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TESTIMONY

Statement of

Omar M. Hammad
Analyst in Environmental Policy

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Hearing on

"Examining the State of Air Quality Monitoring Technology"

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Chairman Carper, Ranking Member Capito, and Members of the Committee, good morning. My name is Omar Hammad, and I am an analyst in Environmental Policy for the Congressional Research Services (CRS). On behalf of CRS, I want to thank you for inviting me to testify today. I have been asked by the committee to discuss the state of air quality monitoring sensor technologies, as well as the opportunities and challenges for communities to obtain accurate and reliable information and data about their local air quality.

In serving the U.S. Congress on a nonpartisan and objective basis, CRS does not take positions on legislation and makes no recommendations to policymakers. My testimony draws on my areas of expertise at CRS—the Clean Air Act and air quality monitoring. I work with a team of analysts and attorneys to address related issues for Congress. My CRS colleagues and I remain available to assist the committee in its consideration of air quality monitoring sensor technology issues.

The U.S. Environmental Protection Agency (EPA) defines *low-cost air sensors* as a class of nonregulatory technology that is lower in cost, portable, and generally easier to operate than the air monitors used for regulatory purposes. Some stakeholders have asserted that EPA, state, and local air agencies should consider the use of low-cost air sensors in their regulatory regimes due to competitive costs, increasingly better technologies, and expanded coverage. Observers noted certain concerns arise regarding such implementation. My testimony aims to introduce and address the elements of this debate. My testimony will discuss ambient air monitors, low-cost air sensors, their uses, and the benefits and challenges of both technologies.

Introduction

Air quality is a term used to describe how much pollution is in the air. Congress recognized the need to address air pollution, establishing the Clean Air Act (CAA) (42 U.S.C. §§7401 et seq.) with the purposes[1]

- "to protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population";
- "to initiate and accelerate a national research and development program to achieve the prevention and control of air pollution";
- "to provide technical and financial assistance to State and local governments in connection with the development and execution of their air pollution prevention and control programs"; and
- "to encourage and assist the development and operation of regional air pollution prevention and control programs."

Air quality management refers to all the activities a regulatory authority may undertake to address the prevention and control of air pollution within its jurisdiction. The process of managing air quality can be illustrated as a dynamic cycle of interrelated elements. The regulatory authority establishes air quality goals, determines the level of emissions reductions needed, develops control strategies, implements programs, and monitors air quality to reevaluate the cycle.[2]

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[1] 42 U.S.C. §7401(b).

[2] For more information, see EPA, "Air Quality Management Process Cycle," https://www.epa.gov/air-quality-management-process/air-quality-management-process-cycle.

Criteria Air Pollutants and the National Ambient Air Quality Standards

Under Sections 108 and 109 of the CAA,[3] EPA is to issue national ambient (outdoor) air quality standards (NAAQS) for certain listed pollutants (1) whose emissions "may reasonably be anticipated to endanger public health or welfare" and (2) whose presence in ambient air "results from numerous or diverse mobile or stationary sources."[4] EPA has identified and promulgated NAAQS for six principal pollutants, commonly referred to as *criteria pollutants*:

1. particulate matter (PM),
2. ozone (O_3),
3. nitrogen dioxide (NO_2),[5]
4. sulfur dioxide (SO_2),
5. carbon monoxide (CO), and
6. lead (Pb).

The CAA directs EPA to establish two types of NAAQS:

1. *primary standards*, "the attainment and maintenance of which in the judgment of the [EPA] Administrator ... are requisite to protect the public health" with "an adequate margin of safety";[6] and
2. *secondary standards*,[7] which are necessary to protect *public welfare*,[8] a broad term that includes visibility impairment as well as damage to crops and vegetation, and effects on soil and nutrient cycling, water, wildlife, property, and building materials, among other things.

Establishment of NAAQS does not directly limit emissions or compel specific emissions controls; rather, it represents EPA's formal judgment regarding the level of ambient air pollution that protects public health with an adequate margin of safety. In setting the NAAQS, EPA may not consider the costs of implementing the standards.[9] Promulgation of NAAQS sets in motion a process under which the states and tribes first identify geographic *nonattainment areas* (i.e., those areas failing to meet the NAAQS) based on monitoring and analysis of relevant air quality data. EPA then establishes nonattainment areas in these locations based on the data and recommendations from states and tribes.[10] States with nonattainment areas then submit State Implementation Plans (SIPs) to EPA. The SIPs identify specific state and federal

[3] 42 U.S.C. §7408 and §7409.

[4] For more information regarding the Clean Air Act (CAA) and its major requirements, see CRS Report RL30853, *Clean Air Act: A Summary of the Act and Its Major Requirements*, by Richard K. Lattanzio.

[5] The national ambient air quality standard (NAAQS) is for nitrogen dioxide (NO_2); nitrogen gases that are ozone precursors are referred to as *nitrogen oxides*, or NO_x.

[6] 42 U.S.C. §7409(b)(1).

[7] 42 U.S.C. §7409(b)(2).

[8] 42 U.S.C. 7602(h). The use of the term *public welfare* in the CAA "includes, but is not limited to, effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility, and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being, whether caused by transformation, conversion, or combination with other air pollutants."

[9] The D.C. Circuit's holding on the cost and constitutional issues were appealed to the U.S. Supreme Court. In 2001, the Supreme Court issued a unanimous decision upholding EPA's position on both the cost and constitutional issues. Am. Trucking Ass'ns v. EPA, 531 U.S. 457, 465–472, 475–76 (2001); Am. Trucking Ass'ns, Inc. v. EPA, 283 F.3d 355 (D.C. Cir. 2002).

[10] While CAA Section 107(d) (42 U.S.C. §7407(d)) specifically addresses states, EPA generally follows the same process and schedule for tribes pursuant to CAA Section 301(d) (42 U.S.C. §7601(d)). For more information, see EPA, "Tribal Authority Rule (TAR) Under the Clean Air Act," https://www.epa.gov/tribal-air/tribal-authority-rule-tar-under-clean-air-act.

regulations and emissions control requirements that are to bring areas into compliance, as well as actions for maintaining compliance.[11]

Air Quality Index

EPA and other agencies have developed tools to measure air quality conditions and alert the public if air pollutants reach a certain level. For example, EPA manages AirNow, a multiagency website that reports air quality based on monitoring data received on a regular basis from state, local, and federal agencies.[12] AirNow contains data in a consistent format and displays it through interactive maps. AirNow reports air quality information using the Air Quality Index (AQI), a nationally uniform index. EPA calculates the AQI for a criteria pollutant based on the ambient concentration of that pollutant.[13] AQI values range from 0 to 500. The higher the AQI value, the greater the level of air pollution. EPA describes AQI values of 100 or lower as "satisfactory" or "acceptable." AQI values fluctuate throughout the year, due to a number of factors. For example, ozone levels tend to be higher in the summer months for most states, and particulate pollution is typically affected by winter temperature inversions (in a temperature inversion, cold air at the surface is under a layer of warmer air) and the wildfire season.[14]

Figure 1 is an example of the data AirNow provides for an area. EPA relates current hourly readings from ambient air monitors to AQI values for ozone and particle pollution.[15] Also, most state and local air quality agencies issue forecasts for ozone and particle pollution. A few areas also issue forecasts for nitrogen dioxide and carbon monoxide.

[11] Under certain circumstances EPA may disapprove a State Implementation Plan (SIP) and promulgate a Federal Implementation Plan (FIP). For information regarding SIPs and FIPs, see CAA Section 110 (42 U.S.C. §7410).

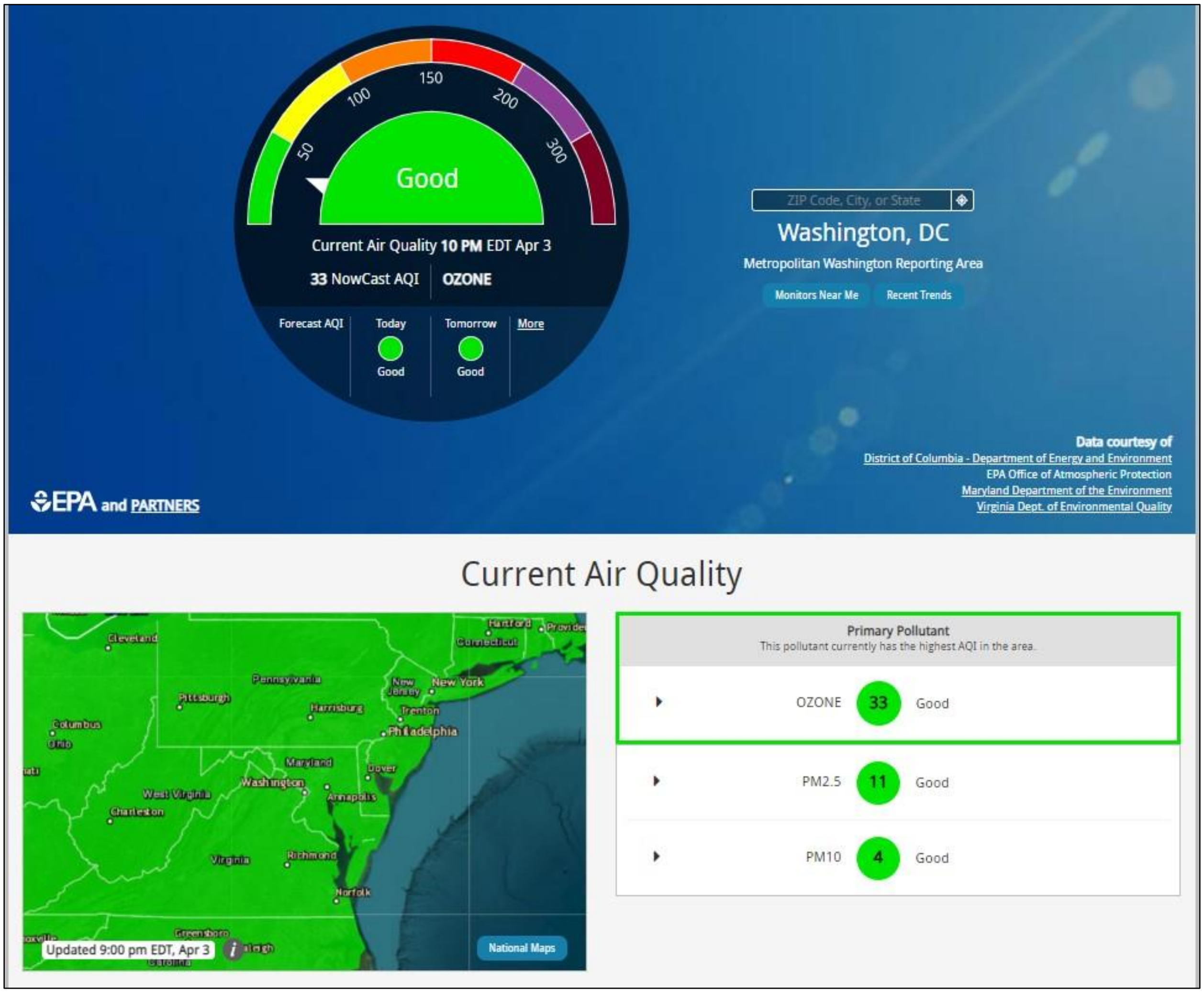
[12] For information on AirNow, see AirNow, "About AirNow," https://www.airnow.gov/about-airnow/. For a list of the participating agencies, see AirNow, "List of Partners," https://www.airnow.gov/partners/.

[13] The Air Quality Index (AQI) is established for five of the six criteria air pollutants. It is not established for lead (Pb). AirNow, "Air Quality Index (AQI) Basics," https://www.airnow.gov/aqi/aqi-basics/. The AirNow maps provide for the two pollutants of concern particulate matter (PM) and ozone.

[14] For more information on inversions, see EPA, "Inversion," https://www.epa.gov/environmental-geophysics/inversion. For more information on air quality trends, see EPA, "National Air Quality: Status and Trends of Key Air Pollutants," https://www.epa.gov/air-trends.

[15] AirNow current AQI and forecasts are often for ozone and particle pollution, two of the most widespread pollutants in the United States. For more information, see AirNow, "Using the Air Quality Index," https://www.airnow.gov/aqi/aqi-basics/using-air-quality-index/.

Figure 1. AirNow Current Air Quality in the Washington, DC, Metropolitan Washington Reporting Area



Source: CRS, using AirNow, https://www.airnow.gov/?city=Washington&state=DC&country=USA.

Notes: AirNow real-time data was obtained on April 3, 2024, at approximately 9:30 PM. Air quality at that time was good or "satisfactory," with an AQI value between 0 to 50 for ozone and particulate air pollution.

Ambient Air Monitoring

Ambient air monitoring is "the systematic, long-term assessment of pollutant levels by measuring the quantity and types of certain pollutants in the surrounding, outdoor air."[16] CAA Section 319 directs EPA to promulgate regulations that establish an ambient air monitoring system throughout the United States which[17]

[16] For more information on EPA's ambient air monitoring, see EPA, "Managing Air Quality - Ambient Air Monitoring," https://www.epa.gov/air-quality-management-process/managing-air-quality-ambient-air-monitoring. For information on EPA's air monitoring methods, see EPA, "Air Monitoring Methods—Criteria Pollutants," https://www.epa.gov/amtic/air-monitoring-methods-criteria-pollutants.

[17] 42 U.S.C. §7619(a).

- "utilizes uniform air quality monitoring criteria and methodology and measures such air quality according to a uniform air quality index,"
- "provides for air quality monitoring stations in major urban areas and other appropriate areas throughout the United States to provide monitoring such as will supplement (but not duplicate) air quality monitoring carried out by the States required under any applicable implementation plan,"
- "provides for daily analysis and reporting of air quality based upon such uniform air quality index," and
- "provides for recordkeeping with respect to such monitoring data and for periodic analysis and reporting to the general public by the Administrator with respect to air quality based upon such data."

In addition, CAA Section 319 directs EPA to develop requirements and guidance for various aspects of these networks.[18] In accordance with Section 319, the ambient air monitoring system required for NAAQS implementation under CAA Section 110 would "utilize the standard criteria and methodology, and measure air quality according to the standard index, established under such regulations." Most of the ambient air monitoring networks supporting air quality management are designed and operated by tribal, state, and local governments.[19]

Criteria Pollutant Ambient Air Monitoring and Monitoring Networks

The national ambient air monitoring system measures air pollution levels at fixed locations across the country.[20] EPA, state, and local agencies cooperatively manage this system's infrastructure. Various methods and instruments are available to measure ambient air pollutants. The selection of the appropriate device is generally based on the application.

Per EPA-established regulations, states, tribes, and local air program managers develop five-year network assessments and annual ambient monitoring network plans. The five-year network assessments are used to determine if the ambient monitoring network is meeting the regulatory objectives. The annual ambient monitoring network plans ensure networks comply with design requirements.[21] EPA conducts on-site reviews and inspections to assess compliance with the regulations governing the collection, analysis, validation, and reporting of ambient air monitoring data.[22]

The number and type of required monitors and pollutants monitored differ at each site. These monitors must meet either a designated reference or an equivalent method for monitoring. The *Federal reference method* (FRM) is a method of sampling and analyzing the ambient air for an air pollutant that EPA has

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[18] Requirements related to network monitoring methods are in the appendices to 40 C.F.R. Part 50. Requirements related to monitoring reference and equivalent methods are in 40 C.F.R. Part 53, "Ambient Air Monitoring Reference and Equivalent Methods." EPA requires monitoring agencies to develop network assessments and annual monitoring network plans that include the information described in 40 C.F.R. Part 58, "Ambient Air Quality Surveillance."

[19] 42 U.S.C. §7619.

[20] Site relocations are subject to EPA approval in accordance with 40 C.F.R. Parts 50, 53, and 58.

[21] According to 40 C.F.R. 58.10(d) "the state, or where applicable local, agency shall perform and submit to the EPA Regional Administrator an assessment of the air quality surveillance system every 5 years 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." According to 40 C.F.R. 58.10(a), the annual monitoring plans "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."

[22] For further information on ambient air monitoring and monitoring network requirements, see EPA, "Ambient Monitoring Technology Information Center (AMTIC): Ambient Air Monitoring Networks," https://www.epa.gov/amtic/amtic-ambient-air-monitoring-networks.

specified as a reference method in regulation. FRMs are EPA-accepted standards for analyzing an air pollutant. The *Federal equivalent method* (FEM) is a method for measuring the concentration of an air pollutant in the ambient air that has been designated as an equivalent method in regulation.[23] FEMs are methods that have been approved through regulation to be equivalent to FRMs.[24] **Figure 2** shows examples of ambient air monitoring sites and monitoring equipment.

Figure 2. Examples of Ambient Air Monitoring Sites and Monitoring Equipment

National Core network (NCore) monitoring site operated by the Wyoming Department of Environmental Quality

Near-road monitoring site operated by the Rhode Island Department of Environmental Management

Equipment for monitoring criteria pollutants operated by the Colorado Department of Public Health and Environment

Canisters used to collect samples for measuring air toxics operated by the Wisconsin Department of Natural Resources

Particulate matter monitoring site atop a building at the Illinois State Fairgrounds operated by the Illinois Environmental Protection Agency

Source: U.S. Government Accountability Office, *Air Pollution: Opportunities to Better Sustain and Modernize the National Air Quality Monitoring System*, GAO-21-38, December 7, 2020, p. 21, https://www.gao.gov/products/gao-21-38.

A collection of monitoring sites makes up an air program's monitoring network. **Figure 3** illustrates the District of Columbia's air program's existing five-station ambient air monitoring network. These sites collectively make up national ambient air monitoring networks. These networks include[25]

- Air Toxics

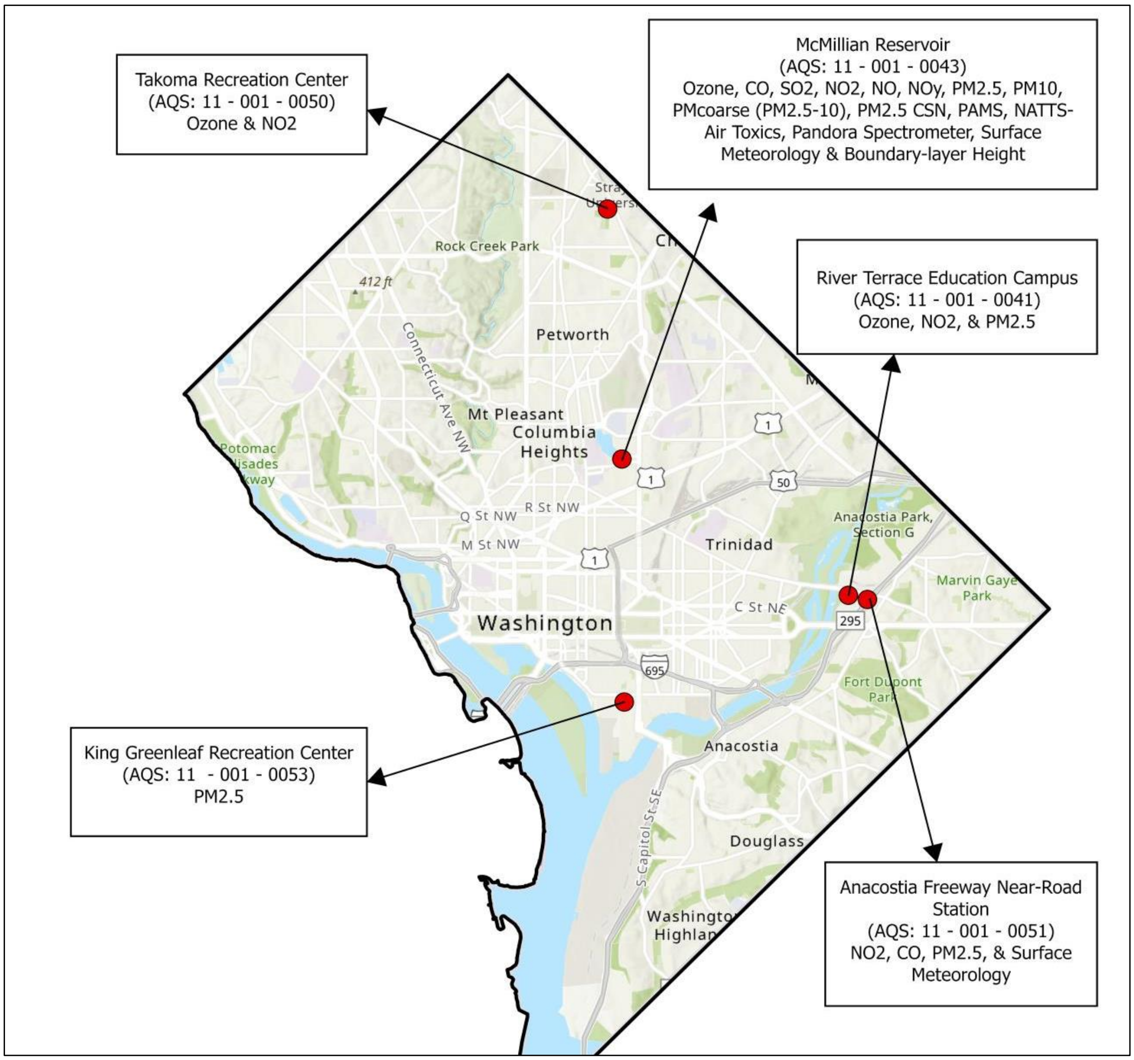
[23] For the full definition of Federal equivalent method (FEM) and Federal reference method (FRM), see 40 C.F.R. § 53.1.

[24] In addition to reference and equivalent methods of air monitoring, EPA may approve a non-designated continuous fine particulate matter ($PM_{2.5}$) method of air monitoring as an Approved Regional Method (ARM) if it meets the requirements stipulated in 2.02.4 of 40 C.F.R. Appendix C to Part 58.

[25] For further information on the various networks listed, see EPA, "Ambient Monitoring Technology Information Center (AMTIC): Ambient Air Monitoring Networks," https://www.epa.gov/amtic/amtic-ambient-air-monitoring-networks.

- Lead Monitoring
- National Core Network (NCore)
- Near-Road Monitoring
- Ozone: Photochemical Assessment Monitoring Stations (PAMS)
- Particulate Matter (PM) Networks
    - Fine Particulate Matter ($PM_{2.5}$)
    - Chemical Speciation Network (CSN)
    - Interagency Monitoring of Protected Visual Environments (IMPROVE)
- Susceptible and Vulnerable Populations—NO_2 Monitoring

Figure 3. The District of Columbia's Ambient Air Monitoring Network



Source: District of Columbia, Department of Energy and Environment (DOEE), "District of Columbia's Calendar Year 2024 Draft Annual Ambient Air Monitoring Network Plan," DOEE, https://doee.dc.gov/release/public-comment-period-2024-annual-ambient-air-monitoring-network-plan.

Notes: AQS = Air Quality System, NO_2 = Nitrogen Dioxide, CO = Carbon Monoxide, SO_2 = Sulfur Dioxide NO = Nitrogen Oxide, NO_y = Nitrogen Oxides.

Air Toxics Ambient Air Monitoring and Monitoring Networks

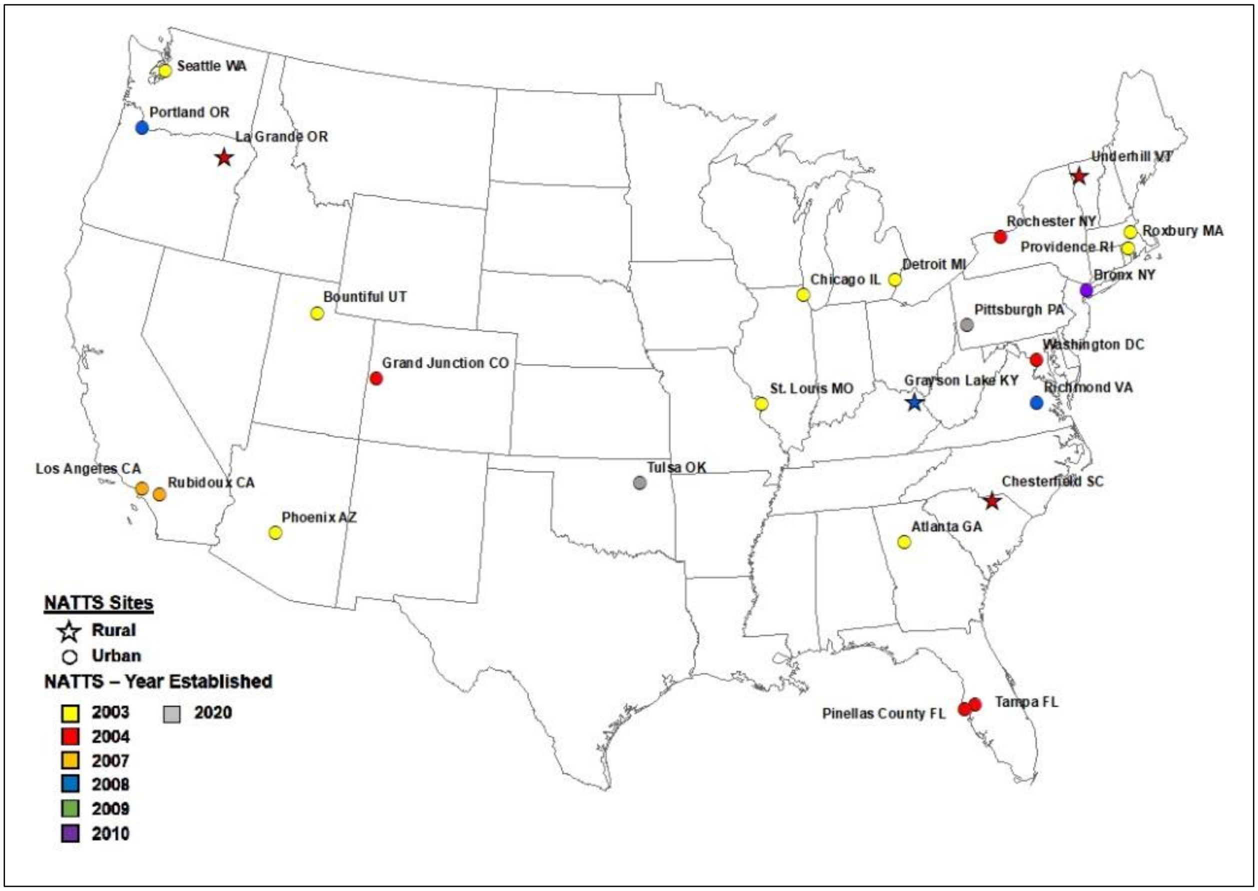
In addition to monitoring the ambient air for criteria air pollutants, EPA monitors for the 188 hazardous air pollutants (HAPs) informally referred to as "air toxics." Section 112 of the CAA directs EPA to promulgate emission standards for the sources of HAPs that are listed in Section 112(b).[26] Ambient air toxics monitoring provides air toxics data, which have a critical role in characterizing HAP concentrations across the country. The monitoring data help support trend analyses across cities, regions, and specific areas of interest over time; provide exposure assessments to help examine the relationships between ambient HAP concentrations, human activities, and the related personal exposures that are used as inputs for HAP modeling; and help HAP model evaluations.

EPA established the National Air Toxics Trends Station (NATTS) Network in 2003. The current network configuration (as illustrated in **Figure 4**) includes 26 sites (21 urban, 5 rural) across the United States. Typically, each NATTS monitors over 100 pollutants; 19 of those are formally required. Target HAPs include volatile organic compounds (VOCs), carbonyls, PM_{10} metals (PM_{10} is particulate matter with a diameter smaller than 10 micrometers and greater than 2.5 micrometers), and polycyclic aromatic hydrocarbons (PAHs).[27]

[26] 42 U.S.C. §7412. The 1990 CAA amendments specified 189 pollutants. The list has been modified through a series of rulemakings and now includes 188 pollutants. EPA, "Initial List of Hazardous Air Pollutants with Modifications," https://www.epa.gov/haps/initial-list-hazardous-air-pollutants-modifications.

[27] For more information on the National Air Toxics Trends Station (NATTS) Network, see EPA, "Air Toxics Ambient Monitoring," https://www.epa.gov/amtic/air-toxics-ambient-monitoring.

Figure 4. The National Air Toxic Trends Monitoring Sites



Source: U.S. Environmental Protection Agency (EPA), "Air Toxics Ambient Monitoring," https://www.epa.gov/amtic/air-toxics-ambient-monitoring.

Note: No National Air Toxic Trends Stations (NATTS) are located in Alaska or Hawaii.

Ambient Air Monitoring Regulatory Context

For NAAQS compliance, air monitors must meet regulations promulgated by EPA and any applicable state, tribal, or local regulations. Technical requirements include detailed sampling, siting, and quality assurance requirements. Air monitors used in policymaking and regulatory decisions provide the data needed to calculate *design values*, a statistic that describes the air quality status of a given location relative to the level of the NAAQS.[28] For example, NAAQS designations are based on the most recently available design values computed using air quality data reported by state, tribal, and local air monitoring agencies to EPA's Air Quality System (AQS).[29] An area's attainment and implementation of the NAAQS rely on ambient air monitors.[30] An air agency's permitting decision for new sources of air pollution and

[28] For more information on the NAAQS, see EPA, "Criteria Air Pollutants NAAQS Table," https://www.epa.gov/criteria-air-pollutants/naaqs-table.

[29] The Air Quality System (AQS) contains ambient air pollution data collected by EPA, state, local, and tribal air pollution control agencies from over thousands of monitors. AQS also contains meteorological data, descriptive information about each monitoring station, and data quality assurance/quality control information. See EPA, "Air Quality System (AQS)," https://www.epa.gov/aqs.

[30] For further information on the NAAQS implementation process, see EPA, "Process of Working with Areas to Attain and (continued...)

the levels of source-specific controls or offsets required are determined by the design values established through regulatory ambient air monitoring.[31] A nonattainment area's level of emission reductions and control requirements, needed to meet nonattainment progress goals or achieve attainment, are partially determined by the design values established through regulatory ambient air monitoring.[32]

Low-Cost Air Sensors

EPA defines *low-cost air sensors* as a class of nonregulatory technology that is lower in cost, portable, and generally easier to operate than the air monitors used for regulatory purposes.[33] A low-cost air sensor is a relatively low-priced device that uses one or more sensors and other components to detect, monitor, and report on specific air pollutants like particulate matter (PM) or carbon monoxide (CO) and specific environmental conditions, such as temperature and humidity.[34] Depending on the sensor or combination of sensors used, it can detect one or more, or a combination of, pollutants and/or environmental factors.[35]

Low-cost air sensors typically have a price point below $2,500, compared to regulatory ambient air monitors that reach price points of up to $50,000.[36] These low-cost air sensors typically provide relatively quick or instant air pollutant concentration measurements, and they allow for the measurement of air quality in more locations.

Many low-cost air sensors fall into one of four types, depending on how they measure air pollution:

1. light scattering (used for PM),
2. electrochemical (gaseous pollutants including O_3, SO_2, NO_2, total volatile organic compounds (VOCs), and CO),
3. metal oxide semiconductor (gaseous pollutants including O_3, CO, NO_2, and total VOCs), and
4. photoionization (total VOCs).[37]

Advancements in technology, microprocessing capabilities, and miniaturization have led to an expansion in the availability of low-cost air sensors to measure a variety of air pollutants. As these sensors have become more readily available, they have been increasingly used for measuring air quality conditions and thus provide additional low-cost air sensor data sets.[38] According to the U.S. Government Accountability

Maintain NAAQS (Implementation Process)," https://www.epa.gov/criteria-air-pollutants/process-working-areas-attain-and-maintain-naaqs-implementation-process.

[31] For further information on CAA permitting, see EPA, "Permitting Under the Clean Air Act," https://www.epa.gov/caa-permitting.

[32] For further information on implementation plans and requirements, see EPA, "Air Quality Implementation Plans," https://www.epa.gov/air-quality-implementation-plans.

[33] A. Clements et al., *The Enhanced Air Sensor Guidebook*, U.S. Environmental Protection Agency, Washington, DC, 2022.

[34] Low-cost air sensors have also been referred to as air sensors, air quality sensors, air quality monitors, air pollutant monitors, air pollutant meters or detectors, or low-cost air monitors. This testimony refers to them as low-cost air sensors.

[35] For further information on low-cost air sensor technology, see GAO, *Air Quality Sensors: Policy Options to Help Address Implementation Challenges*, GAO-24-106393, March 19, 2024, https://www.gao.gov/products/gao-24-106393.

[36] While low-cost air sensors may be priced below $2,500, some multi-pollutant low-cost air sensors can reach price points close to $10,000. For more information, see A. Clements, et al., *The Enhanced Air Sensor Guidebook*, U.S. Environmental Protection Agency, Washington, DC, 2022; and EPA, "How to Evaluate Low-Cost Sensors by Collocation with Federal Reference Method Monitors," https://www.epa.gov/sites/default/files/2018-01/documents/collocation_instruction_guide.pdf.

[37] GAO, *Air Quality Sensors: Policy Options to Help Address Implementation Challenges*, GAO-24-106393, March 19, 2024, p. 7, https://www.gao.gov/products/gao-24-106393.

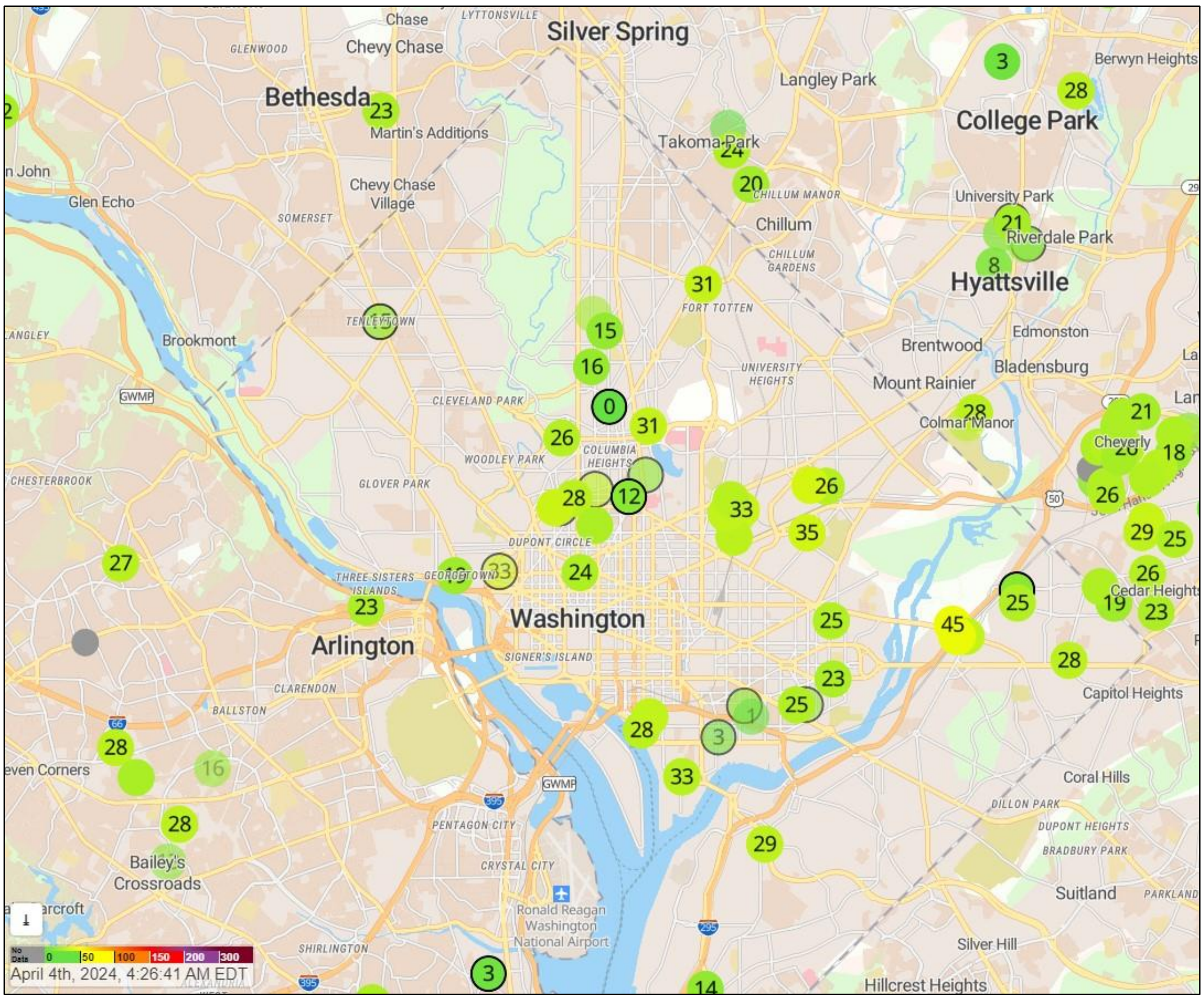
[38] A. Clements, et al., *The Enhanced Air Sensor Guidebook*, U.S. Environmental Protection Agency, Washington, DC, 2022.

Office (GAO), the use of low-cost air sensors is "increasing, driven in part by policy and public interest in air quality stemming from wildfire smoke, neighborhoods near pollution sources, and other concerns."[39]

Figure 5 illustrates the use of low-cost air sensors to measure $PM_{2.5}$ in the District of Columbia by various users of PurpleAir sensors. Community members using the sensors are able to link their sensors and provide data to the mapping tool. The number of regulatory monitors noted in **Figure 3** were five total monitors, four of which monitored $PM_{2.5}$ in the District, compared to the over three dozen nonregulatory low-cost $PM_{2.5}$ PurpleAir sensors.[40]

Figure 5. PurpleAir Low-Cost Air Sensor Map for the District of Columbia

Daily $PM_{2.5}$ AQI Data



Source: CRS, using PurpleAir, https://map.purpleair.com/1/mAQI/a1440/p604800/cC0#10.58/38.9186/-77.0803.

Notes: Map settings were set to "US EPA PM2.5 AQI," with an averaging period = "1-day", and the remaining settings were left at default values.

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[39] GAO, *Air Quality Sensors: Policy Options to Help Address Implementation Challenges*, GAO-24-106393, March 19, 2024, p. 1, https://www.gao.gov/products/gao-24-106393.

[40] *PurpleAir sensors* are light scattering particle counters for the measurements of $PM_{1.0}$, $PM_{2.5}$, and PM_{10} mass concentrations. Once connected to Wi-Fi, all of these sensors appear on the PurpleAir map, where data can be viewed and shared. For more information, see PurpleAir, "FAQ," https://community.purpleair.com/c/faq/27.

Low-Cost Air Sensor Regulatory Context

EPA is involved in the advancement of low-cost air sensor technology, including performance evaluations of sensor devices and best practices for effective use. EPA evaluated low-cost sensors for how well they measured air pollutants and how easy they were to use. Placing the sensors near a regulatory monitor, EPA collected data on air quality with both technologies. By assessing the data collected under the same air quality and weather conditions, EPA compared how accurate and reliable low-cost technologies were compared to regulatory methods.[41] Based on its assessment of the accuracy of low-cost sensors, in a June 2020 EPA memorandum, EPA stated that "data from new air sensor instruments should not be used in a regulatory context at this time unless those instruments meet all applicable regulatory requirements." These requirements would include meeting EPA monitoring-related regulations.[42] In the memorandum, EPA recognized that these low-cost air sensors may not meet the requirements for use as regulatory monitors; however, it stated, these sensors "could still be very useful in non-regulatory applications."[43]

Although EPA found that these low-cost air sensors are generally less accurate than their more expensive regulatory counterparts, GAO noted that they can be deployed in large numbers to supplement information provided by the national ambient air monitoring networks.[44] Among the possible uses are identifying pollution "hot spots," providing local community-scale air monitoring, assisting in the site selection for new or relocated regulatory monitors, and conducting scientific research.[45]

EPA announced 132 community air monitoring projects to be conducted by a range of entities, including nonprofits, state and local agencies, and tribes, that would receive $53.4 million from the American Rescue Plan Act of 2021 (P.L. 117-2) and P.L. 117-169, known as the Inflation Reduction Act of 2022. The majority of the announced projects plan on using low-cost air sensors.[46] For the announced projects, quality assurance requirements apply to the collection of environmental information.[47] *Environmental information collections* are any measurements or information that describe environmental processes, locations, or conditions; ecological or health effects and consequences; or the performance of environmental technology.[48]

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[41] For more information on EPA's evaluation of low-cost air sensor technology, see EPA, "Evaluation of Emerging Air Sensor Performance," https://www.epa.gov/air-sensor-toolbox/evaluation-emerging-air-sensor-performance.

[42] Requirements related to network monitoring methods are in the appendices to 40 C.F.R. Part 50. Requirements related to monitoring reference and equivalent methods are in 40 C.F.R. Part 53, "Ambient Air Monitoring Reference and Equivalent Methods." EPA requires monitoring agencies to develop network assessments and annual monitoring network plans that include the information described in 40 C.F.R. Part 58, "Ambient Air Quality Surveillance."

[43] EPA, "Memorandum on use of air sensor data for NAAQS compliance," https://www.epa.gov/air-sensor-toolbox/memorandum-use-air-sensor-data-naaqs-compliance.

[44] GAO, *Air Quality Sensors: Policy Options to Help Address Implementation Challenges*, GAO-24-106393, March 19, 2024, p. 1-2, https://www.gao.gov/products/gao-24-106393.

[45] An example of research project, the National Park Service (NPS) is working with parks on a smoke monitoring pilot program. For more information, see NPS, "More Parks Can Now Track Air Quality During Wildfires," at https://www.nps.gov/articles/smoke-monitoring-pilot.htm.

[46] GAO, *Air Quality Sensors: Policy Options to Help Address Implementation Challenges*, GAO-24-106393, March 19, 2024, https://www.gao.gov/products/gao-24-106393.

[47] Funding recipients conducting low-cost air sensor data collection would be required to submit a Quality Assurance Project Plan (QAPP) to EPA per the requirements in 2 C.F.R. §1500.12. A QAPP is a written document that provides a blueprint for the entire project and each specific task to ensure that the project produces reliable data that can be used to meet the project's overall objectives and goals. For more information, see EPA, "Frequently Asked Questions: Quality Assurance Project Plans," https://www.epa.gov/participatory-science/frequently-asked-questions-quality-assurance-project-plans.

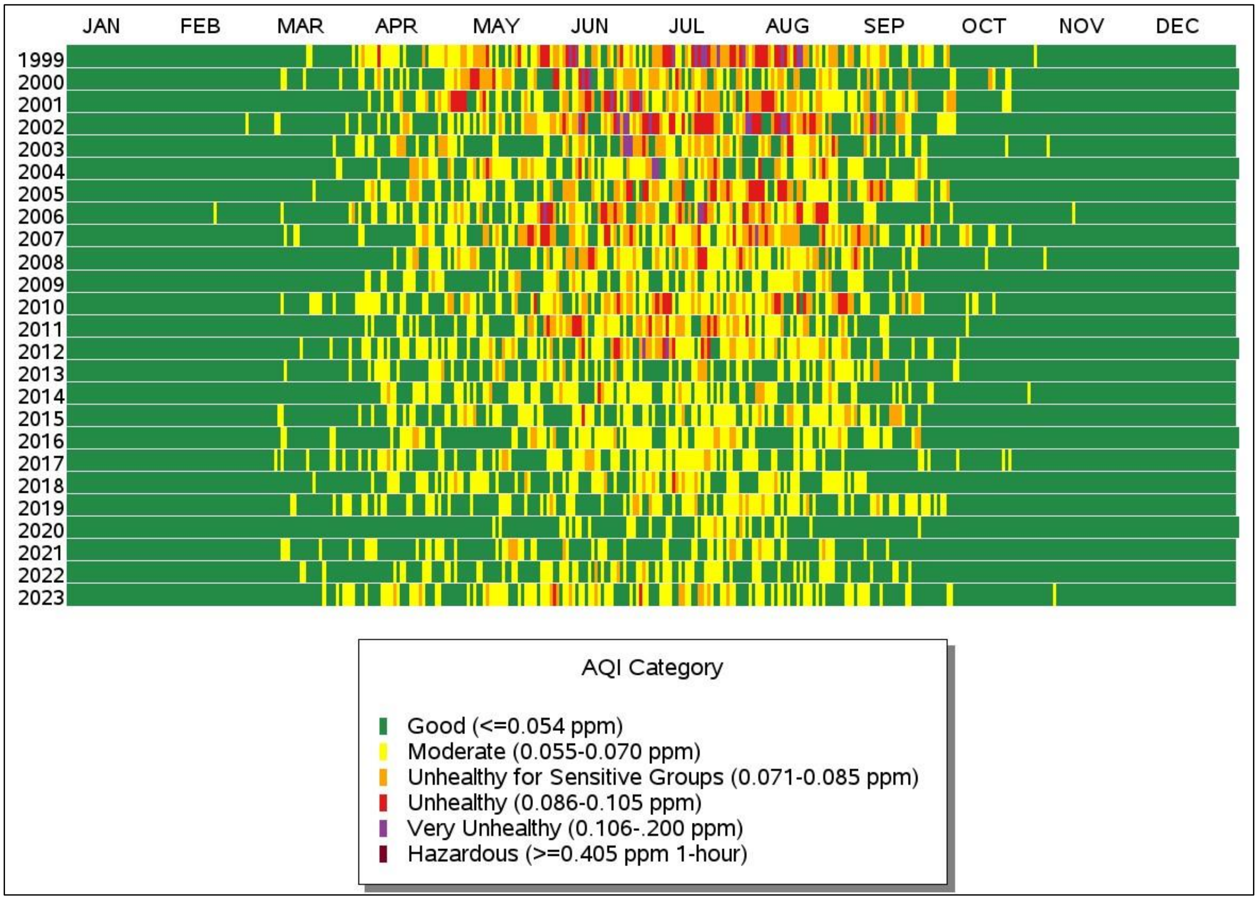
[48] For more information, see EPA, "Managing the Quality of Environmental Information: Specifications for Non-EPA Organizations," https://www.epa.gov/quality/specifications-non-epa-organizations.

Concluding Observations

Ambient air monitoring networks have provided reliable air quality data throughout the country for decades. The data are standardized and accessible through EPA's AQS and other air quality data tools. Regulators, researchers, communities, and others have relied on the network to provide the data needed for studies, source permitting, NAAQS attainment and implementation, air quality alerts, and a host of other applications.[49] **Figure 6** is an example of one of the visualization tools EPA provides. The figure illustrates the daily AQI in the Washington, DC metro area from 1999 to 2023.

Figure 6. Daily Ozone AQI Values, 1999 to 2023

Washington-Arlington-Alexandria, DC-VA-MD-WV



Source: EPA, "Air Data—Multiyear Tile Plot," https://www.epa.gov/outdoor-air-quality-data/air-data-multiyear-tile-plot.

Note: Generated April 4, 2024.

Some observers have raised concerns about the ambient air monitoring networks. In particular, observers have noted the increasing costs to establish and maintain ambient air monitoring networks. For example, according to a 2020 report from GAO, "modern monitoring equipment technology is significantly more expensive than its predecessor technology." In the report, GAO found that the level of funding EPA provided for air quality management programs from 2004 to 2019 remained relatively steady. When

[49] The air quality data made available by EPA to the general public date back to the 1980s. For more information, see EPA, "Air Data: Air Quality Data Collected at Outdoor Monitors Across the US," https://www.epa.gov/outdoor-air-quality-data.

adjusted for inflation, the amount of federal funding declined by an average of $4 million per year over the same time frame.[50] According to the 2020 report:[51]

> The ambient air quality monitoring system is a national asset that provides standardized information for implementing the Clean Air Act and protecting public health. The Environmental Protection Agency (EPA) and state and local agencies cooperatively manage the system, with each playing different roles in design, operation, oversight, and funding. For example, EPA establishes minimum requirements for the system, and state and local agencies operate the monitors and report data to EPA. Officials from EPA and selected state and local agencies identified challenges related to sustaining the monitoring system. For example, they said that infrastructure is aging while annual EPA funding for state and local air quality management grants, which cover monitoring, has decreased by about 20 percent since 2004 after adjusting for inflation.

While GAO highlighted funding issues associated with regulatory monitoring, EPA noted that ambient air monitoring networks might not properly identify hot spots or community-level air pollution issues if no ambient air monitor is within the direct vicinity to properly characterize the possible air pollution issue.[52]

Considering these concerns, a question facing policymakers is what role low-cost air sensors could play in support of ambient air monitoring networks. Some state and local air agencies contend that low-cost air sensors have been successfully used to supplement regulatory monitors and fill data gaps. The low-cost sensors help decisionmakers address specific needs. For example, some air agencies have used low-cost air sensors to help direct limited enforcement resources.[53] This nonregulatory use of low-cost air sensors may help an air agency ensure it is achieving the maximum emission reductions through its regulatory enforcement actions, saving it time and money. The emission reductions achieved may also be pivotal in maintaining a lower NAAQS design value and maintaining or achieving the attainment of NAAQS.

[50] The report identified a low of $190 million in 2007 and a high of approximately $230 million in 2011 and 2012. GAO, *Air Pollution: Opportunities to Better Sustain and Modernize the National Air Quality Monitoring System*, GAO-21-38, December 7, 2020, p.26, https://www.gao.gov/products/gao-21-38.

[51] GAO, *Air Pollution: Opportunities to Better Sustain and Modernize the National Air Quality Monitoring System*, GAO-21-38, December 7, 2020, https://www.gao.gov/products/gao-21-38.

[52] According to EPA, low-cost air sensors could "be very useful in nonregulatory applications such as providing a better understanding of local air quality, helping in the siting of regulatory monitors, or identifying hot spots." For more information, see EPA, "Memorandum on use of air sensor data for NAAQS compliance," https://www.epa.gov/air-sensor-toolbox/memorandum-use-air-sensor-data-naaqs-compliance.

[53] For example, the Maryland Department of the Environment (MDE) developed a targeted inspection initiative in Cheverly, MD, where it deployed 22 low-cost air sensors. For more information, see MDE, "Cheverly Targeted Inspection Initiative," https://mde.maryland.gov/programs/Air/AirQualityCompliance/Pages/CheverlyTargetedInspectionInitiative.aspx.

In addition to their support of compliance programs, low-cost sensors have been used in nonregulatory contexts. For example, federal agencies have deployed low-cost air sensors to monitor smoke during wildfires and communicate possible risks to stakeholders.[54] In addition, some agencies make low-cost air sensors available for deployment to wildland fire locations upon request of firefighting agencies. These low-cost air sensors can help inform firefighting agency decisions on allocating resources.[55] Low-cost air sensors have been particularly useful for monitoring wildfire smoke in areas without regulatory monitors.

Agencies and stakeholders may need to consider the proper siting, use, and understanding of the data obtained from low-cost air sensors deployed for wildfire smoke initiatives. Furthermore, during a wildfire event, the readiness and availability of low-cost air sensors to be deployed during an emergency is a key feature of the technology, but a sensor's data may be questionable if the device was not previously calibrated with a regulatory monitor.

According to state and local air agencies, one of the challenges with low-cost sensors regards communication with community members to address the limitations and nonregulatory aspects of low-cost air sensors.[56] This raises questions about how low-cost air sensors and their air quality data are perceived and used by the public.

I thank the committee for its time. I am available to answer any questions you may have about these technologies and their implementation. CRS can assist with any additional research and analysis regarding this issue.

[54] The National Wildfire Coordinating Group (NWCG) defines *wildland fire* as any nonstructured fire that occurs in vegetation or natural fuels, including prescribed fire and wildfire. NWCG defines *wildfire* as a wildland fire originating from an unplanned ignition, including unauthorized human-caused fires, escaped prescribed fire projects, and all other wildland fires where the objective is to put out the fire. See NWCG, "Glossary of Wildland Fire Terminology," https://www.nwcg.gov/glossary/a-z.

[55] Interagency Wildland Fire Air Quality Response Program (IWFAQRP) was founded by the U.S. Department of Agriculture (USDA) Forest Service delivers information to people in areas affected by wildland fire smoke. For more information, see USDA Forest Service, "A Continued Success: The U.S. Interagency Wildland Fire Air Quality Response Program," https://www.fs.usda.gov/research/news/highlights/continued-success-u.s.-interagency-wildland-fire-air-quality-response-program#partnerships. For further information on IWFAQRP smoke monitoring program, see IWFAQRP, "Smoke Monitoring," https://www.wildlandfiresmoke.net/home/smoke-monitoring. Additionally, EPA, with five other federal agencies, established a wildfire sensor challenge. For more information and a list of winning sensors, see EPA, "Winners of the Wildland Fire Sensors Challenge Develop Air Monitoring System Prototypes," https://www.epa.gov/air-research/winners-wildland-fire-sensors-challenge-develop-air-monitoring-system-prototypes#about.

[56] EPA says it recognizes the need for context and guidance related to the interpretation of real-time, nonregulatory sensor data and that the agency will likely be asked to use or respond to streams of nonregulatory data. For more information, see EPA, "Memorandum on use of air sensor data for NAAQS compliance," https://www.epa.gov/air-sensor-toolbox/memorandum-use-air-sensor-data-naaqs-compliance.

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