Mojave Desert Air Quality Management District
Antelope Valley Air Pollution Control District

Emissions Inventory Guidance

Mineral Handling and Processing Industries

I. Reason for Guidance

The mineral handling and processing industry is the Mojave Desert Air Quality Management District's (District) dominant industry in terms of emissions, number of permit units, and revenue. The mineral industry performs a number of characteristic operations associated with extracting minerals from the Earth's crust and processing them. Aside from equipment and material differences, these operations and processes are essentially the same from facility to facility. Accordingly, the District has prepared this document to ensure that these common operations and processes have their emissions estimated consistently throughout the region.

Why is the District concerned with consistency? Two reasons: accuracy and fairness. The District emissions inventory as a whole will be more accurate if every process of a given type has its emissions estimated using the same methodology (as opposed to a myriad methods of unknown or questioned accuracy). Actions taken by the District that depend on the emissions inventory (such as attainment plans and the rules that implement them) will be fairly applied if all processes are represented in the emissions inventory to the same extent.

This attempt to impose regularity and claim to improve accuracy should not be construed as a criticism of existing inventories or methodologies. On the contrary, District staff greatly appreciates the efforts of the many individuals who have created the existing methodologies and used them to estimate emissions. Nor does District staff claim to have the most accurate inventory; rather, District staff are attempting to establish a minimum level of known accuracy. Methods more accurate than those presented herein will be accepted.

II. Background

Federal and State law requires air districts to prepare and maintain as accurate and current an emissions inventory as possible. This inventory must include criteria (oxides of nitrogen, volatile organic compounds, carbon monoxide, oxides of sulfur, particulate matter, and lead), hazardous, and toxic air pollutants. The emissions inventory is used to determine attainment strategies, progress towards clean air goals, and air quality relative to other districts.

III. Approach of this Guidance

This guidance will present methodologies for a large number of emissions-generating operations and processes. The methodologies will be provided with several levels of increasing complexity and accuracy; each level of increased complexity will require greater input (and effort) from the user. In practice, this means that an equation is provided for each process, with a variety of default equation inputs specified. At the lowest level of complexity, an emission factor is specified that can simply be multiplied by a process activity rate.

The greatest level of complexity and accuracy involves the use of data from a source test (if feasible). Of course, the District would prefer all emission inventories to be based on source test results or continuous emission monitor (CEMS) data. This is not feasible due to obvious cost and time constraints. However, a properly performed and documented source test (and/or CEMS data) provides the greatest accuracy possible, and represents a method that will always be accepted in lieu of a methodology presented herein. Other methods may be accepted, if they have been documented and approved by the District.

This guidance document is accompanied by a set of electronic spreadsheets that contains each of the equations used in these methodologies. This allows the user to 'plug-in' her local values and calculates her local result.

IV. Source Test Data

For a source test to be used to generate an emission factor, it must include additional emissions- and activity-related information. The following can be considered required supplemental elements for a source test report that is submitted to support or generate a set of equipment-specific emission factors.

A. <u>Process flow diagram</u> that specifies pickup points
B. <u>Control equipment description</u> that defines operational parameters during test (such as water use or pressure drop).
C. <u>Throughput</u> during test in hourly units (or shorter term units), including a discussion of maximum design throughput, average throughput, and actual throughput during the test.
D. <u>Exhaust concentrations and mass emission rates</u>, including front half, back half, and total

emissions. The concentrations and mass rates should identify values for total hydrocarbon, reactive organic gases and volatile organic compounds. The concentrations and mass rates should also identify values for total suspended particulate, particulate 10 microns and less, and particulate 2.5 microns and less.

V. Calculation Spreadsheet Accessory

An accessory spreadsheet has been prepared for this document. The spreadsheet contains each of the equations referenced in the guidance. The equations are programmed into input and output spreadsheet cells to assist the user. The spreadsheet was prepared in Microsoft Excel, and two versions are available. The spreadsheet is titled "Mineral Guidance Equations" and is in Microsoft Excel 97 format. The version titled "Mineral Guidance Equations 95" is in Microsoft Excel 95 format.

The spreadsheet is in the format of a multiple-worksheet workbook, with a separate worksheet for each method (the worksheets have individual tabs at the lower left). Those values which can be entered by the user are defined in dark blue, and the cells in which the values can be typed have a turquoise background. Selected turquoise cells may have a value pre-entered; these values are the District default values, and can be replaced by a known local value. After all necessary turquoise cells have a value, the results of the equation are automatically calculated (the user may need to hit the 'enter' key after entering the last value). In each case the calculated values are displayed in units of pounds and tons of the applicable pollutants.

Please contact District emissions inventory staff if you encounter any problems or errors with the calculation spreadsheet accessory.

VI. Methods

Each method will be presented in the same format. The method will begin with a detailed discussion of the processes and operations for which it is an applicable emissions estimation methodology. The method itself will then be provided, beginning with the most conservative and least complex version, and followed by increasingly complex and data-intensive versions. Each method will culminate with the complete equation (where possible), for which the user has the option of providing all inputs. The District has prepared tables calculating likely values for various common inputs. Each method contains a discussion of applicable control strategies (where possible), and appropriate calculation methods for those. Each method concludes with a source reference.

A. Blast Hole Drilling

This procedure applies to the drilling of charge holes for open pit or open shelf blasting. Note that the activity input for the equation requires the total amount of material shifted, including, topsoil, overburden and ore. Blast hole drilling is often performed by portable internal combustion engine powered drills; exhaust emissions from this equipment are not accounted for by this method. Such exhaust emissions should be estimated using methods presented elsewhere.

"Shifted" is defined as loosened sufficiently to require removal or further handling.

Least Complex:

Assume negligible particulate emissions from blast hole drilling. This can only be assumed by facilities shifting less than 50,000 tons per year of ore, overburden and topsoil combined.

Intermediate Complexity:

This method employs a conservative factor times the total amount of material shifted by blasting.

$$E = E_f \times Q$$

E = Particulate matter emissions rate in pounds per year
E_f = Emission factor in units of pounds of particulate per ton shifted by blasting
Q = Amount of material of all types shifted by blasting during the year in tons

TSP E_f = 0.001 pounds/ton
PM_{10} E_f = 0.0008 pounds/ton
$PM_{2.5}$ E_f = 0.0008 pounds/ton

Blast Hole Drilling Table 1 -- Blasting Activity Based Emissions									
Activity in tons (yearly)	50000	75000	100000	125000	150000	175000	200000	225000	250000
TSP Emissions (tons)	0.03	0.04	0.05	0.06	0.08	0.09	0.10	0.11	0.13
PM10 Emissions (tons)	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10
PM2.5 Emissions (tons)	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10

Most Complex:

This method requires an estimate of the number of shot holes drilled on an annual basis.

$$E = E_f \times N$$

E = Particulate matter emissions rate in pounds per year
E_f = Emission factor in units of pounds of particulate per hole drilled
N = Number of blast holes drilled per year

$TSP\ E_f$ = 1.3 pounds/hole
$PM_{10}\ E_f$ = 0.68 pounds/hole
$PM_{2.5}\ E_f$ = 0.68 pounds/hole

Blast Hole Drilling Table 2 -- Drilling Activity Based Emissions														
Number of Holes (yearly)	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400
TSP Emissions (tons)	0.07	0.13	0.20	0.26	0.33	0.39	0.46	0.52	0.59	0.65	0.72	0.78	0.85	0.91
PM10 Emissions (tons)	0.03	0.07	0.10	0.14	0.17	0.20	0.24	0.27	0.30	0.34	0.37	0.41	0.44	0.47
PM2.5 Emissions (tons)	0.03	0.07	0.10	0.14	0.17	0.20	0.24	0.27	0.30	0.34	0.37	0.41	0.44	0.47

Control Techniques:

None are presently quantified. The methods assume a wet drilling operation. Enclosures, air return or other control strategies can be employed for an estimated control efficiency, subject to District review and approval.

Source:

The intermediate complexity method employs a low confidence emission factor presented in Chapter 15 of the Air & Waste Management Association Air Pollution Engineering Manual, 1992 edition (Stone and Quarrying Processing). The high complexity method employs a relatively highly rated emission factor derived from overburden drilling operations at western surface coal mines presented in §11.9 of USEPA's AP-42 (January 1995 reformatted version).

B. Dust Entrainment from Blasting

This procedure applies to the fracturing and loosening of topsoil, ore, overburden and substrate in open pits and open shelves through the use of explosives. Note that activity rates for this method require the total amount of material shifted through the use of blasting, including topsoil, overburden and ore. “Shifted” is defined as loosened sufficiently to require removal or further handling.

Least Complex:

This method employs a conservative factor times the total amount of material shifted by blasting.

$$E = E_f \times B$$

E = Particulate matter emissions rate in pounds per year
E_f = Emission factor in units of pounds of particulate per ton shifted by blasting
B = Amount of material of all types shifted by blasting during the year in tons

E_f (TSP) = 0.16 pounds/ton
E_f (PM_{10}) = 0.08 pounds/ton
E_f ($PM_{2.5}$) = 0.08 pounds/ton

Blasting Table 1 -- Weight Based Emissions									
Activity in tons (yearly)	50000	75000	100000	125000	150000	175000	200000	225000	250000
TSP Emissions (tons)	4	6	8	10	12	14	16	18	20
PM10 Emissions (tons)	2	3	4	5	6	7	8	9	10
PM2.5 Emissions (tons)	2	3	4	5	6	7	8	9	10

Most Complex:

This method requires information on the horizontal area shifted by blasting, and the number of such blasts performed during the year. This method cannot be used if blasting depth exceeds 70 feet.

$$E = k \times N \times 0.0005 \times A^{1.5}$$

E = Particulate matter emissions rate in pounds per year
k = Particulate matter size factor
N = Number of blasts per year
A = Horizontal area shifted by each blast in square feet

k (TSP) = 1.00
k (PM_{10}) = 0.52
k ($PM_{2.5}$) = 0.52

Blasting Table 2 -- Area Based TSP Emissions in tons per year							
	Number of Weekly Blasts						
Typical Shelf Area	1	2	3	4	5	6	7
1000	0.41	0.82	1.23	1.64	2.06	2.47	2.88
1500	0.76	1.51	2.27	3.02	3.78	4.53	5.29
2000	1.16	2.33	3.49	4.65	5.81	6.98	8.14
2500	1.63	3.25	4.88	6.50	8.12	9.75	11.38
3000	2.14	4.27	6.41	8.54	10.68	12.82	14.95
3500	2.69	5.38	8.08	10.77	13.46	16.15	18.84
4000	3.29	6.58	9.87	13.16	16.44	19.73	23.02

Blasting Table 3 -- Area Based PM10 and PM2.5 Emissions in tpy							
	Number of Weekly Blasts						
Typical Shelf Area	1	2	3	4	5	6	7
1000	0.21	0.43	0.64	0.86	1.07	1.28	1.50
1500	0.39	0.79	1.18	1.57	1.96	2.36	2.75
2000	0.60	1.21	1.81	2.42	3.02	3.63	4.23
2500	0.84	1.69	2.54	3.38	4.23	5.07	5.92
3000	1.11	2.22	3.33	4.44	5.55	6.66	7.78
3500	1.40	2.80	4.20	5.60	7.00	8.40	9.80
4000	1.71	3.42	5.13	6.84	8.55	10.26	11.97

Control Techniques:

None are presently quantified. The method does not assume any emission reducing procedures. Certain control techniques are available, such as blast blankets. Control strategies can be employed for an estimated control efficiency, subject to District review and approval.

Source:

The most complex method employs a poorly rated emission factor derived from blasting operations at western surface coal mines presented in §11.9 of USEPA's AP-42 (January 1995 reformatted version).

C. Criteria Emissions from Blasting Explosives

This procedure estimates the criteria pollutants generated by the detonation of explosives for blasting. This is a "least complex" method that multiplies an emission factor by the total amount of explosives detonated in a year.

$$E = E_f \times A$$

E = Pollutant emissions rate in pounds per year
E_f = Emission factor in units of pounds of pollutant per ton of explosive detonated
A = Amount of explosive detonated throughout the year in tons

Explosives Table 1 -- Emission Factors				
Explosive Type	Composition	CO	NOx	TOG
Black Powder	Potassium nitrate, charcoal and sulfur	170	---	4.2
Smokeless Powder	Nitrocellulose	77	---	1.1
Dynamite, straight	Nitroglycerine, sodium nitrate, wood pulp, calcium carbonate	281	---	2.5
Dynamite, ammonia	Nitroglycerine, ammonium nitrate, sodium nitrate, wood pulp	63	---	1.3
Dynamite, gelatin	Nitroglycerine	104	53	0.7
ANFO	Ammonium nitrate, fuel oil	67	17	---
TNT	Trinitrotoluene	796	---	14.3
RDX	Cyclotrimethylenetrinitroamine	196	---	---
PETN	Pentaerythritol tetranitrate	297	---	---

Note that VOC emissions are considered negligible for all explosives. TSP, PM_{10} and $PM_{2.5}$ emissions are subsumed within the dust entrainment estimations.

Source:

This method is presented in §13.3 of USEPA's AP-42 (January 1995 reformatted version).

D. Bulldozing, Scraping and Grading of Materials

This procedure applies to the bulldozing, scraping and grading of topsoil, overburden, waste material, and ore through the use of heavy equipment such as bulldozers, graders, scrapers, etc. This procedure does not apply to the lifting and dumping of said materials; such lifting and dumping emissions should be estimated using methods presented elsewhere.

Least Complex:

This method applies a conservative factor times the annual hours of operation.

$$E = E_f \times T$$

E = Particulate matter emissions rate in pounds per year
E_f = Emission factor in units of pounds of particulate per hour of operation
T = Annual activity in hours

TSP E_f = 886 pounds/hour
PM_{10} E_f = 431 pounds/hour
$PM_{2.5}$ E_f = 132 pounds/hour
(These emission factors were calculated using the defaults given in the Most Complex section)

Bulldozing Table 1 - Time Based Emissions					
Activity in hours (yearly)	1040	2080	2920	6240	8760
TSP Emissions (tons)	460.72	921.44	1293.56	2764.32	3880.68
PM10 Emissions (tons)	224.12	448.24	629.26	1344.72	1887.78
PM2.5 Emissions (tons)	68.64	137.28	192.72	411.84	578.16

Most Complex:

This method presents an equation requiring inputs for the moisture content and silt content of the material being moved, as well as an estimate of the total amount of material moved.

$$E = E_f \times T \qquad E_f = 2.76 \times k \times \frac{s^{1.5}}{M^{1.4}}$$

E = Particulate matter emissions rate in pounds per year
E_f = Emission factor in pounds per hour of operation
T = Extent of material moving operation in hours per year
k = Particulate aerodynamic factor (see below)
s = Average silt content in percent (%)
M = Average moisture content of material in percent (%)

k (TSP) = 0.74 (dimensionless)
k (PM_{10}) = 0.36
k ($PM_{2.5}$) = 0.11

Conservative silt content default is 30 percent
Conservative moisture content default is 0.5 percent

Bulldozing Table 2 -- Emission Factor (Ef) for Total Suspended Particulates (TSP)							
	Moisture Content (%)						
Silt Content (%)	0.25	0.50	0.75	1.00	1.50	2.00	2.50
0.50	5.0290	1.9056	1.0802	0.7221	0.4093	0.2736	0.2002
1.00	14.2241	5.3899	3.0553	2.0424	1.1577	0.7739	0.5663
5.00	159.0303	60.2612	34.1594	22.8347	12.9440	8.6527	6.3311
10.00	449.8055	170.4444	96.6173	64.5864	36.6111	24.4737	17.9071
15.00	826.3455	313.1264	177.4974	118.6527	67.2589	44.9610	32.8974
20.00	1272.2422	482.0896	273.2751	182.6778	103.5519	69.2219	50.6489
25.00	1778.0125	673.7407	381.9135	255.3000	144.7182	96.7406	70.7840
30.00	2337.2581	885.6552	502.0384	335.6006	190.2370	127.1688	93.0479
50.00	5028.9787	1905.6266	1080.2146	722.0974	409.3248	273.6238	200.2072
70.00	8330.5150	3156.6749	1789.3780	1196.1561	678.0475	453.2584	331.6438

Bulldozing Table 3 -- Emission Factor (Ef) for PM10							
	Moisture Content (%)						
Silt Content (%)	0.25	0.50	0.75	1.00	1.50	2.00	2.50
0.50	2.4465	0.9271	0.5255	0.3513	0.1991	0.1331	0.0974
1.00	6.9198	2.6221	1.4864	0.9936	0.5632	0.3765	0.2755
5.00	77.3661	29.3163	16.6181	11.1088	6.2971	4.2094	3.0800
10.00	218.8243	82.9189	47.0030	31.4204	17.8108	11.9061	8.7116
15.00	402.0059	152.3318	86.3501	57.7229	32.7206	21.8729	16.0041
20.00	618.9286	234.5301	132.9446	88.8703	50.3766	33.6755	24.6400
25.00	864.9790	327.7658	185.7958	124.2000	70.4034	47.0630	34.4354
30.00	1137.0445	430.8593	244.2349	163.2651	92.5477	61.8659	45.2666
50.00	2446.5302	927.0616	525.5098	351.2906	199.1310	133.1143	97.3981
70.00	4052.6830	1535.6797	870.5082	581.9138	329.8609	220.5041	161.3402

Bulldozing Table 4 -- Emission Factor (Ef) for PM2.5							
	Moisture Content (%)						
Silt Content (%)	0.25	0.50	0.75	1.00	1.50	2.00	2.50
0.50	0.7476	0.2833	0.1606	0.1073	0.0608	0.0407	0.0298
1.00	2.1144	0.8012	0.4542	0.3036	0.1721	0.1150	0.0842
5.00	23.6396	8.9577	5.0777	3.3944	1.9241	1.2862	0.9411
10.00	66.8630	25.3363	14.3620	9.6007	5.4422	3.6380	2.6619
15.00	122.8351	46.5458	26.3847	17.6376	9.9979	6.6834	4.8902
20.00	189.1171	71.6620	40.6220	27.1548	15.3928	10.2897	7.5289
25.00	264.2992	100.1507	56.7709	37.9500	21.5122	14.3804	10.5219
30.00	347.4303	131.6514	74.6273	49.8866	28.2785	18.9035	13.8314
50.00	747.5509	283.2688	160.5724	107.3388	60.8456	40.6738	29.7605
70.00	1238.3198	469.2355	265.9886	177.8070	100.7908	67.3762	49.2984

Control Techniques:

Water spray is commonly used to reduce fugitive dust from this type of activity. Water spray essentially increases the moisture content of the material. Therefore, to take credit for the use of water spray as an emissions control technique, measure the moisture content of the material when being actively moistened and use this value in the method.

Particulate emissions can also be reduced through the use of wind screens or enclosures (on a relatively small scale). The District assumes that complete coverage by wind screens (on the windward side) will provide a control efficiency of 75 percent.

$$E_c = E \times \left(\frac{100 - C}{100} \right)$$

E_c	=	Controlled emissions
E	=	Uncontrolled emissions
C	=	Control efficiency in percent (%)

Source:

The method is derived from the Western Surface Coal Mining discussion in §11.9 of USEPA's AP-42 (January 1995 reformatted version).

E. Material Handling Operations

This procedure applies to the handling of materials in batches and conveyor belts, including loading, unloading, transferring and dropping. "Materials" include topsoil, overburden, waste material and ore. This procedure specifically applies to the operation of heavy equipment such as front end loaders and shovels as well as conveyor belts. This procedure is intended to be applied to each material handling point. This means that each batch drop should be counted. For example, a loader dropping a quantity of material into a temporary storage pile, then dropping into a dump truck, then the dump truck dumping into a long term storage pile would be three separate operations which should be separately accounted for.

Least Complex:

This method multiplies a conservative factor by the total amount of material moved in a year.

$$E = E_f \times Q$$

E = Particulate matter emissions rate in pounds per year
E_f = Emission factor in units of pounds of particulate per ton handled
Q = Quantity of material handled per year in tons

TSP E_f = 0.029 pounds/ton
PM_{10} E_f = 0.014 pounds/ton
$PM_{2.5}$ E_f = 0.004 pounds/ton

(These emission factors were calculated using the defaults given in the Most Complex section)

Material Handling Table 1 - Weight Based Emissions

Activity in tons (yearly)	10000	20000	30000	40000	50000	60000	70000	80000	90000	100000	110000
TSP Emissions (tons)	0.15	0.29	0.44	0.58	0.73	0.87	1.02	1.16	1.31	1.45	1.60
PM10 Emissions (tons)	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.56	0.63	0.70	0.77
PM2.5 Emissions (tons)	0.06	0.11	0.17	0.22	0.28	0.33	0.39	0.44	0.50	0.55	0.61

Most Complex:

This method presents an equation requiring inputs for the mean wind speed at the handling site, moisture content of the material being moved, and an estimate of the total amount of material handled.

$$E = E_f \times Q \qquad E_f = k \times 0.0032 \times \frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

E = Particulate matter emissions rate in pounds per year
E_f = Emission factor in pounds per ton handled
Q = Quantity of material handled per year in tons
k = Particulate aerodynamic factor (see below)

U = Mean wind speed in miles per hour
M = Average moisture content of material handled in percent (%)

k (TSP) = 0.74 (dimensionless)
k (PM_{10}) = 0.36
k ($PM_{2.5}$) = 0.11

Conservative mean wind speed default is 7.7 mph
Conservative moisture content default is 0.5 percent

Material Handling Table 2 -- Emission Factor (Ef) for TSP							
	Wind Speed (mph)						
Moisture Content (%)	5.0	7.5	10.0	12.5	15.0	20.0	25.0
0.25	0.0435	0.0737	0.1072	0.1432	0.1815	0.2639	0.3527
0.50	0.0165	0.0279	0.0406	0.0543	0.0688	0.1000	0.1336
0.75	0.0093	0.0158	0.0230	0.0308	0.0390	0.0567	0.0758
1.00	0.0062	0.0106	0.0154	0.0206	0.0261	0.0379	0.0506
1.50	0.0035	0.0060	0.0087	0.0117	0.0148	0.0215	0.0287
2.00	0.0024	0.0040	0.0058	0.0078	0.0099	0.0144	0.0192
2.50	0.0017	0.0029	0.0043	0.0057	0.0072	0.0105	0.0140

Material Handling Table 3 -- Emission Factor (Ef) for PM10							
	Wind Speed (mph)						
Moisture Content (%)	5.0	7.5	10.0	12.5	15.0	20.0	25.0
0.25	0.0212	0.0359	0.0521	0.0697	0.0883	0.1284	0.1716
0.50	0.0080	0.0136	0.0198	0.0264	0.0335	0.0486	0.0650
0.75	0.0045	0.0077	0.0112	0.0150	0.0190	0.0276	0.0369
1.00	0.0030	0.0052	0.0075	0.0100	0.0127	0.0184	0.0246
1.50	0.0017	0.0029	0.0042	0.0057	0.0072	0.0104	0.0140
2.00	0.0012	0.0020	0.0028	0.0038	0.0048	0.0070	0.0093
2.50	0.0008	0.0014	0.0021	0.0028	0.0035	0.0051	0.0068

Material Handling Table 4 -- Emission Factor (Ef) for PM2.5							
	Wind Speed (mph)						
Moisture Content (%)	5.0	7.5	10.0	12.5	15.0	20.0	25.0
0.25	0.0065	0.0110	0.0159	0.0213	0.0270	0.0392	0.0524
0.50	0.0025	0.0042	0.0060	0.0081	0.0102	0.0149	0.0199
0.75	0.0014	0.0024	0.0034	0.0046	0.0058	0.0084	0.0113
1.00	0.0009	0.0016	0.0023	0.0031	0.0039	0.0056	0.0075
1.50	0.0005	0.0009	0.0013	0.0017	0.0022	0.0032	0.0043
2.00	0.0004	0.0006	0.0009	0.0012	0.0015	0.0021	0.0029
2.50	0.0003	0.0004	0.0006	0.0008	0.0011	0.0016	0.0021

Control Techniques:

Water spray is commonly used to reduce fugitive dust from this type of activity. Water spray essentially increases the moisture content of the material. Therefore, to take credit for the use of water spray as an emissions control technique, measure the moisture content of the material when being actively moistened and use this value in the method.

Some materials and process lines are exposed and lose moisture rapidly. Measuring moisture content at a given point in the process line will not accurately reflect the control efficiency of the wet suppression. In these cases, refer to the following table.

Material Handling Table 5 -- Control Techniques		
Control Technique	Control Efficiency (%)	Discussion
Water Spray (Application Point)	75	
Chemical Additive (Application Point)	85	
Water Spray (Downstream Effect)	75-(5*n)	n = number of transfer points from initial application
Chemical Additive (Downstream Effect)	85-(5*n)	
Conveyor with Half Cover	50	Covers less than 60 percent of conveyor
Conveyor with Three Quarter Cover	70	Covers less than 85 percent of conveyor
Conveyor with Full Cover	85	Completely covers conveyor width
Baghouse with Multiple Pickups	95	Baghouse must meet minimum flow standard given in Table 6
Baghouse with Single Pickup (Unenclosed)	97	
Baghouse with Single Pickup (Partial Enclosure)	98	
Baghouse with Single Pickup (Full Enclosure)	99	
Baghouse with Single Pickup (Attached)	99.5	

Material Handling Table 6 -- Required Baghouse Flow Ratios (in cfm/sq ft)																				
	Type of Material																			
Type of Baghouse/ Filter Cloth	Alumina	Bauxite	Carbon Black	Cement	Clay	Feldspar	Fly Ash	Graphite	Gypsum	Iron Oxide	lead Oxide	Lime	Limestone	Quartz	Rock Dust	Sand	Silica	Slate	Talc
Shaker/Woven or Reverse Air/Woven	2.5	2.5	1.5	2.0	2.5	2.2	2.5	2.0	2.0	2.5	2.0	2.5	2.7	2.8	3.0	2.5	2.5	3.5	2.5
Pulse Jet/Felt or Reverse Air/Felt	8	8	5	8	9	9	8	8	10	7	6	10	8	8	9	10	7	12	10

Note that higher baghouse control efficiencies can be justified with source tests, permit conditions and/or design factors.

Particulate emissions can also be reduced through the use of wind screens or enclosures (on a relatively small scale). The District assumes that complete coverage by wind screens (on the windward side) will provide a control efficiency of 75 percent.

Once the control efficiency of the applicable control technique is known, the following equation is used to determine the "controlled" emissions from the operation or process:

$$E_c = E \times \left(\frac{100 - C}{100} \right)$$

E_c = Controlled emissions
E = Uncontrolled emissions
C = Control efficiency in percent (%)

Source:

The method is presented in the Aggregate Handling and Storage Pile discussion in §13.2.4 of USEPA's AP-42 (January 1995).

F. Material Crushing and Screening Operations

This procedure applies to the crushing and screening of materials. This is effectively a "least complex" method that multiplies an emission factor by annual throughput. This method applies to each occurrence of a crushing or screening operation; in a process line with primary crushing and a screen, secondary crushing and a screen, and tertiary crushing followed by a screen, this method should be applied six times (to six potentially different throughputs).

$$E = E_f \times T$$

E = Particulate matter emissions rate in pounds per year
E_f = Emission factor in units of pounds of particulate per ton of throughput
T = Throughput of material processed per year in tons

Material Crushing and Screening Table 1 -- Emission Factors			
	Emission Factor		
Processing Device	TSP	PM10	PM2.5
Dry Primary or Secondary Crushing	0.280	0.017	0.005
Wet Primary or Secondary Crushing	0.018	0.001	0.001
Tertiary Crushing	1.850	0.112	0.035
Dry Screening	0.160	0.120	0.038
Wet Screening	neg	neg	neg

Note: "neg" indicates negligible emissions.

Control Techniques:

Please refer to the control techniques discussion in the Material Handling Operations section.

Source:

The method is derived from the Sand and Gravel Processing discussion in the Air & Waste Management Association Air Pollution Engineering Manual (1992 edition).

G. Wind Erosion From Stockpiles

This procedure applies to wind erosion from open storage piles.

Least Complex:

This method employs a conservative emission factor multiplied by the surface area of a stockpile.

$$E = E_f \times A$$

E = Particulate matter emissions rate in tons per year
E_f = Emission factor in units of tons of particulate per surface acre
A = Exposed surface area of stockpile in acres

TSP E_f = 8.10 tons/acre
PM_{10} E_f = 4.05 tons/acre
$PM_{2.5}$ E_f = 1.62 tons/acre
(These emission factors were calculated using the defaults given in the Most Complex section)

Stockpile Table 1 -- Area Based Emissions								
Area (acres)	0.02	0.11	0.23	0.46	1.00	2.00	5.00	10.00
Area (square feet)	1000	5000	10000	20000	43560	87120	217800	435600
TSP Emissions (tons)	0.19	0.93	1.86	3.72	8.10	16.20	40.50	81.00
PM10 Emissions (tons)	0.09	0.46	0.93	1.86	4.05	8.10	20.25	40.50
PM2.5 Emissions (tons)	0.04	0.19	0.37	0.74	1.62	3.24	8.10	16.20

Most Complex:

This method presents an equation requiring inputs for the silt content of the stockpiled material, the average number of days during the year in question that experienced at least 0.01 inches of precipitation, the percentage of time during the year that the unobstructed wind speed exceeded 12 mph, and the exposed surface area of the stockpile.

$$E = E_f \times A \qquad E_f = J \times 1.7 \times \frac{sL}{1.5} \times \frac{(365 - P)}{235} \times \frac{I}{15} \times \frac{365}{2000}$$

E = Particulate matter emissions rate in tons per year
E_f = Emission factor in tons per acre
A = Exposed surface area of stockpile in acres
J = Particulate aerodynamic factor (see below)
sL = Average silt loading of storage pile in percent (%), see below
P = Average number of days during the year with at least 0.01 inches of precipitation
I = Percentage of time with unobstructed wind speed >12 mph in percent (%)

J (TSP)	=	1.0
J (PM_{10})	=	0.5
J ($PM_{2.5}$)	=	0.2

Conservative silt loading default is 30 percent
Conservative days with precipitation default is 20
Conservative windy hours default is 13.3 percent

Stockpile Table 2 -- Silt Content Percentages	
Stockpile Material	Silt Content (%)
Limestone	0.5
Crushed Limestone	1.5
Asphalt Batching	5.0
Coal	6.0
Concrete Batching	6.0
Sand and Gravel Processing	8.0
Overburden	10.0
Blend Ore and Dirt	15.0
Flue Dust	20.0
Inorganic Minerals	30.0

Stockpile Table 3 -- TSP Emissions for P = 20 days with >=0.01 inches								
I (% of winds > than 12 mph)	Silt Content (%)							
	0.5	1.0	5.0	10.0	15.0	20.0	25.0	30.0
5	0.051	0.101	0.506	1.012	1.518	2.024	2.530	3.036
10	0.101	0.202	1.012	2.024	3.036	4.049	5.061	6.073
15	0.152	0.304	1.518	3.036	4.555	6.073	7.591	9.109
20	0.202	0.405	2.024	4.049	6.073	8.097	10.122	12.146

Stockpile Table 4 -- PM10 Emissions for P = 20 days with >=0.01 inches								
I (% of winds > than 12 mph)	Silt Content (%)							
	0.5	1.0	5.0	10.0	15.0	20.0	25.0	30.0
5	0.025	0.051	0.253	0.506	0.759	1.012	1.265	1.518
10	0.051	0.101	0.506	1.012	1.518	2.024	2.530	3.036
15	0.076	0.152	0.759	1.518	2.277	3.036	3.796	4.555
20	0.101	0.202	1.012	2.024	3.036	4.049	5.061	6.073

Stockpile Table 5 -- PM2.5 Emissions for P = 20 days with >=0.01 inches								
I (% of winds > than 12 mph)	Silt Content (%)							
	0.5	1.0	5.0	10.0	15.0	20.0	25.0	30.0
5	0.010	0.020	0.101	0.202	0.304	0.405	0.506	0.607
10	0.020	0.040	0.202	0.405	0.607	0.810	1.012	1.215
15	0.030	0.061	0.304	0.607	0.911	1.215	1.518	1.822
20	0.040	0.081	0.405	0.810	1.215	1.619	2.024	2.429

Control Techniques:

Fugitive particulate emissions from storage piles can be reduced through the use of water spray (by increasing the moisture content of the material). The following table presents the required minimum water application rates to achieve a given control efficiency. Water application or use records must accompany any watering control efficiency claim.

Stockpiles Table 6 -- Watering Control Efficiency (%)	
Desired Efficiency (%)	Daily Water Application Rate (gal/acre)
50	1703
60	2390
70	3396
80	5083
85	6506
90	8892
95	14279

Stockpile fugitive particulate emissions can also be reduced through the use of wind screens or enclosures. The District assumes that complete coverage by wind screens (on the windward side) will provide a control efficiency of 75 percent.

Once the control efficiency of the applicable control technique is known, the following equation is used to determine the "controlled" emissions from the operation or process:

$$E_c = E \times \left(\frac{100 - C}{100} \right)$$

E_c = Controlled emissions
E = Uncontrolled emissions
C = Control efficiency in percent (%)

Source:

The method is derived from the Fugitive Emissions discussion in the Air & Waste Management Association Air Pollution Engineering Manual (1992 edition).

H. Stationary Equipment Exhaust

This procedure estimates exhaust from a wide variety of fuel-burning stationary equipment used in the mineral industry. This is a “least complex” method that multiplies an emission factor by annual fuel use, and should be used only if source test or manufacturer guaranteed emissions data is not available for the equipment in question. This method requires fuel type and annual fuel use as inputs. Boilers, Space Heaters, Generic Industrial Process Heaters, Internal Combustion Engines, and Gas Turbines are covered by this method.

$$E = E_f \times F$$

E = Pollutant emissions rate in pounds per year
E_f = Emission factor in units of pounds of pollutant per unit of fuel use
F = Annual fuel consumption in millions of cubic feet (MMCF) for natural gas or 1000’s of gallons for gasoline, diesel or propane

Stationary Equipment Table 1 -- Emission Factors

Equipment Type	Fuel Type	Fuel Units	TOG	ROG	CO	NOx	SOx	TSP	PM10
Boiler >100 MMBTU/hr	Natural Gas	MMCF	3.18	1.40	40.0	550.0	0.60	3.00	3.00
Boiler 10-100 MMBTU/hr	Natural Gas	MMCF	6.36	2.80	35.0	140.0	0.60	3.00	3.00
Boiler <10 MMBTU/hr	Natural Gas	MMCF	12.05	5.30	20.0	100.0	0.60	3.00	3.00
Boiler, Cogeneration	Natural Gas	MMCF	3.18	1.40	40.0	275.0	0.60	3.00	3.00
Boiler	Fuel Oil #2, 0.5% S	1000 gal	0.21	0.20	5.0	20.0	71.80	2.00	1.95
	Fuel Oil #2, 0.05% S	1000 gal	0.21	0.20	5.0	20.0	7.18	2.00	1.95
	Propane or LPG	1000 gal	0.65	0.60	1.8	8.8	1.50	0.26	0.26
Space Heater	Natural Gas	MMCF	12.05	5.30	20.0	100.0	0.60	3.00	3.00
	Fuel Oil #2, 0.5% S	1000 gal	0.74	0.70	5.0	18.0	72.00	2.50	2.44
	Fuel Oil #2, 0.05% S	1000 gal	0.74	0.70	5.0	18.0	7.20	2.50	2.44
	Propane or LPG	1000 gal	0.69	0.63	2.0	7.5	1.50	1.85	1.85
Generic Industrial Process Heater	Natural Gas	MMCF	12.05	5.30	20.0	100.0	0.60	3.00	2.85
	Fuel Oil #2, 0.5% S	1000 gal	0.21	0.20	5.0	20.0	53.50	2.00	1.95
	Fuel Oil #2, 0.05% S	1000 gal	0.21	0.20	5.0	20.0	5.35	2.00	1.95
	Propane or LPG	1000 gal	0.65	0.60	1.8	8.8	1.50	0.26	0.25
Internal Combustion Engine	Natural Gas	MMCF	799.42	187.06	430.0	3400.0	0.60	10.00	9.94
	Fuel Oil #2, 0.5% S	1000 gal	37.42	33.08	102.0	469.0	15.60	33.50	32.70
	Fuel Oil #2, 0.05% S	1000 gal	37.42	33.08	102.0	469.0	1.56	33.50	32.70
	Propane or LPG	1000 gal	800.39	187.29	129.0	139.0	0.35	5.00	4.97
	Gasoline	1000 gal	164.13	148.96	3940.0	102.0	5.31	6.47	6.43
Gas Turbine, Cogeneration	Natural Gas	MMCF	66.54	15.57	115.0	413.0	0.60	14.00	13.92
Gas Turbine	Natural Gas	MMCF	121.50	28.43	115.0	413.0	0.60	14.00	13.92
	Fuel Oil #2, 0.5% S	1000 gal	5.56	4.92	15.4	67.8	70.00	5.00	4.88
	Fuel Oil #2, 0.05% S	1000 gal	5.56	4.92	15.4	67.8	7.00	5.00	4.88

Note that, for the above table, the ROG emission factors can be used as VOC emission factors, and the PM_{10} emission factors can be used as $PM_{2.5}$ emission factors.

Source:

These generic factors are derived from a variety of sources (primarily USEPA’s AP-42).

I. Mobile Equipment and Vehicular Exhaust

This procedure estimates the exhaust and brake wear emissions from a variety of mobile equipment common in the mineral industry. Note that this method estimates exhaust from mobile equipment only, and dust entrainment due to the travel of mobile equipment on paved and unpaved surfaces should be estimated using the methods presented elsewhere in this document. This is effectively a "least complex" method that multiplies a conservative emission factor by annual activity in hours of use, fuel consumption in 1000's of gallons, or travel in 1000's of miles.

$$E = E_f \times A$$

E	=	Pollutant emissions rate in pounds per year
E_f	=	Emission factor in units of pounds of pollutant per unit of activity
A	=	Annual activity consumption in 1000's of horsepower-hours, 1000's of gallons of diesel fuel burned, or 1000's of vehicle miles traveled

Mobile Equipment Table 1 -- Emission Factors

Equipment Type	Activity Type	Activity Units	TOG	ROG	CO	NOx	SOx	TSP	PM10
Heavy Duty Diesel Off Road	Hours of Operation	1000 hp-hr	2.42	2.34	7.5	24.3	2.91	1.54	1.53
Heavy Duty Gasoline Off Road	Hours of Operation	1000 hp-hr	16.53	15.99	474.0	9.9	2.82	0.13	0.13
Miscellaneous Natural Gas or Propane Off Road	Hours of Operation	1000 hp-hr	10.40	10.06	275.6	11.9	1.50	0.13	0.13
Locomotives	Fuel Burned	1000 gal	36.00	34.46	115.0	659.0	47.35	15.50	14.88
Light Duty Gasoline On or Off Road	Distance Traveled	1000 vmt	2.92	2.67	18.8	2.3	0.12	0.47	0.21
Heavy Duty Diesel On Road	Distance Traveled	1000 vmt	4.21	4.10	17.4	29.1	0.94	4.62	4.02

Note that, for the above table, the ROG emission factors can be used as VOC emission factors, and the PM_{10} emission factors can be used as $PM_{2.5}$ emission factors.

Control Techniques:

None are presently quantified.

Source:

This method is consists of fleet average emission factors derived from the District emission inventory.

J. Dust Entrainment from Paved Roads

This procedure applies to all traffic on paved roads. This procedure estimates the dust entrainment due to vehicular travel on paved surfaces. Vehicular exhaust emissions should be estimated using methods presented elsewhere.

Least Complex:

This method consists of multiplying a conservative default emission factor for a typical haul truck operating on a material laden surface by an estimate of that haul trucks annual activity in vehicle mile traveled.

$$E = E_f \times V$$

E = Particulate matter emissions rate in pounds per year
E_f = Emission factor in units of pounds of pollutant per mile traveled
V = Annual travel in units of vehicle miles traveled

E_f (TSP) = 55 pounds/mile traveled
E_f (PM_{10}) = 11 pounds/mile traveled
E_f ($PM_{2.5}$) = 3 pounds/mile traveled
(These emission factors were calculated using the defaults given in the Most Complex section)

Paved Roads Table 1 -- Activity Based Emissions									
Activity (miles traveled)	500	1000	5000	10000	20000	50000	100000	150000	200000
TSP Emissions (tons)	13.75	27.50	137.50	275	550	1375	2750	4125	5500
PM10 Emissions (tons)	2.75	5.50	27.50	55	110	275	550	825	1100
PM2.5 Emissions (tons)	0.75	1.50	7.50	15	30	75	150	225	300

Most Complex:

This method calculates a vehicle-specific emission factor based on paved surface silt loading and vehicle weight, and multiplies it by annual vehicular activity in miles traveled.

$$E = E_f \times V \qquad E_f = k \times \left(\frac{sL}{2}\right)^{0.65} \times \left(\frac{W}{3}\right)^{1.5}$$

E = Particulate matter emissions rate in pounds per year
E_f = Emission factor in units of pounds of pollutant per mile traveled
V = Annual travel in units of vehicle miles traveled
k = Aerodynamic particle size multiplier (see below)
sL = Roadway silt loading, in grams per square meter
W = Mean vehicle weight in tons

k (TSP) = 0.082

k (PM_{10}) = 0.016
k ($PM_{2.5}$) = 0.004

Conservative silt loading default is 100 grams per square meter
Conservative mean vehicle weight default is 42 tons

Paved Roads Table 2 -- Default Silt Loadings	
Paved Surface	Silt Loading (g/m2)
Freeway or High Traffic	0.1
Low Traffic Road	0.4
Municipal Solid Waste Landfill	7
Quarry	8
Concrete Batching	12
Sand and Gravel Processing	70
Industrial Site	100
Asphalt Batching	120

Paved Roads Table 3 -- Emission Factors (Ef) for TSP							
Silt Loading (g/m2)	Mean Vehicle Weight (W) in tons						
	2.5	5.0	10.0	15.0	25.0	50.0	100.0
0.4	0.02	0.06	0.18	0.32	0.69	1.96	5.54
1.0	0.04	0.11	0.32	0.58	1.26	3.56	10.06
1.5	0.05	0.15	0.41	0.76	1.64	4.63	13.09
5.0	0.11	0.32	0.91	1.66	3.58	10.12	28.63
10.0	0.18	0.50	1.42	2.61	5.62	15.88	44.92
15.0	0.23	0.65	1.85	3.40	7.31	20.67	58.47
25.0	0.32	0.91	2.58	4.73	10.19	28.81	81.49
50.0	0.51	1.43	4.04	7.43	15.98	45.21	127.88
100.0	0.79	2.24	6.35	11.66	25.08	70.94	200.66
150.0	1.03	2.92	8.26	15.17	32.65	92.34	261.17
200.0	1.24	3.52	9.96	18.29	39.36	111.32	314.87

Paved Roads Table 4 -- Emission Factors (Ef) for PM10							
Silt Loading (g/m2)	Mean Vehicle Weight (W) in tons						
	2.5	5.0	10.0	15.0	25.0	50.0	100.0
0.4	0.00	0.01	0.03	0.06	0.14	0.38	1.08
1.0	0.01	0.02	0.06	0.11	0.25	0.69	1.96
1.5	0.01	0.03	0.08	0.15	0.32	0.90	2.55
5.0	0.02	0.06	0.18	0.32	0.70	1.97	5.59
10.0	0.03	0.10	0.28	0.51	1.10	3.10	8.77
15.0	0.05	0.13	0.36	0.66	1.43	4.03	11.41
25.0	0.06	0.18	0.50	0.92	1.99	5.62	15.90
50.0	0.10	0.28	0.79	1.45	3.12	8.82	24.95
100.0	0.15	0.44	1.24	2.27	4.89	13.84	39.15
150.0	0.20	0.57	1.61	2.96	6.37	18.02	50.96
200.0	0.24	0.69	1.94	3.57	7.68	21.72	61.44

Paved Roads Table 5 -- Emission Factors (Ef) for PM2.5							
Silt Loading (g/m2)	Mean Vehicle Weight (W) in tons						
	2.5	5.0	10.0	15.0	25.0	50.0	100.0
0.4	0.001	0.003	0.009	0.016	0.034	0.096	0.270
1.0	0.002	0.005	0.016	0.029	0.061	0.173	0.491
1.5	0.003	0.007	0.020	0.037	0.080	0.226	0.639
5.0	0.006	0.016	0.044	0.081	0.175	0.494	1.396
10.0	0.009	0.024	0.069	0.127	0.274	0.775	2.191
15.0	0.011	0.032	0.090	0.166	0.357	1.008	2.852
25.0	0.016	0.044	0.126	0.231	0.497	1.405	3.975
50.0	0.025	0.070	0.197	0.362	0.780	2.205	6.238
100.0	0.039	0.109	0.310	0.569	1.224	3.461	9.788
150.0	0.050	0.142	0.403	0.740	1.592	4.504	12.740
200.0	0.061	0.172	0.486	0.892	1.920	5.430	15.360

Control Techniques:

Several control techniques are effective in reducing dust entrainment emissions from paved surfaces. Broom sweeping provides a 20 percent control effectiveness. Vacuum sweeping with at least a 12,000 cfm blower provides 45 percent control effectiveness (30 percent for PM_{10} and $PM_{2.5}$). Water flushing can also be used, but at least 0.48 gallons per square yard (or 8448 gallons per mile of 30 foot road) must be used to qualify for the following control efficiencies:

Paved Road Table 6 -- Water Flushing Control Efficiency		
Method	Control Efficiency (%)	Discussion
Water flushing	69-(0.231*V)	V is the number of vehicle passes since the last water flush
Water flushing followed by sweeping	96-(0.263*V)	

Once the control efficiency of the applicable control technique is known, the following equation is used to determine the "controlled" emissions from the operation or process:

$$E_c = E \times \left(\frac{100 - C}{100} \right)$$

E_c = Controlled emissions
E = Uncontrolled emissions
C = Control efficiency in percent (%)

Source:

These methods were derived from the Paved Roads discussion in §13.2.1 of USEPA's AP-42 (October 1997 version).

K. Dust Entrainment from Unpaved Roads

This procedure applies to all traffic on unpaved roads. This procedure estimates the dust entrainment due to vehicular travel on unpaved surfaces. Vehicular exhaust emissions should be estimated using methods presented elsewhere.

Least Complex:

This method consists of a conservative default emission factor (based on average vehicle weight in tons) multiplied by an estimate of annual vehicular activity in miles traveled.

$$E = E_f \times V$$

E = Particulate matter emissions rate in pounds per year
E_f = Emission factor in units of pounds of particulate per mile traveled
V = Annual travel in units of vehicle miles traveled
(These emission factors were calculated using the defaults given in the Most Complex section)

Unpaved Road Table 1 -- Default Emission Factors (Ef) in pounds/vmt								
Average weight (tons):	3	5	10	20	50	100	150	200
TSP Emission Factor	9.33	12.04	17.03	24.08	38.08	53.85	65.96	76.16
PM10 Emission Factor	2.43	2.97	3.93	5.18	7.47	9.86	11.60	13.01
PM2.5 Emission Factor	0.35	0.43	0.57	0.76	1.09	1.44	1.69	1.90

Most Complex:

This method calculates a vehicle specific emission factor based on unpaved surface silt content in percent, average vehicle weight in tons, and unpaved surface moisture content in percent, and multiplies it by annual vehicular activity in miles traveled.

$$E = E_f \times V$$

$$E_{f(TSP)} = 10 \times \left(\frac{s}{12}\right)^{0.8} \times \left(\frac{W}{3}\right)^{0.5} \times \left(\frac{M}{0.2}\right)^{-0.4}$$

$$E_{f(PM_{10})} = 2.6 \times \left(\frac{s}{12}\right)^{0.8} \times \left(\frac{W}{3}\right)^{0.4} \times \left(\frac{M}{0.2}\right)^{-0.3}$$

$$E_{f(PM_{2.5})} = 0.38 \times \left(\frac{s}{12}\right)^{0.8} \times \left(\frac{W}{3}\right)^{0.4} \times \left(\frac{M}{0.2}\right)^{-0.3}$$

E = Particulate matter emissions rate in pounds per year
E_f = Emission factor in units of pounds of pollutant per mile traveled
V = Annual travel in units of vehicle miles traveled (vmt)
s = Unpaved surface silt content in percent (%)
W = Average vehicle weight in tons

M = Unpaved surface moisture content in percent (%)

Unpaved Roads Table 2 -- Default Silt Content	
Source	Silt Loading (%)
Sand & gravel plant road	5
Landfill road	6
Rural road (gravel/crushed limestone surface)	6
Industrial haul road	8
Construction site scraper route	9
Stone quarrying and processing plant road	10
Rural road (dirt surface)	11
Coal mine scraper route	17
Coal mine freshly graded haul road	24

Conservative default silt content is 11 percent
Conservative default surface moisture content is 0.2 percent
Default average vehicle speed is assumed to be at least 15 mph

Control Techniques:

Several techniques are used to reduce fugitive dust emissions from vehicular travel on unpaved roads. The equation suggests that reducing travel, speed, and vehicle weight will directly reduce emissions. In addition, changing the nature of the unpaved surface can reduce emissions, as can be seen from the default silt loading table. Chemical stabilization is often used, but the control efficiency of chemical stabilization is very dependent on the material used and how it is applied; consult with the vendor and the District to derive a control efficiency for chemical stabilization (no control efficiency will be allowed for calcium chloride). Watering is the most common control technique for unpaved roads. What follows is an equation to calculate the control efficiency for a given water application rate:

$$C_f = 100 - \left(0.0012 \times \frac{A \times D \times T}{I}\right)$$

C_f = Control efficiency of watering application in percent
A = Average annual class A pan evaporation in inches
D = Average hourly traffic rate in vehicles per hour
T = Time between water applications in hours
I = Water application intensity in gallons per square yard

Conservative average annual evaporation is 75 inches
Conservative time between applications is 3 hours
Conservative watering intensity is 0.11 gal/yd^2 or 1936 gallons per mile of 30 foot road
(These defaults equate to no control efficiency for 41 vehicles per hour)

Once the control efficiency of the applicable control technique is known, the following equation is used to determine the “controlled” emissions from the operation or process:

$$E_c = E \times \left(\frac{100 - C}{100} \right)$$

E_c = Controlled emissions
E = Uncontrolled emissions
C = Control efficiency in percent (%)

Source:

These methods are presented in the Unpaved Roads discussion (§13.2.2) in USEPA’s AP-42 (September 1998).

L. Wind Erosion from Unpaved Operational Areas and Roads

This procedure applies to actively disturbed unpaved areas, specifically including plant or operational areas (such as quarries) and roads. Actively disturbed is defined as being disturbed by man's activity at least once per day. This procedure estimates the particulate emissions from these areas due to wind erosion. Particulate emissions due to actual vehicular travel on these areas should be estimated using methods presented elsewhere.

Least Complex:

This method multiplies a conservative emission factor by the amount of disturbed area.

$$E = E_f \times A$$

E = Particulate matter emission rate in tons per year
E_f = Emission factor in tons per acre (see below)
A = Disturbed area in acres

E_f (TSP) = 16 tons/acre
E_f (PM_{10}) = 8 tons/acre
E_f ($PM_{2.5}$) = 3.2 tons/acre

(These emission factors were calculated using the defaults given in the Intermediate Complexity section)

Wind Erosion Table 1 -- Area Based Emissions							
Area Disturbed (acres)	1	2	5	10	20	50	100
TSP Emissions (tons)	16	32	80	160	320	800	1600
PM10 Emissions (tons)	8	16	40	80	160	400	800
PM2.5 Emissions (tons)	3.2	6.4	16	32	64	160	320

Intermediate Complexity:

This method presents an equation requiring inputs for the fraction of vegetative cover on the disturbed area, mean wind speed in meters per second, threshold value of wind speed in meters per second (a derived value), and a correction factor (a derived value). The derived values can be estimated from tables presented below.

$$E = k \times E_f \times A \qquad Ef = 2.814 \times (1 - v) \times \left(\frac{u}{u_t}\right)^3 \times C(x) \qquad u_t = u_t^* \times u^*$$

E = Particulate matter emission rate in tons per year
k = Particulate aerodynamic factor (see below)
E_f = Emission factor in tons per acre
A = Disturbed area in acres
v = Amount of vegetative cover as a fraction
u = Mean wind speed in meters per second

u_t = Threshold value of wind speed in meters per second (calculated)
C(x) = Correction factor (see Table 4 below)
$u*_t$ = Threshold friction velocity in meters per second (see Table 2 below)
u* = Ratio of wind speed to friction velocity

k (TSP) = 1.0
k (PM_{10}) = 0.5
k ($PM_{2.5}$) = 0.2

Wind Erosion Table 2 -- Threshold Friction Velocity		
Area Use	Typical friction velocity particle size (mm)	Threshold friction velocity (m/s)
Mine tailings	0.05	0.14
Abandoned agricultural land	0.10	0.25
Construction site	0.11	0.26
Disturbed desert	0.20	0.33
Scrub desert	0.30	0.38
Coal dust	0.60	0.52
Active agricultural land	0.60	0.52
Coal pile	1.00	0.64

Wind Erosion Table 3 -- Ratio of wind speed to friction velocity		
Area use	Typical roughness height (cm)	Ratio
Open space	2	15.0
Light industrial	35	8.0
Moderate industrial	70	6.5
Heavy industrial	100	5.0

$$x = 0.886 \times \frac{u_t}{u}$$

Wind Erosion Table 4 -- C(x) Correction Factor																		
x	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
C(x)	1.91	1.90	1.89	1.86	1.83	1.77	1.70	1.60	1.48	1.33	1.20	1.05	0.90	0.78	0.62	0.50	0.40	0.29

Conservative default for mean wind speed is 2.36 m/s (7.7 mph)
Conservative default for roughness height is 70 cm (medium industry)
Conservative default for particle size is 0.1 mm (abandoned ag. land)

Most Complex:

This method presents an additional equation that is used as an alternative depending on the nature of the surface being eroded. Erodible surfaces can be characterized as “limited” or “unlimited” reservoirs of erodible material. The following table determines the type of surface and the appropriate equation:

Wind Erosion Table 5 -- Limited vs Unlimited		
	Reservoir Type	
Variable	Limited	Unlimited
Surface cover	Stones and/or clumps of vegetation	Bare with finely divided materials such as sand or soil
Threshold Frictional Velocity	Greater than 75 cm/s with particle size 1.5 mm or greater	Equal to or less than 75 cm/s with particle size less than 1.5 mm
Surface crust	Crust thicker than 0.25 inch and not easily crumbled between fingers (modulus of rupture > one bar)	Crust less than 0.25 inch or easily crumbled between fingers

If the surface in question is best characterized as an "unlimited" reservoir, use the moderate complexity method above.

The method for limited reservoirs involves a summation of the particulate emissions from each individual day in the year, based on each day's maximum wind speed in meters per second and the friction velocity of the surface in question. Those days without sufficient wind speed are ignored.

$$E = \frac{k \times \sum_{i=1}^{N} \left(9.813 \times A \times \left(58 \times (u_i - u_t)^2 + 25 \times (u_i - u_t)\right)\right)}{2000} \qquad u_i = 0.056 \times u_d$$

E = Particulate emissions in tons per year
k = Particulate aerodynamic multiplier (see below)
N = Number of days that daily maximum wind speed exceeded equivalent threshold friction velocity (threshold friction velocity multiplied by 17.9)
A = Disturbed area in acres (disturbed on a daily basis)
u_i = Friction velocity (at surface) in meters per second
u_t = Threshold friction velocity in meters per second (see Table 2)
u_d = Maximum wind speed of the *i*th day in meters/second (tower measurement)

k (TSP) = 1.0
k (PM_{10}) = 0.5
k ($PM_{2.5}$) = 0.2

Control Techniques:

Water spray is commonly used to reduce fugitive dust from unpaved surfaces. Water spray essentially increases the moisture content of the material. The control discussion presented in the previous section (unpaved roads) includes a method for estimating the control efficiency of watering. Other forms of stabilization can be used to reduce the erodibility of the unpaved surface and/or increase its threshold frictional velocity. For the most part, these control techniques will require case-by-case analysis, and review and approval of the District.

Once the control efficiency of the applicable control technique is known, the following equation is used to determine the "controlled" emissions from the operation or process:

$$E_c = E \times \left(\frac{100 - C}{100} \right)$$

E_c	=	Controlled emissions
E	=	Uncontrolled emissions
C	=	Control efficiency in percent (%)

Source:

These methods are presented in the Industrial Wind Erosion discussion (§13.2.5) in USEPA's AP-42 (January 1995).