

Unpaved Road Area Source Category Calculation Methodology Sheet

I. Source Category: Unpaved Roads

II. Pollutants: PM₁₀ and PM_{2.5}

III. SCC: 2296000000

IV. Description:

This document describes the methodology to be used to calculate emissions of particulate matter with an aerodynamic diameter of less than or equal to 2.5 microns (PM_{2.5}) and particulate matter with an aerodynamic diameter of less than or equal to 10 microns (PM₁₀) from Fugitive Dust from Unpaved Roads activity. PM is generated by pulverization of surface materials by vehicles and entrainment of dust by air currents.

V. Current Methodology:

The methodology is based on an equation from AP-42 to calculate PM emission factors from re-entrained road dust on unpaved roads. The particulate emissions from vehicle exhaust, brake wear and tire wear are estimated separately in MOBILE 6.2 for publicly accessible unpaved roads.

Once PM emission factors are calculated, they are multiplied by the vehicle miles traveled (VMT) for each state (or county) from each type of unpaved road category to obtain PM emissions per road type per state (or county).

VI. Emission Calculation:

A. Emission Factor for Industrial sites unpaved roads

1. Equation :

$$EF = k (s/12)^a(W/3)^b$$

2. Variables - Listed below

B. Emission Factor for publicly accessible unpaved roads

1.. Equation :

$$EF = [k (s/12)^a(S/30)^d] / (M/0.5)^c - C$$

2. Variables

a. EF = Size-specific emission factor (lb/VMT)

b. s = Surface material silt content (%)

Industry	Road Use or Surface Material	Silt Content (%)	
		Range	Mean
Copper Smelting	Plant Road	16-19	17
Iron and Steel Production	Plant Road	0.2-19	6.0
Sand and Gravel Processing	Plant Road	4.1-6.0	4.8

	Material Storage Area	7.1	7.1
Stone Quarrying and Processing	Plant Road	2.4-16	10
	Haul Road to/from pit	5.0-15	8.3
Taconite mining and processing	Service Road	2.4-7.1	4.3
	Haul Road to/from pit	3.9-9.7	5.8
Western Surface Coal Mining	Haul Road to/from pit	2.8-18	8.4
	Plant Road	4.9-5.3	5.1
	Scraper Route	7.2-25	17
	Haul Road (freshly graded)	18-29	24
Construction Sites	Scraper Route	0.56-23	8.5
Lumber Sawmills	Log Yards	4.8-12	8.4
Municipal Solid Waste Landfills	Disposal Routes	2.2-21	6.4
Publicly Accessible Roads	Gravel/crushed limestone	0.1-15	6.4
	Dirt (i.e local material compacted, bladed and crowned)	0.83-68	11

- c. W = Mean vehicle weight (tons)
 - i. Average default value = 2.2 tons
- d. M = Surface material moisture content (%)
- e. S = Mean vehicle speed (mph)
- f. k, a, b, c, and d are empirical constants, listed below:

Constant	Industrial Roads		Public Roads	
	PM _{2.5}	PM ₁₀	PM _{2.5}	PM ₁₀
k (lb/VMT)	0.23	1.5	0.27	1.8
a	0.9	0.9	1	1
b	0.45	0.45	-	-
c	-	-	0.2	0.2
d	-	-	0.5	0.5
Quality Rating	C	B	C	B

- g. C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear

Particle Size Range	C, Emission Factor for exhaust, Brake Wear and Tire Wear Lb/VMT
PM _{2.5}	0.00036

PM ₁₀	0.00047
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3. Calculation for PM_{2.5} Emission Factor on Publicly Accessible Unpaved Roads

$$EF = \frac{[k (s/12)^a (S/30)^d] / (M/0.5)^c - C}{[0.27 (8.5/12)^1 (25/30)^{0.5}] / (5/0.5)^{0.2} - 0.00036}$$

$$EF = 0.1097967 \text{ lb/VMT}$$

C. Adjustment for Precipitation

1. Equation

$$E_{\text{ext}} = EF [(365 - P) / 365]$$

2. Variables

- a. E_{ext} = Annual size-specific emission factor adjusted for precipitation (lb/VMT)
- b. EF = Size-specific emission factor (lb/VMT)
- c. P = Number of days in a year with at least 0.254 mm (0.01 in) of precipitation

3. Calculation of Annual Emission Factor adjusted for Precipitation on unpaved roads (public access)

$$E_{\text{ext}} = EF \times [(365 - P) / 365]$$

$$E_{\text{ext}} = 0.1097967 \times [(365-128)/ 365]$$

$$E_{\text{ext}} = 0.0712926 \text{ lb/ VMT}$$

D. PM Emissions Calculation for State and Road Type

1. Equation:

$$UPVD_EMIS_{ST,y} = VMT_{ST,y} \times E_{\text{ext}}$$

2. Variables:

- a. $UPVD_EMIS_{ST,y}$ = State PM emissions from unpaved roads for each roadtype y
- b. $VMT_{ST,y}$ = Total State VMT for unpaved roads for road type y
- c. E_{ext} = annual size specific PM emissions factor adjusted for precipitation

E. PM Emissions Calculation for County and Road type

1. Equation:

$$UPVD_EMIS_{x,y} = UPVD_EMIS_{ST,y} \times VMT_{x,y} / VMT_{ST,y}$$

2. Variables

- a. $UPVD_EMIS_{x,y}$ = PM emissions from unpaved roads for county x and roadtype y
- b. $UPVD_EMIS_{ST,y}$ = State PM emissions from unpaved roads for each roadtype y
- c. $VMT_{x,y}$ = VMT for unpaved roads in county x and for road type y
- d. $VMT_{ST,y}$ = Total State VMT for unpaved roads for road type y

VII. Point Source Adjustments:

If fugitive emissions from private unpaved roads located at point sources are accounted for in the point source calculations, then these emissions should be subtracted from the area source inventory to avoid double-counting.

VIII. Adjustments for Controls:

Controls for fugitive dust sources involve vehicle restrictions, surface improvement, surface treatment, or reduction of surface wind speed with windbreaks or source enclosures. In a Technical Memorandum to EPA, MRI (MRI, 2001) provides an equation to calculate the control efficiency from watering roads. As this method isn't validated by EPA, it isn't included in this document, but is available for your reference at the AP-42 website.

IX. Spatial Adjustments:

Any state specific VMT data should be applied for unpaved roads if available. The NEI VMT data for unpaved roads is obtained from national databases and is available only for state totals and is allocated to counties.

X. Temporal Adjustments:

Temporal adjustments are not available for this category.

XI. Assumptions:

- A. Mean vehicle weight (W) of 2.2 tons (based on average vehicle weight for a typical vehicle mix).
- B. Surface material silt content (S) (state averages based on a set of measurement data collected over the past 15 years).
- C. Surface material moisture content under dry, uncontrolled conditions (M_{dry}).
- D. Number of days in the month with greater than 0.01 inches of precipitation (P) (representative weather station)

XII. Rule Effectiveness:

There are no known rules that would affect these calculations.

XIII. Uncertainties/Shortcomings of Methodology

- A. Unpaved road source conditions have extreme variations and actual emissions can vary by orders of magnitude pointing out the importance of using as much local data as possible in the empirical equation.
- B. The national method uses a default value for vehicle weight of 2.2 tons may not apply in all areas and should be reviewed for each specific area.
- C. Average values for silt content are used for entire state areas. The values are based on some 200 samples in 30 states. The average silt content was calculated for each state that had at least three representative samples. Emissions from states without sample representation were assumed to have a silt content of the average of all 200 samples.

- D. Precipitation data for a state was collected from one meteorological station to represent precipitation for the rural areas of the state.
- E. VMT for unpaved roads as obtained from available national databases is not reliable. Moreover, it is available only for state totals and must be allocated to counties, which introduces considerable error.
- F. The current emission factors may overpredict emissions for mean vehicle speeds below 15 mph.
- G. The moisture term does not isolate the effect of watering a specific road.
- H. The emissions factor equation was developed only from tests on traffic on unpaved roads in a range of certain source conditions (see below).

Range of Source Conditions used in developing the Emission Factor Equation

Emission Factor	Surface Silt Content %	Mean Vehicle Weight		Mean Vehicle Speed		Mean No. of Wheels	Surface Moisture Content %
		Mg	Ton	Km/hr	mph		
Industrial Roads	1.8-25.2	1.8-260	2-290	8-69	5-46	4-17	0.03-13
Public Roads	1.8-35	1.4-2.7	1.5-3	16-88	10-55	4-4.8	0.03-13

XIV. Recommendations to Improve Methods/Data

- A. Update values for VMT on unpaved roads by county with local data
- B. Update the local area's ADTV, and road classification
- C. Estimates of actual local silt content on unpaved road surfaces will enhance accuracy of emissions estimates.
- D. The moisture content in the national emission calculation is based on the precipitation from one reporting station in each state. Use local precipitation data that better represents the closest reporting station in the area will further improve the accuracy of the estimates.

XV. Additional Information/Guidance:

EPA Contact: Mr. William B. Kuykendal, MD-14
 Emission Factor and Inventory Group
 E-mail: Kuykendal.Bill@epa.gov
 Telephone: 919-541-5372

National Air Pollutant Emissions Trends Procedures Document for 1900-1999
www.epa.gov/ttn/chief/publications.html

AP-42, Section 13.2.2
<http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s0202.pdf>

NEI Methodology Description:
www.epa.gov/ttn/chief/trends/procedures/ (Section 4.8.1.4, pages 4-248 – 4-253) Note: This document is currently being revised.

Procedures for Sampling Surface/Bulk Dust Loading

www.epa.gov/ttn/chief/ap42/appendix/app-c1

Procedure for Laboratory Analysis of Surface/Bulk Loading Samples

<http://www.epa.gov/ttn/chief/ap42/appendix/app-c2.pdf>

XVI. References:

Emission Inventory Improvement Program, EIIP Document Series - Volume IX,
Particulate Emissions, Fugitive Dust from Unpaved Roads

<http://www.epa.gov/ttn/chief/eiip/techreport/volume09/unpavd3.pdf>

Midwest Research Institute, *Technical Memorandum, subject: Revisions to AP-42 Section 13.2.2, "Unpaved Roads," EPA Contract 68-D-1-002, Work Assignment No. 1-03, MRI Project No. 110130.1.003*, September 2001.

http://www.epa.gov/ttn/chief/ap42/ch13/draft/d13s02-2memo_oct2001.pdf

AP42 Section 13.2.2, "Unpaved Roads," Environmental Protection Agency, October 2001.

U.S. Environmental Protection Agency. *National Air pollutant emission trends procedures document for 1900-1996*, May 1998.