The Corporation of the District of Saanich 2021 GPC BASIC+ Community Greenhouse Gas (GHG) Emissions Inventory Report

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Executive Summary

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

Beyond the costs associated with delayed climate action, there are cost savings to be realized through efforts to improve energy efficiency, conserve energy, and reduce GHG emissions intensity. To make informed decisions on reducing energy use and GHG emissions at the community scale, community managers must have a good understanding of these sources, the activities that drive them, and their relative contribution to the total. This requires the completion of an energy and GHG emissions inventory. To allow for credible and meaningful reporting locally and internationally, the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (the GPC Protocol) was developed. The GPC Protocol has been adopted by the Global Covenant of Mayors—an agreement led by city networks to undertake a transparent and supportive approach to measure GHG emissions community-wide. The Global Covenant of Mayors 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 The Corporation of the District of Saanich (the District) for the 2021 reporting year using the GPC Protocol. 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 by the District to calculate GHG emissions for the 2021 reporting year, and to present the District's 2021 community GHG emissions.

Following the requirements of the GPC Protocol BASIC+ reporting level, the District's 2021 community GHG emissions are estimated to be 474,673 tCO_2e. A summary of the 2021 GHG emissions is presented in Table E-1.

Table E-1 BASIC+ 2007 Base Year and 2021 Reporting Year GHG Emissions

Sector	Sub-Sector	2007 GHG Emissions (tCO_2e)	2021 GHG Emissions (tCO_2e)
Stationary Energy	Residential Buildings	113,145	86,996
	Commercial & Institutional Buildings	63,289	59,214
	Manufacturing Industries & Construction	0	-
	Energy Industries	418	9,850
	Agriculture, Forestry & Fishing activities	29,343	27,606
	Fugitive Emissions	314	480
Transportation	In-Boundary On-road Transportation	102,328	79,578
	Trans-Boundary On-road Transportation	170,500	123,495

Sector	Sub-Sector	2007 GHG Emissions (tCO_2e)	2021 GHG Emissions (tCO_2e)
	Waterborne Navigation	11,924	10,238
	Aviation	8,252	4,402
	Off-road Transportation	17,785	16,113
Waste	Solid Waste	35,144	10,113
	Biological Treatment of Waste	0	3,236
	Wastewater Treatment & Discharge	4,989	4,212
IPPU	IPPU	24,438	38,644
AFOLU	Land-Use: Emissions Sequestered (**Disclosure Only - Not Included In Total**)	-15,421	(17,123)
	Land-Use: Emissions Released (**Disclosure Only - Not Included In Total**)	22,453	13,619
	Livestock	444	445
	Non-CO_2 Land Emission Sources	107	51
Total GHG Emissions		**582,422**	**474,673**
Change in Absolute GHG Emissions from Baseline Year			**-18.5%**
Total Per Capita GHG Emissions		**5.2**	**3.8**
Per Capita Change from Baseline Year			**-27.4%**

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

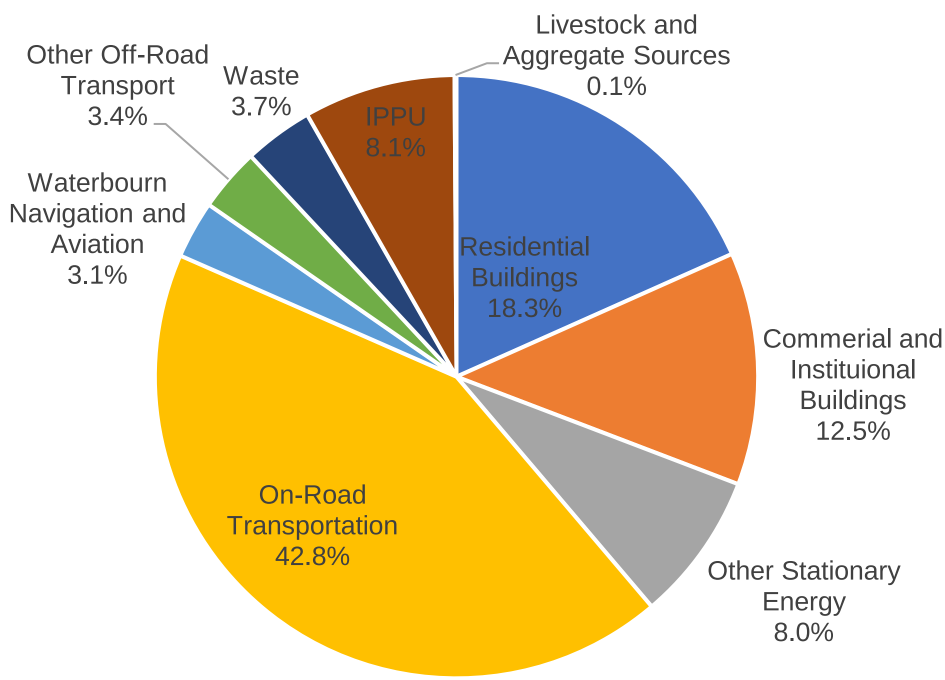

Figure E-1 District of Saanich's BASIC+ GHG Emissions Profile

Abbreviations

ACERT	Airport Carbon Emissions Reporting Tool
AFOLU	Agriculture, Forestry, and Other Land Use
C40	C40 Cities Climate Leadership Group
CH_4	Methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents
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
GWP	global warming potentials
HFC	Hydrofluorocarbons
ICAO	International Civil Aviation Organization
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: • Natural gas for 3-4 days of household use • The electricity used by a typical house in 10 days

Global warming	A gradual increase in the Earth's temperature which is attributed to the greenhouse effect caused by the release of greenhouse gas (GHG) emissions into the atmosphere.
Global warming potential (GWP)	An index measuring the radiative forcing following an emission of a unit mass of a given substance, accumulated over a chosen time horizon, relative to that of the reference substance, carbon dioxide (CO_2). The GWP thus represents the combined effect of the differing times these substances remain in the atmosphere and their effectiveness in causing radiative forcing. The Kyoto Protocol is based on global warming potentials over a 100-year period (IPCC 2014).
Greenhouse gas (GHG)	GHGs are the seven gases covered by the UNFCCC: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); sulphur hexafluoride (SF_6); and nitrogen trifluoride (NF_3) (GPC, 2014).
GHG intensity	The annual rate to which GHG emissions are released in the atmosphere, relative to a specific intensity.
Gross domestic product (GDP)	An economic measure of all goods and services produced in an economy.
In-boundary	Occurring within the established geographic boundary (GPC, 2014).
Reporting year	The year for which emissions are reported (GPC, 2014).
Scope 1	Emissions that physically occur within a city.
Scope 2	Emissions that occur from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross City boundaries.
Scope 3	Emissions that occur outside a city but are driven by activities taking place within a city's boundaries.
Tonne of CO_2e	A tonne of greenhouse gases (GHGs) is the amount created when we consume: • 385 litres of gasoline (about 10 fill-ups) • $200 of natural gas (a month of winter heating) • 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 the District of Saanich (the District) – 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 CITIES 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 an internationally accepted, credible emissions accounting and reporting practice that will help communities to develop comparable GHG inventories.

[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

1.3 PURPOSE OF THIS REPORT

The purpose of this document is to describe the quantification methodologies used by the District to calculate its BASIC+ GHG emissions for the 2007-2021 reporting years. The focus of this report is on the 2021 reporting year.

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

- Defining GHG emissions data sources to be relied on.
- 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 city-wide GHG emissions. It sets out requirements and provides guidance for calculating and reporting city-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 city-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 District-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).

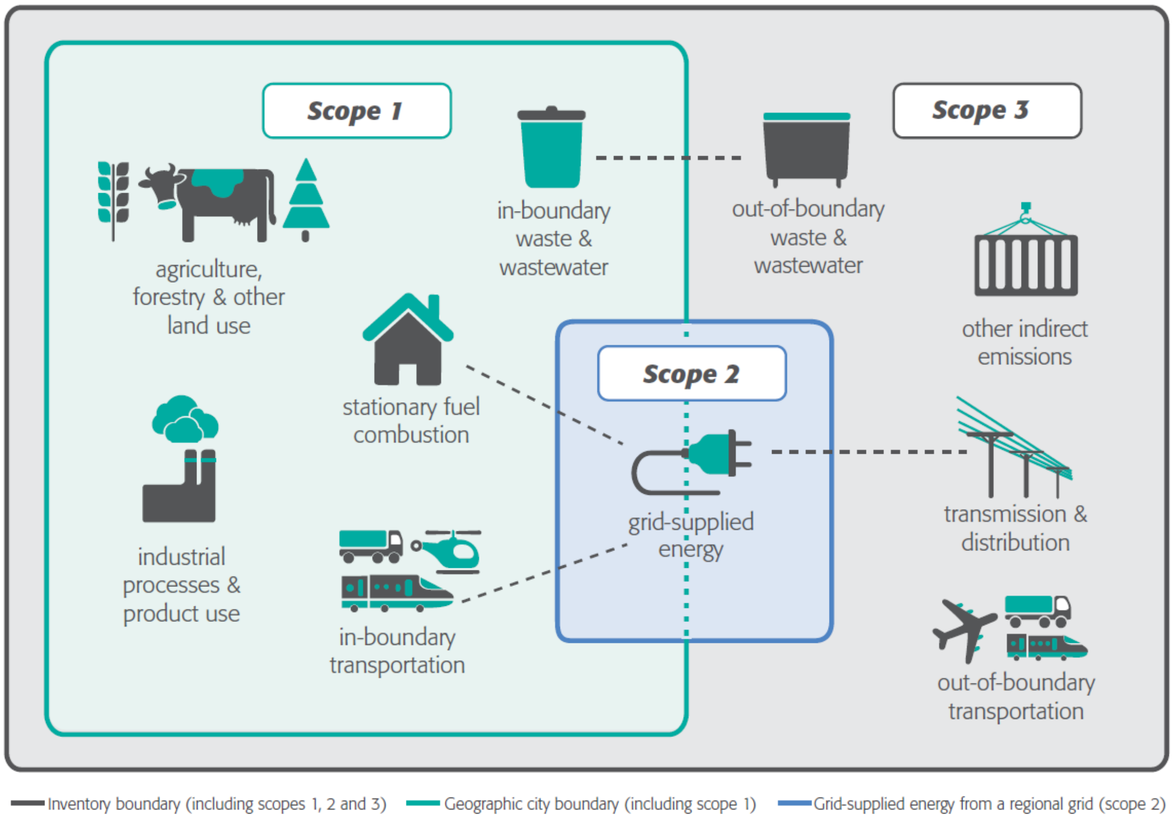

Figure 1 Sources and Boundaries of a Community's GHG Emissions (GPC 2014)

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. Emissions associated with distribution losses from grid-supplied electricity/steam/heating/cooling are also included, as are some fugitive emissions from sources such as coal piles, natural gas. They include the emissions from energy to heat and cool residential, commercial, and industrial buildings, as well as the activities that occur within the residences and facilities. Emissions associated with distribution losses from grid-supplied electricity/steam/heating/cooling are also included, as are fugitive emissions from sources such as coal piles, natural gas pipelines, and related Off-road Transportation GHG emission sources.

The Stationary Energy Sector includes the following Sub-Sectors:

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

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

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

2.3.2 Transportation

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

The Transportation Sector includes the following Sub-Sectors:

- On-road

- Railways
- Waterborne
- Aviation
- Off-road

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

2.3.3 Waste

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

The Waste Sector includes the following Sub-Sectors:

- Solid waste disposal
- 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 District, 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 city limits.

2.5 BASE YEAR AND REPORTING YEAR RECALCULATIONS

As cities grow and expand, significant changes to the GHG emissions profile of a community 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 1.

Table 1 GPC Protocol Recalculation Thresholds

Threshold	Example Change	Recalculation Needed	No Recalculation Needed
Changes in the assessment boundary	A community is annexed in or removed from a city’s administrative boundary	X	
	Change in protocol reporting method (e.g., from BASIC to BASIC+, addition of GHGs reported, etc.)	X	
	Shut down of a power plant		X
	Building a new cement factory		X
Changes in calculation methodology or improvements in data accuracy	Change in calculation methodology for landfilled municipal solid waste (MSW)	X	
	Adoption of a more accurate local emission factor, instead of a national average emission factor.	X	
	Change in electricity emission factor due to energy efficiency improvement and growth of renewable energy utilization		X
Discovery of significant errors	Discovery of mistake in unit conversion in formula used	X	

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”. For example, in the District, there is no biomass burning and thus “NO” was reported.
- If the GHG sink, source or reservoir does occur in the District, 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. For example, in the District, GHG emissions from stationary energy—agriculture is included in stationary energy—residential as the utility data provider does not disaggregate the energy use amongst these categories.
- When GHG emissions are occurring in the District, 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 2.

Table 2 GPC Protocol Data Quality Assessment Notation Keys

Data Quality	Activity Data	Emission Factor
High (H)	Detailed activity data	Site-specific emission factors
Medium (M)	Modeled activity data using robust assumptions	More general emission factors
Low (L)	Highly modeled or uncertain activity data	Default emission factors

3.0 GHG ASSESSMENT BOUNDARIES

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

3.1 SPATIAL BOUNDARIES

This GHG inventory is defined geographically by the District municipal boundaries, as shown in Figure 2.

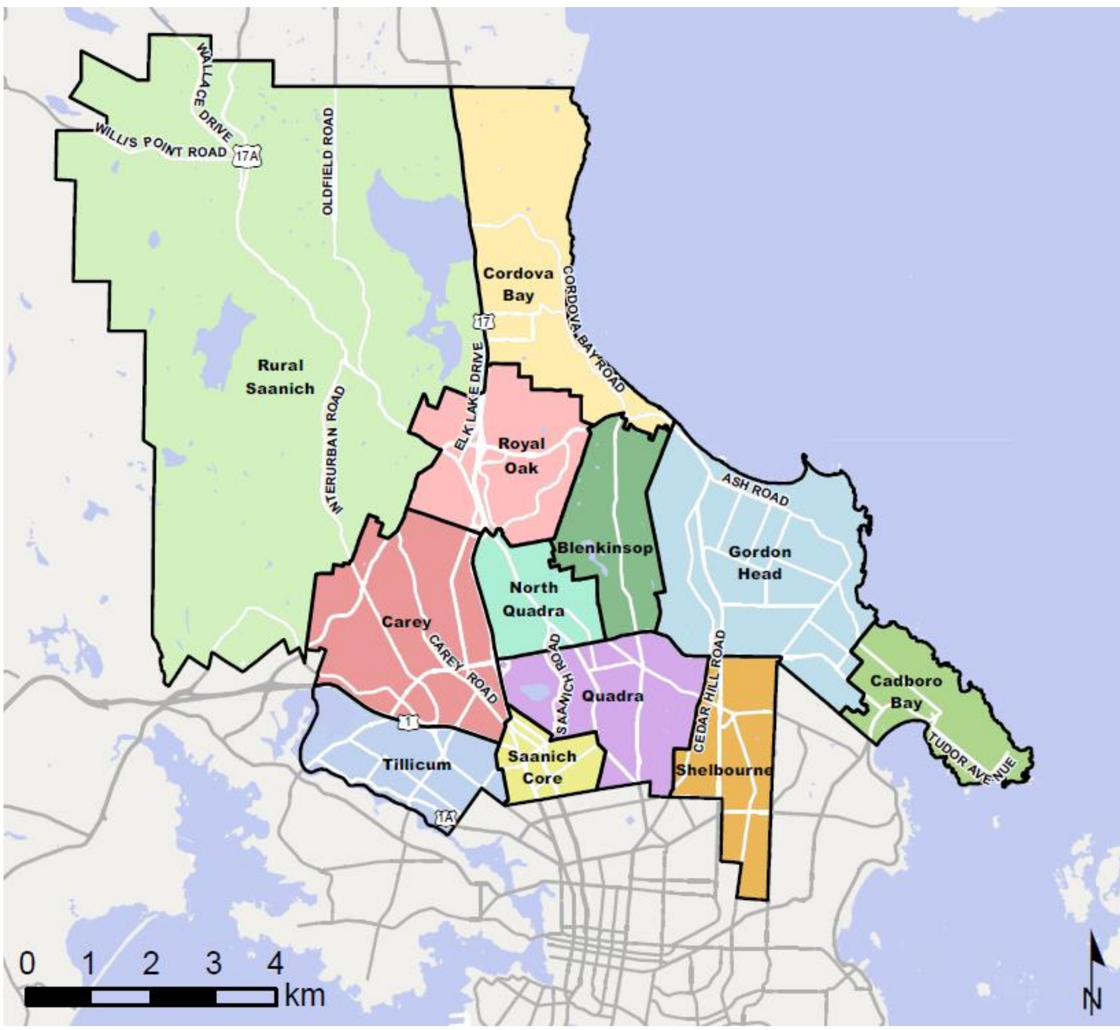

Figure 2 District of Saanich Municipal Boundary

Table 3 Inventory Information for the District

Inventory Boundary	City Information
Name of City	District of Saanich
Country	Canada
Inventory Year	2021
Geographic Boundary	See Figure 2
Land Area (km^2)	107.16
Resident population	124,639
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.

To maintain consistency with the current reporting year, and as required by the GPC Protocol, the District has updated its 2007 GHG Base Year 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.

Table 4 summaries the original 2007 Base Year and the updated 2007 Base Year. Like the reporting year (2021), the Base Year also uses the same GWPs from the 4th IPCC report.

Table 4 Original And Updated BASIC+ Base Year

Aspect	Quantification Protocol	2007 GHG Base Year (tCO_2e)
Original Base Year	B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions	521,000
Updated Base Year	GPC Protocol BASIC+	582,422

3.2.2 2021 GHG Boundary

This inventory covers all GHG emissions for the 2021 reporting year. Where 2021 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 is currently applying GWPs from the fourth IPCC report in light of the fact that there are updated GWPs in available in the fifth IPCC report. On this basis, the District is applying GWPs from the fourth IPCC report 'until such time that new GWPs are incorporated into existing GHG legislation.
- **Stationary Energy: Emission Factors.** The BC Government updated 2010-2021 electricity emission factors to include emissions from imported electricity resulting in a 5-10% increase in GHG emissions intensities. Since there was no update to the 2007, the BC Government has suggested utilizing the 2010 emission factor for 2007.
- **Emission Factors.** Environment and Climate Change Canada publishes emission factors annually in the National Inventory Report (NIR). Currently, these emission factors from the 2022 NIR are for the 2020 reporting year, and as such, any emission factors that are used in the 2021 reporting year have been carried forward from 2020 or have been recalibrated as necessary.
- **Stationary Energy: Electricity Data.** In 2019, the Province of BC received updated electricity data for 2007-2018 as a systematic error was uncovered across all years of BC Hydro data. The 2007 inventory was updated with the corrected information.
- **Stationary Energy: Residential, Commercial and Institutional Buildings.** 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, and heating degree days (HDD) published by Environment Canada. Heating oil GHG emissions were estimated based on the number of known tanks, average heated floor areas and estimated average fuel volumes collected by the District through onsite energy audits.
- **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 applied to the 2021 year as well based on the number of reported natural gas connections.
- **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, 2021 – March 31, 2022.
- **Transportation: Aviation.** 2021 aviation GHG emissions were estimated using 2015 aircraft flight profiles (the last available data), and the total number of aircraft movements reported in 2021.
- **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.
- **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 (including the District) on a per capita basis.
- **IPPU: Product Use.** The product use emissions are based on the 2022 NIR as prepared by Environment and Climate Change Canada. These are pro-rated to the District on a per capita basis.
- **AFOLU: Aggregate Sources And Non-CO_2 Emission Sources On Land.** These emissions are based on the 2021 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. 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 2021, 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. The City has also aligned with this approach for now.

3.3 GHG EMISSION SOURCES AND SCOPES

The following table summarizes the District's GHG emissions by source and GHG emission scope.

Table 5 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 City limits: • Stationary fuel combustion: – Residential buildings – Commercial and institutional buildings, and facilities – Agriculture, forestry, and fishing activities – Energy industries – Energy generation supplied to the grid – Fugitive emissions from oil and natural gas systems • Transportation: – On-road: In Boundary – Off-road • Waste: – Solid waste disposal – Biological treatment of solid waste • Industrial processes and product use (IPPU): – Product use • Agriculture, Forestry, and Other Land Use (AFOLU): – Livestock – Land – Aggregate sources and non-CO_2 emission sources on land
Scope 2	The GHG emissions occurring from using grid-supplied electricity, heating and/or cooling within the District boundary: • Stationary fuel combustion:

GHG Emissions Scope	GPC Protocol Reporting Sector
	– Residential buildings – Commercial and institutional buildings, and facilities • Transportation: – On-road – Transboundary
Scope 3	Other GHG emissions occurring outside of the District limits as a result of City activities: • Stationary Energy: – Transmission, Distribution, and Line Losses • Transportation: – On-road: Transboundary – Aviation – Waterborne – Off-road • Waste: – Solid waste disposal – Biological treatment of solid waste – Wastewater treatment and discharge

3.4 GHG REPORTING

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

Each GHG listed above has a different global warming potential (GWP) due to its ability to absorb and re-emit infrared radiation. This chemical property is recognized by the GWP set out by the IPCC Fourth 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 = 25, N_2O = 298 (IPCC, 2006).

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 6 below which also indicates the reporting level (BASIC / BASIC+) for each source.

Table 6 GPC Protocol Summary Table

GPC Protocol Reference Number	Reporting Level	Emissions Scope	GHG Emissions Source
I	**Stationary Energy Sources**		

Table 6 GPC Protocol Summary Table

GPC Protocol Reference Number	Reporting Level	Emissions Scope	GHG Emissions Source
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

Table 6 GPC Protocol Summary Table

GPC Protocol Reference Number	Reporting Level	Emissions Scope	GHG Emissions Source
II.2	**Railways**		
II.2.1	BASIC	1	Emissions from in-boundary transport
II.2.2	BASIC	2	Emissions from consumption of grid-supplied energy
II.2.3	BASIC+	3	Emissions from transboundary journeys
II.3	**Water-borne 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 District
III.1.2	BASIC	3	Emissions from waste generated within but treated outside of the District
III.2	**Biological Treatment of Waste**		
III.2.1	BASIC	1	Emissions from waste generated and treated within the District
III.2.2	BASIC	3	Emissions from waste generated within but treated outside of the District
III.3	**Incineration and Open Burning**		
III.3.1	BASIC	1	Emissions from waste generated and treated within the District
III.3.2	BASIC	3	Emissions from waste generated within but treated outside of the District
III.4	**Wastewater Treatment and Discharge**		
III.4.1	BASIC	1	Emissions from wastewater generated and treated within the District

Table 6 GPC Protocol Summary Table

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

4.0 GHG METHODOLOGIES BY SOURCE CATEGORY

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

4.1 STATIONARY ENERGY

4.1.1 Overview

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

- Scope 1 Emissions:
  - Residential buildings
  - Commercial and institutional buildings, and facilities
  - Agriculture, forestry, and fishing activities
  - Energy industries
  - Energy generation supplied to the grid
  - Fugitive emissions from natural gas distribution systems
- Scope 2 Emissions:
  - Emissions from the consumption of grid-supplied electricity, steam, heating, and cooling.
- Scope 3 Emissions:
  - Transmission and distribution losses of electricity, steam, heating, and cooling.

4.1.2 Scope 2: Market Based Method

As per the GPC Protocol, cities can report on Scope 2 GHG emissions using either the market-based, or the location-based method. A market-based method utilizes utility-specific grid emission intensity factor, whereas a location-based method uses a regional or Provincial average grid emission intensity factor. At present, the fuel mix and GHG emissions data relative to the District's energy consumption is not available. As such, the District is defaulting to the BC Provincial 2021 electricity grid consumption intensity factor of 0.00970 tCO_2e/MWh reported by the BC Government.[3]

4.1.3 Activity Data

BC Hydro and Fortis BC provided the 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"

[3] https://www2.gov.bc.ca/gov/content/environment/climate-change/industry/reporting/quantify/electricity

- Commercial and Institutional Buildings/Facilities based on BC Hydro and Fortis BC descriptors: “Commercial”, and “CSMI”

The 2021 energy data was provided to the District in draft form and may be subject to change.

The Province developed 2012-2019 residential fuel oil, 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. This data was used to estimate the 2021 reporting year GHG emissions for these sources.

Fortis BC provided a fugitive emission factor for the 2020 reporting year for the Victoria Capital Regional District. This factor was used to estimate 2021 fugitive emissions.

To calculate heating oil use, the District provided a heating oil tracking database, which contained addresses, size of tank, and whether a tank had been removed or not. Heating oil GHG emissions were estimated based on the number of known tanks, estimated heated floor areas, and estimated average heating oil energy use reported by NRCan.

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

Fortis BC provided the fugitive emission estimate.

Applicable, off-road GHG emissions included in the Stationary Energy Sector are based on the 2022 NIR as prepared by Environment and Climate Change Canada. These emissions are pro-rated to the District on a per capita basis.

4.1.4 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2021 GHG emissions:

- The Province of BC received updated electricity data for 2007-2018 as a systematic error was uncovered across all years of BC Hydro data. The 2007 base year inventory was updated with the corrected information.
- The BC Government updated 2010-2020 electricity emission factors to include emissions from imported electricity resulting in a significant change in GHG emissions intensities between 2010 and 2021. Since there was no update to the 2007 value, the BC Government has suggested utilizing the 2010 emission factor for 2007.
- 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.
- The off-road transportation emissions included in the Stationary Energy Sector are based on the 2022 NIR as prepared by Environment and Climate Change Canada. This is deemed to be the best available data.

- The 2021 propane, heating oil 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 2016-2018 CEEIs, and heating degree days (HDD) published by Environment and Climate Change Canada.
- Heating oil GHG emissions were estimated based on the number of known tanks, estimated heated floor area and estimated average heating oil energy use reported by NRCan.

4.1.5 Data Quality Assessment

Table 7 presents the activity data quality assessment for the stationary energy sources.

Table 7 Stationary Energy Data Source Quality Assessment

Data	Quality Assessment Rating
Electricity	Medium
Natural Gas	Medium
Agriculture, Forestry & Fishing Activities	Low
Manufacturing Industries & Construction	Low
Fugitive Emissions	Low
Energy Generation Supplied to the Grid	High
Transmission, Distribution and Line Losses	Low
Off-Road Transportation Emissions	Low

4.1.6 Calculation Methodology

The Province of BC developed residential fuel oil, 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 2021 propane and wood energy use, historical 2007-2018 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. This resulted in the development of the following equations:

- Propane (L) = 163,133 + 87.38 * HDD
- Wood (GJ) = 557,864 + 191.39 * HDD

The calculated total heating oil use is based on adjusting 2018 calculations for estimated changes in square footages. The 2018 estimate was derived using BC Assessment building data, zoning GIS data, and a database of addresses with heating oil tanks. The data was used to estimate the total oil heated square footage for the District categories. In conjunction with this GJ/ft^2 data from the NRCAN Comprehensive Energy Use Database for BC was used to estimate the total heating oil energy use in GJ. For each reporting year, the District provides an estimate of the number of buildings and associated square footages that have removed on-site heating oil tanks. The 2021 data used to estimate heating oil GHG emissions is presented in Table 8.

Table 8 Heating Oil Units, Estimated Heating Oil Floor Space, and Heating Oil Energy Intensity Values

Stationary Energy Sub-Sector	Number of Heating Oil Units	Total Estimated Square Feet Heated (ft^2)	Energy Intensity (GJ/ft^2)
Residential buildings	2,537	5,256,664.00	0.054152986
Commercial and institutional buildings and facilities	39	340,912.82	0.359921421

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:

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

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

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

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

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

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

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

The emission factors used in the 2021 reporting year are from the Province of BC and the 2022 NIR. 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	0.0097000	Medium
Natural Gas	tonne CO_2e / m^3	0.0019374	Medium
Propane	tonne CO_2e / L	0.0015478	Medium
Heating Oil	tonne CO_2e / GJ	0.0683759	Medium
Wood	tonne CO_2e / kg	0.0004227	Medium

Fortis BC provided an emission factor for natural gas fugitive emissions which was based upon the number of customer meter sets at the municipality relative to the total region. This factor was then applied to the total fugitive emissions to determine the fugitive-related emissions for the District.

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 District, the Transportation Sector encompasses the following GHG emissions scopes and Sub-Sectors:

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

4.2.2 Activity Data

The Province of BC provided 2021 ICBC vehicle registration data.

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

The 2017 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. Recent vehicle kilometer travelled (VKT) surveys for Victoria and Saanich was used to derive average VKT values for vehicle classes.

Aviation GHG emissions from the Victoria International Airport were estimated using 2015 aircraft flight profiles, and the total number of aircraft movements reported in 2021. These data sets were provided by the Victoria International Airport.

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. This data was taken from Statistics Canada.

Marine watercraft GHG emissions were estimated using published BC Ferries fuel statistics. 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.

Off-road transportation emissions are based on the 2022 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, 2021 – March 31, 2022.
- Gasoline, diesel and compressed natural gas (CNG) GHG emissions from BC Transit busses are pro-rated to the District based on the District’s proportion of population in the CRD. A more accurate estimation method would be to prorate fuel use based on total bus service kilometers in the District. 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 2021 reporting year.
- The aviation GHG emissions are prorated based on the total District of Saanich 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”. These GHG emissions were estimated at the CRD level and applied on a per capita basis.
- 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.
- No railway GHG emissions are occurring in the District and the notation key “Not Occurring” was used.
- The off-road transportation emissions are based on the 2022 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 10 presents the activity data quality assessment for the transportation data sources.

Table 10 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-High
Aviation Movement Data	High
Aviation GHG Data	Medium
Waterborne Fuel & Boat Data: Personal Watercraft	Low
Waterborne Fuel Data: BC Ferries	Low
Other Off-Road Transportation GHG Data	Low

4.2.5 Calculation Methodology

4.2.5.1 On-Road

The GPC Protocol identifies several methods for determining on-road emissions. The vehicle kilometers travelled (VKT) methodology was utilized to estimate the GHG emissions from on-road transportation (Scope 1) and transboundary transportation (Scope 3). The VKT uses the number and type of vehicles registered in a geopolitical boundary, the estimated fuel consumption rate of individual vehicles, and an estimate of the annual vehicle kilometres traveled (VKT) by various vehicle classes. ICBC provided the number of registered vehicles in the District by style, and by fuel type for the 2021 reporting year. To estimate the split between on-road in-boundary and transboundary traffic, data from the 2017 CRD Origin Destination Survey was applied. The results of the survey as it applies to the District of Saanich is presented in Table 11.

Table 11 On-Road In-Boundary/Transboundary Split

Aspect	By Vehicle
Estimated proportion of on-road in-boundary travel	39%
Estimated proportion of on-road transboundary travel	61%

To quantify the 2021 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 12).
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 Province. Adjust the VKTs as needed to make sure that the fuel estimate is within 0.1% of the total fuel sales volumes reported for the region.

The outcome from this exercise is presented in the following tables.

Table 12 Estimated VKT And Fuel Efficiencies by Vehicle Class

Vehicle Classification	Estimated VKT / Year	Estimated Fuel Efficiency (L/100 km)
Diesel-HDV	20,482	45.6
Diesel-LDT	4,068	11.8
Diesel-LDV	2,539	9.2
Diesel-ORVE	Not Estimated	45.6
Electric-HDV	9,651	30.0
Electric-LDT	10,118	20.0
Electric-LDV	10,618	20.0
Electric-ORVE	Not Estimated	30.0
Gasoline-HDV	11,069	54.1
Gasoline-Hybrid-HDV	7,064	37.9
Gasoline-Hybrid-LDT	9,396	10.0
Gasoline-Hybrid-LDV	7,567	7.0
Gasoline-Hybrid-ORVE	Not Estimated	37.9
Gasoline-LDT	9,787	12.2
Gasoline-LDV	6,620	9.0
Gasoline-ORVE	7,984	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	1,348	9.9
Natural Gas-HDV	25,731	22.9
Natural Gas-LDT	12,916	8.3
Natural Gas-LDV	14,746	5.4
Natural Gas-ORVE	Not Estimated	22.9
Propane-HDV	25,731	22.9
Propane-Hybrid-LDV	16,385	13.1
Propane-LDT	12,916	12.6

Vehicle Classification	Estimated VKT / Year	Estimated Fuel Efficiency (L/100 km)
Propane-LDV	14,746	8.2
Propane-ORVE	Not Estimated	22.9

Table 13 Total Registered Vehicles & Estimated Fuel Use For Reporting Year

Vehicle Classification	Total Estimated Registered Vehicles	Total Estimated Fuel Use	Units
Diesel-HDV	488	4,845,233	Liters (L)
Diesel-LDT	2,328	3,771,478	Liters (L)
Diesel-LDV	385	639,694	Liters (L)
Diesel-ORVE	522	-	Liters (L)
Electric-HDV	9	26,057	kWh
Electric-LDT	1,759	1,795,439	kWh
Electric-LDV	1,491	2,874,517	kWh
Electric-ORVE	11	-	kWh
Gasoline-HDV	589	3,083,186	Liters (L)
Gasoline-Hybrid-HDV	-	-	Liters (L)
Gasoline-Hybrid-LDT	221	341,503	Liters (L)
Gasoline-Hybrid-LDV	1,498	793,762	Liters (L)
Gasoline-Hybrid-ORVE	1	-	Liters (L)
Gasoline-LDT	42,396	50,254,789	Liters (L)
Gasoline-LDV	29,391	21,556,488	Liters (L)
Gasoline-ORVE	570	1,631,677	Liters (L)
Hydrogen-Hybrid-LDV	-	-	Liters (L)
Hydrogen-LDV	5	-	Liters (L)
Hydrogen-LDT	-	-	Liters (L)
Motorcycle - Electric	-	-	kWh
Motorcycle - Non catalyst	1,505	504,837	Liters (L)
Natural Gas-HDV	-	-	Kilogram (kg)
Natural Gas-LDT	11	11,792	Kilogram (kg)
Natural Gas-LDV	1	796	Kilogram (kg)
Natural Gas-ORVE	-	-	Kilogram (kg)
Propane-HDV	12	70,799	Liters (L)
Propane-Hybrid-LDV	-	-	Liters (L)

Vehicle Classification	Total Estimated Registered Vehicles	Total Estimated Fuel Use	Units
Propane-LDT	33	53,704	Liters (L)
Propane-LDV	-	-	Liters (L)
Propane-ORVE	21	-	Liters (L)
Total	**83,247**	**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:

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

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

The emission factors used in the reporting year GHG inventory are from the 2022 NIR. These are summarized in Table 14.

Table 14 Vehicle GHG Emission Factors

Vehicle Class	Units	tCO_2e	Quality Assessment Rating
Gasoline-LDV	tonne CO_2e / L	0.00234581	Medium
Gasoline-LDT	tonne CO_2e / L	0.00237884	Medium
Gasoline-HDV	tonne CO_2e / L	0.00227660	Medium
Gasoline-ORVE	tonne CO_2e / L	0.00241650	Medium
Gasoline-Hybrid-LDV	tonne CO_2e / L	0.00234581	Medium
Gasoline-Hybrid-LDT	tonne CO_2e / L	0.00237884	Medium
Gasoline-Hybrid-HDV	tonne CO_2e / L	0.00227660	Medium
Gasoline-Hybrid-ORVE	tonne CO_2e / L	0.00241650	Medium
Electric-LDV	tonne CO_2e / kWh	0.00002990	Medium
Electric-LDT	tonne CO_2e / kWh	0.00002990	Medium
Electric-HDV	tonne CO_2e / kWh	0.00002990	Medium
Electric-ORVE	tonne CO_2e / kWh	0.00002990	Medium
Diesel-LDV	tonne CO_2e / L	0.00264884	Medium
Diesel-LDT	tonne CO_2e / L	0.00264926	Medium
Diesel-HDV	tonne CO_2e / L	0.00262975	Medium

Vehicle Class	Units	tCO_2e	Quality Assessment Rating
Diesel-ORVE	tonne CO_2e / L	0.00288375	Medium
Hydrogen-Hybrid-LDV	tonne CO_2e / L	-	Medium
Hydrogen-LDV	tonne CO_2e / L	-	Medium
Hydrogen-LDT	tonne CO_2e / L	-	Medium
Natural Gas-LDV	tonne CO_2e / kg	0.00308863	Medium
Natural Gas-LDT	tonne CO_2e / kg	0.00308863	Medium
Natural Gas-HDV	tonne CO_2e / kg	0.00308863	Medium
Natural Gas-ORVE	tonne CO_2e / kg	0.00308863	Medium
Propane-LDV	tonne CO_2e / L	0.00153934	Medium
Propane-LDT	tonne CO_2e / L	0.00153934	Medium
Propane-HDV	tonne CO_2e / L	0.00153934	Medium
Propane-ORVE	tonne CO_2e / L	0.00153934	Medium
Propane-Hybrid-LDV	tonne CO_2e / L	0.00153934	Medium
Motorcycle - Non catalyst	tonne CO_2e / L	0.00238780	Medium

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 District's 2021 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 15). The total reported flight movements for the reporting year (98,721), as provided by Statistics Canada, and the aircraft flight profile data was used to estimate aviation GHG emissions for the reporting year at the VIA. The emissions were estimated for the CRD and pro-rated to the District on a per capita basis. These GHG emissions are reported in Scope 3.

Table 15 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))*

Lastly, as the VIA does not collect origin traveler data, aviation emissions were prorated based on the District population relative to the CRD population. These were reported in the Scope 3 category as the VIA is located outside of the District boundaries.

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

***Emissions** Per Aviation Class = (Saanich Population / CRD Population) * ((Vol. Fuel * Aviation Class EF_{CO2}) + (Vol. Fuel * Aviation Class EF_{CH4} * GWP_{CH4}) + (Vol. Fuel * Aviation Class EF_{N2O} * GWP_{N2O}))*

The ACERT GHG calculator used by the VIA utilized emission factors from the 2022 NIR. Actual airplane emission factors are from the International Civil Aviation Organization (ICAO) GHG database. These are summarized in Table 16.

Table 16 Aviation GHG Emission Factors

Airplane Type	Units	tCO_2e	Quality Assessment Rating
Jet	tCO_2e/kg fuel	0.0032254	Medium
Turbo Propeller	tCO_2e/kg fuel	0.0032254	Medium

Airplane Type	Units	tCO_2e	Quality Assessment Rating
Piston	tCO_2e/kg fuel	0.0034154	Medium
Helicopter	tCO_2e/kg fuel	0.0032254	Medium

4.2.5.3 Aviation: Victoria Harbour

Victoria harbor aviation emissions were estimated using 2021 Statistics Canada airplane movement statistics, estimated taxi times, and estimated fuel use for the DHC-6 Twin Otter type of plane (Table 17).

Table 17 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))*

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

The GHG quantification method is as follows:

Emissions ***Per Aviation Class*** **=** *(Saanich Population / CRD Population) * ((Vol. Fuel * Aviation Class* EF_{CO2}*) + (Vol. Fuel * Aviation Class* EF_{CH4} * GWP_{CH4}*) + (Vol. Fuel * 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 18.

Table 18 Marine Aviation GHG Emission Factors

Airplane Type	Units	tCO_2e	Quality Assessment Rating
Turbo Propeller	tCO_2e/kg fuel	0.0032254	Medium

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. GHG emissions from BC Ferries are estimated using total estimated fuel use for the 2021 reporting year, and provincially derived GHG emissions factors (Table 19).

Table 19 BC Ferries GHG Emission Factors

Aspect	Units	tCO_2e	Quality Assessment Rating
Ferry: Diesel	tonne CO_2e / L	0.0029136	Medium
Ferry: Natural Gas	tonne CO_2e / L	0.00141370	Medium

As BC Ferries operate outside of the District's boundary, the GHG emissions were allocated to Scope 3 based on the proportion of the District 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".

The Transport Canada Vessel Registration System provided the total number of registered waterborne vehicles which was 2,260 vessels for the Victoria harbor; 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 20).
1. Take the total number of registered vessels (3,708), 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 21).
2. Using 2022 NIR emission factors estimate the GHG emissions from other watercraft.

Table 20 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
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 21 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	104
Inboard: Diesel	1	312
Outboard: 2 stroke - gasoline	60	69
Outboard: 4 stroke - gasoline	2	11
Stemdrive: 2 stroke - gasoline	0	118
Stemdrive: 4 stroke - gasoline	17	81
Stemdrive: Diesel	2	276
Personal Watercraft: 2 stroke - gasoline	2170	0
Sailboat Auxiliary Inboard: 4 stroke - gasoline	1	1
Sailboat Auxiliary Inboard: Diesel	3	6
Sailboat Auxiliary Outboard: 2 stroke - gasoline	1	1
Sailboat Auxiliary Outboard: Diesel	0	10

To calculate the GHG emissions, for the other watercraft, provincially derived GHG emissions factors were used (Table 22).

Table 22 Watercraft GHG Emission Factors

Aspect	Units	tCO_2e	Quality Assessment Rating
Marine Gasoline	tonne CO_2e / L	0.0022522	Low
Marine Diesel	tonne CO_2e / L	0.0029136	Low

Due to a lack of detailed registration data, GHG emissions were assigned to the Scope 3 category based on the proportion of the Saanich population relative to CRD population.

The GHG quantification method, that was applied to the BC Ferries and other watercraft was as follows:

$$Emissions_{Waterborne\ Other} = (Saanich\ Population / CRD\ Population) * ((Vol.\ Fuel * EF_{CO2}) + (Vol.\ Fuel * EF_{CH4} * GWP_{CH4}) + (Vol.\ Fuel * EF_{N2O} * GWP_{N2O}))$$

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

4.2.5.5 Off-Road

Currently, there is limited data available on 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 2022 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 (2020). Each derived per-capita value was applied to the current reporting year City population (2021) 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 *$_{\text{Off-Road}}$ = (NIR Off-Road GHG Emissions $_{BC}$ / NIR Population $_{BC}$) * Current Reporting Year Population $_{\text{Saanich}}$*

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

- Scope 1: Emissions:
  - Solid waste disposal
  - Biological treatment of waste
- Scope 3: Emissions:
  - Solid waste disposal
  - Biological treatment of waste
  - Wastewater treatment and discharge

No GHG emissions from incineration and open burning are occurring and thus the notation key for “Not Occurring” has been used to indicate this.

4.3.1 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 occurring in the District, but cannot readily be estimated, and thus the notation key for “Not Estimated” has been used to indicate this.

4.3.2 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2021 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.

- The City assumes that it contributes 31% of total waste being sent to the Hartland Landfill.
- 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.

4.3.3 Data Quality Assessment

Table 23 presents the activity data quality assessment for the waste data sources.

Table 23 Waste Data Quality Assessment

Data	Quality Assessment Rating
Landfill Tonnage Data By Municipal Government	Low
Landfill Fugitive Methane Data	High
Wastewater Volume Data	High
Wastewater BOD and TKN Data	High
Composting Waste Data	High

4.3.4 Calculation Methodology

4.3.4.1 Solid Waste

The Hartland Landfill serves most of the CRD. The GHG emissions estimates have been generated 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. Landfill emissions are proportioned on a per-capita basis after the City of Victoria accounts for 31% of the landfill GHG emissions.

As the Hartland Landfill is within the municipal boundary, GHG emissions are reported under the following Scope 1 categories:

- Solid waste generated in the city
- Solid waste generated outside the city

The GHG quantification methods are captured as follows:

$$\textit{Emissions}_{\textit{Solid Waste In City}} = (1-31\%) * \textit{Saanich Population} / (\textit{CRD Population} - \textit{Victoria Population}) * \textit{Hartland Landfill Fugitive}_{CH4} * GWP_{CH4}$$

$$Emissions_{\text{Solid Waste Outside of City}} = (\text{Hartland Landfill Fugitive}_{CH4} * GWP_{CH4}) - \text{Saanich Landfill GHG Emissions}$$

4.3.4.2 Biological Treatment of Solid Waste

The City collects and diverts all organic waste from entering the landfill – in 2021, the CRD estimates that 20,609 tonnes of organic waste was diverted from the landfill which is treated aerobically.

The composting emission factors used in the estimation of GHG emissions from the biological treatment of solid waste is from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 5, Chapter 4: Biological Treatment of Solid Waste) (Table 24).

Table 24 Composting Emission Factor

Emission Factor	Units	tCO_2e	Quality Assessment Rating
Composting	t / kg waste	0.0000250	Low

As the treatment facilities are within the municipal boundary, the GHG emissions are reported under the following Scope 1 categories:

- Biological waste generated in the city
- Biological waste generated outside the city

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

$$Emissions_{\text{In City Anaerobic Waste}} = \text{District Waste}_{\text{Total}} * EF_{CH4} * GWP_{CH4}$$

$$Emissions_{\text{Outside of city Anaerobic Waste}} = (\text{CRD Waste}_{\text{Total}} - \text{District Waste}_{\text{Total}}) * EF_{CH4} * GWP_{CH4}$$

4.3.4.3 Wastewater Treatment And Discharge

Wastewater is treated to a tertiary level and then discharged to ocean-based outfalls. The CRD provided the 2021 wastewater volumes (m^3) by municipality, 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 untreated wastewater being deposited into deep or moving waters. It is likely that ocean sequesters more CH_4 than what has been estimated.

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

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

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

4.4 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 District, the IPPU encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 1 Emissions:
  - Product use

No GHG emissions from Industrial Processes are 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 2022 NIR GHG data and Statistics Canada population data for the reporting year.

4.4.3 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2021 GHG emissions:

- The product use emissions are based on the 2022 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.

4.4.4 Data Quality Assessment

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

Table 25 IPPU Data Quality Assessment

Data	Quality Assessment Rating
Industrial Process Emissions Data	Low
Industrial Product Use Emissions Data	Low

4.4.5 Calculation Methodology

4.4.5.1 Product Use Emissions

For the 2021 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 District, a per capita estimate was developed using the Provincial emissions data from the 2022 NIR, and BC's NIR reporting year (2020) population from Statistics Canada. This value was applied to the 2021 reporting year City population for the reporting year to estimate the total product use emissions for the District.

The GHG quantification method is presented below:

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

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 city's boundaries. For the District, the AFOLU encompasses the following GHG emissions scopes and Sub-Sectors:

- Scope 1 Emissions:
  - Land
  - 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 counts were derived using Statistics Canada data.

Aggregate sources and non-CO_2 emissions sources on land were estimated using GHG emissions data from the 2022 NIR, and land-use data from the 2021 Statistics Canada Census of Agriculture, to create a GHG emissions per hectare value.

4.5.3 Assumptions and Disclosures

The following assumptions were made in the calculation of the 2021 GHG emissions:

- 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 2021, the 2019 estimates were applied.
- It is conservatively assumed that all cropland is used for livestock and agricultural purposes.

4.5.4 Data Quality Assessment

Table 26 presents the activity data quality assessment for the AFOLU data sources.

Table 26 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

4.5.5 Calculation Methodology

4.5.5.1 Land Use

Remotely sensed imagery was used to estimate land-cover changes during the 2007-2021 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 27 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'
	2021	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 28 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	-

IPCC Land Cover	EOSD Land Cover	HAT Land Cover	Annual Crop Inventory
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 29).

Table 29 Land-Use Change Emission Factors

Sector	Emission Factor	Units	Quality Assessment Rating
Forestland	224.1	tCO_2e / ha	Medium
Grasslands	205.7	tCO_2e / ha	Low
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	Medium
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:

$$Emissions_{\text{Lands Not Converted}} = Land\ Type_{ha} * EF_{Sequester}$$

$$Emissions_{\text{Lands Converted}} = Land\ Type_{ha} * (EF_{Release} / (Current\ Land\ Reporting_{Year} - Last\ Land\ Reporting_{Year} + 1))$$

4.5.5.2 Emissions from Livestock

Emissions from livestock includes enteric fermentation and manure management emission sources. IPCC derived emission factors were used to estimate this emissions source (Table 30).

Table 30 Livestock Emission Factors

Animal	Enteric Methane (tCO_2e / head / year)	Methane from Wastes (tCO_2e / head / year)	Quality Assessment Rating
Dairy Breeding Herd	2.875	0.325	Medium
Beef Herd	1.200	0.069	Medium
Cattle: Others>1, Dairy Heifers	1.200	0.150	Medium
Cattle: Others<1	0.820	0.074	Medium
Pigs	0.038	0.075	Medium
Breeding Sheep	0.200	0.005	Medium
Other Sheep	0.200	0.005	Medium
Lambs < 1 year	0.080	0.002	Medium
Goats	0.125	0.003	Medium
Sheep / Lamb / Goat	0.151	0.004	Medium
Horses	0.450	0.035	Medium
Deer (Stags & Hinds)	0.260	0.007	Medium
Deer (Calves)	0.130	0.003	Medium
Poultry	-	0.002	Medium

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

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

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

Emissions from Aggregate Sources and Non-CO_2 Emission Sources on Land includes direct N_2O emissions from agricultural soil management and indirect N_2O emissions from applied nitrogen. To estimate these GHG emissions, the total area of farmland for BC is used in conjunction with 2022 NIR data to develop a tCO_2e / ha value. This is then be applied to the total crop land in hectares to derive a GHG emissions estimate.

The GHG quantification method is presented below:

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

$$\textbf{Emissions}_{\textbf{Urea Application}} = \text{District Cropland}_{ha} * 0.133\ tCO_2e / ha$$

5.0 2021 GHG REPORTING YEAR RESULTS

5.1 OVERVIEW

This section presents the 2021 reporting year GHG emissions for the District. The following table classifies each of the GPC Protocol GHG emission categories by scope and reporting level. Note that these are cumulative.

Table 31 District of Saanich 2021 GHG Emissions by GPC Reporting Method

GHG Emissions Scope	BASIC Reporting Level	BASIC+ Reporting Level
Scope 1	• Emissions from in boundary fuel combustion • In boundary fugitive emissions • Emissions from in boundary transport	Everything in the box at left, plus in-boundary emissions from: • Industrial process and product use • Land
Scope 2	• Emissions from consumption of grid-supplied energy	• Emissions from consumption of grid-supplied energy
Scope 3	• Emissions from solid waste, and composting generated within but treated outside of the District	Everything in the box at left, plus: • Transmission, distribution, and line losses from grid-supplied energy • Emissions from transboundary journeys
Outside of Reporting Scopes & GPC Protocol	• Upstream fuel emission extraction, processing, and transport • Food and drink imports • Construction materials (imports) • Other supply chain emissions • Vehicle fuel exports	

5.2 SUMMARY

Total BASIC, and BASIC+ emissions for the District for the 2021 reporting year are presented in the Figure 3 below.

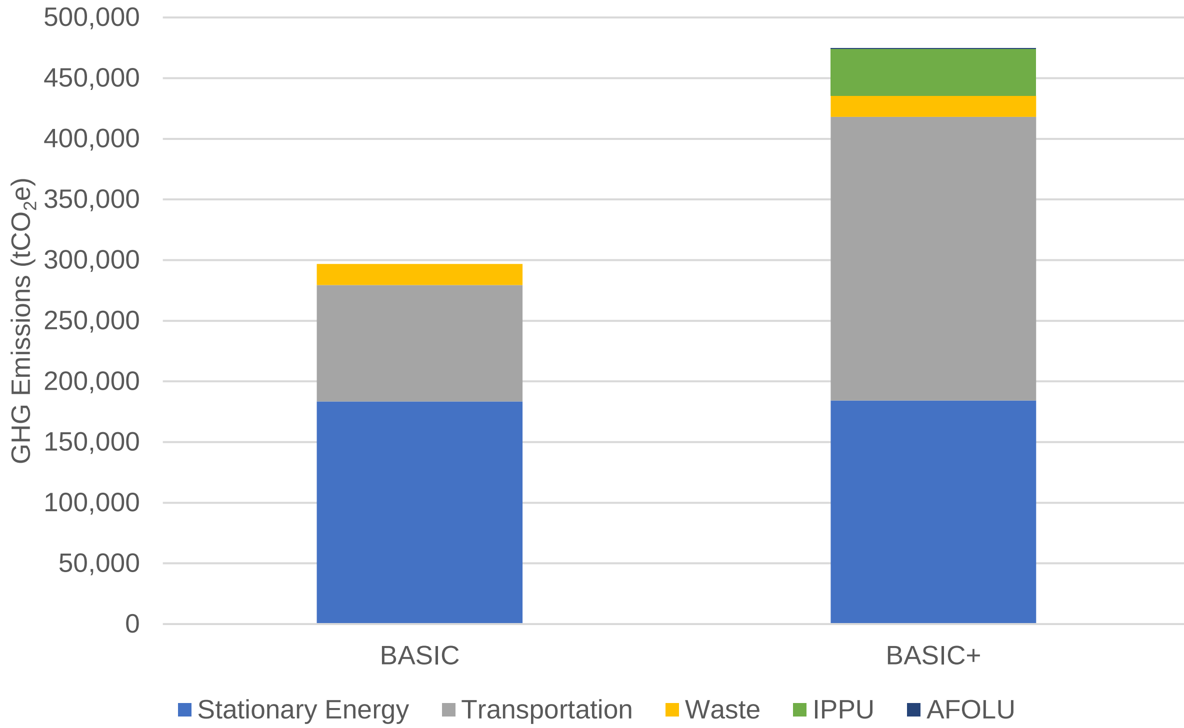

Figure 3 2021 GHG Emissions Summary by GPC Reporting Level

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 city. 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 Saanich's 2021 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)	175,381	8,215	550	183,596	184,146	184,146
	Energy generation supplied to the grid (I.4.4)	8,160					
Transportation	(all II emissions)	95,673	46	138,107	95,719	233,826	233,826
Waste	Waste generated in the District (III.X.1 and III.X.2)	13,348		4,212	17,560	17,560	17,560
	Waste generated outside city (III.X.3)	46,052					
IPPU	(all IV emissions)	38,644				38,644	38,644
AFOLU	(all V emissions)	496				496	496
Other Scope 3 (S3)	(all VI emissions)			NE			NE
TOTAL		**323,543**	**8,261**	**142,870**	**296,875**	**474,673**	**474,673**

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 District's BASIC+ GHG emissions by Sector and Sub-Sector.

Table 33 Breakdown of Saanich's 2021 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	81,024	5,596	375	86,996
I.2	Commercial and institutional buildings and facilities	56,420	2,619	175	59,214
I.3	Manufacturing industries and construction	NE	NE	NE	NE
I.4.1/2/3	Energy industries	9,850	NO	NO	9,850
I.4.4	Energy generation supplied to the grid	8,160			
I.5	Agriculture, forestry, and fishing activities	27,606	IE	IE	27,606
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	480			480
Sub-Total	(city induced framework only)	**175,381**	**8,215**	**550**	**184,146**
II	**Transportation**				
II.1	On-road transportation	79,560	46	123,467	203,073
II.2	Railways	NO	NO	NO	NO
II.3	Waterborne navigation	IE	IE	10,238	10,238
II.4	Aviation	IE	IE	4,402	4,402
II.5	Off-road transportation	16,113	IE	IE	16,113
Sub-total	(city induced framework only)	**95,673**	**46**	**138,107**	**233,826**
III	**Waste**				
III.1.1/2	Solid waste generated in the District	10,113		NO	10,113
III.2.1/2	Biological waste generated in the District	3,236		NO	3,236
III.3.1/2	Incinerated and burned waste generated in the District	NO		NO	NO
III.4.1/2	Wastewater generated in the District	IE		4,212	4,212
III.1.3	Solid waste generated outside the District	28,679			
III.2.3	Biological waste generated outside the District	17,373			
III.3.3	Incinerated and burned waste generated outside city	NO			

Table 33 Breakdown of Saanich's 2021 BASIC+ GHG Emissions in the GPC Protocol Reporting Format

GPC ref No.	GHG Emissions Source (by Sector and Sub-Sector)	Total GHGs (metric tonnes CO_2e)			
		Scope 1	Scope 2	Scope 3	Total
III.4.3	Wastewater generated outside the District	NO			
Sub-total	(city induced framework only)	**13,348**		**4,212**	**17,560**
IV	**Industrial Processes and Product Uses**				
IV.1	Emissions from industrial processes occurring in the District boundary	NE			NE
IV.2	Emissions from product use occurring within the District boundary	38,644			38,644
Sub-Total	(city induced framework only)	**38,644**			**38,644**
V	**Agriculture, Forestry, and Other Land Use**				
V.1	Emissions from livestock	445			445
V.2	Emissions from land**	-3,504			-3,504
V.3	Emissions from aggregate sources and non-CO_2 emission sources on land	51			51
Sub-Total	(city induced framework only)	**496**			**496**
VI	**Other Scope 3**				
VI.1	Other Scope 3			NE	NE
Total	(city induced framework only)	**323,543**	**8,261**	**142,870**	**474,673**

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
**Reporting only; not included in totals

5.3 TOTAL GHG EMISSIONS

Under the BASIC+ method, the District's GHG emissions totaled 474,673 tCO_2e. On a per capita basis, this works out to 3.8 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	3,777,218	86,996	30	0.7
	Commercial & Institutional Buildings	2,080,323	59,214	17	0.5
	Manufacturing Industries & Construction	-	-	-	-
	Energy Industries	-	9,850	-	0.1
	Agriculture, Forestry & Fishing Activities	393,505	27,606	3	0.2
	Fugitive Emissions	-	480	-	0.0
Transportation	In-Boundary On-road Transportation	1,203,227	79,578	10	0.6
	Trans-Boundary On-road Transportation	1,867,248	123,495	15	1.0
	Waterborne Navigation	139,526	10,238	1	0.1
	Aviation	59,171	4,402	0	0.0
	Off-road Transportation	229,676	16,113	2	0.1
Waste	Solid Waste	-	10,113	-	0.1
	Biological Treatment of Waste	-	3,236	-	0.0
	Wastewater Treatment & Discharge	-	4,212	-	0.0
IPPU	Product Use	-	38,644	-	0.3
AFOLU	Land-Use: Emissions Sequestered **(Disclosure Only - Not Included In Total)**		(17,123)		(0.1)
	Land-Use: Emissions Released **(Disclosure Only - Not Included In Total)**	-	13,619	-	0.1
	Livestock	-	445	-	0.0
	Non-CO_2 Land Emission Sources	-	51	-	0.0
Total		**9,749,896**	**474,673**	**78.2**	**3.8**

Total GHG emissions for 2021 are 474,673 tCO_2e and have decreased 18.5% from the 2007 Base Year and decreased 2.7% from the prior reporting year. Scope 1 and 2 Emissions are 68.2% and 1.7% of the total GHG inventory. Scope 1 emissions are the GHG emissions that result from the combustion of fuel in sources within the District limits, primarily from Stationary Energy and Transportation. Scope 1 GHG emissions also include IPPU and AFOLU GHG emissions. Scope 2 emissions result from the use of electricity supplied to the District 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 District that are occurring outside of the District limits. For 2021, Scope 3 GHG emissions make up 30.1% of the GHG inventory. This breakdown by emission scope is depicted in Figure 4.

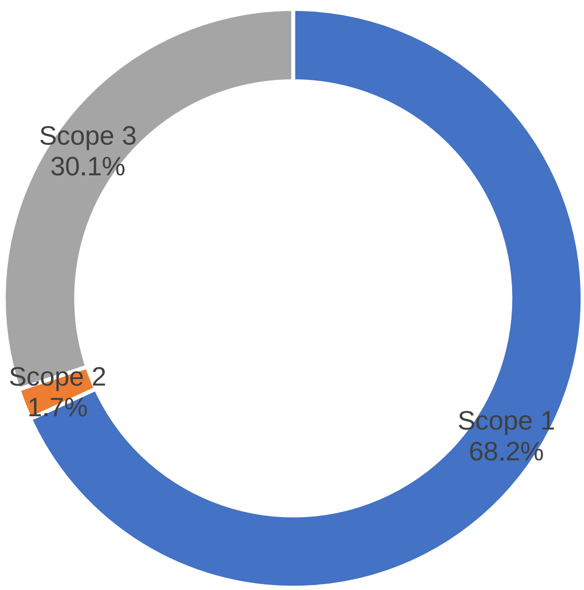

Figure 4 Total District BASIC+ GHG Emissions by Emissions Scope

5.4 COMPARATIVE ANALYSIS

Compared to the 2007 base year, the District's 2021 GHG emissions have decreased 107,749 tCO_2e or 18.5% (Table 35).

Table 35 Change in GHG Emissions from 2007 Base Year

Emissions Scope	2007 GHG Emissions (tCO_2e)	2021 GHG Emissions (tCO_2e)	Change
Scope 1	351,702	323,543	-8.0%
Scope 2	32,852	8,261	-74.9%
Scope 3	197,867	142,870	-27.8%
Total	**582,422**	**474,673**	**-18.5%**

5.5 SECTORAL GHG EMISSIONS ANALYSIS

5.5.1 Stationary Energy

Stationary energy sources are one of the largest contributors to the District's GHG emissions. In 2021, it contributed 38.8% 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 2021 reporting year.

Table 36 2021 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	5,971	45,821	19,464	5,846	4,924	4,969	**86,996**	**3,774,879**
Commercial & Institutional Buildings	2,794	44,239	1,388			10,793	**59,214**	**2,075,242**
Energy Industries						9,850	**9,850**	
Agriculture, Forestry & Fishing activities						27,606	**27,606**	**380,508**
Fugitive Emissions						480	**480**	
Total GHG Emissions (tCO_2e)	**8,766**	**90,060**	**20,852**	**5,846**	**4,924**	**53,698**	**184,146**	
Total Energy (GJ)	**3,253,154**	**1,769,458**	**304,966**	**95,593**	**209,712**	**597,747**		**6,230,629**

It can be seen in Figure 5 that heating oil and natural gas use contribute to 60.2% of the District's total Stationary Energy GHG emissions.

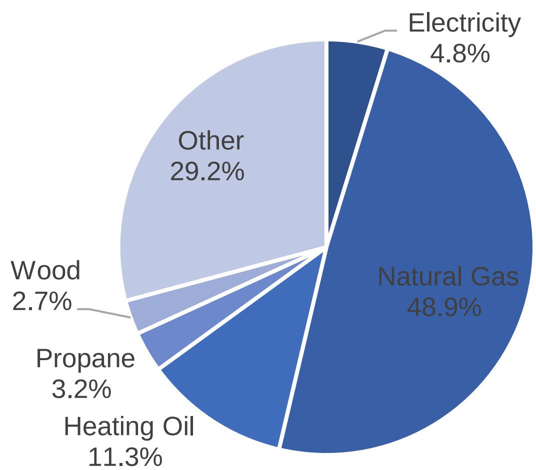

Figure 5 Stationary Energy GHG Emissions Contribution to the GHG Inventory

Figure 6 shows that more than 47.2% of the stationary GHG emissions arise from the operation of residential buildings and 32.2% from the operation of commercial and institutional buildings.

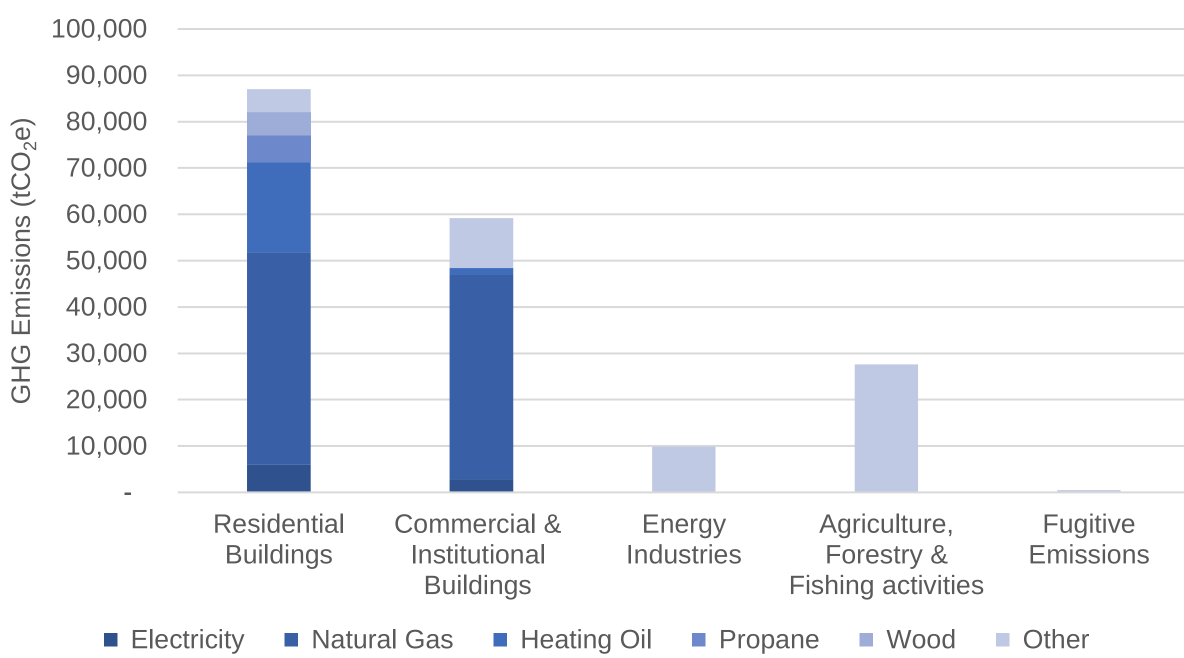

Figure 6 Total Stationary Energy Use By Sub-Sector

Stationary energy GHG emissions have decreased by 10.8% since the 2007 Base Year. Between the reporting years, there has been a 10.2% decrease in GHG emissions and a 2.4% increase in energy use (Table 37). The decrease in GHG emissions between reporting years is largely due to the change in the 2020 and 2021 electricity emission factors (an overall decline of 75.8% between 2020 and 2021).

Table 37 Stationary Energy—Energy and GHG Emissions Trends

Sector	Change in GJ: 2007 & 2021	Change in GJ a & 2021	Change in tCO_2e: 2007 & 2021	Change in tCO_2e: 2020 & 2021
Residential Buildings	-6.0%	2.1%	-23.1%	-16.1%
Commercial & Institutional Buildings	-2.3%	4.0%	-6.4%	-7.5%
Agriculture, Forestry & Fishing Activities	-3.3%	-2.6%	-5.9%	0.7%
Fugitives			52.9%	3.5%
Total	**-4.7%**	**2.4%**	**-10.8%**	**-10.2%**

5.5.2 Transportation

Transportation covers all emissions from combustion of fuels in journeys by road, rail, water, and air, including inter-city and international travel. For the 2021 reporting year, transportation GHG emissions accounted for 49.3% of the community GHG inventory with the bulk of transportation GHG emissions resulting from the on-road transportation sub-sector. 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 2021 reporting year.

Table 38 2021 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	3,270	4,696,012	kWh	17	46
Gasoline	76,171	78,166,242	Liters (L)	2,709,242	179,000
Diesel	3,723	9,256,405	Liters (L)	358,038	23,845
Propane	66	124,503	Liters (L)	3,179	180
Hydrogen	5	-	Liters (L)	-	-
Natural Gas	12	12,588	Kilograms (kg)	1	3
Total	**83,247**	**N/A**	**N/A**	**3,070,476**	**203,073**

The majority of the on-road transportation GHG emissions (88.6%) come from passenger vehicles, light trucks, and SUVs (Figure 7).

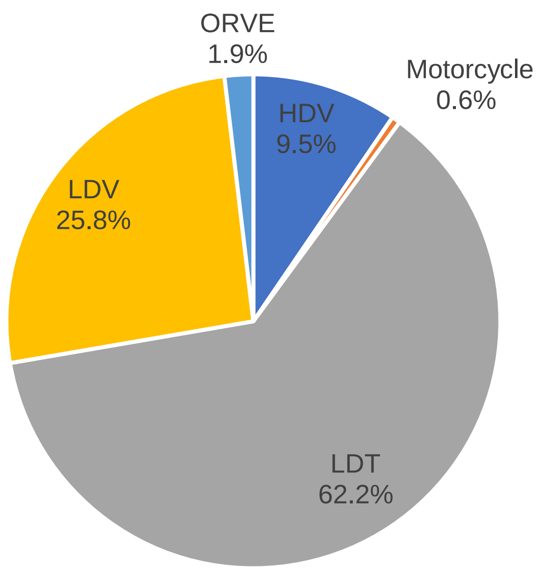

Figure 7 Breakdown of On-Road GHG Emissions by Vehicle Type

Overall, GHG emissions from on-road transportation have decreased by 25.6% compared to the 2007 base year.

Table 39 summarizes the aviation, waterborne, and off-road transportation energy and emissions by fuel type. These GHG emissions contribute to 13.2% of the total transportation GHG emissions and 6.5% to the total inventory (Figure 8).

Table 39 2021 Aviation, Waterborne, and Off-Road Transportation Energy and Emissions by Fuel Type

Fuel Type	Total	Units	Energy (GJ)	GHG Emissions (tCO_2e)
Marine Gasoline	2,239	Liters (L)	78	5
Marine Diesel	3,201,722	Liters (L)	123,843	9,328
Marine Natural Gas	401,703	Liters (L)	15,606	905
Aviation Jet Fuel	1,705,219	Liters (L)	59,171	4,402
Other Off-Road Transportation Diesel	5,741,740	Liters (L)	222,091	16,113
Total	**N/A**	**N/A**	**420,788**	**30,753**

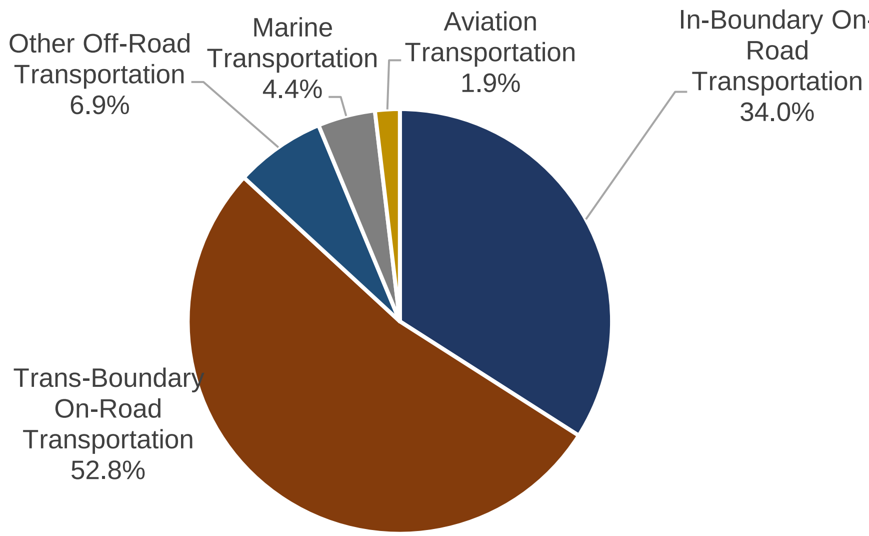

Figure 8 Summary of Transportation GHG Emissions by Sub-Sector

5.5.3 Waste

Cities 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 2021 reporting year, the total waste emissions contribute to 3.7% of 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	2021 GHG Emissions (tCO_2e)	GHG Emissions Per Capita (tCO_2e / Capita)	Change from Base Year (2007)
Wastewater Treatment And Discharge	4,212	0.03	-15.6%
Biological Treatment of Solid Waste	3,236	0.03	100%
Solid Waste	10,113	0.08	-71.2%
Total	**17,560**	**0.14**	**-56.2%**

For the 2021 reporting year, in scope GHG emissions from waste have decreased by 56.2% compared to the 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 57.6% of total waste GHG emissions (Figure 9). To reduce the amount of waste landfilled, and thus

GHG emissions, the District is making a significant effort to reduce waste going to landfills through organics diversion, and recycling.

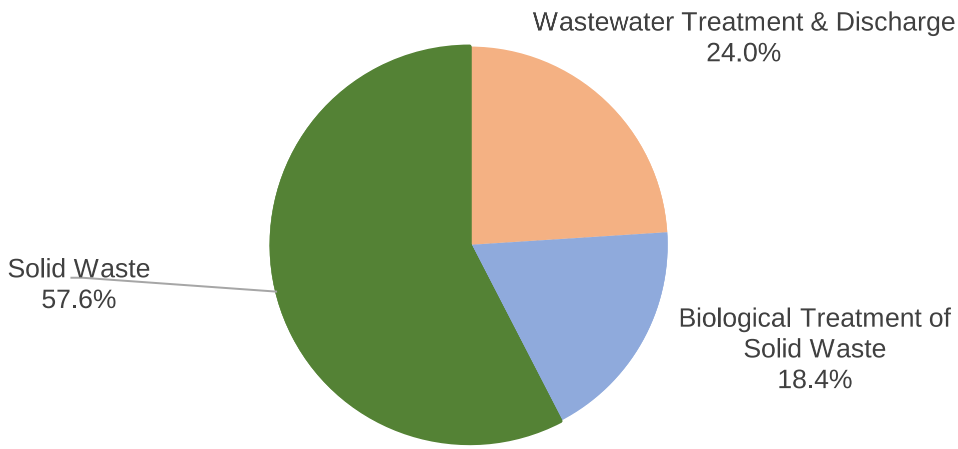

Figure 9 2021 GHG Emissions from Waste (tCO_2e)

5.5.4 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. There are no industrial GHG emissions occurring within the District's boundaries, and a "Not Occurring" notation is used.

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 District on the basis that other GHG emissions sources identified in the NIR are not likely to be occurring in the District. To estimate Product Use GHG emissions for the District, a per capita estimate was developed using the Provincial emissions data from the 2022 NIR, and BC's NIR reporting year (2020) population from Statistics Canada. This value was applied to the 2021 reporting year City population to estimate the total Product Use emissions for the District.

It should be noted that the District has little influence over product use GHG emissions as these are consumption driven emissions.

Between the 2007 and 2021 reporting years, IPPU GHG emissions have increased 58.1%. The reason for the increase is attributed to Environment 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 2021 Reporting Years

Sub-Sector	2007 (tCO_2e)	2021 (tCO_2e)	Change
Product Use Emissions	24,438	38,644	**58.1%**
Total	24,438	38,644	**58.1%**

5.5.5 Agriculture, Forestry, and Other Land Use

The AFOLU Sector includes GHG emissions from livestock, land use, and all other agricultural activities occurring within the District's boundaries. Using remotely sensed imagery, land cover data was used to estimate land use changes between the reporting years.

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 2021, the District's greenspace is estimated to have sequestered and stored 17,123.0 tCO_2e (Table 42), released 13,618.7 tCO_2e for a net effect of -3,504.27 tCO_2e. At the regional level, the land-use results were deemed to contradict expectations relative known trends of development in the region. Therefore, the land use GHG emissions were excluded from the total inventory calculations. For consistency, the District is also excluding these GHG emissions.

Table 42 Summary of Land-Use Change in 2021

Land Type	Total Hectares (Ha)	GHG Emissions Sequestered (tCO_2e)	GHG Emissions Released (tCO_2e)
Forest Land	4,744.1	(8,793.6)	-
Cropland	863.6	(358.1)	-
Grassland	210.3	(639.8)	-
Wetlands	2,017.9	(7,331.5)	-
Settlements	2,385.5	-	10,078.9
Other Land	477.6	-	3,539.8
Total	**10,699.0**	**(17,123.0)**	**13,618.7**

5.5.5.1 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 District reports on GHG emissions from the following sources, and Sub-Sectors:

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

The GHG emissions from this source is presented in Table 43.

Table 43 Summary of Livestock and Aggregate Sources and Non-CO_2 Emissions Sources On Land Change GHG Emissions Between 2007 and 2021

Land Type	2007 GHG Emissions (tCO_2e)	2021 GHG Emissions (tCO_2e)	Change From 2007
Livestock	444	445	0.1%
Aggregate Sources and Non-CO_2 Emissions Sources On Land	107	51	-52.2%
Total	**551**	**496**	**-10.0%**

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 District, 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 City reviews to confirm assumptions, data, and reasonableness of the estimates.

7.0 RECOMMENDATIONS

To remain accurate and reflective of the current community conditions, the District 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 2021 GHG emissions inventory, there are several assumptions were made in the analysis that will have some influence on accuracy of the District's estimate of community 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 District prioritize improvements for that are likely to have a material (>10%) improvement in 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.

Sector	Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
Stationary Energy	Propane and wood GHG emissions were estimated based on 2007-2019 CEEI GHG emissions.	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 and propane fuel use.
Stationary Energy	FortisBC provided a total estimate of fugitive emissions for the CRD region for 2020; however, this did not include upstream fugitive emissions as suggested as best practice by the GPC Protocol.	Immaterial impact on the GHG inventory (<5%)	Work with FortisBC to refine this estimate.
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.	Immaterial impact on the GHG inventory (<5%)	Work with local harbor airports to get actual fuel consumption.
Waste	There is tracking to the origin of solid waste but is based on reported origin which may or	Immaterial impact on the GHG inventory (<5%)	Work with waste haulers to devise a better system to track waste origination.

Sector	Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
	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. Because of this, the City of Victoria has assumed that 31% of waste comes from Victoria which may or may not be accurate.		
IPPU	Product use emissions were estimated on a per capita basis using the 2021 NIR estimates. The product use emissions were estimated by the NIR using an IPCC Tier 1 approach and thus will have high uncertainty.	Immaterial impact on the GHG inventory (<5%)	No recommendations currently.
AFOLU	GHG estimates for land use change are based on a period of years (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 average value between the data years.	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.
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	Immaterial impact on the GHG inventory (<5%)	Work with the Province and the post-secondary institutions to derive refined sequestration emission factors.

Sector	Assumption	Possible Impact on The GHG Inventory	Recommended Improvements
	non-site emission factors may result in an over or underestimate of GHG emissions.		

8.0 REFERENCES

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