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Ambient Air Quality Monitoring: Siting, Guidance, Evaluation Criteria

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Ambient Monitoring Objectives

1. Provide air pollution data to the general public in a timely manner
2. Support compliance with ambient air quality standards and emissions strategy development
   Providing direct support of the National Ambient Air Quality Standards (NAAQS)
3. Support for air pollution research studies

Current US Ambient Air Quality Standards

National Ambient Air Quality Standards

	Primary Standards		Secondary Standards	
Pollutant	**Level**	**Averaging Time**	**Level**	**Averaging Time**
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour [1]	None	
	35 ppm (40 mg/m^3)	1-hour [1]		
Lead	0.15 µg/m^3 [2]	Rolling 3-Month Average	Same as Primary	
Nitrogen Dioxide	53 ppb [3]	Annual (Arithmetic Average)	Same as Primary	
	100 ppb	1-hour [4]	None	
Particulate Matter (PM_{10})	150 µg/m^3	24-hour [5]	Same as Primary	
Particulate Matter ($PM_{2.5}$)	15.0 µg/m^3	Annual [6] (Arithmetic Average)	Same as Primary	
	35 µg/m^3	24-hour [7]	Same as Primary	
Ozone	0.075 ppm (2008 std)	8-hour [8]	Same as Primary	
	0.08 ppm (1997 std)	0-hour [9]	Same as Primary	
	0.12 ppm	1-hour [10]	Same as Primary	
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Average)	0.5 ppm	3-hour [1]
	0.14 ppm	24-hour [1]		
	75 ppb [11]	1-hour	None	

Current as of June 2011

www.epa.gov/air/criteria

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Overview of U.S. Ambient Air Monitoring Efforts

- Ambient air monitors are operated by state and local (county) air monitoring agencies
- US EPA provides:
  - Minimum monitoring requirements
  - Some or all of necessary funding
  - Technical guidance
  - Measurement methods development and approval
  - Quality assurance (procedures and some oversight)
  - National database for data reporting and archiving
- EPA works with state and local partners to revise monitoring requirements and attempt to keep networks updated based on changes in emissions, demographics, technology, and national standards

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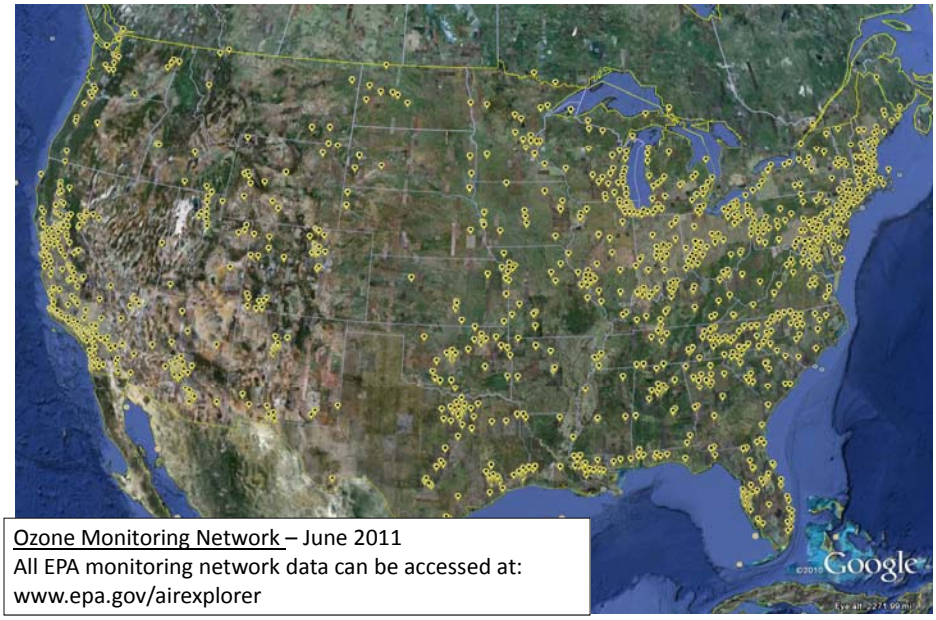
Monitoring Networks

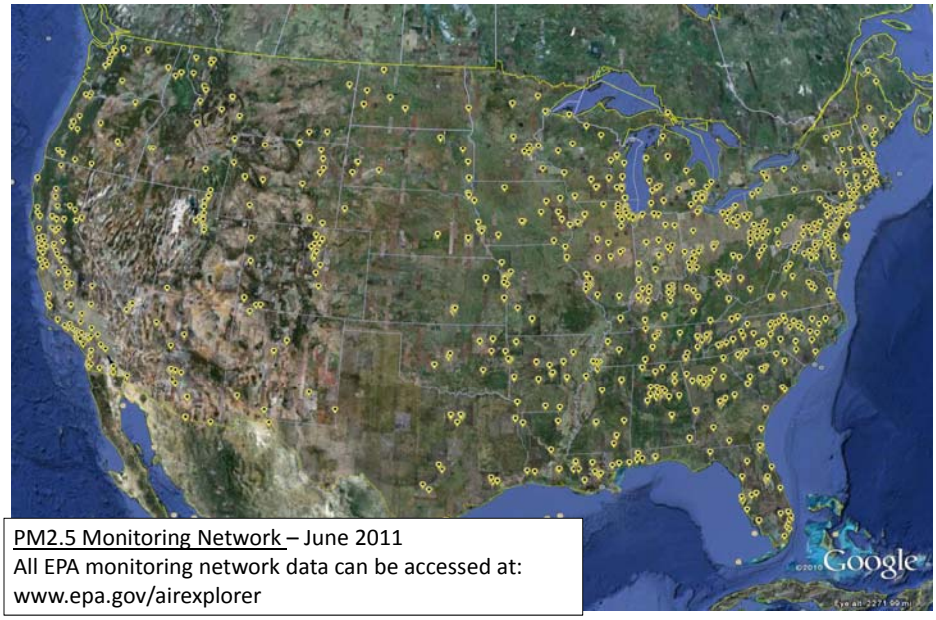
- Monitoring networks are designed to support the individual NAAQS – utilizing minimum monitoring requirements
  - Each criteria pollutant has its own minimum monitoring requirements, instructing states how many monitors are required, how they should be installed, and in some cases, specifically where to put the monitoring sites
  - Examples include the requirement to monitoring near roads, near stationary sources, and/or locations of expected maximum ambient concentrations
- Monitoring sites can characterize multiple metrics:
  - Population exposure
  - Highest concentration in an area
  - Emission source impacts
  - Regional transport
  - Background concentrations
  - Environmental welfare
- The US EPA encourages the measurement of multiple pollutants at the same monitoring locations when possible (known as multi-pollutant monitoring)
  - Multi-pollutant monitoring is a way to broaden the understanding of air quality conditions and pollutant interactions, furthering the capability to evaluate air quality models, develop emission control strategies, and support long-term studies

Current Monitoring Network

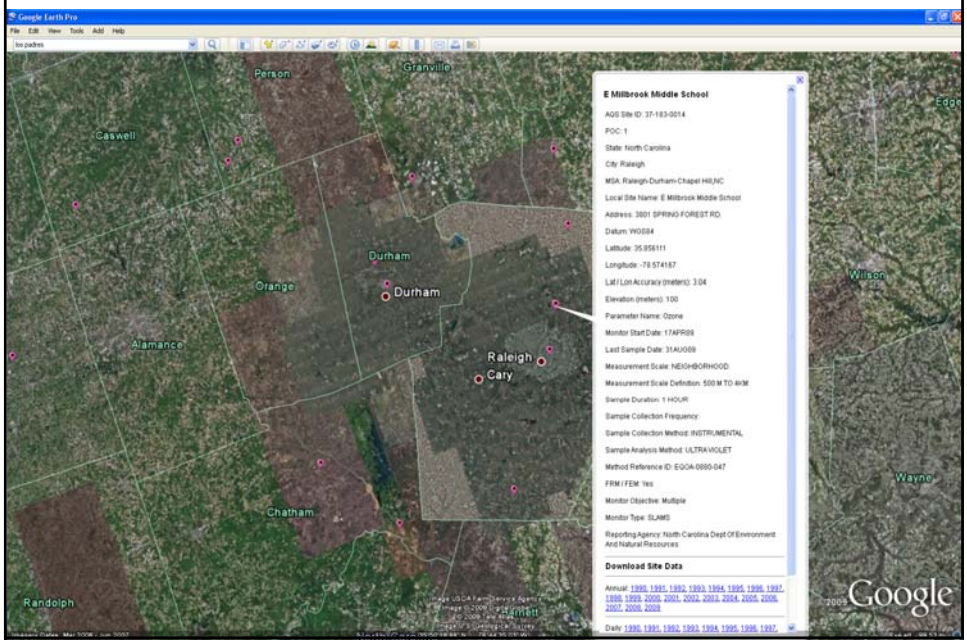
- Current (June 2011) monitoring network nationwide statistics:
  - 1224 Ozone sites
  - 1028 $PM_{2.5}$ sites
  - 702 PM_{10} sites
  - 471 SO_2 sites
  - 388 NO_2 sites
  - 152 Lead (Pb) sites
- States report quality assured data to EPA on a quarterly basis
  - EPA stores all data in its AQS database
- Some real-time data is also available through EPA's AIRNow website (www.airnow.gov)



Ozone Monitoring Network – June 2011
All EPA monitoring network data can be accessed at:
www.epa.gov/airexplorer



PM2.5 Monitoring Network – June 2011
All EPA monitoring network data can be accessed at:
www.epa.gov/airexplorer



Monitoring Requirements - Resources

- All monitoring requirements are maintained in the Code of Federal Regulations (CFR), Title 40, Part 58
- To view all up-to-date monitoring regulations, EPA recommends using "eCFR" :

http://ecfr.gpoaccess.gov/

Navigate to Title 40

Select Volume 5 (Parts 53 through 58)

All minimum monitoring requirements, including required quality assurance procedures, network design components, data reporting, and siting criteria are within Part 58 and its appendices

Ozone Minimum Monitoring Network Requirements (Table D-2)

MSA Population[1,2]	Most recent 3-year design value ≥ 85% of any O_3 NAAQS[3]	Most recent 3-year design value < 85% of any O_3 NAAQS[3,4]
> 10M	4	2
4 - 10M	3	1
350K – 4M	2	1
50K – 350K[5]	1	0

[1] Minimum monitoring requirements apply to the Metropolitan statistical area (MSA).
[2] Population based on latest available census figures.
[3] The ozone (O_3) National Ambient Air Quality Standards (NAAQS) levels and forms are defined in 40 CFR part 50.
[4] These minimum monitoring requirements apply in the absence of a design value.
[5] Metropolitan statistical areas (MSA) must contain an urbanized area of 50,000 or more population.

- At least one ozone site in each area's network must be designed to record the **maximum concentration** for that particular area.
- Deviations allowed by the Regional Administrator.

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$PM_{2.5}$ Minimum Monitoring Network Requirements (Table D-5)

MSA Population[1,2]	Most recent 3-year design value ≥ 85% of any $PM_{2.5}$ NAAQS[3]	Most recent 3-year design value < 85% of any $PM_{2.5}$ NAAQS[3,4]
> 1M	3	2
500K – 1M	2	1
50K – 500K[5]	1	0

[1] Minimum monitoring requirements apply to the Metropolitan statistical area (MSA).
[2] Population based on latest available census figures.
[3] The $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS) levels and forms are defined in 40 CFR part 50.
[4] These minimum monitoring requirements apply in the absence of a design value.
[5] Metropolitan statistical areas (MSA) must contain an urbanized area of 50,000 or more population.

- At least one population oriented site in an area of **maximum concentration** and one site in an area of **poor air quality** (where more than 1 site required)
- Regional background and transport monitors required in each State – with flexibility to use IMPROVE or nearby States monitor
- Exemptions from monitoring requirements by Regional Administrator
- One half (rounded up) of required FRM/FEM samplers need continuous monitors (first continuous monitor must be collocated with an FRM)

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PM_{10} Minimum Monitoring Requirements (Approximate Number of Stations Per MSA) – (Table D-4)

MSA population[1]	High Concentration[2]	Medium Concentration[3]	Low Concentration[4]
>1,000,000	6-10	4-8	2-4
500k – 1,000,000	4-8	2-4	1-2
250k – 500k	3-4	1-2	0-1
100k – 250k	1-2	0-1	0

\1\ Selection of urban areas and actual numbers of stations per area will be jointly determined by EPA and the State agency.
\2\ High concentration areas are those for which ambient PM_{10} data show ambient concentrations exceeding either PM_{10} NAAQS by 20 percent or more.
\3\ Medium concentration areas are those for which ambient PM_{10} data show ambient concentrations exceeding 80 percent of the PM_{10} NAAQS.
\4\ Low concentration areas are those for which ambient PM_{10} data show ambient concentrations less than 80 percent of the PM_{10} NAAQS.

"As contained in the monitoring DFR and proposal: "Modifications from these PM10 monitoring requirements must be approved by the Regional Administrator."

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Monitoring Near Roads

- NO_2 – US EPA recently introduced requirements for states to monitor near highly trafficked roads in larger urban areas (Installation beginning in 2012)
- Near-road NO_2 monitors are sited as close to roads a practicable, being no further than 50 meters from the edge of the target road
- NO_2 site selection is based upon traffic volume, fleet mix (accounting for diesel vehicles), congestion, roadway design, terrain, and meteorology
- The US EPA also has a historical practice of monitoring for Carbon Monoxide near roads
- Other pollutants of interest that could be measured at roadside monitoring sites include particulate matter (multiple size fractions), black/elemental carbon and organic carbon, and air toxics

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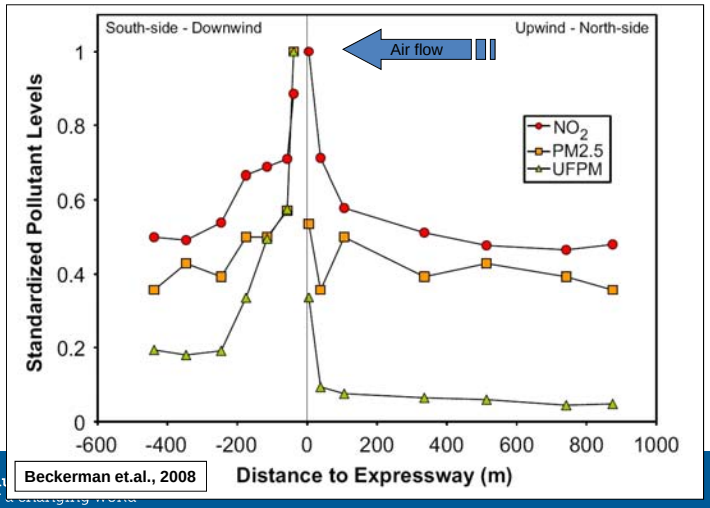
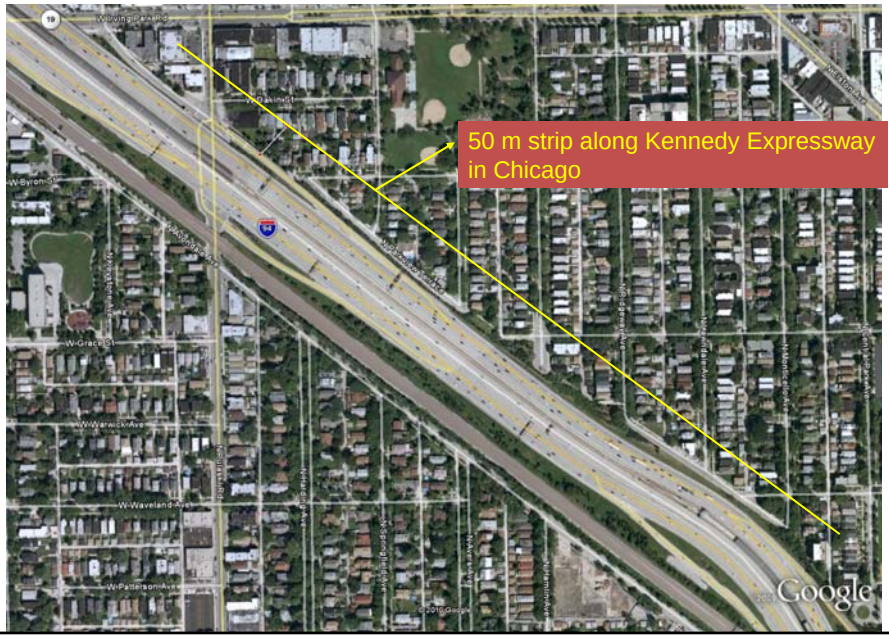
Why worry about near-road exposure?

Tens of millions of people live near major roads – their exposure is higher than areas away from roads

Multiple articles have reviewed NO_2 behavior in the near road, suggesting general ranges of influence



Beckerman et.al., 2008



Monitor Representativeness (Monitor Spatial Scales)

- To clarify the nature of the link between general monitoring objectives, site types, and the physical location of a particular monitor, the concept of spatial scale of representativeness is defined.
- The goal in locating monitors is to correctly match the spatial scale represented by the sample of monitored air with the spatial scale most appropriate for the monitoring site type, air pollutant to be measured, and the monitoring objective.
- The spatial scale of representativeness is described in terms of the **physical dimensions of the air parcel nearest to a monitoring site throughout which actual pollutant concentrations are reasonably similar.**

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Monitor Spatial Scales

smaller

larger

1) Microscale--defines the concentrations in air volumes associated with area dimensions ranging from several meters up to about 100 meters.
(2) Middle scale--defines the concentration typical of areas up to several city blocks in size with dimensions ranging from about 100 meters to 0.5 kilometer.
(3) Neighborhood scale--defines concentrations within some extended area of the city that has relatively uniform land use with dimensions in the 0.5 to 4.0 kilometers range. The neighborhood and urban scales listed below have the potential to overlap in applications that concern secondarily formed or homogeneously distributed air pollutants.
(4) Urban scale--defines concentrations within an area of city-like dimensions, on the order of 4 to 50 kilometers. Within a city, the geographic placement of sources may result in there being no single site that can be said to represent air quality on an urban scale.
(5) Regional scale--defines usually a rural area of reasonably homogeneous geography without large sources, and extends from tens to hundreds of kilometers.
(6) National and global scales--these measurement scales represent concentrations characterizing the nation and the globe as a whole.

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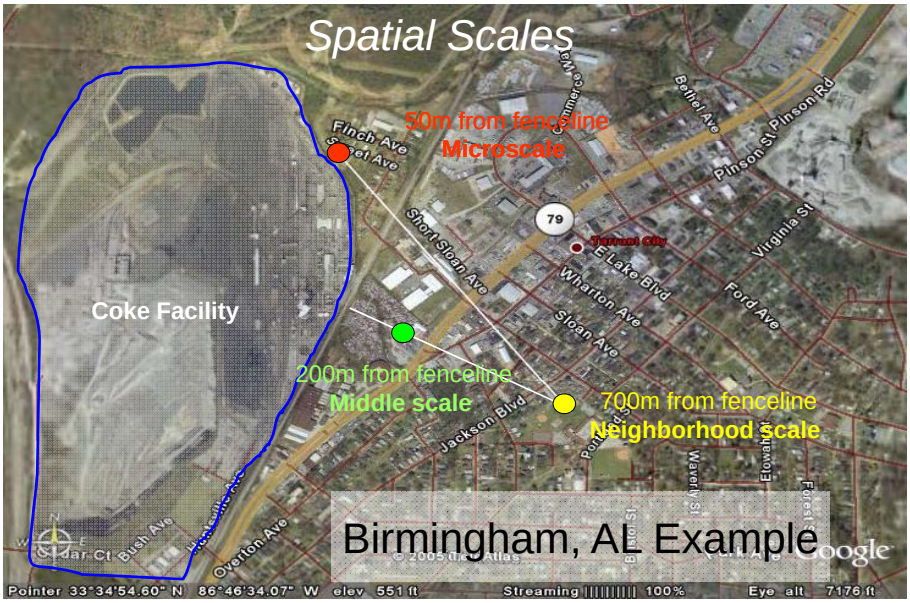

Monitor Siting
40 CFR 58 Appendix E

- Monitors must be physically situated within certain parameters:
  - Permissible height above the ground for monitor/sampler inlet
  - Vertical and horizontal spacing from supports
  - Spacing from minor sources, obstructions, and trees
  - Spacing from roadways (as neccesary)
  - Requirements for probe material and sampling residence time
  - Waiver provisions

Real-world Siting Challenges – Meeting Appendix E requirements

- Trees
- Restrictions on airflow in an arc around the inlet
- Impact of nearby minor sources such as wood stoves, residential/commercial boilers, or unpaved roads/driveways
  - Table E-4 footnote 6 – "The probe, sampler, or monitoring path should be away from minor sources, such as furnace or incineration flues. The separation distance is dependent on the height of the minor source's emission point (such as a flue), the type of fuel or waste burned, and the quality of the fuel (sulfur, ash, or lead content). This criterion is designed to avoid undue influences from minor sources."
  - Related language in Guidance For Network Design and Optimum Site Exposure For PM2.5 And PM10, EPA-454/R-99-022 – e.g., page 5-2, Distance from Nearby Emitters w.r.t. wood burning appliances.
- Roads with too much traffic
- Vertical placement – security versus breathing zone versus logistics
- Also:
  - Use of inappropriate manifold materials other than glass or teflon.
  - Maintaining acceptable residence times within manifolds

Putting It All Together

- Agencies have to find site locations to meet minimum monitoring requirements and satisfy other monitoring objectives.
- These sites must meet the combination of site types and spatial scales appropriate to answer pertinent monitoring questions.
- Sites must be compliant with probe siting criteria.
- Let's look at some examples.....

Carbon Monoxide NAAQS Compliance

- Rule says: "Microscale and middle scale measurements are useful site classifications for SLAMS sites since most people have the potential for exposure on these scales. Carbon monoxide maxima occur primarily in areas near major roadways and intersections with high traffic density and often poor atmospheric ventilation."

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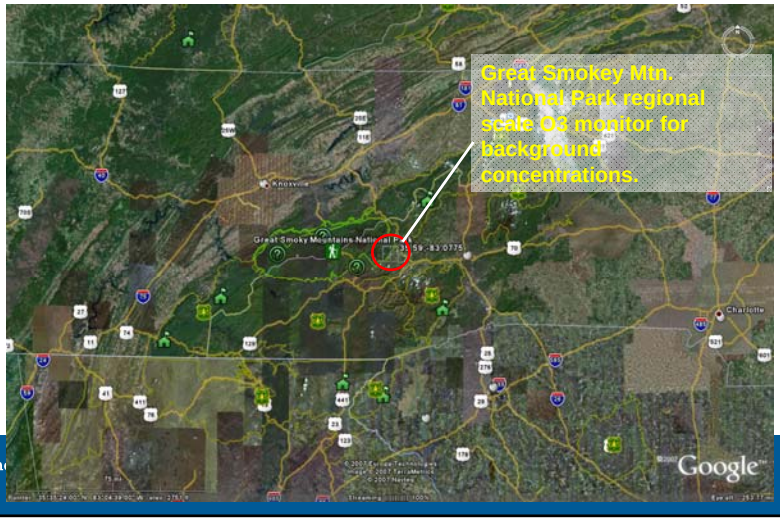
Ozone NAAQS Compliance

- Rule says: "For locating a neighborhood scale site to measure typical city concentrations, a reasonably homogeneous geographical area near the center of the region should be selected which is also removed from the influence of major NOx sources."

Ene

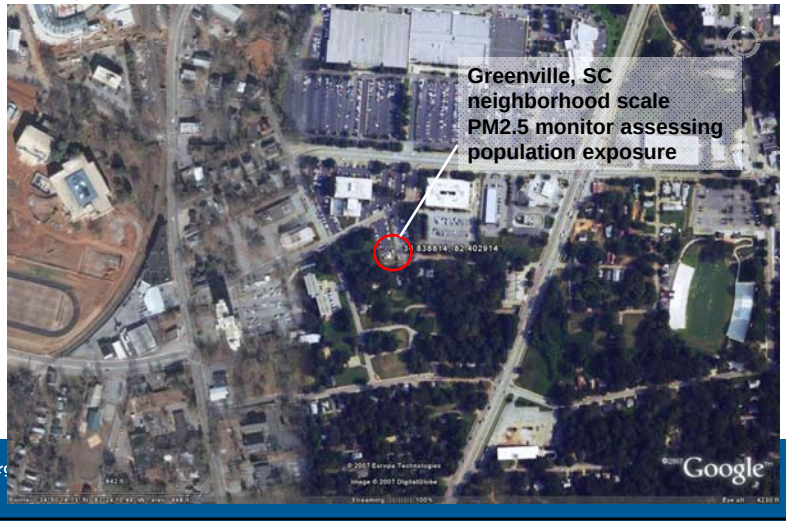
Ozone Research

- Rule says: "Development of effective pollution control strategies requires an understanding at regional geographical scales of the emission sources and atmospheric processes that are responsible for elevated PM2.5 levels and may also be associated with elevated O3 and regional haze.



PM2.5 NAAQS Compliance

- Rule says (paraphrased): "In some cases, a PM2.5 location carefully chosen to provide neighborhood scale data would represent the immediate neighborhood as well as neighborhoods of the same type in other parts of the city. ."



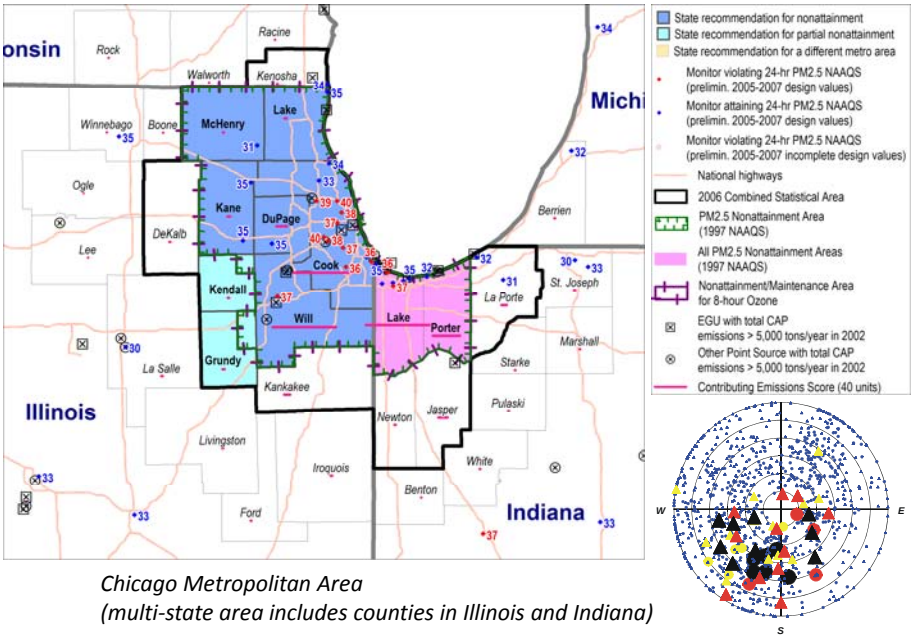
Responsibilities in the Air Quality Management Process

Federal Government	State Governments
• Sets national ambient air quality standards • Designates areas as attainment, nonattainment, or unclassifiable • Establishes national controls for certain source categories states cannot regulate (e.g., mobile sources) • Promulgates regulations to address interstate transport of pollution (power plant focus) • Develops rules to implement federal Clean Air Act requirements • Provides guidance on technical and policy issues • Approves and enforces SIPs	• Recommend designation of areas • Develop emission inventories • Operate air quality monitoring networks • Perform air quality modeling and identify emissions control strategies needed to attain standards • Adopt the necessary measures into their State Implementation Plans (SIPs) • Enforce regulations • Issue pre-construction permits and operating permits to individual facilities

Designating Areas

- EPA designates all areas as attaining or **not attaining**
  - Nonattainment areas include **violating** areas and areas **contributing** to violations
  - Additional **more stringent control** requirements apply to areas that are not attaining specific air quality standards
- Area designations commonly based on the most recent 3 years of monitoring data.
- Factors considered: air quality data, emissions data, population density, degree of urbanization, traffic and commuting patterns, growth rates, meteorology, geography/topography, jurisdictional boundaries and level of control of emission sources.

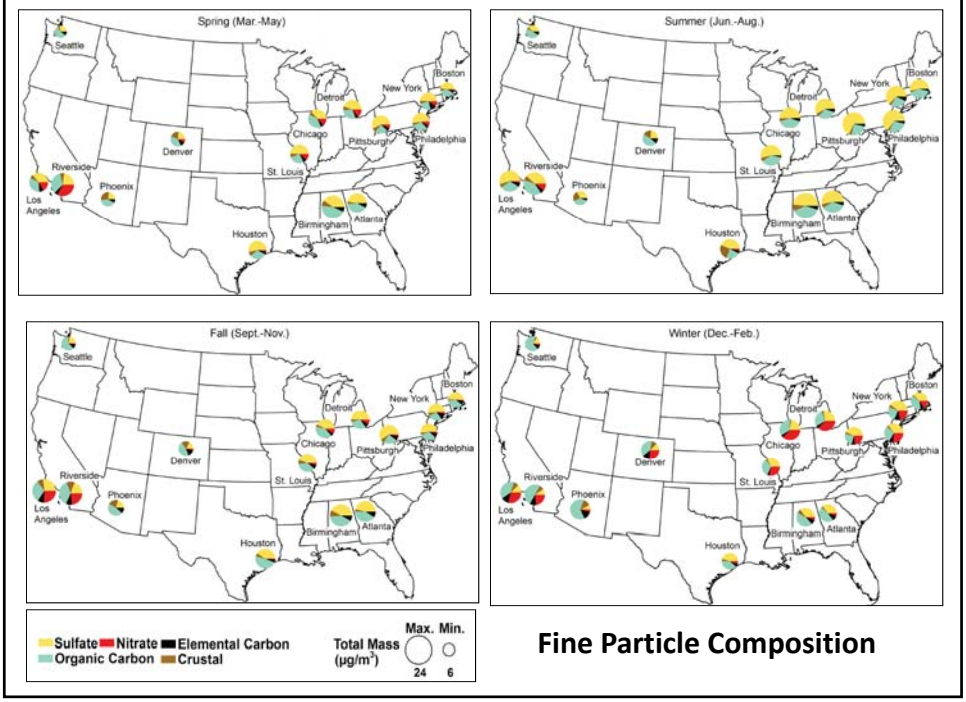
Example PM2.5 Nonattainment Area, Including Contributing Counties as well as Counties with Violating Monitors (in red)



Chicago Metropolitan Area
(multi-state area includes counties in Illinois and Indiana)

Attainment Demonstration

- Plans must show that the area can **attain and maintain** the relevant air quality standard
- **Photochemical grid modeling** is used to demonstrate attainment for ozone and PM2.5
- Model results are used to determine the **level of emission reductions** that are needed for the area to attain the NAAQS.
- Requires **expertise** in meteorology, atmospheric science, emission inventories, control strategies

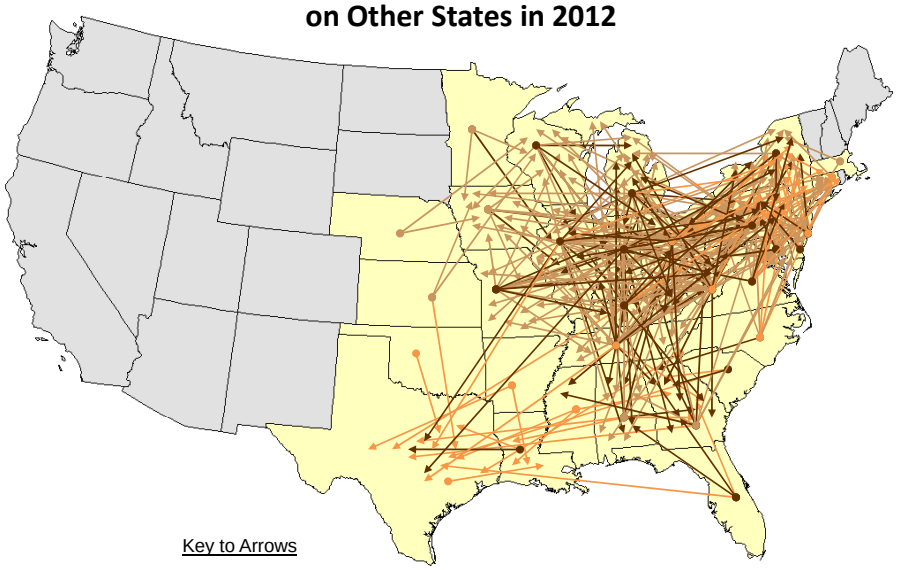


Fine Particle Composition

Interstate Transport of Pollution

- State plans must address transport of pollutants to air quality problems in other states.
- State plans must prohibit "significant contributions" to nonattainment and "interference" with maintenance
- For the Eastern US, this provided EPA with authority for:
  - Regional "NOx SIP Call" Rule (1998)
  - Clean Air Interstate Rule (2005)
  - Cross State Air Pollution Rule (2011)
  - Possible future transport rules

States Projected to Have Significant Air Quality Impacts on Other States in 2012



Key to Arrows

- Linkage of Upwind to Downwind for Ozone
- Linkage of Upwind to Downwind for Annual $PM_{2.5}$
- Linkage of Upwind to Downwind for 24 hour $PM_{2.5}$

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AIRNow

Providing real-time air quality data to the public

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About AIRNow – Goals

- Protect public health and promote data exchange
  - Stakeholder participation through technical support, guidance, and assistance
  - High-quality products
    - Public/media use for health-based decision-making
  - Timely and reliable operations
    - Widespread usage
    - Tight media deadlines
  - Flexibility
    - Adding new features, addressing media/outside requests
  - Innovation

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Pollutants Included and Calculation of Air Quality Index (AQI):

- Pollutants:
  - $PM_{2.5,}$ Ozone, Carbon Monoxide, Sulfur Dioxide
- Calculation of AQI
  - Data from monitor with highest value in metropolitan area

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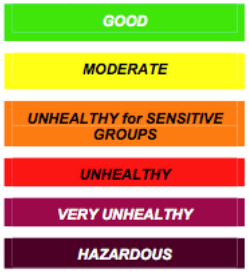
Information Provided by AIRNow

- Air quality data color coded:
  - Green= good, AQI <50
  - Yellow= moderate, AQI= 51-100
  - Orange= unhealthy for sensitive groups, AQI= 101-150
  - Red= unhealthy, AQI=151-200
  - Purple=very unhealthy, AQI 201-300
  - Maroon= hazardous, AQI 301-500



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Pollutant-Specific Sub-indices and Health Effects Statements for Guidance on the Air Quality Index (AQI)

AQI Categories: ndex Values	Ozone (ppm)		Particulate Matter (µg/m^3)		Carbon Monoxide (ppm)	Sulfur Dioxide (ppm)
	[8-hour]	[1-hour]	$PM_{2.5}$ [24-hour]	PM_{10} [24-hour]	[8-hour]	[24-hour]
ood p to 50)	0 - 0.064 None		0 - 15 None	0 - 50 None	0 - 4 None	0 - 0.03 None
oderate 1 - 100)	0.065 - 0.084 Unusually sensitive individuals may experience respiratory symptoms.		>15 - 40 Respiratory symptoms possible in unusually sensitive individuals, possible aggravation of heart or lung disease in people with cardiopulmonary disease and older adults.	>50 - 150	>4 - 9 None	>0.03 - 0.14 None
nhealthy for ensitive Groups 01 - 150)	0.085 - 0.104 Increasing likelihood of respiratory symptoms and breathing discomfort in active children and adults and people with lung disease, such as asthma.	0.125 - 0.164	>40 - 65 Increasing likelihood of respiratory symptoms in sensitive individuals, aggravation of heart or lung disease and premature mortality in people with cardiopulmonary disease and older adults.	>150 - 250	>9 - 12 Increasing likelihood of reduced exercise tolerance due to increased cardiovascular symptoms, such as chest pain, in people with heart disease.	>0.14 - 0.22 Increasing likelihood of respiratory symptoms, such as chest tightness and breathing discomfort, in people with asthma.
nhealthy 51 - 200)	0.105 - 0.124 Greater likelihood of respiratory symptoms and breathing difficulty in active children and adults and people with lung disease, such as asthma; possible respiratory effects in general population.	0.165 - 0.194	>65 - 150 Increased aggravation of heart or lung disease and premature mortality in people with cardiopulmonary disease and older adults; increased respiratory effects in general population.	>250 - 350	>12 - 15 Reduced exercise tolerance due to increased cardiovascular symptoms, such as chest pain, in people with heart disease.	>0.22 - 0.30 Increased respiratory symptoms, such as chest tightness and wheezing in people with asthma; possible aggravation of heart or lung disease.

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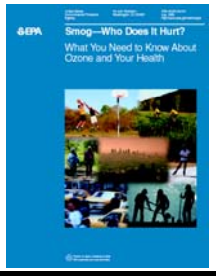
About AIRNow – Goals

- Educate and support the voluntary AIRNow community of agencies
  - Stakeholders supply data, forecasts, and expertise
  - Educate media/public to promote responsible use of AIRNow/AQI information
- Make AIRNow America's "go to" resource for current and forecasted air quality information



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About RAP

The Regulatory Assistance Project (RAP) is a global, non-profit team of experts that focuses on the long-term economic and environmental sustainability of the power and natural gas sectors. RAP has deep expertise in regulatory and market policies that:

- Promote economic efficiency
- Protect the environment
- Ensure system reliability
- Allocate system benefits fairly among all consumers

Learn more about RAP at www.raponline.org

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