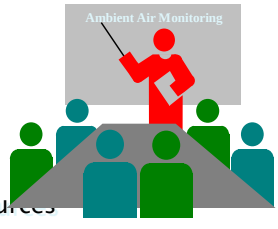
Course Overview

- Regulations and Standards
- Monitoring Networks
- Station Siting
- Instrumentation
- Documentation
- Data Handling
- Quality Assurance
- References and Resources



EPA Responsibilities Under CAA

- National Ambient Air Quality Standards (NAAQS)
  - Identification
  - Attainment
- Toxic air pollutants
  - Identification
  - Control
- Acid Rain
- Pollution Index
- PSD

Monitoring

- Attainment
- Progress Toward Attainment
- Pollution Trends
- Emergency Control Procedures
- Database.

Regulations

- U.S. EPA
  - 40 CFR 50 – NAAQS
  - 40 CFR 53 – Methods
  - 40 CFR 58 – Monitoring criteria
  - 40 CFR 51.24 – PSD
- State and Local Regs

Monitoring Networks

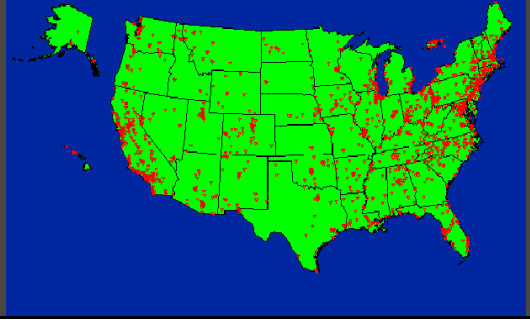
SLAMS -- State and Local Air Monitoring Station
NAMS -- National Air Monitoring Station
PAMS -- Photochemical Assessment Monitoring Station
NCore—National Core Multipollutant Network

Monitoring Networks

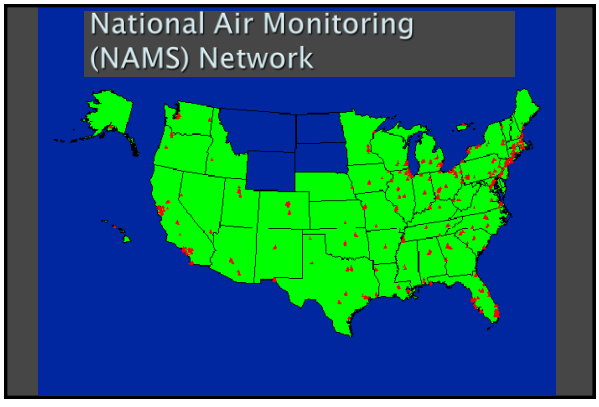
- PSD -- Prevention of Significant Deterioration
- SPM -- Special Purpose Monitoring
- IMPROVE -- Interagency Monitoring of Protected Visual Environments

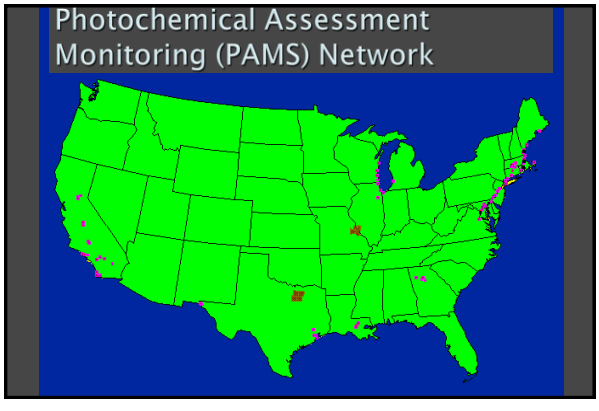
Acid Rain Network

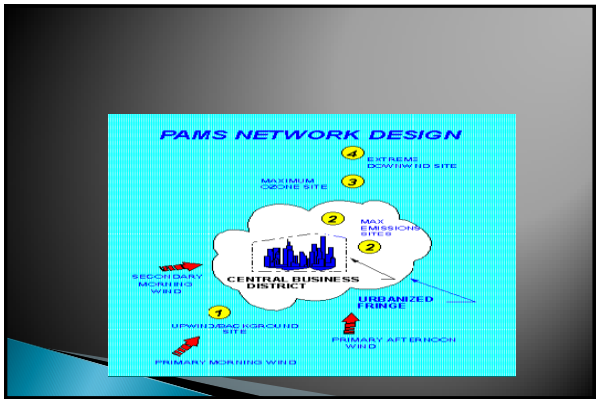
State and Local Monitoring (SLAMS) Network



Ambient Air Monitoring

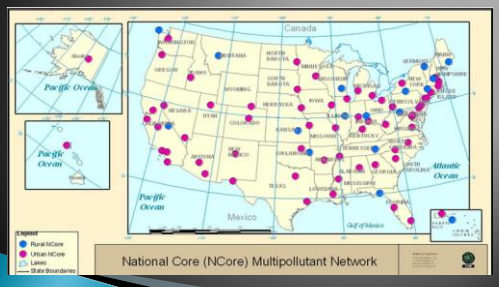






Ambient Air Monitoring

NCore Network



NCore pollutants

Parameter	Comments
PM2.5 speciation	Organic and elemental carbon, major ions and trace metals (24 hour average; every 3rd day); IMPROVE or CSN
PM2.5 FRM mass	24 hr. average at least every 3rd day
continuous PM2.5 mass	1 hour reporting interval; FEM or pre-FEM monitors
PM(10-2.5) mass	Filter-based or continuous
ozone (O3)	all gases through continuous monitors
carbon monoxide (CO)	capable of trace levels (low ppm and below) where needed
sulfur dioxide (SO2)	capable of trace levels (low ppb and below) where needed
nitrogen oxide (NO)	capable of trace levels (low ppb and below) where needed
total reactive nitrogen (NOy)	capable of trace levels (low ppb and below) where needed
surface meteorology	wind speed and direction (reported as "Resultant"), temperature, RH

IMPROVE Sites

Ambient Air Monitoring

CURRENT NAAQS

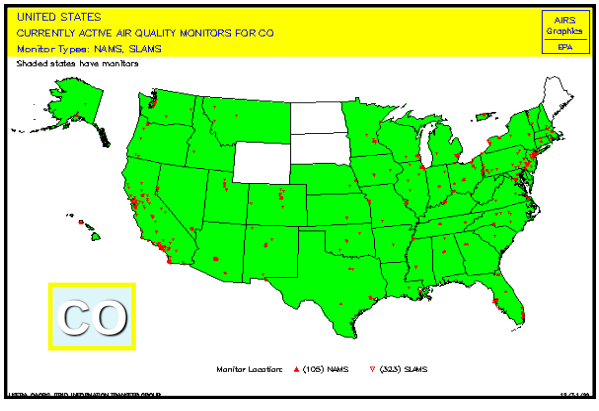
Pollutant [final rule cite]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide 76 FR 54294, Aug 31, 2011		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead 73 FR 66964, Nov 12, 2008		primary and secondary	Rolling 3 month average	0.15 μg/m³ [a]	Not to be exceeded
Nitrogen Dioxide 75 FR 6474, Feb 9, 2010 61 FR 52852, Oct 8, 1996		primary	1-hour	100 ppb	98th percentile, averaged over 3 years
			Annual Mean		
primary and secondary	Annual	53 ppb [a]			
Ozone 73 FR 16436, Mar 27, 2008		primary and secondary	8-hour	0.075 ppm [a]	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution 71 FR 61144, Oct 17, 2006	$PM_{2.5}$	primary and secondary	Annual	15 μg/m³	annual mean, averaged over 3 years
			24-hour	35 μg/m³	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24-hour	150 μg/m³	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide 75 FR 35520, Jun 22, 2010 38 FR 25678, Sep 14, 1973		primary	1-hour	75 ppb [a]	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

Carbon Monoxide(CO) Standards–Table of Historical CO NAAQS

Final Rule/Decision	Primary/ Secondary	Indicator	Averaging Time	Level [a]	Form
1971 36 FR 8186 Apr 30, 1971	Primary and Secondary	CO [b]	1-hour period	35 ppm	Maximum, not to be exceeded more than once in a year
			8-hour period	9 ppm	Maximum, not to be exceeded more than once in a year [c]
1985 50 FR 37484 Sept 13, 1985	Primary standards retained, without revision; secondary standards revoked.				
1994 59 FR 38905 Aug 1, 1994	Primary standards retained, without revision.				
2011 76 FR 54294 Aug 31, 2011	Primary standards retained, without revision.				

Carbon Monoxide Classifications 1990 CAA

- Serious Area has a design value of 16.5 ppm and above.
- Moderate Area has a design value of 9.1 up to 16.4 ppm.
- Not Classified an area designated as an carbon monoxide nonattainment area as of the date of enactment of the Clean Air Act Amendments of 1990 and did not have sufficient data to determine if it is meeting or is not meeting the carbon monoxide standard.



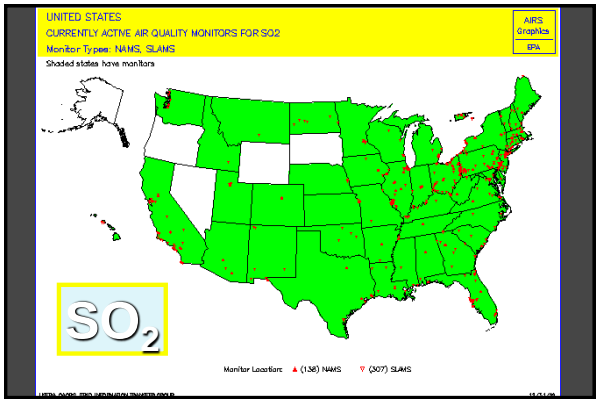
Nitrogen Dioxide (NO2) Standards– Table of Historical NO2 NAAQS

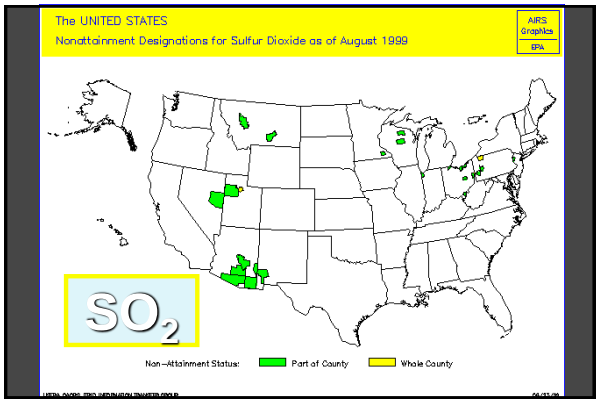
Final Rule/Decision	Primary/ Secondary	Indicator	Averaging Time	Level	Form
1971 36 FR 8186 Apr 30, 1971	Primary and Secondary	NO_2	Annual	53 ppb	Annual arithmetic average
1985 50 FR 25532 Jun 19, 1985	Primary and secondary NO_2 standards retained, without revision.				
1996 61 FR 52852 Oct 8, 1996	Primary and secondary NO_2 standards retained, without revision.				
2010 75 FR 6474 Feb 9, 2010	Primary	NO_2	1-hour	100 ppb	98th percentile, averaged over 3 years
		Primary annual NO_2 standard retained, without revision.			

Ambient Air Monitoring

Oxides of Sulfur (SO2) Standards–Table of Historical SO2 NAAQS

Final Rule/Decision	Primary/ Secondary	Indicator[a]	Averaging Time	Level[b]	Form
1971 36 FR 8186 Apr 30, 1971	Primary	SO_2	24-Hour	0.14 ppm	Not to be exceeded more than once per year
			Annual	0.03 ppm	Annual arithmetic average
	Secondary		3-Hour	0.5 ppm	Not to be exceeded more than once per year
			Annual [c]	0.02 ppm	Annual arithmetic average
1973 38 FR 25678 Sept 14, 1973	Secondary	Secondary 3-hour SO_2 standard retained, without revision; secondary annual SO_2 standard revoked.			
1996 61 FR 25566 May 22, 1996	Primary	Existing primary SO_2 standards retained, without revision.			
2010 75 FR 35520 Jun 22, 2010[d]	Primary	SO_2	1-hour	75 ppb	99th percentile, averaged over 3 years [e]
		Primary annual and 24-hour SO_2 standards revoked.			

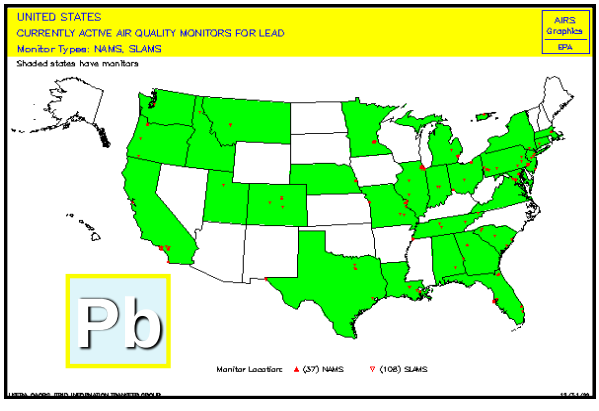


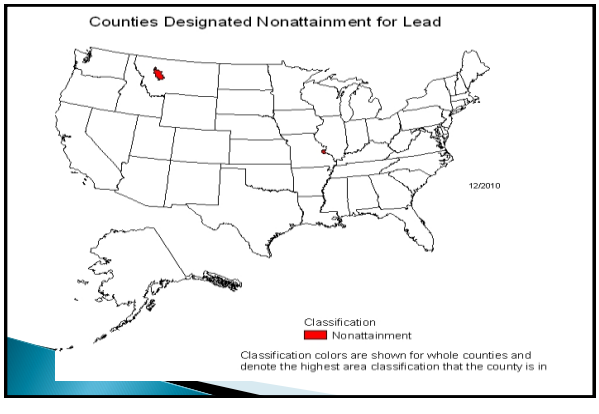


Ambient Air Monitoring

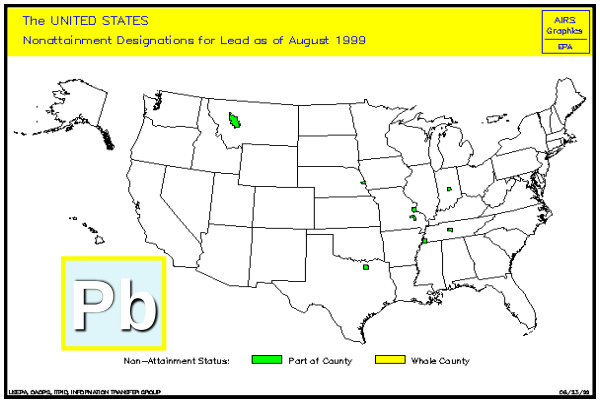
Lead (Pb) Standards– Table of Historical Pb NAAQS

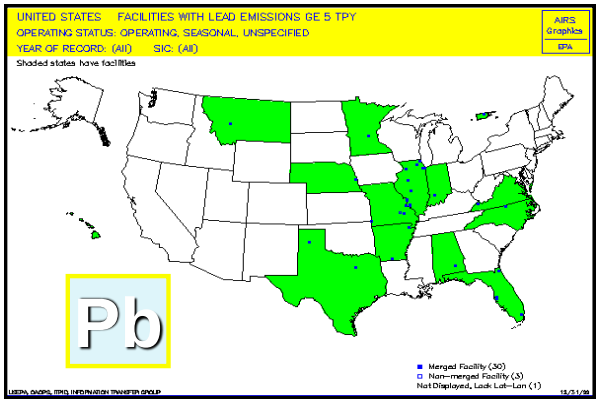
Final Rule/Decision	Primary/ Secondary	Indicator	Averaging Time	Level [1]	Form
1978 43 FR 46246 Oct 5, 1978	Primary and Secondary	Pb-TSP [2]	Calendar Quarter	1.5 μg/m³	Not to be exceeded
Feb 21, 1991 – Agency released multimedia "Strategy for Reducing Lead Exposures" [3]					
2008 73 FR 66964 Nov 12, 2008	Primary and Secondary	Pb-TSP	3-month period	0.15 μg/m³	Not to be exceeded





Ambient Air Monitoring

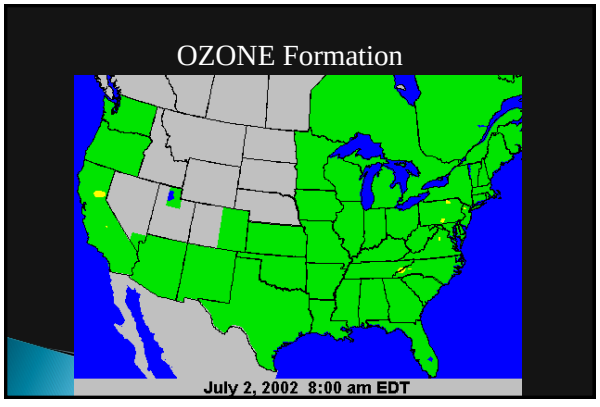


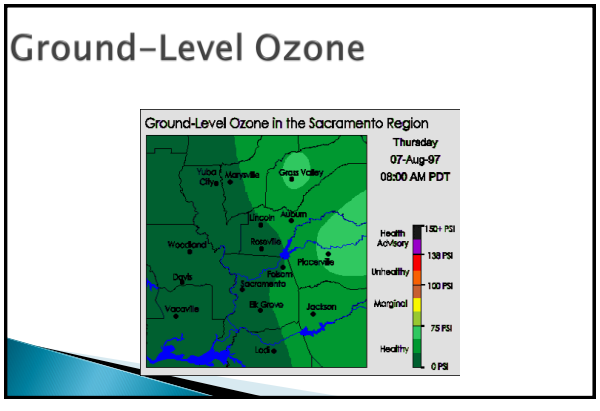


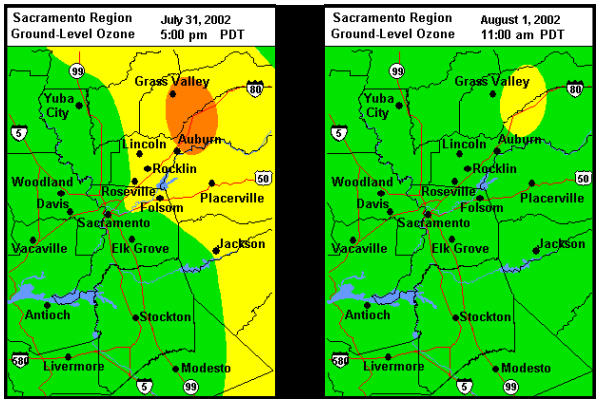
Ozone (O3) Standards– Table of Historic O3 NAAQS

Final Rule/Decision	Primary/ Secondary	Indicator[1]	Averaging Time	Level[2]	Form
1971 36 FR 8186 Apr 30, 1971	Primary and Secondary	Total photochemical oxidants	1-hour	0.08 ppm	Not to be exceeded more than one hour per year
1979 44 FR 8202 Feb 8, 1979	Primary and Secondary	O_3	1-hour	0.12 ppm	Attainment is defined when the expected number of days per calendar year, with maximum hourly average concentration greater than 0.12 ppm, is equal to or less than 1
1993 58 FR 13008 Mar 9, 1993	EPA decided that revisions to the standards were not warranted at the time				
1997 62 FR 38855 Jul 18, 1997	Primary and Secondary	O_3	8-hour	0.08 ppm	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
2008 73 FR 16483 Mar 27, 2008	Primary and Secondary	O_3	8-hour	0.075 ppm	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years

Ambient Air Monitoring







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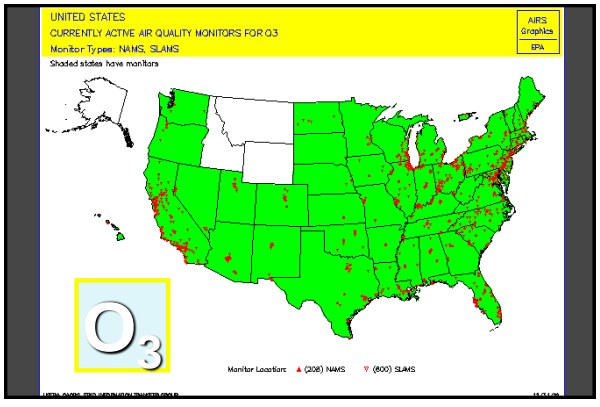
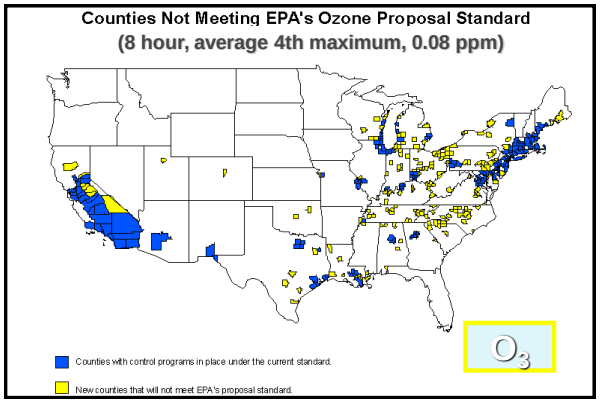
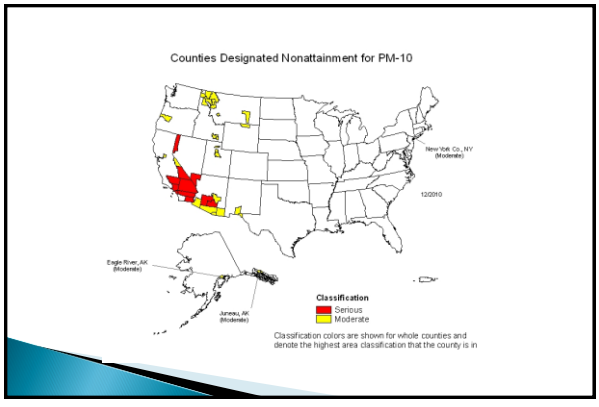


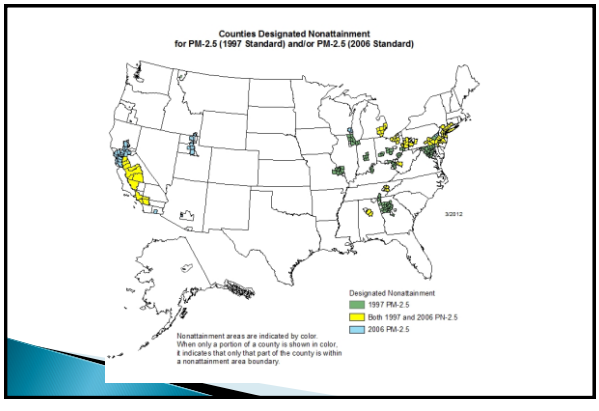


Particulate Matter (PM) Standards–Table of Historical PM NAAQS

Final Rule	Primary/ Secondary	Indicator	Averaging Time	Level	Form
1971 36 FR 8186 Apr 30, 1971	Primary	TSP	24-hour	260 μg/m³	Not to be exceeded more than once per year
			Annual	75 μg/m³	Annual Average
	Secondary	TSP	24-hour	150 μg/m³	Not to be exceeded more than once per year
1987 52 FR 24634 Jul 1, 1987	Primary and Secondary	PM_{10}	24-hour	150 μg/m³	Not to be exceeded more than once per year on average over a 3-year period
			Annual	50 μg/m³	Annual arithmetic mean, averaged over 3 years
1997 62 FR 38652 Jul 18, 1997	Primary and Secondary	$PM_{2.5}$	24-hour	65 μg/m³	98th percentile, averaged over 3 years
			Annual	15.0 μg/m³	Annual arithmetic mean, averaged over 3 years
		PM_{10}	24-hour	150 μg/m³	Initially promulgated 99th percentile, averaged over 3 years; when 1997 standards for PM10 were vacated, the form of 1987 standards remained in place (not to be exceeded more than once per year on average over a 3-year period)
			Annual	50 μg/m³	Annual arithmetic mean, averaged over 3 years
2006 71 FR 61144 Oct 17, 2006	Primary and Secondary	$PM_{2.5}$	24-hour	35 μg/m³	98th percentile, averaged over 3 years
			Annual	15.0 μg/m³	Annual arithmetic mean, averaged over 3 years
		PM_{10}	24-hour	150 μg/m³	Not to be exceeded more than once per year on average over a 3-year period

Ambient Air Monitoring





Network Design Considerations

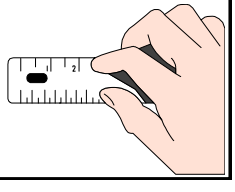
- Concentration Expected
- Representative Concentrations
- Significant Sources or Source Categories

Network Design Conciderations

- Background Concentrations
- Regional Transport
- Welfare-Related Impacts for Rural Areas

Scales of Monitoring

- Micro
- Middle
- Neighborhood



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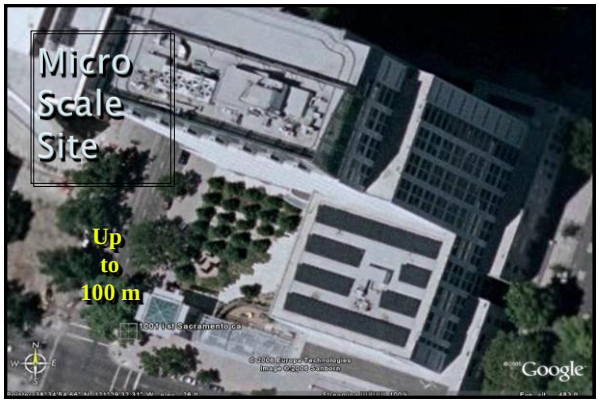
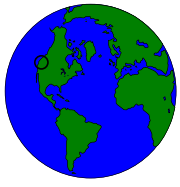
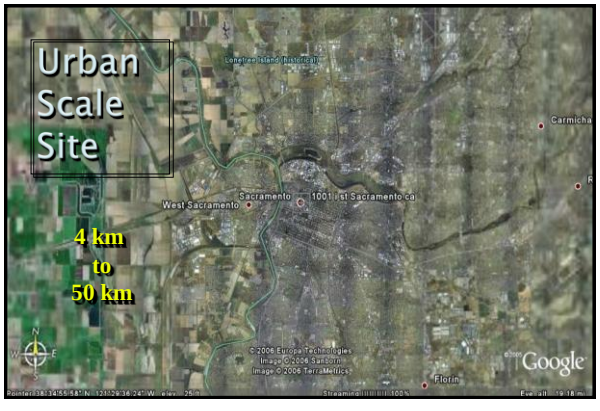


Additional Scales of Monitoring

- Urban
- Regional
- National and Global





Monitoring Objectives & Scale

Monitoring Objective	Appropriate Siting Scales
Highest concentration	**Micro, middle, neighborhood (sometimes urban)**
Source impact	**Micro, middle, neighborhood**
Population	**Neighborhood, urban**
General / Background	**Neighborhood, regional, global**

Network Design Considerations

- Priority area (zone of highest pollution conc.)
- Air Transport
- Evaluation

Network Design Considerations

- Population Areas
- Future development
- Full Representation

Number of Stations – SO_2

Population	Expected Maximum Concentration		
	High[1]	Medium[2]	Low[3]
> 1,000,000	6 - 10	4 - 8	2 - 4
500,000 - 1,000,000	4 - 8	2 - 4	1 - 2
250,000 - 500,000	3 - 4	1 - 2	0 - 1
100,000 - 250,000	1 - 2	0 - 1	0

[1] Exceeding Primary NAAQS
[2] Exceeding 60% of Primary or 100% of Secondary NAAQS
[3] Less than 60% of Primary or 100% of Secondary NAAQS

Number of Stations – $PM_{2.5}$ & PM_{10}

Population	Expected Maximum Concentration		
	High[1]	Medium[2]	Low[3]
> 1,000,000	6 - 10	4 - 8	2 - 4
500,000 - 1,000,000	4 - 8	2 - 4	1 - 2
250,000 - 500,000	3 - 4	1 - 2	0 - 1
100,000 - 250,000	1 - 2	0 - 1	0

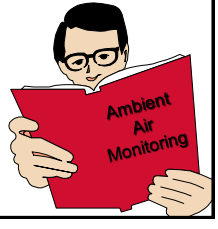
[1] Exceeding NAAQS by 20% or more, or 95% Probability of PM_{10} Nonattainment
[2] Exceeding 80% of NAAQS, or 20% to 95% Probability of PM_{10} Nonattainment
[3] Less than 80% NAAQS, or < 20% Probability of PM_{10} Nonattainment

Station Siting Considerations

- Available sites
- Start-up costs
  - Equipment
  - Facility improvements
- Operation costs
  - Equipment operation and maintenance
  - Station costs (lease payments, heating, etc.)
  - Expendables (calibration gases, chart paper, etc.)
  - Personnel

Station Siting Considerations

- Types of Pollutants
- Topography
- Air flow

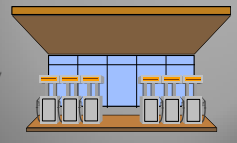


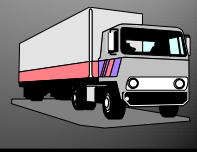
Station Categories

A (Ground Level)	Heavy pollutant concentration, high potential for pollutant buildup
B (Ground Level)	Heavy pollutant concentration, minimal potential for buildup
C (Ground Level)	Moderate pollution concentration
D (Ground Level)	Low pollutant concentration
E (Air Mass)	Sampler probe that is between 6-45m (20-150 ft) above ground
F (Source-Oriented)	

Site Information

- Local Sources
  - Flues & Vents by Inlet
  - Non-Vehicular/Local Industry
  - Traffic
- Dominant Influence Category
  - Industrial
  - Residential
  - Commercial
  - Vehicular
  - Urbanization
  - Near Urban
  - Agricultural
  - Recreational Area





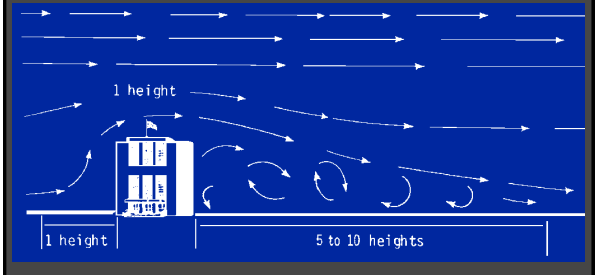
Site Information

- Data Acquisition Objective
- Station Type
- Spatial Scale
- Instrumentation
- Sampling System
- Influential Pollutant Sources
- Topography
- Atmospheric Exposure

Site Information

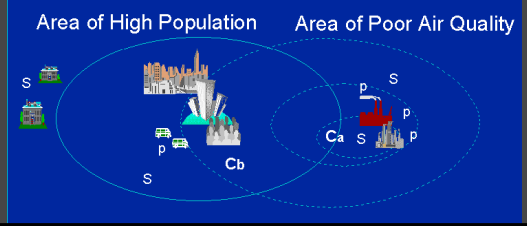
- Obstacles
  - Description
  - Distance
  - Height above inlet
  - Walls
  - Air flow arc
- Trees
  - As obstacles
  - As interferants

Obstacle Effects



Location of Monitors

- C = Core site
- S = SLAMS site
- p = Special Purpose Monitor

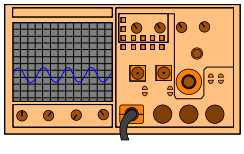


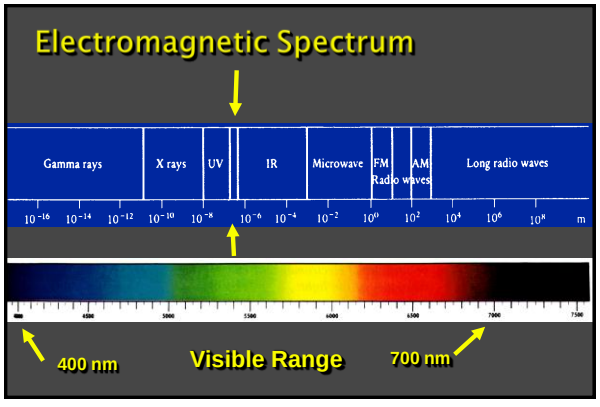
Air Pollutant Measurement Process

- Separate pollutant from air
- Determine pollutant quantity and air volume
- Calculate pollution concentration by dividing pollutant quantity by air volume
- Analyze data

Types of Monitoring

- Automated analytical methods
  - Point analyzers
  - Open path analyzers
- Time averaged samplers
  - Manual methods
  - Filter (ex. PM_{10}) samples





Beer–Lambert Law

- Absorption of light related to:
  - Absorption coefficient dependencies
    - Wavelength of light
    - Properties of the pollutant molecule
  - Number of molecules in light path
    - Concentration
    - Path length

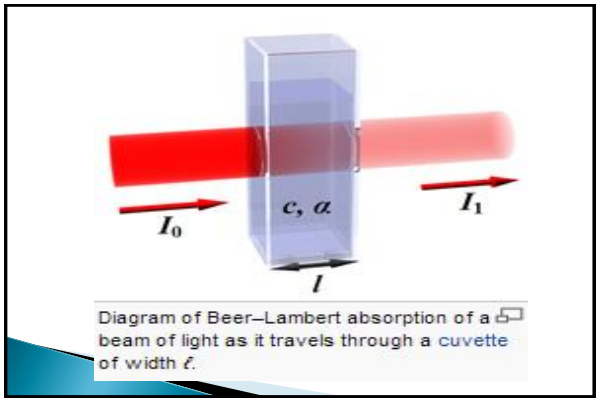
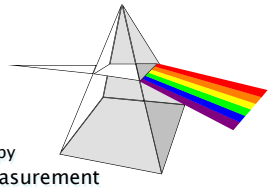


Diagram of Beer–Lambert absorption of a beam of light as it travels through a cuvette of width ℓ.

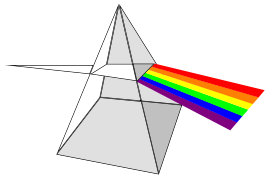
Analytical Techniques

- Infrared Methods
  - Differential Absorption
  - Gas Filter Correlation
  - Fourier Transform Infrared
- Ultraviolet Methods
  - Differential Absorption
  - Second Derivative Spectroscopy
- Visible Light – Opacity Measurement
  - Scattering & Absorption



Analytical Techniques

- Luminescence Methods
  - Fluorescence
  - Chemiluminescence
  - Flame Photometry
- Electroanalytical Methods
  - Polarography
  - Electrocatalytic
  - Paramagnetism
  - Conductivity



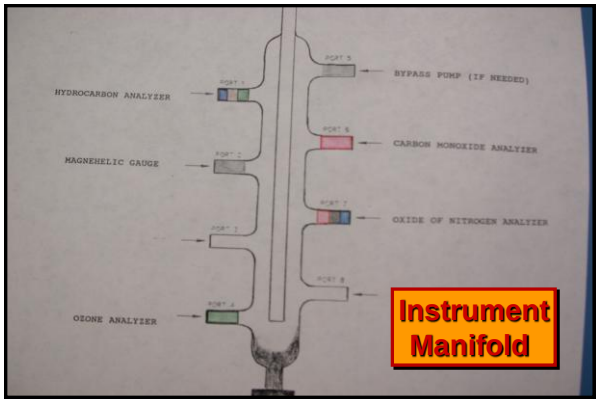
Site Information

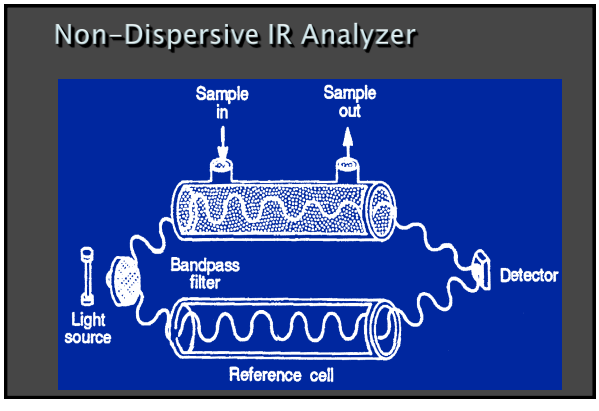
- Site Description
  - Ground Cover
  - Height of Inlet
  - Type of Samplers
  - Spacing Between Samplers
  - Inlet Boom Description and Orientation
  - Meteorological Instrument Tower Description
  - Meteorological Instrument Radiation Shield

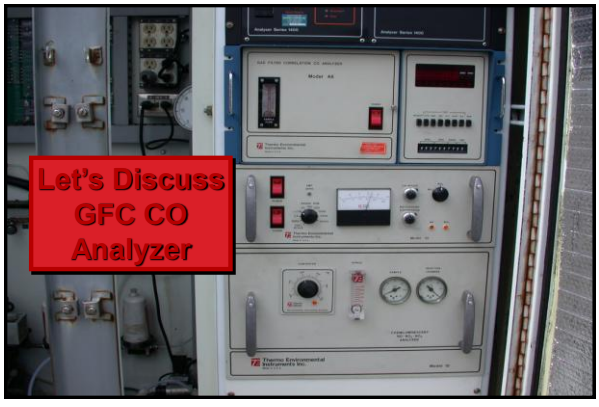
Site Information

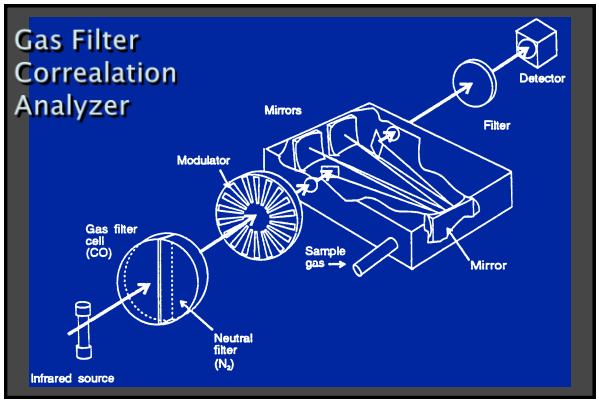
- Probe Information
  - Probe Material
  - Probe Dimensions
  - Manifold Description
  - Manifold Dimensions
  - Tubing Material
  - Tubing Dimensions
  - Residence Time
    - Probe, Manifold, Tubing, Total

Ambient Air Monitoring

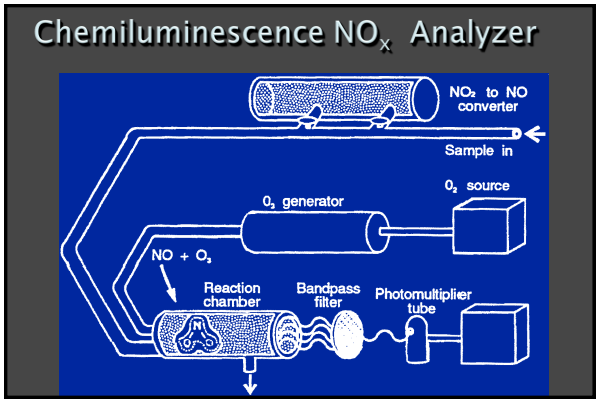


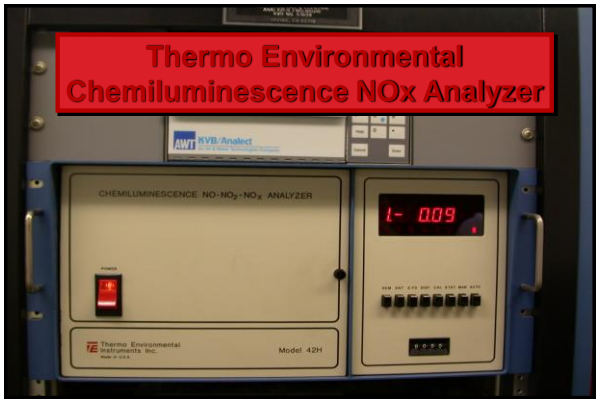


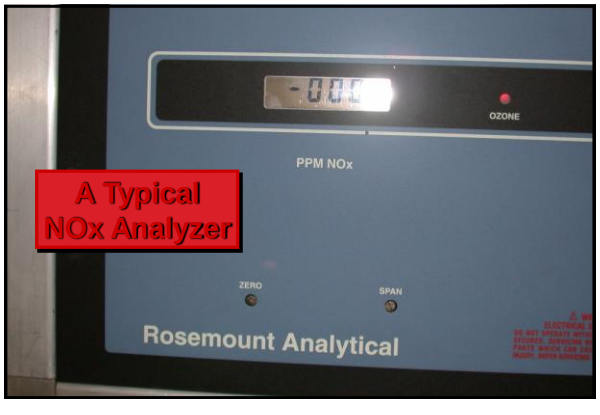

Let's Discuss
GFC CO
Analyzer

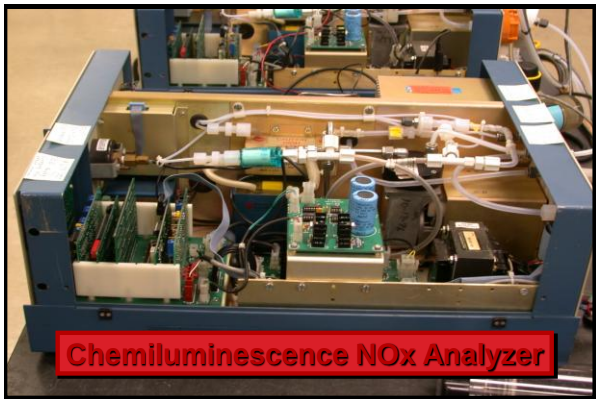

Gas Filter
Correalation
Analyzer
Detector
Mirrors
Filter
Modulator
Gas filter
cell
(CO)
Sample
gas
Mirror
Neutral
filter
(N_2)
Infrared source

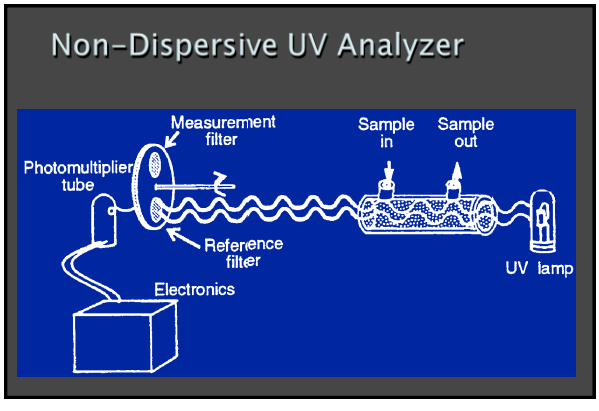
Looking Inside
a GFC CO
Analyzer

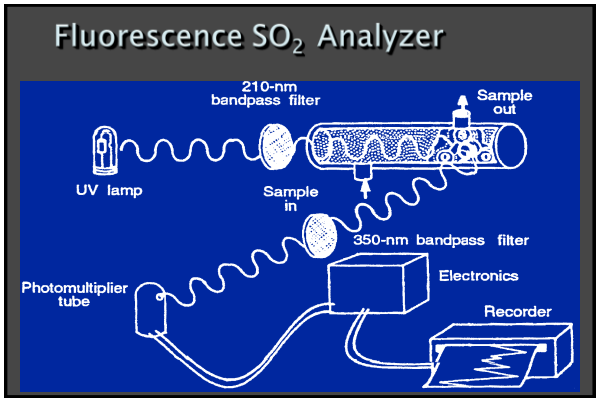

Chemiluminescence NO_x Analyzer
NO_2 to NO converter
Sample in
O_2 source
O_3 generator
NO + O_3
Reaction chamber
Bandpass filter
Photomultiplier tube

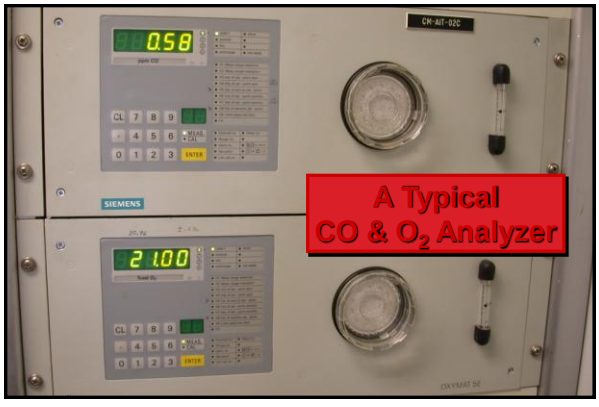

Thermo Environmental
Chemiluminescence NOx Analyzer
CHEMILUMINESCENCE NO-NO2-NOx ANALYZER
Model 42H


A Typical
NOx Analyzer
OZONE
PPM NOx
ZERO
SPAN
Rosemount Analytical


Chemiluminescence NOx Analyzer


Non-Dispersive UV Analyzer
Measurement filter
Sample in
Sample out
Photomultiplier tube
Reference filter
UV lamp
Electronics

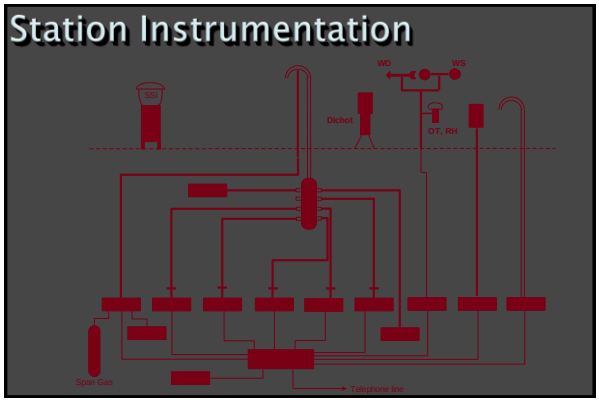

Fluorescence SO_2 Analyzer
210-nm bandpass filter
Sample out
UV lamp
Sample in
350-nm bandpass filter
Electronics
Photomultiplier tube
Recorder



Calibrations and Zero Air

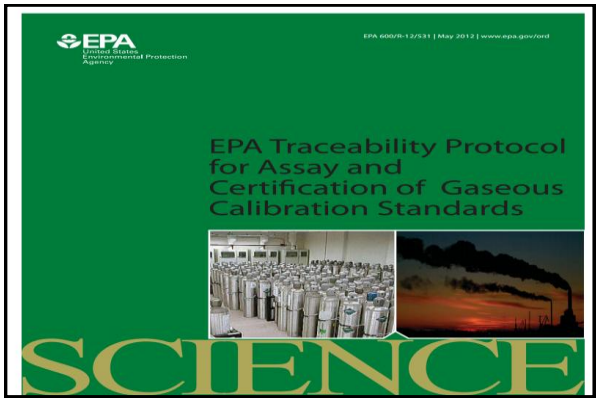
Calibration is the process of establishing the relationship between the output of a measurement process and a known input

- Pure (zero) air generators
- Certified cylinder gases
- Dilution calibration systems



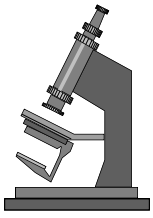
Calibration
Gases

Calibration Gases

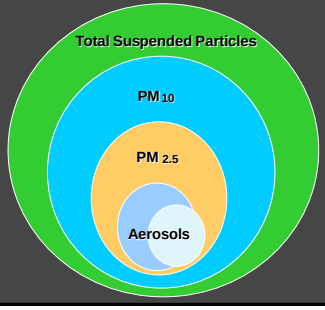

EPA
United States
Environmental Protection
Agency
EPA 600/R-12/531 | May 2012 | www.epa.gov/ord
EPA Traceability Protocol
for Assay and
Certification of Gaseous
Calibration Standards
SCIENCE

Particulate Properties

- Collected Mass
- Inertial Properties
- Particle Size
- Optical Density
  - Haze and Opacity in the Air
  - Density of Collected Deposit



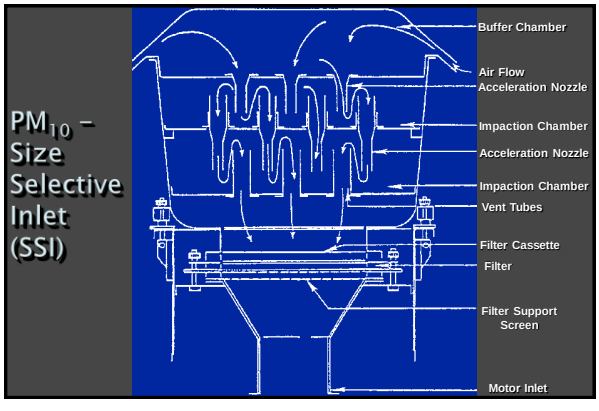
Measures of Particulate Matter in the Atmosphere



Particulate

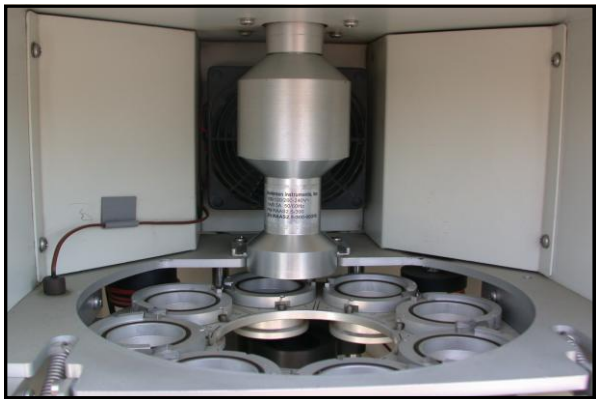
- Total Suspended Particulate (TSP) Samplers
  - Lead
- PM10 and/or PM2.5 samplers
  - Size Selective Inlet
  - BAM
  - TEOM
- Visibility Samplers
  - Nephelometer
  - Optical Test Tape Sampler

Size
Selective
Inlet (SSI)
Sampler

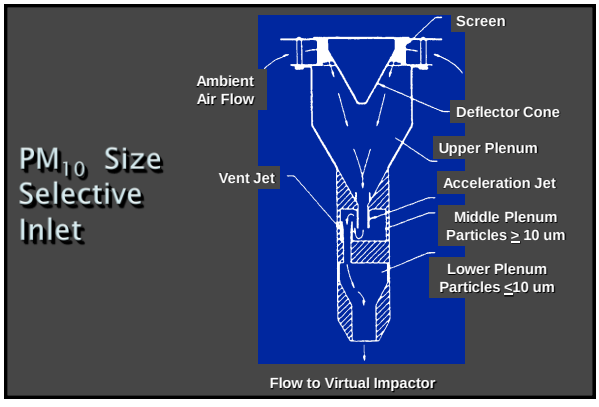

PM10 –
Size
Selective
Inlet
(SSI)
Buffer Chamber
Air Flow
Acceleration Nozzle
Impaction Chamber
Acceleration Nozzle
Impaction Chamber
Vent Tubes
Filter Cassette
Filter
Filter Support
Screen
Motor Inlet

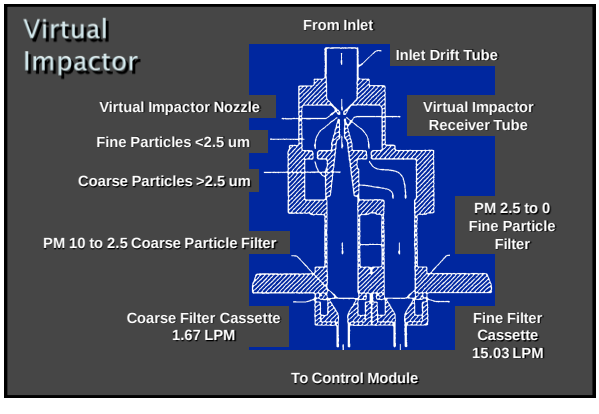
Inside SSI Head

Ambient Air Monitoring

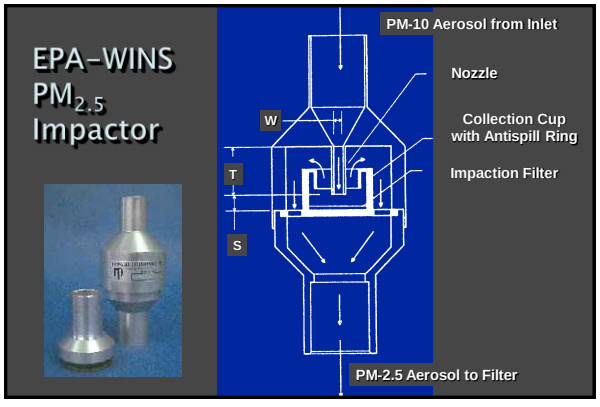


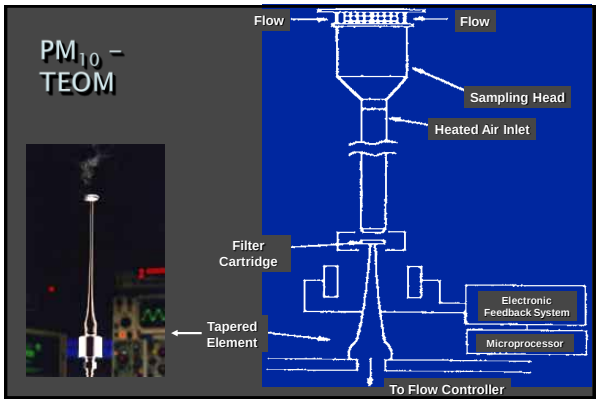
Ambient Air Monitoring



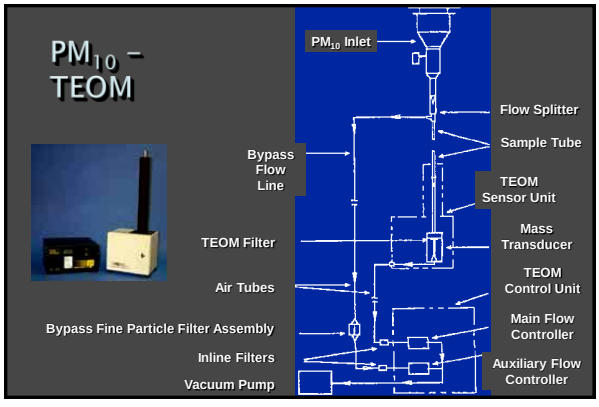


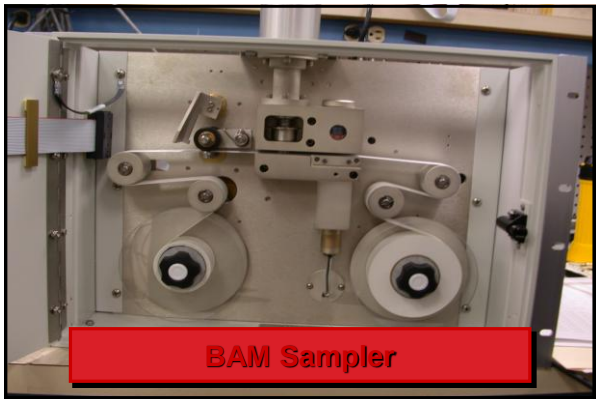
Ambient Air Monitoring





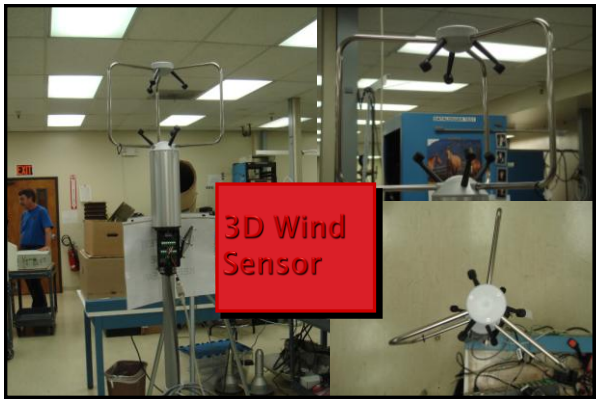
Ambient Air Monitoring





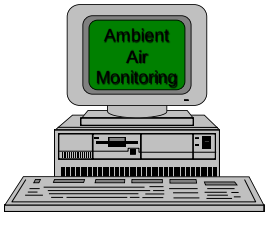
Meteorological Instruments

- Wind speed
- Wind direction
- Atmospheric pressure
- Temperature
- Relative humidity, dew pt
- Solar radiation

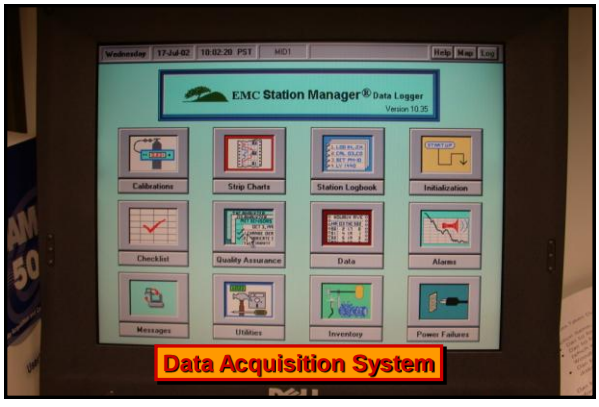


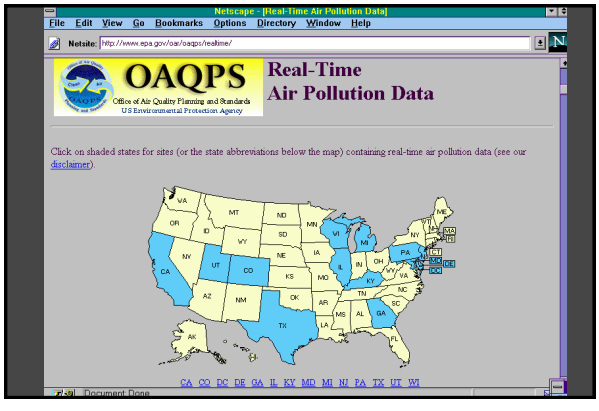
Data Handling

- Data loggers
  - Strip charts
  - Computers
  - Temporary data storage
  - On-line data retrieval



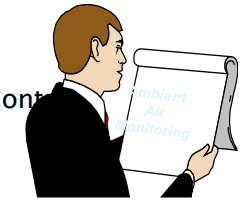
Ambient Air Monitoring





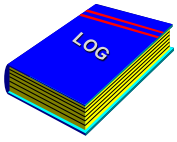
Site Survey Data

- Quality Assurance Procedures and Plans
- Cleaning Schedule
- Calibrations
- Station Temperature Cont
- In-Line Filters



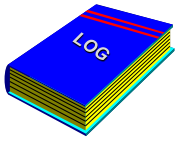
Documentation

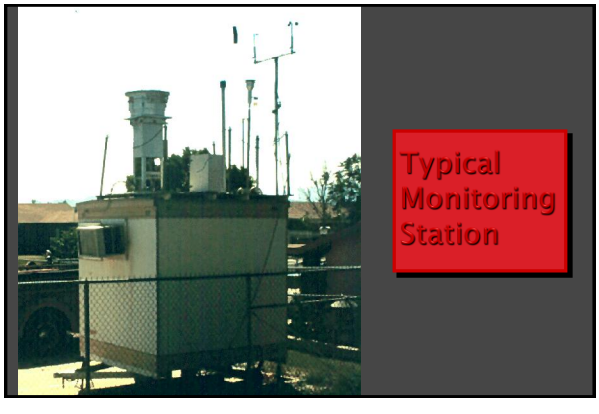
- Instrument Log
  - Stays with Instrument
  - Documents Acceptance Tests
  - Documents Routine Maintenance
  - Documents Repairs
  - Documents Calibrations
  - Other Instrument Specific Information
    - i.e. Location, History, etc.

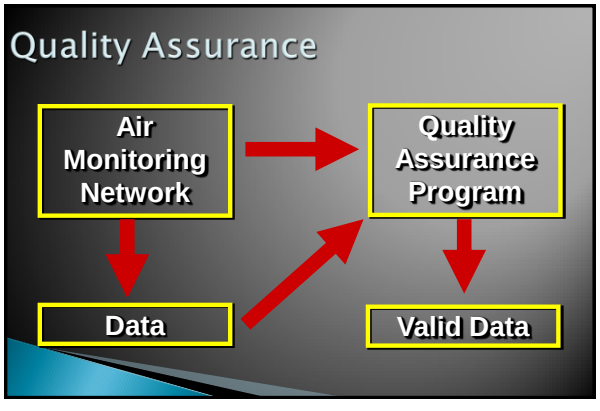


Documentation

- Station Log
  - Stays at Station
  - Documents Conditions that may Influence Data
    - Nearby Construction
    - Changes in Traffic Patterns and Flow
  - Documents Alterations of Sampling Train
    - Probe and Equipment Changes
  - Contains Completed Site Reports







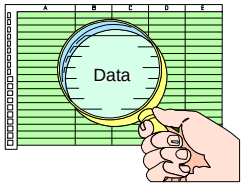
Quality Assurance

- Field QA
  - Daily and Weekly Zero and Span Checks
  - Semi-Annual Multipoint Calibrations
  - External Audits
    - ARB Audits
    - EPA NPAP (National Pollutant Audit Program)

QA

Data Handling

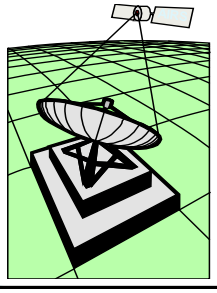
- Data review and editing
  - Complete data set
  - Reviewed for accuracy
  - Reviewed for consistency



QA

Data Handling

- Data Processing
  - Upload to AIRS Database
  - Air Quality Data Actions
    - Data Deletion
    - Data Correction
    - Links Data to Field QA



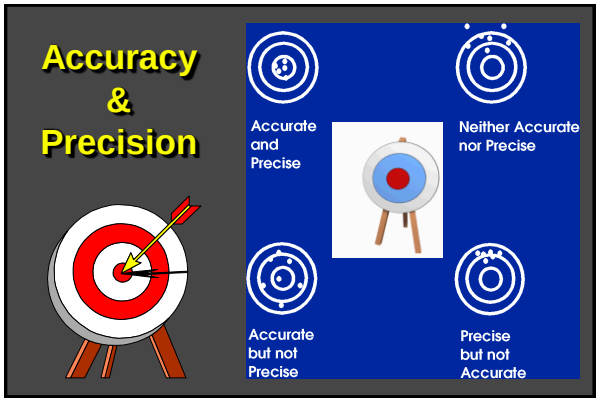
Station Inspection

- Review Siting
- Examine Instruments
  - Condition, Zero/Spans, Calibration, Audit Results
- Examine Gases
  - Certification
- Review Logs
- Evaluate Overall Station C
  and Operation

QA

ARB Audit Van

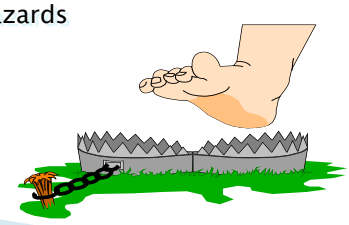
ARB Audit Van
Instrumentation

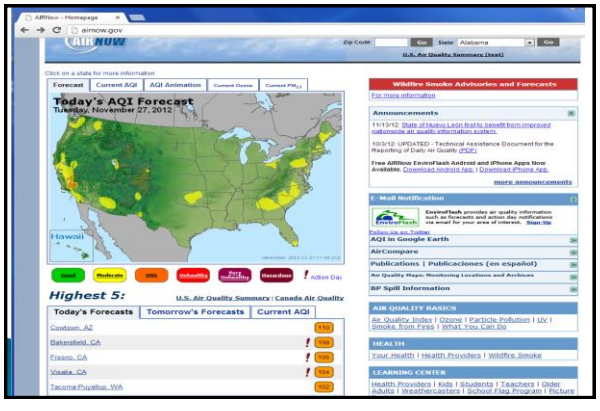

Accuracy
&
Precision
Accurate and Precise
Neither Accurate nor Precise
Accurate but not Precise
Precise but not Accurate

Ambient Air Monitoring

Safety

- Compressed Gas Cylinders
- Hazardous Gases
- Electrical Hazards
- Heights





Ambient Air Monitoring

WWW.EPA.GOV/AIRQUALITY/AIRDATA

Air Quality statistics

- AirData
- **You are here:** EPA Home
- AirData
- Reports
- Air Quality Statistics Report
- **Air Quality Statistics Report**
- This report provides standards-related summary data by city or county. Read more about what's in this report.
- 1. Year
- 2. Geographic Area
  -- or --

  -- or --
- 3. Group Results by City (defined as CBSA)
  County
- 4. Exceptional Events Include exceptional events data
  Exclude exceptional events

Air Quality Statistics

EPA Air Quality Standards:
Carbon Monoxide: 35 ppm (1-hour), 9 ppm (8-hour)
Nitrogen Dioxide: 100 ppb (1-hour)
Ozone: 0.12 ppm (1-hour), 0.075 ppm (8-hour)
Sulfur Dioxide: 75 ppb (1-hour), 140 ppb (24-hour)
PM2.5: 35 ug/m3 (24-hour), 15.0 ug/m3 (annual)
PM10: 150 ug/m3 (24-hour)
Lead: The 3-month avg statistic currently is not available from the AQS Data Mart. We will add it to this report when it becomes available.

The following data links are active for the next 10 minutes, after which you must resubmit your query.
Download PHP (printable pages)
Download CSV (spreadsheet)
To sort a column in the table below, click on the column heading.

CBSA	CO 1-hr 2nd Max	CO 8-hr 2nd Max	NO2 98th %ile	O3 1-hr 2nd Max	O3 8-hr 4th Max	SO2 99th %ile	SO2 24-hr 2nd Max	PM2.5 98th %ile	PM2.5 Wtd. Mean	PM10 24-hr 2nd Max
Barnstable Town, MA	.	.	.	0.08	0.068	.	.	.	.	.
Boston-Cambridge-Quincy, MA-NH	2.5	1.7	53	0.1	0.073	37	12	24	10.3	41
Pittsfield, MA	.	.	.	0.07	0.067	.	.	29	9.1	.
Providence-New Bedford-Fall River, RI-MA	1.8	1.3	45	0.1	0.078	65	34	26	10	35
Springfield, MA	4.7	3	54	0.1	0.074	22	8	28	9.7	30
Worcester, MA	2.2	1.7	62	0.1	0.068	12	8	24	9	35

Monitor Values

- 1. Pollutant
- 2. Year
- 3. Geographic Area
  -- or --

  -- or --
- 4. Exceptional Events Include exceptional events data
  Exclude exceptional events data

The future

- Greenhouse Gases
- Real time Particulate Speciation
- Satellite Stations
- ???????

The Web

- http://www.arb.ca.gov/qaweb/district_sitelist.php
  - Site List
- http://www.tceq.state.tx.us/compliance/monitoring/air/monops/naaqs.html
  - NAAQS
- http://www.epa.gov/oar/oaqps/greenbk/index.html
  - Non attainment Areas