2020 National Emissions Inventory Technical Support Document: Dust – Paved Roads

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U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Assessment Division
Research Triangle Park, NC

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23.1 Sector Descriptions and Overview

The paved road dust sector reflects emissions of particulate matter from vehicles driving over paved roads. The SCCs that belong in this sector are provided in Table 23-1. EPA estimates emissions for total fugitives only. Fugitive dust emissions from paved road traffic were estimated for PM10-PRI, PM10-FIL, PM25-PRI, and PM25-FIL. Since there are no PM-CON emissions for this category, PM10-PRI emissions are equal to PM10-FIL emissions and PM25-PRI emissions are equal to PM25-FIL emissions.

Table 23-1: SCCs in the paved road dust sector

SCC	SCC Level 1	SCC Level 2	SCC Level 3	SCC Level 4
2294000000	Mobile Sources	Paved Roads	All Paved Roads	Total: Fugitives
2294000002	Mobile Sources	Paved Roads	All Paved Roads	Total: Sanding/Salting - Fugitives

23.2 EPA-developed estimates

Uncontrolled paved road emissions were calculated at the county level by roadway type for the year 2020. This was done by multiplying the county/roadway class paved road vehicle miles traveled (VMT) by the appropriate paved road emission factor. Next, control factors were applied to the paved road emissions in PM_{10} nonattainment and maintenance status counties. Emissions by roadway class were then totaled to the county level for reporting in the NEI. The following provides further details on the emission factor equation, determination of paved road VMT, and controls.

23.2.1 Emission factors

Re-entrained road dust emissions for paved roads were estimated using paved road VMT and the emission factor equation from AP-42 [ref 1]:

$$E = [k \times (sL)^{0.91} \times (W)^{1.02}]$$

Where:

E = paved road dust emission factor (g/VMT)
k = particle size multiplier (g/VMT)
sL = road surface silt loading (g/ m^2) (dimensionless in eq.)
W = average weight (tons) of all vehicles traveling the road (dimensionless in eq.)

The particle size multipliers for both PM10-PRI/-FIL and PM25-PRI/-FIL for paved roads came from AP-42. Paved road silt loadings were assigned to each of the fourteen functional roadway classes (seven urban and seven rural) based on the average annual daily traffic volume (ADTV) of each functional system by county [ref 2]. The silt loading values per average daily traffic volume come from the ubiquitous baseline values from Section 13.2.1 of AP-42 and are provided in Table 23-2.

Table 23-2: Assumed paved roads silt loading by road type (gm2) based on ADTV range

FHWA road type	0 -499	500-4,999	5,000-9,999	10,000+
Rural Interstate	0.015	0.015	0.015	0.015
Rural Other Freeways and Expressways	0.015	0.015	0.015	0.015
Rural Other Principal Arterial	0.6	0.2	0.06	0.03
Rural Minor Arterial	0.6	0.2	0.06	0.03
Rural Major Collector	0.6	0.2	0.06	0.03
Rural Minor Collector	0.6	0.2	0.06	0.03
Rural Local	0.6	0.2	0.06	0.03
Urban Interstate	0.015	0.015	0.015	0.015
Urban Other Freeways and Expressways	0.015	0.015	0.015	0.015
Urban Other Principal Arterial	0.6	0.2	0.06	0.03
Urban Minor Arterial	0.6	0.2	0.06	0.03
Urban Major Collector	0.6	0.2	0.06	0.03
Urban Minor Collector	0.6	0.2	0.06	0.03
Urban Local	0.6	0.2	0.06	0.03

Average daily traffic volume (ADTV) was calculated by dividing an estimate of VMT by functional road length and then by 365. State FHWA road length by functional road type data was broken down to the county level by multiplying by the ratio of county VMT to state VMT for each FHWA road type.

To better estimate paved road fugitive dust emissions, the average vehicle weight was estimated by road type for each county in the U.S. based on the VMT by vehicle type. The VMT for each vehicle type (per MOVES road type and county) was divided by the sum of the VMT of all vehicle types for the given road type in each county. This ratio was multiplied by the vehicle type mass (see Table 23-3) and summed to road type for each county to calculate a VMT-weighted average vehicle weight for each county/road type combination in the database. The VMT-weighted average vehicle weight by MOVES vehicle type was converted to FWHA vehicle type using the crosswalk in Table 23-4 to be used in the emission factor equation above.

Table 23-3: Average vehicle weights by FWHA vehicle class

MOVES Vehicle Type	Source Mass (tons)
Motorcycle	0.285
Passenger Car	1.479
Passenger Truck	1.867
Light Commercial Truck	2.0598
Intercity Bus	19.594
Transit Bus	16.556
School Bus	9.070
Refuse Truck	23.114
Single Unit Short-haul Truck	8.539
Single Unit Long-haul Truck	6.984
Motor Home	7.526
Combination Short-haul Truck	22.975

MOVES Vehicle Type	Source Mass (tons)
Combination Long-haul Truck	24.601

Table 23-4: MOVES and FWHA vehicle type crosswalk

MOVES Road Type Description	FWHA Road Type
Rural Restricted Access	Rural Interstate
Rural Unrestricted Access	Rural Principal Arterial
Rural Unrestricted Access	Rural Minor Arterial
Rural Unrestricted Access	Rural Collector
Rural Unrestricted Access	Rural Local
Urban Restricted Access	Urban Interstate
Urban Unrestricted Access	Urban Principal Arterial
Urban Unrestricted Access	Urban Minor Arterial
Urban Unrestricted Access	Urban Collector
Urban Unrestricted Access	Urban Local

**Note: Other Freeways and Expressways were not included in the crosswalk, and so were assumed to be restricted access like Interstates.*

23.2.2 Activity data

Generally, VMT on US roads can be obtained from the Federal Highway Administration (FHWA). Total VMT in each county is provided by FHWA to EPA for use in EPA's MOtor Vehicle Emission Simulator (MOVES) model to calculate emissions for the mobile sector. The road dust methodology uses these same county-level VMT data from FHWA. FHWA categorizes roads into 14 different types based on road function and access; these road types can be found in Table 23-5.

Table 23-5: FHWA road types

FHWA Road Type
Rural Interstate
Rural Other Freeways and Expressways
Rural Other Principal Arterial
Rural Minor Arterial
Rural Major Collector
Rural Minor Collector
Rural Local
Urban Interstate
Urban Other Freeways and Expressways
Urban Other Principal Arterial
Urban Major Collector
Urban Minor Collector
Urban Local
Urban Minor Arterial

To estimate the portion of the total VMT occurring on paved roads, first the VMT on unpaved roads were estimated using a procedure to estimate the proportion of unpaved vs. paved VMT (see the full description for VMT development in the “Activity Data” subsection under the *Unpaved Road Dust* section below). The estimated VMT on unpaved roads was then subtracted from the total VMT from MOVES to estimate the VMT on paved roads for each road type category where applicable.

23.2.3 Allocation

County level emissions were calculated by multiplying the county unpaved VMT (by road type) by the emission factors calculated according to Section 23.2.1 above and aggregating based on county and urban/rural classification.

23.2.4 Controls

Paved road dust controls were applied by county to urban and rural roads in serious PM_{10} nonattainment areas and to urban roads in moderate PM_{10} nonattainment areas. The assumed control measure is vacuum sweeping of paved roads twice per month. A control efficiency of 79% was assumed for this control measure [ref 3]. The assumed rule penetration varies by roadway class and PM_{10} nonattainment area classification (serious or moderate). The rule penetration rates are shown in Table 23-6. Rule effectiveness was assumed to be 100% for all counties where this control was applied.

Table 23-6: Penetration rate of Paved Road vacuum sweeping

PM_{10} Nonattainment Status	Roadway Class	Vacuum Sweeping Penetration Rate
Moderate	Urban Freeway & Expressway	0.67
Moderate	Urban Minor Arterial	0.67
Moderate	Urban Collector	0.64
Moderate	Urban Local	0.88
Serious	Rural Minor Arterial	0.71
Serious	Rural Major Collector	0.83
Serious	Rural Minor Collector	0.59
Serious	Rural Local	0.35
Serious	Urban Freeway & Expressway	0.67
Serious	Urban Minor Arterial	0.67
Serious	Urban Collector	0.64
Serious	Urban Local	0.88

Note that the controls were applied at the county/roadway class level, and the controls differ by roadway class. No controls were applied to interstate or principal arterial roadways because these road surfaces typically do not have vacuum sweeping. In the excel spreadsheet, the total emissions for all roadway classes were summed to the county level. Therefore, the emissions at the county level can represent several different control efficiency and rule penetration levels and may include both controlled and uncontrolled emissions in the composite value.

23.2.5 Meteorological adjustment

After controls were applied, emissions were summed to the county level and converted to tons prior to applying the meteorological adjustment. The meteorological adjustment accounts for the reduction in fugitive dust emissions via the impact of precipitation and other meteorological factors over each hour of the year and then averaged to an annual meteorological adjustment factor for each grid cell in each county, aggregated to a single county-level factor. The county-level meteorological adjustment factors were developed by EPA based on the ratio of the unadjusted to meteorology-adjusted county-level emissions from the SMOKE Flat Files. The county-level meteorological adjustment is a scalar between 0 and 1 that is multiplied by the estimated emissions, where lower-values/greater-reductions are typically found in areas with more frequent precipitation.

23.2.6 Improvements/Changes in the 2020 NEI

The 2017 NEI used one county-level meteorological adjustment factors for both paved and unpaved roads. For the 2020 NEI, separate county-level meteorological adjustment factors were developed for paved roads and unpaved roads. The adjustment factors, which are updated each inventory cycle based on modeling conducted by EPA, also showed that roads generally contained less residual moisture than the factors used in 2017, and road dust emissions were higher in 2020.

23.2.7 Puerto Rico and Virgin Islands

Since insufficient data exists to calculate emissions for the counties in Puerto Rico and the US Virgin Islands, emissions are based on two proxy counties in Florida: Broward (state-county FIPS=12011) for Puerto Rico and Monroe (state-county FIPS=12087) for the US Virgin Islands. The total emissions in tons for these two Florida counties are divided by their respective populations creating a tons per capita emission factor. For each Puerto Rico and US Virgin Island county, the tons per capita emission factor is multiplied by the county population (from the same year as the inventory's activity data) which served as the activity data. In these cases, the throughput (activity data) unit and the emissions denominator unit are "EACH".

23.3 References

1. United States Environmental Protection Agency, Office of Air Quality Planning and Standards. "Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Section 13.2.1, Paved Roads." Research Triangle Park, NC. January 2011.
2. U.S. Department of Transportation, Federal Highway Administration. https://www.fhwa.dot.gov/policyinformation/statistics/2020/. Table HM-51. Office of Highway Policy Information. Washington, DC. September 2022.
3. E.H. Pechan & Associates, Inc. "Phase II Regional Particulate Strategies; Task 4: Particulate Control Technology Characterization," draft report prepared for U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation. Washington, DC. June 1995.

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