

# Water/Wastewater Utility Greenhouse Gas (GHG) Emissions Inventory Tool

## User Guide

WEAO/OWWA Climate Change Committee Task Group

### Version History

Version	Date	Description
01	March 10, 2023	First Release for Beta Testing
02	April 17, 2023	First official release on OWWA & WEAO websites

### Disclaimer

Use of the WEAO/OWWA GHG Inventory Tool and its accompanying user guide shall indicate agreement with the following conditions:

1. Neither OWWA nor WEAO may be held liable for any losses that may be incurred directly or indirectly from use of this model. Those who use this model do so at their own risk.
2. Anyone who downloads or uses this model in any way shall not sell it or profit in any manner from its sale, distribution or use.

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## 1. Introduction & Background

The Greenhouse Gas Emissions Inventory Tool (GHG Inventory Tool) is hosted and maintained by a Task Group of the joint Climate Change Committee of the Water Environment Association of Ontario (WEAO) and the Ontario Water Works Association (OWWA). The tool was based on a GHG Inventory developed by the University of Toronto, under contract to Toronto Water.

The first step toward reducing emissions is understanding all emission sources and their relative contributions to their total. Completing a GHG emissions inventory helps utilities to achieve this and to effectively target their emission reduction efforts.

Although the tool was primarily developed for the use of Ontario water and wastewater utilities, guidance is provided further on in this guide to enable its use by any Canada utility. The GHG Inventory Tool is free, transparent, and was designed to be accessible to all users, with inputs that utilities commonly already use. The spreadsheet tool and this user guide are both living documents that the Climate Change Committee has committed to keep current. The Task Group welcomes feedback, and users are encouraged to please send corrections and improvement suggestions to the committee whose contact information can be found at <https://weao.org/committees/climate-change/>. As the tool will continue to be updated over time, users are encouraged to always access the latest version online.

## 2. About this User Guide

Wherever particular, guidance to users of the spreadsheet tool has been provided right in the spreadsheet, either as visible text or as cell comments. In some areas however, the amount of supporting detail needed to make the tool fully transparent was too much for spreadsheet comments.

This guide provides background information for understanding the Tool including its inputs, calculation methods and outputs. Step-by-step instructions for using the Tool are also provided here.

## 3. Scope of the GHG Inventory Tool

The GHG Inventory Tool goes beyond direct facility GHG emissions to quantify the most significant impacts utility operations have on GHG emissions on and off site. This section outlines which GHG emission sources have been included, and which significant sources have been excluded, from the tool.

### 3.1. Scope 1, 2 & 3 Emissions

Some GHG emissions occur directly on a facility site- these are known as "direct" or "Scope 1" emissions. Other "indirect" emissions occur offsite, but because of the plant operations (e.g. because a chemical is purchased by the utility, that chemical is manufactured and shipped which results in GHG emissions). In carbon accounting, indirect emissions are further subdivided into "Scope 2" (offsite emission from imported electricity) and "Scope 3" (all other indirect emissions), as follows:

- Scope 1 emissions are direct GHG emissions related to onsite combustion and treatment processes within the system boundary, as well as mobile combustion of fleet vehicles owned and operated by the utility.
- Scope 2 encompasses indirect emissions related to the consumption of purchased electricity, steam, heating, or cooling. These emissions are a result of the treatment plant operations, but offsite.
- Scope 3 includes all other (non-Scope 2) indirect GHG emissions that result from treatment plant operations, as well as any offsets.

Scope 3 emissions are less commonly included in GHG inventories but are important to consider because although not generated on utility-owned sites, they are controlled by the utility through their decisions and purchasing power. It is especially important to include Scope 3 emissions when comparing emissions from different alternatives. If for example an alternative with higher chemical usage is being compared to an alternative with higher electricity emissions, it is important to include all these GHG emissions sources in the analysis.

### 3.2. Included Emission Sources

The GHG Inventory Tool accounts for the three types of GHG emissions found to be produced in meaningful quantities in the urban water cycle: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O). The tool cover emissions from the following utility operations:

- Wastewater treatment
- Wastewater collection
- Drinking water treatment
- Drinking water transmission
- Fleet vehicles
- Support services (fuel combustion & purchased electricity)

The GHG Inventory Tool includes all the emissions sources that utilities who report to regulators will be familiar with, like natural gas combustion, digester gas combustion, and process and fugitive emissions of nitrous oxide and methane.

There are also a few “lifecycle” emissions sources included in this tool that historically have been less commonly included in utility GHG inventories. These include:

- Upstream (Scope 3) Electricity- Scope 2 electricity is commonly the only electricity emissions included in inventories. Scope 2 electricity includes the direct emissions from power generation facilities, like the emissions from the stack of the natural gas power plant. Scope 3 electricity emissions include all upstream emissions from power generation, like the emissions from extracting the natural gas or nuclear fuel, and the emissions from building the nuclear power plant.
- Upstream (Scope 3) Fuel Combustion- Similarly to electricity, Scope 1 is commonly the only scope reported for fuel combustion. Scope 1 for fuel combustion includes emissions from burning the fuel on your site or in your fleet vehicle. Scope 3 fuel combustion includes all the upstream emissions from extracting and refining the fuel and transporting it to where it is combusted.

- Scope 3 Chemicals- The GHG Inventory Tool and this guide contain some information about quantifying emissions from chemicals imported by a utility, both from manufacturing and from transportation to the site. Chemical lifecycle emissions can be significant and are worth quantifying, especially on the scale of a drinking water treatment facility's total emissions.

### 3.3. Excluded Emission Sources

There are also some significant emissions sources that have been excluded from the first iteration of the GHG Inventory Tool, although it is hoped that more sources will be added over time. Significant exclusions include:

- Scope 1 Sewer Methane- emerging research shows that sewer methane emissions may be very significant, potentially on the same scale as a wastewater facility's total onsite process emissions (Willis 2017). However there are currently no standard approaches available to quantify this emission. These methods are however under development and are anticipated to be included in future versions of the GHG Inventory Tool.
- Scope 3 Construction and Embodied Emissions- The GHG Inventory Tool is intended to cover operational emissions only (not one-time capital emissions).
- Some treatment process types are not included. Users are encouraged to provide suggestions for improvement at <https://weao.org/committees/climate-change/>, as the Task Force intends to continuously improve the tool.

### 3.4. Notes on Using the Tool Outside Ontario

The GHG Inventory Tool was adapted from an inventory developed for an Ontario utility, and has been validated and tested for Ontario utilities. However, the tool could be adapted relatively easily for use by any Canadian utility.

Some of the emission factors used in the tool were taken from Ontario Guidelines for Greenhouse Gas Emissions Reporting. Replacement factors for other provinces can be found in Canada's National Inventory Report (NIR) and Canada Fuel LCA Methodology.

The following inputs should be revised for use in other Canadian provinces and territories:

- Scope 1 combustion- Use High Heating Values and emission factors from Canada's National Inventory Report (NIR) instead of Ontario GHG reporting guidelines, or just use Ontario factors (combustion emissions per unit of each fuel type do not vary significantly across regional boundaries)
- Electrical grid intensity (Scope 2)- using the same reference source as noted in the spreadsheet tool (NIR), look up factors for the applicable province/territory
- Upstream electrical emissions (Scope 3)- using the same reference source as noted in the spreadsheet tool (Canada Fuel LCA Methodology), look up factors for the applicable province/territory
- Upstream fuel combustion emissions (Scope 3)- using the same reference source (Canada Fuel LCA Methodology), look up factors for the applicable province/territory

### 3.5. Notes on Updates and Tool Currency

Emission factors, global warming potentials and other referenced values in the tool will not always reflect the most frequent available information, and they will not align with all reporting protocols. The intent of the WEAO/OWWA Climate Change Committee Task Group is to update the tool annually, or more frequently. The planned approach for updates will be to update the tool with the most recently available information.

## 4. GHG Inventory Tool Overview

The GHG Inventory Tool is a fully editable Excel spreadsheet. The spreadsheet includes the following tabs:

- **Instructions-** contains basic instructions for using the tool and directs users toward this User Guide
- **References-** contains links to all the commonly referenced data sources in the spreadsheet
- **Inputs-** this is where all the inputs are entered by the user- all subsequent tabs summarize calculations and results but have no inputs
- **Summary-** where results are summarized and displayed
- **Detailed Tabs:**
  - Scope 1- Process
  - Scope 1- Combustion
  - Scope 2 - Electricity
  - Scope 3 - Electricity upstream
  - Scope 3 - Fuel upstream
  - Scope 3- Biosolids
  - Scope 3- Chemicals

The following colour coding has been used throughout the spreadsheet tool:

Utility-Specific Data
Value Adopted by Utility
Default Input, Typical Range or Value Adapted from Literature
Output Calculated based on Utility-Specific data

## 5. Steps for Using the GHG Inventory Tool

Here are the steps to follow to use the GHG Inventory Tool:

1. Save a backup version of the tool and give it a meaningful filename in case you make unintended changes and want to go back to the file you originally downloaded (e.g. “GHG Inventory- BLANK”).
2. Save the version you will work on and give it a meaningful file name (e.g. “GHG Inventory- Town Name- April 2023”).
3. Read the “Instructions” and “References” tabs
4. In the “Inputs” tab:

- a) Populate the names of your facilities. The Tool provides columns for four wastewater treatment plants and four drinking water treatment plants- it is suggested that additional columns be left blank rather than deleted- additional facilities can be removed in the Summary tab at the end of the process
  - b) Enter utility data into all blue cells
  - c) Feel free to overwrite yellow cells as well (default inputs) if utility-specific data are available
5. Delete additional facilities from the Summary Tab
6. You are now ready to review and interpret results on the Summary tab.
7. Refer to this User Guide when desired, in places where comments in the Tool indicate that the User Guide offers more detailed information/guidance

## 6. References Tab

This tab provides web links for a few references that are commonly used throughout the rest of the Tool. Each reference is also given a “Short Name” which is then used elsewhere throughout the document. For example, “2006 IPCC Guidelines for National Greenhouse Gas Inventories” becomes “IPCC 2006”.

## 7. Inputs Tab

As previously noted, the Inputs tab is where all the inputs are entered by the user. All subsequent tabs summarize calculations and results but have no inputs. The Inputs tab is where users will spend most of their time.

### 7.1. Nitrogen Concentrations

Note that for municipal wastewater facility influent, “Average Total Nitrogen Concentration in Wastewater Influent” will be equivalent to Total Kjeldahl Nitrogen (TKN), which is what most facilities measure. Note the units are “as N”. This is typically what laboratories use as reporting units, but this should be confirmed before data are entered. As a reminder, Total Kjeldahl Nitrogen (TKN) measures organic nitrogen + ammonia nitrogen. Total Nitrogen includes all forms of nitrogen: TKN, nitrate and nitrite.

### 7.2. Alternative Wastewater Facility Bypass Configurations

The GHG Inventory Tool was originally developed for a facility that was configured to bypass primary treated flows around secondary treatment during high flows. Users will notice that the sheet is therefore set up to estimate emissions from “secondary treatment effluent flow” and “secondary treatment bypass flow”.

If the user’s facility has filters/tertiary treatment, tertiary quality and flow numbers can be entered instead of secondary. Facilities without any bypass capability can just leave the bypass flows as blank or “0”. Facilities with different bypassing configurations may have to adapt the tool to work for them. The spreadsheet is fully editable by design so that users can adapt it to fit their facilities.

### 7.3. Biosolids Management

This GHG Inventory Tool has been designed to accept inputs from the widely adopted BEAM models (BEAM 2011 or BEAM 2022) for biosolids management emissions. BEAM 2011 and 2022 links are in the "References" tab in the spreadsheet.

BEAM 2011 (v1.1) was developed by the Canadian Council of Ministers of the Environment (CCME) based on work done by SYLVIS Environmental under contract to CCME. It has been freely, publicly available and has been used by biosolids programs and consultants around the world.

BEAM2022 includes numerous updates beyond the original BEAM v1.1 based on recent research and reviews - including:

- additional spreadsheet tabs for additional unit processes, such as different landfill conditions and pyrolysis
- improved flow of inputs and data through the spreadsheet
- updated default values and assumptions based on reviews of recent literature

Although BEAM 2022 is the more up-to-date reference, access to BEAM 2022 is not free. It was therefore decided to enable for users of the GHG Inventory Tool to easily import values from BEAM 2011 as well, since this older version is still available for free.

The purpose of facilitating data input from BEAM is to account for biosolids-related emissions that were not included in the rest of the GHG Inventory. This is intended to primarily cover emissions from "outside the fence" of the WWTP, such as from biosolids transport and land application.

It is possible the some of the processes in BEAM may be co-located with user wastewater treatment facilities. In this case, when completing the BEAM model, it is important that users do not include emissions that are already included in the main inventory. For example, if alkaline stabilization is co-located at the wastewater facility and the electricity use for that process has already been included in the total facility electricity consumption, users should enter zero electricity use in the alkaline stabilization module of BEAM to avoid double counting.

## 8. Summary Tab

This tab displays summarized results of the assessment. Users are free to tabulate and display the data in other ways.

## 9. Scope 1- Process

### 9.1. N<sub>2</sub>O emissions from secondary treatment

The GHG Inventory Tool uses default factor for centralized aerobic treatment plants from the 2019 IPCC Refinements to the 2006 guidelines. This was the most up to date global emissions factor at the time of the tool's release in early 2023. The 2019 IPCC factor is 0.016 kg N<sub>2</sub>O (as N) of emission per kg influent N. In other words, the factor assumes that 1.6% of the nitrogen entering the facility is released as nitrous oxide.



Use of the 2019 IPCC emissions factor results in a very significant nitrous oxide emission estimate. Utilities on a low-carbon grid (e.g. Ontario, British Columbia, and Quebec) will find that use of this factor will make N<sub>2</sub>O their largest wastewater facility emission. It should be emphasized that there is significant uncertainty in this estimate; the real N<sub>2</sub>O emission might significantly lower or higher than the estimate. This is because nitrous oxide formation has very significant spatial and temporal variability and can vary by many orders of magnitude depending on process configuration and operational conditions.

Some countries have developed their own country-specific default emissions factors for process N<sub>2</sub>O emissions, based on research undertaken in the country. Canada does not have its own country-specific factor, which is why the IPCC global default has been used in the GHG Inventory Tool.

It is also noted that some recent studies (de Haas and Andrews, 2022), suggest 1.1% is a more appropriate global default factor based on identifying errors in the original IPCC data analysis.

The best way for a utility to determine its N<sub>2</sub>O emissions is onsite measurement. It is recommended that this be done over the course of a full year to capture seasonal variations, and continuously if possible. More detail on how to approach N<sub>2</sub>O onsite measurement can be found in an excellent open-access book from the IWA: Quantification and Modelling of Fugitive Greenhouse Gas Emissions from Urban Water Systems, IWA, 2022.

### 9.2. Liquid Train CH<sub>4</sub> Emissions

The WEAO/OWWA GHG Inventory Tool utilizes the approach in Canada's National Inventory Report (NIR) for calculating methane emissions which differs slightly from IPCC 2019. The difference being that NIR uses a lower B<sub>0</sub> factor. The user is referred to page 293 of NIR 2022 for further discussion.

### 9.3. CH<sub>4</sub> Emission from Effluent Discharge

The WEAO/OWWA GHG Inventory Tool instead uses an Emission Factor of 0.068 from Table 6.3 of IPCC 2019 which is Tier 1 for discharge to aquatic environments. This assumes little to no knowledge of the character of the receiver water. That table 6.3 in IPCC 2019 provides other factors (Tier 2) if better understanding by the user is available.

### 9.4. CH<sub>4</sub> emissions from anaerobic digestion

Two methods are offered for calculation of this emission. The two methods (generally) lead to similar results. One uses mass of organic waste and the other uses volume of digester gas produced & assumes 2.1% fugitive emissions as per NIR (IPCC default is 5% but range in IPCC is 0-10%). IPCC is global whereas NIR should in theory provide more accurate estimates for Canadian facilities. Both are included, to give users a choice based on the data they have available.

Like N<sub>2</sub>O process emissions, onsite CH<sub>4</sub> emissions vary widely by site and as for nitrous oxide, the best way for utilities to determine their methane emissions is onsite measurement. More detail on how to approach onsite measurement of CH<sub>4</sub> can be found in an excellent open-access book from the IWA: Quantification and Modelling of Fugitive Greenhouse Gas Emissions from Urban Water Systems, IWA, 2022.

## 10. Scope 3- Fuel Upstream

A generic emissions factor for biodiesel has been provided and is appropriate to use where a small proportion of the fuel being combusted is biodiesel. It is important to note that if using a significant amount of biodiesel, an emissions factor should be researched based on the type of biodiesel being combusted, as lifecycle emissions can vary significantly between different biodiesel feedstocks.

## 11. Scope 3- Chemicals

Most utilities purchase chemicals like chlorine, coagulants and polymers and others to achieve various treatment goals. The manufacturing and the transport of these chemicals to the treatment plant results in Scope 3 emissions. Although many Scope 3 emissions have been left out of the GHG Inventory Tool to reduce complexity, chemicals are an emission source that is worth some effort to include, for two reasons:

1. Chemicals are a significant emission source- the carbon footprint of imported chemicals for a drinking water treatment plant in Ontario can be about the same as the imported electricity carbon footprint
2. Utilities have some control over how much and which chemicals are purchased and used

To estimate the emissions associated with each imported chemical, the first step is to determine the following for each chemical:

- How much was purchased in that inventory year (kg), and
- Where was it manufactured
- How it was shipped from manufacturing facility to treatment plant (truck, rail, or sea freight) (km)

For transport emissions, the GHG Inventory Tool includes a calculation using emission factors per tonne shipped, per kilometre transported.

For manufacturing emissions however, utilities must derive their own emissions factors. This can be accomplished in one of two ways:

1. Request an emissions factors from the chemical manufacturer, or
2. Use a lifecycle Inventory (LCI) database to find an appropriate emissions factor for each chemical

The gold standard for an emissions factor from the manufacturer would be an Environmental Product Disclosure (EPD). This is an analysis of GHG emissions from manufacturing of that chemical which has been independently 3<sup>rd</sup> party verified.

If an emissions factor is not available from the chemical manufacturer, a life cycle inventory (LCI) database can be used (#2 above). Some of the common LCI databases include ecoinvent, GaBi and Environmental Footprint. Other common LCI databases are listed at <https://nexus.openlca.org/databases>. They may also be called LCA (lifecycle assessment) databases. LCI databases bring together emissions information from the available body of LCA literature to give estimates for manufacturing each product in each geographical location. They include emissions from production processes and everything upstream (e.g. extraction and transport of raw materials). It should be noted that LCI databases are generally not free, and interpreting data from LCI databases

benefits from specialized expertise in lifecycle assessment. Obtaining information from the chemical manufacturer is recommended as the preferred approach, both because the estimate will likely be more accurate, and because that approach is simpler and does not require specialized expertise.

## 12. Scope 3- Biosolids Management

See comments under “Inputs Tab” on how to bring biosolids management numbers in from BEAM 2011 or BEAM 2022.

Important notes on maintaining GWP value consistency between BEAM and the inventory tool:

- BEAM 2011 uses old GWP values from The Climate Registry Protocol. If users use BEAM 2011, they should change the GWP values on the “References Assumptions” tab (cell B217 for methane, cell B220 for nitrous oxide) to the same AR values used in the inventory tool (found on the Inputs tab under generic data).
- BEAM 2022 uses AR4 GWP values. If users choose AR5 or AR6 GWP values in the inventory tool, they should also update the 100-year GWP values in cells F285 and F286 in the BEAM model on the “References Assumptions” tab to the same GWP values (found on the Inputs tab under generic data).

### 13. References

Deemer, B. R. et al. (2016) 'Greenhouse gas emissions from reservoir water surfaces: A new global synthesis', *BioScience*, 66(11), pp. 949–964. doi: 10.1093/biosci/biw117.

de Haas, David, Andrews, John (2022) 'Nitrous Oxide Emissions from Wastewater Treatment- Revisiting the IPCC 2019 Refinement Guidelines', *Environmental Challenges* (2022), doi: <https://doi.org/10.1016/j.envc.2022.100557>

Sahely, H. R. et al. (2006) 'Comparison of on-site and upstream greenhouse gas emissions from Canadian municipal wastewater treatment facilities', *Journal of Environmental Engineering and Science*, 5, pp. 405–415. Available at: <https://doi.org/10.1139/s06-009>.

North East Biosolids and Residuals Association (NEBRA), Northern Tilth, LLC and Northwest Biosolids. 2022. Estimating greenhouse gas emissions from biosolids management. BEAM\*2022 spreadsheet model and supporting information. <https://www.BiosolidsGHGs.org>. Accessed April 12, 2023.