Appendix E

Road Dust Estimation for Paved and Unpaved Roads

FUGITIVE DUST FROM PAVED ROADS

SCC: 2294000000

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.

Emission Factors

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

$$E = [\ k * (sL/2)^{0.65} * (W/3)^{1.5} - C\ ] * [1 - P/(4*N)]$$

where: E = paved road dust emission factor (g/VMT)
k = particle size multiplier (7.3 g/VMT for PM-10 and 1.8 g/VMT for PM-2.5)
sL = road surface silt loading (g/m^2)
W = average weight (tons) of all vehicles traveling the road
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear
N = number of days in the month
P = number of days in the month with at least 0.01 inches of precipitation

Paved road silt loadings were assigned to each of the twelve functional roadway classifications (six urban and six rural) based on the average annual traffic volume of each functional system by county, according to the baseline values provided in Table 13.2.1-3 of the AP-42 documentation.[2] This AP-42 table also provides a set of adjustments that can be applied to the baseline silt loading values to better represent "wintertime baseline conditions in areas that experience frozen precipitation with periodic application of antiskid material."[2] Average annual daily traffic volumes (AADTV) were calculated by county and road classification by dividing the average annual daily VMT by the roadway mileage. The silt loading values assigned by AADTV category from the AP-42 documentation are shown in Table 1. The adjusted winter baseline silt loading values are also shown in this table. The MANE-VU States provided information on which months it would be most appropriate to apply this wintertime adjustment to. Based on the information provided by the States, Table 2 lists in which months the winter baseline silt values were applied for each of the MANE-VU States.

The average vehicle weight was calculated separately for each county and road type. This represents an improvement over the NEI method which uses a single average default vehicle weight of 3.2 tons nationwide. Table 3 shows the values that were assumed for the weight of each vehicle class. These values were then multiplied by the fraction of VMT in each county and road class of that vehicle type and these products were then summed by county and road class to determine a weighted average vehicle weight for each county and road class.

The AP-42 equation listed above includes a correction factor term to adjust for the number of days with measurable precipitation in each month. The factor of 4 in the precipitation adjustment accounts for the fact that paved roads dry more quickly than unpaved roads and that precipitation may not occur over the entire 24-hour daily period. The number of days with at least 0.01 inches of precipitation in each month by county was obtained from data provided by the National Climatic Data Center (NCDC).[3] For counties with more than one precipitation collection station with valid data from the NCDC data set, an average number of precipitation days was calculated for each month from all valid stations in the county. Counties with no precipitation collection station or no valid data were assigned the data from an adjacent county. The 2002 monthly precipitation data used for MANE-VU counties is shown in Table 4. This method of assigning monthly precipitation days by county improves on the NEI approach of assigning monthly precipitation data by State.

In some cases, the emission factor calculated using the equation above is negative due to the subtraction of the C term that accounts for vehicle exhaust, brake wear, and tire wear. In these cases, the emission factor was reset to 0, under the assumption that the emissions have been accounted for in the onroad emission inventory.

Activity

Total VMT by county and road type were obtained from the MANE-VU 2002 onroad emission inventory. Paved road VMT was calculated by subtracting the county/road type-level unpaved road VMT from total county/road type total VMT. The estimates of the unpaved road VMT were based on data obtained from the Federal Highway Administration's (FHWA) annual Highway Statistics report by State and road type.[2] The State/road type unpaved VMT was allocated by county/road type based on rural population. Because of differences in the methodologies for calculating total and unpaved VMT, there were several instances where unpaved VMT were higher than total VMT. For these instances, unpaved VMT was reduced to total VMT and paved road VMT was assigned a value of zero. The paved road VMT data were temporally allocated by month using NAPAP temporal allocation factors for VMT.[4]

Controls

The MANE-VU States contain two moderate PM_{10} nonattainment counties. These are New Haven County, Connecticut and New York County, New York. In addition, a portion of Allegheny County, Pennsylvania and Aroostook County, Maine are currently moderate PM_{10} maintenance areas. Paved road dust controls were applied to urban roads in these moderate PM_{10} nonattainment and maintenance areas. The assumed control measure was vacuum sweeping of paved roads twice per month. A control efficiency of 79 percent was assumed for this control measure. The assumed rule penetration varies by road type and these penetration rates are shown in Table 5.

Caveat

It should be noted that the New York State Department of Environmental Conservation believes that **road dust is indeterminate at this time**; the existing model has far too many shortcomings, and does not yield inventory values that correlate with monitoring data, particularly for $PM_{2.5}$.[5] However, for the purposes of consistency with the other MANE-VU States, New York has agreed to include these paved road fugitive dust estimates in the MANE-VU 2002 emission inventory. The District of Columbia supports the findings of New York and lacks confidence in these fugitive dust estimates, but has agreed to include the fugitive dust emission estimates for the District of Columbia in this inventory for consistency with the other MANE-VU States.

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. December 2003.

2. U.S. Department of Transportation, Federal Highway Administration. *Highway Statistics 2001*. Office of Highway Policy Information. Washington, DC. 2002. Available at http://www.fhwa.dot.gov/ohim/hs01/index.htm.

3. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Summary of the Day Element TD-3200, 2002 data provided on CD. National Climatic Data Center. 2003.

4. U.S. Environmental Protection Agency. "The 1985 NAPAP Emissions Inventory: Development of Temporal Allocation Factors," EPA-600/7-89-010d. Air & Energy Engineering Research Laboratory. Research Triangle Park, NC. April 1990.

5. W.J. Pienta. "NYS $PM_{2.5}$ Road Dust Estimates for CY 2002," memorandum prepared by W.L. Pienta, New York State Department of Environmental Conservation, Division of Air Resources, Bureau of Air Quality Planning, October 28, 2004.

Table 1. AP-42 Silt Loading Values by Average Annual Daily Traffic Volume

Average Annual Daily Traffic Volume	Baseline Silt Loading Value (g/m^2)	Winter Baseline Silt Loading Value during Months with Frozen Precipitation (g/m^2)
< 500	0.6	2.4
500 - 5,000	0.2	0.6
5,000 - 10,000	0.06	0.12
>10,000	0.03	0.03
Limited Access Roads	0.015	0.015

Table 2. Months in Which Winter Baseline Silt Loading Values were Applied

State	Months Winter Baseline Silt Loading Values Applied
Connecticut	December - April
Delaware	January - February
District of Columbia	January - February
Maine	November - May 15
Maryland	No winter adjustment
Massachusetts	December - February
New Hampshire	December - April
New Jersey	No winter adjustment
New York	December - February
Pennsylvania	December - February
Rhode Island	December - April
Vermont	December - April

Table 3. Average Vehicle Weight by Vehicle Class

Vehicle Type	Vehicle Type Description	Assumed Average Vehicle Weight (lbs)
LDV	Light-Duty Vehicles (Passenger Cars)	3,075
LDT1	Light-Duty Trucks 1 (0-6,000 lbs. GVWR, 0-3750 lbs. LVW)	4,105
LDT2	Light-Duty Trucks 2 (0-6,000 lbs. GVWR, 3751-5750 lbs. LVW)	4,105
LDT3	Light-Duty Trucks 3 (6,001-8,500 lbs. GVWR, 0-5750 lbs. ALVW)	7,000
LDT4	Light-Duty Trucks 4 (6,001-8,500 lbs. GVWR, 5751 lbs. and greater ALVW)	7,000
HDV2B	Class 2b Heavy-Duty Vehicles (8,501-10,000 lbs. GVWR)	9,250
HDV3	Class 3 Heavy-Duty Vehicles (10,001-14,000 lbs. GVWR)	12,000
HDV4	Class 4 Heavy-Duty Vehicles (14,001-16,000 lbs. GVWR)	15,000
HDV5	Class 5 Heavy-Duty Vehicles (16,001-19,500 lbs. GVWR)	17,750
HDV6	Class 6 Heavy-Duty Vehicles (19,501-26,000 lbs. GVWR)	22,750
HDV7	Class 7 Heavy-Duty Vehicles (26,001-33,000 lbs. GVWR)	29,500
HDV8A	Class 8a Heavy-Duty Vehicles (33,001-60,000 lbs. GVWR)	46,500
HDV8B	Class 8b Heavy-Duty Vehicles (>60,000 lbs. GVWR)	70,000
HDBS	School Buses	70,000
HDBT	Transit and Urban Buses	70,000
MC	Motorcycles	550

GVWR = Gross Vehicle Weight Rating
LVW = Loaded Vehicle Weight
ALVW = Average Loaded Vehicle Weight

Table 4. 2002 Number of Days with at Least 0.01 Inches of Precipitation in MANE-VU Counties

State	County	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CT	FAIRFIELD	14	8	11	16	10	9	5	5	11	11	13	11
CT	HARTFORD	12	7	13	14	11	12	5	6	10	10	16	12
CT	LITCHFIELD	12	8	13	16	12	10	6	8	8	11	16	12
CT	MIDDLESEX	13	8	11	14	9	10	9	7	11	8	15	12
CT	NEW HAVEN	9	6	12	13	14	11	3	7	8	10	11	11
CT	NEW LONDON	13	8	11	14	9	10	9	7	11	8	15	12
CT	TOLLAND	13	8	11	14	9	10	9	7	11	8	15	12
CT	WINDHAM	10	6	12	14	12	14	7	9	8	8	15	12
DC	WASHINGTON	8	6	13	11	10	9	6	6	9	13	10	8
DE	KENT	11	5	11	13	9	9	7	7	9	13	10	12
DE	NEW CASTLE	11	6	12	12	9	12	8	5	7	14	14	8
DE	SUSSEX	13	5	12	11	9	8	8	3	7	14	12	11
MA	BARNSTABLE	15	7	16	13	9	10	3	5	12	11	14	13
MA	BERKSHIRE	11	6	13	13	15	15	7	8	9	12	17	16
MA	BRISTOL	14	8	13	16	12	15	10	6	10	10	18	12
MA	DUKES	13	9	11	9	8	9	4	5	12	10	16	11
MA	ESSEX	13	7	13	14	13	16	7	7	9	12	15	12
MA	FRANKLIN	9	7	14	16	15	17	9	10	12	17	17	9
MA	HAMPDEN	5	2	3	9	8	11	3	4	4	7	7	4
MA	HAMPSHIRE	12	8	12	16	15	16	7	9	9	14	17	11
MA	MIDDLESEX	11	8	12	13	11	16	8	8	9	10	15	11
MA	NANTUCKET	13	9	11	9	8	9	4	5	12	10	16	11
MA	NORFOLK	13	7	14	14	13	15	10	8	11	10	16	13
MA	PLYMOUTH	14	8	13	16	12	15	10	6	10	10	18	12
MA	SUFFOLK	13	7	13	12	9	15	7	9	11	9	14	12
MA	WORCESTER	13	8	15	16	13	13	8	9	11	11	19	14
MD	ALLEGANY	7	8	11	14	18	13	10	10	11	13	14	13
MD	ANNE ARUNDEL	10	6	12	10	11	6	8	6	6	12	10	8
MD	BALTIMORE	12	7	12	12	8	8	9	7	5	13	9	11
MD	BALTIMORE CITY	12	7	12	12	8	8	9	7	5	13	9	11
MD	CALVERT	10	4	11	10	7	7	8	4	8	14	9	5
MD	CAROLINE	12	4	10	9	7	7	5	5	6	12	10	8
MD	CARROLL	10	6	12	14	12	10	9	7	8	16	10	11
MD	CECIL	7	5	12	12	13	7	7	7	7	11	12	8
MD	CHARLES	10	4	11	10	7	7	8	4	8	14	9	5
MD	DORCHESTER	11	2	12	7	6	5	8	3	4	10	9	9
MD	FREDERICK	9	4	12	13	14	8	7	5	7	14	10	4
MD	GARRETT	9	9	13	14	17	12	11	9	9	16	14	11
MD	HARFORD	7	5	12	12	13	7	7	7	7	11	12	8
MD	HOWARD	9	7	12	11	13	8	6	7	7	13	12	7
MD	KENT	12	4	10	9	7	7	5	5	6	12	10	8
MD	MONTGOMERY	9	7	12	11	13	8	6	7	7	13	12	7
MD	PRINCE GEORGE'S	9	4	11	11	9	9	5	7	7	12	8	8
MD	QUEEN ANNE'S	12	4	10	9	7	7	5	5	6	12	10	8
MD	SOMERSET	13	4	15	12	8	9	9	6	7	16	14	8
MD	ST. MARY'S	10	4	11	10	7	7	8	4	8	14	9	5
MD	TALBOT	12	4	10	9	7	7	5	5	6	12	10	8
MD	WASHINGTON	7	4	11	12	15	10	8	8	8	14	11	9

Table 4 (continued)

State	County	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MD	WICOMICO	13	4	15	12	8	9	9	6	7	16	14	8
MD	WORCESTER	15	5	12	12	6	7	5	10	7	12	12	8
ME	ANDROSCOGGIN	11	9	14	15	10	19	12	8	9	12	16	8
ME	AROOSTOOK	14	15	14	12	19	13	18	8	12	15	18	10
ME	CUMBERLAND	11	9	15	15	14	14	11	9	10	13	19	10
ME	FRANKLIN	11	8	11	13	12	14	11	7	8	11	14	5
ME	HANCOCK	14	10	9	12	11	16	17	5	9	9	14	8
ME	KENNEBEC	10	7	12	13	12	13	13	8	10	13	17	8
ME	KNOX	16	10	10	14	9	14	17	9	10	12	19	11
ME	LINCOLN	16	9	12	15	14	14	14	6	8	12	18	9
ME	OXFORD	13	9	14	14	12	17	11	9	8	13	15	10
ME	PENOBSCOT	15	10	10	13	13	13	12	7	10	11	15	11
ME	PISCATAQUIS	11	11	14	17	12	12	15	9	11	13	17	7
ME	SAGADAHOC	11	9	13	13	12	15	13	7	7	9	17	8
ME	SOMERSET	15	10	13	15	13	15	14	6	10	11	14	7
ME	WALDO	13	6	7	12	9	10	8	2	6	10	11	5
ME	WASHINGTON	10	10	13	17	13	14	14	6	9	11	16	7
ME	YORK	11	8	15	14	11	17	9	6	9	12	16	10
NH	BELKNAP	13	7	15	15	13	15	5	7	12	13	20	10
NH	CARROLL	13	7	14	15	12	17	7	9	10	14	16	12
NH	CHESHIRE	10	11	15	14	16	17	4	7	6	19	17	13
NH	COOS	24	15	20	21	19	17	15	8	11	19	20	20
NH	GRAFTON	11	7	14	12	16	15	11	11	8	15	17	13
NH	HILLSBOROUGH	12	6	15	15	13	21	4	9	9	9	15	11
NH	MERRIMACK	12	7	13	15	15	14	5	9	12	12	16	12
NH	ROCKINGHAM	14	9	11	14	10	16	8	5	8	12	15	11
NH	STRAFFORD	11	8	15	14	11	18	7	7	9	15	17	11
NH	SULLIVAN	13	10	13	11	10	16	7	9	7	13	17	10
NJ	ATLANTIC	12	7	12	15	9	11	8	9	7	15	12	9
NJ	BERGEN	11	6	10	14	9	8	3	9	7	11	10	10
NJ	BURLINGTON	9	7	11	10	10	11	5	8	7	12	11	10
NJ	CAMDEN	9	7	11	10	10	11	5	8	7	12	11	10
NJ	CAPE MAY	11	5	13	10	9	8	9	7	7	15	11	7
NJ	CUMBERLAND	8	6	11	15	12	12	9	6	7	17	12	7
NJ	ESSEX	11	5	13	16	8	9	3	8	7	13	12	8
NJ	GLOUCESTER	9	7	11	10	10	11	5	8	7	12	11	10
NJ	HUDSON	11	7	11	12	9	9	2	8	7	12	12	9
NJ	HUNTERDON	9	4	13	14	11	10	5	10	5	14	11	11
NJ	MERCER	10	6	12	13	11	12	6	10	8	14	12	11
NJ	MIDDLESEX	9	6	11	13	11	11	4	10	7	13	9	9
NJ	MONMOUTH	8	2	9	9	9	10	2	5	7	10	8	9
NJ	MORRIS	10	7	9	12	11	11	4	7	7	10	10	7
NJ	OCEAN	8	2	9	9	9	10	2	5	7	10	8	9
NJ	PASSAIC	9	6	10	13	14	11	5	8	7	11	10	9
NJ	SALEM	8	6	11	15	12	12	9	6	7	17	12	7
NJ	SOMERSET	9	6	12	14	11	10	4	9	7	14	11	10
NJ	SUSSEX	10	7	10	13	11	11	4	7	7	10	9	8
NJ	UNION	9	5	10	15	10	10	4	9	7	13	13	9
NJ	WARREN	9	3	12	14	15	15	7	11	9	17	14	13
NY	ALBANY	11	9	14	16	15	18	7	10	6	12	18	13
NY	ALLEGANY	10	11	17	19	18	12	9	8	9	11	19	15

Table 4 (continued)

State	County	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NY	BRONX	11	7	10	12	10	9	5	9	7	13	11	7
NY	BROOME	15	10	16	16	18	13	10	6	10	14	21	16
NY	CATTARAUGUS	18	13	18	22	21	14	11	12	11	13	19	20
NY	CAYUGA	15	11	15	18	17	14	5	7	7	13	18	18
NY	CHAUTAUQUA	16	12	17	18	16	9	7	11	10	13	17	17
NY	CHEMUNG	9	6	12	12	18	12	8	7	4	13	11	11
NY	CHENANGO	14	12	20	15	20	14	9	13	9	18	21	20
NY	CLINTON	12	9	12	13	13	14	7	2	8	13	15	12
NY	COLUMBIA	6	7	8	15	12	13	5	9	8	13	10	9
NY	CORTLAND	17	13	15	21	17	17	7	12	12	14	21	21
NY	DELAWARE	16	12	15	15	17	12	7	10	9	14	19	18
NY	DUTCHESS	11	7	13	14	13	12	4	8	9	11	17	13
NY	ERIE	15	13	22	20	16	13	9	8	8	13	19	16
NY	ESSEX	25	13	14	14	15	16	10	11	9	16	19	16
NY	FRANKLIN	17	15	14	14	14	17	8	7	8	15	24	14
NY	FULTON	13	7	15	13	18	13	7	9	7	15	10	17
NY	GENESEE	9	3	9	13	16	16	9	6	9	12	14	11
NY	GREENE	11	11	17	15	17	15	6	13	9	14	15	15
NY	HAMILTON	20	12	18	14	20	15	9	9	10	19	21	16
NY	HERKIMER	25	15	18	14	20	14	8	9	10	16	20	19
NY	JEFFERSON	13	11	16	15	16	13	6	5	8	17	19	14
NY	KINGS	10	6	11	14	8	8	4	10	7	13	0	11
NY	LEWIS	24	16	20	18	20	16	6	9	8	19	21	21
NY	LIVINGSTON	11	11	16	14	18	12	10	9	8	9	13	16
NY	MADISON	20	17	21	18	18	16	9	11	11	15	22	23
NY	MONROE	12	15	18	16	17	12	8	7	7	14	19	22
NY	MONTGOMERY	10	10	16	13	16	15	8	10	7	15	10	11
NY	NASSAU	11	10	11	14	11	11	6	10	9	12	14	11
NY	NEW YORK	10	7	11	15	8	10	6	8	7	13	15	12
NY	NIAGARA	16	14	20	18	18	14	7	7	8	14	17	17
NY	ONEIDA	16	15	20	17	17	17	6	8	11	17	21	21
NY	ONONDAGA	21	16	19	15	16	13	7	5	9	20	23	20
NY	ONTARIO	12	10	15	15	18	13	7	9	10	14	14	15
NY	ORANGE	6	4	10	12	12	11	4	9	4	10	10	10
NY	ORLEANS	10	8	12	17	13	11	4	7	7	12	14	10
NY	OSWEGO	14	14	25	15	17	10	6	5	5	12	14	14
NY	OTSEGO	17	13	16	16	18	15	6	10	8	15	14	17
NY	PUTNAM	11	7	13	14	13	12	4	8	9	11	17	13
NY	QUEENS	11	7	10	12	10	9	5	9	7	13	11	7
NY	RENSSELAER	13	9	13	18	19	14	6	12	8	14	16	12
NY	RICHMOND	10	6	11	14	8	8	4	10	7	13	0	11
NY	ROCKLAND	11	6	10	14	9	8	3	9	7	11	10	10
NY	SARATOGA	12	6	11	16	16	14	6	11	5	13	15	10
NY	SCHENECTADY	10	10	16	13	16	15	8	10	7	15	10	11
NY	SCHOHARIE	10	10	16	13	16	15	8	10	7	15	10	11
NY	SCHUYLER	12	10	15	15	18	13	7	9	10	14	14	15
NY	SENECA	12	10	15	15	18	13	7	9	10	14	14	15
NY	ST. LAWRENCE	14	14	16	13	17	13	7	4	9	15	17	7
NY	STEUBEN	11	10	13	16	19	12	7	8	6	16	15	11
NY	SUFFOLK	13	8	11	12	9	10	4	8	11	10	13	10
NY	SULLIVAN	12	8	14	15	16	13	4	10	8	14	16	14

Table 4 (continued)

State	County	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NY	TIOGA	10	9	14	13	17	12	6	8	7	11	13	14
NY	TOMPKINS	12	9	11	14	20	15	8	7	7	12	20	15
NY	ULSTER	11	5	15	15	13	12	7	10	8	13	13	11
NY	WARREN	12	11	13	15	13	13	7	7	7	15	20	12
NY	WASHINGTON	8	9	10	14	16	16	7	7	7	14	12	12
NY	WAYNE	12	12	13	17	17	13	8	8	7	13	18	17
NY	WESTCHESTER	11	6	11	16	10	12	5	9	9	9	12	9
NY	WYOMING	12	10	16	17	20	12	11	10	8	12	14	17
NY	YATES	12	10	15	15	18	13	7	9	10	14	14	15
PA	ADAMS	8	7	11	14	15	10	9	9	7	14	13	9
PA	ALLEGHENY	12	9	14	16	16	10	8	10	6	12	14	15
PA	ARMSTRONG	10	8	12	13	11	11	5	9	3	12	14	15
PA	BEAVER	11	12	14	16	15	11	5	8	9	13	15	15
PA	BEDFORD	7	5	9	13	15	11	9	10	11	14	11	10
PA	BERKS	6	7	8	13	13	11	5	8	8	12	9	7
PA	BLAIR	9	7	13	13	16	9	8	9	10	13	15	10
PA	BRADFORD	7	6	13	14	19	8	8	7	6	13	11	7
PA	BUCKS	8	7	11	13	11	12	5	9	7	16	11	11
PA	BUTLER	11	12	13	13	17	13	10	11	9	13	14	15
PA	CAMBRIA	9	11	10	10	13	12	7	8	7	11	13	13
PA	CAMERON	16	12	13	19	17	13	7	9	8	16	20	17
PA	CARBON	9	6	8	10	12	8	4	8	6	13	9	7
PA	CENTRE	10	8	10	13	18	12	8	11	7	15	11	13
PA	CHESTER	9	7	11	13	13	13	6	6	7	14	12	13
PA	CLARION	15	12	16	20	15	12	8	11	7	12	16	16
PA	CLEARFIELD	8	6	9	13	13	11	5	6	11	14	14	7
PA	CLINTON	11	8	13	18	19	11	8	5	4	14	13	15
PA	COLUMBIA	12	7	12	13	18	9	8	8	7	12	9	12
PA	CRAWFORD	18	15	17	22	16	13	7	9	8	13	19	19
PA	CUMBERLAND	8	4	11	12	14	8	7	9	7	14	12	8
PA	DAUPHIN	8	6	11	13	13	8	7	11	7	16	12	8
PA	DELAWARE	11	7	13	14	9	11	7	6	6	11	13	8
PA	ELK	15	12	15	18	17	11	10	11	8	16	19	18
PA	ERIE	18	14	19	19	15	10	7	8	7	12	18	19
PA	FAYETTE	11	10	15	16	14	11	11	9	9	14	16	14
PA	FOREST	19	12	16	19	16	14	6	10	10	13	14	18
PA	FRANKLIN	8	5	13	14	13	9	7	10	9	15	11	9
PA	FULTON	8	5	13	14	13	9	7	10	9	15	11	9
PA	GREENE	9	7	12	14	11	10	11	8	10	14	17	12
PA	HUNTINGDON	6	6	10	12	14	11	7	10	11	13	13	10
PA	INDIANA	15	10	14	15	17	15	11	11	8	17	16	15
PA	JEFFERSON	15	12	15	18	17	11	10	11	8	16	19	18
PA	JUNIATA	8	6	12	13	16	12	9	9	7	14	10	11
PA	LACKAWANNA	9	9	12	15	14	11	7	12	8	15	13	11
PA	LANCASTER	8	6	11	14	12	10	6	8	8	14	11	10
PA	LAWRENCE	9	10	13	19	18	12	8	11	8	10	14	14
PA	LEBANON	7	4	10	16	11	11	8	8	8	15	12	12
PA	LEHIGH	9	6	12	18	11	10	5	8	7	15	12	10
PA	LUZERNE	9	9	12	15	14	11	7	12	8	15	13	11
PA	LYCOMING	10	6	13	13	16	9	9	9	9	16	16	12
PA	MCKEAN	17	12	19	17	18	10	11	10	12	16	23	18

Table 4 (continued)

State	County	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
PA	MERCER	13	12	15	13	16	14	6	8	6	9	14	8
PA	MIFFLIN	6	9	11	13	17	11	5	8	7	12	12	9
PA	MONROE	10	7	12	15	15	11	5	10	6	18	15	12
PA	MONTGOMERY	9	6	12	13	17	14	5	9	8	15	13	10
PA	MONTOUR	12	7	12	13	18	9	8	8	7	12	9	12
PA	NORTHAMPTON	8	7	11	13	11	12	5	9	7	16	11	11
PA	NORTHUMBERLAND	9	6	9	13	16	11	6	8	8	13	11	10
PA	PERRY	8	6	11	13	13	8	7	11	7	16	12	8
PA	PHILADELPHIA	11	6	10	12	10	12	8	4	8	14	15	9
PA	PIKE	12	9	12	13	19	13	4	12	7	15	16	10
PA	POTTER	15	11	17	18	16	11	5	9	8	17	17	14
PA	SCHUYLKILL	9	6	11	15	14	12	5	7	8	13	12	14
PA	SNYDER	8	6	12	13	16	12	9	9	7	14	10	11
PA	SOMERSET	11	12	12	16	21	12	8	8	11	10	18	16
PA	SULLIVAN	15	10	15	13	17	13	9	13	8	15	13	17
PA	SUSQUEHANNA	12	9	12	14	17	11	8	9	8	13	10	14
PA	TIOGA	9	7	11	11	13	12	6	6	6	13	11	10
PA	UNION	7	5	10	15	15	11	9	6	7	15	12	12
PA	VENANGO	14	12	13	17	13	12	6	13	9	15	14	15
PA	WARREN	19	11	14	18	16	11	7	9	8	15	20	19
PA	WASHINGTON	11	8	12	16	15	12	9	9	8	15	14	13
PA	WAYNE	5	4	10	7	9	8	4	7	6	10	9	9
PA	WESTMORELAND	12	8	14	13	16	11	7	8	7	13	15	13
PA	WYOMING	15	10	15	13	17	13	9	13	8	15	13	17
PA	YORK	8	6	10	12	12	9	8	9	8	13	12	9
RI	BRISTOL	15	8	15	15	12	12	6	6	11	9	13	13
RI	KENT	12	8	13	12	11	13	5	7	11	7	12	13
RI	NEWPORT	15	8	15	15	12	12	6	6	11	9	13	13
RI	PROVIDENCE	14	9	14	14	11	13	7	9	10	12	14	12
RI	WASHINGTON	12	7	13	13	11	13	4	7	10	12	16	11
VT	ADDISON	11	8	13	14	15	12	11	9	9	16	13	11
VT	BENNINGTON	14	10	16	15	18	18	5	9	7	15	19	15
VT	CALEDONIA	20	11	17	15	15	16	13	9	11	17	19	14
VT	CHITTENDEN	15	9	12	16	15	17	11	10	10	12	19	13
VT	ESSEX	17	12	15	14	20	18	14	8	10	14	20	14
VT	FRANKLIN	17	9	13	13	16	14	10	9	10	11	14	12
VT	GRAND ISLE	17	9	13	13	16	14	10	9	10	11	14	12
VT	LAMOILLE	18	14	13	15	15	17	11	7	8	13	20	17
VT	ORANGE	16	10	14	13	18	18	11	10	8	20	19	16
VT	ORLEANS	13	11	13	8	11	14	10	2	6	10	9	6
VT	RUTLAND	15	7	11	15	12	13	10	8	6	15	19	15
VT	WASHINGTON	17	7	14	13	16	13	15	8	10	15	21	12
VT	WINDHAM	15	12	16	14	18	20	8	6	11	18	19	14
VT	WINDSOR	14	10	20	15	12	17	8	11	12	16	21	16

Table 5. Penetration Rate of Paved Road Vacuum Sweeping

PM_{10} Nonattainment Status	Roadway Type	Vacuum Sweeping Penetration Rate
Moderate	Urban Intersate	0.42
Moderate	Urban Freeway & Expressway	0.67
Moderate	Urban Other Principal Arterial	0.90
Moderate	Urban Minor Arterial	0.67
Moderate	Urban Collector	0.64
Moderate	Urban Local	0.88

FUGITIVE DUST FROM UNPAVED ROADS
SCC: 2296000000

Fugitive dust emissions from unpaved 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.

Emission Factors

Reentrained road dust emissions for unpaved roads were estimated using unpaved road VMT and the emission factor equation from AP-42[1]:

$$E = [\, k * (s/12)^a * (SPD/30)^b] \,/\, (M/0.5)^c - C$$

where k, a, b, and c are empirical constants given in Table 6 and

E = size specific emission factor (lb/VMT)
s = surface material silt content (%)
SPD = mean vehicle speed (mph)
M = surface material moisture content (%)
C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)

Average State-level unpaved silt content values, developed as part of the 1985 National Acid Precipitation Assessment Program (NAPAP) Inventory, were obtained from the Illinois State Water Survey.[2] Silt contents of over 200 unpaved roads from over 30 States were obtained. Average silt contents of unpaved roads were calculated for each State that had three or more samples for that State. For States that did not have three or more samples, the average for all samples from all States was used. Table 7 provides a table of the silt content values by State, and identifies if the values are based on samples or are default values.

Table 8 lists the speeds modeled on the unpaved roads by roadway type. These speeds were determined based on national average speeds modeled for onroad emission calculations and weighted to determine a single average speed for each of the roadway types. The value of 0.5 percent for M was chosen as the national default as sufficient resources were not available to determine more locally-specific values for this variable.

Correction factors were applied to the emission factors to account for the number of days with a sufficient amount of precipitation to prevent road dust resuspension. Monthly corrected emission factors by State and roadway classification were calculated using the following equation:

$$E_{corr} = E * [(D-p)/D]$$

where: E_{corr} = unpaved road dust emission factor corrected for precipitation effects
E = uncorrected emission factor
D = number of days in the month
p = number of days in the month with at least 0.01 inches of precipitation

The number of days in each county with at least 0.01 inches of precipitation in each month was obtained from the National Climatic Data Center.[3] For counties with more than one precipitation collection station with valid data from the NCDC data set, an average number of precipitation days was calculated for each month from all valid stations in the county. Counties with no precipitation collection station or no valid data were assigned the data from an adjacent county. The 2002 monthly precipitation data for MANE-VU counties is shown in Table 4. This method of assigning monthly precipitation days by county improves on the NEI approach of assigning monthly precipitation data by State. These are the same precipitation data used to calculate paved road emissions for the MANE-VU States.

Activity

Unpaved roadway mileage estimates were obtained from the FHWA's 2002 Highway Statistics report.[4] Table HM-51 of this publication lists the unpaved road mileage by State for the following six roadway categories: rural major collectors, rural minor collectors, rural locals, urban minor arterials, urban collectors, and urban locals. In the 1996 Highway Statistics publication (the last year that these data were published), mileage on urban and rural local roads was broken down into four groups of average daily travel (ADT) volume ranges. These groups are shown in Table 9. The fraction of ADT occurring in each of these four groups was then multiplied by the 2002 mileage for the rural and urban local roads to allocate the 2002 unpaved local road mileage to these same volume groups. As shown in Table 9, a single value of ADT was assigned to each volume group. The estimated mileage in each group was then multiplied by the assigned ADT value and the four values summed to obtain an estimate of VMT on rural and urban local roads in each State. Once the VMT for the rural and urban local roads were determined, the overall ADT on these roads was calculated for each State by dividing the VMT by the total mileage for urban or rural local roads in that State. The calculated ADT for rural local roads was then multiplied by the mileage for the remaining rural unpaved road types in the State to estimate total daily VMT on those roads. Similarly, the calculated ADT for urban local roads was then multiplied by the mileage for the remaining urban unpaved road types in the State to estimate total daily VMT on those roads. These values were then all multiplied by 365 to obtain annual VMT estimates.

Note that Maine provided unpaved road mileage by county. These values were used rather than the Highway Statistics unpaved road mileage for Maine. However, the data from Highway Statistics were used to break the Maine unpaved road mileage down by functional class. VMT on the Maine unpaved roads were then calculated in a manner similar to that described above. There are no unpaved roads in Delaware or the District of Columbia, so no unpaved road VMT or unpaved road fugitive dust emissions were calculated for these areas.

Allocation of VMT

The State/road type-level unpaved road VMT estimates were allocated by county using estimates of the ratio of county rural population to the State rural population from the U.S. Census Bureau as shown by the following equation:

$$UNPVMT_{x,y} = (CL_x / SL) * UNPVMT_{,y}$$

where: $UNPVMT_{x,y}$ = unpaved road VMT for county x and road type y (millions of miles)
CL_x = rural population in county x
SL = rural population in the State
$UNPVMT_{,y}$ = unpaved road VMT in entire State for road type y (millions of miles)

The unpaved road VMT data were temporally allocated by month using the NAPAP temporal allocation factors.[5]

Controls

The MANE-VU States contain only moderate PM_{10} nonattainment areas. These are New Haven County, Connecticut and New York County, New York. In addition, a portion of Allegheny County, Pennsylvania and Aroostook County, Maine are currently moderate PM_{10} maintenance areas and, therefore, the unpaved road controls were applied in these counties as well. It should be noted that these two maintenance areas cover only a small portion of the counties, but without further information, the unpaved road controls were applied countywide. The controls assumed for urban unpaved roads in moderate PM_{10} nonattainment and maintenance areas was paving of the unpaved road. A control efficiency of 96 percent and a rule penetration of 50 percent were applied. No controls were applied on rural roads in the moderate PM_{10} nonattainment and maintenance areas.

Caveat

It should be noted that the New York State Department of Environmental Conservation believes that **road dust is indeterminate at this time**; the existing model has far too many shortcomings, and does not yield inventory values

that correlate with monitoring data, particularly for $PM_{2.5}$.[6] However, for the purposes of consistency with the other MANE-VU States, New York has agreed to include these unpaved road fugitive dust estimates in the MANE-VU 2002 emission inventory.

Note that New Jersey provided its own unpaved road fugitive dust emissions and did not use the unpaved road dust emissions calculated by MANE-VU.

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 13.2.2 Unpaved Roads." Research Triangle Park, NC. 2003.

2. G. Stensland, Illinois State Water Survey, personal communication with W. Barnard of E.H. Pechan & Associates, Inc., Durham, NC. 1989.

3. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Summary of the Day Element TD-3200, 2002 data provided on CD. National Climatic Data Center. 2003.

4. U.S. Department of Transportation, Federal Highway Administration. *Highway Statistics 2002.* Office of Highway Policy Information. Washington, DC. 2003. Available at http://www.fhwa.dot.gov/ohim/hs02/index.htm.

5. U.S. Environmental Protection Agency. "The 1985 NAPAP Emissions Inventory: Development of Temporal Allocation Factors," EPA-600/7-89-010d. Air & Energy Engineering Research Laboratory. Research Triangle Park, NC. April 1990.

6. W.J. Pienta. "NYS $PM_{2.5}$ Road Dust Estimates for CY 2002," memorandum prepared by W.L. Pienta, New York State Department of Environmental Conservation, Division of Air Resources, Bureau of Air Quality Planning, October 28, 2004.

Table 6. Constants for Unpaved Roads Reentrained Dust Emission Factor Equation

Constant	PM-2.5	PM-10
k (lb/VMT)	0.27	1.8
a	1	1
b	0.5	0.5
c	0.2	0.2
C	0.00036	0.00047

Source : AP-42

Table 7. State-level Unpaved Road Surface Material Silt Content Values Used in MANE-VU Fugitive Dust Calculations

State	Unpaved Road Surface Material Silt Content (%)	Data Source
Connecticut	3.9	DEFAULT
Delaware	0	No Unpaved Roads
DC	0	No Unpaved Roads
Maine	3.9	DEFAULT
Maryland	3.9	DEFAULT
Massachusetts	3.9	DEFAULT
New Hampshire	3.9	DEFAULT
New Jersey	N/A	Used State-calculated unpaved road dust emissions
New York	4.7	SAMPLES
Pennsylvania	3.3	SAMPLES
Rhode Island	3.9	DEFAULT
Vermont		DEFAULT

Table 8. Speeds Modeled by Roadway Type on Unpaved Roads

Unpaved Roadway Type	Speed (mph)
Rural Minor Arterial	39
Rural Major Collector	34
Rural Minor Collector	30
Rural Local	30
Urban Other Principal Arterial	20
Urban Minor Arterial	20
Urban Collector	20
Urban Local	20

Table 9. Assumed Values for Average Daily Traffic Volume by Volume Group

Rural Roads				
Volume Category (vehicles per day per mile)	< 50	50-199	200-499	> 500
Assumed ADTV	5*	125**	350**	550***
Urban Roads				
Volume Category (vehicles per day per mile)	< 200	200-499	500-1999	> 2000
Assumed ADTV	20*	350**	1250**	2200***

Notes: *10% or volume group's maximum range endpoint
** Average of volume group's range endpoints
*** 110% or volume group's minimum