
Motorcycle - Non catalyst	12,195	6.3
Natural Gas-HDV	3,357	39.5
Natural Gas-LDT	Not Estimated	15.6
Natural Gas-LDV	Not Estimated	Not Estimated
Natural Gas-ORVE	Not Estimated	Not Estimated
Propane-HDV	4,121	17.8
Propane-Hybrid-LDV	Not Estimated	Not Estimated
Propane-LDT	5,131	14.3
Propane-LDV	3,278	10.5
Propane-ORVE	Not Estimated	Not Estimated

Table 14 Total Registered Vehicles & Estimated Fuel Use For Reporting Year

Vehicle Classification	Total Estimated Registered Vehicles	Total Estimated Fuel Use	Units
Diesel-HDV	5,159	99,695,540	Liters (L)
Diesel-LDT	3,486	1,947,536	Liters (L)
Diesel-LDV	1,636	1,303,268	Liters (L)
Diesel-ORVE	-	225,699	Liters (L)
Electric-HDV	32	12,259	kWh
Electric-LDT	1,023	309,299	kWh
Electric-LDV	1,733	115,286	kWh

Vehicle Classification	Total Estimated Registered Vehicles	Total Estimated Fuel Use	Units
Electric-ORVE	-	-	kWh
Gasoline-HDV	4,649	17,152,066	Liters (L)
Gasoline-Hybrid-HDV	185	1,256,322	Liters (L)
Gasoline-Hybrid-LDT	-	-	Liters (L)
Gasoline-Hybrid-LDV	42	63,837	Liters (L)
Gasoline-Hybrid-ORVE	-	-	Liters (L)
Gasoline-LDT	60,985	117,906,014	Liters (L)
Gasoline-LDV	63,580	161,646,539	Liters (L)
Gasoline-ORVE	-	13,736	Liters (L)
Hydrogen-Hybrid-LDV	-	-	Liters (L)
Hydrogen-LDV	2,196	1,016,269	Liters (L)
Hydrogen-LDT	405	654,046	Liters (L)
Motorcycle - Electric	116	54,977	kWh
Motorcycle - Non catalyst	3,840	3,051,978	Liters (L)
Natural Gas-HDV	59	1,723,473	Kilogram (kg)
Natural Gas-LDT	-	-	Kilogram (kg)
Natural Gas-LDV	-	-	Kilogram (kg)
Natural Gas-ORVE	-	-	Kilogram (kg)
Propane-HDV	25	18,285	Liters (L)
Propane-Hybrid-LDV	-	-	Liters (L)
Propane-LDT	1,192	1,200,526	Liters (L)
Propane-LDV	553	218,732	Liters (L)
Propane-ORVE	-	-	Liters (L)
Total	**150,897**	**N/A**	**N/A**

Once the fuels were allocated amongst the vehicle classes and sectors, the GHG emissions were calculated accordingly. The GHG quantification method is captured, for all fuel types, is as follows:

$$\textbf{Emissions}_{\textbf{On-road}} = \text{In-Boundary Split \%} * ((\text{Vol. Fuel} * EF_{CO2}) + (\text{Vol. Fuel} * EF_{CH4} * GWP_{CH4}) + (\text{Vol. Fuel} * EF_{N2O} * GWP_{N2O}))$$

$$\textbf{Emissions}_{\textbf{Transboundary}} = \text{Transboundary Split \%} * ((\text{Vol. Fuel} * EF_{CO2}) + (\text{Vol. Fuel} * EF_{CH4} * GWP_{CH4}) + (\text{Vol. Fuel} * EF_{N2O} * GWP_{N2O}))$$

The emission factors used in the reporting year GHG inventory are from the 2020 B.C. Best Practices Methodology For Quantifying Greenhouse Gas Emissions. These are summarized in Table 15.

Table 15 Vehicle GHG Emission Factors

Vehicle Class	Units	tCO_2e	Quality Assessment Rating
Gasoline-LDV	tonne CO_2e / L	0.0020388	Medium-Low
Gasoline-LDT	tonne CO_2e / L	0.0020388	Medium-Low
Gasoline-HDV	tonne CO_2e / L	0.0020806	Medium-Low
Gasoline-ORVE	tonne CO_2e / L	0.0021773	Medium-Low
Gasoline-Hybrid-LDV	tonne CO_2e / L	0.0020388	Medium-Low
Gasoline-Hybrid-LDT	tonne CO_2e / L	0.0020388	Medium-Low
Gasoline-Hybrid-HDV	tonne CO_2e / L	0.0020806	Medium-Low
Gasoline-Hybrid-ORVE	tonne CO_2e / L	0.0021773	Medium-Low
Electric-LDV	tonne CO_2e / kWh	0.0000115	Medium-Low
Electric-LDT	tonne CO_2e / kWh	0.0000115	Medium-Low
Electric-HDV	tonne CO_2e / kWh	0.0000115	Medium-Low
Electric-ORVE	tonne CO_2e / kWh	0.0000115	Medium-Low
Diesel-LDV	tonne CO_2e / L	0.0024777	Medium-Low
Diesel-LDT	tonne CO_2e / L	0.0024781	Medium-Low
Diesel-HDV	tonne CO_2e / L	0.0024620	Medium-Low
Diesel-ORVE	tonne CO_2e / L	0.0024799	Medium-Low
Hydrogen-Hybrid-LDV	tonne CO_2e / L	-	Medium-Low
Hydrogen-LDV	tonne CO_2e / L	-	Medium-Low
Hydrogen-LDT	tonne CO_2e / L	-	Medium-Low
Natural Gas-LDV	tonne CO_2e / kg	0.0000029	Medium-Low
Natural Gas-LDT	tonne CO_2e / kg	0.0000029	Medium-Low
Natural Gas-HDV	tonne CO_2e / kg	0.0000029	Medium-Low
Natural Gas-ORVE	tonne CO_2e / kg	0.0000029	Medium-Low
Propane-LDV	tonne CO_2e / L	0.0014495	Medium-Low
Propane-LDT	tonne CO_2e / L	0.0014495	Medium-Low
Propane-HDV	tonne CO_2e / L	0.0014495	Medium-Low
Propane-ORVE	tonne CO_2e / L	0.0014495	Medium-Low
Propane-Hybrid-LDV	tonne CO_2e / L	0.0014495	Medium-Low
Motorcycle - Non catalyst	tonne CO_2e / L	0.0020931	Medium-Low
Motorcycle - Electric	tonne CO_2e / L	0.0000115	Medium-Low

4.2.5.2 Waterborne Transportation

4.2.5.2.1 BC Ferries

Marine waterborne transportation emissions encompass GHG emissions from the use of the BC Ferries. GHG emissions from BC Ferries are estimated using total estimated fuel use for the 2023 reporting year, and provincially derived GHG emissions factors (Table 16).

Table 16 BC Ferries GHG Emission Factors

Aspect	Units	tCO_2e	Quality Assessment Rating
Ferry: Diesel	tonne CO_2e / L	0.0028777	Medium
Ferry: Natural Gas	tonne CO_2e / L	0.0014140	Medium

BC Ferries GHG emissions were assigned to the RDN based on total annual passenger counts to Departure Bay and Duke Point relative to the total number of passengers using BC Ferries for the reporting year. These assigned GHG emissions where then prorated to each RDN member population relative to the RDN population.

The GHG quantification method, that was applied to assigned and quantify GHG emissions to the RDN is as follows:

$$\textbf{Emissions}_{\textbf{Waterborne}} = (Passengers_{Total\ BC\ Ferries} * Passengers_{RDN}) *((Vol.\ Fuel * EF_{CO2}) + (Vol.\ Fuel * EF_{CH4} * GWP_{CH4}) + (Vol.\ Fuel * EF_{N2O} * GWP_{N2O}))$$

4.2.5.2.2 Personal Watercraft

The Transport Canada Vessel Registration System provided the total number of registered waterborne vehicles; however, the registration system does not provide any detail on the type, size, use, and owner of the watercraft. It was therefore assumed that 50% of the boats are sail (60% diesel; 40% gas) and 50% are power (25% diesel, 75% gas). To estimate the GHG emissions, the estimated annual fuel consumption rates from the Victoria Harbour Study “Marine Vessel Air Emissions in BC and Washington State Outside of the GVRD and FVRD for the Year 2000” and BC based emission factors were applied (Table 17).

Table 17 Watercraft GHG Emission Factors

Aspect	Units	tCO_2e	Quality Assessment Rating
Marine Gasoline	tonne CO_2e / L	0.0022539	Medium-Low
Marine Diesel	tonne CO_2e / L	0.0026083	Medium-Low

The GHG quantification method, that was applied to personal watercraft was as follows:

$$Emissions_{Waterborne} = Total\ Boats * Fuel_{Percent} * ((Vol.\ Fuel * EF_{CO2}) + (Vol.\ Fuel * EF_{CH4} * GWP_{CH4}) + (Vol.\ Fuel * EF_{N2O} * GWP_{N2O}))$$

4.2.5.2.3 Cruise Ship & Deep Sea Vessels

The GHG emissions from the operation of cruise ship and deep-sea vessels within the RDN's boundary was based on the number of reported vessels and cargo tonnages as reported by the Nanaimo Port Authority, and GHG emission estimates as reported by the Victoria Greater Harbor Authority and the Port of Vancouver. Only the container cargo tonnages were used and excluded logs and other forest products.

The GHG emission factors used to quantify these GHG emissions are presented in Table 18.

Table 18 Watercraft GHG Emission Factors

Aspect	Units	Emission Factor	Quality Assessment Rating
Cruise Ships	tCO_2e/Cruise Ship	49.9443	Medium-Low
Deep-Sea Vessels	tCO_2e /Tonne of Cargo	0.0070	Medium-Low

The GHG quantification method, that was applied to estimate these GHG emissions were as follows:

$$Emissions_{Cruise\ Ships} = Cruise\ Ships_{Total} * EF_{CO2e}$$

$$Emissions_{Deep\ Sea\ Vessels} = (Cargo_{Total} - Cargo_{Logs,\ Forest\ Products}) * EF_{CO2e}$$

4.2.5.3 Railways

The Island Rail Corridor is 225 kilometers in length to which approximately 52 kilometers of rail crosses through the RDN. To account for these GHG emissions from freight transport, the ECCC 2024 NIR estimates for railways in BC, and total kilometres of rail in BC (as reported by Statistics Canada) were used to derive a GHG per km of rail emission factor. This factor along with the estimated length of rail crossing the RDN was used to derive an estimate of GHG emissions. The factor derived is presented in Table 19.

Table 19 Railway GHG Emission Factor

Aspect	Units	Emission Factor	Quality Assessment Rating
Railway GHG Emissions	tCO_2e/km-Rail	31.4	Low

The GHG quantification method is as follows:

$$\textbf{Emissions}_{Railway} = Railway_{km} * EF_{tCO2e}$$

4.2.5.4 Off-Road

Currently, there is limited data available to estimate off-road GHG emissions. As such, a GHG emissions estimate for each off-road category was developed using Provincial emissions data from the 2024 NIR, and population and employment statistics from Statistics Canada.

Residential, commercial, and institutional building related off-road GHG emissions are based on the ECCC 2024 NIR estimates for BC and were pro-rated to the RDN on a per capita basis.

Agriculture, forestry and fishing related off-road GHG emissions are based on the ECCC 2024 NIR estimates for BC and were pro-rated to the RDN on a per hectare of agricultural land basis.

Manufacturing industries and construction, and manufacturing, mining and construction related off-road GHG emissions are based on the ECCC 2024 NIR estimates for BC and were pro-rated to the RDN based on the number of employees in each of the reported sectors.

Other off-road GHG emissions are based on the ECCC 2024 NIR estimates for BC and were pro-rated to the RDN on a per capita basis. These GHG emissions were reported in the Transportation Other Off-Road Sub-Sector.

The GHG quantification method is presented below:

$$\textbf{Emissions}_{Off\text{-}Road} = (NIR\ Off\text{-}Road\ GHG\ Emissions_{BC} / BC\ Population_{BC}) * Current\ Reporting\ Year\ Population_{RDN}$$

$$\textbf{Emissions}_{Agriculture,\ Forestry\ And\ Fishing} = (NIR\ Off\text{-}Road\ GHG\ Emissions_{BC} / BC\ Lands\ in\ Agriculture_{HA}) * RDN\ Lands\ in\ Agriculture_{HA}$$

$$\textbf{Emissions}_{Manufacturing\ Industries\ And\ Construction\ \&\ Manufacturing,\ Mining\ and\ Construction\ Off\text{-}Road} = (NIR\ Off\text{-}Road\ GHG\ Emissions_{BC} / BC\ Employment\ Statistics_{BC}) * Current\ Reporting\ Year\ Employment\ Statistics_{RDN}$$

$$\textbf{Emissions}_{Other\ Off\text{-}Road} = (NIR\ Off\text{-}Road\ GHG\ Emissions_{BC} / BC\ Population_{BC}) * Current\ Reporting\ Year\ Population_{RDN}$$

4.3 WASTE

Cities produce GHG emissions because of the disposal and management of solid waste, incineration and open burning of waste, the biological treatment of waste, and through wastewater treatment and discharge. Waste does not directly consume energy, but releases GHG emissions because of decomposition, burning, incineration, and other management methods.

For the RDN, the Waste Sector encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 3: Emissions:
  - Solid waste disposal
  - Biological treatment of waste
  - Incineration and opening burning
  - Wastewater treatment and discharge

There are no incineration activities, but there are open burning activities.

4.3.1 Activity Data

The RDN provided the following data sources:

- Total fugitive landfill fugitive GHG emissions
- Total organic material sent for treatment
- Total volume of wastewater treated for the following wastewater treatment plants:
  - Greater Nanaimo Pollution Control Centre
  - French Creek Pollution Control Centre
  - Nanoose Bay Pollution Control Centre
  - Duke Point Pollution Control Centre
- Annual average BOD and TKN for each of the wastewater treatment plants
- Volume of landfill gas flared

4.3.2 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2023 GHG emissions:

- The assignment of fugitive GHG emissions from the landfill based on a per capita basis. While there is waste entering the landfill from outside of the RDN, is currently not tracked. As such, for conservativeness, all landfill fugitive emissions are allocated to RDN members.
- Composting GHG emissions are estimated based on the total tonnage estimated by the RDN. It is assumed that all compost, other than the City of Courtenay's waste steam, is treated aerobically.
- It is assumed that all residential dwellings in the Electoral Areas backyard compost.
- It is assumed that the wastewater influent volumes include any septage received.
- It is assumed that the Electoral Areas without wastewater treatment have septic tanks.
- Open burning GHG emissions are estimated using a 2015 particulate matter emissions inventory that was prepared for the Comox Valley. The GHG emissions are adjusted to 2007 and 2023 using population data.

4.3.3 Data Quality Assessment

Table 20 presents the activity data quality assessment for the waste data sources.

Table 20 Waste Data Quality Assessment

Data	Quality Assessment Rating
Landfill fugitive methane and flaring data	Medium-High
Landfill tonnages sent to landfill by RDN member data	Medium-Low
Wastewater volume data	High
Wastewater BOD and TKN data	High
Wastewater septic system data	Medium-Low
Composting waste data (compost and biosolids)	Medium
Incineration and open burning data	Low

4.3.4 Calculation Methodology

4.3.4.1 Solid Waste

The RDN provided fugitive landfill GHG emissions estimates and solid waste tonnage by RDN member. The GHG emissions were allocated based on solid waste tonnage sent to the landfill by RDN member. To quantify GHG emissions from the biological treatment of solid waste, the following GHG quantification method was deployed:

$$Emissions_{Fugitive\ Landfill} = Waste_{Total} * (Population_{RDN\ Member} / Population_{RDN}) * EF_{CH4} * GWP_{CH4}$$

4.3.4.2 Biological Treatment of Solid Waste

The RDN provided composting data which is assumed to be treated aerobically. The composting emission factor used in the estimation of GHG emissions was derived from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 5, Chapter 4: Biological Treatment of Solid Waste) (Table 21).

Table 21 Composting Emission Factor

Emission Factor	Units	tCO_2e	Quality Rating Assessment
Composting: Anerobic	tCO_2e / kg waste	0.00019150	Low
Composting: Aerobic	tCO_2e / kg waste	0.00002800	Low

To quantify GHG emissions from the biological treatment of solid waste, the following GHG quantification methods was deployed:

$$Emissions_{Anaerobic\ Waste} = Compost\ Waste_{Total} * EF_{CH4} * GWP_{CH4}$$

4.3.4.3 Waste Incineration And Open Burning

Thera are no incineration activities occurring within the RDN.

Open burning GHG emissions are estimated using a 2015 factor of tonnes combusted per household. For the purposes of estimation, it is assumed that all open burning occurs in the Electoral Areas of the RDN. The GHG emissions are adjusted to 2007 and 2023 using population data.

The emission factor used in the estimation of GHG emissions was derived from 2001 US EPA GHG methodology quantification guidance document (Chapter 16, Open Burning). It is assumed that the material being burned is evenly split amongst leaf species, forest residues, and weeds. The emission factor is presented in Table 22.

Table 22 Open Burning Emission Factor

Emission Factor	Units	tCO_2e	Quality Rating Assessment
Open Burning	tCO_2e / tonne waste	0.04622430	Medium-Low

To quantify GHG emissions from the biological treatment of solid waste, the following GHG quantification methods was deployed:

$$Emissions_{Open\ Burning} = Burned\ Waste_{Total} * EF_{CO2}$$

4.3.4.4 Wastewater Treatment And Discharge: Treatment Systems

Wastewater is currently treated prior to discharge. To estimate GHG emissions, the total wastewater volumes (m^3), the average biological oxygen demand (BOD) and the average Total Kjeldal Nitrogen (TKN) in treated wastewater area used. IPCC default wastewater methane (CH_4) producing capacity (0.6 kg CH_4/kg BOD) and methane correction factor (MCF) (0.1 – unit less) were used to estimate CH_4 from the wastewater. To estimate N_2O from the wastewater, the Total Kjeldal Nitrogen (TKN) annual average in conjunction with the total wastewater volumes to calculate the total TKN in the wastewater. The IPCC default conversion value of 0.01 kg N_2O-N/kg sewage-N was used to estimate N_2O from the wastewater. These factors used are for treated wastewater being deposited into deep or moving waters. It is likely that ocean sequesters more CH_4 than what has been estimated.

To quantify GHG emissions from the wastewater treatment, the following GHG quantification method is deployed:

$$Emissions_{Wastewater\ CH4} = ((Wastewater_{m3} * (BOD_{ml/L} / 1000) * (0.018_{kg\ CH4/kg\ BOD} * 0.01)) / 1000) * GWP_{CH4}$$

$$Emissions_{Wastewater\ N2O} = ((Wastewater_{m3} * (TKN_{ml/L} / 1000) * 0.01_{kg\ N2O\text{-}N/kg\ sewage\text{-}N}) / 1000) * GWP_{N2O}$$

4.3.4.5 Wastewater Treatment And Discharge: Septic Systems

There are several households within the RDN are on septic systems. The number of homes not receiving wastewater treatment, based on service area, was used to estimate the fugitive wastewater GHG emissions from septic systems. The method is presented as follows:

$$Emissions_{Septic} = Homes_{Septic} * Population_{Septic} * EF$$

The emission factor derived from septic GHG emissions research by the Water Environment Research Foundation is presented in Table 23.

Table 23 Septic System Emission Factor

Emission Factor	Units	tCO_2e	Quality Rating Assessment
Septic Systems	tCO_2e / capita / year	0.0010302	Medium-Low

4.4 INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)

4.4.1 Overview

Emissions from the IPPU Sector are only required for BASIC+ GHG reporting under the GPC Protocol. This Sector encompasses GHG emissions produced from industrial processes that chemically or physically transform materials and using products by industry and end-consumers (e.g., refrigerants, foams, and aerosol cans) (GPC, 2014).

For the RDN, the IPPU encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 1 Emissions:
  - Product use

No significant GHG emissions from Industrial Processes, like the release of chemicals and refrigerants because of manufacturing or processing of materials, are reported to be occurring and thus the notation key for “Not Occurring” has been used to indicate this. It should be noted that the reporting threshold for the BC government is 10,000 tCO_2e so it is possible that there are small industrial GHG emissions sources occurring within the RDN, but there is no data to support a conclusion.

4.4.2 Activity Data

The IPPU data was derived from the ECCC 2024 NIR.

4.4.3 Data Quality Assessment

Table 24 presents the activity data quality assessment for the IPPU data sources.

Table 24 IPPU Data Quality Assessment

Data	Quality Assessment Rating
Industrial process emissions data	Low
Industrial product use emissions data	Low

4.4.4 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2023 GHG emissions:

- The product use emissions are based on the 2024 NIR product use GHG emissions as prepared by Environment and Climate Change Canada. These are applied to the RDN on a per capita basis.
- The NIR uses the Tier 1 methodology to estimate these emissions and thus uncertainty around their accuracy remains quite high.

4.4.5 Calculation Methodology

4.4.5.1 Product Use Emissions

For the 2023 reporting year, only the emissions estimated were production and consumption of halocarbons, SF_6 and NF_3 were estimated for the province. To estimate product use GHG emissions for the RDN, the ECCC 2024 NIR estimates for BC were pro-rated to the RDN based on the number of employees in the manufacturing, construction, and mining, quarrying and oil and gas extraction sectors.

The GHG quantification method is presented below:

$$Emissions_{Product\ Use} = (NIR\ Product\ Use\ GHG\ Emissions_{BC} / Employment\ Population_{BC}) * Current\ Reporting\ Year\ Population_{RDN\ Manufacturing,\ Construction\ And\ Mining,\ Quarrying\ And\ Oil\ And\ Gas\ Extraction\ Employee\ Count}$$

4.5 AGRICULTURE, FORESTRY, AND OTHER LAND USE (AFOLU)

4.5.1 Overview

The AFOLU Sector includes emissions from livestock, land-use, and all other agricultural activities occurring within a community's boundaries. For the RDN, the AFOLU encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 1 Emissions:
  - Land (*reported, but not included in the GHG totals*)

- Livestock
- Aggregate Sources and Non-CO_2 Emissions Sources On Land

4.5.2 Activity Data

The 2005, 2010, 2015 and 2020 Agriculture and Agri-Food Canada semi-decadal land use time series remotely sensed imagery datasets were used to estimate land-cover change between 2007 and 2023. The RDN provided jurisdictional boundary geospatial datasets.

Livestock counts were derived using Statistics Canada data.

Aggregate sources and non-CO_2 emissions sources on land were estimated using GHG emissions data from the 2024 NIR, and land-use data from the 2021 Statistics Canada Census of Agriculture, to create a GHG emissions per hectare value.

4.5.3 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2023 GHG emissions:

- It is conservatively assumed that all cropland is used for livestock and agricultural purposes.
- Infrequent and small source open burning may be occurring, but there is no data to estimate this emissions source.
- The land cover change analysis requires a consistent land-use category attribution and spatial data. Landsat spatial data was available for the 2005, 2010, 2015 and 2020 reporting years. Since annual data was not available, the change between land cover data years (2007-2023) for all areas was averaged and may not represent actual changes in each year.

4.5.4 Data Quality Assessment

Table 25 presents the activity data quality assessment for the AFOLU data sources.

Table 25 AFOLU Data Quality Assessment

Data	Quality Assessment
Land-use data	High
Urea application GHG data	Low
Direct, indirect, and manure nitrous oxide (N_2O) GHG data	Low
Livestock data	Medium

4.5.5 Calculation Methodology

4.5.5.1 Land Use

Remotely sensed imagery was used to estimate land-cover changes during the 2007-2023 reporting periods. Using the remotely sensed imagery an annual average land-use change between land classes (e.g., cropland, forestland, etc.) was determined and applied to BC-based emission factors to estimate GHG emissions resulting from changes between land-uses for the reporting year.

The spatial data sources representing land cover in this analysis did not categorize lands by the 6 IPCC land-use categories. To align with the IPCC land classification definitions (as required by the GPC Protocol), the following data categories were re-assigned to the most appropriate IPCC land class.

Table 26 IPCC Land Use Classification Cross-References

Data Label	Definition	IPCC Land Use Classification
Settlement	Urban and rural residential, commercial, industrial, transportation or other built infrastructure use	Settlement
Settlement Forest	Settlement areas mostly or entirely covered by tree canopy	Settlement
Vegetated Settlement	Settlement areas with observable vegetation such as lawns, golf courses, and settlement areas with 30-50% tree canopy	Settlement
High Reflectance Settlement	Settlement areas with high spectral reflectance such as pavement, buildings, or other surfaces with little to no observable vegetation	Settlement
Very High Reflectance Settlement	Settlement areas with very high spectral reflectance such as pavement, buildings, or other surfaces with no observable vegetation	Settlement
Roads	Primary, secondary, and tertiary roads	Settlement
Water	Open water	Other
Forest	Land covered by trees with a canopy cover >10% and a minimum height of 5m, or capable of growing to those measurements within 50 years	Forest Land
Forest Wetland	Wetland with forest cover (canopy cover over 10% and minimum height 5m, or capable of growing to those measurements within 50 years)	Wetlands
Forest Regenerating after Harvest <20 years	Forest regenerating from tree harvesting activity that took place less than 20 years prior	Forest Land
Forest Wetland Regenerating after Harvest <20 years	Wetland with forest cover regenerating from tree harvesting activity that took place less than 20 years prior	Wetlands

Data Label	Definition	IPCC Land Use Classification
Forest Regenerating after Fire <20 years	Forest Regenerating after a fire less than 20 years prior	Forest Land
Forest Regenerating after Harvest 20-29 years	Forest regenerating from tree harvesting activity that took place 20 to 29 years prior (this class is identified beginning in 2010)	Forest Land
Forest Wetland Regenerating after Harvest 20-29 years	Wetland with forest cover regenerating from tree harvesting activity that took place 20 to 29 years prior	Wetlands
Cropland	Annual and perennial cropland	Cropland
Annual Cropland	Annual cropland (identified beginning in 2015)	Cropland
Land Converted to Cropland	Cropland that did not appear to be cropland 10 years prior (this class is identified beginning in 2010)	Cropland
Land Converted to Annual Cropland	Annual cropland that did not appear to be cropland 10 years prior (this class is identified beginning in 2015)	Cropland
Grassland Managed	Natural grass and shrubs used for cattle grazing	Grassland
Grassland Unmanaged	Natural grass and shrubs with no discerned human intervention (e.g., perpetual meadows, tundra)	Grassland
Wetland	Wetland with vegetation at or above the surface of the water	Wetlands
Newly-Detected Settlement <10 years	Settlement (21) that was first identified as a Settlement land use less than 10 years prior (this class is identified beginning in 2010)	Settlement
Newly-Detected Settlement Forest <10 years	Settlement Forest (24) that was first identified as a Settlement land use less than 10 years prior (this class is identified beginning in 2010)	Settlement
Newly-Detected Vegetated Settlement <10 years	Vegetated Settlement (28) that was first identified as a Settlement land use less than 10 years prior (this class is identified beginning in 2010)	Settlement
Newly-Detected High Reflectance Settlement <10 years	High Reflectance Settlement (22) that was first identified as a Settlement land use less than 10 years prior (this class is identified beginning in 2010)	Settlement
Newly-Detected Very High Reflectance Settlement <10 years	Very High Reflectance Settlement (29) that was first identified as a Settlement land use less than 10 years prior (this class is identified beginning in 2010)	Settlement
Other Land	Rock, beaches, ice, barren land	Other
Snow and Ice	Snow and Ice on mountains (this class is identified only in 2020)	Other

The analysis resulted in an estimate of an annual average change in hectares' value for each land class. Once the land use change values were determined for the reporting year, BC-based and IPCC emission factors were applied to estimate reported and disclosed (not-reported) GHG emissions from land use (Table 27).

Table 27 Land-Use Change Emission Factors

Land-Use Classification	Emission Factor	Units	Quality Assessment Rating
Forestland	224.1	tCO_2e / ha	Low
Shrubland/Scrubland	112.0	tCO_2e / ha	Low
Grasslands	205.7	tCO_2e / ha	Low
Wetlands	471.5	tCO_2e / ha	Low
Cropland	237.8	tCO_2e / ha	Low
Settlements	0	tCO_2e / ha	Low
Other	0	tCO_2e / ha	Low
Forestland	1.8	tCO_2e / ha / year	Low
Shrubland/Scrubland	0.1	tCO_2e / ha / year	Low
Grasslands	2.6	tCO_2e / ha / year	Low
Wetlands	3.3	tCO_2e / ha / year	Low
Croplands	0.4	tCO_2e / ha / year	Low
Settlements	0	tCO_2e / ha / year	Low
Other	0	tCO_2e / ha / year	Low

The GHG quantification methods for land use change is presented below:

$$\textbf{Emissions}_{\text{Lands Not Converted}} = \textit{Land Type}_{ha} * EF_{Sequester}$$

$$\textbf{Emissions}_{\text{Lands Converted}} = \textit{Land Type}_{ha} * (EF_{Release} / (\textit{Current Land Reporting}_{Year} - \textit{Last Land Reporting}_{Year} + 1))$$

4.5.5.2 Emissions from Livestock

Emissions from Livestock includes enteric fermentation and manure management emission sources. IPCC derived emission factors were used to estimate this emissions source (Table 28).

Table 28 Livestock Emission Factors

Animal	Enteric Methane (tCO_2e / head / year)	Methane from Wastes (tCO_2e / head / year)	Quality Assessment Rating
Dairy Breeding Herd	2.875	0.325	Medium

Animal	Enteric Methane (tCO_2e / head / year)	Methane from Wastes (tCO_2e / head / year)	Quality Assessment Rating
Beef Herd	1.200	0.069	Medium
Cattle: Others>1, Dairy Heifers	1.200	0.150	Medium
Cattle: Others<1	0.820	0.074	Medium
Pigs	0.038	0.075	Medium
Breeding Sheep	0.200	0.005	Medium
Other Sheep	0.200	0.005	Medium
Lambs < 1 year	0.080	0.002	Medium
Goats	0.125	0.003	Medium
Sheep / Lamb / Goat	0.151	0.004	Medium
Horses	0.450	0.035	Medium
Deer (Stags & Hinds)	0.260	0.007	Medium
Deer (Calves)	0.130	0.003	Medium
Poultry	-	0.002	Medium

The GHG quantification methods to estimate livestock emissions is presented below:

$$\textbf{Emissions}_{\text{Livestock}} = Livestock\ Type_{Head} * (EF_{Enteric\ Methane} + EF_{Methane\ From\ Waste})$$

4.5.5.3 Emissions from Aggregate Sources and Non-CO_2 Emission Sources on Land

Emissions from Aggregate Sources and Non-CO_2 Emission Sources on Land includes direct N_2O emissions from agricultural soil management and indirect N_2O emissions from applied nitrogen. To estimate these GHG emissions, the total area of farmland for BC is used in conjunction with 2024 NIR data to develop a tCO_2e / ha value. This is then be applied to the total crop land in hectares to derive a GHG emissions estimate.

The GHG quantification method is presented below:

$$\textbf{Emissions}_{\text{Direct \& Indirect N2O}} = ((BC_{Direct\ N2O\ Emissions} + BC_{Indirect\ N2O\ Emissions} + BC_{Indirect\ N2O\ Manure\ Management\ Emissions}) / BC_{Land\ In\ Crops\ ha}) * RDN\ Cropland_{ha}$$

$$\textbf{Emissions}_{\text{Urea Application}} = RDN\ Cropland_{ha} * 0.06\ tCO_2e / ha$$

5.0 2023 GHG REPORTING YEAR RESULTS

This section presents the 2023 reporting year GHG emissions for the RDN.

5.1 SUMMARY

Total BASIC, and BASIC+ emissions for the RDN for the 2023 reporting year are presented in Figure 3 below.

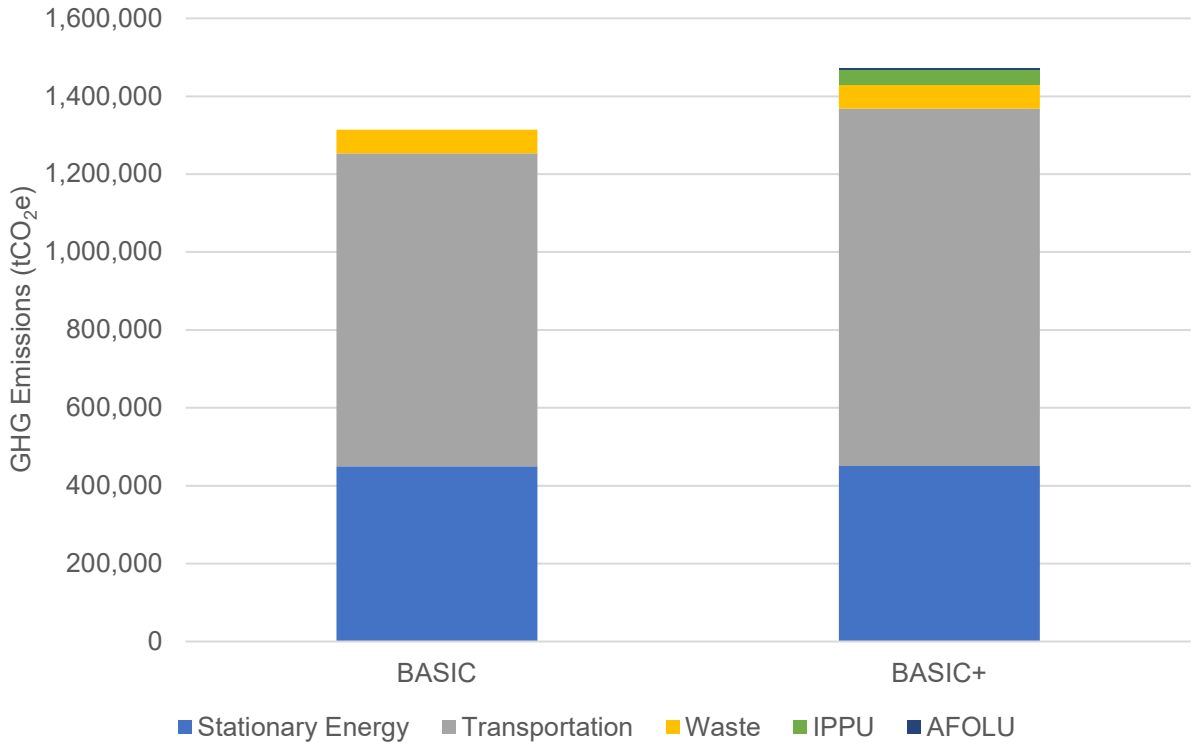

Figure 3 2023 GHG Emissions Summary by GPC Reporting Level

Emissions by reporting level are presented in Table 29 below which shows a difference in emissions under the GPC Protocol's BASIC, and BASIC+ reporting levels. This is due to the inclusion of additional sources in BASIC+ which are very significant for almost any growing community. These additional emissions include transboundary emissions, industrial and product use emissions, and emissions from land-use change. Under the GPC Protocol, emissions included within each higher reporting level are cumulative from lower levels.

Table 29 Breakdown of the RDN's 2023 GHG Emissions in GPC Reporting Format

GHG Emissions Source (by Sector)		Total GHGs (metric tonnes CO_2e)					
		Scope 1	Scope 2	Scope 3	BASIC	BASIC+	BASIC+ S3
Stationary Energy	Energy use (all emissions except I.4.4)	433,576	16,087	1,078	449,663	450,741	450,741
	Energy generation supplied to the grid (I.4.4)	0					
Transportation	(all II emissions)	803,633	6	114,326	803,638	917,964	917,964
Waste	Waste generated in the Community (III.X.1 and III.X.2)	61,098		0	61,098	61,098	61,098
	Waste generated outside community (III.X.3)	NO					
IPPU	(all IV emissions)	38,817				38,817	38,817
AFOLU	(all V emissions)	4,273				4,273	4,273
Other Scope 3 (S3)	(all VI emissions)			NE			NE
TOTAL		**1,341,397**	**16,093**	**115,404**	**1,314,400**	**1,472,894**	**1,472,894**

NOTES:
Notation Keys: IE = Included Elsewhere; NE = Not Estimated; NO = Not Occurring.
Cells in green are required for BASIC reporting.
Cells in green and blue are required for BASIC+ reporting.
Cells in purple are for disclosure purposes only but are not included in the summary totals as required by the GPC Protocol.
Cells in orange are not required for BASIC or BASIC+ reporting

Table 30 presents the breakdown of the RDN's BASIC+ GHG emissions by Sector and Sub-Sector.

Table 30 Breakdown of the RDN's 2023 BASIC+ GHG Emissions in the GPC Protocol Reporting Format

GPC ref No.	GHG Emissions Source (by Sector and Sub-Sector)	Total GHGs (metric tonnes CO_2e)			
		Scope 1	Scope 2	Scope 3	Total
I	**Stationary Energy**				
I.1	Residential buildings	122,235	10,164	681	133,080
I.2	Commercial and institutional buildings and facilities	79,417	5,923	397	85,737
I.3	Manufacturing industries and construction	174,495	IE	IE	174,495
I.4.1/2/3	Energy industries	582	IE	IE	582
I.4.4	Energy generation supplied to the grid	0			
I.5	Agriculture, forestry, and fishing activities	55,697	IE	IE	55,697
I.6	Non-specified sources	IE	IE	IE	IE
I.7	Fugitive emissions from mining, processing, storage, and transportation of coal	NO			NO
I.8	Fugitive emissions from oil and natural gas systems	1,151			1,151
Sub-Total	(community induced framework only)	**433,576**	**16,087**	**1,078**	**450,741**
II	**Transportation**				
II.1	On-road transportation	756,616	6	114,326	870,947
II.2	Railways	1,630	IE	IE	1,630
II.3	Waterborne navigation	9,606	IE	IE	9,606
II.4	Aviation	NE	IE	NE	NE
II.5	Off-road transportation	35,781	IE	IE	35,781
Sub-total	(community induced framework only)	**803,633**	**6**	**114,326**	**917,964**
III	**Waste**				
III.1.1/2	Solid waste generated in the Community	53,826		NO	53,826
III.2.1/2	Biological waste generated in the Community	4,015		NO	4,015
III.3.1/2	Incinerated and burned waste generated in the Community	160		NO	160
III.4.1/2	Wastewater generated in the Community	3,097		IE	3,097
III.1.3	Solid waste generated outside the Community	IE			
III.2.3	Biological waste generated outside the Community	NO			

Table 30 Breakdown of the RDN's 2023 BASIC+ GHG Emissions in the GPC Protocol Reporting Format

GPC ref No.	GHG Emissions Source (by Sector and Sub-Sector)	Total GHGs (metric tonnes CO_2e)			
		Scope 1	Scope 2	Scope 3	Total
III.3.3	Incinerated and burned waste generated outside community	NO			
III.4.3	Wastewater generated outside the Community	NO			
Sub-total	(community induced framework only)	**61,098**		**0**	**61,098**
IV	**Industrial Processes and Product Uses**				
IV.1	Emissions from industrial processes occurring in the Community boundary	IE			IE
IV.2	Emissions from product use occurring within the Community boundary	38,817			38,817
Sub-Total	(community induced framework only)	**38,817**			**38,817**
V	**Agriculture, Forestry, and Other Land Use**				
V.1	Emissions from livestock	4,184			4,184
V.2	Emissions from land (not included in total)	-261,593			-261,593
V.3	Emissions from aggregate sources and non-CO_2 emission sources on land	89			89
Sub-Total	(community induced framework only)	**4,273**			**4,273**
VI	**Other Scope 3**				
VI.1	Other Scope 3			NE	NE
Total	(community induced framework only)	**1,341,397**	**16,093**	**115,404**	**1,472,894**

NOTES:
Cells in green are required for BASIC reporting.
Cells in green and blue are required for BASIC+ reporting.
Cells in purple are for disclosure purposes only but are not included in the summary totals as required by the GPC Protocol.
Cells in orange are not required for BASIC or BASIC+ reporting

5.2 TOTAL GHG EMISSIONS

Under the BASIC+ method, the RDN's GHG emissions totaled 1,472,894 tCO_2e. On a per capita basis, this works out to 8.0 tCO_2e per person (Table 31).

Table 31 Total Energy and GHG Emissions Per Person by Sector

Sector	Sub-Sector	Energy (GJ)	GHG Emissions (tCO_2e)	GJ Per Capita	tCO_2e Per Capita
Stationary Energy	Residential Buildings	6,083,056	133,080	33.2	0.7
	Commercial & Institutional Buildings	3,516,822	85,737	19.2	0.5
	Manufacturing Industries & Construction	3,282,061	174,495	17.9	1.0
	Agriculture, Forestry & Fishing activities	-	582	-	0.0
	Non-Specified Sources	868,725	55,697	4.7	0.3
	Fugitive Emissions	-	1,151	-	0.0
Transportation	In-Boundary On-road Transportation	12,566,270	756,621	68.7	4.1
	Trans-Boundary On-road Transportation	1,898,785	114,327	10.4	0.6
	Waterborne Navigation	129,828	9,606	0.7	0.1
	Aviation	-	-	-	-
	Railways	25,429	1,630	0.1	0.0
	Off-road Transportation	557,763	35,781	3.0	0.2
Waste	Solid Waste		53,826		0.3
	Biological Treatment of Waste		4,015		0.0
	Waste Incineration & Open Burning		160		0.0
	Wastewater Treatment & Discharge		3,097		0.0
IPPU	Product Use		38,817		0.2
AFOLU	Land-Use: Emissions Sequestered		(270,915)		(1.5)
	Land-Use: Emissions Release		9,322		0.1
	Livestock		4,184		0.0
	Non-CO_2 Land Emission Sources		89		0.0
Total		**28,928,738**	**1,472,894**	**158.0**	**8.0**

Total GHG emissions for 2023 are 1,472,894 tCO_2e and have increased 16.1% from the 2007 reporting year. Scope 1 and 2 Emissions are 91.1% and 1.1% of the total GHG inventory. Scope 1 emissions are the GHG emissions that result from the combustion of fuel in sources within the RDN's boundaries, primarily from Stationary Energy and Transportation. Scope 1 GHG emissions also include IPPU and some AFOLU GHG emissions. Scope 2 emissions result from the use of electricity supplied to the RDN which includes emissions associated with the generation of electricity and other forms of energy (e.g., heat and steam). Scope 2 emissions are low compared to other geographies, due to the predominance of hydroelectric generation technologies in the BC. Scope 3 emissions are emissions from electricity line losses, transboundary traffic, and emissions associated with the RDN that are occurring outside of the RDN's boundaries. For 2023, Scope 3 GHG emissions make up 7.8% of the GHG inventory. This breakdown by emission scope is depicted in Figure 4.

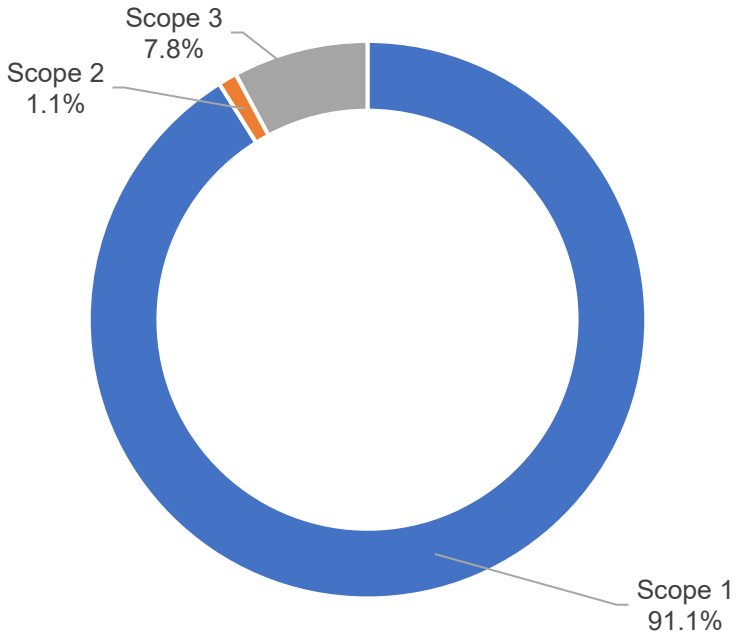

Figure 4 RDN BASIC+ GHG Emissions by Emissions Scope

A breakdown of GHG emissions by reporting scope for the 2007 and 2023 reporting years are presented in Table 32.

Table 32 Change in GHG Emissions Between 2007 & 2023 Reporting Years

Emissions Scope	2007 GHG Emissions (tCO_2e)	2023 GHG Emissions (tCO_2e)	Change
Scope 1	1,127,031	1,341,397	19.0%
Scope 2	49,710	16,093	-67.6%
Scope 3	92,235	115,404	25.1%
Total	**1,268,976**	**1,472,894**	**16.1%**

5.3 SECTORAL GHG EMISSIONS ANALYSIS

5.3.1 Stationary Energy

Stationary energy sources are one of the largest contributors to the RDN's GHG emissions. In 2023, excluding sequestered GHG emissions, it contributed 30.6% of the community's GHG emissions. In general, stationary energy emissions include the energy to run manufacturing processes and other industrial activities (e.g., compressor stations), energy to heat and cool residential, commercial, and industrial buildings, as well as the activities that occur within these residences and facilities. Fugitive methane emissions from natural gas pipelines and other distribution facilities, and related off-road GHG emissions, are also reported in this Sector. The table below shows the breakdown of energy use in the stationary energy reporting category.

Table 33 summarizes the energy and GHG emissions for the 2023 reporting year.

Table 33 2023 Energy and GHG Emissions by Stationary Energy Sector

Sector	Electricity (tCO_2e)	Natural Gas (tCO_2e)	Heating Oil (tCO_2e)	Propane (tCO_2e)	Wood (tCO_2e)	Other Sources (tCO_2e)	**Total GHG Emissions (tCO_2e)**	**Total Energy (GJ)**
Residential Buildings	10,845	79,588	20,963	8,002	10,861	2,821	**133,080**	**6,083,056**
Commercial & Institutional Buildings	6,320	51,124	-			28,293	**85,737**	**3,516,822**
Manufacturing Industries & Construction		143,403				31,092	**174,495**	**3,282,061**
Agriculture, Forestry & Fishing activities						582	**582**	
Non-Specified Sources						55,697	**55,697**	**868,725**
Fugitive Emissions						1,151	**1,151**	
Total GHG Emissions (tCO_2e)	**17,165**	**274,116**	**20,963**	**8,002**	**10,861**	**119,635**	**450,741**	
Total Energy (GJ)	**5,468,491**	**5,514,468**	**302,234**	**131,146**	**497,436**	**1,836,888**		**13,750,664**

It can be seen in Figure 5 that natural gas use contributed to 60.8% of the RDN's total Stationary Energy GHG emissions.

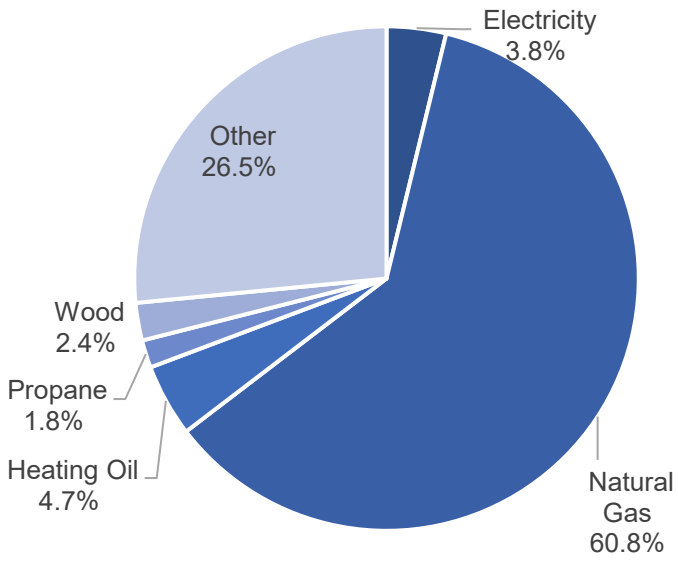

Figure 5 Stationary Energy GHG Emissions Contribution to the GHG Inventory

Figure 6 shows that the stationary GHG emissions largely arise from the operation of residential and commercial buildings.

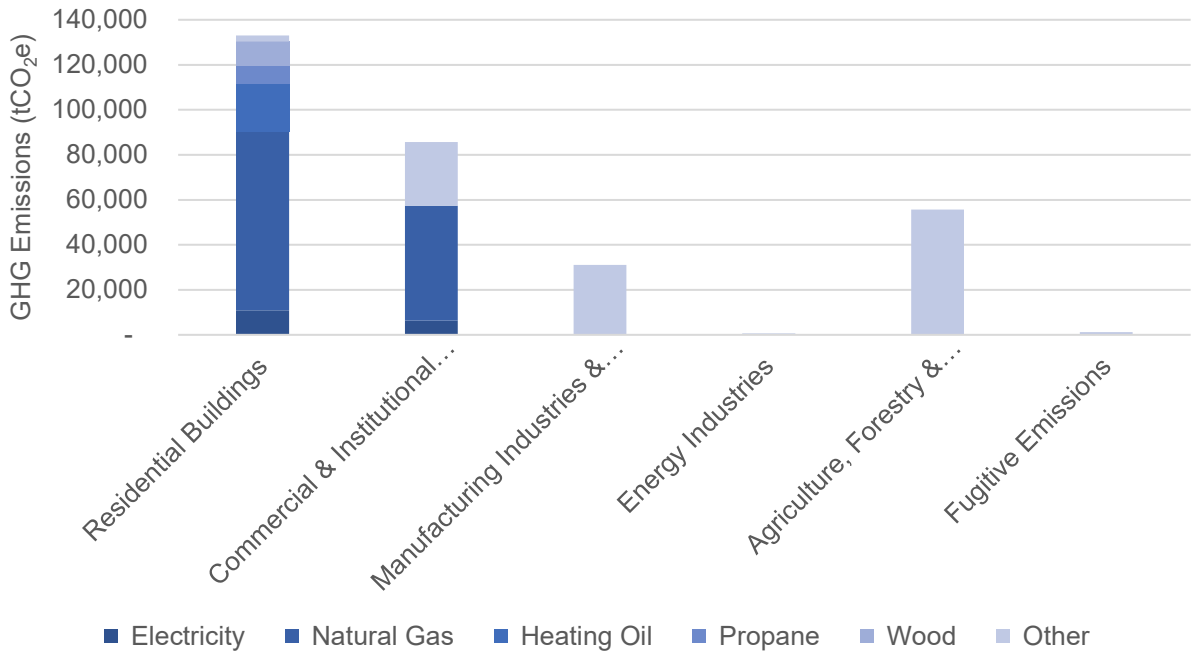

Figure 6 Total Stationary Energy Use By Sub-Sector

Stationary energy GHG emissions has increased 4.5% as compared to the 2007 base year and declined 2.1% as compared to the 2022 reporting year (Table 34).

Table 34 Stationary Energy—Energy and GHG Emissions Trends

Sector	Change in tCO_2e: 2007 & 2023	Change in tCO_2e: 2002 & 2023
Residential Buildings	-24.2%	-8.2%
Commercial & Institutional Buildings	-3.2%	2.4%
Manufacturing Industries & Construction	33.0%	0.1%
Energy Industries	25.9%	-7.3%
Agriculture, Forestry & Fishing activities	60.0%	0.0%
Fugitives	97.4%	0.0%
Total	**4.5%**	**-2.1%**

5.3.2 Transportation

Transportation covers all emissions from combustion of fuels in journeys by road, rail, water, and air, including inter-community and international travel. For the 2023 reporting year, transportation GHG emissions accounted for 62.3% of the RDN GHG inventory with the bulk of transportation GHG emissions resulting from the on-road transportation sub-sector (94.9%). The transportation GHG emissions are produced directly by the combustion of fuel or indirectly because of the use of grid-supplied electricity. Unlike stationary emission sectors, transit is mobile and can pose challenges in both accurately calculating emissions and allocating them to the cities linked to the transit activity. The following sections summarize energy and GHG emissions by on-road transportation, which is then followed by off-road transportation (marine, aviation, and other).

Table 35 summarizes the on-road energy and GHG emissions for the 2023 reporting year.

Table 35 2023 On-Road Transportation Energy And GHG Emissions by Fuel Type

Fuel Type	Number of Registered Vehicles	Total Fuel Use	Fuel Use Units	Energy (GJ)	GHG Emissions (tCO_2e)
Electricity	2,904	491,821	kWh	1,771	6
Gasoline	133,281	301,090,493	Liters (L)	10,435,796	614,787
Diesel	10,282	103,172,044	Liters (L)	3,990,695	254,066
Propane	1,770	1,437,543	Liters (L)	36,700	2,084
Hydrogen	2,601	1,670,315	Liters (L)	-	-
Natural Gas	59	1,723,473	Kilograms (kg)	93	5
Total	**150,897**	**N/A**	**N/A**	**14,465,055**	**870,947**

Overall, GHG emissions from on-road transportation has increased by 18.7% compared to the 2007 reporting year. Figure 7 provides a breakdown of GHG emisisons by vehicle classification. More than 65% of the on-road GHG emissions come from light duty vehciles and trucks.

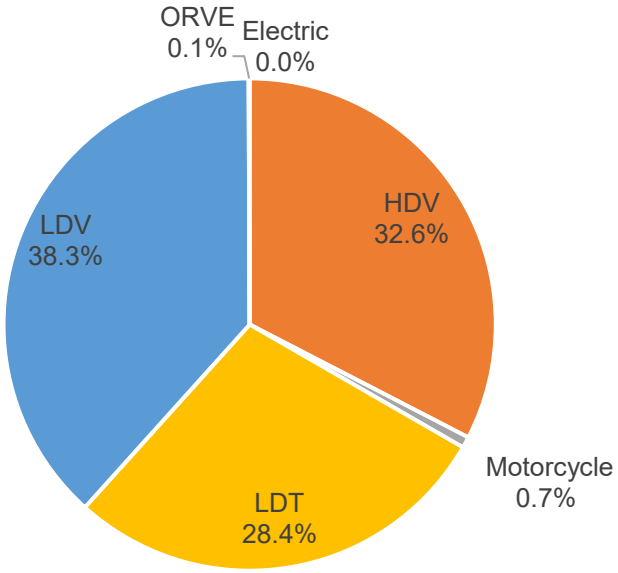

Figure 7 Breakdown of On-Road GHG Emissions by Vehicle Type

Table 36 summarizes the waterborne, and off-road transportation energy and emissions by fuel type. These GHG emissions contribute to 5.1% of the total transportation GHG emissions and 3.1% to the total inventory, after excluding for land use sequestration (Figure 8).

Table 36 2023 Aviation, Waterborne, and Off-Road Transportation Energy and Emissions by Fuel Type

Fuel Type	Total	Units	Energy (GJ)	GHG Emissions (tCO_2e)
Marine Gasoline	3,231	Liters (L)	112	7
Marine Diesel	3,276,592	Liters (L)	126,739	9,429
Marine Natural Gas	76,624	Liters (L)	2,977	170
Railway Diesel	657,428	Liters (L)	25,429	1,630
Aviation Jet Fuel	-	Liters (L)	-	-
Other Off-Road Transportation Diesel	14,427,970	Liters (L)	557,763	35,781
Total	**N/A**	**N/A**	**713,020**	**47,017**

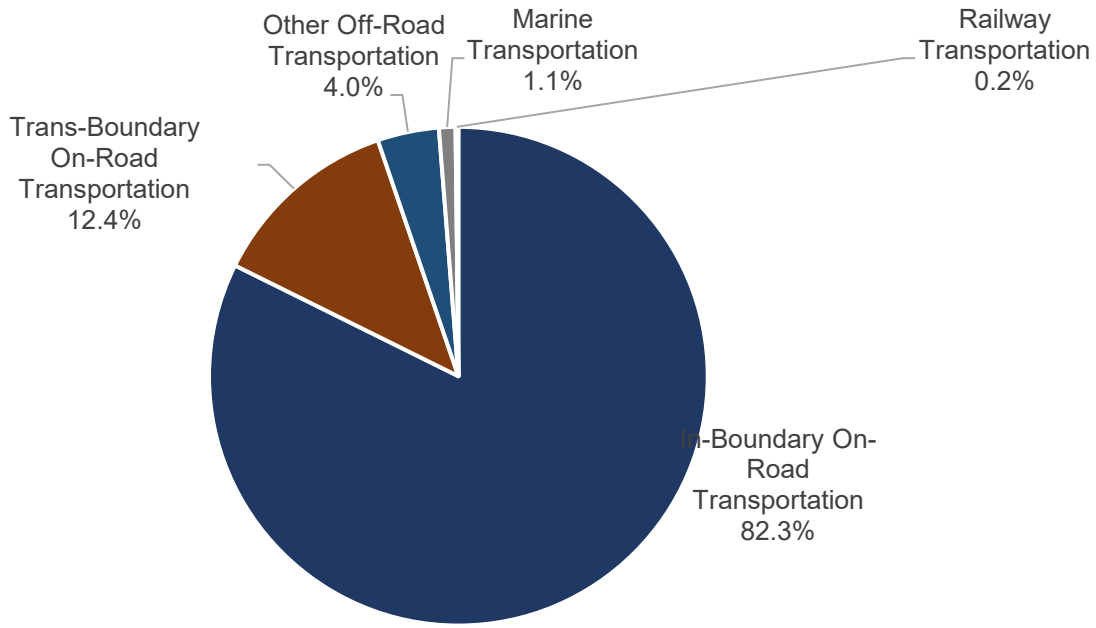

Figure 8 Summary of Transportation GHG Emissions by Sub-Sector

5.3.3 Waste

Communities produce solid waste, compost, and wastewater. Waste does not directly consume energy, but when deposited into landfills, or left exposed to the atmosphere, it decomposes and releases methane (CH_4) gas which is a potent GHG. The GHG emissions from the solid waste, composting, and wastewater facilities for the reporting year is summarized in the following table. For the 2023 reporting year, waste emissions contributed 4.1% to the GHG inventory after excluding sequestration GHG emissions. A breakdown of the Waste Sub-Sector GHG emissions is presented in Table 37.

Table 37 Summary of Waste Sub-Sector GHG Emissions

Sector	2023 GHG Emissions (tCO_2e)	GHG Emissions Per Capita (tCO_2e / Capita)	Change from Reporting year (2007)
Wastewater Treatment & Discharge	3,097	0.02	57.6%
Biological Treatment of Solid Waste	4,015	0.02	920%
Waste Incineration & Open Burning	160	0.00	27%
Solid Waste	53,826	0.29	16.1%
Total	**61,098**	**0.33**	**29.9%**

For the 2023 reporting year, in scope GHG emissions from waste have increased by 29.9% compared to the 2007 reporting year. Fluctuations in waste will occur over the reporting periods as waste is driven by both the population, as well as economic prosperity in the region. The Solid Waste Sub-Sector contributes more than 88% of total waste GHG emissions (Figure 9). To reduce the amount of waste landfilled, and thus GHG emissions, the RDN and its members are making a significant effort to reduce waste going to landfills through organics diversion and recycling.

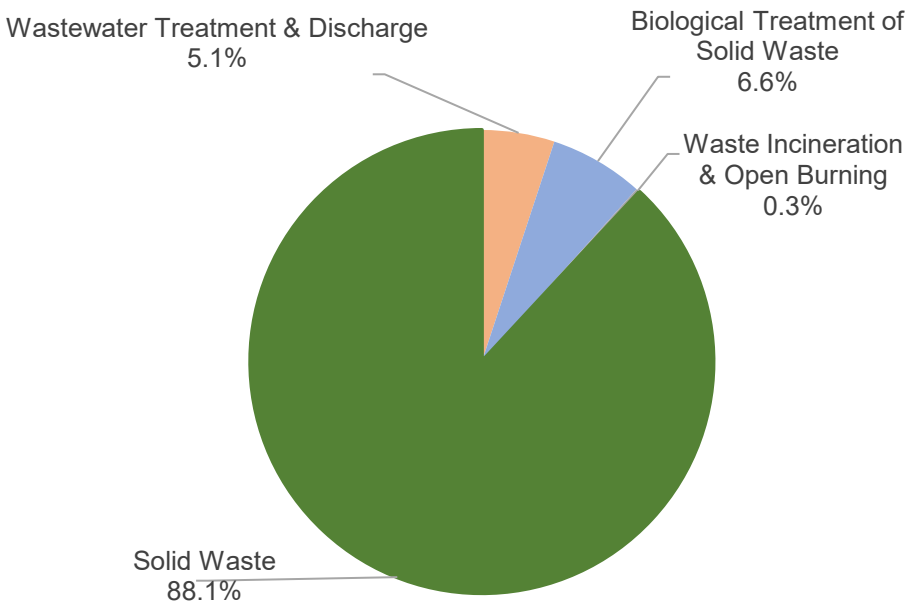

Figure 9 2023 GHG Emissions from Waste (tCO_2e)

5.3.4 Industrial Processes and Product Use (IPPU)

Reporting on IPPU GHG emissions is required for BASIC+ reporting only. Industrial GHG emissions are produced from a wide variety of non-energy related industrial activities which are typically releases from industrial processes that chemically or physically transform materials. During these processes, many different GHGs can be produced. It is not clear if there are industrial GHG emissions occurring within the RDN's boundaries and thus a "Not Estimated" notation is used in the GPC tables.

Also included in the IPPU Sector is Product Use GHG emissions. Certain products used by industry and end-consumers, such as refrigerants, foams, or aerosol cans, also contain GHGs which can be released during use and disposal and thus, as with best-practice, must be accounted for. For the reporting year, only the emissions estimated were production and consumption of halocarbons, SF_6 and NF_3 were estimated for the RDN on the basis that other GHG emissions sources identified in the NIR are not likely to be occurring in the RDN. The sources of these GHG emissions are typically fridges, heat pumps, and air conditioners.

Between the 2007 and 2023 reporting years, IPPU GHG emissions have increased by 90.4% (Table 38). The increase in GHG emissions is largely related to ECCC's estimate of GHG emissions for BC which is allocated to the RDN on a per capita basis.

Table 38 Product Use GHG Emissions for the 2007 and 2023 Reporting Years

Sub-Sector	2007 GHG Emissions (tCO_2e)	2023 GHG Emissions (tCO_2e)	Change
Product Use Emissions	38,817	20,388	90.4%

5.3.5 Agriculture, Forestry, and Other Land Use

The AFOLU Sector includes GHG emissions from livestock, land use, and all other agricultural activities occurring within the RDN's boundaries.

The following information is provided for disclosure purposes only. Using remotely sensed imagery, land cover data was used to estimate land use changes between the reporting years. In 2023, the RDN's greenspace is estimated to have sequestered and stored 270,915 tCO_2e (Table 39), and released 9,322 tCO_2e for a net reduction of 261,593 tCO_2e. Due to limitations in how to quantify GHG emissions resulting from land use change (e.g., residential development) and ecosystem sequestration, these GHG emissions have been excluded from the RDN's GHG emissions inventory, but have been disclosed, until a more robust measurement methodology can be developed.

Table 39 Summary of Land Area & GHG Emissions By Land Use Sector

Land Use Sector	Average Area in Hectares (ha)	GHG Emissions Sequestered (tCO_2e)	GHG Emissions Released (tCO_2e)
Settlement Forest	5,682	(4,275)	
Vegetated Settlement	4,254	(2,242)	
Forest Regenerating after Fire <20 years	289	(1,489)	
Forest Regenerating after Harvest <20 years	57,058	(34,130)	
Forest Wetland Regenerating after Harvest <20 years	78	(37)	
Wetland	525	(1,734)	
Forest	121,053	(219,118)	
Cropland	1,954	(788)	
Forest Wetland	2,088	(6,891)	

Land Use Sector	Average Area in Hectares (ha)	GHG Emissions Sequestered (tCO_2e)	GHG Emissions Released (tCO_2e)
Grassland Unmanaged	522	(210)	
High Reflectance Settlement	1,028		1,261
Other Land	319		
Roads	5,466		1,096
Very High Reflectance Settlement	565		1,054
Water	108,112		
Settlement	3,707		5,912
Total	**312,701**	**(270,915)**	**9,322**

Figure 10 presents the land use classes by proportion of total area. It shows that the majority of lands within the RDN are forested.

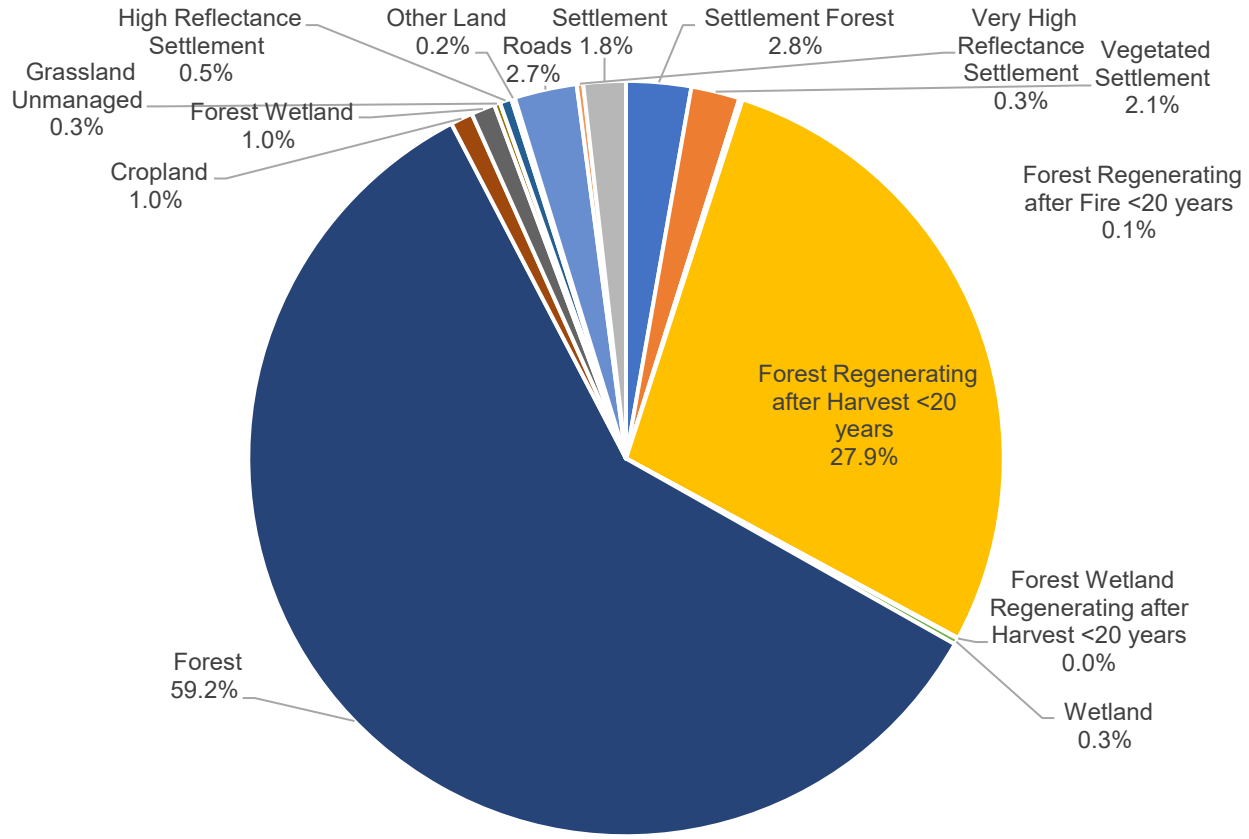

Figure 10 Breakdown of Land Classes

5.3.5.1 Livestock and Other Agriculture

In addition to land use change, GHG emissions from the AFOLU Sector are produced through a variety of non-land use pathways, including livestock (enteric fermentation and manure management), and aggregate sources and non-CO_2 emission sources on land (e.g., fertilizer application). Under this Sector, the RDN reports on GHG emissions from the following sources, and Sub-Sectors:

- Scope 1 GHG Emissions:
  - Livestock:
    - Methane (CH_4) Emissions from Enteric Fermentation
    - Methane (CH_4) Emissions from Manure Management
    - Direct Nitrous Oxide (N_2O) GHG Emissions
  - Aggregate Sources and Non-CO_2 Emissions Sources on Land
    - Direct Nitrous Oxide (N_2O) Emissions from Agricultural Soil Management
    - Indirect Nitrous Oxide (N_2O) Emissions from Applied Nitrogen

The GHG emissions from this source is presented in Table 40. Livestock GHG emissions have increased as a result of increasing livestock populations. Other land use GHG emissions sources have declined as the area of cropland in the RDN has also declined since the 2007 base year and this emission source is primarily driven by cropping activities (e.g., tilling, fertilizer application)

Table 40 Summary of Livestock and Aggregate Sources and Non-CO_2 Emissions Sources On Land Change GHG Emissions Between 2007 and 2023

Land Type	2007 GHG Emissions (tCO_2e)	2023 GHG Emissions (tCO_2e)	Change From 2007
Livestock	3,818	4,184	9.6%
Aggregate Sources and Non-CO_2 Emissions Sources On Land	109	89	-18.1%
Total	**3,927**	**4,273**	**8.8%**

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

Quality Assurance and Quality Control (QA/QC) procedures are applied to add confidence that all measurements and calculations have been made correctly and to reduce uncertainty in data. Examples include:

- Checking the validity of all data before it is processed, including emission factors.
- Performing recalculations to reduce the possibility of mathematical errors.
- Recording and explaining any adjustments made to the raw data.
- Documenting quantification methods, assumptions, emission factors and data quality

With respect to the GHG inventory, the data was subject to various quality assurance and quality control checks throughout the collection, analysis, and reporting phases. Specifically, the following procedures were followed:

- Upon receipt of data from the RDN, the data was checked for completeness (e.g., all months of data are present), relevancy (e.g., the correct calendar year is presented), and reasonableness (e.g., comparing similar transportation data sets). Incorrect or incomplete datasets were queried directly with the data provider.
- Where estimates were used (e.g., fuel oil consumption), all possible data sources were considered for their accuracy and relevance to the community before a final method and data source was selected.
- All manual data transfers were double-checked for data transfer accuracy.
- The inventory was compared to other third-party inventories (e.g., CEEI) to assess for reasonableness of the estimates.
- The inventory underwent internal RDN reviews to confirm assumptions, data and reasonableness of the estimates.

7.0 RECOMMENDATIONS

To remain accurate and reflective of the current community conditions, the RDN should revise and improve its GHG emissions inventory either annually or in line with capital planning cycles (i.e., every 3-4 years), focusing on these general aspects:

- Improving activity data collection and management, including Sector and Sub-Sector allocations.
- Performing recalculations, where applicable, and tracking GHG emissions over time.
- Reviewing methodologies and data to assess for opportunities to improve the estimates.
- Assessing changes to boundaries, methodologies, assumptions, or data that may be material and require a reporting year restatement.

The next section provides a summary of specific GHG inventory improvement recommendations.

7.1 INVENTORY ASSUMPTIONS, ASSESSMENT, AND RECOMMENDATIONS

In the preparation of the 2023 GHG emissions inventory, there are several assumptions were made in the analysis that will have some influence on accuracy of the RDN's estimate of GHG emissions. Most emission sources have been calculated with a high level of confidence, due to the presence of utility records, and direct energy and emissions data being provided by stakeholders. Data sources and assumptions with medium to high uncertainty are presented in Table 41 which summarizes the main assumptions, possible impacts on the data, and recommended improvement. It is recommended that the RDN prioritize improvements that are likely to have a material (>5%) influence on the GHG inventory estimate.

Table 41 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements

Sector	Issue / Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
Stationary Energy	The energy utility providers provide energy in lump sum amounts for: residential, commercial, and industrial. As such, energy consumption from industrial operations had to be estimated and removed from the total.	Immaterial impact on the GHG inventory (<5%)	Work with the utility provider to get a more detailed breakdown of energy use by sub-sector. Reach out to the industrial entities to see if they would be amendable to sharing their energy consumption data.
Stationary Energy	Manufacturing, mining construction and agricultural off-road emissions were estimated using the 2024 NIR estimates for BC.	Immaterial impact on the GHG inventory (<10%)	Work with local industry to support GHG emission reporting.

Table 41 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements

Sector	Issue / Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
Stationary Energy	FortisBC provided a total estimate of fugitive emissions for the CRD region for 2020; however, this did not include upstream fugitive emissions as suggested as best practice by the GPC Protocol.	Immaterial impact on the GHG inventory (<1%)	Work with FortisBC to refine this estimate.
Transportation	Vehicle kilometers travelled (VKT) was estimated; the Province has a low certainty value.	Possible material impact on the GHG inventory (>10%)	Consider completing an origin destination study that includes collecting annual travel distances by mode.
Transportation	The GHG emissions from recreational watercraft were estimated based on an average boat count at a harbor. The energy split is based on a publicly available year 2000 study.	Immaterial impact on the GHG inventory (<5%)	Work with the harbors to deploy a database tracking the types of boats entering the harbor.
Transportation	Cruise ships and deep-sea vessel GHG emissions were estimated using third party emission factors.	Immaterial impact on the GHG inventory (<5%)	Work with the Nanaimo Port Authority to derive a localized estimate of GHG emissions.
Transportation	BC Ferries fuel consumption was estimated based on total passengers.	Immaterial impact on the GHG inventory (<5%)	Work with BC Ferries to improve this estimate and/or get actual fuel volumes for the routes servicing the RDN.
Transportation	The Nanaimo airport air traffic GHG emissions were not estimated at the request of the airport.	Immaterial impact on the GHG inventory (<5%)	Work with the Airport to derive a localized estimate of GHG emissions.
Transportation	Seaplane GHG emissions and movements were not estimated.	Immaterial impact on the GHG inventory (<1%)	Work with Sea Plane organizations to derive a localized estimate of GHG emissions.
Transportation	Rail GHG emissions were estimated using 2022 EC NIR data and total km of rail.	Immaterial impact on the GHG inventory (<1%)	No recommendations currently.
Waste	The number of homes on septic was estimated using the number of homes not being serviced.	Immaterial impact on the GHG inventory (<1%)	No recommendations currently.

Table 41 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements

Sector	Issue / Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
Waste	Incineration and open burning GHG emissions were estimated and are based on data in a 2015 air quality report.	Immaterial impact on the GHG inventory (<1%)	Complete an air quality study on open burning and incineration GHG emissions.
IPPU	Product use emissions were estimated on a per capita basis using the 2024 NIR estimates. The product use emissions were estimated by the NIR using an IPCC Tier 1 approach and thus will have high uncertainty.	Immaterial impact on the GHG inventory (<5%)	No recommendations currently.
AFOLU	GHG estimates for land use change are based on a period of years (2007-2023) and thus were averaged for each period. As there was no annual data, land use change for the reporting year was estimated using the average value between the data years. Furthermore, there were issues with the spatial data (not being consistent, granular enough for analysis, and not all land-classes considered).	Possibly a material impact on the GHG inventory (>10%)	Work with the planning department to track land-use change annually so that a more refined estimate can be made. Work with the GIS department to gather and process LIDAR data for the region. Aim to collect this data every 3-5 years. This is a secondary priority to the recommended improvement below.
AFOLU	The land-use sequestration and storage GHG emission factors are taken from the literature, for BC ecozones, and may not reflect the productivity, or lack thereof, of land uses in the RDN. The land-change emission factors for changes between land types were derived by the Province. These are average values by ecozone and are based on a 20-year horizon. Since land-use change in the RDN is typically related to development, it was assumed that the loss of emissions is	Possibly a material impact on the GHG inventory (>10%)	Work with the Province and the post-secondary institutions to derive refined sequestration emission factors.

Table 41 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements

Sector	Issue / Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
	immediate which may overestimate GHG emission losses. In both emission factor applications, the use of non-site emission factors may result in an over or underestimate of GHG emissions.		

8.0 REFERENCES

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Appendix A

The following tables summarize RDN Member GHG Emissions by sector for the 2007, 2010, 2012, 2015-2023 reporting years. Also included is a comparison of the 2007 CEEI GHG emissions inventories as prepared by the Province.

July 11, 2024

Table A1. RDN GHG Emissions Summary (all units are tCO_2e)

Sector	2007 CEEI	2007 Updated	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022	2023
Residential Buildings	161,287	175,592	194,055	209,919	180,941	188,347	208,838	197,359	207,600	223,594	136,651	145,019	133,080
Commercial & Institutional Buildings	69,716	88,577	73,328	77,691	77,095	83,135	96,440	89,649	97,543	100,096	79,588	83,768	85,737
Manufacturing Industries & Construction	6,574	131,220	95,707	97,130	158,110	166,234	176,038	158,935	155,668	163,923	162,486	174,361	174,495
Energy Industries	-	462	464	594	350	497	511	546	589	631	688	628	582
Non-Specified Sources	-	-	-	-	-	-	-	-	-	-	-	-	-
Agriculture, Forestry & Fishing activities	12,482	34,815	28,292	30,103	43,110	40,748	47,480	56,431	53,931	47,611	48,671	55,697	55,697
Fugitive Emissions	-	583	915	950	1,012	1,040	1,076	1,115	1,167	1,151	1,151	1,151	1,151
In-Boundary On-road Transportation	527,905	644,726	654,025	667,806	690,639	702,269	666,725	681,806	646,036	597,913	731,720	715,660	756,621
Trans-Boundary On-road Transportation	-	88,904	90,187	92,087	95,236	96,839	91,938	92,858	90,187	67,470	101,621	108,137	114,327
Waterborne Navigation	-	6,518	7,690	8,289	9,647	11,209	9,009	10,118	9,094	7,211	9,122	9,636	9,606
Aviation	-	-	-	-	-	-	-	-	-	-	-	-	-
Railway	-	1,248	1,264	1,564	1,413	1,373	1,554	1,653	1,716	1,620	1,602	1,630	1,630
Off-road Transportation	-	24,215	21,240	20,278	24,294	29,965	32,718	33,615	33,299	35,352	34,862	35,629	35,781
Solid Waste	51,146	45,315	52,783	-	46,981	-	-	51,175	49,191	46,537	43,188	43,217	53,826
Biological Treatment of Waste	-	394	400	412	2,147	-	-	2,210	2,681	3,102	3,112	3,172	4,015
Incineration & Open Burning	-	126	129	132	135	136	137	140	142	145	147	150	160
Wastewater Treatment & Discharge	-	1,965	1,934	-	2,729	2,051	2,756	2,448	2,211	2,655	2,887	2,225	3,097
IPPU	-	20,388	31,645	34,690	40,225	43,321	42,669	46,640	46,640	46,782	46,361	39,436	38,817
Land-Use Change	83,158	(294,814)	(288,585)	(284,433)	(278,204)	(276,127)	(274,051)	(271,975)	(269,898)	(267,822)	(265,745)	(263,669)	(261,593)
Livestock	5,628	3,818	3,818	3,904	4,034	4,078	4,099	4,120	4,141	4,163	4,184	4,184	4,184
Non-CO2 Land Emission Sources	-	109	104	105	114	119	117	128	123	133	99	89	89
Total	**834,738**	**1,268,976**	**1,257,979**	**1,245,655**	**1,378,212**	**1,371,361**	**1,382,105**	**1,430,946**	**1,401,961**	**1,350,089**	**1,408,140**	**1,423,789**	**1,472,894**
Total W/Out Harmac Pulp Mill & N.Gas Gate GHG Emissions	**834,738**	**1,162,140**	**1,179,135**	**1,166,810**	**1,244,203**	**1,229,154**	**1,234,714**	**1,307,071**	**1,279,089**	**1,212,389**	**1,272,507**	**1,280,386**	**1,329,491**

Table A2. City of Nanaimo GHG Emissions Summary (all units are tCO_2e)

The 2010 CEEI data is also provided for Nanaimo as the City set 2010 as the baseline year.

Sector	2007 CEEI	2007 Updated	2010 CEEI	2010 Updated	2012	2015	2016	2017	2018	2019	2020	2021	2022	2023
Residential Buildings	87,833	95,065	83,188	111,102	122,962	103,195	109,234	123,460	117,148	123,223	132,836	82,560	81,289	74,001
Commercial & Institutional Buildings	55,888	67,863	51,456	52,050	54,949	55,113	59,753	70,600	64,976	71,252	72,476	55,458	57,084	58,138
Manufacturing Industries & Construction	-	121,934	-	89,285	90,094	148,564	156,632	164,699	145,190	142,935	153,839	152,259	162,571	162,654
Energy Industries		462	-	464	594	350	497	511	546	589	631	688	628	582
Non-Specified Sources		-	-	-	-	-	-	-	-	-	-	-	-	-
Agriculture, Forestry & Fishing activities		1,418	-	1,111	1,152	1,584	1,475	1,694	1,983	1,866	1,621	1,631	1,835	1,803
Fugitive Emissions		402	-	668	700	748	773	801	835	862	851	851	851	851
In-Boundary On-road Transportation	300,360	335,895	316,230	329,557	329,996	335,262	341,486	312,843	317,537	309,780	272,933	327,442	317,983	339,822
Trans-Boundary On-road Transportation		97,054	-	95,223	95,350	96,871	98,669	90,393	96,252	85,211	77,823	96,457	99,252	106,069
Waterborne Navigation		5,759	-	6,967	7,522	8,948	10,494	8,933	9,390	8,389	6,831	8,524	8,953	8,795
Aviation		-	-	-	-	-	-	-	-	-	-	-	-	-
Railway		367	-	371	460	415	403	457	486	504	476	471	479	479

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Sector	2007 CEEI	2007 Updated	2010 CEEI	2010 Updated	2012	2015	2016	2017	2018	2019	2020	2021	2022	2023
Off-road Transportation		13,958	-	12,305	11,800	14,346	17,753	19,431	20,000	19,856	21,067	20,691	21,045	20,786
Solid Waste	29,135	26,315	32,921	30,532	-	27,591	-	-	30,393	29,269	27,751	25,737	25,651	31,793
Biological Treatment of Waste		-	-	-	-	963	-	-	1,025	1,374	1,641	1,585	1,571	1,462
Incineration & Open Burning		-	-	-	-	-	-	-	-	-	-	-	-	-
Wastewater Treatment & Discharge		1,094	-	1,129	-	1,589	1,329	1,847	1,414	1,181	1,730	1,875	1,259	1,831
IPPU		12,623	-	19,593	21,340	24,292	26,008	25,780	28,356	28,356	28,619	28,533	24,417	24,034
Land-Use Change		(4,616)	-	(4,558)	(4,519)	(4,461)	(4,441)	(4,422)	(4,402)	(4,383)	(4,363)	(4,344)	(4,324)	(4,305)
Livestock		-	-	-	-	-	-	-	-	-	-	-	-	-
Non-CO2 Land Emission Sources		4		4	4	4	4	4	5	4	5	3	3	3
Total	**473,216**	**780,213**	**483,795**	**750,361**	**736,923**	**819,836**	**824,512**	**821,455**	**835,535**	**824,654**	**801,129**	**804,765**	**804,870**	**833,102**
Total W/Out Harmac Pulp Mill & N.Gas Gate GHG Emissions	**473,216**	**673,377**	**483,795**	**671,517**	**658,079**	**685,827**	**682,305**	**674,064**	**711,661**	**701,781**	**663,429**	**669,132**	**661,466**	**689,699**

Table A3. Town of Qualicum Beach GHG Emissions Summary (all units are tCO_2e)

Sector	2007 CEEI	2007 Updated	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022	2023
Residential Buildings	11,311	12,237	10,296	10,628	9,791	9,995	10,585	9,944	10,558	11,485	10,408	12,577	11,552
Commercial & Institutional Buildings	3,250	4,048	3,995	4,227	4,005	4,106	4,555	4,339	4,561	4,380	4,257	4,533	4,954
Manufacturing Industries & Construction	-	990	685	773	1,133	1,165	1,343	1,588	1,434	1,105	1,090	1,257	1,262
Energy Industries	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-Specified Sources	-	-	-	-	-	-	-	-	-	-	-	-	-
Agriculture, Forestry & Fishing activities	-	316	239	242	317	291	328	377	347	295	290	319	305
Fugitive Emissions	-	67	58	59	63	63	64	64	69	68	68	68	68
In-Boundary On-road Transportation	28,863	31,446	32,590	33,309	33,826	34,218	33,890	32,890	30,977	34,575	38,133	35,062	33,938
Trans-Boundary On-road Transportation	-	9,086	9,417	9,624	9,774	9,887	9,792	9,969	8,521	9,859	11,233	10,944	10,593
Waterborne Navigation	-	110	102	107	97	100	11	100	96	51	80	89	100
Aviation	-	-	-	-	-	-	-	-	-	-	-	-	-
Railway	-	-	-	-	-	-	-	-	-	-	-	-	-
Off-road Transportation	-	1,483	1,260	1,180	1,384	1,715	1,850	1,867	1,824	1,923	1,894	1,896	1,843
Solid Waste	3,083	2,775	3,180	-	2,691	-	-	2,894	2,732	2,550	2,349	2,348	2,864
Biological Treatment of Waste	-	-	-	-	229	-	-	227	226	243	263	279	525
Incineration & Open Burning	-	-	-	-	-	-	-	-	-	-	-	-	-
Wastewater Treatment & Discharge	-	275	233	-	325	201	252	300	313	268	280	273	364
IPPU	-	828	1,285	1,466	1,891	2,101	2,001	2,113	2,113	2,045	1,954	1,601	1,576
Land-Use Change	-	(1,351)	(1,337)	(1,329)	(1,315)	(1,311)	(1,307)	(1,302)	(1,298)	(1,293)	(1,289)	(1,285)	(1,280)
Livestock	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-CO2 Land Emission Sources	-	1	1	1	1	1	1	1	1	1	1	1	1
Total	**46,507**	**63,663**	**63,339**	**61,615**	**65,525**	**63,843**	**64,671**	**66,671**	**63,772**	**68,847**	**72,302**	**71,246**	**69,944**

Table A4. District of Lantzville GHG Emissions Summary (all units are tCO_2e)

Sector	2007 CEEI	2007 Updated	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022	2023
Residential Buildings	3,114	3,525	3,326	3,529	3,051	3,112	3,351	3,112	3,295	3,659	2,845	3,580	3,544
Commercial & Institutional Buildings	401	496	497	552	503	526	618	626	670	716	649	642	598
Manufacturing Industries & Construction	-	572	395	435	595	600	707	854	789	623	630	726	729
Energy Industries	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-Specified Sources	-	-	-	-	-	-	-	-	-	-	-	-	-
Agriculture, Forestry & Fishing activities	-	140	110	115	159	149	172	202	190	166	168	189	187
Fugitive Emissions	-	10	11	12	12	12	12	12	13	13	13	13	13
In-Boundary On-road Transportation	16,321	14,396	14,937	15,191	14,748	14,942	14,851	15,282	14,863	13,578	14,809	14,400	15,514
Trans-Boundary On-road Transportation	-	4,159	4,316	4,389	4,261	4,317	4,291	4,632	4,088	3,871	4,363	4,495	4,842
Waterborne Navigation	-	47	44	44	40	41	4	42	40	21	33	38	44
Aviation	-	-	-	-	-	-	-	-	-	-	-	-	-
Railway	-	-	-	-	-	-	-	-	-	-	-	-	-
Off-road Transportation	-	637	543	490	569	704	756	776	756	800	788	802	806
Solid Waste	1,331	1,184	1,371	-	1,123	-	-	1,183	1,136	1,056	978	976	1,212
Biological Treatment of Waste	-	-	-	-	96	-	-	93	94	100	109	116	222
Incineration & Open Burning	-	-	-	-	-	-	-	-	-	-	-	-	-
Wastewater Treatment & Discharge	-	20	20	-	27	22	31	23	19	28	30	20	29
IPPU	-	478	742	825	993	1,082	1,052	1,136	1,136	1,125	1,101	925	910
Land-Use Change	-	(3,267)	(3,227)	(3,200)	(3,160)	(3,147)	(3,133)	(3,120)	(3,107)	(3,093)	(3,080)	(3,066)	(3,053)
Livestock	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-CO2 Land Emission Sources	-	0	0	0	0	0	0	0	0	0	0	0	0
Total	**21,167**	**25,664**	**26,313**	**25,582**	**26,178**	**25,509**	**25,845**	**27,972**	**27,090**	**25,758**	**26,515**	**26,922**	**28,649**

Table A5. City of Parksville GHG Emissions Summary (all units are tCO_2e)

Sector	2007 CEEI	2007 Updated	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022	2023
Residential Buildings	15,168	16,250	15,488	15,976	14,715	15,048	16,225	15,506	16,412	17,699	14,125	19,422	18,214
Commercial & Institutional Buildings	7,001	10,371	10,580	11,130	10,620	11,395	12,414	11,835	12,579	12,648	12,125	12,692	12,890
Manufacturing Industries & Construction	-	1,689	1,168	1,280	1,737	1,747	2,063	2,500	2,316	1,834	1,860	2,144	2,153
Energy Industries		-	-	-	-	-	-	-	-	-	-	-	-
Non-Specified Sources		-	-	-	-	-	-	-	-	-	-	-	-
Agriculture, Forestry & Fishing activities		294	237	250	354	334	387	459	437	384	391	446	444
Fugitive Emissions		92	98	99	105	107	110	113	123	122	122	122	122
In-Boundary On-road Transportation	35,606	38,796	40,455	41,910	44,290	44,839	44,282	43,619	41,198	35,963	44,537	43,384	46,127
Trans-Boundary On-road Transportation		11,210	11,689	12,109	12,797	12,956	12,795	13,222	11,332	10,254	13,120	13,542	14,398
Waterborne Navigation		145	140	150	137	141	15	144	140	75	120	132	150
Aviation		-	-	-	-	-	-	-	-	-	-	-	-
Railway		156	158	196	177	172	195	207	215	203	201	204	204
Off-road Transportation		1,955	1,729	1,660	1,948	2,419	2,637	2,696	2,663	2,814	2,833	2,831	2,783

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Sector	2007 CEEI	2007 Updated	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022	2023
Solid Waste	4,047	3,655	4,248	-	3,766	-	-	4,124	3,945	3,722	3,438	3,512	4,276
Biological Treatment of Waste		-	-	-	320	-	-	323	327	354	385	418	784
Incineration & Open Burning		-	-	-	-	-	-	-	-	-	-	-	-
Wastewater Treatment & Discharge		407	344	-	480	296	372	443	463	395	414	403	537
IPPU		1,412	2,192	2,428	2,899	3,150	3,073	3,326	3,326	3,304	3,242	2,731	2,688
Land-Use Change		(511)	(501)	(494)	(484)	(480)	(477)	(473)	(470)	(466)	(463)	(460)	(456)
Livestock		-	-	-	-	-	-	-	-	-	-	-	-
Non-CO2 Land Emission Sources		1	1	1	1	1	1	1	1	1	1	1	1
Total	**61,822**	**86,432**	**88,527**	**87,189**	**94,346**	**92,605**	**94,569**	**98,519**	**95,476**	**89,773**	**96,912**	**101,983**	**105,773**

Table A6. Electoral Areas (All) GHG Emissions Summary (all units are tCO_2e)

Sector	2007 CEEI	2007 Updated	2010	2012	2015	2016	2017	2018	2019	2020	2021	2022	2023
Residential Buildings	43,863	48,516	53,843	56,823	50,190	50,958	55,217	51,650	54,112	57,915	26,713	28,152	25,768
Commercial & Institutional Buildings	3,176	5,799	6,206	6,833	6,854	7,355	8,253	7,872	8,481	9,876	7,099	8,816	9,158
Manufacturing Industries & Construction	-	6,036	4,174	4,549	6,081	6,090	7,226	8,802	8,195	6,522	6,647	7,663	7,696
Energy Industries	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-Specified Sources	-	-	-	-	-	-	-	-	-	-	-	-	-
Agriculture, Forestry & Fishing activities	-	32,647	26,595	28,345	40,696	38,500	44,899	53,411	51,091	45,144	46,191	52,908	52,957
Fugitive Emissions	-	11	79	80	84	86	88	91	100	98	98	98	98
In-Boundary On-road Transportation	146,729	148,641	159,844	169,142	181,578	184,488	182,728	185,142	180,580	160,705	218,795	217,003	228,364
Trans-Boundary On-road Transportation	-	42,949	46,186	48,872	52,466	53,306	52,798	56,120	49,672	45,823	64,452	67,733	71,279
Waterborne Navigation	-	457	437	466	425	431	46	443	430	233	365	424	517
Aviation	-	-	-	-	-	-	-	-	-	-	-	-	-
Railway	-	725	734	909	821	798	903	960	997	941	931	947	947
Off-road Transportation	-	6,182	5,402	5,149	6,047	7,374	8,044	8,275	8,199	8,747	8,656	9,056	9,564
Solid Waste	13,550	11,386	13,452	-	11,811	-	-	12,582	12,110	11,459	10,686	10,731	13,682
Biological Treatment of Waste	-	394	400	412	540	-	-	543	660	764	770	788	1,020
Incineration & Open Burning	-	126	129	132	135	136	137	140	142	145	147	150	160
Wastewater Treatment & Discharge	-	169	209	-	309	203	253	266	234	234	287	270	336
IPPU	-	5,047	7,833	8,630	10,150	10,980	10,763	11,709	11,709	11,689	11,530	9,762	9,609
Land-Use Change	-	(285,069)	(278,962)	(274,891)	(268,784)	(266,748)	(264,713)	(262,677)	(260,641)	(258,606)	(256,570)	(254,534)	(252,499)
Livestock	-	3,818	3,818	3,904	4,034	4,078	4,099	4,120	4,141	4,163	4,184	4,184	4,184
Non-CO2 Land Emission Sources	-	102	98	99	107	112	111	121	116	126	94	85	85
Total	**207,318**	**313,004**	**329,439**	**334,346**	**372,327**	**364,892**	**375,566**	**402,248**	**390,969**	**364,582**	**407,646**	**418,768**	**435,425**

Appendix B

The following table presents adjusted RDN Member CEEI equivalent GHG emissions summaries for the 2023 reporting year.

Table B1. RDN 2023 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	6,039,050	130,258
Commercial & Institutional Buildings	3,075,529	57,445
Manufacturing Industries & Construction	3,282,061	143,403
In-Boundary On-road Transportation	12,566,270	756,621
Trans-Boundary On-road Transportation	1,898,785	114,327
Solid Waste	-	53,826
Biological Treatment of Waste	-	4,015
Total	**26,861,695**	**1,259,895**

Table B2. City of Nanaimo 2023 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	3,192,303	72,362
Commercial & Institutional Buildings	2,017,536	40,438
Manufacturing Industries & Construction	3,098,163	143,403
In-Boundary On-road Transportation	5,668,407	339,822
Trans-Boundary On-road Transportation	1,769,281	106,069
Solid Waste	-	31,793
Biological Treatment of Waste	-	1,462
Total	**15,745,691**	**735,350**

Table B3. Town of Qualicum Beach 2023 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	437,889	11,407
Commercial & Institutional Buildings	152,324	3,873
Manufacturing Industries & Construction	19,607	-
In-Boundary On-road Transportation	570,072	33,938
Trans-Boundary On-road Transportation	177,937	10,593
Solid Waste	-	2,864
Biological Treatment of Waste	-	525
Total	**1,357,828**	**63,200**

Table B4. District of Lantzville 2023 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	167,354	3,481
Commercial & Institutional Buildings	21,535	398
Manufacturing Industries & Construction	11,321	-
In-Boundary On-road Transportation	257,272	15,514
Trans-Boundary On-road Transportation	80,302	4,842
Solid Waste	-	1,212
Biological Treatment of Waste	-	222
Total	**537,784**	**25,669**

Table B5. City of Parksville 2023 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	635,479	17,995
Commercial & Institutional Buildings	396,924	10,068
Manufacturing Industries & Construction	33,443	-
In-Boundary On-road Transportation	772,319	46,127
Trans-Boundary On-road Transportation	241,064	14,398
Solid Waste	-	4,276
Biological Treatment of Waste	-	784
Total	**2,079,229**	**93,649**

Table B6. Electoral Areas (All) 2023 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	1,606,025	25,014
Commercial & Institutional Buildings	487,210	2,667
Manufacturing Industries & Construction	119,527	-
In-Boundary On-road Transportation	3,756,030	228,364
Trans-Boundary On-road Transportation	1,172,370	71,279
Solid Waste	-	13,682
Biological Treatment of Waste	-	1,020
Total	**7,141,162**	**342,027**

Table B7. Electoral Area: A 2023 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	247,052	3,848
Commercial & Institutional Buildings	74,947	410
Manufacturing Industries & Construction	22,642	-
In-Boundary On-road Transportation	658,001	40,006
Trans-Boundary On-road Transportation	205,382	12,487
Solid Waste	-	2,397
Biological Treatment of Waste	-	179
Total	**1,208,023**	**59,327**

Table B8. Electoral Area: B 2023 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	232,832	3,626
Commercial & Institutional Buildings	70,633	387
Manufacturing Industries & Construction	11,813	-
In-Boundary On-road Transportation	395,737	24,061
Trans-Boundary On-road Transportation	123,521	7,510
Solid Waste	-	1,442
Biological Treatment of Waste	-	108
Total	**834,537**	**37,133**

Table B9. Electoral Area: C 2023 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	97,939	1,525
Commercial & Institutional Buildings	29,711	163
Manufacturing Industries & Construction	10,419	-
In-Boundary On-road Transportation	294,076	17,880
Trans-Boundary On-road Transportation	91,790	5,581
Solid Waste	-	1,071
Biological Treatment of Waste	-	80
Total	**523,935**	**26,300**

Table B10. Electoral Area: E 2023 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	254,123	3,958
Commercial & Institutional Buildings	77,092	422
Manufacturing Industries & Construction	17,692	-
In-Boundary On-road Transportation	595,073	36,180
Trans-Boundary On-road Transportation	185,740	11,293
Solid Waste	-	2,167
Biological Treatment of Waste	-	162
Total	**1,129,721**	**54,182**

Table B11. Electoral Area: F 2023 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	294,804	4,592
Commercial & Institutional Buildings	89,433	490
Manufacturing Industries & Construction	25,048	-
In-Boundary On-road Transportation	722,528	43,929
Trans-Boundary On-road Transportation	225,523	13,712
Solid Waste	-	2,632
Biological Treatment of Waste	-	196
Total	**1,357,336**	**65,551**

Table B12. Electoral Area: G 2023 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	287,352	4,476
Commercial & Institutional Buildings	87,172	477
Manufacturing Industries & Construction	20,618	-
In-Boundary On-road Transportation	713,220	43,363
Trans-Boundary On-road Transportation	222,618	13,535
Solid Waste	-	2,598
Biological Treatment of Waste	-	194
Total	**1,330,981**	**64,643**

Table B13. Electoral Area: H 2023 Reporting Year CEEI Equivalent Energy & GHG Emissions Summary

Sector	Energy (GJ)	GHG Emissions (tCO_2e)
Residential Buildings	191,923	2,989
Commercial & Institutional Buildings	58,223	319
Manufacturing Industries & Construction	11,294	-
In-Boundary On-road Transportation	377,395	22,945
Trans-Boundary On-road Transportation	117,796	7,162
Solid Waste	-	1,375
Biological Treatment of Waste	-	103
Total	**756,630**	**34,892**