MISCELLANEOUS PROCESS METHODOLOGY 7.9

Entrained Road Travel, Paved Road Dust

Revised and updated, March 2021
California Air Resources Board

Emission Inventory Source Category

Miscellaneous Processes/Road Dust

Emission Inventory Codes (CES Codes) and Description

640-635-5400-0000 (83618) Paved Entrained Road Dust-Freeways
640-637-5400-0000 (83626) Paved Entrained Road Dust-Major Streets
640-639-5400-0000 (83634) Paved Entrained Road Dust-Collector Streets
640-641-5400-0000 (83642) Paved Entrained Road Dust-Local Streets
640-643-5400-0000 (89656) Paved Entrained Road Dust-Rural Streets
640-636-5400-0000 (47456) Paved Entrained Road Dust-Unspecified Paved Roads

Table of Contents

Methods and Sources

The paved road dust category includes emissions of particulate matter (PM) from resuspended road surface material that are entrained by vehicular travel on public and industrial paved roads. Entrained paved road dust, or fugitive dust, contributes to airborne PM emissions throughout California. Since it is not feasible to directly measure region-wide emissions from travel on paved roads, the California Air Resources Board (CARB) computes emissions using the emission factor equation provided in the Final Section of the Fifth Edition, Volume 1, Chapter 13.2.1, of the U.S. EPA's AP-42 document (January 2011).[1] The emission factor equation was derived from regression analyses of 83 tests for particulate matter emissions less than or equal to 10 microns in diameter (PM_{10}) on public and industrial paved roads. Airborne PM emissions were closely correlated with vehicle weight and silt loading (the mass of material 75 microns or less per square meter of roadway). Inputs to the paved road dust emission factor equation were developed from California-specific roadway silt loading measurements [2.3.4.5] and average vehicle weight data measured by Midwest Research Institute (MRI).[5] This update estimates California paved road dust emissions for 2017. Data from CARB, air districts, and transportation planning agencies were used to estimate county-specific vehicle miles traveled (VMT).[6] California Department of Transportation (Caltrans) Highway Performance Monitoring System (HPMS) data were used to estimate the fraction of travel on each of four road types in each county: freeway, major, collector, and local.[7,8] Gridded precipitation data from gridMET daily high-spatial resolution dataset were used to estimate the average number of days per year that each county within an air basin received 0.01 inch or greater of precipitation during 2007-2017.[9]

Overview of Estimation Methodology

PM_{10} emissions from resuspension of road surface material by vehicle travel on paved roads (entrained paved road dust) are computed using the emission factor equation in the Final Section of the U.S. EPA's January 2011 AP-42, Fifth Edition, Volume 1, Chapter 13.2.1.[1] Total particulate matter emissions (PM) and particulate matter emissions less than or equal to 2.5 microns in diameter ($PM_{2.5}$) from resuspension of road surface material by vehicle travel on paved roads (entrained paved road dust) are computed using CARB's speciation profile #471 for paved road dust as described in the CARB Speciation Profile section below.[12,13,14,15,16,17,28] Emission estimates for dust from constructing new roads are provided in CARB's Road Construction Dust methodology.[11] The methodology does not include directly emitted motor vehicle emissions (exhaust, brake or tire wear), nor TOG, CO, NOx, SOx, or PM exhaust emissions; these emissions are included in CARB's mobile source emission inventory.[10]

Emission Estimation Methodology

The AP-42 emission factor equation used to estimate paved road dust emissions for PM_{10} is provided below, followed by a description of the inputs to the equation:[1]

$$E=[k(sL)^{0.91} \times (W)^{1.02}] \times (1-P/4N)$$

Where:

E=the particulate emission factor in units of pounds of particulate matter per VMT,

k=the U.S. EPA AP-42 particle size multiplier (PM_{10}=0.0022 lb/VMT),[1]

sL=the roadway-specific silt loading in grams/square meter (g/m^2),[2,3,4,5]

W=the average weight of vehicles traveling the road (California statewide default =2.4 tons),[5]

P=number of "wet" days, when at least one site per county received at least 0.01 inch of precipitation during the annual averaging period,[9] and

N=the number of days in the annual averaging period (default=365).

Paved road dust emissions for Total PM and $PM_{2.5}$ are calculated using particle size weight fractions from CARB's speciation profile #471 for paved road dust.[12,13,14,15,16,17,28]

Roadway Category Splits

The HPMS, a federally mandated inventory system and planning tool designed to assess the nation's highway system, is used by State and Federal governments and local agencies to analyze the system's condition and performance. HPMS provides data on VMT for seven functional systems, based on mobility and access considerations defined by the Federal Highway Administration (FHWA).[7,8] To calculate county-specific travel fractions for each roadway type, CARB apportioned 2017 Caltrans HPMS paved road VMT to four CARB roadway classifications (freeway, major, collector, and local), based on their anticipated usage, modes of usage, and silt loading potential.[7] As available, CARB can incorporate more refined travel fraction data for COABDIS regions. The 2021 update of this methodology uses data for unspecified roads (e.g., canals, drainage ditches) provided by air districts and counties as listed in the revised and updated methodology in 2018 for paved road dust.[2] Table 1 shows how HPMS functional systems are distributed to CARB road categories and provides FWHA functional system characteristics. Table 2 presents total VMT (in millions of miles) for 2017 for each county, air basin, and air district (COABDIS) region, and the 2017 travel fractions used to distribute VMT to each roadway category.

Vehicle Miles Traveled & Travel Fractions

CARB developed both the paved road dust planning emissions inventory and the modeling inventory using 2017 VMT data from CARB's EMFAC2017 model[1], and data from transportation planning agencies. VMT are distributed using 2017 travel fractions assigned using Caltrans data.[2] VMT and travel factions for each COABDIS are presented in Table 2.

Table 1. CARB Roadway Categories, Caltrans HPMS Functional Systems, and FHWA Functional System Characteristics

CARB Category	HPMS Functional System	FHWA Functional System Characteristics
Freeway	Interstate	All designated routes of the Interstate System. Provides substantial interstate travel, highest overall travel speeds.
Freeway	Principal Arterial-Other Freeways and Expressways	Highest level of mobility, highest traffic volumes and travel speeds, controlled access routes. Serves longest trips and through-movement as well as access to major urban centers. Provides intra-area travel, intra-urban and inter-city bus routes. Integrates with major rural connections.
Major	Principal Arterial-Other	Provides substantial statewide travel, links cities and larger towns, links to interstates and inter-county service; relatively high travel speeds. Can also provide service to major traffic movements, uncontrolled access to adjacent land.
Major	Minor Arterial	Interconnects, augments urban principal arterial system, distributes travel to smaller geographic areas, may carry local bus routes. Serves trips of moderate length at somewhat lower mobility and speeds. Connects to rural collector roads.
Collector	Major Collector	Primarily intra-county; shorter distances and more moderate travel speeds than arterials.
Local	Minor Collector	Collects traffic from local roads, services smaller communities, links locally important traffic generators with remote areas.
Local	Local	Provides access to adjacent land over relatively short distances.

[1] The latest available activity data from Metropolitan Planning Organizations were used in the development of this methodology.
[2] California Department of Transportation Highway Performance Monitoring System (HPMS) Vehicle Miles Traveled (VMT) per Day by County and Roadway Functional Classification was used to calculate 2017 travel fractions.

Table 2. 2017 Roadway Travel Fraction and VMT Estimates for California Entrained Paved Road Dust

Air Basin	County	Air District	2017 VMT (Million VMT per year)	2017 HPMS Travel Fraction				
				Freeway	Major	Collector	Local, Local Urban	Local Rural[3]
GB	Alpine	GBU	82	0.00	0.80	0.14	0.06	
GB	Inyo	GBU	947	0.00	0.65	0.27	0.08	
GB	Mono	GBU	439	0.00	0.80	0.09	0.10	
LC	Lake	LAK	842	0.00	0.60	0.29	0.11	
LT	El Dorado	ED	426	0.14	0.63	0.10	0.12	
LT	Placer	PLA	340	0.43	0.30	0.11	0.15	
MC	Amador	AMA	385	0.00	0.69	0.14	0.17	
MC	Calaveras	CAL	489	0.00	0.67	0.16	0.17	
MC	El Dorado	ED	1,354	0.14	0.63	0.10	0.12	
MC	Mariposa	MPA	181	0.00	0.56	0.13	0.32	
MC	Nevada	NSI	1,254	0.37	0.29	0.15	0.19	
MC	Placer	PLA	538	0.43	0.30	0.11	0.15	
MC	Plumas	NSI	401	0.00	0.62	0.16	0.23	
MC	Sierra	NSI	142	0.31	0.29	0.12	0.28	
MC	Tuolumne	TUO	698	0.00	0.49	0.17	0.34	
MD	Kern	KER	2,064	0.42	0.37	0.09	0.12	
MD	Los Angeles	AV	3,782	0.44	0.44	0.07	0.05	
MD	Riverside	MOJ	387	0.50	0.29	0.12	0.08	
MD	Riverside	SC	435	0.50	0.29	0.12	0.08	
MD	San Bernardino	MOJ	9,022	0.52	0.32	0.09	0.07	
NC	Del Norte	NCU	322	0.00	0.64	0.20	0.16	
NC	Humboldt	NCU	1,676	0.00	0.73	0.13	0.14	
NC	Mendocino	MEN	1,617	0.00	0.58	0.17	0.25	
NC	Sonoma	NS	725	0.42	0.28	0.19	0.11	
NC	Trinity	NCU	488	0.00	0.57	0.10	0.33	
NCC	Monterey	MBU	4,261	0.48	0.27	0.14	0.11	
NCC	San Benito	MBU	813	0.24	0.57	0.08	0.10	
NCC	Santa Cruz	MBU	2,051	0.43	0.33	0.14	0.10	
NEP	Lassen	LAS	611	0.00	0.70	0.14	0.15	
NEP	Modoc	MOD	252	0.00	0.44	0.46	0.09	

[3] SJU District distributes Local Roads VMT to Local and Local Rural fractions. For all other regions, the Local Roads fraction includes both Local and Local Rural VMT.

Air Basin	County	Air District	2017 VMT (Million VMT per year)	2017 HPMS Travel Fraction				
				Freeway	Major	Collector	Local, Local Urban	Local Rural[3]
NEP	Siskiyou	SIS	1,341	0.46	0.24	0.15	0.15	
SC	Los Angeles	SC	80,869	0.44	0.44	0.07	0.05	
SC	Orange	SC	29,362	0.50	0.39	0.04	0.08	
SC	Riverside	SC	17,927	0.50	0.29	0.12	0.08	
SC	San Bernardino	SC	15,526	0.52	0.32	0.09	0.07	
SCC	San Luis Obispo	SLO	2,848	0.49	0.30	0.10	0.11	
SCC	Santa Barbara	SB	4,026	0.37	0.37	0.15	0.10	
SCC	Ventura	VEN	7,549	0.24	0.57	0.11	0.09	
SD	San Diego	SD	30,217	0.58	0.27	0.09	0.06	
SF	Alameda	BA	14,328	0.57	0.26	0.07	0.09	
SF	Contra Costa	BA	8,276	0.50	0.37	0.09	0.04	
SF	Marin	BA	2,313	0.63	0.16	0.14	0.08	
SF	Napa	BA	1,119	0.18	0.57	0.16	0.09	
SF	San Francisco	BA	3,341	0.39	0.41	0.07	0.13	
SF	San Mateo	BA	5,960	0.63	0.27	0.05	0.05	
SF	Santa Clara	BA	14,706	0.49	0.37	0.06	0.07	
SF	Solano	BA	2,966	0.20	0.50	0.15	0.15	
SF	Sonoma	BA	3,083	0.42	0.28	0.19	0.11	
SJV	Fresno	SJU	8,437	0.35	0.30	0.12	0.17	0.06
SJV	Kern	SJU	7,775	0.42	0.37	0.09	0.11	0.01
SJV	Kings	SJU	1,507	0.39	0.37	0.13	0.09	0.02
SJV	Madera	SJU	1,808	0.46	0.34	0.12	0.02	0.06
SJV	Merced	SJU	2,830	0.49	0.27	0.12	0.08	0.04
SJV	San Joaquin	SJU	7,179	0.55	0.24	0.11	0.09	0.02
SJV	Stanislaus	SJU	4,118	0.35	0.33	0.19	0.11	0.01
SJV	Tulare	SJU	3,974	0.41	0.27	0.14	0.13	0.05
SS	Imperial	IMP	2,377	0.22	0.36	0.07	0.34	
SS	Riverside	SC	4,906	0.50	0.29	0.12	0.08	
SV	Butte	BUT	1,853	0.03	0.54	0.25	0.18	
SV	Colusa	COL	796	0.51	0.18	0.09	0.23	
SV	Glenn	GLE	749	0.65	0.14	0.13	0.08	
SV	Placer	PLA	3,198	0.43	0.30	0.11	0.15	
SV	Sacramento	SAC	12,863	0.37	0.32	0.10	0.21	
SV	Shasta	SHA	2,749	0.54	0.30	0.08	0.08	
SV	Solano	YS	3,385	0.20	0.50	0.15	0.15	
SV	Sutter	FR	776	0.28	0.51	0.08	0.13	

Air Basin	County	Air District	2017 VMT (Million VMT per year)	2017 HPMS Travel Fraction				
				Freeway	Major	Collector	Local, Local Urban	Local Rural[3]
SV	Tehama	TEH	1,422	0.59	0.20	0.14	0.06	
SV	Yolo	YS	2,215	0.46	0.32	0.11	0.11	
SV	Yuba	FR	635	0.24	0.38	0.17	0.21	
Statewide 2017 VMT Total			**358,330**					

Silt Loadings

CARB assigned silt loading values to four roadway types (freeway, major, collector, local), assuming that more highly traveled roadways with fewer entrance and exit points (limited access roadways such as freeways) have less silt loading compared to roadways with multiple access and exit points, and that roads with similar configurations and usage have similar silt loadings statewide. While CARB understands the limitations to this assumption, especially in computing localized emissions, our current strategy is to use the best available California roadway silt loading data to estimate regional entrained road dust emissions. Tables 3, presents the statewide default silt loading values for the four CARB roadway categories, as well as the derivation of several district and county specific silt loadings. Silt loadings for unspecified roads were provided directly by air districts and counties. Table 4 presents silt loading values and associated PM_{10} emission factors, by roadway category, for each COABDIS region. A summary of the data used to develop the silt loadings is provided in Appendix A, Table 1. The basis for the proposed silt loading values is as follows:

Statewide Default Silt Loadings

- Freeway-U.S. EPA AP-42 (January 2011) default.[1]
- Major and Collector roadways-geometric mean of 31 California-specific silt measurements of roads with high average daily traffic (ADT) conducted by MRI[2,5] and the University of California, Davis (UCD).[2,3,4]
- Local roadways-mean of 11 California-specific silt measurements of roads with low ADT conducted by MRI.[2,5]

District and County Specific Silt Loadings

- The San Joaquin Valley Air Pollution Control District (SJVAPCD) splits local roads into urban and rural classes and assigns separate silt loading values to each class. Local urban roads are assigned the statewide Local road default silt loading value. A higher silt loading value (derived from U.S. EPA AP-42 data) is assigned to local rural roads due to anticipated higher silt loading levels from agricultural activities.[2]

- For Major, Collector and Local roads, the portion of Los Angeles County in the South Coast Air Quality Management District (SCAQMD) and all portions of Orange, Riverside and San Bernardino counties use silt loading values based on subsets of measurements collected in the SCAQMD and Riverside County.[2,5]

Table 3.a. - California Default Statewide Silt Loading Values

Roadway Category	Silt Loading (sL) (g/m^2)	Source of sL Value
Freeway	0.015	U.S. EPA default value[1]
Major	0.032	Geometric mean of 31 California samples[2,3,4,5]
Collector	0.032	Geometric mean of 31 California samples[2,3,4,5]
Local	0.32	Average of 11 California BACM samples[5]

Table 3.b. - District Specific Silt Loading Values

Roadway Category	Silt Loading (sL) (g/m^2)	Source of sL Value
SJVAPCD[a]-Local Rural (PM_{10})	1.6	Average sL, AP-42 Local roads[1,2]

Table 3.c.1. - County Specific Silt Loading Values - Major, Collector

Roadway Category	Silt Loading (sL) (g/m^2)	Source of sL Value
Los Angeles & Orange counties: $Maj\text{-}Coll_{[LA\&OR]}$	0.013	0.013=Mean of 3 of the 4 South Coast High ADT[c] BACM[d] sL measurements[2,5]
Riverside & San Bernardino counties: $Maj\text{-}Coll_{[RIV\&SB]}$	0.08	0.08=Mean of all South Coast Low ADT BACM sL measurements[2,5]

Table 3.c.2. - County Specific Silt Loading Values - Major-Collector Scaling Ratio

Roadway Category	Silt Loading (sL) (g/m^2)	Source of sL Value
$Maj\text{-}Coll_{[RIV\&SB]}/Maj\text{-}Coll_{[LA\&OR]}$	(0.08/0.013)=6.2	6.2 is used below to scale sL $Local_{[LA\&OR]}$ to sL $Local_{[RIV\&SB]}$

Table 3.c.3. - County Specific Silt Loading Values – Local

Roadway Category	Silt Loading (sL) (g/m^2)	Source of sL Value
Los Angeles & Orange counties: $Local_{[LA\&OR]}$	0.135	0.135=Geometric mean of 11 CA High ADT sL measurements[5]
Riverside & San Bernardino counties: $Local_{[RIV\&SB]}$	$Local_{[LA\&OR]} \times 6.2 = Local_{[RIV\&SB]}$ $0.135 \times 6.2 = 0.84$	$Local_{[LA\&OR]}$ scaled using ratio of: $Maj\text{-}Coll_{[RIV\&SB]} / Maj\text{-}Coll_{[LA\&OR]}$[2,5]

[a] San Joaquin Valley Air Pollution Control District
[b] Silt loadings apply to the portion of Los Angeles County in the South Coast Air Quality

Management District and all portions of Orange, Riverside, and San Bernardino counties
[c] ADT, Average Daily Traffic
[d] BACM, Best Available Control Measure

Table 4. 2008 Silt Loadings and PM_{10} Emission Factors for California Entrained Paved Road Dust Estimates

Air Basin	County	Air District	Silt Loadings (SL, g/m^2) and PM_{10} Emission Factors (EF; lbs PM_{10}/10^6 VMT)										Ave. Vehicle Weight (tons)
			Freeway		Major		Collector[4]		Local, Local Urban[Error! Bookmark not defined.]		Local Rural[5], Sand/Gravel Proc.		
			SL	EF	SL	EF	SL	EF	SL	EF	SL	EF	
GB	Alpine	GBU	0.015	108.6	0.032	216.3	0.032	216.3	0.320	1,758.4			2.4
GB	Inyo	GBU	0.015	113.1	0.032	225.3	0.032	225.3	0.320	1,831.6			2.4
GB	Mono	GBU	0.015	110.3	0.032	219.7	0.032	219.7	0.320	1,786.1			2.4
LC	Lake	LAK	0.015	110.8	0.032	220.8	0.032	220.8	0.320	1,794.3			2.4
LT	El Dorado	ED	0.015	109.5	0.032	218.2	0.032	218.2	0.320	1,773.7			2.4
LT	Placer	PLA	0.015	110.0	0.032	219.1	0.032	219.1	0.320	1,781.2			2.4
MC	Amador	AMA	0.015	110.6	0.032	220.4	0.032	220.4	0.320	1,791.2			2.4
MC	Calaveras	CAL	0.015	111.2	0.032	221.6	0.032	221.6	0.320	1,801.2			2.4
MC	El Dorado	ED	0.015	109.7	0.032	218.7	0.032	218.7	0.320	1,777.6			2.4
MC	Mariposa	MPA	0.015	111.8	0.032	222.8	0.032	222.8	0.320	1,811.1			2.4
MC	Nevada	NSI	0.015	109.5	0.032	218.2	0.032	218.2	0.320	1,773.8			2.4
MC	Placer	PLA	0.015	109.5	0.032	218.2	0.032	218.2	0.320	1,773.3			2.4
MC	Plumas	NSI	0.015	109.3	0.032	217.9	0.032	217.9	0.320	1,770.8			2.4
MC	Sierra	NSI	0.015	109.4	0.032	217.9	0.032	217.9	0.320	1,771.4			2.4

[4] For Major, Collector and Local roads, the portion of Los Angeles County in the SC Air District (South Coast Air Quality Management District, SCAQMD) and all portions of Orange, Riverside and San Bernardino counties use silt loading values derived from a subset of measurements collected in the SCAQMD and Riverside County. Silt loading measurements used are presented in Appendix A, Table 1. See Tables 3 for more information on how silt loading values were derived.

[5] The SJU District (San Joaquin Valley Air Pollution Control District) splits local roads into urban and rural classes and uses separate silt loading values. A higher silt loading value derived from AP-42 data is used to compute emissions for local rural roads due to anticipated higher loading levels.

Air Basin	County	Air District	Silt Loadings (SL, g/m^2) and PM_{10} Emission Factors (EF; lbs $PM_{10}/10^6$ VMT)										Ave. Vehicle Weight (tons)
			Freeway		Major		Collector[4]		Local, Local Urban[Error! Bookmark not defined.]		Local Rural[5], Sand/Gravel Proc.		
			SL	EF	SL	EF	SL	EF	SL	EF	SL	EF	
MC	Tuolumne	TUO	0.015	110.2	0.032	219.5	0.032	219.5	0.320	1,784.5			2.4
MD	Kern	KER	0.015	113.6	0.032	226.4	0.032	226.4	0.320	1,840.0			2.4
MD	Los Angeles	AV	0.015	114.4	0.032	227.9	0.032	227.9	0.320	1,852.2			2.4
MD	Riverside	MOJ	0.015	115.7	0.080	530.7	0.080	530.7	0.840	4,509.3			2.4
MD	Riverside	SC	0.015	115.4	0.080	529.5	0.080	529.5	0.840	4,499.0			2.4
MD	San Bernardino	MOJ	0.015	114.0	0.080	523.0	0.080	523.0	0.840	4,444.2			2.4
NC	Del Norte	NCU	0.015	106.1	0.032	211.5	0.032	211.5	0.320	1,719.2			2.4
NC	Humboldt	NCU	0.015	107.3	0.032	213.9	0.032	213.9	0.320	1,738.5			2.4
NC	Mendocino	MEN	0.015	109.8	0.032	218.7	0.032	218.7	0.320	1,778.0			2.4
NC	Sonoma	NS	0.015	111.2	0.032	221.7	0.032	221.7	0.320	1,801.7			2.4
NC	Trinity	NCU	0.015	108.5	0.032	216.3	0.032	216.3	0.320	1,757.8			2.4
NCC	Monterey	MBU	0.015	112.6	0.032	224.3	0.032	224.3	0.320	1,823.5			2.4
NCC	San Benito	MBU	0.015	113.1	0.032	225.3	0.032	225.3	0.320	1,831.2			2.4
NCC	Santa Cruz	MBU	0.015	112.0	0.032	223.1	0.032	223.1	0.320	1,813.7			2.4
NEP	Lassen	LAS	0.015	109.2	0.032	217.6	0.032	217.6	0.320	1,768.5			2.4
NEP	Modoc	MOD	0.015	108.1	0.032	215.5	0.032	215.5	0.320	1,751.5			2.4
NEP	Siskiyou	SIS	0.015	106.3	0.032	211.8	0.032	211.8	0.320	1,721.7			2.4
SC	Los Angeles	SC	0.015	113.9	0.013	100.0	0.013	100.0	0.140	869.5			2.4
SC	Orange	SC	0.015	114.1	0.013	100.2	0.013	100.2	0.140	871.3			2.4
SC	Riverside	SC	0.015	113.5	0.080	520.7	0.080	520.7	0.840	4,424.5			2.4

Air Basin	County	Air District	Silt Loadings (SL, g/m^2) and PM_{10} Emission Factors (EF; lbs $PM_{10}/10^6$ VMT)										Ave. Vehicle Weight (tons)
			Freeway		Major		Collector[4]		Local, Local Urban[Error! Bookmark not defined.]		Local Rural[5], Sand/Gravel Proc.		
			SL	EF	SL	EF	SL	EF	SL	EF	SL	EF	
SC	San Bernardino	SC	0.015	113.2	0.080	519.2	0.080	519.2	0.840	4,411.9			2.4
SCC	San Luis Obispo	SLO	0.015	113.3	0.032	225.8	0.032	225.8	0.320	1,835.3			2.4
SCC	Santa Barbara	SB	0.015	113.8	0.032	226.7	0.032	226.7	0.320	1,842.9			2.4
SCC	Ventura	VEN	0.015	114.1	0.032	227.4	0.032	227.4	0.320	1,848.5			2.4
SD	San Diego	SD	0.015	113.3	0.032	225.8	0.032	225.8	0.320	1,835.5			2.4
SF	Alameda	BA	0.015	112.4	0.032	224.1	0.032	224.1	0.320	1,821.4			2.4
SF	Contra Costa	BA	0.015	112.4	0.032	224.0	0.032	224.0	0.320	1,820.9			2.4
SF	Marin	BA	0.015	111.7	0.032	222.6	0.032	222.6	0.320	1,809.5			2.4
SF	Napa	BA	0.015	112.1	0.032	223.5	0.032	223.5	0.320	1,816.5			2.4
SF	San Francisco	BA	0.015	112.4	0.032	224.0	0.032	224.0	0.320	1,820.9			2.4
SF	San Mateo	BA	0.015	111.7	0.032	222.5	0.032	222.5	0.320	1,808.8			2.4
SF	Santa Clara	BA	0.015	112.6	0.032	224.3	0.032	224.3	0.320	1,823.0			2.4
SF	Solano	BA	0.015	112.4	0.032	224.1	0.032	224.1	0.320	1,821.4			2.4
SF	Sonoma	BA	0.015	111.7	0.032	222.6	0.032	222.6	0.320	1,809.5			2.4
SJV	Fresno	SJU	0.015	112.0	0.032	223.2	0.032	223.2	0.320	1,814.3	1.600	7,848.1	2.4
SJV	Kern	SJU	0.015	113.6	0.032	226.4	0.032	226.4	0.320	1,839.9	1.600	7,958.9	2.4
SJV	Kings	SJU	0.015	114.3	0.032	227.7	0.032	227.7	0.320	1,851.0	1.600	8,007.1	2.4
SJV	Madera	SJU	0.015	111.8	0.032	222.9	0.032	222.9	0.320	1,811.4	1.600	7,835.8	2.4
SJV	Merced	SJU	0.015	113.3	0.032	225.8	0.032	225.8	0.320	1,835.7	1.600	7,940.9	2.4

Air Basin	County	Air District	Silt Loadings (SL, g/m^2) and PM_{10} Emission Factors (EF; lbs $PM_{10}/10^6$ VMT)										Ave. Vehicle Weight (tons)
			Freeway		Major		Collector[4]		Local, Local Urban[Error! Bookmark not defined.]		Local Rural[5], Sand/Gravel Proc.		
			SL	EF	SL	EF	SL	EF	SL	EF	SL	EF	
SJV	San Joaquin	SJU	0.015	113.1	0.032	225.4	0.032	225.4	0.320	1,832.4	1.600	7,926.6	2.4
SJV	Stanislaus	SJU	0.015	113.2	0.032	225.6	0.032	225.6	0.320	1,833.7	1.600	7,932.2	2.4
SJV	Tulare	SJU	0.015	112.3	0.032	223.8	0.032	223.8	0.320	1,819.5	1.600	7,870.6	2.4
SS	Imperial	IMP	0.015	115.7	0.032	230.5	0.032	230.5	0.320	1,873.9			2.4
SS	Riverside	SC	0.015	114.4	0.080	524.9	0.080	524.9	0.840	4,460.2			2.4
SV	Butte	BUT	0.015	110.6	0.032	220.3	0.032	220.3	0.320	1,790.7			2.4
SV	Colusa	COL	0.015	112.0	0.032	223.1	0.032	223.1	0.320	1,813.7			2.4
SV	Glenn	GLE	0.015	111.5	0.032	222.2	0.032	222.2	0.320	1,805.7			2.4
SV	Placer	PLA	0.015	112.2	0.032	223.7	0.032	223.7	0.320	1,818.1			2.4
SV	Sacramento	SAC	0.015	112.7	0.032	224.5	0.032	224.5	0.320	1,825.2			2.4
SV	Shasta	SHA	0.015	109.0	0.032	217.2	0.032	217.2	0.320	1,765.9			2.4
SV	Solano	YS	0.015	112.7	0.032	224.5	0.032	224.5	0.320	1,824.8			2.4
SV	Sutter	FR	0.015	112.5	0.032	224.2	0.032	224.2	0.320	1,822.6			2.4
SV	Tehama	TEH	0.015	110.0	0.032	219.2	0.032	219.2	0.320	1,781.9			2.4
SV	Yolo	YS	0.015	112.6	0.032	224.4	0.032	224.4	0.320	1,824.1			2.4
SV	Yuba	FR	0.015	111.1	0.032	221.4	0.032	221.4	0.320	1,799.8			2.4

Vehicle Weight Estimates

The estimated statewide average vehicle weight is based on an informal traffic count conducted by MRI while performing California silt loading measurements.[2,5] The statewide default fleet vehicle weight is 2.4 tons; Table 4 contains fleet vehicle weights.

Rainfall Adjustment

Table 5 shows the average number of days per year each county within an air basin received 0.01 inch or more of precipitation during the 2007-2017 time period.[9]

Table 5. Annual Rainfall Days[9]: Average Days per Year that California Counties Received 0.01 Inch or Greater Precipitation Over 2007-2017[6]

Air Basin	County	Air District	Annual Rainfall Days
GBV	Alpine	GBU	112
GBV	Inyo	GBU	56
GBV	Mono	GBU	91
LC	Lake	LAK	85
LT	El Dorado	ED	101
LT	Placer	PLA	95
MC	Amador	AMA	87
MC	Calaveras	CAL	80
MC	El Dorado	ED	98
MC	Mariposa	MPA	72
MC	Nevada	NSI	101
MC	Placer	PLA	101
MC	Plumas	NSI	103
MC	Sierra	NSI	102
MC	Tuolumne	TUO	92
MD	Kern	KER	50
MD	Los Angeles	AV	41
MD	Riverside	MOJ	24
MD	Riverside	SC	27
MD	San Bernardino	MOJ	45
NC	Del Norte	NCU	142
NC	Humboldt	NCU	128
NC	Mendocino	MEN	97
NC	Sonoma	NS	79
NC	Trinity	NCU	113
NCC	Monterey	MBU	63
NCC	San Benito	MBU	57
NCC	Santa Cruz	MBU	70
NEP	Lassen	LAS	105
NEP	Modoc	MOD	118
NEP	Siskiyou	SIS	141
SC	Los Angeles	SC	46
SC	Orange	SC	43
SC	Riverside	SC	51
SC	San Bernardino	SC	55
SCC	San Luis Obispo	SLO	54
SCC	Santa Barbara	SB	48
SCC	Ventura	VEN	43
SD	San Diego	SD	53

[6]Average daily precipitation data for 2007-2017 was obtained from gridMET *http://www.climatologylab.org/gridmet.html*

Air Basin	County	Air District	Annual Rainfall Days
SF	Alameda	BA	64
SF	Contra Costa	BA	65
SF	Marin	BA	73
SF	Napa	BA	68
SF	San Francisco	BA	65
SF	San Mateo	BA	74
SF	Santa Clara	BA	63
SF	Solano	BA	64
SF	Sonoma	BA	73
SJV	Fresno	SJU	70
SJV	Kern	SJU	50
SJV	Kings	SJU	41
SJV	Madera	SJU	72
SJV	Merced	SJU	53
SJV	San Joaquin	SJU	56
SJV	Stanislaus	SJU	55
SJV	Tulare	SJU	66
SS	Imperial	IMP	24
SS	Riverside	SC	40
SV	Butte	BUT	88
SV	Colusa	COL	70
SV	Glenn	GLE	76
SV	Placer	PLA	67
SV	Sacramento	SAC	61
SV	Shasta	SHA	107
SV	Solano	YS	62
SV	Sutter	FR	63
SV	Tehama	TEH	94
SV	Yolo	YS	62
SV	Yuba	FR	81

Particle Size Weight Fractions-Carb Speciation Profiles

CARB's database system maintains particulate emissions as Total PM (total particulate matter) using CARB's speciation profile #471 for paved road dust (see Table 6, below), based on paved road dust sampling conducted in California and on evaluations conducted by CARB and MRI.[12,13,14,15,16,17,18]. It is estimated that PM_{10} is 45.72% of Total PM. Based on 2006 updates to CARB speciation profiles for $PM_{2.5}$ (particulate matter less than 2.5 microns in diameter), $PM_{2.5}$ is estimated to be 6.86% of Total PM, or 15% of PM_{10}.[15]

$$\text{Total PM} = PM_{10}/0.4572$$

$$PM_{2.5} = [PM_{10} \times (0.0686/0.4572)]$$

$$= PM_{10} \times 15\%$$

Table 6. CARB Paved Road Dust Particulate Matter (PM) Weight Fractions Speciation Profile #471

Particulate Matter	Size	Fraction of Total PM
PM2.5	≤ $PM_{2.5}$	0.0686
PM10	≤ PM_{10}	0.4572
PM	> PM_{10}	0.5428
Total PM	All PM	1.0000

Statewide Total PM, PM_{10} and $PM_{2.5}$ emissions (tons/year) for 2017 are presented in Tables 7.1, 7.2, and 7.3 by COABDIS region and roadway type, along with total VMT.

Paved Road Dust PM Emission Estimates

Table 4 presents PM_{10} emission factors (lbs $PM_{10}/10^6$ VMT) and roadway silt loadings (g/m^2), by COABDIS region and roadway type. Tables 7.1, 7.2, and 7.3 present uncontrolled paved road dust Total PM, PM_{10}, and $PM_{2.5}$ emissions (tons/year) for 2017, respectively by paved road category within COABDIS region, except for SCAQMD Unspecified Roads, which reflect District controls.

Table 7.1. 2017 Entrained Road Dust Emissions for Total PM

Air Basin	County	Air District	2017 VMT (Million VMT per year)	2017 Paved Road Dust PM Emissions, tons/year					
				Freeway	Major	Collector	Local[7]	Local Rural, Sand/ Gravel Proc.[8]	Total PM Emissions
GBV	Alpine	GBU	82	0.00	15.56	2.62	9.60		27.78
GBV	Inyo	GBU	947	0.00	151.91	63.25	148.91		364.07
GBV	Mono	GBU	439	0.00	84.78	9.85	89.31		183.94
LC	Lake	LAK	842	0.00	121.09	59.65	183.16		363.89
LT	El Dorado	ED	426	7.31	63.97	10.38	103.22		184.88
LT	Placer	PLA	340	17.68	24.60	9.02	102.08		153.37
MC	Amador	AMA	385	0.00	63.53	13.26	129.57		206.35
MC	Calaveras	CAL	489	0.00	79.17	18.85	167.40		265.42
MC	El Dorado	ED	1,354	23.28	203.81	33.08	328.86		589.02
MC	Mariposa	MPA	181	0.00	24.63	5.57	113.77		143.97
MC	Nevada	NSI	1,254	56.04	86.59	44.53	458.58		645.74
MC	Placer	PLA	538	27.90	38.82	14.23	161.10		242.04
MC	Plumas	NSI	401	0.00	59.01	14.90	175.08		248.99
MC	Sierra	NSI	142	5.22	9.90	4.12	77.28		96.51

[7] As with the previous version of this methodology, the current 2021 update notes that SJU District splits local roads into local and local rural classes, and uses separate silt loading values. Due to anticipated higher silt loading levels, a higher silt loading value derived from AP-42 data is used in computing emissions for local rural roads. Local emissions include only local urban roadways. Local rural emissions are captured under the "Local Rural, Sand/Gravel Proc." roadway category.

[8] The updated 2021 methodology uses the same emissions as the 2018 update provided by SC District (South Coast Air Quality Management District, SCAQMD) from paved roads at sand and gravel processing facilities (Unspecified Paved Roads).

Air Basin	County	Air District	2017 VMT (Million VMT per year)	2017 Paved Road Dust PM Emissions, tons/year					
				Freeway	Major	Collector	Local[7]	Local Rural, Sand/ Gravel Proc.[8]	Total PM Emissions
MC	Tuolumne	TUO	698	0.00	82.23	29.04	458.04		569.31
MD	Kern	KER	2,064	106.51	189.43	46.84	508.51		851.30
MD	Los Angeles	AV	3,782	209.85	417.66	63.46	351.96		1,042.94
MD	Riverside	MOJ	387	24.39	65.59	27.88	161.80		279.66
MD	Riverside	SC	435	27.37	73.61	31.29	181.59		313.87
MD	San Bernardino	MOJ	9,021	586.05	1,648.37	458.72	3,096.90		5,790.05
NC	Del Norte	NCU	322	0.00	47.57	15.17	95.15		157.89
NC	Humboldt	NCU	1,676	0.00	286.29	51.08	444.54		781.91
NC	Mendocino	MEN	1,617	0.33	224.51	65.34	781.97		1,072.14
NC	Sonoma	NS	725	37.18	49.76	32.53	157.44		276.91
NC	Trinity	NCU	488	0.00	65.59	11.99	306.89		384.48
NCC	Monterey	MBU	4,261	251.73	285.82	143.41	930.28		1,611.24
NCC	San Benito	MBU	813	24.41	114.66	17.01	162.65		318.74
NCC	Santa Cruz	MBU	2,051	109.15	163.80	70.42	396.09		739.46
NEP	Lassen	LAS	611	0.00	102.25	20.95	180.33		303.54
NEP	Modoc	MOD	252	0.00	26.34	27.35	45.72		99.42
NEP	Siskiyou	SIS	1,341	72.02	74.68	45.64	380.41		572.75
SC	Los Angeles	SC	80,869	4,468.90	3,918.42	595.40	3,532.38	577.87	13,092.97
SC	Orange	SC	29,362	1,825.63	1,251.59	114.31	2,163.46	170.73	5,525.71
SC	Riverside	SC	17,927	1,109.53	2,983.85	1,268.30	7,360.59	302.06	13,024.32
SC	San Bernardino	SC	15,526	1,001.30	2,816.31	783.75	5,291.20	262.66	10,155.22
SCC	San Luis Obispo	SLO	2,848	173.86	207.89	73.52	613.11		1,068.38

Air Basin	County	Air District	2017 VMT (Million VMT per year)	2017 Paved Road Dust PM Emissions, tons/year					
				Freeway	Major	Collector	Local[7]	Local Rural, Sand/ Gravel Proc.[8]	Total PM Emissions
SCC	Santa Barbara	SB	4,026	186.32	371.10	153.01	835.45		1,545.88
SCC	Ventura	VEN	7,549	222.08	1,061.69	204.26	1,372.88		2,860.91
SD	San Diego	SD	30,217	2,161.04	1,983.84	695.36	3,874.08		8,714.31
SF	Alameda	BA	14,328	1,000.56	930.28	257.57	2,677.63		4,866.04
SF	Contra Costa	BA	8,276	505.67	753.28	183.11	679.80		2,121.86
SF	Marin	BA	2,313	177.78	88.59	77.84	344.56		688.77
SF	Napa	BA	1,119	25.36	156.04	43.43	191.20		416.03
SF	San Francisco	BA	3,341	161.11	337.75	56.34	839.42		1,394.62
SF	San Mateo	BA	5,960	461.71	389.70	71.79	559.61		1,482.80
SF	Santa Clara	BA	14,706	895.58	1,324.23	232.25	2,161.99		4,614.05
SF	Solano	BA	2,966	74.54	360.11	112.63	857.44		1,404.73
SF	Sonoma	BA	3,083	158.80	212.56	138.96	672.47		1,182.78
SJV	Fresno	SJU	8,437	360.97	624.05	247.36	2,804.54	4,349.79	8,386.71
SJV	Kern	SJU	7,775	401.11	713.36	176.39	1,716.56	858.20	3,865.61
SJV	Kings	SJU	1,507	73.70	139.03	48.00	285.66	219.49	765.87
SJV	Madera	SJU	1,808	100.82	150.05	52.99	68.92	992.47	1,365.25
SJV	Merced	SJU	2,830	170.49	191.52	82.43	453.15	1,034.67	1,932.26
SJV	San Joaquin	SJU	7,179	487.27	430.64	187.87	1,237.63	992.15	3,335.55
SJV	Stanislaus	SJU	4,118	178.54	334.04	197.29	935.77	478.89	2,124.55
SJV	Tulare	SJU	3,974	199.41	266.63	131.51	1,036.75	1,752.29	3,386.60
SS	Imperial	IMP	2,377	66.80	217.38	44.78	1,657.85		1,986.81
SS	Riverside	SC	4,906	306.10	823.21	349.91	2,030.70		3,509.92

Air Basin	County	Air District	2017 VMT (Million VMT per year)	2017 Paved Road Dust PM Emissions, tons/year					
				Freeway	Major	Collector	Local[7]	Local Rural, Sand/ Gravel Proc.[8]	Total PM Emissions
SV	Butte	BUT	1,853	6.04	239.09	113.02	668.00		1,026.15
SV	Colusa	COL	796	49.67	34.50	16.91	357.26		458.34
SV	Glenn	GLE	749	59.47	25.36	23.34	119.65		227.81
SV	Placer	PLA	3,198	169.88	236.39	86.65	981.03		1,473.95
SV	Sacramento	SAC	12,863	587.13	1,016.63	310.18	5,379.98		7,293.92
SV	Shasta	SHA	2,749	177.47	192.73	52.32	441.82		864.33
SV	Solano	YS	3,385	85.24	411.80	128.79	980.50		1,606.34
SV	Sutter	FR	776	26.43	97.65	15.04	203.22		342.33
SV	Tehama	TEH	1,422	101.18	69.26	48.41	175.44		394.30
SV	Yolo	YS	2,215	124.90	172.25	61.66	493.66		852.46
SV	Yuba	FR	635	18.58	57.70	26.26	267.14		369.68
Statewide Totals			358,330	19,947.40	30,536.01	8,924.35	67,210.68	11,991.27	138,609.71

Table 7.2. 2017 Entrained Road Dust Emissions for PM_{10}

Air Basin	County	Air District	2017 VMT (Million VMT per year)	2017 Paved Road Dust PM_{10} Emissions, tons/year					
				Freeway	Major	Collector	Local[9]	Local Rural, Sand/Gravel Proc.[10]	Total PM_{10} Emissions
GBV	Alpine	GBU	82	0.00	7.11	1.20	4.39		12.70
GBV	Inyo	GBU	947	0.00	69.45	28.92	68.08		166.45
GBV	Mono	GBU	439	0.00	38.76	4.50	40.83		84.10
LC	Lake	LAK	842	0.00	55.36	27.27	83.74		166.37
LT	El Dorado	ED	426	3.34	29.25	4.75	47.19		84.53
LT	Placer	PLA	340	8.08	11.25	4.12	46.67		70.12
MC	Amador	AMA	385	0.00	29.05	6.06	59.24		94.34
MC	Calaveras	CAL	489	0.00	36.20	8.62	76.53		121.35
MC	El Dorado	ED	1,354	10.64	93.18	15.12	150.36		269.30
MC	Mariposa	MPA	181	0.00	11.26	2.55	52.01		65.82
MC	Nevada	NSI	1,254	25.62	39.59	20.36	209.66		295.23
MC	Placer	PLA	538	12.75	17.75	6.51	73.65		110.66
MC	Plumas	NSI	401	0.00	26.98	6.81	80.05		113.84
MC	Sierra	NSI	142	2.39	4.52	1.88	35.33		44.13
MC	Tuolumne	TUO	698	0.00	37.60	13.28	209.42		260.29
MD	Kern	KER	2,064	48.70	86.61	21.42	232.49		389.21

[9] As with the previous version of this methodology, the current 2021 update notes that SJU District splits local roads into local and local rural classes, and uses separate silt loading values. Due to anticipated higher silt loading levels, a higher silt loading value derived from AP-42 data is used in computing emissions for local rural roads. Local emissions include only local urban roadways. Local rural emissions are captured under the "Local Rural, Sand/Gravel Proc." roadway category.

[10] The updated 2021 methodology uses the same emissions as the 2018 update provided by SC District (South Coast Air Quality Management District, SCAQMD) from paved roads at sand and gravel processing facilities (Unspecified Paved Roads).

Air Basin	County	Air District	2017 VMT (Million VMT per year)	2017 Paved Road Dust PM_{10} Emissions, tons/year					
				Freeway	Major	Collector	Local[9]	Local Rural, Sand/Gravel Proc.[10]	Total PM_{10} Emissions
MD	Los Angeles	AV	3,782	95.95	190.96	29.02	160.92		476.83
MD	Riverside	MOJ	387	11.15	29.99	12.75	73.97		127.86
MD	Riverside	SC	435	12.52	33.66	14.31	83.02		143.50
MD	San Bernardino	MOJ	9,021	267.94	753.63	209.73	1,415.90		2,647.21
NC	Del Norte	NCU	322	0.00	21.75	6.94	43.50		72.19
NC	Humboldt	NCU	1,676	0.00	130.89	23.35	203.24		357.49
NC	Mendocino	MEN	1,617	0.15	102.65	29.87	357.52		490.18
NC	Sonoma	NS	725	17.00	22.75	14.87	71.98		126.60
NC	Trinity	NCU	488	0.00	29.99	5.48	140.31		175.78
NCC	Monterey	MBU	4,261	115.09	130.68	65.57	425.32		736.66
NCC	San Benito	MBU	813	11.16	52.42	7.78	74.36		145.73
NCC	Santa Cruz	MBU	2,051	49.90	74.89	32.20	181.09		338.08
NEP	Lassen	LAS	611	0.00	46.75	9.58	82.45		138.78
NEP	Modoc	MOD	252	0.00	12.04	12.50	20.91		45.45
NEP	Siskiyou	SIS	1,341	32.93	34.14	20.87	173.92		261.86
SC	Los Angeles	SC	80,869	2,043.18	1,791.50	272.22	1,615.01	264.20	5,986.10
SC	Orange	SC	29,362	834.68	572.23	52.26	989.13	78.06	2,526.36
SC	Riverside	SC	17,927	507.28	1,364.22	579.87	3,365.26	138.10	5,954.72
SC	San Bernardino	SC	15,526	457.79	1,287.62	358.33	2,419.13	120.09	4,642.97
SCC	San Luis Obispo	SLO	2,848	79.49	95.05	33.61	280.31		488.46
SCC	Santa Barbara	SB	4,026	85.19	169.67	69.95	381.97		706.77
SCC	Ventura	VEN	7,549	101.54	485.41	93.39	627.68		1,308.01
SD	San Diego	SD	30,217	988.03	907.01	317.92	1,771.23		3,984.18
SF	Alameda	BA	14,328	457.46	425.33	117.76	1,224.21		2,224.76

Air Basin	County	Air District	2017 VMT (Million VMT per year)	2017 Paved Road Dust PM_{10} Emissions, tons/year					
				Freeway	Major	Collector	Local[9]	Local Rural, Sand/Gravel Proc.[10]	Total PM_{10} Emissions
SF	Contra Costa	BA	8,276	231.19	344.40	83.72	310.81		970.11
SF	Marin	BA	2,313	81.28	40.50	35.59	157.53		314.91
SF	Napa	BA	1,119	11.60	71.34	19.86	87.42		190.21
SF	San Francisco	BA	3,341	73.66	154.42	25.76	383.78		637.62
SF	San Mateo	BA	5,960	211.09	178.17	32.82	255.85		677.94
SF	Santa Clara	BA	14,706	409.46	605.44	106.18	988.46		2,109.54
SF	Solano	BA	2,966	34.08	164.64	51.49	392.02		642.24
SF	Sonoma	BA	3,083	72.60	97.18	63.53	307.45		540.77
SJV	Fresno	SJU	8,437	165.04	285.32	113.09	1,282.23	1,988.72	3,834.40
SJV	Kern	SJU	7,775	183.39	326.15	80.64	784.81	392.37	1,767.36
SJV	Kings	SJU	1,507	33.69	63.56	21.95	130.60	100.35	350.16
SJV	Madera	SJU	1,808	46.09	68.60	24.23	31.51	453.76	624.19
SJV	Merced	SJU	2,830	77.95	87.56	37.69	207.18	473.05	883.43
SJV	San Joaquin	SJU	7,179	222.78	196.89	85.89	565.84	453.61	1,525.02
SJV	Stanislaus	SJU	4,118	81.63	152.72	90.20	427.84	218.95	971.34
SJV	Tulare	SJU	3,974	91.17	121.90	60.13	474.00	801.15	1,548.35
SS	Imperial	IMP	2,377	30.54	99.39	20.47	757.97		908.37
SS	Riverside	SC	4,906	139.95	376.37	159.98	928.44		1,604.74
SV	Butte	BUT	1,853	2.76	109.31	51.67	305.41		469.16
SV	Colusa	COL	796	22.71	15.77	7.73	163.34		209.55
SV	Glenn	GLE	749	27.19	11.59	10.67	54.70		104.16
SV	Placer	PLA	3,198	77.67	108.08	39.62	448.52		673.89
SV	Sacramento	SAC	12,863	268.44	464.80	141.82	2,459.72		3,334.78
SV	Shasta	SHA	2,749	81.14	88.11	23.92	202.00		395.17

Air Basin	County	Air District	2017 VMT (Million VMT per year)	2017 Paved Road Dust PM_{10} Emissions, tons/year					
				Freeway	Major	Collector	Local[9]	Local Rural, Sand/Gravel Proc.[10]	Total PM_{10} Emissions
SV	Solano	YS	3,385	38.97	188.27	58.88	448.29		734.42
SV	Sutter	FR	776	12.08	44.64	6.87	92.91		156.51
SV	Tehama	TEH	1,422	46.26	31.66	22.14	80.21		180.27
SV	Yolo	YS	2,215	57.10	78.75	28.19	225.70		389.75
SV	Yuba	FR	635	8.50	26.38	12.00	122.14		169.02
Statewide Totals			**358,330**	**9,119.95**	**13,961.06**	**4,080.21**	**30,728.73**	**5,842.41**	**63,372.36**

Table 7.3. 2017 Entrained Road Dust Emissions for $PM_{2.5}$

Air Basin	County	Air District	2017 VMT (Million VMT per year)	2017 Paved Road Dust $PM_{2.5}$ Emissions, tons/year					
				Freeway	Major	Collector	Local[11]	Local Rural, Sand/Gravel Proc.[12]	Total $PM_{2.5}$ Emissions
GBV	Alpine	GBU	82	0.00	1.07	0.18	0.66		1.91
GBV	Inyo	GBU	947	0.00	10.42	4.34	10.21		24.97
GBV	Mono	GBU	439	0.00	5.81	0.68	6.13		12.61
LC	Lake	LAK	842	0.00	8.30	4.09	12.56		24.96
LT	El Dorado	ED	426	0.50	4.39	0.71	7.08		12.68
LT	Placer	PLA	340	1.21	1.69	0.62	7.00		10.52

[11] As with the previous version of this methodology, the current 2021 update notes that SJU District splits local roads into local and local rural classes, and uses separate silt loading values. Due to anticipated higher silt loading levels, a higher silt loading value derived from AP-42 data is used in computing emissions for local rural roads. Local emissions include only local urban roadways. Local rural emissions are captured under the "Local Rural, Sand/Gravel Proc." roadway category.
[12] The updated 2021 methodology uses the same emissions as the 2018 update provided by SC District (South Coast Air Quality Management District, SCAQMD) from paved roads at sand and gravel processing facilities (Unspecified Paved Roads).

Air Basin	County	Air District	2017 VMT (Million VMT per year)	2017 Paved Road Dust $PM_{2.5}$ Emissions, tons/year					
				Freeway	Major	Collector	Local[11]	Local Rural, Sand/Gravel Proc.[12]	Total $PM_{2.5}$ Emissions
MC	Amador	AMA	385	0.00	4.36	0.91	8.89		14.15
MC	Calaveras	CAL	489	0.00	5.43	1.29	11.48		18.20
MC	El Dorado	ED	1,354	1.60	13.98	2.27	22.55		40.40
MC	Mariposa	MPA	181	0.00	1.69	0.38	7.80		9.87
MC	Nevada	NSI	1,254	3.84	5.94	3.05	31.45		44.28
MC	Placer	PLA	538	1.91	2.66	0.98	11.05		16.60
MC	Plumas	NSI	401	0.00	4.05	1.02	12.01		17.08
MC	Sierra	NSI	142	0.36	0.68	0.28	5.30		6.62
MC	Tuolumne	TUO	698	0.00	5.64	1.99	31.41		39.04
MD	Kern	KER	2,064	7.30	12.99	3.21	34.87		58.38
MD	Los Angeles	AV	3,782	14.39	28.64	4.35	24.14		71.52
MD	Riverside	MOJ	387	1.67	4.50	1.91	11.10		19.18
MD	Riverside	SC	435	1.88	5.05	2.15	12.45		21.53
MD	San Bernardino	MOJ	9,021	40.19	113.05	31.46	212.39		397.08
NC	Del Norte	NCU	322	0.00	3.26	1.04	6.53		10.83
NC	Humboldt	NCU	1,676	0.00	19.63	3.50	30.49		53.62
NC	Mendocino	MEN	1,617	0.02	15.40	4.48	53.63		73.53
NC	Sonoma	NS	725	2.55	3.41	2.23	10.80		18.99
NC	Trinity	NCU	488	0.00	4.50	0.82	21.05		26.37
NCC	Monterey	MBU	4,261	17.26	19.60	9.83	63.80		110.50
NCC	San Benito	MBU	813	1.67	7.86	1.17	11.15		21.86
NCC	Santa Cruz	MBU	2,051	7.49	11.23	4.83	27.16		50.71
NEP	Lassen	LAS	611	0.00	7.01	1.44	12.37		20.82
NEP	Modoc	MOD	252	0.00	1.81	1.88	3.14		6.82

Air Basin	County	Air District	2017 VMT (Million VMT per year)	2017 Paved Road Dust $PM_{2.5}$ Emissions, tons/year					
				Freeway	Major	Collector	Local[11]	Local Rural, Sand/Gravel Proc.[12]	Total $PM_{2.5}$ Emissions
NEP	Siskiyou	SIS	1,341	4.94	5.12	3.13	26.09		39.28
SC	Los Angeles	SC	80,869	306.48	268.73	40.83	242.25	39.63	897.92
SC	Orange	SC	29,362	125.20	85.83	7.84	148.37	11.71	378.95
SC	Riverside	SC	17,927	76.09	204.63	86.98	504.79	20.72	893.21
SC	San Bernardino	SC	15,526	68.67	193.14	53.75	362.87	18.01	696.45
SCC	San Luis Obispo	SLO	2,848	11.92	14.26	5.04	42.05		73.27
SCC	Santa Barbara	SB	4,026	12.78	25.45	10.49	57.30		106.02
SCC	Ventura	VEN	7,549	15.23	72.81	14.01	94.15		196.20
SD	San Diego	SD	30,217	148.20	136.05	47.69	265.68		597.63
SF	Alameda	BA	14,328	68.62	63.80	17.66	183.63		333.71
SF	Contra Costa	BA	8,276	34.68	51.66	12.56	46.62		145.52
SF	Marin	BA	2,313	12.19	6.08	5.34	23.63		47.24
SF	Napa	BA	1,119	1.74	10.70	2.98	13.11		28.53
SF	San Francisco	BA	3,341	11.05	23.16	3.86	57.57		95.64
SF	San Mateo	BA	5,960	31.66	26.73	4.92	38.38		101.69
SF	Santa Clara	BA	14,706	61.42	90.82	15.93	148.27		316.43
SF	Solano	BA	2,966	5.11	24.70	7.72	58.80		96.34
SF	Sonoma	BA	3,083	10.89	14.58	9.53	46.12		81.12
SJV	Fresno	SJU	8,437	24.76	42.80	16.96	192.34	298.31	575.16
SJV	Kern	SJU	7,775	27.51	48.92	12.10	117.72	58.86	265.10
SJV	Kings	SJU	1,507	5.05	9.53	3.29	19.59	15.05	52.52
SJV	Madera	SJU	1,808	6.91	10.29	3.63	4.73	68.06	93.63
SJV	Merced	SJU	2,830	11.69	13.13	5.65	31.08	70.96	132.51
SJV	San Joaquin	SJU	7,179	33.42	29.53	12.88	84.88	68.04	228.75

Air Basin	County	Air District	2017 VMT (Million VMT per year)	2017 Paved Road Dust $PM_{2.5}$ Emissions, tons/year					
				Freeway	Major	Collector	Local[11]	Local Rural, Sand/Gravel Proc.[12]	Total $PM_{2.5}$ Emissions
SJV	Stanislaus	SJU	4,118	12.24	22.91	13.53	64.18	32.84	145.70
SJV	Tulare	SJU	3,974	13.68	18.29	9.02	71.10	120.17	232.25
SS	Imperial	IMP	2,377	4.58	14.91	3.07	113.70		136.26
SS	Riverside	SC	4,906	20.99	56.46	24.00	139.27		240.71
SV	Butte	BUT	1,853	0.41	16.40	7.75	45.81		70.37
SV	Colusa	COL	796	3.41	2.37	1.16	24.50		31.43
SV	Glenn	GLE	749	4.08	1.74	1.60	8.21		15.62
SV	Placer	PLA	3,198	11.65	16.21	5.94	67.28		101.08
SV	Sacramento	SAC	12,863	40.27	69.72	21.27	368.96		500.22
SV	Shasta	SHA	2,749	12.17	13.22	3.59	30.30		59.28
SV	Solano	YS	3,385	5.85	28.24	8.83	67.24		110.16
SV	Sutter	FR	776	1.81	6.70	1.03	13.94		23.48
SV	Tehama	TEH	1,422	6.94	4.75	3.32	12.03		27.04
SV	Yolo	YS	2,215	8.57	11.81	4.23	33.85		58.46
SV	Yuba	FR	635	1.27	3.96	1.80	18.32		25.35
Statewide Totals			**358,330**	**1,367.99**	**2,094.16**	**612.03**	**4,609.31**	**822.36**	**9,505.85**

Temporal Activity

Total annual entrained paved road dust emissions are allocated on a monthly basis. During the wet winter months, the relative contribution of paved road emissions is reduced compared to non-rainy months. Table 8 presents the temporal adjustments used to reflect seasonal rainfall patterns for each county, by air basin.

Table 8. Temporal Profile for Paved Road Dust Emissions, Based on Monthly Days of Rain[13,14]

Air Basin	County	Air District	Monthly Rainfall Fraction											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GBV	Alpine	GBU	0.082	0.081	0.081	0.082	0.083	0.087	0.087	0.086	0.087	0.083	0.082	0.080
GBV	Inyo	GBU	0.080	0.079	0.084	0.084	0.084	0.089	0.083	0.084	0.086	0.085	0.084	0.079
GBV	Mono	GBU	0.081	0.080	0.082	0.083	0.083	0.087	0.084	0.085	0.087	0.084	0.084	0.081
LC	Lake	LAK	0.079	0.078	0.078	0.082	0.085	0.088	0.090	0.091	0.089	0.083	0.080	0.077
LT	El Dorado	ED	0.081	0.080	0.079	0.082	0.083	0.087	0.088	0.088	0.087	0.084	0.082	0.079
LT	Placer	PLA	0.081	0.079	0.079	0.082	0.084	0.087	0.088	0.088	0.087	0.084	0.081	0.079
MC	Amador	AMA	0.080	0.078	0.079	0.082	0.082	0.088	0.090	0.090	0.087	0.084	0.081	0.079
MC	Calaveras	CAL	0.080	0.077	0.078	0.082	0.083	0.088	0.090	0.090	0.087	0.084	0.081	0.079
MC	El Dorado	ED	0.081	0.079	0.079	0.082	0.082	0.088	0.090	0.089	0.087	0.084	0.081	0.079
MC	Mariposa	MPA	0.079	0.077	0.079	0.082	0.082	0.089	0.090	0.090	0.088	0.084	0.082	0.079
MC	Nevada	NSI	0.081	0.079	0.079	0.082	0.083	0.087	0.089	0.088	0.087	0.084	0.082	0.079
MC	Placer	PLA	0.081	0.079	0.079	0.082	0.083	0.087	0.089	0.088	0.087	0.084	0.081	0.079
MC	Plumas	MSI	0.081	0.079	0.079	0.081	0.082	0.087	0.088	0.089	0.087	0.084	0.082	0.079
MC	Sierra	NSI	0.081	0.079	0.080	0.082	0.083	0.087	0.088	0.088	0.087	0.085	0.082	0.079
MC	Tuolumne	TUO	0.081	0.079	0.080	0.082	0.082	0.088	0.088	0.088	0.087	0.084	0.082	0.079
MD	Kern	KER	0.077	0.076	0.081	0.083	0.086	0.089	0.088	0.088	0.088	0.084	0.082	0.077
MD	Los Angeles	AV	0.076	0.076	0.082	0.084	0.088	0.090	0.087	0.087	0.087	0.084	0.082	0.077
MD	Riverside	MOJ	0.080	0.082	0.087	0.086	0.090	0.090	0.080	0.076	0.082	0.086	0.084	0.077
MD	Riverside	SC	0.079	0.082	0.087	0.086	0.090	0.090	0.078	0.078	0.082	0.087	0.085	0.076
MD	San Bernardino	MOJ	0.079	0.081	0.086	0.085	0.088	0.090	0.079	0.078	0.084	0.085	0.086	0.079

[13] Average precipitation data for 2007-2017 was obtained from gridMET, average days per month with rainfall of 0.01 inch or greater.[9]
[14] Normalized Rainfall per Month=1- [Rain days per month/annual rain days]
Monthly Rainfall Fraction=[Normalized Rainfall per Month]/[Total Normalized Rainfall]

Air Basin	County	Air District	Monthly Rainfall Fraction											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NC	Del Norte	NCU	0.081	0.080	0.078	0.082	0.084	0.086	0.089	0.089	0.088	0.083	0.080	0.079
NC	Humboldt	NCU	0.080	0.079	0.078	0.081	0.084	0.087	0.090	0.090	0.088	0.084	0.080	0.079
NC	Mendocino	MEN	0.079	0.078	0.078	0.082	0.085	0.088	0.090	0.090	0.089	0.084	0.080	0.078
NC	Sonoma	NS	0.079	0.077	0.078	0.082	0.086	0.089	0.090	0.090	0.088	0.083	0.080	0.077
NC	Trinity	NCU	0.081	0.079	0.078	0.082	0.084	0.087	0.089	0.089	0.088	0.084	0.081	0.079
NCC	Monterey	MBU	0.078	0.075	0.079	0.083	0.086	0.090	0.090	0.091	0.089	0.084	0.080	0.076
NCC	San Benito	MBU	0.077	0.075	0.080	0.082	0.086	0.090	0.090	0.090	0.090	0.084	0.080	0.076
NCC	Santa Cruz	MBU	0.078	0.075	0.078	0.082	0.087	0.089	0.090	0.091	0.089	0.084	0.081	0.076
NEP	Lassen	LAS	0.082	0.080	0.080	0.082	0.082	0.086	0.088	0.088	0.088	0.084	0.082	0.078
NEP	Modoc	MOD	0.082	0.080	0.080	0.081	0.083	0.086	0.088	0.088	0.088	0.084	0.081	0.079
NEP	Siskiyou	SIS	0.081	0.080	0.079	0.082	0.084	0.086	0.088	0.088	0.088	0.084	0.080	0.079
SC	Los Angeles	SC	0.077	0.074	0.082	0.084	0.086	0.090	0.089	0.090	0.088	0.083	0.081	0.075
SC	Orange	SC	0.078	0.075	0.082	0.083	0.086	0.090	0.089	0.090	0.088	0.083	0.080	0.076
SC	Riverside	SC	0.078	0.077	0.083	0.083	0.086	0.090	0.087	0.086	0.086	0.085	0.082	0.077
SC	San Bernardino	SC	0.080	0.077	0.082	0.083	0.086	0.090	0.086	0.086	0.086	0.085	0.083	0.077
SCC	San Luis Obispo	SLO	0.077	0.072	0.081	0.082	0.087	0.090	0.091	0.091	0.089	0.082	0.081	0.077
SCC	Santa Barbara	SB	0.077	0.073	0.081	0.083	0.087	0.089	0.090	0.091	0.089	0.083	0.082	0.076
SCC	Ventura	VEN	0.077	0.073	0.082	0.083	0.086	0.090	0.090	0.089	0.089	0.083	0.082	0.076
SD	San Diego	SD	0.079	0.077	0.083	0.084	0.087	0.090	0.087	0.086	0.085	0.085	0.082	0.076
SF	Alameda	BA	0.078	0.076	0.078	0.082	0.087	0.089	0.091	0.091	0.089	0.084	0.080	0.076
SF	Contra Costa	BA	0.078	0.076	0.078	0.082	0.086	0.089	0.091	0.091	0.089	0.084	0.080	0.076
SF	Marin	BA	0.078	0.076	0.079	0.082	0.087	0.089	0.090	0.090	0.089	0.083	0.080	0.076
SF	Napa	BA	0.078	0.076	0.078	0.082	0.086	0.089	0.091	0.091	0.089	0.084	0.080	0.076
SF	San Francisco	BA	0.078	0.075	0.078	0.083	0.087	0.090	0.090	0.090	0.089	0.084	0.080	0.077
SF	San Mateo	BA	0.079	0.076	0.078	0.083	0.086	0.089	0.089	0.090	0.089	0.084	0.080	0.077

Air Basin	County	Air District	Monthly Rainfall Fraction											
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SF	Santa Clara	BA	0.078	0.076	0.078	0.082	0.087	0.089	0.091	0.091	0.089	0.084	0.080	0.076
SF	Solano	BA	0.078	0.076	0.078	0.083	0.086	0.089	0.091	0.091	0.089	0.083	0.080	0.076
SF	Sonoma	BA	0.079	0.077	0.078	0.082	0.087	0.089	0.090	0.090	0.088	0.083	0.080	0.076
SJV	Fresno	SJU	0.079	0.076	0.080	0.083	0.083	0.088	0.088	0.089	0.088	0.084	0.082	0.078
SJV	Kern	SJU	0.077	0.074	0.080	0.083	0.086	0.090	0.090	0.090	0.089	0.084	0.081	0.077
SJV	Kings	SJU	0.077	0.073	0.080	0.083	0.087	0.090	0.090	0.091	0.090	0.085	0.081	0.075
SJV	Madera	SJU	0.079	0.076	0.080	0.083	0.082	0.088	0.089	0.090	0.088	0.084	0.082	0.079
SJV	Merced	SJU	0.076	0.075	0.079	0.082	0.087	0.090	0.091	0.091	0.090	0.084	0.081	0.076
SJV	San Joaquin	SJU	0.077	0.075	0.079	0.082	0.086	0.089	0.091	0.091	0.090	0.084	0.080	0.076
SJV	Stanislaus	SJU	0.077	0.075	0.079	0.082	0.086	0.089	0.091	0.091	0.090	0.084	0.080	0.076
SJV	Tulare	SJU	0.079	0.076	0.081	0.083	0.084	0.089	0.087	0.088	0.087	0.084	0.083	0.079
SS	Imperial	IMP	0.080	0.083	0.087	0.086	0.090	0.090	0.080	0.077	0.080	0.086	0.083	0.078
SS	Riverside	SC	0.080	0.079	0.085	0.085	0.088	0.091	0.083	0.081	0.084	0.086	0.083	0.076
SV	Butte	BUT	0.080	0.078	0.078	0.082	0.084	0.088	0.091	0.090	0.088	0.084	0.080	0.078
SV	Colusa	COL	0.078	0.078	0.078	0.083	0.085	0.088	0.091	0.091	0.088	0.083	0.080	0.077
SV	Glenn	GLE	0.079	0.078	0.078	0.083	0.084	0.087	0.090	0.090	0.088	0.084	0.080	0.077
SV	Placer	PLA	0.079	0.076	0.078	0.083	0.085	0.089	0.091	0.091	0.089	0.084	0.080	0.076
SV	Sacramento	SAC	0.078	0.076	0.079	0.082	0.085	0.089	0.091	0.091	0.089	0.084	0.080	0.076
SV	Shasta	SHA	0.081	0.079	0.079	0.081	0.083	0.086	0.089	0.090	0.088	0.084	0.081	0.079
SV	Solano	YS	0.078	0.076	0.078	0.083	0.086	0.089	0.091	0.091	0.089	0.084	0.081	0.076
SV	Sutter	FR	0.077	0.077	0.079	0.083	0.085	0.089	0.091	0.091	0.089	0.083	0.080	0.076
SV	Tehama	TEH	0.080	0.078	0.078	0.082	0.084	0.087	0.090	0.090	0.088	0.083	0.081	0.078
SV	Yolo	YS	0.078	0.077	0.078	0.083	0.085	0.089	0.091	0.091	0.089	0.084	0.081	0.076
SV	Yuba	FR	0.079	0.077	0.078	0.082	0.084	0.088	0.091	0.090	0.088	0.084	0.080	0.077

Growth Forecasting

In the 1997 methodology, freeways and major roads were grown based on increases in roadway centerline mileage, and local and collector roads were grown based on increases in VMT.[18] For the 2018 update, based on discussions with U.S. EPA Region IX staff, growth for all four roadway categories was assumed to be proportional to changes in VMT. The current 2021 update uses the same VMT methodology as the 2018 update to estimate growth on roadway categories.[2]

As with previous versions of this methodology, the current 2021 update presents uncontrolled paved road dust emissions.

Assumptions and Limitations

1. The current U.S. EPA AP-42 emission factor equation assumes that entrained paved road dust emissions are proportional to VMT, roadway silt loading, and average vehicle weight.
2. The methodology assumes that roadway silt loading varies by road type, quickly reaches an equilibrium condition, and is adequately characterized by a roadway-specific silt loading factor. Thus, the emission factor varies by the type of road.
3. The Major, Collector and Local roadway silt loadings are based on a total of 42 silt loading measurements collected from 1995 to 1997 in the South Coast Air Basin, Coachella Valley, Bakersfield and Sacramento. This does not fully represent the variability in California silt loading.
4. It is assumed that the U.S. EPA PM_{10} particle size multiplier (i.e., the 'k' factor in the AP-42 equation) reasonably represents the size distribution of California paved road dust.
5. CARB's speciation profile for entrained paved road dust is based on six measurements collected in the San Joaquin Valley and in Imperial and Mono counties and may not fully reflect the variability of particle size distributions throughout California.
6. The average vehicle fleet weight is assumed to be 2.4 tons statewide.
7. Caltrans HPMS VMT data by county for 2017 are assumed to accurately represent actual California roadway travel and thus the travel fractions for each roadway type.
8. It is assumed that the average number of days per year of precipitation $\geq$0.01 inch, based on precipitation data for 2007-2017 time period, remains constant for each county within an air basin for all future years.
9. It is assumed that the temporal profile, based on county and air basin specific monthly days of rainfall, provides appropriate adjustments to allocate paved road dust emissions on a monthly basis.
10. This methodology informs CARB's CEIDARS database, and is the basis of the process and emission transaction files. It assumes that on-road motor vehicles see peak activity at 7 AM and 4 PM, with uniform activity on weekdays and reduced activity on weekends, 52 weeks a year.

Sample Calculations

The steps below summarize the data computations necessary to estimate the annual tons of paved road dust PM_{10} emissions in Santa Cruz County. Sample emissions calculation values are provided below in Table 9.

Step 1: Travel Fractions. From Table 2, enter the road-specific travel fractions.

Step 2: VMT. From Table 2, enter total 2017 VMT. Calculate VMT for each road category by multiplying total VMT by the associated travel fraction.

Total VMT x Travel Fraction=Road Category VMT

Step 3: Emission Factor. From Table 4, enter the emission factor for each road type. Emission factors (E, lbs $PM_{10}/10^6$ VMT/year) were calculated using the U.S. EPA AP-42 PM_{10} emission factor equation shown below, with k=0.0022 lb PM_{10}/VMT, roadway silt loadings (sL) and default average vehicle weight (W) of 2.4 tons from Table 4, 70 days of annual rainfall (P) from Table 5, and 365 days/year (N).

$E=[k(sL)^{0.91} \times (W)^{1.02}] \times (1-P/4N)$

Step 4: Multiply each emission factor from Step 3 by the VMT data from Step 2 to compute annual pounds of PM_{10} emissions for each road type; divide by 2,000 to calculate the annual tons of PM_{10}/year from paved road dust for each roadway type. Sum roadway emissions for total paved road dust emissions.

(E x VMT)/2000=tons/year PM_{10} Road Emissions

Step 5: Calculate $PM_{2.5}$ emissions using particle size fractions for CARB's speciation profile #471, shown in Table 6:

Tons/year $PM_{2.5}$=Tons/year PM_{10} x Fraction(<PM2.5/<PM10)

=Tons/year PM_{10} x (0.0686/0.4572)

Step 6: Calculate Total PM emissions using particle size fractions from CARB's speciation profile #471, shown in Table 6:

Tons/year Total PM=Tons/year PM_{10} / 0.4572

Table 9. Estimating Paved Road Dust Emissions in Santa Cruz County[15]

Steps	Values	Source	CARB Roadway Category				
			Freeway	Major	Collector	Local	Totals
1	Travel Fractions	Table 2	0.43	0.33	0.14	0.10	1
2	2017 VMT (*million/yr)*	Table 2	891.35	671.25	288.60	199.69	2,051
3	Emission Factor PM_{10} *(lbs PM_{10}/million VMT)*	Table 4	112.00	223.1	223.1	1,813.7	
4	PM_{10} Emissions, *tons/yr*	Table 7.2	49.90	74.89	32.20	181.09	338.08
5	$PM_{2.5}$ Emissions, *tons/yr*	Table 7.3	7.49	11.23	4.83	27.16	50.71
6	PM Emissions, tons/yr	Table 7.1	109.15	163.80	70.42	396.09	739.46

Changes in the Methodology

There were several revisions in the paved road dust emission estimates for this update. These include:

1. Updated VMT data based on EMFAC2017 and the latest available activity data from the transportation planning agencies (annualized VMT per average weekday) for the year 2017.[6]
2. Updated fractions of vehicle miles traveled on Freeway, Major, Collector, and Local roads (travel fractions) to reflect 2017 Caltrans HPMS data.[7,8]
3. Updated average number of days per year that each county within an air basin received 0.01 inch or more of precipitation during 2007-2017 using gridMET precipitation data.[9]
4. Updated entrained road dust emissions for PM_{10} and $PM_{2.5}$, by COABDIS. The 2021 revision also presents Total PM emissions, by COABDIS.

The above changes increased statewide PM_{10} emissions for entrained paved road dust by about 14.54% from the previously published inventory estimates.[2]

Comments and Recommendations

Research is ongoing to better understand and quantify paved road dust emissions, with recent studies employing mobile monitoring technologies.[20,21] When available, the studies will be evaluated and incorporated as appropriate into this methodology. Effort is also

[15] Table 4 emission factors and Table 1 travel fractions are rounded from raw data; calculated emissions in Table 9 will differ slightly from emissions shown in Table 7.

needed to better account for the variability in dust emissions based on population density, adjacent land uses, and geographic location.

Silt Loading. This methodology assumes that silt loading values vary by roadway type. Additional research is needed to fully characterize the relationship between roadway type and silt loading values. Also, additional county-specific silt loading measurements are needed to more accurately reflect the variability of silt loading throughout California.

Fleet Vehicle Weight. Based on a 1995 informal traffic count conducted by MRI, the average fleet vehicle weight is assumed to be 2.4 tons.[2,5] This value should be re-evaluated to ensure accurate average vehicle fleet weights are used to estimate dust emissions. Since the vehicle distribution among regions may vary, the evaluation should consider developing county-specific average weights.

Calculating Paved Road $PM_{2.5}$. The Final Section of the U. S. EPA's January 2011

AP-42 for paved roads assigns a particle size fraction of 25% to $PM_{2.5}$ ($PM_{2.5}$=PM_{10} x 25%).[1] This fraction is based on test conditions that include heavy vehicles traveling at very slow speeds (less than 5 mph) at corn processing facilities in the Midwest, and are not representative of typical travel on public and industrial paved roads in California. The January 2011 $PM_{2.5}$ fraction is 60% greater than the $PM_{2.5}$ particle size fraction of 15% used in the previous update of AP-42.

For this update, paved road $PM_{2.5}$ is calculated using CARB speciation profile #471, which was derived from testing conducted in the San Joaquin Valley and in Imperial and Mono counties.[12,13,14] CARB updated their $PM_{2.5}$ fugitive dust profiles in 2006, after a review of recent Western Regional Air Partnership (WRAP) studies and CARB's emission inventory vs. ambient air quality measurement data indicated that $PM_{2.5}$ from these sources was overestimated in California.[15,16,17,22] The paved road $PM_{2.5}/PM_{10}$ fraction was updated from 16.9% to 15% to more accurately reflect measured $PM_{2.5}$ emissions.[15]

Temporal Profiles. The previous update applied a single temporal profile statewide.[2] In 2001, under the sponsorship of the Central California Ozone Study (CCOS), researchers developed temporal profiles for a number of area and off-road emission sources, including paved roads.[23,24] On a statewide basis, the temporal profile proposed by the CCOS study allocated an average of up to 75% of annual emissions to the summer months. However, full documentation was not provided for their derivation and CARB could not re-create the results. Based on newer research that shows minimal seasonal variation for paved road dust emissions, CARB developed relatively flat monthly allocations of annual paved road dust emissions for this update.[25,26,27] The new temporal profiles (Table 8) are calculated using county-specific records, within air basin, for monthly days of rain (Table 5).[9]

Additional Codes

SOURCE CATEGORY GROWTH AND CONTROL CODES:
Various

SOURCE CATEGORY CODE POLLUTANT SPECIATION PROFILES:
For All: PM_{10}=471, VOC=not applicable

SOURCE CATEGORY CODE REACTIVITY FACTORS
Not Applicable

Prepared By

Janet Spencer
April 2014

Revised By

Janet Spencer
November 2016

Updated statewide emissions to reflect 2012 VMT from EMFAC 2014 and transportation planning agencies. Minor editorial changes.

Tiffanie Be
March 2018

Updated Table 7. Minor editorial changes.

Alejandra Cervantes & Victoria Villa
Air Pollution Specialists
Area Source Improvement and Community Inventory Development Section
Air Quality Planning and Science Division
March 2021

Updated statewide emissions to reflect 2017 VMT from EMFAC2017 and the latest available activity data from transportation planning agencies. Updated fractions of vehicle miles traveled on Freeway, Major, Collector, and Local roads (travel fractions) to reflect 2017 Caltrans HPMS data. Updated annual average days of rain per month for counties receiving more than 0.01 in of rainfall based on rainfall data for 2007-2017 from gridMET. Minor editorial and structural changes.

References

1. U.S. Environmental Protection Agency. Compilation of Air Pollutant Emissions Factors, AP-42, Section 13.2.1, Paved Roads. January 2011. *http://www.epa.gov/ttn/chief/ap42/ch13/index.html*
2. Spencer, J.. Entrained Dust from Paved Road Travel, Emission Estimation Methodology Background Document. California Air Resources Board. March 2018. *https://ww3.arb.ca.gov/ei/areasrc/fullpdf/full7-9_2018.pdf*
3. Ashbaugh, L., Flocchini, R., et al. Final Report, Traffic Generated PM_{10} "Hot Spots". Prepared for Caltrans by the Air Quality Group, Crocker Nuclear Laboratory, University of California, Davis, Contract Number 53V606 A2, August, 1996. *http://aqp.engr.ucdavis.edu/Documents/1996-Ashbaugh-UCDCaltrans.pdf*
4. Ashbaugh, L., Flocchini, R., et al. Final Report, Wintertime Traffic Generated PM_{10} "Hot Spots". Prepared for Caltrans by the Air Quality Group, Crocker Nuclear Laboratory, University of California, Davis, Contract Number 43X878, September 3, 1998. *http://aqp.engr.ucdavis.edu/Documents/pm10_hotspot_Sunrise.pdf*
5. Muleski, G. Improvement of Specific Emission Factors (BACM Project No. 1), Final Report. Midwest Research Institute, March 29, 1996.
6. EMFAC2017, Version 1.0.2. 2017 Default Statewide Vehicle Miles Traveled (VMT) by County/Air Basin, per Average Weekday.
7. California Department of Transportation. Highway Performance Monitoring System (HPMS) Vehicle Miles Traveled (VMT) per Day by County and Roadway Functional Classification for 2017. Excel file provided by Jin Miao, January 9th, 2020.
8. U.S. Department of Transportation, Federal Highway Administration, FHWA Functional Classification Guidelines. 2013 Edition. https://www.fhwa.dot.gov/planning/processes/statewide/related/highway_functional_classifications/
9. Abatzoglou, J. T. (2013), Development of gridded surface meteorological data for ecological applications and modelling. Int. J. Climatol., 33: 121–131. Precipitation data for 2007-2017 was obtained from *http://www.climatologylab.org/gridmet.html*
10. California Air Resources Board, EMFAC2017 Web Database. *https://www.arb.ca.gov/emfac/2017/*
11. Gaffney, P. Emission Estimation Methodology Section 7.8, Road Construction Dust, California Air Resources Board. August 1997. *http://www.arb.ca.gov/ei/areasrc/fullpdf/full7-8.pdf*
12. California Air Resources Board, Speciation Profiles Used in CARB Modeling. *https://ww3.arb.ca.gov/ei/speciate/speciate.htm*
13. Houck, J.E., Chow, J.C., Watson, J.G., et al. Determination of Particle Size Distribution and Chemical Composition of Particulate Matter from Selected Sources in California, Final Report. Desert Research Institute & OMNI Environmental. Prepared for California Air Resources Board. Agreement No. A6-175-32. June 30, 1989. ©

14. Chow, J.C., Watson, J.G., Ashbaugh, L.L., Magliano, K.L. 2003. Similarities and differences in PM_{10} chemical source profiles for geological dust from the San Joaquin Valley, California. Atmospheric Environment 37:1317-1340. 2003. *http://www.arb.ca.gov/ei/speciate/r01t20/rf13doc/Ref%2013%20-%20Chowetal2003AESJVFugDustProfiles.pdf*
15. Gaffney, P. Updating the CCARB PM2.5 Size Speciation Profiles for Fugitive Dust Sources. California Air Resources Board. August 2006. *https://ww3.arb.ca.gov/ei/areasrc/fullpdf/2006pm2.5profiles.pdf*
16. Countess Environmental. Western Regional Air Partnership's (WRAP) Fugitive Dust Handbook, prepared for the Western Governors' Association, WGA Contract No. 30204-111. September 7, 2006. *http://www.wrapair.org/forums/dejf/fdh/index.html*
17. Cowherd, C. Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors. Prepared by Midwest Research Institute for Western Governors' Association, Western Regional Air Partnership. MRI Project No. 110397. Finalized Nov. 1, 2006 *http://www.epa.gov/ttnchie1/ap42/ch13/bgdocs/b13s02.pdf*
18. Gaffney, P. Emission Estimation Methodology Section 7.9, Entrained Paved Road Dust. California Air Resources Board. July 1997. *http://www.arb.ca.gov/ei/areasrc/arbmiscprocpaverddst.htm*
19. California Air Resources Board, California Emissions and Air Quality, 2013 Edition. *https://www.arb.ca.gov/aqd/almanac/almanac.htm*
20. Cowherd, C., Technical Support Document for Mobile Monitoring Technologies. Midwest Research Institute. Prepared for Rodney Langston and Russell S. Merle, Jr., Clark County Department of Air Quality and Environmental Management, Las Vegas, NV. Jan. 2009. *http://www.epa.gov/ttnchie1/ap42/ch13/related/Mobile_Monitoring_TSD_010909.pdf*
21. Langston, R., Merle, R. S., Jr. Clark County (Nevada) Paved Road Dust Emission Studies in Support of Mobile Monitoring Technologies. Clark County Department of Air Quality and Environmental Management (DAQEM). December 22, 2008. *http://www.epa.gov/ttnchie1/ap42/ch13/related/Final_Test_Report.pdf*
22. Cowherd, C., Donaldson, J. Analysis of the Fine Fraction of Particulate Matter in Fugitive Dust, Final Report. October 12, 2005. Prepared by Midwest Research Institute for the Western Governors' Association, Western Regional Air Partnership. MRI Project No. 110397. *http://www.wrapair.org/forums/dejf/documents/fffd/Final_Fine_Fraction_Dust_Report.pdf*
23. California Air Resources Board. Central California Air Quality Studies. *http://www.arb.ca.gov/airways/*
24. Sonoma Technology, Inc. Revised Temporal Allocation Factors for Area and Off-Road Emissions Sources. Technical Memorandum of Sept. 26, 2001, STI Ref. No. 900201. *http://www.arb.ca.gov/ei/areasrc/temporalprofile010926.pdf*

25. Mid-Atlantic Regional Air Management Association, Inc. (MARAMA). Paved Road Area Source Category Calculation Methodology Sheet. December 20, 2004. *http://www.marama.org/visibility/Calculation_Sheets/index.htm*
26. Kuhns, H., Etyemezian, V., Green, M., et al. Vehicle-based road dust emission measurement-Part II: Effect of precipitation, wintertime road sanding, and street sweepers on inferred PM_{10} emission potentials from paved and unpaved roads. *Atmospheric Environment* Vol. 37, Issue 32 (2003) 4573-4582. *http://www.sciencedirect.com/science/article/pii/S1352231003005296*
27. ENVIRON International Corp. WRAP Mobile Source Emission Inventories Update, Final Report. Prepared for the Western Governors' Association. May 2006. *https://www.wrapair.org/forums/ef/umsi/0606_WRAP_Mobile_Source_EI_Final_Report.pdf*
28. California Air Resources Board, CRPAQS PM10 Samples from 1997. *https://ww3.arb.ca.gov/ei/speciate/r01t20/rf13doc/refnum13.htm?_ga=2.165106872.661865671.1597077884-1697201361.1589242323*

Appendices

Appendix A. Table 1. 1995-1997 Silt Loading Values HIGH Average Daily Traffic (ADT) Roads (> 5,000 vehicle passes/day)

Location	Date	Silt Loading (g/m^2)	Sampling Location	Researcher[16]
South Coast	Apr-95	0.012	Composite of 4 roads of same class	MRI
South Coast	Jun-95	0.015	Repeat sample of above roads	MRI
South Coast	Jun-95	0.011	Composite of 4 roads of same class	MRI
South Coast	Jun-95	0.046	Composite of 4 roads of same class	MRI
Bakersfield	Apr-95	0.054	Composite of 4 roads of same class	MRI
Bakersfield	Jul-95	0.015	Repeat sample of above roads	MRI
Bakersfield	Jul-95	0.051	Composite of 4 roads of same class	MRI
Bakersfield	Jul-95	0.039	Composite of 4 roads of same class	MRI
Coachella Valley	Apr-95	0.027	Composite of 4 roads of same class	MRI
Coachella Valley	Jul-95	0.037	Repeat sample of above roads	MRI
Coachella Valley	Jul-95	0.082	Composite of 4 roads of same class	MRI
Coachella Valley	Jul-95	0.03	Composite of 4 roads of same class	MRI
Sacramento	1997	0.0332	Sunrise Crosswalk North	UCD
Sacramento	1997	0.0261	Sunrise Crosswalk south	UCD
Sacramento	1997	0.0184	Greenback Crosswalk West	UCD
Sacramento	1997	0.0136	Greenback Crosswalk East	UCD
Sacramento	8/23/1995	0.0543	Florin Rd East	UCD
Sacramento	8/23/1995	0.0034	Florin Road West	UCD
Sacramento	8/23/1995	0.0016	Stockton Blvd South	UCD
Sacramento	8/23/1995	0.002	Stockton Blvd North	UCD
Riverside	3/18/1997	0.065	Canyon Crest Drive	UCR
Riverside	6/5/1997	0.085	Canyon Crest Drive	UCR
Riverside	6/19/1996	0.00593	Main Street	UCR
Riverside	9/3/1996	0.00593	Main Street	UCR
Riverside	3/17/1997	0.2	Riverside Street	UCR
Riverside	5/29/1997	0.17	Riverside Street	UCR
Riverside	3/19/1997	0.19	Riverside Street	UCR

[16] Researcher:
MRI=Midwest Research Institute
http://www.arb.ca.gov/ei/areasrc/arbmiscprocpaverddstbkgrnd.pdf
UCR=Univ. of California, Riverside (*http://aqp.engr.ucdavis.edu/Documents/DraftRoadDustreport.pdf*
UCD=Univ. of California, Davis (*http://aqp.engr.ucdavis.edu/Documents/pm10_hotspot_Sunrise.pdf*

Location	Date	Silt Loading (g/m^2)	Sampling Location	Researcher[16]
Riverside	6/4/1997	0.085	Riverside Street	UCR
Riverside	5/27/1997	0.38	Fogg Street	UCR
Riverside	3/26/1997	0.13	Fogg Street	UCR
Riverside	6/3/1997	0.14	Fogg Street	UCR
Geometric mean of high ADT roads=0.032 g/m^2, used as California statewide default silt loading for Major and Collector roads. See Tables 3 for information on deriving statewide, district and county specific silt loading values.				

Appendix A. Table 1. 1995-1997 Silt Loading Values LOW ADT Roads (< 5,000 vehicle passes/day)

Location	Date	Silt Loading (g/m^2)	Sampling Location	Researcher
South Coast	Apr-95	0.18	Composite of 4 roads of same class	MRI
South Coast	Jun-95	0.05	Repeat sample of above roads	MRI
South Coast	Jun-95	0.17	Composite of 4 roads of same class	MRI
South Coast	Jun-95	0.14	Composite of 4 roads of same class	MRI
Bakersfield	Apr-95	0.52	Composite of 4 roads of same class	MRI
Bakersfield	Jul-95	0.19	Repeat sample of above roads	MRI
Bakersfield	Jul-95	0.94	Composite of 4 roads of same class	MRI
Bakersfield	Jul-95	0.41	Composite of 4 roads of same class	MRI
Coachella Valley	Jul-95	0.42	Repeat sample of above roads	MRI
Coachella Valley	Jul-95	0.35	Composite of 4 roads of same class	MRI
Coachella Valley	Jul-95	0.2	Composite of 4 roads of same class	MRI
Mean of low ADT roads=0.32 g/m^2, used as California statewide default slit loading for Local roads. See Tables 3 for information on deriving statewide, district and county specific silt loading values				