Midwest Research Institute

Solutions through science and technology

Proposed Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors

Chatten Cowherd

Midwest Research Institute

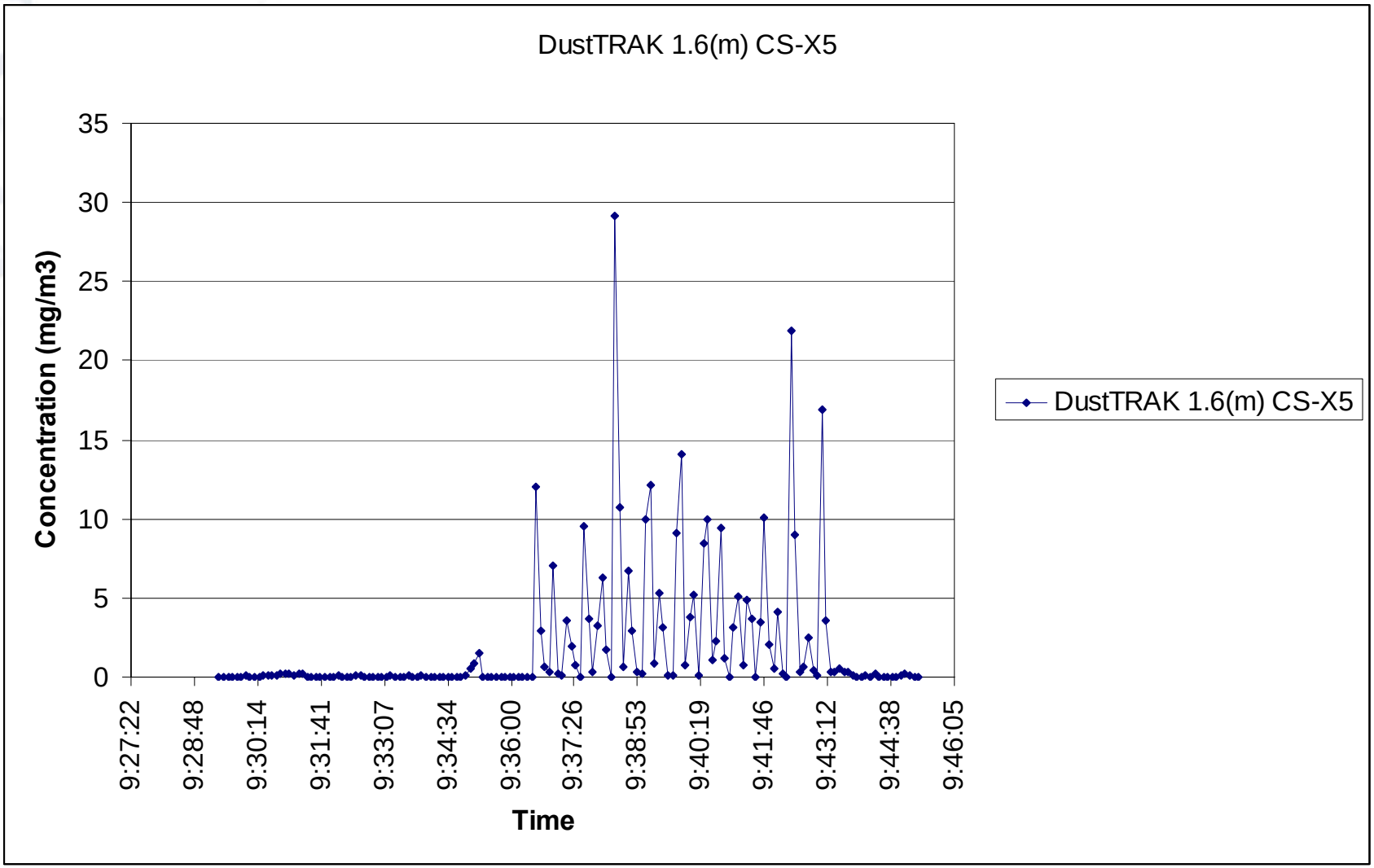
Duane Ono

Great Basin UAPCD

Fugitive Dust Emissions

- Highly fluctuating plume impacts at emission measurement site
- PM concentrations vary from background to plume core values
- Emissions depend on energy inputs and properties of emitting surface material

Road Dust Plume Concentrations



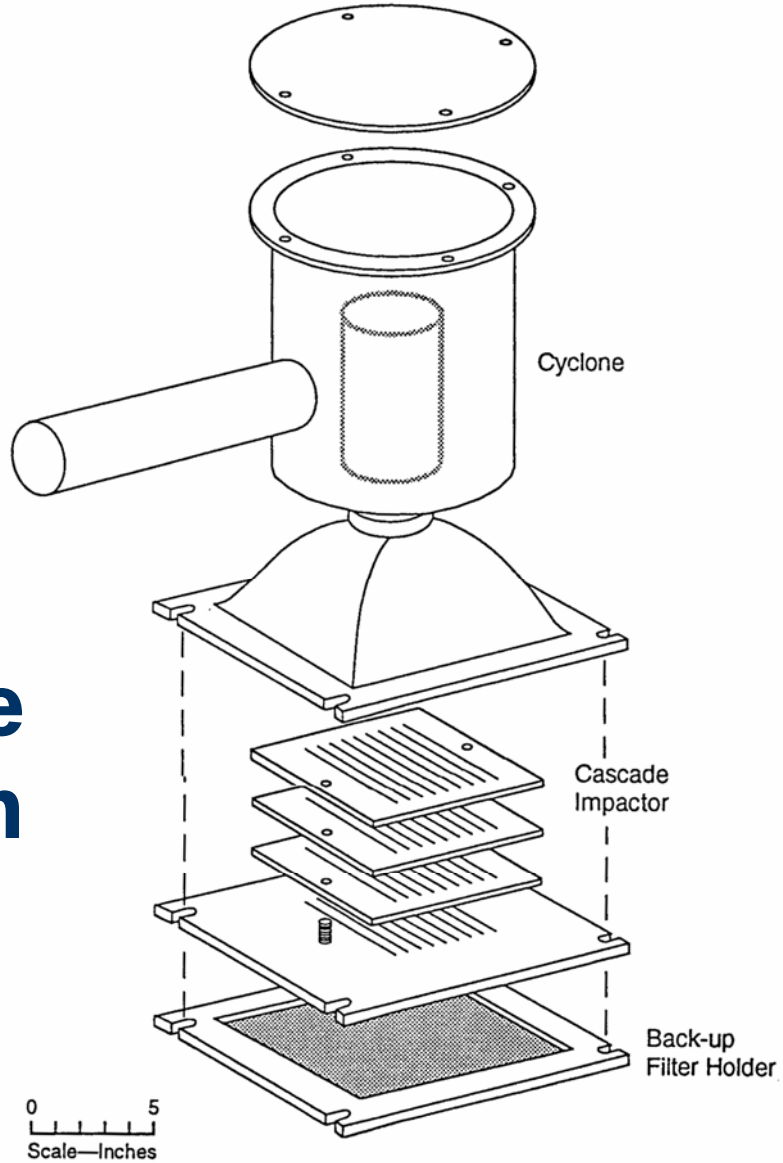
AP-42 Emission Factors

- Predictive equations with particle size multipliers
- Historically, particle size multipliers based on data from high-volume cyclone/cascade impactors
- Potential for particle size bias in overpredicting fine fractions

Discrepancy in Fine Fraction Data

- Emission data from the high-volume cyclone/impactor system have provided the basis for a $PM_{2.5}/PM_{10}$ of ~0.20 for many fugitive dust sources in EPA's AP-42
- Ambient air monitoring data suggest that $PM_{2.5}/PM_{10}$ may be less than 0.10

MRI Cyclone/Cascade Impactor System



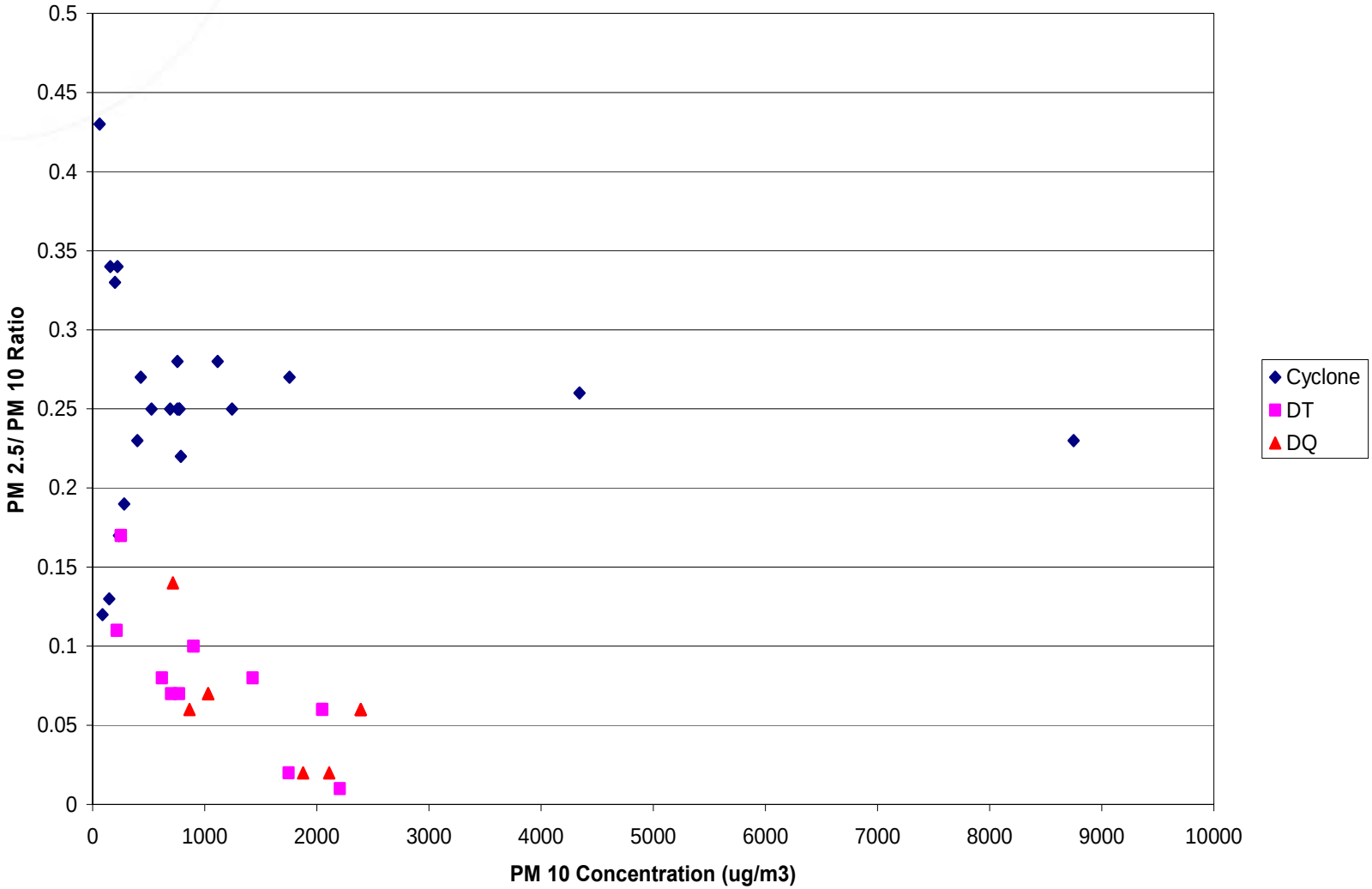
Plume Characterization Options

- Field studies produce highly variable results because of wind variations
- Laboratory exposure chambers can produce nearly steady-state conditions
- Confounding factors can be reduced in controlled laboratory flow settings

EPA Field Study in 1990s

- Purpose to resolve fine fraction emission biases for paved and unpaved roads
- Geographic distribution of test sites
- Cyclone/Impactor biases evident
- New AP-42 fine fractions were averages between cyclone/impactor and dichotomous sampler results

C/I Biases from Prior Field Study



Revisions to AP-42 Fine Fractions

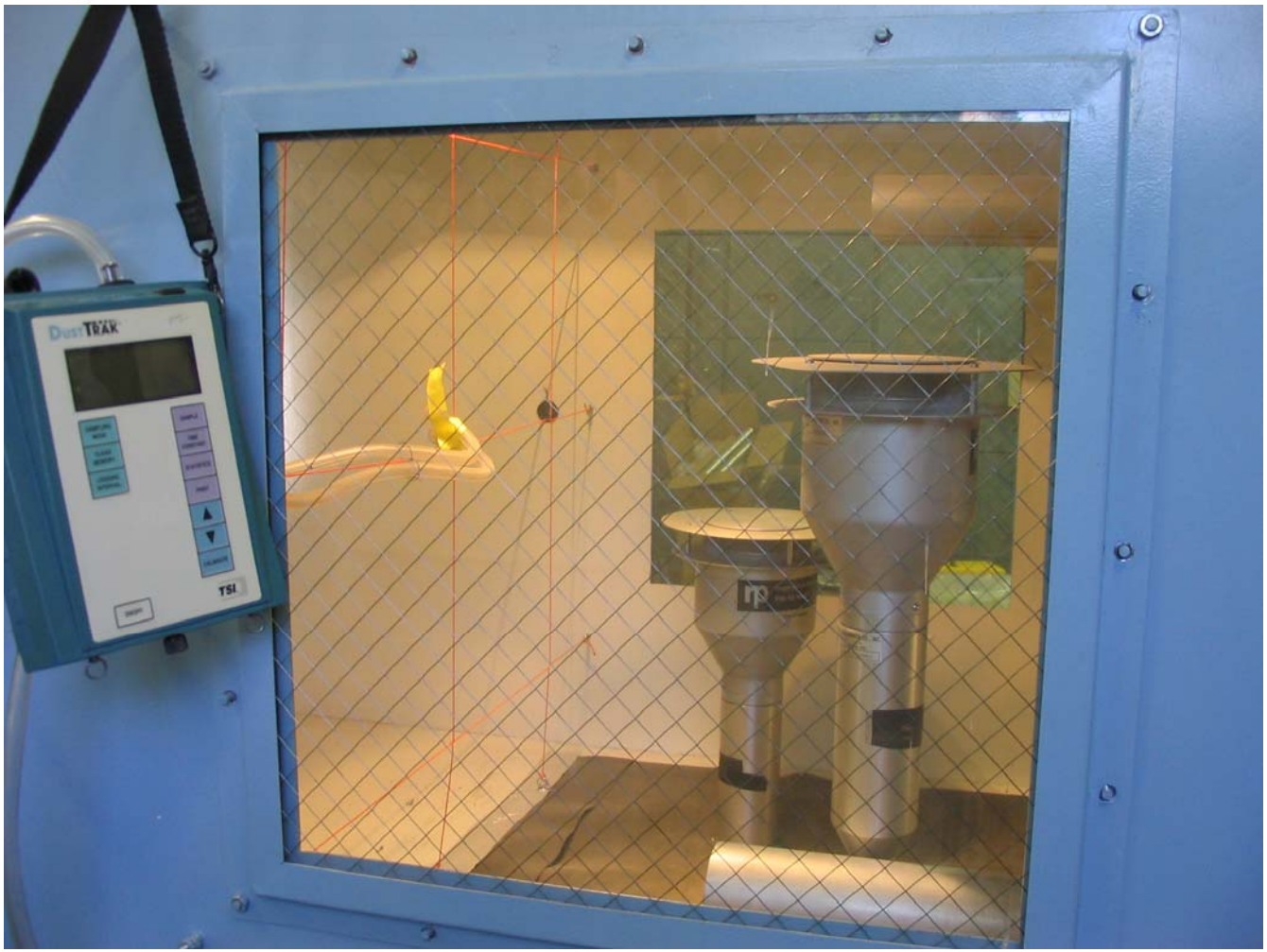
- PM2.5/PM10 ratio for unpaved roads (dominated by fugitive dust) was reduced from 0.26 to 0.15
- PM2.5/PM10 ratio for paved roads was reduced from 0.46 to 0.25
- Non-dust component of paved road emissions assigned a PM2.5/PM10 ratio of 0.76, accounting for vehicle exhaust and brake and tire wear

Purpose of Controlled Lab Study

- Collect new controlled data from collocated reference PM monitors with MRI high-volume cyclone/impactor system
- Determine extent of any bias in the $PM_{2.5}/PM_{10}$ ratio as determined by the cyclone/impactor system

Looking through tunnel toward Inlet flow straighteners

Viewing Window with Continuous PM Mass Monitor



Ref. Method Sampling Equipment

Phase I Testing

- Purpose: Determine potential bias in PM-2.5 concentration as measured by cyclone/impactor system
- RFM: Partisol Model 2000 for PM-2.5
- Test materials: ISO 12103-1 Arizona Test Dusts—fine and coarse grades; Owens Dry Lake surface soil

Air Samplers: Phase I

Unit	Sampler	Manufacturer/ model	Flow rate	Particle size cutpoint
2	Cyclone pre-separators	Sierra Model 230 CP	20 acfm	10.2 µmA
2	Multistage impactor	Sierra Model 230	20 acfm	2.1 µmA
2	Partisol	R&P Model 2000	16.7 alpm	2.5 µmA
2	DustTRAK	TSI Model 8520	5 alpm	2.5 µmA and 10 µmA

MRI Cyclone for Sampling of PM-10 in Fugitive Dust

Exposure Chamber with Sampler Inlets

Phase II Testing

- Purpose: Determine PM-2.5/PM-10 ratios for a variety of western surface materials
- FRMs: Partisol Model 2000 for PM-2.5 and PM-10
- Test materials: Soils, aggregates, and unpaved road surface materials
- Aerosolization system: Constant flow energy

Air Samplers: Phase II

Unit	Sampler	Manufacturer/ model	Flow rate	Particle size cutpoint
2	Partisol	R&P Model 2000	16.7 alpm	2.5 µmA
2	Partisol	R&P Model 2000	16.7 alpm	10 µmA
2	DustTRAK	TSI Model 8520	5 alpm	2.5 µmA and 10 µmA.

Contributors of Test Samples

- Great Basin UAPCD—Owens Dry Lake
- CH2MHill—Salton Sea
- WY AQD—Thunder Basin mine
- NM AQB—South-Central New Mexico
- Alaska DEC—Matanuska Valley
- Arizona DEQ—Maricopa & Pima Counties

Properties of Test Soils/Surface Materials

Code	State	Location	Type of material	Moisture content (%)	Dry silt content (%)	Dry Silt rank
TF	Arizona	–	Standard Test Dust—Fine	–	–	–
TC	Arizona	–	Standard Test Dust—Coarse	0.60	87.6	1
AK	Alaska	MAT-SU Knik River Bed	Sediments	0.80	8.69	6
AZal	Arizona	Phoenix Area	Alluvial Channel	0.33	17.3	3
AZag	Arizona	Phoenix Area	Agricultural Soil	1.06	21.6	2
NMr	New Mexico	Las Cruces Landfill	Road Dust	1.27	12.2	4
NMs	New Mexico	Radium Springs	Grazing Soil	0.47	10.9	5
OW	California	Owens Dry Lake	Lakebed Soil	0.27	3.14	9
SS	California	Salton Sea	Shoreline Soils	5.46*	3.63	8
WY	Wyoming	Thunder Basin Mine	Barrow Pit for Access Road Surface Material	2.47*	6.83	7

Wind Erodibility Groups

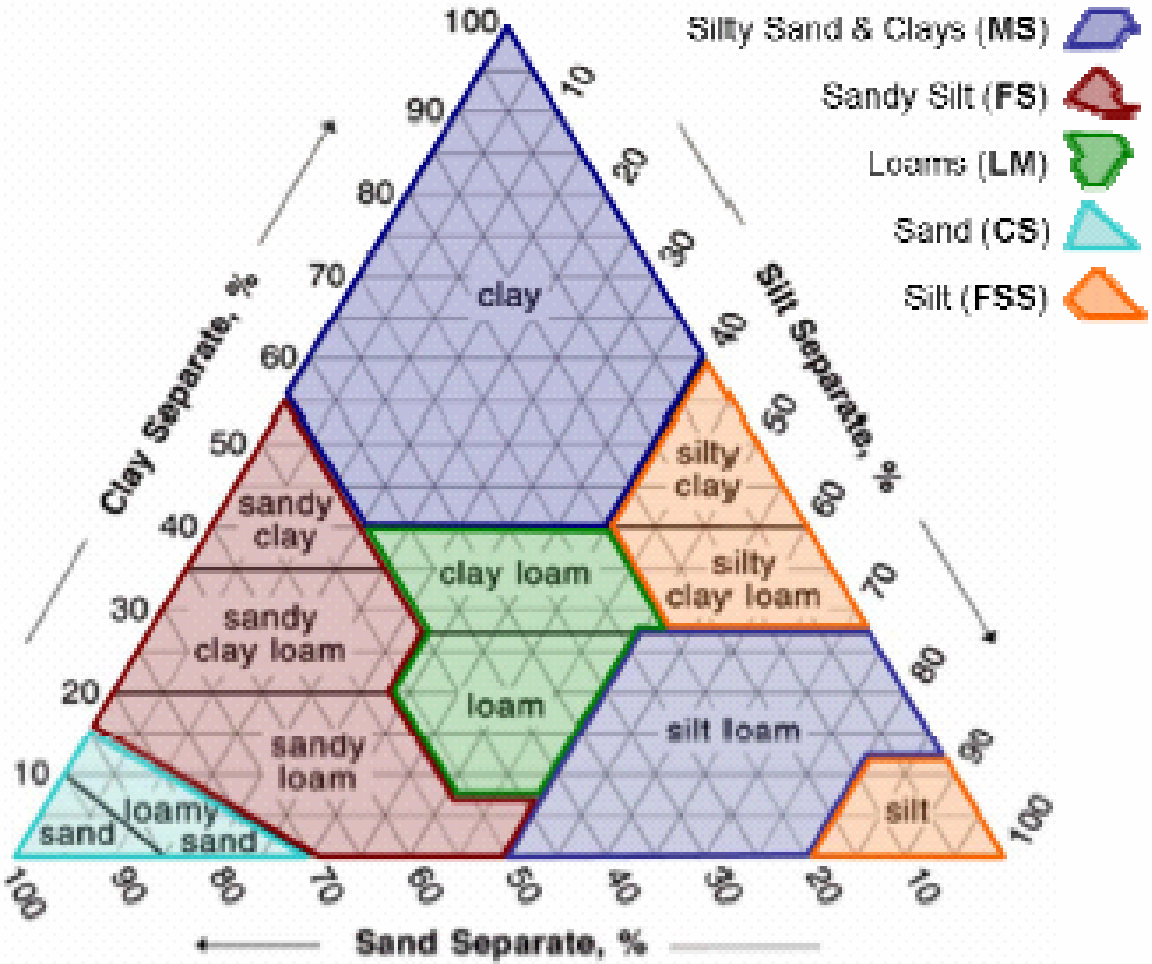
- WEG values developed by USDA/NRCS to indicate the susceptibility of surface soil to blowing (Nine WEG values)
- Soil blowing correlated with:
  - Soil texture
  - Organic matter content
  - Effervescence due to carbonate reaction with HCl
  - Rock and pararock fragment content
  - Mineralogy
  - Soil moisture and frozen soil

PM-10 Emission Categories vs. Wind Erodibility Groups

- 1 – Silty Sand & Clay (WEG 4 and 5)
- 2 – Sandy Silt (WEG 2 and 3)
- 3 – Loam (WEG 4L)
- 4 – Sand (WEG 1)
- 5 – Silt (WEG 6 and 7)

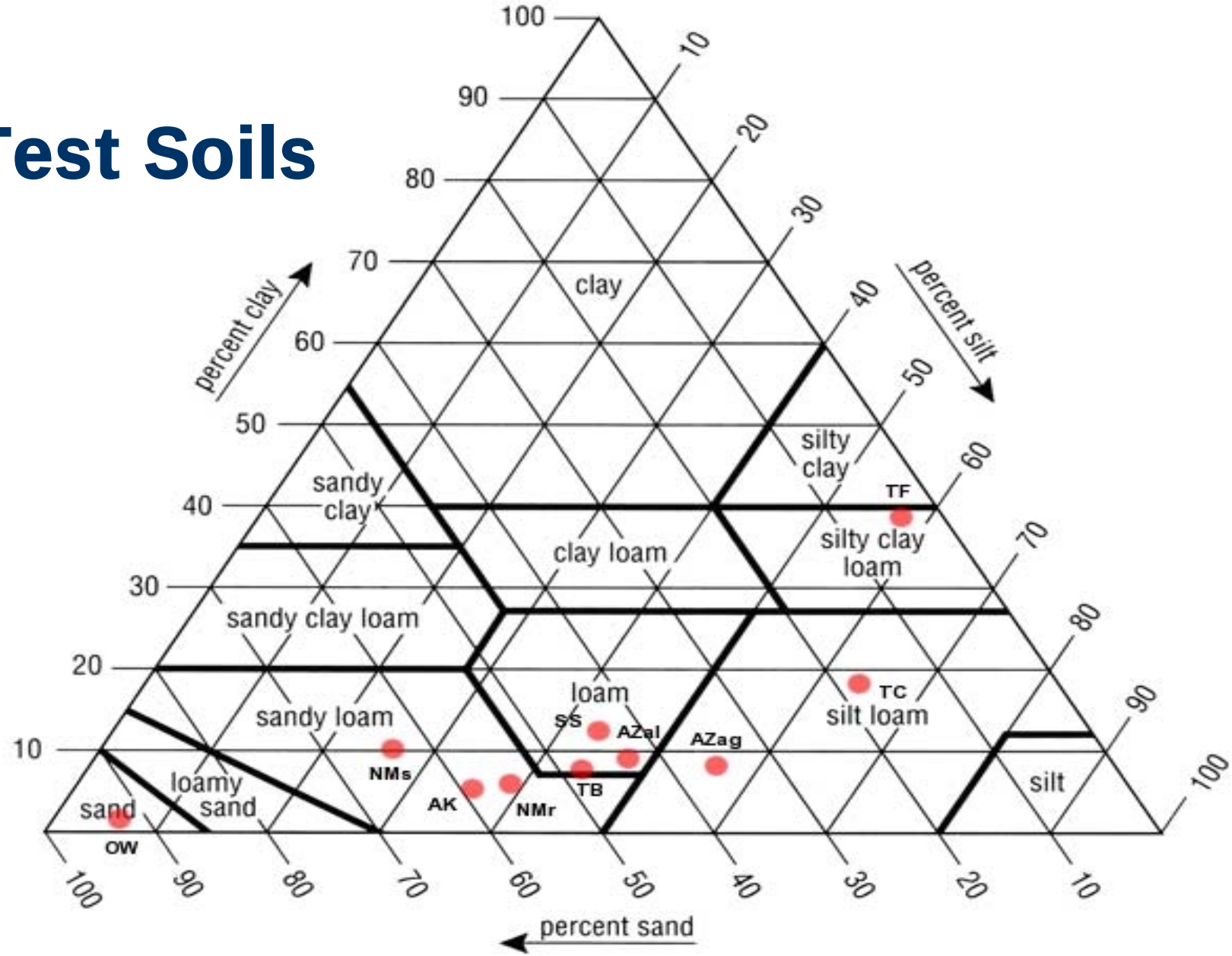
Note: USDA provides national soil database (SSURGO) with WEG values for GIS analysis.

Soil Texture Triangle



Soil Textures
Assignment Triangle
(Figure 1-8)

Test Soils


100
90
80
70
60
50
40
30
20
10
percent clay
percent silt
percent sand
clay
silty clay
sandy clay
silty clay loam
clay loam
sandy clay loam
loam
silt loam
sandy loam
silt
loamy sand
sand
TF
TC
SS
AZal
AZag
NMs
TB
AK
NMr
OW

Results of Controlled Wind Tunnel Study

- PM2.5 concentrations measured by the high-volume cyclone/impactor were factor-of-2 higher than measured by reference-method samplers.
- Geometric mean bias of 2.01
- Arithmetic mean bias of 2.15

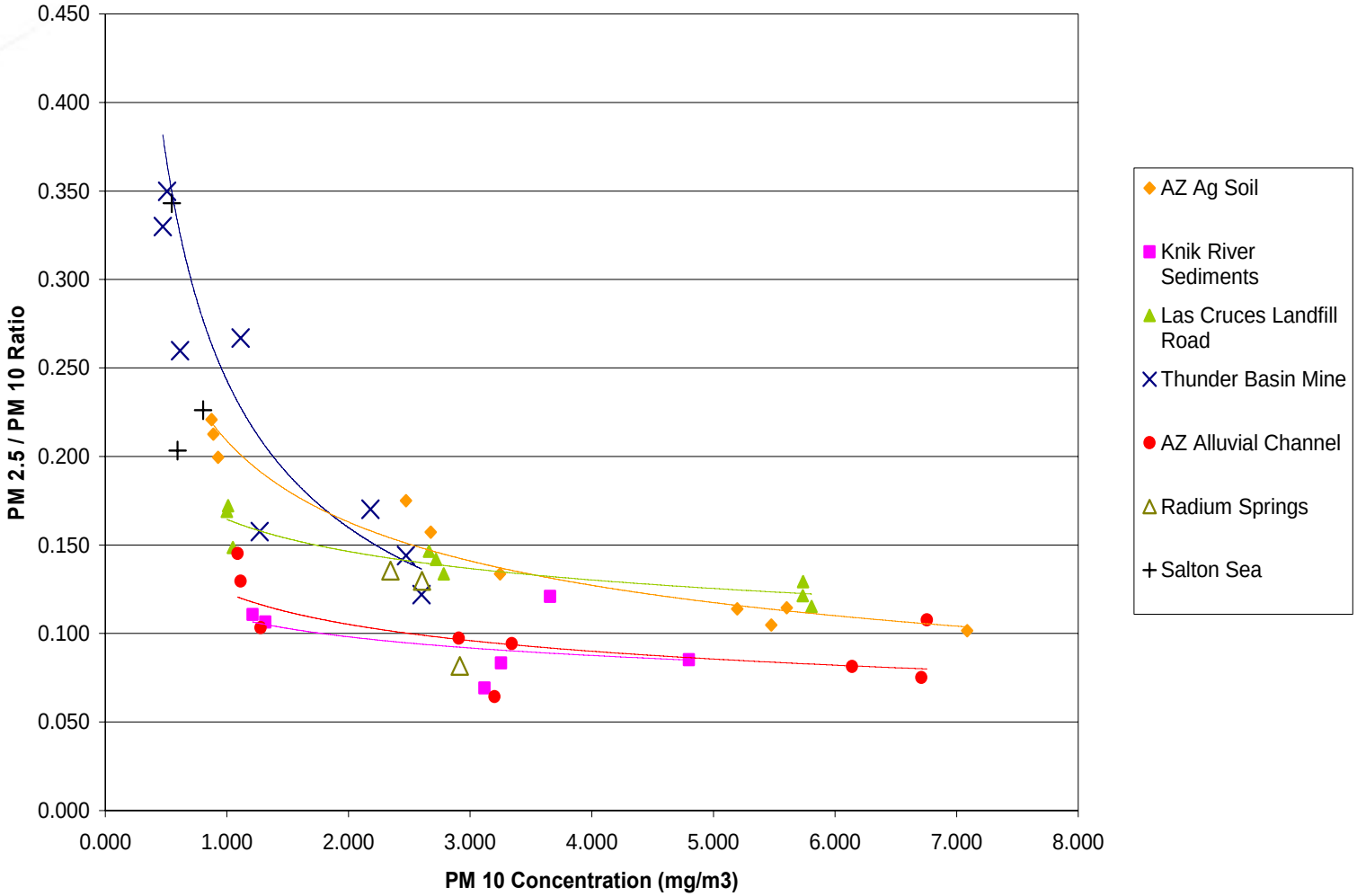
Comparability of Field and Laboratory Test Results

- PM2.5 bias of cyclone/impactor system
  - Measured under controlled laboratory conditions
  - Closely replicated by the bias observed in the prior EPA-funded field study
  - Both studies used reference method samplers for comparison

Reporting Process

- Test Plan--with opportunity to observe laboratory wind tunnel facility
- Draft Test Report--with independent peer reviewers
- Comment/Response Log--for each review comment
- Revised Test Report

C/I Biases from Lab Study



Recommended AP-42 Fine Fractions

- Paved Roads [13.2.1]
- Unpaved Roads (Public & Industrial) [13.2.2]
- Construction & Demolition [13.2.3]
- Aggregate Handling & Storage Piles [13.2.4]
- Industrial Wind Erosion [13.2.5]
- Agricultural Tilling
- Open Area Wind Erosion

Paved Roads

- Current PM2.5/PM10 Ratios
  - Dust component: 0.25
  - Non-dust component: 0.76
- Proposed Change
  - Dust component: **0.15**
- Justification
  - Factor of 2 bias in cyclone/impactor data

Unpaved Roads

- Current PM2.5/PM10 ratio: 0.15
- Proposed PM2.5/PM10 ratio: **0.1**
- Justification
  - Controlled wind tunnel test results
  - Field test results

Construction & Demolition

- AP-42 recommends referring to other sections (e.g., unpaved roads)
- Category emissions normally dominated by travel over unpaved surfaces
- Proposed PM2.5/PM10 ratio: **0.1** (ref. earlier justification)
- Large cleared areas possible significant source of wind erosion (ref. section on open area wind erosion)

Aggregate Handling and Storage Piles

- Open storage pile emissions usually dominated by traffic on unpaved surfaces around piles
- Proposed PM2.5/PM10 ratio: **0.1** (ref. earlier justification)
- Proposed PM2.5/PM10 ratio for transfer operations: **0.15** (justification based on factor-of-two bias in cyclone/impactor system)

Industrial Wind Erosion

- Examples include open tailings piles or raw material storage piles
- Proposed PM2.5/PM10 ratio: **0.15**
- Justification based on
  - Controlled wind tunnel test results
  - Prior tests with portable wind tunnel

Agricultural Tilling

- Original AP-42 section “under review”
- WRAP Handbook recommends PM2.5/PM10 ratio of 0.2
- Ratio of **0.2** consistent with controlled wind tunnel results, considering lower plume concentrations generated by slow moving implements

Open Area Wind Erosion

- Examples are disturbed soils such as agricultural fields
- Prior portable wind tunnel tests show ratios in the range of 0.3
- Proposed PM2.5/PM10 ratio: **0.15**
- Justification:
  - Factor-of-two bias in C/I system
  - Owens Lake plume data

Summary of Proposed Fine Fractions

Fugitive dust source category	AP-42 section	$PM_{2.5}/PM_{10}$ Ratio	
		Current	Proposed
Paved Roads	13.2.1	0.25	0.15
Unpaved Roads (Public & Industrial)	13.2.2	0.15	0.1
Construction & Demolition	13.2.3	0.208	0.1
Aggregate Handling & Storage Piles	13.2.4	0.314 (transfer)	0.1 (traffic) 0.15 (transfer)
Industrial Wind Erosion	13.2.5	0.40	0.15
Agricultural Tilling	–	0.222	0.2 (no change)
Open Area Wind Erosion	–	-	0.15

Conclusions

- Tested materials showed consistent particle size characteristics under constant energy input
- Tests results consistent with prior field study
- Sound basis for proposed revisions to PM2.5/PM10 ratios in AP-42