$PM_{2.5}$ Air Emissions Assessments: Challenges and Suggested Solutions

Presented at CPANS AGM, May 9, 2018

Paresh Thanawala, P.Eng; QEP
2020 Environmental Solutions

Purpose

- Explain complexities in assessing $PM_{2.5}$ emissions and AQ impacts
- Develop better understanding of background $PM_{2.5}$ concentrations
- Offer solutions to address above

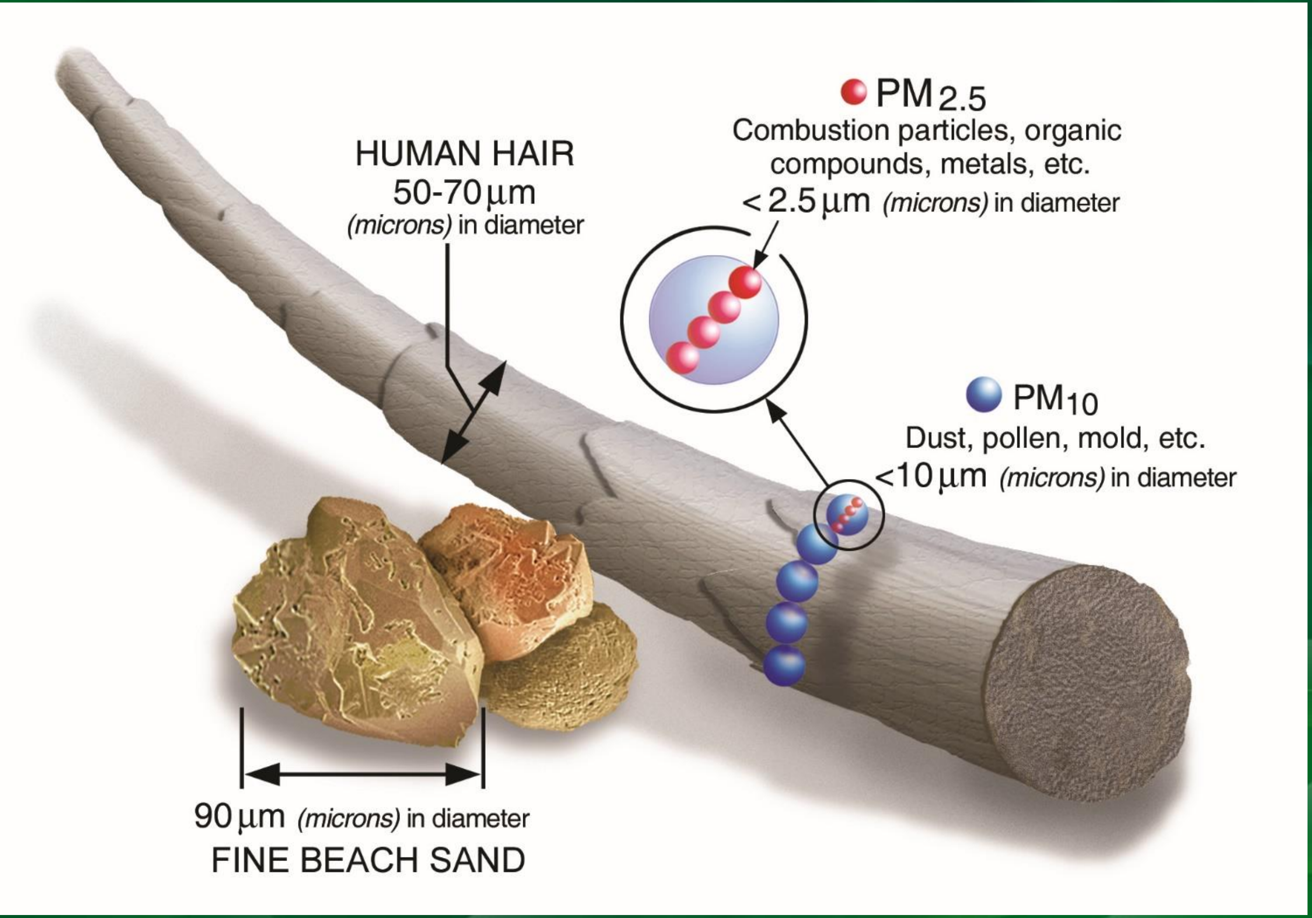
Health impact assessment, not within scope of this presentation

Issues with $PM_{2.5}$ Assessments

- Uncertainties in Emissions Factors. Only 2.5% of US EPA emission factors rated A/B

  Ref: NACAA $PM_{2.5}$ Modeling Implementation Workgroup, January 7, 2011
- Accounting for Condensable $PM_{2.5}$ (CPM)?
- Secondary $PM_{2.5}$ formation
- What really is the background?

Illustration of Particle Sizes



https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

1 µ = 10^{-3} mm = 10^{-6} m

AAAQO and CWS for $PM_{2.5}$ ambient concentration = 30 µg/m^3 as 24-hour average

Typical $PM_{2.5}$ Emissions

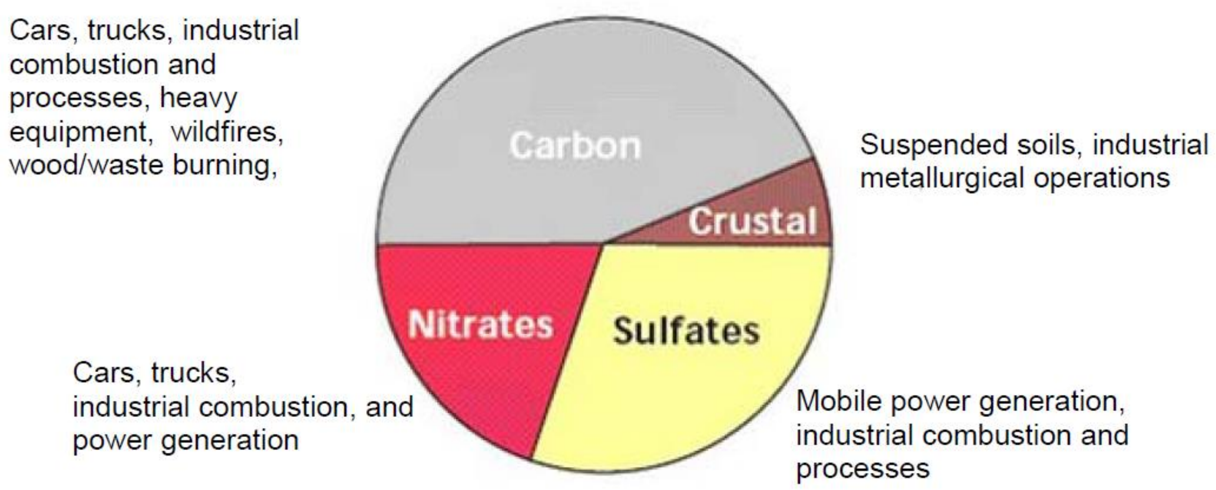


Figure 2-1. National Average of Source Contribution to Fine Particle Levels

Source: The Particulate Matter Report, USEPA 454-R-04-002, Fall 2004. Carbon reflects both organic carbon and elemental carbon. Organic carbon accounts for emissions from automobiles, biogenics, gas-powered off-road vehicles, and wildfires. Elemental carbon is mainly from diesel powered sources.

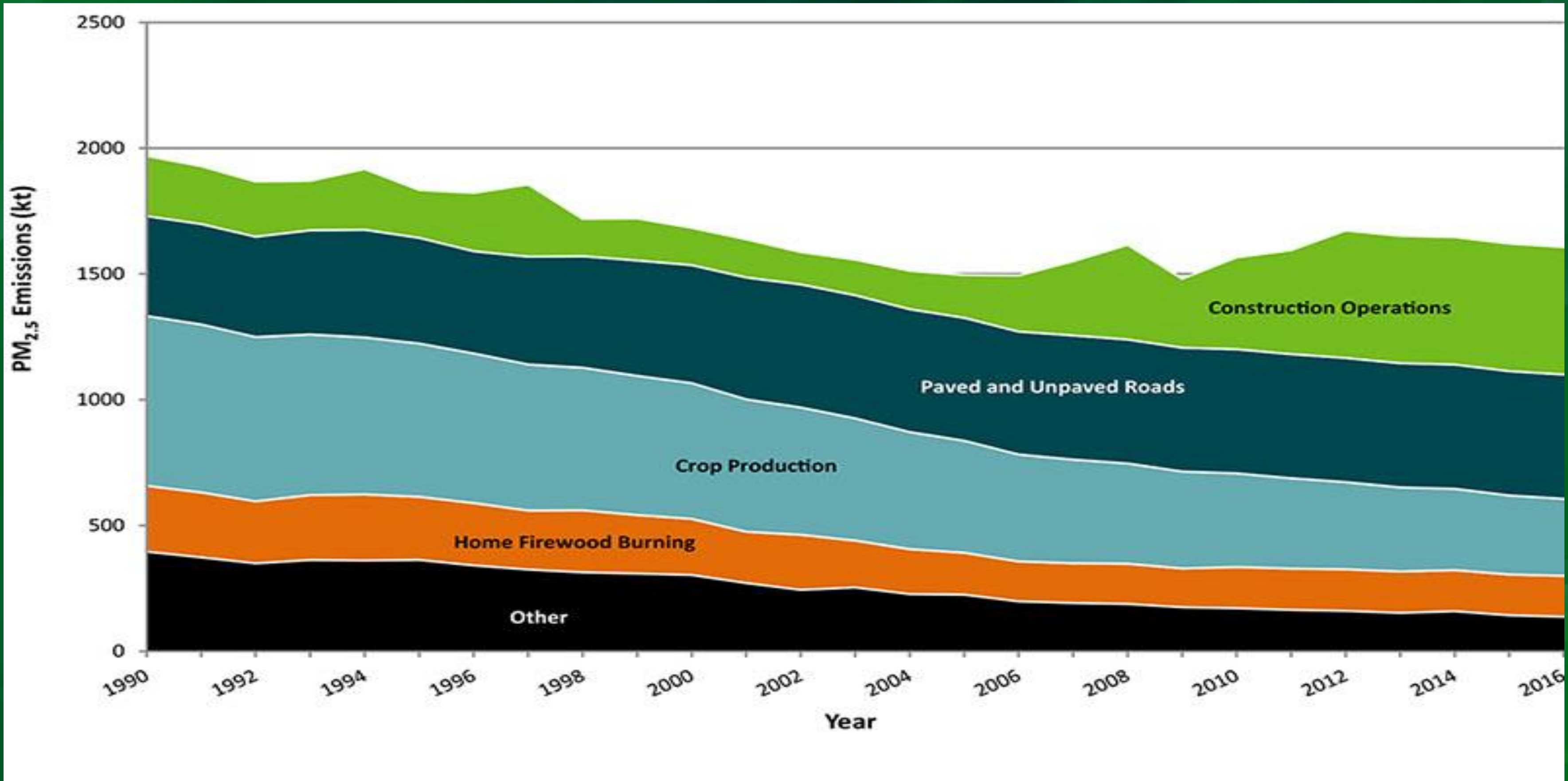
Rule of thumb: Combustion processes will have a larger portion of $PM_{2.5}$, dust will have a lager portion of PM_{10}

2016 National $PM_{2.5}$ Emissions

2016 National $PM_{2.5}$ Emissions		
Source	$PM_{2.5}$, Tonnes	% Total
Dust	1,000,000	62.5
Agriculture	310,000	19.38
Commercial / Residential / Institutional	180,000	11.25
Transportation and Mobile Equipment	36,000	2.25
Ore and Mineral Industries	33,000	2.06
Manufacturing	18,000	1.13
Oil and Gas Industry	11,000	0.69
Fires	9,100	0.57
Electric Power Generation (Utilities)	3,300	0.21
Incineration and Waste	2,700	0.17
Paints and Solvents	13	0.0008
Grand Total	1,600,000	100.00

https://www.canada.ca/en/environment-climate-change/services/air-pollution/publications/emission-inventory-report-2016/chapter-2-1.html#table-2-3

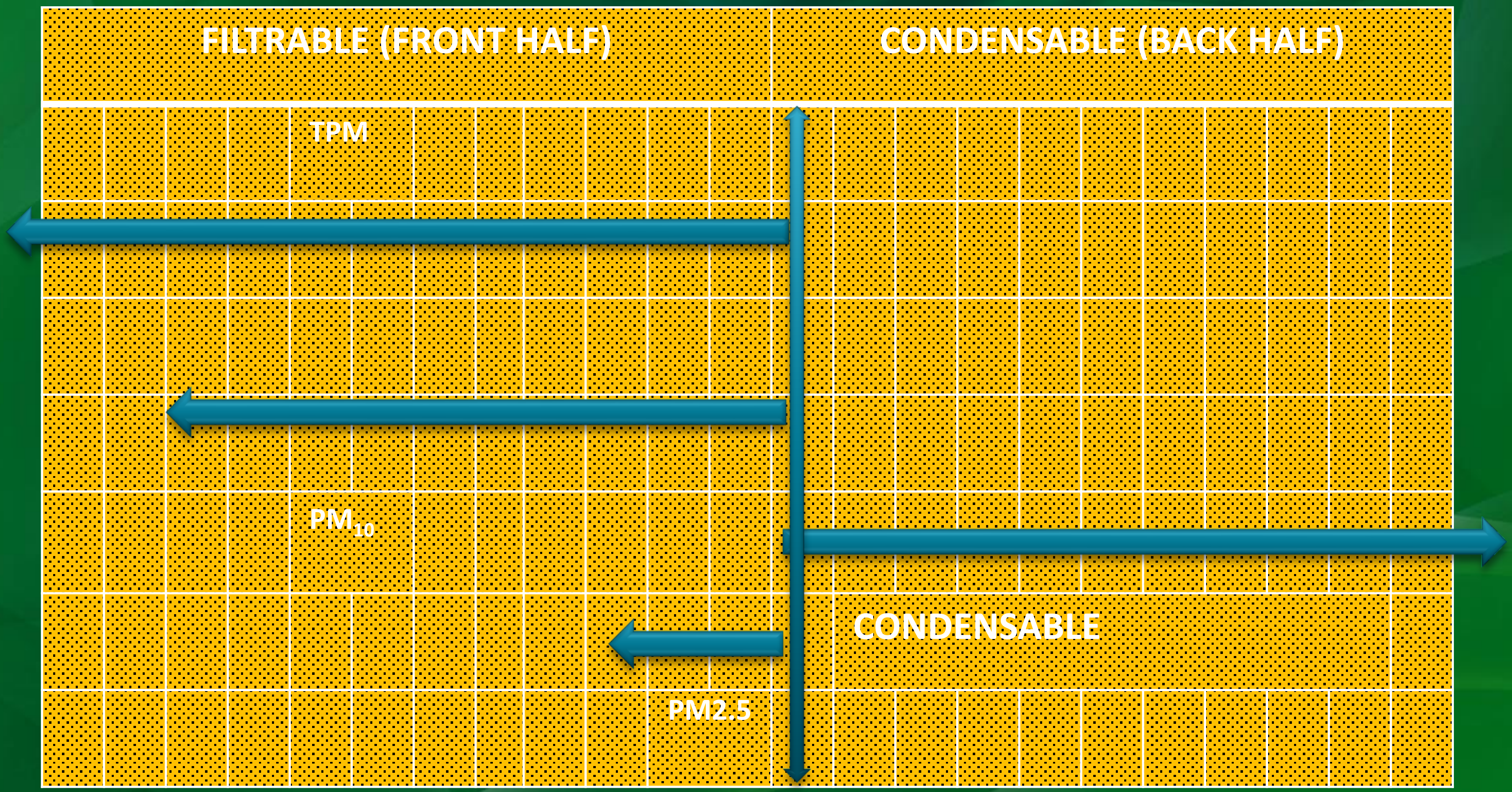
Where Should Our Focus be?



https://www.canada.ca/en/environment-climate-change/services/air-pollution/publications/emission-inventory-report-2016/chapter-2-1.html#table-2-3

What contributes to background $PM_{2.5}$?

Primary $PM_{2.5}$



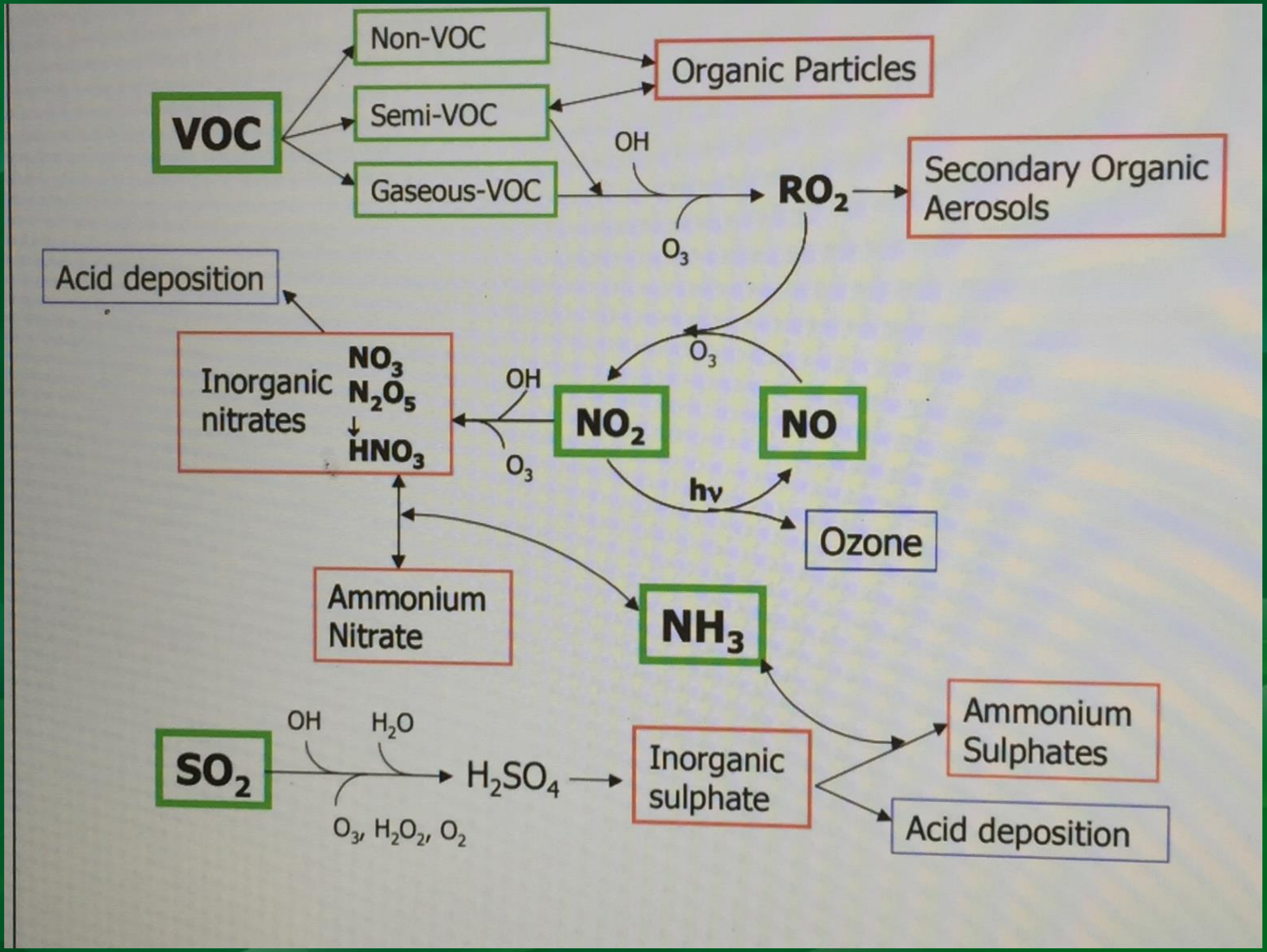
Primary $PM_{2.5}$ = Filtrable $PM_{2.5}$ + Condensable $PM_{2.5}$

Secondary $PM_{2.5}$

Formed due to complex atmospheric chemical Reactions. Precursors are:

- SO_2
- NOx
- VOC
- NH_3

Formation of Secondary $PM_{2.5}$



Meteorological Service of Canada "Precursor Contributions to Ambient Fine Particulate Matter in Canada", ISBN 0-662-30650-3, May 2001.

Assessing Secondary $PM_{2.5}$

Very Complex Subject

- Ambient concentrations assessment
- Photochemical Grid Models CMAX, CMAQ

https://www3.epa.gov/ttn/scram/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance-2014.pdf

Other Models

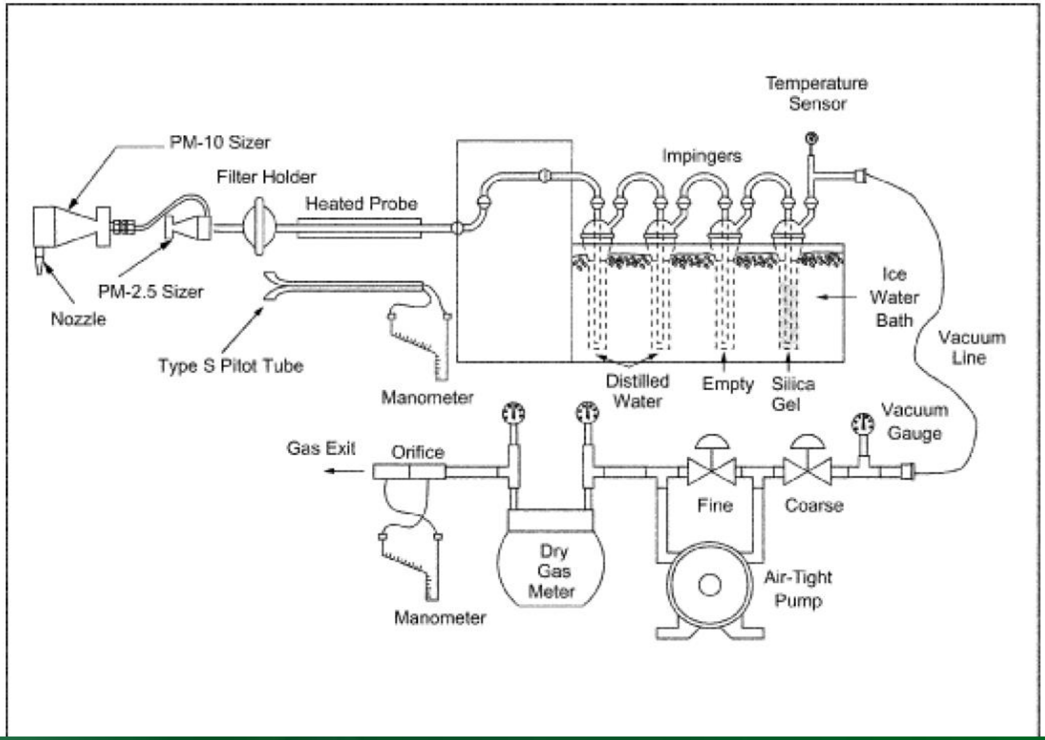
- SCFIPUFF
- SCICHEM
- CALPUFF
- AERMOD NOT APPROPRIATE FOR ASSESSING CUMULATIVE EFFECTS

Run model w/wo precursor emissions to assess secondary contribution

What is the Best Emission Factor?

Site-Specific Measurements for Stationary Sources

- Method 201A: Filtrable PM<10µ
- Method 202: Condensable PM (CPM)



https://www.epa.gov/sites/production/files/2018-03/documents/method_201a_1.pdf

Process/Engineering Review

Controls: Baghouses, ESPs, Wet Scrubbers

- Know make/model (Name Plate)
- Find design info (O/M Manual). Design loading
- Contact supplier if info N/A
- Know particle size distribution
- Know activity rate
- Find collection efficiencies
- Apply mass balance/collection efficiencies

Motor Vehicular Emissions Estimator (MOVES)

- US EPA's MOVES 2014a (most recent) model designed to estimate emissions from mobile sources. Moves 2010 a/b are older versions
  www.epa.gov/otaq/models/moves/index.htm
- Can estimate criteria pollutants, PM, toxics and greenhouse gases per vehicle mile travelled (VMT)
- On-road/off-road vehicles
- Significant improvements in 2014a compared to previous models. Accuracy as good as input

PAVED ROADS

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

where: E = paved road dust emission factor (g/VMT)

k = particle size multiplier (7.3 g/VMT for PM_{10} and 1.8 g/VMT for $PM_{2.5}$)

sL = road surface silt loading (g/m^2)

W = average weight (tons) of all vehicles traveling the road

C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear

N = number of days in the month

P = number of days in the month with at least 0.01 inches of precipitation

United States Environmental Protection Agency, Office of Air Quality Planning and Standards. "Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Section 13.2.2 Unpaved Roads." Research Triangle Park, NC. 2003

UNPAVED ROADS

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

where k, a, b, and c are empirical constants

E = size specific emission factor (lb/VMT)

s = surface material silt content (%)

SPD = mean vehicle speed (mph)

M = surface material moisture content (%)

C = emission factor for 1980's vehicle fleet exhaust, brake wear, and tire wear (lb/VMT)

Constant	$PM_{2.5}$	PM_{10}
k (lb/VMT)	0.27	1.8
a	1	1
b	0.5	0.5
c	0.2	0.2
C	0.00036	0.00047

United States Environmental Protection Agency, Office of Air Quality Planning and Standards. “Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: Stationary Point and Area Sources, Section 13.2.2 Unpaved Roads.” Research Triangle Park, NC. 2003

PM Augmentation (US EPA)

1. The PM Augmentation tool helps to ensure completeness of PM inventories
2. Tables in MS ACCESS offer replacements where filtrable/condensable data are missing (stationary, point and non-point sources)
3. Data quality/accuracy?

https://www.epa.gov/air-emissions-inventories/pm-augmentation

Preferred Emission Estimation Methods

1. Site-specific measurements (EPA 202 most recent for CPM)
2. Manufacturer's data (performance guarantee or actual measurements)
3. Mass balance/process engineering estimates
4. Emission factors (A or B rated – Very Limited data). Assess uncertainties and risks/costs of using measurements)

Recommendations

1. Updating regulatory expectations: measurements preferred, monitoring, QA/QC, modeling guidance
2. Use high quality emissions data
   - Measurements (preferred wherever feasible)
   - Manufacturers' data
   - Process/engineering assessments
   - High quality rated emission factors
3. Consider secondary $PM_{2.5}$ using advanced models
4. Use background data with a proper review
5. Stay on top with EIIP Initiatives
6. Use ambient monitoring/receptor-based approach as necessary
7. Use of best available control technology (BACT)/preventive measures