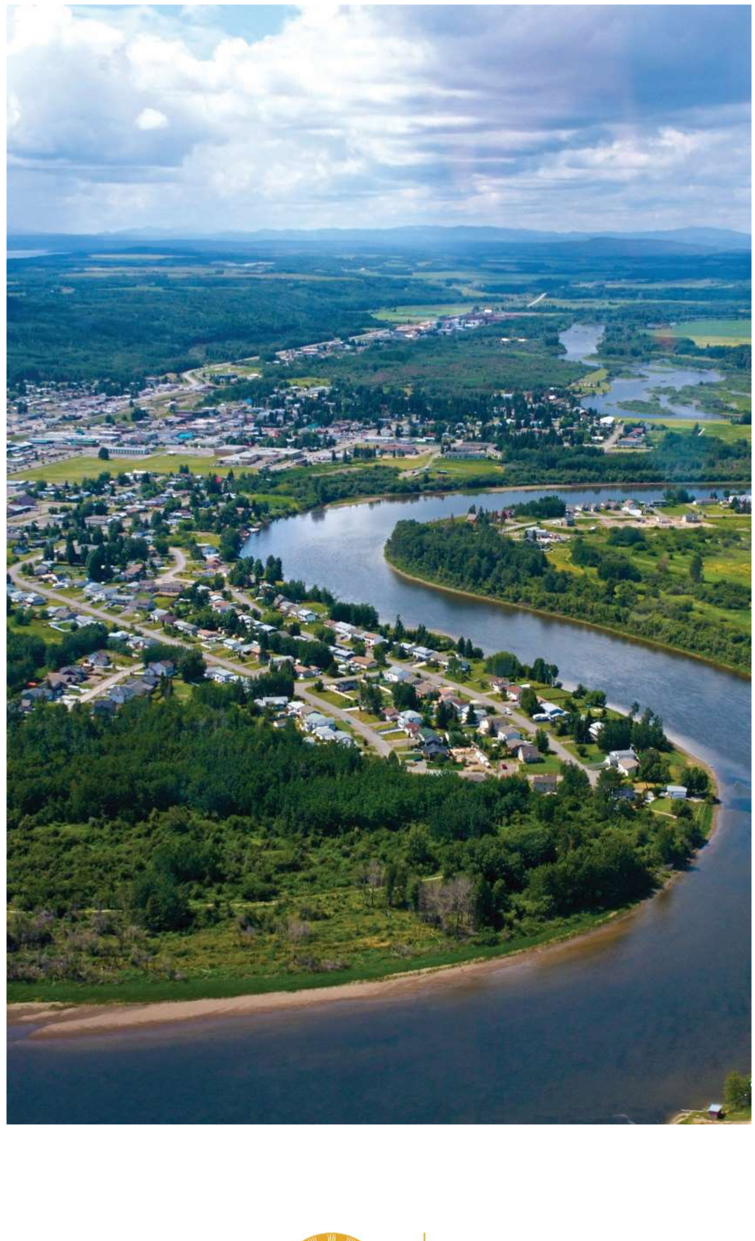
Emission Inventory for Vanderhoof and Surrounding Areas

2018 Base Year



Lin Li Guo, Clean Air, Environmental Standard Branch
Ben Weinstein, Air Quality Section, Regional Operations Branch
Vickie Irish, Air Quality Section, Regional Operations Branch

BRITISH COLUMBIA
Ministry of Environment and Climate Change Strategy

ISBN: 978-1-0399-0047-9

Citation:

Lin Li Guo, Ben Weinstein, and Vickie Irish.2023. Emission Inventory for Vanderhoof and Surrounding Areas (2018 Base Year). Environmental Protection Division, Ministry of Environment and Climate Change Strategy, Prov. B.C., Victoria B.C.

Authors' Affiliation:

B.C. Ministry of Environment and Climate Change Strategy

ACKNOWLEDGEMENTS

The authors would like to express their sincere appreciation and gratitude to the organizations and individuals who provided valuable information and assistance during the course of this study.

- Vanderhoof, District Municipality,
- B.C. Ministry of Environment and Climate Change Strategy, Air Quality Section, Regional Operations Branch, and
- B.C. Ministry of Environment and Climate Change Strategy, Clean Air, Environmental Standard Branch
    - Markus Kellerhals Sr. Air Quality Science Officer, Section Head, and
    - Cindy Walsh Air Quality Science Specialist.

LIST OF ACRONYMS

AMS	Authorization Management System
APEI	Air Pollutants Emission Inventory
AP- 42	Compilation of Air Pollutant Emissions Factors
B.C.	British Columbia
BRN	Burning Registration Number
CAC	Common Air Contaminants
CEEI	Community Energy and Emission Inventory
CEMS	Continuous Emission Monitoring Systems
CFR	Code of Federal Regulations
CN	Canadian National Railway
ECCC	Environment and Climate Change Canada
ENV	Ministry of Environment and Climate Change Strategy
EMA	Environmental Management Act
EPA	Environmental Protection Agency
FOR	Ministry of Forests
GIS	Geographic Information System
GJ	Gigajoule
ha	Hectare
ID	Identification Number
km	Kilometre
LPG	Liquefied Petroleum Gas
LTO	Landing and Takeoff
MMBTU	One Million British Thermal Unit
MV	Metro Vancouver
MOVES	Motor Vehicle Emission Simulator
NG	Natural Gas
NPRI	National Pollutant Release Inventory

NOx	Nitrogen Oxides
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
OFTS	Open Fire Tracking System
PFR	Permit Fees Regulation
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter Less than 2.5 microns in Equivalent Diameter
PM_{10}	Particulate Matter Less than 10 microns in Equivalent Diameter
RDBN	Regional District of Bulkley–Nechako
TPM	Total Particulate Matter
U.S.	United States
VKT	Vehicle Kilometres Travelled
VSWP	Vanderhoof Specialty Wood Products
WRAP	Western Regional Air Partnership

EXECUTIVE SUMMARY

An inventory of air pollutant emissions in Vanderhoof and its surrounding area was developed by the British Columbia (B.C.) Ministry of Environment and Climate Change Strategy (ENV) to support future air quality management actions. The air pollutants of concern in this emission inventory include:

- Nitrogen oxides (NOx) – a collective form of nitrogen oxide (NO) and nitrogen dioxide (NO_2)
- Total particulate matter (TPM) – a mixture of solid particles and liquid droplets found in air,
- PM_{10} – particulate matter less than 10 microns in equivalent diameter, and
- $PM_{2.5}$ – particulate matter less than 2.5 microns in equivalent diameter.

Emissions were categorized as point, mobile and area sources. The study area includes Vanderhoof and the surrounding areas, of which there are four sub-regions:

- **Vanderhoof DM:** District of Vanderhoof,
- **Fraser Lake:** Village of Fraser Lake,
- **Area D:** Electoral Area D of Regional District of Bulkley–Nechako (RDBN), and
- **Area F:** Electoral Area F of RDBN.

In the 2018 reporting year the study area emitted 1669 tonnes of NOx, 10220 tonnes of TPM, 6750 tonnes of PM_{10}, and 5799 tonnes of $PM_{2.5}$. Wildfires were responsible for 8% of NOx, 68% of TPM, 76% of PM_{10}, and 81% of $PM_{2.5}$ emissions. Table ES-1 presents a summary of the total emissions (excluding wildfire) for each air pollutant in the four sub-regions.

Table ES-1: Total Emissions in the Study Area

Area	Total Emissions (tonnes/year)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
Vanderhoof DM	253	235	83.56	46.23
Fraser Lake	35.49	46.27	19.36	10.65
Area D	546	881	513	363
Area F	702	2065	1030	669
Total in Study Area (without Wildfire)	**1537**	**3227**	**1646**	**1089**
Total in Study Area (with Wildfire)	1669	10220	6750	5799

Table ES-2 summarizes the emissions contribution (excluding wildfire) from significant sources across the entire study area.

Table ES-2: Emission Distribution (without Wildfire) in the Study Area

Air Pollutants	Point Sources	Mobile Sources	Area Sources Open Burning	Area Sources Space Heating	Area Sources Agriculture	Area Sources Fugitive Dust
NOx Emission	40.22%	42.51%	15.11%	2.17%	0.00%	0.00%
TPM Emission	9.19%	1.40%	39.76%	3.65%	22.48%	23.53%
PM_{10} Emission	8.64%	2.74%	55.47%	6.76%	13.60%	12.79%
$PM_{2.5}$ Emission	7.47%	3.44%	72.92%	10.21%	3.65%	2.31%

Upon excluding wildfire emissions mobile sources emerged as the primary contributors to NOx emissions in the entire study area, closely followed by point sources. Area sources arising from open burning were identified as the predominant contributors to TPM, PM_{10}, and $PM_{2.5}$ emissions after removing wildfire emissions.

Table of Contents

ACKNOWLEDGEMENTS i
EXECUTIVE SUMMARY iv
1. INTRODUCTION 1
1.1 Background Information 1
1.2 Air Pollutants of Concern 1
1.3 Study Area 2
2. EMISSION ESTIMATES 2
2.1 Point Sources 3
2.1.1 Data Resources 3
2.1.2 Methods 4
2.2 Mobile Sources 7
2.2.1 On-Road Vehicles 7
2.2.2 Tire Wear and Brake Lining 10
2.2.3 Off-road Vehicles and Equipment 11
2.2.4 Rail Transportation 12
2.2.5 Air Transportation 14
2.3 Area Sources 15
2.3.1 Open Burning 15
2.3.2 Space Heating 18
2.3.3 Agriculture 23
2.3.4 Fugitive Dust 32
2.3.5 Wildfire 36
3. RESULT SUMMARY 36
4. ANALYSIS 39

List of Tables

Table 1: Summary of Emissions from Point Sources 3
Table 2: NPRI and B.C. ENV Permit Identification Number (ID) for Industries Identified in the Study Area 4
Table 3: Point Source Emissions 5
Table 4: Emission Factors for On-road Vehicles 7
Table 5: Annual Emissions from On-road Gasoline Vehicles 8
Table 6: Annual Emissions from On-road Diesel Vehicles 9
Table 7: Annual Emissions from Tire Wear and Brake Lining of On-road Vehicles 10
Table 8: Annual Emissions from Off-road Vehicles and Equipment used for Agriculture 11
Table 9: Annual Emissions from Off-road Vehicles and Equipment Used for Construction 12
Table 10: Emissions Factors for Line-Haul Locomotives 13
Table 11: Annual Emissions from Rail Transportation 13
Table 12: Annual Emissions from Air Transportation in the Study Area 14
Table 13: Emission Factors for Pile Open Burning 16
Table 14: Annual Emissions from Provincially Regulated Open Burning in the Study Area 16
Table 15: Emission Factors for Backyard Burning 17
Table 16: Annual Emissions from Backyard Burning 18
Table 17: Emission Factors for Space Heating (Non-wood Fuel) 18
Table 18: Annual Emission from Space Heating Burning Fuel Oil 19
Table 19: Annual Emission from Space Heating Burning NG 20
Table 20: Annual Emission from Space Heating Burning Propane 20
Table 21: Emission Factors for Wood Burning 21
Table 22: Annual Emissions from Residential Wood Burning 23
Table 23: Emissions Factors for the Movement of Farm Animal 23
Table 24: Annual Emissions from the Movement of Farm Animal in the Study Area 24
Table 25: Annual Emissions from Inorganic Fertilizer Application 25
Table 26: Emission factors for Application of Pesticide 25
Table 27: Annual Emissions from Pesticides Application 25
Table 28: Emission Factors for Tilling Soil 27
Table 29: Annual Emissions from Tilling Soil 27
Table 30: Emission Factors for Crop Harvesting 28
Table 31: Annual Emissions from Crop Harvesting 28
Table 32: Annual Emissions from Wind Erosion of Agricultural Soils 31
Table 33: Emission factors for Construction Operation 32
Table 34: Annual Emissions from Construction Operations 33
Table 35: Annual Fugitive Dust Emissions from Landfill Operation 34
Table 36: Fugitive Dust Emissions Factors for Rail Transportation of Coal 34
Table 37: Annual Fugitive Dust Emissions from Rail Transportation of Coal 35
Table 38: 2018 Road Dust Emissions from Entire B.C. 35
Table 39: Annual Fugitive Dust Emissions from Paved and Unpaved Roads 36
Table 40: Annual Emissions from Wildfire 36
Table 41: 2018 Emission Estimates for Vanderhoof and Surrounding Area 37

Table 42: Emission Distributions for Vanderhoof and Surrounding Areas in 2018 40
Table 43: Emission Distributions for Vanderhoof DM in 2018 41
Table 44: Emission Distributions for Fraser Lake in 2018 42
Table 44: Emission Distributions for Area D in 2018 43
Table 46: Emission Distributions for Area F in 2018 44

List of Figures

Figure 1: Project Study Area 2
Figure 2: Emission Distributions (without Wildfire) (%) in the Study Area 40
Figure 3: Emission Distributions (without Wildfire) (%) in Vanderhoof DM.. 41
Figure 4: Emission Distributions (without Wildfire) (%) in Fraser Lake 42
Figure 5: Emission Distributions (without Wildfire) (%) in Area D... 43
Figure 6: Emission Distributions (without Wildfire) (%) in Area F 44

1. INTRODUCTION

1.1 Background Information

In 2021, the British Columbia (B.C.) Ministry of Environment and Climate Change Strategy (ENV) implemented two projects to support air quality management in Vanderhoof. One of the projects was to develop an air pollutant emission inventory. The goal of the inventory was to identify and quantify major local emission sources for nitrogen oxide (NOx) and particulate matter (PM) within the study area.

The project supports informed, science-based decision-making with respect to local airshed management and raises public awareness of local sources of air pollution.

1.2 Air Pollutants of Concern

The project focused on three size categories of PM:

- TPM – total particulate matter,
- PM_{10} – particulate matter less than 10 microns in equivalent diameter, and
- $PM_{2.5}$ – particulate matter less than 2.5 microns in equivalent diameter.

The potential for causing health effects is linked to the size of PM since the smallest particles can transport deep into a human's lung or even the bloodstream [1]. $PM_{2.5}$, the fine fraction of PM, has the strongest correlation with adverse health outcomes and is mostly generated from combustion of gasoline, oil, diesel fuel or wood[2]. The coarse fraction of PM, particles between 2.5-10 microns in diameter typically originates from the mechanical process (e.g., dust from roadways, construction sites, and farming)[3]. TPM has been included in the emission inventory due to the prevalence of its reference in Ministry-issued authorizations (e.g., permits).

Although the determination of PM emissions was a primary focus of this work, NOx was also scoped into the inventory due to its significance as a common air contaminant (CAC) and in knowing that there are local contributions from transportation and nearby industrial facilities. NOx is usually reported as nitrogen dioxide (NO_2) equivalent, including nitric oxide (NO) and NO_2, it forms from the liberation of nitrogen contained in fuel and nitrogen contained in combustion air during combustion processes[4].

---

[1] U.S. EPA. Health and Environmental Effects of PM. www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm. Accessed in October 2023.

[2] California Air Resources Board. Inhalable Particulate Matter and Health ($PM_{2.5}$ and PM_{10}). ww2.arb.ca.gov/resources/inhalable-particulate-matter-and-health. Accessed in October 2023.

[3] Robert et. al, 2014. Hemodynamic, Autonomic, and Vascular Effects of Exposure to Coarse Particulate Matter Air Pollution from a Rural Location. Environ Health Perspectives, 2014 June; 122(6): 624–630. www.ncbi.nlm.nih.gov/pmc/articles/PMC4050508/.

[4] Government of Canada. Common air pollutants: nitrogen oxides. www.canada.ca/en/environment-climate-change/services/air-pollution/pollutants/common-contaminants/nitrogen-oxides.html. Accessed in October 2023.

1.3 Study Area

The information presented in this report is for Vanderhoof and the surrounding areas, comprising of the following regions shown in Figure 1:

- **Vanderhoof DM:** District of Vanderhoof,
- **Fraser Lake:** Village of Fraser Lake,
- **Area D:** Electoral Area D of RDBN, and
- **Area F:** Electoral Area F of RDBN.

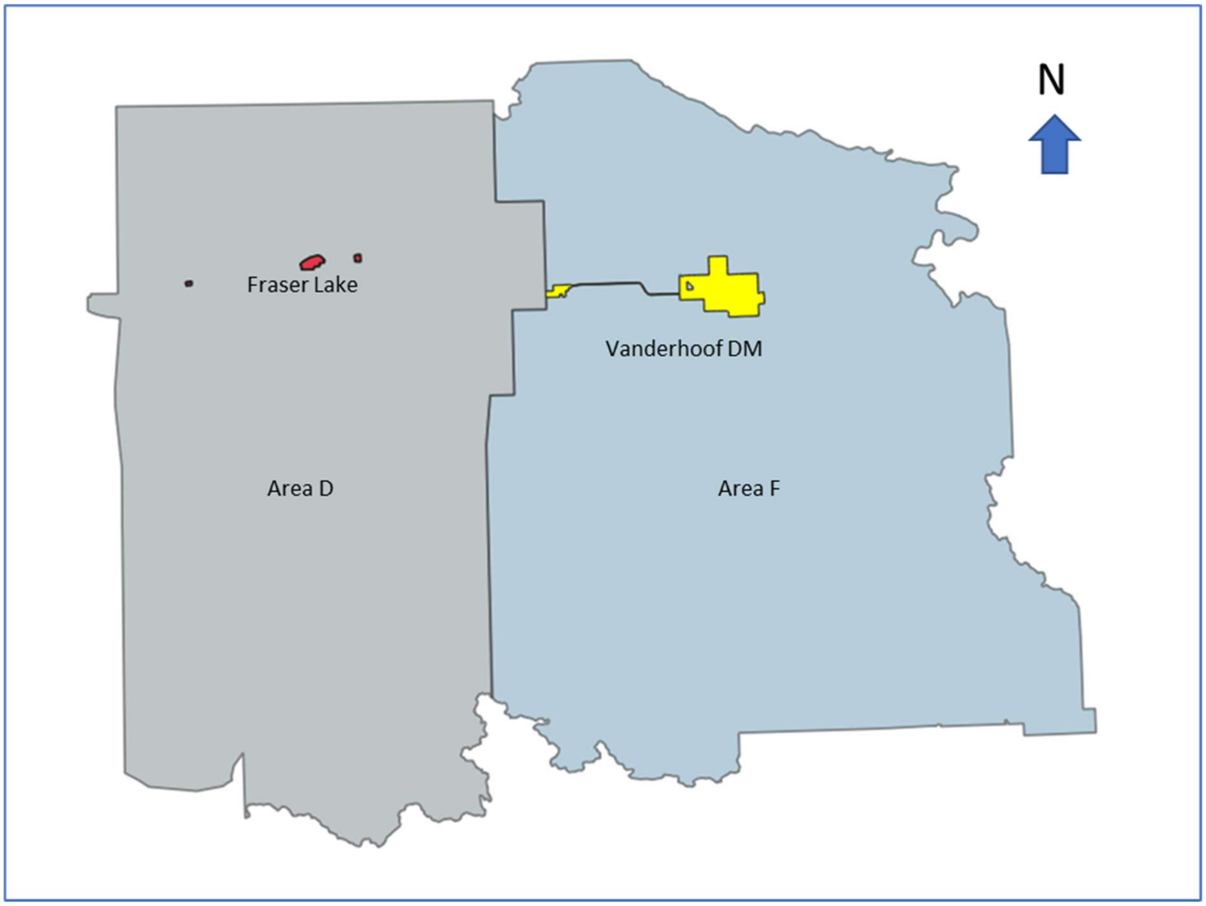


Figure 1: Project Study Area

2. EMISSION ESTIMATES

In this section, comprehensive information pertaining to the annual emission inventory estimation for the study area in 2018 is presented, encompassing data resources, methodologies, and structured results. The emission inventory is classified into three distinct categories of emission sources: point sources, mobile sources, and area sources.

- Point sources refer to substantial stationary sources originating from industrial facilities, which operate under discharge permits from provincial authorities or necessitate emissions reporting to the national pollutant release inventory.

An example of a point source would be a cyclone from an industrial facility such as a pellet plant or a sawmill,

- Mobile sources encompass various modes of vehicles or equipment utilized for motorized transportation. Mobile sources include cars, trucks, rail, and offroad equipment used in farming and other activities, and
- Area sources comprise smaller, widely distributed sources that are not encompassed within the point source and mobile source categories. Area sources are either too small or too numerous to be quantified individually so they are estimated over an area. Area sources could include residential heating and open burning.

An in-depth analysis of point sources, mobile sources, and area sources is provided in Sections 2.1, 2.2, and 2.3, respectively.

Note that due to rounding of numbers presented in some of the tables, the sums in certain tables may not add up to the total or subtotal indicated. This limitation applies to all tables presented in this report. Additionally, the 2016 data from Statistics Canada is assumed to represent the corresponding data for the year 2018.

2.1 Point Sources

Emissions from point sources consist of releases from stacks, flares, vents, ducts, pipes, or other confined process streams associated with industrial facilities, typically operating under authorizations such as permits, or approvals. A synopsis of point source emissions within the study area is presented in Table 1.

Table 1: Summary of Emissions from Point Sources

Facility	**Annual Average Emissions from Point Sources (tonnes/year)**			
	NOx	**TPM**	**PM_{10}**	**$PM_{2.5}$**
Nechako Lumber Company Ltd.	53.17	57.00	14.70	9.00
Premium Pellet Ltd.	31.80	43.50	14.50	9.40
Vanderhoof Specialty Wood Products (VSWP)	0.00	2.80	1.10	1.10
Canadian Forest Products Ltd, Plateau Division	70.39	46.33	26.84	19.19
Fraser Lake Lumber (Div of West Fraser Mills Ltd.), Fraser Lake Sawmills	262	138	75.62	33.26
Pacific Northern Gas Ltd.	201	9.39	9.39	9.39
Total for Point Sources	**618**	**297**	**142**	**81.34**

2.1.1 Data Resources

Due to the absence of on-site information such as continuous emission monitoring systems (CEMS) data or stack sampling results, the National Pollutant Release Inventory (NPRI) 2018 and

B.C. ENV authorization management system (AMS) database were primarily used to estimate point source emissions.

The NPRI is Canada's legislated and publicly accessible inventory of pollutant releases, disposals, and recycling[5]. The NPRI "releases to air" from point sources serve as the best estimate of actual (normal) emissions from identified industrial facilities within the study area for 2018. The list of industries in the project study area is presented in Table 2. The Endako mine, located within the study area, has been under care and maintenance (not in operation) since 2015. Consequently, emissions from the Endako mine have been excluded from this emission inventory.

Emissions derived from the B.C. ENV AMS database generally pertain to the maximum emissions from point sources. These emissions are generated through permit limits, flow rates, and release frequency, which are documented in the authorizations under the B.C. *Environmental Management Act* (EMA). In instances where these parameters were not specified in the authorization documents, emission factors, also referred to as discharge factors in AMS, as specified in the Permit Fees Regulation (PFR), were utilized for emission calculations.

Table 2: NPRI and B.C. ENV Permit Identification Number (ID) for Industries Identified in the Study Area

Company Name	NPRI ID	B.C. ENV Permit ID
Nechako Lumber Company Ltd.	20016	3133
Premium Pellet Ltd.	29071	16502
Vanderhoof Specialty Wood Products (VSWP)	-	10606
Canadian Forest Products Ltd, Plateau Division	7710	2684
Fraser Lake Lumber (Div of West Fraser Mills Ltd.), Fraser Lake Sawmills	5161	5625
Thompson Creek Mining Ltd., Endako Mine	2794	2399
Pacific Northern Gas Ltd.	-	6690

2.1.2 Methods

The methods used for estimating emissions from point sources in the study area are as follows:

Firstly, total emissions for each facility were extracted from the 2018 NPRI, which was a reliable representation of normal industrial operations. According to the 2018 NPRI guideline, facilities were required to report air pollutant emissions that met specific thresholds. In cases where specific air pollutant emissions were not reported in the NPRI dataset, emissions from the AMS (i.e., Pacific Northern Gas Ltd.) and emissions calculated based on the 2006 Vanderhoof Emissions Inventory[6] (i.e., VSWP) were used for estimation.

[5] NPRI Guideline 2018. Guide to Report to the National Pollutant Release Inventory: 2018 and 2019.
[6] B.C. ENV 2008. Vanderhoof Emissions Inventory For 2006. August 2008.

Secondly, the total facility emissions from the NPRI dataset were scaled to each point source based on its emissions of NOx and TPM, as specified in the AMS database. Since TPM is the only PM emission listed in AMS permits, the ratio of TPM from each source to total facility emissions was used to scale NPRI's listed PM_{10} and $PM_{2.5}$ facility emissions in order to obtain the individual point source's emissions of PM_{10} and $PM_{2.5}$.

A detailed breakdown of point source emissions is presented in Table 3.

Table 3: Point Source Emissions

Facility	Source	Point Sources Annual Average Emissions 2018 (tonnes/year)			
		NOx	**TPM**	**PM_{10}**	**$PM_{2.5}$**
Nechako Lumber Company Ltd.	Nechako Lumber Wood Residue Energy Recovery System	53.17	27.97	7.21	4.42
	Debarker Cyclone	0.00	1.36	0.35	0.22
	Nechako Lumber Two Cyclones	0.00	4.01	1.03	0.63
	Nechako Four Lumber Kilns	0.00	21.1	5.45	3.33
	Planer Baghouse	0.00	2.14	0.55	0.34
	#1 Bin Vent Baghouse	0.00	0.20	0.05	0.03
	#2 Bin Vent Baghouse	0.00	0.20	0.05	0.03
	Total	**53.17**	**57.00**	**14.70**	**9.00**
Premium Pellet Ltd.	One Wood Fiber Dryer	31.8	32.8	10.93	7.09
	Two Pellet Coolers - With Cyclone	0.00	6.99	2.33	1.51
	Dry Shavings Bin Storage System (Baghouse #1)	0.00	0.36	0.12	0.08
	Hammermill Dust Recovery System (Baghouse #2)	0.00	0.87	0.29	0.19
	Sawdust Storage Bin Vents	0.00	2.47	0.82	0.53
	Total	**31.80**	**43.50**	**14.50**	**9.40**
Vanderhoof Specialty Wood Products (VSWP)	Boiler (not operating)	0.00	0.00	0.00	0.00
	Cooling Tower Cyclone	0.00	0.37	0.15	0.15
	Dunage Cyclone	0.00	0.06	0.02	0.02
	Finger Joint Cyclone	0.00	0.23	0.09	0.09
	Pellet Plant Cyclone	0.00	1.07	0.42	0.42
	Storage Bin Cyclone	0.00	1.07	0.42	0.42
	Total	**0.00**	**2.80**	**1.10**	**1.10**
Canadian Forest Products Ltd, Plateau Division	B Mill #1 Dust Collection Cyclone	0.00	6.47	3.75	2.68
	B Mill #2 Dust Collection Cyclone	0.00	6.26	3.63	2.59
	Chip Bin Cyclone	0.00	0.75	0.43	0.31
	Sawmill Bandmill Grinder Cyclone	0.00	0.27	0.15	0.11
	Sawmill Debarker Cyclone	0.00	4.29	2.49	1.78
	2 Deltech Wood Residue Fired Energy Systems	24.68	4.47	2.59	1.85

Facility	Source	Point Sources Annual Average Emissions 2018 (tonnes/year)			
		NOx	**TPM**	**PM_{10}**	**$PM_{2.5}$**
	Natural Gas Fired Hot Oil Booster	45.71	0.21	0.12	0.09
	A Mill Dust Collection Cyclone	0.00	3.61	2.09	1.50
	Two Sawmill Sawdust Bin Cyclones	0.00	1.25	0.73	0.52
	Sawmill Filing Room Cyclone	0.00	0.72	0.42	0.30
	Two Planermill Shavings Cyclones	0.00	1.23	0.71	0.51
	Hammer Mill Storage Bin Cyclone	0.00	0.55	0.32	0.23
	Two Planermill Pneumatic Dust Collection Systems	0.00	2.22	1.29	0.92
	Eleven Lumber Dry Kilns	0.00	14.02	8.12	5.81
	Total	**70.39**	**46.33**	**26.84**	**19.19**
Fraser Lake Lumber (Div of West Fraser Mills Ltd.), Fraser Lake Sawmills	Filing Room Cyclone	0.00	1.60	0.88	0.39
	Hogger Cyclone	0.00	1.70	0.94	0.41
	Konus Kessel Unit Four	20.68	8.11	4.46	1.96
	Konus Kessel Unit One	20.68	8.11	4.46	1.96
	Konus Kessel Unit Three	20.68	8.11	4.46	1.96
	Konus Kessel Unit Two	20.68	8.11	4.46	1.96
	Konus Shavings Silo Cyclone	0.00	1.60	0.88	0.39
	Planer Chip High Pressure Cyclone	0.00	1.08	0.60	0.26
	Planer Screen Rm Cyclone	0.00	6.09	3.35	1.47
	Planer Shavings Cyclone #1	0.00	10.48	5.76	2.53
	Planer Shavings Cyclone #2	0.00	10.48	5.76	2.53
	Sawdust Truck Bin Cyclone	0.00	1.70	0.94	0.41
	Sawmill Dust Cyclone #1	0.00	4.65	2.56	1.12
	Sawmill Dust Cyclone #2	0.00	8.52	4.68	2.06
	Sawmill Dust Cyclone #3	0.00	17.04	9.37	4.12
	West Fraser Lejac Biomass Power Boiler	179	15.27	8.39	3.69
	Five Thermal Oil Heated Lumber Dry Kilns	0.00	24.87	13.68	6.01
	Total	**262**	**138**	**75.62**	**33.26**
Pacific Northern Gas Ltd.	Gas compressor exhaust stack	201	9.39	9.39	9.39
	Total	**201**	**9.39**	**9.39**	**9.39**
Total in Study Area		**618**	**297**	**142**	**81.34**

2.2 Mobile Sources

Mobile sources in the study area were categorized into the following five groups:

- On-road vehicles,
- Tire wear and brake lining,
- Off-road vehicles and equipment,
- Rail transportation, and
- Air Transportation.

Sections 2.2.1 to 2.2.5 provide detailed information on the methods used to estimate emissions from each of these five mobile sources.

2.2.1 On-Road Vehicles

On-road vehicle emissions were estimated by multiplying the vehicle kilometres traveled (VKT) with the emission factors specific to each air pollutant of concern. Typically, these emission factors were obtained from the United States (U.S.) Environmental Protection Agency's (EPA) Motor Vehicle Emission Simulator (MOVES) model.

Total VKTs in B.C. and VKTs in each region were extracted from the 2010 Community Energy and Emissions Inventory (CEEI) Report[7] . To match these VKTs with the emissions factors of different types of vehicles, certain assumptions were made. For instance:

- Hybrid vehicles were classified under the gasoline fuel category, and
- Other fuel vehicles were placed in the diesel fuel category, to be conservative.

The emission factors for TPM, PM_{10}, and $PM_{2.5}$ were taken from the Particulate Matter Emissions Inventory for the Alberni Airshed[8], while the NOx emission factors for on-road vehicles were based on 2005 Lower Fraser Valley Emission Inventory Report[9], assuming the vehicle age distributions, vehicle type populations, speed distributions, etc. are similar in B.C., and the emission factors mentioned above are applicable for the study area. Table 4 provides a detailed list of the emission factors used for calculation.

Table 4: Emission Factors for On-road Vehicles

Fuel Type	Vehicle Type	Emission factors for On-road Vehicles (g/VKT)			
		NO_X	TPM	PM_{10}	$PM_{2.5}$
Gasoline	Bus	2.98	0.12	0.12	0.03
	Commercial Vehicles	1.20	0.03	0.03	0.01

[7] CEEI 2010. Community Energy and Emissions Inventory. www2.gov.bc.ca/gov/content/environment/climate-change/data/ceei accessed in December 2021.

[8] B.C. ENV and Alberni Air Quality Society (AAQS) 2019. Particulate Matter Emissions Inventory for the Alberni Airshed (2017 Base Year). March 2019.

[9] Metro Vancouver, 2010. 2005 Lower Fraser Valley Air Emissions, Inventory & Forecast and Backcast, Detailed Listing of Results and Methodology. January 2010.

Fuel Type	Vehicle Type	Emission factors for On-road Vehicles (g/VKT)			
		NO_X	TPM	PM_{10}	$PM_{2.5}$
	Large Passenger Cars	0.66	0.03	0.03	0.01
	Light Trucks, Vans, SUVs	1.20	0.03	0.03	0.01
	Motorcycles, Mopeds	0.91	0.02	0.02	0.01
	Motorhomes	2.98	0.11	0.11	0.04
	Small Passenger Cars	0.66	0.03	0.03	0.01
	Tractor Trailer Trucks	2.98	0.09	0.09	0.03
Diesel	Bus	6.79	0.24	0.24	0.15
	Commercial Vehicles	0.92	0.06	0.06	0.03
	Large Passenger Cars	0.49	0.06	0.06	0.03
	Light Trucks, Vans, SUVs	0.92	0.06	0.06	0.03
	Motorhomes	6.79	0.24	0.24	0.18
	Small Passenger Cars	0.49	0.03	0.03	0.01
	Tractor Trailer Trucks	6.79	0.14	0.14	0.06

Emissions for on-road gasoline vehicles and on-road diesel vehicles were calculated separately for each region due to different gasoline and diesel emissions factors. The results are shown in Tables 5 and 6.

Table 5: Annual Emissions from On-road Gasoline Vehicles

Area	Vehicle Types	Emissions from On-Road Gasoline Vehicles (tonnes/year)			
		NO_X	TPM	PM_{10}	$PM_{2.5}$
Vanderhoof DM	Bus	0.20	0.01	0.01	2.0E-03
	Commercial Vehicles	6.10	0.15	0.15	0.04
	Large Passenger Cars	4.08	0.19	0.19	0.06
	Light Trucks, Vans, SUVs	26.80	0.65	0.65	0.16
	Motorcycles, Mopeds	0.23	0.01	0.01	3.0E-03
	Motorhomes	1.05	0.04	0.04	0.02
	Small Passenger Cars	5.68	0.24	0.24	0.07
	Tractor Trailer Trucks	0.23	0.01	0.01	2.4E-03
	Subtotal	**44.36**	**1.28**	**1.28**	**0.34**
Fraser Lake	Bus	0.00	0.00	0.00	0.00
	Commercial Vehicles	1.71	0.04	0.04	0.01
	Large Passenger Cars	1.42	0.06	0.06	0.02
	Light Trucks, Vans, SUVs	9.76	0.24	0.24	0.06
	Motorcycles, Mopeds	0.03	7.4E-04	7.4E-04	4.0E-04
	Motorhomes	0.31	0.01	0.01	4.6E-03
	Small Passenger Cars	2.00	0.09	0.09	0.02
	Tractor Trailer Trucks	0.00	0.00	0.00	0.00
	Subtotal	**15.23**	**0.44**	**0.44**	**0.12**
Area D	Bus	0.08	3.3E-03	3.3E-03	8.1E-04
	Commercial Vehicles	1.83	0.04	0.04	0.01

Area	Vehicle Types	Emissions from On-Road Gasoline Vehicles (tonnes/year)			
		NO_X	TPM	PM_{10}	$PM_{2.5}$
	Large Passenger Cars	1.45	0.07	0.07	0.02
	Light Trucks, Vans, SUVs	10.71	0.26	0.26	0.06
	Motorcycles, Mopeds	0.08	2.0E-03	2.0E-03	1.1E-03
	Motorhomes	0.41	0.01	0.01	0.01
	Small Passenger Cars	2.21	0.09	0.09	0.03
	Tractor Trailer Trucks	0.00	0.00	0.00	0.00
	Subtotal	**16.76**	**0.48**	**0.48**	**0.13**
Area F	Bus	0.20	0.01	0.01	2.0E-03
	Commercial Vehicles	4.55	0.11	0.11	0.03
	Large Passenger Cars	3.61	0.17	0.17	0.05
	Light Trucks, Vans, SUVs	26.65	0.65	0.65	0.16
	Motorcycles, Mopeds	0.20	4.9E-03	4.9E-03	2.7E-03
	Motorhomes	1.02	0.04	0.04	0.02
	Small Passenger Cars	5.50	0.23	0.23	0.07
	Tractor Trailer Trucks	0.00	0.00	0.00	0.00
	Subtotal	**41.74**	**1.21**	**1.21**	**0.32**
Total in Study Area		**118**	**3.42**	**3.42**	**0.90**

Table 6: Annual Emissions from On-road Diesel Vehicles

Area	Vehicle Types	Emissions from On-Road Diesel Vehicles (tonnes/year)			
		NO_X	TPM	PM_{10}	$PM_{2.5}$
Vanderhoof DM	Bus	2.75	0.10	0.10	0.06
	Commercial Vehicles	9.92	0.59	0.59	0.34
	Large Passenger Cars	0.03	3.5E-03	3.5E-03	2.1E-03
	Light Trucks, Vans, SUVs	0.74	0.04	0.04	0.03
	Motorhomes	2.12	0.08	0.08	0.06
	Small Passenger Cars	0.34	0.02	0.02	4.2E-03
	Tractor Trailer Trucks	48.87	1.04	1.04	0.45
	Subtotal	**64.76**	**1.86**	**1.86**	**0.94**
Fraser Lake	Bus	0.00	0.00	0.00	0.00
	Commercial Vehicles	2.29	0.14	0.14	0.08
	Large Passenger Cars	0.00	0.00	0.00	0.00
	Light Trucks, Vans, SUVs	0.33	0.02	0.02	0.01
	Motorhomes	0.60	0.02	0.02	0.02
	Small Passenger Cars	0.18	0.01	0.01	2.2E-03
	Tractor Trailer Trucks	6.66	0.14	0.14	0.06
	Subtotal	**10.05**	**0.33**	**0.33**	**0.17**
Area D	Bus	0.27	0.01	0.01	0.01
	Commercial Vehicles	3.56	0.21	0.21	0.12

Area	Vehicle Types	Emissions from On-Road Diesel Vehicles (tonnes/year)			
		NO_X	TPM	PM_{10}	$PM_{2.5}$
	Large Passenger Cars	0.01	7.1E-04	7.1E-04	4.3E-04
	Light Trucks, Vans, SUVs	0.37	0.02	0.02	0.01
	Motorhomes	0.73	0.03	0.03	0.02
	Small Passenger Cars	0.13	0.01	0.01	1.6E-03
	Tractor Trailer Trucks	12.49	0.27	0.27	0.12
	Subtotal	**17.56**	**0.54**	**0.54**	**0.28**
Area F	Bus	0.67	0.02	0.02	0.01
	Commercial Vehicles	8.86	0.53	0.53	0.31
	Large Passenger Cars	0.02	1.8E-03	1.8E-03	1.1E-03
	Light Trucks, Vans, SUVs	0.92	0.06	0.06	0.03
	Motorhomes	1.82	0.06	0.06	0.05
	Small Passenger Cars	0.32	0.02	0.02	0.004
	Tractor Trailer Trucks	31.1	0.66	0.66	0.29
	Subtotal	**43.71**	**1.35**	**1.35**	**0.69**
Total in Study Area		**136**	**4.08**	**4.08**	**2.08**

2.2.2 Tire Wear and Brake Lining

PM emissions from tire wear and brake lining of on-road vehicles refer to the airborne portion of the "wear" generated by abrasion, corrosion, and turbulence, which can result in suspended particles in the atmosphere[10].

Emissions from tire wear and brake lining of on-road vehicles were scaled from the 2022 air pollutants emission inventory[11] (APEI) by Environment and Climate Change Canada (ECCC) based on the percentage of VKT associated with each region. For example, the TPM annual emissions from Vanderhoof DM, were estimated as TPM emissions from total B.C. multiplied by the VKT percentage (0.07%).

The total VKTs in B.C. and VKTs in each region were extracted from the 2010 CEEI report[7].

It was assumed that tire wear and brake lining emissions from on-road vehicles correlated linearly with VKTs in B.C. The annual emissions for the study area are presented in Table 7.

Table 7: Annual Emissions from Tire Wear and Brake Lining of On-road Vehicles

Area	VKT Percentage	Emissions from Tire Wear and Brake Lining (tonnes/year)			
		NOx	TPM	PM_{10}	$PM_{2.5}$
British Columbia	100%	-	**1411**	**1411**	**184**
Vanderhoof DM	0.07%	-	0.95	0.95	0.12
Fraser Lake	0.02%	-	0.29	0.29	0.04

[10] U.S. EPA 2014. Brake and Tire Wear Emissions from On-road Vehicles in MOVES2014 (EPA-420-R-14-013). December 2014.
[11] ECCC 2022. Canada's Air Pollutant Emissions Inventory Report 1990-2020, 2022.

Area	VKT Percentage	Emissions from Tire Wear and Brake Lining (tonnes/year)			
		NOx	TPM	PM_{10}	$PM_{2.5}$
Area D	0.02%	-	0.34	0.34	0.05
Area F	0.06%	-	0.85	0.85	0.11
Total in Study Area		-	**2.44**	**2.44**	**0.32**

2.2.3 Off-road Vehicles and Equipment

Off-road vehicles and equipment were classified into two main categories:

- Agriculture, and
- Construction operations.

This report estimated emissions from these two major contributors while emissions from small sources such as lawnmowers were neglected.

2.2.3.1 Off-road Vehicles and Equipment from Agriculture

Regarding off-road vehicles and equipment from agriculture, the 2014 B.C. emissions from farm equipment, as reported in the B.C. Agricultural Air Emissions Inventory Report [12] were scaled to 2018 for B.C., based on the market value increase rate of total farm capital[13]. Additionally, the percentages of different types of farm equipment from each study region over the entire province were obtained from the same reference.

There were no reported off-road vehicles and equipment from agriculture in Vanderhoof DM and Fraser Lake. Assuming that emissions from agricultural off-road vehicles and equipment depend on the percentage of types of farm equipment, B.C. emissions were distributed to the study area and summarized in Table 8.

Table 8: Annual Emissions from Off-road Vehicles and Equipment used for Agriculture

Area	Percentage of Farm Equipment	Emissions from Farm Equipment (tonnes/year)			
		NOx	TPM	PM_{10}	$PM_{2.5}$
British Columbia	100%	8365	1051	1051	1020
Area D	0.54%	45.34	5.70	5.70	5.53
Area F	2.29%	191	24.06	24.06	23.34
Total in Study Area	**2.83%**	**237**	**29.75**	**29.75**	**28.86**

2.2.3.2 Off-road Vehicles and Equipment from Construction

The estimation of emissions from off-road vehicles and equipment used for construction followed four steps:

[12] B.C. Ministry of Agriculture. B.C. Agricultural Air Emissions Inventory, June 2014.

[13] Statistics Canada. Table 32-10-0437-01 Farm capital, Census of Agriculture, 2011 and 2016, inactive.

Firstly, the provincial 2018 emissions from off-road diesel vehicles and equipment were added to the emissions from off-road gasoline/ liquefied petroleum gas (LPG)/natural gas (NG) vehicles and equipment (both from APEI 2022) to obtain the total B.C. 2018 emissions of off-road vehicles and equipment.

Secondly, the B.C. farm equipment emissions (Section 2.2.3.1) were subtracted from the total B.C. 2018 off-road emissions to obtain off-road vehicles and equipment from construction.

Thirdly, the dollar values of building permits in B.C. and each study region were obtained from British Columbia Building Permits by Type[14]. To calculate the percentage of dollar values of building permits in each study region, the following equation was applied:

Percentage in each study region = Dollar values of building permits in the region/ Dollar values of building permits in B.C.

Lastly, assuming that the emissions from construction off-road vehicles and equipment have a linear relationship with the percentage of dollar values of building permits, the total B.C. off-road construction emissions were scaled to the study area and summarized in Table 9.

Table 9: Annual Emissions from Off-road Vehicles and Equipment Used for Construction

Area	Emissions from Construction Equipment (tonnes/year)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
Vanderhoof DM	2.03	0.17	0.17	0.16
Fraser Lake	0.01	7.8E-04	7.6E-04	7.3E-04
Area D	0.82	0.07	0.07	0.06
Area F	1.83	0.15	0.15	0.14
Total in Study Area	**4.69**	**0.39**	**0.38**	**0.37**

2.2.4 Rail Transportation

Fuel consumed by locomotive engines generates emissions from rail transportation. To calculate these emissions locomotive emission factors were multiplied by horsepower rating and load factors, as documented in the U.S. EPA PM Hot-spot Guidance[15].

For the study regions, line haul locomotives GE AC 4400 (4400 hp) from Canadian National Railway (CN) and EMD SD40 (3000 hp) from Via Rail were used based on the 2006 Vanderhoof Emissions Inventory Report[6].

Canadian Locomotive Emissions Regulation[16] employs the exhaust emission standard defined in section 1033.101, Tables 1 and 2 of the U.S. Code of Federal Regulations (CFR)[17]. The NOx and

---

[14] B.C. Stats. British Columbia Building Permits. September 2021.

[15] U.S. EPA PM Hot-spot Guidance EPA-420-B-21-037. Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas. Appendix I: Estimating Locomotive Emissions. October 2021.

[16] Canadian Locomotive Emissions Regulations. Registration SOR/2017-121. June 9, 2017.

[17] U.S. Code of Federal Regulations (CFR). PART 1033 - Control of Emissions From Locomotives. 73 FR 37197, June 30, 2008.

PM emission factors (shown in Table 10) were adopted from this standard and applied in this inventory.

In the CFR, PM is defined as respirable PM with a diameter of less than or equal to 10 microns[17]. This is consistent with the definition of PM_{10} used in this inventory.

$PM_{2.5}$ and TPM emissions were subsequently estimated based on the ratios of TPM/PM_{10} and $PM_{2.5}$/PM_{10} obtained from 2005 Lower Fraser Valley Air Emissions[9].

Table 10: Emissions Factors for Line-Haul Locomotives

Tier of standards	Emission Factors (g/bhp-hr)	
	NOx	**PM_{10}**
Tier 0	8.00	0.22
Tier 1	7.40	0.22

Some assumptions were adopted from the 2006 Vanderhoof Emissions Inventory report[6]:

For the GE AC 4400 locomotive, which belongs to the Tier 1 fleet, ten trains per day passed through the study area (five loaded, five unloaded), with two active locomotive engines per loaded train and one active locomotive engine per unloaded train. An additional estimate of half an hour of idling time for three locomotives each day was assumed for yard activity based on the Canadian Locomotive Emissions Regulation[16].

For the EMD SD40 locomotive, which belongs to the Tier 0 fleet, six trains per week passed through the study area, with an idling time of 540 seconds at Vanderhoof station, Fort Fraser station (in Area D), and Endako station (in Area D) for passenger rail at the terminals.

The train speed for both locomotives was assumed to be 50 km/h adopted from the 2006 Vanderhoof Emissions Inventory report[6], except for GE AC 4400 in areas D and F based on the speed limitation for freight trains in Canada, which is 80 km/h.

The emissions from rail transportation are summarized in Table 11.

Table 11: Annual Emissions from Rail Transportation

Area	Model	Status	Power Rating (HP)	Emissions from Rail Transportation (tonnes/year)			
				NOx	**TPM**	**PM_{10}**	**$PM_{2.5}$**
Vanderhoof DM	GE AC 4400	Idling	4400	0.18	0.01	0.01	0.01
		Moving	4400	10.46	0.32	0.31	0.31
	EMD SD40	Idling	3000	4.5E-03	1.3E-04	1.2E-04	1.2E-04
		Moving	3000	0.44	0.01	0.01	0.01
	Subtotal			**11.09**	**0.34**	**0.33**	**0.33**
Fraser Lake	GE AC 4400	Idling	4400	0.00	0.00	0.00	0.00

Area	Model	Status	Power Rating (HP)	Emissions from Rail Transportation (tonnes/year)			
				NOx	TPM	PM_{10}	$PM_{2.5}$
		Moving	4400	5.62	0.17	0.17	0.17
	EMD SD40	Idling	3000	0.00	0.00	0.00	0.00
		Moving	3000	0.24	0.01	0.01	0.01
	Subtotal			**5.86**	**0.18**	**0.17**	**0.17**
Area D	GE AC 4400	Idling	4400	0.21	0.01	0.01	0.01
		Moving	4400	46.75	1.42	1.39	1.37
	EMD SD40	Idling	3000	0.01	2.5E-04	2.5E-04	2.4E-04
		Moving	3000	3.14	0.09	0.09	0.09
	Subtotal			**50.12**	**1.52**	**1.48**	**1.47**
Area F	GE AC 4400	Idling	4400	0.00	0.00	0.00	0.00
		Moving	4400	56.02	1.70	1.67	1.65
	EMD SD40	Idling	3000	0.00	0.00	0.00	0.00
		Moving	3000	3.77	0.11	0.10	0.10
	Subtotal			**59.79**	**1.81**	**1.77**	**1.75**
Total in Study Area				**127**	**3.84**	**3.75**	**3.71**

2.2.5 Air Transportation

Air transportation emissions were assumed to result from aircraft landing and takeoffs (LTO). The 2022 ECCC APEI[11] air transportation emissions for 2018 were scaled to the Vanderhoof airport.

To calculate the scaling factors, aircraft movements by class of operation were obtained from Statistic Canada for airports with NAV CANADA (Canada's air navigation service provider) flight service stations[18].

Since no aircraft movement data is available for the Vanderhoof airport, data from the Quesnel airport were assumed to be similar and used to determine a scaling factor of 0.019 for aircraft movements from the Vanderhoof airport over total B.C.

Assuming that emissions from air transportation only relate to aircraft movements, they were calculated and summarized in Table 12.

Table 12: Annual Emissions from Air Transportation in the Study Area

Area	Emissions from Air Transportation (tonnes/year)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
Vanderhoof DM	30.81	1.19	1.19	1.16

[18] Statistics Canada. Table 23-10-0025-01 Aircraft movements, by class of operation, for airports with NAV CANADA flight service stations, annual.

2.3 Area Sources

This section outlines the methods for calculating emissions and underlying assumptions made to determine the annual average emission rates for area sources within the study area. Area sources refer to air pollutant sources that are spread over a defined area and are broadly categorized as agricultural, residential/commercial, or other naturally occurring and human-generated sources.

The report identifies the following area sources:

- Open burning,
- Space heating,
- Agriculture,
- Fugitive Dust, and
- Wildfires.

Miscellaneous area sources were not included in the emission inventory as the primary objective of the project was to identify the major contributors to NOx and PM emissions in Vanderhoof and its surrounding areas. Each area source type is discussed in detail in subsections 2.3.1 to 2.3.5.

2.3.1 Open Burning

Open burning, can be controlled or uncontrolled combustion activities that emit air pollutants of concern. Thousands of piles of vegetative debris are open burned every year as a result of:

- Tree harvesting activities from the logging sector,
- Resource management and land clearing for development and agricultural activities, and
- Cleanup (small piles) of yard waste and trimmings from residential lots.

This report categorizes open burning sources into two groups: provincially regulated open burning and backyard burning. Sections 2.3.1.1 and 2.3.1.2 provide detailed information on the estimation methodologies used to determine emissions for each category.

2.3.1.1 Provincially regulated Open Burning

Open fires under the B.C. Wildfire Act and Wildfire Regulation are categorized into outdoor stoves, campfires, category 2 open fires (smaller piled debris), category 3 open fires (larger piled debris), and Category 4 resource management open fires. Emissions from the latter two categories are discussed in detail in this section.

B.C. ENV Open Burning CAC Emissions Inventory for 2018 Report[19] was adopted to estimate the provincially regulated open burning emissions in the study area. Note that the B.C. open burning emission inventory was developed for CAC from open burning of vegetative debris in B.C. for 2018 by using the Open Fire Tracking System (OFTS) data from the Ministry of Forests (FOR).

[19] B.C. ENV 2020. Open Burning CAC Emission Inventory for 2018. June 2020.

Operators conducting Category 4 resource management open fires and Category 3 burning are required to obtain a Burning Registration Number (BRN).

Although OFTS is the only database available for compiling information on open burning for inventory purposes in B.C., it has some limitations that should be considered:

- The OFTS only records Category 3 and Category 4 resource management open fire data. Campfires and Category 2 open fires are not included in the system,
- Duplicate records may exist, i.e., an operator may apply for new BRNs for unburned piles under a prior BRN. (BRNs may be re-issued if the operator did not complete some or all of their burns.),
- OFTS is restricted to forest Crown Land and some private forest land. Some municipalities and higher-populated regional district areas are not covered under the OFTS database,
- Actual open burning might not necessarily happen even if debris piles are registered with OFTS, and
- No other information is recorded, such as the size and shape of piles, types of wood/debris, and other best practices used in piling and smoke management.

To determine provincially regulated open burning emissions in the study area, OFTS BRNs issued in 2018 were identified using GIS software (QGIS) based on recorded latitudes and longitudes. QGIS is a free and open-source cross-platform desktop geographic information system.

Net mass burned was calculated based on the number of registered piles in the study area assuming certain pile sizes, shapes, and types of wood/debris as detailed in the 2018 provincial open burning emissions inventory. Emissions factors from the 2018 open burning emission inventory (shown in Table 13) were utilized and the results are presented in Table 14, depicting the annual emissions.

Table 13: Emission Factors for Pile Open Burning

Category	#piles	Class	Emission Factor (kg/tonne Net Mass Consumed)			
			NOx	TPM	PM_{10}	$PM_{2.5}$
Clean	>19.5	A	2.00	11.00	7.75	6.75
Dirty	>9.5<19.5	B	2.00	13.50	10.00	8.50
Very Dirty	<9.5	C	2.00	18.00	14.00	11.90

Table 14: Annual Emissions from Provincially Regulated Open Burning in the Study Area

Area	Annual Emission from Provincially Regulated Open Burning (tonnes/year)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
Area D	77.54	430	305	266
Area F	150	842	599	521
Total in Study Area	**228**	**1272**	**904**	**786**

2.3.1.2 Backyard burning

Backyard burning, as discussed in this report, refers to the burning of yard residues and vegetative debris on residential properties.

The 2018 Solid Waste Management Plan[20] prepared for the RDBN reported the disposal rate in RDBN was 600 kg per capita in 2016. The report showed a total of just over 23,100 tonnes of municipal solid waste was disposed of in the regions' landfills, of which 38% was organic waste, including food waste (assume 40%) and yard waste & compostable paper products like paper toweling and tissues (assume 60%)[8].

The 2016 population of regional electoral areas and municipalities were used for calculating 2018 yard waste burned (assuming all 60% of organic waste belonged to yard waste and was openly burned) in the study area.

The U.S. EPA AP 42 Chapter 2.5 Open Burning[21] emission factors for waste burning, listed in Table 15, were used to calculate emissions from backyard open burning. Table 16 displays the annual emissions resulting from backyard open burning for 2018.

Table 15: Emission Factors for Backyard Burning

Category	Emission factors (kg/tonne)			
	NOx	**TPM**	**PM_{10}**	**$PM_{2.5}$**
Waste burning	3.00	8.00	5.90	5.44
Note: NOx and TPM emission factor were based on U.S. EPA Ap42 2.5, and PM_{10}/TPM & $PM_{2.5}$/TPM ratios were based on APEI 2022.				

[20] 2018 RDBN. 2018 Regional District of Bulkley-Nechako solid waste management plan. October 2018.

[21] U.S. EPA AP42, Fifth Edition, Volume I, Chapter 2.5 Open Burning, www3.epa.gov/ttn/chief/ap42/ch02/final/c02s05.pdf, accessed in June 2023.

Table 16: Annual Emissions from Backyard Burning

Area	Backyard Burning Emissions (tonnes/year)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
Vanderhoof DM	1.82	4.86	3.58	3.30
Fraser Lake	0.41	1.08	0.80	0.74
Area D	0.60	1.61	1.19	1.10
Area F	1.50	4.01	2.96	2.73
Total in Study Area	**4.34**	**11.56**	**8.52**	**7.86**

2.3.2 Space Heating

The process of heating commercial, industrial, and residential spaces by means of fossil fuels such as fuel oil, natural gas, and propane, as well as wood, is known to release substantial amounts of air pollutants. In the study area, emissions from space heating were estimated based on the type of fuel combusted, including:

- Fuel oil,
- Natural gas,
- Propane, and
- Wood.

The estimation of combustion emissions from natural gas, residential oil, and residential propane for space heating used the corresponding emission factors from U.S. EPA Compilation of Air Pollutant Emissions Factors (AP-42), which are presented in Table 17.

Table 17: Emission Factors for Space Heating (Non-wood Fuel)

Emission factors for Space Heating (non-wood)					
Fuel Types	**Unit**	**NOx**	**TSP**	**PM_{10}**	**$PM_{2.5}$**
Natural Gas	lb/MMBTU	9.2E-02	7.5E-03	7.5E-03	7.5E-03
Residential Oil (Fuel Oil)	lb/MMBTU	0.13	1.2E-02	1.2E-02	1.2E-02
Residential Propane	lb/MMBTU	0.14	7.7E-03	7.7E-03	7.7E-03

2.3.2.1 Fuel oil

The study area's fuel oil consumption for residential space heating was obtained from the latest Community Energy and Emissions Inventory (CEEI 2012)[22].

Emission factors for residential furnaces were sourced from the U.S. EPA AP-42, Chapter 1.3 "Fuel Oil Combustion"[23] (condensable PM emission factor is sourced from No. 2 oil fired). To convert to lb/MMBtu of No. 2 oil (generally referred to as home heating oil), the emission factors were

[22] CEEI 2012. Community Energy and Emissions Inventory. www2.gov.bc.ca/gov/content/environment/climate-change/data/ceei. Accessed in December 2021.

[23] U.S. EPA 2010. AP-42 Chapter 1.3 Fuel Oil Combustion www.epa.gov/sites/default/files/2020-09/documents/1.3_fuel_oil_combustion.pdf. Accessed in December 2021.

divided by 140 MMBtu/10^3 gal. Table 17 provides the NOx and PM emission factors used for fuel oil.

Assumptions were made during the emission estimation process, including the exclusion of fuel oil usage for space heating in areas lacking data from CEEI 2012[22]. Additionally, the 2018 fuel oil consumption was estimated to have increased from 2012 based on the increase or decrease in total private dwellings in each region.

Table 18 presents a summary of the annual space heating emissions resulting from fuel oil combustion.

Table 18: Annual Emission from Space Heating Burning Fuel Oil

Area	Emissions from Space Heating (Fuel Oil)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
	(tonnes/year)			
Vanderhoof DM	0.45	0.04	0.04	0.04
Fraser Lake	-	-	-	-
Area D	0.50	0.05	0.05	0.05
Area F	1.11	0.11	0.11	0.11
Total in Study Area	**2.06**	**0.19**	**0.19**	**0.19**

2.3.2.2 Natural Gas

The NG consumption for space heating in residential, commercial, and small-to-medium industrial buildings within the study area was obtained from the latest Community Energy and Emissions Inventory (CEEI 2012)[22]. Emission factors for residential furnaces were sourced from the U.S. EPA AP-42, Chapter 1.4 "Natural Gas Combustion"[24]. To convert from lb/10^6 scf to lb/MMBtu of NG, the emission factors were divided by 1020 Btu/scf. Table 17 in Section 2.3.2 provides the NOx and PM emission factors used for estimating NG space heating emissions.

Several assumptions were made during the emission estimation process. For instance, it was assumed that residential NG consumption had a linear correlation with the percentage of private dwellings in Vanderhoof DM and Fraser Lake. In contrast, NG consumption from commercial and small-to-medium industrial space heating had a linear correlation with the percentage of population in Vanderhoof DM and Fraser Lake. The use of NG was very limited in Area D and Area F, so the emissions were neglected.

Table 19 provides a summary of the annual space heating emissions resulting from NG combustion.

---

[24] U.S. EPA 1998. AP-42 Chapter 1.4 Natural Gas Combustion. www.epa.gov/sites/default/files/2020-09/documents/1.4_natural_gas_combustion.pdf. Accessed in December 2021.

Table 19: Annual Emission from Space Heating Burning NG

Area	Emissions from Space Heating (NG)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
	(tonnes/year)			
Vanderhoof DM	8.48	0.69	0.69	0.69
Fraser Lake	1.85	0.15	0.15	0.15
Total in Study Area	**10.32**	**0.83**	**0.83**	**0.83**

2.3.2.3 Propane

The residential space heating propane consumption data was sourced from the latest Community Energy and Emissions Inventory (CEEI 2012)[22].

The emission factors for residential furnaces were obtained from the U.S. EPA AP-42, Chapter 1.5 "Liquefied Petroleum Gas Combustion"[25]. To convert to lb/MMBtu of propane, the emission factors were divided by the heat content of 91.5 MMBtu/10^3 gal. The NOx and PM emission factors for estimating propane space heating emissions are presented in Table 17 in Section 2.3.2.

Propane consumption was assumed to correlate with the percentage of private dwellings in each region. Based on this assumption, the emissions resulting from space heating burning propane were estimated and are presented in Table 20.

Table 20: Annual Emission from Space Heating Burning Propane

Area	Emissions from Space Heating (Propane)			
	NOX	TPM	PM_{10}	$PM_{2.5}$
	(tonnes/year)			
Vanderhoof DM	1.35	0.07	0.07	0.07
Fraser Lake	0.51	0.03	0.03	0.03
Area D	1.49	0.08	0.08	0.08
Area F	3.32	0.18	0.18	0.18
Total in Study Area	**6.68**	**0.36**	**0.36**	**0.36**

2.3.2.4 Wood

In 2017, the District of Vanderhoof and B.C. ENV jointly funded a door-to-door residential wood-burning appliances survey[26]. The purpose of the survey was to provide insight into future air quality improvement initiatives. The results of the survey were used to estimate the annual consumption of wood and pellets as residential heating fuels for Vanderhoof DM and Fraser Lake:

- Over one-third of residents (37%) reported using a wood-burning appliance,

[25] U.S. EPA 2008. AP-42 Chapter 1.5 Liquefied Petroleum Gas Combustion. www.epa.gov/sites/default/files/2020-09/documents/1.5_liquefied_petroleum_gas_combustion.pdf. Accessed in December 2021.

[26] District of Vanderhoof and B.C. ENV, 2017. Residential Wood-Burning Appliances: District of Vanderhoof Door to Door Survey Results

- 71% of wood-burning appliances in the community were emission-certified,
- Among the wood-burning appliances, 30% were wood stoves, 15% were wood fireplaces, 2% were wood furnaces, 44% were pellet stoves, 2% were pellet furnaces, 2% were wood fireplace inserts, and 3% were outdoor wood boilers, and
- Additionally, the report summarized the percentage of pellet and wood cords combusted per year for different usage categories.

In 2012, B.C. commissioned Mustel Group to conduct a province-wide survey of B.C. residents regarding the use of residential wood-burning appliances[27]. The outcomes for the northern region served as a basis to calculate annual wood and pellet consumption for residential heating in Areas D and F:

- In rural areas, 63% of residents reported using a wood-burning appliance,
- 37% of wood stoves and 67% of wood fireplaces or inserts[28] in northern region were emission certified, and
- Among the wood-burning appliances, the breakdown was as follows: 53% were wood stoves, 29% were wood fireplaces/inserts, 12% were central heating wood burners, and 14% were pellet stoves/furnaces. These figures, normalized to 100%, were applied to Area D and Area F.

The total number of households (i.e., total private dwellings) within the study area was sourced from Statistics Canada's 2016 data. The emission factors for each appliance type were adopted from: the Residential Wood-Burning Emissions in British Columbia[29] and the 2005 Lower Fraser Valley Air Emissions report[9]. These factors are presented in Table 21.

Table 21: Emission Factors for Wood Burning

Emission Factors for Wood Burning				
	Emission Factors (kg/tonne material consumed)			
Appliance Type	**NOx**	**TPM**	**PM_{10}**	**$PM_{2.5}$**
Fireplace — Advanced[1]	1.40	5.10	4.80	4.80
Fireplace — Conventional without glass doors[1]	1.40	19.30	18.50	18.40
Fireplace — Conventional glass doors	1.40	13.50	13.00	12.90
Central Furnace/Boiler (inside & outside)[1]	1.40	14.10	13.30	13.30
Fireplace Insert — Advanced Technology & Catalytic[1]	1.40	5.10	4.80	4.80
Fireplace Insert — Conventional[1]	1.40	14.40	13.60	13.60
Wood Stove — Advanced Technology & Catalytic[1]	1.40	5.10	4.80	4.80
Wood Stove — Conventional[1]	1.40	24.60	23.20	23.20
Pellet appliances[2]	1.40	1.20	1.10	1.10

[27] B.C. ENV, 2012. Inventory of Wood-burning Appliance Use in British Columbia, Report of Findings. March 2012.
[28] B.C. ENV, 2012. Wood Stove Inventory and Behaviour Analysis. December 2012.
[29] B.C. ENV, 2005. Residential Wood-Burning Emissions in British Columbia, April 1, 2004. Revised many 17, 2005.

Emission Factors for Wood Burning				
	Emission Factors (kg/tonne material consumed)			
Appliance Type	**NOx**	**TPM**	**PM_{10}**	**$PM_{2.5}$**
Notes: (1) Emission factors from Residential Wood-Burning Emissions in British Columbia were used for fireplaces, central furnaces, and wood stoves. (2) Emission factors from 2005 Lower Fraser Valley Air Emissions were used for pellet appliances.				

The emissions resulting from residential wood burning for space heating were calculated by multiplying the annual consumption of wood cords and pellets within the study area by the emission factors associated with different wood appliance types, as presented in Table 21.

Several assumptions were made during the emission estimation process:

- The District of Vanderhoof door-to-door 2017 survey results were applicable to Vanderhoof DM and Fraser Lake in terms of appliance type distributions,
- 2012 B.C. survey results were applicable to Area D and Area F in terms of appliance type distributions,
- Emission factors for advanced technology appliances applied to certified devices and emission factors for conventional appliances applied to uncertified wood appliances,
- 50 bags of pellets were equivalent to 1 tonne of pellets[26],
- As a conservative estimate, three tonnes of pellets were used for "others" or blank survey responses,
- In the 2017 Vanderhoof survey, an unconventional unit of measure, 'armfuls' was utilized, wherein 25 armfuls of wood were equivalent to a maximum of 0.5 cords [26],
- A conservative estimate of four cords was used for "do not know," "others," or blank survey responses, and
- The average amount within each category range of “pellet” or “wood cord” was used for estimation.

Based on the percentage of pellet and wood cords combusted (as primary heating source) per year, as identified from different usage categories, the annual average consumption of pellet per household was estimated at 2.13 tonnes, and the annual average consumption of wood cords per household was estimated at 4.21 tonnes in the study area.

Table 22 provides a summary of the emissions resulting from wood burning for space heating. For instance, emissions of TPM from residential wood burning were calculated using the following equation:

TPM annual emission rate = Number of households * Percent of households using a specific type of wood burning appliance * Annual average wood (or pellet) burnt per household (tonne/household) * TPM emission factor

Table 22: Annual Emissions from Residential Wood Burning

Area	Emissions from Space Heating (Wood Burning)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
	(tonnes/year)			
Vanderhoof DM	3.09	16.49	15.55	15.54
Fraser Lake	1.58	8.45	7.97	7.96
Area D	2.97	28.34	26.76	26.75
Area F	6.61	63.12	59.61	59.57
Total in Study Area	**14.25**	**116**	**110**	**110**

2.3.3 Agriculture

Air emissions from agriculture sources were estimated according to the following categories:

- Movements from farm animals,
- Fertilizer application,
- Pesticides application,
- Tilling Soil,
- Harvesting Crops, and
- Wind Erosion.

Sections 2.3.3.1 to 2.3.3.6 provide detailed information on how to calculate TPM, PM_{10}, $PM_{2.5}$ emissions from each category. Negligible emissions were associated with agriculture in Vanderhoof DM, and Fraser Lake, and therefore can be disregarded.

2.3.3.1 Movements of Farm Animals

Farm animals generate particulate matter through their movement, including the entrainment of feeds, dry manure, soil, and other materials. To determine the number of cattle, pigs, poultry, and horses on farms, data were extracted from the 2016 Census of Agriculture. If no data were available for 2016, 2011 census data were used[30].

The emission factors for cattle, pigs, and horses were obtained from the 2005 Lower Fraser Valley Air Emissions report[9] and are shown in Table 23. The PM emission factors for poultry were drawn from the PM Emissions Inventory for the Alberni Airshed Report[8], also shown in Table 23.

Table 23: Emissions Factors for the Movement of Farm Animal

Farm Animal		Emission Factors (kg/head/year)			
		NOx	TPM	PM_{10}	$PM_{2.5}$
Cattle	**Steers, 1 year and over**	-	6.38	2.13	0.32
Pigs	**Boars**	-	3.74	1.87	0.37
	Sows	-	2.76	1.38	0.28

[30] Statistics Canada. https://www150.statcan.gc.ca/n1/en/type/data?MM=1 accessed in December 2021.

Farm Animal		Emission Factors (kg/head/year)			
		NOx	TPM	PM_{10}	$PM_{2.5}$
	Pigs	-	0.76	0.38	0.08
Poultry	**Pullets under 19 weeks**	-	8.3E-03	1.7E-03	1.7E-04
	Laying hens, 19 weeks and over	-	2.0E-02	4.0E-03	4.0E-04
	Layer and broiler breeders (pullets and hens)	-	2.0E-02	4.0E-03	4.0E-04
	Broilers, roasters and Cornish	-	3.7E-02	3.7E-03	3.7E-04
	Turkeys	-	1.8E-01	1.8E-02	1.8E-03
	Other poultry	-	6.5E-02	6.5E-03	6.5E-04
Horses	**Paddocks**	-	2.15	0.72	0.11
	Rings	-	1.61	0.54	0.08

To estimate PM emissions from the movements of farm animals, the number of each type of farm animal in the study area was multiplied by the emission factors listed in Table 23.

The following assumptions were made:

- The movements of farm animals were universal in B.C.,
- Only cattle (steers, one year and over) were included in the emissions inventory, consistent with the assumption used in the 2005 Lower Fraser Valley Air Emissions Report[9], and
- 22% of horses were in paddocks and the remaining (78%) were in riding rings[9].

Table 24 provides a summary of emissions resulting from farm animal movements in Areas D and Area F.

Table 24: Annual Emissions from the Movement of Farm Animal in the Study Area

Area		Emissions from Movements of Farm Animals (tonnes/year)			
		NOx	TPM	PM_{10}	$PM_{2.5}$
Area D	**Cattle**	-	1.36	0.45	0.07
	Pigs	-	0.05	0.03	0.01
	Poultry	-	0.03	3.4E-03	3.4E-04
	Horses	-	0.36	0.12	0.02
Area F	**Cattle**	-	10.08	3.37	0.51
	Pigs	-	0.35	0.18	0.04
	Poultry	-	0.11	0.01	1.4E-03
	Horses	-	1.79	0.60	0.09
Total in Study Area		-	**14.14**	**4.76**	**0.73**

2.3.3.2 Fertilizer Application

Fertilizer Application includes emissions resulting from the use of synthetic nitrogen fertilizers in annual and perennial crop production. The total emissions resulting from inorganic fertilizer applications in B.C. in 2018 are provided in the APEI 2022 report[11].

Additionally, Statistics Canada published 2016 data on commercial fertilizer usage in hectares for farms located in the RDBN Areas D and F [31].

The total B.C. emissions from inorganic fertilizer applications were scaled by calculating the percentage of fertilizer applications to RDBN Electoral Areas D and Area F relative to the commercial fertilizer usage for all of B.C. The assumption made here was that the quantities of commercial fertilizer applied to the farm area are correlated with the emissions generated by inorganic fertilizer application. The annual emissions in the study area have been calculated and are presented in Table 25.

Table 25: Annual Emissions from Inorganic Fertilizer Application

Area	Emissions from Inorganic Fertilizer Application (tonnes/year)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
British Columbia	-	87.00	43.00	12.00
Area D	-	1.31	0.65	0.18
Area F	-	6.84	3.38	0.94
Total in Study Area	-	**8.15**	**4.03**	**1.12**

2.3.3.3 Pesticide Application

The hectares of land area to which pesticides were applied in 2016 were obtained from the Statistics Canada 2016 Land Inputs data in Table 32-10-0409-01[31]. It was assumed that the 2016 data represents the land area to which pesticides were applied in 2018. These pesticides include herbicides, insecticides, and fungicides. The PM emission factors for the application of pesticides were drawn from the 2005 Lower Fraser Valley Air Emissions Report[9] and are presented in Table 26.

Table 26: Emission factors for Application of Pesticide

Activity	Emission factors for Application of Pesticide (kg/ha pesticide applied)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
Pesticide Application	-	1.67	0.82	0.23

Emissions resulting from the application of herbicides, insecticides, and fungicides were calculated for the study area by multiplying the hectares of the land areas by the corresponding emission factors presented in Table 26. The calculated emissions are presented in Table 27.

Table 27: Annual Emissions from Pesticides Application

Area	Emissions from Application of Pesticides (tonnes/year)			
	NOx	TPM	PM_{10}	$PM_{2.5}$

[31] Statistic Canada. Land Inputs, Table 32-10-0409-01. www150.statcan.gc.ca.Accessed in December 2021.

Area D	-	0.06	0.03	0.01
Area F	-	9.60	4.72	1.32
Total in Study Area	-	**9.66**	**4.74**	**1.33**

2.3.3.4 Tilling Soil

PM can be generated by mechanical disturbances such as seeding, seedbed preparation, and cultivation of tilling soil. The emissions generated depend on various factors such as crop types, and the number of tilling events per year per crop.

The Census of Agriculture provided tilling areas for each crop type in 2016, including field crops[32], fruits[33], and field vegetables[34].

The number of tilling practices per month by crop category for the study area was obtained from the B.C. Agricultural Air Emissions Inventory Report[12].

Various factors, such as moisture conditions, percentage of tillage practice, and silt content of lands, play important roles in air emission generation from soil tilling. The moisture reduction factor reflects the precipitation accumulation, which decreases the likelihood of particles becoming airborne. The tillage factor was assumed to be 100% minus the percentage of area managed with no-till or zero-till practices. The moisture reduction factors by month, silt content (43%), and tillage factors (54%) for the Nechako region from the same B.C. Agricultural Air Emissions Inventory Report[12] were adopted for the emission estimation for both Area D and Area F.

The methodology for estimating emissions from dry field tillage used in the B.C. Agricultural Air Emissions Inventory Report[12] was adopted for this report.

The particle size multipliers were 1.00 for TPM, 0.21 for PM_{10}, and 0.042 for $PM_{2.5}$ [12].

Tilling emission factors (shown in Table 28) were calculated using the following equation:

$$\textit{Emission Factor } (TPM, PM_{10}, PM_{2.5}) = \textit{Empirically Derived Constant } (5.38) \times \textit{Moisture reduction factor per month} \times \textit{Particle size multiplier } (TPM, PM_{10}, PM_{2.5}) \times \textit{Silt content per region } (\%)^{0.6}$$

To estimate emissions resulting from tilling soil per month, the following equation was used:

$$\textit{Emission per crop per month } (TPM, PM_{10}, PM_{2.5}) = \textit{Area per crop (ha)} \times \textit{Tillage Factor} \times \textit{Number of tilling per crop per month} \times \textit{Emission Factor } (TPM, PM_{10}, PM_{2.5})$$

The number of tilling per crop per month was sourced from the B.C. Agricultural Air Emissions Inventory Report[12]. The monthly emissions were added together, and the 2018 emissions are presented in Table 29.

[32] Statistic Canada. Table 32-10-0416-01 Field Crops and hay, Census of Agriculture. 2011 and 2016.
[33] Statistic Canada. Table 32-10-0417-01 Fruits, Census of Agriculture. 2011 and 2016.
[34] Statistic Canada. Table 32-10-0418-01 Field vegetables, Census of Agriculture. 2011 and 2016.

Table 28: Emission Factors for Tilling Soil

Crop Type	Emission Factors for Tilling Soil (kg/ha)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
Alfalfa and alfalfa Mixture	-	13.57	2.85	0.57
Mixed grains	-	87.46	18.37	3.67
Oats	-	87.46	18.37	3.67
Barley	-	87.46	18.37	3.67
Rye	-	87.46	18.37	3.67
All other tame hay and fodder crops	-	11.02	2.31	0.46
Fruits, berries and nuts	-	69.66	14.63	2.93
Vegetables	-	61.90	13.00	2.60

Table 29: Annual Emissions from Tilling Soil

Area	Crop Type	Emissions from Tilling Soil (tonnes/year)				
		Crop Area (ha)	NOx	TPM	PM_{10}	$PM_{2.5}$
Area D	**Alfalfa and alfalfa Mixture**	3168	-	23.21	4.87	0.97
	Mixed grains	312	-	2.29	3.09	0.62
	Oats	95.00	-	0.70	0.94	0.19
	Barley	-	-	0.00	0.00	0.00
	Rye	-	-	0.00	0.00	0.00
	All other tame hay and fodder crops	762	-	5.58	0.95	0.19
	Fruits, berries and nuts	-	-	0.00	0.00	0.00
	Vegetables	2.00	-	0.01	0.01	2.8E-03
	Total Emissions in Area D		-	***31.79***	***9.88***	***1.98***
Area F	**Alfalfa and alfalfa Mixture**	16807	-	123	25.86	5.17
	Mixed grains	338	-	15.96	3.35	0.67
	Oats	1813	-	85.63	17.98	3.60
	Barley	3681	-	174	36.51	7.30
	Rye	40.00	-	1.89	0.40	0.08
	All other tame hay and fodder crops	5494	-	32.70	6.87	1.37
	Fruits, berries and nuts	4.00	-	0.15	0.03	0.01
	Vegetables	4.00	-	0.13	0.03	0.01
	Total Emissions in Area F		-	***433***	***91.02***	***18.20***
Total in Study Area			-	**465**	**101**	**20.18**

2.3.3.5 Harvesting Crops

PM generated from agricultural harvesting, also known as grain dust, includes grain and dry plant particles, molds, pollen and spores, silica, bacteria, fungi, insects, and possibly pesticide residues.

These emissions are generated by vehicles travelling over soil or by the processing of plant materials by agricultural equipment[11].

Crop types include crops, fruits, and field vegetables. The areas for each crop type in 2016 (assuming that 2016 data represent that of 2018) were obtained from the Census of Agriculture (field crops[32], fruits[33], and field vegetables[34]).

The PM_{10} emission factors were available from the B.C. Agricultural Air Emissions Inventory Report[12] for dry regions, which are summarized in Table 30. The particle size multipliers of 2.20 for TPM, 1.00 for PM_{10}, and 0.15 for $PM_{2.5}$ were taken from California Air Resource Board, Miscellaneous Process Methodology.[35]

Table 30: Emission Factors for Crop Harvesting

Crop Type	Emission Factors for Harvesting (kg/ha)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
Alfalfa and alfalfa Mixture	-	2.75	1.25	0.19
Mixed grains	-	5.20	2.36	0.35
Oats	-	5.20	2.36	0.35
Barley	-	5.20	2.36	0.35
Rye	-	5.20	2.36	0.35
All other tame hay and fodder crops	-	2.75	1.25	0.19
Fruits, berries and nuts	-	0.02	0.01	1.5E-03
Vegetables	-	0.07	0.03	4.5E-03

Emissions from crop harvesting were calculated by multiplying areas of each type of crop in hectares by their specific emission factors. Table 31 summarizes the emissions for Areas D and Area F.

Table 31: Annual Emissions from Crop Harvesting

Area	Crop Type	Emissions from harvesting Crop (tonnes/year)				
		Crop Area (Ha)	NOx	TPM	PM_{10}	$PM_{2.5}$
Area D	**Alfalfa and alfalfa Mixture**	3168	-	8.72	3.96	0.59
	Mixed grains	312	-	1.62	0.74	0.11
	Oats	95.00	-	0.49	0.22	0.03
	Barley	-	-	0.00	0.00	0.00
	Rye	-	-	0.00	0.00	0.00
	All other tame hay and fodder crops	762	-	2.10	0.95	0.14
	Fruits, berries and nuts	-	-	0.00	0.00	0.00
	Vegetables	2.00	-	1.3E-04	6.0E-05	9.0E-06

[35] California Air Resource Board. Miscellaneous Process Methodology 7.5 Agricultural Harvest Operations. Revised March 2017.

Area	Crop Type	Emissions from harvesting Crop (tonnes/year)				
		Crop Area (Ha)	NOx	TPM	PM_{10}	$PM_{2.5}$
	Total Emissions in Area D		-	**12.93**	**5.87**	**0.88**
Area F	Alfalfa and alfalfa Mixture	16807	-	46.24	21.00	3.15
	Mixed grains	338	-	1.76	0.80	0.12
	Oats	1813	-	9.43	4.28	0.64
	Barley	3681	-	19.14	8.70	1.30
	Rye	40.00	-	0.21	0.09	0.01
	All other tame hay and fodder crops	5494	-	15.11	6.87	1.03
	Fruits, berries and nuts	4.00	-	8.8E-05	4.0E-05	6.0E-06
	Vegetables	4.00	-	2.6E-04	1.2E-04	1.8E-05
	Total Emissions in Area F		-	**91.90**	**41.75**	**6.26**
Total in Study Area			-	**105**	**47.62**	**7.14**

2.3.3.6 Wind Erosion

Wind erosion occurs when wind blows across exposed agricultural land, resulting in PM emissions from the entrained particles[11].

Based on the B.C. Agricultural Air Emissions Inventory report[12], the PM emission factor for wind erosion of agricultural soils has a linear relationship with the following factors:

- Soil erodibility (I),
- Surface roughness factor (K),
- Climatic factor (C),
- Unsheltered field width factor (L'), and
- Vegetative cover factor (V').

Soil erodibilities for various soil textural classes were drawn from B.C. Agricultural Air Emissions Inventory report[12]. The report also provided the surface roughness factors (K), the climatic factors (C), the unsheltered field width in foot (L), and vegetative cover in lb/acre (V). Unsheltered filed width factor (L') derived from L and vegetative cover factor (V') derived from V, were obtained from U.S. EPA-450 /3-74-037[36].

The areas for each crop type in 2016 were sourced from the Census of Agriculture (field crops[32], fruits[33], and field vegetables[34]).

In order to get K, L, V, some assumptions were made:

- K, L, V of mixed grains are the same as those of wheat (crop type),
- K, L, V of all other tame hay and fodder crops are the same as those of grain hays (crop type), and

[36] U.S. EPA-450 /3-74-037. Development of Emission Factor for fugitive Dust Sources. June 1974.

- K, L, V of fruits, berries, and nuts are the same as those of sunflower (crop type).

The following equation drawn from U.S. EPA-450 /3-74-037 was used to calculate annual emissions from agricultural soil wind erosion.

$$Emission\ Factor\ (ton/acre) = \mathrm{A} \times I \times K \times \mathrm{C} \times L' \times V'$$

"A" was estimated to be 0.025 and is defined as the portion of total wind erosion losses measured as suspended particulates[12].

This method uses the speciation of total PM to PM_{10} and $PM_{2.5}$ as referenced in the Western Regional Air Partnership (WRAP) Fugitive Dust Handbook[37]. The PM_{10}/TPM ratio for wind erosion is 0.5. The $PM_{2.5}/PM_{10}$ ratio for windblown fugitive dust is 0.15. The annual emissions resulting from wind erosion are shown in Table 32.

[37] Countess Environmental, WRAP Fugitive Dust Handbook, September 2006.

Table 32: Annual Emissions from Wind Erosion of Agricultural Soils

Area	Crop Type	Crop Area (ha)	Emission Factors (ton/acre year)				Annual Emissions from Wind Erosion (tonnes/year)			
			NOx	TPM	PM_{10}	$PM_{2.5}$	NOx	TPM	PM_{10}	$PM_{2.5}$
Area D	**Alfalfa and alfalfa Mixture**	3168	-	0.00	0.00	0.00	-	0.00	0.00	0.00
	Mixed grains	312	-	0.00	0.00	0.00	-	0.00	0.00	0.00
	Oats	95.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00
	Barley	-	-	0.02	9.5E-03	1.4E-03	-	0.00	0.00	0.00
	Rye	-	-	0.00	0.00	0.00	-	0.00	0.00	0.00
	All other tame hay and fodder crops	762	-	0.00	0.00	0.00	-	0.00	0.00	0.00
	Fruits, berries and nuts	-	-	0.00	0.00	0.00	-	0.00	0.00	0.00
	Vegetables	2.00	-	0.15	0.08	0.01	-	0.69	0.35	0.05
	Emission from Area D						-	**0.69**	**0.35**	**0.05**
Area F	**Alfalfa and alfalfa Mixture**	16807	-	0.00	0.00	0.00	-	0.00	0.00	0.00
	Mixed grains	338	-	0.00	0.00	0.00	-	0.00	0.00	0.00
	Oats	1813	-	0.00	0.00	0.00	-	0.00	0.00	0.00
	Barley	3681	-	0.02	7.4E-03	1.1E-03	-	122	60.91	9.14
	Rye	40.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00
	All other tame hay and fodder crops	5494	-	0.00	0.00	0.00	-	0.00	0.00	0.00
	Fruits, berries and nuts	4.00	-	0.00	0.00	0.00	-	0.00	0.00	0.00
	Vegetables	4.00	-	0.10	0.05	7.53E-03	-	0.90	0.45	0.07
	Emission from Area F						-	**123**	**61.36**	**9.20**
Total in Study Area								**123**	**61.71**	**9.26**

2.3.4 Fugitive Dust

Significant atmospheric dust arises from the mechanical disturbance of granular material exposed to the air. Dust generated from these open sources is termed "fugitive" because it is not discharged to the atmosphere in a confined flow stream[38]. Fugitive dust emission sources in this report include:

- Construction operations,
- Landfill operations,
- Rail transportation of coal, and
- Unpaved and paved roads.

Some agricultural operations such as tilling soil, are common sources of fugitive dust, however, these have been classified as agricultural area emissions and were discussed in Section 2.3.3.

Sections 2.3.4.1 to 2.3.4.4 provide detailed emission estimations of the above four types of fugitive dust emissions.

2.3.4.1 Fugitive Dust from Construction Operations

PM emissions resulting from soil disturbance on construction sites are commonly classified as fugitive dust generated from construction operations.

The magnitude of fugitive dust emissions from construction operations is contingent upon the type of buildings constructed, as reported in the 2005 Lower Fraser Valley Air Emissions Inventory[9]. For this study, all relevant parameters including conversion factors, duration parameters, and adjusted emission factors for PM_{10} outlined in Table 33 were sourced from the 2005 Lower Fraser Valley Air Emissions Inventory[9].

Table 33: Emission factors for Construction Operation

Building Type	Conversion Factor (ha/unit)	Duration (months)	Adjusted Emission Factor (PM_{10}/ha-month)
Single-detached (unit: dwellings)	0.07	4.20	0.01
Duplex/Row (unit: dwellings)	0.07	4.20	0.01
Apartment (unit: dwellings)	0.02	12.00	0.05
Commercial (unit: million dollars)	0.55	11.00	0.09
Industrial (unit: million dollars)	0.55	11.00	0.09
Institutional (unit: million dollars)	0.27	11.00	0.09

[38] U.S. EPA AP42 CH 13.2. Fugitive Dust Sources. January 1995.

Building counts or building costs of different types (residential single-detached, residential duplex/row, residential apartment, commercial, industrial, and institutional buildings) were obtained from B.C. Stats, Building Permits, Housing Starts & Sales[39]. Since there was no information for Fraser Lake, Area D, and Area F, assume the emissions are minimal and can be neglected.

The fugitive dust emissions presented in Table 34 were calculated based on the emission factors outlined in Table 33 and the counts or costs of various building types, with the ratios of PM_{10}/TPM and $PM_{2.5}$/TPM set to 80% and 20% respectively (based on 2022 APEI[11]).

Table 34: Annual Emissions from Construction Operations

Area	Building Type	Number	Unit	Fugitive Dust Emissions from Construction Operations (tonnes/year)			
				NOX	TPM	PM_{10}	$PM_{2.5}$
Vanderhoof DM	Single-detached	2.00	dwellings	-	0.01	0.01	2.0E-03
	Duplex/Row	0.00	dwellings	-	0.00	0.00	0.00
	Apartment	0.00	dwellings	-	0.00	0.00	0.00
	Commercial	0.38	million dollars	-	0.25	0.20	0.05
	Industrial	1.21	million dollars	-	0.78	0.62	0.16
	Institutional	1.08	million dollars	-	0.34	0.27	0.07
Total in Study Area				-	**1.38**	**1.10**	**0.28**

2.3.4.2 Fugitive Dust from Landfill Operations

Emission estimations of PM from landfill operations depend on the amount of the material landfilled and PM emission factors.

The total annual amounts of material landfilled for Vanderhoof transfer station, Fraser Lake Rural Transfer Station (located in Area D), and Clearview Landfill (located in Area F) were obtained from the 2018 RDBN Solid Waste Management Plan[20].

The TPM emission factor of 0.193 kg per tonne of material landfilled was drawn from the 2005 Lower Fraser Valley Air Emissions Inventory Report[9]. PM_{10} and $PM_{2.5}$ emissions were calculated to be 36% and 10% of the TPM emissions, respectively, according to the same reference.

Assuming the landfill activities such as material moving in the study area were the same as those in the Lower Fraser valley, the annual fugitive dust emissions (shown in Table 35) were calculated using activity data of material landfilled multiplied by the emission factors discussed above.

[39] B.C. Stats, Building Permits, Housing Starts & Sales, www2.gov.bc.ca/gov/content/data/statistics/economy/building-permits-housing-starts-sales. Accessed in April 2022.

Table 35: Annual Fugitive Dust Emissions from Landfill Operation

Area	Amount of Material Landfilled (tonnes)	Annual Fugitive Dust Emissions from Landfill (tonnes/year)			
		NOx	TPM	PM_{10}	$PM_{2.5}$
Vanderhoof DM	**3892**	-	0.75	0.27	0.08
Area D	**1078**	-	0.21	0.08	0.02
Area F	**8400**	-	1.62	0.58	0.16
Total in Study Area		-	**2.58**	**0.93**	**0.26**

2.3.4.3 Fugitive Dust from Rail Transportation of Coal

According to the APEI 2022 report[11], most of the coal mined in Canada is transferred to the port terminal or to end-use facilities (i.e., facilities that use coal as fuel) by trains. PM emissions were estimated based on the amounts of coal transported and the emission factors developed for TPM, PM_{10}, and $PM_{2.5}$. For this report, the CN mainline Jasper–Prince Rupert was identified to estimate the total rail distance (1160km).

The method for calculating emission factors (shown in Table 36) of fugitive losses of dust from the rail transportation of coal was based on the following equation indicated in the 2005 Lower Fraser Valley Air Emissions Inventory report[9]. Emissions for PM_{10} and $PM_{2.5}$ were calculated as 0.5 and 0.2 of those of TPM, respectively, according to the same reference.

$$\mathbf{EF\ (kg/tonne) = 0.1*(0.62*D)^{0.6} \times (365-P)/365 \times (Segment\ Distance/D) \times (100–Control\ Efficiency)/100}$$

where:

- D: total rail distance (km),
- P: number of precipitation days greater than 3 mm rainfall or 10 mm snow,
- Segment Distance: distance travelled in a province or region, and
- Control Efficiency: coal dust control efficiency = 99%.

Table 36: Fugitive Dust Emissions Factors for Rail Transportation of Coal

Area	Segment Distance (km)	Emissions Factors for Rail Transportation of Coal (kg/tonne)			
		NOx	TPM	PM_{10}	$PM_{2.5}$
Vanderhoof DM	6.70	-	2.5E-04	1.3E-04	5.2E-05
Fraser Lake	3.60	-	1.3E-04	6.8E-05	2.8E-05
Area D	47.90	-	1.8E-03	9.1E-04	3.7E-04
Area F	57.40	-	2.1E-03	1.1E-03	4.5E-04

The quantities of coal conveyed through the study area have been estimated based on the assumptions in the 2006 Vanderhoof Emission Inventory Report[6]. The annual fugitive dust emissions (Table 37) from the rail transportation (in transit) of coal were calculated by multiplying the amount of coal transported by rail by the emission factors.

Table 37: **Annual Fugitive Dust Emissions from Rail Transportation of Coal**

Area	Dust Emissions for Rail Transportation of Coal (tonnes/year)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
Vanderhoof DM	-	0.90	0.46	0.19
Fraser Lake	-	0.48	0.25	0.10
Area D	-	6.44	3.32	1.37
Area F	-	7.71	3.97	1.64
Total in Study Area	-	**15.53**	**8.00**	**3.29**

2.3.4.4 Fugitive Dust from Paved and Unpaved Roads

Fugitive emissions from paved roads arise from both primary sources, such as road abrasion, and secondary sources, such as resuspension of particles. Unpaved roads generate emissions primarily from suspended or resuspended silt from the road surface. Typically, road dust emissions are estimated by multiplying emission factors with the vehicle kilometers travelled (VKT).

The 2022 APEI report[11] presented PM emissions from paved and unpaved roads in B.C. Emissions from paved roads for Vanderhoof DM and Fraser Lake were firstly estimated by scaling the total emissions from B.C.'s paved roads in accordance with the VKTs of Vanderhoof DM, and Fraser Lake, respectively, and emissions from unpaved roads for Area D and Area F were then calculated by scaling the total emissions from B.C.'s unpaved roads in accordance with VKTs of Area D and Area F, respectively; The ratio of unpaved to paved roads in each region and the VKTs for each region, extracted from the 2010 CEEI report[7], were then used to determine emissions from paved roads in Area D and Area F, as well as emissions from unpaved roads in Vanderhoof DM and Fraser Lake. For Vanderhoof DM and Fraser Lake, assume 86% of roads are paved while the remaining 14% are unpaved based on the 2006 Vanderhoof emission inventory[6]. For Area D and Area F, assume 92% of roads are unpaved while the remaining 8% are paved based on Environmental Reporting for B.C.[40]

The emissions for TPM, PM_{10}, and $PM_{2.5}$ from both paved and unpaved roads in 2018 for B.C. are summarized in Table 38, and the emissions from both paved and unpaved roads in 2018 for each region in the study area are presented in Table 39.

Table 38: **2018 Road Dust Emissions from Entire B.C.**

Year	Road Dust	TPM (tonnes)	PM_{10} (tonnes)	$PM_{2.5}$ (tonnes)
2018	Paved Roads	42354	8503	2238
2018	Unpaved Roads	707631	194588	19356

[40] Environmental Reporting B.C. www.env.gov.bc.ca/soe/indicators/land/roads.html. Accessed in July 2023.

Table 39: Annual Fugitive Dust Emissions from Paved and Unpaved Roads

Emission Source	Area	Road Dust Emission (tonnes/year)			
		NOx	TPM	PM_{10}	$PM_{2.5}$
Paved Road	Vanderhoof DM	-	28.57	5.74	1.51
	Fraser Lake	-	8.66	1.74	0.46
	Area D	-	0.96	0.19	0.05
	Area F	-	2.39	0.48	0.13
	Subtotal	-	**40.58**	**8.15**	**2.14**
Unpaved Road	Vanderhoof DM	-	72.64	19.97	1.99
	Fraser Lake	-	26.18	7.20	0.72
	Area D	-	172	47.31	4.71
	Area F	-	428	118	11.72
	Subtotal	-	**699**	**192**	**19.13**
Total in Study Area		-	**740**	**200**	**21.27**

2.3.5 Wildfire

The B.C. Wildfire Emission Inventory for 2018[41] was developed to estimate CAC emissions. The inventory was compiled based on reported fires, with a total of 1231 recorded in B.C. in 2018. Of these, 26 fires were in Area D, and 24 fires were located in Area F.

The wildfire emissions for Areas D and Area F were extracted from the 2018 B.C. Wildfire CAC Emission Inventory Report[41]. Detailed information regarding the methodology and assumptions used for emission estimation can be found in the same inventory. Table 40 provides a summary of the annual emissions from wildfires in the study area.

Table 40: Annual Emissions from Wildfire

Area	Annual Emissions from Wildfire (tonnes/year)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
Area D	21.67	1143	835	770
Area F	111	5849	4270	3940
Total in Study Area	**133**	**6992**	**5105**	**4710**

3. RESULT SUMMARY

The B.C. ENV compiled this emission inventory for Vanderhoof and its surrounding areas. The air pollutants of concern included NOx, TPM, PM_{10}, and $PM_{2.5}$. The study area comprised the following regions:

- Vanderhoof DM,
- Fraser Lake,
- Area D, and
- Area F.

[41] B.C. ENV. Wildfire CAC Emission Inventory for 2018.2020.

The emission sources identified for the study area included point sources, mobile sources, and area sources. A summary of the emission inventory is shown in Table 41.

Table 41: 2018 Emission Estimates for Vanderhoof and Surrounding Area

Emission Sources	Category		Emission Estimates for Vanderhoof and Surrounding Area (tonnes/year)			
			NOx	TPM	PM_{10}	$PM_{2.5}$
Point Sources	Nechako Lumber Company Ltd.		53.17	57.00	14.70	9.00
	Premium Pellet Ltd.		31.80	43.50	14.50	9.40
	Vanderhoof Specialty Wood Products (VSWP)		0.00	2.80	1.10	1.10
	Canadian Forest Products Ltd, Plateau Division		70.39	46.33	26.84	19.19
	Fraser Lake Lumber (Div of West Fraser Mills Ltd.), Fraser Lake Sawmills		262	138	75.62	33.26
	Pacific Northern Gas Ltd.		201	9.39	9.39	9.39
	Total-Point Sources		**618**	**297**	**142**	**81.34**
Mobile Sources	On-Road Vehicles		254	7.50	7.50	2.99
	Tire wear and brake lining		-	2.44	2.44	0.32
	Off-road vehicles and equipment		242	30.14	30.13	29.23
	Rail Transportation		127	3.84	3.75	3.71
	Air Transportation		30.81	1.19	1.19	1.16
	Total-Mobile Sources		**653**	**45.11**	**45.01**	**37.41**
Area Sources	Open Burning	Province Regulated Open Burning (pile and area)	228	1272	904	786
		Backyard burning	4.34	11.56	8.52	7.86
		Subtotal-Open Burning	**232**	**1283**	**913**	**794**
	Space Heating	Fuel oil	2.06	0.19	0.19	0.19
		Natural Gas	10.32	0.83	0.83	0.83
		Propane	6.68	0.36	0.36	0.36
		Wood burning appliances	14.25	116	110	110
		Subtotal-Space Heating	**33.31**	**118**	**111**	**111**

Emission Sources	Category		Emission Estimates for Vanderhoof and Surrounding Area (tonnes/year)			
			NOx	**TPM**	**PM_{10}**	**$PM_{2.5}$**
	Agriculture	Movements from farm animals	-	14.14	4.76	0.73
		Fertilizer application	-	8.15	4.03	1.12
		Pesticides application	-	9.66	4.74	1.33
		Tilling Soil	-	465	101	20.18
		Harvesting crops	-	105	47.62	7.14
		Wind Erosion	-	123	61.71	9.26
		Subtotal-Agriculture	**0**	**725**	**224**	**39.76**
	Fugitive Dust	Construction operation	-	1.38	1.10	0.28
		Landfill operation	-	2.58	0.93	0.26
		Rail transportation of coal	-	15.53	8.00	3.29
		Paved Road	-	40.58	8.15	2.14
		Unpaved Road	-	699	192	19.13
		Subtotal-Fugitive Dust	**0**	**759**	**210**	**25.10**
	Wildfire		**133**	**6992**	**5105**	**4710**
	Total-Area Sources		**398**	**9878**	**6563**	**5680**
	Total-Area Sources without Wildfire		**265**	**2886**	**1458**	**970**
Total Emissions			**1669**	**10220**	**6750**	**5799**
Total Emissions without Wildfire			**1537**	**3227**	**1646**	**1089**

4. ANALYSIS

Table 42 summarizes the 2018 annual emissions from major contributors for Vanderhoof and its surrounding areas. The percentage distribution of NOx, TPM, PM_{10}, and $PM_{2.5}$ emissions (without wildfire) by source type for all study areas is shown in Figure 2. Tables 43 to 46 summarize the 2018 annual emissions for Vanderhoof DM, Fraser Lake, Area D, and Area F, with the percentage distribution demonstrated in Figures 2 to 6, respectively.

- NOx: In 2018, 1669 tonnes of NOx were emitted in the study area. Of these, 8% of total NOx emissions were from wildfire. After removing emissions from wildfire, mobile sources, followed by point sources, were two significant contributors to the study area's emissions. Similarly, mobile sources accounted for 60% of emissions in Vanderhoof DM, 88% in Fraser Lake, and 48% in Area F. Point sources were the most significant contributors to Area D, accounting for 60% of emissions.
- PM: 10220, 6750, and 5799 tonnes of TPM, PM_{10}, and $PM_{2.5}$ were emitted in the study area, respectively. Of these 68%, 76%, 81% of TPM, PM_{10}, and $PM_{2.5}$ emissions were from wildfire, respectively. After removing emissions from wildfire, area sources from open burning accounted for 40%, 55%, and 73% of TPM, PM_{10}, and $PM_{2.5}$ emissions, respectively.
    - In Vanderhoof DM, the most significant contributor to $PM_{2.5}$ emissions was point sources, closely followed by space heating, which is an area source;
    - In Fraser Lake, space heating emerged as the leading contributor to $PM_{2.5}$ emissions, followed by fugitive dust.
    - For Area D and Area F, open burning was identified as the dominant emission source for TPM, PM_{10}, and $PM_{2.5}$.

Table 42: Emission Distributions for Vanderhoof and Surrounding Areas in 2018

Emission Sources	Emission Distributions for Vanderhoof and Surrounding Areas (tonnes/year)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
Point sources	618	297	142	81.34
mobile sources	653	45.11	45.01	37.41
Area sources-Open burning	232	1283	913	794
Area sources-Space Heating	33.31	118	111	111
Area sources-Agriculture	0.00	725	224	39.76
Area sources-Fugitive Dust	0.00	759	210	25.10
Area sources-Wildfire	133	6992	5105	4710
Total Emissions with Wildfire	**1669**	**10220**	**6750**	**5799**
Total Emissions without Wildfire	**1537**	**3227**	**1646**	**1089**

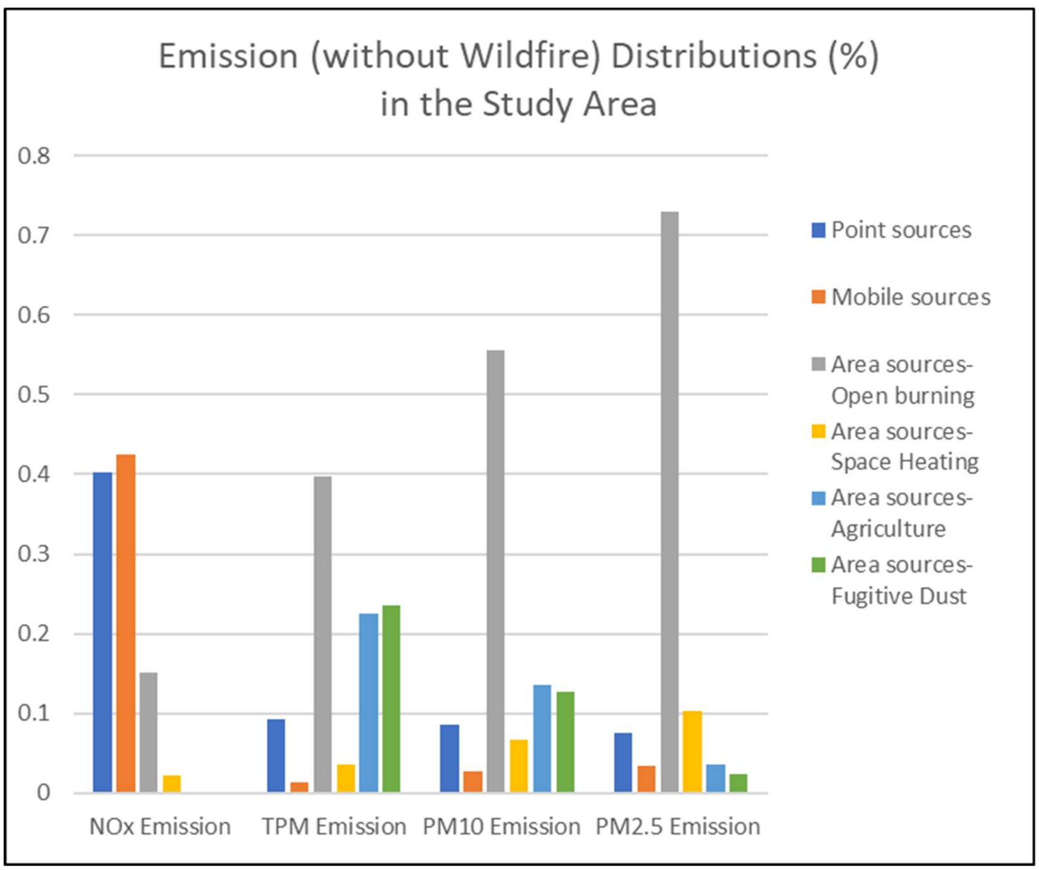


Figure 2: Emission Distributions (without Wildfire) (%) in the Study Area

Table 43: Emission Distributions for Vanderhoof DM in 2018

Emission Sources	Emission Distributions for Vanderhoof DM (tonnes/year)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
Point sources	84.97	103	30.30	19.50
mobile sources	153	5.80	5.78	3.05
Area sources-Open burning	1.82	4.86	3.58	3.30
Area sources-Space Heating	13.37	17.29	16.36	16.34
Area sources-Agriculture	0.00	0.00	0.00	0.00
Area sources-Fugitive Dust	0.00	104	27.55	4.04
Area sources-Wildfire	0.00	0.00	0.00	0.00
Total Emissions with Wildfire	**253**	**235**	**83.56**	**46.23**
Total Emissions without Wildfire	**253**	**235**	**83.57**	**46.23**

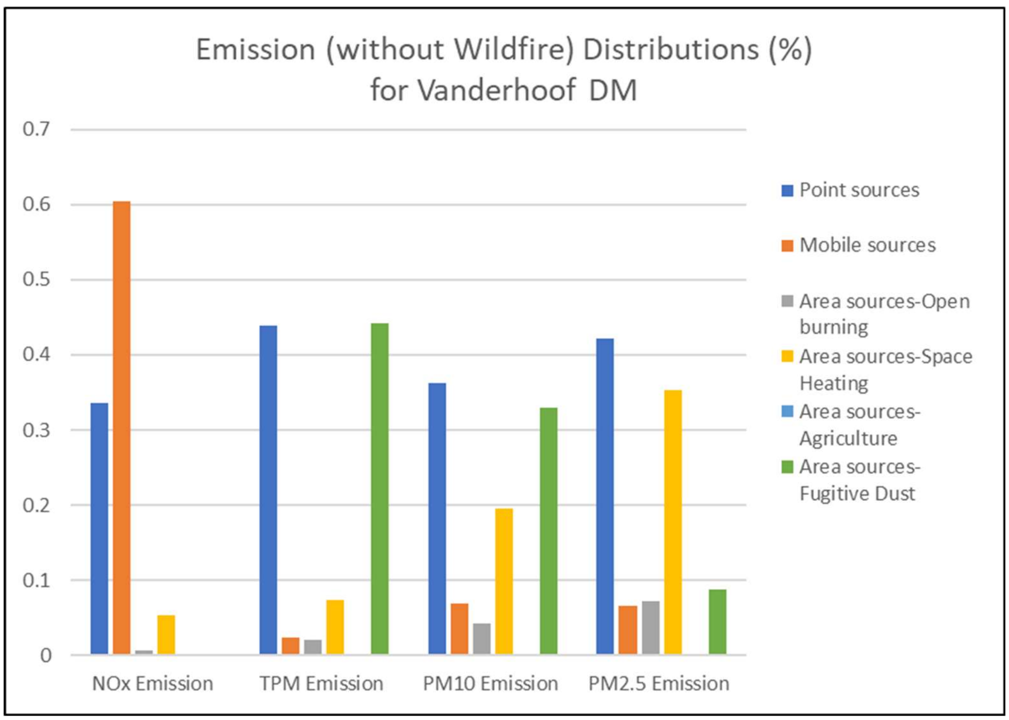


Figure 3: Emission Distributions (without Wildfire) (%) in Vanderhoof DM

Table 44: Emission Distributions for Fraser Lake in 2018

Emission Sources	Emission Distributions for Fraser Lake (tonnes/year)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
Point sources	0.00	0.00	0.00	0.00
mobile sources	31.15	1.23	1.23	0.50
Area sources-Open burning	0.41	1.08	0.80	0.74
Area sources-Space Heating	3.94	8.62	8.15	8.14
Area sources-Agriculture	0.00	0.00	0.00	0.00
Area sources-Fugitive Dust	0.00	35.33	9.19	1.28
Area sources-Wildfire	0.00	0.00	0.00	0.00
Total Emissions with Wildfire	**35.49**	**46.27**	**19.36**	**10.65**
Total Emissions without Wildfire	**35.49**	**46.27**	**19.36**	**10.65**

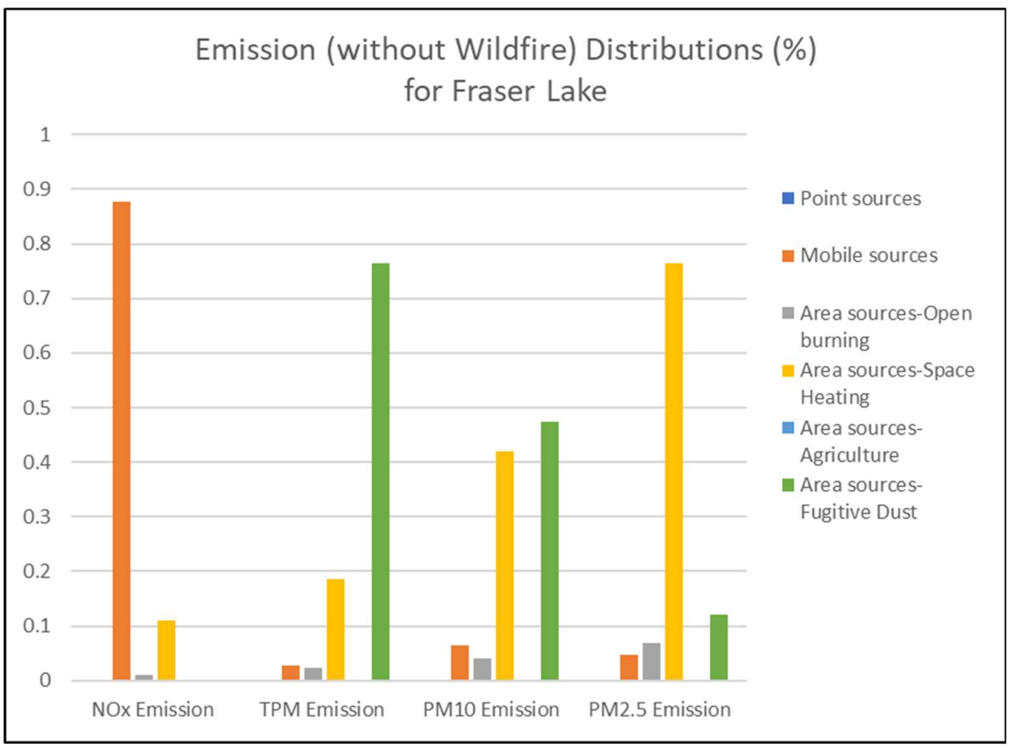


Figure 4: Emission Distributions (without Wildfire) (%) in Fraser Lake

Table 45: Emission Distributions for Area D in 2018

Emission Sources	Emission Distributions for Area D (tonnes/year)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
Point sources	332	184	102	52.44
mobile sources	131	8.65	8.61	7.51
Area sources-Open burning	78.14	431	306	267
Area sources-Space Heating	4.96	28.47	26.89	26.87
Area sources-Agriculture	0.00	48.59	17.38	3.19
Area sources-Fugitive Dust	0.00	180	50.89	6.14
Area sources-Wildfire	21.68	1143	835	770
Total Emissions with Wildfire	**568**	**2024**	**1347**	**1133**
Total Emissions without Wildfire	**546**	**881**	**513**	**363**

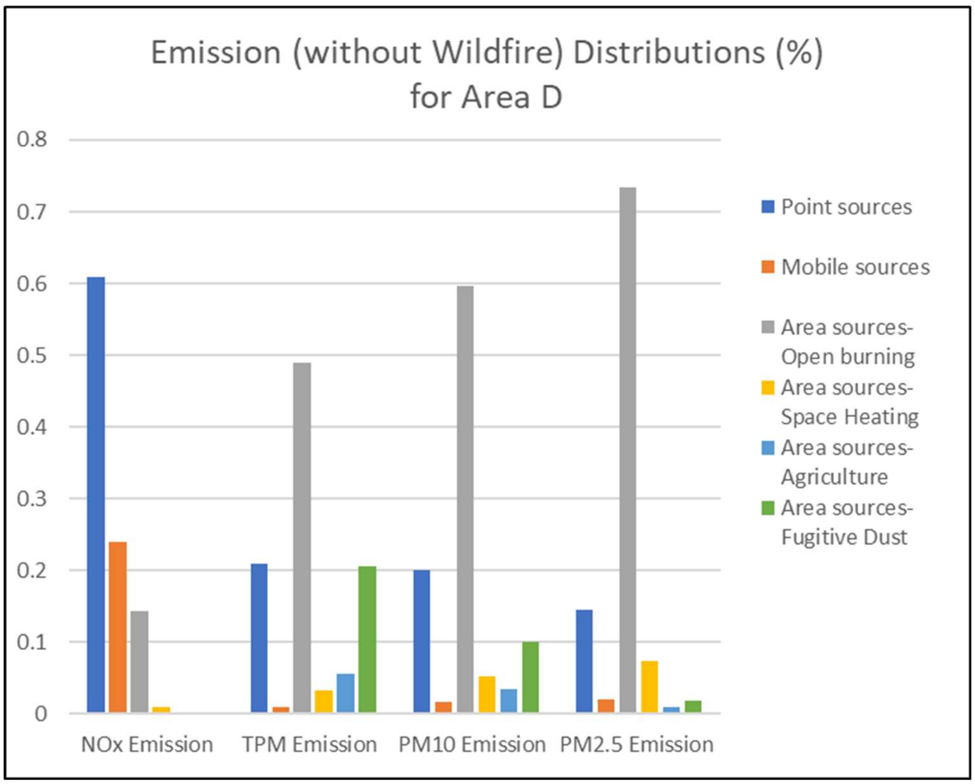


Figure 5: Emission Distributions (without Wildfire) (%) in Area D

Table 46: Emission Distributions for Area F in 2018

Emission Sources	Emission Distributions for Area F (tonnes/year)			
	NOx	TPM	PM_{10}	$PM_{2.5}$
Point sources	201	9.39	9.39	9.39
mobile sources	339	29.43	29.38	26.36
Area sources-Open burning	152	846	602	523
Area sources-Space Heating	11.04	63.41	59.89	59.85
Area sources-Agriculture	0.00	677	206	36.57
Area sources-Fugitive Dust	0.00	440	123	13.64
Area sources-Wildfire	111	5849	4270	3940
Total Emissions with Wildfire	**813**	**7914**	**5300**	**4609**
Total Emissions without Wildfire	**702**	**2065**	**1030**	**669**

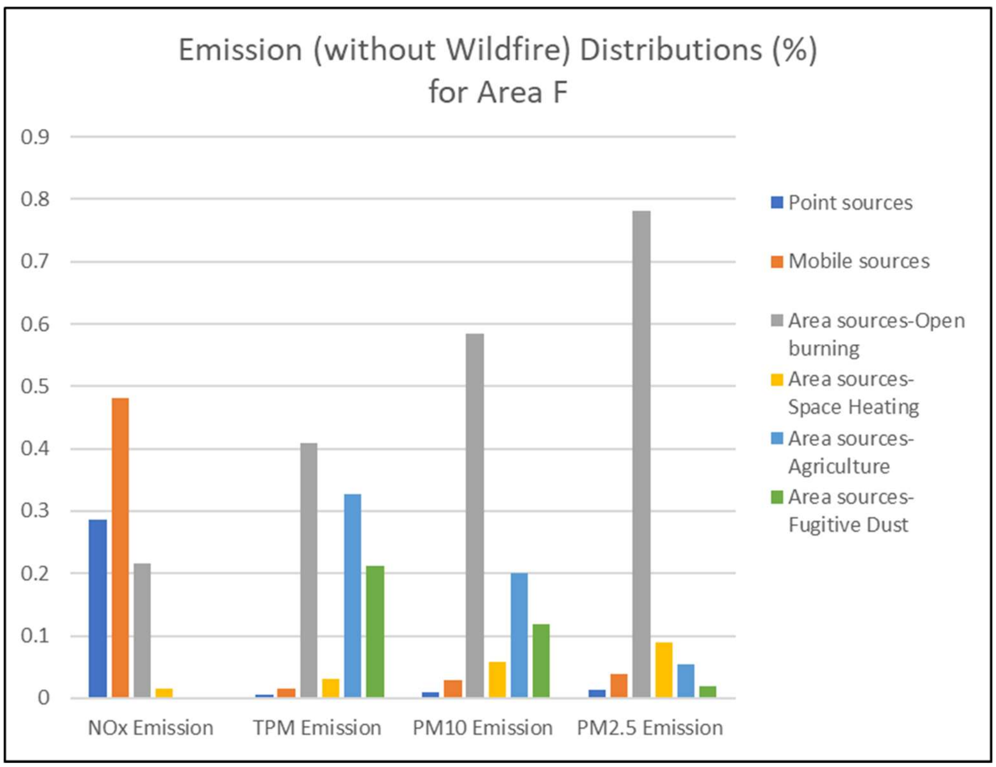


Figure 6: Emission Distributions (without Wildfire) (%) in Area F