Correlating Particulate Matter Mobile Source Emissions to Ambient Air Quality

Kevin N. Black, Federal Highway Administration
Frank Divita Jr, Ph.D., E.H. Pechan & Associates
Richard A. Margiotta, Ph.D., Cambridge Systematics, Inc.
Randall Guensler, Ph.D., Trans/AQ

EPA Emission Inventory Conference
June 10, 2004

Background

- Mobile Source component of emissions uncertain
- FHWA PM Research Program
- Designation of nonattainment Areas of NAAQS $PM_{2.5}$ Standard and development of control strategies for SIPs
- Areas must know apportionment of sources, conformity analyses required

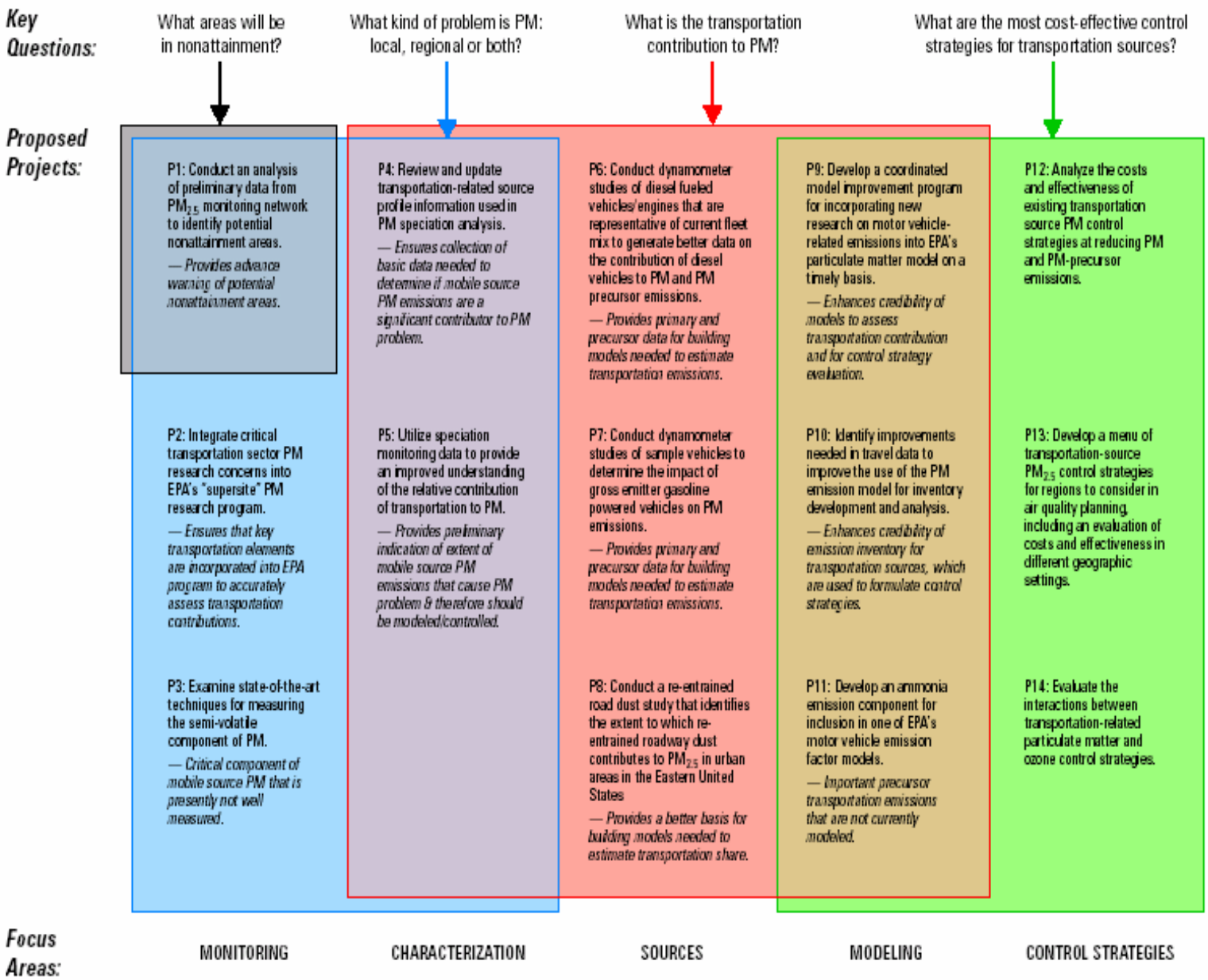
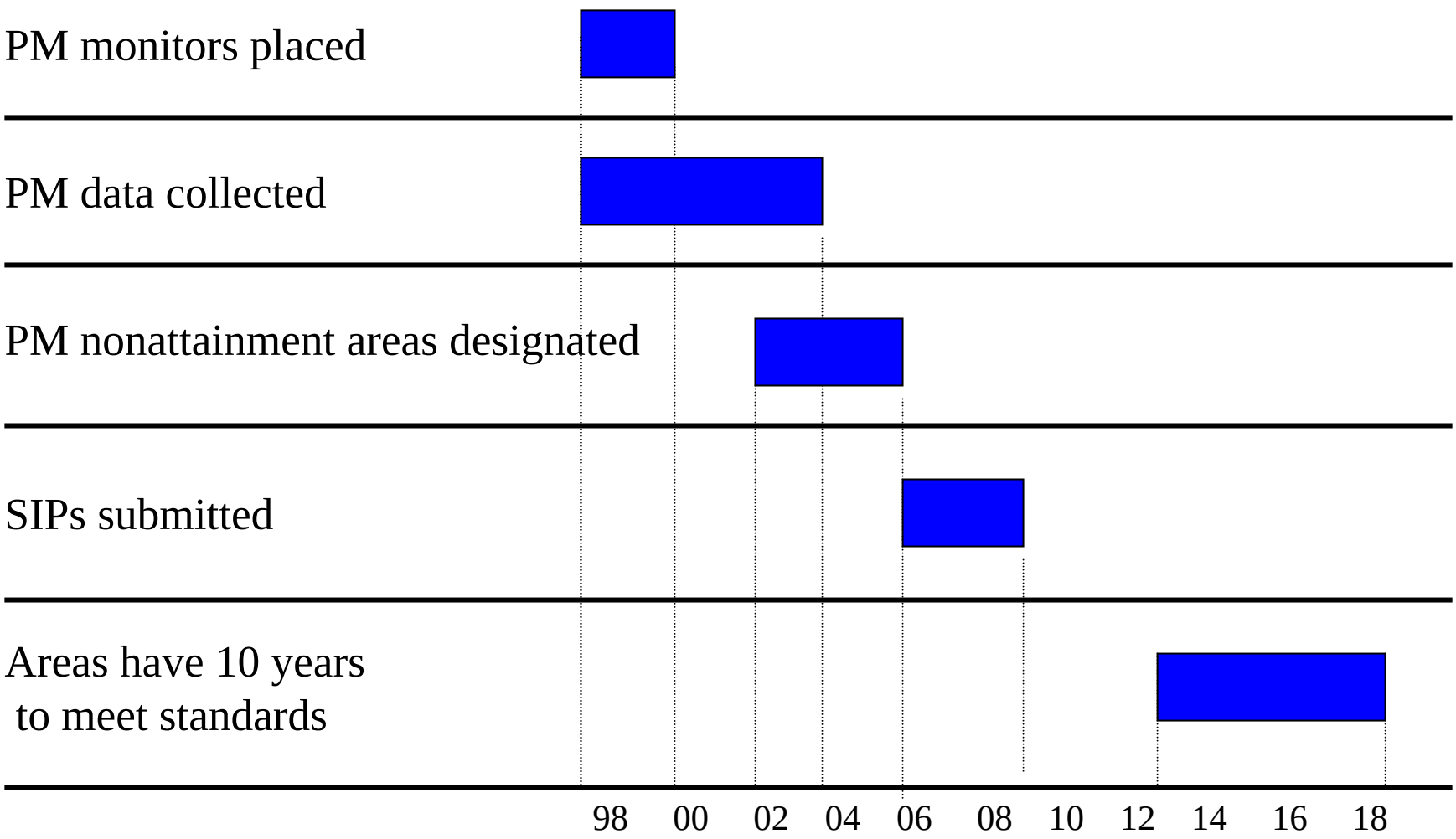
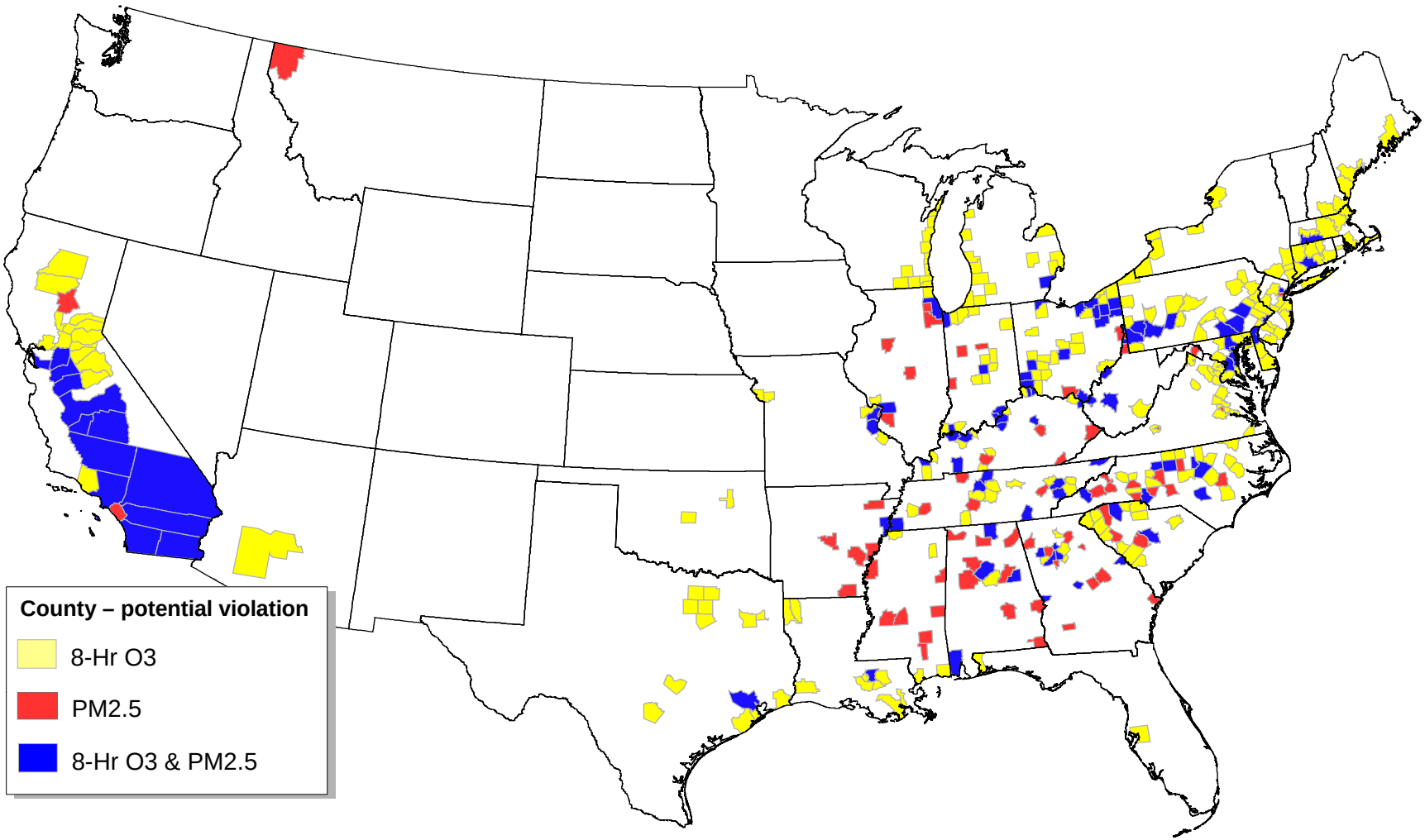


Figure 3. Connection Between Transportation Issues and Research Agenda

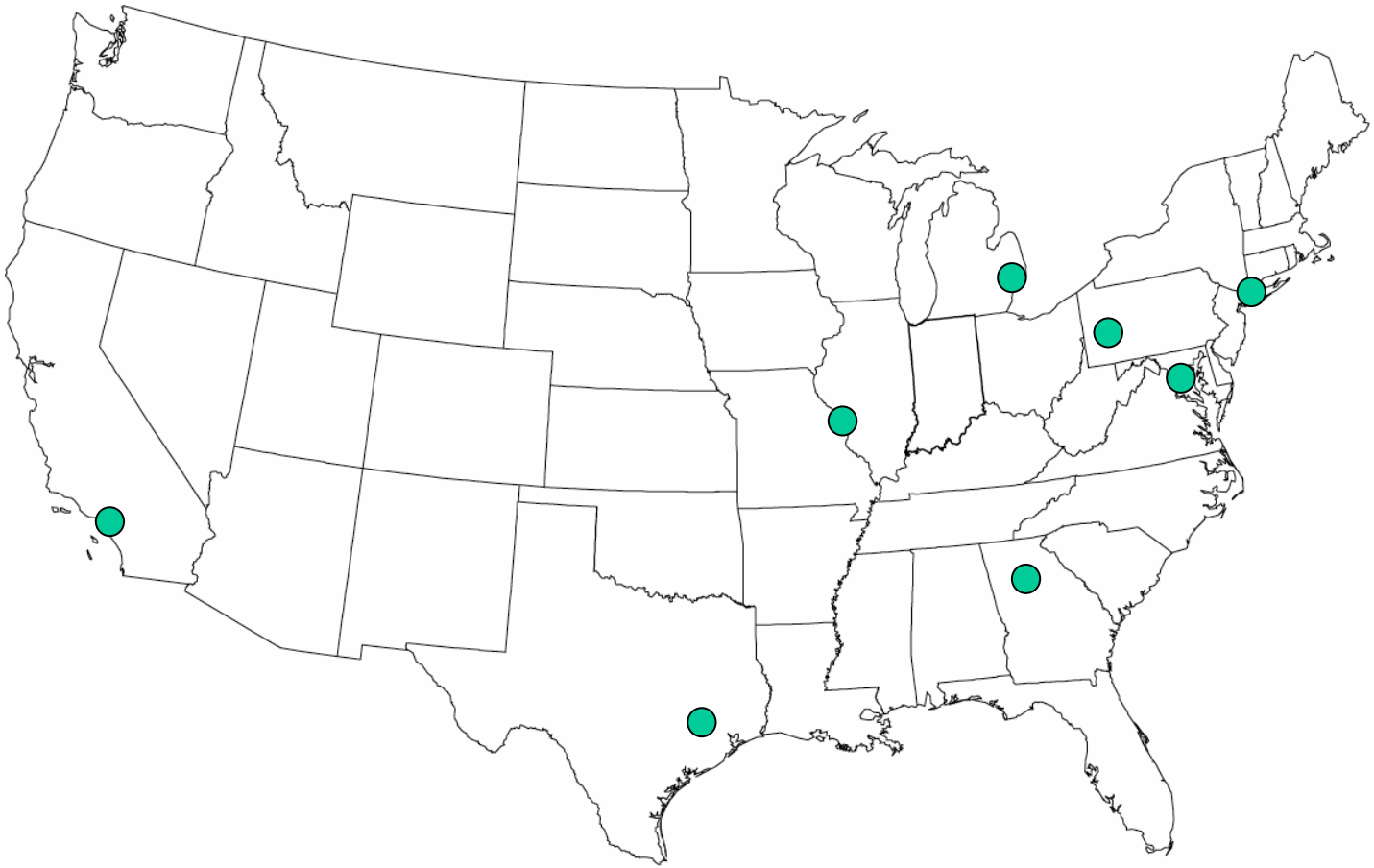
$PM_{2.5}$ Standard Implementation Schedule



Potential Violations of PM2.5 and 8-Hr Ozone



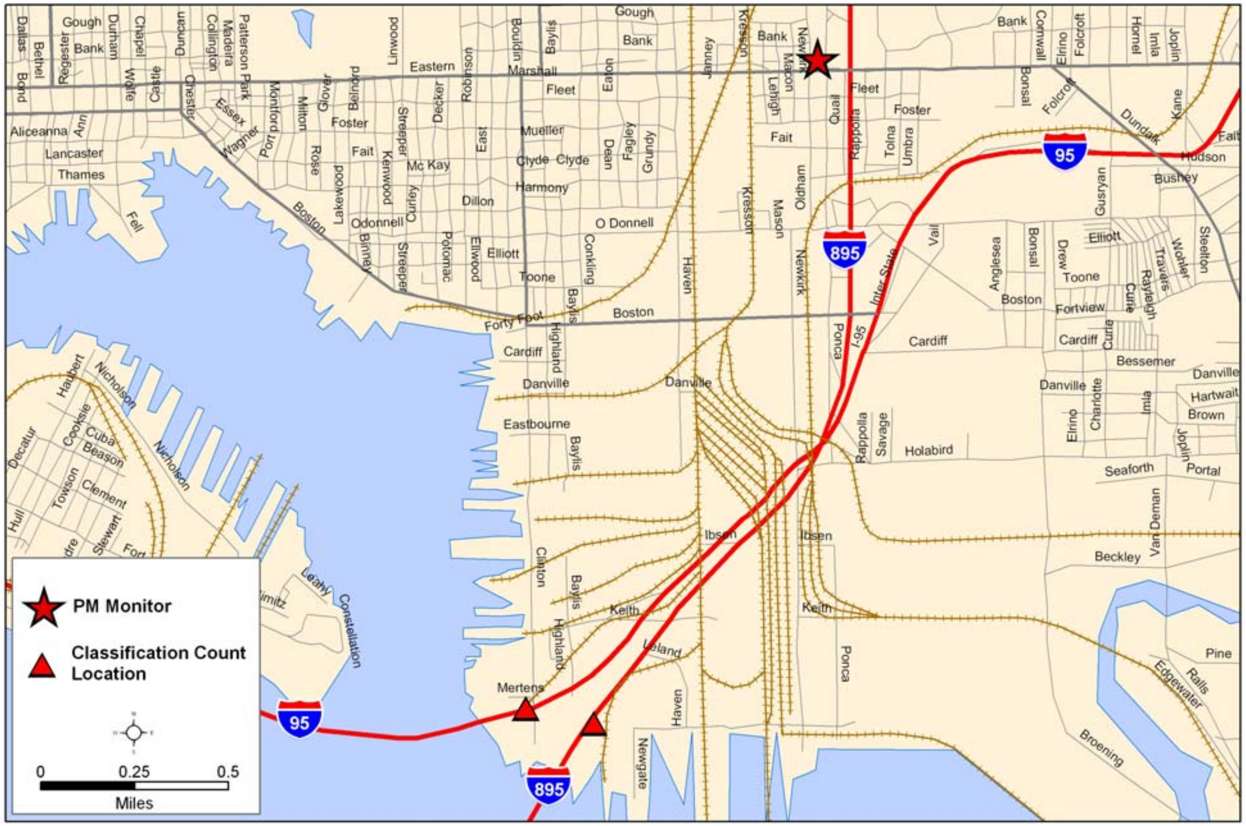
Locations Selected for PM Study



Cities Selected for the PM Study

- Baltimore
- Detroit
- New York
- Pittsburgh
- Atlanta

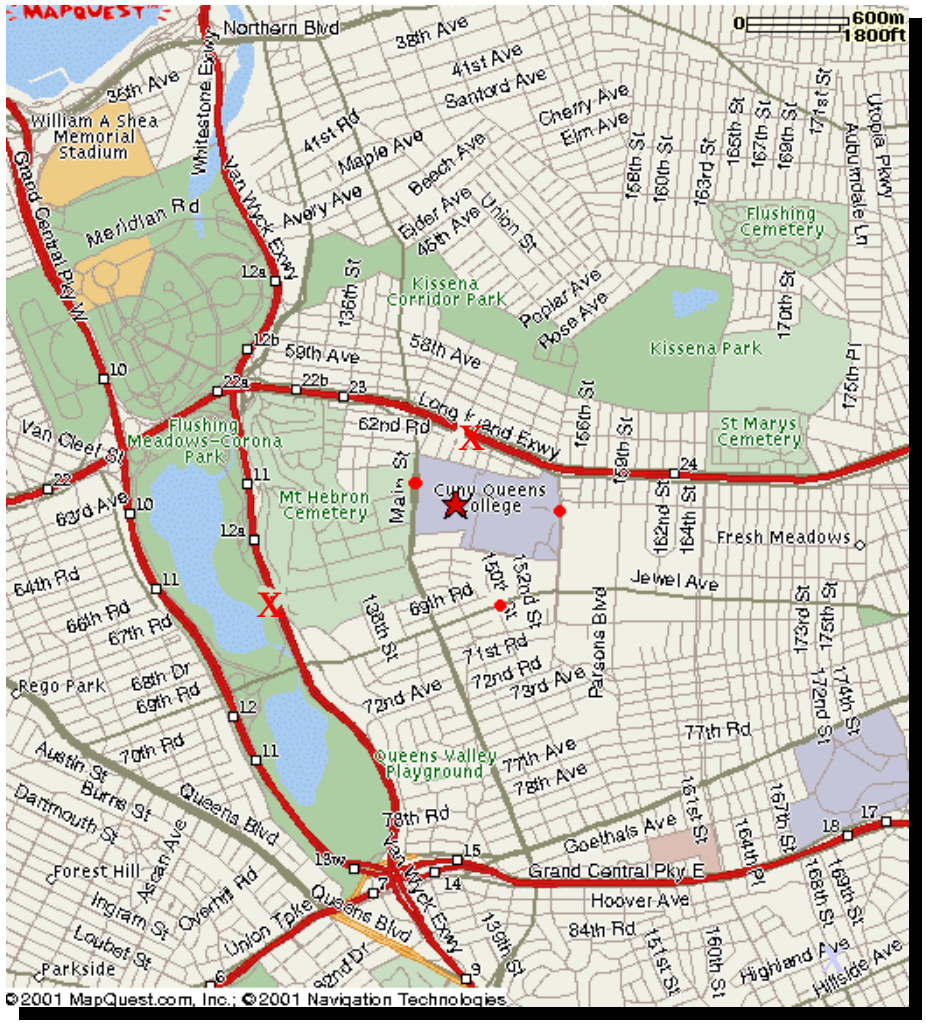
Baltimore



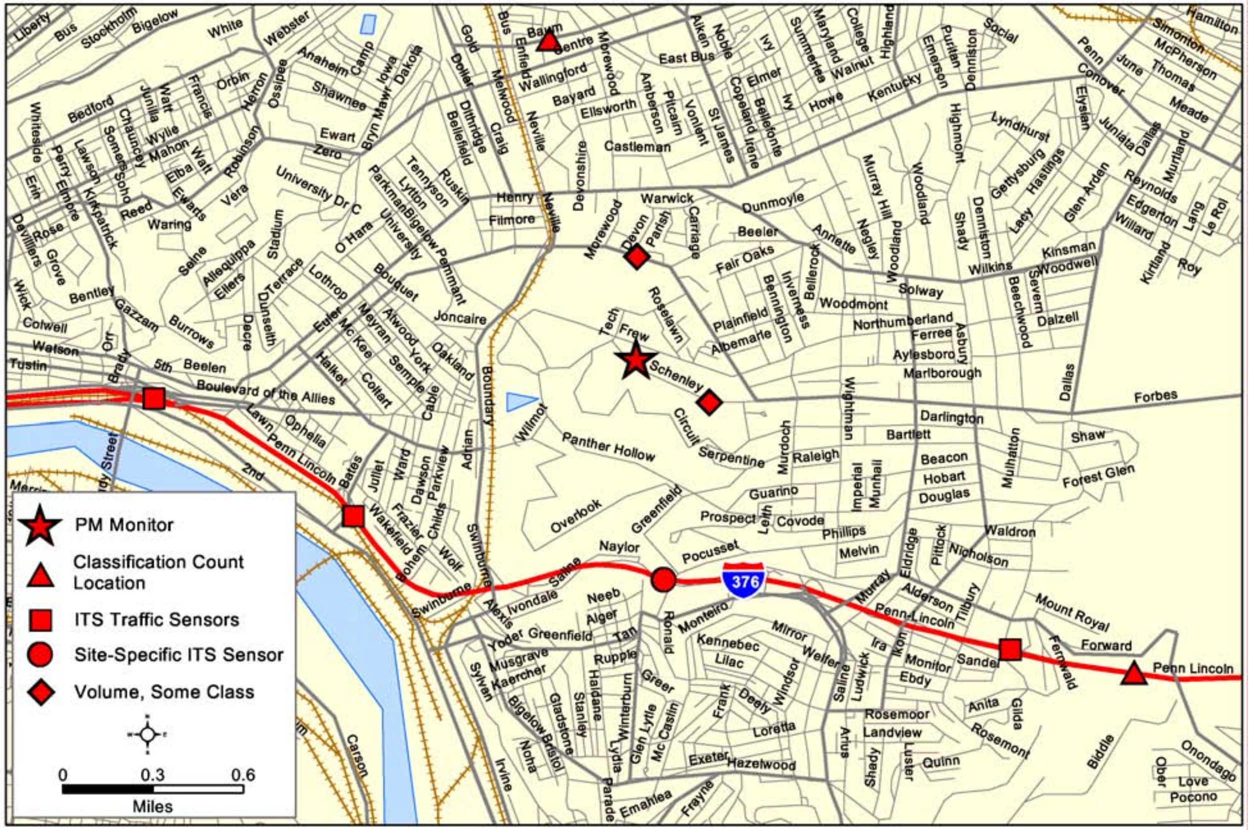
Detroit


PM Monitor
Classification Count Locations
ITS Traffic Sensors
Site-Specific ITS Sensor
0
0.5
1
Miles
75

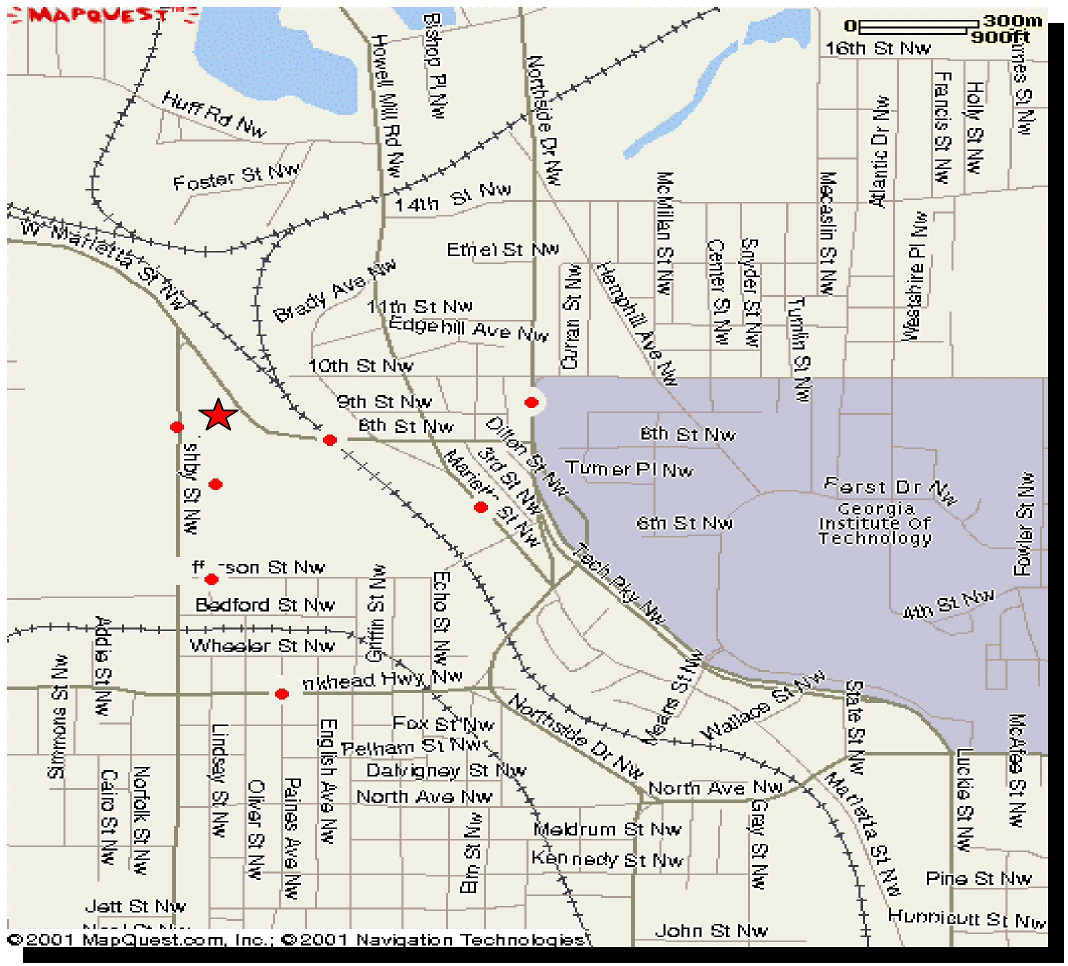
New York


MAPQUEST
0
600m
1800ft
Northern Blvd
38th Ave
41st Ave
Sanford Ave
35th Ave
William A Shea Memorial Stadium
Whitestone Expwy
Grand Central Pkwy W
Meridian Rd
41st Rd
Maple Ave
Beach Ave
Cherry Ave
Elm Ave
Avery Ave
Elder Ave
45th Ave
Union St
Van Wyck Expwy
Kissena Corridor Park
Flushing Cemetery
Kissena Park
Poplar Ave
Rose Ave
136th St
158th St
160th St
163rd St
165th St
167th St
169th St
171st St
Utopia Pkwy
Auburndale Ln
170th St
175th Pl
59th Ave
58th Ave
62nd Rd
Long Island Expwy
156th St
159th St
St Marys Cemetery
Van Cleef St
Flushing Meadows-Corona Park
63rd Ave
Mt Hebron Cemetery
Main St
Cuny Queens College
162nd St
164th St
Fresh Meadows
64th Rd
66th Rd
67th Rd
68th Dr
69th Rd
Rego Park
Jewel Ave
138th St
69th Rd
71st Rd
72nd Rd
73rd Ave
72nd Ave
Parsons Blvd
173rd St
175th St
177th St
70th Rd
Austin St
Burns St
Dartmouth St
Queens Blvd
Queens Valley Playground
77th Ave
78th Ave
77th Rd
78th Rd
169th St
Goethals Ave
Grand Central Pkwy E
Hoover Ave
84th Rd
Forest Hill
Ascan Ave
Overhill Rd
Ingram St
Laubet St
Parkside
Union Tpke
Queens Blvd
62nd Dr
Van Wyck Expwy
139th St
151st St
160th St
168th St
169th St
Highland Ave
Hillside Ave
©2001 MapQuest.com, Inc.; ©2001 Navigation Technologies

Pittsburgh


PM Monitor
Classification Count Location
ITS Traffic Sensors
Site-Specific ITS Sensor
Volume, Some Class
0
0.3
0.6
Miles
376
Forbes
Fifth
Boulevard of the Allies
Penn Lincoln
Panther Hollow
Schenley
Baum
Centre
Greenfield
Forward
Mount Royal
Carson
Bigelow
Liberty
Murray
Beechwood
Wightman
Shady
Overlook
Pocusset
Naylor
Hazelwood

Atlanta


MAPQUEST
0
300m
900ft
16th St Nw
Huff Rd Nw
Foster St Nw
Howell Mill Rd Nw
Bishop Pl Nw
Northside Dr Nw
14th St Nw
W Marietta St Nw
Ethel St Nw
Brady Ave Nw
11th St Nw
Edgehill Ave Nw
10th St Nw
9th St Nw
8th St Nw
McMillan St Nw
Center St Nw
Snyder St Nw
Mecaslin St Nw
Atlantic Dr Nw
Francis St Nw
Holly St Nw
Westshire Pl Nw
Curran St Nw
Hemphill Ave Nw
Turnlin St Nw
Dalton St Nw
3rd St Nw
Marietta St Nw
6th St Nw
Turner Pl Nw
Ferst Dr Nw
Georgia Institute of Technology
6th St Nw
Tech Pky Nw
Fowler St Nw
4th St Nw
Bedford St Nw
Wheeler St Nw
Griffin St Nw
Echo St Nw
Addie St Nw
Simmons St Nw
Fox St Nw
Pelham St Nw
Dalvigney St Nw
North Ave Nw
Northside Dr Nw
Means St Nw
Wallace St Nw
State St Nw
McAfee St Nw
Luckie St Nw
Cairo St Nw
Norfolk St Nw
Lindsay St Nw
Oliver St Nw
Paines Ave Nw
English Ave Nw
Elm St Nw
Meldrum St Nw
Kennedy St Nw
Gray St Nw
Marietta St Nw
Pine St Nw
Hunnicutt St Nw
John St Nw
Jett St Nw
©2001 MapQuest.com, Inc.; ©2001 Navigation Technologies

Study Variations Considered

- Temporal Variations
  - Time of Day (morning, mid-day, evening)
  - Time of Week (weekday versus weekend)
  - Time of year (seasonal variations)
- Spatial Variations
  - Within Region
  - Across Country (Northeast, Mid-Atlantic, Southeast, Midwest)

Other Variations Considered

- Vehicle types (gasoline, diesel)
- Atmospheric transport
- Fugitive dust
- Background

Data Used in The Study

- Traffic Data
  - Regional Counts
  - Local Counts
  - Supplemental Counts
- Ambient PM Data
  - PM, PM precursors, other pollutants
- Meteorological Data
  - Wind direction, speed, temperature, other

Traffic Data

Site	Location	Measurement	Parameter	Duration	Notes
New York	Long Island Expwy, Kissena Blvd, Jewel Ave, Main St.	ITS, special counts	Volume, speed, occupancy	ITS continuously for CY2001-2002, counts variable	85 freeway miles, 191 count locations
Baltimore	Toll Plazas at Tunnels	ITS/AVC, special counts	Volume, vehicle class	Continuous for CY2002	
Pittsburgh	Freeways, Schenley Avenue	ITS	Volume, speed, occupancy	Continuously for CY2001-2002, other counts variable	78 freeway miles, 58 count locations
Detroit	Freeways, 6-Mile Road	ITS, special counts	Volume, speed, occupancy, vehicle class	Continuously for CY2001-2002, other counts variable	117 freeway miles, 58 count locations
Atlanta	Freeways, Jefferson St	ITS, special counts	Volume, speed, occupancy	Continuously for CY2001-2002, other counts variable	95 freeway miles, 240 count locations

Traffic Data

Site	Location	Proximity to PM Monitor (zone of influence)	Volume Vehicles per hour (vph)	Vehicle Classification	Notes
New York	Long Island Expressway, Kissena Blvd, Jewel Ave, Main St	1,600 feet to 6,600 feet	500 to 5000 vph	13 length based classes	Local volumes
Baltimore	Toll Plazas at Tunnels	400 feet to 1.9 miles	500 to 5000 vph	6 axle based classes	Local volumes
Pittsburgh	Freeways, Schenley Ave	3,700 feet to 3 miles	1000 to 7000 vph		Local volumes
Detroit	Freeways, 6-Mile Road	2,000 feet to 4.6 miles	500 to 4000 vph	13 length based classes	Local volumes
Atlanta	Freeways, Jefferson St	1.3 miles to 4.8 miles	50,000 to 300,000 vph		Regional and Local volumes

Air Quality Data

	Site Location	Site Type	$PM_{2.5}$ Measurement Dates	PM Data Obtained by the Team	Sampling Duration
1	Atlanta, GA	Supersite	July 1999 - Ongoing	Aug. 2002 - Sept. 2002	Ongoing
2	St. Louis, MO	Supersite	April 2001 - Ongoing	July 2001	12 months or longer
3	Pittsburgh, PA	Supersite	June 2001 - Aug. 2002	July 2001 - Aug. 2002	18 months
4	Baltimore, MD	Supersite	Jan. 2002 - Jan. 2003	Jan. 2002 - Jan. 2003	12 months
5	Los Angeles, CA	Supersite	Oct. 2000 - Ongoing	Oct. 2001 - July 2002	Ongoing
6	Queens, NY	Supersite/ AIRS	1997 - Ongoing	Jan. 2001 - Sept. 2002	Ongoing
7	Detroit, MI: Goddard, Towner	AIRS	1997 - Ongoing	Jan. 2001 - Dec. 2001	Ongoing
8	Seattle, WA: 0057, 2004, 0017	AIRS	1997 - Ongoing	None	Ongoing

Air Quality Data

Site	Location	Measurement	Parameter	Duration	Notes
New York	New York Supersite	Air Quality	$PM_{2.5}$ mass, EC, OC, CO, NOx, NO_2, SO_2, O_3, Trace Elements, Organics	1 hour to 24 hours	
Baltimore	Baltimore Supersite	Air Quality	$PM_{2.5}$ mass, EC, OC, CO, NO, NOx, NO_2, SO_2, O_3, Trace Elements, other	1 hour to 24 hours	NO_3, Na, NH_4, SO_4
Pittsburgh	Pittsburgh Supersite	Air Quality	$PM_{2.5}$ mass, EC, OC, CO, NO, NOx, NO_2, SO_2, O_3, Trace Elements, other	1 hour to 24 hours	NO_3, NH_4, SO_4, Cl
Detroit	Goddard Street	Air Quality	$PM_{2.5}$ mass, EC, OC, Trace Elements, Organics, other	1 hour to 24 hours	Na, NH_4, SO_4
Atlanta	Atlanta Supersite	Air Quality	$PM_{2.5}$ mass, EC, OC, CO, NO_3, Trace Elements	1 hour to 24 hours	

Air Quality Data - Baltimore

City	Location	Measurement	Parameter	Duration	Year	
					2001	2002
Baltimore	Ponca Street	Air Quality	$PM_{2.5}$ Mass	1-hr	Jan-Dec	Jan-Sep
			EC, OC	24-hr	Apr-Dec	Jan-Aug
			CO, NO_X	1-hr	Jun-Dec	Jan-Aug
			NO_2, SO_2, O_3	1-hr	Jun-Dec	
			Trace Elements, Organics	1-hr, 24-hr	Jan-Dec	

Meteorological Data

Site	Location	Measurement	Parameter	Duration	Notes
New York	New York Supersite	Meteorology	WD, WS, temperature, barometric pressure	1 hour	other parameters may have been measured but only those used are noted
Baltimore	Baltimore Supersite	Meteorology	WD, WS, temperature, barometric pressure	1 hour	other parameters may have been measured but only those used are noted
Pittsburgh	Pittsburgh Supersite	Meteorology	WD, WS, temperature, barometric pressure	1 hour	other parameters may have been measured but only those used are noted
Detroit	Goddard Street	Meteorology	WD, WS, temperature, barometric pressure	1 hour	other parameters may have been measured but only those used are noted
Atlanta	Atlanta Supersite	Meteorology	WD, WS, temperature, barometric pressure	1 hour	other parameters may have been measured but only those used are noted

Data Analysis

- Graphical Correlation Analysis
- Statistical Correlation Analysis

  General

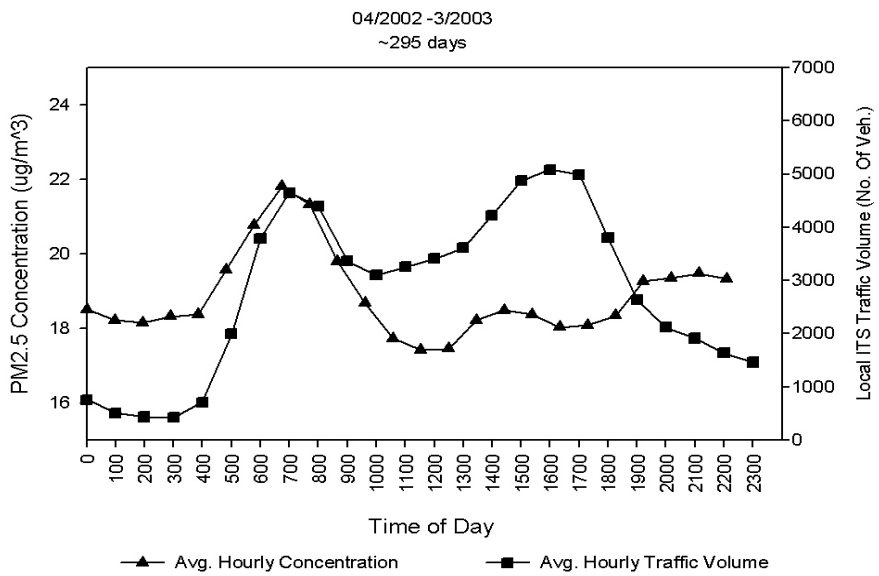
  Pearson

  Analysis of Covariance

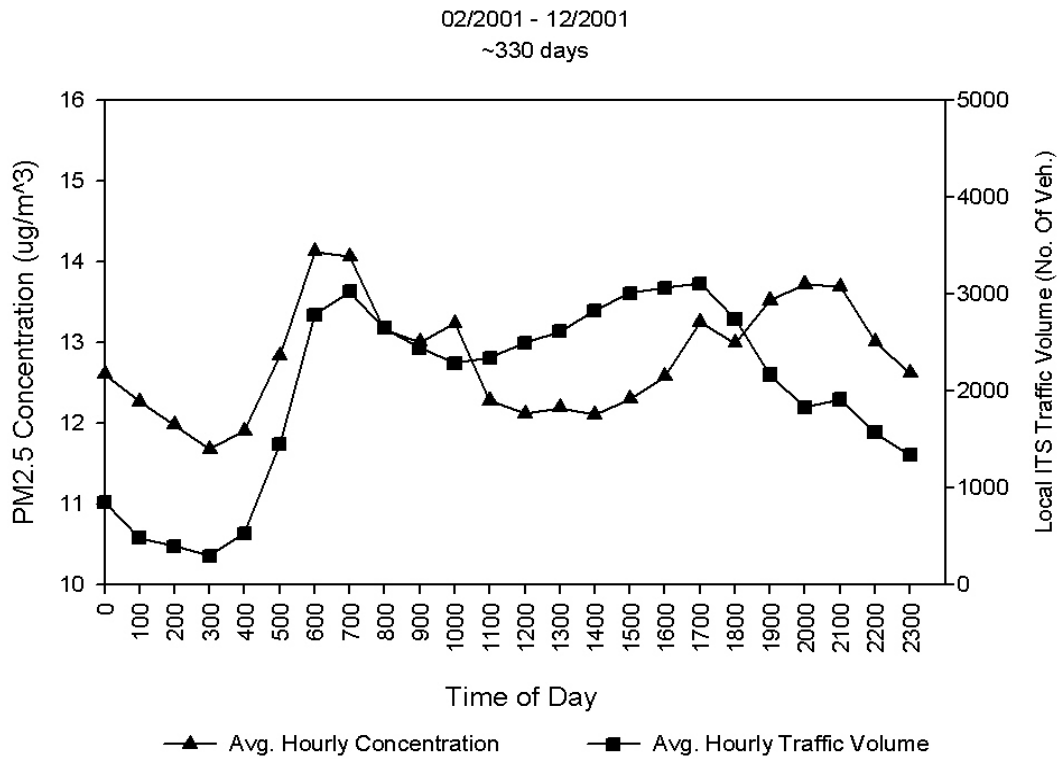
Graphical Analysis

- Traffic plotted against $PM_{2.5}$ Ambient Concentrations
- Data plotted represents different time periods based on site sampling frequency

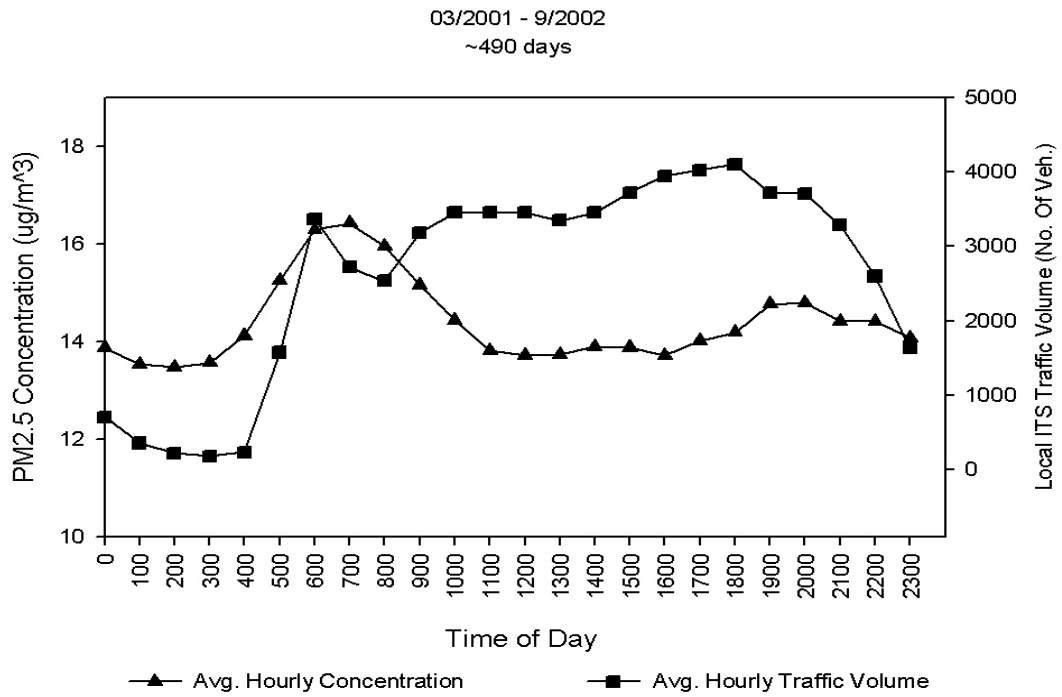
Graphical Analysis for Baltimore



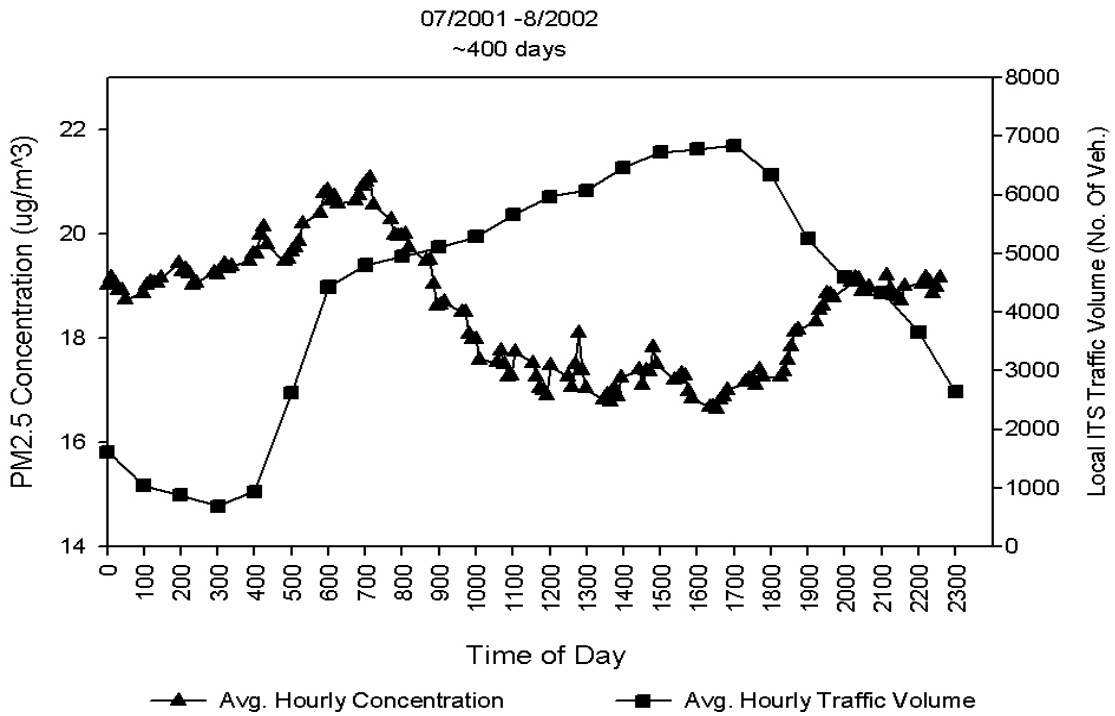
Graphical Analysis for Detroit



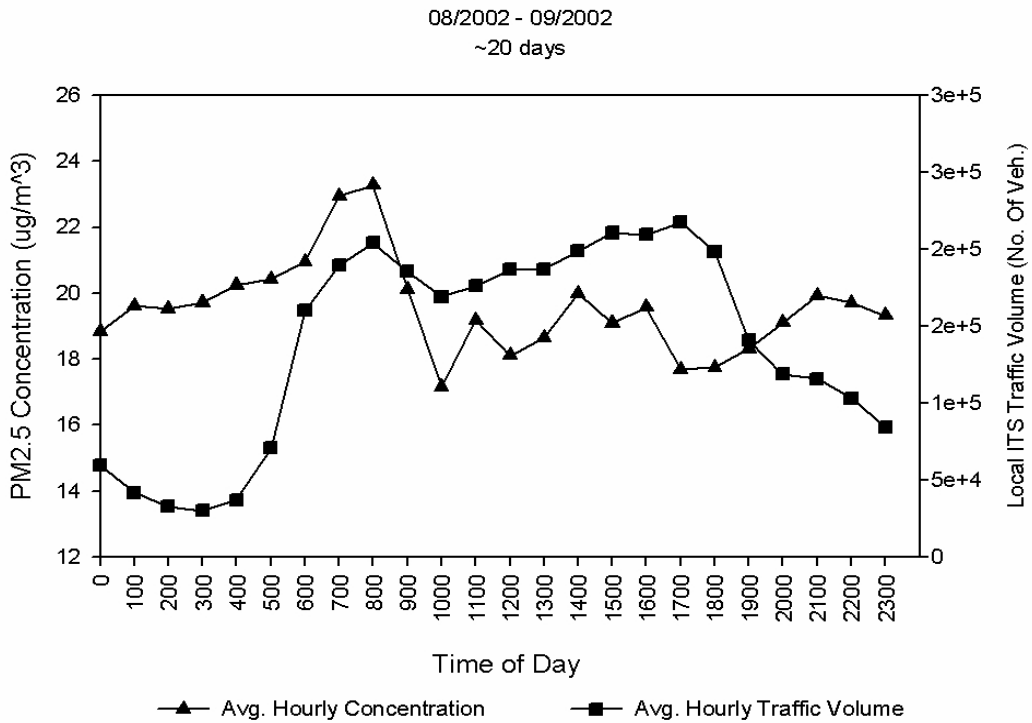
Graphical Analysis for New York



Graphical Analysis for Pittsburgh



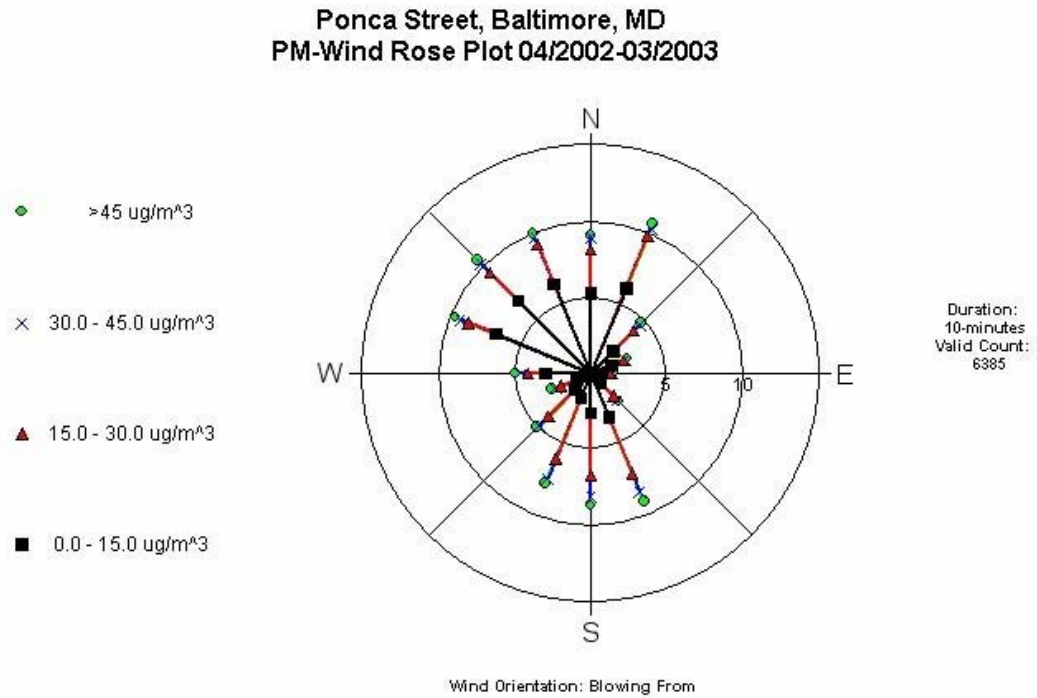
Graphical Analysis for Atlanta



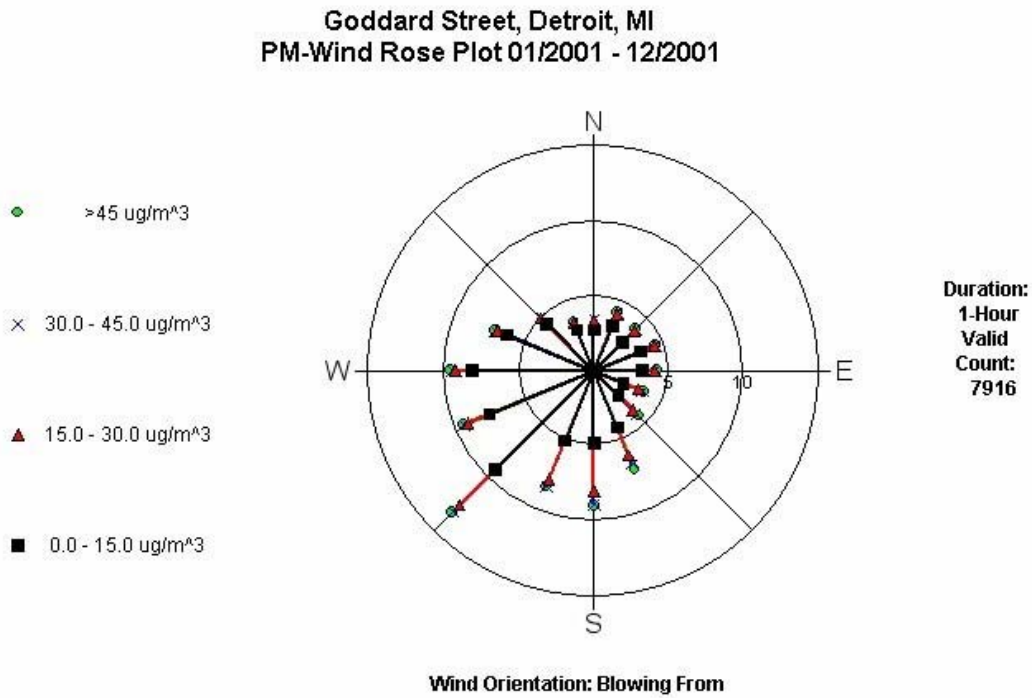
Weekday vs. Weekend Comparisons

	Weekend		Weekday	
City	**Daily Avg. $PM_{2.5}$**	**Regional VMT (thousands)**	**Daily Avg. $PM_{2.5}$**	**Regional VMT (thousands)**
Baltimore	17.44	N/A	19.53	N/A
Detroit	11.36	10,884	13.45	15,755
Los Angeles	31.99	51,372	46.47	59,653
New York[1]	12.34	4,242	15.28	5,314
Pittsburgh	17.07	3,114	19.24	4,107

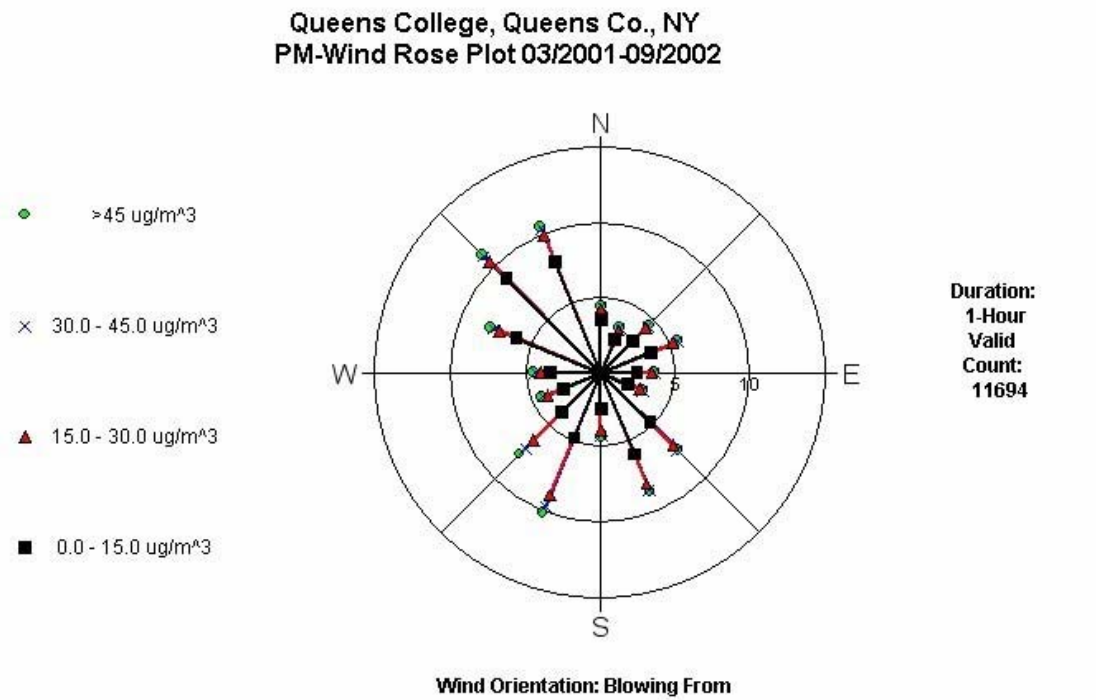
Meteorological Analysis for Baltimore



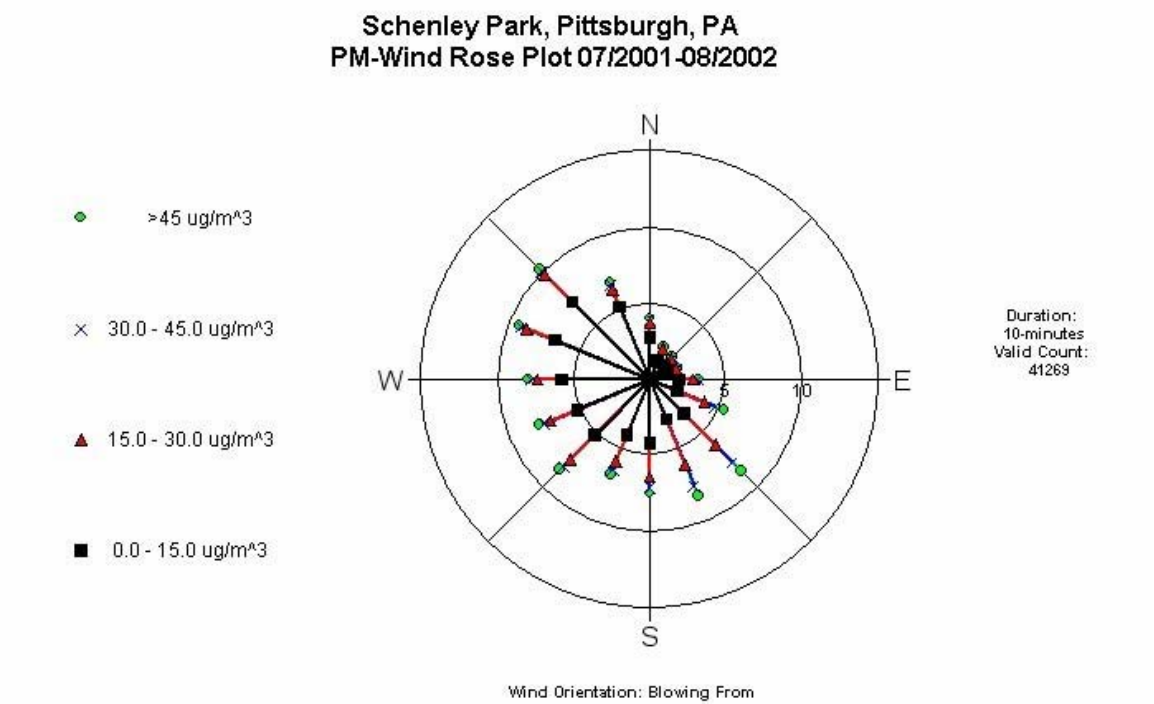
Meteorological Analysis for Detroit



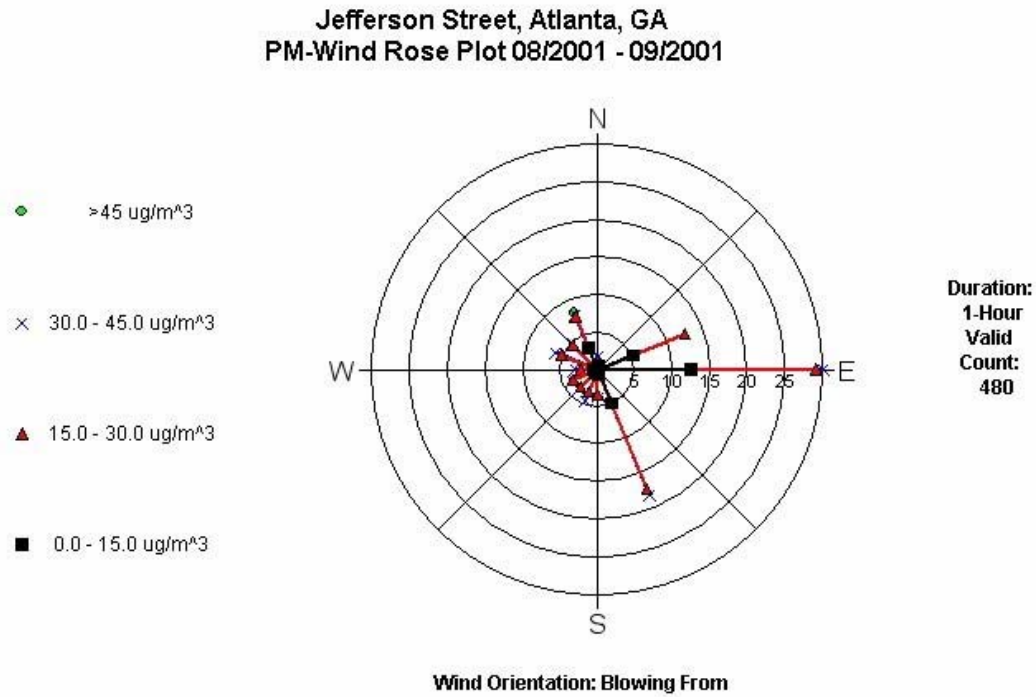
Meteorological Analysis for New York



Meteorological Analysis for Pittsburgh



Meteorological Analysis for Atlanta



Statistical Analysis

- Various statistical parameters compared including (number of measurements, minimum value, maximum value, mean, median)
- Allowed comparison with NAAQS
- Allowed comparison between cities

Pearson Correlation Coefficients for $PM_{2.5}$

$PM_{2.5}$ Sampling Site		$PM_{2.5}$	Local ITS Volume	Regional VMT	Local Street Volume
Goddard Street, Detroit, MI	Coefficient	1.00000	0.06162	0.06112	-0.10262
	Count	7,883	6,234	6,194	7,883
Riverside, Los Angeles, CA	Coefficient	1.00000		0.40646	
	Count	836		807	
Queens College, Queens, NY	Coefficient	1.00000	0.08928	0.08930	0.05674
	Count	11,746	3,440	2,881	11,746
Schenley Park, Pittsburgh, PA	Coefficient	1.00000	-0.02887	0.12254	
	Count	500	178	123	
Ponca Street, Baltimore, MD	Coefficient	1.00000	0.3513		0.20851
	Count	6,395	5,589		6,395

$PM_{2.5}$ As A Project Level Issue

- Is $PM_{2.5}$ regional issue or a project level issue
- Implications for transportation plans
- Implications for NEPA analysis
- Atlanta site evaluated

$PM_{2.5}$ As A Project Level Issue

- MOBILE-Matrix Model
- CALINE-Grid Model
- Pearson Correlation Analysis

$PM_{2.5}$ As A Project Level Issue

- MOBILE-Matrix
  - MOBILE6 model run in Monte Carlo mode to create a multi-dimensional lookup matrix
  - Emission rates for any link, fleet, speed, temp, etc.
- CALINE-Grid
  - A grid-based iterative CALINE4 application
  - Emissions impacts for a grid of receptors (or one receptor) from every transportation link

Findings

- Graphical analysis suggested weak correlation although some correlation in morning, not in afternoon
- Pearson correlations showed weak correlations at best, some locations no correlation

Findings

- Proximity Effect must be evaluated
- Information needed on other sources
- Information needed on background concentrations

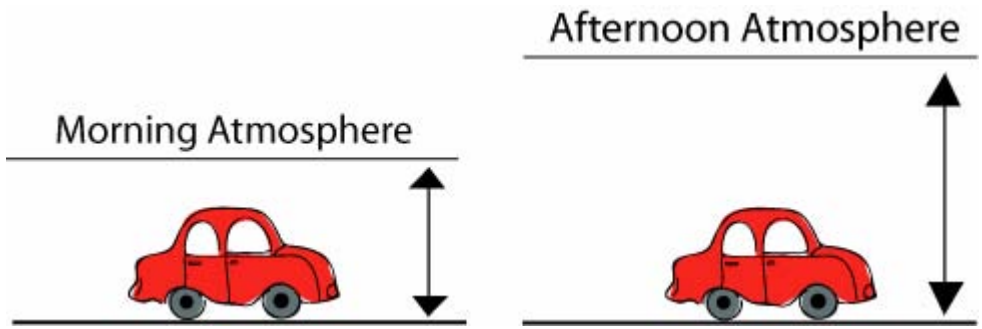
Findings

- Temporal variations exist at least as related to morning/evening/weekends
- Spatial variations exist but no conclusions can be made at this time
- Vehicle type contribution requires further evaluation of speciation data

Findings

- Role of atmospheric processes (transport), fugitive dust, and background must be evaluated
- Atmospheric warming during day may be a factor

Atmospheric Processes Potentially Effecting Concentrations



Summary

- Findings indicate additional work needed
  - Speciation data
  - Modeling data
- Proximity to monitors important
- Surrogate used for analysis may be modified

Summary

- Look at remaining data at current sampling sites
- Apply the Mobile6/CALINE4 modeling tool in other locations
- More information about this project

Kevin Black, FHWA

Kevin.n.black@fhwa.dot.gov