User's Guide for Estimating Methane and Nitrous Oxide Emissions from Wastewater Using the State Inventory Tool

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Prepared by:
ICF

Prepared for:
State Energy and Environment Program,
U.S. Environmental Protection Agency

This section of the User's Guide provides instruction on using the Wastewater module of the State Inventory Tool (SIT), and describes the methodology used for estimating greenhouse gas (GHG) emissions from the treatment of wastewater at the state level.

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1.1 GETTING STARTED

The Wastewater module was developed using Microsoft® Excel 2000. While the module will operate with older versions of Excel, it functions best with Excel 2000 or later. If you are using Excel 2007 or later, instructions for opening the module will vary as outlined in the Excel basics below. Before you use the Wastewater module, make sure your computer meets the system requirements. In order to install and run the Wastewater module, you must have:

- IBM-PC compatible computer with the Windows 95 operating system or later;
- Microsoft® Excel 1997 or later, with calculation set to automatic and macros enabled;
- Hard drive with at least 20MB free; and
- Monitor display setting of 800 x 600 or greater.

Microsoft Excel Settings

Excel 2003 and Earlier: For the SIT modules to function properly, Excel must be set to automatic calculation. To check this setting, launch Microsoft Excel before opening the Wastewater module. Go to the Tools menu and select "Options..." Click on the "Calculations" tab and make sure that the radio button next to "Automatic" is selected, and then click on "OK" to close the window. The security settings (discussed next) can also be adjusted at this time.

Excel 2007 and Later: For the SIT modules to function properly, Excel must be set to automatic calculation. Go to the Formulas ribbon and select "Calculation Options." Make sure that the box next to the "Automatic" option is checked from the pop-up menu.

Microsoft Excel Security

Excel 2003 and Earlier: Because the SIT employs macros, you must have Excel security set to medium (recommended) or low (not recommended). To change this setting, launch Microsoft Excel before opening the Wastewater module. Once in Excel, go to the Tools menu, click on the Macro sub-menu, and then select "Security" (see Figure 1). The Security pop-up box will appear. Click on the "Security Level" tab and select medium. When set to high, macros are automatically disabled; when set to medium, Excel will give you the choice to enable macros; when set to low, macros are always enabled.

When Excel security is set to medium, users are asked upon opening the module whether to enable macros. Macros must be enabled in order for the Wastewater module to work. Once they are enabled, the module will open to the control worksheet. A message box will appear welcoming the user to the module. Clicking on the "x" in the upper-right-hand corner of the message box will close it.

Excel 2007 and Later: If Excel's security settings are set at the default level a Security Warning appears above the formula box in Excel when the Wastewater module is initially opened. The Security Warning lets the user know that some active content from the spreadsheet has been disabled, meaning that Excel has prevented the macros in the spreadsheet from functioning. Because SIT needs macros in order to function properly, the user must click the "Options" button in the security message and then select, "Enable this

content" in the pop-up box. Enabling the macro content for the SIT in this way only enables macros temporarily in Excel but does not change the macro security settings. Once macros are enabled, a message box will appear welcoming the user to module. Click on the "x" in the upper right-hand corner to close the message box.

If the Security Warning does not appear when the module is first opened, it may be necessary to change the security settings for macros. To change the setting, first exit out of the Wastewater module and re-launch Microsoft Excel before opening the Wastewater module. Next, click on the Microsoft Excel icon in the top left of the screen. Scroll to the bottom of the menu and select the "Excel Options" button to the right of the main menu. When the Excel Options box appears, select "Trust Center" in left hand menu of the box. Next, click the gray "Trust Center Settings" button. When the Trust Center options box appears, click "Macro Settings" in the left-hand menu and select "Disable all macros with notification." Once the security level has been adjusted, open the Stationary Combustion module, and enable macros in the manner described in the preceding paragraph.

Viewing and Printing Data and Results

The Wastewater module contains some features to allow users to adjust the screen view and the appearance of the worksheets when they are printed. Once a module has been opened, you can adjust the zoom by going to the Module Options Menu, and either typing in a zoom percentage or selecting one from the drop-down menu. In addition, data may not all appear on a single screen within each worksheet; if not, you may need to scroll up or down to view additional information.

You may also adjust the print margins of the worksheets to ensure that desired portions of the Wastewater module are printed. To do so, go to "View" and then select "Page Break Preview." Drag the blue lines to the desired positions (see Figure 2). To print this view, go to the File menu, and click "Print." To return to the normal view, go to "View " and then click "Normal" next to "Page Break Preview."

Figure 1. Changing Security Settings

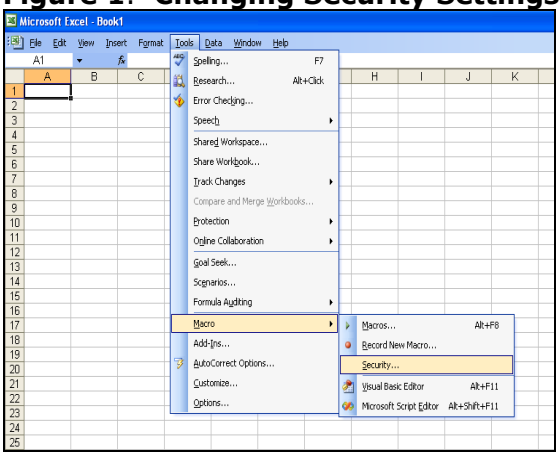
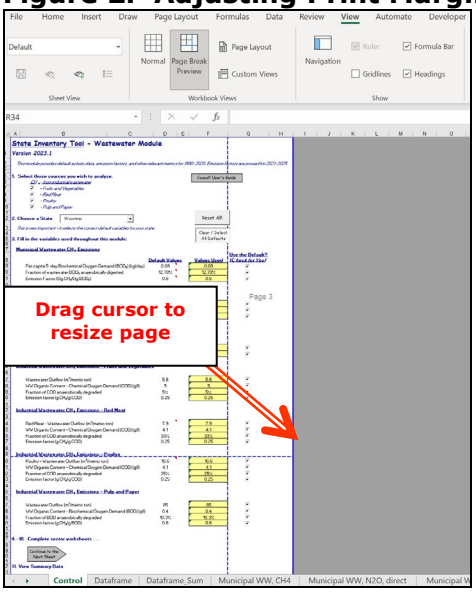


Figure 2. Adjusting Print Margins



1.2 MODULE OVERVIEW

This User's Guide accompanies and explains the Wastewater module of the SIT. The SIT was originally developed in conjunction with EPA's Emissions Inventory Improvement Program (EIIP) in order to automate the steps states would need to take in developing their own emission estimates in a manner that was consistent with prevailing national and state guidelines. The result was a user-friendly and comprehensive set of eleven modules that help users estimate greenhouse gas emissions at the state level.

Because most state inventories developed today rely heavily on the SIT, User's Guides have been developed for each of the SIT modules. These User's Guides contain the most up-to-date methodologies that are, for the most part, consistent with the Inventory of U.S. Greenhouse Gas Emissions and Sinks (EPA 2022a). Users can refer to the chapters and annexes of the U.S. Inventory to obtain additional information not found in the SIT or in the companion User's Guide.

In 2021, EPA began publishing the results of the Inventory of U.S. Greenhouse Gas Emissions and Sinks disaggregated by U.S. state (EPA 2022b) to make consistent state-level GHG data available for all states for use by states, researchers, and the general public. However, EPA recognizes that there will be differences between the state-level estimates published by EPA and inventory estimates developed by states using the SIT or other tools. Inventories compiled by states may differ for several reasons, and differences do not necessarily mean that one set of estimates is more accurate, or "correct." In some cases, the Inventory of U.S. Greenhous Gas Emissions and Sinks may be using different methodologies, activity data, and emission factors, or may have access to the latest facility-level information through the Greenhouse Gas Reporting Program (GHGRP). In other cases, because of state laws and regulations, states may have adopted accounting decisions that differ from those adopted by UNFCCC and IPCC to ensure comparability in national reporting (e.g., use of different category definitions and emission scopes consistent with state laws and regulations). Users of state GHG data should take care to review and understand differences in accounting approaches to ensure that any comparisons of estimates are equivalent or an apples-to-apples comparison of estimates.

The Wastewater module calculates methane (CH_4) and nitrous oxide (N_2O) emissions from the treatment of municipal and industrial wastewater. The module provides default data for most inputs, however other more state-specific data may be used if available (see Box 1 for suggestions on where to find data). If using outside data sources, or for a more thorough understanding of the tool, please refer to the Methodology section below for data requirements and methodology.

Box 1: Wastewater Data Sources

In-state sources, such as state departments of environmental protection, should be consulted first. Otherwise, default data provided by the Wastewater module may be used.

Disposal and treatment of industrial and municipal wastewater often result in CH_4 emissions. Wastewater may be treated using aerobic and/or anaerobic technologies, or if untreated, may degrade under either aerobic or anaerobic conditions. CH_4 is produced when organic material is treated in anaerobic environment and when untreated wastewater degrades anaerobically, i.e., in the absence of oxygen.

N_2O is emitted from both domestic and industrial wastewater containing nitrogen-rich organic matter. N_2O is produced through the natural processes of nitrification and denitrification. Nitrification occurs aerobically and converts ammonia into nitrate, whereas

denitrification occurs anaerobically, and converts nitrate to N_2O. Human sewage is believed to constitute a significant portion of the material responsible for N_2O emissions from wastewater (Spector 1997).

1.2.1 Data Requirements

To calculate greenhouse gas emissions from wastewater, the data listed in Table 1 are required inputs (again, note that defaults are available for most of these data).

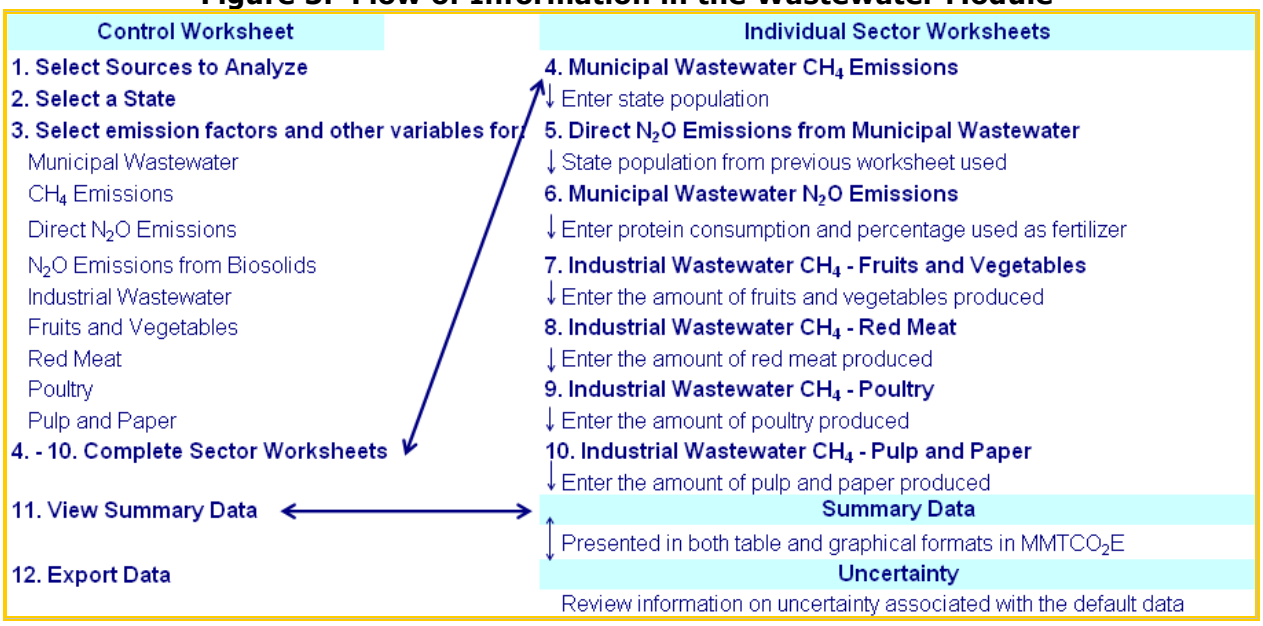
Table 1. Required Data Inputs for the Wastewater Module

Wastewater Sectors	Input Data
Municipal Wastewater: CH_4 Emissions	Per capita 5-day biochemical oxygen demand (BOD_5) (kg/day) Fraction of wastewater BOD_5 anaerobically digested Emission factor (Gg CH_4/Gg BOD_5) State population
Municipal Wastewater: Direct N_2O Emissions	Factor for non-consumption nitrogen Fraction of population not on septic Direct wastewater treatment plant emissions (g N_2O/person/year)
Municipal Wastewater: N_2O Emissions from Biosolids	Emission factor (kg N_2O-N/kg sewage N produced) Fraction of nitrogen in protein ($Frac_{NPR}$) Protein content (kg/person/year) Biosolids used as fertilizer (percentage)
Industrial Wastewater: Fruits and Vegetables	Wastewater Outflow (m^3/metric ton) WW organic content - chemical oxygen demand (COD) (g/L) Fraction of COD anaerobically degraded Emission factor (g CH_4/g COD) Production processed (metric tons)
Industrial Wastewater: Red Meat	
Industrial Wastewater: Poultry	
Industrial Wastewater: Pulp and Paper	Wastewater Outflow (m^3/metric ton) WW organic content - chemical oxygen demand (COD) (g/L) Fraction of COD anaerobically degraded Emission factor (g CH_4/g COD) Production processed of woodpulp and paper & paperboard (metric tons)

1.2.2 Tool Layout

Because the methodology for estimating emissions from Wastewater treatment is complex, it is important to understand the module's overall design. The layout of the Wastewater module and the purpose of its worksheets are presented in Figure 3.

Figure 3. Flow of Information in the Wastewater Module



1.3 METHODOLOGY

This section provides a guide to using the Wastewater module of the SIT to estimate greenhouse gas emissions from municipal and industrial wastewater treatment. The methods used in this module are taken from the report by the Intergovernmental Panel on Climate Change (IPCC) entitled *IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 2006) and are presented as used in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (U.S. EPA 2022a).

The Wastewater module follows the general methodology from the National Inventory Report (NIR) GHG Inventory by U.S. State. However, SIT default data are not available for all sources (e.g., fruits and vegetables, poultry, pulp & paper, ethanol refineries, breweries, and petroleum refineries).

There are twelve general steps involved in estimating emissions using the Wastewater module: (1) select industrial wastewater sources; (2) select a state; (3) select emission factors and other variables used throughout the module; (4) complete municipal wastewater worksheet; (5) review direct N_2O emissions from municipal wastewater treatment worksheet; (6) complete municipal wastewater N_2O emissions worksheet; (7) complete industrial wastewater CH_4 - fruits and vegetables worksheet; (8) complete industrial wastewater CH_4 – red meat worksheet; (9) complete industrial wastewater CH_4 – poultry worksheet; (10) complete industrial wastewater CH_4 – pulp and paper worksheet; (11) review summary information; and (12) export data. The Wastewater module will automatically calculate emissions after you make choices on the control worksheet and enter the required data on the individual sector worksheets. The tool provides default data for most sectors.

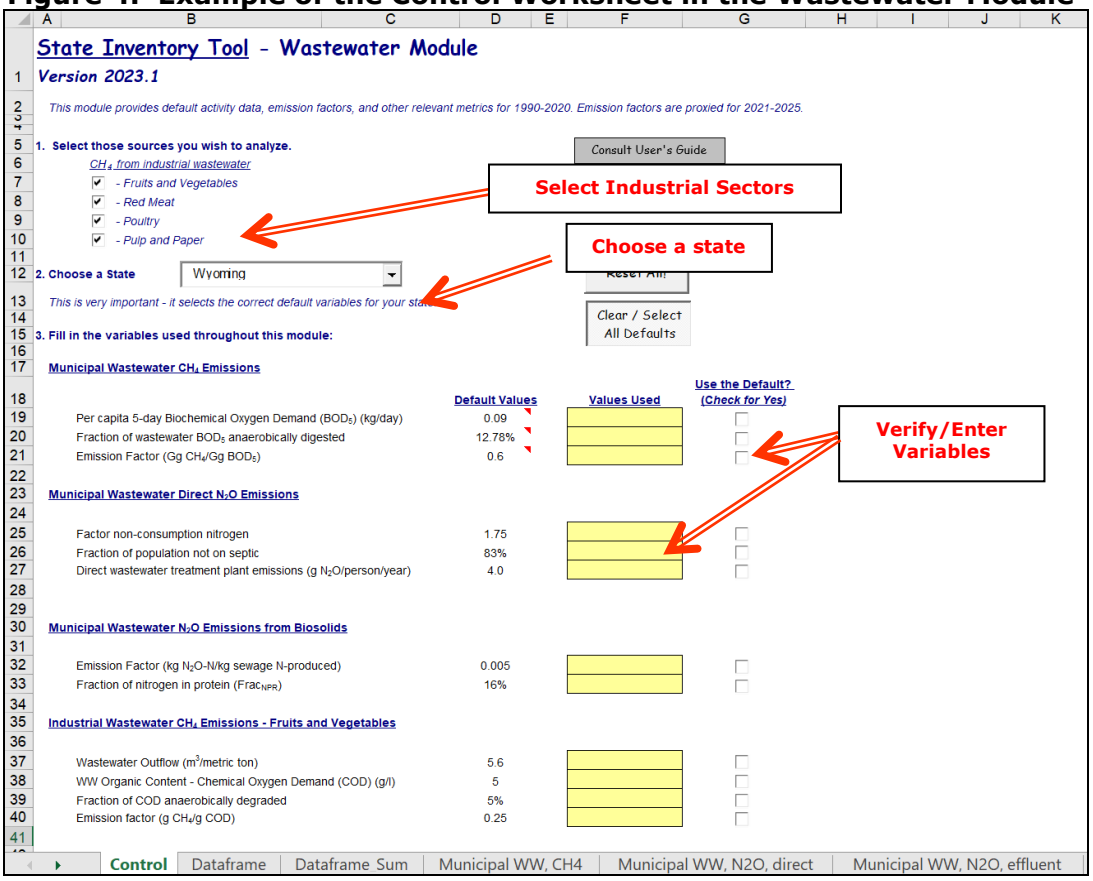
Step (1) Select Industrial Wastewater Sources

To begin, select the industrial wastewater sources you would like to analyze in step 1 of the control worksheet. Check the box to the left of the following industrial wastewater sectors you would like to analyze: fruits and vegetables, red meat, poultry, and pulp and paper.

Step (2) Select a State

Next, select the state you are interested in evaluating. By selecting a state, the rest of the tool will automatically reset to reflect the appropriate state default data and assumptions for use in subsequent steps of the tool. Figure 4 shows an example of the control worksheet.

Figure 4. Example of the Control Worksheet in the Wastewater Module



Step (3) Select Emission Factors and Other Variables Used Throughout the Module

The next part of the control worksheet involves selecting default variables or entering state specific variables in the yellow cells on the control worksheet, as seen in Figure 4. The required inputs for each sector are discussed further in following steps. Box 2 explains terminology used throughout the module. Default factors for all parameters are provided in the control worksheet and may be selected by clicking the gray "Clear / Select All Defaults" at the top of the worksheet. These factors are drawn from the Inventory of U.S. Greenhouse Gas Emissions and Sinks (U.S. EPA 2022a) and are used to estimate emissions from industrial wastewater. If the user-specific inputs do not match the default data in the control worksheet (i.e., the default value is overwritten), the text will appear red.

Box 2: Wastewater Terminology

In highly organic wastewater streams, e.g., streams from food processing plants or pulp and paper plants, the available oxygen in the water is rapidly depleted as the organic matter decomposes. The organic content (sometimes known as "loading") of these wastewater streams is expressed in terms of biochemical oxygen demand, or BOD. BOD represents the amount of oxygen taken up by the organic matter in the wastewater during decomposition. Alternatively, the chemical oxygen demand (COD) is often used to characterize industrial wastewater. COD refers to the amount of oxygen consumed during the oxidation of both organic matter and oxidizable *in*organic matter. Under the same conditions, wastewater with a higher BOD or COD will produce more CH_4 than wastewater with a lower BOD/COD.

CH_4 from Municipal Wastewater

In the yellow cells for this sector on the control worksheet, enter total biochemical oxygen demand (BOD_5)[1] produced, the fraction of wastewater BOD_5 anaerobically digested, and the CH_4 emission factor for municipal wastewater emissions.

Direct N_2O from Municipal Wastewater

In the yellow cells for this sector on the control worksheet, enter the factor for non-consumption nitrogen[2], the fraction of your state population not on septic systems, and the direct wastewater treatment plant emissions per person per year.

N_2O from Biosolids

In the yellow cells for this sector on the control worksheet, enter the N_2O emission factor for biosolids (the solid potion of human sewage) and the fraction of nitrogen in protein ($FRAC_{NPR}$).

Industrial Wastewater: Fruits and Vegetables, Red Meat, Poultry, and Pulp and Paper

In the yellow cells for these sectors on the control worksheet, enter the wastewater outflow of the particular industrial facility, the organic content of the wastewater, the fraction of COD anaerobically degraded, and the CH_4 emission factor.

Step (4) Complete Municipal Wastewater Worksheet

Click on the gray navigational arrow in step 4 of the control worksheet to complete sector worksheets and continue to the CH_4 from Municipal Wastewater worksheet. On this worksheet, the annual state population is entered into the blue cells as seen in Figure 5. Default data from U.S. Census (2021) is provided, if the "Select Default Data" button is selected.

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[1] BOD represents the amount of oxygen that would be required to completely consume the organic matter contained in the wastewater through aerobic decomposition processes (U.S. EPA 2022). A standardized measurement of BOD is the "5-day test" denoted as BOD_5.

[2] This factor represents the nitrogen loading occurring from wastewater going directly into the waste stream from residences (i.e. bathwater, laundry, and use of garbage disposals) as well as industrial wastewater that is not included in the four industries analyzed in this module.

Figure 5. Example of the Municipal Wastewater CH_4 Emissions Worksheet

4. Wyoming Municipal Wastewater Methane Emissions

Click here to find where these data are available.

To calculate methane emissions from municipal wastewater treatment, the total annual BOD_5 production in metric tons is multiplied by the fraction that is treated anaerobically and by the CH_4 produced per metric ton of BOD_5, converted to million metric tons carbon equivalent (MMTCE), and converted to million metric tons carbon dioxide equivalent ($MMTCO_2E$). The methodology and factors used for these calculations are discussed in detail in the Wastewater Chapter of the User's Guide.

Continue to the Next Sheet

Select Default Data

Clear All Data

	State Population	Per Capita BOD_5 (kg/day)	Days per Year (days)	Unit Conversion (metric tons/kg)	Emission Factor (Gg CH_4/Gg BOD_5)	WW BOD_5 anaerobically digested (percent)	Emissions (metric tons CH_4)	CH_4 GWP (CO_2 Eq.)	Unit Conversion (MMT/MT)	C/CO_2	Emissions (MMTCE)	Emissions ($MMTCO_2E$)
1990	453,690	0.0900	365	0.001	0.60	12.78%	1,142.5	25	0.000001	0.27	0.008	0.029
1991	459,260	0.0900	365	0.001	0.60	12.78%	1,156.5	25	0.000001	0.27	0.008	0.029
1992	466,251	0.0900	365	0.001	0.60	12.78%	1,174.1	25	0.000001	0.27	0.008	0.029
1993	473,081	0.0900	365	0.001	0.60	12.78%	1,191.3	25	0.000001	0.27	0.008	0.030
1994	480,283	0.0900	365	0.001	0.60	12.78%	1,209.4	25	0.000001	0.27	0.008	0.030
1995	485,160	0.0900	365	0.001	0.60	12.78%	1,221.7	25	0.000001	0.27	0.008	0.031
1996	488,167	0.0900	365	0.001	0.60	12.78%	1,229.3	25	0.000001	0.27	0.008	0.031
1997	489,451	0.0900	365	0.001	0.60	12.78%	1,232.5	25	0.000001	0.27	0.008	0.031
1998	490,787	0.0900	365	0.001	0.60	12.78%	1,235.9	25	0.000001	0.27	0.008	0.031
1999	491,780	0.0900	365	0.001	0.60	12.78%	1,238.4	25	0.000001	0.27	0.008	0.031
2000	494,300	0.0900	365	0.001	0.60	12.78%	1,244.7	25	0.000001	0.27	0.008	0.031
2001	494,657	0.0900	365	0.001	0.60	12.78%	1,245.6	25	0.000001	0.27	0.008	0.031
2002	500,017	0.0900	365	0.001	0.60	12.78%	1,259.1	25	0.000001	0.27	0.009	0.031
2003	503,453	0.0900	365	0.001	0.60	12.78%	1,267.8	25	0.000001	0.27	0.009	0.032
2004	509,106	0.0900	365	0.001	0.60	12.78%	1,282.0	25	0.000001	0.27	0.009	0.032

Control | Dataframe | Dataframe_Sum | **Municipal WW, CH4** | Municipal WW, N2O, direct | Municipal WW, N2O, effluent | Ind WW Fruit | Ind WW Meat | Ind WW Pou

The CH_4 emissions from municipal wastewater treatment are calculated by multiplying the state population by the total annual BOD_5 production in metric tons, by the fraction that is treated anaerobically, and by the CH_4 produced per metric ton of BOD_5 (i.e. the emission factor); the total is then converted to million metric tons carbon dioxide equivalent ($MMTCO_2E$). This calculation is shown in Equation 1.

Equation 1. CH_4 Emissions from Municipal Wastewater Treatment

CH_4 Emissions ($MMTCO_2E$) =
State Popu[illegible] Production (kg/day) × 3[illegible] ×
0.001 (met[illegible] ton[illegible] Treated Anaerobically[illegible] actor (Gg
CH_4/Gg BOD_5) × 10^{-6} (MMT/metric ton) × 28 (GWP)

Enter Population Data

Select Default Data

Click on the gray navigational arrow to estimate direct N_2O emissions from municipal wastewater treatment.

Step (5) Review Direct N_2O Emissions from Municipal Wastewater Treatment Worksheet

There is no required data for this worksheet because the annual state population was entered in Step (4). Direct N_2O emissions from municipal wastewater treatment are calculated by multiplying total population served, by the fraction of the population not using septic systems, by an N_2O emission factor per person per year, and then converting to $MMTCO_2E$ as seen in Equation 2.

Equation 2. Direct N_2O Emissions from Municipal Wastewater Treatment

Direct N_2O Emissions ($MMTCO_2E$) =
State Population × Fraction of Population not on Septic (%) ×
Emission Factor (g N_2O/person/year) × 10^{-6} (metric ton/g) ×
10^{-6} (MMT/metric ton) × 265 (GWP)

Click on the gray navigational arrow to estimate direct N_2O emissions from biosolids in municipal wastewater treatment.

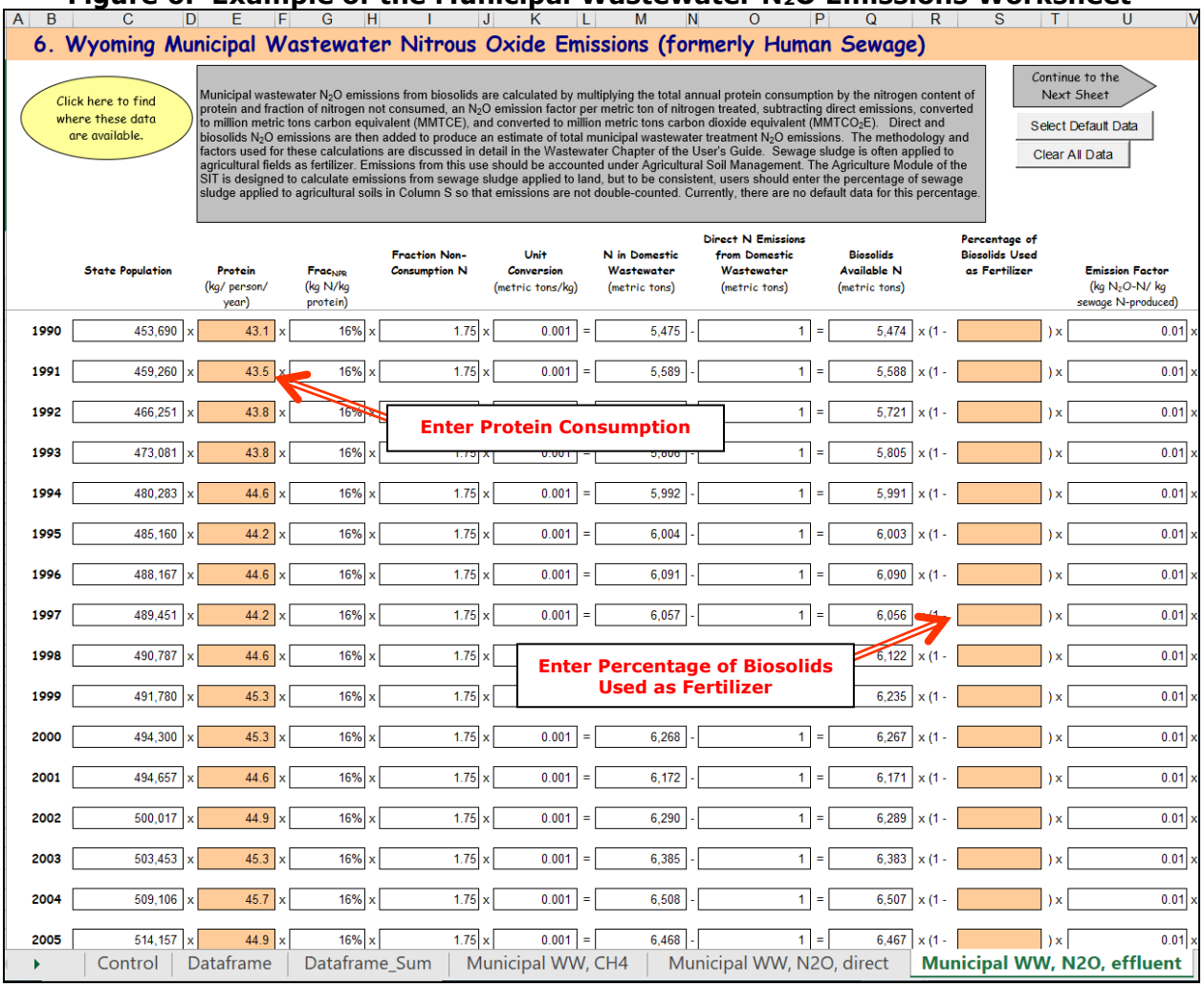
Step (6) Complete Municipal Wastewater N_2O Emissions Worksheet

Municipal wastewater N_2O emissions from biosolids are calculated by multiplying the state population by the total annual protein consumption, by the nitrogen content of protein and fraction of nitrogen not consumed, and by an N_2O emission factor per metric ton of nitrogen treated, then subtracting direct emissions as well as the percentage of biosolids used as fertilizer, and finally converting to $MMTCO_2E$. Direct and biosolids N_2O emissions are then added to produce an estimate of total municipal wastewater treatment N_2O emissions. This calculation is shown below in Equation 3. Data on annual per capita protein consumption for the United States have been published by the United States EPA in Table 7-34 of the Inventory of U.S. Greenhouse Gas Emissions and Sinks (U.S. EPA 2022a).

Equation 3. N_2O Emissions from Biosolids Municipal Wastewater Treatment

N_2O Emissions ($MMTCO_2E$) =
[State Population × Protein Consumption (kg/person/year) ×
$FRAC_{NPR}$ (kg N/kg protein) × Fraction of Nitrogen not Consumed
0.001 (metric ton/kg) – Direct N Emissions (metric tons)] ×
[1 – Percentage of Biosolids used as Fertilizer (%)] ×
Emission Factor (kg N_2O-N/kg sewage N produced) ×
44/28 (kg N_2O /kg N) × 10^{-6} (MMT/metric ton) × 265 (GWP) +
Direct N_2O Emissions

Figure 6. Example of the Municipal Wastewater N_2O Emissions Worksheet



6. Wyoming Municipal Wastewater Nitrous Oxide Emissions (formerly Human Sewage)

Click here to find where these data are available.

Municipal wastewater N_2O emissions from biosolids are calculated by multiplying the total annual protein consumption by the nitrogen content of protein and fraction of nitrogen not consumed, an N_2O emission factor per metric ton of nitrogen treated, subtracting direct emissions, converted to million metric tons carbon equivalent (MMTCE), and converted to million metric tons carbon dioxide equivalent ($MMTCO_2E$). Direct and biosolids N_2O emissions are then added to produce an estimate of total municipal wastewater treatment N_2O emissions. The methodology and factors used for these calculations are discussed in detail in the Wastewater Chapter of the User's Guide. Sewage sludge is often applied to agricultural fields as fertilizer. Emissions from this use should be accounted under Agricultural Soil Management. The Agriculture Module of the SIT is designed to calculate emissions from sewage sludge applied to land, but to be consistent, users should enter the percentage of sewage sludge applied to agricultural soils in Column S so that emissions are not double-counted. Currently, there are no default data for this percentage.

Continue to the Next Sheet

Select Default Data

Clear All Data

	State Population	Protein (kg/ person/ year)	$Frac_{NPR}$ (kg N/kg protein)	Fraction Non-Consumption N	Unit Conversion (metric tons/kg)	N in Domestic Wastewater (metric tons)	Direct N Emissions from Domestic Wastewater (metric tons)	Biosolids Available N (metric tons)	Percentage of Biosolids Used as Fertilizer	Emission Factor (kg N_2O-N/ kg sewage N-produced)
1990	453,690	43.1	16%	1.75	0.001	5,475	1	5,474		0.01
1991	459,260	43.5	16%	1.75	0.001	5,589	1	5,588		0.01
1992	466,251	43.8	16%				1	5,721		0.01
1993	473,081	43.8	16%				1	5,805		0.01
1994	480,283	44.6	16%	1.75	0.001	5,992	1	5,991		0.01
1995	485,160	44.2	16%	1.75	0.001	6,004	1	6,003		0.01
1996	488,167	44.6	16%	1.75	0.001	6,091	1	6,090		0.01
1997	489,451	44.2	16%	1.75	0.001	6,057	1	6,056		0.01
1998	490,787	44.6	16%	1.75				6,122		0.01
1999	491,780	45.3	16%	1.75				6,235		0.01
2000	494,300	45.3	16%	1.75	0.001	6,268	1	6,267		0.01
2001	494,657	44.6	16%	1.75	0.001	6,172	1	6,171		0.01
2002	500,017	44.9	16%	1.75	0.001	6,290	1	6,289		0.01
2003	503,453	45.3	16%	1.75	0.001	6,385	1	6,383		0.01
2004	509,106	45.7	16%	1.75	0.001	6,508	1	6,507		0.01
2005	514,157	44.9	16%	1.75	0.001	6,468	1	6,467		0.01

Enter Protein Consumption

Enter Percentage of Biosolids Used as Fertilizer

Control | Dataframe | Dataframe_Sum | Municipal WW, CH4 | Municipal WW, N2O, direct | Municipal WW, N2O, effluent

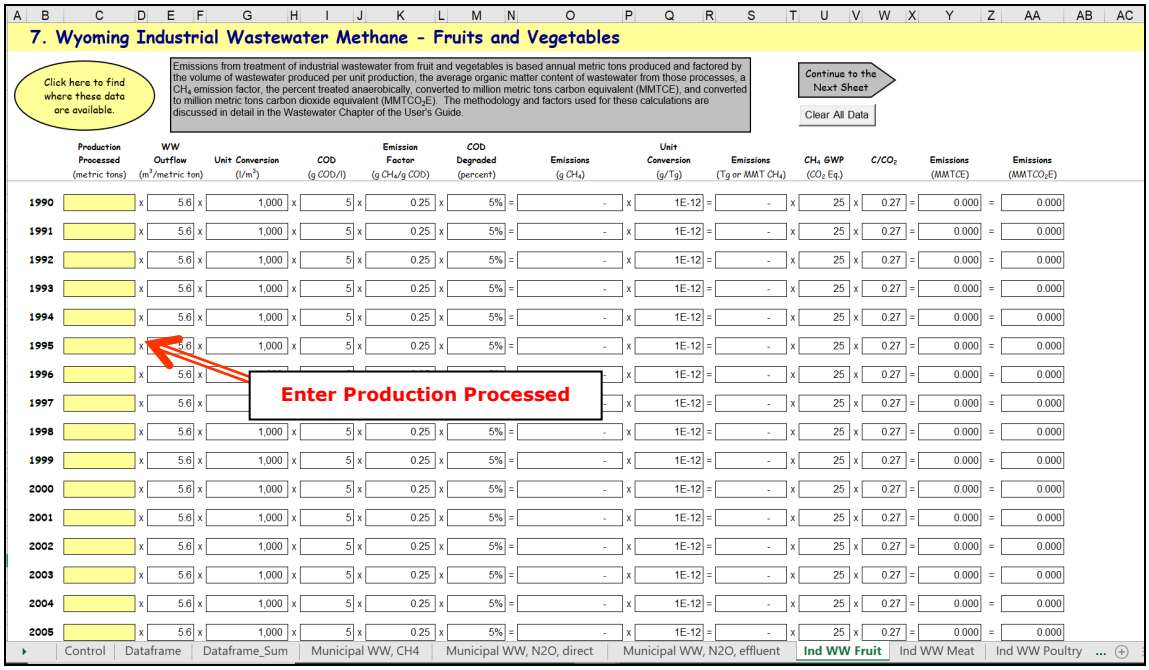
Sewage sludge is often applied to agricultural fields as fertilizer. Emissions from this use should be accounted for under Agricultural Soil Management. The Agriculture module of the SIT is designed to calculate emissions from sewage sludge applied to land, but to be consistent, users need to enter the percentage of sewage sludge applied to agricultural soils in the second column of orange cells in order to not double-count emissions, as shown in Figure 6. At this time, there is no default data for the percentage of biosolids used as fertilizer.

Click on the gray navigational arrow to estimate CH_4 emissions from the industrial wastewater sectors selected on the control worksheet.

Step (7) Complete Industrial Wastewater CH_4 – Fruits and Vegetables Worksheet

This worksheet calculates emissions from wastewater used for fruits and vegetables. Please enter the amount of fruits and vegetables processed in metric tons in the yellow cells, as shown in Figure 7.

Figure 7. Example of Industrial Wastewater CH_4 – Fruits and Vegetables Worksheet



7. Wyoming Industrial Wastewater Methane - Fruits and Vegetables

Click here to find where these data are available.

Emissions from treatment of industrial wastewater from fruit and vegetables is based annual metric tons produced and factored by the volume of wastewater produced per unit production, the average organic matter content of wastewater from those processes, a CH_4 emission factor, the percent treated anaerobically, converted to million metric tons carbon equivalent (MMTCE), and converted to million metric tons carbon dioxide equivalent ($MMTCO_2E$). The methodology and factors used for these calculations are discussed in detail in the Wastewater Chapter of the User's Guide.

Continue to the Next Sheet

Clear All Data

	Production Processed (metric tons)	WW Outflow (m^3/metric ton)	Unit Conversion (l/m^3)	COD (g COD/l)	Emission Factor (g CH_4/g COD)	COD Degraded (percent)	Emissions (g CH_4)	Unit Conversion (g/Tg)	Emissions (Tg or MMT CH_4)	CH_4 GWP (CO_2 Eq.)	C/CO_2	Emissions (MMTCE)	Emissions ($MMTCO_2E$)
1990		5.6	1,000	5	0.25	5%	-	1E-12	-	25	0.27	0.000	0.000
1991		5.6	1,000	5	0.25	5%	-	1E-12	-	25	0.27	0.000	0.000
1992		5.6	1,000	5	0.25	5%	-	1E-12	-	25	0.27	0.000	0.000
1993		5.6	1,000	5	0.25	5%	-	1E-12	-	25	0.27	0.000	0.000
1994		5.6	1,000	5	0.25	5%	-	1E-12	-	25	0.27	0.000	0.000
1995		5.6	1,000	5	0.25	5%	-	1E-12	-	25	0.27	0.000	0.000
1996		5.6						1E-12	-	25	0.27	0.000	0.000
1997		5.6						1E-12	-	25	0.27	0.000	0.000
1998		5.6	1,000	5	0.25	5%	-	1E-12	-	25	0.27	0.000	0.000
1999		5.6	1,000	5	0.25	5%	-	1E-12	-	25	0.27	0.000	0.000
2000		5.6	1,000	5	0.25	5%	-	1E-12	-	25	0.27	0.000	0.000
2001		5.6	1,000	5	0.25	5%	-	1E-12	-	25	0.27	0.000	0.000
2002		5.6	1,000	5	0.25	5%	-	1E-12	-	25	0.27	0.000	0.000
2003		5.6	1,000	5	0.25	5%	-	1E-12	-	25	0.27	0.000	0.000
2004		5.6	1,000	5	0.25	5%	-	1E-12	-	25	0.27	0.000	0.000
2005		5.6	1,000	5	0.25	5%	-	1E-12	-	25	0.27	0.000	0.000

Enter Production Processed

Control | Dataframe | Dataframe_Sum | Municipal WW, CH4 | Municipal WW, N2O, direct | Municipal WW, N2O, effluent | Ind WW Fruit | Ind WW Meat | Ind WW Poultry

Emissions from treatment of industrial wastewater from processing fruits and vegetables are based on annual production in metric tons, multiplied by the volume of wastewater produced per unit production, the average organic matter content of wastewater from those processes, the CH_4 emission factor, the percent treated anaerobically, and then converted to $MMTCO_2E$ as shown in Equation 4.

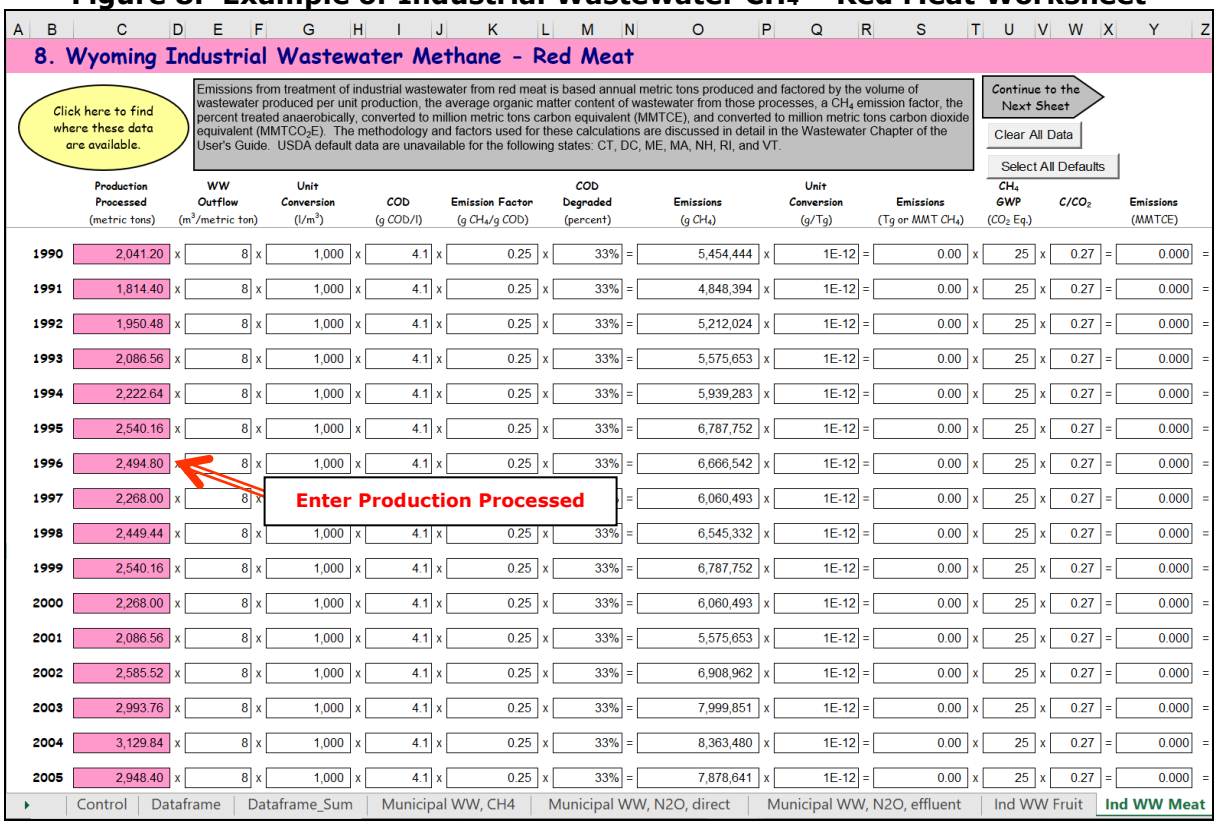
Equation 4. CH_4 Emissions from Industrial Wastewater for Fruits and Vegetables

$$CH_4 \text{ Emissions } (MMTCO_2E) = \text{Production Processed (Metric Tons)} \times \text{Wastewater Produced } (m^3/\text{metric ton}) \times 1{,}000\ (L/m^3) \times \text{Organic Matter Content } (g\ COD/L) \times \text{Emission Factor } (g\ CH_4/g\ COD) \times \text{Percent Treated Anaerobically } (\%) \times 10^{-12}\ (MMT/g) \times 28\ (GWP)$$

Step (8) Complete Industrial Wastewater CH_4 – Red Meat Worksheet

This worksheet calculates emissions from wastewater from red meat processing. In the pink cells, enter the amount of red meat processed in metric tons, as shown in Figure 8.

Figure 8. Example of Industrial Wastewater CH_4 – Red Meat Worksheet



8. Wyoming Industrial Wastewater Methane - Red Meat

Click here to find where these data are available.

Emissions from treatment of industrial wastewater from red meat is based annual metric tons produced and factored by the volume of wastewater produced per unit production, the average organic matter content of wastewater from those processes, a CH_4 emission factor, the percent treated anaerobically, converted to million metric tons carbon equivalent (MMTCE), and converted to million metric tons carbon dioxide equivalent ($MMTCO_2E$). The methodology and factors used for these calculations are discussed in detail in the Wastewater Chapter of the User's Guide. USDA default data are unavailable for the following states: CT, DC, ME, MA, NH, RI, and VT.

Continue to the Next Sheet

Clear All Data

Select All Defaults

Enter Production Processed

	Production Processed (metric tons)	WW Outflow (m^3/metric ton)	Unit Conversion (l/m^3)	COD (g COD/l)	Emission Factor (g CH_4/g COD)	COD Degraded (percent)	Emissions (g CH_4)	Unit Conversion (g/Tg)	Emissions (Tg or MMT CH_4)	CH_4 GWP (CO_2 Eq.)	C/CO_2	Emissions (MMTCE)
1990	2,041.20	8	1,000	4.1	0.25	33%	5,454,444	1E-12	0.00	25	0.27	0.000
1991	1,814.40	8	1,000	4.1	0.25	33%	4,848,394	1E-12	0.00	25	0.27	0.000
1992	1,950.48	8	1,000	4.1	0.25	33%	5,212,024	1E-12	0.00	25	0.27	0.000
1993	2,086.56	8	1,000	4.1	0.25	33%	5,575,653	1E-12	0.00	25	0.27	0.000
1994	2,222.64	8	1,000	4.1	0.25	33%	5,939,283	1E-12	0.00	25	0.27	0.000
1995	2,540.16	8	1,000	4.1	0.25	33%	6,787,752	1E-12	0.00	25	0.27	0.000
1996	2,494.80	8	1,000	4.1	0.25	33%	6,666,542	1E-12	0.00	25	0.27	0.000
1997	2,268.00	8					6,060,493	1E-12	0.00	25	0.27	0.000
1998	2,449.44	8	1,000	4.1	0.25	33%	6,545,332	1E-12	0.00	25	0.27	0.000
1999	2,540.16	8	1,000	4.1	0.25	33%	6,787,752	1E-12	0.00	25	0.27	0.000
2000	2,268.00	8	1,000	4.1	0.25	33%	6,060,493	1E-12	0.00	25	0.27	0.000
2001	2,086.56	8	1,000	4.1	0.25	33%	5,575,653	1E-12	0.00	25	0.27	0.000
2002	2,585.52	8	1,000	4.1	0.25	33%	6,908,962	1E-12	0.00	25	0.27	0.000
2003	2,993.76	8	1,000	4.1	0.25	33%	7,999,851	1E-12	0.00	25	0.27	0.000
2004	3,129.84	8	1,000	4.1	0.25	33%	8,363,480	1E-12	0.00	25	0.27	0.000
2005	2,948.40	8	1,000	4.1	0.25	33%	7,878,641	1E-12	0.00	25	0.27	0.000

Control | Dataframe | Dataframe_Sum | Municipal WW, CH4 | Municipal WW, N2O, direct | Municipal WW, N2O, effluent | Ind WW Fruit | Ind WW Meat

Emissions from treatment of industrial wastewater from red meat are based on annual production in metric tons, multiplied by the volume of wastewater produced per unit production, the average organic matter content of wastewater from those processes, the CH_4 emission factor, the percent treated anaerobically, and then converted to $MMTCO_2E$ as shown in Equation 5. Default data on red meat production are available from USDA (2022).

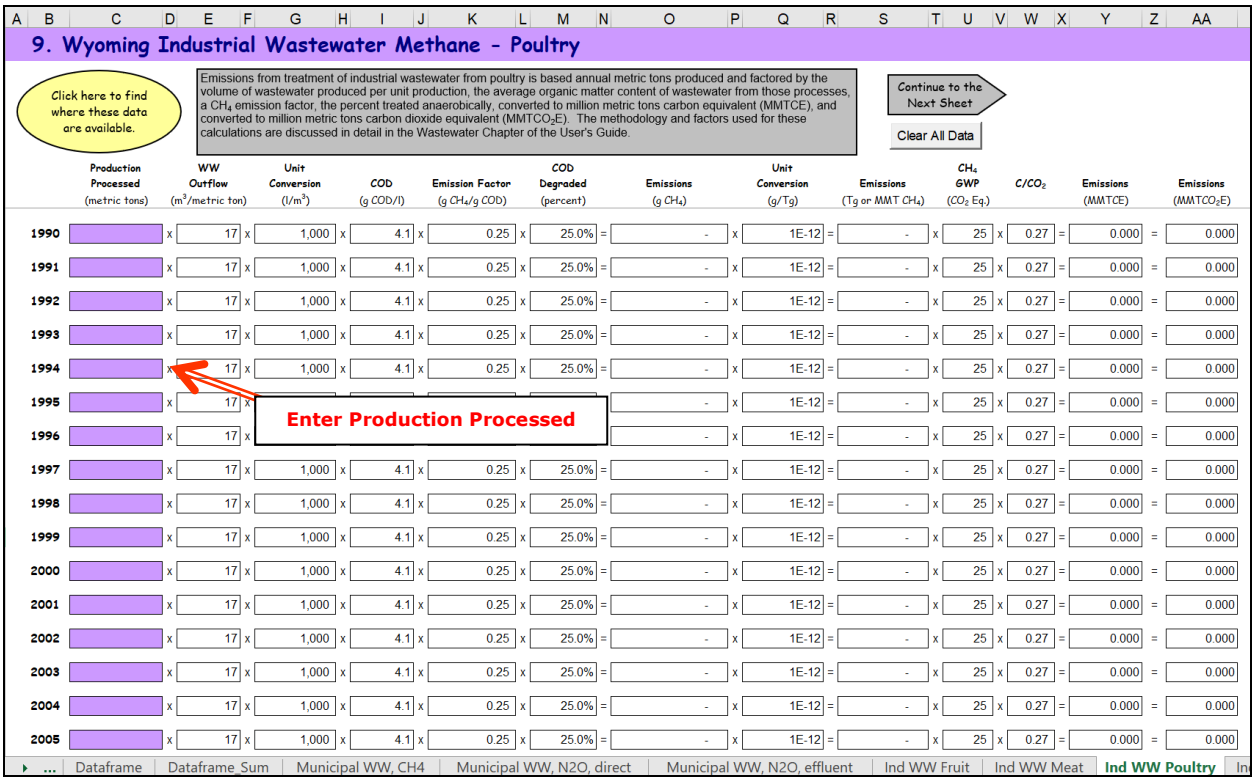
Equation 5. CH_4 Emissions from Industrial Wastewater for Red Meat

$$\text{CH}_4 \text{ Emissions (MMTCO}_2\text{E)} = \text{Production Processed (Metric Tons)} \times \text{Wastewater Produced (m}^3\text{/metric ton)} \times 1{,}000\ (\text{L/m}^3) \times \text{Organic Matter Content (g COD/L)} \times \text{Emission Factor (g CH}_4\text{/g COD)} \times \text{Percent Treated Anaerobically (\%)} \times 10^{-12}\ (\text{MMT/g}) \times 28\ (\text{GWP})$$

Step (9) Complete Industrial Wastewater CH_4 - Poultry Worksheet

This worksheet calculates emissions from wastewater used for poultry. The required input is amount of production processed in metric tons in the purple cells, as shown in Figure 9.

Figure 9. Example of Industrial Wastewater CH_4 - Poultry Worksheet



Equation 6 shows that emissions from treatment of industrial wastewater from poultry are based on annual production in metric tons, multiplied by the volume of wastewater produced per unit production, the average organic matter content of wastewater from those processes, the CH_4 emission factor, the percent treated anaerobically, with the total then converted to $MMTCO_2E$.

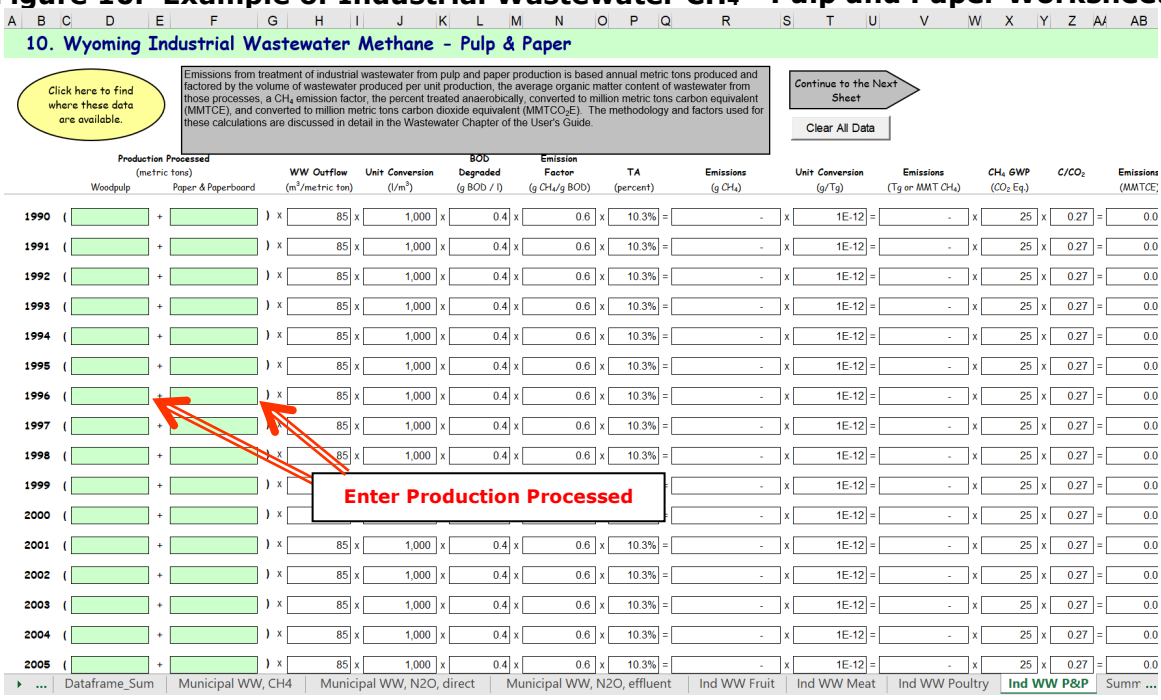
Equation 6. CH_4 Emissions from Industrial Wastewater for Poultry

$$CH_4 \text{ Emissions } (MMTCO_2E) = \text{Production Processed (Metric Tons)} \times \text{Wastewater Produced } (m^3/\text{metric ton}) \times 1{,}000\ (L/m^3) \times \text{Organic Matter Content (g COD/L)} \times \text{Emission Factor } (g\ CH_4/g\ COD) \times \text{Percent Treated Anaerobically (\%)} \times 10^{-12}\ (MMT/g) \times 28\ (GWP)$$

Step (10) Complete Industrial Wastewater CH_4 - Pulp and Paper Worksheet

This worksheet calculates emissions from wastewater used for pulp and paper. The required data (in the green cells) is the amount in metric tons of (1) woodpulp and (2) paper and paperboard processed, as shown in Figure 10.

Figure 10. Example of Industrial Wastewater CH_4 - Pulp and Paper Worksheet



As shown in Equation 7, emissions from treatment of industrial wastewater from pulp and paper are based on annual woodpulp, paper, and paperboard produced in metric tons, multiplied by the volume of wastewater produced per unit production, the average organic matter content of wastewater from those processes, the CH_4 emission factor, and the percent treated anaerobically. The total emissions are then converted to $MMTCO_2E$.

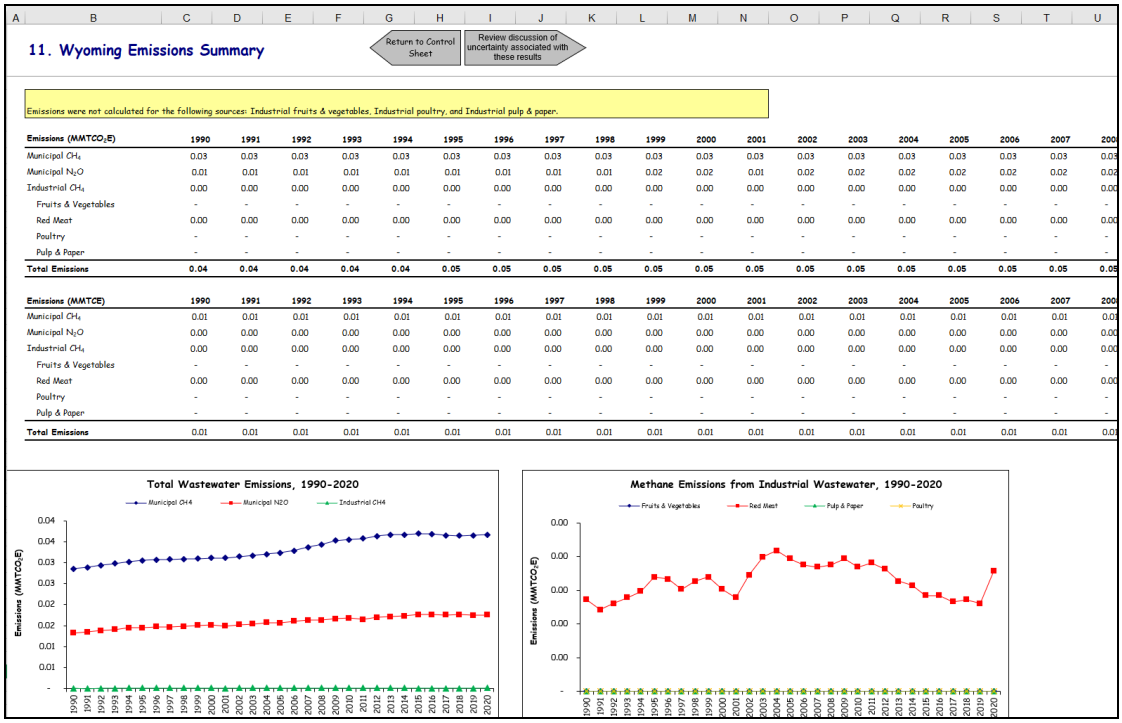
Equation 7. CH_4 Emissions from Industrial Wastewater for Pulp and Paper

CH_4 Emissions ($MMTCO_2E$) =
[Production Processed Woodpulp (Metric Tons) + Production Processed Paper & Paperboard (Metric Tons)] × Wastewater Produced (m^3/metric ton) × 1,000 (L/m^3) × Organic Matter Content (g BOD/L) ×
Emission Factor (g CH_4/g BOD) × Percent Treated Anaerobically (%) × 10^{-12} (MMT/g) × 28 (GWP)

Step (11) Review Summary Information

The steps above provide estimates of total emissions from wastewater. The information from the control worksheet and data entry worksheets is collected on the summary worksheet, which displays results in $MMTCO_2E$. Figure 11 shows the summary worksheet that sums the emissions from all sectors in the Wastewater module. In addition, the results are displayed in graphical format at the bottom of the summary worksheet.

Figure 11. Example of the Emissions Summary Worksheet in the Wastewater Module



11. Wyoming Emissions Summary

Return to Control Sheet | Review discussion of uncertainty associated with these results

Emissions were not calculated for the following sources: Industrial fruits & vegetables, Industrial poultry, and Industrial pulp & paper.

Emissions ($MMTCO_2E$)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	200
Municipal CH_4	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Municipal N_2O	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Industrial CH_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fruits & Vegetables	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red Meat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pulp & Paper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Emissions	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**	**0.05**

Emissions ($MMTCE$)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	200
Municipal CH_4	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Municipal N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Industrial CH_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fruits & Vegetables	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red Meat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poultry	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pulp & Paper	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Emissions	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Step (12) Export Data

The final step is to export the summary data. Exporting data allows the estimates from each module to be combined later by the Synthesis Module to produce a comprehensive greenhouse gas inventory for the state.

To access the "Export Data" button, return to the control worksheet and scroll down to step 12. Click on the "Export Data" button and a message box will open that reminds the user to make sure all steps of the module have been completed. If you make any changes to the Wastewater module later, you will then need to re-export the results.

Clicking "OK" prompts you to save the file.

> **Note: the resulting export file should not be modified.** The export file contains a summary worksheet that allows users to view the results, as well as a separate data worksheet with an unformatted version of the results. The second worksheet, the data worksheet, contains the information that is exported to the Synthesis Tool. Users may not modify that worksheet... Adding/removing rows, moving data, or making other modifications jeopardize the ability of the Synthesis Module to accurately analyze the data.

The file is already named, so you only need to choose a convenient place to save the file. After the file is saved, a message box will appear indicating that the data was successfully exported.

While completing the modules, you are encouraged to save each completed module; doing so will enable you to easily make changes without re-running it entirely.

Following data export, the module may be reset and run for an additional state. Alternatively, you may run the remaining modules of the SIT to obtain a comprehensive profile of emissions for your state.

1.4 UNCERTAINTY

In the upper right-hand corner of the summary worksheet is a button: "Review discussion of uncertainty associated with these results." By clicking on this button, you are taken to a worksheet that discusses the uncertainty surrounding the activity data and emission factors, and how the uncertainty estimates for this source category affect the uncertainty of the emission estimates for your state.

1.5 REFERENCES

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