# Capital Regional District 2022 GPC BASIC+ Community Greenhouse Gas (GHG) Emissions Inventory Report

Prepared for:
Capital Regional District
625 Fisgard Street, PO Box 1000
Victoria, BC V8W 2S6

Prepared by:
Stantec Consulting Ltd.
200-325 25 Street SE
Calgary, AB T2A 7H8

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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 capital region of British Columbia (the CRD) for the 2022 reporting year using the GPC Protocol. The CRD Region 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 CRD 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 2022 reporting year, and to present the CRD's 2022 community GHG emissions.

In 2022, the CRD's Regional BASIC+ GHG emissions totaled 1,858,325 tonnes of carbon dioxide equivalent ($tCO_2e$). On an absolute basis, this is an 7% decline from the 2007 base year GHG emissions and a decline of 25% on a per capita basis. Due to limitations in how to quantify GHG emissions resulting from land use change (e.g., residential development) and sequestration, these GHG emissions have been excluded from the CRD's GHG emissions inventory, but have been disclosed, until a more robust measurement methodology can be developed.

A summary of the 2022 GHG emissions is presented in Table E-1.

**Table E-1 BASIC+ 2007 Base Year And 2022 Reporting Year GHG Emissions**

| Sector | Sub-Sector | 2007 GHG Emissions ($tCO_2e$) | 2022 GHG Emissions ($tCO_2e$) |
|---|---|---|---|
| Stationary Energy | Residential Buildings | 422,256 | 275,044 |
| | Commercial & Institutional Buildings | 270,524 | 344,011 |
| | Manufacturing Industries & Construction | 0 | 0 |
| | Energy Industries | 418 | 6,497 |
| | Agriculture, Forestry & Fishing activities | 89,497 | 101,034 |
| | Fugitive Emissions | 1,003 | 1,510 |
| Transportation | In-Boundary On-road Transportation | 864,570 | 765,180 |
| | Trans-Boundary On-road Transportation | 13,256 | 6,949 |
| | Waterborne Navigation | 48,218 | 55,107 |
| | Aviation | 26,097 | 15,746 |
| | Off-road Transportation | 60,629 | 87,673 |
| Waste | Solid Waste | 110,955 | 39,699 |
| | Biological Treatment of Waste | 73 | 5,602 |
| | Wastewater Treatment & Discharge | 18,998 | 4,975 |
| IPPU | IPPU | 70,418 | 135,461 |
| AFOLU | Land-Use: Emissions Sequestered **(Disclosure Only - Not Included In Total)** | -33,172 | -401,842 |
| | Land-Use: Emissions Released **(Disclosure Only - Not Included In Total)** | 24,093 | 89,610 |
| | Livestock | 6,867 | 12,431 |
| | Non-$CO_2$ Land Emission Sources | 849 | 1,406 |
| **Total GHG Emissions** | | **2,004,628** | **1,858,325** |
| **Change in GHG Emissions from Base Year** | | | **-7.3%** |
| **Total Per Capita GHG Emissions** | | **5.6** | **4.2** |
| **Change GHG Emissions per Capita from Base Year** | | | **-25.1%** |

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

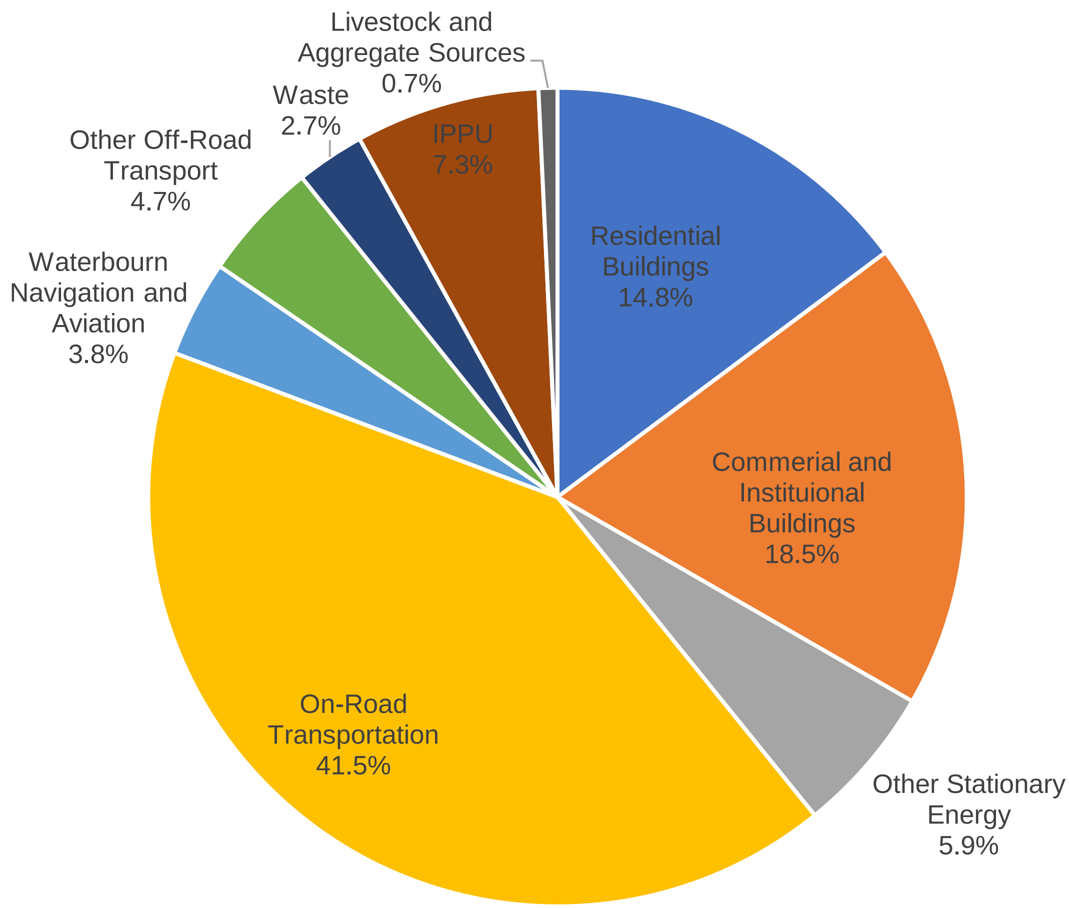


**Figure E-1 CRD's 2022 BASIC+ GHG Emissions Profile**

## Abbreviations

| | |
|---|---|
| ACERT | Airport Carbon Emissions Reporting Tool |
| 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 |
| CRD | Capital Regional District |
| VIA | Victoria International Airport |
| 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 |
| GVHA | Greater Victoria Harbour Authority |
| GWP | global warming potentials |
| HFC | Hydrofluorocarbons |
| ICAO | International Civil Aviation Organization |
| 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 |
| MWh | megawatt hours |
| $N_2O$ | nitrous oxides |
| NE | not estimated |
| NIR | National Inventory Report |
| NPRI | National Pollutant Release Inventory |
| NO | not occurring |
| PCP | Partnership for Climate Protection |
| PFC | Perfluorocarbons |
| SC | Other Scope 3 |
| $SF_6$ | sulfur hexafluoride |
| 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. |
| Base 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:<br>• Natural gas for 3-4 days of household use<br>• 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:<br>• 385 litres of gasoline (about 10 fill-ups)<br>• Enough electricity for three homes for a year (38,000 kWh) |
| Transboundary GHG emissions | Emissions from sources that cross the geographic boundary (GPC, 2014). |

# 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 CRD 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 CRD 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 in that it is an in-boundary inventory, the most recent version published is for 2012, and the CEEI Protocol does not fully meet the requirements of the GPC Protocol BASIC or BASIC+ reporting requirements which is the required reporting standard for local governments that have committed to the Global Covenant of Mayors—an agreement led by community networks to undertake a transparent and supportive approach to measure GHG emissions community-wide. 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 | 2007-2019 CEEIs | 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 | | ✓ | ✓ |

| Reporting Sector | 2007-2019 CEEIs | GPC BASIC | GPC BASIC+ |
|---|---|---|---|
| Wastewater | | ✓ | ✓ |
| Emissions From Industrial Processes | | | ✓ |
| Emissions From Product Use | | | ✓ |
| Emissions From Livestock | ✓ | | ✓ |
| Emissions From Land | | | ✓ |
| Emissions From Aggregate Sources And Non-$CO_2$ Emission Sources On Land | ✓ | | ✓ |

## 1.4 PURPOSE OF THIS REPORT

The purpose of this document is to describe the quantification methodologies used by the CRD to calculate its BASIC+ GHG emissions for the 2007 base and 2022 reporting years. The focus of this report is on the 2022 reporting year. The CRD 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 base 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).

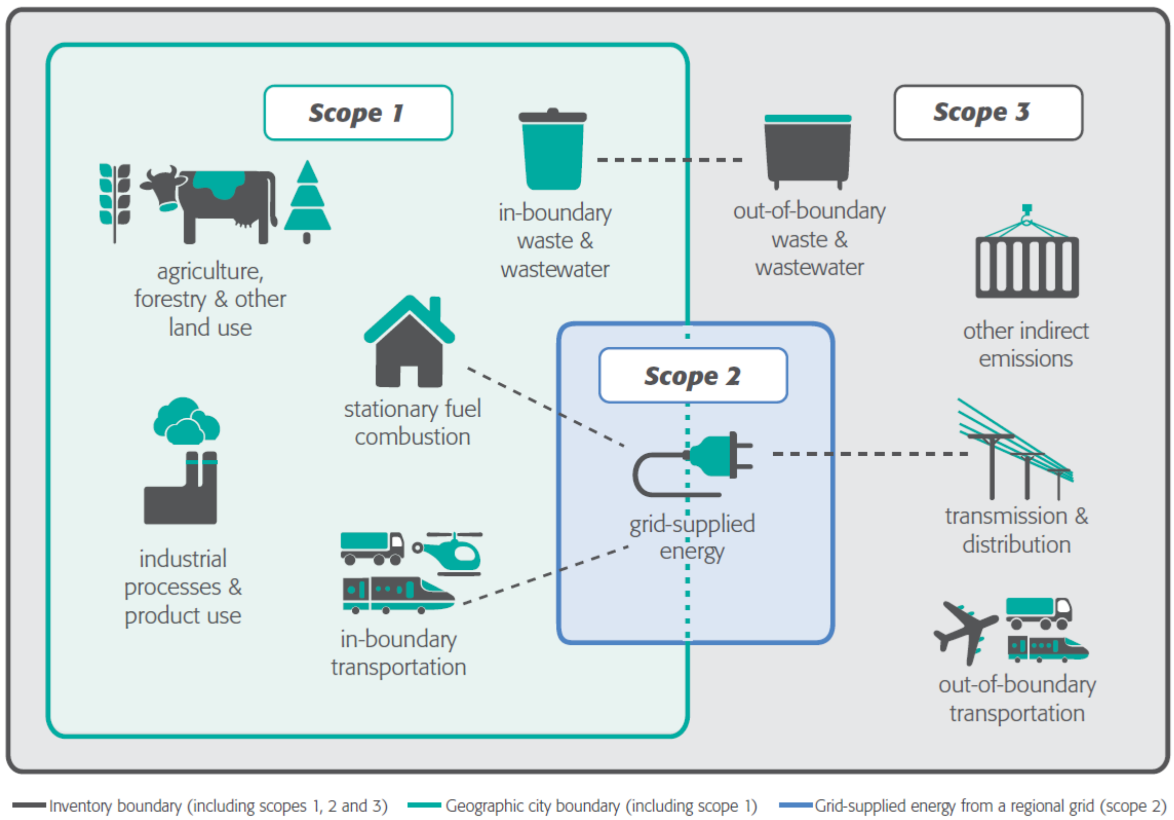


**Figure 1 Sources and Boundaries of a Community's GHG Emissions (GPC 2014)**

## 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

Stationery 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, such as off-road transportation emissions from construction equipment. 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, and natural gas distribution systems.

The Stationary Energy Sector includes the following Sub-Sectors:

- 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-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 included in the total GHG inventory 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
- Incineration and open burning
- Biological treatment of waste
- 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. 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 CRD, 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 factors that results in a material change in GHG emissions (i.e., +/-10%). | ✓ | |
| | 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 CRD, 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 CRD's GHG inventory.

## 3.1 SPATIAL BOUNDARIES

This GHG inventory is defined geographically by the capital region of British Columbia jurisdictional boundaries. As shown in Figure 2, this region consists of 13 municipalities and 3 electoral areas. For the purposes of this report, only the CRD GHG emissions are presented. A breakdown of GHG emissions by each CRD municipality and electoral area has been presented in a separate report.

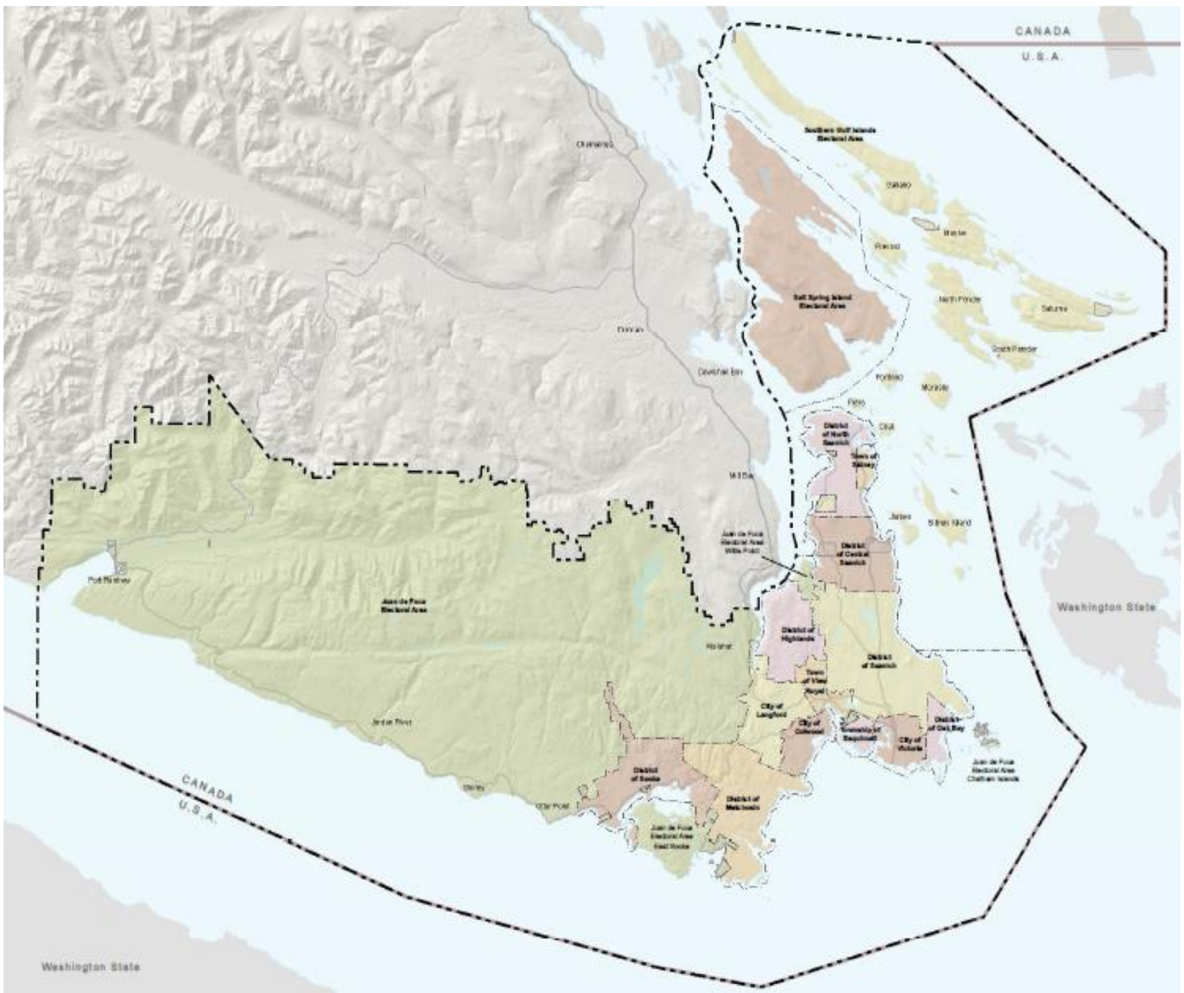


**Figure 2 Region GHG Boundary**

**Table 4 Inventory Information**

| Inventory Boundary | Community / District Information |
|---|---|
| Name of Community / District | Capital Regional District |
| Municipality / Electoral Area | • District of Central Saanich<br>• City of Colwood<br>• Township of Esquimalt<br>• District of Highlands<br>• Juan de Fuca Electoral Area<br>• City of Langford<br>• District of Metchosin<br>• District of North Saanich<br>• District of Oak Bay<br>• District of Saanich<br>• Salt Spring Island Electoral Area<br>• Town of Sidney<br>• District of Sooke<br>• City of Victoria<br>• Town of View Royal<br>• Southern Gulf Islands Electoral Area |
| Country | Canada |
| Inventory Year | 2022 |
| Geographic Boundary | See Figure 2 |
| Land Area (km$^2$) | 2,310.18 |
| Resident population | 432,931 |
| GDP (US$) | Unknown at time of reporting |
| Composition of Economy | Government |
| Climate | Temperate, warm summer |

## 3.2 TEMPORAL BOUNDARIES

### 3.2.1 2007 Base Year

Federal and provincial initiatives and legislation have been implemented to support local governments in acting to advance energy efficiency, promote energy conservation, and reduce GHG emissions. The CRD and its local governments have already been working to address sustainability and climate change through several initiatives for many years. The CRD's Regional Growth Strategy set an absolute regional GHG reduction target of 61% by 2038 (below 2007 levels).

To maintain consistency with the current reporting year, and as required by the GPC Protocol, the CRD has updated its 2007 GHG base year GHG emissions profile to be consistent with the GPC Protocol BASIC+ reporting level. Between the current reporting year and the 2007 base year, there were no boundary changes (e.g., annexes) and thus no additional modifications were made. All methods and assumptions, adjusted for the 2007 reporting year, are the same.

Due to limitations in how to quantify GHG emissions resulting from land use change (e.g., residential development) and sequestration, these GHG emissions have been excluded from the CRD's 2007 and 2022 GHG emissions inventories, but have been disclosed, until a more robust measurement methodology can be developed.

Table 5 summaries the original 2007 and the updated 2007 base year GHG emissions reported as tonnes of carbon dioxide equivalent ($tCO_2e$). The base year has been updated (in 2023) to reflect the adoption of the IPCC's 5th assessment report GWPs.

**Table 5 Original And Updated BASIC+ Base Year**

| Aspect | Quantification Protocol | 2007 GHG Base Year ($tCO_2e$) |
|---|---|---|
| Original Base Year | CEEI Protocol | 1,563,000 |
| Updated Base Year | GPC Protocol BASIC+ | 2,004,628 |

### 3.2.2 GHG Reduction Target

Recognizing the role that the CRD plays in achieving a significant and immediate reduction in global GHG emissions, the CRD has set a regional GHG reduction target of 61% (from 2007 levels) by 2038. With the CRD's 2007 base year GHG emissions being 2,004,628 $tCO_2e$, a 61% reduction would require a reduction of approximately 1,222,823 $tCO_2e$. On a per capita basis, this amounts to reducing emissions from approximately 4.3 $tCO_2e$ per person in 2022 to 2.4 $tCO_2e$ per person by 2038.

In February 2019, the CRD declared a climate emergency and committed to regional carbon neutrality.

### 3.2.3 2022 GHG Boundary

This inventory covers all GHG emissions for the 2022 reporting year. Where 2022 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 CRD is applying GWPs from the fifth IPCC report.
- **Stationary Energy: Residential, Commercial and Institutional Buildings**. Propane, and wood GHG emissions were estimated using linear regression methods. The data used in the estimates included historical propane and wood energy data published in the 2007-2019 CEEIs, and heating degree days (HDD) published by Environment and Climate Change Canada.

- **Stationary Energy: Residential, Commercial and Institutional Buildings**. The CRD used real-estate sales data between 2019 and 2022 to estimate the number of heating oil tanks and average household consumption for the 2020 reporting year. The 2020 heating oil numbers were adjusted using a change in heating degree days between 2020 and 2022. This approach was used to estimate heating oil consumption for all local governments, except the City of Victoria and District of Saanich. For the District of Saanich and the City of Victoria, heating oil GHG emissions were estimated based on the number of known tanks, average heated floor areas and fuel volume intensity.
- **Stationary Energy: Fugitives**. Fortis BC provided total fugitive emissions for the 2020 reporting year at the CRD level. Since no historical numbers were provided, the 2020 value was used to estimate the 2022 emissions.
- **Stationary Energy: Other Off-Road.** The ECCC 2023 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 CRD on a per capita basis.
- **Transportation: On-Road**. The on-road transportation emissions are based on the total estimated fuel sales in the CRD, and the number of registered vehicles. Insurance Corporation of BC (ICBC) compiles data on an April 1 to March 31 basis, and thus the current on-road GHG emission estimate is based on the number of registrations from April 1, 2022 – March 31, 2023.
- **Transportation: Aviation.** 2022 aviation GHG emissions were estimated using 2015 aircraft flight profiles (the last available data), and the total number of aircraft movements reported in 2022.
- **Transportation: Waterborne Recreational Watercraft.** GHG emissions from recreational watercraft and US/Canada ferries were estimated based on a publicly available year 2000 study for the Victoria, Vancouver, and Washington harbors.
- **Transportation: Cruise Ships.** The Greater Victoria Harbour Authority (GVHA) reported on cruise ship emissions for the 2018 reporting year but did not provide an estimate for 2022. As a result, the 2018 GHG emissions estimate and number of cruise ship visits to Ogden Point was used to create a proxy to estimate 2022 cruise ship emissions.
- **Waste: Solid Waste.** To quantify GHG emissions from the Hartland Landfill, the CRD utilized the waste-in-place (WIP) method which is accepted under the GPC Protocol. The WIP assigns landfill emissions based on total waste deposited during that year. It counts GHGs emitted that year, regardless of when the waste was disposed. Except for the City of Victoria, who claims 31% of the CRD's landfill GHG emission, the remaining landfill GHG emissions were allocated to each local government on a per capita basis. Using this allocation method, the CRD members may over, or underestimate associated solid waste GHG emissions as the current year landfill GHG emissions are based upon cumulative waste over time, and each member may have contributed more waste in past years than the current year (and vice versa).
- **AFOLU: Aggregate Sources And Non-$CO_2$ Emission Sources On Land.** These emissions are based on the 2023 NIR as prepared by ECCC and the total area of farmland BC in 2021 as reported by Statistics Canada. These GHG emissions were assigned to each local government on a per hectare (ha) of cropland basis.

- **AFOLU: Land-Use.** The land cover change analysis requires a consistent land-use category attribution and spatial data. For parts of the CRD, spatial data was available for the 2007, 2011 and 2019 reporting years. Differences between these data sets in terms of resolution and their timing of collection increase the uncertainty as to the accuracy of the land-use classifications. For example, the 2007 and 2011 land use data was collected at different times of the year and may not accurately reflect tree cover. Furthermore, no land use spatial data was collected the Juan de Fuca, Salt Spring Island and Gulf Islands and thus Annual Crop Inventory (ACI) settlement data collected by Agriculture Canada was used to inform the analysis. The challenge in utilizing this data is that it is provided in a 30m resolution. Furthermore, since annual data is not available, the change between land cover data years (2007-2011, 2011-2019) for all areas was averaged and may not represent actual changes in each year. Since no data was available for 2022, the 2019 estimates were applied.
  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 CRD's GHG emissions inventory, but have been disclosed, until a more robust measurement methodology can be developed.

## 3.3 GHG EMISSION SOURCES AND SCOPES

Table 6 summarizes the CRD's GHG emissions by source and GHG emission scope.

**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 CRD's limits:<br>• Stationary fuel combustion:<br>– Residential buildings<br>– Agriculture, forestry, and fishing activities<br>– Commercial and institutional buildings, and facilities<br>– Energy industries<br>– Fugitive emissions from oil and natural gas systems<br>• Transportation:<br>– On-road: In Boundary<br>– Waterborne Navigation<br>– Off-road<br>• Waste:<br>– Solid waste disposal<br>– Biological treatment of solid waste<br>– Wastewater treatment and discharge<br>• Industrial processes and product use (IPPU):<br>– Product use<br>• Agriculture, Forestry, and Other Land Use (AFOLU):<br>– Land-use: emissions sequestered<br>– Livestock<br>– Aggregate sources and non-$CO_2$ emission sources on land |

| GHG Emissions Scope | GPC Protocol Reporting Sector |
|---|---|
| Scope 2 | The GHG emissions occurring from using grid-supplied electricity, heating and/or cooling within the CRD's boundary:<br>• Stationary fuel combustion:<br>– Residential buildings<br>– Commercial and institutional buildings and facilities<br>• Transportation:<br>– On-road |
| Scope 3 | Other GHG emissions occurring outside of the CRD's limits as a result of the CRD's activities:<br>• Stationary Energy:<br>– Transmission, Distribution, and Line Losses<br>• Transportation:<br>– Aviation<br>– On-Road: Transboundary<br>– Waterborne Navigation |

## 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. These include:

- Carbon Dioxide ($CO_2$)
- Methane ($CH_4$)
- Nitrous oxide ($N_2O$)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulfur hexafluoride ($SF_6$)
- Nitrogen trifluoride ($NF_3$)

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.

**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 |
| 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 |

### Table 7 GPC Protocol Summary Table

| GPC Protocol Reference Number | Reporting Level | Emissions Scope | GHG Emissions Source |
|---|---|---|---|
| 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** | | |
| 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 |

### Table 7 GPC Protocol Summary Table

| GPC Protocol Reference Number | Reporting Level | Emissions Scope | GHG Emissions Source |
|---|---|---|---|
| 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 CRD's GHG emissions. For the District, the Stationary Energy Sector encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 1 Emissions:
  - Residential buildings
  - Agriculture, forestry, and fishing activities
  - Commercial and institutional buildings, and facilities
  - Energy industries
  - 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.

There are GHG emissions from construction of buildings and infrastructure as the capital region grows and changes. However, these GHG emissions have not been quantified due to a lack of available data. Environment and Climate Change Canada does estimate BC GHG emissions for manufacturing industries, mining and construction, but these GHG emission sources are not disaggregated and cannot reasonably be applied to the CRD (there is no mining and limited manufacturing activities). As a result, the notation "Not Estimated (NE)" is reported.

### 4.1.2 Activity Data

BC Hydro and Fortis BC provided the Province of BC electricity and natural gas consumption data 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"

The Province developed 2007-2019 residential, propane and wood GHG energy use estimates from the number and type of dwellings and the average dwelling consumption by authority and region from the BC

Hydro Conservation Potential Review. In conjunction with heading degree days data, this provincial data was used to estimate the 2022 reporting year propane and wood GHG emissions for all CRD members.

The CRD provided 2020 heating oil values for all member municipalities except for the District of Saanich and the City of Victoria who provided their own fuel oil estimates for residential and commercial buildings.

Fortis BC provided the fugitive emission estimate for the 2020 reporting year.

The CRD provided landfill gas energy generation data from the Hartland landfill.

Applicable, off-road GHG emissions included in the Stationary Energy Sector are based on the 2023 NIR as prepared by Environment and Climate Change Canada. These emissions are pro-rated to the CRD on a per capita basis.

### 4.1.3 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2022 GHG emissions:

- The 2022 natural gas and electricity energy data was provided to the CRD in draft form and may be subject to change.
- BC Hydro estimates that the combined energy losses- transmission and distribution- to be approximately 6.28%. This value was used to calculate the Scope 3 emissions for each Stationary Energy Sub-Sector. It is assumed that this is accurate.
- Fugitive emissions from the natural gas distribution network within the CRD is based on the Fortis fugitive emission factor for the 2020 reporting year. This factor was used to estimate 2022 fugitive emissions for residential natural gas use in the CRD and assumes a direct change with the number of reported natural gas connections (as reported by Fortis BC). This value is assumed to be stable and has been applied to the 2022 reporting year.
- Propane and wood GHG emissions were estimated using linear regression methods. The data used in the estimate included historical propane and wood energy data published in the 2007-2019 CEEIs by the Province of BC, and heating degree days (HDD) as published by Environment and Climate Change Canada.
- The CRD fuel oil estimates are based on the percentage of homes sold (relative to the total number of homes in each municipality) with heating oil systems between 2019 and 2022. Using this 4-year average, and BC assessment data, the CRD estimated the size and number of homes with heating oil for each member municipality for the 2020 reporting year. The guiding assumption is that oil systems are not increasing overtime; they are stable or decreasing in number. However, the 2020 heating oil consumption volume was adjusted for the number of heating degree days in 2022.

### 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 | Medium for Source Category; Low for Distribution between CRD Members |
| Residential, Commercial and Industrial Natural Gas | Medium for Source Category; Low for Distribution between CRD Members |
| 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 |
| Landfill Gas Volumes Utilized / Flared | High |

### 4.1.5 Calculation Methodology

The Province of BC developed residential propane and wood GHG energy use estimates using heating degree days (HDD) the number and type of dwellings and the average dwelling consumption by authority and region contained in the BC Hydro Conservation Potential Review. To estimate the 2022 propane and wood energy use, historical 2019 values and the number of heating degree days (HDD) were linearly regressed to estimate future propane and wood energy use using reporting year HDD values. These values were prorated to each local government.

Except for Saanich and Victoria who provided their own fuel oil consumption estimates, the CRD provided 2020 fuel oil estimates for all member municipalities based on the percentage of homes sold (relative to the total number of homes in each municipality) with heating oil systems between 2019 and 2022. Similar to wood and propane fuel consumption, heating oil consumption was estimated using 2020 data and HDDs.

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:

***Energy*** *Stationary Energy – Electricity =* *Electricity * (1 – Line Loss (%)*

***Energy*** *Stationary Energy – Transmission, Distribution, and line Losses =* *Electricity * Line Loss (%)*

$$Emissions_{Stationary\ Energy - Electricity} = Fuel\ (MWh) * EF_{tCO2e}$$

$$Emissions_{Stationary\ Energy - Natural\ Gas} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

$$Emissions_{Stationary\ Energy - Propane} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

$$Emissions_{Stationary\ Energy - Wood} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

$$Emissions_{Stationary\ Energy - Heating\ Oil} = (Fuel\ (GJ) * EF_{CO2}) + (Fuel\ (GJ) * EF_{CH4} * GWP_{CH4}) + (Fuel\ (GJ) * EF_{N2O} * GWP_{N2O})$$

The emission factors used in the 2022 reporting year are from the 2023 NIR, unless identified otherwise. These are summarized in Table 9.

**Table 9 Stationary Energy GHG Emission Factors**

| Emission Factor | Units | $tCO_2e$ | Quality Assessment Rating |
|---|---|---|---|
| Electricity (BC Hydro) | $tCO_2e$ / MWh | 0.00970000 | Medium |
| Natural Gas | tonne $CO_2e$ / $m^3$ | 0.0019763 | Medium |
| Propane | tonne $CO_2e$ / L | 0.0015443 | Medium |
| Heating Oil | tonne $CO_2e$ / GJ | 0.0683516 | Medium |
| Wood | tonne CO2e / kg | 0.0004624 | Medium |

### 4.1.6 Biogas & Flaring GHG Emissions

The Hartland 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 electricity generation and exported to 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.

To quantify these GHG emissions, the high heat value (HHV) of landfill fugitive is used – this methodology is as follows.

$$Emissions_{Landfill\ Fugitive\ Gas} = Landfill\ Fugitive\ Gas\ Volume_{m3} * Landfill\ Fugitive\ Gas\ HHV\ (0.0187)_{GJ/m3} * EF_{tCO2e}$$

The biogas combustion emission factor is presented in Table 10.

**Table 10 Landfill Fugitive Gas Combustion GHG Emission Factor**

| Emission Factor | Units | Emission Factor | Quality Assessment Rating |
|---|---|---|---|
| Landfill Fugitive Gas | $tCO_2e$/GJ Landfill Fugitive Gas | 0.054898 | Medium |

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 CRD, 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 2022 ICBC vehicle registration data to the CRD.

BC Transit provided total diesel and gasoline fuel use. This data was used to estimate GHG emissions from busses serving the CRD.

The 2022 CRD Origin Destination Travel Survey was used to estimate on-road in-boundary and transboundary split for registered vehicles and busses. The CRD Origin Destination Travel Survey is based on travel patterns observed in the Capital Regional District (CRD) level.

The City of Victoria and District of Saanich provided an estimate of vehicle kilometer travelled (VKT) data for light duty and heavy vehicles. This data is based on survey's completed in prior years.

Transport Canada provided total domestic and international itinerant movements, by type of operation, airports with NAV CANADA flight service stations for the Victoria International Airport and the Victoria Harbour. The Victoria International Airport provided 2015 GHG emissions estimates; this was used to estimate the 2022 emissions data.

Marine watercraft GHG emissions were estimated using published BC Ferries 2022 GHG emissions estimates. GHG emissions from the Coho Ferry, the Victoria Clipper Ferry, personal and commercial watercraft, were estimated based on a Study entitled "Marine Vessel Air Emissions in BC and Washington State Outside of the GVRD and FVRD for the Year 2000". The Transport Canada Vessel Registration System provided the total number of registered waterborne vehicles for the reporting year. The Greater Victoria Harbor Authority provided 2018 GHG emissions estimates per cruise ship and the number of 2022 cruise ships docked in Victoria Harbor.

Other off-road transportation emissions are based on the 2023 NIR as prepared by Environment and Climate Change Canada.

### 4.2.3 Assumptions and Disclosures

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

- The on-road transportation emissions are based on the total estimated fuel sales in the CRD, and the number of registered vehicles. Insurance Corporation of BC (ICBC) compiles data on an April 1 to March 31 basis, and thus the current on-road GHG emission estimate is based on the number of registrations from April 1, 2022 – March 31, 2023.
- Vehicle fuel consumption rates and Vehicle Kilometer Travelled (VKT) were taken from the activity data summary for British Columbia on-road transportation from the 2023 National Inventory Report (1990-2021) as prepared by Environment and Climate Change Canada. Based on the clear diesel and clear gasoline consumption values reported by the Province of BC for the Victoria region, the VKT and fuel efficiency values are reasonable and result in a similar estimate of fuel consumption for the Region.
- Gasoline and diesel GHG emissions from BC Transit busses are pro-rated to the CRD based on the proportion of population in each municipality within the CRD. A more accurate estimation method would be to prorate fuel use based on total bus service kilometers in the CRD. However, this data is not available, and thus the method applied provides the best estimate at the time of reporting.
- It is assumed that the 2015 aircraft flight profiles at the Victoria International Airport are representative of the 2022 reporting year.

- Victoria harbour aviation GHG emissions were estimated using Victoria harbor aircraft movement statistics, estimated taxi times, and estimated fuel use for the DHC-6 Twin Otter type of plane.
- All aviation GHG emissions are prorated based on the total Victoria population relative to the CRD population.
- As there is currently no publicly available energy or GHG related information on the operation of the Coho and the Victoria Clipper Ferries, it was assumed that the GHG emissions for these ferries calculated in 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 were based on the Greater Victoria Harbor Authority’s 2018 GHG emissions estimates per cruise ship and the number of 2022 cruise ships reported to dock in Victoria Harbor.
- BC Ferries did not disclose its total reported fuel use for 2022 but did publish 2022 GHG emissions by Scope. Fuel consumption was back calculated using emissions factors.
- The Transport Canada Vessel Registration System provided the total number of registered waterborne vehicles for the reporting year; however, it does not provide any detail on the type, size, use, and owner of the watercraft. It was therefore assumed that the watercraft would have been similar to those in the referenced study.
- All marine GHG emissions are prorated to each member municipality relative to the CRD population.
- No railway GHG emissions are occurring in the CRD.
- The off-road transportation emissions are based on the 2023 NIR as prepared by Environment and Climate Change Canada. This is deemed to be the best available data.

### 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 | Medium-High |
| Vehicle Registry Data | High |
| Vehicle Kilometers Travelled (VKT) Data | Medium-Low |
| Aviation GHG Data | Medium-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 and fuel sales methods were 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. ICBC provided the number of registered vehicles in the CRD by style and by fuel type for 2022. To estimate the split between on-road in-boundary and transboundary traffic, data from the 2022 CRD Origin Destination Survey was applied. The results of the survey as it applies to the CRD is presented in Table 12.

### Table 12 CRD On-Road In-Boundary/Transboundary Split

| Aspect | By Vehicle |
|---|---|
| Estimated proportion of on-road in-boundary travel | 99.3% |
| Estimated proportion of on-road transboundary travel | 0.7% |

To quantify the 2022 reporting year on-road and transboundary GHG emissions, the following steps were taken:

1. Sort the ICBC vehicle registration data by postal code.
2. Review each vehicle model and fuel type and assign it to one of 4 classes (for each fuel type): LDV, LDT, HDV, ORVE
3. Assign estimated NRCan vehicle fuel consumption rates and estimated VKT to each vehicle class (Table 13).
4. Estimate total fuel use by vehicle classification.
5. Summate and allocate estimated fuel use, by vehicle class using the applicable in-boundary and transboundary split.
6. Pro-rate the gasoline and diesel fuel use from busses.
7. Summate and allocate estimated bus fuel use using the applicable in-boundary and transboundary split.
8. Compare fuel estimated fuel volumes to the regional fuel sales volumes reported by the CRD. Adjust the VKTs as needed to make sure that the fuel estimate is at least above the fuel sales volumes reported in the region.

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

| Vehicle Classification | Estimated VKT / Year | Estimated Fuel Efficiency (L/100 km) |
|---|---|---|
| Diesel-HDV | 27,791 | 45.6 |
| Diesel-LDT | 24,516 | 11.8 |
| Diesel-LDV | 23,597 | 9.2 |
| Diesel-ORVE | Not Estimated | 45.6 |
| Electric-HDV | 9,651 | 30.0 |
| Electric-LDT | 10,290 | 20.0 |
| Electric-LDV | 11,328 | 20.0 |
| Electric-ORVE | Not Estimated | 30.0 |
| Gasoline-HDV | 9,759 | 54.1 |

| Vehicle Classification | Estimated VKT / Year | Estimated Fuel Efficiency (L/100 km) |
|---|---|---|
| Gasoline-Hybrid-HDV | 8,732 | 37.9 |
| Gasoline-Hybrid-LDT | 9,462 | 10.0 |
| Gasoline-Hybrid-LDV | 8,333 | 7.0 |
| Gasoline-Hybrid-ORVE | Not Estimated | 37.9 |
| Gasoline-LDT | 8,545 | 12.2 |
| Gasoline-LDV | 9,270 | 9.0 |
| Gasoline-ORVE | Not Estimated | 54.1 |
| Hydrogen-Hybrid-LDV | 10,883 | Not Estimated |
| Hydrogen-LDV | 11,717 | Not Estimated |
| Hydrogen-LDT | 12,840 | Not Estimated |
| Motorcycle - Electric | 1,973 | 17.0 |
| Motorcycle - Non catalyst | 1,973 | 9.9 |
| Natural Gas-HDV | 27,791 | 22.9 |
| Natural Gas-LDT | 24,516 | 8.3 |
| Natural Gas-LDV | 23,597 | 5.4 |
| Natural Gas-ORVE | Not Estimated | 22.9 |
| Propane-HDV | 27,791 | 22.9 |
| Propane-Hybrid-LDV | 16,386 | 13.1 |
| Propane-LDT | 24,516 | 12.6 |
| Propane-LDV | 23,597 | 8.2 |
| Propane-ORVE | Not Estimated | 22.9 |

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

| Vehicle Classification | Total Estimated Registered Vehicles | Total Estimated Fuel Use | Units |
|---|---|---|---|
| Diesel-HDV | 2,203 | 29,822,878 | Liters (L) |
| Diesel-LDT | 10,109 | 23,720,905 | Liters (L) |
| Diesel-LDV | 1,540 | 2,605,908 | Liters (L) |
| Diesel-ORVE | 2,437 | - | Liters (L) |
| Electric-HDV | 35 | 101,332 | kWh |
| Electric-LDT | 2,923 | 5,131,320 | kWh |
| Electric-LDV | 5,585 | 11,992,543 | kWh |
| Electric-ORVE | 71 | - | kWh |
| Gasoline-HDV | 3,308 | 18,414,669 | Liters (L) |
| Gasoline-Hybrid-HDV | 5 | 15,903 | Liters (L) |
| Gasoline-Hybrid-LDT | 5,547 | 6,222,292 | Liters (L) |

| Vehicle Classification | Total Estimated Registered Vehicles | Total Estimated Fuel Use | Units |
|---|---|---|---|
| Gasoline-Hybrid-LDV | 4,892 | 2,713,645 | Liters (L) |
| Gasoline-Hybrid-ORVE | 3 | - | Liters (L) |
| Gasoline-LDT | 154,048 | 170,158,970 | Liters (L) |
| Gasoline-LDV | 98,045 | 73,956,005 | Liters (L) |
| Gasoline-ORVE | 2,671 | 2,909,461 | Liters (L) |
| Hydrogen-Hybrid-LDV | - | - | Liters (L) |
| Hydrogen-LDV | 24 | - | Liters (L) |
| Hydrogen-LDT | 2 | - | Liters (L) |
| Motorcycle - Electric | - | - | kWh |
| Motorcycle - Non catalyst | 6,437 | 1,395,105 | Liters (L) |
| Natural Gas-HDV | 19 | 127,517 | Kilogram (kg) |
| Natural Gas-LDT | 38 | 60,955 | Kilogram (kg) |
| Natural Gas-LDV | 4 | 4,141 | Kilogram (kg) |
| Natural Gas-ORVE | 7 | - | Kilogram (kg) |
| Propane-HDV | 38 | 234,115 | Liters (L) |
| Propane-Hybrid-LDV | 2 | 4,284 | Liters (L) |
| Propane-LDT | 160 | 383,154 | Liters (L) |
| Propane-LDV | 8 | 13,302 | Liters (L) |
| Propane-ORVE | 84 | - | Liters (L) |
| **Total** | **300,245** | **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:

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

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

The emission factors used in the reporting year GHG inventory are from the 2023 NIR unless otherwise indicated. 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 | 0.00234581 | Medium-Low |
| Gasoline-LDT | tonne $CO_2e$ / L | 0.0022579 | Medium-Low |
| Gasoline-HDV | tonne $CO_2e$ / L | 0.0022851 | Medium-Low |
| Gasoline-ORVE | tonne $CO_2e$ / L | 0.0022033 | Medium-Low |
| Gasoline-Hybrid-LDV | tonne $CO_2e$ / L | 0.0023293 | Medium-Low |
| Gasoline-Hybrid-LDT | tonne $CO_2e$ / L | 0.0022579 | Medium-Low |
| Gasoline-Hybrid-HDV | tonne $CO_2e$ / L | 0.0022851 | Medium-Low |
| Gasoline-Hybrid-ORVE | tonne $CO_2e$ / L | 0.0022579 | Medium-Low |
| Electric-LDV (BC Hydro) | tonne $CO_2e$ / kWh | 0.0000097 | Medium-Low |
| Electric-LDT (BC Hydro) | tonne $CO_2e$ / kWh | 0.0000097 | Medium-Low |
| Electric-HDV (BC Hydro) | tonne $CO_2e$ / kWh | 0.0000097 | Medium-Low |
| Electric-ORVE | tonne $CO_2e$ / kWh | 0.0000097 | Medium-Low |
| Diesel-LDV | tonne $CO_2e$ / L | 0.0025786 | Medium-Low |
| Diesel-LDT | tonne $CO_2e$ / L | 0.0025790 | Medium-Low |
| Diesel-HDV | tonne $CO_2e$ / L | 0.0025629 | Medium-Low |
| Diesel-ORVE | tonne $CO_2e$ / L | 0.0027757 | 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 | 0.0002337 | Medium-Low |
| Natural Gas-LDT | tonne $CO_2e$ / kg | 0.0002337 | Medium-Low |
| Natural Gas-HDV | tonne $CO_2e$ / kg | 0.0002337 | Medium-Low |
| Natural Gas-ORVE | tonne $CO_2e$ / kg | 0.0002337 | 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 | 0.0022420 | Medium-Low |
| Motorcycle - Electric | tonne $CO_2e$ / L | 0.0000097 | Medium-Low |

#### 4.2.5.2 Aviation: Victoria International Airport

The Victoria International Airport (VIA) estimated its 2015 airplane GHG emissions following the ACI ACERT standard. This includes GHG emissions from aircraft and GHG emissions from auxiliary power units (APU). APUs provides electricity to the aircraft prior to the engine start up. Within the ACERT model, it is assumed all aircraft have APUs and the duration of the APU operation (of five minutes per aircraft) was generically applied to every landing take-off (LTO) cycles. It should also be noted that the EIA has quantified aircraft GHG emissions from planes up to 3,000 ft. to avoid double counting with other airports and cities. This is consistent with the ACERT standard.

The CRD's 2022 aviation emissions estimate is based on the 2015 aircraft flight profiles, which included the estimated landing and takeoff (LTO) and auxiliary power unit (APU) fuel use, and an estimated percentage allocation of total flights to the following aviation class groupings (Table 16). The total reported flight movements for the reporting year (99,988) and the aircraft flight profile data was used to estimate aviation GHG emissions for the reporting year at the VIA.

**Table 16 Aircraft Type, Estimated Percentage of Total Reported Movements, And Estimated Fuel Use**

| Aviation Class | Aircraft Type | Estimated Percentage of Annual Movements | Estimated LTO Fuel Use by Aircraft Type (kg) | Estimated APU Fuel Use by Aircraft Type (kg/min) |
|---|---|---|---|---|
| Jet | Large: 2-aisle, long-haul | 0.01% | 1,853 | 4.00 |
| | Medium: 2-aisle, medium-haul | 0.01% | 1,321 | 4.00 |
| | Small: 1-aisle, small/medium haul | 7.95% | 565 | 1.78 |
| | Regional: 1-aisle, short-haul | 0.01% | 315 | 1.78 |
| | Business: 2-eng business jets | 0.01% | 41 | 1.78 |
| Turboprop | Turboprop (all engines) | 22.29% | 46 | 1.78 |
| Piston | Piston (all engines) | 66.30% | 41 | 0.00 |
| Helicopter | Helicopter small (1 engine/turbine) | 1.72% | 13 | 0.00 |
| | Helicopter large (2 engine/turbine) | 1.72% | 8 | 0.00 |

Calculating fuel use for each aviation class applied the following equation:

***Fuel Use** Per Aviation Class = Number of Aircraft Movements * (LTO Fuel Use + (APU Fuel Use * 15 minutes))*

The GHG quantification method, that was applied to each aviation class, is as follows:

$$\textit{Emissions}_{\text{Per Aviation Class}} = (\text{Vol. Fuel} * \text{Aviation Class } EF_{CO2}) + (\text{Vol. Fuel} * \text{Aviation Class } EF_{CH4} * GWP_{CH4}) + (\text{Vol. Fuel} * \text{Aviation Class } EF_{N2O} * GWP_{N2O}))$$

The ACERT GHG calculator used by the VIA utilized emission factors from the 2023 NIR. Actual airplane emission factors are from the International Civil Aviation Organization (ICAO) GHG database. These are summarized in Table 17.

These GHG emissions were reported in the Scope 3 category as directed by the GPC Protocol.

**Table 17 Aviation GHG Emission Factors**

| Airplane Type | Units | $tCO_2e$ | Quality Assessment Rating |
|---|---|---|---|
| Jet | $tCO_2e$/kg fuel | 0.0032254 | Medium-Low |
| Turbo Propeller | $tCO_2e$/kg fuel | 0.0032254 | Medium-Low |
| Piston | $tCO_2e$/kg fuel | 0.0034154 | Medium-Low |
| Helicopter | $tCO_2e$/kg fuel | 0.0032254 | Medium-Low |

#### 4.2.5.3 Aviation: Victoria Harbour

Victoria harbor aviation emissions were estimated using 2022 NAV Canada airplane movement statistics, estimated taxi times, and estimated fuel use for the DHC-6 Twin Otter type of plane (Table 18).

**Table 18 Aircraft Type, Estimated Percentage of Total Reported Movements, And Estimated Fuel Use**

| Aviation Class | Aircraft Type | Estimated Percentage of Annual Movements | Estimated LTO Fuel Use by Aircraft Type (kg) | Estimated APU Fuel Use by Aircraft Type (kg/min) |
|---|---|---|---|---|
| Turboprop | DHC-6 Twin Otter | 100% | 56 | 0.00 |

Calculating aviation fuel use in the Victoria harbor for applied the following equation:

***Fuel Use*** ***Per Aviation Class*** = *Number of Aircraft Movements * (LTO Fuel Use + (APU Fuel Use * 15 minutes))*

The GHG quantification method is as follows:

$$\textbf{Emissions}_{\textbf{Per Aviation Class}} = \textit{CRD Population} * ((\textit{Vol. Fuel} * \textit{Aviation Class } EF_{CO2}) + (\textit{Vol. Fuel} * \textit{Aviation Class } EF_{CH4} * GWP_{CH4}) + (\textit{Vol. Fuel} * \textit{Aviation Class } EF_{N2O} * GWP_{N2O}))$$

The airplane emission factors are from the International Civil Aviation Organization (ICAO) GHG database. These are summarized in Table 19.

### Table 19 Marine Aviation GHG Emission Factors

| Units | $tCO_2e$ | Quality Assessment Rating |
|---|---|---|
| Turbo Propeller | 0.0032163 | Medium-Low |

As there is no publicly available origin traveler data for harbor flights, the aviation GHG emissions were prorated based on the local government populations relative to the CRD population. These were reported in the Scope 3 category.

### 4.2.5.4 Waterborne Transportation

#### 4.2.5.4.1 BC Ferries

Marine waterborne transportation emissions encompass GHG emissions from the use of the BC Ferries. BC Ferries reported their 2022 GHG emissions which were pro-rated based on total service populations. The GHG emissions reported by BC Ferries are based on provincially derived GHG emissions factors (Table 20).

### Table 20 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 |

As BC Ferries operate outside of the CRD's boundary, the GHG emissions were allocated to Scope 3 based on the proportion of the CRD population relative to the total Vancouver Island and Mainland / Southwest populations.

#### 4.2.5.4.2 Other Watercraft

The GHG emissions from the Coho Ferry, the Victoria Clipper Ferry, and personal and commercial watercraft were estimated based on a publicly available year 2000 study for the Victoria, Vancouver, and Washington harbors and the Transport Canada Vessel Registration System. As there is currently no publicly available energy or GHG related information on the operation of the Coho and the Victoria Clipper Ferries, it was assumed that the GHG emissions for these ferries calculated in the Study entitled "Marine Vessel Air Emissions in BC and Washington State Outside of the GVRD and FVRD for the Year 2000" is still valid for 2022. The GHG emissions for these ferries are summarized in Table 21.

### Table 21 Coho and the Victoria Clipper Ferries Estimated GHG Emissions

| Aspect | Units | $CO_2$ | $CH_4$ | $N_2O$ | $tCO_2e$ |
|---|---|---|---|---|---|
| Coho Ferries | tonnes | 1,160.00 | 0.10 | 0.40 | 1,281.70 |
| Victoria Clipper | tonnes | 1,895.00 | 0.10 | 0.80 | 2,135.90 |

Cruise ship GHG emissions were estimated by the Greater Victoria Harbour Authority.[3] The Greater Victoria Harbour Authority (GVHA) reported on cruise ship emissions for the 2018 reporting year but did not derive an estimate for 2022. As a result, the 2018 GHG emissions estimate and number of cruise ship visits to Ogden Point in 2022 was used to create a proxy to estimate 2022 cruise ship emissions. The GVHA reported 329 visits in 2022.

The GHG quantification method to estimate 2022 GHG emissions from the Odgen Point cruise ship terminal was as follows:

$$Emissions_{Waterborne} = (GVHA\ Reported\ Emissions_{2018} / Cruise\ Ship\ Visits_{2018}) * Cruise\ Ship\ Visits_{2022}$$

The Transport Canada Vessel Registration System provided the total number of registered waterborne vehicles which was 2,254 vessels all registered boats in the CRD; however, the registration system does not provide any detail on the type, size, use, and owner of the watercraft. It was therefore assumed that the watercraft would have been similar to those in the referenced study. To estimate the personal / watercraft GHG emissions, the breakdown of vessels and total fuel use by category were used to estimate what the current population and fuel use might be in the reporting year. To do this, the following steps were taken.

1. Calculate the percentage of the population and per unit fuel use of the year 2000 population (Table 22).
1. Take the total number of registered vessels, and the percentage breakdown of the year 2000 population, and apply the per unit fuel use factor to determine the total gasoline and diesel fuel use (Table 23).
2. Using 2023 NIR emission factors estimate the GHG emissions from other watercraft.

### Table 22 Year 2000 Other Watercraft Population Breakdown And Estimated Fuel Use

| Type of Watercraft from Year 2000 Study | Year 2000 Study Vancouver Island Population | Percentage of Population | Fuel Use ($m^3$/Year) | Fuel Use Per Unit ($m^3$/Year) |
|---|---|---|---|---|
| Inboard: 4 stroke - gasoline | 1,689 | 0.19% | 175 | 0.10 |

[3] https://gvha.ca/wp-content/uploads/2019/10/EmissionsInventory-2019.pdf

| Type of Watercraft from Year 2000 Study | Year 2000 Study Vancouver Island Population | Percentage of Population | Fuel Use ($m^3$/Year) | Fuel Use Per Unit ($m^3$/Year) |
|---|---|---|---|---|
| Inboard: Diesel | 199 | 0.02% | 62 | 0.31 |
| Outboard: 2 stroke - gasoline | 23,494 | 2.66% | 1,632 | 0.07 |
| Outboard: 4 stroke - gasoline | 622 | 0.07% | 7 | 0.01 |
| Stemdrive: 2 stroke - gasoline | 68 | 0.01% | 8 | 0.12 |
| Stemdrive: 4 stroke - gasoline | 6,576 | 0.74% | 535 | 0.08 |
| Stemdrive: Diesel | 784 | 0.09% | 216 | 0.28 |
| Personal Watercraft: 2 stroke - gasoline | 848,492 | 96.00% | 342 | 0.00 |
| Sailboat Auxiliary Inboard: 4 stroke - gasoline | 428 | 0.05% | 1 | 0.00 |
| Sailboat Auxiliary Inboard: Diesel | 1,088 | 0.12% | 6 | 0.01 |
| Sailboat Auxiliary Outboard: 2 stroke - gasoline | 396 | 0.04% | 1 | 0.00 |
| Sailboat Auxiliary Outboard: Diesel | 1 | 0.00% | 0 | 0.01 |

**Table 23 Reporting Year Other Watercraft Population Breakdown and Estimated Fuel Use**

| Type of Watercraft | Estimated Breakdown of Currently Registered Vessels | Estimated Fuel Use (L/year) |
|---|---|---|
| Inboard: 4 stroke - gasoline | 4 | 438.6 |
| Inboard: Diesel | 0 | 155.4 |
| Outboard: 2 stroke - gasoline | 59 | 4,090.0 |
| Outboard: 4 stroke - gasoline | 2 | 17.5 |
| Stemdrive: 2 stroke - gasoline | 0 | 20.0 |
| Stemdrive: 4 stroke - gasoline | 16 | 1,340.8 |
| Stemdrive: Diesel | 2 | 541.3 |
| Personal Watercraft: 2 stroke - gasoline | 2,126 | 857.1 |
| Sailboat Auxiliary Inboard: 4 stroke - gasoline | 1 | 1.3 |
| Sailboat Auxiliary Inboard: Diesel | 3 | 15.0 |
| Sailboat Auxiliary Outboard: 2 stroke - gasoline | 1 | 1.3 |
| Sailboat Auxiliary Outboard: Diesel | 0 | 0.0 |

To calculate the GHG emissions, for the other watercraft, provincially derived GHG emissions factors were used (Table 24).

### Table 24 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 the BC Ferries and other watercraft was as follows:

$$Emissions_{Waterborne} = (CRD\ Population / Vancouver\ Island; Mainland; Southwest\ Population) * ((Vol.\ Fuel * EF_{CO2}) + (Vol.\ Fuel * EF_{CH4} * GWP_{CH4}) + (Vol.\ Fuel * EF_{N2O} * GWP_{N2O}))$$

#### 4.2.5.5 Off-Road

Currently, there is limited data available to estimate off-road GHG emissions. As such, a GHG emissions per capita estimate for each off-road category was developed using Provincial emissions data from the 2023 NIR, and BC's population from Statistics Canada. To develop each off-road factor, the total BC GHG emissions for each reporting category was divided by the BC population for the NIR reporting year (2021). Each derived per-capita value was applied to the current reporting year CRD population (2022) to estimate off-road GHG emissions.

The NIR currently reports the following off-road emissions:

- Total BC off-road agriculture and forestry GHG emissions
- Total BC off-road commercial and institutional GHG emissions
- Total BC off-road residential GHG emissions
- Total BC other off-road GHG emissions

Total BC off-road manufacturing, mining, and construction GHG emissions were not included on the basis that manufacturing and mining GHG emission could not be split out.

Other than other off-road GHG emissions, which is reported in the Off-Road Transportation Sub-Sector, the remaining off-road GHG emissions are reported in the Stationary Energy Sector as required by the GPC Protocol.

The GHG quantification method is presented below:

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

## 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 CRD, the Waste Sector encompasses the following GHG emissions scopes and Sub-Sectors:

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

### 4.3.1 Data Quality Assessment

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

**Table 25 Waste Data Quality Assessment**

| Data | Quality Assessment Rating |
|---|---|
| Wastewater volume data | High |
| Wastewater BOD and TKN data | High |
| Composting waste data | Low |

### 4.3.2 Activity Data

The CRD provided landfill gas volumes, energy and GHG related data for the Hartland landfill (fugitives and flaring), total CRD wastewater volumes, average biological oxygen demand (BOD) and Total Kjeldal Nitrogen (TKN) annual average values (mg/L) from the wastewater for all relevant outfalls. The wastewater volumes are based on total budgeted sewer costs.

Some GHG emissions from incineration and open burning are likely to be occurring in the CRD but cannot readily be estimated. This the notation key for “Not Estimated” has been used to indicate this.

### 4.3.3 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2022 GHG emissions:

- To quantify GHG emissions from the Hartland Landfill, the CRD utilized the waste-in-place method which is accepted under the GPC Protocol. The Waste-in-place (WIP) assigns landfill emissions based on total waste deposited during that year. It counts GHGs emitted that year, regardless of when the waste was disposed. GHG emissions from the Hartland Landfill for the reporting year are allocated based upon the percentage of Community waste, relative to total waste received at to the

Hartland Landfill. It is assumed that the GHG emissions data provided is reasonably accurate and the method deployed correct.

- It is assumed that the landfill gas has a constant higher heating value (HHV) of 0.01865 ($GJ/m^3$).
- Composting GHG emissions are estimated based on the total tonnage estimated by the CRD. It is assumed that all compost is treated aerobically.
- Wastewater is not currently treated. As such, IPCC wastewater methane ($CH_4$) producing capacity and $CH_4$ correction default factors were used. These factors used are for untreated wastewater being deposited into deep or moving waters. It is likely that ocean sequesters more $CH_4$ than is estimated.
- It is likely that GHG emissions from incineration and open burning are occurring on an infrequent and controlled (property by property) basis, but without available data the GHG emissions cannot be reasonably quantified.

## 4.3.4 Calculation Methodology

### 4.3.4.1 Solid Waste

The Hartland Landfill has a landfill gas (LFG) collection and destruction system at the Hartland Landfill to which the LFG is either combusted in a flare, or in an engine to generate electricity which is exported to the grid. The GHG emissions associated with energy generation are reported as a reporting only GHG emission under Stationary Energy: Energy Industries Reporting Only and are not included in the total GHG emissions estimate. The GHG emissions associated with flaring of the landfill gas are reported under Stationary Energy: Energy Industries Scope 1.

The GHG quantification method for Stationary Energy: Energy Industries is as follows:

$$\textbf{Emissions}_{\text{Stationary Energy: Energy Industries}} = (LFG\ Consumed_{m3} * HHV_{LFG} * EF_{RNG\ CH4} * GWP_{CH4}) + (LFG\ Consumed_{m3} * HHV_{LFG} * EF_{RNG\ N2O} * GWP_{N2O})$$

The fugitive landfill GHG emissions estimates were generated by the CRD using the waste-in-place (WIP) method which is accepted under the GPC Protocol. The WIP assigns landfill emissions based on emissions during that year. It counts GHGs emitted that year, regardless of when the waste was disposed.

### 4.3.4.2 Biological Treatment of Solid Waste

The CRD provided 2022 composting data which is assumed to be treated aerobically at the Hartland Landfill. 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 26).

**Table 26 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:

$$\textbf{Emissions}_{\textbf{Anaerobic Waste}} = Compost\ Waste_{Total} * EF_{CH4} * GWP_{CH4}$$

#### 4.3.4.3 Wastewater Treatment And Discharge

Wastewater is currently treated on Vancouver Island prior to being sent to ocean-based outfalls. The CRD provided the 2022 wastewater volumes ($m^3$), the average biological oxygen demand (BOD) and the average Total Kjeldal Nitrogen (TKN) in wastewater. 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:

$$\textbf{Emissions}_{\textbf{Wastewater CH4}} = ((Wastewater_{m3} * (BOD_{ml/L} / 1000) * (0.06_{kg\ CH4/kg\ BOD} * 0.01)) / 1000) * GWP_{CH4}$$

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

## 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 CRD, the IPPU encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 1 Emissions:
  - Product use

No GHG emissions from Industrial Processes are known to be occurring and thus the notation key for “Not Occurring” has been used to indicate this.

### 4.4.2 Activity Data

As there is limited data available on Product Use GHG emissions, the GHG Emissions estimate was derived on a per capita basis using the 2023 NIR GHG data for the Province of BC and BC population data for the reporting year.

### 4.4.3 Data Quality Assessment

Table 27 presents the activity data quality assessment for the IPPU data sources.

**Table 27 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 2022 GHG emissions:

- The product use emissions are based on the 2023 NIR product use GHG emissions as prepared by Environment and Climate Change Canada.
- 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 2022 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 CRD, a per capita estimate was developed using the Provincial emissions data from the 2023 NIR, and BC’s NIR reporting year population from Statistics Canada. This value was applied to the 2022 reporting year CRD population to estimate the total product use emissions.

The GHG quantification method is presented below:

***Emissions** <sub></sub>*

$$\textit{Emissions}_{\textit{Product Use}} = (\textit{NIR Product Use GHG Emissions}_{BC} / \textit{NIR Population}_{BC}) * \textit{Current Reporting Year Population}$$

# 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 CRD, 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 CRD provided remotely sensed imagery to estimate land-cover change. This data included:

- Habitat Acquisition Trust (HAT) Land Cover Mapping (2007 and 2011)
- Annual Crop Inventory (ACI), Agriculture Canada
- Satellite Imagery interpretation (2011 and 2019), CRD
- Vegetation Resources Inventory (VRI), British Columbia Government.
- Earth Observation for Sustainable Development of Forests (EOSD) Land Cover Classification, Service Natural Resources Canada

Livestock and aggregate sources and non-$CO_2$ emissions sources on land were estimated using GHG emissions data from the 2023 NIR, and land-use data from the 2021 Statistics Canada Census of Agriculture, to create a GHG emissions per hectare value.

## 4.5.3 Data Quality Assessment

Table 28 presents the activity data quality assessment for the AFOLU data sources.

**Table 28 AFOLU Data Quality Assessment**

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

## 4.5.4 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2022 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. For parts of the CRD, spatial data was available for the 2007, 2011 and 2019 reporting years. Differences between these data sets in terms of resolution and their timing of collection increase the uncertainty as to the accuracy of the land-use classifications. For example, the 2007 and 2011 land use data was collected at different times of the year and may not accurately reflect tree cover. Furthermore, no land use spatial data was collected for the Juan de Fuca, Salt Spring Island or Gulf Islands and thus Annual Crop Inventory (ACI) settlement data collected by Agriculture Canada was used to inform the analysis. The challenge in utilizing this data is that it is provided in a 30m resolution. Furthermore, since annual data is not available, the change between land cover data years (2007-2011, 2011-2019) for all areas was averaged and may not represent actual changes in each year. Lastly, 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 CRD's GHG emissions inventory, but have been disclosed, until a more robust measurement methodology can be developed. Since no data was available for 2022, the 2019 estimates were applied.

## 4.5.5 Calculation Methodology

### 4.5.5.1 Land Use

Remotely sensed imagery was used to estimate land-cover changes during the 2007-2019 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 following table identifies the data sources used for the reporting years for each of the study area's geographies.

**Table 29 Spatial Data Sources Representing Land Cover For The CRD Study Area**

| | | CRD Study Area Geography | | |
|---|---|---|---|---|
| | | **CRD Core** | **Gulf Islands** | **Juan de Fuca Region** |
| **Reporting Year** | **2007** | 2005 HAT Land Cover Mapping | 2001 EOSD Land Cover Classification | 2011 HAT Land Cover Mapping[2] |
| | **2011** | 2011 HAT Land Cover Mapping | 2001 EOSD Land Cover Classification + 2011 ACI 'Settlement' | 2011 HAT Land Cover Mapping[2] + 2011 ACI 'Settlement' |
| | **2022** | 2019 HAT Land Cover Mapping + 'Settlement' satellite image interpretation[1] | 2001 EOSD Land Cover Classification + 2019 ACI 'Settlement' | 2011 HAT Land Cover Mapping[2] + 2019 ACI 'Settlement' |

Notes:

[1] Settlements land cover category is a combination of i) municipality provided building footprint as acquired mostly from digitizing roofline from satellite and orthoimagery, ii) new roads (ParcelMap BC parcel with parcel start dates > 2011 and parcel class = 'road') and iii) and theoretical building footprints (average building footprint areas as buffered centroids of new ParcelMap BC parcel with start dates > 2011 with a residential parcel class)

[2] The 2011 land cover classification was interpreted mostly from 2005 imagery in the Juan de Fuca region making it more suitable for the 2007 reporting year.

The spatial data sources representing land cover in this analysis include more categories than 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 30 IPCC Land Use Classification Cross-References

| IPCC Land Cover | EOSD Land Cover | HAT Land Cover | Annual Crop Inventory |
|---|---|---|---|
| **Cropland** | Annual Cropland, Perennial Cropland And Pasture | Agricultural Fields | - |
| **Forest** | Broadleaf Dense, Broadleaf Open, Coniferous Dense, Coniferous Open, Coniferous Sparse | Tree | - |
| **Grassland** | Grassland, Herb, Shrub Low | Grass, Herb | - |
| **Settlement** | Developed | Pavement/Building | Developed |
| **Wetland** | Wetland - Herb, Wetland - Shrub, Wetland - Treed | Riparian Tree, Riparian Herb, Pond | - |
| **Other** | Water, Exposed Land | Shadow, Ocean, Lake, River, Sand/Gravel Shoreline, Bedrock Shoreline, Exposed Soil, Exposed Bedrock | - |

The analysis resulted 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 31).

### Table 31 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 |

| Land-Use Classification | Emission Factor | Units | Quality Assessment Rating |
|---|---|---|---|
| Wetlands | 471.5 | $tCO_2e$ / ha | Low |
| Cropland | 239.8 | $tCO_2e$ / 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:

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

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

### 4.5.5.2 Emissions from 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 was used in conjunction with 2023 NIR data to develop a $tCO_2e$ / ha value estimate for:

- Livestock
- Aggregate Sources And Non-$CO_2$ Emissions Sources On Land

To calculate GHG emissions from urea application, the calculated total crop land in hectares for the reporting year was applied against an IPCC GHG emissions factor of 0.20 $tCO_2e$ / ha. This emission factor is also applied in the 2023 NIR.

The GHG quantification method is presented below:

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

$$\textbf{Emissions}_{\textbf{Urea Application}} = \textit{CRD Cropland}_{ha} * 0.66\ tCO_2e / ha$$

# 5.0 2022 GHG REPORTING YEAR RESULTS

## 5.1 SUMMARY

Total BASIC, and BASIC+ emissions for the CRD for the 2022 reporting year are presented in the Figure 3 below.

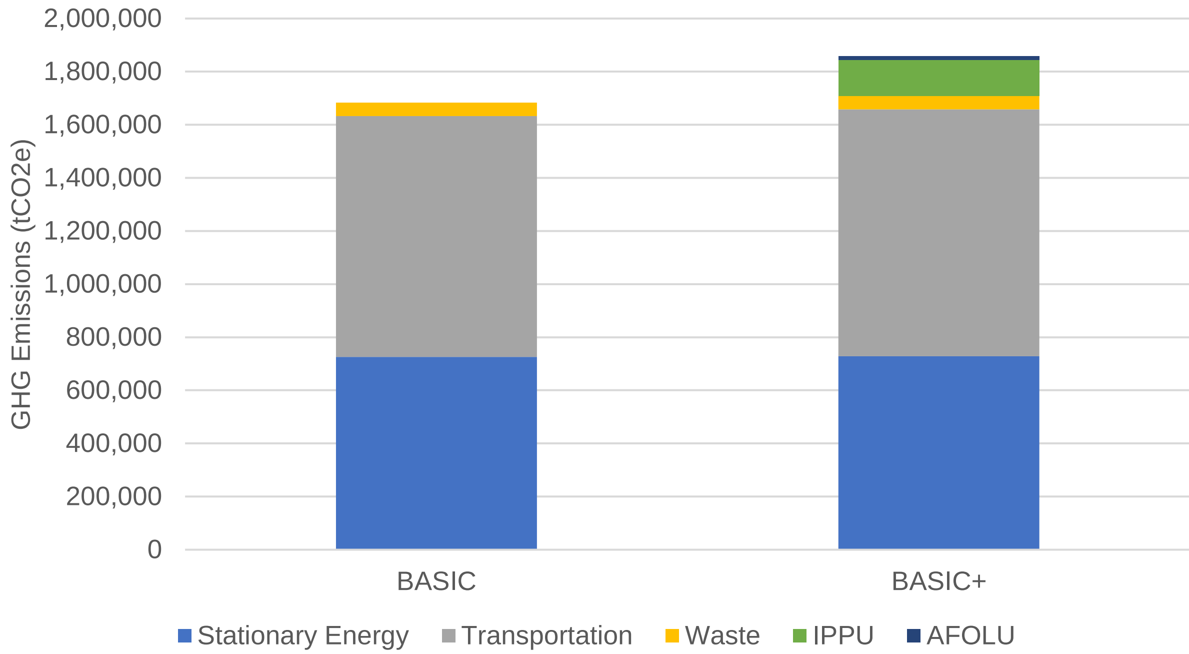


**Figure 3 2022 GHG Emissions Summary by GPC Reporting Level**

Emission by reporting level are presented in the Table 32 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 32 Breakdown of the CRD's 2022 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) | 686,323 | 39,149 | 2,623 | 725,472 | 728,096 | 728,096 |
| | Energy generation supplied to the grid (I.4.4) | 8,217 | | | | | |
| Transportation | (all II emissions) | 907,764 | 198 | 22,694 | 907,962 | 930,656 | 930,656 |
| Waste | Waste generated in the Community (III.X.1 and III.X.2) | 50,275 | | 0 | 50,275 | 50,275 | 50,275 |
| | Waste generated outside community (III.X.3) | NO | | | | | |
| IPPU | (all IV emissions) | 135,461 | | | | 135,461 | 135,461 |
| AFOLU | (all V emissions) | 13,837 | | | | 13,837 | 13,837 |
| Other Scope 3 (S3) | (all VI emissions) | | | NE | | | NE |
| **TOTAL** | | **1,793,660** | **39,347** | **25,317** | **1,683,710** | **1,858,325** | **1,858,325** |

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 33 presents the breakdown of the CRD's BASIC+ GHG emissions by Sector and Sub-Sector.

**Table 33 Breakdown of the CRD's 2022 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 | 248,785 | 24,609 | 1,649 | 275,044 |
| I.2 | Commercial and institutional buildings and facilities | 328,496 | 14,540 | 974 | 344,011 |
| I.3 | Manufacturing industries and construction | NE | NE | NE | NE |
| I.4.1/2/3 | Energy industries | 6,497 | NO | NO | 6,497 |
| I.4.4 | Energy generation supplied to the grid | 8,217 | | | |
| I.5 | Agriculture, forestry, and fishing activities | 101,034 | IE | IE | 101,034 |
| 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 | 1,510 | | | 1,510 |
| **Sub-Total** | (community induced framework only) | **686,323** | **39,149** | **2,623** | **728,096** |
| **II** | **Transportation** | | | | |
| II.1 | On-road transportation | 764,983 | 198 | 6,947 | 772,129 |
| II.2 | Railways | NO | NO | NO | NO |
| II.3 | Waterborne navigation | 55,107 | IE | IE | 55,107 |
| II.4 | Aviation | IE | IE | 15,746 | 15,746 |
| II.5 | Off-road transportation | 87,673 | IE | IE | 87,673 |
| **Sub-total** | (community induced framework only) | **907,764** | **198** | **22,694** | **930,656** |
| **III** | **Waste** | | | | |
| III.1.1/2 | Solid waste generated in the Community | 39,699 | | NO | 39,699 |
| III.2.1/2 | Biological waste generated in the Community | 5,602 | | NO | 5,602 |
| III.3.1/2 | Incinerated and burned waste generated in the Community | NO | | NO | NO |
| III.4.1/2 | Wastewater generated in the Community | 4,975 | | IE | 4,975 |
| III.1.3 | Solid waste generated outside the Community | NO | | | |
| III.2.3 | Biological waste generated outside the Community | NO | | | |
| 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) | **50,275** | | **0** | **50,275** |
| **IV** | **Industrial Processes and Product Uses** | | | | |

**Table 33 Breakdown of the CRD's 2022 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 |
| IV.1 | Emissions from industrial processes occurring in the Community boundary | NE | | | NE |
| IV.2 | Emissions from product use occurring within the Community boundary | 135,461 | | | 135,461 |
| **Sub-Total** | (community induced framework only) | **135,461** | | | **135,461** |
| **V** | **Agriculture, Forestry, and Other Land Use** | | | | |
| V.1 | Emissions from livestock | 12,431 | | | 12,431 |
| V.2 | Emissions from land | -312,232 | | | -312,232 |
| V.3 | Emissions from aggregate sources and non-$CO_2$ emission sources on land | 1,406 | | | 1,406 |
| **Sub-Total** | (community induced framework only) | **13,837** | | | **13,837** |
| **VI** | **Other Scope 3** | | | | |
| VI.1 | Other Scope 3 | | | NE | NE |
| **Total** | (community induced framework only) | **1,793,660** | **39,347** | **25,317** | **1,858,325** |

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 CRD's GHG emissions totaled 1,858,325 $tCO_2e$. On a per capita basis, this works out to 4.3 $tCO_2e$ per person.

**Table 34 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 | 13,310,014 | 275,044 | 30 | 0.6 |
| | Commercial & Institutional Buildings | 10,788,422 | 344,011 | 25 | 0.8 |
| | Manufacturing Industries & Construction | - | - | - | - |
| | Energy Industries | - | 6,497 | - | 0.0 |
| | Agriculture, Forestry & Fishing Activities | 1,407,950 | 101,034 | 3 | 0.2 |
| | Fugitive Emissions | - | 1,510 | - | 0.0 |
| Transportation | In-Boundary On-road Transportation | 11,641,173 | 765,180 | 26 | 1.7 |
| | Trans-Boundary On-road Transportation | 105,722 | 6,949 | 0 | 0.0 |
| | Waterborne Navigation | 709,978 | 55,107 | 2 | 0.1 |
| | Aviation | 211,848 | 15,746 | 0 | 0.0 |
| | Off-road Transportation | 1,221,764 | 87,673 | 3 | 0.2 |
| Waste | Solid Waste | | 39,699 | | 0.1 |
| | Biological Treatment of Waste | | 5,602 | | 0.0 |
| | Wastewater Treatment & Discharge | | 4,975 | | 0.0 |
| IPPU | Product Use | | 135,461 | | 0.3 |
| AFOLU | Land-Use: Emissions Sequestered **(Disclosure Only - Not Included In Total)** | | (401,842) | | (0.9) |
| | Land-Use: Emissions Released **(Disclosure Only - Not Included In Total)** | | 89,610 | | 0.2 |
| | Livestock | | 12,431 | | 0.0 |
| | Non-CO2 Land Emission Sources | | 1,406 | | 0.0 |
| **Total** | | **39,396,871** | **1,858,325** | **89.5** | **4.2** |

Total GHG emissions for 2022 are 1,858,325 $tCO_2e$ and have decreased 8% from the 2007 base year. Scope 1 and 2 Emissions are 97% and 2% of the total GHG inventory. Scope 1 emissions are the GHG emissions that result from the combustion of fuel in sources within the CRD'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 CRD 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 CRD that are occurring outside of the CRD's boundaries. For 2022, Scope 3 GHG emissions make up 1% of the GHG inventory. This breakdown by emission scope is depicted in Figure 4.

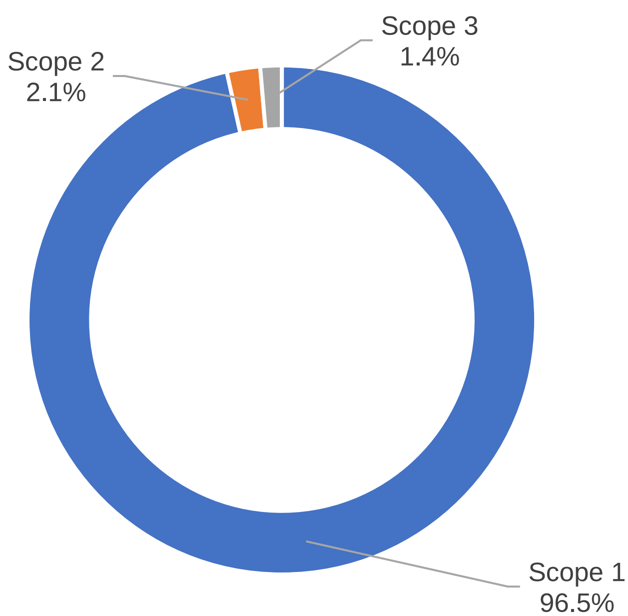


**Figure 4 CRD BASIC+ GHG Emissions by Emissions Scope**

A breakdown of GHG emissions by reporting scope for the 2007 base and reporting year are presented in Table 35 below.

**Table 35 Change in GHG Emissions from Base Year**

| Emissions Scope | 2007 GHG Emissions ($tCO_2e$) | 2022 GHG Emissions ($tCO_2e$) | Change |
|---|---|---|---|
| Scope 1 | 1,841,365 | 1,793,660 | -2.6% |
| Scope 2 | 116,129 | 39,347 | -66.1% |
| Scope 3 | 47,134 | 25,317 | -46.3% |
| **Total** | **2,004,628** | **1,858,325** | **-7.3%** |

## 5.3 SECTORAL GHG EMISSIONS ANALYSIS

### 5.3.1 Stationary Energy

Stationary energy sources are one of the largest contributors to the CRD's GHG emissions. In 2022, it contributed 39% of the community's GHG emissions. In general, stationary energy emissions include the 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 36 summarizes the energy and GHG emissions for the 2022 reporting year.

**Table 36 2022 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 | 26,258 | 141,472 | 42,240 | 25,703 | 28,855 | 10,516 | **275,044** | **13,310,014** |
| Commercial & Institutional Buildings | 15,514 | 235,444 | 9,775 | | | 83,278 | **344,011** | **10,788,422** |
| Energy Industries | | | | | | 6,497 | **6,497** | |
| Agriculture, Forestry & Fishing activities | | | | | | 101,034 | **101,034** | **1,407,950** |
| Fugitive Emissions | | | | | | 1,510 | **1,510** | |
| **Total GHG Emissions ($tCO_2e$)** | **41,773** | **376,916** | **52,014** | **25,703** | **28,855** | **202,835** | **728,096** | |
| **Total Energy (GJ)** | **13,076,561** | **7,409,355** | **760,983** | **421,254** | **1,123,230** | **2,715,004** | | **25,506,387** |

It can be seen in Figure 5 that heating oil and natural gas use contributed to almost 60% of the CRD's total Stationary Energy GHG emissions.

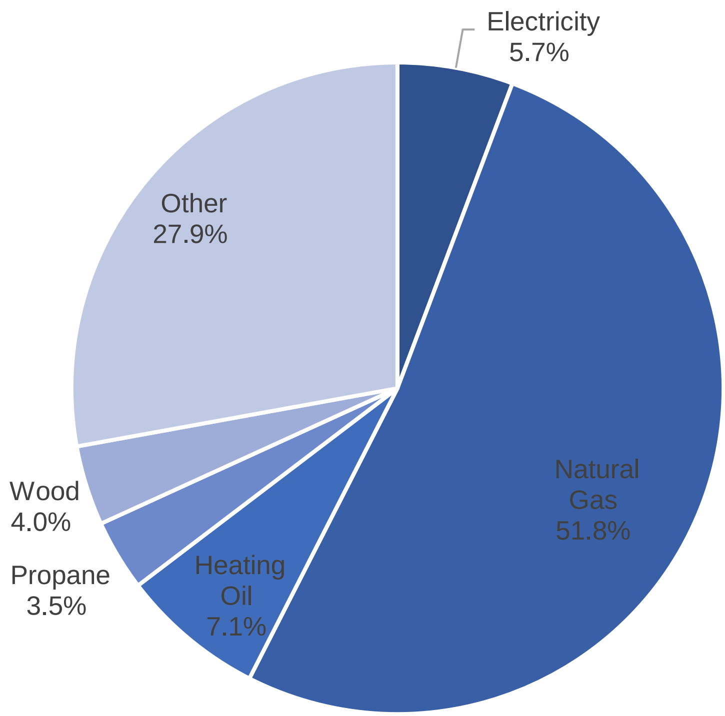


**Figure 5 Stationary Energy GHG Emissions Contribution to the GHG Inventory**

Figure 6 shows that more than 90% of the stationary GHG emissions arise from the operation of buildings. Historically, residential buildings contributed more to the CRD's GHG emissions inventory, but this is now declining with the focus on reducing heating oil and energy efficiency building retrofits.

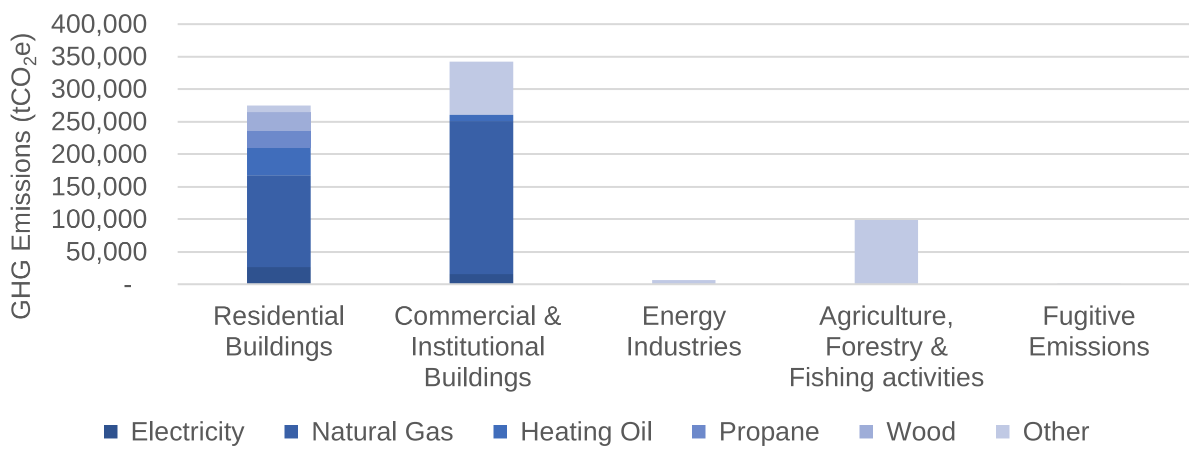


**Figure 6 Total Stationary Energy Use By Sub-Sector**

Stationary energy GHG emissions have decreased by nearly 8% since the base year (Table 37). This is mainly the result of the changing electricity emission factor which increased by 12% in 2022 (as compared to 2007) as well as a decline in the use of heating oil.

**Table 37 Stationary Energy—Energy and GHG Emissions Trends**

| Sector | Change in GJ: 2007 & 2022 | Change in $tCO_2e$: 2007 & 2022 |
|---|---|---|
| Residential Buildings | -5.7% | -34.9% |
| Commercial & Institutional Buildings | 19.6% | 27.2% |
| Energy Industries | N/A | 1454.3% |
| Agriculture, Forestry & Fishing activities | 16.0% | 12.9% |
| Fugitives | N/A | 50.6% |
| **Total** | **4.7%** | **-7.1%** |

### 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 2022 reporting year, transportation GHG emissions accounted for 50% of the CRD GHG inventory with the bulk of transportation GHG emissions resulting from the on-road transportation sub-sector (84%). 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 38 summarizes the on-road energy and GHG emissions for the 2022 reporting year.

**Table 38 2022 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 | 8,614 | 17,225,195 | kWh | 62,010 | 198 |
| Gasoline | 274,956 | 275,786,050 | Liters (L) | 9,558,744 | 626,637 |
| Diesel | 16,289 | 56,149,691 | Liters (L) | 2,171,870 | 144,329 |
| Propane | 292 | 634,856 | Liters (L) | 16,208 | 920 |
| Hydrogen | 26 | - | Liters (L) | - | - |
| Natural Gas | 68 | 192,612 | Kilograms (kg) | 10 | 45 |
| Total | **300,245** | **N/A** | **N/A** | **11,746,895** | **772,129** |

Overall, GHG emissions from on-road transportation have decreased by 12% compared to the 2007 base year. The majority of these GHG emissions (84%) are from passenger vehicles, light trucks, and SUVs (Figure 7).

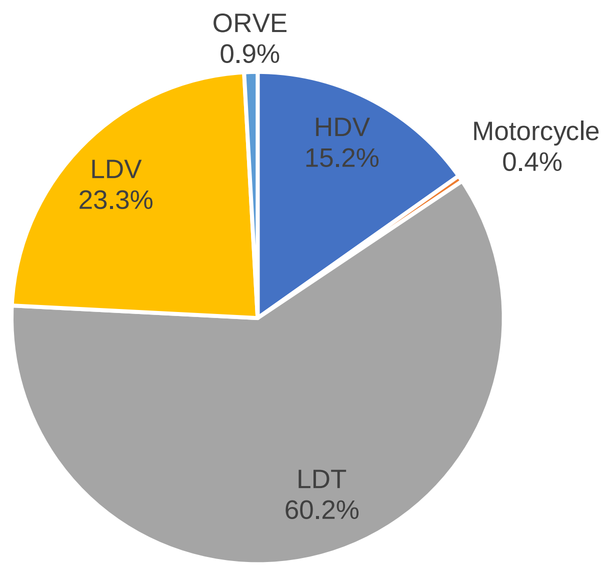


**Figure 7 Breakdown of On-Road GHG Emissions by Vehicle Type**

Table 39 summarizes the aviation, waterborne, and off-road transportation energy and emissions by fuel type. These GHG emissions contribute to 17% of the total transportation GHG emissions and 9% to the total inventory (Figure 8).

**Table 39 2022 Aviation, Waterborne, and Off-Road Transportation Energy and Emissions by Fuel Type**

| Fuel Type | Total | Units | Energy (GJ) | GHG Emissions ($tCO_2e$) |
|---|---|---|---|---|
| Marine Gasoline | 7,610 | Liters (L) | 264 | 17 |
| Marine Diesel | 17,090,167 | Liters (L) | 661,048 | 51,990 |
| Marine Natural Gas | 1,252,662 | Liters (L) | 48,666 | 3,099 |
| Aviation Jet Fuel | 6,105,118 | Liters (L) | 211,848 | 15,746 |
| Other Off-Road Transportation Diesel | 31,586,453 | Liters (L) | 1,221,764 | 87,673 |
| **Total** | **N/A** | **N/A** | **2,143,589** | **158,527** |

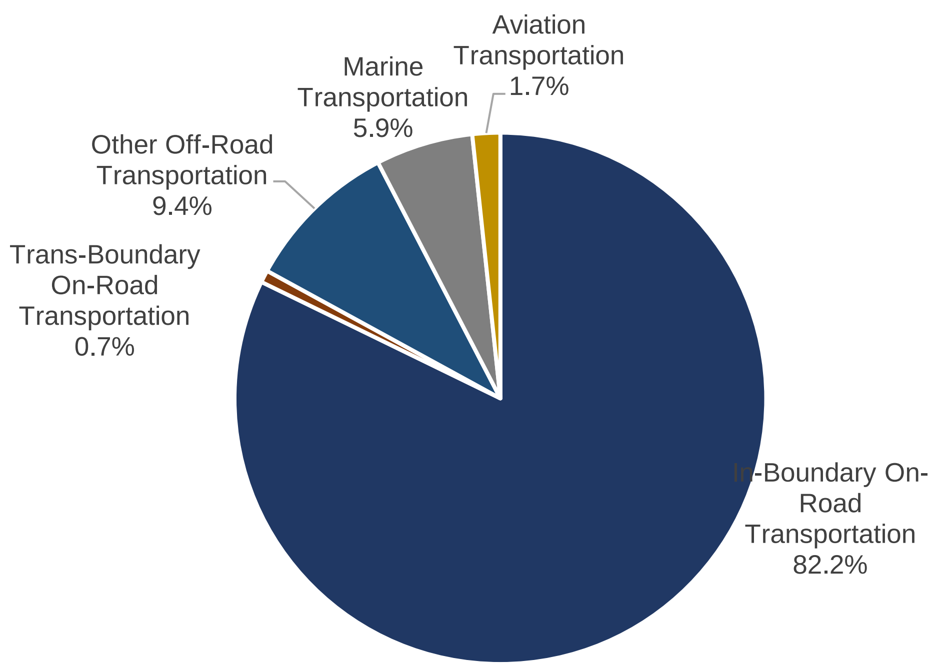


**Figure 8 Summary of Transportation GHG Emissions by Sub-Sector**

### 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 2022 reporting year, waste emissions contributed 3% to the GHG inventory. A breakdown of the Waste Sub-Sector GHG emissions is presented in Table 40.

**Table 40 Summary of Waste Sub-Sector GHG Emissions**

| Sector | 2022 GHG Emissions ($tCO_2e$) | GHG Emissions Per Capita ($tCO_2e$ / Capita) | Change from Base Year (2007) |
|---|---|---|---|
| Wastewater Treatment And Discharge | 4,975 | 0.01 | -73.8% |
| Biological Treatment of Solid Waste | 5,601 | 0.01 | 7556% |
| Solid Waste | 39,699 | 0.09 | -64.3% |
| **Total** | **50,274** | **0.12** | **-61.4%** |

For the 2022 reporting year, in scope GHG emissions from waste have decreased by 61% compared to the 2007 base 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 79% of total waste GHG emissions (Figure 9). To reduce the amount of waste landfilled, and thus GHG emissions, the CRD and its members are making a significant effort to reduce waste going to landfills through organics diversion and recycling.

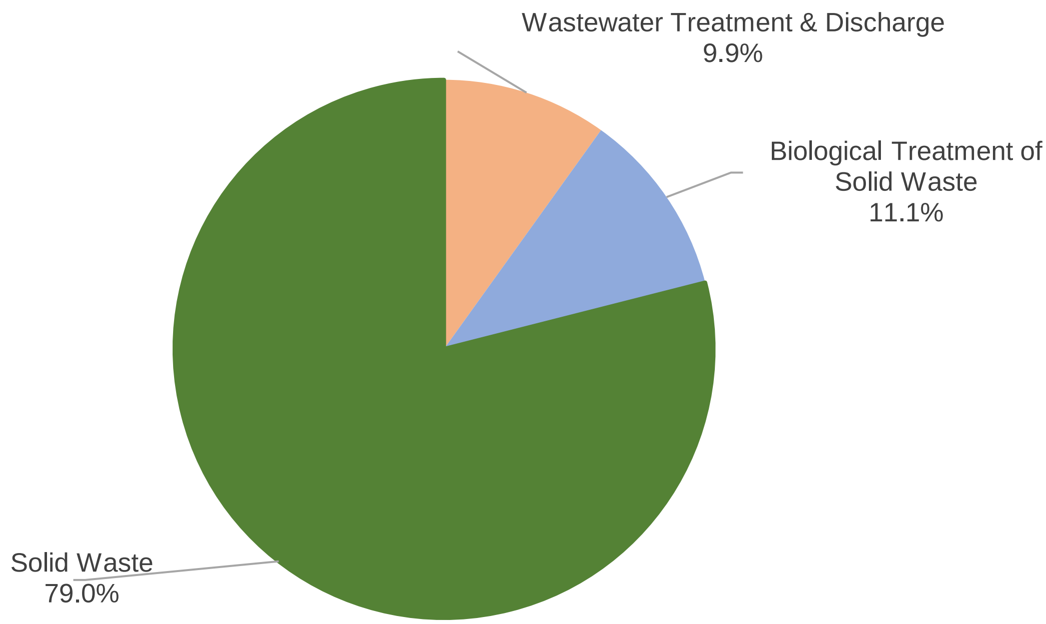

**Figure 9 2022 GHG Emissions from Waste ($tCO_2e$)**

### 5.3.4 Industrial Processes and Product Use (IPPU)

Reporting on IPPU GHG emissions are 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 CRD'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 CRD on the basis that other GHG emissions sources identified in the NIR are not likely to be occurring in the CRD. The sources of these GHG emissions are typically fridges, heat pumps, and air conditioners. To estimate Product Use GHG emissions for the CRD, a per capita estimate was developed using the Provincial emissions data from the 2023 NIR, and BC's NIR reporting year population from Statistics Canada. This value was applied to the 2022 reporting year population to estimate the total Product Use emissions for the CRD.

Between the 2007 and 2022 reporting years, IPPU GHG emissions have increased 92%. The reason for the increase is attributed to Environment and Climate Change Canada having better data available to make the estimate, than the actual GHG emissions increasing such an amount.

**Table 41 Product Use GHG Emissions for the 2007 and 2022 Reporting Years**

| Sub-Sector | 2007 GHG Emissions ($tCO_2e$) | 2022 GHG Emissions ($tCO_2e$) | Change |
|---|---|---|---|
| Product Use Emissions | 70,418 | 135,461 | 92.4% |

### 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 CRD'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 2022, the CRD's greenspace is estimated to have sequestered and stored 401,842 $tCO_2e$ (Table 42), released 89,610 $tCO_2e$ for a net effect of 312,232 $tCO_2e$. Upon review, the result was deemed to contradict expectations relative known trends of development in the region. Therefore, it was excluded from the total inventory calculations.

**Table 42 Summary of Land-Use Change in 2022**

| Land Type | Total Hectares (Ha) | GHG Emissions Sequestered ($tCO_2e$) | GHG Emissions Released ($tCO_2e$) |
|---|---|---|---|
| Forest Land | 171,008.8 | (312,121.9) | - |
| Cropland | 6,347.2 | (2,714.9) | - |
| Grassland | 15,864.1 | (43,300.6) | - |
| Wetlands | 12,511.1 | (43,704.2) | - |
| Settlements | 11,821.8 | - | 46,066.8 |
| Other Land | 13,439.6 | - | 43,542.9 |
| **Total** | **230,992.6** | **(401,841.6)** | **89,609.7** |

#### 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 CRD is reporting 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

Table 43 summarizes these other land-use GHG emissions for the 2022 reporting year. Compared to the 2007 base year, these GHG emissions have increased 79%.

**Table 43 Total AFOLU GHG Emissions for 2022**

| AFOLU Sub-Sector | GHG Emissions ($tCO_2e$) |
|---|---|
| Livestock | 12,431 |
| Aggregate Sources And Non-$CO_2$ Emissions Sources On Land | 1,406 |
| **Total** | **13,837** |

# 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 CRD, 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 CRD reviews to confirm assumptions, data and reasonableness of the estimates.

# 7.0 RECOMMENDATIONS

To remain accurate and reflective of the current community conditions, the CRD should revise and improve its GHG emissions inventory either annually or in line with capital planning cycles (i.e., every 3-4 years), to which there are the following aspects should be focused on:

- 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 base 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 2022 GHG emissions inventory, there are several assumptions were made in the analysis that will have some influence on accuracy of the CRD'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 44 which summarizes the main assumptions, possible impacts on the data, and recommended improvement. It is recommended that the CRD prioritize improvements for that are likely to have a material (>5%) influence on the GHG inventory estimate.

**Table 44 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements**

| Sector | 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, other sectors, like agricultural buildings, could not be split out. A related accuracy issue is the assignment of mixed-use buildings without separate metering. | No impact on the GHG inventory. The change would only happen between emission sub-sectors. | Work with the utility provider to get a more detailed breakdown of energy use by sub-sector. |

**Table 44 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements**

| Sector | Assumption | Possible Impact on The GHG Inventory | Recommended Improvements |
|---|---|---|---|
| Stationary Energy | Propane and wood GHG emissions were estimated based on a 2005 study, 2007-2019 CEEIs and HDD data. it is assumed that the consumption patterns have remained consistent since the 2005 study. | Immaterial impact on the GHG inventory (<5%) | Consider completing a residential energy labelling program. With such a program, an energy and fuel profile for buildings could be developed so that a reasonable estimate of other fuel use be determined. Work with the Province on developing a methodology to estimate wood fuel use. |
| Stationary Energy | The CRD estimated heating oil consumption for the member municipalities (except for Saanich and Victoria) using real-estate sales data and an estimated consumption factor. | Immaterial impact on the GHG inventory (<5%) | Consider completing a residential energy labelling program. With such a program, an energy and fuel profile for buildings could be developed so that a reasonable estimate of other fuel use be determined. |
| Stationary Energy | FortisBC provided a total estimate of fugitive emissions for the CRD region for 2022; 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 | Taxable fuel volumes only represent about 67% of taxable fuel sales (a value that fluctuates yearly). Without more detailed information, a fuel allocation amount could not be allocated to the CRD. As such, the CRD had to rely on vehicle registration data from ICBC and estimated vehicle kilometers travelled (VKT). | Possibly material (>10%) impact to the GHG inventory. Using the estimated VKT data, it is likely that the CRD is over-estimating the GHG emissions from transportation (fuel consumption volumes would include other-off-road consumption). This is the most conservative approach available to the CRD at this point. | If the CRD can get complete fuel sales data for the Region, a more robust estimate of fuel use and GHG emissions, using vehicle registration data, can be determined. |

**Table 44 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements**

| Sector | Assumption | Possible Impact on The GHG Inventory | Recommended Improvements |
|---|---|---|---|
| Transportation | The CRD is relying on ECCC data and models applied at a Provincial level to estimate off-road fuel consumption (e.g., construction, etc.). These emissions are assigned on a per capita basis. It is likely that this approach is over-estimating and possibly double counting GHG emissions. | Possibly material (>10%) impact to the GHG inventory. | Work with member municipalities to estimate infrastructure and building construction GHG emissions for different project types. Use this information with building and infrastructure construction data to estimate these GHG emissions. |
| Transportation | The Victoria International Airport does not report on GHG emissions from tenants or aircraft. Keeping in line with the GPC Protocol, only the aircraft GHG emissions were estimated using NAV Canada airplane movement statistics, estimated taxi times, and estimated fuel use. The fuel use only accounts for departing and arriving planes up to 3,000ft to avoid double counting with other cities. | Immaterial impact on the GHG inventory (<5%) | The Victoria International Airport will not be collecting or reporting on GHG emissions from tenants or aircraft. This is the best available data at this point. |
| Transportation | The GHG emissions from recreational watercraft and US/Can ferries were estimated based on a publicly available year 2000 study for the Victoria, Vancouver, and Washington harbors. | Immaterial impact on the GHG inventory (<5%) | Work with the Victoria Harbor Master as they begin to deploy a database tracking the types and number of boats entering the Victoria harbor. |
| Transportation | The GHG emissions from marine aviation are estimated based on Victoria Harbor NAV Canada air traffic movements and an estimate of fuel consumption for a typical plane. | Immaterial impact on the GHG inventory (<5%) | Work with Harbour Air and other marine aircraft companies to provide fuel consumption volumes. |
| Transportation | The GHG inventory does not include refrigerant losses from vehicles. Derive a | Immaterial impact on the GHG inventory (<5%) | Develop a method to estimate these GHG emissions. |

**Table 44 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements**

| Sector | Assumption | Possible Impact on The GHG Inventory | Recommended Improvements |
|---|---|---|---|
| | method to estimate these GHG emissions. | | |
| Waste | There is tracking to the origin of solid waste but is based on reported origin which may or may not be accurate. For example, some haulers will identify that they are hauling waste from Victoria when in fact the waste is originating from Saanich. | There is no impact to the GHG Inventory for the CRD but will have impacts to the CRD member inventories. | Work with waste haulers to devise a better system to track waste origination. |
| Waste | The inventory does not estimate the fugitive emissions from septic tanks. | Immaterial impact on the GHG inventory (<1%) | Work with member municipalities to inventory the number of homes on septic systems so that an estimate can be derived. |
| Waste | The inventory does estimate open burning GHG emissions. | Immaterial impact on the GHG inventory (<1%) | Work with member municipalities to estimate the likely occurrence of open burning in their jurisdictions so that an estimate can be derived. |
| IPPU | Product use emissions were estimated on a per capita basis using the 2023 NIR estimates. The product use emissions were estimated by the NIR using an IPCC Tier 1 approach and thus will have high uncertainty. There are many emission sources in this category, but the largest one is likely from building air conditioner and heat pump units. | Immaterial impact on the GHG inventory (<5%) | Explore the use of using LIDAR to estimate the number of air conditioners on buildings, and other means to collection information on how many residential buildings have heat pumps and air conditioners. Use this information to estimate refrigerant losses. |
| AFOLU | GHG estimates for land use change are based on a period of years (2011-2019) and thus were averaged for each period. As there was no current data, land use change for the reporting year was estimated using the | Immaterial impact on the GHG inventory (<5%) | Work with the planning department to track land-use change annually so that a more refined estimate can be made. |

**Table 44 Summary of GHG Inventory Assumptions, Estimated Impacts, and Recommended Improvements**

| Sector | Assumption | Possible Impact on The GHG Inventory | Recommended Improvements |
|---|---|---|---|
| | average value between the data years. | | |
| 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 CRD. 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 CRD is typically related to development, it was assumed that the loss of emissions is 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. | Possibly a material impact on the GHG inventory (>10%) | Work with the Province and the post-secondary institutions to derive refined sequestration emission factors. |

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# CAPITAL REGIONAL DISTRICT 2022 GPC BASIC+ COMMUNITY GREENHOUSE GAS (GHG) EMISSIONS INVENTORY REPORT

September 14, 2023

Stantec