

GREENHOUSE GAS EMISSIONS INVENTORIES METHODOLOGY GUIDE

This guide provides an overview of procedures to develop local and regional community-scale greenhouse gas inventories in metropolitan Washington.

March 2026

GREENHOUSE GAS EMISSION INVENTORIES METHODOLOGY GUIDE

Prepared for COG staff and the Built Environment and Energy Advisory Committee (BEEAC)
March 2026

ABOUT COG

The Metropolitan Washington Council of Governments (COG) is an independent, nonprofit association that brings area leaders together to address major regional issues in the District of Columbia, suburban Maryland, and northern Virginia. COG's membership is comprised of 300 elected officials from 24 local governments, the Maryland and Virginia state legislatures, and U.S. Congress.

CREDITS

Editor: Maia Davis, Tim Masters

Contributing Editors: Alissa Boggs, Alex Bonelli, Mukhtar Ibrahim, Jeff King, Sunil Kumar, Erin Morrow, John Snarr, Dusan Vuksan

ACCOMMODATIONS POLICY

Alternative formats of this document are available upon request. Visit www.mwcog.org/accommodations or call (202) 962-3300 or (202) 962-3213 (TDD).

TITLE VI NONDISCRIMINATION POLICY

The Metropolitan Washington Council of Governments (COG) operates its programs without regard to race, color, and national origin and fully complies with Title VI of the Civil Rights Act of 1964 and related statutes and regulations prohibiting discrimination in all programs and activities. For more information, to file a Title VI related complaint, or to obtain information in another language, visit www.mwcog.org/nondiscrimination or call (202) 962-3300.

El Consejo de Gobiernos del Área Metropolitana de Washington (COG) opera sus programas sin tener en cuenta la raza, el color, y el origen nacional y cumple con el Título VI de la Ley de Derechos Civiles de 1964 y los estatutos y reglamentos relacionados que prohíben la discriminación en todos los programas y actividades. Para más información, presentar una queja relacionada con el Título VI, u obtener información en otro idioma, visite www.mwcog.org/nondiscrimination o llame al (202) 962-3300.

TABLE OF CONTENTS

INTRODUCTION	1
Purpose	1
Background	1
Methodology Basics	1
Process	3
Stakeholder Engagement	3
ClearPath	3
Methodology Updates	3
COVID-19 Impacts	4
Getting Started	4
Setting Up the GHG Inventory	4
BUILT ENVIRONMENT	6
Residential Energy	6
Emissions from Grid Electricity	6
Emissions from Stationary Fuel	6
Commercial Energy	8
Emissions from Grid Electricity	8
Emissions from Stationary Fuel	9
Process and Fugitive Emissions	12
Fugitive Emissions from Natural Gas Distribution	12
Other Process and Fugitive Emissions	12
TRANSPORTATION AND MOBILE EMISSIONS	14
On Road Transportation	14
Emissions from Off Road Vehicles	15
Aviation Travel	16
Rail Transportation	17
WASTE	19
Solid Waste	19

Waste Generation	19
Combustion of Solid Waste Generated by the Community	19
Water and Wastewater	20
Fugitive Emissions from Septic Systems	20
Nitrification/Denitrification Process N ₂ O Emissions from Wastewater	21
Process N ₂ O from Effluent Discharge to Rivers and Estuaries	21
LAND USE	23
Agriculture	23
Emissions from Agricultural Activities	23
Forests and Trees Outside Forests	25
Forests	25
Trees Outside of Forests	26
ACKNOWLEDGEMENTS	28
APPENDIX A: 2020 METHODOLOGY SUMMARY TABLE	29
APPENDIX B: DATA NEEDS AND AVAILABILITY SUMMARY TABLE	31
APPENDIX C: 2020 EMISSIONS FACTOR LIBRARY	33
APPENDIX D: INVENTORY CHANGE LOG	34

INTRODUCTION

Purpose

This report outlines the methodologies of the Metropolitan Washington Council of Governments' (COG) greenhouse gas (GHG) inventory work, providing for completeness, consistency, accuracy, replicability, transparency, and quality control. The ability to develop relevant, robust sets of inventories supports COG's Climate, Energy and Environment Policy Committee (CEEPC) and member local governments track progress towards GHG emission reduction goals and support decision-making around policies and programs that support emission reduction.

Background

COG's Climate, Energy and Environment Policy Committee (CEEPC) was created by the COG Board in 2009 and is responsible for managing implementation of the *National Capital Region Climate Change Report* adopted by the COG Board in 2008. Since its inception, CEEPC has made it a priority to track progress towards emissions reduction and set goals for all COG members and the region to complete GHG inventories.

Over the next five years, COG supported its members on inventory development by coordinating GHG inventory work group meetings and a series of trainings with national experts from ICLEI. COG also participated in development of a national protocol for local community-scale inventories, provided consultant support for COG member local inventory development, and began working on applying consistent methodologies across jurisdictions.

Members of both CEEPC and its sub-committees requested additional support to ensure 100 percent of COG members were able to have consistent, comparable GHG inventories completed and have updates on their inventories completed to track progress towards GHG emission reduction goals. COG has completed local and regional GHG inventories for all COG members, northern Virginia, and metropolitan Washington for 2005, 2012, 2015, 2018, 2020 and 2023.

Methodology Basics

COG completes GHG community-scale inventories for all 24 local government members, northern Virginia, and metropolitan Washington. COG makes every effort to capture an accurate picture of GHG trends for each of its local government members, while also providing for a consistently applied methodology across all its members' communities. Local inventory results are added together to get the total regional GHG emissions.

COG GHG inventories are compliant with both the U.S. Communities Protocol for Accounting and Reporting Greenhouse Gas Emissionsⁱ (USCP) and Global Protocol for Community-Scale Greenhouse Gas Inventoriesⁱⁱ (GPC) and meet the requirements for LEED for Cities and Communities designation.ⁱⁱⁱ The U.S. and Global Protocols provide guidance on what emission types should at minimum be included in all local community GHG inventories. Additional guidance on approaches to

calculating emissions are offered, but not prescribed. COG mainly follows the calculation guidance from USCP as the USCP identifies sources of data widely available to communities in the US. If COG has reliable local data available that could provide more accurate results, then an alternative approach, calculation, or tool is used. For specific methodology information by emissions activity or source, see Appendix A.

COG inventories use public data readily-available on a consistent basis for all its local government members. Data sources used must be available for past, current, and potential future inventories to accurately capture trends. While both accuracy and consistency are important to GHG inventories, consistency is given a higher priority. COG inventories use GWP Factors from the Intergovernmental Panel on Climate Change Fourth and Fifth Assessment Report (IPCC AR4 and AR5).^{iv} Any models used, such as the MOVES model, are applied as consistently as possible. If a new version of the model is used, it will be noted. Appendices B, C, and D have additional information on data needs and availability, emission factors, and changes to data, models, and methods.

COG inventories follow an activities-based approach, meaning emissions are calculated based on the result of an activity happening in a community. An example of this is that solid waste emissions are calculated based on the tonnage of trash the community sends to a landfill(s). Simply because they do not have a landfill within their jurisdiction’s boundaries, does not mean that they are not contributing to landfill emissions.

The broad categories of emission types covered by COG’s GHG inventory work include the built environment (including some process and fugitive emissions), transportation and mobile emissions, waste (solid waste and wastewater), and some land use (agriculture, forests, and trees outside of forests). Most of these are required elements to be compliant with the USCP and GPC. Neither require land use; however, it was requested for inclusion by COG member jurisdictions (Table 1).

Table 1: Emission Types in COG Inventories Compared to Protocol Requirements

Emissions Types	COG Inventory?	USCP Required?	GPC Required?
Built Environment	√	√	√
Some Process and Fugitive	√	X	√
Transportation and Mobile	√	√	√
Solid Waste Treatment	√	√	√
Wastewater Treatment	√	√	√
Agriculture	√	X	X
Forests and Trees Outside of Forests	√	X	X

These emission types are further broken down into 18 emissions activities and 28 separate inventory records that are calculated and added together to get total emissions by type and overall emissions. The gases calculated within these inventory records include carbon dioxide (CO₂), methane (CH₄), Nitrous oxide (N₂O), Hydrofluorocarbons (HFCs), and Perfluorocarbons (PFCs).

Process

STAKEHOLDER ENGAGEMENT

COG continues to work with its local government members to capture as accurate a picture as possible for each community while providing consistent data inputs and methodologies across all communities. To accomplish this, COG staff needs to help members understand the existing process and methodologies, provide opportunities for their input on methodologies and the products, and support them on how they want to communicate results to their communities. The local government stakeholder engagement process includes the following:

1. Make COG members aware of the inventory procedure at the beginning of the process and listen to and address any questions/comments/concerns. Discuss any new priorities that need to be considered, potential methodology refinements, etc. with COG members.
2. Request information and feedback as needed during the development of the inventories.
3. Present draft results to each community and provide a comment period. Address questions/comments/concerns. Revise as needed.
4. Offer and provide one-on-one meetings, as needed, to COG local government members.
5. Provide final products to each community.
6. Support local governments, as needed, in communicating results to their communities.

CLEARPATH

ICLEI's ClearPath tool is an online tool for preparing local GHG inventories, forecasts, climate action plans, and monitoring reports. The tool is consistent with both US and global accounting protocols. COG uses the Community Scale Inventory Module to support completing its GHG inventory work for its members and the region.

COG created inventory records in ClearPath for emission activities in the inventories. Some of the tool's calculators are used to calculate emissions as inventory records are created, while in other instances, emissions are calculated outside the tool and recorded in the inventory record.

METHODOLOGY UPDATES

The practice of developing community-scale inventories is relatively has evolved rapidly in recent years. The practice will continue to evolve to provide for more accurate, measured results (rather than modeled). Therefore, the methodologies used in COG inventory work should continue to evolve over time to incorporate the best available data and methods.

Some methodology updates, like a change in GWP Factors, may affect all emission calculations in an inventory year. However, more often it may be refinements to the calculations for a specific activity or source. Methodology updates should be prioritized first by how much of an impact they have on the overall inventory. Priority should be given to an activity that accounts for a larger percent of the inventory. Secondly, methodology update needs should be based on current data quality confidence

levels. Activities or sources with low-to-medium data quality confidence levels could be investigated to see if more accurate data or calculations methods could be applied.

If methodology changes to how an activity/source is calculated results in more than a 1-2 percent difference, if possible, COG will back cast to change the methodologies from previous years. If methodology changes result in less than a 1-2 percent difference, back casting is not typical nor is it called for by the Protocols. All changes and differences in methodologies between inventory years need to be noted. Methodology changes have been documented in Appendix D.

To ensure methodology changes are Protocol compliant, COG refers to the USCP and GPC methodologies for guidance throughout the process and requests review of methodology updates by ICLEI, COG members, and other GHG inventory experts.

COVID-19 IMPACTS

The COVID-19 pandemic has had far-reaching impacts on the global economic and social system. Pandemic impacts on GHG emissions are largely due to reduced economic and travel activity. Globally, the pandemic impacted GHG emissions by 4-5% in 2020.^v The state of Maryland estimates the pandemic had a 4% impact on GHG emission reduction in 2020.^{vi} COG estimates the pandemic had a 4-6% impact on metropolitan Washington's 2020 GHG emissions.

The pandemic impacted the anticipated reduction in a few key sectors of metropolitan Washington's 2020 GHG emissions inventory. Emissions from the built environment were lower than projected for 2020, in part due to the pandemic; however, the grid getting cleaner and weather impacts also played a role. Emissions from the transportation sector were lower than previously projected for 2020 because less people were on the roads and flying during the height of the pandemic. Finally, solid waste emissions were overall lower than projected for 2020. However, waste that would have been generated and collected from businesses were generated within individual residences during the height of the pandemic^{vii} and thus it did not make a significant impact on overall GHG emissions in 2020.

Getting Started

Setting Up the GHG Inventory

DESCRIPTION

Gathering demographic and economic data is the first step taken in developing the inventories. Some of the demographic and economic data is used to estimate GHG emissions. For instance, household and commercial building data is used to estimate non-utility fuel consumption, such as fuel oil. Also, population data may serve as a means to downscale to a local community when local data is unavailable.

The demographic and economic data can be used as a benchmark to gauge emissions per person, household, employee, etc. Therefore, it is important to gather this information at the start of the inventory process and use it as consistently as possible across all emissions activity calculations.

DATA COLLECTION

COG's Cooperative Forecast has population, household, and employment data readily available for most COG member local governments.^{viii} Some COG member Maryland city data are not available. For these cities, population data is acquired from the US Census Bureau American Community Survey (ACS).^{ix}

In addition, COG uses CoStar^x, a commercial building database, to track commercial construction in the region. It also provides readily available data for the GHG inventories.

BUILT ENVIRONMENT

Residential Energy

EMISSIONS FROM GRID ELECTRICITY

Residential Electricity

DESCRIPTION

Residential Electricity accounts for emissions resulting in electricity use in residential buildings. Energy use in buildings account for a significant portion of GHG emissions. According to the USCP, local jurisdictions can often influence energy use through building codes, incentives, and technical assistance.

METHODOLOGY

The Residential Electricity emission calculations follow the USCP recommended methodology as outlined in Appendix C, BE.2.1 from Version 1.2 of the Protocol.

DATA COLLECTION

COG annually collects aggregated account and consumption data from the 7 electric utilities that serve metropolitan Washington.^{xi}

Data Needs:

- Accounts: Number of residential electric accounts from all utilities serving metropolitan Washington.
- Consumption: Annual residential electricity use in kilowatt hours from all utilities serving metropolitan Washington.
- U.S. Environmental Protection Agency (EPA) eGRID Subregion Output Emission Rates – Greenhouse Gases: Subregions RFC East (RFCE) and SERV Virginia/Carolina (SRVC) total output emission rates of CO₂ (lb/MWh), CH₄ (lb/GWh), and N₂O (lb/GWh).

EMISSIONS FROM STATIONARY FUEL

Residential Natural Gas

DESCRIPTION

Residential Natural Gas consumption accounts for combustion emissions from stationary fuel applications, such as furnaces. Energy use in buildings account for a significant portion of GHG emissions. According to the USCP, local jurisdictions can often influence energy use through building codes, incentives, and technical assistance.

METHODOLOGY

The Residential Natural Gas emission calculations generally follow the USCP recommended methodology as outlined in Appendix C, BE.1.1 from Version 1.2 of the Protocol.

DATA COLLECTION

COG annually collects aggregated account and consumption data from the 3 natural gas utilities that serve metropolitan Washington.^{xi}

Data Needs:

- Accounts: Number of residential natural gas accounts from all utilities serving metropolitan Washington.
- Consumption: Annual residential consumption of natural gas in Therms from all utilities serving metropolitan Washington.

Residential Fuel Oil

DESCRIPTION

Residential Fuel Oil accounts for both distillate fuel oils and kerosene used in stationary applications. Energy use in buildings account for a significant portion of GHG emissions. According to the USCP, local jurisdictions can often influence energy use through building codes, incentives, and technical assistance.

Distillate fuel oils include both fuel oils and diesel fuels that are further classified by level of volatility, listed from least to greatest (No. 1, No. 2, and No. 4). Residential fuel oils are less volatile than gasoline and are burned for space heating or water heating by private household consumers. No.2 fuel oil (Heating Oil) is the most common type used by households for the specific purpose of heating their home, water heating, cooking, etc., excluding farmhouses, farming, and apartment buildings. No. 1 fuel oil is used by households mainly for portable outdoor stoves, portable outdoor heaters and some residential space heating. Kerosene is a distilled product of oil or coal with the generic name kerosene, having properties like those of No. 1 fuel oil.

METHODOLOGY

The Residential Fuel Oil emissions calculations follow the USCP recommended methodology as outlined in Appendix C, BE.1.2 from Version 1.2 of the Protocol. This methodology estimates residential fuel oil consumption in gallons (including distillate fuel oil and kerosene) by multiplying the estimated number of households using fuel oil as a home heating fuel in the region and each jurisdiction with residential fuel oil energy intensity data for the region. Gallons are used to estimate emissions.

DATA COLLECTION

Local data on households and consumption related to fuel oil is not readily available for all COG members. However, the Energy Information Administration (EIA) has readily available fuel oil energy intensity data for the South Atlantic region and the ACS has readily available data on number of households using fuel oil as a home heating fuel.

Data Needs:

- Households using Fuel Oil: Number of households using fuel oil data for all COG jurisdictions and states collected from the ACS' Selected Housing Characteristics.^{xii}
- Regional Residential Fuel Oil Consumption: EIA Residential Energy Consumption Survey (RECS) fuel oil average site energy consumption for the South Atlantic region.^{xiii}

Residential LPG

DESCRIPTION

Liquefied Petroleum Gas (LPG) refers to a group of hydrocarbon gases derived from crude oil refining or natural gas processing. Propane is the most common LPG. In the U.S. and Canada, commercially available propane (LPG) is not totally pure; its typically at least 90 percent propane, with the rest being ethane, propylene, butane, and odorants including ethyl mercaptan. LPGs are used as fuel in heating appliances, cooking equipment, and vehicles. It is usually delivered by tank trucks and stored near a housing unit in a tank or cylinder until used; however, propane stored in canisters can also be purchased from retail stores. For COG inventory purposes, LPG's are equated with propane, yet propane also encompasses similar fuel gases, such as butane, supplied to a residence in liquid form. According to the USCP, local jurisdictions can often influence energy use through building codes, incentives, and technical assistance.

METHODOLOGY

The Residential LPG emission calculations follows the USCP recommended methodology as outlined in Appendix C, BE.1.2 from Version 1.2 of the Protocol. This methodology estimates residential LPG consumption in gallons by multiplying the estimated number of households using fuel oil as a home heating fuel in the region and each jurisdiction with residential LPG energy intensity data for the region. Gallons are used to estimate emissions.

DATA COLLECTION

Local data on households and consumption related to fuel oil is not readily available for all COG members. However, the EIA has readily available LPG energy intensity data for the South Atlantic region and the ACS has readily available data on number of households using LPG as a home heating fuel.

Data Needs:

- Households using LPG: Number of households using LPG data for all COG jurisdictions and states collected from the ACS's Selected Housing Characteristics.^{xii}
- Regional Residential LPG Consumption: EIA Residential Energy Consumption Survey (RECS) propane average site energy consumption for the South Atlantic region.^{xiii}

Commercial Energy

EMISSIONS FROM GRID ELECTRICITY

Commercial Electricity

DESCRIPTION

Commercial Electricity accounts for emissions resulting in electricity use in commercial, government, industrial, and other non-residential buildings and facilities. Energy use in buildings account for a significant portion of GHG emissions. According to the USCP, local jurisdictions can often influence energy use through building codes, incentives, and technical assistance.

METHODOLOGY

The Commercial Electricity emission calculations follow the USCP recommended methodology as outlined in Appendix C, BE.2.1 from Version 1.2 of the Protocol. Consumption data and the U.S. EPA eGRID emission data are factored into the emission estimates calculated in ClearPath.

DATA COLLECTION

COG annually collects aggregated account and consumption data from the 7 electric utilities that serve metropolitan Washington.^{xi}

Data Needs:

- Accounts: Number of commercial electric accounts from all utilities serving metropolitan Washington.
- Consumption: Annual commercial electricity consumption in kilowatt hours from all utilities serving metropolitan Washington.
- U.S. Environmental Protection Agency (EPA) eGRID Subregion Output Emission Rates – Greenhouse Gases: Subregions RFC East (RFCE) and SERV Virginia/Carolina (SRVC) total output emission rates of CO₂ (lb/MWh), CH₄ (lb/GWh), and N₂O (lb/GWh).

EMISSIONS FROM STATIONARY FUEL

Commercial Natural Gas

DESCRIPTION

Natural gas consumption in the non-residential setting produces combustion emissions from stationary applications, such as boilers and furnaces. Energy use in buildings account for a significant portion of GHG emissions. According to the USCP, local jurisdictions can often influence energy use through building codes, incentives, and technical assistance.

METHODOLOGY

The Commercial Natural Gas emission calculations generally follow the USCP recommended methodology as outlined in Appendix C, BE.1.1 from Version 1.2 of the Protocol.

DATA COLLECTION

COG annually collects aggregated account and consumption data from the 3 natural gas utilities that serve metropolitan Washington.^{xi}

Data Needs:

- Accounts: Number of commercial natural gas accounts from all utilities serving metropolitan Washington.
- Consumption: Annual commercial consumption of natural gas in Therms from all utilities serving metropolitan Washington.

Commercial Fuel Oil

DESCRIPTION

Commercial Fuel Oil refers to a liquid petroleum product used as an energy source that is less volatile than gasoline. Commercial Fuel Oil is comprised of distillate fuels (No. 1, 2 and 4), residual fuels (No. 5 and 6) and kerosene (No. 1). Distillate fuel oils represent the lighter petroleum fractions produced in conventional distillation processes that include both fuel oils and diesel fuels that are further classified by level of volatility, listed from least to greatest (No. 1, No. 2, and No. 4). Products known as No. 1, No. 2, and No. 4 fuel oils are lighter oils primarily used for space heating and electric power generation. Residual fuels are generally classified as heavier oils, known as No. 5 and No. 6 fuel oils, that remain after the distillate fuel oils and lighter hydrocarbons are distilled in refinery operations. Kerosene is a light petroleum distillate with properties like those of No. 1 fuel oil; primarily used in space heaters, cook stoves, and water heaters and is suitable for use as a light source when burned in wick-fed lamps. According to the USCP, local jurisdictions can often influence energy use through building codes, incentives, and technical assistance.

METHODOLOGY

The Commercial Fuel Oil emission calculations follows the USCP recommended methodology as outlined in Appendix C, BE.1.3 from Version 1.2 of the Protocol, with one exception. This methodology calculates percent of square footage using fuel oil instead of percent of number of buildings using fuel oil.

Values for commercial building square footage using Fuel Oil were scaled locally by multiplying the local jurisdictional commercial square footage by the percentage of commercial building square footage using Fuel Oil in the broader South Atlantic Region. These values, in turn, were multiplied by the fuel energy intensity in gallons per square foot (gallons/ft.²) to get total Fuel Oil consumption in gallons per locality and region. Gallons are used to estimate emissions.

DATA COLLECTION

The number of commercial buildings and total square footage for each COG member jurisdiction is readily available from the CoStar Commercial Property Records. There is not data readily available on stationary fuel use for these buildings. The Energy Information Administration (EIA) does have data available for larger regions on total commercial buildings and square footage; number and square footage of buildings using Fuel Oil; and energy intensity. EIA's South Atlantic Region in the Commercial Building Energy Consumption Survey (CBECS) includes DC, MD, VA, DE, WV, NC, SC, GA, and FL.

Data Needs:

- Commercial buildings and total square footage: Data for all COG jurisdictions and region are collected from the CoStar Commercial Property Records. This database is available via subscription by COG's Department of Community Planning and Services Department (DCPS).^x
- Total Commercial Floorspace and Commercial Square Footage using Fuel Oil: Values for the South Atlantic Region (most specific region) were derived from the EIA CBECS.^{xiv}
- Fuel Oil Energy Intensity: A value for the South Atlantic Region was derived directly from the EIA CBECS.^{xiv}

Commercial LPG

DESCRIPTION

Liquefied Petroleum Gas (LPG) refers to a group of hydrocarbon gases derived from crude oil refining processing. Propane is the most common LPG. In the U.S. and Canada, commercially available propane (LPG) is not totally pure; its typically at least 90 percent propane, with the rest being ethane, propylene, butane, and odorants including ethyl mercaptan. According to the USCP, local jurisdictions can often influence energy use through building codes, incentives, and technical assistance.

METHODOLOGY

In this methodology, any LPG reported was assumed to be propane. The Commercial LPG emission calculations follow the USCP recommended methodology as outlined in Appendix C, BE.1.3 from Version 1.2 of the Protocol. This methodology calculates percent of square footage using fuel oil instead of percent of buildings using fuel oil.

Values for commercial building square footage using LPG were scaled locally by multiplying the local jurisdictional commercial square footage by the percentage of commercial building square footage using LPG in the broader South Atlantic Region. These values, in turn, were multiplied by the fuel energy intensity in gallons per square foot (gallons/ft.²) to get total LPG consumption in gallons per locality and region. Gallons are used to estimate emissions.

DATA COLLECTION

The number of commercial buildings and total square footage for each COG member jurisdiction is readily available from the CoStar Commercial Property Records. There is not data readily available on stationary fuel use for these buildings. The Energy Information Administration (EIA) does have data available on total commercial buildings and square footage for larger regions; number and square footage of buildings using LPG; and energy intensity. EIA's South Atlantic Region in the Commercial Building Energy Consumption Survey (CBECS) includes DC, MD, VA, DE, WV, NC, SC, GA, and FL.

Data Needs:

- Commercial buildings and total square footage: Data for all COG jurisdictions and region are collected from the CoStar Commercial Property Records. This database is available via subscription by COG's Department of Community Planning and Services Department (DCPS).^x
- Total Commercial Floorspace and Commercial Square Footage using LPG: Values for the South Atlantic Region (most specific region) were derived from the EIA CBECS.^{xiv}
- LPG Energy Intensity: A value for the South Atlantic Region was derived directly from the EIA CBECS.^{xiv}

Process and Fugitive Emissions

FUGITIVE EMISSIONS FROM NATURAL GAS DISTRIBUTION

Natural Gas Fugitive Emissions

DESCRIPTION

Natural Gas Fugitive Emissions accounts for emissions resulting from local natural gas system losses within the community.

METHODOLOGY

The Fugitive Emissions from Natural Gas emission calculations uses a ClearPath calculator. The fugitive emissions are calculated based on a leakage rate for total annual natural gas consumption. The ClearPath calculator uses a leakage rate of 0.3 percent.

DATA COLLECTION

Data from the Metropolitan Washington Annual Utility survey needs to first be collected and analyzed for the inventory year prior to completing these steps.

Data Needs:

- Natural Gas Consumption: Total Annual Therms for each jurisdiction from the analyzed results of the Metropolitan Washington Annual Utility Survey.^{xi}

OTHER PROCESS AND FUGITIVE EMISSIONS

Hydrofluorocarbon Emissions

DESCRIPTION

Hydrofluorocarbons (HFCs) are a type of GHG and are comprised of several organic compounds composed of hydrogen, fluorine, and carbon. HFCs are produced synthetically and are commonly used in air conditioning and refrigerants in place of older halons and chlorofluorocarbons (CFCs), which were attributed to the depletion of Earth's Ozone layer. Following the implementation of the Montreal Protocol, HFCs gradually replaced CFCs because of their minimal impact on the Ozone layer, having an Ozone depletion potential of zero. However, HFCs are potent greenhouse gases (HFC's are 3,830 times more potent than CO₂) with high global warming potentials.

METHODOLOGY

HFC emissions in this inventory represent GHG emissions from substitutions for Ozone depleting substances. Total U.S emissions from substitutes for Ozone depleting substances are scaled locally by population to estimate jurisdictional and regional values. Substitutions for Ozone depleting substances primarily result in HFC emissions; however, small amounts of perfluorocarbon (PFC) emissions also result from this source.

DATA INPUTS

Local data on substitutes for Ozone depleting substances is not available. It would take extensive research and local surveys to develop this data and it only accounts for a small portion of emissions.

The U.S. Environmental Protection Agency's (EPA) annual inventory reports on GHG emissions calculates nationwide emissions for substitutes for Ozone depleting substances.

Data Needs:

- Population: Population data for all COG jurisdictions and the regions are collected from COG Cooperative Forecasts^{viii} and the ACS.^{viii}
- U.S. Emission of Ozone Depleting Substances: National data for HFC emissions is recorded in Million Metric Tons of Carbon Dioxide Equivalent (MMTCO_{2e}) from the U.S. EPA, Inventory of U.S. GHG Emissions and Sinks.^{xv}

TRANSPORTATION AND MOBILE EMISSIONS

On Road Transportation

On Road Mobile Emissions

DESCRIPTION

On Road Mobile Emissions represent exhaust and evaporative emissions of carbon dioxide (CO₂), nitrous oxide (N₂O), and methane (CH₄) from on road passenger and freight motor vehicles. On road mobile emissions account for approximately one third of metropolitan Washington GHG emissions. On Road emissions can be influenced by local governments mainly through supporting electrification of the transportation system and overall improvement of the fuel vehicle economy and to a lesser extent increasing alternative trip modes, transportation infrastructure investments, and land use and urban design decisions.

METHODOLOGY

The On Road Transportation emission calculations generally follows the USCP recommended methodology as outlined in Appendix D, TR.1.A from Version 1.2 of the Protocol.

COG Department of Transportation Planning (DTP) staff prepare estimated GHG emissions and modeled vehicle miles traveled (VMT) data based on planning assumptions included in the Transportation Planning Board's (TPB) Constrained Long Range Plan (CLRP), COG Cooperative Forecasts (demographic data), vehicle registration (VIN) data, and modeling tools such as the TPB's travel demand model and the Environmental Protection Agency's (EPA) mobile emissions model, MOVES.

For 2020 and 2023, Highway Performance Monitoring System (HPMS) observed VMT data was used to inform and adjust modeled VMT data inputs into the MOVES model to capture the VMT impacts from during and post COVID-19 pandemic. All years of the inventories have been updated using the most recent input data and assumptions available for use by COG, including the MOVES4 mobile emissions model and the Travel Demand Forecasting Model.

DATA COLLECTION

DTP staff provide GHG emissions estimates by state, jurisdiction, and vehicle type. Emissions are based on both travel and non-travel related inputs to the MOVES model. Additional details on MOVES model inputs are described in COG's Air Quality Conformity Analyses. Vehicle types include passenger cars, passenger trucks, motorcycles, school buses, transit buses, intercity buses, refuse trucks, light commercial trucks, motor homes, single unit short-haul trucks, single-unit long-haul truck, combination short-haul trucks, and combination long-haul trucks.

It is important to note that the modeled jurisdiction-level vehicle VMT inputs to the model are based on all travel occurring on the roadways in each jurisdiction, regardless of where the trips originate and terminate.

DTP staff provide GHG emissions estimates from EPA's MOVES model for the District of Columbia, Maryland counties, Virginia counties, and the City of Alexandria. In Maryland, data is provided for

Charles, Frederick, Montgomery, and Prince George's Counties. In Virginia data is provided for City of Alexandria, Arlington County, Fairfax County (including Fairfax City and City of Falls Church), Loudoun County, and Prince William County (including Manassas and Manassas Park).

Data Needs:

- Population: Population data for all COG jurisdictions and the region are collected from COG's Cooperative Forecasts^{viii} and the ACS.^{viii}
- Emissions: Emissions of Atmospheric Carbon Dioxide (CO₂), Methane (CH₄), and Nitrous Oxide (N₂O) from the EPA MOVES model is obtained from DTP staff.^{xvi}
- Vehicle Miles Traveled: Modeled VMT data by jurisdiction is obtained from DTP staff. This is not used to further calculate emissions; however, it is used as an indicator to support local jurisdictions in their understanding of resultant emissions. As noted above, HPMS observed VMT data was used to inform and adjust modeled VMT data inputs into the MOVES model for 2020 and 2023 to capture the VMT impacts during and post COVID-19 pandemic.^{xvi}

Emissions from Off Road Vehicles

Off Road Mobile Emissions

DESCRIPTION

Off Road Mobile Emissions account for nonroad equipment using gasoline, diesel, compressed natural gas, and liquified petroleum gas. Nonroad mobile sources are broken down into the following categories:

- Lawn and garden equipment
- Airport service and ground equipment
- Logging equipment
- Recreational marine equipment
- Light commercial equipment
- Industrial equipment
- Construction equipment
- Agricultural or farm equipment
- Recreational land vehicles or equipment
- Railroad maintenance equipment

METHODOLOGY

The Off Road Transportation emission calculations generally follow the USCP recommended methodology as outlined in Appendix D, TR.1.8 from Version 1.2 of the Protocol. EPA's Motor Vehicle Emissions Simulator, the MOVES model, calculates past, present, and future emission inventories (i.e., tons of pollutant) for nonroad equipment. Off Road emissions data for Atmospheric Carbon Dioxide (CO₂) and Methane (CH₄) are pulled from the model for the inventory year.

Off Road categories excluded from the model include large commercial marine, passenger and freight locomotives, and aircraft. Metropolitan Washington does not have a large marine port, so excluding large commercial marine vessels is not a concern for the purposes of COG's GHG inventory work. Emissions from locomotives and aircraft are, however, included in separate calculations.

DATA COLLECTION

The MOVES model Off Road data outputs are available for the District of Columbia, Maryland counties, and Virginia counties and independent cities.

Data Needs:

- Population: Population data for all COG jurisdictions and the regions are collected from COG Cooperative Forecasts^{viii} and the ACS.^{viii}
- Emissions: Emissions in short tons of Atmospheric Carbon Dioxide (CO₂) and Methane (CH₄) from the EPA MOVES model is obtained from COG Department of Environment's Air Quality Program.^{xvi}

Aviation Travel

Passenger Air Travel

DESCRIPTION

Passenger air travel emissions accounts for commercial aircraft emissions from major commercial airports serving the region and allocates those emissions to local communities based on users of the airport. The USCP states that aircraft emissions often represent more than 90 percent of airport related emissions.

METHODOLOGY

The Passenger Air Travel emission calculations generally follows the USCP recommended methodology as outlined in Appendix D, TR.6.D from Version 1.2 of the Protocol. COG's approach uses the best available data to estimate air travel passenger emissions by airport and allocates emissions by the percent of passengers traveling from a COG member jurisdiction to the airport. This includes all air passengers leaving a COG member jurisdiction to fly out of Baltimore-Washington International Thurgood Marshall Airport (BWI), Ronald Reagan Washington National Airport (DCA), and Washington Dulles International Airport (IAD). This includes personal travel and business travel by people who live, work, or were visiting a COG member jurisdiction.

To estimate emissions per airport, national aircraft emissions are downscaled based on the local to national ratio of revenue passenger miles for BWI, DCA, and IAD. Emissions are applied locally based on a community's contribution to each airport's originating passengers. This approach does not account for aircraft emissions and air passengers that are, for instance, flying into IAD and taking a connecting flight elsewhere.

Special analyses were conducted for 2020 and 2023 to identify originating air passengers by jurisdiction. In 2020, COG initiated COVID-19 Travel Monitoring Snapshots to track travel impacts from the pandemic. COG leveraged data collected for the snapshots to conduct a special analysis of air trips by jurisdiction and an air travel counts analysis to support GHG estimates that fully capture impacts from the pandemic. For 2023, the Air Passenger Travel Survey approach was updated and COG used preliminary data not published in the survey findings reports. More information on this change is available in Appendix D.

DATA COLLECTION

For all originating air passengers departing from the region’s three commercial airports – BWI, DCA, IAD – the biennial Washington-Baltimore Regional Air Passenger Survey provides readily available origin-destination data by mode of access, trip origination (home, non-home), resident status (resident, non-resident), and trip purpose (work, non-work), for base and forecast years. There is also readily available data on commercial aircraft emissions and passenger miles travelled for the airports serving the region through EPA and the Bureau of Transportation Statistics, respectively.

Data Needs:

- Number of Originating Air Passengers: Data for number of originating air passengers to each airport for each COG jurisdiction is collected from the Washington-Baltimore Regional Air Passenger Survey Geographic Findings Report.^{xvii} Data is pulled by “Jurisdiction” for the counties, District of Columbia, and the City of Alexandria. Data for the rest of the cities is pulled by “Airport Analysis Zone.” As noted above, a special analysis was conducted to capture 2020 and 2023.
- Total Revenue Passenger Miles: Data for each airport and U.S. totals are from the Bureau of Transportation Statistics.^{xviii}
- U.S. Total Commercial Aircraft Emissions: Values in MMTCO_{2e} are from the U.S. Environmental Protection Agency Inventory of U.S. GHG Emissions and Sinks.^{xv}
- Total Enplanements: Volume for BWI, DCA, and IAD are from the COG Washington-Baltimore Regional Air Passenger Survey Geographic Findings Report and the special analyses for 2020 and 2023.^{xvii}

Rail Transportation

Commuter Rail

DESCRIPTION

Rail Transportation calculates emissions resulting from MARC and Virginia Railway Express (VRE) trains carrying commuters from Maryland and Virginia. These commuter rail services serve an important role in providing a balanced intermodal transit for metropolitan Washington. Local jurisdictions may have influence on service levels in its community via supportive land use policies, infrastructure investments, and connecting transit services.

METHODOLOGY

The Commuter Rail Transportation emission calculations generally follow the USCP recommended methodology as outlined in Appendix D, TR.4 from Version 1.2 of the Protocol. In this approach, emissions are calculated from annual diesel consumption of commuter rail operators.

Maryland Transit Administration (MTA) and VRE reports diesel consumption for their full commuter rail operations, some of which occurs outside of metropolitan Washington. MTA and VRE annual diesel consumption are attributed to the region by the percent of stations located in the region – 59 percent of MTA’s MARC stations and 75 percent of VRE stations are in the region.

DATA COLLECTION

Diesel consumption of commuter rail systems (code CR) is readily available via the Federal Transit Administration’s (FTA) National Transit Database. Data is downscaled by station locations and

population because there is no public readily available, consistent data for both MTA and VRE commuter rail passenger travel activity.

Data Needs:

- Population: Population data for all COG jurisdictions and the regions are collected from COG Cooperative Forecasts^{viii} and the ACS.^{viii}
- Diesel Consumption: Annual diesel consumption in gallons for the MTA and VRE as reported to the FTA National Transit Database.^{xix}

WASTE

Solid Waste

WASTE GENERATION

Landfill Waste Generation

DESCRIPTION

Landfill Waste Generation accounts for the emissions resulting from waste generated by the community in a year and disposed of at a landfill. In other words, it accounts for the resultant methane emissions from the decomposition of biologic solid waste produced by the community that year. Methane capture has a significant influence over resulting GHG emissions. If a landfill receiving waste has no methane capture, the resultant GHG emissions are much higher. According to the USCP, local jurisdictions' municipal solid waste (MSW), recycling, and composting programs can influence the amount of waste generated, the methods of disposal, and locations.

METHODOLOGY

The Landfill Waste Generation emission calculations follow the USCP recommended methodology as outlined in Appendix E, SW.4 from Version 1.2 of the Protocol. The calculations are based on tons of MSW from each jurisdiction going to a landfill and whether the receiving landfills have methane capture. It is important to make this distinction and identify how many tons are annually disposed of at these landfills.

DATA COLLECTION

The best available MWS data from local and regional sources was used to calculate these emissions. Unlike other activities in this inventory, there is not a regional, state, or federal source of MSW data that comprehensively reports data in the way that is needed for GHG inventory calculations.

Data Needs:

- Municipal Solid Waste (MSW): Annual mass in tons of MSW landfilled retrieved are from local and regional sources.^{xx}
- Methane Collection: Identify landfills that regularly receive MSW from each jurisdiction and whether those landfills have methane collection using the EPA FLIGHT Tool.^{xxi} Gather information on landfill methane collection efficiency from jurisdictions or landfill operators.^{xx}

COMBUSTION OF SOLID WASTE GENERATED BY THE COMMUNITY

Combustion of Solid Waste

DESCRIPTION

The Combustion of Solid Waste accounts for the emissions resulting from municipal solid waste (MSW) generated by the community in a year and disposed of at a waste-to-energy (WTE) facility. WTE facilities burn garbage and typically generate steam and/or electricity from the combustion of MSW. According to the USCP, local jurisdictions' MSW, recycling, and composting programs can influence the amount of waste generated, the methods of disposal, and locations.

METHODOLOGY

The Combustion of Solid Waste Generated by the Community emission calculations follow the USCP recommended methodology as outlined in Appendix E, SW.2.2 from Version 1.2 of the Protocol. The calculations are based on tons of MSW from each jurisdiction going to a WTE.

DATA COLLECTION

The best available municipal MWS data from local and regional sources was used to calculate these emissions. Unlike other activities in this inventory, there is not a regional, state, or federal source of MSW data that comprehensively reports data in the way that is needed for GHG inventory calculations.

Data Needs:

- Municipal Solid Waste (MSW): Annual mass in tons of MSW combusted is retrieved from local and regional sources.^{xx}

Water and Wastewater

FUGITIVE EMISSIONS FROM SEPTIC SYSTEMS

Septic System Emissions

DESCRIPTION

Septic Systems Emissions account for the fugitive emissions resulting from the physical settling and biologic activity during the treatment process in septic tanks. According to the USCP, local governments can influence community septic through local building codes, providing and promoting incentives, etc.

METHODOLOGY

The Fugitive Emissions from Septic Systems calculations follow the USCP recommended methodology as outlined in Appendix F.WW.11 from Version 1.2 of the Protocol. The methodology estimates GHG emissions based on the population served by septic.

The Regional Wastewater Flow Forecast Model (RWFFM) and COG Cooperative Forecasts are leveraged to estimate population served by sewer and septic.

DATA COLLECTION

The RWFFM provides data that is available to use for the purposes of the GHG inventories. COG Cooperative Forecasts are used for population estimates.

Data Needs:

- Population served by septic.^{xxii}

NITRIFICATION/DENITRIFICATION PROCESS N₂O EMISSIONS FROM WASTEWATER

Sewer System Emissions

DESCRIPTION

This calculation of Sewer System Emissions accounts for N₂O emissions during the treatment process at wastewater treatment plants (WWTPs). All WWTPs in the region operate with nitrification (converting ammonia to nitrate) and denitrification (converting nitrate into nitrogen gas) processes to remove nutrients from wastewater. This process protects the water quality of local waterways. More than 90 percent of the population in the region is served by a WWTP.

According to the USCP, wastewater utilities can potentially offset GHG emissions through renewable energy generation from biogas and/or biosolids, using reclaimed water to displace imported water, or producing biosolids as fertilizer for use.

METHODOLOGY

The Nitrification/Denitrification Process N₂O Emissions from Wastewater Treatment calculations follow the USCP recommended methodology as outlined in Appendix F.WW.7 from Version 1.2 of the Protocol. The methodology estimates GHG emissions based on the population served by sewer. The Regional Wastewater Flow Forecast Model (RWFFM) and COG Cooperative Forecasts are leveraged to estimate population served by sewer.

DATA COLLECTION

The RWFFM is processed annually by COG staff and produces data that is available to use for the purposes of the GHG inventories. COG Cooperative Forecasts are used for population estimates. For cities that do not have Cooperative Forecast data available ACS population estimates are leveraged.

Data Needs:

- Population served by sewer.^{xxii}

PROCESS N₂O FROM EFFLUENT DISCHARGE TO RIVERS AND ESTUARIES

N₂O Effluent Discharge Emissions

DESCRIPTION

N₂O Effluent Discharge Emissions account for the emissions resulting from treated wastewater that flows out of a treatment facility and is discharged into waterways. Most of the nitrogen content is removed in the treatment process; however, when effluent containing nitrogen reaches the natural watershed a reaction occurs that releases N₂O emissions. N₂O emission levels can vary year-to-year due to weather conditions (i.e. precipitation levels, drought) effecting inflow and infiltration. New technology can significantly reduce N₂O emissions at WWTPs.

METHODOLOGY

The Process N₂O from Effluent Discharge to Rivers calculations follow the USCP recommended methodology as outlined in Appendix F.WW.12 from Version 1.2 of the Protocol. The methodology estimates GHG emissions based on the population served by sewer and daily Nitrogen loads.

The Regional Wastewater Flow Forecast Model (RWFFM) and COG Cooperative Forecasts are leveraged to estimate population served by sewer. Data inputs on Nitrogen loads are downloaded from CAST for inventories 2018 and beyond. For previous inventories they were provided via personal communication from Chesapeake Bay Program staff. This data represents a simple average of the annual loads recorded by the Bay Program.

DATA COLLECTION

The RWFFM is processed by COG staff and produces data that is available to use for the purposes of the GHG inventories. COG Cooperative Forecasts are used for population estimates. For cities that do not have Cooperative Forecast data available ACS population estimates are leveraged.

Data Needs:

- Population served by sewer.^{xxii}
- Daily Nitrogen Load: Values in kg N/day are retrieved from COG Department of Environmental Programs Wastewater Modeler.^{xxii}

LAND USE

Agriculture

EMISSIONS FROM AGRICULTURAL ACTIVITIES

Enteric Fermentation

DESCRIPTION

Enteric Fermentation accounts for the methane produced from animal digestion in cows, sheep, goats, swine, and horses. According to the USCP, enteric fermentation accounts for 25 percent of nationwide methane emissions from anthropogenic activities. The U.S. EPA report titled 'User's Guide for Estimating Methane and Nitrous Oxide Emissions from Agriculture Using the State Inventory Tool' states that a higher quality of feed produces lower emissions from these animals.^{xxiii}

METHODOLOGY

The U.S. EPA's Emission Inventory Improvement Program developed a series of Excel-based State GHG Inventory Tools, which include an Agriculture Module. The Ag Module calculates methane (CH₄) and nitrous oxide (N₂O) emissions from agricultural sources. Agricultural sources and activities relevant to metropolitan Washington were calculated using this tool including Enteric Fermentation, Manure Management, and Ag Soils. The module takes data inputs and applies state-specific data and factors to calculate emissions. The methodologies applied in the tool are generally consistent with EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks.

The USCP does offer similar suggested calculations for enteric fermentation and manure management, where national default factors are applied. While Ag emissions calculated offline can be documented in ClearPath, it does not currently offer a calculator that estimates emissions. At this time, EPA's State Inventory Tool offers the most streamlined calculation process with the most locally relevant default factors for COG's GHG inventory work.

DATA COLLECTION

Metropolitan Washington data inputs into the EPA's State GHG Inventory Tool are pulled at the county-scale from the EPA Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST). CAST is a web-based nitrogen, phosphorus, and sediment load estimator tool that streamlines environmental planning.

Data Needs:

- Livestock: Livestock population ('000 head) for dairy cows, beef cattle, sheep, goats, swine, horses are derived from the CAST Tool.^{xxiv}

Manure Management

DESCRIPTION

Manure Management accounts for emissions from management systems that stabilize or store livestock manure. It accounts for manure from dairy cows, beef cattle, sheep, goats, swine, horses,

and poultry operations. Methane (CH₄) is a natural by-product of manure decomposition and nitrous oxide (N₂O) is also produced during the storage and treatment of animal manure.

The U.S. EPA report titled 'User's Guide for Estimating Methane and Nitrous Oxide Emissions from Agriculture Using the State Inventory Tool' states that the greater energy content of the feed results in an increased capacity to produce CH₄ in manure. In addition, the report states that the amount of N₂O released depends on the system and duration of waste management.

METHODOLOGY

EPA's Emission Inventory Improvement Program developed a series of Excel-based State GHG Inventory Tools, which include an Agriculture Module. The Ag Module calculates CH₄ and N₂O emissions from agricultural sources. Agricultural sources and activities relevant to metropolitan Washington were calculated using this tool including Enteric Fermentation, Manure Management, and Ag Soils. The module takes data inputs and applies state-specific data and factors to calculate emissions. The methodologies applied in the tool are generally consistent with EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks.

The USCP does offer similar suggested calculations for enteric fermentation and manure management, where national default factors are applied. While Ag emissions calculated offline can be documented in ClearPath, it does not currently offer a calculator that estimates emissions. At this time, EPA's State Inventory Tool offers the most streamlined calculation process with the most locally relevant default factors for COG's GHG inventory work.

DATA COLLECTION

Metropolitan Washington data inputs into the EPA's State GHG Inventory Tool are pulled at the county-scale from the EPA Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST). CAST is a web-based nitrogen, phosphorus, and sediment load estimator tool that streamlines environmental planning.

Data Needs:

- Livestock: Livestock population ('000 head) for dairy cows, beef cattle, sheep, goats, swine, horses, pullets, chickens, broilers, and turkeys are derive from CAST.^{xxiv}

Ag Soils

DESCRIPTION

Ag Soils account for nitrous oxide (N₂O) emissions from animals, crop production, and fertilizer application. The U.S. EPA report titled 'User's Guide for Estimating Methane and Nitrous Oxide Emissions from Agriculture Using the State Inventory Tool' states that N₂O is naturally produced in soils; however, animal and crop management practices and fertilizer application increase the amount of N₂O emitted. Higher levels of N₂O are a result of:

- The type of animal waste management systems used;
- Cultivation of certain types of nitrogen-fixing crops;
- Crop residues remaining on agricultural fields; and
- The use of synthetic and organic fertilizer in ag and urban soils.

METHODOLOGY

The U.S. EPA's Emission Inventory Improvement Program developed a series of Excel-based State GHG Inventory Tools, which include an Agriculture Module. The Ag Module calculates methane (CH₄) and N₂O emissions from agricultural sources. Agricultural sources and activities relevant to metropolitan Washington were calculated using this tool including Enteric Fermentation, Manure Management, and Ag Soils. The module takes data inputs and applies state-specific data and factors to calculate emissions. The methodologies applied in the tool is generally consistent with EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks.

The USCP does offer similar suggested calculations for enteric fermentation and manure management, where national default factors are applied. While Ag emissions calculated offline can be documented in ClearPath, it does not currently offer a calculator that estimates emissions. At this time, EPA's State Inventory Tool offers the most streamlined calculation process with the most locally relevant default factors for COG's GHG inventory work.

DATA COLLECTION

Metropolitan Washington data inputs into EPA's State GHG Inventory Tool are pulled at the county-scale from the EPA Chesapeake Bay Program's Chesapeake Assessment Scenario Tool (CAST). CAST is a web-based nitrogen, phosphorus and sediment load estimator tool that streamlines environmental planning.

Data Needs:

- **Livestock:** Livestock population ('000 head) for dairy cows, beef cattle, sheep, goats, swine, horses, layers (pullets and chickens), broilers, and turkeys are derived from CAST.^{xxiv}
- **Crops:** Crop production ('000 bushels) for corn for grain, all wheat, and soybeans are derived from CAST.^{xxiv}
- **Fertilizer:** Fertilizer applied (kg N) for synthetic fertilizers, manure, and biosolids are derived from CAST.^{xxiv}

Forests and Trees Outside Forests

FORESTS

Emissions and Removals from Forests

DESCRIPTION

Forests sequester CO₂ during the process of photosynthesis and store this carbon in leaves, roots, branches, trunks, soil, and woody debris and other plant litter. Through this process, forests can curb atmospheric GHG emissions. Land use activities can impact emissions. For example, conversion of forested land to urban areas can contribute significantly to carbon emissions. Thus, forests can act as a sink for carbon emissions, and if removed they can be a source of emissions. Increasing carbon sequestration and reducing emissions from local forests and trees supports climate change mitigation.

METHODOLOGY

ICLEI's Land Emissions And Removals Navigator (LEARN) tool^{xxv} estimates the local GHG impacts of forests and trees in a local community. This tool provides information on land cover, including forest cover and change. Emissions and removals from forests were calculated using this tool for each jurisdiction and the region. LEARN combines methods outlined in the USCPⁱ Appendix J with national data sources to derive a first-order approximation of annual GHG impacts over a given time period. The base time period analyzed for forest is 2001-2011 and is applied to the 2005 inventory. The next time period analyzed for forests is 2011-2016 and is applied to the 2012 and 2015 GHG inventories. Lastly, forests were analyzed for 2016-2021 and applied to the 2018, 2020, and 2023 GHG inventories.

DATA INPUTS

The LEARN Tool can produce average annual emissions and removals from forests and trees outside of forests for local jurisdictions and the region leveraging local community boundary GIS layers, land use/landcover data, and emission and removal factors.

Data Needs:

- ArcGIS boundary shapefiles for all 24 COG member jurisdictions
- National Land Cover Dataset (NLCD): 30-meter resolution land use/land cover for 2001-2011, 2011-2016, 2016-2021^{xxiii}

TREES OUTSIDE OF FORESTS

Emissions and Removals from Trees Outside of Forests

DESCRIPTION

Like forests, trees outside of forests sequester CO₂ during the process of photosynthesis and act as a carbon sink and if removed they can be a source of emissions. Trees outside forests may be individual trees or trees in small patches (less than 1 acre). Increasing carbon sequestration and reducing emissions from local forests and trees supports climate change mitigation.

METHODOLOGY

Emissions and removals from trees outside of forests were calculated for each COG member jurisdiction with the i-Tree Canopy tool for the periods between 2006-2011 and the LEARN tool for the period between 2013-2018. The World Resources Institute's (WRI) *Guide to calculating tree canopy and canopy change outside of forests for US communities using i-Tree Canopy*^{xxvi} was followed to develop emissions and removals for trees outside of forests. This guide is available on the LEARN tool website under Resources. GIS shapefiles are created for non-forested areas by jurisdiction and uploaded into the i-Tree Canopy tool to develop statistical estimates using 650 data points for tree canopy outside of forests maintained, gained, or lost. Google Earth Pro is leveraged for assessing historical aerial imagery. The LEARN tool incorporates Chesapeake Watershed (CBW) 1-meter resolution data used to analyze 2013-2018. These analyses provide the outputs needed to calculate emissions and removals from trees outside of forests for each jurisdiction and the region.

DATA INPUTS

The base time period analyzed for trees outside of forests is 2006-2011 and is applied to the 2005 inventory. Google Earth Pro imagery available for the region is not reliable prior to 2006 for the

estimates required of this analysis. Lastly, Trees outside of forests were analyzed for 2013-2018 and applied to the 2012, 2015, 2018, 2020, and 2023 GHG inventories.

Data Needs:

- ArcGIS boundary shapefiles for all 24 COG member jurisdictions.
- ArcGIS shapefiles of non-forested areas for all 24 COG member jurisdictions.
- Google Earth Pro satellite imagery in conjunction with i-Tree Canopy tool.^{xxvii}
- Chesapeake Bay Watershed (CBW) 1-meter resolution land use/land cover ArcGIS shapefiles, 2013/4 – 2017/8.^{xxiii}

ACKNOWLEDGEMENTS

COG Member Local Governments, Sunil Kumar (COG Department of Environmental Programs-DEP), Mukhtar Ibrahim (COG DEP), John Snarr (COG DEP), Brian LeCouteur (COG DEP), Mark Moran (COG Department of Transportation Planning-DTP), Dusan Vuksan (COG DTP), Erin Morrow (COG DTP), Jinchul Park (COG DTP), Daniel Son (COG DTP), Tim Canaan (COG DTP), Kenneth Joh (COG DTP), Zhou Yang (COG DTP), Yu Gao (COG DTP), Ian Newman (COG DTP), Greg Goodwin (COG Department of Community and Planning Services-DCPS), John Kent (COG DCPS), Debbie Spiliotopoulos (Northern Virginia Regional Commission), Ronald Gordy (BGE), Edmond Berman (BGE), David Bloom (BGE), Shane Mathers (BGE), Ran Zhang (BGE), Eric Bateman (Dominion), Sarah Cosby (Dominion), Patrick Haworth (Dominion), Ana Davis (Manassas Electric), Margaret Schaefer (NOVEC), Julianny Tate (Pepco), Marcus Beal (Pepco), Patrice Haskins (Pepco), Dorothy Bonds (Pepco), Ranae Graham (Pepco), William Ellis (Pepco), Brian Havrilla (Potomac Edison), Raymond Valdes (Potomac Edison), Stephanie Fall (Potomac Edison), Jeff Shaw (SMECO), Tom Dennison (SMECO), Stephen Holcomb (Columbia Gas), Keith Weber (Columbia Gas), Jerra Michelle Thomas (Columbia Gas), Cory Taffera (Washington Gas), Jessica Rogers (Washington Gas), Opeoluwa Olawale (Washington Gas), Sally DeLeon (University of Maryland), Eli Yewdall (ICLEI), Matthew Katz (ICLEI), Jadon Basilevac (ICLEI)

APPENDIX A: 2020 METHODOLOGY SUMMARY TABLE

Emissions Type	Emissions Activity or Source	GHG Types (CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆)	Methodology (From US Communities Protocol, v 1.2)	Data Quality Confidence Levels (High, Medium, Low)
BUILT ENVIRONMENT				
Residential Energy	Emissions from Grid Electricity *	CO ₂ , CH ₄ , N ₂ O	Appendix C, BE.2.1	High
	Emissions from Stationary Fuel (Natural Gas) *		Appendix C, BE.1.1	High
	Emissions from Stationary Fuel (Fuel Oil, LPG) *		Appendix C, BE.1.2	Medium
Commercial and Industrial Energy	Emissions from Grid Electricity *	CO ₂ , CH ₄ , N ₂ O	Appendix C, BE.2.1	High
	Emissions from Stationary Fuel (Natural Gas) *		Appendix C, BE.1.1	High
	Emissions from Stationary Fuel (Fuel Oil, LPG) *		Appendix C, BE.1.3	Medium
	Industrial Point Source Emissions from Stationary Fuel Combustion	Any GHG	IE in commercial and industrial stationary fuel and solid waste	N/A
	Consumption of District Energy	CO ₂ , CH ₄ , N ₂ O	IE in commercial and industrial grid electricity and stationary fuel	N/A
Process and Fugitive Emissions	Fugitive Emissions from Natural Gas Distribution	CO ₂ , CH ₄	ClearPath calculator	High
	Fugitive Emissions from Oil Systems, Mining, Processing, Storage, and Transportation of Coal	CO ₂ , CH ₄ , N ₂ O	NE	N/A
	Other Process and Fugitive	HFCs, PFCs, Refridgerant Blends	Alternate Method - Downscale from national inventory	Medium
TRANSPORTATION AND MOBILE EMISSIONS				
Transportation and Mobile Emissions	On Road Transportation *	CO ₂ , CH ₄ , N ₂ O	Appendix D, TR.1.A	High
	Emissions from Off Road Vehicles *		Appendix D, TR.8	High
	Aviation Travel		Appendix D, TR.6.D	Medium
	Rail Transportation *		Appendix D, TR.4	Medium
	Emissions from Public Transit *		IE in On Road	N/A
	Water Transportation *		IE in Off-Road	N/A
WASTE				
Solid Waste	Waste Generation (Landfill) *	Fugitive CH ₄	Appendix E, SW.4 with updated ClearPath calculator that aligns with EPA Warm Model, version 14	High
	Process Emissions Associated with Landfilling	CO ₂ e	NE	N/A
	Combustion of Solid Waste Generated by the Community *	Fossil CO ₂ , N ₂ O, CH ₄ (biologic CO ₂ optional)	Appendix E, SW.2.2	Medium
	Biologic Treatment of Solid Waste (Composting)	CO ₂ , CH ₄ , N ₂ O	NE	N/A
Water and Wastewater	Emissions from Wastewater Treatment Energy Use *	CO ₂ , CH ₄ , and N ₂ O from electricity and fuels	IE in commercial and industrial energy	N/A
	Emissions from the Supply of Potable Water *	CO ₂ , CH ₄ , and N ₂ O from electricity and fuels	IE in commercial and industrial energy	N/A
	Fugitive Emissions from Septic Systems*	Fugitive CH ₄	Appendix F, WW.11	Medium
	Nitrification/Denitrification Process N ₂ O Emissions from Wastewater Treatment *	Process N ₂ O	Appendix F, WW.7	Medium
	Process N ₂ O from Effluent Discharge to Rivers and Estuaries *	Fugitive N ₂ O	Appendix F, WW.12	Medium

Emissions Type	Emissions Activity or Source	GHG Types (CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆)	Methodology (From US Communities Protocol, v 1.2)	Data Quality Confidence Levels (High, Medium, Low)
LAND USE				
Agriculture	Emissions from Agricultural Activities	CH ₄ , N ₂ O	Alternate Method - EPA State Inventory Tool, AG Module	Medium
	Emissions from Stationary Fuel Combustion	CO ₂ , CH ₄ , N ₂ O	IE in commercial and industrial grid electricity and stationary fuel	N/A
	Emissions from Grid Electricity			
Forests and Trees Outside Forests	Forests	CO ₂ e	Appendix J, L.4	Medium
	Trees Outside Forests	CO ₂ e	Appendix J, L.5	Medium
OTHER				
Upstream Impacts of Activities	Upstream Impacts of Electricity Used by the Community	CO ₂ , CH ₄ , N ₂ O	NE	N/A
	Upstream Impacts of Fuels Used in Stationary Combustion by the Community			
	Emissions from Electric Power Transmission and Distribution Losses			
Consumption Based	Consumption Based Emissions, Previously Calculated	Any GHG	NE	N/A

Column Header	Description
Emissions Type	This column lists the main tabs in the online ClearPath tool's GHG inventory entry pages.
Emissions Activity/Source	This column lists the ClearPath calculators that are used to calculate or record emissions from activities/sources. * Indicates that reporting for this activity or source is required by the U.S. Community Protocol or Global Protocol for Community-Scale GHG Inventories (BASIC). Those without a * are not requirements of the protocols.
GHG Types	Summarizes the leading GHG emission types that result from each activity or source, including carbon dioxide (CO ₂), Methane (CH ₄), Nitrous oxide (N ₂ O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF ₆).
Methodology	The methodologies and calculations generally follow ICLEI's US Community Protocol for Accounting and Reporting GHG Emissions Version 1.2. Modified approaches to the ICLEI methodology are used based on data availability. In addition, notations are made in accordance with the Notation Keys legend below.

Notation Keys	Description
IE = Included Elsewhere	Emissions for this activity are estimated and presented in another category of the inventory. The category where these emissions are included should be noted in explanation.
NE = Not Estimated	Emissions occur but have not been estimated or reported (e.g., data unavailable, effort required not justifiable).
NA = Not Applicable	The activity occurs but does not cause emissions; explanation should be provided.
NO = Not Occurring	The source or activity does not occur or exist within the community.

Note: These notations were developed by the Global Communities Protocol and are also used by the U.S. Communities Protocol. See Version 1.2, 2019, Appendix B.

APPENDIX B: DATA NEEDS AND AVAILABILITY SUMMARY TABLE

Emissions Type	Emissions Activity or Source	Data Needs	Data Source	Data Availability	
BUILT ENVIRONMENT					
Residential Energy	Emissions from Grid Electricity	Number of Residential Electricity Accounts	COG Annual Utility Data Survey	Annually available for previous year typically in September	
		Residential Electricity Consumption			
		eGRID Emission Rates	U.S. Environmental Protection Agency (EPA)		Available every 1-2 years with a 1-2-year lag
	Emissions from Stationary Fuel (Natural Gas, Fuel Oil, LPG)	Number of Residential Natural Gas Accounts	COG Annual Utility Data Survey	Annually available for previous year typically in September	
		Residential Natural Gas Consumption			
		Households using Fuel Oil and LPG	American Community Survey (ACS)		Annually available by Dec. for previous year
	Residential Fuel Oil and LPG Statewide Consumption	U.S. Energy Information Administration (EIA) Residential Energy Consumption Survey (RECS)	RECS is not completed in standardized cycles (i.e. every x years); it depends on budget and funding. COG inventories use the 2005, 2009, 2015, and 2020 RECS.		
Commercial and Industrial Energy	Emissions from Grid Electricity	Number of Non-Residential Electricity Accounts	COG Annual Utility Data Survey	Annually available for previous year typically in September	
		Non-Residential Electricity Consumption			
		eGRID Emission Rates	U.S. EPA		Available every 1-2 years with a 1-2-year lag
	Emissions from Stationary Fuel (Natural Gas, Fuel Oil, LPG)	Number of Non-Residential Natural Gas Accounts	COG Annual Utility Data Survey	Annually available for previous year typically in September	
		Non-Residential Natural Gas Consumption			
		Number of Local Commercial Buildings and Total Square Footage	COG's CoStar Database Account		Annually available for previous year in spring/summer
		South Atlantic Region's Total Commercial Floorspace and Square Footage using Fuel Oil and LPG	EIA Commercial Building Energy Consumption Survey (CBECS)		CBECS is not completed in standardized cycles (i.e. every x years); it depends on budget and funding. COG inventories use the 2003, 2012, and 2018 CBECS.
		Fuel Oil and LPG Energy Intensity	EIA CBECS		
Process and Fugitive Emissions	Fugitive Emissions from Natural Gas Distribution	Total Natural Gas Consumption	COG Annual Utility Data Survey	Annually available for previous year typically in September	
	Other Process and Fugitive	Population	COG Cooperative Forecasts and ACS	COG - Every 1-2 years ACS - Annually available by December for previous year	
		U.S. Emissions of Ozone Depleting Substances	U.S. EPA Inventory of U.S. GHG Emissions and Sinks	Annually available in April	
TRANSPORTATION AND MOBILE EMISSIONS					
Transportation and Mobile Emissions	On Road Transportation	Population	COG Cooperative Forecasts and ACS	COG - Every 1-2 years ACS - Annually available by December for previous year	
		Emissions			
		Vehicle Miles Travelled			EPA MOVES and travel demand models
	Emissions from Off Road Vehicles	Population	COG Cooperative Forecasts and ACS	COG - Every 1-2 years ACS - Annually available by December for previous year	
		Emissions			EPA MOVES4
	Aviation Travel	Number of Originating Air Passengers	TPB's Washington-Baltimore Regional Air Passenger Survey	Biennial, special analysis for 2020 pandemic impacts	
		Total Enplanements for BWI, DCA, IAD			
		Total Revenue Passenger Miles	Bureau of Transportation Statistics	Monthly, available 10 weeks after end of the month	
		U.S. Total Commercial Aircraft Emissions	U.S. EPA Inventory of U.S. GHG Emissions and Sinks	Annually available in April	
	Rail Transportation	Population	COG Cooperative Forecasts and ACS	COG - Every 1-2 years ACS - Annually available by December for previous year	
		MTA and VRE Diesel Consumption	FTA National Transit Database	Annually available in October for previous year	

Emissions Type	Emissions Activity or Source	Data Needs	Data Source	Data Availability
WASTE				
Solid Waste	Waste Generation (Landfill)	Municipal Solid Waste (MSW)	Northern Virginia Regional Commission (NVRC) Solid Waste Reports, local and state plans, reports, and sources	Local MSW data reported to state annually in May (state publishing times vary; collect directly from localities) Biennially NVRC reports
	Combustion of Solid Waste Generated by the Community	MSW		
Water and Wastewater	Fugitive Emissions from Septic Systems	Population Served by Septic	COG Regional Wastewater Flow Forecast Model (RWFFM), COG Cooperative Forecasts, and ACS	RWFFM - December after COG Cooperative Forecast adoption COG Cooperative Forecast - Every 1-2 years ACS - Annually available by December for previous year
	Nitrification/Denitrification Process N2O Emissions from Wastewater Treatment	Population Served by Sewer		
	Process N2O from Effluent Discharge to Rivers and Estuaries	Population Served by Sewer		
		Daily Nitrogen Load		
LAND USE				
Agriculture	Emissions from Agricultural Activities	Livestock - dairy cows, beef cattle, sheep, goats, swine, horses, layers (pullets and chickens), broilers, and turkeys	Chesapeake Assessment Scenario Tool (CAST)	Annually, ongoing
		Fertilizer - synthetic, manure, biosolids		
		Crops acreage - corn for grain, all wheat, soybeans		
		Crop yields - bushels/acre for corn, wheat and soybeans by state (MD and VA)	AG Census	Every 5 years
Forests and Trees Outside Forests	Forest Land	ArcGIS boundary shapefiles for COG member jurisdictions and the region	ICLEI's LEARN tool, COG, and some local jurisdictions	Varies
		National Land Cover Dataset (NLCD) 30-meter resolution land use/land cover		Every 1-3 years
	Trees Outside Forest Land	ArcGIS boundary shapefiles for COG member jurisdictions and the region	ICLEI's LEARN tool, COG, and some local jurisdictions	Varies
		ArcGIS boundary shapefiles that exclude forested areas for COG member		
		2006-2019 satellite imagery		
Chesapeake Bay Watershed 1-meter resolution land use/land cover data	ICLEI's LEARN tool	2013-2018 currently available, planned to be updated every few years		

APPENDIX C: 2020 EMISSIONS FACTOR LIBRARY

Emissions Type	Emissions Activity or Source	Inventory Records	2023 Emissions Factors				Source
			CO2	CH4	N2O	Units	
BUILT ENVIRONMENT							
Residential Energy	Emissions from Grid Electricity	Residential Electricity - EPA eGRID RFCE	0.079043	0.000005981	0.000000665	MT/MMBtu	ClearPath
		Residential Electricity - EPA eGRID SRVC	0.078443	0.000005981	0.000000797	MT/MMBtu	
	Emissions from Stationary Fuel	Residential Natural Gas	53.02	0.005	0.0001	kg/MMBtu	
		Residential Fuel Oil	73.96	0.010869565	0.000724638	kg/MMBtu	
Commercial Energy	Emissions from Grid Electricity	Commercial Electricity - EPA eGRID RFC East	0.079043	0.000005981	0.000000665	MT/MMBtu	ClearPath
		Commercial Electricity - EPA eGRID SERC Virginia/ Carolina	0.078443	0.000005981	0.000000797	MT/MMBtu	
	Emissions from Stationary Fuel Combustion	Commercial Natural Gas	53.02	0.005	0.0001	kg/MMBtu	
		Commercial Fuel Oil	73.96	0.010869565	0.000724638	kg/MMBtu	
Process and Fugitive Emissions	Hydrofluorocarbon & Refrigerant Emissions	HFCs	Multiple emission factors not readily available to the public.				EPA US Inventory of Emissions and Sinks
	Fugitive Emissions from Natural Gas Distribution	Natural Gas Fugitive Emissions	0.000000663	0.000061939	N/A	MT/MMBtu natural gas used	ClearPath
	Commercial LPG		62.98	0.010869565	0.001086957	kg/MMBtu	
TRANSPORTATION AND MOBILE EMISSIONS							
Transportation and Mobile Emissions	On Road Transportation	On Road Mobile Emissions	Multiple emission factors embedded into the MOVES2014b model inventory mode is not available to users.				EPA MOVES
	Aviation Travel	Passenger Air Travel	Multiple emission factors not readily available to the public.				EPA US Inventory of Emissions and Sinks
	Rail Transportation	Rail Transportation	0.073934483	0.000005793	0.000001883	MT/MMBtu	ClearPath
	Emissions from Off Road Vehicles	Off Road Mobile Emissions	Multiple emission factors embedded into the MOVES2014b nonroad model not available to users.				EPA MOVES
WASTE							
Solid Waste	Waste Generation	Landfill Waste Generation	N/A	0.648	N/A	MT CH4/wet short ton (mixed MSW)	ClearPath
	Combustion of Solid Waste Generated by the Community	Combustion of Solid Waste	0.032652	0.000032	0.0000042	MT/MMBtu	
Water and Wastewater	Fugitive Emissions from Septic Systems	Septic System Emissions	N/A	0.048213	N/A	MT CH4/daily kg BOD5	ClearPath
	Nitrification/Denitrification Process N2O Emissions from Wastewater Treatment	Sewer System Emissions	N/A	N/A	7	g/person	
	Process N2O from Effluent Discharge to Rivers and Estuaries	N2O Effluent Discharge Emissions	N/A	N/A	0.005	kg N2O/kg N	
LAND USE							
Agriculture	Emissions from Agricultural Activities	Enteric Fermentation	Multiple emission factors embedded into the EPA State Inventory Tool AG Module.				EPA State Inventory Tool, AG Module
		Manure Management AG Soils					
Forests and Trees Outside of Forests	Emissions and Removals from Forests	Forested Land	Multiple emission factors embedded into ICLEI LEARN Tool and Reports that varies for each jurisdiction. Region values presented in this table.				US Community Protocol, ICLEI LEARN Tool
		Forest Change to Cropland	41.66	N/A	N/A	emission factor (t C/hectare)	
		Forest Change to Grassland	37.99	N/A	N/A	emission factor (t C/hectare)	
		Forest Change to Settlement	46.17	N/A	N/A	emission factor (t C/hectare)	
		Forest Change to Wetland	54.86	N/A	N/A	emission factor (t C/hectare)	
		Forest Change to Other	51.76	N/A	N/A	emission factor (t C/hectare)	
		Reforestation	(2.42)	N/A	N/A	removal factor (t C/hectare/year)	
		Forests Remaining Forests	(1.85)	N/A	N/A	removal factor (t C/hectare/year)	
		Disturbed Forests (i.e. harvest, weather, etc.)	62.30	N/A	N/A	emission factor (t C/hectare)	
	Emissions and Removals from Trees Outside of Forests	Trees Outside Forest Land	103.00	N/A	N/A	emission factor (t C/hectare)	
		(3.21)	N/A	N/A	removal factor (t C/hectare/year)		

Column Header	Description
Emissions Type	This column lists the main tabs in the online ClearPath tool's GHG inventory entry pages.
Emissions Activity/Source	This column lists the ClearPath calculators that are used to calculate or record emissions from activities/sources.
Inventory Records	This column lists COG's inventory record entries according to which calculator was used to create that entry.
Emission Factors	A factor expressing an amount of GHG emissions produced per a unit of activity data (e.g., tons of CO2 per ton of fuel consumed), which permits GHG emissions to be estimated for various activity types.
Source	Identifies the source for the emissions factors.

APPENDIX D: INVENTORY CHANGE LOG

Built Environment

EMISSIONS FROM NATURAL GAS (COMMERCIAL)

2005, 2012, 2015, 2018, 2020 Inventories

Commercial Natural Gas consumption and Fugitive Gas emissions updates have been made for the City of College Park, Prince George's County and the COG region for all years of the inventories (2005, 2012, 2015, 2018, 2020, 2023), as well as Charles County for inventory years 2020 and 2023. This update removes the University of Maryland combined heat and power (CHP) plant natural gas consumption from commercial consumption, as well as natural gas power plant consumption in Prince George's County and Charles County. These sources power the grid and their emissions are already accounted for in the electricity grid emissions; therefore, this update eliminates any double-counting in the GHG estimates.

Transportation

ON ROAD TRANSPORTATION

2005, 2012, 2015, 2018, 2020, 2023 Inventories

The 2023 on road GHG emissions were estimated using the most recent input data and assumptions available for use by COG, including the U.S. Environmental Protection Agency's (EPA) MOVES4 mobile emissions model and the COG/TPB Gen2/Version 2.4.6 Travel Demand Forecasting Model. The on road GHG emissions for 2005, 2012, 2015, 2018, and 2020 were re-estimated/re-benchmarked using MOVES4 to allow for more meaningful comparisons of the 2023 inventory against the 2005 baseline and other analysis years. GHG emissions for all years were calculated using the 100-year Global Warming Potential (GWP) values from the 2014 International Panel on Climate Change (IPCC) Fifth Assessment Report (AR5).

AIR PASSENGER TRAVEL

2023 Inventory

The Washington-Baltimore Regional Air Passenger Survey (APS) informs total enplanements by airport and number of originating air passengers for COG member jurisdictions. Due to methodological changes in the 2023 Regional Air Passenger Survey, passenger air travel in 2023 may not necessarily be comparable with previous years. Prior to 2023, the APS was conducted as a paper-based survey at boarding gates and in recent years there was a decline in overall response rate and quality of survey response. Web-based surveys at each airport were implemented for the 2023 APS to allow surveys to be completed directly on mobile devices such as smartphones and tablets. This offered methodological advantages that are further described in the 2023 APS Geographic Findings Report.

Also, due to sample size limitations, passenger air travel for smaller municipalities were calculated by taking the shares for those municipalities of their larger county totals from 2018 and applying them for 2023. Passenger air travel in 2020 was significantly impacted by the pandemic and therefore was not used to estimate smaller municipalities for the purposes of the GHG inventories. This analysis was completed prior to the final 2023 APS findings reports and the data for smaller municipalities may not match final airport analysis zone (AAZ) data in the published reports. Its also important to note that passenger air travel in 2023 shows a large increase from 2020, showing post-pandemic recovery.

Waste

LANDFILL WASTE GENERATION

2020, 2023 Methodology

The District of Columbia and Frederick County had updated solid waste tonnage for the 2020 inventories that have been incorporated into the calculations. As of July 2023, Charles County has operated a pilot landfill gas (LFG) collection system for approximately one-third of the Charles County landfill. Therefore, half of the 2023 MSW tonnage was estimated without an active methane collection system, representing January to June disposal at the landfill, and the other half of the 2023 MSW tonnage was estimates with an active methane collection system.

Land Use

FORESTS AND TREES OUTSIDE OF FORESTS

2012, 2015, 2018, 2020, 2023 Methodology

The LEARN tool was used to develop Forested results for 2001-2011 (serves as a 10-year base period covering the 2005 inventory), 2011-2016 5-year average annual results are applied to the 2012 and 2015 inventory, and 2016-2021 5-year average annual change was applied to the 2018, 2020, and 2023 inventories. During the last round of inventories only 2016-2019 data was available; therefore, it was updated with the latest year of data through 2021.

The i-Tree Canopy tool was used to develop Trees Outside of Forests (TOF) for 2006-2011, which is applied to the 2005 inventory. The LEARN tool Chesapeake Bay 1-meter resolution data was updated since the last round of inventories. This round of inventories the LEARN tool was used to develop TOF from 2013-2018 and was applied to the 2012, 2015, 2018, 2020, and 2023 inventories. Since TOF leverages two different tools, caution is recommended when comparing across the years. While removals results align well across the tools, emissions results did not align as closely. However, the methodology differences on average resulted in a 0.3% difference in overall net GHG emission reductions. When more recent years of data are available and incorporated into the LEARN tool, the results will be updated in a future round of inventories. The table below provides and overview of span of years applied to each inventory year.

Emissions Source	Year Range	Inventory	Data/Tools
Forests	2001-2011	2005	NLCD, LEARN
	2011-2016	2012, 2015	NLCD, LEARN
	2016-2021	2018, 2020, 2023	NLCD, LEARN
TOF	2006-2011	2005	i-Tree, Google Earth
	2013-2018	2012, 2015, 2018, 2020, 2023	Chesapeake Bay data, LEARN

Other

DEMOGRAPHICS

2015, 2018, 2020, 2023 Methodology

The District of Columbia had updated population estimates that were incorporated into the GHG inventories. COG Cooperative Forecast 10.0 was used for 2020 and 2018 was interpolated based on DC 2015 population from Cooperative Forecast 9.2 and DC 2020 population from Cooperative Forecast 10.0.

GWP VALUES

2005, 2020, 2023 Methodology

Global Warming Potential (GWP) values were updated to AR5 for 2005, 2020, and 2023 to provide for a more accurate comparison from the base year to most recent inventories.

-
- ⁱ ICLEI. (2019). U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions Version 1.2. <https://icleiusa.org/us-community-protocol/>
- ⁱⁱ World Resources Institute. (2021). Global Protocol for Community-Scale Greenhouse Gas Inventories: An Accounting and Reporting Standard for Cities Version 1.1. <https://ghgprotocol.org/ghg-protocol-cities>
- ⁱⁱⁱ U.S. Green Building Council. (2026). LEED v4.1 Cities: Energy and Greenhouse Gas Emissions Performance. <https://www.usgbc.org/credits/cities-existing/v41-20>
- ^{iv} Greenhouse Gas Protocol. (2024). IPCC Global Warming Potential Values. <https://ghgprotocol.org/sites/default/files/2024-08/Global-Warming-Potential-Values%20%28August%202024%29.pdf>
- ^v International Monetary Fund. (2022). Greenhouse Emissions Rise to Record, Erasing Drop During Pandemic. <https://www.imf.org/en/Blogs/Articles/2022/06/30/greenhouse-emissions-rise-to-record-erasing-drop-during-pandemic>
- ^{vi} Maryland Department of Environment. (2022). Reducing Greenhouse Gas Emissions in Maryland: A Progress Report. <https://mde.maryland.gov/programs/air/ClimateChange/Documents/GGRA%20PROGRESS%20REPORT%202022.pdf>
- ^{vii} Northern Virginia Regional Commission. (2022). Public Solid Waste Services in Northern Virginia and the District of Columbia. <https://www.novaregion.org/583/Solid-Waste-Report>
- ^{viii} Metropolitan Washington Council of Governments. (Multiple Years). Cooperative Forecasts. Round 10.0, 9.1a, 9.1, 8.4, 8.3, and 8.0 Cooperative Forecasting Summary Tables. <https://www.mwcog.org/documents/2023/11/03/cooperative-forecasts-employment-population-and-household-forecasts-by-transportation-analysis-zone-cooperative-forecast-demographics-housing-population/>
- ^{ix} U.S. Census Bureau. American Community Survey 5-Year Estimates Data Profiles. Demographic and Housing Estimates (2005, 2012, 2015, 2018, 2020, and 2023 ACS, Table DP05). <https://data.census.gov/cedsci/>
- ^x CoStar. (2015, 2018, 2020, and 2023). Commercial Property Records. www.costar.com
- ^{xi} Metropolitan Washington Council of Governments. (2022). Metropolitan Washington Energy Utility Data Survey Analysis for 2005, 2012, 2015, 2018, 2020, and 2023.
- ^{xii} U.S. Census Bureau. American Community Survey. 5 year estimates 2005-2009, 2011-2015, 2016-2020, and 2019-2023. General Housing Characteristics (ACS, DP04). <https://data.census.gov/cedsci/>
- ^{xiii} Energy Information Administration. (2005, 2009, 2015, and 2020). Residential Energy Consumption Survey (RECS). <https://www.eia.gov/consumption/residential/>
- ^{xiv} Energy Information Administration. (2007, 2016, and 2022). Commercial Buildings Energy Consumption Survey (CBECS). <https://www.eia.gov/consumption/commercial/data/>
- ^{xv} U.S. Environmental Protection Agency. (Multiple Years). Inventory of U.S. GHG Emissions and Sinks - 1990-2023. <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks>
- ^{xvi} Metropolitan Washington Council of Governments. (2025). Internal Memorandum: 2023 estimates of on-road, transportation-sector carbon-dioxide-equivalent (CO₂e) emissions for the metropolitan Washington region (COG member jurisdictions) for 2023 CO₂e emissions inventory project.
- ^{xvii} Metropolitan Washington Council of Governments. (2005, 2008, 2013, 2016, and 2019). Washington-Baltimore Regional Air Passenger Survey Geographic Findings Report. <https://www.mwcog.org/documents/2019/04/08/washington-baltimore-regional-air-passenger-survey-geographic-findings-report-airport-access/>
- Metropolitan Washington Council of Governments. (2022). 2020 Air Trips by Jurisdiction Excel Spreadsheet.
- Metropolitan Washington Council of Governments. (2022). 2020 Washington-Baltimore Regional Air Travel Counts Analysis.
- Metropolitan Washington Council of Governments. (2020-2021). COVID-19 Travel Monitoring Snapshots. <https://www.mwcog.org/documents/2021/01/07/covid-19-travel-monitoring-snapshot-covid19-featured-publications-traffic-monitoring/>
- Metropolitan Washington Council of Governments. (2025). 2023 Air Trips by Jurisdiction Excel Spreadsheet.
- Metropolitan Washington Council of Governments. (2025). 2023 Washington-Baltimore Regional Air Travel Counts Analysis.
- ^{xviii} Bureau of Transportation Statistics. Airline Information: Revenue Passenger Miles. All Carriers, Domestic and International by Origin Airport for All Airports, BWI, Dulles, and Reagan. https://www.transtats.bts.gov/Data_Elements.aspx?Data=3
- ^{xix} Federal Transit Administration. (Multiple Years). National Transit Database. 2005, 2012, 2015, 2018, 2020, and 2023 Annual Energy Consumption. <https://www.transit.dot.gov/ntd/data-product/2020-annual-database-energy-consumption>
- ^{xx} District Department of Energy and Environment, Data provided by Jenn Hatch and Brittany Whited, via email.
- District Department of Public Works. (2016). Washington, DC Solid Waste Diversion Progress Report. https://dpw.dc.gov/sites/default/files/dc/sites/dpw/page_content/attachments/FY15WasteDiversionReport_f.pdf
- Charles County Comprehensive Solid Waste Management Plan 2011 – 2021.

Charles County Ten- Year Comprehensive Solid Waste Management Plan (2022-2031). <https://www.charlescountymd.gov/services/environmental-resources/solid-waste-management-plan?msclkid=c5c5bbbdd06c11ec9f4e9fdd9aaf9fff>

Frederick County Division of Utilities and Solid Waste Management. Solid Waste Management Plan 2018 – 2037. <https://frederickcountymd.gov/3563/Solid-Waste-Management-Plan>

Geosyntec and Nexight Group. (2016). Solid Waste Management Options Study Phase I Report. <https://www.frederickcountymd.gov/DocumentCenter/View/287880>

City of Frederick, Data provided by Jenny Willoughby, via email.

Montgomery County Department of Environment, Data provided by Stan Edwards and Lindsey Shaw, via email.

Montgomery County Maryland Division of Solid Waste Services. Comprehensive Ten-Year Solid Waste Management Plan 2020 – 2029. https://www.montgomerycountymd.gov/council/Resources/Files/Agenda/col/2021/20210316/20210316_7.pdf

City of Rockville, Data provided by Erica Shingara, via email.

City of Takoma Park. (2017). Waste Management 101: A Review of Takoma Park's 2016 Efforts.

City of Takoma Park, Data provided by Gina Mathias and Daryl Braithwaite, via email.

Prince George's County 2020 Solid Waste Tonnage Report, provided by Dawn Hawkins-Nixon, Prince George's County, via email, May 2022.

Prince George's County, Maryland. (2017). Comprehensive Ten-Year Solid Waste Management Plan: 2017-2026. <https://www.princegeorgescountymd.gov/sites/default/files/Ten-Year-Solid-Waste-2017-2026--JPG-Edits-6-as-of-September-30-2016.pdf>

Prince George's County, Maryland. (2020). Comprehensive Ten-Year Solid Waste Management Plan: 2020-2029. <https://www.princegeorgescountymd.gov/sites/default/files/media-document/dcv34077.pdf>

Prince George's County, Maryland. (2024). Comprehensive Ten-Year Solid Waste Management Plan: 2024-2033. <https://www.princegeorgescountymd.gov/departments-offices/environment/waste-recycling/studies-initiatives/ten-year-solid-waste-plan-tyswp>

University of Maryland. (2025). SustainableUMD Progress Hub – Waste Minimization. <https://sustainingprogress.umd.edu/measuring-progress/waste-minimization>

Virginia Department of Environment (DEQ). (Multiple years). Commonwealth of Virginia Locality Recycling Rate Report.

City of Alexandria. (2004). Solid Waste Management Plan. <https://www.alexandriava.gov/uploadedfiles/tes/info/solidwastemgmtplan.pdf>

City of Alexandria. (2019). WasteSmart - Alexandria's 20-Year Strategic Plan to Sustainably Recover Resources. <https://www.alexandriava.gov/WasteSmart>

Arlington County Department of Environmental Services. (2004). Solid Waste Management Plan. <https://www.arlingtonva.us/files/sharedassets/public/v/1/recycling/documents/solid-waste-management-plan.pdf>

Fairfax County, Virginia. (2015). Solid Waste Management Plan Update.

City of Fairfax, Virginia Department of Public Works. (2015). Solid Waste Management Plan. <http://www.fairfaxva.gov/government/public-works/operations-division/refuse-recycling>

City of Fairfax, Virginia. (2021). Solid Waste Management Plan Five Year Update. <https://fairfaxva.prelive.opencities.com/files/assets/city/v/1/public-works/documents/final-2021-fairfax-swmp-with-appendices.pdf>

City of Falls Church, Virginia. (2004). Solid Waste Management Plan. <http://www.fallschurchva.gov/DocumentCenter/Home/View/605>

Loudoun County, Virginia. (2004). Solid Waste Management Plan. <https://www.loudoun.gov/441/Solid-Waste-Management-Plan>

Prince William County. (2022). Solid Waste Management Plan. <https://www.pwcva.gov/department/solid-waste-management/solid-waste-management-plan-2022>

City of Manassas, Virginia. (2010). Solid Waste Management Plan 2010-2030.

City of Manassas, Virginia. (2021). Solid Waste Management Plan 2020 Update. <https://cms9files.revize.com/manassasva/Public%20Works/Trash%20&%20Recycling/Manassas%20SWMP%20FINAL%202021.pdf>

Northern Virginia Regional Commission (NVRC). (Multiple years). Public Solid Waste Services in the Washington Metropolitan Region. <https://www.novaregion.org/583/Solid-Waste-Report>

Metropolitan Washington Council of Governments. (2016). Original 2005 Regional Greenhouse Gas Inventory Spreadsheets

^{xxi} U.S. Environmental Protection Agency. (Multiple years). Facility Level Greenhouse Gas Tool (FLIGHT). <https://ghgdata.epa.gov/>

^{xxii} Metropolitan Washington Council of Governments. Regional Wastewater Flow Forecast Model for 2005, 2012, 2015, 2018, 2020, and 2023.

^{xxiii} U.S. Environmental Protection Agency. (2017). User's Guide for Estimating Methane And Nitrous Oxide Emissions From Agriculture Using The State Inventory Tool. https://www.epa.gov/sites/default/files/2017-08/documents/ag_module_users_guide.pdf

^{xxiv} U.S. Environmental Protection Agency. (2018, 2020, and 2025). Chesapeake Assessment Scenario Tool (CAST). <https://cast.chesapeakebay.net>

U.S. Department of Agriculture. (2007, 2012, 2018, 2020, and 2023). National Agricultural Statistics Service. <https://www.agcensus.usda.gov/>

U.S. Environmental Protection Agency. (2017, 2021, and 2025). EPA State GHG Inventory and Projection Tool. Ag Module.
www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool

^{xxv} ICLEI, Global Forest Watch, Woodwell Climate Research Science Center. (2022). Land Emissions And Removals Navigator (LEARN) tool.
<https://icleiusa.org/LEARN/>

^{xxvi} World Resources Institute. (2022). Guide to calculating tree canopy and canopy change outside of forests for US communities using i-Tree Canopy.
<https://icleiusa.org/LEARN/>

^{xxvii} i-Tree Canopy Tool. <https://canopy.itreetools.org/> and Google Earth Pro <https://www.google.com/earth/about/versions/>



Metropolitan Washington
Council of Governments

777 North Capitol Street NE, Suite 300
Washington, DC 20002

mwcog.org