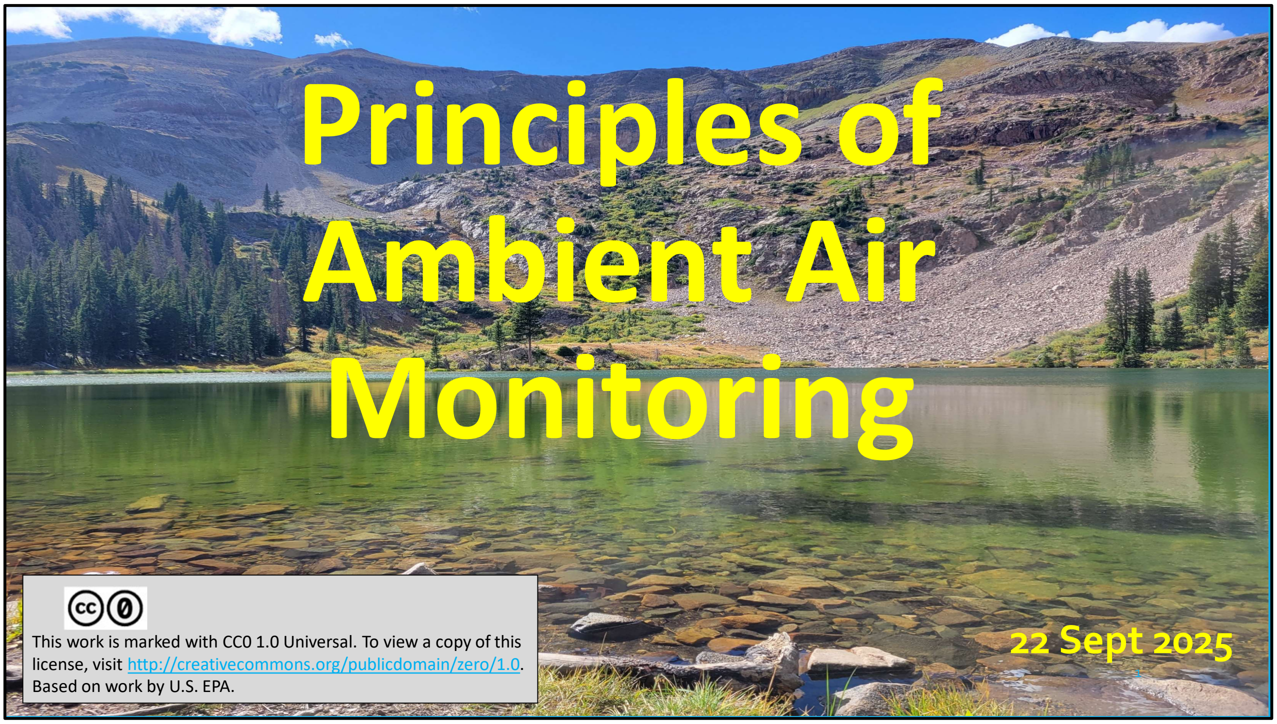
Principles of
Ambient Air
Monitoring
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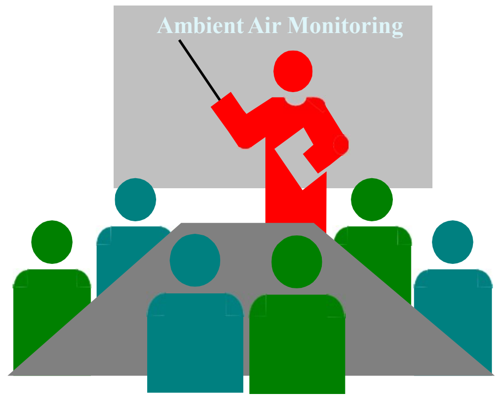
Based on work by U.S. EPA.
22 Sept 2025

Source

- The content of the materials in this training are derived from the AMBM102-CI: Principles of Ambient Air Monitoring (formerly NACT 222) content available from U.S. EPA.
- https://airknowledge.gov/

Course goal

After completion of this course, learners will be able to explain the background and general principles of ambient air monitoring for criteria pollutants



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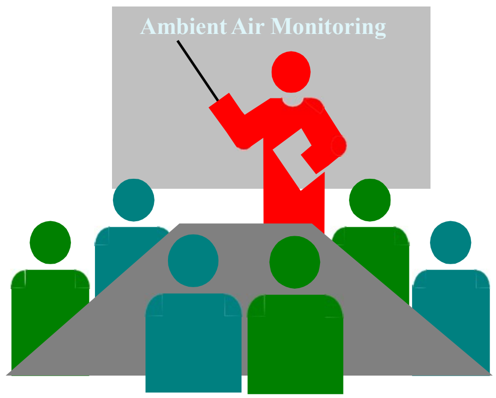
Course overview

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



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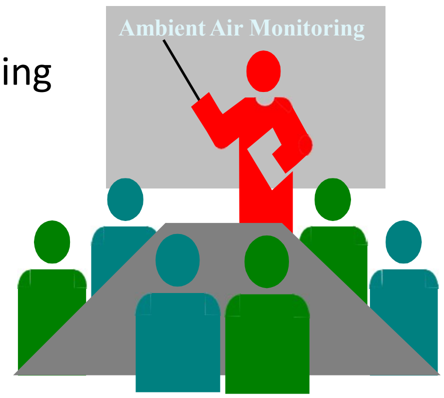
Ground rules

- Start and stop on-time
- Be respectful and courteous
- Keep microphone on mute unless talking
- Ask questions as you think of them
- Return promptly from breaks



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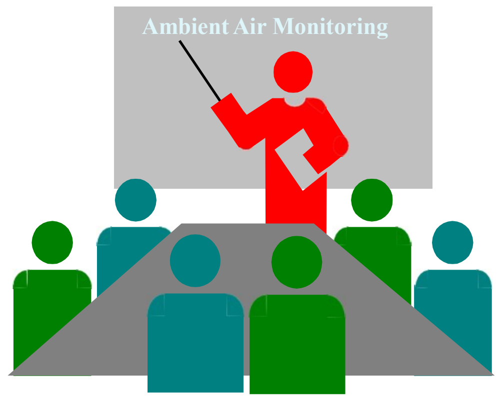
Introductions

- Please introduce yourself
  - Name
  - Agency
  - How long
  - Role



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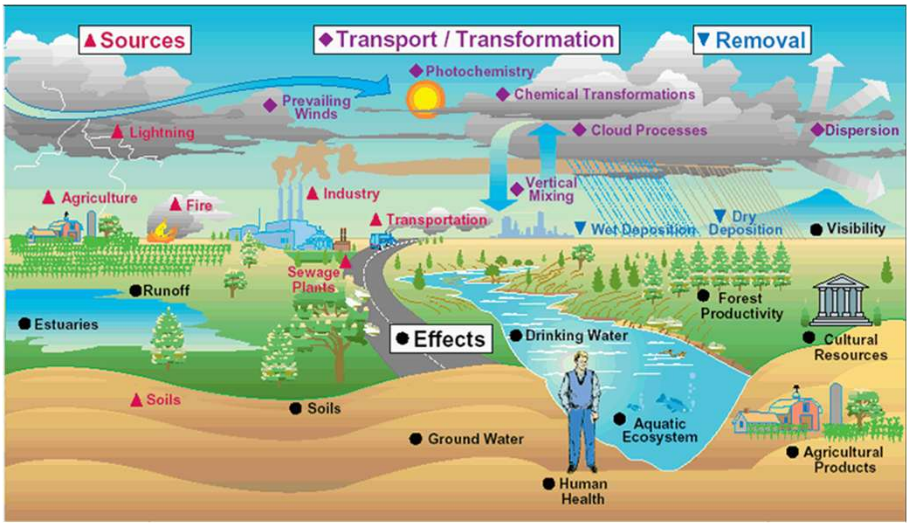
Air respects no boundaries



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Hard to deal with.
Not like water that follows channels.

Sources of air pollution

Source Type	Emission Sector
Biogenics	Vegetation and Soil
Fires	Agricultural Field Burning
	Prescribed Fires
	Wildfires
Mobile	Aircraft
	Commercial Marine Vessels
	Locomotives
	Non-Road Equipment
	On-Road Vehicles
Stationary	Agriculture
	Dust – Roads / Construction
	Fuel Combustion – Commercial / Institutional
	Fuel Combustion – Electric Generation
	Fuel Combustion – Industrial Boilers
	Fuel Combustion – Residential
	Industrial Processes
	Miscellaneous
	Solvents

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Natural and anthropogenic sources.


Regulations and Standards

Clean Air Act (CAA)

- CAA of 1963
  - Established funding for the study and cleanup of air pollution
- CAA of 1970
  - Current CAA
  - (EPA also established in 1970)
  - First comprehensive federal response to address air pollution
  - Revised in 1977 and 1990
  - 1990 Amendments provided EPA even broader authority to implement and enforce regulations reducing air pollutant emissions

The Clean Air Act (CAA) is the comprehensive federal law that regulates air emissions from stationary and mobile sources. Among other things, this law authorizes EPA to establish National Ambient Air Quality Standards (NAAQS) to protect public health and public welfare and to regulate emissions of hazardous air pollutants.

One of the goals of the Act was to set and achieve NAAQS in every state by 1975 in order to address the public health and welfare risks posed by certain widespread air pollutants. The setting of these pollutant standards was coupled with directing the states to develop state implementation plans (SIPs), applicable to appropriate industrial sources in the state, in order to achieve these standards. The Act was amended in 1977 and 1990 primarily to set new goals (dates) for achieving attainment of NAAQS since many areas of the country had failed to meet the deadlines.

Section 112 of the Clean Air Act addresses emissions of hazardous air pollutants. Prior to 1990, CAA established a risk-based program under which only a few standards were developed. The 1990 Clean Air Act Amendments revised Section 112 to first require issuance of technology-based standards for major sources and certain area sources. "Major sources" are defined as a stationary source or group of stationary sources that emit or have the potential to emit 10 tons per year or more of a hazardous air pollutant or 25 tons per year or more of a combination of hazardous air pollutants. An "area source" is any stationary source that is not a major source.

For major sources, Section 112 requires that EPA establish emission standards that require the maximum degree of reduction in emissions of hazardous air pollutants. These emission standards are commonly referred to as "maximum achievable control technology" or "MACT" standards. Eight years after the technology-based MACT standards are issued for a source category, EPA is required to review those standards to determine whether any residual risk exists for that source category and, if necessary, revise the standards to address such risk.

EPA responsibilities under the CAA

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

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The National Ambient Air Quality Standards (NAAQS) govern how much ground-level ozone (O3), carbon monoxide (CO), particulate matter (PM10, PM2.5), lead (Pb), sulfur dioxide (SO2), and nitrogen dioxide (NO2) are allowed in the outdoor air. The NAAQS set the acceptable levels of certain air pollutants in the ambient air in the United States.

The National Emissions Standards for Hazardous Air Pollutants (NESHAPs) govern how much of 187 toxic air pollutants are allowed to be emitted from industrial facilities and other sources. Under the CAA, hazardous air pollutants (HAPs, or air toxics) are air pollutants other than those for which NAAQS exist, which threaten human health and welfare. The NESHAPs are the standards used for controlling, reducing, and eliminating HAPs emissions from stationary sources such as industrial facilities. The 1970 CAA required EPA to develop a list of HAPs, and then develop national emissions standards for each of them. The original NESHAPs were health-based standards. The 1990 CAA Amendments codified EPA's list, and required creation of technology-based standards according to "maximum achievable control technology" (MACT).

The New Source Performance Standards (NSPS) are rules for the equipment required to be installed in new and modified industrial facilities, and the rules for determining whether a facility is "new". The 1970 CAA required EPA to develop standards for newly constructed and modified stationary sources (industrial facilities) using the "best system of emission reduction which (taking into account the cost of achieving such reduction) the [EPA] determines has been adequately demonstrated."

The Acid Rain Program (ARP) is an emissions trading program for power plants to control the pollutants that cause acid rain. The 1990 CAA Amendments created a new title to address the issue of acid rain, and particularly nitrogen oxides (NOx) and sulfur dioxide (SO2) emissions from electric power plants powered by fossil fuels, and other industrial sources. The Acid Rain Program was the first emissions trading program in the United States, setting a cap on total emissions that was reduced over time by way of traded emissions credits, rather than direct controls on emissions.

Prevention of Significant Deterioration (PSD) applies to new major sources or major modifications at existing sources for pollutants where the area the source is located is in attainment or unclassifiable with the National Ambient Air Quality Standards (NAAQS). It requires the following:

- installation of the "Best Available Control Technology" (BACT);
- an air quality analysis;
- an additional impacts analysis; and
- public involvement.

The CAA ozone program is a technology transition program intended to phase out the use of chemicals that harm the ozone layer. Consistent with the US commitments in the Montreal Protocol, CAA Title VI, added by the 1990 CAA Amendments, mandated regulations regarding the use and production of chemicals that harm Earth's stratospheric ozone layer.

Rules for pollutants emitted from internal combustion engines in vehicles. Since 1965, Congress has mandated increasingly stringent controls on vehicle engine technology and reductions in tailpipe emissions. Today, the law requires EPA to establish and regularly update regulations for pollutants that may threaten public health, from a wide variety of classes of motor vehicles, that incorporate technology to achieve the "greatest degree of emission reduction achievable", factoring in availability, cost, energy, and safety.

Much of EPA's regulation of greenhouse gas (GHG) emissions occurs under the programs discussed above. EPA began regulating GHG emissions following the Supreme Court's ruling in Massachusetts v. EPA, the EPA's subsequent endangerment finding, and development of specific regulations for various sources. The EPA's authority to regulate carbon dioxide emissions was questioned by the Supreme Court in West Virginia v. EPA but restored by Congress with the Inflation Reduction Act of 2022, which clarified that carbon dioxide is one of the pollutants covered by the Clean Air Act.

State/Local/Tribal responsibilities under the CAA

- Be the lead agencies to implement emission control measures
- Inspect facilities
- Monitor air quality
- Develop implementation plans

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Delegated authority from EPA. Permitting program for stationary sources.

The 1990 amendments authorized a national operating permit program, sometimes called the "Title V Program", covering thousands of large industrial and commercial sources. It required large businesses to address pollutants released into the air, measure their quantity, and have a plan to control and minimize them as well as to periodically report.

One of the most public aspects of the Clean Air Act, EPA is empowered to monitor compliance with the law's many requirements, seek penalties for violations, and compel regulated entities to come into compliance.

The 1963 act required development of State Implementation Plans (SIPs) as part of a cooperative federalist program for developing pollution control standards and programs. Rather than create a solely national program, the CAA imposes responsibilities on the U.S. states to create plans to implement the Act's requirements. EPA then reviews, amends, and approves those plans. EPA first promulgated SIP regulations in 1971 and 1972.

Purposes of monitoring

- Public health protection
- EPA requirements
- NAAQS compliance / attainment
- Baseline monitoring
- Source impacts
- Air quality trends
- Permit related
- Local concerns and requests
- Community assistance
- SIP’s/maintenance plans
- NEPA/EIS
- Emergency control procedures
- Research support

Regulations

- U.S. EPA
  - 40 CFR 50 - NAAQS
  - 40 CFR 53 - Methods
  - 40 CFR 58 - Surveillance
  - 40 CFR 51.24 - PSD
- State Regulations
- Tribal Regulations
- Local Regulations

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1970 CAA the most significant air act to-date.

40 CFR 60 – NSPS – source/continuous emissions monitoring.
40 CFR 63 – NESHAPS – source/continuous emissions monitoring.

40 CFR 50

- Reference conditions
- National Ambient Air Quality Standards
  - Primary
  - Secondary
- Reference methods
- Measurement principles and calibration procedures
- Interpretation of the standards

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Reference conditions: 25 degC, 760 mmHg.

Primary NAAQS = health-based
Secondary NAAQS = welfare based

Exceptional Events:
Exceptional events are unusual or naturally occurring events that can affect air quality but are not reasonably controllable using techniques that tribal, state or local air agencies may implement in order to attain and maintain the National Ambient Air Quality Standards. Exceptional events that are natural may include wildfires, high wind dust events, prescribed fires, stratospheric ozone intrusions, and volcanic and seismic activities.

Appendices A to U provide information on the reference methods for measuring the criteria pollutants as well as interpretation of the standards.

40 CFR 53

- Requirements for a reference method determination
- Requirements for an equivalent method determination.
- Includes:
  - Manual methods
  - Automated methods
- Designation of methods
- Revision/modification of methods

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How to get a monitor designated as reference or equivalent.

How monitors are designated / designation lists.

How to revise methods when needed for changes to the analyzer. Typically the analytical bench remains essentially unchanged.

40 CFR 58

- Requirements for measuring ambient air quality and for reporting ambient air quality data and related information
- Air quality data reporting, and requirements for the daily reporting of an index of ambient air quality
- The requirements pertaining to provisions for an air quality surveillance system in the SIP
- Establishes a national ambient air quality monitoring network for the purpose of providing timely air quality data upon which to base national assessments and policy decisions.

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Requirements for measuring ambient air quality and for reporting ambient air quality data and related information

Quality assurance procedures for monitor operation and data handling

Methodology used in monitoring stations

Operating schedules

Siting parameters for instruments or instrument probes

Minimum ambient air quality monitoring network requirements used to provide support to the State implementation plans (SIP), national air quality assessments, and policy decisions

Appendix A: QUALITY ASSURANCE REQUIREMENTS FOR MONITORS USED IN EVALUATIONS OF NATIONAL AMBIENT AIR QUALITY STANDARDS

Appendix B: QUALITY ASSURANCE REQUIREMENTS FOR PREVENTION OF SIGNIFICANT DETERIORATION (PSD) AIR MONITORING

Appendix C: AMBIENT AIR QUALITY MONITORING METHODOLOGY

Appendix D: NETWORK DESIGN CRITERIA FOR AMBIENT AIR QUALITYMONITORING

SLAMS: A criteria pollutant monitoring method used for making NAAQS decisions at a SLAMS site must be a reference or equivalent method, or approved regional method (ARM).

NCore: Methods employed in NCore multipollutant sites used to measure SO2, CO, NO2,

O_3, PM 2.5, or PM 10–2.5 must be reference or equivalent methods

PAMS: Methods used for O_3, NO, NO_2, NO_x monitoring at PAMS must be automated reference or equivalent methods. Methods for meteorological measurements and speciated VOC monitoring are included in the guidance provided in references 2 and 3 of this appendix.

Appendix E: PROBE AND MONITORING PATH SITING CRITERIA FOR AMBIENT AIR QUALITY MONITORING

Appendix F: (reserved)

Appendix G: UNIFORM AIR QUALITY INDEX (AQI) AND DAILY REPORTING


Monitoring Networks

Monitoring Networks

- SLAMS
  - State and Local Air Monitoring Station
- NAMS
  - National Air Monitoring Station
- NCore
  - National Core Multipollutant Network
- Near-Roadway NO_2
- SPM
  - Special Purpose Monitoring

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Monitoring Networks

- PAMS
  - Photochemical Assessment Monitoring Station

- NATTS
  - National Air Toxics Trends Stations
- IMPROVE
  - Interagency Monitoring of Protected Visual Environments
- CASTNET
  - Clean Air Status and Trends Network

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Monitoring Networks

- NADP
  - National Atmospheric Deposition Program
    - National Trends Network (NTN)
    - Mercury Deposition Network (MDN)
    - Ammonia Monitoring network (AMoN)
- CSN
  - $PM_{2.5}$ Chemical Speciation Network
  - Includes Speciation Trends Network (STN)
- PSD
  - Prevention of Significant Deterioration

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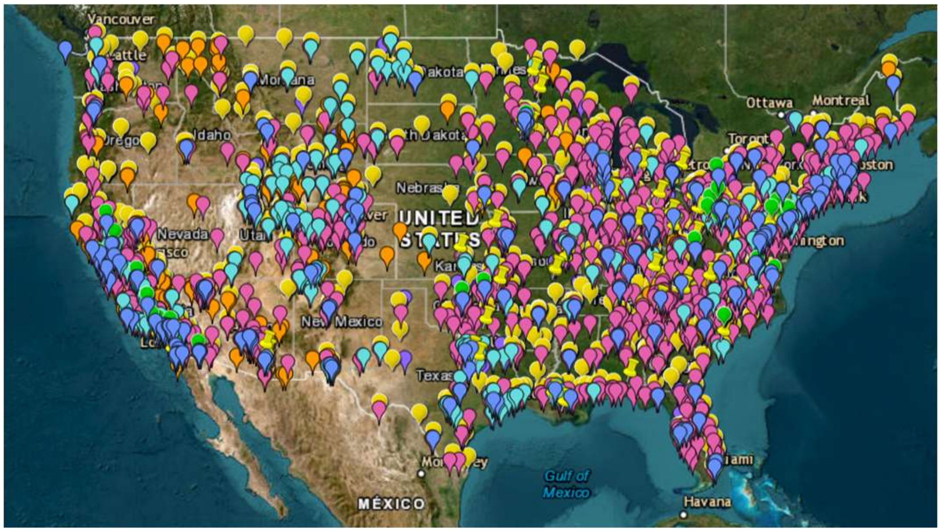
SLAMS/NAMS sites



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The SLAMS make up the ambient air quality monitoring sites that are operated by State or local agencies for the primary purpose of comparison to the National Ambient Air Quality Standards (NAAQS), but may serve other purposes such as:

- provide air pollution data to the general public in a timely manner;
- support compliance with air quality standards and emissions strategy development; and
- support air pollution research studies.

The SLAMS network includes stations classified as NCore, PAMS, and Speciation, and formerly categorized as NAMS, and does not include Special Purpose Monitors (SPM) and other monitors used for non-regulatory or industrial monitoring purposes.

SLAMS must use approved Federal reference method (FRM), Federal equivalent method (FEM), or Approved Regional Method (ARM) monitors for ambient pollutant levels being compared to the NAAQS.

NCore sites

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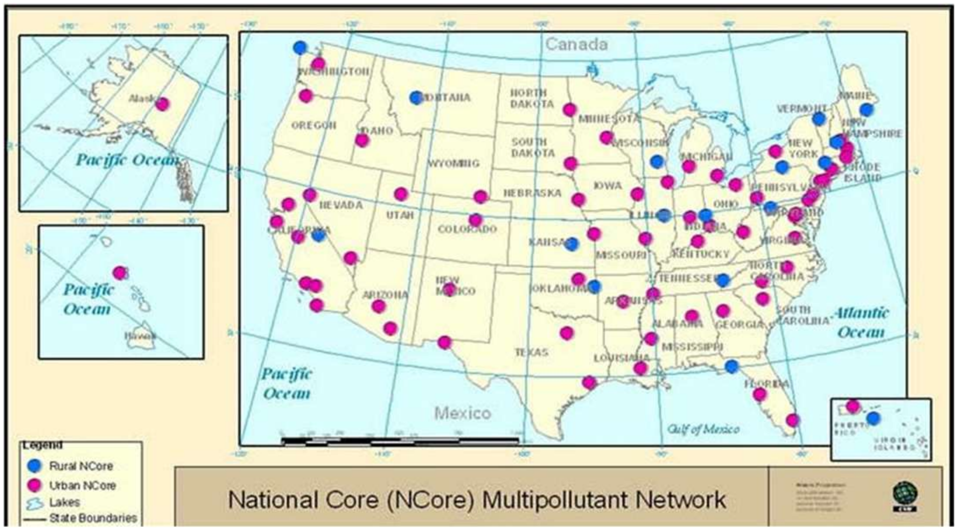
The NCore multi-pollutant stations are part of an overall strategy to integrate multiple monitoring networks and measurements. As required by the revised monitoring regulations promulgated in 2006, monitors at NCore multi-pollutant sites will measure particles (PM2.5, speciated PM2.5, PM10-2.5, speciated PM10-2.5), O3, SO2, CO, nitrogen oxides (NO/NO2/NOy), and basic meteorology. Monitors for all the gases except for O3 will be more sensitive than standard FRM/FEM monitors, so they could accurately report concentrations that are well below the respective NAAQS but that can be important in the formation of O3 and PM.

The objective is to locate sites in broadly representative urban (about 55 sites) and rural (about 20 sites) locations throughout the country to help characterize regional and urban patterns of air pollution. The NCore network must be fully operational by 2011.

NCore network



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Rural vs urban sites (including AK, HI, Puerto Rico)

NCore objectives

- Timely reporting of air quality data to public
- Support for development of emission strategies
- Long-term tracking of emission strategies
- Long-term health assessment for NAAQS reviews
- Establish attainment/nonattainment areas
- Support for scientific studies in technical, health & atmospheric disciplines
- Support to ecosystem assessment

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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

Near-road NO_2 sites

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The near-road monitoring network was initiated as part of the 2010 NO2 NAAQS review and has become a multi-pollutant monitoring network.

PAMS sites

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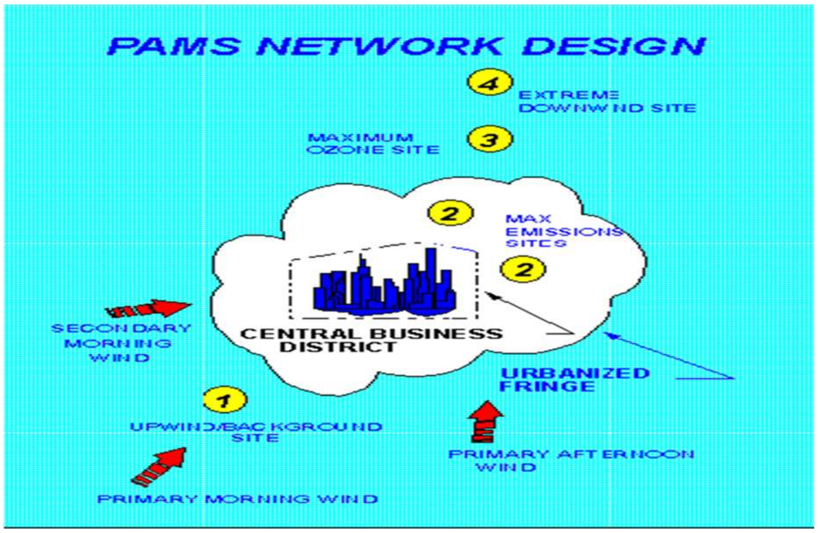
Section 182(c)(1) of the 1990 Clean Air Act Amendments (CAAA) require the Administrator to promulgate rules for the enhanced monitoring of ozone, oxides of nitrogen (NOx), and volatile organic compounds (VOC) to obtain more comprehensive and representative data on ozone air pollution. Immediately following the promulgation of such rules, the affected states were to commence such actions as were necessary to adopt and implement a program to improve ambient monitoring activities and the monitoring of emissions of NOx and VOC. Each State Implementation Plan (SIP) for the affected areas must contain measures to implement the ambient monitoring of such air pollutants. The subsequent revisions to Title 40, Code of Federal Regulations, Part 58 (40 CFR 58) required states to establish Photochemical Assessment Monitoring Stations (PAMS) as part of their SIP monitoring networks in ozone nonattainment areas classified as serious, severe, or extreme.

The chief objective of the enhanced ozone monitoring revisions is to provide an air quality database that will assist air pollution control agencies in evaluating, tracking the progress of, and, if necessary, refining control strategies for attaining the ozone NAAQS. Ambient concentrations of ozone and ozone precursors will be used to make attainment/nonattainment decisions, aid in tracking VOC and NOx emission inventory reductions, better characterize the nature and extent of the ozone problem, and prepare air quality trends. In addition, data from the PAMS will provide an improved database for evaluating photochemical model performance, especially for future control strategy mid-course corrections as part of the continuing air quality management process. The data will be particularly useful to states in ensuring the implementation of the most cost-effective regulatory controls.

PAMS network design



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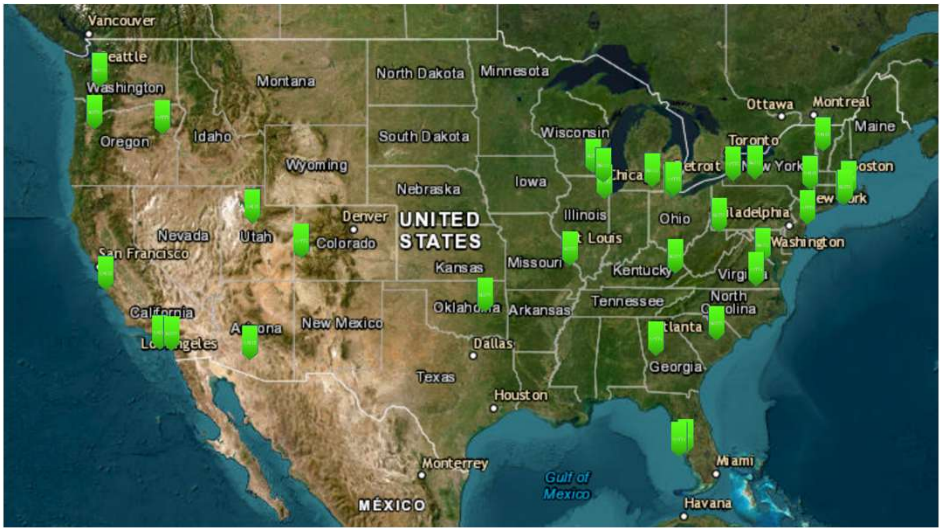
PAMS required for ozone non-attainment areas.

Need to look at monitoring of precursors vs monitoring in the resulting high O3 area.

NATTS sites



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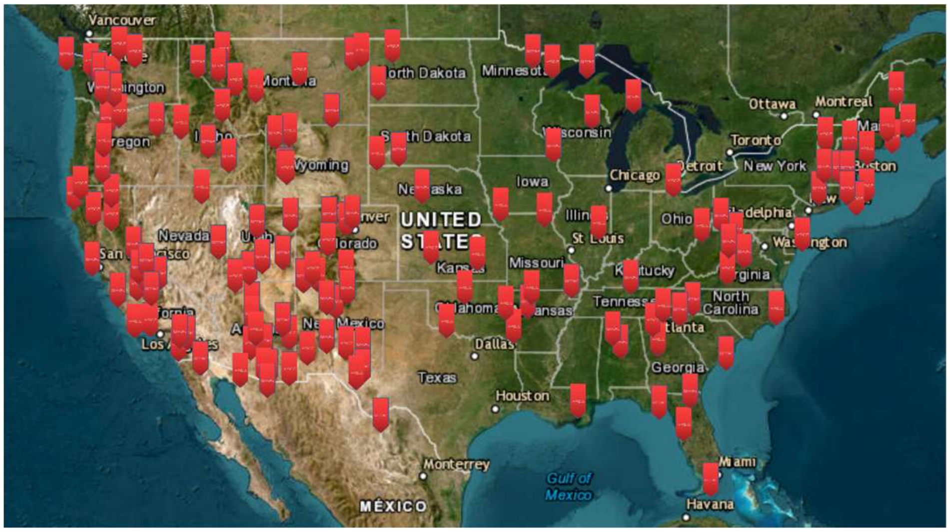
The National Air Toxics Trends Station (NATTS) network was developed to fulfill the need for long-term air toxics, also known as hazardous air pollutant (HAP), monitoring data of consistent quality. Among the principle objectives of the NATTS network are assessing trends and emission reduction program effectiveness, assessing and verifying air quality models (e.g., exposure assessments, emission control strategy development, etc.), and to provide data for direct input to source-receptor models. The network was initiated in 2003, and the current network configuration includes 26 sites (21 urban, 5 rural) across the United States. There are typically over 100 pollutants monitored at each NATTS, although only 19 of those are formally required. Target HAPs include volatile organic compounds (VOCs), carbonyls, PM10 metals, and polycyclic aromatic hydrocarbons (PAHs).

IMPROVE sites



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Under the Clean Air Act, Congress recognized that visibility is a resource to be valued and preserved now and for future generations, and set forth a national goal that calls for "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I federal areas which impairment results from manmade air pollution." The Regional Haze Rule (RHR) expanded this mandate by requiring monitoring in locations representative of the 156 visibility-protected federal Class I areas. Interagency Monitoring of Protected Visual Environments (IMPROVE) was designated as the visibility monitoring network to be used to carry out this responsibility. IMPROVE was initially established as a national visibility network in 1985, and consisted of 30 monitoring sites primarily located in national parks, 20 of which began operation in 1987. With the implementation of the RHR in 1999, the IMPROVE network expanded, and 110 monitoring sites were identified that were deemed representative of the regional haze conditions for 155 of the mandatory 156 Class I areas, the Bering Sea Wilderness being the exception. In addition to the 110 sites that are used to represent Class I areas, a number of IMPROVE protocol sites are in operation that provide expanded spatial coverage for the network. Protocol sites are separately sponsored by state, regional, tribal, and national organizations and use the same instrumentation, monitoring, and analysis protocols as IMPROVE. The use of identical samplers and analysis protocols by the same contractors ensures that data generated by IMPROVE and IMPROVE protocol sites can be treated as directly comparable.

Class 1 areas

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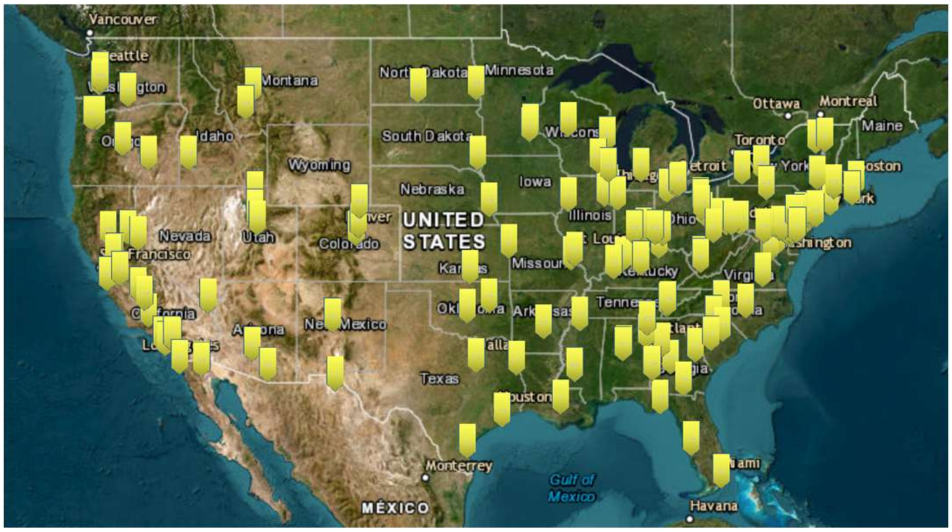
The Clean Air Act gives special air quality and visibility protection to national parks larger than 6,000 acres and national wilderness areas larger than 5,000 acres that were in existence when it was amended in 1977. These are “Class I” areas. All other areas are “Class II” allowing for a moderate amount of air quality deterioration. Because air pollution is often regional in nature, reductions in pollution to improve visibility in Class I parks will also improve visibility in all parks in the surrounding area. Class I areas are managed by the National Park Service, U.S. Fish and Wildlife Service, U.S. Forest Service, and several Native American Tribes.

The Clean Air Act outlines procedures that a State or Tribal governing body may use to redesignate areas as either Class I (greater air quality protection) or Class III (less protection). However, mandatory Class I areas may not be redesignated and Class II "floor" areas may not be redesignated to Class III. Prior to proposing a redesignation, the redesignating authority must analyze and describe the health, environmental, economic, social, and energy effects of the redesignation.

CSN sites



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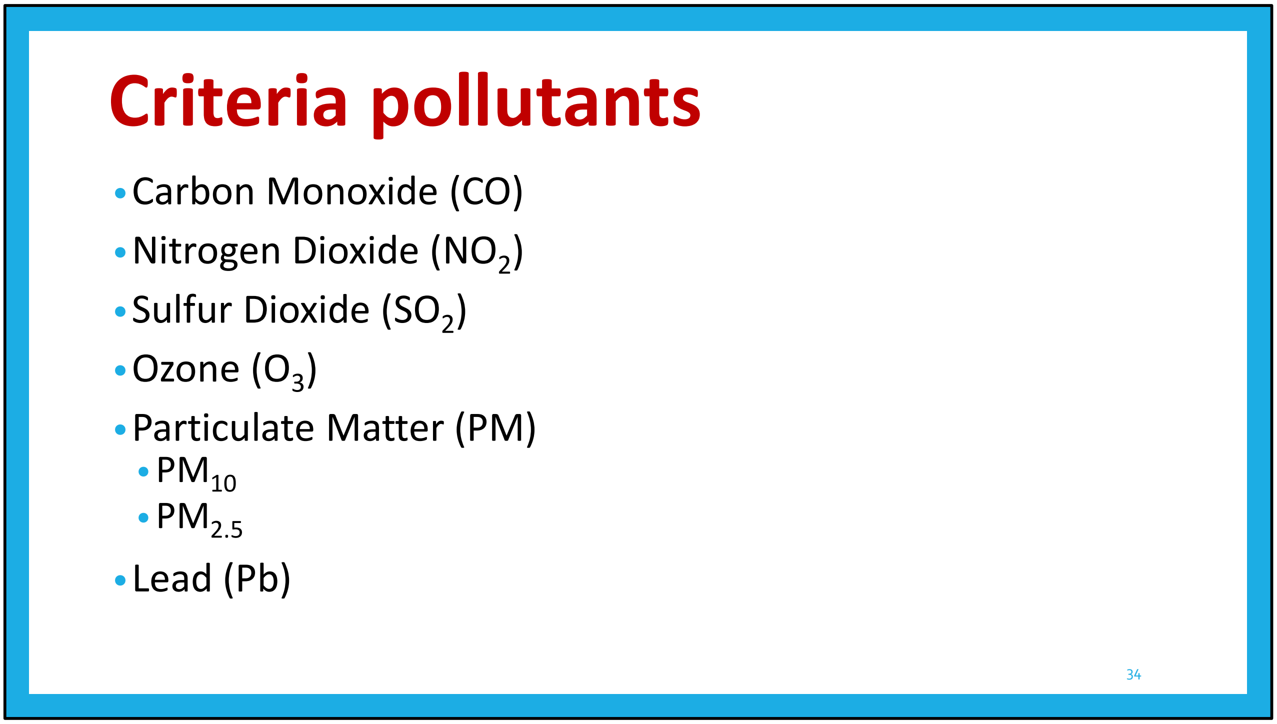
As part of the effort to monitor particulate matter, EPA monitors and gathers data on the chemical makeup of these particles. EPA established a chemical speciation network (CSN) consisting of approximately 300 monitoring sites. These sites are placed at various NAMS and SLAMS across the Nation. Fifty-four of these chemical speciation sites, the Speciation Trends Network (STN), will be used to determine, over a period of several years, trends in concentration levels of selected ions, metals, carbon species, and organic compounds in PM2.5. Further breakdown on the location or placement of the trends sites requires that approximately 20 of the monitoring sites be placed at existing Photochemical Assessment Monitoring Stations (PAMS). The placement of the remaining trends sites will be coordinated by EPA, the Regional offices, and the monitoring agencies. Locations will be primarily in or near larger Metropolitan Statistical Areas (MSAs). The remaining chemical speciation sites will be used to enhance the required trends network and to provide information for developing effective State Implementation Plans (SIPs).

The STN is a component of the National PM2.5 Monitoring Network. Although the STN is intended to complement the activities of the much larger gravimetric PM2.5 measurements network component (whose goal is to establish if NAAQS are being attained), STN data will not be used for attainment or nonattainment decisions.



Some are primary pollutants (i.e. CO).
Some are secondary pollutants formed from reactions (i.e. O3).

Different forms of the standards (1-hr, 3-hr, 8-hr, 24-hr, 3-month, annual).
Many are averaged over 3-years.

Current NAAQS

Pollutant		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead (Pb)		primary and secondary	Rolling 3 month average	0.15 μg/m^3	Maximum arithmetic mean of 3 consecutive monthly means in a 3-year period
Nitrogen Dioxide (NO2)		primary	1 hour	100 ppb	Annual 98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	1 year	53 ppb	Annual Mean
Ozone (O3)		primary and secondary	8 hours	0.070 ppm	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	PM2.5	primary	1 year	9.0 μg/m^3	annual mean, averaged over 3 years
		secondary	1 year	15.0 μg/m^3	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 μg/m^3	98th percentile, averaged over 3 years
	PM10	primary and secondary	24 hours	150 μg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO2)		primary	1 hour	75 ppb	Annual 99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	1 year	10 ppb	annual mean, averaged over 3 years

NAAQS are supposed to be reviewed every 5 years. Hard to meet due to the complexities around health studies and review requirements.

Planning Phase
Each review begins with a public Call for Information to announce the initiation of a review and to solicit information on new scientific evidence and policy issues for consideration. The planning phase of the NAAQS review process may also include a science policy workshop, which is intended to gather input from the scientific community and the public regarding policy-relevant issues and questions that will frame the review. Drawing from the workshop discussions and public comments, EPA prepares an Integrated Review Plan (IRP) that conveys the schedule for the entire review, the process for conducting the review, and the key policy-relevant science issues that will guide the review.

Assessment Phase
In the assessment phase, the EPA prepares the Integrated Science Assessment, Risk and Exposure Assessments (quantitative air quality, exposure and risk analyses), as warranted, and a Policy Assessment.

Integrated Science Assessment (ISA): This assessment is a comprehensive review, synthesis, and evaluation of the most policy-relevant science, including key science judgments that are important to inform the development of the risk and exposure assessments, as well as other aspects of the NAAQS review.

Risk/Exposure Assessment (REA): This assessment draws upon information and conclusions presented in the ISA to develop quantitative characterizations of exposures and associated risks to human health or the environment associated with recent air quality conditions and with air quality estimated to just meet the current or alternative standard(s) under consideration. This assessment includes a characterization of the uncertainties associated with such estimates.

Policy Assessment (PA): This assessment provides a transparent staff analysis of the scientific basis for alternative policy options for consideration by senior EPA management prior to rulemaking. Such an evaluation of policy implications is intended to help ''bridge the gap'' between the Agency's scientific assessments, presented in the ISA and REA(s), and the judgments required of the EPA Administrator in determining whether it is appropriate to retain or revise the NAAQS. In so doing, the PA is also intended to facilitate the Clean Air Scientific Advisory Committee's (CASAC's) advice to the Agency and recommendations to the Administrator, as provided for in the CAA, on the adequacy of the existing standards or revisions that may be appropriate to consider. The PA focuses on the information that is most pertinent to evaluating the basic elements of the NAAQS: indicator, averaging time, form, and level.

Scientific review during the development of these documents is thorough and extensive. Drafts of all documents are reviewed by CASAC and the public has an opportunity to comment on them.

Rulemaking Phase
Taking into consideration the information in the ISA, REA(s), and PA and the advice of CASAC, EPA develops and publishes a notice of proposed rulemaking that communicates the Administrator's proposed decisions regarding the review of the NAAQS. A public comment period, during which public hearings are generally held, follows publication of the notice of proposed rulemaking. Taking into account comments received on the proposed rule, EPA issues a final rule.

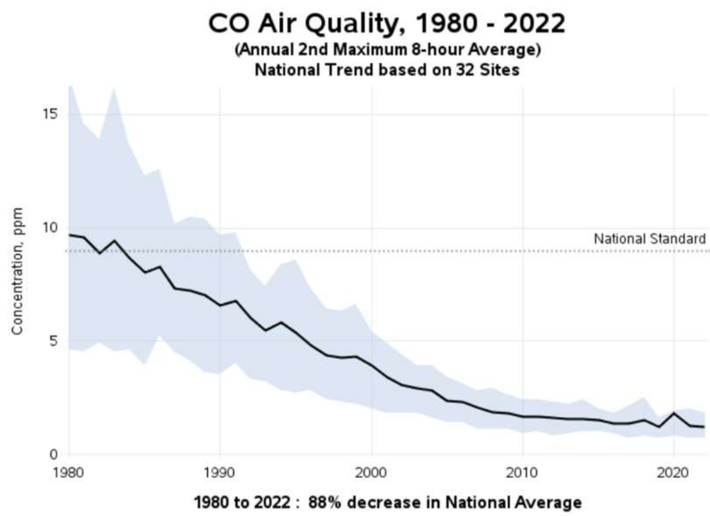
Area designations

- Attainment
- Non-attainment
  - SIP/TIP/FIP
- Maintenance
  - 20-year plan

36

EPA does designations when NAAQS are reviewed every 5 years.

CO trends



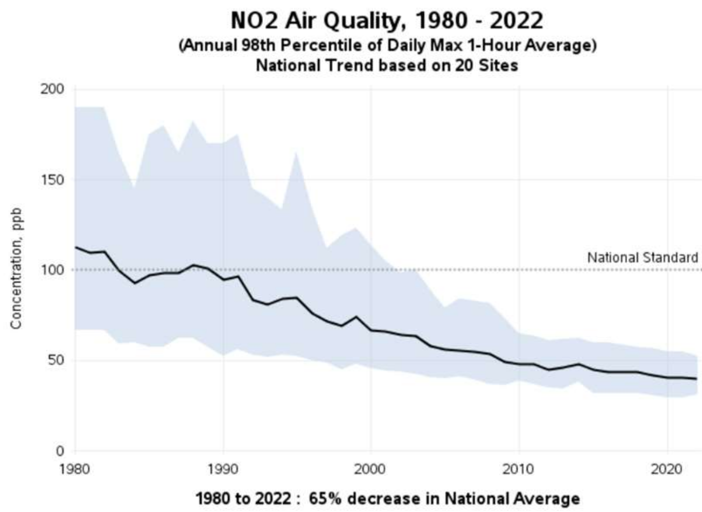
37

Combustion-related.

Vehicles now have catalytic converters.

Success story nationwide.

NO_2 trends

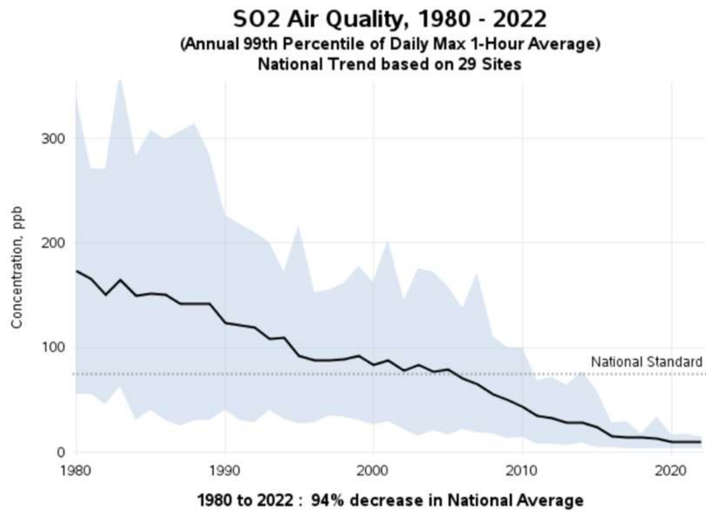


38

Combustion-related.

NO the primary emission, rapidly oxidizes to NO2.

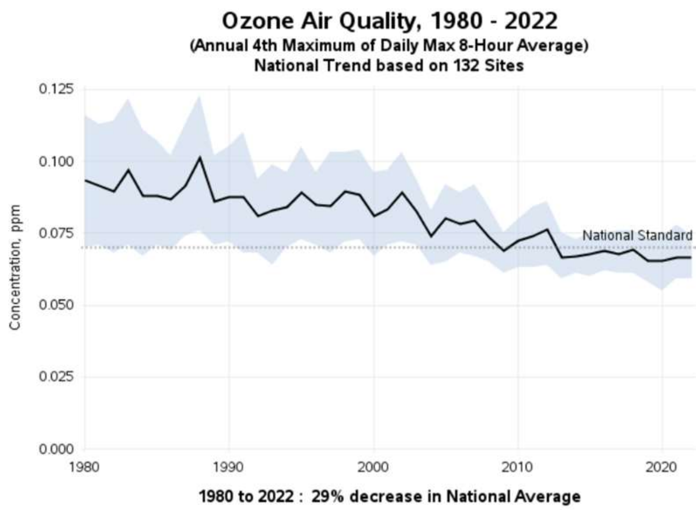
SO_2 trends



39

Diesel and coal combustion-related.

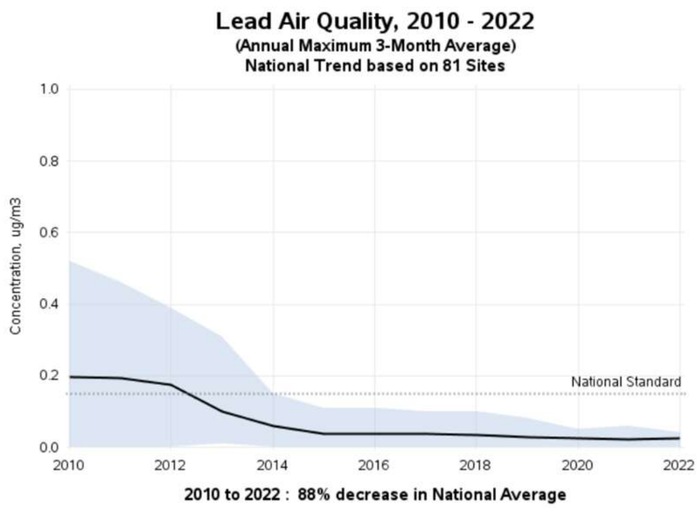
O_3 trends



40

HC’s and NOx reacting in sunlight.

Pb trends

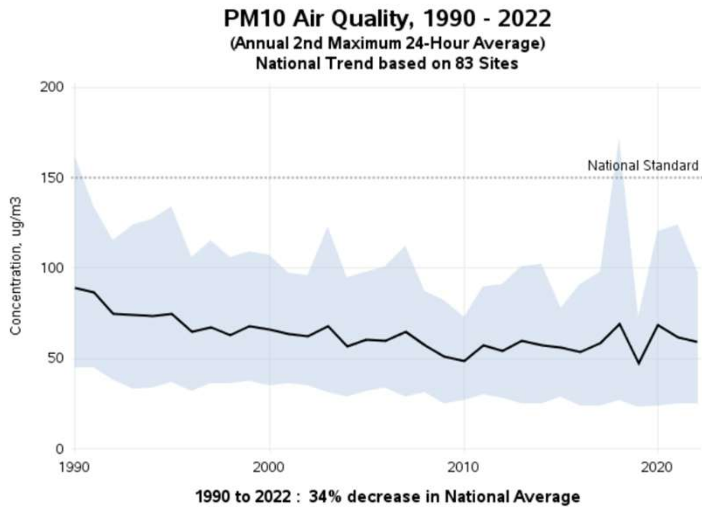


41

Unleaded fuels the key.

Piston driven aircraft and smelters the only significant sources remaining.

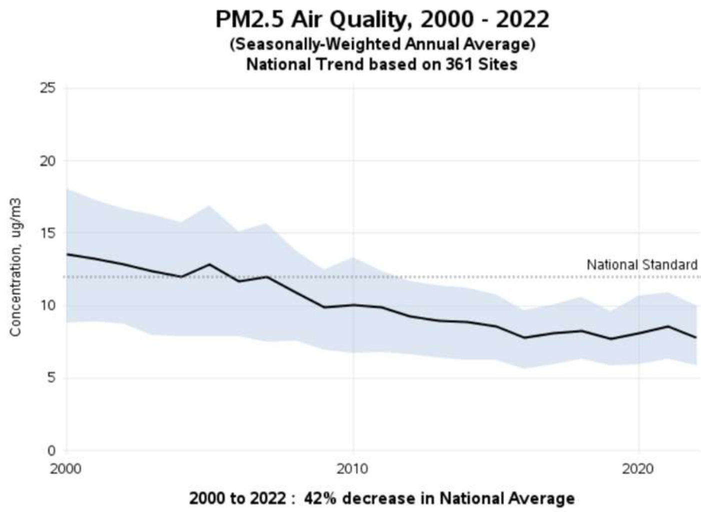
PM_{10} trends



42

Primarily dust.

$PM_{2.5}$ trends



43

Combustion and secondary formation.

Carbon Monoxide (CO) – NAAQS History

Final Rule/Decision	Primary/ Secondary	Indicator	Averaging Time	Level [(2)]	Form
1971 36 FR 8186 Apr 30, 1971	Primary and Secondary	1. CO [(1)]	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 [(3)]
1985 50 FR 37484 Sept 13, 1985	Primary standards retained, without revision; secondary standards revoked.				
1994 59 FR 38906 Aug 1, 1994	Primary standards retained, without revision.				
2011 76 FR 54294 Aug 31, 2011	Primary standards retained, without revision.				

44

No revisions since implemented in 1971.

Current CO monitors

45

Mainly urban areas.

Current CO maintenance areas

1971 Standard

46

As of September 27, 2010, all Carbon Monoxide areas have been redesignated to maintenance.

Nitrogen Dioxide (NO_2) – NAAQS History

Final Rule/Decision	Primary/ Secondary	Indicator [1]	Averaging Time	Level [2]	Form
1971 36 FR 8186 Apr 30, 1971	Primary and Secondary	NO_2	Annual	53 ppb [3]	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 [4]	Primary	NO_2	1-hour	100 ppb	98th percentile, averaged over 3 years [5]
		Primary annual NO_2 standard retained, without revision.			

47

No revisions to the annual standard since implementation in 1971.

1-hour standard implemented in 2010.

Current NO_2 monitors

48

Urban areas, oil & gas development areas, other combustion sources.

Current NO_2 maintenance areas

1971 Standard

49

On September 22, 1998 the only Nitrogen Dioxide (1971) nonattainment area was redesignated to maintenance.

Sulfur Dioxide (SO_2) – NAAQS History

Final Rule/Decision	Primary/ Secondary	Indicator	Averaging Time	Level	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	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	Primary	SO_2	1-hour	75 ppb	99th percentile, averaged over 3 years
		Primary annual and 24-hour SO_2 standards revoked.			
2024 89 FR 105692 Dec. 27, 2024	Secondary	SO2	Annual	10 ppb	Averaged over 3 years
		Secondary SO2 standard revised to be an annual standard.			

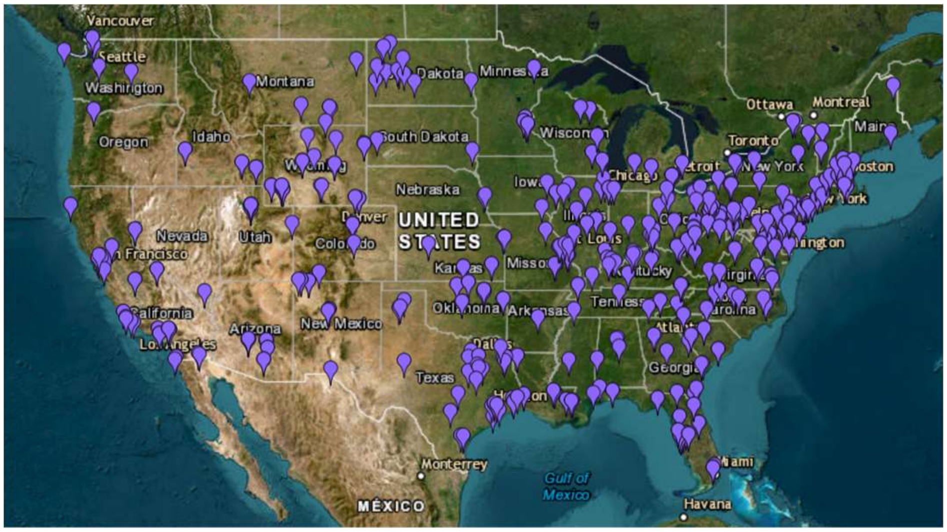
50

Original standards in 1971.

1-hour standard established in 2010 and some others revoked.

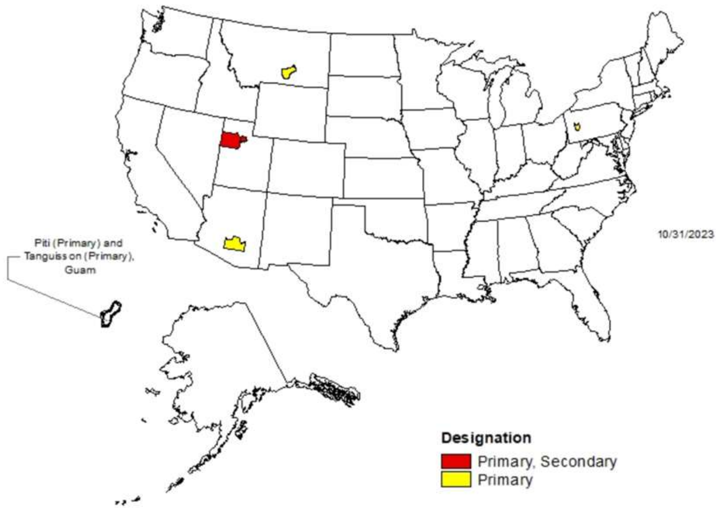
New secondary standard in Dec. 2024.

Current SO_2 monitors



51

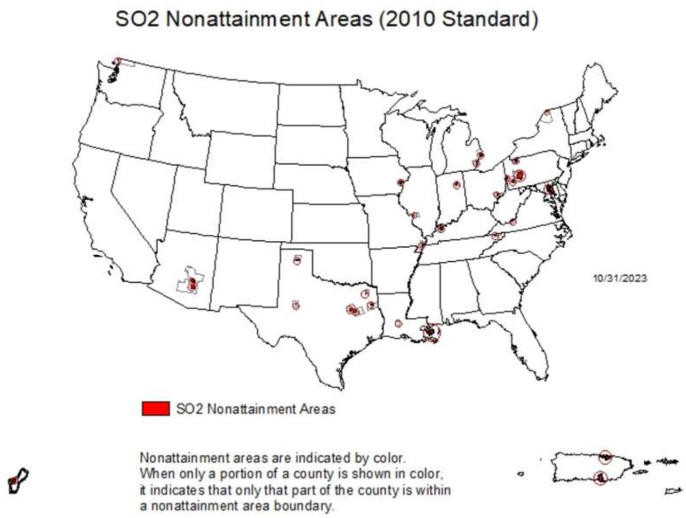
Current SO_2 non-attainment areas



1971 Standard

52

Current SO_2 non-attainment areas



2010 Standard (1-hr)

Ozone (O_3) – NAAQS History

History of the NAAQS for Ozone, from 1971 to 2015

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 38856 Jul 18, 1997	Primary and Secondary	O_3	8 hours	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 hours	0.075 ppm	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
2015 80 FR 65292 Oct 26, 2015	Primary and Secondary	O_3	8 hours	0.070 ppm	Annual fourth-highest daily maximum 8 hour average concentration, averaged over 3 years

54

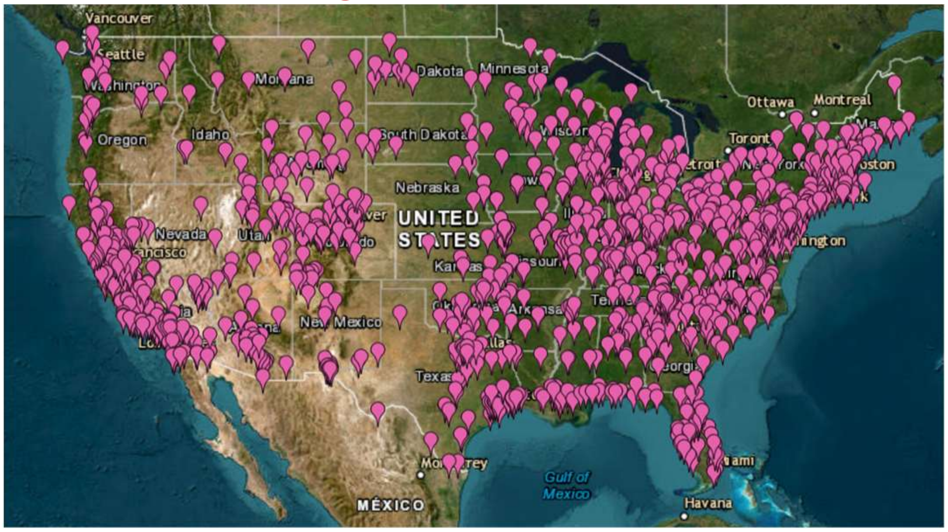
Original 1971 standard was for oxidants.

First true O3 standard implemented in 1979.

8-hour form of the standard commenced in 1997.

Latest revision in 2015 lowered the level.

Current O_3 monitors

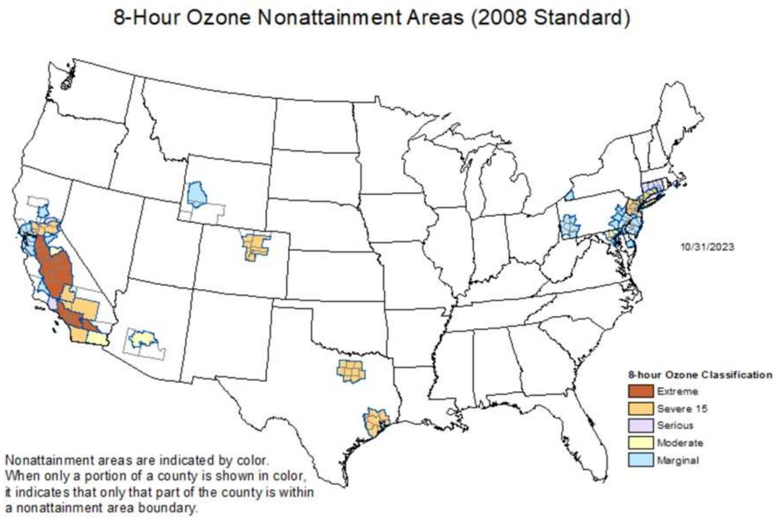


55

Ozone is a higher priority pollutant, so many sites.

Background is a concern in some areas.

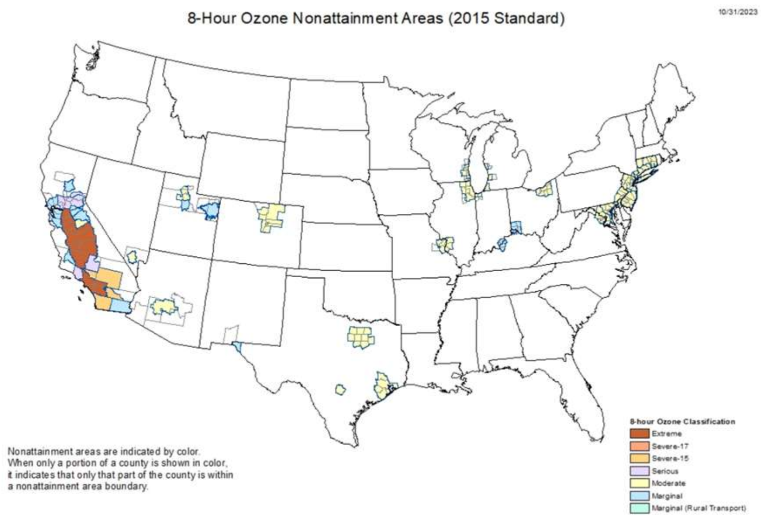
Current O_3 non-attainment areas



2008 Standard (75 ppb)

56

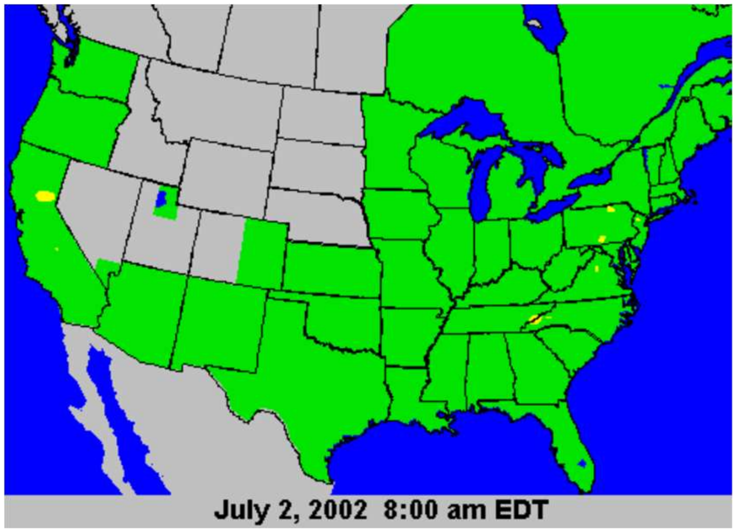
Current O_3 non-attainment areas



2015 Standard (70 ppb)

57

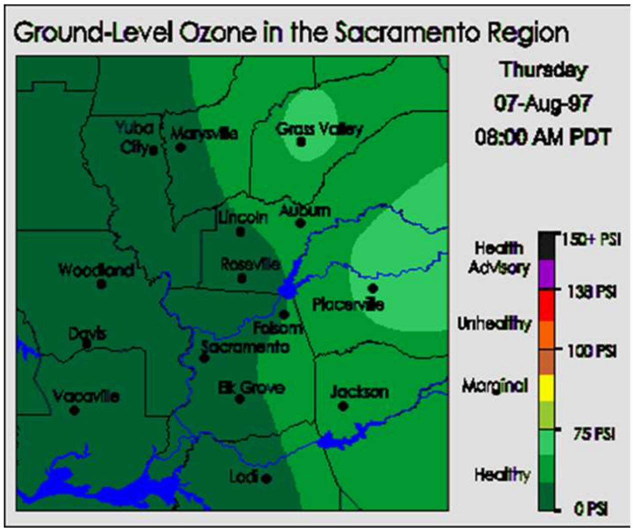
Ozone formation



58

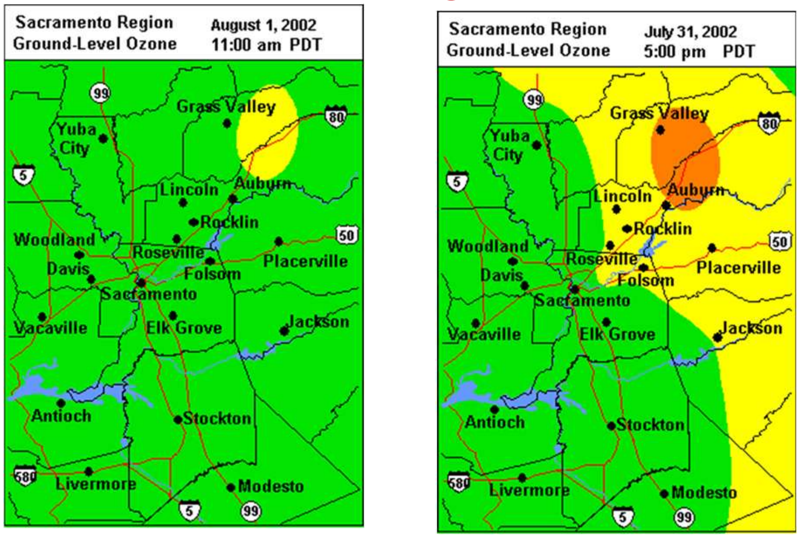
O3 related to VOC's and NOx reacting in sunlight, so typically a summertime pollutant. (There are a few winter-time areas.)

Ground-level O_3



59

Ground-level O_3



60

Note the higher levels in the afternoon after reaction time in sunlight.

Lead (Pb) – NAAQS History

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

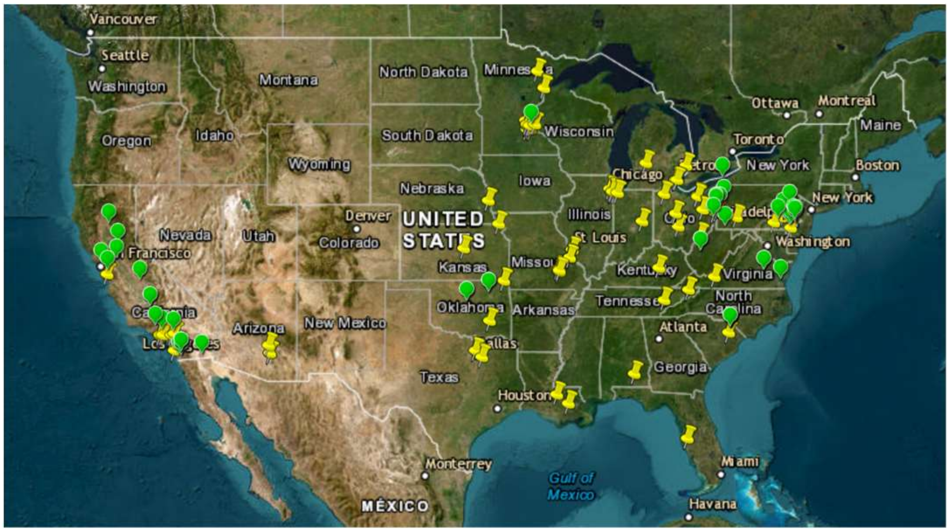
61

Standard first implemented in 1978.

Revised and reduced by a factor of 10 in 2008.

Unleaded fuels in vehicles have played a big part for reductions.

Current Pb monitors

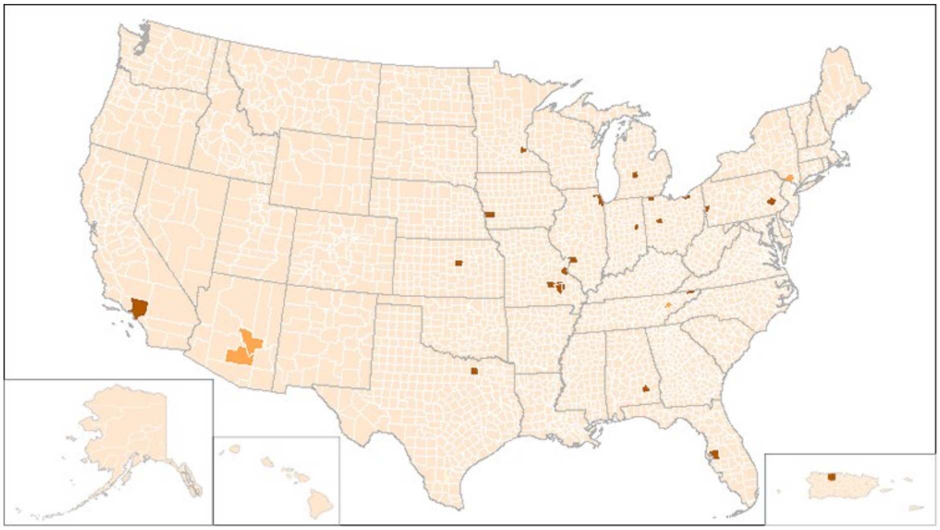


62

Generally near smelters and airports.

Some other networks such as NATTS and CSN also measure Pb.

Current Pb non-attainment areas



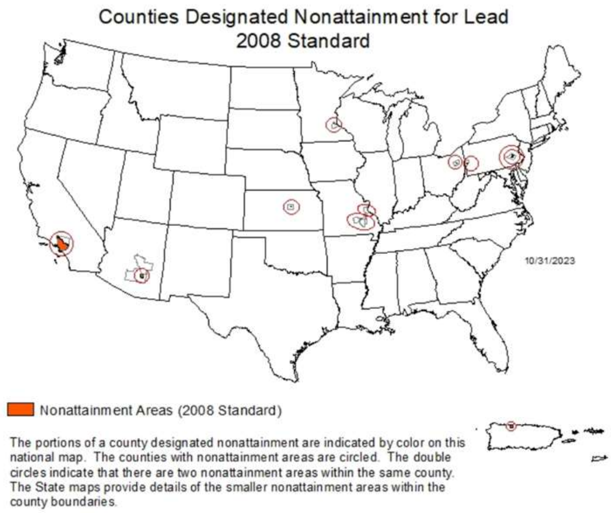
2008 Standard

63

Primarily related to smelting and airports.

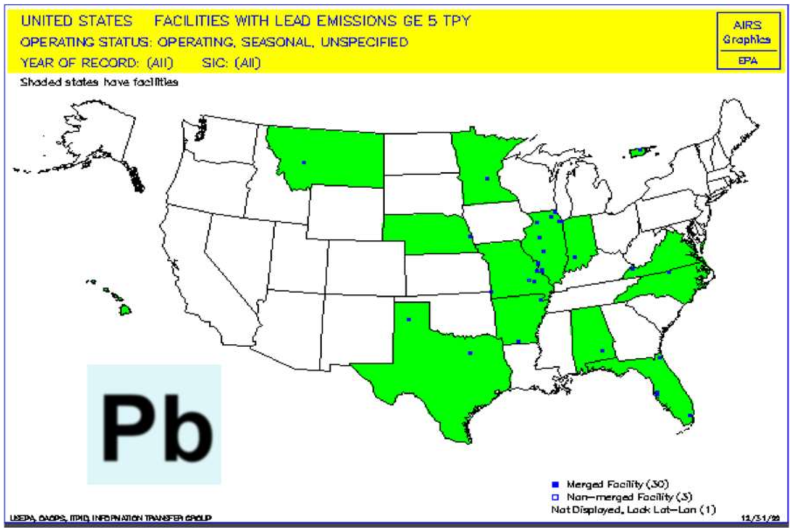
Current Pb non-attainment areas

2008 Standard



64

Pb sources (over 5 tpy)



65

Particulate Matter (PM) – NAAQS History

Final Rule/Decision	Primary/ Secondary	Indicator	Averaging Time	Level	Form
1971 36 FR 8186 30-Apr-71	Primary	TSP	24 hour	260 µg/m3	Not to be exceeded more than once per year
1971 36 FR 8186 30-Apr-71	Primary	TSP	Annual	75 µg/m3	Annual geometric mean
1971 36 FR 8186 30-Apr-71	Secondary	TSP	24 hour	150 µg/m3	Not to be exceeded more than once per year
1971 36 FR 8186 30-Apr-71	Secondary	TSP	Annual	60 µg/m3	Annual geometric mean
1987 52 FR 24634 1-Jul-87	Primary and Secondary	PM10	24 hour	150 µg/m3	Not to be exceeded more than once per year on average over a 3-year period
1987 52 FR 24634 1-Jul-87	Primary and Secondary	PM10	Annual	50 µg/m3	Annual arithmetic mean, averaged over 3 years
1997 62 FR 38652 18-Jul-97	Primary and Secondary	PM2.5	24 hour	65 µg/m3	98th percentile, averaged over 3 years
1997 62 FR 38652 18-Jul-97	Primary and Secondary	PM2.5	Annual	15.0 µg/m3	Annual arithmetic mean, averaged over 3 years
1997 62 FR 38652 18-Jul-97	Primary and Secondary	PM10	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)
1997 62 FR 38652 18-Jul-97	Primary and Secondary	PM10	Annual	50 µg/m3	Annual arithmetic mean, averaged over 3 years

66

First standard was for TSP.

PM10 implemented in 1987 and TSP revoked.

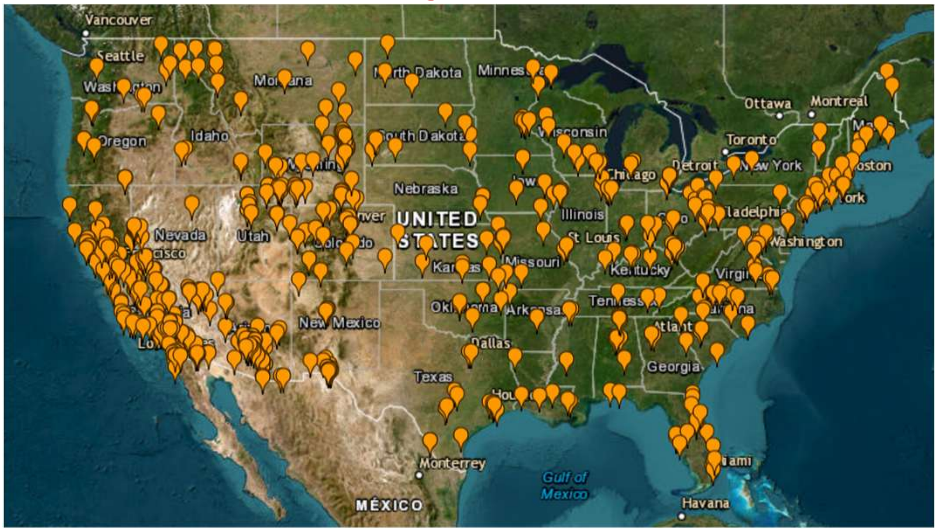
PM2.5 added in 1997.

Particulate Matter (PM) – NAAQS History

Final Rule/Decision	Primary/ Secondary	Indicator	Averaging Time	Level	Form
2006 71 FR 61144 17-Oct-06	Primary and Secondary	PM2.5	24 hour	35 µg/m3	98th percentile, averaged over 3 years
2006 71 FR 61144 17-Oct-06	Primary and Secondary	PM2.5	Annual	15.0 µg/m3	Annual arithmetic mean, averaged over 3 years
2006 71 FR 61144 17-Oct-06	Primary and Secondary	PM10	24 hour	150 µg/m3	Not to be exceeded more than once per year on average over a 3-year period
2012 78 FR 3085 15-Jan-13	Primary	PM2.5	Annual	12.0 µg/m3	Annual arithmetic mean, averaged over 3 years
2012 78 FR 3085 15-Jan-13	Secondary	PM2.5	Annual	15.0 µg/m3	Annual arithmetic mean, averaged over 3 years
2012 78 FR 3085 15-Jan-13	Primary and Secondary	PM2.5	24 hour	35 µg/m3	98th percentile, averaged over 3 years
2012 78 FR 3085 15-Jan-13	Primary and Secondary	PM10	24 hour 8	150 µg/m3	Not to be exceeded more than once per year on average over a 3-year period
2020 85 FR 82684 18-Dec-20	Primary and secondary standards retained, without revision.				
2024 89 FR 16202 7-Feb-24	Primary	PM2.5	Annual	9.0 µg/m3	Annual arithmetic mean, averaged over 3 years
2024 89 FR 16202 7-Feb-24	Secondary PM2.5 standards, and primary and secondary PM10 standards, retained without revision.				

Revisions just completed in 2024.
The annual PM2.5 NAAQS was lowered from 12.0 to 9.0 ug/m3.

Current PM_{10} monitors



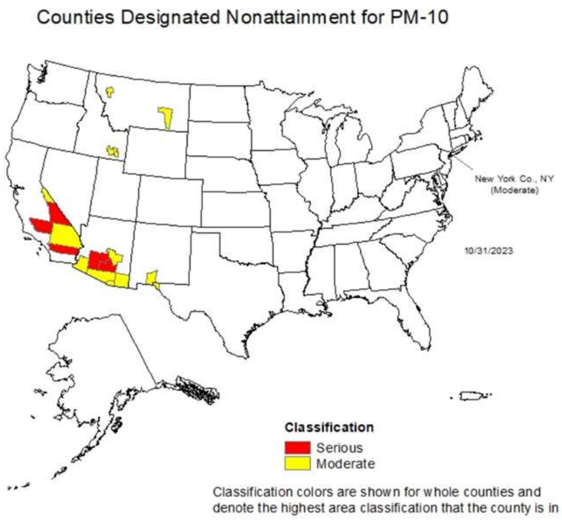
68

Current $PM_{2.5}$ monitors

69

PM2.5 is a pollutant of concern, so a lot of sites.

Current PM_{10} non-attainment areas

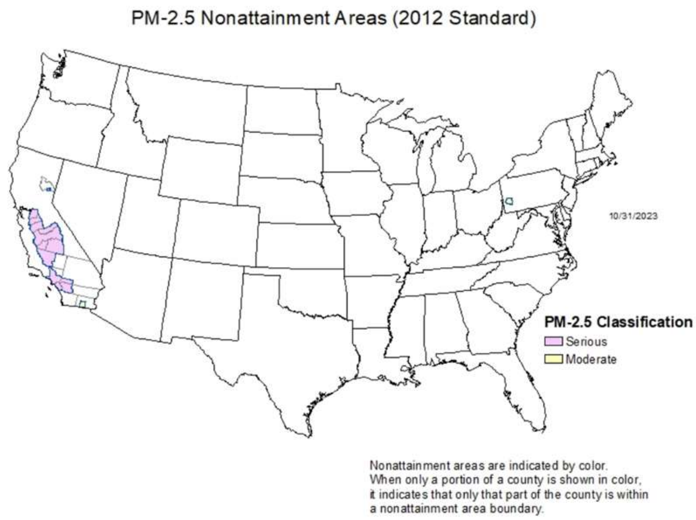


1987
Standard

70

Dust-related.

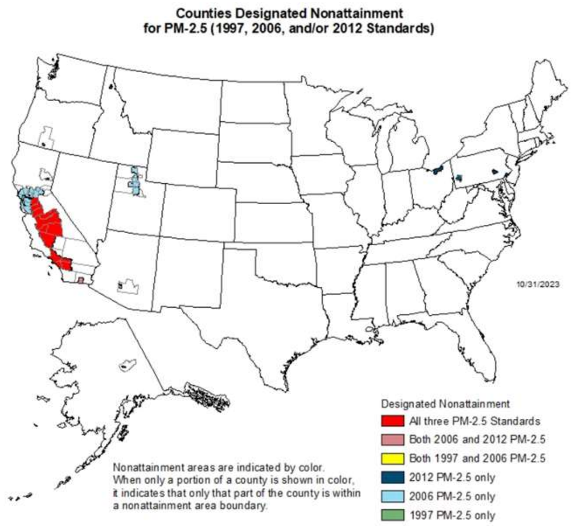
Current $PM_{2.5}$ non-attainment areas



2012 Standard

71

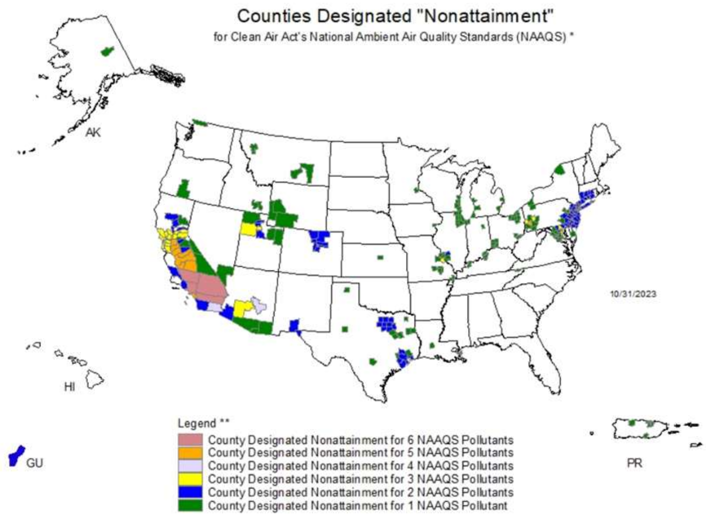
Current $PM_{2.5}$ non-attainment areas



2012, 2006 and 1997 Standards

72

Overall non-attainment areas

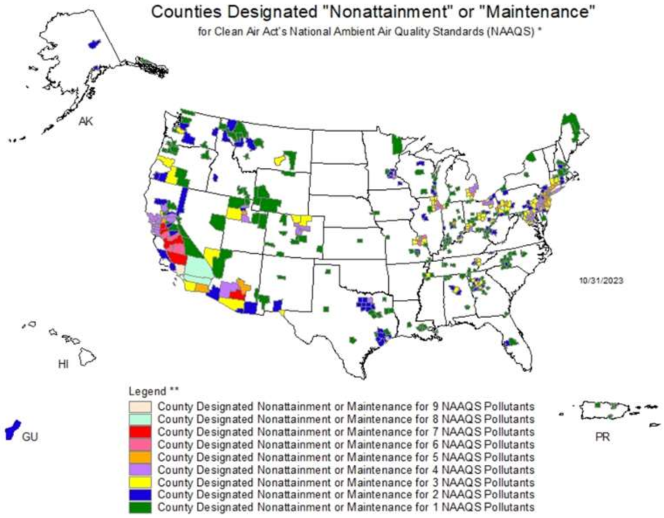


73

Not much non attainment in N. Central, NE, SE.

Some areas are for 1 pollutant only, others for all 6.

Overall non-attainment/maintenance areas



74

Low population and few sources leads to no issues in N. Central area.

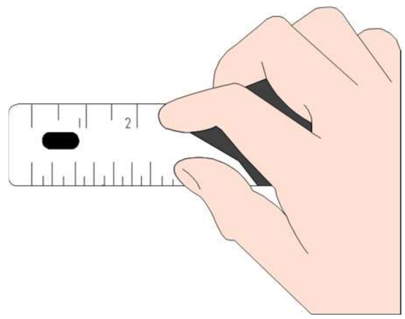

Station Siting Criteria
75

Network Design Considerations

- Concentration Expected
- Representative Concentrations
- Significant Sources or Source Categories
- Background Concentrations
- Regional Transport
- Welfare-Related Impacts for Rural Areas

Scales of Monitoring

- Micro
- Middle
- Neighborhood



77

40 CFR 58, Appendix D.

6 different measurement scales that define the area of representativeness.

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.

Micro scale – up to 100m

78

Microscale - Defines the concentrations in air volumes associated with area dimensions ranging from several meters up to about 100 meters.

Middle scale – 100m to 0.5 km

79

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.

Neighborhood scale – 0.5km – 4km

80

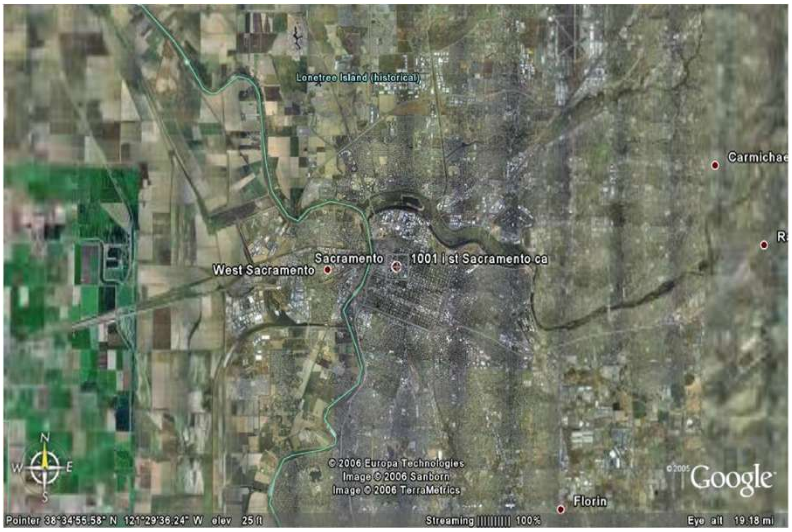
Neighborhood scale - Defines concentrations within some extended area of the city that has relatively uniform land use with dimensions in the 0.5 to 4.0 kilometers range. The neighborhood and urban scales listed below have the potential to overlap in applications that concern secondarily formed or homogeneously distributed air pollutants.

Additional scales of monitoring

- Urban
- Regional
- National and Global

81

Urban scale – 4 km to 50 km



82

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.

Regional scale – 10s km – 100s km

83

Regional scale - Defines usually a rural area of reasonably homogeneous geography without large sources, and extends from tens to hundreds of kilometers.

National and Global scale - 100s to 1,000s km

On the scale of a nation or the world as a whole

84

National and global scales - These measurement scales represent concentrations characterizing the nation and the globe as a whole.

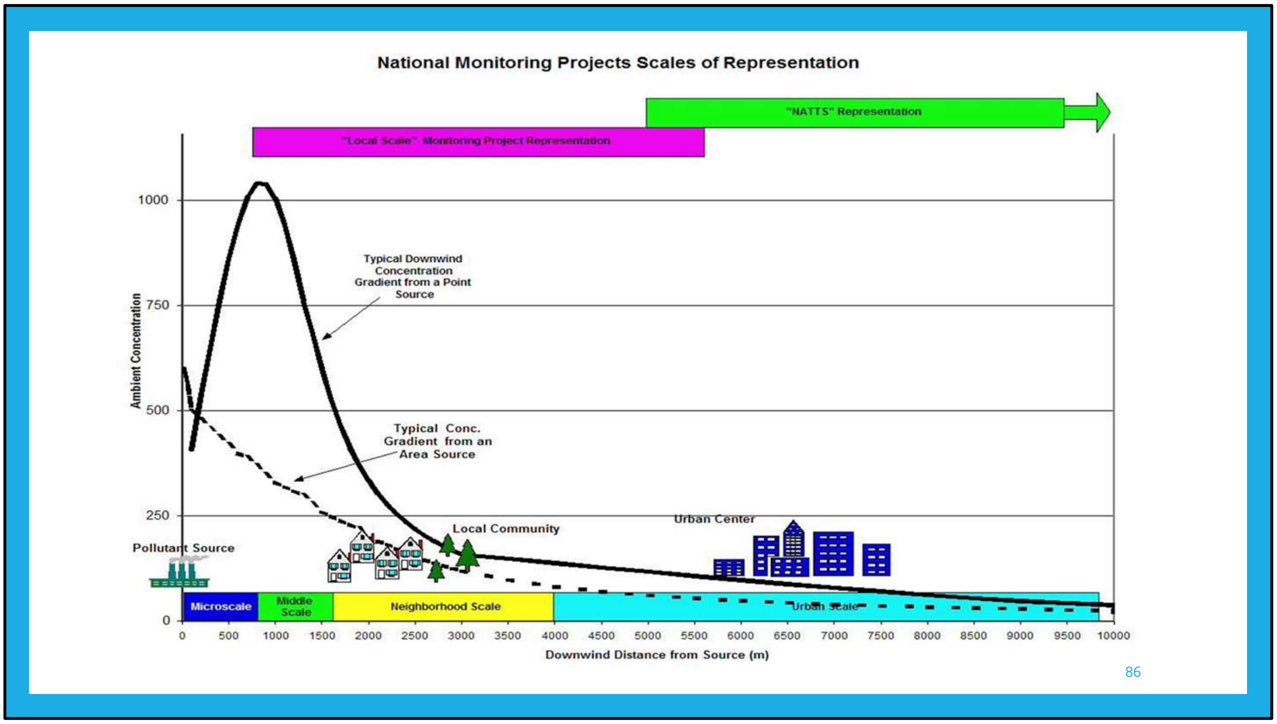
Won’t use for S/L/T monitoring.

Monitoring scales and objectives

Site type	Appropriate siting scales
1. Highest concentration	Micro, middle, neighborhood (*sometimes* urban or regional for secondarily formed pollutants).
2. Population oriented	Neighborhood, urban.
3. Source impact	Micro, middle, neighborhood.
4. General/background & regional transport.	Urban, regional.
5. Welfare-related impacts	Urban, regional.

85

40 CFR 58, Appendix D.



Note that peak ground-level concentration is a little downwind of an elevated point source.

Network design considerations

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

87

Highest concentration, Environmental Justice – big issue these days.

Transport from other areas/cities/states.

Evaluation of suitability, accessibility, etc.

Network design considerations

- Population areas
- Future development
- Full Representation

88

Population centers, EJ areas.

Future planned or likely sources, neighborhoods, roads, etc.

Representative of the spatial scale desired.

Number of stations – O_3

MSA population [1] [2]	Most recent 3-year design value concentrations ≥85% of any O_3 NAAQS [3]	Most recent 3-year design value concentrations <85% of any O_3 NAAQS [3] [4]
>10 million	4	2
4–10 million	3	1
350,000–<4 million	2	1
50,000–<350,000 [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.

89

Some pollutants have a set number of monitors based on population, others based on design values.

NCore: 1-required in each state
CO: 1 required at near-road NO2 site in populations > 1 million
NO2: 1 required in populations > 1 million, + 1 in population > 2.5 million with roadway > 250,000 ADT, + 1 area-wide highest concentration site
SO2: 3 sites in area with population weighted emissions index (PWEI) > 1 million, 2 sites if PWEI > 100,000 and < 1 million, 1 site if PWEI > 5,000 and < 100,000
Pb: 1 required for point sources > 0.5 tpy or airports > 1 tpy

Number of stations – $PM_{2.5}$

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]
>1,000,000	3	2
500,000–1,000,000	2	1
50,000–<500,000 [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.

Number of stations – PM_{10}

Population category	High concentration[2]	Medium concentration[3]	Low concentration[4 5]
>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] 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 PM10 data show ambient concentrations exceeding the PM_{10} NAAQS by 20 percent or more.

[3] Medium concentration areas are those for which ambient PM10 data show ambient concentrations exceeding 80 percent of the PM_{10} NAAQS.

[4] Low concentration areas are those for which ambient PM10 data show ambient concentrations less than 80 percent of the PM_{10} NAAQS.

[5] These minimum monitoring requirements apply in the absence of a design value.

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

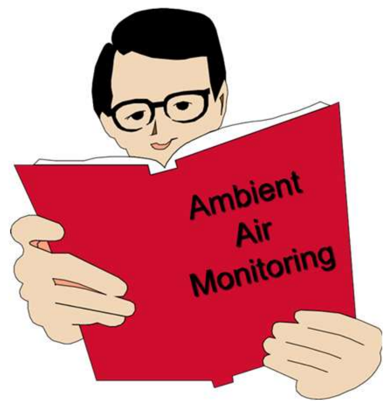
A single pollutant site can cost $75,000 or more.

A willing partner often a big issue.

Power accessibility often a big issue.

Station siting considerations

- Types of Pollutants
- Topography
- Air flow
- Nearby sources



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Topography: In a valley? Down-valley?

Siting design considerations

- Examine possible gaps in monitoring area
- Evaluate existing monitoring, if any
- Evaluate sources in the area
- Land use
- Topography
- Meteorology
- Modeling
- Availability of power and phone
- Land ownership
- Local community needs/desires/requests
- Funding availability
- Relevant EPA criteria

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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)	Sampler that is adjacent to a point source

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

96

Site information

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

97

All of this goes into a site approval request to EPA.

Sample lines typically Teflon, SS or glass (poly is generally too reactive).

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

98

This information refers to setting up a site.
Information is needed by EPA as part of site approval process.
Also need coordinates, address, photos.

Site information

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

TABLE E–4 OF APPENDIX E TO PART 58—SUMMARY OF PROBE AND MONITORING PATH SITING CRITERIA

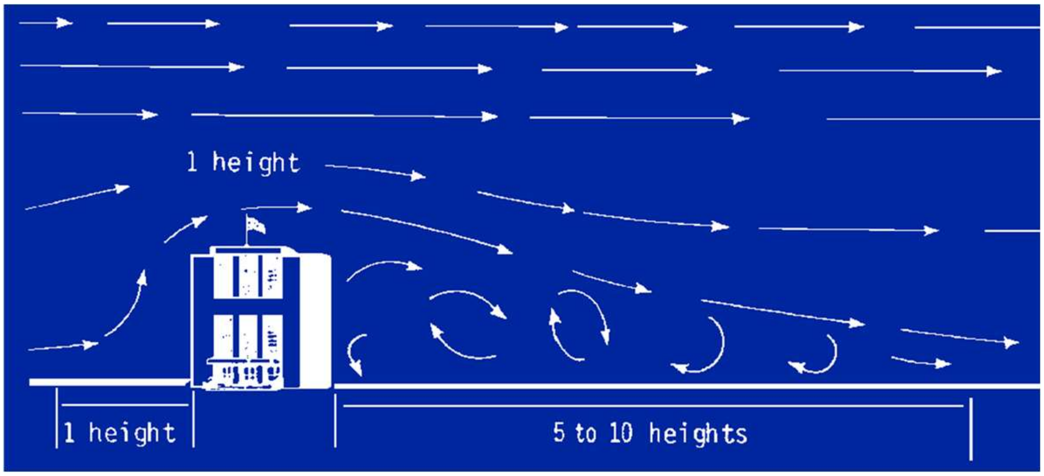
Pollutant	Scale (maximum monitoring path length, meters)	Height from ground to probe, inlet or 80% of monitoring path [1] (meters)	Horizontal and vertical distance from supporting structures [2] to probe, inlet or 90% of monitoring path [1] (meters)	Distance from trees to probe, inlet or 90% of monitoring path [1] (meters)	Distance from roadways to probe, inlet or monitoring path [1] (meters)
SO_2 [3 4 5 6]	Middle (300 m) Neighborhood Urban, and Regional (1 km).	2–15	>1	>10	N/A.
CO [4 5 7]	Micro [downtown or street canyon sites], micro [near-road sites], middle (300 m) and Neighborhood (1 km).	2.5–3.5; 2–7; 2–15	>1	>10	2–10 for downtown areas or street canyon microscale; ≤50 for near-road microscale; see Table E–2 of this appendix for middle and neighborhood scales.
O_3 [3 4 5]	Middle (300 m) Neighborhood, Urban, and Regional (1 km).	2–15	>1	>10	*See* Table E–1 of this appendix for all scales.
NO_2 [3 4 5]	Micro (Near-road [50–300 m]).	2–7 (micro);	>1	>10	≤50 for near-road micro-scale.
	Middle (300 m)	2–15 (all other scales).			
	Neighborhood, Urban, and Regional (1 km).				*See* Table E–1 of this appendix for all other scales.
Ozone precursors (for PAMS) [3 4 5].	Neighborhood and Urban (1 km).	2–15	>1	>10	*See* Table E–4 of this appendix for all scales.
PM, Pb [3 4 5 8]	Micro, Middle, Neighborhood, Urban and Regional.	2–7 (micro); 2–7 (middle $PM_{10-2.5}$); 2–7 for near-road; 2–15 (all other scales).	>2 (all scales, horizontal distance only).	>10 (all scales)	2–10 (micro); *see* Figure E–1 of this appendix for all other scales. ≤50 for near-road.

99

Trees can adsorb or react with some pollutants.

All of this goes into a site approval request to EPA.

Obstacle effects

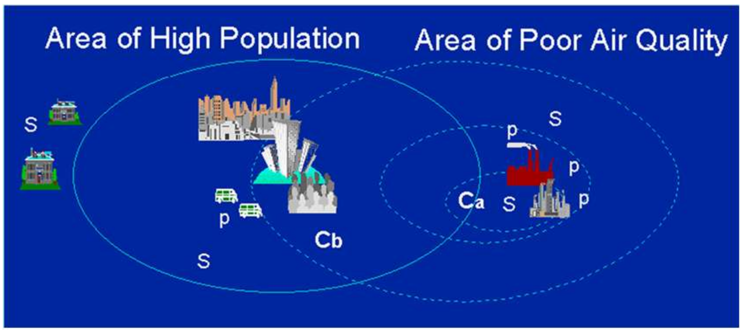


100

Want to be at least 10x the height away from an object.

Location of monitors

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



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Example.

Measurement Process

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

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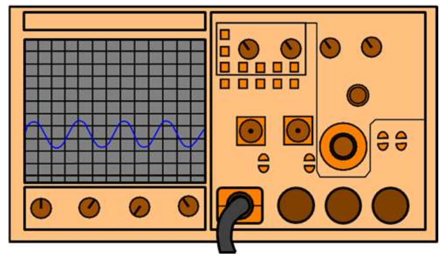
Types of monitoring

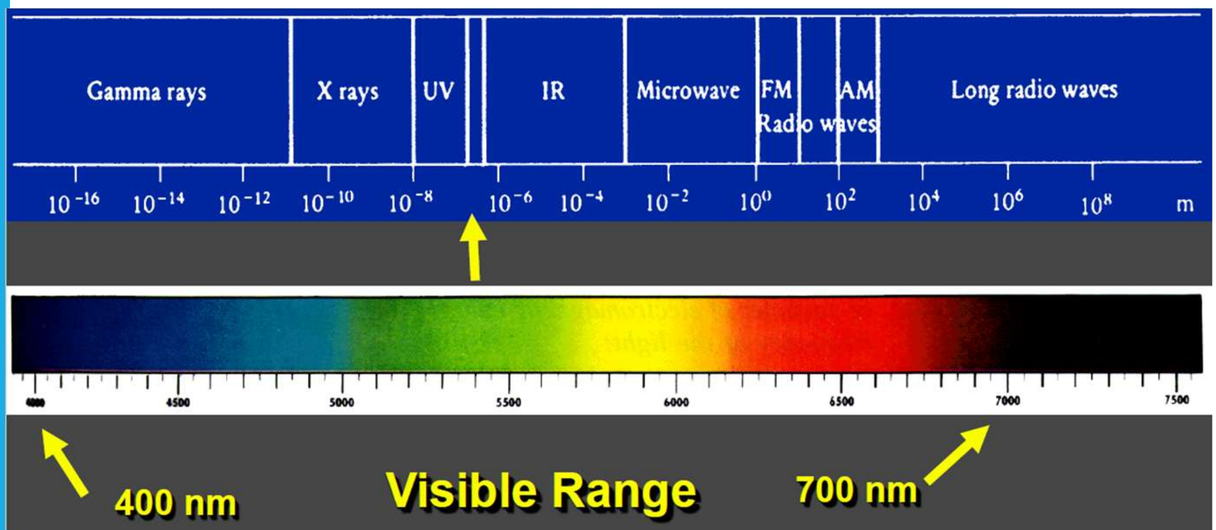
- Automated/continuous analytical methods
  - Point analyzers
  - Open path analyzers
- Time averaged samplers
  - Manual methods
  - Filter (ex. PM_{10}) samples
  - Canister/tube samples



104

Open path = FTIR, DOAS, other. Typically used for fenceline monitoring.

Electromagnetic spectrum



105

Most gaseous analyzers are based on UV or IR absorption.

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

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The Beer-Lambert law is commonly applied to chemical analysis measurements to determine the concentration of chemical species that absorb light. It is often referred to as Beer's law.

Beer-Lambert law

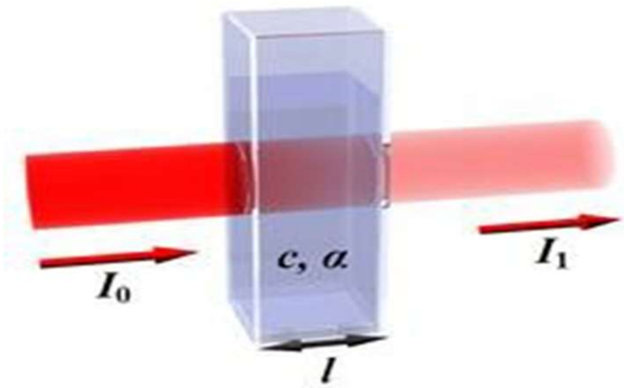

Diagram of Beer–Lambert absorption of a beam of light as it travels through a cuvette of width ℓ.

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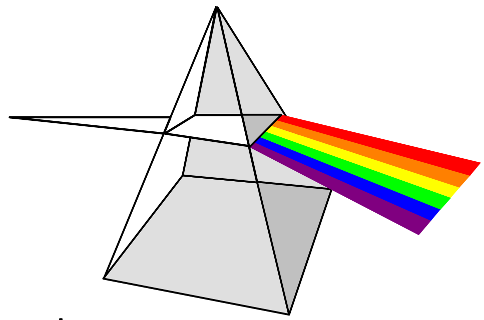
The intensity of the light passing through the sample cell is also measured for that wavelength - given the symbol, I. If I is less than Io, then the sample has absorbed some of the light (neglecting reflection of light off the cuvette surface). A simple bit of math is then done in the computer to convert this into something called the absorbance of the sample - given the symbol, A. The absorbance of a transition depends on two external assumptions.

The absorbance is directly proportional to the concentration (c) of the solution of the sample used in the experiment.

The absorbance is directly proportional to the length of the light path (l), which is equal to the width of the cuvette.

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



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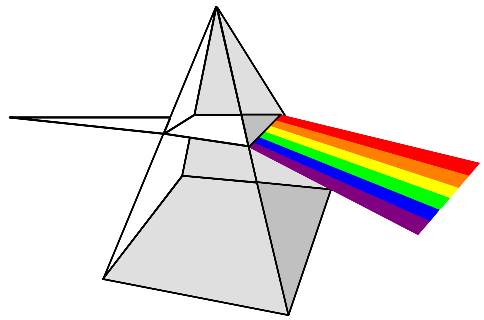
Analytical techniques

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



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Electroanalytical methods generally not used for ambient air measurements.

Probe information

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

110

EPA guidance and CFR defines what tubing may be used.

Inlet materials:
Glass, Teflon or stainless steel are preferred.
Poly is okay for carbon monoxide but O3 and NOx are too reactive.

Gas inlet

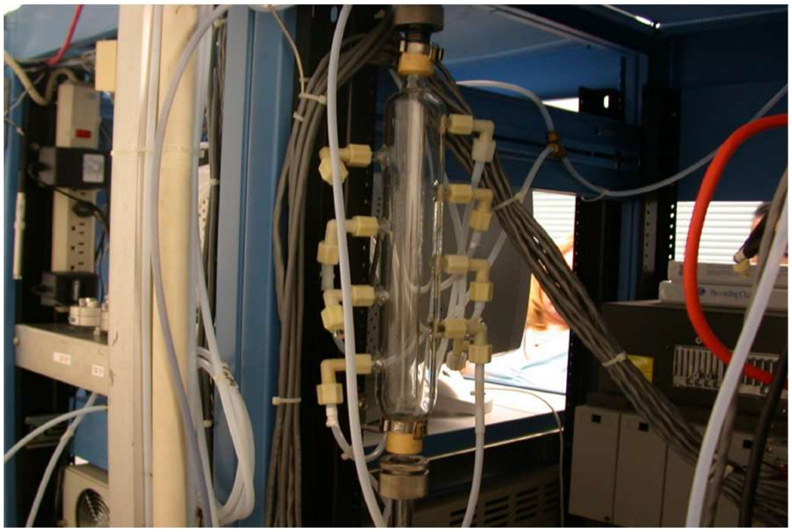
111

Inlet materials:

Glass, Teflon or stainless steel are preferred.
Poly is okay for carbon monoxide.

Note the tee for introducing calibration gas.

Instrument manifold



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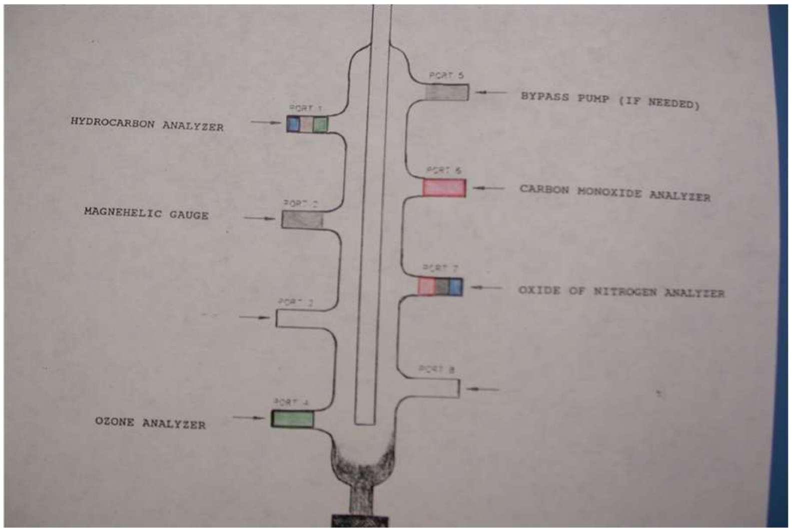
Instrument manifold



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Instruments

- FRM
  - Federal Reference Method
    - Designed to provide the most fundamentally sound and scientifically defensible concentration measurement
- FEM
  - Federal Equivalent Method
    - Designed to provide a comparable level of compliance decision making quality as FRM

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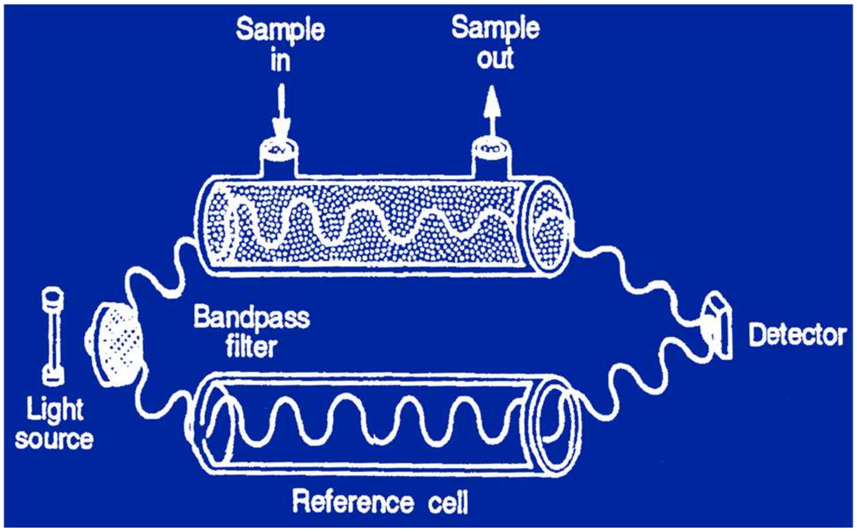
Non-dispersive IR analyzer

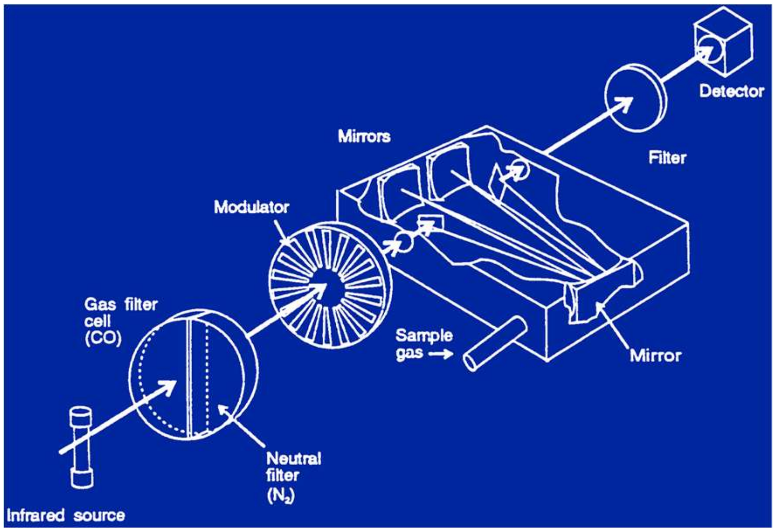


115

Remember Beer-Lambert Law where absorption correlates to a gas concentration.

This is often used for CO_2 measurements.
Basis for GFC for CO.

Gas filter correlation (GFC) CO



116

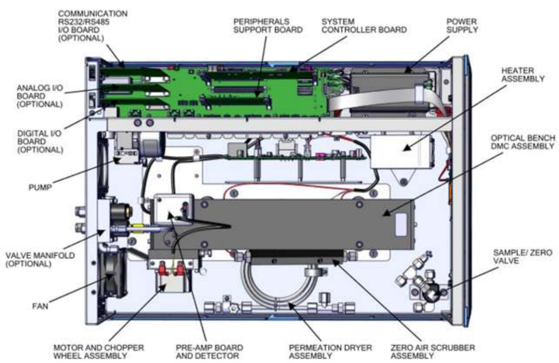
40 CFR 50, Appendix C.

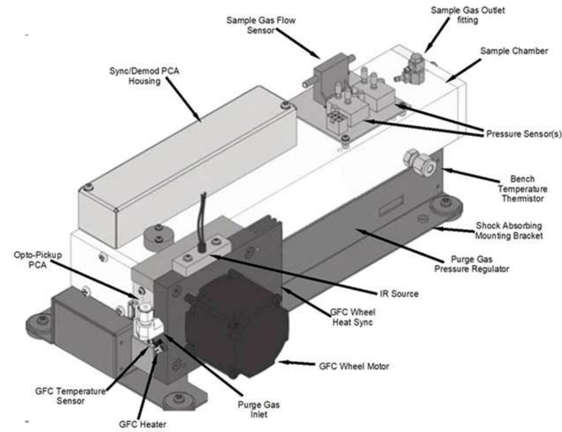
Reference Method.

GFC operates on the principle that carbon monoxide (CO) absorbs infrared radiation at a wavelength of 4.6 microns. Because infrared absorption is a non-linear measurement technique, it is necessary to transform the basic analyzer signal into a linear output.

CO analyzers

Inside a GFC CO analyzer





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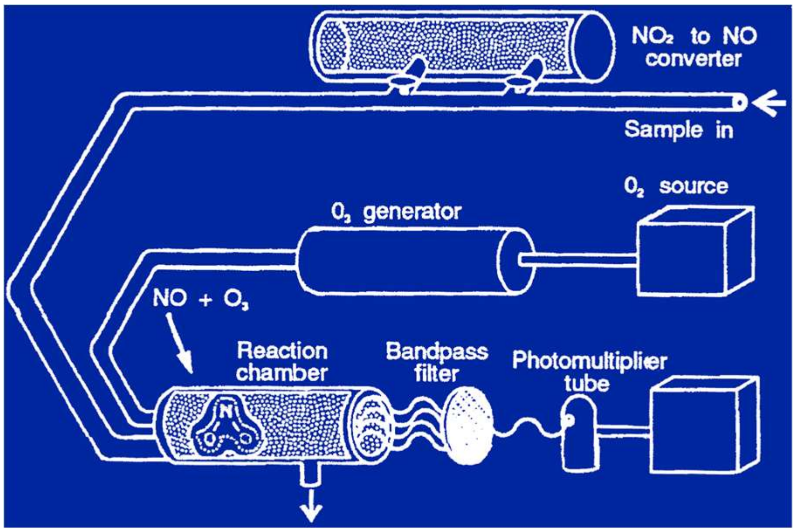
Common electronics bench.

Analytical bench changes.

Chemiluminescence NOx analyzer



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40 CFR 50, Appendix F.

Reference Method.

Chemiluminescent NOx operates on the principle that nitric oxide (NO) and ozone (O3) react to produce a characteristic luminescence with an intensity linearly proportional to the NO concentration. Infrared light emission results when electronically excited NO2 molecules decay to lower energy states.

Specifically:
Nitrogen dioxide (NO2) must first be transformed into NO before it can be measured using the chemiluminescent reaction. NO2 is converted to NO by a molybdenum NO2-to-NO converter heated to about 325 °C (the optional stainless steel converter is heated to 625 °C). The ambient air sample is drawn into the analyzer through the sample bulkhead. The sample flows through a capillary, and then to the mode solenoid valve. The solenoid valve routes the sample either straight to the reaction chamber (NO mode) or through the NO2-toNO converter and then to the reaction chamber (NOx mode). A flow sensor to the reaction chamber measures the sample flow.
Dry air enters the analyzer through the dry air bulkhead, passes through a flow switch, and then through a silent discharge ozonator. The ozonator generates the ozone needed for the

chemiluminescent reaction. At the reaction chamber, the ozone reacts with the NO in the sample to produce excited NO_2 molecules. A photomultiplier tube (PMT) housed in a thermoelectric cooler detects the luminescence generated during this reaction. From the reaction chamber, the exhaust travels through the ozone (O_3) converter to the pump, and is released through the vent.
The NO and NOx concentrations calculated in the NO and NOx modes are stored in memory. The difference between the concentrations is used to calculate the NO_2 concentration.

NOx analyzers

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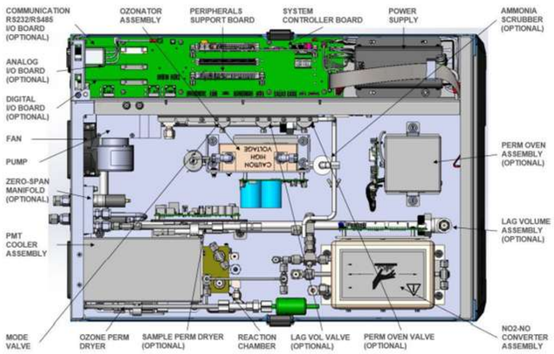
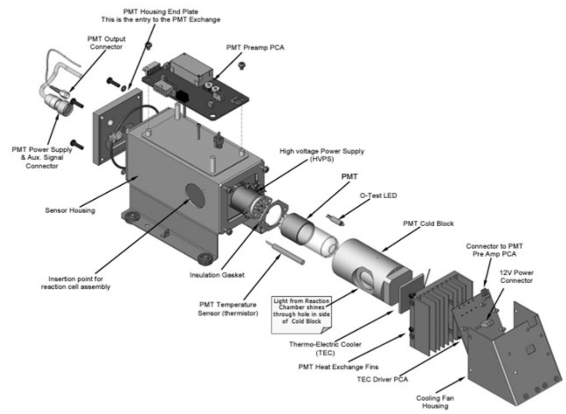
Inside a chemiluminescence NOx analyzer





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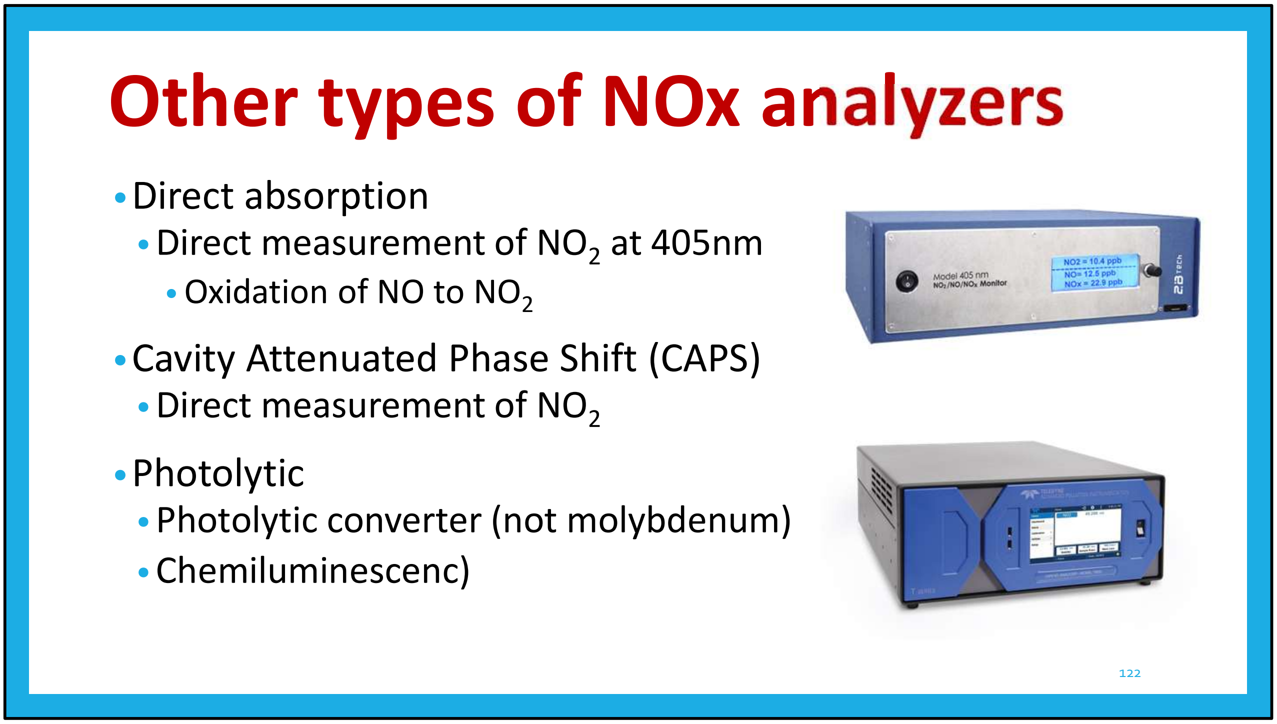


Direct absorption
FEM-approved NO2 monitor that uses the technique of direct absorption of 405 nm light by NO2 molecules. Also measures NO by conversion to NO2 using ozone. The instrument provides a total measurement of NOx as the sum of NO and NO2.

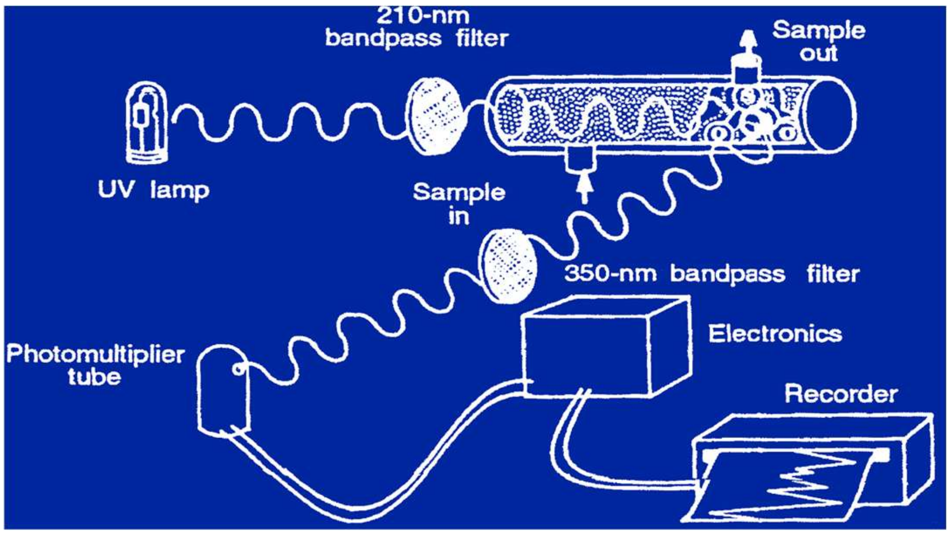
CAPS
Provides a direct NO2 measurement, eliminating the need for catalytic conversion or reagents which introduce measurement artifacts inherent in traditional heated metal converter based chemiluminescence instruments. The CAPS measurement approach also reduces maintenance items, and removes the need for hazardous materials and high temperature scrubbers within the instrument. It has an expected maintenance interval of one year under typical ambient monitoring conditions.
The Cavity Attenuated Phase Shift (CAPS) NO2 monitor operates as an optical absorption spectrometer that yields both reliable and accurate measurements of ambient nitrogen dioxide down to sub ppb concentrations, with lower noise levels than chemiluminescence based monitors. The CAPS method uses light from a blue Ultraviolet (UV) light emitting diode (LED) centered at 450 nm, a measurement cell with high reflectivity mirrors located at either end to provide an extensive optical path length, and a vacuum phototube detector.

Photolytic

Provides measurements of NO and NO2 using a chemiluminescent NOx analyzer combined with a patented high efficiency photolytic converter. Even low temperature molybdenum converters transform other nitrogen-containing compounds such as HNO3, PAN, etc. to a considerable extent. Simultaneous measurements of NO2 performed with molybdenum and photolytic converters have shown significantly different results in the presence of such compounds.

In the photolytic process the sample gas passes through a cell where it is exposed to light at a specific wavelength from an LED array. This causes the NO2 to be selectively converted to NO with negligible interference from other gases. Advances in the photolytic converter technology now yields NO2 conversion efficiency that is similar to molybdenum under typical ambient NO2 concentrations, but without the same interferences.

Pulsed fluorescence SO_2 analyzer



123

40 CFR 50, Appendix A-1, Equivalent Method.

(Reference method is Appendix A-2 measuring Pararosanilline via a colorimetric wet chemistry method).

Pulsed fluorescence operates on the principle that SO2 molecules absorb ultraviolet (UV) light and become excited at one wavelength, then decay to a lower energy state emitting UV light at a different wavelength.

Specifically,
The sample is drawn into the analyzer through the sample bulkhead. The sample flows through a hydrocarbon “kicker,” which removes hydrocarbons from the sample by forcing the hydrocarbon molecules to permeate through the tube wall. The SO2 molecules pass through the hydrocarbon “kicker” unaffected. The sample then flows into the fluorescence chamber, where pulsating UV light excites the SO2 molecules. The condensing lens focuses the pulsating UV light into the mirror assembly. The mirror assembly contains eight selective mirrors that reflect only the wavelengths which excite SO2 molecules. As the excited SO2 molecules decay to lower energy states they emit UV light that is proportional to the SO2 concentration. The bandpass filter (214mn optical filter) allows only the wavelengths emitted by the excited SO2 molecules to reach the photomultiplier tube

(PMT). The PMT detects the UV light emission from the decaying SO_2 molecules. The photodetector, located at the back of the fluorescence chamber, continuously monitors the pulsating UV light source and is connected to a circuit that compensates for fluctuations in the UV light.

SO_2 analyzers

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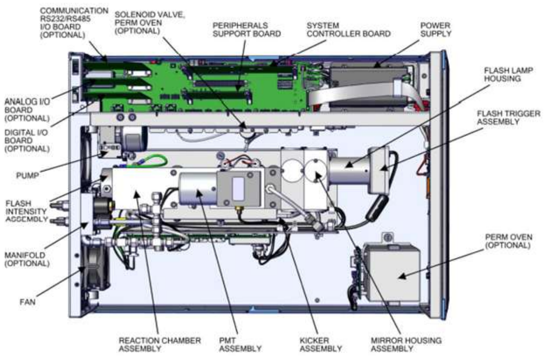
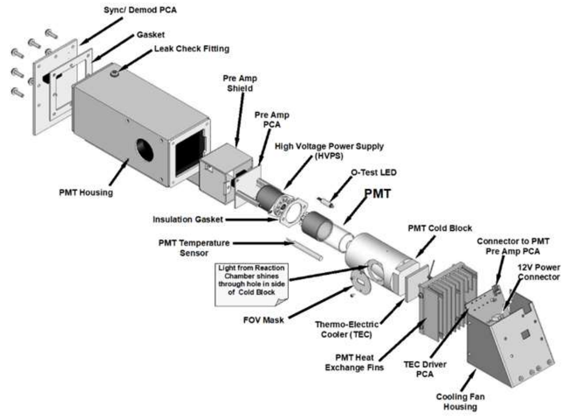
Inside a pulsed fluorescence SO_2 analyzer





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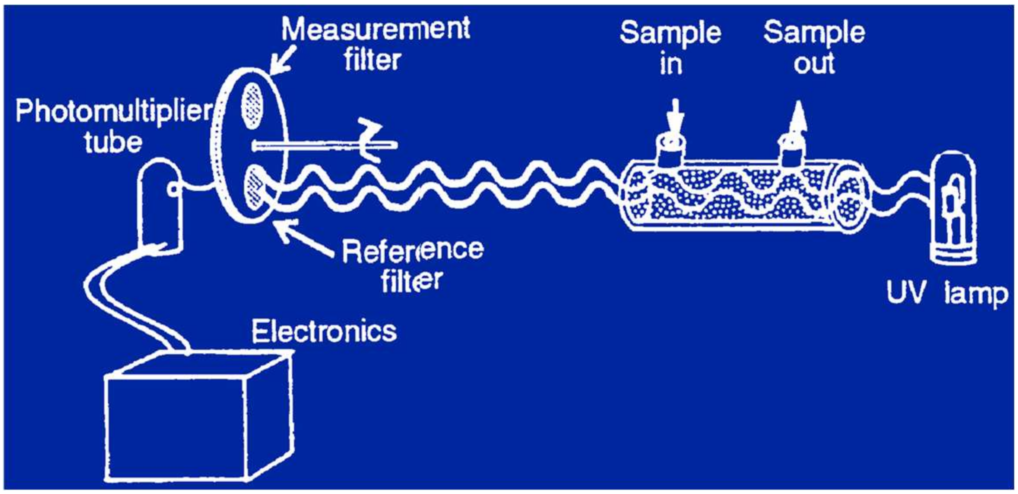
Non-dispersive UV analyzer



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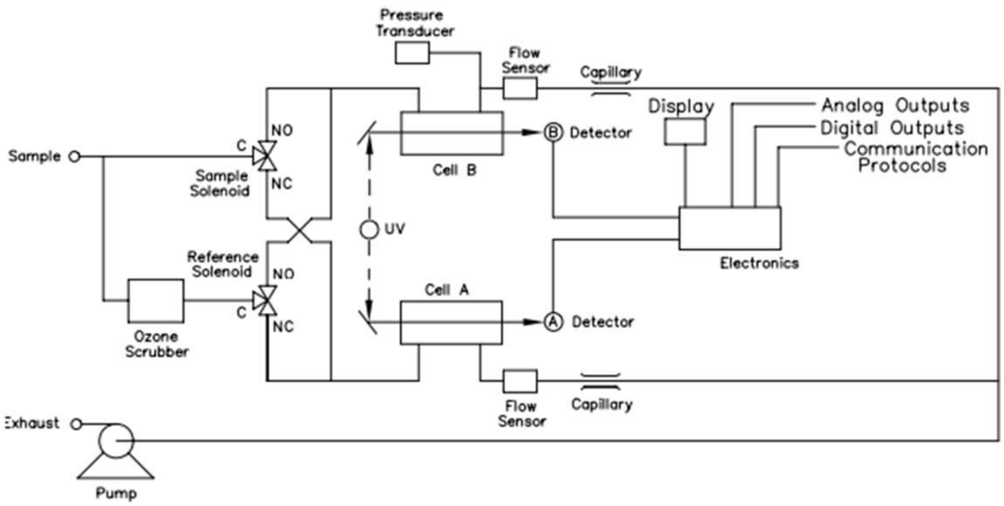
Basis for Ozone

Photometric O_3



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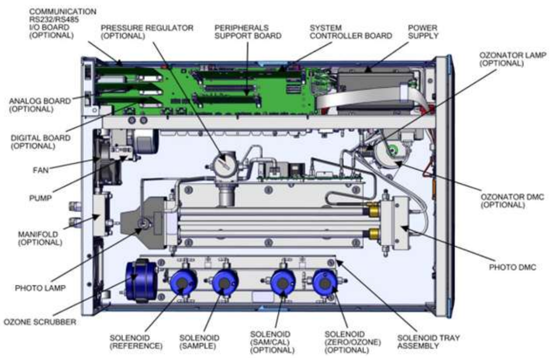
Equivalent Method.

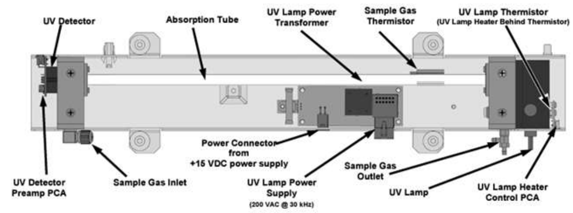
Photometric UV operates on the principle that ozone (O3) molecules absorb UV light at a wavelength of 254 nm. The degree to which the UV light is absorbed is directly related to the ozone concentration as described by the Beer-Lambert Law:

Where:
K = molecular absorption coefficient, 308 cm-1 (at 0°C and 1 atmosphere)
L = length of cell, 38 cm
C = ozone concentration in parts per million (ppm)
I = UV light intensity of sample with ozone (sample gas)
Io = UV light intensity of sample without ozone (reference gas)

O_3 analyzers

Inside a UV absorption O_3 analyzer





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Other types of O_3 analyzers

- Chemiluminescence
  - Reduces cross-interference from VOC’s and other compounds

Chemiluminescence is the current Reference method for O3.
40 CFR 50, Appendix D.

This reference method is based on continuous automated measurement of the intensity of the characteristic chemiluminescence released by the gas phase reaction of O3 in sampled air with either ethylene (C2H4) or nitric oxide (NO) gas.

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
- Direct generators
- Dilution calibration systems

Calibration gases

132

Note that tanks are secured and upright.

Tanks not in use should have the valve removed and cap on.

Calibration gases

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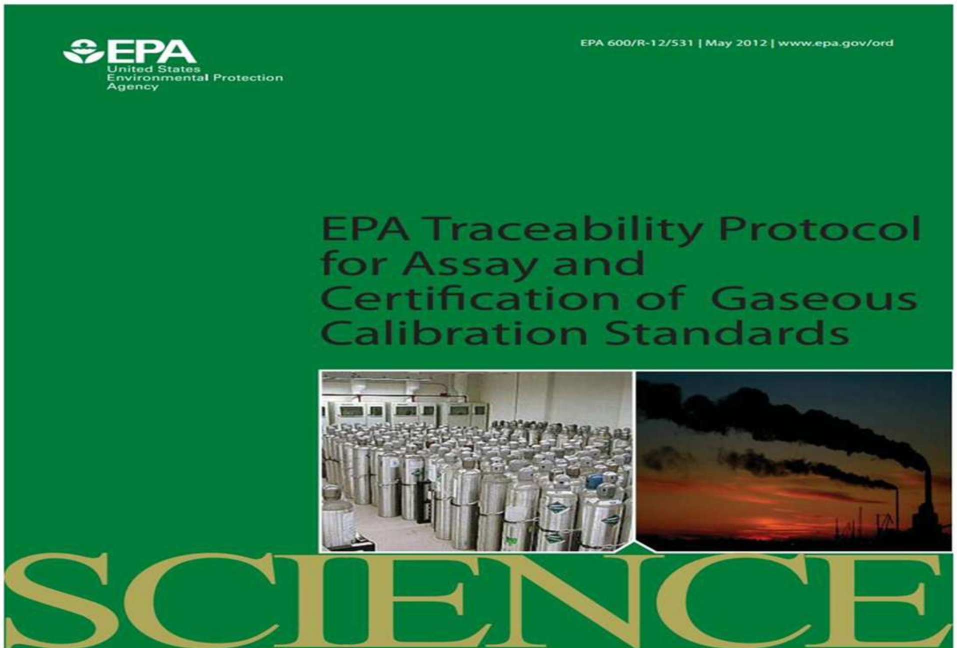
Outside storage:
May be safer, but hard to keep bottle gas temperatures stable.

Note that tanks are secured and upright.

Tanks not in use should have the valve removed and cap on.


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

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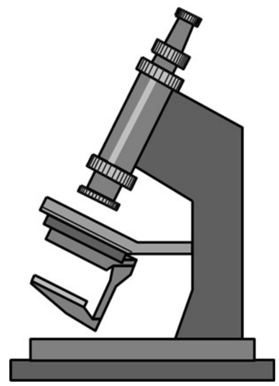
Particulate properties

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



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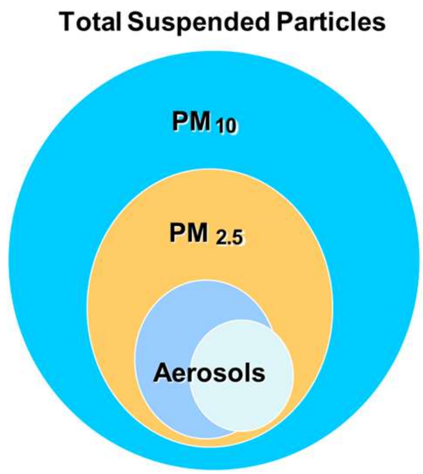
Measures of particulate matter in the atmosphere



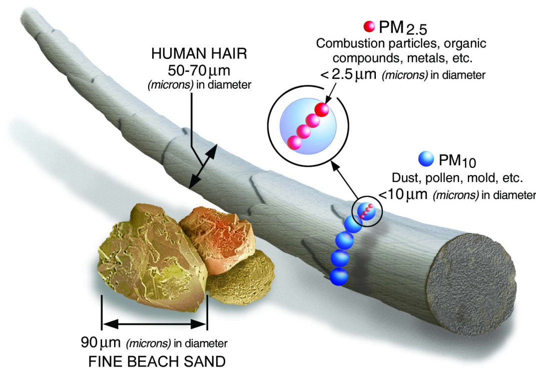
136

PM ultrafine (< 1 um) is a growing concern.

PM10 gets into upper respiratory tract
PM2.5 gets into alveoli
PM1 can cross the membrane into the blood stream

Particulate

- Total Suspended Particulate (TSP) Samplers
  - Hi-volume
- PM_{10}
  - Size Selective Inlet
  - High-volume or Low-volume
- $PM_{2.5}$ Samplers
  - Size Selective Inlet
  - Low-volume
- Visibility Samplers
  - Nephelometer
  - Transmissometer



137

PM ultrafine (<= 1 um) is a growing concern.

TSP sampler

- Hi-volume (1 m^3/min)
- 8” x 10” filter
- No longer a criteria pollutants
- Primarily used now for Pb or other metals monitoring

138

Pb reference method from TSP is ICP-MS.

40 CFR 50, Appendix G.

TSP is no longer a NAAQS.

PM$_{10}$ hi-vol sampler

- Hi-volume (1 m^3/min)
- 8” x 10” filter
- Federal Reference Method

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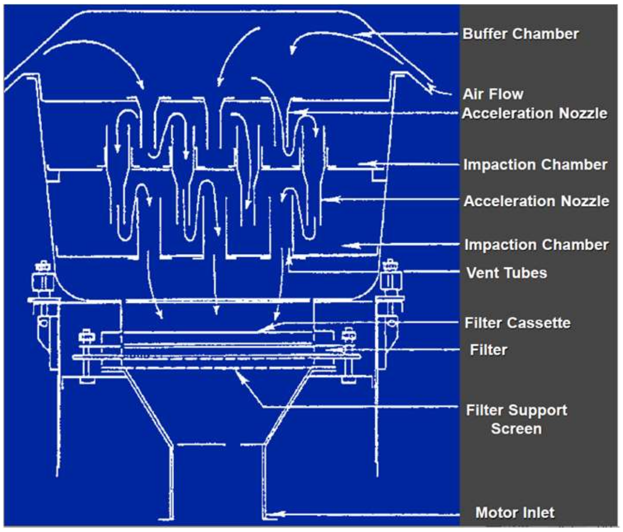
40 CFR 50, Appendix J.

PM_{10} – Size selective inlet



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PM_{10} Size selective inlet (SSI) sampler

Inside PM_{10} SSI head

142

Note the acceleration nozzles and greased plate.

PM_{10} SSI filter area

143

8” x 10” glass fiber filter.

$PM_{2.5}$ (or PM_{10}) sampler

- Low-volume (16.7 l/min)
- 47mm filter
- Federal Reference Method

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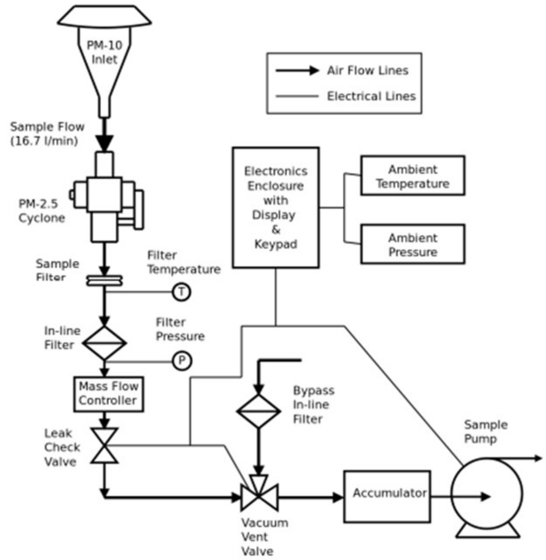
40 CFR 50, Appendix L.

Pb from PM10 reference method is XRF.
40 CFR 50, Appendix Q.

47mm Teflon filters.

$PM_{2.5}$ sampler



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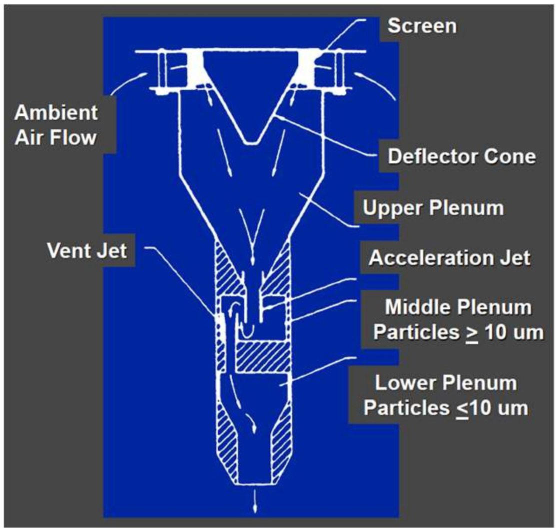
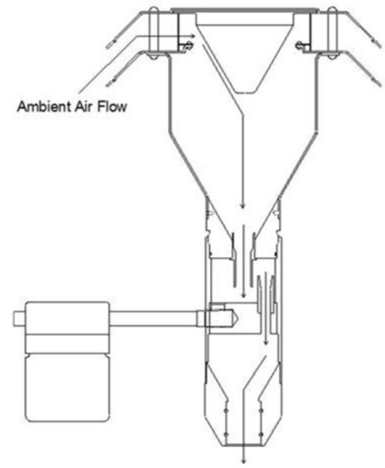
PM10 size selective inlet



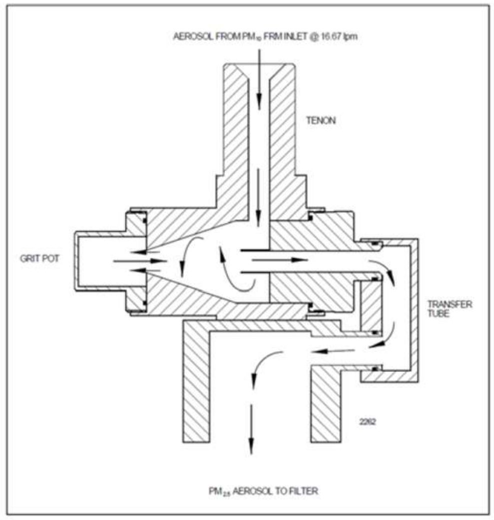


146

The inlet design is specified in 40 CFR 50, Appendix L.

Has acceleration nozzles, similar to hi-vol design.

Very sharp-cut $PM_{2.5}$ cyclone (VSSC)



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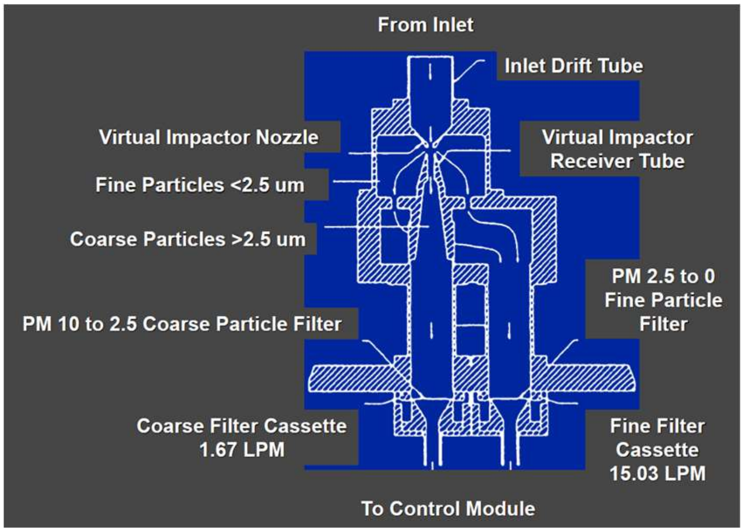
Placed in-line after the PM10 inlet.

Replaces the WINS impactor that had issues with particle bounce and required more maintenance with oiled filter.

Virtual impactor



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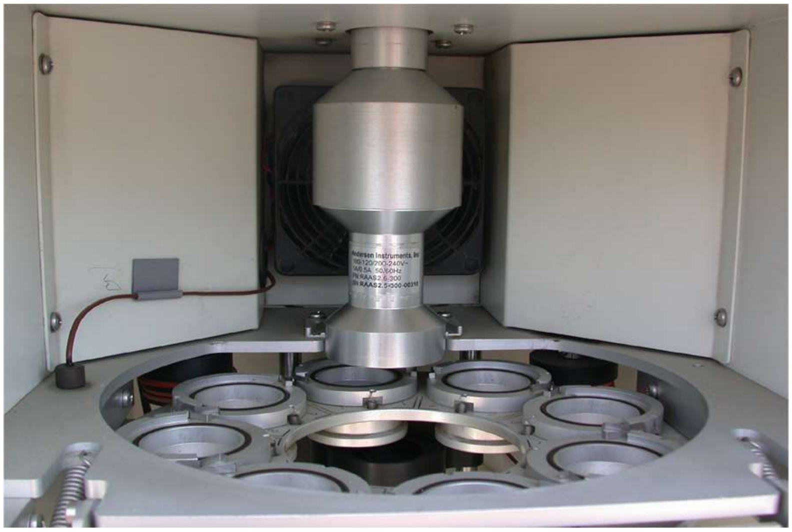
Used to get both fine and coarse particles on 2 filters with one inlet.

Sequential $PM_{2.5}$ sampler



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47mm Teflon filters.

Sequential $PM_{2.5}$ sampler

150

Continuous particulate analyzers

Teledyne-API T640
– light scattering

Durag Grimm EDM-180
– light scatter/particle counter

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A number of different types of continuous PM sampling methods.

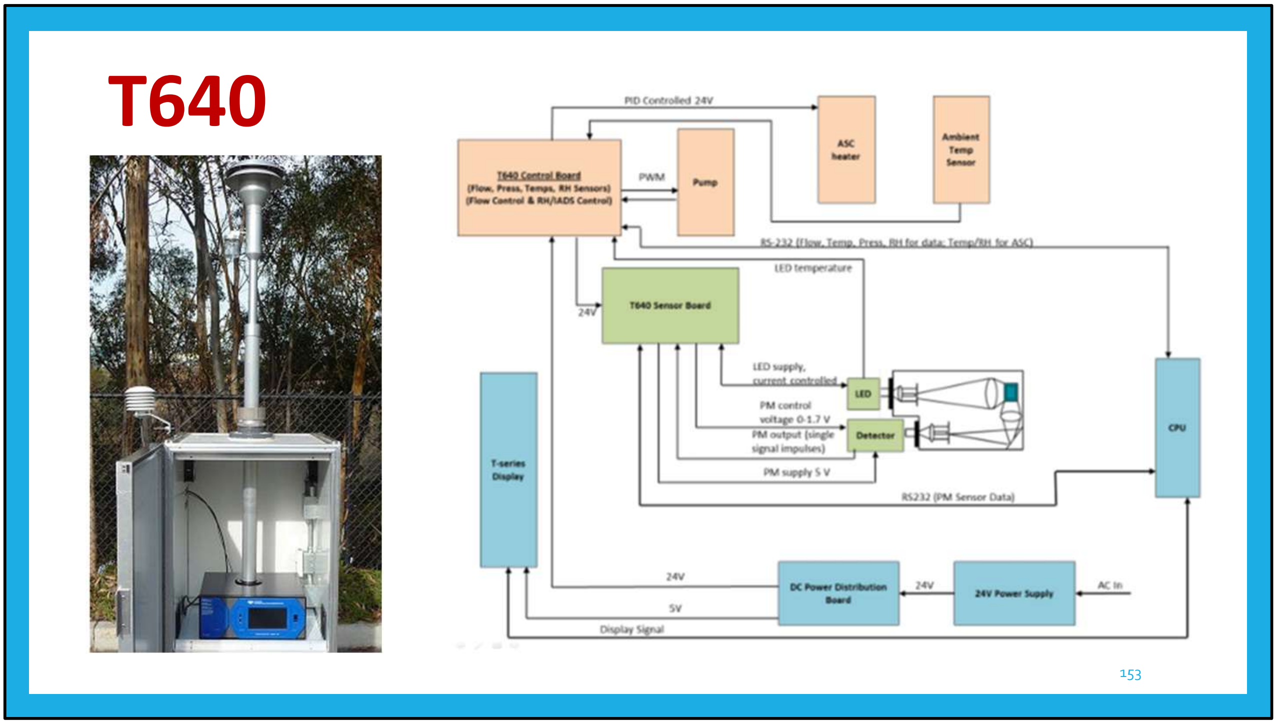
Continuous particulate analyzers

Thermo TEOM-1405
– oscillating microbalance

Met One BAM 1020
– beta attenuation

152

A number of different types of continuous PM sampling methods.



The Model T640 is an optical aerosol spectrometer that converts optical measurements to mass measurements with sharp accuracy by determining sampled particle size via scattered light at the single particle level according to Lorenz-Mie Theory. Briefly, the sampling head draws in ambient air with different-sized particles, which are dried with the Aerosol Sample Conditioner (ASC) and moved into the optical particle sensor where scattered light intensity is measured to determine particle size diameter. The particles move separately into the T-aperture through an optically differentiated measurement volume that is homogeneously illuminated with polychromatic light. The polychromatic light source, an LED, combined with a 90° scattered light detection achieves a precise and unambiguous calibration curve in the Mie range, resulting in a large size resolution. Each particle generates a scattered light impulse that is detected at an 85° to 95° angle where amplitude and signal length are measured; the amplitude (height) of the scattered light impulse is directly related to the particle size diameter. The T-aperture and simultaneous signal length measurements eliminate border zone error, which is characterized by the partial illumination of particles at the border of the measurement range.

64 size bins possible from 0.18 – 20 um.

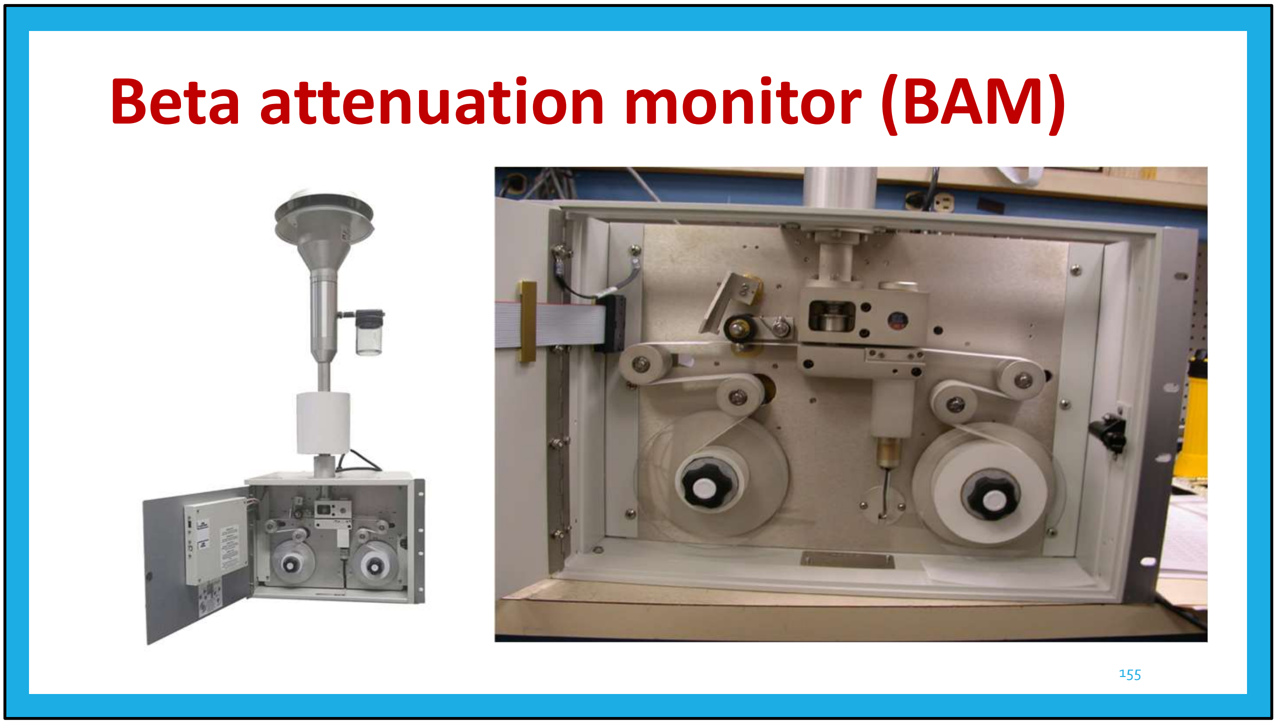
T-640 has equivalency for PM2.5.
T-640X has equivalency for both PM2.5 and PM10.

EDM-180

154

Light scattering at single particles with diode laser.
31 size bins possible from 0.25 – 32 um.

Grimm has equivalency for PM2.5.



Uses the attenuation of beta emissions from a Carbon-14 source by particles on a filter tape.

BAM has equivalency for both PM2.5 and PM10 as separate instruments.

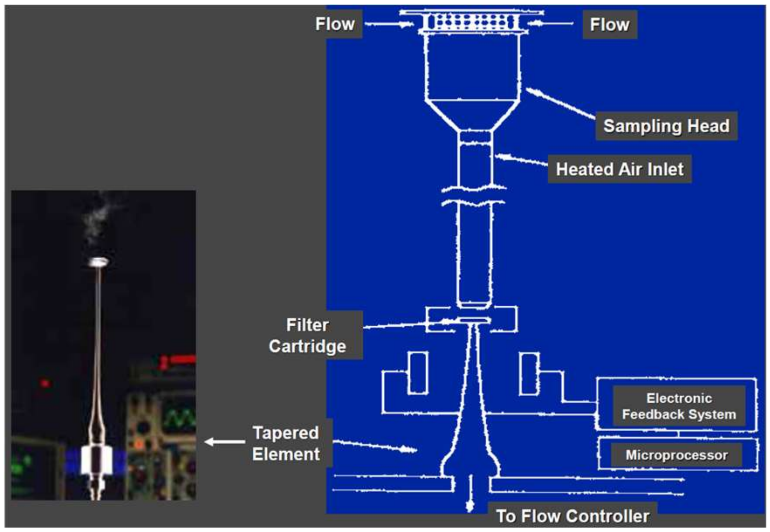
Tapered element oscillating microbalance (TEOM) inlet

156

TEOM uses an oscillating quartz crystal and measures the decrease in vibrational frequency as the mass loading increases.

TEOM has equivalency for both PM2.5 and PM10 as separate instruments.

TEOM



Flow
Flow
Sampling Head
Heated Air Inlet
Filter Cartridge
Electronic Feedback System
Tapered Element
Microprocessor
To Flow Controller

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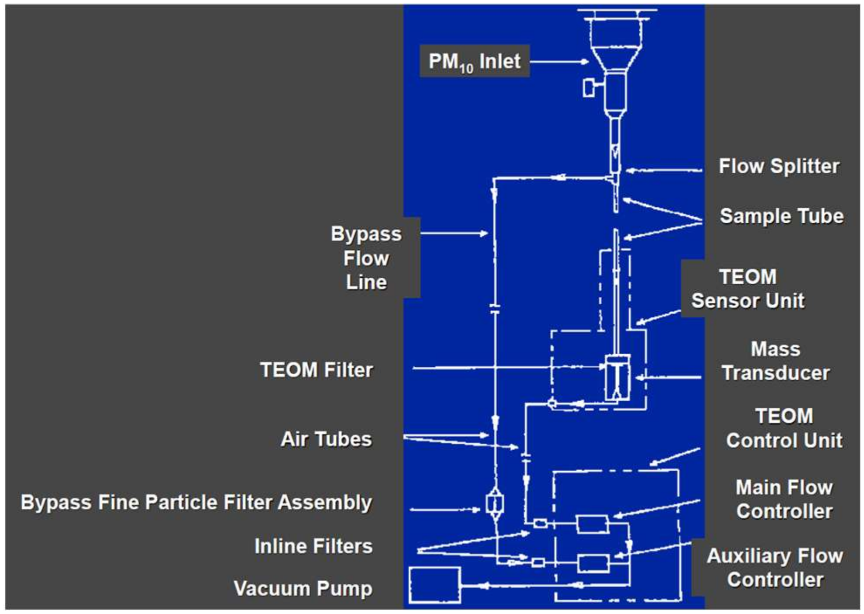
TEOM



PM10 Inlet
Flow Splitter
Sample Tube
Bypass Flow Line
TEOM Sensor Unit
Mass Transducer
TEOM Filter
TEOM Control Unit
Air Tubes
Main Flow Controller
Bypass Fine Particle Filter Assembly
Inline Filters
Auxiliary Flow Controller
Vacuum Pump

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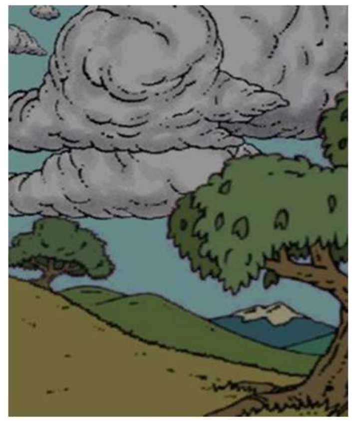
Meteorological instruments

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



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Meteorological instruments

160

Cup and vane with temperature in fan-aspirated shield.

2-D Sonic anemometer with T, RH, P.
Sonic anemometers eliminate the need to change bearings in cup and vane systems.

Meteorological instruments

161

Solar radiation.

Temperature.

3D wind sensor

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Provides vertical wind speeds.

Sensors

- Low cost
- Technologies are improving
- Software and algorithms are key
- Calibration and correction are key
- Low cost sensors available for $PM_{2.5}$, O_3, NO_2, SO_2, CO, CO_2, tVOC, many other compounds
- Some don't have low detection levels
- Many cross-interference and environmental interference issues
- Data often very noisy at short time resolutions

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"Low cost" is somewhat relative. Can vary from a few $100's to a few $1,000's.

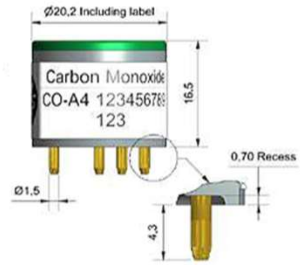
PM2.5 generally pretty good. Some bias at higher end.

Many of the gas sensors are problematic.

Lot of cross-interferences with O3, NO2, others.

Sensors overview

- Particulates
  - Light scattering
- Gases
  - Electrochemical
  - Metal oxide
  - Photoionization



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In an electrochemical sensor, gas diffuses across a porous membrane into a cell containing electrolyte and electrodes. When the gas comes into contact with the electrolyte, a change in electrochemical potential occurs between the electrodes causing electrons to flow.

In heated metal oxide sensors, a metal substrate is heated which allows it to become very sensitive to a gas. An electrical current passes through the metal substrate. The resistance of the current changes according to the amount of the gas present. The sensor outputs the resistance in ppm or ppb.

In a photoionization detector (PID) high-energy photons, typically in the vacuum ultraviolet (VUV) range, break molecules into positively charged ions. As compounds enter the detector they are bombarded by high-energy UV photons and are ionized when they absorb the UV light, resulting in ejection of electrons and the formation of positively charged ions. The ions produce an electric current, which is the signal output of the detector. The greater the concentration of the component, the more ions are produced, and the greater the current.

Electrochemical and metal oxide typically used for criteria gas pollutants.
PID and metal oxide typically used for VOCs.

PurpleAir used in EPA’s Fire Smoke mapping. www.fire.airnow.gov

Sensors

	Reference Monitors	Low-Cost Sensors
Typical Purchase Cost	$15,000 to $40,000 (USD)	$200 to $5,000 (USD)
Staff Training	Highly trained technical staff	Little or no training to operate. May need more training to interpret data
Operating Expense	Expensive – shelter, technical staff, maintenance, repair, quality assurance.	May be less expensive – replacement, data streaming, data management.
Siting Location	Fixed Location. (climate controlled building/trailer needed)	More portable. May require weather shielding. Siting can be easier due to lower flow rates but more tricky because of data streaming.
Data Quality	Known and consistent quality in a variety of conditions.	Unknown. Can vary from sensor to sensor, in different weather conditions, and in different pollution environments.
Operating Lifetime	10+ Years (calibrated and operated to maintain accuracy).	Short (1 year) or Unknown (may become less sensitive over time).
Regulatory Monitoring?	Yes	No

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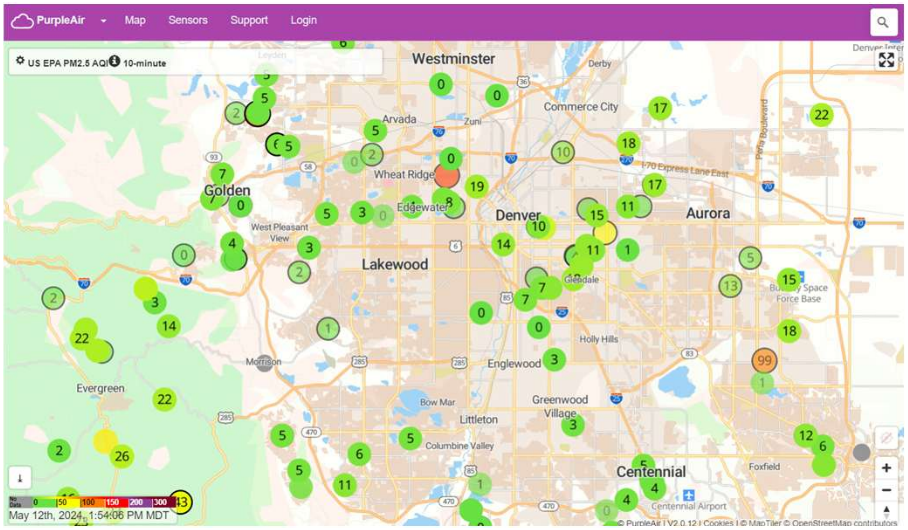
Sensors can be great for screening and community studies.

Example sensor map - PurpleAir



https://map.purpleair.com/

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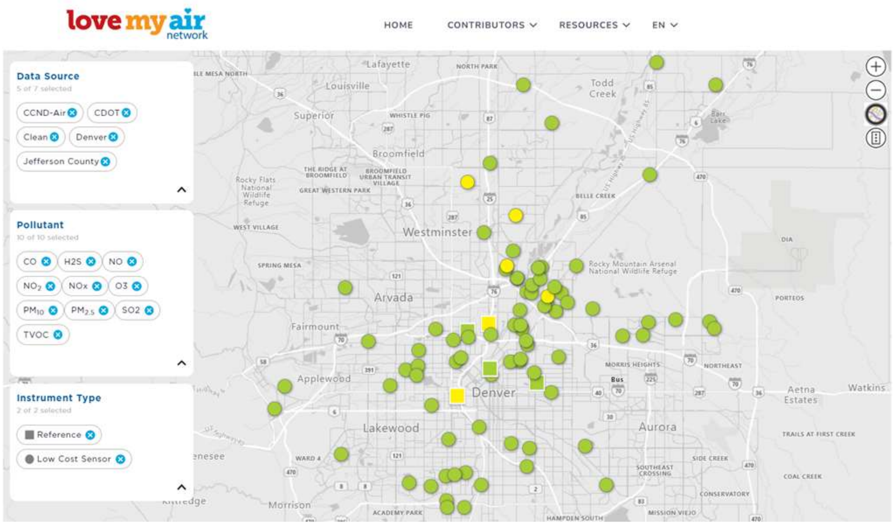
Example of a map from a single sensor integrator/manufacturer.

Example sensor map - Love My Air



https://lovemyair.com/

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Example of a map that pulls in data from sensors and regulatory sites.
Used a lot by communities.


Data Handling
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Data handling

- Data loggers
  - Strip charts
    - Paper
    - Electronic
  - Computers
  - Temporary data storage
    - SD cards
  - On-line data retrieval
    - Ethernet
    - Modbus
    - Wi-fi
    - Cellular

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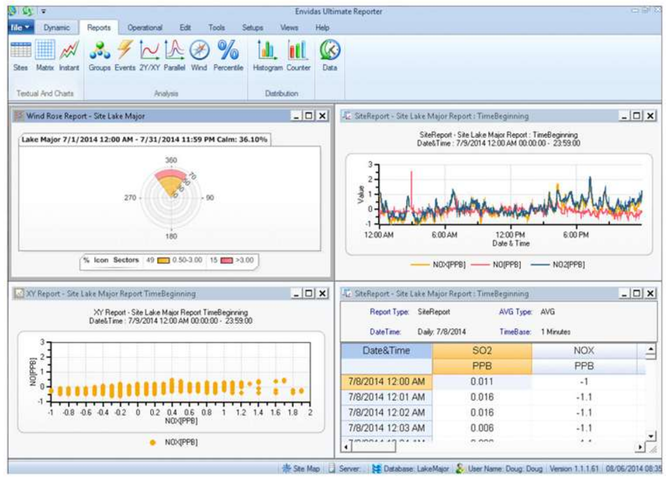
Paper strip charts not used much any more.

Cloud-based systems becoming more common.

Data acquisition system

- Data gathering
- Charting
- Scheduling
  - QA checks
  - Calibrations
- Data validation/flagging/editing
- Data processing
- Messages
- Alarms
- Station logbooks
- Reports/exports/visualizations



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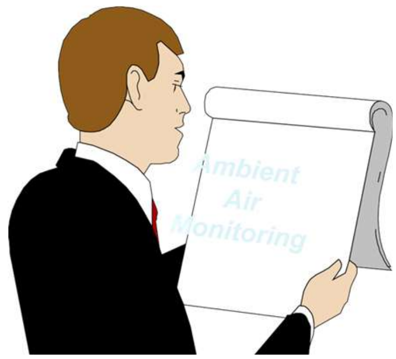
Current DAS are complete systems with data review and reporting capabilities.

Paper strip charts not used much any more.

Site survey data

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



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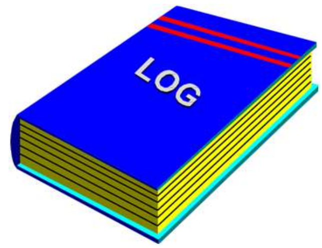
Need to have good records for a defensible monitoring system.

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.



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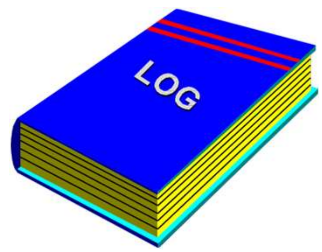
Documentation

- 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



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Quality assurance
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Quality control vs quality assurance

1. Quality Control

- Quality control (QC) is the procedures, policies, and corrective actions necessary to ensure product quality.

2. Quality Assurance

- Quality assurance (QA) procedures are used to evaluate the effectiveness of QC and the quality of data.

Quality control (QC) principles

- QC involves the specific steps and procedures used to assess the quality of data during sampling and analytical processes.
- This includes activities like performing replicate analyses, verifying calibrations, and analyzing QC samples (like matrix spikes and blanks)
- QC measures are designed to determine the validity of the data generated by specific sampling and analytical methods.

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Quality assurance (QA) principles

- QA is the overarching plan and process for ensuring the quality of data collected and reported
- This includes aspects like defining data quality objectives, training personnel, documenting procedures, and ensuring the overall effectiveness of the quality control (QC) system
- QA activities also involve monitoring the QC system and correcting any deficiencies identified by the QC process.

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QA/QC principles

- General QA/QC principles applicable to a monitoring program include:
  - Establish data quality objectives or requirements prior to sample collection and analysis
  - Collect, process and analyze samples according to scientifically valid standardized procedures
  - Maintain integrity and security of samples at all times
  - Ensure recordkeeping and documentation procedures are adequate for traceability of all samples and data
  - Assess, document, and report data quality
  - Report complete and accurate results

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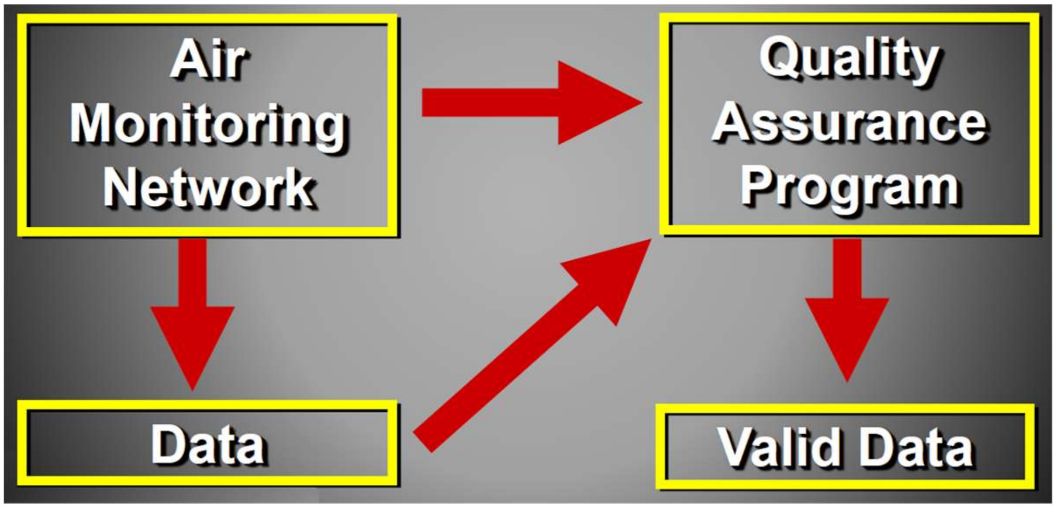
Quality assurance



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QA is required to have defensible air monitoring data.

QA documents

- Quality Management Plan
  - QMP
- Quality Assurance Project Plan
  - QAPP
- Standard Operating Procedures
  - SOP

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The U.S. Environmental Protection Agency (EPA) has developed the Quality Management Plan (QMP) as a means of documenting how an organization will plan, implement, and assess the effectiveness of its quality assurance and quality control operations applied to environmental programs. The process of planning, implementing, and assessing these management systems is called quality management and the product of this process is called the Quality System. The Quality Management Plan is part of the mandatory Agency-wide Quality System that requires all organizations performing work for EPA to develop and operate management processes and structures for assuring that data or information collected are of the needed and expected quality for their desired use.

A QMP describes an organization's quality system, i.e., its systematic approach to quality assurance, while a QAPP describes the necessary QA procedures, quality control (QC) activities, and other technical activities that will be implemented for a specific project or program.

A QA Project Plan (QAPP) describes the activities of an environmental data operations project involved with the acquisition of environmental information whether generated from direct measurements activities, collected from other sources, or compiled from computerized databases and information systems. The QAPP documents the results of a project's technical planning process, providing in one place a clear, concise, and complete plan for the environmental data operation and its quality objectives and identifying key project personnel.

A Standard Operating Procedure (SOP) is a set of written instructions that document a routine or repetitive activity followed by an organization. The development and use of SOPs are an integral part of a successful quality system as it provides individuals with the information to perform a job properly, and facilitates consistency in the quality and integrity of a product or end-result. SOPs describe both technical and fundamental programmatic operational elements of an organization that would be managed under a work plan or a QAPP.

Quality assurance

- Field QA
  - Daily and Weekly Zero and Span Checks
  - Bi-weekly Precision Checks
  - Semi-Annual Multipoint Calibrations
  - Annual Audits
  - External Audits
    - Agency Audits
    - EPA NPAP (National Pollutant Audit Program)
    - EPA PEP (Performance Evaluation Program)
    - EPA Technical Systems Audit (TSA)

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Outlined in 40 CFR 58, Appendix A.

Defines a PQAO (primary quality assurance organization).

Need at least 2 levels of organizational separation between the routine field operations staff and the QA field staff, as well as independent equipment.

National Performance Audit Program (NPAP) for Gaseous Monitoring.
- Provides for through-the-probe audits by an independent contractor.

National PM2.5 Performance Evaluation Program (PEP) for Particulate Monitoring.
- Provides for side-by-side filter-based sample collection with weighing in a different lab.

Technical Systems Audit (TSA)
- Full audit of the agency’s program to evaluate if all procedures/documentation/data collection is being followed.

Quality assurance

- QA of instruments includes:
  - Flow error
  - Zero drift
  - Bias
  - Accuracy to gas standards
  - Accuracy to mass standards
  - Reducing contamination

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Follow all SOP's for QA, including filter changes, line cleanings, etc.

Accuracy to gas standards includes span, precision, audits, calibrations
Accuracy to mass standards includes co-location, polyspheres

Audit van/trailer

184

Most agencies don’t have a van or trailer, but have separate equipment and staff for QA.

CARB audit van instrumentation

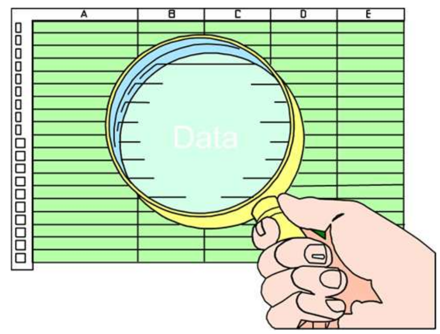
185

Current equipment is more compact.

This van would be similar to what an EPA contractor would use for NPAP through-the-probe audits.

Data review

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



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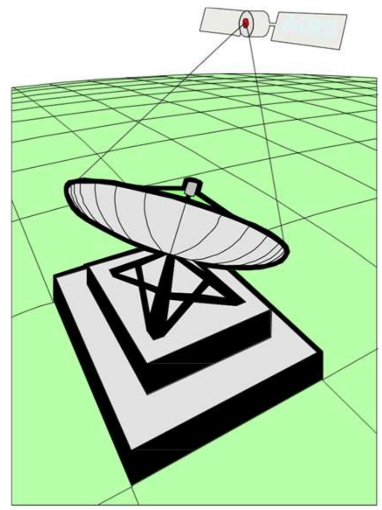
Complete data set: EPA generally requires at least 75% data completeness in each calendar quarter for a complete year.

Data processing

- Data Processing
  - Upload to Air Quality System (AQS)
  - Air Quality Data Actions
    - Data Deletion
    - Data Correction
    - Links Data to Field QA
- Annual Data Certification
  - 40 CFR 58.15



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AQS provides a standardized data format and storage system for air monitoring data nationwide.
AQS generally designed for regulatory data.

Cloud-based systems now used for many databases and data storage systems.

Station inspection

- Review Siting
- Examine Instruments
  - Condition, Zero/Spans, Calibration, Audit Results
- Examine Gases
  - Certification
- Review Logs
- Evaluate overall station cleanliness and operation

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Site QA documents

- EPA site approval documents
  - Initial installation
  - Termination
  - Changes
- Annual Monitoring Network Plan
  - Required in 40 CFR 58.10
- 5-Year Monitoring Network Assessment
  - Required in 40 CFR 58.10

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Annual Monitoring Network Plan which shall provide for the documentation of the establishment and maintenance of an air quality surveillance system that consists of a network of SLAMS monitoring stations that can include FRM, FEM, and ARM monitors that are part of SLAMS, NCore, CSN, PAMS, and SPM stations. The plan shall include a statement of whether the operation of each monitor meets the requirements of appendices A, B, C, D, and E of this part, where applicable.

5-Year Monitoring Network Assessment to determine, at a minimum, if the network meets the monitoring objectives defined in appendix D to this part, whether new sites are needed, whether existing sites are no longer needed and can be terminated, and whether new technologies are appropriate for incorporation into the ambient air monitoring network. The network assessment must consider the ability of existing and proposed sites to support air quality characterization for areas with relatively high populations of susceptible individuals (e.g., children with asthma), and, for any sites that are being proposed for discontinuance, the effect on data users other than the agency itself, such as nearby states and tribes or health effects studies.

Accuracy and precision

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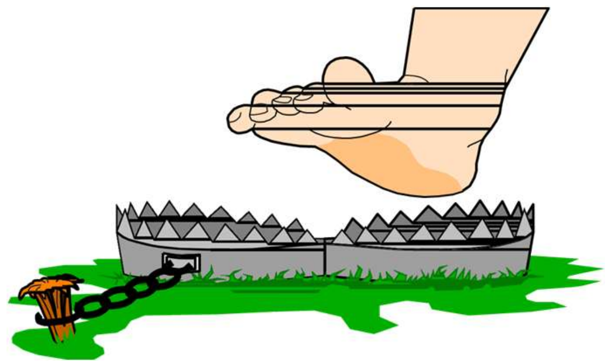
The goal of a good QA program is to have accurate and precise data that is defensible.

Safety

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



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Want good safety protection.

Gas bottles stored upright and secured.

Avoid electric lines crossing the floor and overloading circuits.

Fall protection such as railings.


References and Resources

Air Quality Index (AQI)

- EPA-preferred method
- Health-based
- Multi-pollutant

AIR QUALITY INDEX

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health alert: everyone may experience more serious health effects
Hazardous	301 to 500	Health warnings of emergency conditions. The entire population is more likely to be affected.

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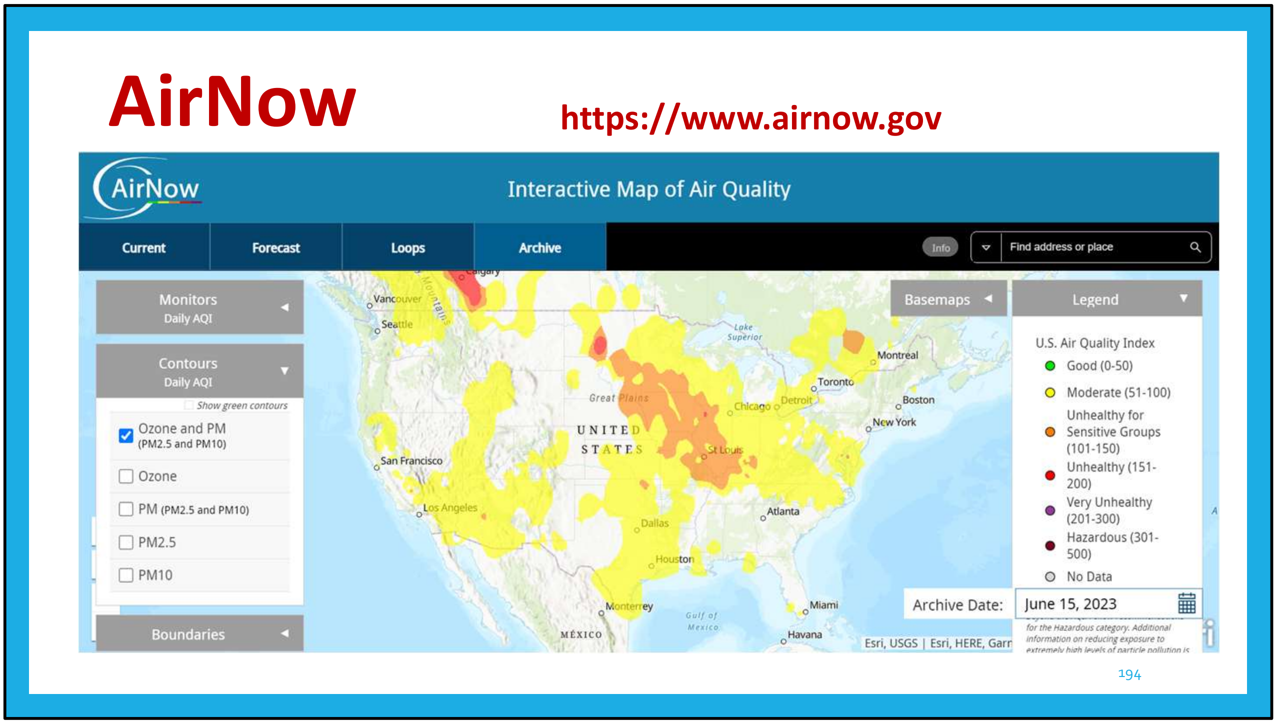
Specified in 40 CFR 58, Appendix G.

AQI has now been around for many years.

Recognized by much of the general public.

Easy way to convey air pollution levels without getting into concentration details.



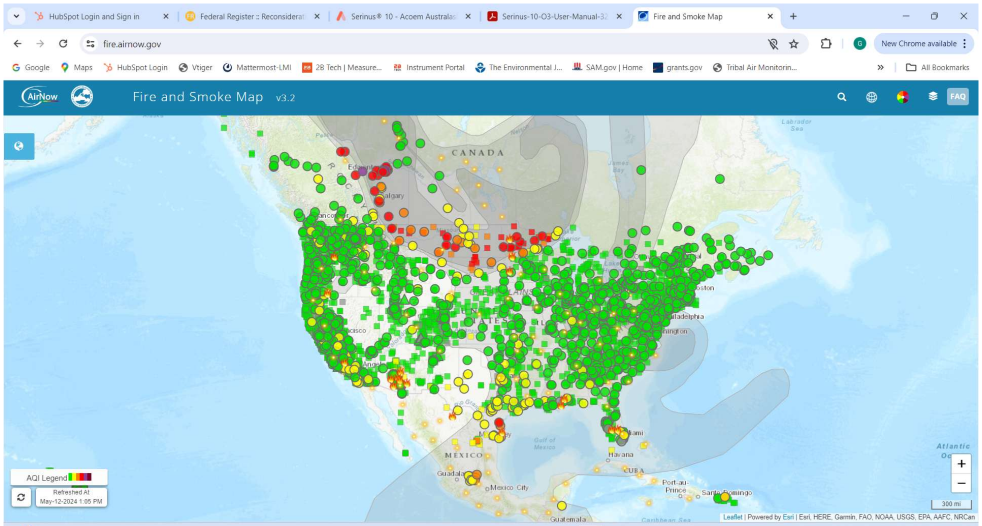
Mapping tool for air pollution levels across the US.

Displays AQI and modeled contours.

Ozone and PM2.5 use a “Nowcast” AQI.

Fire and Smoke Map

https://www.fire.airnow.gov



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Air Data

https://www.epa.gov/outdoor-air-quality-data

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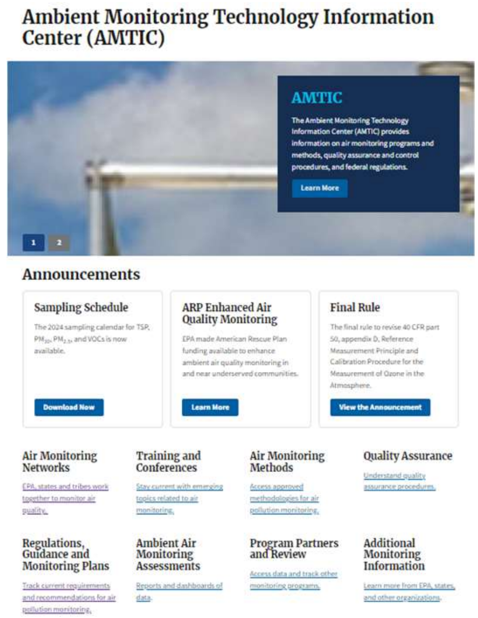
Easy place to get summary data.

Air Monitoring Technology Information Center

https://www.epa.gov/amtic



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Useful site to get general information on air monitoring.

The web

- https://www.epa.gov/amtic
  - Monitoring information
- https://www.epa.gov/outdoor-air-quality-data
  - Monitoring data
- http://www.airnow.gov
  - AQI
- http://www.fire.airnow.gov
  - Fire and smoke map
- https://www.epa.gov/criteria-air-pollutants
  - NAAQS

The web (continued)

- https://www.ecfr.gov/current/title-40
  - Code of Federal Regulations, volume 40
- https://www.epa.gov/quality
  - EPA's main quality assurance site
- https://www.epa.gov/amtic/ambient-air-monitoring-quality-assurance
  - Air quality assurance guidance
- https://www.epa.gov/green-book
  - Non attainment areas
- https://www.epa.gov/air-trends
  - Air quality trends

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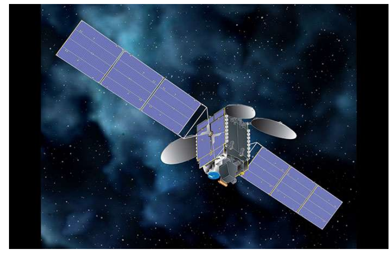
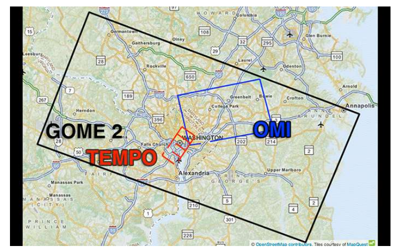
The future

- Sensors
- Air toxics
  - Benzene
  - Ethylene oxide
  - Formaldehyde
- Ultrafine particulates
- Greenhouse gases
  - CO_2
  - Methane
- Real time particulate metals speciation
- Satellite and mobile measurements
- ????





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Air monitoring is always evolving.

Lot of work being done with sensors.

TEMPO – Tropospheric Emissions: Monitoring of Pollution.
- The TEMPO instrument is a UV-visible spectrometer, and is the first ever space-based instrument to monitor air pollutants hourly across the North American continent during daytime.
- collect high-resolution measurements of ozone, nitrogen dioxide, formaldehyde and other pollutants.
- scans the US once per hour, not just once per day.
- much higher spatial resolution, ~2 x 5 km grids.

Column measurements from satellites or mobile can provide a wealth of information on overall amounts of pollution in the atmosphere and for forecasting.