Detailed Appendix

Contents

Detailed List of Activities Included in the Inventory

The inventory was compiled following guidance of the World Business Council for Sustainable Development (WBCSD) and World Resources Institute's (WRI) Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (2004), using the location-based Scope 2 methodology detailed within the GHG Protocol Scope 2 Guidance: An amendment to the GHG Protocol Corporate Standard.

It follows the GHG Protocol's operational control consolidation approach, under which McGill is required to account for 100% of the emissions from operations, facilities, and sources over which it has operational control.

Activity	Scope	Fuel or Gas	Exclusions	Rationale for Exclusions
On-site stationary combustion – large boilers	1	Natural gas, heating oil	None	N/A
On-site stationary combustion – small boilers	1	Natural gas, heating oil, propane	None	N/A
On-site stationary combustion – emergency power generators	1	Diesel, natural gas	Small research stations	No data available and emissions deemed minimal
Uncontrolled leaks of refrigerants	1	Various refrigerants	1) Stand-alone systems from some buildings 2) A/C window units 3) Refrigerants not covered by Kyoto Protocol	1) Data unavailable 2) No inventory of A/C window units 3) Reported separately
Uncontrolled leaks of electrical insulating gas	1	SF_6	None	N/A
On-site combustion – mobile equipment (grounds & landscaping)	1	Diesel	None	N/A
McGill-owned fleet of vehicles	1	Gasoline, diesel	None	N/A
Fertilizers	1	N/A	None	N/A
Livestock	1	N/A	None	N/A
Purchased electricity	2	Electricity	Small research stations	No data available and emissions deemed minimal
Purchased steam	2	Steam	None	N/A
Purchased hot and chilled water	2	Water	None	N/A
Directly financed air travel	3	N/A	None	N/A

Commuting	3	N/A	Commute to and from smaller campuses and research stations	No data available and emissions deemed minimal
Sport teams travel	3	N/A	Varsity teams only; clubs are not included	Emissions deemed minimal
Water supply & treatment	3	N/A	None	N/A
Macdonald Shuttle	3	Diesel, biodiesel	None	N/A
Power distribution losses	3	Electricity	Small research stations	No data available and emissions deemed minimal

List of Activities Reported Separately

Activity	Rationale for Separate Reporting	Exclusions	Rationale for Exclusions
Solid waste (domestic waste, hazardous waste, and construction waste)	This inventory reports GHG emissions avoided through McGill's waste management.	Waste from small research stations; hazardous and construction waste	No data available; hazardous and construction waste not currently part of reduction and diversion strategy
Refrigerants not regulated by the Kyoto Protocol	As per the GHG Protocol's "Corporate Accounting and Reporting Standard"	1) Standalone systems from some buildings 2) A/C window units	1) Data unavailable 2) No inventory of campus A/C units
Emissions data for biologically sourced fuels (e.g., from burning biomass/biofuels)	As per the GHG Protocol's "Corporate Accounting and Reporting Standard"	N/A	N/A
Carbon sequestration from the Morgan Arboretum & Gault Nature Reserve	As per the GHG Protocol's "Corporate Accounting and Reporting Standard"	Molson Reserve, Penfield property, Macdonald Farm	Initial research focused on the Arboretum and Gault Nature Reserve
Carbon offsets purchased from McGill-Bayano Reforestation Project	As per the GHG Protocol's "Corporate Accounting and Reporting Standard"	N/A	N/A

List of Activities Excluded from the Inventory

Activity	Rationale for Exclusion from Inventory Reporting
Research experiments	1) Incomplete data re: types and amounts of chemicals purchased 2) Calculating and/or monitoring types and amounts of experiment products and by-products is currently unfeasible 3) Emissions deemed minimal with respect to total institutional Scope 1 and Scope 2 emissions
Research animals	1) Data on types of animals and headcount are classified and unavailable 2) Given the types of research animals, direct emissions are presumed negligible compared to already-quantified Scope 1 and 2 livestock emissions
Directly financed travel other than air travel (e.g., train, bus, car rentals, and taxis, and trips by personal vehicle)	Information currently unavailable; working to obtain and/or model
Refrigerants, commuting, waste, water supply & water treatment for Gault Nature Reserve and the Bellairs Research Institute	Amounts are negligible and data are not readily available; working to obtain and/or model
Data for smaller offsite research stations	Information unavailable and/or hard to collect; energy for larger research stations has been included, such as Bellairs
Carbon sequestration rate from the Macdonald Farm, Molson Reserve, and Penfield Property	No data. Research conducted to date focused on our largest forested properties. Sequestration rate and potential for these lands may be estimated or investigated in the future.

Additional Buildings Included in Scope 3 Emissions

McGill goes beyond best practice by including in our Scope 3 emissions energy consumption from certain buildings over which we do not have operational control. We have also estimated data for a few smaller research stations and facilities whose emissions are relatively immaterial compared to our main campus emissions. These include the McGill Sub-Arctic Research Station (M-SARS) and energy consumption from the CLUMEQ super-computer shared with the École de technologie supérieure (ETS). We have included rented space at 1010 Sherbrooke and 550 Sherbrooke, the Dentistry Clinic at 2001 McGill College, Campus Outaouais, and other smaller office areas, as well as several cottages and small residences rented out to non-students at the Macdonald and Downtown campuses. We include energy consumption and resulting emissions for some shared buildings where we perceive full operational control. McGill's past and future inventories have been updated to reflect these same scoping and methodological decisions. For all owned or leased buildings with operational control, we have included relevant emissions as Scope 1 and 2.

Unique cases:

- **Buildings that were never or are no longer under McGill ownership or control** are excluded from the inventory. Examples include hospitals affiliated with McGill research or researchers, but that we do not own or have operational control over, such as the MUHC-GLEN, Douglas Hospital, Jewish General Hospital, Montreal General Hospital, and the Presbyterian College.

- **Buildings owned by McGill with emphyteutic leases** (i.e., over which McGill does not have operational control) are excluded from the inventory. These include McCord Museum, University 3605 – 3621 and the Moxley Building.

- **Buildings co-owned or jointly managed** with other organizations:
  - The Neuro: McGill owns the building and shares administration with the MUHC. We perceive operational control due to our current responsibility for the operations, maintenance, and upgrades to the building's HVAC systems. All energy consumption is therefore categorized Scope 1 or 2 as relevant.
  - Stewart Athletic Complex: McGill co-owns the building with John Abbott College. We perceive operational control since we are responsible for the operation and maintenance of the energy systems, so energy consumption is categorized as Scope 1 or 2 as relevant.

- **Buildings where McGill is a lessee without operational control:** In these instances, we cannot modify the building or energy systems and are not responsible for their operation or maintenance. We have included the relevant energy emissions as Scope 3 in our inventory. The buildings are: Aima Inc., Cote de Neiges 5858, 4920 de Maisonneuve West, the ETS-CLUMEQ computer, McGill College 2001, Le James @ 3544 ave du Parc, Peel 1555, Sherbrooke 550, Sherbrooke 1010, Sherbrooke 1980, UQAM Pavillion des Sciences, Leo Pariseau 300, 3501 Peel, 5100 de Maisonneuve West, Campus1 MTL, and Campus Outaouais.

- **Buildings where McGill is a lessee with operational control** are included in the inventory, and we have categorized energy consumption as Scope 1 or 2 as relevant. This includes Parc Avenue 3575.

2015 vs 2022 Greenhouse Gas Inventory

Our base year for comparison is 2015, as: (1) the 2015 inventory was the first to comply with the GHG Protocol; (2) relatively complete datasets were available for all material emission sources; and (3) the inventory was audited by McGill's internal audit team.

CATEGORY	ACTIVITY	2015 (tCO_2e)	2022 (tCO_2e)	Change (tCO_2e)	CHANGE (%)
Scope 1 (direct emissions)					
Stationary combustion	Natural gas	34,334	30,536	-3,798	-11%
	Propane	26	0	-26	-100%
	Heating oil	1,184	799	-385	-33%
	Diesel	98	165	67	68%
McGill-owned fleet of vehicles	Diesel vehicles	414	219	-196	-47%
	Gasoline vehicles	207	138	-69	-33%
	Propane vehicles	9	0	-9	-100%
Refrigerants & chemicals	Refrigerants	1,436	1,677	241	17%
	Insulating gas	47	47	0	0%
Agriculture	Livestock	520	702	182	35%
	Fertilizers	73	82	9	13%
All Scope 1		**38,348**	**34,364**	**-3,984**	**-10%**
Scope 2 (indirect energy emissions)					
Purchased energy	Electricity	261	250	-11	-4%
	Steam	952	706	-245	-26%
	Hot water	2,787	2,673	-114	-4%
	Chilled water	0.2	0	0	67%
All Scope 2		**4,000**	**3,630**	**-370**	**-9%**
Scope 3 (indirect emissions)					
Stationary combustion	Natural gas	1,000	1,462	463	46%
	Electricity	14	23	8	60%
Commuting (faculty, staff, and students)		6,705	4,649	-2,056	-2056
Third-party fleet	Macdonald shuttle	176	267	91	52%
Air travel	Directly financed air travel	8,223	3,317	-4,906	-60%

Sports team travel	Air	153	47	-106	-69%
	Bus	78	34	-44	-56%
	Public transit	2	0	-2	-100%
	Taxi + car	0.002	1	1	32258%
Water	Supply	167	137	-30	-18%
	Treatment	322	261	-62	-19%
Energy losses	Transmission & distribution	20	21	1	7%
All Scope 3		**16,861**	**10,219**	**-6,642**	**-39%**
Total Emissions		**59,209**	**48,213**	**-10,996**	**-19%**

NON-INVENTORY CATEGORY	ACTIVITY	2015 (tCO_2e)	2022 (tCO_2e)	Change (tCO_2e)	CHANGE (%)
Avoided emissions from waste management	Solid waste - recycling	-1,006	-2,674	-1,668	+166%
	Solid waste - composting	-114	-133	-19	+17%
	Total	**-1,120**	**-2,807**	**-1,687**	**+151%**
Refrigerants governed by Montreal Protocol	Refrigerants (e.g., R22)	242	269	+27	+11%
Biogenic emissions	Macdonald shuttle, biodiesel	-	28	+28	-
	Renewable natural gas	-	346	+346	-

Calculation Methodology

Data Sources and Calculation Methods

Abbreviations:

- **FAMIS:** McGill University's Facilities Management and Space System
- **MDDELCC:** Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques du Québec
- **ECCC:** Environment and Climate Change Canada
- **NRCan:** Natural Resources Canada
- **UK BEIS:** United Kingdom Department for Business, Energy and Industrial Strategy
- **US EPA:** United States Environmental Protection Agency

100-year Global Warming Potentials were sourced from the IPCC's 6th Assessment Report released in August 2021.

Scope 1			
Activity	**Data Source**	**Calculation Method**	**Emission Factor Source**
Generators, Downtown	Invoices collected by Facilities Accounting; financial database	Emission factor	MDDELCC
Generators, Macdonald	Invoices collected by Facilities Accounting; financial database	Emission factor	MDDELCC
Grounds, Downtown	Invoices collected by Facilities Accounting; financial database	Emission factor	ECCC
Heating oil, Downtown	Invoices collected by Facilities Accounting; financial database	Emission factor	MDDELCC
Heating oil, Macdonald	Invoices collected by Facilities Accounting; financial database	Emission factor	MDDELCC
Natural gas, large boilers	Invoices collected by Utilities & Energy Management	Emission factor	ECCC
Natural gas, small boilers	Invoices collected by Utilities & Energy Management	Emission factor	ECCC
Renewable Natural Gas	Invoices collected by Utilities & Energy Management	Emission factor	MDDELCC

Purchased steam	Meter data read by Utilities & Energy Management & MUHC invoices	Estimate of production + generation efficiency Emission factor method	ECCC
Vehicles & Grounds, Macdonald	Report from Supervisor of Property and Maintenance based on vehicle logs	Emission factor	MDDELCC, ECCC, NRCan
Vehicles, Downtown	Report from fleet management software from Parking and Transportation Services	Emission factor	MDDELCC, ECCC, NRCan
Vehicles, Research	List of assets from Risk Management & Insurance unit	Emission factor	MDDELCC, ECCC, NRCan
Fertilizers, Macdonald, Lods, and Horticulture Centre	Volumes and types spread according to Chief Agronomy Technicians	Emission factor	US EPA
Livestock	Estimate of headcount and manure management by Farm Manager	Emission factor	ECCC
Refrigerants, Downtown	List of assets from Downtown Operations	Estimate of leak rate Emission factor method	MDDELCC, IPCC
Refrigerants, Macdonald	List of assets from Macdonald Operations	Estimate of leak rate Emission factor method	MDDELCC, IPCC
Insulating gas	List of assets from FAMIS	Emission factor	MDDELCC, IPCC
Scope 2			
Activity	**Data Source**	**Calculation Method**	**Emission Factor Source**
Electricity	Annual report to the Ministry of Higher Education compiled by Facilities Accounting & invoices from Hydro-Québec	Emission factor	ECCC, UNEP/DTU
Electricity, other SHHS buildings	Invoices compiled by Utilities & Energy Management	Emission factor	ECCC
Scope 3			
Activity	**Data Source**	**Calculation Method**	**Emission Factor Source**
Air travel, directly funded	Report from McGill's Travel Helpdesk based on	Emission factors	UK BEIS

	reimbursement requests to Financial services		
Commuting	2011 and 2020 McGill Transportation Survey reports (TRAM) and 2021 Sustainability Survey	Emission factors	STM, ECCC, US EPA
Solid waste: Domestic waste, recycling & compost, Downtown	Report from service suppliers	Calculate reductions from reference scenario	US EPA Warm Model
Solid waste: Composting, Macdonald	Estimates from the Supervisor of Property Maintenance	Calculate reductions from reference scenario	US EPA Warm Model
Solid waste: Domestic waste, recycling, Macdonald	Report from service suppliers	Calculate reductions from reference scenario	US EPA Warm Model
Macdonald Shuttle	Fuel reports from supplier	Emission factor	ECCC, US EPA
Sport teams travel	Athletics travel records	Emission factor	UK BEIS, ECCC, STM
Water supply and treatment	Water audits from Utilities & Energy Management	Emission factor	In-house (McGill)

Emission Factors

Applied emission factors were either sourced from reputable third-party organizations, typically government reports, or developed in-house according to McGill's own systems or transit behaviour. Annual updates to third-party emissions factors were incorporated as necessary and available.

Fuel or Activity	Organization	Source
Air travel – short, medium, and long haul (average class)	UK BEIS	2022 Government GHG Conversion Factors for Company Reporting, Air Travel
Electricity (Québec)	ECCC	National Inventory Report 1990 – 2021: Greenhouse Gas Sources and Sinks in Canada. Part 3, Table A13-6
Electricity (Barbados)	UNEP/DTU	Analysis of Grid Emission Factors for the Electricity Sector in Caribbean Countries, Annex 4
Fertilizers (various)	US EPA	Emissions Factors & AP 42, Compilation of Air Pollutant Emission Factors, Ch. 14.1
Diesel – stationary combustion	MDDELCC	LRQ Q-2, r. 15, Table 1-3, Diesel
Diesel – mobile equipment, on-road	MDDELCC	LRQ Q-2, r. 15, Table 27-1, Diesel vehicle
Diesel – mobile equipment, off-road	ECCC	National Inventory Report 1990 – 2021: Greenhouse Gas Sources and Sinks in Canada, Part 2, Table A6.1-14

Gasoline – mobile equipment, on-road	MDDELCC	LRQ Q-2, r. 15, Table 27-1, Gasoline vehicle
Gasoline – mobile equipment, off-road	ECCC	National Inventory Report 1990 – 2021: Greenhouse Gas Sources and Sinks in Canada, Part 2, Table A6.1-14
Propane – mobile equipment	MDDELCC	LRQ Q-2, r. 15, Table 27-1, Propane vehicle
Heating oil	MDDELCC	LRQ Q-2, r. 15, Table 1-3, Light fuel oil, Institutional
Sulphur hexafluoride (SF_6)	IPCC	Climate Change 2021: The Physical Science Basis, WGI Sixth Assessment Report. Table 7.SM.7. Page 7SM-24 to 7SM-29.
Livestock (various)	NRCan	National Inventory Report 1990 – 2021: Greenhouse Gas Sources and Sinks in Canada, Part 2, Tables A3.4-19–25 and A6.4-1–2. National Inventory Report 1990 - 2011, Annex 8, Table A8-25.
Natural gas – stationary combustion	ECCC	National Inventory Report 1990 – 2021: Greenhouse Gas Sources and Sinks in Canada, Part 2, Tables A6.1-1 and A6.1-3
Propane	MDDELCC	LRQ Q-2, r. 15, Table 1-3, Propane – All other uses
Refrigerants (various)	IPCC	Climate Change 2021: The Physical Science Basis, WGI Sixth Assessment Report. Table 7.SM.7. Page 7SM-24 to 7SM-29.
Diesel – coach bus	ECCC	National Inventory Report 1990 – 2021: Greenhouse Gas Sources and Sinks in Canada, Part 2, Table A6.1-14
Biodiesel – bus	US EPA	Emission Factors for GHG Inventories. EPA Centre for Corporate Climate Leadership. Table 2.
Diesel – bus	MDDELCC	LRQ Q-2, r. 15, Table 27-1, Diesel vehicle
Taxi	ECCC	National Inventory Report 1990 – 2021: Greenhouse Gas Sources and Sinks in Canada, Part 2, Table A6.1-14
Public transit	STM US EPA	Direct communication. Emission Factors for GHG Inventories. EPA Centre for Corporate Climate Leadership. Table 10.
Water supply	McGill	Fall 2015 ENVR401 student project. Emission factors were calculated from information collected from the City of Montreal, City of Sainte-Anne-de-Bellevue, and Montreal Wastewater Treatment Plant.
Water treatment	McGill	

Key Assumptions

Complete, primary data were used whenever possible. For certain emissions sources, data were either unavailable or incomplete, and assumptions and modelling were necessary to conservatively estimate associated emissions.

Stationary Energy Consumption

- Electricity consumption data for major accounts span May–April (fiscal year as reported to the Ministère de l'Enseignement supérieur), rather than the calendar year. However, this has little impact on the inventory since electricity-related emissions are not significant given the low-carbon intensity of Quebec's electrical grid.
- For all buildings with missing energy data (typically smaller buildings or buildings where McGill is the lessee or lessor to a non-student individual), electricity consumption was estimated using an annual energy intensity factor (GJ/m^2) for base load electricity, specific to the Commercial and Institutional sector in Québec (Natural Resources Canada).
- For all buildings with missing energy data, heating and hot water energy consumption was similarly estimated, using an annual energy intensity factor (GJ/m^2) for space heating and domestic hot water in the same sector and location as noted above (Natural Resources Canada). In buildings where the energy source of heating was unknown, natural gas was assumed as a conservative measure. To convert annual energy intensity to fuel combustion, estimated average system efficiencies were applied per energy source (100% for electricity, 80% for natural gas and 75% for heating oil).
- Steam consumption data for the MNI/MNH (Neuro) building was obtained through steam meter data from 2022 MUHC invoices (steam is provided from the Royal Victoria Hospital boiler plant). Total steam consumption was converted into natural gas equivalent by assuming the same distribution efficiency (90%) and combustion efficiency (29 lb/m^3) as for McGill's downtown steam distribution.
- Heating hot water and domestic hot water consumption for the MNI/MNH (Neuro) was obtained from meter readings for 2022 taken from invoices from the MUHC and converted into the natural gas equivalent assuming a distribution efficiency of 95% and combustion efficiency of 90%. Heating and domestic hot water is provided from the Royal Victoria Hospital boiler plant.
- Chilled water consumption from Second Investment (from whom we receive utilities for two buildings) was calculated using a coefficient of performance of 4.0 to determine the electricity consumption corresponding to monthly chilled water invoices for 2022.
- Hot water consumption from Second Investment was calculated using an overall efficiency of 90% to determine the volume of natural gas corresponding to monthly hot water invoices for 2022.
- Electricity and natural gas consumption for the Stewart Athletics Complex was estimated using total cost amount invoiced from John Abbott College in 2022 and assuming a \$0.0701/kWh electricity rate and \$0.398/m^3 for natural gas.

- Heating-related natural gas consumption for the Stewart Athletics Complex was estimated based off actual natural gas consumption for 2022 and adjusted for McGill's portion of the consumption (14.3%).

Vehicle Fleet

- Fuel consumption data for vehicles and mobile equipment at Macdonald Campus was available per vehicle (for Farm and Facilities vehicles), while fuel consumption data for most vehicles and mobile equipment at the Downtown Campus was available aggregated by fuel type (gasoline vs. diesel) in ARI fleet management solution reports. ARI reports aggregate all non-diesel fuels (e.g., ethanol, methanol) into the gasoline total.
- Actual fuel consumption data for a couple vans and light duty vehicles as well as several specialized vehicles downtown—including ATVs, boats, snowmobiles, tractors, forklifts and seadoos—was not available from either of the above data sources. Fuel consumption for the van and light duty vehicles were estimated using average fuel efficiency values per fuel type sourced from the ARI report. Fuel consumption for each category of specialized vehicle was estimated using researched fuel efficiency and usage metrics specific to vehicle type.
- All vehicles and mobile equipment were categorized as either "on-road" (e.g., cars, pickup trucks, vans, SUVs, and maintenance vehicles) or "off-road" (e.g., tractors, ATVs, forklifts, boats, seadoos and small machinery) to allow the application of emission factors specific to off-road and on-road vehicles. All vehicles included in the ARI fuel reports were considered "on-road".

Process Gases

- The amount of refrigerant used and lost per system is not directly available. Refrigerant gas loss for various buildings and systems was estimated following the calculation of the total cooling capacity per system (in BTU/hour or tons of refrigeration) using LEED's methodology and the below assumptions and default values:
    - 2% leakage rate (LEED default value)
    - 10 years equipment lifetime (LEED default value)
    - 10% end-of-life refrigerant loss (LEED default value)
    - Refrigerant charge of 5.0 lbm per ton of cooling
- Using the above data and methodology, the lifetime emissions of the system were calculated and divided by the expected equipment lifetime to estimate annual leakage.
- For refrigeration equipment where the refrigerant gas used was unknown, the most commonly used refrigerant was assumed (R-134a). If no cooling capacity data was available for a piece of equipment, it was not included.

Agriculture and Livestock

- Headcount data and manure management details (e.g., % liquid systems vs. % solid storage; dry lot vs. % pasture, range; and paddock vs. % other) were provided for the Macdonald farm per species of livestock.

- Fertilizer data were provided as quantity spread per fertilizer type for the Macdonald Farm, Lods Research Centre, and Horticultural Centre.
- The EPA's methodology[1] for calculating nitrous oxide emissions from commercial fertilizer was applied to calculate nitrogen content per fertilizer type and resulting emissions.

Commuting

- Jan–Feb 2022 travel was estimated using the Transportation Research at McGill (TRAM)[2] 2020 Transportation Survey of our community's mobility and commuting habits, adjusted for 2022 population numbers.
    - We assumed that Jan–Feb 2022 travel *modes* were equivalent to Jan–Feb 2020 travel modes, but Jan–Feb 2022 travel *frequency* was equivalent to Apr–Aug 2020 travel frequency, given pandemic lockdowns.
    - The 2020 TRAM survey estimated total driving-related GHG emissions based on the person's distance, travel frequency, and make and model of car multiplied by the corresponding expansion factor weighting based on the total McGill population.
    - Transit-related emissions were not calculated in the survey but added for the purposes of our inventory. The total distance traveled in kilometers by bus and rail for each observation and type of transit was multiplied by the corresponding expansion factor and emissions factor.
- Mar–Apr 2022 travel was estimated using the 2011 TRAM survey of our community's mobility and commuting habits (Winter semester) at 60% for staff to reflect COVID measures and adjusted for 2022 population numbers.
- May–Aug 2022 travel was estimated using the 2011 TRAM survey of our community's mobility and commuting habits (Summer semester) at 75% for staff to reflect COVID measures in May and Interim Flexible Work Arrangement as of end of May and adjusted for 2022 population numbers.
- Sep–Dec 2022 travel was estimated using responses to the 2021 Sustainability Survey adjusted for 2022 population numbers. Faculty, staff, and students were asked to estimate how many times per week on average they came to their respective campuses, how far they traveled, and by which usual modes of transport for the Fall 2021 semester.
- An emissions factor of 0 was assumed for travel by metro since emissions are negligible (near-zero) compared to our gross emissions.
- One-way travel (to campus only) was used to be consistent with past inventories based on the 2011 TRAM survey.

Air Travel

- Air travel data were sourced from McGill's expense reporting system, which does not currently request details related to flight origin (but rather only destination), route, multiple legs, or class of travel. The following assumptions were made to account for these gaps in data:
    - Flight class was "average" for all flights.
    - All flights were direct, unless otherwise stated.

[1] https://www3.epa.gov/ttnchie1/ap42/ch14/final/c14s01.pdf
[2] https://tram.mcgill.ca/

  - All flights originated from Montreal's Pierre Elliot Trudeau airport (YUL) and returned to this airport unless otherwise stated.
  - For "Destination City" entries with multiple destinations listed, flight route was in the order entered in the expense report.
- For "Destination City" entries that were stated as a whole country or province/state/region (e.g., "France" or "Florida") and not a specific city, either the capital city or the largest nearby city with an international airport was used, as appropriate.
- Unless stated in the "Destination City" information (e.g., JFK, LHR), airports were determined using the city in the "Destination City" entry and the "TravelMath – nearest major airport" function on https://www.travelmath.com/flights/. The closest international airport was selected as a default unless the closest international airport was a) >400km away or b) located in another country. In these cases, the closest regional airport may have been used.
- Some flights in the Canada dataset were labelled with a "Destination City" of Montreal (various spellings) or MTL. Per the note in the Minerva expense reporting system, which indicates that entries of "Destination City – Montreal" and "Country – Canada" are not travel, these entries were assumed to not be air travel.
- When flights had non-usable "Destination City" entries (e.g., "Various cities", "Aug 26"), in the absence of usable flight data, a median $/mile was calculated from all usable data per dataset and applied to estimate the total distance (and haul category) for these rows.

Macdonald Shuttle

- Since 2019, the Macdonald shuttle bus runs on at least 20% biodiesel, except during the coldest winter months. The emission factor for 100% biodiesel (EPA) was applied to the biofuel share and the emission factor for diesel buses (ECCC) was applied to the remaining consumption.

Sports Team Travel

- Data include the team, origin, and destination of trips, travel mode, number of travelers (i.e., number of team members) or number of vehicles, and travel date. Total return distance was calculated using Google Maps.
- It was assumed that three people travel per taxi, that all athletes traveled to and from airports by taxi, and that this distance was on average 50 km. All taxis and personal vehicles were assumed equivalent to average gasoline cars (ECCC).

Water Supply and Treatment

- Annual water input data was available for approximately 54% of Downtown campus buildings and 61% of Macdonald campus buildings (by area). Consumption for the remaining buildings was estimated using average water use intensity factors (m^3/year/m^2) specific to each campus. To account for water savings achieved since 2016, consumption associated with estimated savings was removed from the Downtown campus' consumption total.

- Water volume attributed to process losses was aggregated with estimated water volume lost to leakage for each campus. Both values were sourced from an ENVR401 student group's applied research conducted for this purpose. Total water output volume was then calculated for each campus and assumed equivalent to wastewater treated.

Transmission & Distribution (T&D) Losses

- Electricity lost to transmission & distribution was estimated using average T&D loss factors. Electricity lost to transmission & distribution was based on loss factors published in HEC Montréal's rapport "Les Surplus Électriques Au Québec 2020", page 9 for Hydro-Québec. T&D losses for the Barbados were based on factors published in the U.S. Department of Energy's Energy Transitions Initiative Energy Snapshot for Barbados, June 2020.

Macdonald Campus Composting

- CY2017 estimates are used since the City of Ste-Anne-de-Bellevue collects compost from the Macdonald campus, and new processes for Mac waste were instated following separation from downtown waste in 2018.

Equations

Commuting

Activity: commuting of McGill students, faculty, and staff to Downtown, Macdonald, and Gault campuses

As per the 2020 TRAM survey, total individual incremental CO_2e = weeks in period * typical weekly one-way trips * (motorized, non-transit travel distance in km/number of people in a carpool to reflect proportional emissions) * CO_2e per kilometre. These results were then multiplied by expansion factors for the 2022 population.

As per the 2011 TRAM survey, TRAM calculated average emission factors for annual commuting emissions per student and per staff. These results were then multiplied by expansion factors for the 2022 population.

In the 2021 Sustainability Survey:

Equation 1: Calculation of greenhouse gas emissions from commuting

$$CO2e = \left(\sum_{i=1}^{n} Days_{\,i} \times Distance_{\,i} \times \left(EF_{CO2,i} \times GWP_{CO2} + EF_{CH4,i} \times GWP_{CH4} + EF_{N2O,i} \times GWP_{N2O}\right)\right) \times ExF$$

Where:

$CO2e$ is the total greenhouse gas emissions in CO_2 equivalent for students, faculty, and staff

Index *i* refers to each travel mode

n is the total number of respondents

$Days_{\ i}$ is the average number of days travelled per week for each travel mode

$Distance_i$ is the total distance travelled in passenger-km for each travel mode

$EF_{CO2,i}$ is the CO_2 emission factor for travel mode *i* (same for CH_4 and N_2O)

$EF_{CO2,i}$ has different values depending on travel mode

GWP_{CO2} is the global warming potential of CO_2 (same for CH_4 and N_2O)

ExF is the expansion factor used to estimate emissions for all students, faculty, and staff

Directly Financed Air Travel

Activity: air travel financed by McGill (faculty, students, and staff)

Activity level: annual compilation of reimbursement claims submitted by all travellers

Equation 2: Calculation of greenhouse gas emissions from directly financed air travel

$$CO2e = \sum_{i=1}^{n} Distance_{\ i} \times \left(EF_{CO2,i} \times GWP_{CO2} + EF_{CH4,i} \times GWP_{CH4} + EF_{N2O,i} \times GWP_{N2O}\right)$$

Where:

CO2e = total greenhouse gas emissions in CO_2 equivalent

Index *i* refers to each journey

n is the total number of journeys, which excludes entries of "Montreal" in the Canada set, per Minerva expense reporting indications that these entries are not travel-related

$Distance_i$ is the total distance travelled in passenger-km for each journey

$EF_{CO2,i}$ is the CO_2 emission factor for journey *i* (same for CH_4 and N_2O)

$EF_{CO2,i}$ has different values depending on the length of the journey leg (short haul <300 miles, medium haul ≥300 miles and <2,300 miles, and long haul ≥2,300 miles) (same applies to CH_4 and N_2O)

GWP_{CO2} is the global warming potential of CO_2 (same for CH_4 and N_2O)

Sport Teams Travel

Activity: sport teams travelling to sports games and competitions

Activity level: total distance travelled by mode per team

Equation 3: Calculation of the greenhouse gas emissions from sport teams travels

$$CO2e = \sum_{i=1}^{n} Distance_{\ i} \times \left(EF_{CO2,i} \times GWP_{CO2} + EF_{CH4,i} \times GWP_{CH4} + EF_{N2O,i} \times GWP_{N2O}\right)$$

Where:

CO2e = total greenhouse gas emissions in CO_2 equivalent

Index i refers to each journey

n is the total number of journey

$Distance_i$ is the total distance travelled in passenger-km for each journey

$EF_{CO2,i}$ is the CO_2 emission factor for journey *i* (same thing for CH_4 and N_2O)

$EF_{CO2,i}$ has different values depending on transportation mode and on the length of the journey leg for air travel

GWP_{CO2} is the global warming potential of CO_2 (same thing for CH_4 and N_2O)

Fertilizers

Chemicals: different types of fertilizers

Activity level: annual report from Macdonald Campus (Farm, Horticultural Centre, LODS Research Centre)

Equation 4: Calculations of GHG emissions from fertilizers

$$CO2e = \left(\sum_{i=1}^{n} FC_i \times \%N_i \times EC \times \frac{44}{28}\right) \times GWP_{N2O}$$

Where:

Index *i* refers to each type of fertilizer used; *n* is the total number of types of fertilizers used

FC_i is the mass of fertilizer spread

$\%N_i$ is the nitrogen content of fertilizer *i*

EC is the emission coefficient and equals 0.0117 tons N_2O-N per ton of N applied

$\frac{44}{28}$ is the molecular weight ratio of N_2O to N_2O as N (i.e., $N_2O \div N_2O$-N)

GWP_{N2O} is the global warming potential of N_2O

Livestock

Activity: different types of farm animals

Activity level: average headcounts estimated for each type of livestock by the manager of the Macdonald Farm

Emissions come from enteric fermentation and manure management.

Equation 5: Calculation of GHG emissions from farm animals

$$CO2e = (CH4_{EF} + CH4_{MM}) \times GWP_{CH4} + N2O_{MM} \times GWP_{N2O}$$

Where:

$CO2e$ is the total greenhouse gas emissions in CO_2 equivalent from farm animals

$CH4_{EF}$ is the total CH_4 emissions from enteric fermentation for all animal categories

$CH4_{MM}$ is the total CH_4 emissions from manure management for all animal categories

$N2O_{MM}$ is the total N_2O emissions from manure management for animal categories

GWP_{CH4} and GWP_{N2O} are the global warming potentials of CH_4 and N_2O respectively

Equation 6: Calculation of CH_4 emissions from enteric fermentation

$$CH4_{EF} = \sum_{i} N_i \times EF_{EF_i}$$

Where:

$CH4_{EF}$ is the total CH_4 emissions from enteric fermentation for all animal categories

Index *i* refers to each animal category

N_i is the total population of each animal category

EF_{EF_i} is the CH_4 emission factor from enteric fermentation for each animal category

Equation 7: Calculation of CH_4 emissions from manure management

$$CH4_{MM} = \sum_{i} N_i \times EF_{MM_i}$$

$CH4_{MM}$ is the total CH_4 emissions from manure management for all animal categories

Index *i* refers to each animal category

N_i is the total population of each animal category

EF_{MM_i} is the CH_4 emission factor from manure management for each animal category

Equation 8: Calculation of N_2O emissions from manure management

$$N2O_{MM} = \sum_{j}\sum_{i} N_i \times N_j \times N_{EX,i} \times EF_j \times \frac{44}{28}$$

$N2O_{MM}$ is the total N_2O emissions from manure management for all animal categories

Index *j* refers to each type of waste management system

Index *i* refers to each animal category

N_i is the total population of each animal category

N_j is the percentage of nitrogen handled by each animal waste management system

$N_{EX,i}$ is the nitrogen excretion rate for each animal category

EF_j is the N_2O emission factor from manure management for each animal waste management system

On-Site Mobile Equipment

Fuels: diesel, gasoline

For centrally managed vehicles, including Macdonald Farm and FMAS vehicles:

Activity level: from ARI fleet management solution

Equation 9: Calculation of the GHG emissions from mobile combustion

$$CO2e = \sum_{i=1}^{n} Fuel_{\,i} \times \left(EF_{CO2,i} \times GWP_{CO2} + EF_{CH4,i} \times GWP_{CH4} + EF_{N2O,i} \times GWP_{N2O}\right)$$

Where:

CO_2e = total greenhouse gas emissions in CO_2 equivalent

Index *i* refers to each activity

n is the total number of activities

$Fuel_{\,i}$ is the amount of fuel (volume) consumed during the reporting period

$EF_{CO2,i}$ is the CO_2 emission factor for activity *i* (same thing for CH_4 and N_2O)

GWP_{CO2} is the global warming potential of CO_2 (same thing for CH4 and N_2O)

For remaining research and other vehicles:

Activity level: the following assumptions were made:

- Passenger cars: same fuel efficiency as calculated for the centrally managed fleet of vehicles
- Snowmobiles, seadoos, and ATVs: annual distance travelled was estimated

On-Site Stationary Combustion

Fuels: natural gas, heating oil, propane, diesel

Activity level: collected from invoices

Equation 10: Calculation of GHG emissions from stationary combustion

$$CO2e = \sum_{i=1}^{n} Fuel_{\ i} \times \left(EF_{CO2,i} \times GWP_{CO2} + EF_{CH4,i} \times GWP_{CH4} + EF_{N2O,i} \times GWP_{N2O}\right)$$

Where:

CO_2e = total greenhouse gas emissions in CO_2 equivalent

Index *i* refers to each activity

n is the total number of activities

$Fuel_{\ i}$ is the amount of fuel (mass or volume) consumed during the reporting period

$EF_{CO2,i}$ is the CO_2 emission factor for activity *i* (same thing for CH_4 and N_2O)

GWP_{CO2} is the global warming potential of CO_2 (same thing for CH_4 and N_2O)

Electricity

Equation 11: Calculation of greenhouse gas emissions from electricity consumption

$$CO2e = \sum_{i=1}^{n} Fuel_{\ i} \times EF_i$$

$CO2e$ is the total greenhouse gas emissions from electricity consumption in CO_2 equivalent

Index *i* refers to each supplier

$Fuel_{\ i}$ is the total electricity purchased from supplier *i*

EF_i is the emission factor for each utility company in g CO_2 equivalent per kWh consumed

Fuel: electricity generated by Hydro Québec for facilities in Québec and BLPC for facilities in Barbados

Activity level: energy consumption from invoices

Purchased Chilled Water

Fuel: Chilled water supplied by a third party.

Activity level: meter readings

Equation 12: Estimating the electrical equivalent of purchased chilled water

$$Electrical\ equivalent = \frac{Chilled\ water\ consumption}{COP} \times Conversion\ Factor$$

Where:

Electrical equivalent: electrical consumption to deliver chilled water to McGill

Chilled water consumption: as read from energy meters

COP: coefficient of performance, assumed 4.0

The volume of electricity calculated is then used in ***Equation 11*** to calculate the equivalent CO_2 emissions.

Purchased Domestic Hot Water

Fuel: Domestic hot water supplied by a third party

Activity level: meter readings

Equation 13: Estimating the natural gas equivalent of purchased domestic hot water

$$Natural\ gas\ equivalent = \frac{V\ \times \rho \times c \times dT \times Conversion\ Factor \times HHV}{Eff.}$$

Where:

V: volume of hot water as read from flow meters

ρ: density of water

c: specific heat of water

dT: assumed temperature differential of street water to supplied domestic hot water temperature

HHV: higher heating value of natural gas

Efficiency: assumed boiler efficiency

Conversion factor: British thermal units to GJ

The volume of natural gas calculated is then used in ***Equation 10*** to calculate the equivalent CO_2 emissions.

Purchased Hot Water

Fuel: hot water supplied by a third party (the MUHC)

Activity level: meter readings

Equation 14: Estimating the natural gas equivalent of purchased hot water

$$Natural\ gas\ equivalent = \frac{Hot\ water\ consumption}{Production\ eff. \times Distribution\ eff.} \times Conversion\ Factor$$

Where:

Natural gas equivalent: natural gas consumption to deliver hot water to McGill

Hot water consumption: as read from energy meters

Production efficiency: assumed to be 90%

Distribution efficiency: assumed to be 95%

Conversion factor: British Thermal Units to cubic meters of natural gas

The volume of natural gas calculated is then used in ***Equation 10*** to calculate the equivalent CO_2 emissions.

Purchased Steam

Fuel: steam supplied by a third party (the MUHC)

Activity level: meter readings

Equation 15: Estimating the natural gas equivalent of purchased steam

$$Natural\ gas\ equivalent = \frac{Steam\ consumption}{Production\ eff. \times Distribution\ eff.}$$

Where:

Natural gas equivalent: natural gas consumption at the MUHC powerhouse to deliver steam to McGill

Steam consumption: as read by McGill's steam meter or invoice

Production efficiency: assumed to be 29 lb/m^3 of natural gas, i.e. similar to McGill's own powerhouse

Distribution efficiency: assumed to be 90%, i.e. similar to McGill's own steam distribution

The volume thus calculated is then used in ***Equation 10*** to calculate the equivalent CO_2 emissions.

Solid Waste

Activity: avoided greenhouse gas emissions from the management of waste generated on the Downtown and Macdonald campuses

Activity level: monthly reports from contracted landfilled waste, recycling, and compost suppliers (downtown campus) + monthly reports from contracted landfilled waste and recycling and estimates of compost at Macdonald Campus.

The difference between the baseline (100% of waste to landfill) and actual (a mix of recycling, composting, and landfilling) disposal streams was calculated using the US EPA's WARM model. The different categories considered are yard trimmings, mixed paper, mixed recyclables, food waste, and mixed municipal solid waste (MSW).

Power Transmission & Distribution (T&D) Losses

Activity: electricity transmission and distribution losses

Activity level: calculated from utility invoices (Hydro Québec and BLPC)

Equation 16: Calculation of greenhouse gas emissions from power transmission and distribution losses

$$CO2e = \sum_{i=1}^{n} Fuel_{\ i} \times TDLF_i \times EF_i$$

Where:

$CO2e$ is the total greenhouse gas emissions from electricity transmission and distribution losses in CO_2 equivalent

Index *i* refers to each supplier

$Fuel_{\ i}$ is the total electricity purchased from supplier i

$TDLF_i$ is the average transmission and distribution loss factor for supplier i

EF_i is the emission factor for each utility company in g CO_2 equivalent per kWh consumed

Uncontrolled Leaks of Electrical Insulating Gas

Chemical: SF_6

Activity level: calculated using an annual leakage rate of 0.5%

Equation 17: Calculation of GHG emissions from uncontrolled leaks of SF_6

$$CO2e = \sum_{j=1}^{m} Mass\ SF6_j \times\ LR \times GWP_{SF6}$$

Where:

$CO2e$ is the total greenhouse gas emissions from uncontrolled leaks of SF_6 in CO_2 equivalent

Index *j* refers to each electrical system which contains SF_6; *m* is the total number of systems

$Mass\ SF6_j$ is the total mass of SF_6 contained in system *j*

LR is the annual leakage rate of SF_6, assumed to be 0.5%

GWP_{SF6} is the global warming potential of SF6

Uncontrolled Leaks of Refrigerants

Chemicals: different types of refrigerants

Activity level: calculated using the equations below

Equation 18: Calculation of the amount of refrigerant leaked by mechanical systems

$$Ref_{i,j} = RC_{i,j} \times \left(LR_j + \frac{EOL_j}{EL_j} \right)$$

Where:

$Ref_{i,j}$ is the amount of refrigerant *i* leaked by system *j* annually

$RC_{i,j}$ is the charge of refrigerant *i* of system *j*, $RC_{i,j} = CC_j \times UC$

CC_j is the total cooling capacity of system *j*

UC is the unitary charge of refrigerant, assuming 5 lbm of refrigerant per ton of cooling

LR_j is the annual leakage rate of system *j*, assumed to be 2% for all systems

EOL_j is the end of life refrigerant loss of system *j*, assumed to be 10%

EL_j is the equipment life of system *j*, set to 10 years by default

Equation 19: Calculation of GHG emissions from uncontrolled leaks of refrigerants

$$CO2e = \sum_{j=1}^{m} \sum_{i=1}^{n} Ref_{\ i,j} \times GWP_i$$

$CO2e$ is the total greenhouse gas emissions from uncontrolled leaks of refrigerant in CO_2-equivalent

Index *i* refers to each type of refrigerant; *n* is the total number of types of refrigerants

Index *j* refers to each mechanical system with refrigerants; *m* is the total number of systems

$Ref_{\ i,j}$ is the amount of refrigerant *i* leaked by system *j* annually as calculated in ***Equation 17***

GWP_i is the global warming potential of refrigerant *i*

Wastewater Treatment

Activity: greenhouse gas emissions related to the collection and treatment of wastewater at Montréal's wastewater treatment plant

Activity level: total effluents estimated by ENV-401 student research project

Equation 20: Calculation of greenhouse gas emissions from water supply

$$CO2e = \sum_{i=1}^{n} Wastewater_i \times EF_i$$

Where:

$CO2e$ is the total greenhouse gas emissions from water consumption in CO_2 equivalent

Index *i* refers to each campus

$Wastewater_i$ is the total wastewater from campus i in m^3

EF_i is the emission factor applicable to each campus in g CO_2 equivalent per m^3 consumed. These factors were computed by McGill students

Water Supply

Activity: greenhouse gas emissions related to the treatment and distribution of fresh water by the City of Montréal and the City of Sainte-Anne-de-Bellevue

Activity level: total consumption estimated in water audits of the Downtown and Macdonald campuses

Equation 21: Calculation of greenhouse gas emissions from water supply

$$CO2e = \sum_{i=1}^{n} Water\ Consumption_i \times EF_i$$

Where:

$CO2e$ is the total greenhouse gas emissions from water consumption in CO_2 equivalent

Index *i* refers to each campus

$Water\ Consumption_i$ is the total water consumed on campus *i* in m^3

EF_i is the emission factor applicable to each campus in g CO_2 equivalent per m^3 consumed. These factors were computed by McGill students in an ENVR401 research project.