

Chapter 14. Miscellaneous Minor Fugitive Dust Sources

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14.1 Introduction

This Chapter identifies emission estimation methods for several minor fugitive dust source categories not addressed in other chapters of the handbook. Because several of these methods have not been approved by federal or state agencies, the reader is cautioned in the use of the emission factors included in these emission estimation methods. The emission estimation methods discussed here address:

- windblown dust from unpaved roads
- uncovered haul trucks,
- unpaved shoulders,
- leaf blowers, and
- explosives detonation.

14.2 Windblown Dust from Unpaved Roads

The California Air Resources Board adopted the U.S. EPA-modified version of the USDA-ARS derived wind erosion equation (WEQ) used to estimate windblown dust from agricultural fields¹ to estimate windblown dust from unpaved roads² as follows:

$$E_S = a I K C L' V' \quad (1)$$

where, E_S = the quantity of unpaved road dust entrained to the air by wind erosion (tons TSP/acre/year)

a = portion of total roadway wind erosion losses that are assumed to be suspended into the air; estimated to be 0.038 for TSP

I = soil erodibility (tons/acre/year)

K = surface roughness factor (dimensionless)

C = climatic factor (dimensionless)

L' = unsheltered width factor (dimensionless)

V' = vegetative cover factor (dimensionless)

In summary, the 'I' term in the windblown dust equation provides an estimate of the soil erosion from an area that is large, flat, bare, and highly erodible. The additional terms in the equation reduce emissions from this worst-case scenario. The climatic, C, factor helps to account for regional differences in wind and rainfall. If a surface is rough, as represented by K, soil erosion is decreased. If the length of the erodible area parallel to the wind is short, then the erosion is decreased, as represented by the L' factor. If there is crop residue on the erodible area, then erosion is further decreased by the V' factor. A detailed discussion of the parameters I, K, C, L', and V' is presented in Chapter 7 of the Handbook.

Soil Erodibility – I. The soil erodibility, I, of an unpaved road is related to the soil type of the road surface. Because roadway soil types are not readily available, the county specific, average soil types are used to estimate the erodibility. The county soil types are computed using a geographic information system (GIS) to average detailed county soil profile maps provided by

the Natural Resources Conservation Service. This approach assumes that unpaved road surfaces have the same soil characteristics as the base soils in the vicinity of the roadway.

Climatic Factor - C. The rate of soil erosion varies directly with the wind velocity and inversely with the soil surface moisture. The climatic factor is used to adjust for these parameters. CARB staff computed the county ‘C’ factors based on regional rainfall and wind speed data measured in California.

Surface Roughness - K. Surface roughness can help to reduce soil erosion. The ‘K’ factor is used to account for ridges or furrows that help to minimize wind related erosion. Because most unpaved roads are flat, the surface roughness factor is assumed to be 1.0, indicating no reduction in emissions due to surface texture.

Unsheltered Width Factor - L’. Soil erosion is directly related to the unprotected width of the area in the prevailing wind direction. For unpaved roads, depending on the wind direction, the width of the erosive area parallel to the wind direction could be very narrow, very long, or somewhere in between. CARB assumes that the wind direction is equally distributed for all roads and that the average value of L’ is 0.32.

Vegetative Cover Factor - V’. Vegetative cover reduces soil erosion. For unpaved roads, it is assumed that there is no vegetative cover, therefore a value of 1.0 is used.

Based on analysis of resuspended California soil samples, CARB estimated that the PM10/TSP ratio for windblown dust from unpaved roads is 0.5. Windblown dust emissions from unpaved roads are calculated for each county by multiplying the PM10 emission rate (i.e., 50% of the TSP emission rate calculated from the TSP emission factor equation, Equation 1) by the unpaved road mileage and the average width of the unpaved roads assumed to average 20 feet. CARB’s estimates does not include windblown dust from agricultural unpaved roads since they assume that windblown emissions from agricultural unpaved roads are included in the source category for windblown dust from agricultural lands.

The CARB methodology is subject to the following assumptions and limitations:

1. It is assumed that the unpaved road soil characteristics are approximately the same as the soils in the vicinity of the unpaved road that are not used for vehicular travel. This implies that no additional gravel or other treatments have been applied to the unpaved roads.
2. It is assumed that the soil wind erosion equation may be reasonably applied to estimate windblown dust from unpaved roads. Because of the large differences between unpaved road surfaces and agricultural lands, the validity of this assumption is questionable.
3. Using the soil erosion equation, it is assumed that 3.8% of the total eroded material is entrained to the air. (‘a’ factor = 0.038).
4. It is assumed that the county average soil erodibility, ‘I’, and climatic, ‘C’, factors are representative (on average) of the overall county conditions.

5. It is assumed that a value of 0.32 for the unsheltered width factor, L', is valid.
6. It is assumed that unpaved roads have no vegetative cover and are essentially flat.
7. The typical unpaved road width is 20 feet.
8. This methodology assumes no extraordinary windstorm activity; only average annual conditions are estimated.

CARB is aware that their methodology for estimating windblown dust from unpaved roads is built on a foundation of dubious assumptions. Because of the differences between unpaved roads and agricultural lands, it is unlikely that the agricultural soil erosion equation provides very accurate estimates of windblown road dust. The emissions estimates could be improved by performing wind tunnel tests on unpaved roads, and then extrapolating the resulting emission factors to the remainder of the State. With the use of geographic information systems, it is also possible to incorporate localized climatological and soil texture properties into the emission estimates. In addition, the mileage of unpaved roads could be improved using available digital maps which include public, as well as private unpaved roads.

14.3 Uncovered Haul Trucks

A total suspended particulate (TSP) emission factors for uncovered haul trucks was included in a USEPA report published in 1989.³ The hourly TSP emission estimate for uncovered haul trucks was estimated from the following equation:

$$\text{TSP (lb/yd}^2\text{/hour)} = 0.00015 u$$

where, u = sum of wind speed and vehicle speed (mph)

To estimate PM10 and PM2.5 emissions, PM10/TSP and PM2.5/TSP ratios will need to be obtained for this source category.

14.4 Unpaved Shoulders

DRI developed a PM10 emission factor for the resuspension of fugitive dust from unpaved shoulders created by the wake of high-profile vehicles such as tractor-trailers (semis) traveling on paved roads at high speed (50-65 mph).⁴ The emission factor for unpaved shoulder with surface loadings of 4,500 to 5,500 g/m², silt content of 3 to 6%, and a surface moisture content under 1% was given as:

$$\text{EF} = 0.028 \pm 0.014 \text{ lb/VMT}$$

DRI concluded that emissions from unpaved shoulders due to smaller vehicles such as cars, vans and SUVs were negligible. It should be pointed out that the PM10 emissions were

estimated utilizing nephelometers that are not quantitative for coarse particles. Thus, PM10 emissions may be underestimated.

14.5 Leaf Blowers

Dennis Fitz and other researchers from CE-CERT at UC Riverside recently completed a study on behalf of the San Joaquin Valley APCD to determine PM2.5 and PM10 emissions from leaf blowing/vacuuming, raking and sweeping activities.⁵ Real-time PM2.5 and PM10 measurements were obtained with DustTrak aerosol monitors calibrated against Arizona road dust (NIST SRM 8632). The precision of the DustTrak PM2.5 and PM10 measurements were determined to be 19% and 27%, respectively, based on collocated DustTrak monitors. The accuracy of the DustTrak measurements was determined by comparing the DustTrak measurements to the filter-based measurements. In general the two data sets agreed to within 50%, which was similar to the variability between replicate tests. The PM2.5 and PM10 emission factors determined by DustTrak monitors for different cleaning activities and surfaces are summarized in Table 14-1. The DustTrak results for blowing leaves on asphalt and concrete surfaces as a function of power blower type are presented in Table 14-2.

Table 14-1. PM Emission Factors for Leaf Blowing/Vacuuming, Raking and Sweeping Activities (mg/m²)

Cleaning Action and Surface Cleaned	PM2.5	PM10
Power blowing/vacuuming over concrete surfaces	30	80
Power blowing/vacuuming over asphalt surfaces	20	60
Push broom to sweep asphalt surfaces	0	20
Push broom to sweep concrete surfaces	20	80
Raking asphalt surfaces	0	0
Raking on concrete surfaces	0	0
Raking lawns	0	1
Power blowing on lawns	1	2
Power blowing from gutters	9	30
Power blowing on packed dirt	80	120
Power blowing cut grass on walkways	2	6

Table 14-2. PM Emission Factors by Power Blower Type and Surface (mg/m²)

Power Blower Type	Surface	PM2.5	PM10
Electric	Asphalt	20	60
Gas Hand Held	Asphalt	10	40
Gas Backpack	Asphalt	20	60
Electric: vacuum mode	Asphalt	40	120
Electric: vacuum mode, full bag	Asphalt	20	70
Electric	Concrete	40	130
Gas Hand Held	Concrete	10	40
Gas Backpack	Concrete	30	70
Electric: vacuum mode	Concrete	30	80

14.6 Explosives Detonation

Emissions from the detonation of industrial explosives and firing of small arms (excluding military operations) are addressed in Section 13.3 of AP-42.⁶ This section of AP-42 was last updated in February 1980 (and reformatted in January 1995). Such large quantities of particulate are generated in the shattering of rock and earth by the explosive that the quantity of particulates from the explosive charge cannot be distinguished. With the exception of a few studies in underground mines, most studies have been performed in laboratory test chambers that differ substantially from the actual environment. Any estimates of emissions from explosives use must be regarded as approximations that cannot be made more precise because explosives are not used in a precise, reproducible manner.

14.7 References

1. USEPA, 1974. *Development of Emission Factors for Fugitive Dust Sources*, EPA 450/3-74-037, U.S. EPA, Research Triangle Park, NC, June; updated in September 1988 in *Control of Open Fugitive Dust Sources*, EPA-450/3-88-008.
2. CARB, 1997. *Windblown Dust – Unpaved Roads*, Section 7.13 in: CARB's Emission Inventory Procedural Manual, Volume III: Methods for Assessing Area Source Emissions.
3. USEPA, January 1989. *Air/Superfund National Technical Guidance Study Series; Volume III – Estimation of Air Emissions from Cleanup Activities at Superfund Sites*, Interim final report EPA-450/1-89-003.
4. Moosmuller, H., Gillies, J.A., Rogers, C.F., Dubois, D.W., Chow, J.C., Watson, J.G., Langston, R., 1998. *Particulate Emission Rates for Unpaved Shoulders along a Paved Road*, JAWMA 48:398.
5. Fitz, D., et al., 2006. *Determination of Particulate Emission Rates from Leaf Blowers*, paper presented at the USEPA 15th International Emission Inventory Conference, New Orleans, LA, May 24.
6. USEPA, 2006. *Compilation of Air Pollutant Emission Factors*, AP-42 Section 13.3 (Explosives Detonation), Fifth Edition.