CMAQ EMISSIONS CALCULATOR TOOLKIT

The purpose of the Congestion Mitigation and Air Quality Improvement Program Emissions Calculator Toolkit (CMAQ Toolkit) is to provide users with a standardized approach to estimating emission reductions from the implementation of a CMAQ-funded project. The CMAQ Toolkit uses emission rates for highway vehicles based on a series of project-scale and national-scale runs of the Motor Vehicle Emission Simulator (MOVES) as well as other data sources. For each tool in the toolkit, the inputs and methodology are described in user guides along with some example cases. Emission estimates from the CMAQ Toolkit are not intended to meet specific requirements for State Implementation Plans (SIPs) or transportation conformity analyses. Information regarding the development of default emission rates and guidance on incorporating user-supplied emission rates can be found in the accompanying documentation of the emissions data.

Dust Mitigation Tool

Significant atmospheric dust arises from the mechanical disturbance of both paved and unpaved road surfaces by vehicle traffic. The force of the wheels on the road surface causes pulverization of surface material and strong air currents uplift particulate matter. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. Dust generated from such open sources is termed "fugitive" because it is not discharged to the atmosphere in a confined flow stream.[1] This tool allows users to calculate emissions benefits from three different categories of dust mitigation projects, which are organized into the following modules: Paved Roads, Unpaved Roads, and Unpaved to Paved.[2]

This document is organized into three sections – User Guide, Tool Methodology, and Examples – to aid the user in understanding and interpreting results from the calculator. The User Guide directs the user on how to properly input values into the tool, and provides definitions of both user inputs and tool outputs. The Tool Methodology section outlines the steps taken by the tool to calculate emission reductions, as well as any assumptions incorporated into the tool. This section also describes the equations used within the tool to calculate emission benefits. The Examples section provides instructive examples of how to use the tool for project analysis. Descriptions of each dust mitigation method are provided in the appendix.

[1] AP-42, Ch. 13.2 (Fugitive Dust Sources): https://www.epa.gov/sites/default/files/2020-10/documents/13.2_fugitive_dust_sources.pdf

[2] The most current version of the tool is dated July 2022. To verify the version, check the date on the Introduction page of the tool. Release notes are included in the Change Log tab, which can be viewed by right-clicking on any tab in the tool, selecting “Unhide”, and revealing the tab.

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USER GUIDE

This section describes each user input and tool output, as well as the emissions reductions report, error messages, and other assumptions present in the tool. The tool is organized into three modules: Paved Roads, Unpaved Roads, and Unpaved to Paved. The Paved Roads module may be used to determine emissions benefits from street sweeping projects. Unpaved Roads may be used for projects which involved application of water or chemical dust suppressants. The Unpaved to Paved module may be used for projects involving paving of an unpaved road. See the appendix for descriptions of fugitive dust terminology and dust control methods. Example data sources for road surface and street sweeper operating parameters are also provided in the appendix.

User Inputs

The Dust Mitigation Tool modules contain a series of questions to guide the user in properly inputting information for emission reductions calculations in a step-by-step process. The inputs for this tool should be specific to the vehicles and road types involved in the dust mitigation project. The user-defined inputs for the three modules are described in **Table 1** through 3.

The Paved Roads module (Table 1) may be used to determine reductions in fugitive dust emissions from street sweeping projects. The module takes into account the potential contribution of street sweeper exhaust and brake and tire wear emissions to overall emissions reductions. See the appendix for further detail of street sweeping and silt loading.

Table 1. User Inputs for Paved Roads Module

Item	User Input	Units	Description
(1)	Project Evaluation Year	-----	Use the drop-down menu to choose a year between 2018 and 2040.
(2)	Annual Activity	Miles	Enter the total annual activity as both fleet VMT and sweeper VMT (miles of road swept).
(3)	Heavy vs. Light-Duty Vehicles	Percent	Enter the percentages (as whole numbers between 0 and 100) of light-duty and heavy-duty vehicles travelling on the paved road. The percentages should sum to 100.
(4)	Silt Loading	g/m^2	Use the drop-down menu to select a default value based on roadway type, or enter your own value in g/m^2.
(5)	Dust Control Efficiency	-----	Use the radio buttons to either use a default control efficiency or input your own value (as a decimal 0.01 to 0.99). This value represents the fraction of fugitive dust (PM) uptake by the sweeper.[3]
(6)	Street Sweeper Operating Hours		Enter the annual operating hours of the street sweeper fleet.
(7)	Street Sweeper Model Year	----	Enter a model year between 1993 and 2040.

[3] For example, a control efficiency of 0.85 indicates the sweeper picks up 85% of PM present on the roadway.

Item	User Input	Units	Description
(8)	Sweeper Exhaust Emission Rates	g/hr or g/mi	Select the radio button to input your own sweeper emission rates and fill out the table to the right for all pollutants. Indicate units of g/hr or g/mi. If you do not select the radio button, the tool will use default emission rates.
(9)	Street Sweeper Fuel	-----	***Complete only if using default sweeper emission rates.*** Use the drop-down menu to select a fuel type. Fuel types include diesel/alternative/clean, gasoline, and zero emissions.
(10)	Street Sweeper Weight	Pounds	***Complete only if using default sweeper emission rates.*** Use the drop-down menu to select gross vehicle weight of a single vehicle (<14,000 or ≥14,000 lbs).

The Unpaved Roads module (Table 2) may be used to determine the reduction in fugitive dust emissions from application of water (wet suppression) or a chemical treatment[4] to unpaved roads (industrial sites and publicly accessible). See the appendix for descriptions of silt content and moisture content.

Table 2. User Inputs for Unpaved Roads Module

Item	User Input	Units	Description
(1)	Project Evaluation Year[5]	-----	Use the drop-down menu to choose a year between 2018 and 2040.
(2)	Annual Activity	Miles	Enter the total annual activity of the fleet as vehicle miles traveled (VMT).
(3)	Silt Content	----	Use the checkbox and drop-down menu to select a default value based on surface material, or enter your own value (% silt content).
(4)	Primary Roadway Use	----	Use the drop-down menu to indicate the primary roadway use: industrial or public access.
(5)	Heavy vs. Light-Duty Vehicles	-----	***Complete for industrial sites only.*** Enter the fractions (as decimal 0.00 to 1.00) of light-duty and heavy-duty vehicles travelling on the paved road. The fractions should sum to 1.
(6)	Mean Vehicle Speed	Miles/Hour	***Complete for public access roads only.*** Use the checkbox and drop-down menu to select a default value based on roadway type, or enter your own value in mph.

[4] Application of water and chemical agents can reduce uplift of dust from the road surface. See the Emissions Data Documentation for further detail.

[5] Note that project evaluation year is not used in calculations in the Unpaved Roads module, but was left as an input in the interface for consistency with other modules and tools in the CMAQ Toolkit.

Item	User Input	Units	Description
(7)	Moisture Content	-----	***Complete for public access roads only.*** Use the checkbox and drop-down menu to select a default value based on moisture conditions, or enter your own value (% moisture content).
(8)	Dust Control Strategy	-----	Use the drop-down menu to select a dust control strategy (wet suppression or chemical treatment).
(9)	Control Efficiency	-----	Select the radio button to use a national default or input your own value.

The Unpaved to Paved module (Table 3) may be used for projects which involve paving of an unpaved road. The module takes into account fugitive dust emissions, as well as the potential contribution of vehicle exhaust emissions due to the mean vehicle speed changing after paving.

Table 3. User Inputs for Unpaved to Paved Module

Item	User Input	Units	Description
(1)	Project Evaluation Year	-----	Use the drop-down menu to choose a year between 2018 and 2040.
(2)	Annual Activity	Miles	Enter the total annual activity of the fleet as vehicle miles traveled (VMT).
(3)	Mean Speed Before Paving	Miles/Hour	Use the checkbox and drop-down menu to select a default value based on roadway type, or enter your own value in mph.
(4)	Silt Content	----	Use the checkbox and drop-down menu to select a default value based on surface material or enter your own value (% silt content).
(5)	Moisture Content	-----	Use the checkbox and drop-down menu to select a default value based on moisture conditions or enter your own value (% moisture content).
(6)	Roadway Access Type	-----	Use the drop-down menu to select a roadway access type after paving.
(7)	Mean Speed After Paving	Miles/Hour	Enter the mean speed (mph) expected after paving. Input the same speed used in Question 3 if no change is expected (see table with default values for reference).
(8)	Control Efficiency	-----	Select the radio button to use a national default or input your own value.

Tool Outputs

Once the input parameters are entered, click the 'Calculate Output' button to generate your results. Emission results will not automatically update: if any changes are made to the input parameters, this button must be clicked again to calculate updated emission reductions. If you would like to return to default settings and clear input values, click on the 'Reset Inputs' button.

The Paved Roads and Unpaved to Paved modules calculate emission reductions for five pollutants – carbon monoxide (CO), particulate matter < 2.5 µm ($PM_{2.5}$), particulate matter < 10 µm (PM_{10}), nitrogen oxides (NOx), and volatile organic compounds (VOC) – in kilograms per year, and then divided by 365 days to generate the CMAQ daily emission reductions reporting in kilograms per day. Reductions in carbon dioxide (CO_2), carbon dioxide equivalents (CO_2e), and total energy consumption (million BTU) are also provided for the Unpaved to Paved module. These parameters are outputs from MOVES related to greenhouse gas reporting. The Unpaved Roads module only reports emissions reductions for fugitive dust ($PM_{2.5}$ and PM_{10}).

Note that a '0' value for an emission reduction indicates no change in emissions associated with the project, while a grayed-out cell indicates that the module does not calculate this particular metric.

The emission benefits are derived from the decrease in the amount of daily emissions resulting from a reduction in fugitive dust ($PM_{2.5}$ and PM_{10}). In addition:

- The Paved Roads module takes into account running emissions from street sweeper activity (all pollutants).
- The Unpaved to Paved module takes into account the change in emissions due to a potential change in mean vehicle speed after paving (all pollutants).

Error Messages

Tables 4-6 below list error messages the user may encounter in this tool, the reason for the error message, and the solution. Once you correct any errors, please press 'Calculate Output' to recalculate the results.

Table 4. Error Messages – Paved Roads Module

Error Message	Reason for Error	Solution
WARNING: Please select a project evaluation year in Question 1.	Invalid input for project evaluation year.	Input a year between 2018 and 2040 by using the drop-down menu.
WARNING: Please enter values for total annual activity in Question 2.	Missing fleet VMT, sweeper, VMT, or both values.	Enter values for both fleet and sweeper VMT.
WARNING: Please complete Question 3 by entering percentages of light- and heavy-duty vehicles.	Missing activity data for average weight calculation.	Enter data for both light- and heavy-duty vehicles.
WARNING: Please check that vehicle activity percentages sum to 100 in Question 3.	The sum of the light and heavy duty percentages does not equal 100.	Check light and heavy duty inputs and ensure that they sum to 100. The percentages must be whole numbers between 0 and 100.
WARNING: Please complete Question 4 by using a default or entering your own value for silt loading.	Missing silt loading data.	Select the radio button to use a default value, or enter your own value.

Error Message	Reason for Error	Solution
WARNING: Please provide a dust control efficiency or use the default value in Question 5.	Missing control efficiency.	Select the radio button to use the default or input a value between 0.01 and 0.99.
WARNING: The dust control efficiency must be a value between 0.01 and 0.99.	Control efficiency outside of allowable range.	Input a control efficiency between 0.01 and 0.99.
WARNING: Please complete Question 6 by entering the annual operating hours of the sweeper fleet.	Missing value for sweeper operating hours.	Input annual operating values of the street sweeper fleet.
WARNING: Please check that street sweeper model year is between 1993 and 2040.	Year provided is outside of the allowed range.	Input a year between 1993 and 2040 for Question 7.
WARNING: Please provide emission rates for all pollutants or uncheck the radio button to use default values.	Missing emission rates for sweepers.	Complete the table to the right of Question 8 for all pollutants, or uncheck the radio button.
WARNING: If you are providing your own emission rates, please indicate the units.	Missing sweeper emission rate units.	Use the drop-down menu to select units of g/hr or g/mi.
WARNING: Please complete Question 9 by indicating the sweeper fuel type.	Missing sweeper fuel type.	Use the drop-down menu to select a fuel type.
WARNING: Please complete Question 10 by selecting the street sweeper weight.	Missing sweeper weight data.	Use the drop-down menu to select a weight class.

Table 5. Error Messages – Unpaved Roads Module

Error Message	Reason for Error	Solution
WARNING: Please select a project evaluation year in Question 1.	Invalid input for project evaluation year.	Input a year between 2018 and 2040 by using the drop-down menu.
WARNING: Please enter a value for total annual activity in Question 2.	Missing value for annual activity.	Enter the vehicle miles traveled on the unpaved road.
WARNING: Please complete Question 3 by using a default or entering your own value for mean silt content.	Missing silt content data.	Provide silt content by selecting a default value, or enter your own value.
WARNING: Please select the primary roadway use in Question 4	Missing primary road use.	Use the drop-down menu to indicate the primary road use.
WARNING: Please complete Question 5 by entering the fractions of heavy- and light-duty vehicles.	Missing activity data for average weight calculation.	Enter data for both light- and heavy-duty vehicles.

Error Message	Reason for Error	Solution
WARNING: Please check that the fractions of heavy- and light-duty vehicles sum to 1.	The sum of the light and heavy duty fractions does not equal 1.	Check light and heavy duty inputs and ensure that they sum to 1. The fractions must be in decimal form (0.00 to 1.00).
WARNING: Please complete Question 6 by using a default or entering your own value for mean vehicle speed.	Missing mean speed data.	Provide mean speed by selecting a default value, or enter your own value.
WARNING: Please complete Question 7 by using a default or entering your own value for mean moisture content.	Missing moisture content data.	Provide moisture content by selecting a default value, or enter your own value.
WARNING: Please select a dust control strategy in Question 8.	Missing input for dust control strategy.	Use the drop-down menu to select a dust control strategy.
WARNING: Please complete Question 9. Either enter a control efficiency or select the default option.	Missing control efficiency.	Select the radio button to use the default or input a value between 0.01 and 0.99.
WARNING: The control efficiency must be a value between 0.01 and 0.99.	Control efficiency outside of allowable range.	Input a control efficiency between 0.01 and 0.99.
Note: The mean vehicle speed is only reported when the primary roadway use is public access roads.	Mean vehicle speed is not reported for industrial sites.	No solution needed.

Table 6. Error Messages – Unpaved to Paved Module

Error Message	Reason for Error	Solution
ERROR: The value you entered is not a valid project evaluation year.	Invalid input for project evaluation year.	Input a year between 2018 and 2040 by using the drop-down menu.
WARNING: Please enter a value for total annual activity in Question 2.	Missing value for annual activity.	Enter the vehicle miles traveled on the unpaved road.
WARNING: Please complete Question 3 by using a default or entering your own value for mean vehicle speed.	Missing mean speed data.	Provide mean speed by selecting a default value, or enter your own value.
WARNING: Please complete Question 4 by using a default or entering your own value for mean silt content.	Missing silt content data.	Provide silt content by selecting a default value, or enter your own value.
WARNING: Please complete Question 5 by using a default or entering your own value for mean moisture content.	Missing moisture content data.	Provide moisture content by selecting a default value, or enter your own value.

Error Message	Reason for Error	Solution
WARNING: Please complete Question 6 by selecting a roadway access type.	Missing an input for roadway access.	Use the drop-down menu to select a roadway access type.
WARNING: Please complete Question 7 by entering the mean vehicle speed after paving.	Missing speed change.	Enter a speed in mph. Enter the same speed used in Question 3 if there is no change anticipated.
WARNING: The mean vehicle speed after paving must be between 0 and 75 mph.	Invalid speed change.	Enter a speed between 0 and 75 mph.
WARNING: Please complete Question 8. Either enter a control efficiency or select the default option.	Missing control efficiency.	Select the radio button to use the default or input a value between 0.01 and 0.99.
WARNING: The control efficiency must be a value between 0.01 and 0.99.	Control efficiency outside of allowable range.	Input a control efficiency between 0.01 and 0.99.

TOOL METHODOLOGY

Emissions Data Sources

See the Emissions Data Documentation for details of the activity and emissions equations used in each of three modules. Fugitive dust emissions for all modules in this tool were derived from the U.S. EPA's Compilation of Air Pollutant Emission Factors (AP-42).[6] Chapters 13.2.1 and 13.2.2 of AP-42 discuss emissions from paved roads and unpaved roads, respectively.

EPA's Emission Standards for Heavy-Duty Highway Engines and Vehicles[7] were used to determine emissions from street sweeping activity in the Paved Roads module. See the Dust Mitigation Tool's Emissions Data Documentation for further detail.

Project-level data from MOVES3 (version from January 2022)[8] was used to determine emissions benefits from a speed change after paving in the Unpaved to Paved module, while national-scale data from MOVES3 was used to determine brake and tire wear emissions from street sweepers in the Paved Roads module.[9] See the Emissions Data Documentation for additional details related to the MOVES runs.

[6] AP-42: Compilation of Air Emissions Factors. https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors

[7] EPA Emission Standards for Heavy-Duty Highway Engines and Vehicles. https://www.epa.gov/emission-standards-reference-guide/epa-emission-standards-heavy-duty-highway-engines-and-vehicles

[8] https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves

[9] Several manufacturers have developed electric and fuel cell-powered street sweepers designed to have zero exhaust emissions. This tool assumes zero running exhaust emissions for these sweepers, but includes brake and tire wear emissions.

Annualization

Note that annual emission reductions are converted to daily emission reductions by dividing the yearly emissions by the number of days per year that the dust mitigation project is active (default is 365 days). If a user wishes to adjust the annualization, simply multiply the emission reduction totals in the output by 365 and divide by the desired annualization.

EXAMPLES

The examples below describe how to use each of the Dust Mitigation tool's three modules. See the appendix for potential data sources for input parameters, including silt content and street sweeper operations.

Example 1: Paved Roads

A city plans to purchase several 10 new low-emissions street sweepers to reduce dust emissions on rural roadways.

In the tool, the user would select the following inputs, shown in the images below:

Project evaluation year: 2024

Activity:
Sweeper VMT: 50,000 miles
Fleet VMT: 250,000 miles

(1) What is your project evaluation year?	2024	
(2) Please input total annual activity on the paved road for both the street sweeper(s) and entire fleet, as vehicle miles traveled (VMT).	Sweeper VMT	Fleet VMT
	50,000	250,000

For question 3, average weight is calculated based on the relative percentages of light-duty and heavy-duty vehicles using the paved road.

Activity percentages:
Light-duty: 75%
Heavy-duty: 25%

Silt loading: Default based on "Rural Restricted Access" road type. *Default silt loading values are provided as reference to the left of Question 4.*

(3) What are the relative percentages of light- and heavy-duty vehicles in the entire fleet? These values are used to calculate average vehicle weight for fugitive dust emissions.

Vehicle Type	Activity	
Light-Duty Vehicles	75	%
Heavy-Duty Vehicles	25	%

(4) What is the silt loading (g/m^2) of the paved surface? You may use a national default based on roadway type or input your own value.

Use a default ☑ Rural Restricted Access

Input my own value: Enter g/m^2

For questions 5-10, enter information about the street sweeper(s) to be purchased.

Dust control efficiency: input own value of 0.92

Annual operating hours: 10,000[10]

Model year: 2020

Emission rates: input own rates in units of g/hr. Enter emission rates in the Question 8 table, as shown below.

*** Fuel type and vehicle weight – Questions 9 and 10 are not required if you provide your own street sweeper exhaust emission rates.*

[10] Operating hours estimate in Question 6 based on 10 street sweepers operating 8 hours per day on weekdays, approximately 6 months out of the year. Using an average speed of 5 mi/hr, this gives a street sweeper VMT of 50,000 miles for Question 2.

STREET SWEEPER DATA

(5) What is the dust control efficiency of the street sweepers? You may use a national default or input your own value.	○ Use the default (0.79) ◉ Enter my own value: 0.92
(6) What are the annual operating hours of the street sweeper fleet?	10,000
(7) What is the model year of the street sweeper?	2020
(8) Do you know the exhaust emission rates for all pollutants for the street sweepers? If yes, check the box and fill out the table to the right. Indicate units of rates (g/hr or g/mi). If no, proceed to questions 9 and 10.	Yes, I will input rates ☑ Note: The tool will use default emission rates if you do not check the box.
(9) What type of fuel does the sweeper use?	Select
(10) What is the gross vehicle weight (in lbs) of a single street sweeper?	Select lbs

Optional Input Table for Question 8

Emission rate units: g/hr

Pollutant	Emission Rate
Carbon Monoxide (CO)	12.00
Nitrogen Oxide (NOx)	2.00
Particulate Matter <2.5 µm (PM2.5)	0.05
Particulate Matter <10 µm (PM10)	0.05
Volatile Organic Compounds (VOC)	1.00

Click the 'Calculate Output' button to generate results.

FLEET PERFORMANCE

50,000 **Miles of Road Swept**

Fleet Performance

Miles of Road Swept: 50,000

EMISSION REDUCTIONS

Pollutant	Total kg/day
Carbon Monoxide (CO)	-0.329
Nitrogen Oxide (NOx)	-0.055
Particulate Matter <2.5 µm ($PM_{2.5}$)	6.063
Particulate Matter <10 µm (PM_{10})	24.591
Volatile Organic Compounds (VOC)	-0.027
Carbon Dioxide (CO_2)	*N/A*
Carbon Dioxide Equivalents (CO_2e)	*N/A*
Total Energy Consumption (MMBTU)	*N/A*

Emissions Reductions

Carbon Monoxide (CO): -0.329 kg/day
Nitrogen Oxide (NOx): -0.055 kg/day
Particulate Matter <2.5 µm (PM2.5): 6.063 kg/day
Particulate Matter <10 µm (PM10): 24.591 kg/day
Volatile Organic Compounds (VOC): -0.027 kg/day
Carbon Dioxide (CO_2): N/A
Carbon Dioxide Equivalents (CO_2e): N/A
Total Energy Consumption (MMBTU): N/A

Note that reductions in CO_2, CO_2e, or total energy consumption are not reported. These parameters are not reported in EPA's AP-42 or heavy-duty engine emission standards, the two emissions data sources used for this tool.

Example 2: Unpaved Roads

A county will be implementing a regular program of chemical treatment to reduce fugitive dust emissions on gravel roads near industrial areas. The county has done some preliminary testing and shown that the chemical suppressant reduces fugitive dust by approximately 76%.

In the tool, the user would select the following inputs, shown in the images below:

Project evaluation year: 2024

Activity: 150,000 miles

(1) What is your project evaluation year?	2024
(2) Please input the total annual activity on the unpaved road, as vehicle miles traveled (VMT).	150,000

Silt content: Default based on "Gravel" surface

Primary roadway use: Industrial Site

***Default values for mean vehicle speed and silt content are provided for reference to the left of Questions 3 through 5*

(3) What is the mean silt content (%) of the unpaved surface? You may use a national default based on surface material or enter your own value.	Use a default ☑	Gravel
	Input my own value:	Enter %
(4) Indicate the primary roadway use: industrial site with heavy-duty traffic or publicly accesible road domicated by light-duty vehicles.	Industrial Site	

Vehicle activity fractions:
Light-duty: 0.30
Heavy-duty: 0.70

***If the road use is industrial, proceed to Question 8 after completing Question 5 (do not complete Questions 6-7).*

For Industrial Sites Only

(5) What are the relative proportions of light- and heavy-duty vehicles in the entire fleet? These values are used to calculate fugitive dust emissions. Proceed to Question 8.

Vehicle Type	Activity
Light-Duty Vehicles	0.30
Heavy-Duty Vehicles	0.70

Dust control strategy: Chemical Stabilization

Dust control efficiency: input own value of 0.76

***This efficiency assumes a common application interval of 2 weeks to 1 month.*

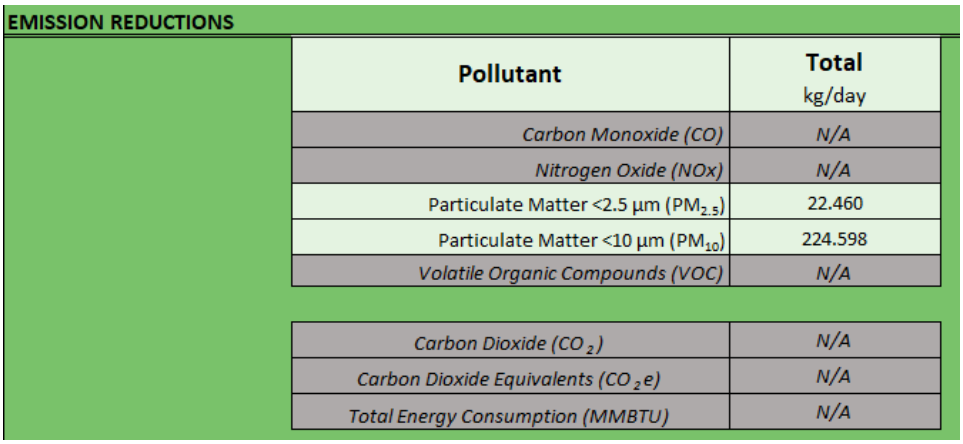
(8) What type of dust control will be applied?	Chemical Stabilization	
(9) What is the efficiency of the control strategy? You may use a national default or enter your own value.	Use a default ☐	
	Input my own value:	0.76

Click the 'Calculate Output' button to generate results.

FLEET PERFORMANCE		
	N/A	Mean Vehicle Speed (mph)
	150,000	Annual Miles Traveled by Fleet

Fleet Performance

Mean Vehicle Speed: N/A
Annual Miles Traveled by Fleet: 150,000



EMISSION REDUCTIONS

Pollutant	Total kg/day
Carbon Monoxide (CO)	*N/A*
Nitrogen Oxide (NOx)	*N/A*
Particulate Matter <2.5 µm ($PM_{2.5}$)	22.460
Particulate Matter <10 µm (PM_{10})	224.598
Volatile Organic Compounds (VOC)	*N/A*

Carbon Dioxide (CO_2)	*N/A*
Carbon Dioxide Equivalents (CO_2e)	*N/A*
Total Energy Consumption (MMBTU)	*N/A*

Emissions Reductions

Carbon Monoxide (CO): N/A
Nitrogen Oxide (NOx): N/A
Particulate Matter <2.5 µm (PM2.5): 22.460 kg/day
Particulate Matter <10 µm (PM10): 224.598 kg/day
Volatile Organic Compounds (VOC): N/A
Carbon Dioxide (CO_2): N/A
Carbon Dioxide Equivalents (CO_2e): N/A
Total Energy Consumption (MMBTU): N/A

Note that there are no emissions reductions reported for pollutants other than PM10 and PM2.5, as this module only calculates impacts of a control strategy on fugitive dust. The mean vehicle speed is also not reported for projects where the primary roadway use is industrial sites.

Example 3: Unpaved to Paved

A county plans to pave an unpaved road which experiences 100,000 miles of annual activity. Traffic analysis shows that mean vehicle speed will increase by approximately 4 mph after paving.

In the tool, the user would select the following inputs, shown in the images below:

Project evaluation year: 2024

Activity: 100,000 miles

(1) What is your project evaluation year?	2024
(2) Please input the total annual activity for all vehicles on the road, as vehicle miles traveled (VMT).	100,000

Mean vehicle speed: input own value of 32 mph

Silt content: use a default based on a “Gravel” surface

Moisture content: input own value of 0.5%

(3) What is the mean vehicle speed on the road before paving? You may use a default based on roadway type or input your own value.	Use a default ☐	Select
	Input my own value:	32 mph
(4) What is the mean silt content (%) of the road before paving? You may use a national default based on surface material or input your own value.	Use a default ☑	Gravel
	Input my own value:	Enter %
(5) What is the mean moisture content (%) of the road before paving? You may use a national default based on moisture conditions or input your own value.	Use a default ☐	Select
	Input my own value:	0.5 %

Roadway access after paving: Rural Unrestricted Access

Speed after paving: 36 mph

(6) What is the roadway access type after paving the road?	Rural Unrestricted Access
(7) Do you expect a change in mean vehicle speed on the roadway after paving? Please enter the mean speed (mph) on the road after paving as a whole number up to 75.	36 mph

Paving control efficiency: use default

(8) What is the paving control efficiency? You may use a default or enter your own value.	Use the default (0.96) ☑	
	Input my own value:	Enter

Click the 'Calculate Output' button to generate results.

FLEET PERFORMANCE

100,000	Annual Vehicle Miles Traveled
4	Speed Change after Paving (mph)

Fleet Performance

Annual Vehicle Miles Travelled: 100,000
Speed Change after Paving: 4 mph

EMISSION REDUCTIONS

Pollutant	Total kg/day
Carbon Monoxide (CO)	0.083
Nitrogen Oxide (NOx)	0.032
Particulate Matter <2.5 µm ($PM_{2.5}$)	11.788
Particulate Matter <10 µm (PM_{10})	118.234
Volatile Organic Compounds (VOC)	0.003

Carbon Dioxide (CO_2)	8.524
Carbon Dioxide Equivalents (CO_2e)	8.575
Total Energy Consumption (MMBTU)	0.111

Emissions Reductions

Carbon Monoxide (CO): 0.083 kg/day
Nitrogen Oxide (NOx): 0.032 kg/day
Particulate Matter <2.5 µm (PM2.5): 11.788 kg/day
Particulate Matter <10 µm (PM10): 118.234 kg/day
Volatile Organic Compounds (VOC): 0.003 kg/day
Carbon Dioxide (CO_2): 8.524 kg/day
Carbon Dioxide Equivalents (CO_2e): 8.575 kg/day
Total Energy Consumption (MMBTU): 0.111

There are reductions in emissions of all pollutants, as well as CO_2, CO_2 equivalents, and total energy consumption. These results included the contribution of the speed change (32 vs. 36 mph after paving); there are reduced emissions of all pollutants at higher speeds.

If the same scenario is run with no speed change (i.e., 32 mph input for question 7), the project would only reduce fugitive dust emissions (zero emissions reductions for all pollutants other than PM).

Appendix – Dust Control Methods and Terminology

Street Sweeping

Street sweepers help to reduce the amount of debris and particulate matter on a road surface. Sweepers fall into three main categories: vacuum, regenerative air, and mechanical broom. Vacuum and regenerative air sweepers are the most common types in use today, with the latter being better at picking up smaller particles due to the air blast/suction of the sweeper head. Control efficiency of street sweeping is dependent on the silt loading and the average weight of all vehicles using the road.

Wet Suppression

Watering increases the road surface moisture content, which conglomerates the silt particles and reduces their likelihood to become suspended when a vehicle passes over the road surface. The control efficiency of watering depends upon the road surface material, water application rate, the time between applications, traffic volume during the period, and the meteorological conditions (e.g., wind, temperature, frequency of precipitation) during the period. In this tool, the default control efficiency for wet suppression dust treatment projects is 0.75.

Chemical Treatment

Chemical stabilization suppresses emissions by changing the physical characteristics of the road surface. Many chemical type unpaved road dust suppressants form a hardened surface that binds particles together. The control effectiveness of chemical dust suppressants depends on the dilution rate, application rate, time between applications, and traffic volume between applications. In this tool, an average control efficiency of 0.80 is applied for chemical dust treatment projects.[10] This efficiency assumes a common application interval of 2 weeks to 1 month.

Paving

In this tool, paving refers to paving of an unpaved road (dirt or gravel). A paved road has a semi-permanent surface applied to it, such as asphalt. Paved roads have significantly lower fugitive dust emissions than unpaved roads. They are also typically designed for and subject to higher speeds than unpaved roads, which can impact the running emissions of the fleet travelling the road.

Silt Loading

The term silt loading (sL) refers to the mass of silt-size material (less than or equal to 75 µm in diameter) per unit area of the travel surface. Dust emissions from paved roads have been found to vary directly with silt loading.

Silt Content

Silt content refers to the fraction of silt particles (less than or equal to 75 µm in diameter) in the road surface materials. Dust emissions from unpaved roads have been found to vary directly with silt content.

Moisture Content

Dust emissions on unpaved roads in particular vary directly with moisture content. Moisture helps to conglomerate silt particles and reduces the likelihood that they will be suspended with vehicle traffic.

Appendix – Dust Control Data Sources

The following table provides potential sources that users may look to for data such as silt content, moisture content, and street sweeper operations.

Parameter	Source	Notes
Silt content or silt loading	State DOT, City/County Operations or Construction Dept.	Research studies by LTAPs or local universities may also provide this type of data
Moisture Content	State DOT, City/County Operations or Construction Dept.	Research studies by LTAPs or local universities may also provide this type of data
Hours of street sweeper fleet operation	City/County Public Works	
Dust control efficiency of the street sweepers	City/County Public Works, manufacturer	May be able to request proprietary information from manufacturer testing
Gross vehicle weight of a single street sweeper	City/County Public Works, manufacturer	
Model year of the street sweeper	City/County Public Works Office	
Fuel type of street sweeper	City/County Public Works Office	
Dust control efficiency of chemical treatment	City/County Public Works Office, manufacturer	
Highway facility type being swept	State DOT, City/County Operations or Construction Dept.	
Mean vehicle speed	State DOT, City/County Operations or Construction Dept.	
Type of dust control	State DOT, City/County Operations or Construction Dept.	
Paving control efficiency	State DOT, City/County Operations or Construction Dept.	