2017 AIR QUALITY TRENDS REPORT

December 2017

NORTHEAST OHIO AREAWIDE COORDINATING AGENCY

NOACA: Planning For Greater Cleveland

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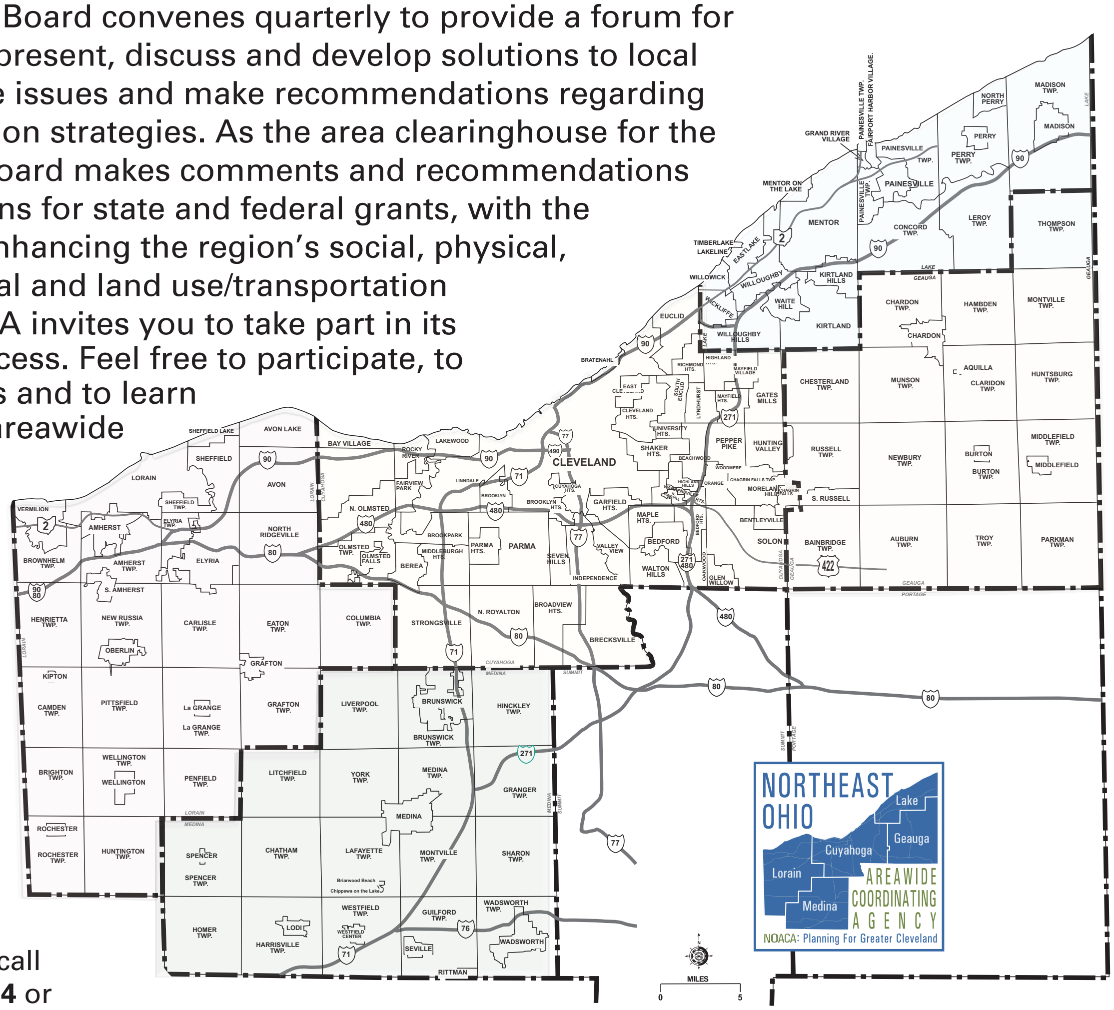
The Northeast Ohio Areawide Coordinating Agency (NOACA) is a public organization serving the counties of and municipalities and townships within Cuyahoga, Geauga, Lake, Lorain and Medina (covering an area with 2.1 million people). NOACA is the agency designated or recognized to perform the following functions:

- Serve as the Metropolitan Planning Organization (MPO), with responsibility for comprehensive, cooperative and continuous planning for highways, public transit, and bikeways, as defined in the current transportation law.
- Perform continuous water quality, transportation-related air quality and other environmental planning functions.
- Administer the area clearinghouse function, which includes providing local government with the opportunity to review a wide variety of local or state applications for federal funds.
- Conduct transportation and environmental planning and related demographic, economic and land use research.
- Serve as an information center for transportation and environmental and related planning.
- As directed by the Board, provide transportation and environmental planning assistance to the 172 units of local, general purpose government.

NOACA's Board of Directors is composed of 45 local public officials. The Board convenes quarterly to provide a forum for members to present, discuss and develop solutions to local and areawide issues and make recommendations regarding implementation strategies. As the area clearinghouse for the region, the Board makes comments and recommendations on applications for state and federal grants, with the purpose of enhancing the region's social, physical, environmental and land use/transportation fabric. NOACA invites you to take part in its planning process. Feel free to participate, to ask questions and to learn more about areawide planning.



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Air Quality Trends and Attainment Status for Northeast Ohio

2016 Update

December 2017

NORTHEAST OHIO
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ABSTRACT

This report presents information on air quality trends in Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit counties for the six criteria pollutants: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide. These are the pollutants for which the Clean Air Act requires the United States Environmental Protection Agency (U.S. EPA) to establish National Ambient Air Quality Standards (NAAQS). The NAAQS are the maximum allowable ambient concentrations for each pollutant. The primary NAAQS are intended to protect people by preventing adverse health impacts from excessive pollution concentrations. The report also includes chapters on the link between transportation and air quality, as well as on climate change and greenhouse gas (GHG) emissions. Data are generally reported under some form of nonattainment classification for the pollutant under discussion. The nonattainment areas and the associated U.S. EPA Attainment Dates are also discussed with updates through 2016, as of the time of printing this report.

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In 1970, the United States Congress passed its first round of amendments to the federal Clean Air Act (CAA), which led the U.S. Environmental Protection Agency (U.S. EPA) to create and enforce federal limits for six so-called criteria air pollutants—ozone, particulate matter (coarse and fine), carbon monoxide, sulfur dioxide, lead, and nitrogen dioxide. These limits, known as the National Ambient Air Quality Standards (NAAQS), protect human health and public welfare.

This document summarizes the most current data on air quality in eight counties in Northeast Ohio (Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit), which constitute the NOACA air quality planning area. As the report demonstrates, while air quality has generally improved throughout the region, portions of Northeast Ohio remain in nonattainment for two of the six NAAQS. Additionally, this report examines the links between transportation and air quality (Chapter 3), as well as greenhouse gas emissions and climate change (Chapter 6).

NAAQS Attainment Status Summary:

1. **Ozone (Section 5.1):** On January 6, 2017 (82 FR 1603), U.S. EPA re-designated all eight counties in Northeast Ohio as a maintenance area for the 2008 8-hour ozone NAAQS of 75 parts per billion (ppb). U.S. EPA revised this standard to 70 ppb on October 26, 2015.

2. **Particulate Matter (Section 5.2):** Cuyahoga County was re-designated as a maintenance area for PM_{10} on January 10, 2001. In January 2013, U.S. EPA strengthened the annual $PM_{2.5}$ NAAQS to 12 micrograms per cubic meter ($\mu g/m^3$). Accordingly, both Cuyahoga and Lorain counties were designated as nonattainment areas effective April 15, 2015.

3. **Carbon Monoxide (Section 5.3):** Cuyahoga County remains in maintenance status for the 1971 carbon monoxide NAAQS, while all other counties are in attainment.

4. **Sulfur Dioxide (Section 5.4):** On August 5, 2013, U.S. EPA designated Lake County as a nonattainment area for the 2010 1-hour sulfur dioxide NAAQS of 75 ppb.

5. **Lead (Section 5.5):** On May 31, 2017 (82 FR 24871), U.S. EPA re-designated a portion of Cuyahoga County as a maintenance area for the 2008 lead NAAQS of 0.15 $\mu g/m^3$.

6. **Nitrogen Dioxide (Section 5.6):** All counties in Northeast Ohio are in unclassifiable/attainment for the 2010 1-hour nitrogen dioxide NAAQS of 100 ppb.

Air Quality Trends: Northeast Ohio's historic reliance on manufacturing, heavy industry, coal-fired electricity generation, and single-occupancy vehicles has contributed to the region's legacy air pollution. Air quality has improved significantly in Northeast Ohio in recent years (see Chapter 4); however, as U.S. EPA continues to strengthen the NAAQS to protect public and environmental health, portions of the region remain in nonattainment for one or more of the NAAQS.

Despite Northeast Ohio's reliance on heavy industry and coal-fired electricity generation, transportation is the primary driver of the region's air quality issues. On-road vehicles continue to generate a plurality of emissions of criteria pollutants. Additionally, two of the pollutants most closely linked to mobile emissions—ozone (O_3) and fine particulate matter ($PM_{2.5}$)—have declined by a smaller margin than the other criteria pollutants. Accordingly, transportation infrastructure and mode choice remain intricately linked to regional air quality.

1. Introduction

In 1970, the United States Congress passed its first round of amendments to the existing federal Clean Air Act (CAA), significantly reforming the way that the United States regulates air quality and pollution. The CAA (40 C.F.R. § 50), which was last amended in 1990, requires the U.S. EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. The CAA identifies two types of national ambient air quality standards. Primary standards protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards protect public welfare against decreased visibility and damage to animals, crops, vegetation, and buildings.

Table 1: Summary of National Ambient Air Quality Standards (2016)

Pollutant (final rule cite)		Primary or Secondary Standard	Averaging Time	Level	Form
Carbon Monoxide (76 FR 54294, August 31, 2011)		Primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead (73 FR 66964, November 12, 2008)		Primary & Secondary	Rolling 3-month average	0.15 $\mu g/m^3$	Not to be exceeded
Nitrogen Dioxide (75 FR 6474, February 9, 2010) (61 FR 52852, October 8, 1996)		Primary	1-hour	100 ppb	98^{th} percentile, average over three years
		Primary & Secondary	Annual	53 ppb	Annual mean
Ozone (80 FR 65291, October 27, 2015)		Primary & Secondary	8-hour	70 ppb	Annual fourth-highest daily maximum 8-hour concentration, averaged over three years
Particle Pollution (78 FR 3085, January 13, 2013)	$PM_{2.5}$	Primary	Annual	12 $\mu g/m^3$	Annual mean, averaged over three years
		Secondary	Annual	15 $\mu g/m^3$	Annual mean, averaged over three years
		Primary & Secondary	24-hour	35 $\mu g/m^3$	98^{th} percentile, averaged over three years
	PM_{10}	Primary & Secondary	24-hour	150 $\mu g/m^3$	Not to be exceeded more than once per year, on average over three years
Sulfur Dioxide (75 FR 35520, June 22, 2010) (38 FR 25678, September 14, 1973)		Primary	1-hour	75 ppb	99^{th} percentile of 1-hour daily maximum concentrations, averaged over three years
		Secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

Source: U.S. EPA, www.epa.gov/air/criteria.html (accessed June 1, 2017).

In response to the legislation, U.S. EPA has created NAAQS for six principal pollutants, known as the criteria air pollutants. EPA uses this term, because the NAAQS for each pollutant are based on human and environmental health criteria. The current NAAQS are listed in Table 1 above. Units of measure are parts per million (ppm) and parts per billion (ppb) by volume and micrograms per cubic meter of air ($\mu g/m^3$).

Under the CAA, EPA must periodically revisit these standards. Section 109(d)(1) of the law states that, effective December 31, 1980, the agency is required to complete a thorough review of each NAAQS every five years; if appropriate, EPA must revise the standards to protect public health and the environment.[1] The CAA also called for the creation of an independent scientific review panel—the Clean Air Scientific Advisory Committee (CASAC)—to complete this review and advise the EPA Administrator.[2] Once EPA, in concert with CASAC and other stakeholder groups, completes its scientific review for a given NAAQS, the agency undertakes a rulemaking process, ultimately setting a new standard for the pollutant. The CAA stipulates that EPA must set standards that "allowing an adequate margin of safety, are requisite to protect the public health."[3] EPA most recently completed this process when it strengthened the existing NAAQS for ground-level ozone (O_3) to 70 ppb from 75 ppb on October 26, 2015 (80 FR 65291).

Within two years of the promulgation of a new NAAQS, EPA must determine whether regions comply with the standard. Taking input from states and tribes, EPA designates whether areas meet the standard (attainment areas) or do not meet the standard (nonattainment areas). EPA typically bases its final area designations on the following five factors:[4]

1. Air quality data
2. Emissions and emissions-related data
3. Meteorology
4. Geography/Topography
5. Jurisdictional Boundaries

Within 18 to 36 months, states must submit State Implementation Plans (SIPs) for all nonattainment areas within their borders. The Ohio EPA is responsible for developing SIPs, in coordination with appropriate agencies within the nonattainment area and based upon public input. Once approved by U.S. EPA, these SIPs identify the means by which the nonattainment area will come into compliance with the NAAQS by its specific attainment date.[5] For certain pollutants, such as O_3, the attainment date may be based upon the severity of the nonattainment area's designation. These dates can range from three years for the least severe areas (Marginal) to 20 years for the most severe areas (Extreme).[6] Once a nonattainment area has attained the relevant NAAQS, U.S. EPA will re-designate it as a "Maintenance" area.[7] For all maintenance areas in Ohio, the Ohio EPA must develop a 10-year Maintenance Plan, which identifies the necessary measures to ensure that the area will remain in attainment of the NAAQS.[8]

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[1] 42 Code of Federal Regulations (C.F.R.) §7409(d)(1).
[2] Ibid., (d)(2).
[3] , Ibid., (b)(1).
[4] U.S. EPA, "Area Designations for the 2020 Annual Fine Particle ($PM_{2.5}$) Standard: Designations Guidance and Data," https://www3.epa.gov/pmdesignations/2012standards/techinfo.htm (accessed June 1, 2017).
[5] 42 C.F.R. §7502(a)(2).
[6] Ibid., §7511(a)(1).
[7] Ibid., §7407(d)(3)(E).
[8] Ibid., §7505(a).

2. National Ambient Air Quality Standards (NAAQS) Attainment Status in Northeast Ohio

This section summarizes information on air quality within the NOACA air quality planning area (Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit counties).

Table 2: Attainment Status for NAAQS in Northeast Ohio (2016)

Pollutant	Recent Trend Direction	Designated Attainment Status	Counties in Nonattainment	Major Contributing Sources
Ozone (8-hour)	Stable	Maintenance	None	Automobiles, Industry, Utilities, Solvents, Paints, Other Fossil Fueled Engines
Coarse Particulate Matter (24-hour)	Stable	Maintenance	None	Automobiles, Industry, Construction Sites, Tilled Fields, Unpaved Roads, Stone Crushing, and Wood Burning
Fine Particulate Matter (24-hour)	Decreasing	Maintenance	None	Automobiles, Industry, Construction Equipment, Ships, Trains, Road Salt, Dirt, and Burning of Wood
Fine Particulate Matter (Annual)	Decreasing	Nonattainment	Cuyahoga, Lorain	Automobiles, Industry, Construction Equipment, Ships, Trains, Road Salt, Dirt, and Burning of Wood
Carbon Monoxide (1-hour)	Stable	Maintenance	None	Automobiles, Non-Road Vehicles, Steel Mills, Other Combustion Sources
Carbon Monoxide (8-hour)	Stable	Maintenance	None	Automobiles, Non-Road Vehicles, Steel Mills, Other Combustion Sources
Sulfur Dioxide (1-hour)	Decreasing	Nonattainment	Lake	Electric Utilities and Other Industrial Combustion Sources
Nitrogen Dioxide	Decreasing	Unclassifiable/ Attainment	None	Automobiles, Electric Utilities and Other Industrial, Commercial, and Residential Combustion
Lead	Stable	Maintenance	None	Metal Processing Plants

Source: U.S. EPA, *Green Book*, https://www.epa.gov/green-book (accessed June 1, 2017).

2.1 Attainment Status Summary for Northeast Ohio

1. **Ozone (O_3):** On May 21, 2012, U.S. EPA designated Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit counties as a marginal nonattainment area for the 2008 8-hour ozone NAAQS of 75 ppb (77 *Federal Register* (FR) 30088). In May 2016, U.S. EPA approved an extension of the region's Attainment Date for the 2008 NAAQS (81 FR 26697), extending it to July 20, 2016. On January 6, 2017, U.S. EPA re-designated the region to maintenance, based upon 2013-2015 monitor data (82 FR 1603).

   On October 26, 2015, U.S. EPA strengthened the 8-hour ozone NAAQS to 70 ppb (80 FR 65291), a standard that took effect December 28, 2015. EPA has indicated that it will issue area designations for the 2015 8-hour ozone NAAQS no later than April 30, 2018.

2. **Particulate Matter:**

   - Coarse Particles (PM_{10}): Cuyahoga County was re-designated as a maintenance area for the 1987 PM_{10} NAAQS, effective January 10, 2001 (65 FR 77308).

   - Fine Particles ($PM_{2.5}$): In December 2009, U.S. EPA designated Cuyahoga, Lake, Lorain, Medina, Portage and Summit counties as nonattainment areas for the 2006 24-hour $PM_{2.5}$ NAAQS of 35 µg/m^3 (74 FR 58688). U.S. EPA re-designated Ashtabula, Cuyahoga, Lake, Lorain, Medina, Portage, and Summit counties from nonattainment to maintenance on September 18, 2013 (78 FR 57270), based on monitoring data.

     U.S. EPA strengthened the annual $PM_{2.5}$ NAAQS to 12 µg/m^3 on January 15, 2013 (79 FR 3085). Accordingly, both Cuyahoga and Lorain Counties were designated as nonattainment areas effective April 15, 2015.

3. **Carbon Monoxide (CO):** Cuyahoga County continues to be in maintenance status for CO, a designation promulgated on July 12, 1993 (58 FR 37453).

4. **Sulfur Dioxide (SO_2):** On August 5, 2013, U.S. EPA designated Lake County as a nonattainment area for the 2010 1-hour SO_2 NAAQS of 75 ppb (78 FR 47191).

5. **Lead (Pb):** On May 31, 2017 (82 FR 24871), U.S. EPA re-designated a small area in Cuyahoga County as a maintenance area for the 2008 lead NAAQS of 0.15 µg/m^3.[9]

6. **Nitrogen Dioxide (NO_2):** All counties in Northeast Ohio are in unclassifiable/attainment for the 2010 1-hour NO_2 NAAQS of 100 ppb (77 FR 9532).

[9] Please refer to page 52 of this report for a description of the lead maintenance area.

2.2 Air Quality Index (AQI)

The AQI is an index used to report daily air quality in a given region. The AQI expresses how clean or polluted a region's air is and what the associated health effects may be for a person living in that region. The AQI focuses on the potential health effects a person may experience within hours or days of breathing polluted air. The EPA calculates the AQI for five of the six criteria air pollutants: O_3, $PM_{2.5}$, CO, SO_2, and NO_2.

The AQI acts like a yardstick that illustrates air quality in a range from 0 to 500. The higher the AQI value, the higher the concentration of a pollutant in the air and the greater the potential health impacts. The 2016 AQI trends are provided in this report (see Chapter 5). The figure below shows the relationship between AQI and NAAQS.

Table 3: Air Quality Index and Corresponding NAAQS Concentrations

AQI Level	Ozone (ppb)	$PM_{2.5}$ (μg/m^3)	Carbon Monoxide (ppm)	Sulfur Dioxide (ppm)	Nitrogen Dioxide (ppm)
Good (0-50)	0-54	0-12.0	0-4.4	0.00-0.034	0- 0.053
Moderate (51-100)	55-70	12.1-35.4	4.5-9.4	0.035-0.075	0.054-0.1
Unhealthy for Sensitive Groups (101-150)	71-85	35.5-55.4	9.5-12.4	0.076-0.185	0.101- 0.36
Unhealthy (151-200)	86-105	55.5-150.4	12.5-15.4	0.186-0.304	0.361- 0.649
Very Unhealthy (201-300)	106-200	150.5-250.4	15.5-30.4	0.305-0.604	0.65-1.244
Hazardous (> 300)	> 201	> 250.5	> 30.5	> 0.604	> 1.244

Source: U.S. EPA, http://airnow.gov/index.cfm?action=aqibasics.aqi (accessed June 1, 2017).

3. Mobile Emissions and Transportation Conformity

Mobile emissions, those that stem from the transportation sector, account for a significant share of air pollution in the United States, particularly in urban areas. According to U.S. EPA, mobile sources make up the majority of emissions of carbon monoxide (CO) and nitrogen oxides (NO_x), nationwide.[10] Prior to the U.S. ban on the use of lead in gasoline, mobile sources also accounted for the vast majority of airborne lead.[11] Traffic-related air pollution (TRAP) can be particularly harmful for human health for two key reasons. First, TRAP is emitted in close proximity to where large numbers of people live. TRAP emissions also occur at a lower height, making them easier to inhale directly than emissions from smokestacks.[12] Finally, TRAP can contain certain pollutants that are particularly harmful for human health. Black carbon (BC), a species of $PM_{2.5}$ that makes up a significant share of particle pollution from vehicles, may be up to 16 times worse for human health than $PM_{2.5}$ as a whole.[13]

U.S. EPA has implemented a number of regulations to reduce mobile emissions since the passing of the CAA. These include restrictions on the amount of pollution vehicles can emit per mile, such as the Tier 3 Motor Vehicle Emissions and Fuel Standards (79 FR 23414), and guidelines for vehicle fuel economy, chiefly the corporate average fuel economy (CAFE) standards.

To ensure that federal transportation investments neither worsen air quality, nor interfere with a region's ability to attain and maintain the NAAQS, the 1977 Clean Air Act Amendments (CAAA) introduced the concept of transportation conformity. Under this provision, a region's transportation plans, programs, and projects must not create new NAAQS violations, increase the frequency or severity of existing NAAQS violations, or delay a region's attainment of the NAAQS.[14] Under existing law, metropolitan planning organizations (MPOs) such as NOACA must demonstrate their 20-year long-range transportation plans (LRTPs) and three-year transportation improvement programs (TIPs) conform to the NAAQS. This process is known as a conformity determination.[15]

When developing SIPs, MPOs work in coordination with state officials to create a motor vehicle emissions budget (MVEB) that details the portion of total allowable emissions allocated to on-road mobile sources, such as cars, trucks, and buses. MVEBs define the total level of on-road emissions that an area can generate while still meeting the goals laid out in the SIP.[16] Through its conformity demonstration, NOACA must prove that projected on-road mobile emissions within the region will not exceed the MVEB contained in the SIP.

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[10] U.S. EPA, "Air Pollutant Emissions Trends Data," https://www.epa.gov/sites/production/files/2015-07/national_tier1_caps.xlsx (accessed June 1, 2017).

[11] U.S. EPA, "Basic Information about Lead Air Pollution," https://www.epa.gov/lead-air-pollution/basic-information-about-lead-air-pollution#how (accessed June 1, 2017).

[12] Transport & Environment, *Don't Breathe Here: Beware the Invisible Killer* (London: Transport & Environment, 2015), https://www.transportenvironment.org/sites/te/files/publications/Dont_Breathe_Here_exec_summary_FINAL.pdf (accessed June 1, 2017).

[13] World Health Organization (WHO), *Reducing global health risks through mitigation of short-lived climate pollutants* (Geneva: WHO, 2015), http://www.who.int/phe/publications/climate-reducing-health-risks/en/ (accessed June 1, 2017).

[14] 42 C.F.R. §7506 (c)(2).

[15] Federal Highway Administration (FHWA), *Transportation Conformity: A Basic Guide for State and Local Officials* (Washington, D.C.: FHWA, 2010), https://www.fhwa.dot.gov/environment/air_quality/conformity/guide/ (accessed June 1, 2017).

[16] Ibid.

If a region fails to meet this requirement, it may be classified as “in a conformity lapse.” If a region fails to address a conformity lapse, the Federal Highway Administration (FHWA) may impose restrictions on the area. These restrictions can include the freezing of federal transportation funding, in the most extreme cases. To date, NOACA has never experienced a conformity lapse. Both NOACA’s current LRTP, *Aim Forward 2040*, and its current TIP, which covers state fiscal years (SFY) 2018-2021, conform to the requirements laid out in the region’s SIPs.[17]

[17] NOACA, *Aim Forward 2040* (Cleveland: NOACA, 2017), http://www.noaca.org/modules/showdocument.aspx?documentid=39 (accessed June 1, 2017). NOACA, *Transportation Improvement Program SFY 2018 – 2021: Highway, Transportation Alternatives and Transit Elements* (Cleveland, NOACA: 2017), http://www.noaca.org/modules/showdocument.aspx?documentid=8046 (accessed June 1, 2017).

4. Air Quality and Public Health

As noted earlier, the CAA requires EPA to set NAAQS that "are requisite to protect the public health." This statement alludes to the substantial public health burden that air pollution poses. Air pollution is connected to a host of health issues, including respiratory illnesses (e.g., asthma, bronchitis, and emphysema); pre- and neonatal health risks, including low birthweight, premature birth, and infant mortality; stroke; heart disease, including heart attacks; behavioral conditions, such as attention deficit hyperactivity disorder (ADHD); cognitive issues, including IQ decrements and dementia; lung cancer; and premature death.[18] According to the World Health Organization (WHO), ambient air pollution is responsible for 3.7 million deaths, worldwide, each year.[19] While the majority of these premature deaths occur in the developing world, the U.S. continues to bear a major health burden from air pollution. Scientists calculate that, as of 2005, air pollution accounted for approximately 200,000 premature deaths per year in the U.S., though estimates have ranged from 130,000 to 340,000.[20] In the Cleveland metropolitan area, ambient concentrations of O_3 and $PM_{2.5}$ were responsible for an estimated 1,363 premature deaths in 2005.[21] Of these, 384 (28.2%) were attributable to on-road vehicles.

Since its passage in 1970, the CAA has significantly enhanced air quality in the U.S. From 1980-2004, ambient concentrations of the six criteria air pollutants declined by 63% nationwide, even as the economy grew by 147% and vehicle miles traveled (VMT) nearly doubled.[22] In 2012, U.S. EPA has published a detailed report tracing improvements in air quality for each of the criteria air pollutants during this period.[23] It provides valuable context on broader, national patterns in air quality, along with regional breakdowns. Table 4, below, illustrates the change, over time, for each of the criteria pollutants.

[18] For further information on the public health effects of air pollution, consult the U.S. EPA's *Integrated Science Assessments* on the criteria air pollutants at https://www.epa.gov/isa (accessed June 1, 2017).
[19] WHO, *Preventing disease through healthy environments: a global assessment of the burden of disease from environmental risks* (Geneva: WHO, 2016), http://apps.who.int/iris/bitstream/10665/204585/1/9789241565196_eng.pdf?ua=1 (accessed June 1, 2017).
[20] F. Caiazzo, A. Ashok, I.A. Waitz, S.H. Yim, and S.R. Barrett, "Air pollution and early deaths in the United States. Part I: Quantifying the impact of major sectors in 2005," *Atmospheric Environment*, 79 (2013), 198-208. N. Fann,A.D. Lamson, S.C. Anenberg, K. Wesson, D. Risley, and B.J. Hubbell, "Estimating the National Public Health Burden Associated with Exposure to Ambient $PM_{2.5}$ and Ozone," *Risk Analysis* 32, no. 1 (2013), 81-95.
[21] Caiazzo, et al., 204.
[22] U.S. EPA, "Air Quality Trends," https://www3.epa.gov/airtrends/aqtrends.html (accessed June 1, 2017).
[23] U.S. EPA Office of Air Quality Planning and Standards, *Our Nation's Air—Status and Trends Through 2010* (Research Triangle Park, NC: U.S. EPA, 2012), http://www.epa.gov/airtrends/2011/report/fullreport.pdf (accessed June 1, 2017).

Table 4: Change in Criteria Air Pollutant Concentrations for USA (1980-2010)

Pollutant Type	1980-2010	1990-2010	2000-2010
Carbon Monoxide (CO)	-84%	-73%	-54%
Ozone (O_3) (8-hour)	-33%	-17%	-11%
Lead (Pb)	-92%	-83%	-62%
Nitrogen Dioxide (NO_2) (annual)	-60%	-45%	-38%
Nitrogen Dioxide (NO_2) (1-hour)	-58%	-46%	-29%
PM_{10} (24-hour)	n/a[a]	-38%	-29%
$PM_{2.5}$ (annual)	n/a[a]	n/a[a]	-27%
$PM_{2.5}$ (24-hour)	n/a[a]	n/a[a]	-29%
Sulfur Dioxide (SO_2) (1-hour)	-81%	-68%	-48%

[a]Not available for this pollutant during this timeframe.
Source: U.S. EPA, *Our Nation's Air—Status and Trends Through 2010*, http://www.epa.gov/airtrends/2011/ (accessed June 1, 2017).

This decline in pollutant concentrations has also reduced the associated health burden of air pollution. In 1997, U.S. EPA concluded that, from 1970 to1990, the CAA prevented approximately 205,000 premature deaths and generated $22.2 trillion in economic benefits.[24] In a follow-up study that examined the effects of the 1990 CAAA, U.S. EPA concluded that this legislation prevented an additional 160,000 premature deaths from 1990 to 2010, a number that the agency expects to grow to 230,000 by 2020.[25]

Table 5 charts the change in concentrations of the criteria air pollutants from 1990-2010 in the Cleveland, Columbus, and Cincinnati metropolitan areas. Air quality has improved dramatically in Ohio over the past few decades. Northeast Ohio has directly benefited from these changes. One recent analysis found that, since 1970, air quality improvements associated with the CAA have extended the average life expectancy of people within the region by 2.3 years.[26] More recent reductions in pollution concentrations have also improved public health. According to a 2013 study, changes in O_3 and $PM_{2.5}$ levels from 2000 to 2007 have reduced premature mortality throughout the NOACA air quality planning area. In Cuyahoga County, for instance, better air quality prevented roughly 300 premature deaths per year during this period.[27]

[24] U.S. EPA, *The Benefits and Costs of the Clean Air Act, 1970 to 1990—Retrospective Study* (Washington, D.C.: U.S. EPA, 1997), https://www.epa.gov/sites/production/files/2015-06/documents/contsetc.pdf (accessed June 1, 2017).
[25] U.S. EPA, *Benefits and Costs of the Clean Air Act 1990-2020, the Second Prospective Study* (Washington, D.C.: U.S. EPA, 2011), https://www.epa.gov/clean-air-act-overview/benefits-and-costs-clean-air-act-1990-2020-second-prospective-study (accessed June 1, 2017).
[26] M. Greenstone, "The Connection Between Cleaner Air and Longer Lives," *The New York Times*, http://www.nytimes.com/2015/09/25/upshot/the-connection-between-cleaner-air-and-longer-lives.html?_r=1 (accessed June 1, 2017).
[27] N. Fann, and D. Risely, "The public health context for $PM_{2.5}$ and ozone air quality trends," *Air Quality, Atmosphere & Health* 6, no. 1 (2013), 1-11.

Table 5: Change in Criteria Air Pollutant Concentrations for Ohio Metropolitan Areas[28]

Pollutant Type	Metropolitan Area[a]	1990-2010	2000-2010
Carbon Monoxide (CO)	Cleveland-Akron	-62%	-49%
	Columbus	-65%	-39%
	Cincinnati	-75%	-63%
Ozone (O_3) (8-hour)	Cleveland-Akron	-13%	-5%
	Columbus	-13%	-16%
	Cincinnati	-18%	-7%
Nitrogen Dioxide (NO_2) (1-hour)[b]	Cleveland-Akron	-33%	-5%
	Cincinnati	-28%	-11%
PM_{10} (24-hour)	Cleveland-Akron	-30%	-24%
	Columbus	-38%	-85%
	Cincinnati	-42%	-13%
$PM_{2.5}$ (annual)	Cleveland-Akron	n/a[c]	-29%
	Columbus	n/a[c]	-29%
	Cincinnati	n/a[c]	-21%
Sulfur Dioxide (SO_2) (1-hour)[b]	Cleveland-Akron	-72%	-53%
	Cincinnati	-53%	-34%

[a]The metropolitan areas in this table are defined by the parameters of their three respective metropolitan planning organizations: NOACA (Cleveland-Akron), Mid-Ohio Regional Planning Commission (Columbus), and the Ohio-Kentucky-Indiana Regional Council of Governments (Cincinnati).
[b]Not available for the Columbus metropolitan area for this pollutant.
[c]Not available for this pollutant during this timeframe.

Source: U.S. EPA, "Air Trends," http://www.epa.gov/airtrends/index.html (accessed June 1, 2017).

[28] This table includes data only from air monitoring stations for which there has been consistent monitoring for the respective pollutants by the U.S. EPA throughout the timeframes listed (1990-2010 and/or 2000-2010).

5. Trends for the Six Criteria Air Pollutants in Northeast Ohio

This chapter details the trends for each of the six criteria air pollutants in Northeast Ohio. It includes information on the properties of the pollutants, their effects on public health, their formation, and their major sources within the region. This section also provides further detail on the region's attainment status for each pollutant, as well as information on the air quality monitoring network operating within Northeast Ohio. Data on Tier 1 emissions sources and quantities are from U.S. EPA's *2014 National Emissions Inventory*, the most recent year for which data are available.

As noted in Chapter 4, air quality has improved dramatically within the NOACA air quality planning region over the past four decades; however, because the U.S. EPA has continued to strengthen several of the NAAQS to reflect new scientific evidence on the impacts of air pollution, portions of the eight-county area remain in nonattainment for two of the six NAAQS. Transportation is the primary driver of the region's air quality issues, with on-road vehicles representing a plurality of total criteria pollutant emissions. Two of the pollutants for which the region is, or was recently, in nonattainment—O_3 and $PM_{2.5}$—are closely linked to mobile emissions. Ambient levels of these pollutants have fallen by a smaller margin than the other pollutants of concern, as documented in Table 5. Accordingly, transportation infrastructure and modal choice will continue to be intricately linked to the quality of the region's air in the coming years. Given the importance of O_3 and $PM_{2.5}$ to air quality in Northeast Ohio, the first two sections of this chapter focus on these two pollutants. The discussion then shifts to the other NAAQS for which a portion of the region is in nonattainment—SO_2. The final three sections examine CO, Pb, and NO_2.

5.1 Ground-Level Ozone (O_3)

5.1.1 Properties

Ground-level, or tropospheric, ozone (O_3) is formed when ultraviolet radiation in the atmosphere splits nitrogen oxide (NO_x) into nitric oxide (NO) and an oxygen atom (O). This oxygen atom is then able to join with other oxygen molecules (O_2) to form O_3. Volatile organic compounds (VOCs) play an important role in this process, as they help facilitate the continual production of O_3 in the atmosphere.[29] Accordingly, NO_x and VOCs are called O_3 precursors. Motor vehicle exhaust, industrial emissions, and chemical solvents are the major anthropogenic sources of these chemicals. Although these precursors often originate in urban areas, winds can carry these precursor chemicals hundreds of miles. Additionally, O_3 production takes several hours, ensuring that maximum O_3 concentrations typically occur downwind from primary emissions sources. In Northeast Ohio, the prevailing winds are southwest to northeast, meaning that O_3 precursor emissions from Cuyahoga and Summit Counties often form O_3 in Lake, Geauga, and Ashtabula counties. While urban areas are typically VOC-limited (that is, O_3 production is more contingent upon the availability of VOC emissions), most rural areas are NO_x-limited.[30]

O_3 can irritate the respiratory system, causing coughing, irritation in the throat, or a burning sensation in the airways. It can reduce lung function, with feelings of chest tightness, wheezing, or shortness of breath. O_3 can aggravate asthma and trigger asthma attacks. People at greater

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[29] U.S. EPA, *Guideline on Ozone Monitoring Site Selection* (Research Triangle Park, NC: U.S. EPA, 1998).
[30] U.S. EPA, *Final Ozone NAAQS Regulatory Impact Analysis* (Research Triangle Park, NC: U.S. EPA, 2008), 2-1, http://www.epa.gov/ttnecas1/regdata/RIAs/452_R_08_003.pdf.

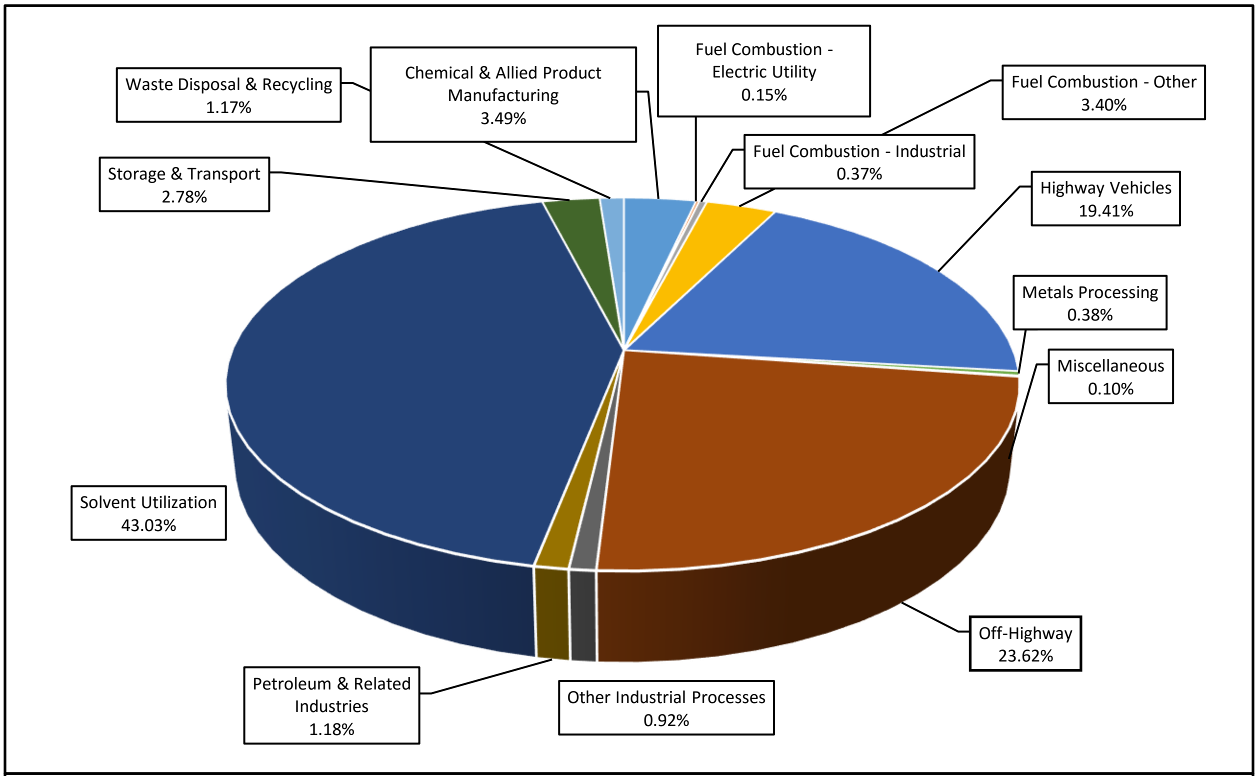
risk from ground-level O_3 are people with lung diseases, such as asthma and emphysema, and children and adults who are active outdoors.[31]

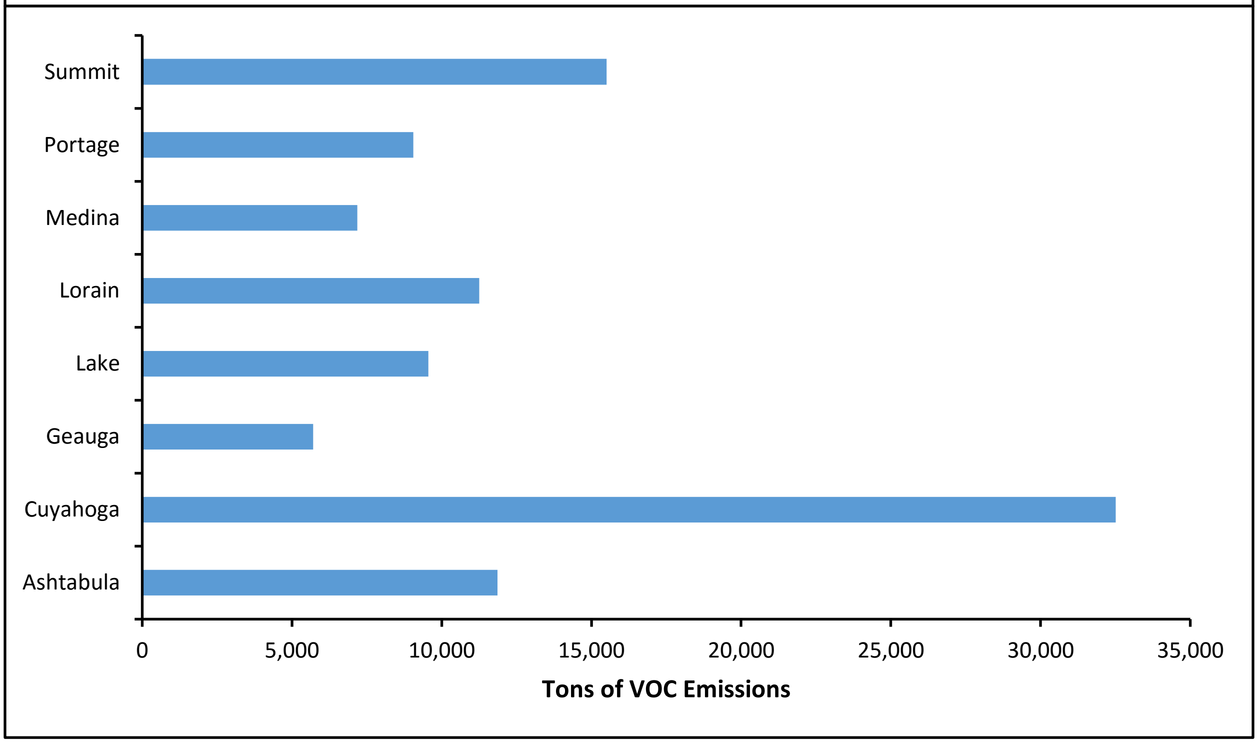
Ground-level O_3 levels are highest in cities with high levels of automobile traffic during daylight hours in the summer months. Decreases in atmospheric NO_x and VOCs generally result in decreases of O_3 formed under a given set of conditions. Because the actual ambient O_3 concentration is strongly dependent upon weather conditions (including maximum daily temperatures, cloud cover, wind speed, and wind direction), reductions in O_3 concentrations based on reductions in precursors are difficult to predict until sufficient data have been accumulated to allow for the removal of weather effects. As the O_3 NAAQS is tightened, it becomes more difficult to forecast O_3 formation.

Sources: O_3 levels can be controlled indirectly by regulating NO_x and VOC emissions. Significant sources of NO_x include cars, trucks, ships, trains, non-road equipment powered by fossil fuels, and industries such as electric utilities that combust fossil fuels. Significant sources of VOCs include gasoline-powered cars; non-road vehicles, such as aircraft, boats, lawn care equipment, and railroads; solvents, such as dry cleaning, degreasing, and surface coating; and gasoline distribution facilities. VOCs can also come from natural (biogenic) sources, including trees and other vegetation. Figure 1 breaks down the main sources of VOCs in Northeast Ohio during 2014.[32]

[31] U.S. EPA, *Smog—Who Does It Hurt?: What You Need to Know About Ozone and Your Health* (Washington, D.C.: U.S. EPA, 1999), http://epa.gov/airquality/ozonepollution/pdfs/smog.pdf.
[32] For data on the primary sources of NO_x, consult Figure 32 on page 60.

Figure 1: 2014 VOC Emissions Inventory for Northeast Ohio



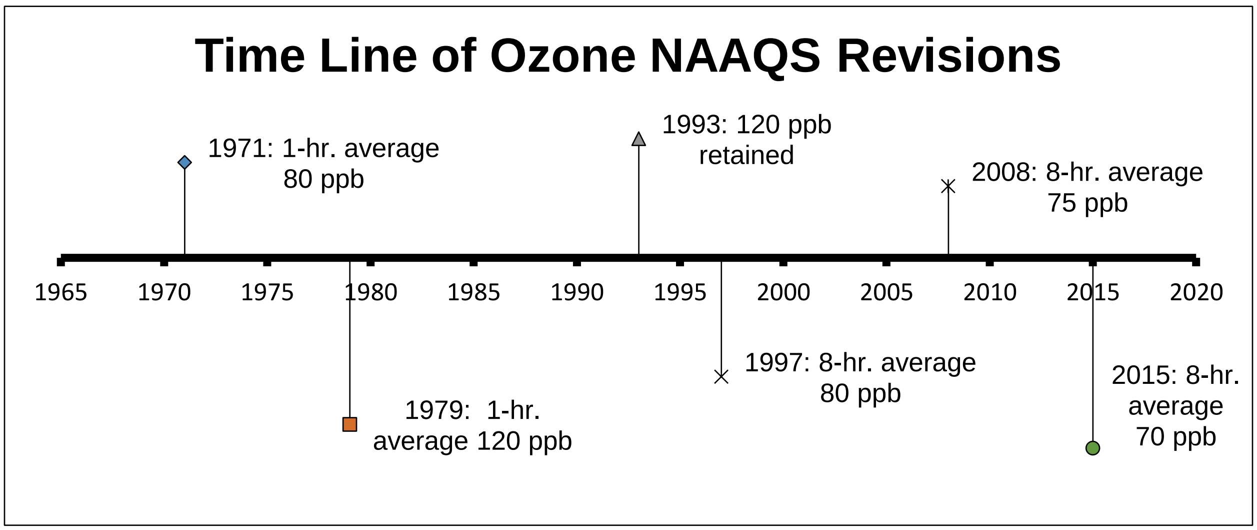


Source: U.S. EPA, *2014 National Emissions Inventory*, https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data (accessed June 1, 2017).

NAAQS and Nonattainment Status: The full timeline of Ozone NAAQS revisions is shown in Figure 2. On March 12, 2008, U.S. EPA promulgated revised 8-hour primary and secondary O_3 NAAQS (73 FR 16436). The 2008 8-hour O_3 NAAQS was 75 ppb. On April 30, 2012, U.S. EPA issued the final area designations under the 2008 standards using the certified air quality data from 2008 to 2010. U.S. EPA classified Northeast Ohio (the counties of Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, and Summit) as a marginal nonattainment area. Because O_3 is readily transported throughout a region, U.S. EPA classifies the entire regional airshed as the O_3 nonattainment area even if only one monitor in one county registers exceedance concentrations. The region's attainment date for 2008 area designations was July 20, 2015; however, U.S. EPA granted the region a one-year extension on May 4, 2016 (81 FR 26697). On January 6, 2017 (82 FR 1603), U.S. EPA formally re-designated the region to maintenance for the 2008 NAAQS, based upon 2013-2015 monitor data.

On October 26, 2015, U.S. EPA strengthened the existing O_3 NAAQS from 75 ppb to 70 ppb (80 FR 65291), a revision that took effect December 28, 2015. EPA has indicated that it will likely issue area designations for the 2015 8-hour O_3 NAAQS by April 30, 2018. These designations will be made based upon air quality data from 2014 to 2016. This revised standard of 70 ppb could place all of Northeast Ohio into nonattainment.

Figure 2: Time Line of Revisions to Ozone NAAQS, 1971-2016



Control Measures: The Ohio EPA is responsible for submitting SIPs for all regions within the state. Please visit the Ohio EPA website to review the relevant O_3 SIPs for Northeast Ohio: http://www.epa.ohio.gov/dapc/SIP/ozone.aspx.

In 2005, NOACA convened a public participation process—headed by the NOACA Air Quality Public Advisory Task Force—that generated recommendations to Ohio EPA for inclusion in the SIP for the 8-hour O_3 NAAQS. The NOACA Board of Directors modified the recommendations and submitted them to the Ohio EPA in 2006.[33] To date, Ohio EPA has acted upon more than half of the NOACA recommendations. NOACA also encourages localities to implement those recommendations that do not require a state action, such as municipal anti-idling ordinances.

[33] NOACA, *Final Report of the NOACA Air Quality Public Advisory Task Force on the 8-Hour Ozone SIP Options* (Cleveland: NOACA, 2006), http://www.noaca.org/modules/showdocument.aspx?documentid=654 (accessed June 1, 2017).

In its capacity as the air quality planning agency for Northeast Ohio, NOACA plays a role in coordinating air quality monitoring, public outreach, and control efforts. Throughout the O_3 monitoring season, which lasts 245 days (March 1 to October 31), NOACA forecasts 8-hour average O_3 concentrations throughout the region. On days when ambient O_3 levels are projected to exceed the NAAQS (currently 70 ppb), the agency issues an air quality advisory, encouraging Northeast Ohio residents, particularly those who belong to sensitive groups, to modify certain behaviors (e.g., walk, bike, or ride public transit versus drive alone) and limit their time outdoors.

Monitoring: U.S. EPA provides clear guidelines on how regions should develop their monitoring networks for O_3.[34] Northeast Ohio's O_3 monitoring network was developed to meet these requirements. There are 12 operating O_3 monitors in Northeast Ohio (Table 6 and Figure 3).

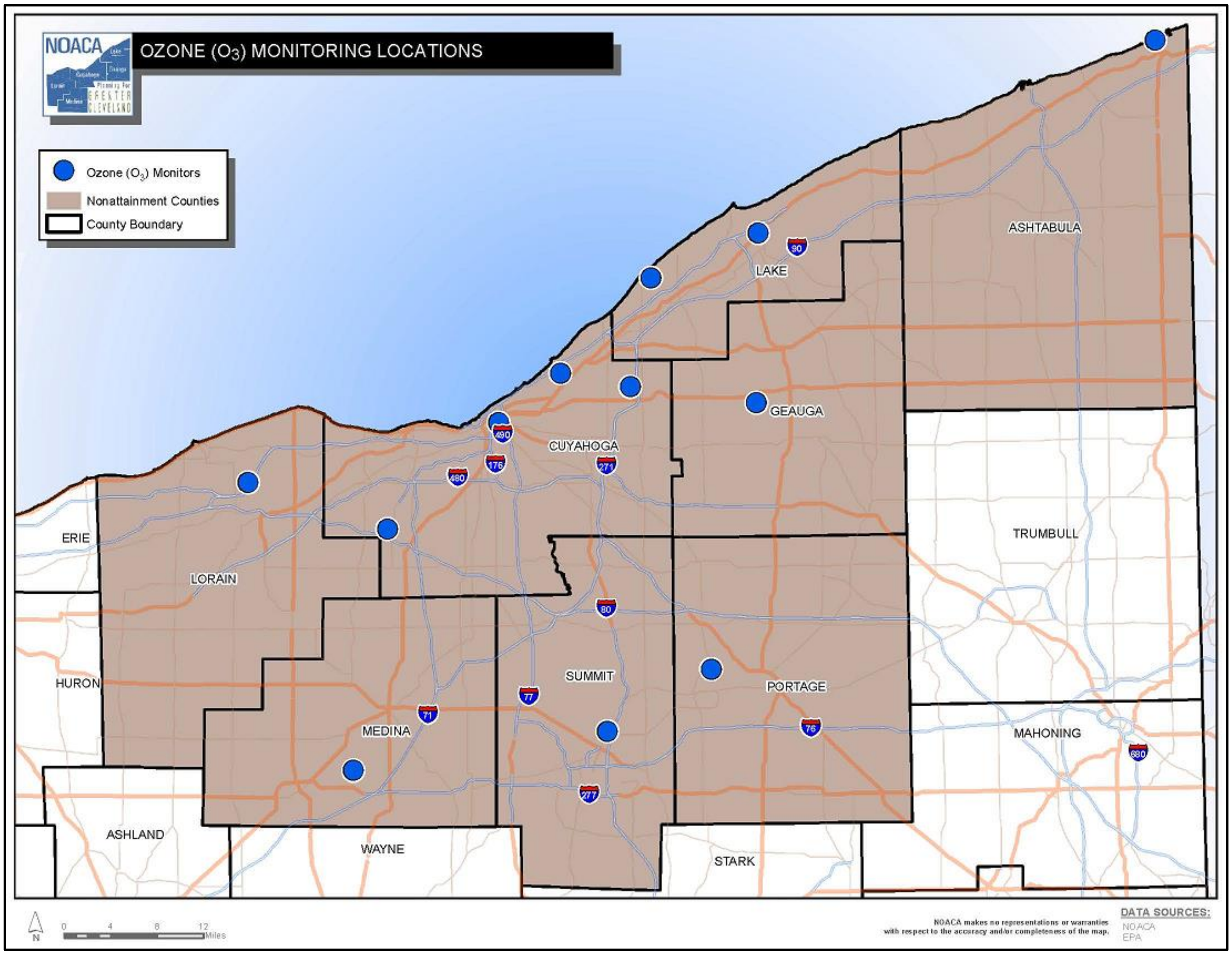
[34] U.S. EPA, *Guideline on Ozone Monitoring Site Selection*.

Table 6: Locations of Ozone Monitors in Northeast Ohio

Monitor	County	FIPS ID	Site ID	Latitude	Longitude	Address
1	Ashtabula	7	1001	41.95	-80.57	Conneaut Water Plant
2	Cuyahoga	35	0034	41.55	-81.57	891 E. 152 St.
3			0060	41.49	-81.67	GT Craig, E. 14th St. & Orange Ave., Cleveland
4			0064	41.36	-81.86	Board of Education, 390 Fair St., Berea
5			5002	41.53	-81.45	6116 Wilson Road, Mayfield
6	Geauga	55	0004	41.51	-81.24	Notre Dame School, Munson
7	Lake	85	0003	41.67	-81.42	Jefferson School, Eastlake
8			0007	41.72	-81.24	177 Main St., Painesville
9	Lorain	93	0018	41.42	-82.09	Fire Station, Sheffield
10	Medina	103	0004	41.06	-81.92	Ballash Rd., Lafayette Twp.
11	Portage	133	1001	41.18	-81.33	1570 Ravenna Rd., Kent
12	Summit	153	0020	41.10	-81.50	800 Patterson Ave., Akron

Source: Ohio EPA, *Ohio Air Monitoring Network Plan 2016-2017*, http://epa.ohio.gov/Portals/27/ams/sites/Ohio_2016-2017_AirMonNetPlan_MainRep_RevNov2016_FINAL.pdf (accessed June 1, 2017).

Figure 3: Northeast Ohio O_3 Monitor Locations



Currently, U.S. EPA oversees three pollution monitoring networks: the State and Local Air Monitoring Stations (SLAMS), the National Air Monitoring Stations (NAMS), and the Photochemical Assessment Monitoring Stations (PAMS). Each network satisfies different monitoring requirements and serves a different purpose.[35]

SLAMS monitors fulfill four roles:

- Determine the highest concentrations of a given air pollutant expected to occur in the monitored area;
- Determine the representative concentrations of that pollutant in areas of high population density;
- Determine the impact of ambient pollution levels of significant pollutant sources or source categories; and
- Determine the general background concentration levels of the pollutant.

NAMS is a broader, national monitoring network that includes a subset of SLAMS monitors in urban areas with populations of at least 200,000 people. NAMS monitoring networks must include at least two SLAMS monitors. PAMS monitors, in turn, conduct enhanced, continuous air quality monitoring in nonattainment areas.

Under current guidelines, U.S. EPA requires that O_3 monitors be placed at the following locations:

- **Maximum exposure sites:** These are areas where the greatest population is expected to be exposed to high concentrations of O_3, typically just downwind of the urbanized area.
- **Maximum downwind concentration sites:** These are the locations farther downwind of the urbanized area where O_3 concentrations are likely to be highest, accounting for the direction of the prevailing wind and the amount of time it takes O_3 to form.
- **Upwind sites:** These are sites located upwind of the air quality monitoring area, which enables officials to track background O_3 levels and pollution entering the region.
- **Maximum emissions sites:** These are sites located immediately downwind of the main sources of O_3 precursor emissions in the region, typically near the edge of the central business district.

In its 2015 revision to the O_3 NAAQS (80 FR 65291), U.S. EPA revised its rules for both the O_3 monitoring network and the O_3 monitoring season. Previously, PAMS monitors were required for those nonattainment areas designated as serious, severe, or extreme. U.S. EPA now requires that PAMS monitors be distributed across the country at 63 urban and 17 rural sites. Cleveland houses one of these monitors at the GT Craig monitoring site (see Table 6). This site will conduct continuous monitoring 365 days per year, though enhanced O_3 monitoring will occur only from June through August.

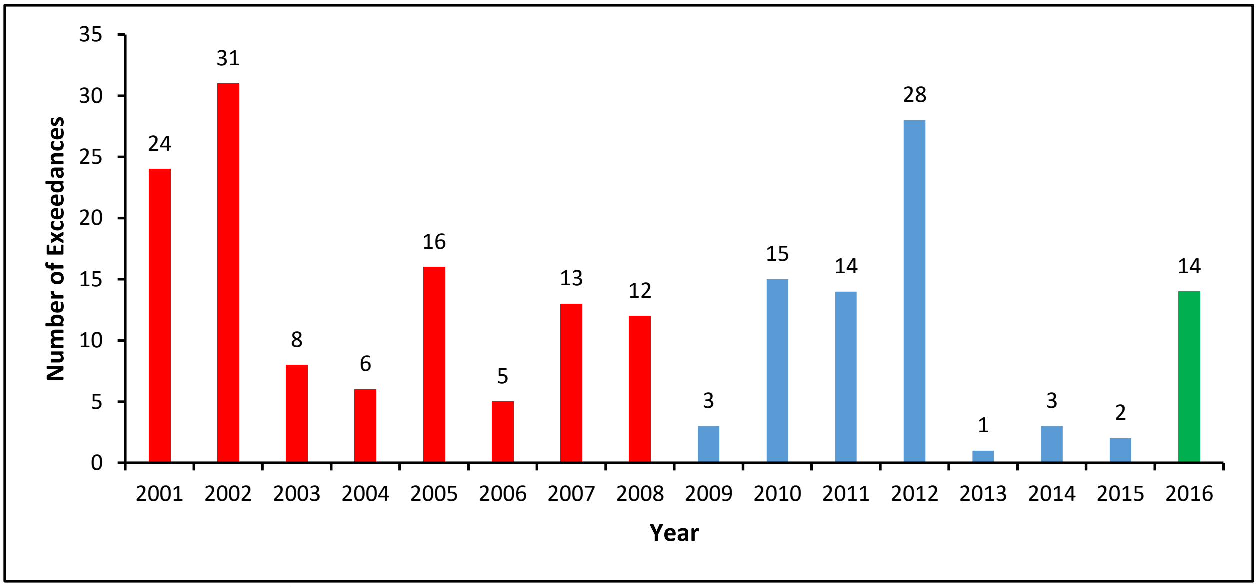
Trends: One should consider Northeast Ohio's O_3 history in light of national trends. While the region has, at one point or another, been in nonattainment for each of the historical O_3 NAAQS, it is far from the only metropolitan area that fits this description. According to U.S. EPA, there are currently 216 counties located in the 44 O_3 nonattainment areas nationwide. These counties are home to more than 120 million people.[36] Additionally, as Chapter 4 notes, while the region's O_3 levels have declined by only 13% since 1990, this change is largely in line with the national average (17% decline).

[35] Consult 40 C.F.R. §58 for additional information.
[36] U.S. EPA, "8-Hr Ozone (2008) Nonattainment Area Summary," https://www3.epa.gov/airquality/greenbook/hnsum.html (accessed June 1, 2017).

All told, as the figures below demonstrate, O_3 concentrations within Northeast Ohio continue to decline over time. This trend is expected to continue into the future, as the U.S. EPA implements new and existing regulations, such as the Cross-State Air Pollution Rule (CSAPR, 76 FR 48208), CAFE standards for light-duty vehicles and heavy-duty trucks (77 FR 62624, 80 FR 40137), and the Tier 3 Motor Vehicle Emissions and Fuel Standards (79 FR 23414).

Figure 4 displays the number of days with 8-hour O_3 exceedances from 2001-2016 in Northeast Ohio, based upon the NAAQS in place at the time. When a monitor records an ambient pollution concentration that is greater than the NAAQS, the event is classified as an exceedance. Red bars indicate the NAAQS was 85 ppb, blue bars indicate 75 ppb, and the green bar indicates the new 70 ppb standard.

Figure 4: Number of Exceedance Days for the 8-Hour Ozone NAAQS (2001-2016)[37]



Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

O_3 exceedances range widely from a low of one (1) day in 2013 to a high of 31 days in 2002. Exceedance days have generally decreased over this period, even as the NAAQS have become more stringent. While the number of exceedance days jumped noticeably in 2016, this outcome is due to the tightening of the NAAQS to 70 ppb from 75 ppb. While there were just two days with O_3 concentrations over 75 ppb in 2015, 11 days registered concentrations over 70 ppb.

Hot, dry weather usually produces more exceedance days, while cool, rainy weather typically suppresses the number of exceedances. Northeast Ohio was considerably warmer than normal during 2016. The average annual temperature was 54.2ºF, well above the long-term average of 50.7ºF, making 2016 the warmest year for the region since recordkeeping began in 1871. Six months were among the 10 warmest such months on record; this group included August, which tied for the warmest August in the Northeast Ohio history.[38] These warmer temperatures likely contributed to higher O_3 levels, as O_3 increases by roughly 2.2 ppb per degree Celsius (1.8˚F).[39]

[37] For a list of the dates when exceedance days occurred, see Appendix A: Ozone Exceedance Days.
[38] National Weather Service Cleveland, *2016: Notable Weather Events* (Cleveland: National Weather Service, 2017) http://www.weather.gov/cle/event_2016_notable_events (accessed June 1, 2017).
[39] B. Bloomer, J. Stehr, C. Piety, R. Salawitch, and R. Dickerson, "Observed relationships of ozone air pollution with temperature and emissions," *Geophysical Research Letters*, 36, no. 9 (2009), L09803.

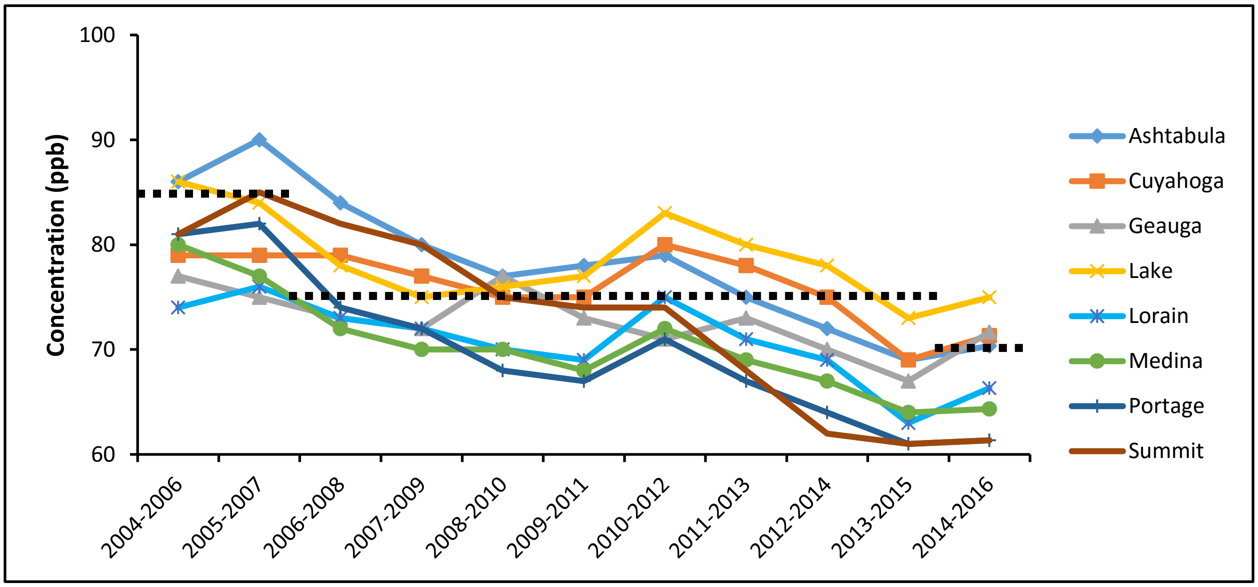
The region recorded 14 O_3 exceedance days in 2014. U.S. EPA bases its NAAQS on the three-year average of the fourth highest daily 8-hour O_3 values, which better accounts for long-term ambient O_3 levels to which people are exposed. Table 7, below, captures the three-year average O_3 concentrations for each of the eight counties in the NOACA air quality monitoring area from 2004-2006 to 2014-2016. Values that exceeded the NAAQS in effect at the time are highlighted in red. The new NAAQS took effect on January 1, 2016; accordingly, all O_3 values above 70 ppb from 2014-2016 are highlighted in red. Figure 5 displays the falling O_3 levels throughout the region during this same period. The black dashed lines denote the NAAQS in effect during each period.

Table 7: 3-Year Average 8-Hour Ozone Readings in Northeast Ohio (2004-2016)[40]

	2004 - 2006	2005 - 2007	2006 - 2008	2007 - 2009	2008 - 2010	2009 - 2011	2010 - 2012	2011 - 2013	2012 - 2014	2013 - 2015	2014 - 2016
Ashtabula	86	90	84	80	77	78	79	75	72	69	70
Cuyahoga	79	79	79	77	75	75	80	78	75	69	71
Geauga	77	75	73	72	77	73	71	73	70	67	72
Lake	86	84	78	75	76	77	83	80	78	73	75
Lorain	74	76	73	72	70	69	75	71	69	63	66
Medina	80	77	72	70	70	68	72	69	67	64	64
Portage	81	82	74	72	68	67	71	67	64	61	61
Summit	81	85	82	80	75	74	74	68	62	61	61

Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

Figure 5: Rolling 3-Year Ozone Averages for Northeast Ohio (2004-2016)[41]



Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

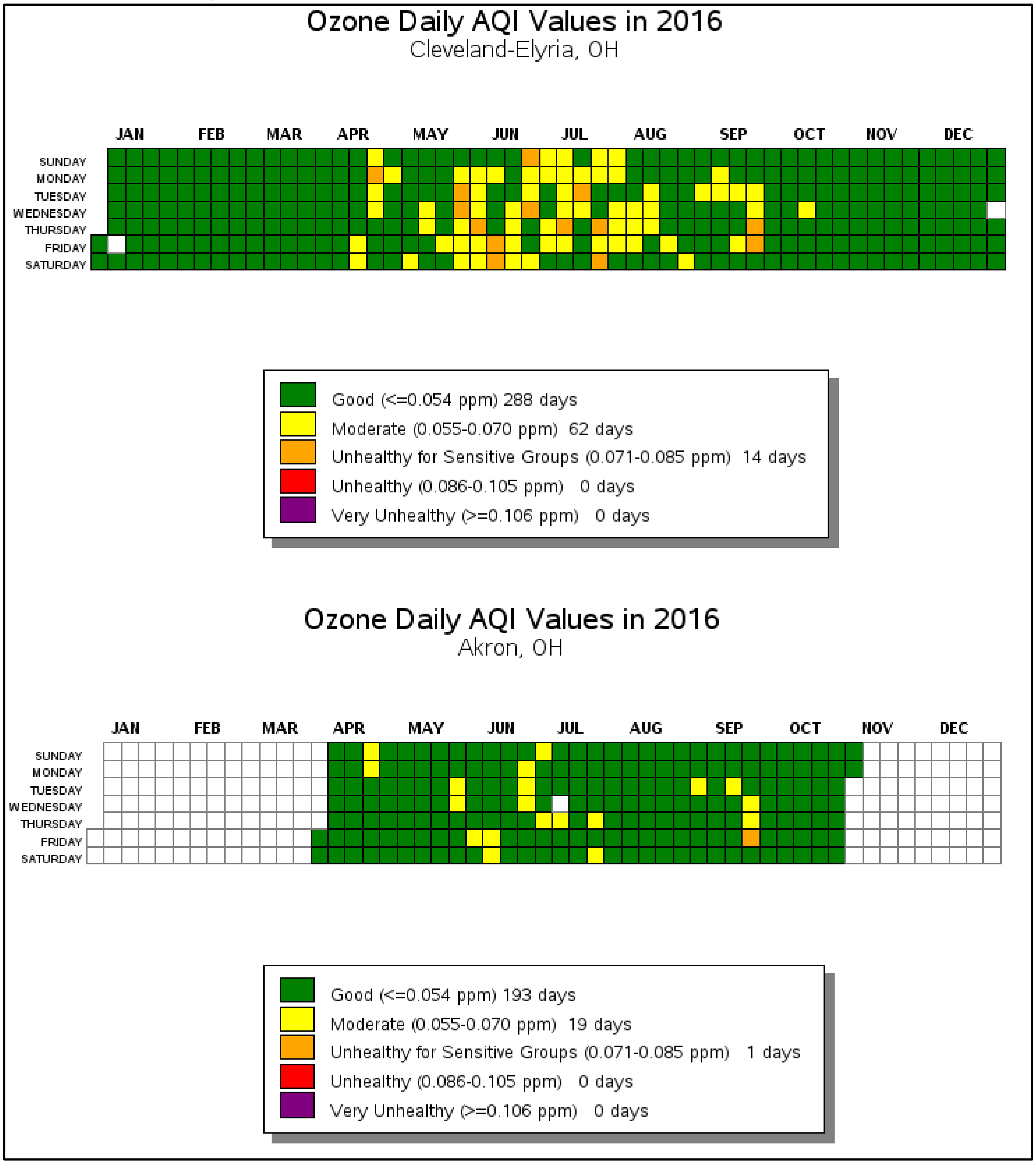
[40] The monitor with the highest average in the county was used for each three-year period. The concentrations are the truncated, not rounded, values (i.e., 87.7 is listed as 87 not 88).
[41] The dashed black lines indicate the NAAQS in effect during each period.

The data show a long-term downward trend in O_3 for Northeast Ohio. Average concentrations are expected to continue this decline in the coming years. Based on U.S. EPA projections, every county in the NOACA air quality monitoring area will have ozone values below 70 ppb by 2025.[42]

As noted in Chapter 2, U.S. EPA uses the AQI to translate the NAAQS for each pollutant into a normalized metric that allows individuals to gauge air quality on a given day. Figure 6 below depicts the daily AQI values for O_3 for the Cleveland and Akron metropolitan areas during 2016. Green and yellow squares denote good and moderate air quality levels, respectively, while orange squares show days in which the O_3 level exceeded the 8-hour NAAQS.

[42] U.S. EPA, *Counties Projected to Violate the 2015 Primary Ground-Level Ozone Standard* (Washington, D.C.: U.S. EPA, 2015), https://www.epa.gov/sites/production/files/2016-03/documents/20151001datatable2025.pdf (accessed June 1, 2017).

Figure 6: Daily O_3 AQI Levels for Cleveland & Akron (2016)



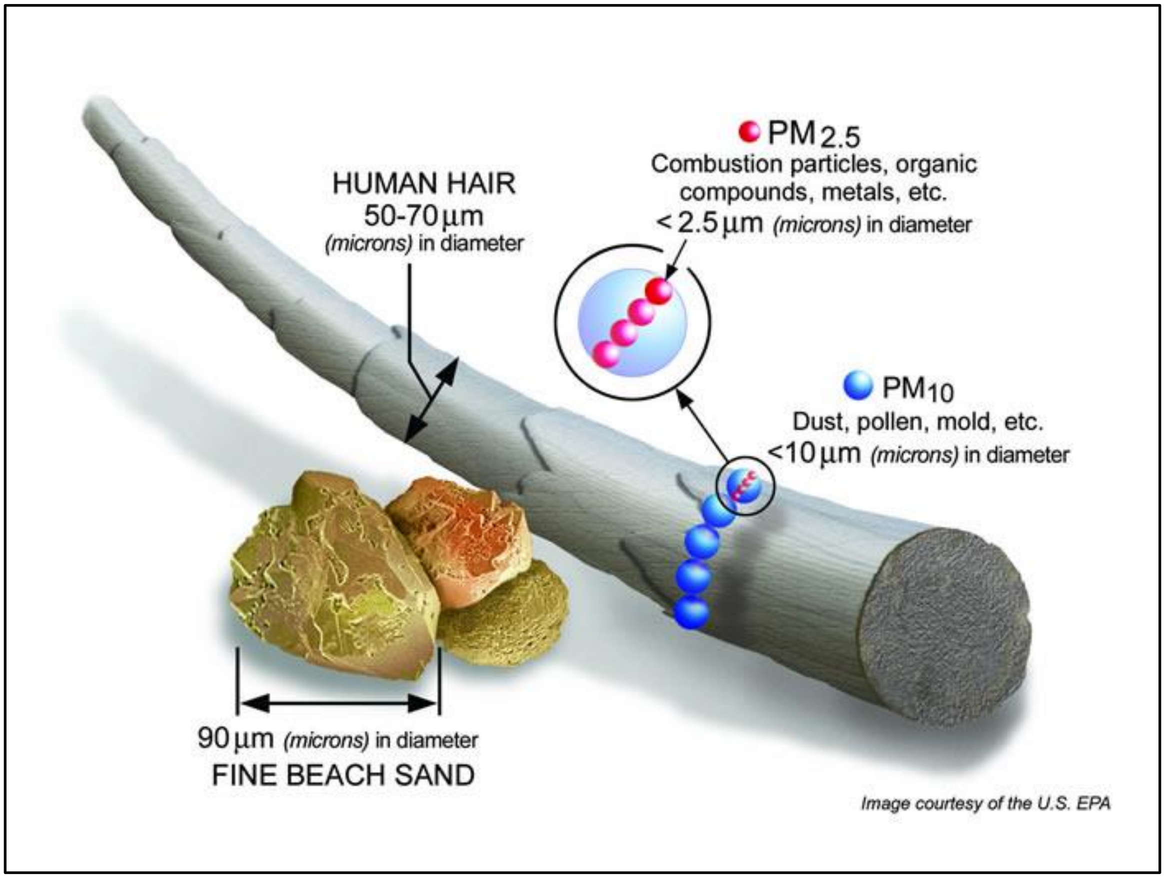
Source: U.S. EPA, "AirData Tile Plot," http://www.epa.gov/airquality/airdata/ad_viz_tile.html (accessed June 1, 2017).

5.2 Particulate Matter (PM)

Properties: Particulate matter (PM) is the term applied to both solid and liquid droplets suspended in the atmosphere. It can be emitted directly from a source (primary) or result from chemical reactions in the atmosphere (secondary). Inhalation of these particles can irritate one's nose, throat, and lung tissues. This irritation can easily create or exacerbate existing respiratory problems or even cause premature death.

U.S. EPA has focused on smaller particles in setting standards. The smaller the particle, the deeper it can travel into one's respiratory system. A subscript number generally follows references to PM. This number is the largest diameter of the particles covered by the standard or discussion. Thus, PM_{10} refers to particles less than or equal to 10 micrometers in diameter, while $PM_{2.5}$ refers to particles less than or equal to 2.5 micrometers in diameter. "Coarse" particulate matter is used to refer to PM_{10}, while "Fine" particulate matter is used to refer to $PM_{2.5}$. Prior to 1987, U.S. EPA focused on total suspended particulate (TSP), which included particles approximately 25 to 45 micrometers in diameter. Particles smaller than one micrometer, known as ultrafine particles (UFP), can also harm human health, but U.S. EPA does not currently set NAAQS for these. PM_{10} is one-seventh the diameter of a human hair, while $PM_{2.5}$ is just 1/28 of the diameter of a human hair (see Figure 7).

Figure 7: Particulate Matter Size

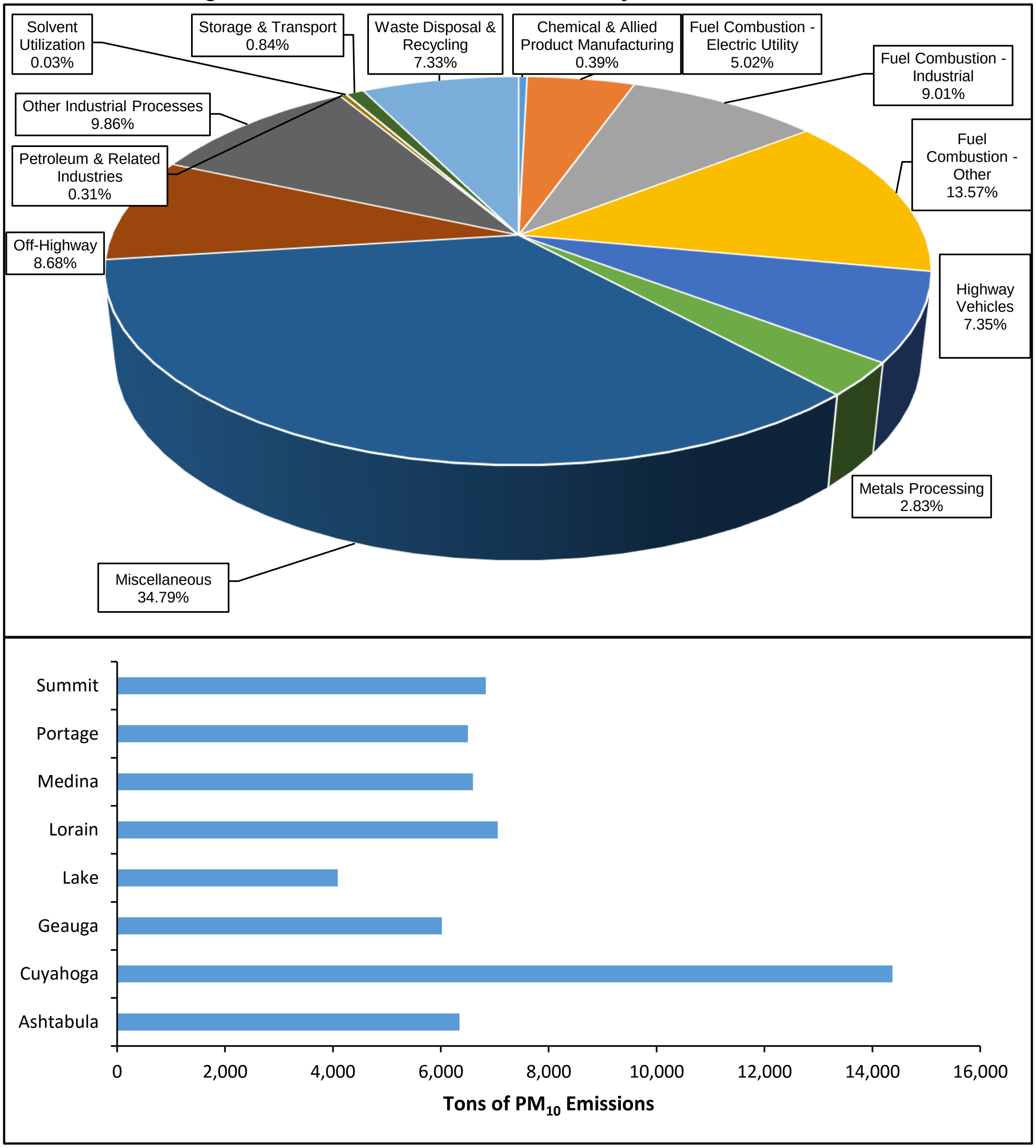


Source: U.S. EPA, "Particulate Matter: Basic Information," https://www.epa.gov/pm-pollution/particulate-matter-pm-basics (accessed June 1, 2017).

5.2.1 Coarse Particulate Matter (PM_{10})

Sources: In Northeast Ohio, PM_{10} largely comes from miscellaneous sources, such as fugitive dust emissions and the agriculture/forestry sector; industries that combust fossil fuels; gasoline and diesel-powered automobiles, trucks, construction equipment, ships, trains, and aircraft; and wood-burning stoves and fireplaces (see Figure 8).

Figure 8: 2014 PM_{10} Emission Inventory for Northeast Ohio



Source: U.S. EPA, *2014 National Emissions Inventory*, https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data (accessed June 1, 2017).

NAAQS and Nonattainment Status: Since 2006, there has been only one PM_{10} NAAQS, a daily (24-hour) standard. U.S. EPA revoked its annual standard in December 2006 because there was insufficient health-based evidence to continue it.

The 24-hour PM_{10} NAAQS is 150 micrograms per cubic meter (µg/m^3), not to be exceeded more than once per year, averaged over three years. No county in Northeast Ohio is in nonattainment for the PM_{10} NAAQS. Cuyahoga County was re-designated as a maintenance area for PM_{10} effective January 10, 2001 (65 FR 77308).

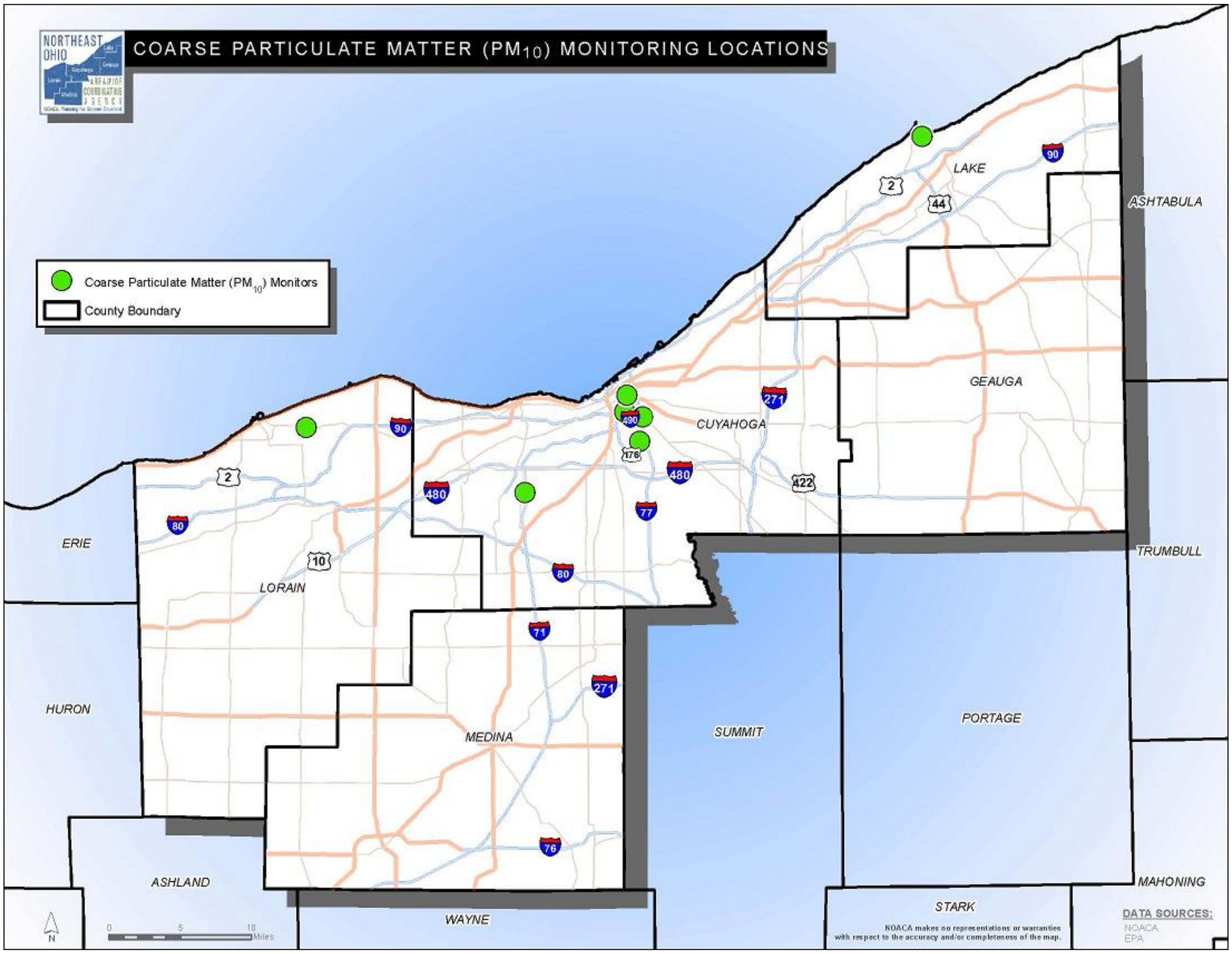
Monitors: There are seven operating PM_{10} monitors in Northeast Ohio (see Table 8 and Figure 9).

Table 8: Locations of PM_{10} Monitors in Northeast Ohio

Monitor	County	FIPS ID	Site ID	Latitude	Longitude	Address
1	Cuyahoga	035	0038	41.47	-81.68	St. Theodosius, St. Tikhon Ave., Cleveland
2			0045	41.47	-81.65	FS 13, 4950 Broadway Ave., Cleveland
3			0060	41.49	-81.67	GT Craig, E.14th St. & Orange Ave.
4			0065	41.44	-81.66	4600 Harvard Ave., Newburgh Heights
5			1002	41.39	-81.81	16900 Holland Road, Brookpark
6	Lake	085	1001	41.75	-81.27	Fairport High School, Fairport
7	Lorain	093	3002	41.46	-82.11	Barr School, Sheffield

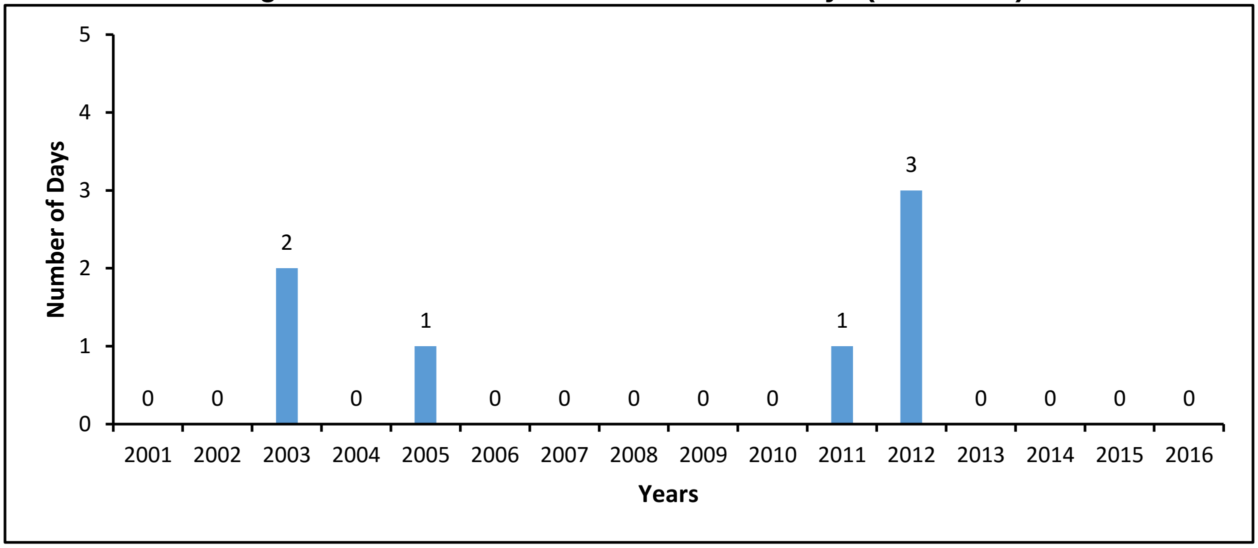
Source: Ohio EPA, *Ohio Air Monitoring Network Plan 2016-2017*, http://epa.ohio.gov/Portals/27/ams/sites/Ohio_2016-2017_AirMonNetPlan_MainRep_RevNov2016_FINAL.pdf (accessed June 1, 2017).

Figure 9: Northeast Ohio PM_{10} Monitor Locations



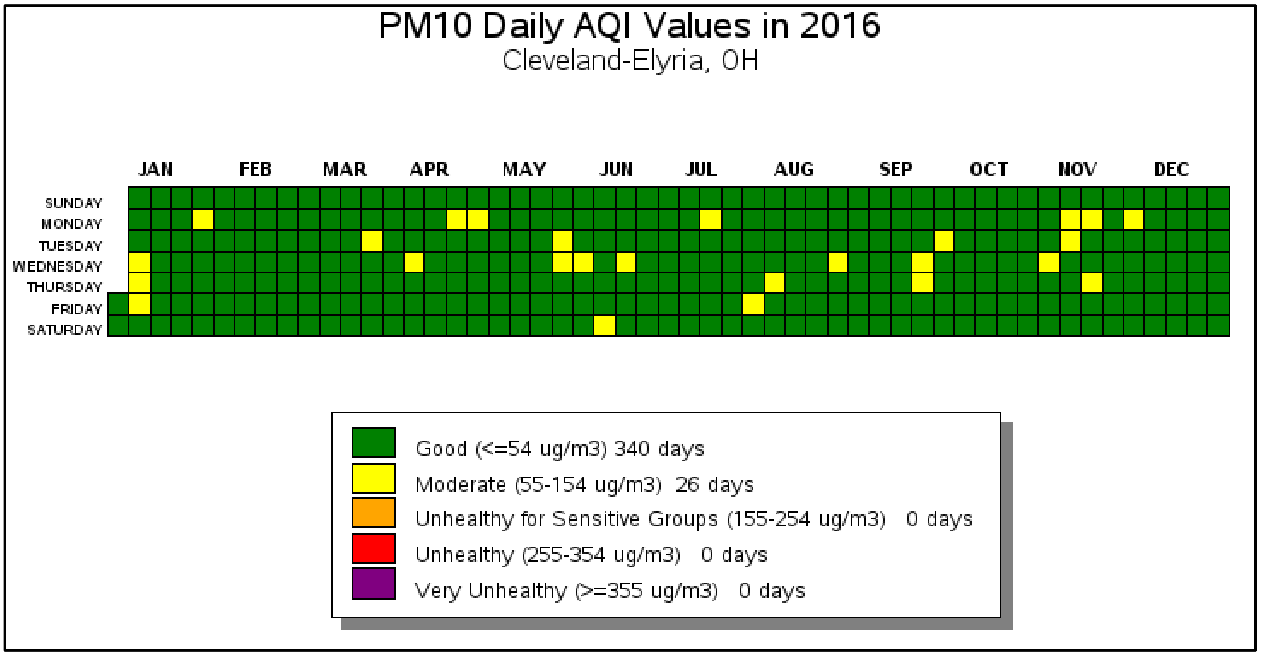
Trends: Figure 10 displays the number of PM_{10} exceedance days during 2001-2016. Northeast Ohio has consistently remained at or near zero exceedance days per year over the past two decades. While there was a jump to three days in 2012, the region has not registered an exceedance day since then. Figure 11 displays the 2016 daily AQI values for the Cleveland-Elyria-Mentor area. As it shows, the region had 340 Good AQI Days and just 26 Moderate AQI Days in 2016.

Figure 10: Number of PM_{10} Exceedance Days (2001-2016)



Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

Figure 11: Daily PM_{10} AQI levels for Cleveland (2016)



Source: U.S. EPA, "AirData Tile Plot," http://www.epa.gov/airquality/airdata/ad_viz_tile.html (accessed June 1, 2017).

5.2.2 Fine Particulate Matter ($PM_{2.5}$)

Properties: $PM_{2.5}$ is a complex mixture of extremely small particles and liquid droplets. It is so small that it can be inhaled into the lungs and remain there; it may even travel into the bloodstream. Numerous adverse health effects are associated with breathing $PM_{2.5}$, including lung cancer, heart attack, stroke, and premature death. $PM_{2.5}$ is the major source of haze that reduces visibility in many parts of the United States, including the national parks. $PM_{2.5}$ affects vegetation and ecosystems by settling on soil and water, upsetting delicate nutrient and chemical balances. It also causes soil erosion and damage to structures, including culturally important objects such as monuments and statues.

Figure 12: Air Monitor Filter Before and After Trapping $PM_{2.5}$

Clean and dirty $PM_{2.5}$ monitor filters, showing six weeks' difference; Lorain County.
Source: Ohio EPA, Northeast District Office.

$PM_{2.5}$ is made up of a number of components, including acids, such as ammonium nitrates and ammonium sulfates; organic chemicals, including various forms of carbon; metals; and soil and crust particles. Water is also a component of $PM_{2.5}$, which ensures that ambient concentrations increase in Northeast Ohio when humidity levels are high or when fog is present. Secondary formation in the atmosphere accounts for more $PM_{2.5}$ than does primary formation (such as smoke or industrial emissions). $PM_{2.5}$ can occur year-round, ordinarily showing a bimodal distribution of high concentrations in winter and summer, with lower concentrations during spring and fall.

Sources: Direct sources of $PM_{2.5}$ include coal-fired electric utilities; industries that emit metal particles; wood burning; and diesel-powered trucks, construction equipment, ships, trains, and aircraft. Sulfates are more readily formed from SO_2 released by power plants from July through September, which may result in spiked $PM_{2.5}$ levels.[43] Indirect sources that contribute through secondary formation in the atmosphere include agriculture (ammonia from fertilizer and manure), electric utilities, industry, gasoline-powered cars, and diesel engines. In Northeast Ohio, road salt is also a factor during the winter. Figure 13 shows the primary sources of $PM_{2.5}$ in the region.

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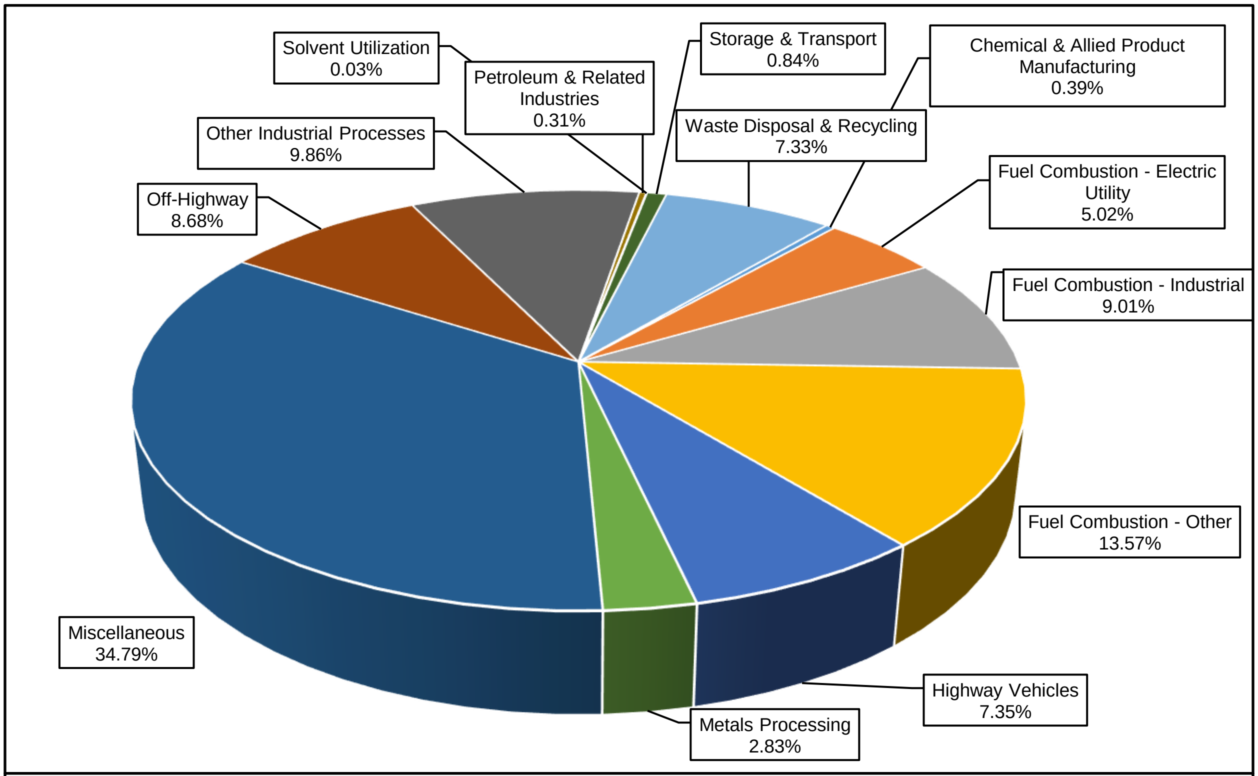
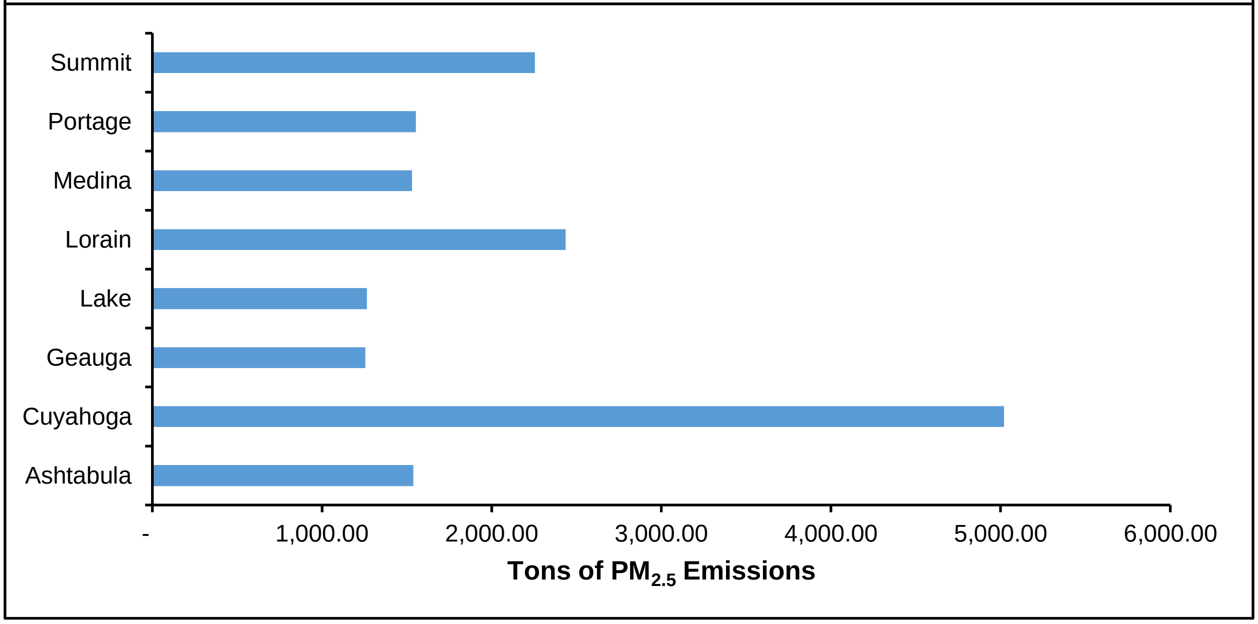
[43] U.S. EPA Office of Air Quality Planning and Standards, *The Particle Pollution Report: Current Understanding of Air Quality and Emissions through 2003* (Research Triangle Park, NC: U.S. EPA, 2003), https://hero.epa.gov/hero/index.cfm/reference/details/reference_id/190219 (accessed June 1, 2017).

Figure 13: 2014 Primary $PM_{2.5}$ Emissions Inventory for Northeast Ohio



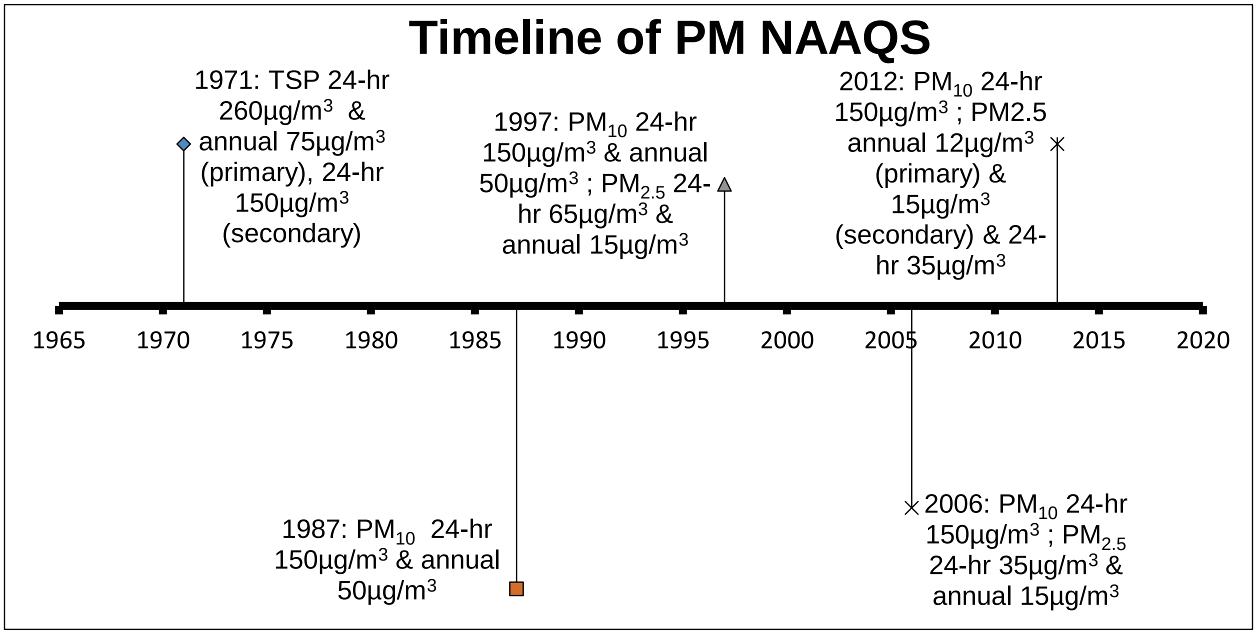


Source: U.S. EPA, *2014 National Emissions Inventory*, https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data (accessed June 1, 2017).

NAAQS and Nonattainment Status: Monitoring for $PM_{2.5}$ began in 1999. U.S. EPA completed its latest revision to the $PM_{2.5}$ NAAQS on January 15, 2013 (78 FR 3085), when it issued three new $PM_{2.5}$ standards. These include two annual standards and a 24-hour standard. The primary annual NAAQS is 12 µg/m^3. The secondary annual NAAQS is 15 µg/m^3. The three-year average of the weighted annual mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed the annual standards. The 24-hour primary and secondary NAAQS is 35 µg/m^3. The three-year average of the 98th percentile of 24-hour concentrations at each monitor within an area must not exceed 35 µg/m^3.

U.S. EPA issued nonattainment designations for this NAAQS in December 2014. Both Cuyahoga County and Lorain County were classified as moderate nonattainment areas for the annual NAAQS (80 FR 2206), a ruling that took effect on April 15, 2015.

Figure 14: Time Line of Revisions to PM NAAQS (1971-2016)



$PM_{2.5}$ Control Measures: The Ohio EPA is responsible for submitting SIPs for all regions within the state. The agency faced a deadline of October 2016 to submit a new $PM_{2.5}$ SIP for Cuyahoga and Lorain counties (80 FR 2206). Please visit the Ohio EPA website to review the relevant $PM_{2.5}$ SIPs for Northeast Ohio: http://www.epa.ohio.gov/dapc/SIP/pm2_5.aspx.

In 2006, NOACA convened a public participation process, headed by the NOACA Air Quality Public Advisory Task Force, which generated recommendations to Ohio EPA in 2007 for inclusion in the $PM_{2.5}$ SIP. The NOACA Board of Directors modified the recommendations and submitted them to the Ohio EPA in December 2007.[44]

[44] NOACA, *EAC Air Quality Subcommittee—Final Report $PM_{2.5}$ SIP Recommendations* (Cleveland: NOACA, 2007), http://www.noaca.org/modules/showdocument.aspx?documentid=688 (accessed June 1, 2017).

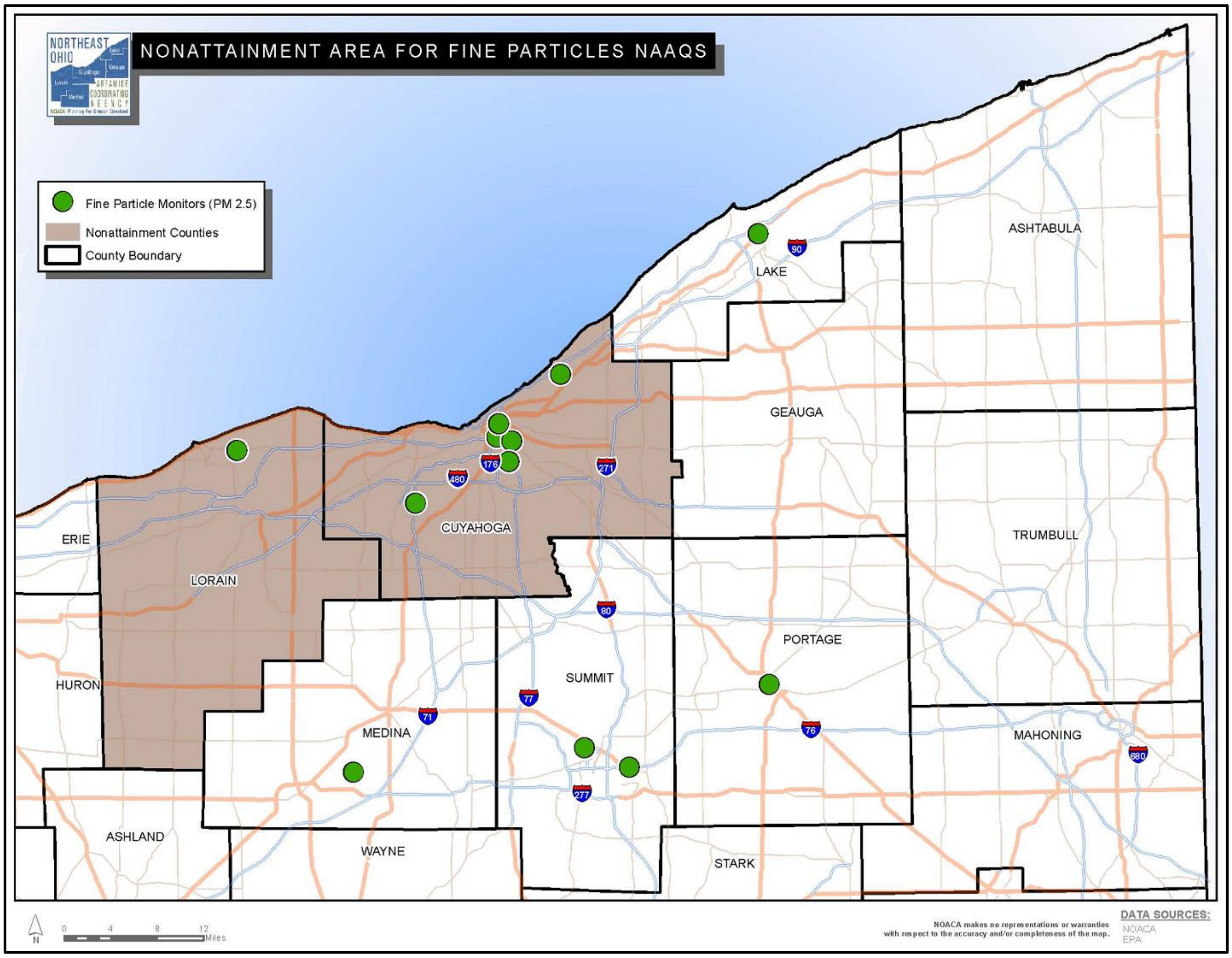
Monitors: There are 12 operating $PM_{2.5}$ monitors in Northeast Ohio (see Table 9 and Figure 15).

Table 9: Locations of $PM_{2.5}$ Monitors in Northeast Ohio

Monitor	County	FIPS ID	Site ID	Latitude	Longitude	Address
1	Cuyahoga	035	0034	41.55	-81.57	891 East 152nd St., Cleveland
2			0038	41.47	-81.68	St. Theodosius, St. Tikhon Ave., Cleveland
3			0045	41.47	-81.65	FS 13, 4950 Broadway Ave., Cleveland
4			0060	41.49	-81.67	GT Craig, East 14th St. & Orange Ave., Cleveland
5			0065	41.44	-81.66	4600 Harvard Ave., Newburgh Hts.
6			1002	41.39	-81.81	16900 Holland Road, Brookpark
7	Lake	085	0007	41.72	-81.24	177 Main St., Painesville
8	Lorain	093	3002	41.46	-81.11	Barr School, Sheffield
9	Medina	103	0004	41.06	-81.92	Ballash Rd., Lafayette Twp.
10	Portage	133	0002	41.16	-81.23	531 Washington Ave., Ravenna
11	Summit	153	0017	41.06	-81.46	East High School, Akron
12			0023	41.08	-81.54	660 W. Exchange St., Akron

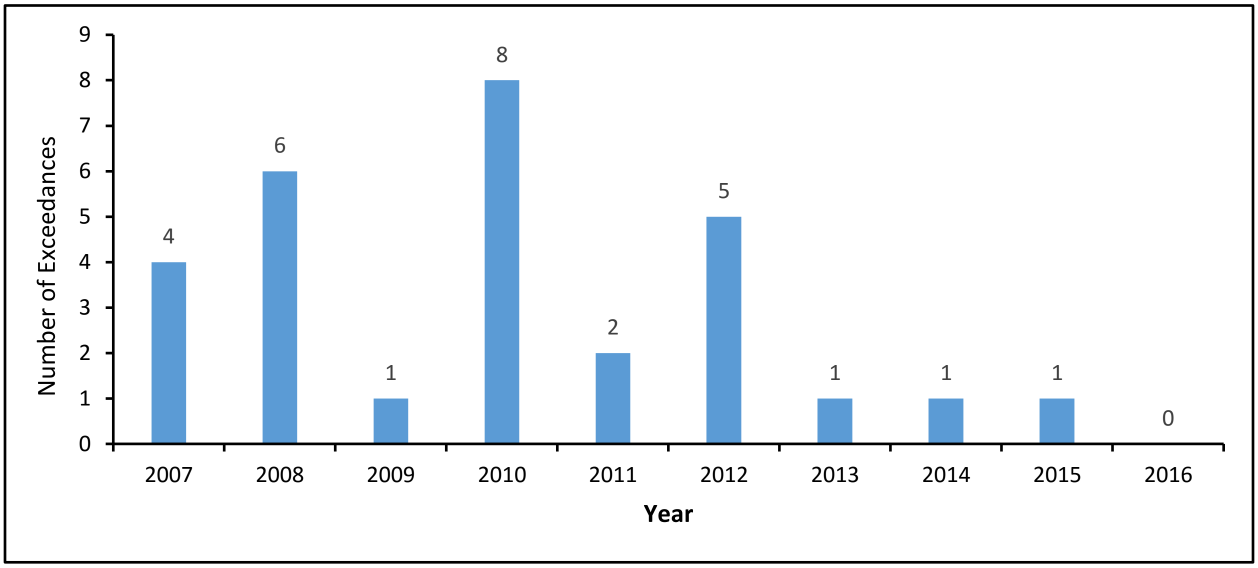
Source: Ohio EPA, *Ohio Air Monitoring Network Plan 2016-2017*, http://epa.ohio.gov/Portals/27/ams/sites/Ohio_2016-2017_AirMonNetPlan_MainRep_RevNov2016_FINAL.pdf (accessed June 1, 2017).

Figure 15: Northeast Ohio $PM_{2.5}$ Monitor Locations



Trends: Figure 16 shows the number of exceedance days for the $PM_{2.5}$ 24-hour NAAQS since it was tightened to 35 µg/m^3 in 2007. There were no exceedance days in 2016, while there was only one in each of the previous three years. For a list of the dates of each exceedance and the number of exceeding monitors, please see Appendix B: $PM_{2.5}$ Exceedance Days 2007-2016.

Figure 16: Number of $PM_{2.5}$ Exceedance Days (2007-2016)



Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

Table 10 shows the three-year rolling averages for annual $PM_{2.5}$, monitor-by-monitor, from 2004-2016. Table 11, in turn, lays out the three-year rolling averages for the daily (24-hour) $PM_{2.5}$, monitor by monitor, for this same period. Cells marked N/A in either table indicate that the monitor was not operating during that period.

Table 10: Monitor-by-Monitor 3-Year Rolling Averages for Annual $PM_{2.5}$ NAAQS[a]

Monitor[b]	ID Number	County	2004-06	2005-07	2006-08	2007-09	2008-10	2009-11	2010-12	2011-13	2012-14	2013-15	2014-16
N/A	39-035-0027	Cuyahoga	15.3	14.9	13.6	12.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	39-035-0034		13.5	13.8	12.0	11.6	10.7	10.4	10.1	9.6	9.5	9.4	8.9
2	39-035-0038		17.2	16.8	15.1	14.4	13.6	13.1	13.0	12.4	12.2	12.1	11.4
3	39-035-0045		16.2	16.2	14.4	13.6	12.9	12.3	12.2	11.5	11.3	11.2	10.6
4	39-035-0060		16.9	16.8	14.9	14.1	13.4	12.8	13.1	12.5	12.5	12.1[c]	11.3[c]
5	39-035-0065		15.6	15.8	14.5	14.3	13.4	12.7	12.7	12.1	12.1	12.4	12.2
6	39-035-1002		13.9	14.3	12.7	12.1	11.4	10.9	10.5	9.7	9.5	9.3	8.9
N/A	39-085-3002	Lake	N/A	N/A	12.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	39-085-0007		N/A	N/A	N/A	N/A	N/A	10.1	9.6	9.0	8.7	8.5	7.9
N/A	39-093-0016	Lorain	13.6	12.7	10.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	39-093-3002		12.6	13.0	11.9	11.4	10.6	9.9	9.8	9.2	9.1	8.7	8.1
N/A	39-103-0003	Medina	N/A	13.3	12.1	11.8	11.1	10.9	10.3	9.7	N/A	N/A	N/A
9	39-103-0004		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9.0	9.3	N/A
10	39-133-0002	Portage	13.2	13.6	12.6	12.3	11.5	10.9	10.3	9.5	8.8	8.9[c]	8.3[c]
11	39-153-0017	Summit	14.9	14.8	13.9	13.7	13.3	12.6	N/A	N/A	10.6	11.2	11.0
12	39-153-0023		14.1	14.1	13.1	12.7	12.3	11.7	11.2	10.4	10.2	9.9	9.2

[a] Values that exceeded the NAAQS in place at the time are highlighted in red.

[b] Monitors numbered N/A are no longer in operation.

[c] Annual values that do not meet Ohio EPA completeness criteria. In order for a monitor to meet completeness criteria, at least 75% of its scheduled sample days must register valid readings for each quarter of each calendar year.

Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

Table 11: Monitor-by-Monitor 3-Year Rolling Averages for 24-Hour $PM_{2.5}$ NAAQS[a]

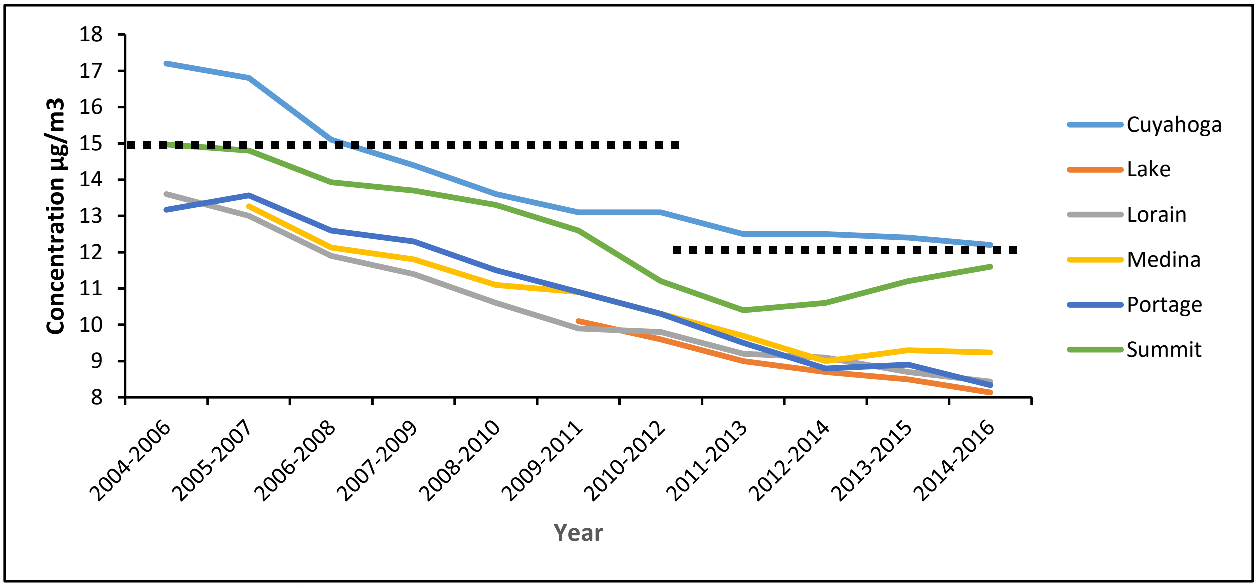
Monitor[b]	ID Number	County	2004-06	2005-07	2006-08	2007-09	2008-10	2009-11	2010-12	2011-13	2012-14	2013-15	2014-16
N/A	39-035-0027		35.6	35.4	36.1	33	N/A	N/A	N/A	N/A	N/A	N/A	
1	39-035-0034		35.3	36.8	32.7	32	28	25	23	22	22	23	20
2	39-035-0038		43.3	42.3	38.4	36	33	30	29	28	27	27	25
3	39-035-0045	Cuyahoga	37.3	37.6	33.9	31	31	27	27	24	25	25	23
4	39-035-0060		40.9	39.7	35.9	35	32	29	30	29	30	28[c]	25[c]
5	39-035-0065		37.3	38.3	33.6	34	30	28	26	24	24	25	25
6	39-035-1002		33.3	34.8	31.0	29	26	24	23	22	22	22	20
N/A	39-085-3002	Lake	N/A	N/A	33.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	39-085-0007		N/A	N/A	N/A	N/A	N/A	N/A	23	21	N/A	19	17
N/A	39-093-0016	Lorain	31.5	28.6	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	39-093-2003		30.8	31.8	31.2	29	26	23	23	22	22	22	20
8	39-093-3002	Medina	N/A	32.0	29.2	28	28	N/A	N/A	N/A	N/A	N/A	N/A
N/A	39-103-0003		N/A	N/A	N/A	N/A	N/A	N/A	22	22	21	22	20
9	39-103-0004	Portage	N/A	N/A	N/A	N/A	N/A	N/A	22	22	21	21[c]	18[c]
10	39-133-0002		34.2	34.6	30.3	28	28	26	24	22	20	25	24
11	39-153-0017	Summit	37.9	36.7	34.1	33	33	29	26	24	23	23	20
12	39-153-0023		36.6	33.5	30.3	29	29	27	25	23	22	N/A	N/A

[a] Values that exceeded the NAAQS in place at the time are highlighted in red.
[b] Monitors numbered N/A are no longer in operation.
[c] Annual values that do not meet Ohio EPA completeness criteria. In order for a monitor to meet completeness criteria, at least 75% of its scheduled sample days must register valid readings for each quarter of each calendar year.

Source: U.S. EPA, “Air Quality System” data, https://www.epa.gov/aqs (accessed June 1, 2017).

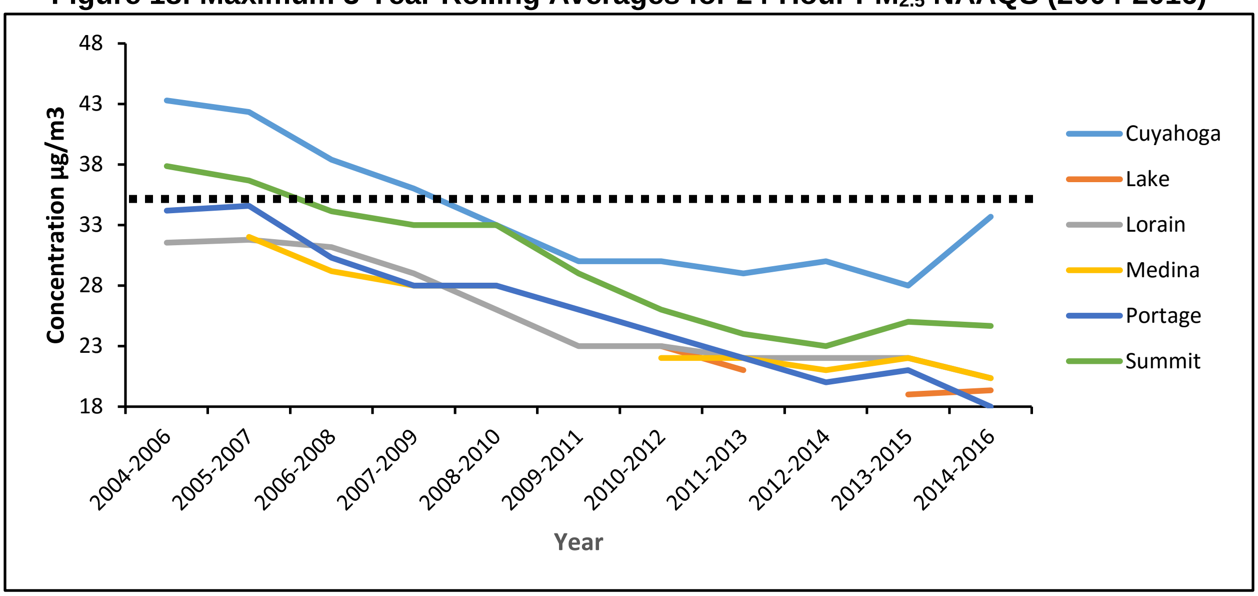
Figures 17 and 18 illustrate the information from Tables 10 and 11. The data show a clear downward trend over the past decade, most likely due to new controls on coal-fired power plants, cleaner fuels (e.g., low sulfur diesel), and alternative vehicle technologies (e.g., vehicle retrofits, repowers, replacements, and anti-idling mechanisms).

Figure 17: Maximum 3-Year Rolling Averages for Annual $PM_{2.5}$ NAAQS (2004-2016)[45]



Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

Figure 18: Maximum 3-Year Rolling Averages for 24-Hour $PM_{2.5}$ NAAQS (2004-2016)

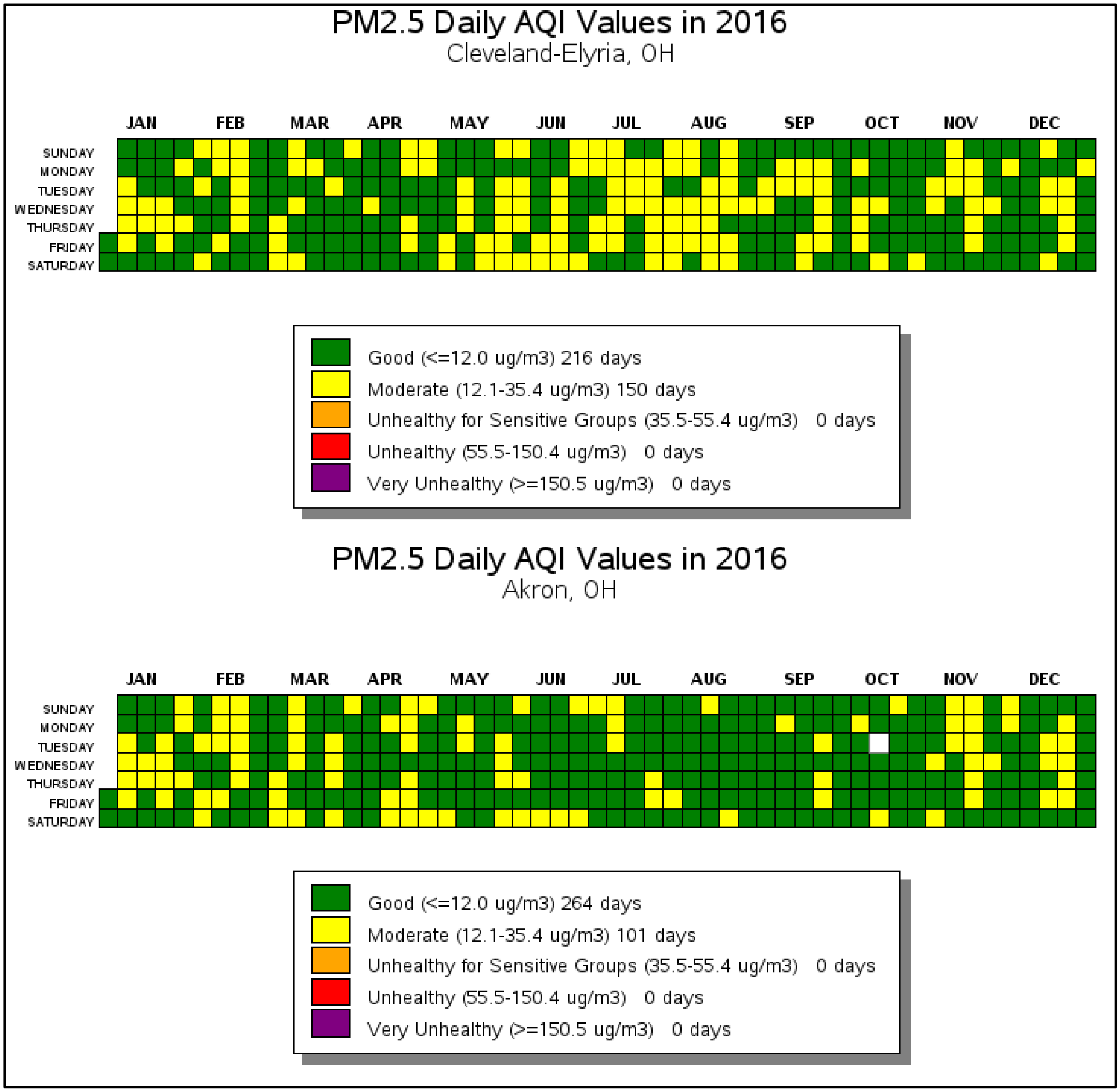


Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

45 Figures 17 and 18 depict the data only from the highest value monitor in each county, for each year. The dashed black lines in each chart indicate the NAAQS in effect during each period.

Figure 19 displays the 2016 daily AQI values for the Cleveland-Elyria-Mentor area. The region had no unhealthy air days during 2016, and roughly two-thirds of all days had good AQI values.

Figure 19: Daily $PM_{2.5}$ AQI levels in 2016



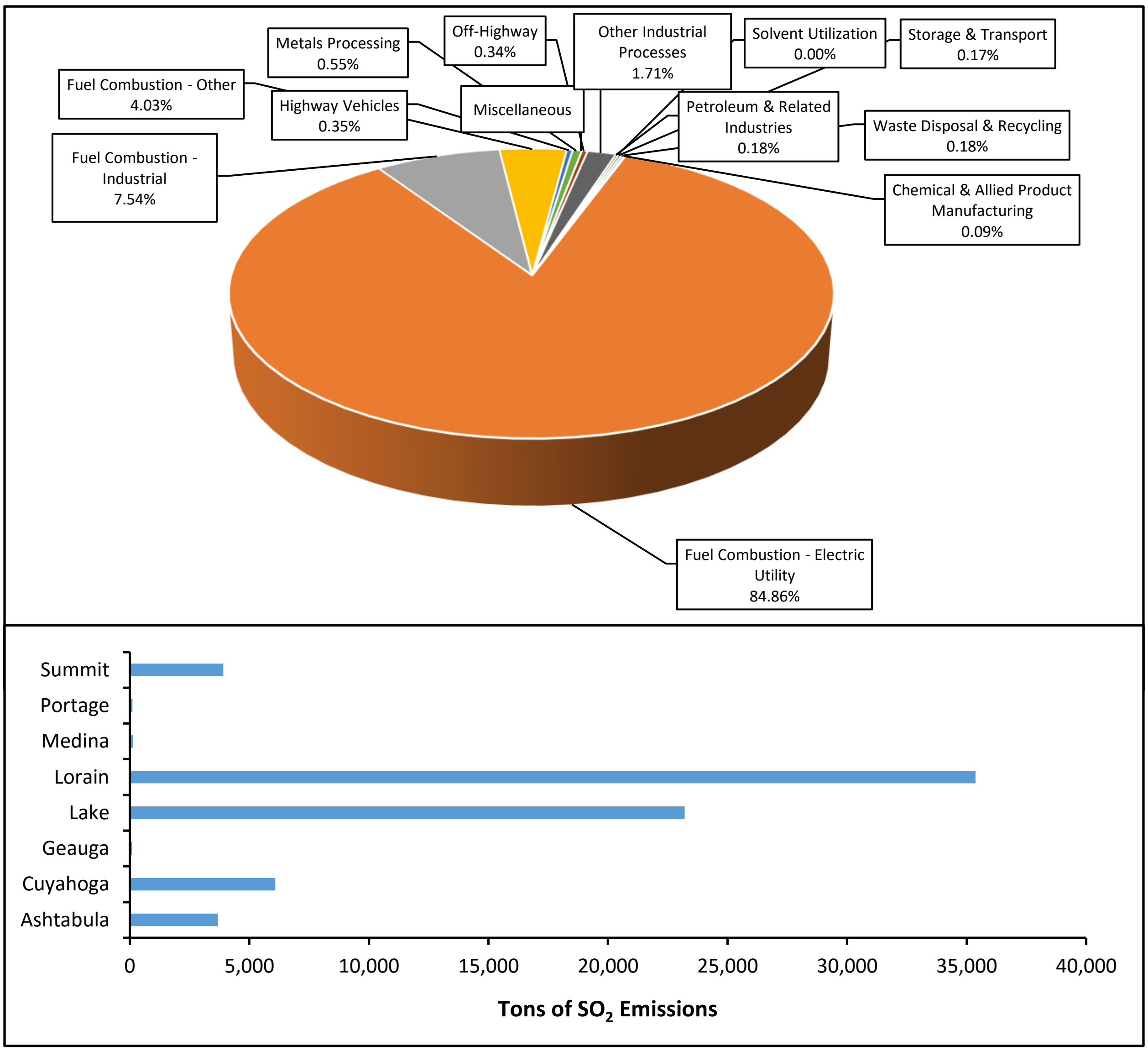
Source: U.S. EPA, "Air Data Tile Plot," http://www.epa.gov/airquality/airdata/ad_viz_tile.html (accessed June 1, 2017).

5.3 Sulfur Dioxide

Properties: Sulfur dioxide (SO_2) is released primarily by the combustion of fuels that contain sulfur as a contaminant. Like O_3, it irritates lung tissue and can exacerbate preexisting respiratory and cardiovascular conditions. It also contributes to acid rain, which deteriorates man-made structures, damages plants, and can alter pH levels sufficiently to destroy ecosystems. Moreover, SO_2 is a major source of secondary $PM_{2.5}$ formation.

Sources: Coal and diesel fuel are contributors to sulfur dioxide concentrations. U.S. EPA has eliminated sulfur from diesel fuel, on a phased-in basis. Nearly 85% of SO2 emissions in Northeast Ohio come from power plants, more than the national average (67%).[46]

Figure 20: 2014 SO_2 Emissions Inventory



Source: U.S. EPA, *2014 National Emissions Inventory*, https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data (accessed June 1, 2017).

[46] U.S. EPA, "Sulfur Dioxide," http://www.epa.gov/oaqps001/sulfurdioxide/ (accessed June 1, 2017).

NAAQS and Nonattainment Status: On June 22, 2010, U.S. EPA strengthened the NAAQS for SO_2, creating a single 1-hour NAAQS of 75 ppb and revoking the 24-hour and annual NAAQS. This final rule took effect August 23, 2010 (75 FR 35519). There is also a secondary NAAQS set at a three-hour average concentration of 0.5 ppm, not to be exceeded more than once per year.

Most of Northeast Ohio is currently in attainment for SO_2. Lake County was designated as a nonattainment area for the one-hour NAAQS on July 25, 2013 (78 FR 47191). Lake County's Attainment Date for the 2010 SO_2 NAAQS is October 4, 2018.

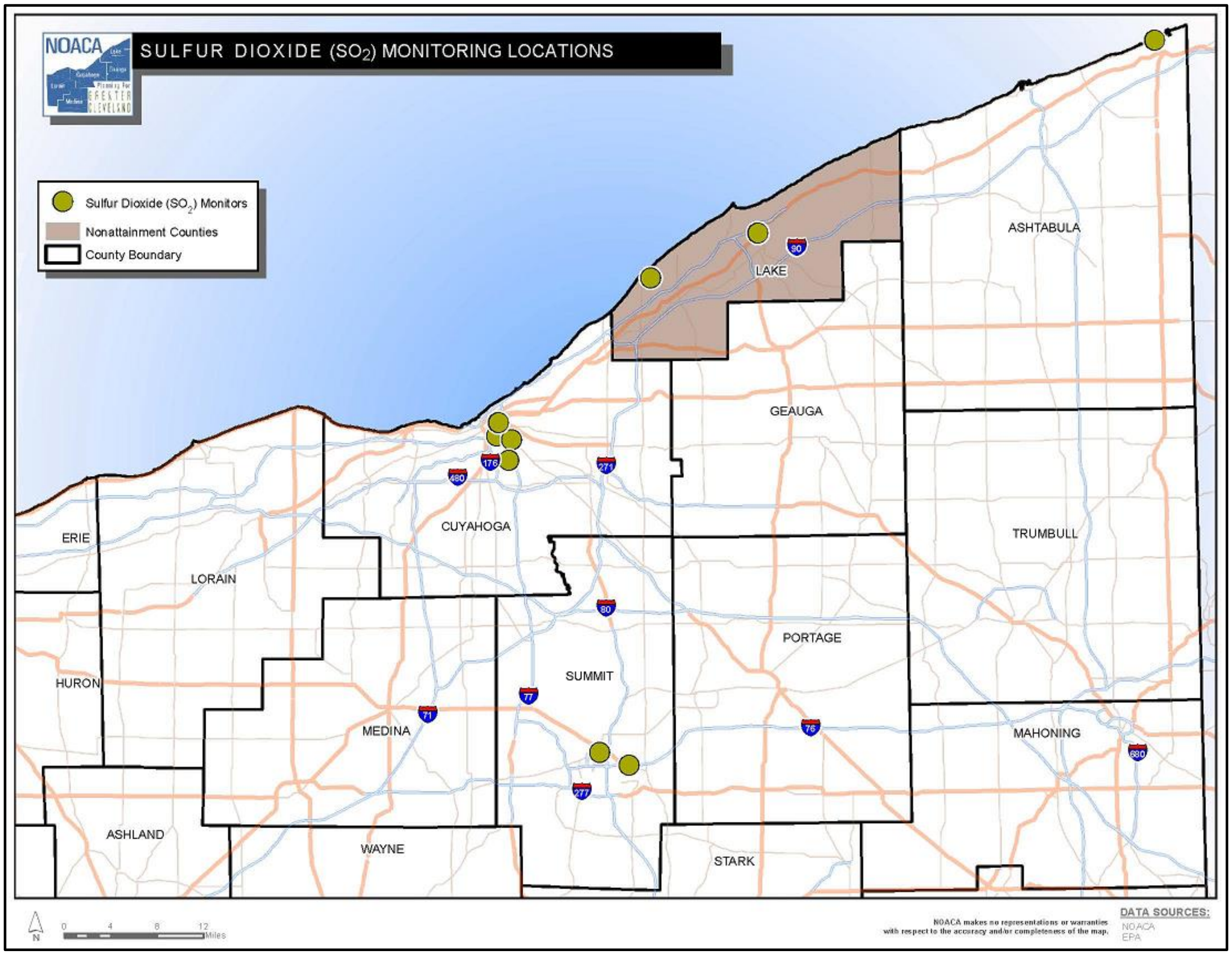
Monitors: There are nine operating SO_2 monitors in Northeast Ohio (see Table 12 and Figure 21).

Table 12: Locations of SO_2 Monitors in Northeast Ohio

Monitor	County	FIPS ID	Site ID	Latitude	Longitude	Address
1	Ashtabula	007	1001	41.95	-80.57	Conneaut Water Plant
2	Cuyahoga	035	0038	41.47	-81.68	St. Theodosius, St. Tikhon Ave., Clevleand
3			0045	41.47	-81.65	FS 13, 4950 Broadway Ave., Cleveland
4			0060	41.49	-81.67	GT Craig, E. 14^{th} St. & Orange Ave., Cleveland
5			0065	41.44	-81.66	4600 Harvard Ave., Newburgh Hts.
6	Lake	085	0003	41.67	-81.42	Jefferson School, Eastlake
7			0007	41.72	-81.24	177 Main St., Painesville
8	Summit	153	0017	41.06	-81.46	East High School., Akron
9			0022	41.08	-81.51	199 S. Broadway, Akron

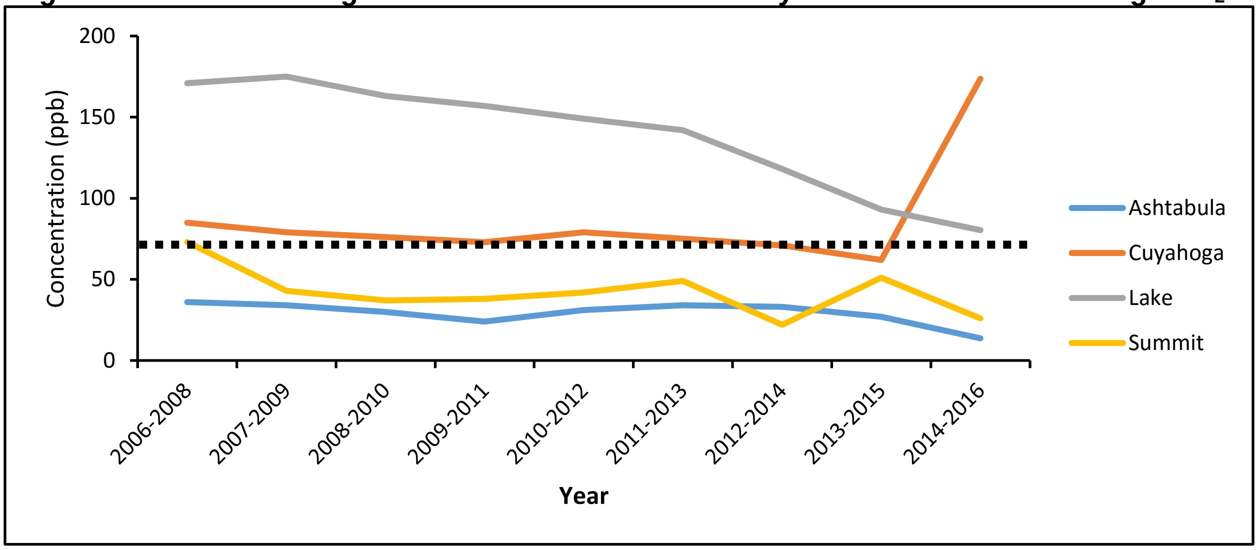
Source: Ohio EPA, *Ohio Air Monitoring Network Plan 2016-2017*, http://epa.ohio.gov/Portals/27/ams/sites/Ohio_2016-2017_AirMonNetPlan_MainRep_RevNov2016_FINAL.pdf (accessed June 1, 2017).

Figure 21: Northeast Ohio SO_2 Monitor Locations



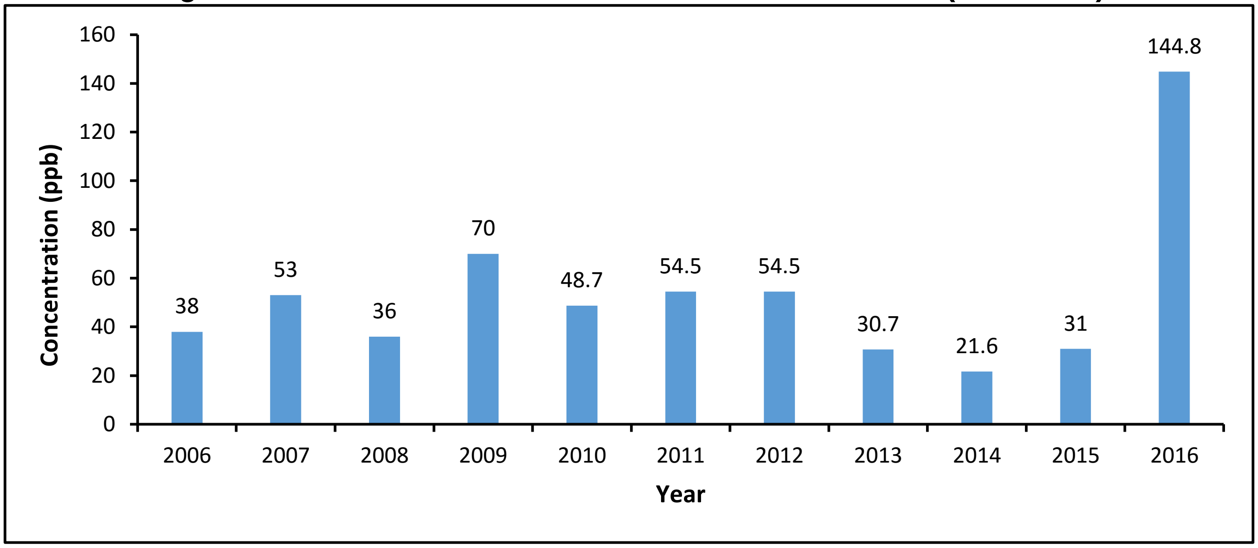
Trends: For 2016, the maximum three-year average of the 99th percentile of the daily maximum one-hour average occurred at monitor 39-035-0065 in Cuyahoga County (174 ppb). The dramatic spike in Cuyahoga County's concentration, shown in Figures 22 and 23, stems from fugitive emissions in the Industrial Flats during February 2016. Figure 24, illustrates these five days (highlighted in red) on which SO2 values reached unhealthy AQI levels due to this episode. This three-year average places Cuyahoga well in excess of the NAAQS, but Ohio EPA and U.S. EPA have worked together to rectify the underlying problem, enabling the county to remain in attainment. Lake County's SO2 levels continue to decline, though it remains above the standard. Figure 23 shows the second maximum 24-hour concentration for all SO_2 monitors in the region. In 2016, the highest concentration was at monitor 39-035-0065, located in Newburgh Heights.

Figure 22: 3-Year Average of the 99th Percentile of Daily Maximum 1-Hour Average SO_2[47]



Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

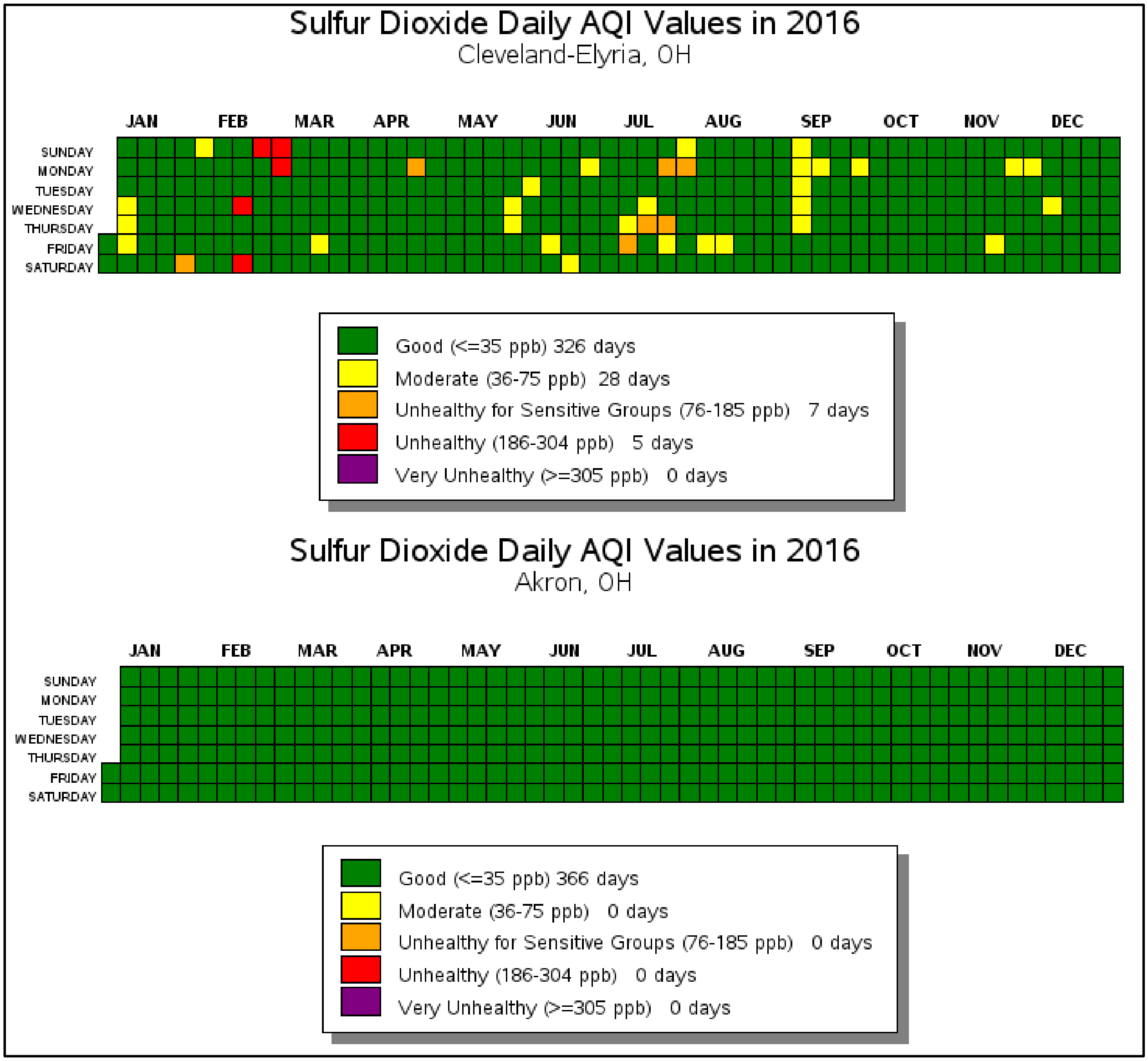
Figure 23: Second Maximum 24-Hour SO_2 Concentration (2006-2016)



Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

[47] The dashed black line indicates the NAAQS in effect during this period.

Figure 24: Daily SO_2 AQI Levels in 2016



Source: U.S. EPA, "AirData Tile Plot," http://www.epa.gov/airquality/airdata/ad_viz_tile.html (accessed June 1, 2017).

5.4 Carbon Monoxide

Properties: Carbon monoxide (CO) forms whenever a fuel is burned incompletely due to insufficient oxygen. It enters the bloodstream during normal respiration and leads to insufficient oxygen delivery to body tissues. Depending on its concentration, health effects can include increased discomfort for those with cardiovascular ailments, visual impairment, reduced work capacity, and even premature death.[48]

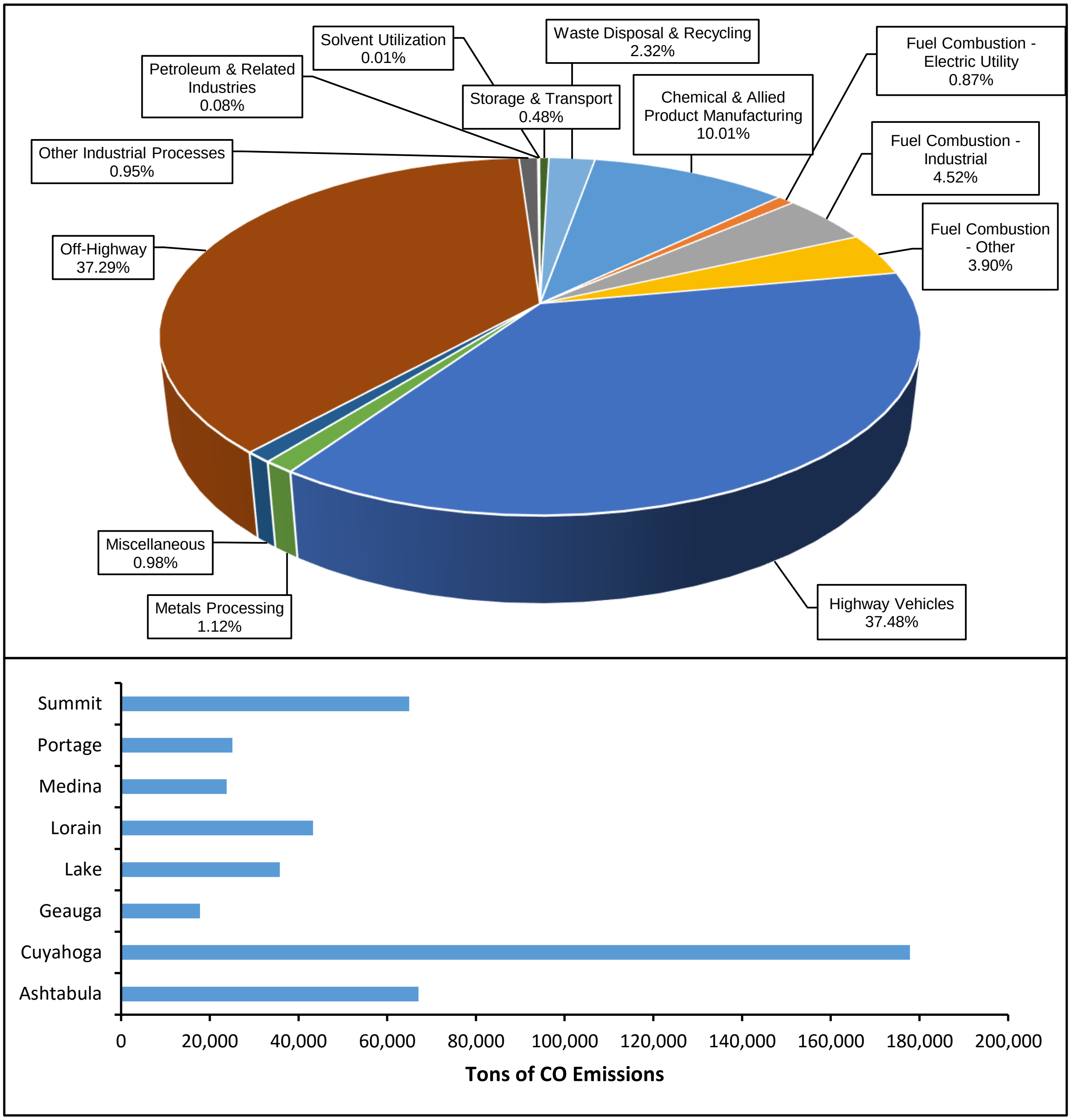
Sources: Primary sources of CO in Northeast Ohio include motor vehicles and steel mills. Passenger cars produce far less CO per car than they did 40 years ago, due to the widespread adoption of the catalytic converter.[49] As Figure 25 shows, in Northeast Ohio, off-highway vehicles are the largest source of CO in Northeast Ohio, followed by highway vehicles.

NAAQS and Nonattainment Status: There are two primary NAAQS for carbon monoxide. The one-hour NAAQS is an average concentration of 35 ppm that cannot be exceeded more than once per year. Additionally, the eight-hour NAAQS is an average concentration of 9 ppm that cannot be exceeded more than once per year.

No part of Northeast Ohio is in nonattainment for carbon monoxide. Cuyahoga County was designated as in nonattainment for carbon monoxide from 1978 to 1994 and is now in maintenance. The Ohio EPA, with NOACA's assistance, completed a maintenance plan update in 2003. On January 28, 2011, U.S. EPA proposed to retain the existing NAAQS for CO. Hence the rest of the region is expected to remain in attainment under the current NAAQS in the immediate future.

[48] U.S. EPA, "Carbon Monoxide," http://www.epa.gov/airquality/carbonmonoxide/index.html (acessed December 1, 2016).
[49] U.S. EPA Office of Mobile Sources, "Automobiles and Carbon Monoxide," http://www.epa.gov/oms/consumer/03-co.pdf (accessed June 1, 2017).

Figure 25: 2014 CO Emissions Inventory for Northeast Ohio



Source: U.S. EPA, *2014 National Emissions Inventory*, https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data (accessed June 1, 2017).

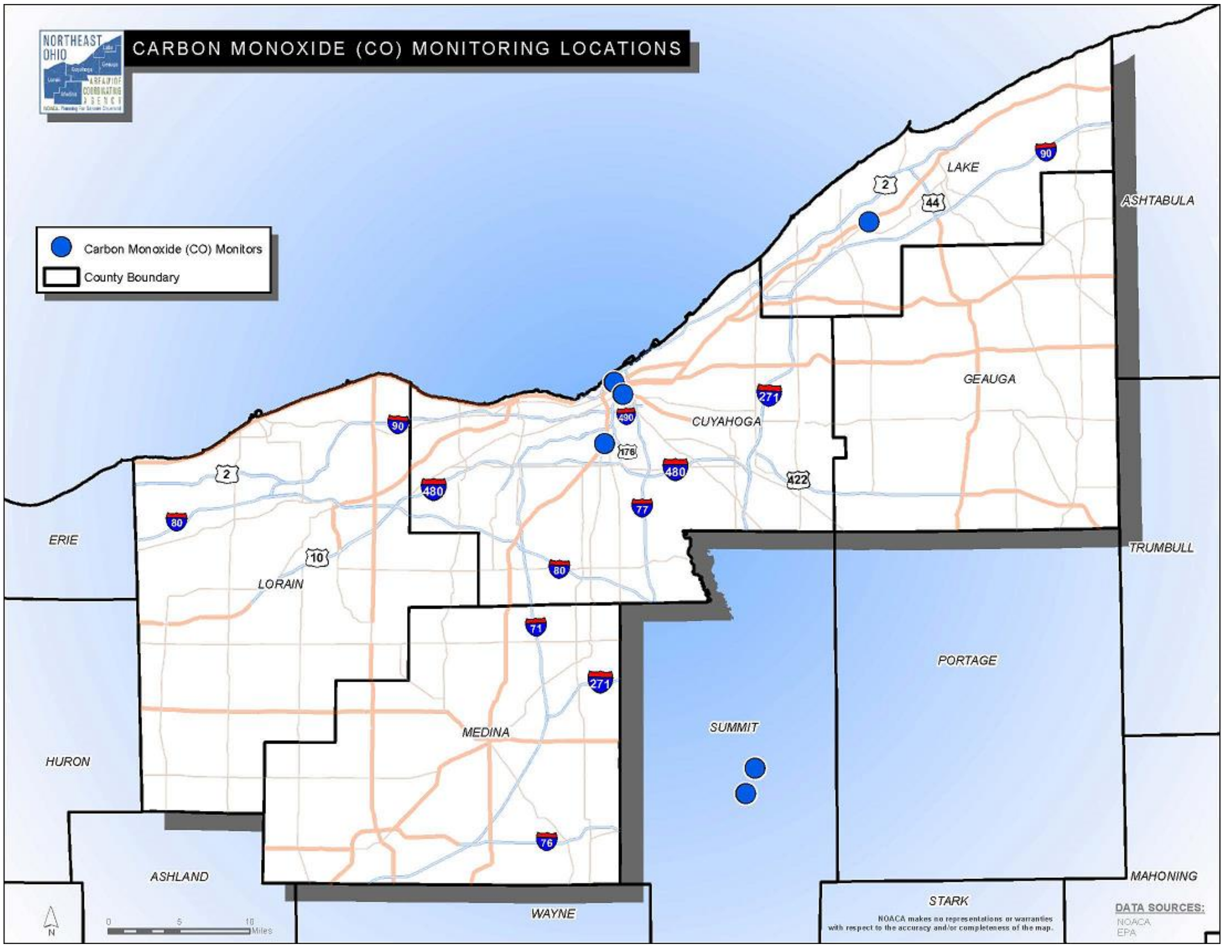
Monitors: There are six operating CO monitors in Northeast Ohio (see Table 13 and Figure 26).

Table 13: Locations of CO Monitors in Northeast Ohio

Monitor	County	FIPS ID	Site ID	Latitude	Longitude	Address
1	Cuyahoga	035	0051	41.50	-81.69	Galleria, E.9th St. & St. Clair Ave., Cleveland
2			0060	41.49	-81.67	GT Craig, E.14th St. & Orange Ave., Cleveland
3			0073	41.44	-81.49	26565 Miles Rd., Warrensville Hts.
4	Lake	085	0006	41.66	-81.33	8443 Mentor Ave., Mentor
5	Summit	153	0020	41.10	-81.50	800 Patterson Ave, Akron
6			0022	41.07	-81.51	199 S. Broadway, Akron

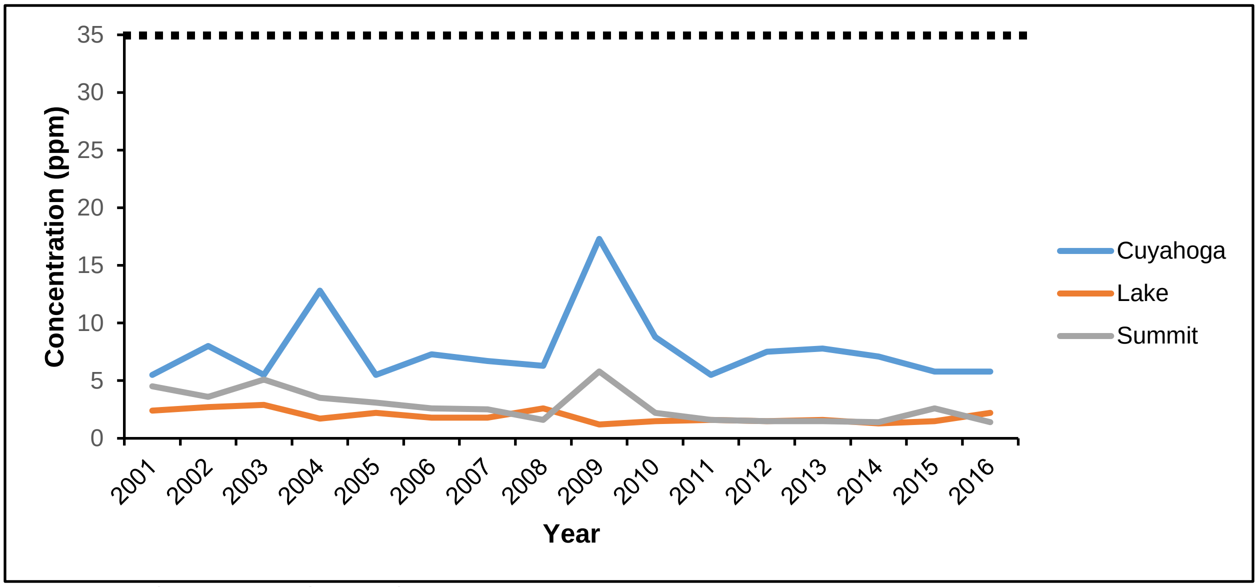
Source: Ohio EPA, *Ohio Air Monitoring Network Plan 2016-2017*, http://epa.ohio.gov/Portals/27/ams/sites/Ohio_2016-2017_AirMonNetPlan_MainRep_RevNov2016_FINAL.pdf (accessed June 1, 2017).

Figure 26: Northeast Ohio CO Monitor Locations



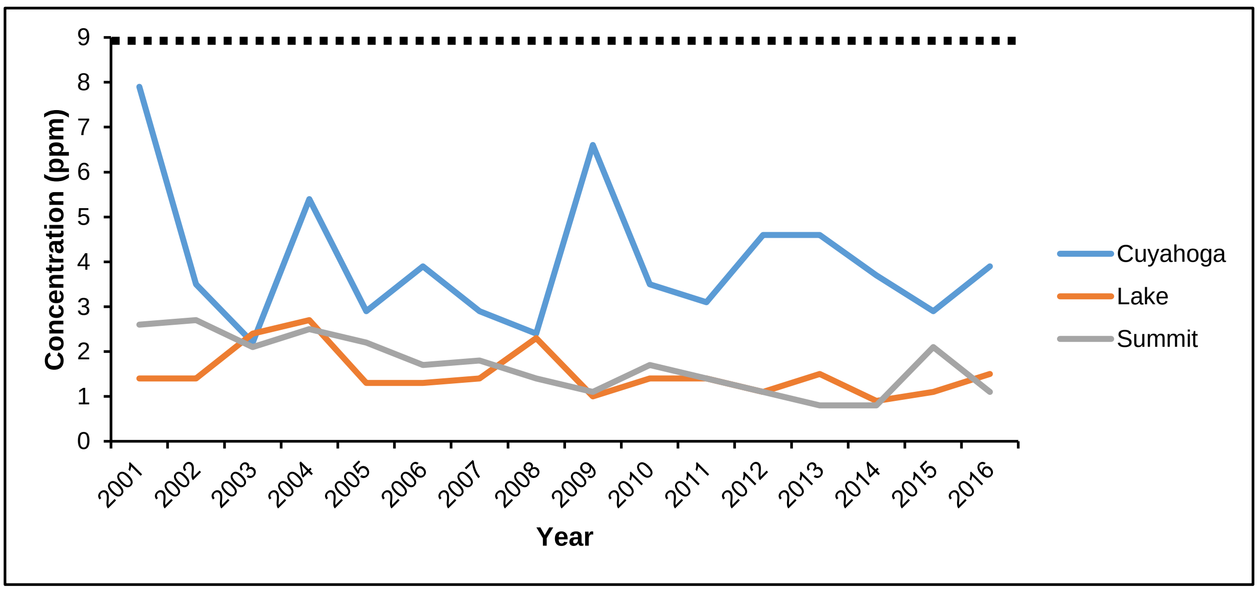
Trends: Figure 27 displays second maximum one-hour concentration data for carbon monoxide from those counties currently operating monitors (Cuyahoga, Lake, and Summit). Figure 28 displays the second maximum eight-hour concentration data for these three counties. The dashed black lines indicate the NAAQS.

Figure 27: Second Maximum 1-Hour CO Concentrations (2001-2016)[50]



Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

Figure 28: Second Maximum 8-Hour CO Concentrations (2001-2016)

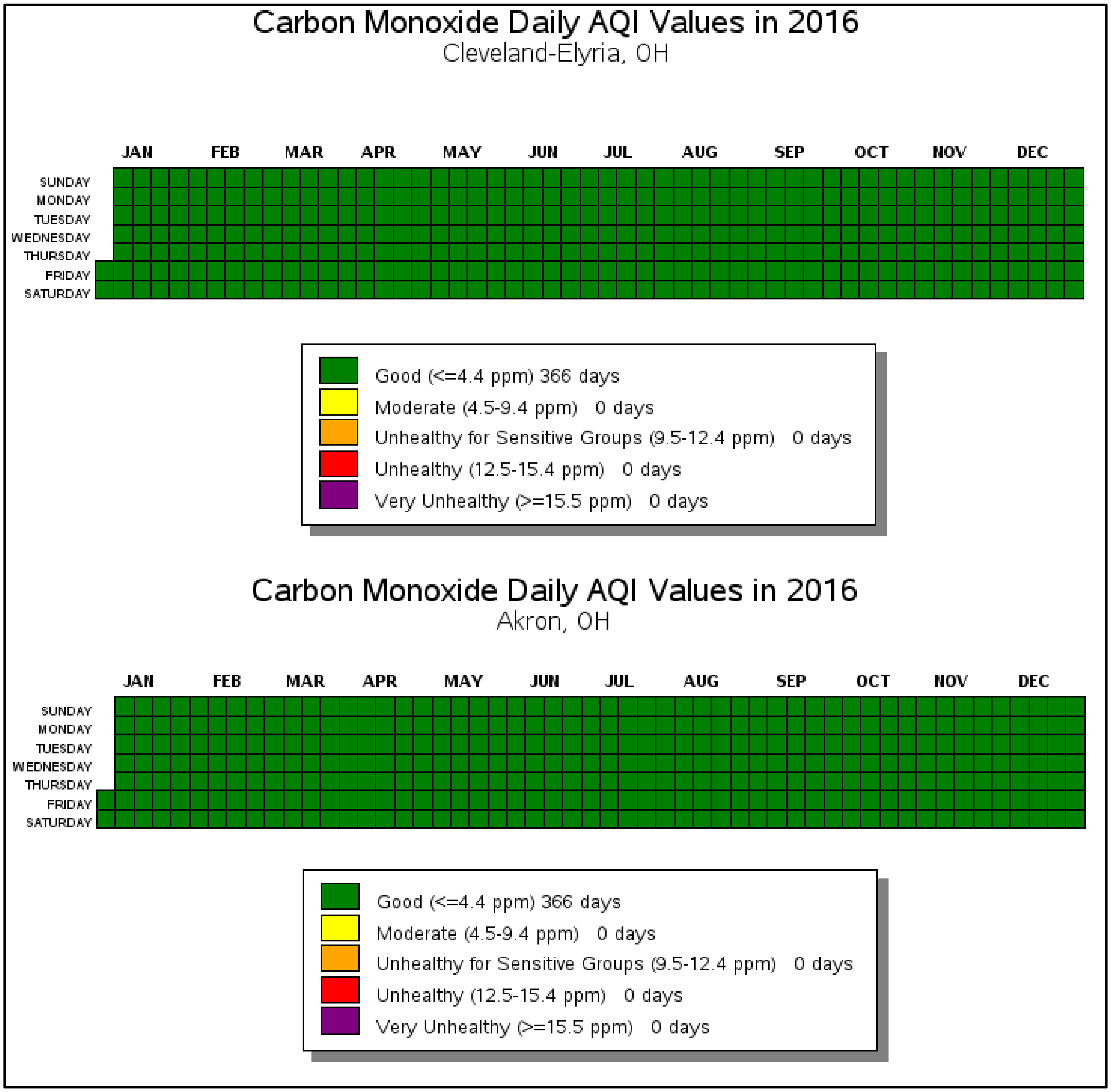


Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

The CO concentrations appear to be trending somewhat randomly. Cuyahoga County experienced a noticeable increase in 2016, as its 8-hour CO jumped from 2.9 to 3.9 ppm. That said, concentrations remain well below both the 1-hour and 8-hour NAAQS. As Figure 29 shows, both Cleveland and Akron registered good AQI values for CO on every day during 2016.

50 The dashed black lines in Figures 27 and 28 indicate the NAAQS in effect during each period.

Figure 29: Daily CO AQI Levels in 2016[51]



Source: U.S. EPA, "Air Data Tile Plot," http://www.epa.gov/airquality/airdata/ad_viz_tile.html (accessed June 1, 2017).

[51] U.S. EPA rounds all concentrations at the first decimal place. Accordingly, EPA rounds down all values below 9.5 ppm, while those greater than or equal to 9.5 are rounded up and treated as an exceedance.

5.5 Lead

Properties: Lead (Pb) exists in its elemental form in the atmosphere and, in Northeast Ohio, in the ground, where particles from leaded gasoline and lead-based paint have settled. Pb accumulates in the body and can damage kidneys, liver, the nervous system, and other organs.

Sources: Historically, leaded gasoline was the primary source of Pb emissions, although in Cleveland a single source, Master Metals, was responsible for large amounts of fugitive lead emissions. Master Metals is now defunct, and a comprehensive environmental remediation has been performed at its former site.

U.S. EPA began efforts to phase out the use of lead in gasoline in the early 1970s, but it was not until December 31, 1995, that the use of leaded gasoline in on-road vehicles was officially banned. Lead additives are still used in off-road engines. Lead-based paint is also no longer manufactured, but it remains in a large number of older buildings throughout the region. Only metal industries and battery manufacturers remain significant contributors to atmospheric Pb pollution. In Northeast Ohio, the primary source of Pb pollution has been the area surrounding the Ferro Corporation in Cleveland's Industrial Flats.

NAAQS and Nonattainment Status: On November 12, 2008, U.S. EPA substantially strengthened the primary NAAQS for Pb by lowering it from 1.5 $\mu g/m^3$—a level set in 1978—to a level of 0.15 $\mu g/m^3$ (73 FR 66964).

On November 16, 2010, U.S. EPA designated the portions of Cuyahoga County that surround the Ferro Corporation as a nonattainment area for Pb, based on data from 2007-2009 (FR 76 72097). This designation was effective as of November 22, 2011, with an attainment date set for December 31, 2015. U.S. EPA defines the nonattainment area as the "portions of Cuyahoga County that are bounded on the west by Washington Park Boulevard/Crete Avenue/East 49th Street, on the east by East 71st Street, on the north by Fleet Avenue, and on the south by Grant Avenue."[52] The rest of Cuyahoga County, and all other counties in Northeast Ohio, are unclassified/attainment areas.[53]

On February 20, 2015, Ohio EPA submitted a request to U.S. EPA to determine if Cleveland had attained the Pb NAAQS. U.S. EPA responded on May 26, 2015 (80 FR 29964). Based upon 2012-2015 monitoring data, U.S. EPA determined that Cleveland had attained the 2008 Pb NAAQS. U.S. EPA formally re-designated Cleveland as a maintenance area for the 2008 Pb NAAQS on May 31, 2017 (82 FR 24871), and this action took effect on July 31, 2017.

Monitors: There are six operating Pb monitors in Northeast Ohio, all in Cuyahoga County (see Table 14 and Figure 30).

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[52] 40 C.F.R. § 81.336 (2010).

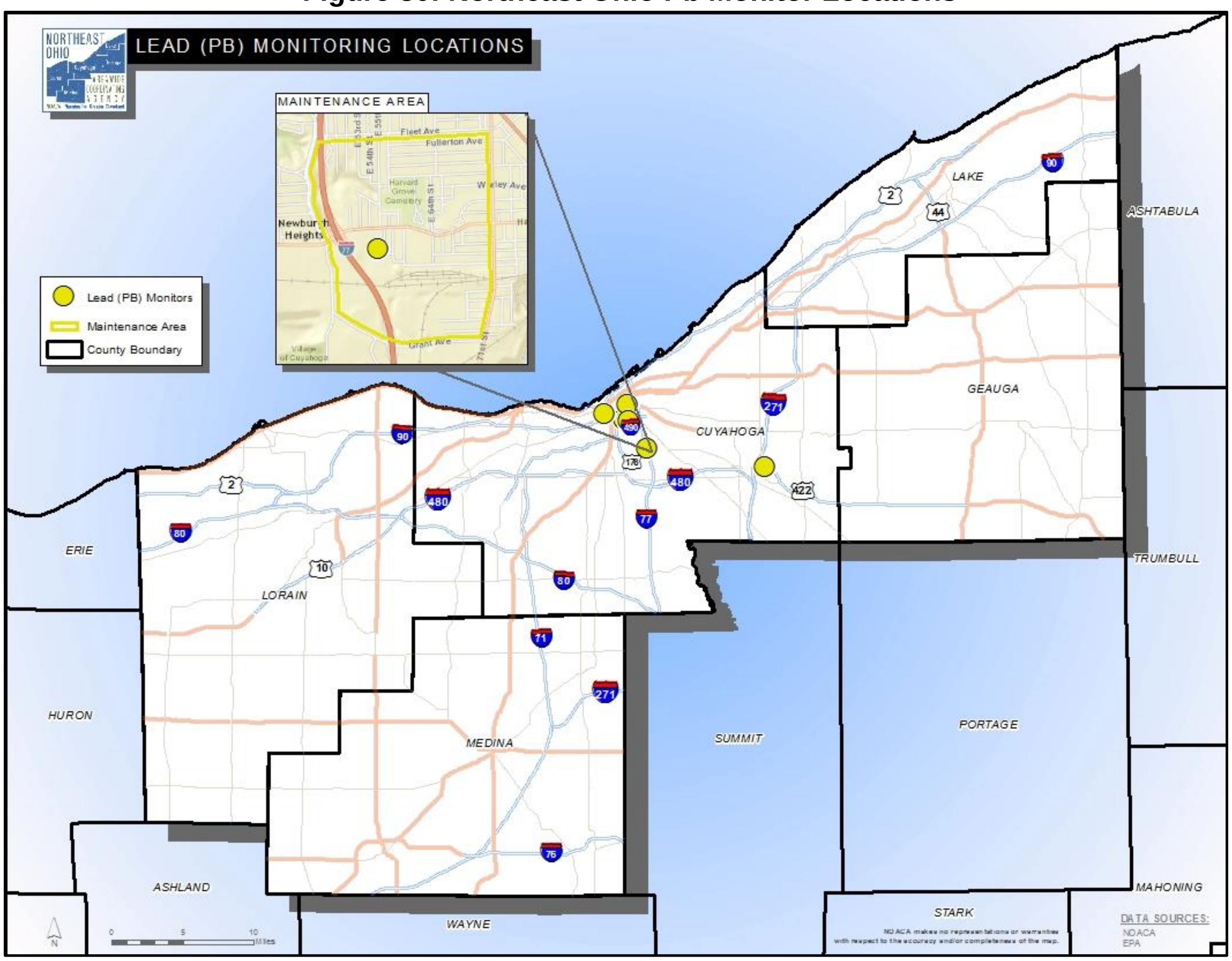
[53] Ohio EPA Division of Air Pollution Control, *Ohio's 2008 Lead Standard: Second Round of Recommended Designations* (Columbus, OH: Ohio EPA, 2010), http://www.epa.ohio.gov/portals/27/SIP/lead/2008_Lead_Standard_Updated_Recommendated_NA_Areas-FINAL.pdf (accessed December 1, 2016).

Table 14: Locations of Pb Monitors in Cuyahoga County

Monitor	County	FIPS ID	Site ID	Latitude	Longitude	Address
1	Cuyahoga	035	0038	41.47	-81.68	St. Theodosius, St. Tikhon Ave., Cleveland
2			0042	41.48	-81.70	Fire Station 4, 3136 Lorain Ave., Cleveland
3			0049	41.44	-81.65	Ferro Corp., East 56th St., Cleveland
4			0060	41.49	-81.67	East 14th St. & Orange Ave., Cleveland
5			0061	41.44	-81.66	South Side West 3rd St., Cleveland
6			0072	41.42	-81.49	26565 Miles Rd., Warrensville

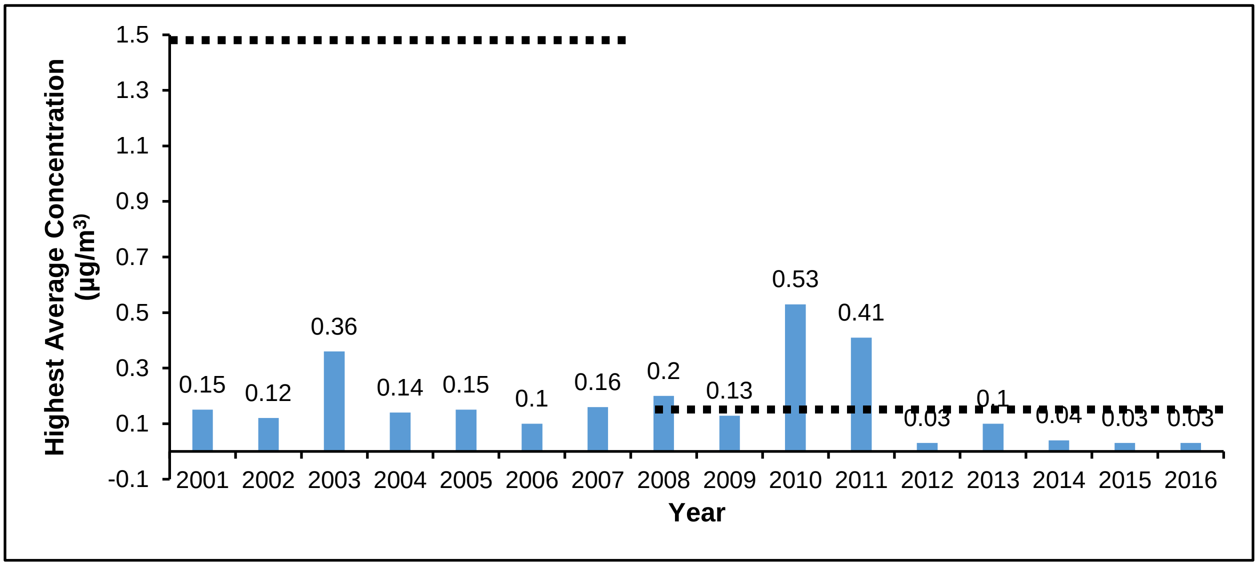
Source: Ohio EPA, Ohio Air Monitoring Network Plan 2016-2017, http://epa.ohio.gov/Portals/27/ams/sites/Ohio_2016-2017_AirMonNetPlan_MainRep_RevNov2016_FINAL.pdf (accessed June 1, 2017).

Figure 30: Northeast Ohio Pb Monitor Locations



Trends: Figure 31 displays three-month average Pb concentrations. The highest average in 2016, a three-month concentration of 0.03 µg/m^3, was reported at monitor 39-035-0061 on West 3rd Street in Cleveland. This concentration remains well below the NAAQS levels.

Figure 31: Highest 3-Month Average Pb Concentrations in Cuyahoga County (2001-2016)[54]



Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

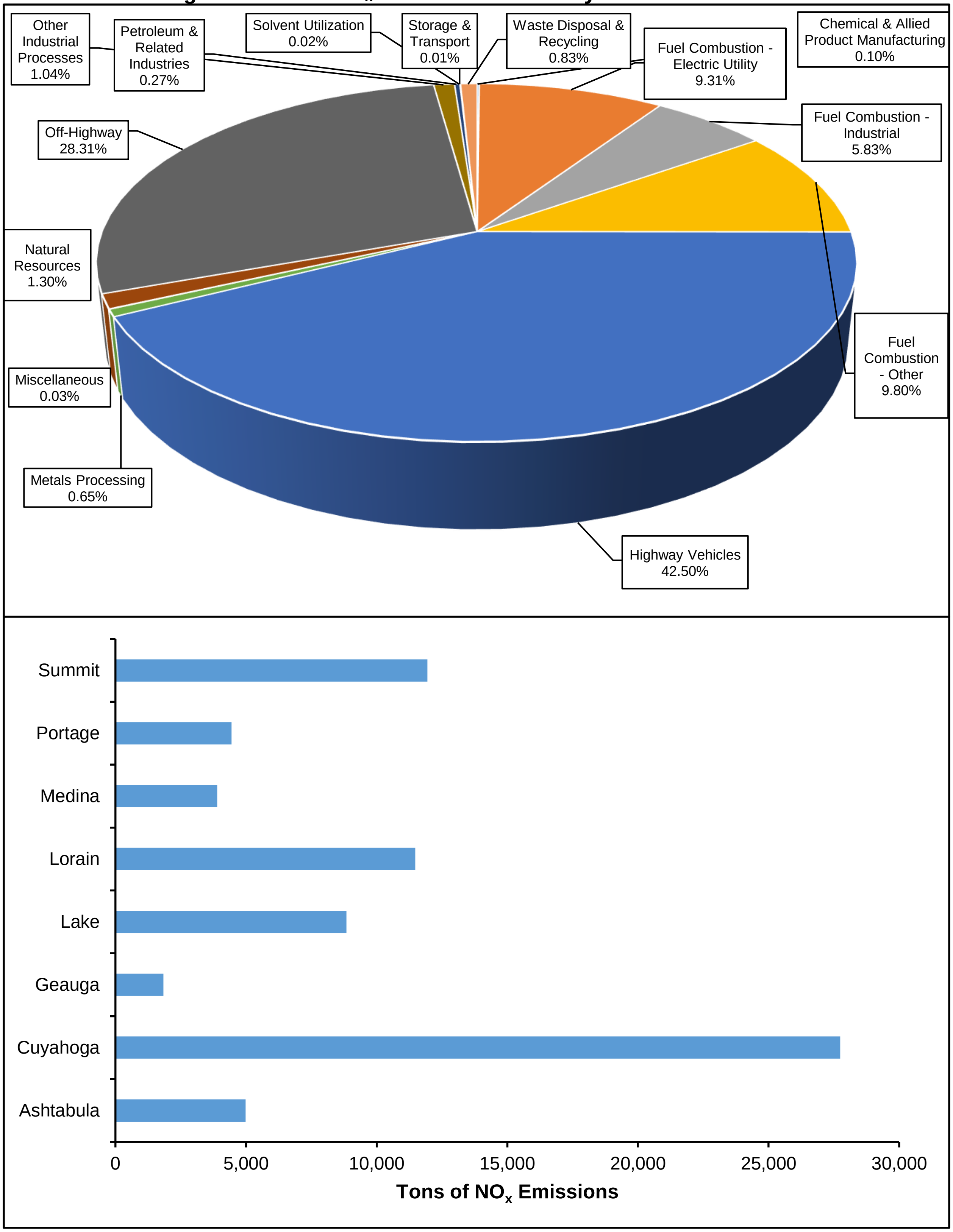
5.6 Nitrogen Dioxide

Properties: Nitrogen dioxide (NO_2) is formed by the oxidation of nitric oxide (NO) in the atmosphere. NO_2 is one of a family of compounds known collectively as nitrogen oxides (NO_x). NO_2 is a reddish-brown gas. It is readily apparent around urban areas during hot, stagnant weather. On its own, NO_2 is dangerous, as it can worsen respiratory conditions and reduce one's resistance to lung infection. It also plays a major role in O_3 formation, secondary $PM_{2.5}$ formation, climate change, and stratospheric ozone depletion. Accordingly, actions that reduce NO_2 emissions also tend to reduce emissions from other members of the NO_x family, improving overall air quality.[55]

Sources: High-temperature combustion processes release NO_2. Figure 32 shows the source sectors of NO_x in Northeast Ohio, which includes NO_2. The largest sources of NO_x are highway vehicles, off-highway vehicles, and industrial fossil fuel combustion, including electricity generation.

[54] The dashed black line indicates the NAAQS in effect during this period.
[55] U.S. EPA, "Nitrogen Dioxide," http://www.epa.gov/airquality/nitrogenoxides/index.html (accessed June 1, 2017).

Figure 32: 2014 NO_x Emissions Inventory for Northeast Ohio



Source: U.S. EPA, *2014 National Emissions Inventory*, https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data (accessed June 1, 2017).

NAAQS and Nonattainment Status: Effective January 22, 2010, there are two primary NAAQS for NO_2: an annual arithmetic mean of 53 ppb and a one-hour standard of 100 ppb. To attain the NAAQS, the three-year average of the 98th percentile of the daily maximum one-hour average at each monitor within an area must not exceed 100 ppb.

No portion of Northeast Ohio is designated as in nonattainment for NO_2. Cuyahoga County is the only county monitoring for this pollutant within the region. U.S. EPA designated all areas as unclassifiable/attainment for the new standard on February 12, 2012 (77 FR 9532).

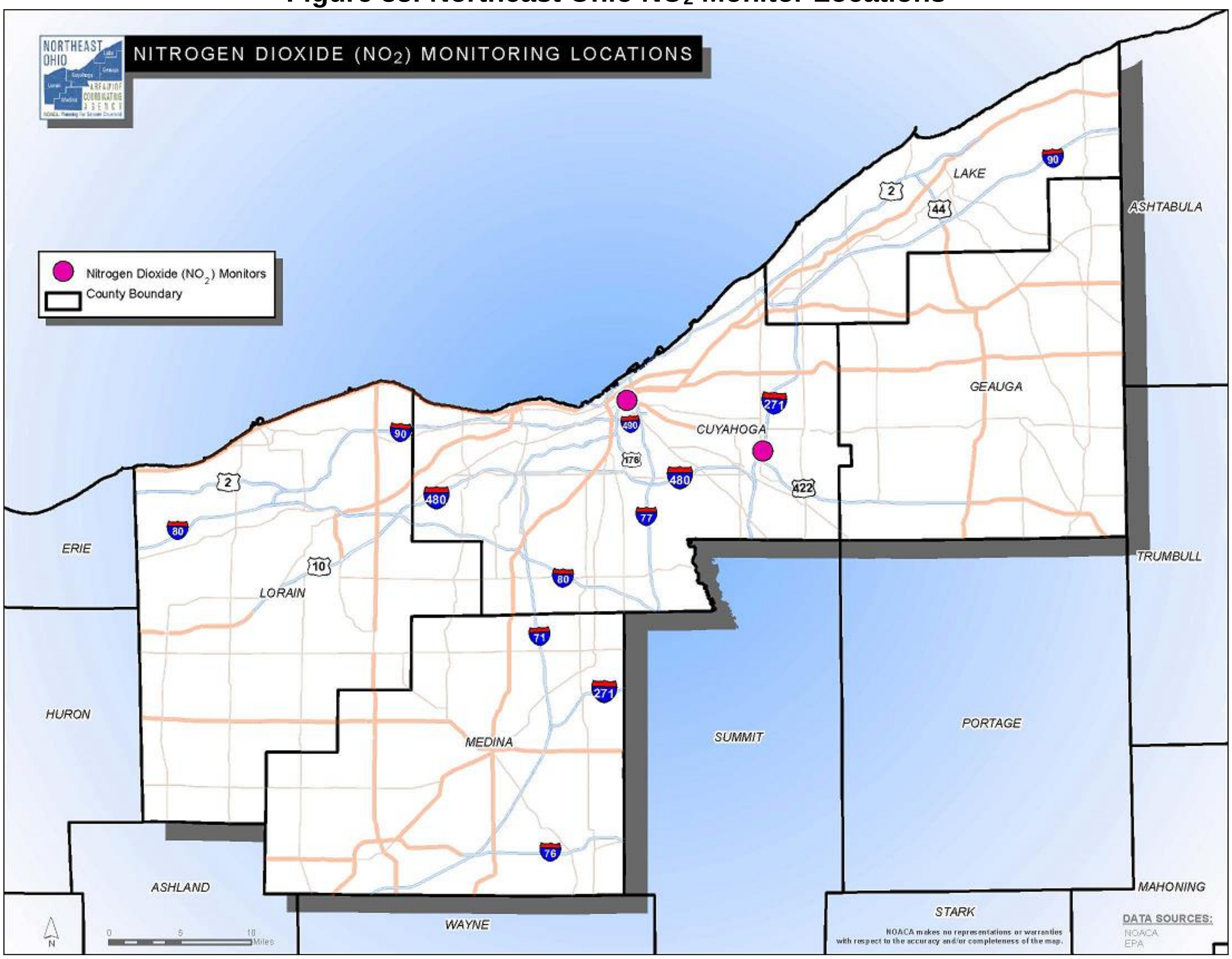
Monitors: There are two monitors for NO_2 in Northeast Ohio, both in Cuyahoga County (see Table 15 and Figure 33).

Table 15: Locations of NO_2 Monitors in Northeast Ohio

Monitor	County	FIPS ID	Site ID	Latitude	Longitude	Address
1	Cuyahoga	035	0060	41.49	-81.67	GTCraig, East 14th St. & Orange Ave., Cleveland
2			0073	41.44	-81.49	ODOT, 26565 Miles Rd., Warrensville Hts.

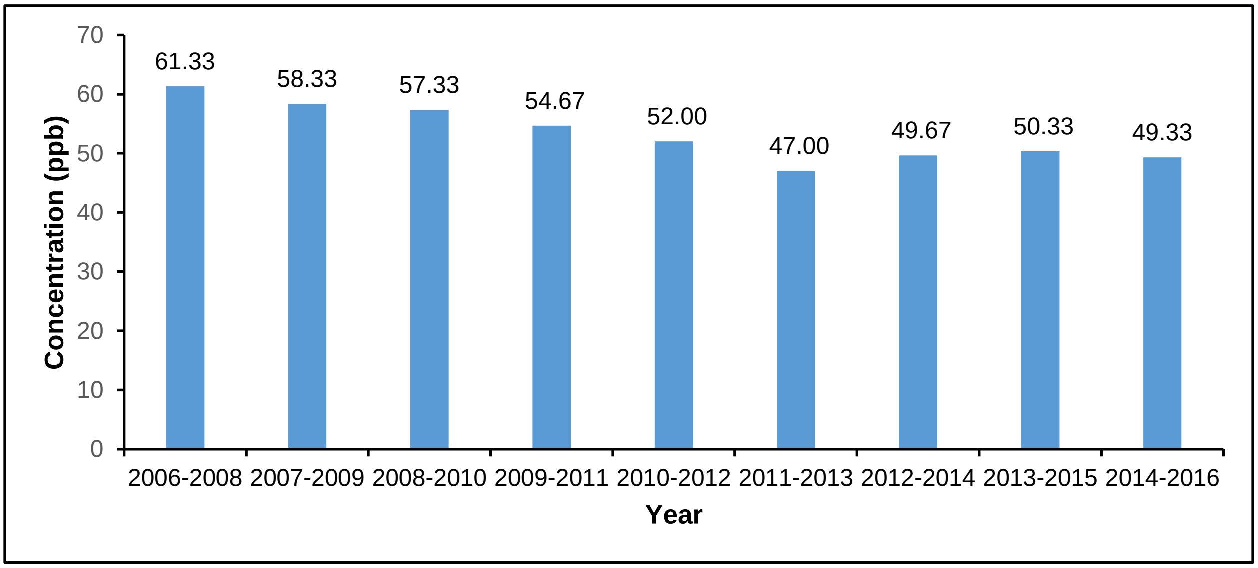
Source: Ohio EPA, *Ohio Air Monitoring Network Plan 2016-2017*, http://epa.ohio.gov/Portals/27/ams/sites/Ohio_2016-2017_AirMonNetPlan_MainRep_RevNov2016_FINAL.pdf (accessed June 1, 2017).

Figure 33: Northeast Ohio NO_2 Monitor Locations



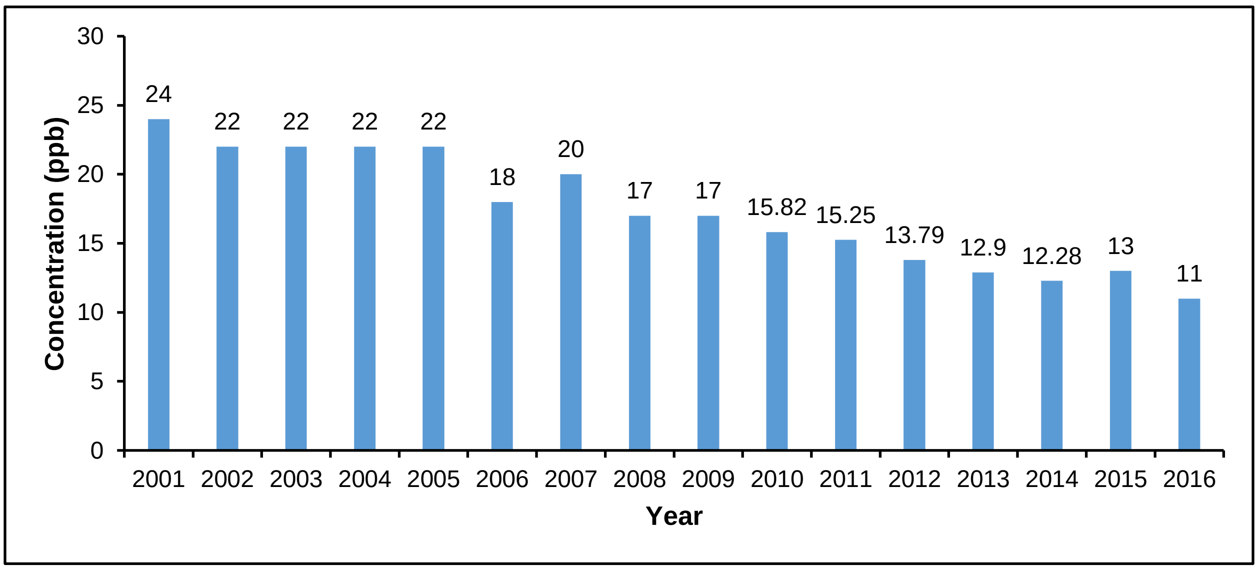
Trends: Figure 34 displays the three-year average of the 98th percentile of the daily maximum one-hour average (100 ppb NAAQS). Figure 35, in turn, shows the annual mean concentrations for NO_2 in Cuyahoga County (53ppb NAAQS). NO_2 levels decreased over the past decade, though that progress has largely stalled in recent years.

Figure 34: 3-Year Average of the 98th Percentile of the Daily Maximum 1-Hour Average NO_2 for Cuyahoga County (2006-2016)



Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

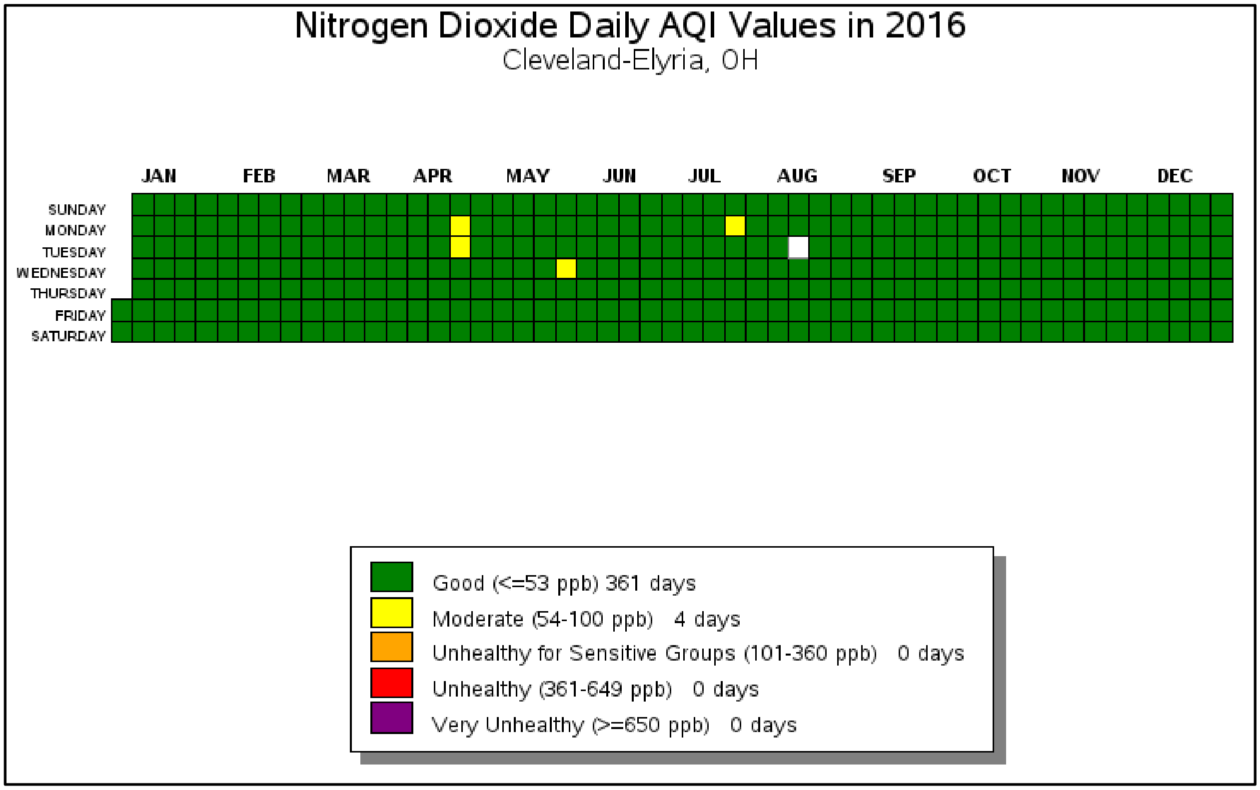
Figure 35: Annual Mean NO_2 Concentration for Cuyahoga County (2001-2016)



Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

Figure 36 shows the daily AQI values for NO_2 in Northeast Ohio during 2016. As it illustrates, the region had 361 Good AQI days and just four Moderate AQI days for NO_2.

Figure 36: Daily NO_2 AQI Levels in 2016



Source: U.S. EPA, "Air Data Tile Plot," http://www.epa.gov/airquality/airdata/ad_viz_tile.html (accessed June 1, 2017).

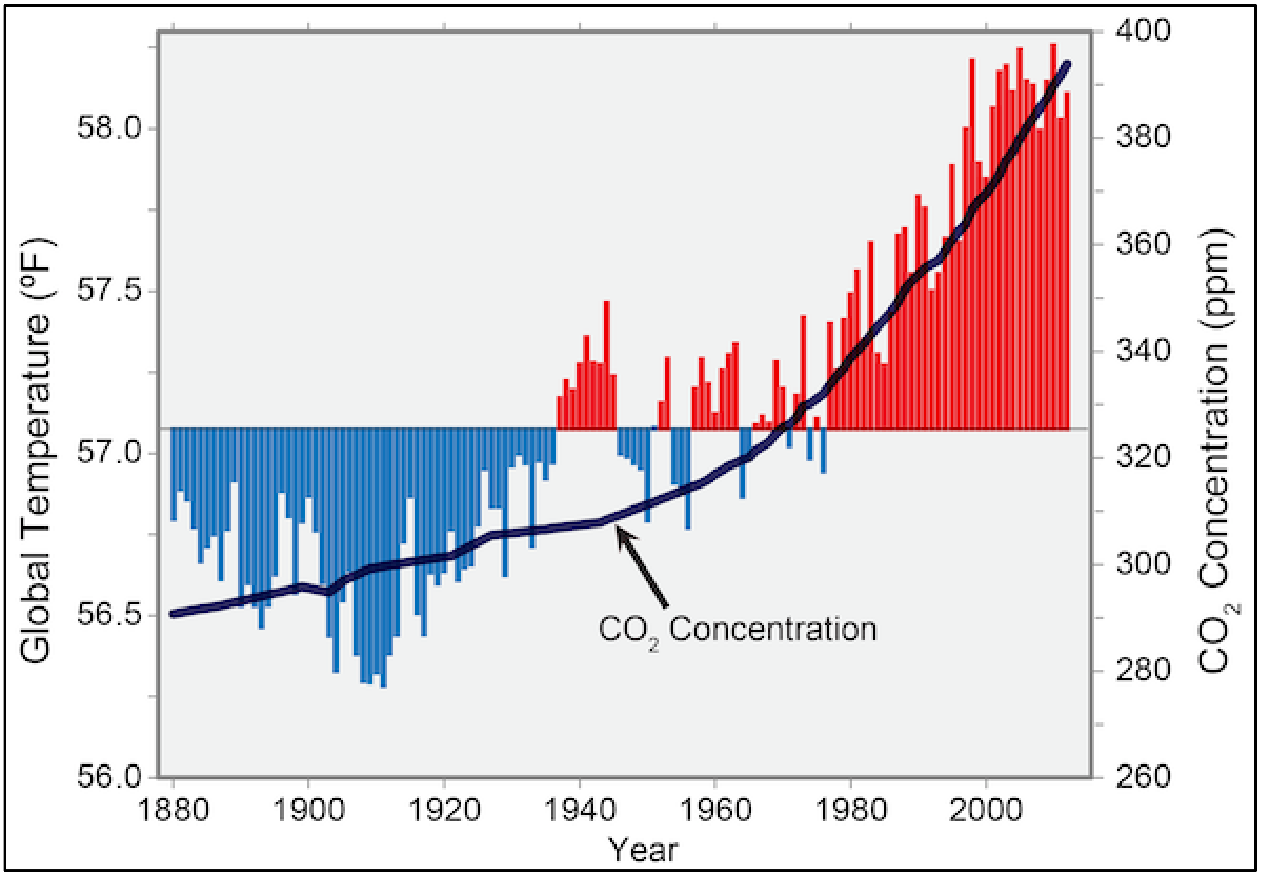
6. Climate Change and Greenhouse Gas Emissions

Climate change is a global phenomenon that includes any significant change in the climate that lasts for extended periods of time. Global warming, which refers to the observed increase in average global surface temperatures over the past several decades, is one facet of climate change.[56] Other components include changes in precipitation, wind patterns, the cryosphere, and extreme weather events. Over the past century, humans have released large amounts of CO_2 and other greenhouse gases (GHGs) into the atmosphere. Most of these emissions have come from the combustion of fossil fuels, such as coal, natural gas, and oil; however, land-use changes, such as deforestation and agriculture, are also major contributors, both due to direct emissions and the elimination of carbon sinks (which pull carbon out of the atmosphere and sequester it, such as forests). According to the Intergovernmental Panel on Climate Change (IPCC), human activities have increased atmospheric concentrations of GHGs to their highest levels in at least 800,000 years, and humans are the dominant cause of changes to the global climate since the mid-20th century.[57]

GHGs act like a form of atmospheric insulation, trapping energy in the atmosphere and increasing global temperatures. GHGs allow ultraviolet radiation from the sun to enter the atmosphere; however, because they trap infrared radiation, they prevent a portion of that energy from escaping back into space. Though GHGs make up a tiny fraction of the composition of the atmosphere (0.04%), they can significantly affect the global climate. As a result, global average surface temperatures have increased by approximately 0.85ºC since 1880.[58] Figure 37, below, shows the strong correlation between the increase in carbon dioxide (CO_2) concentrations and global temperatures.

[56] U.S. EPA, "Climate Change: Basic Information," https://www3.epa.gov/climatechange/basics/ (accessed June 1, 2017).
[57] Intergovernmental Panel on Climate Change, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Geneva: IPCC, 2014), http://www.ipcc.ch/report/ar5/syr/ (accessed June 1, 2017).
[58] Ibid.

Figure 37: Correlation between CO_2 Concentrations and Global Temperatures (1880-2016)



Source: U.S. Global Change Research Program, *Climate Change Impacts in the United States: The Third National Climate Assessment*, 23, http://www.globalchange.gov/browse/reports/climate-change-impacts-united-states-third-national-climate-assessment-0 (accessed June 1, 2017).

GHG Control Measures: Although the CAA does not list CO_2 among the criteria air pollutants, U.S. EPA has taken steps to regulate GHG emissions under the Clean Air Act. In its 2007 ruling in *Massachusetts v. EPA,* the U.S. Supreme Court ruled that GHGs, including CO_2, are pollutants covered by the Act.[59] The Court ordered the U.S. EPA to determine whether GHGs contribute to air pollution and pose a threat to human health. U.S. EPA issued its "endangerment finding" on December 7, 2009, ruling that GHGs exacerbate air pollution and threaten human health and welfare (74 FR 66496).

Research demonstrates that taking steps to mitigate GHG emissions can help improve air quality and public health. One study found that the air quality benefits associated with cutting GHG emissions can offset the costs of implementing these regulations by orders of magnitude.[60] U.S. EPA projects that its CAFE standards for light-duty vehicles (77 FR 62624), which will increase average fuel economy to 54.5 miles per gallon (mpg), will generate $3.1-9.2 billion in public health benefits from reducing ambient levels of O_3 and $PM_{2.5}$.[61]

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[59] *Massachusetts v. EPA*, 127 S. Ct. 1438 (2007).
[60] T.M. Thompson, S. Rausch, R.K. Saari, and N.E. Selin, "A systems approach to evaluating the air quality co-benefits of US carbon policies," *Nature Climate Change* 4 (2014), 917-923.
[61] U.S. EPA, *Regulatory Impact Analysis: Final Rulemaking for 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards* (Washington, D.C.: U.S. EPA, 2012), https://www3.epa.gov/otaq/climate/documents/420r12016.pdf (accessed June 1, 2017).

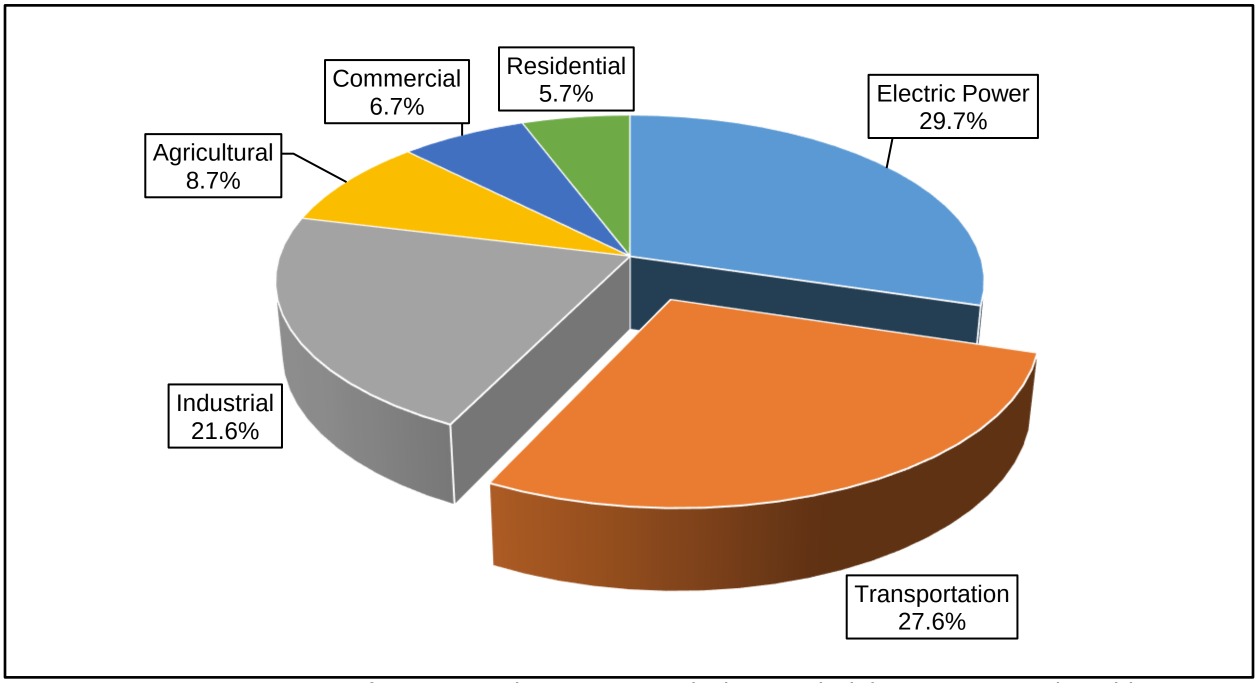
In December 2015, leaders of 196 countries adopted the Paris Agreement, which commits the international community to hold the increase in global temperatures "to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C."[62] To remain below 2°C, global GHG emissions must peak by 2030, decline approximately 40-70% by 2050 (compared to 2010 levels), and reach near-zero levels by 2100.[63] To meet these benchmarks, emissions will need to decline by approximately 5.5% per year globally.[64]

Sources: GHG emissions have increased dramatically in recent years. Nearly half of all manmade GHG emissions generated since 1750 were released over the past four decades.[65] Global GHG emissions reached approximately 49 gigatons of CO_2 equivalent ($GtCO_2e$) in 2010, up from 27 $GtCO_2e$ in 1970.[66] Electric generation accounts for the largest share (25%) of emissions, followed closely by agriculture, forestry, and other land uses (24%) and industry (21%). While transportation trails these three other sectors, its relative contribution to global emissions has increased rapidly during this period. In 2010, global transportation GHG emissions rose to 7 $GtCO_2e$ (14%), more than double the 2.8 $GtCO_2e$ (10%) released four decades earlier.

In the U.S., the electric power sector released 1,941.4 million metric tons of CO_2 equivalent ($MMTCO_2e$) in 2015, accounting for 29.7% of total emissions (see Figure 38).[67] But transportation makes up a larger share of GHG emissions in the U.S. than it does globally—the sector generated 1,806.6 $MMTCO_2e$, equal to 27.6% of emissions. Transportation sector emissions rose by 16% from 1990 to 2015; however, this increase in emissions was smaller than the 40% increase in VMT, as a result of the improving vehicle fuel economy during that period.[68]

[62] *Paris Agreement,* United Nations Framework Convention on Climate Change (UNFCCC), Dec., 12, 2015, FCCC/CP/2015/10/Add.1. On June 1, 2017, President Donald Trump announced his intention to withdraw the U.S. from the Paris Agreement, a decision which could take effect on November 4, 2020.
[63] IPCC, 20.
[64] Michael R. Raupach, Steven J. Davis, Glenn P. Peters, et al., "Sharing a quota on cumulative carbon emissions," *Nature Climate Change* (2014): vol. 4, 873-879.
[65] IPCC, 4.
[66] U.S. EPA, "Global Greenhouse Gas Emissions Data," https://www3.epa.gov/climatechange/ghgemissions/global.html (Accessed June 1, 2017).
[67] U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2014* (Washington, D.C.: U.S. EPA, 2016), https://www.epa.gov/sites/production/files/2016-04/documents/us-ghg-inventory-2016-main-text.pdf (accessed June 1, 2017).
[68] Ibid., 2-29 – 2-31.

Figure 38: Share of GHG Emissions by Sector – United States

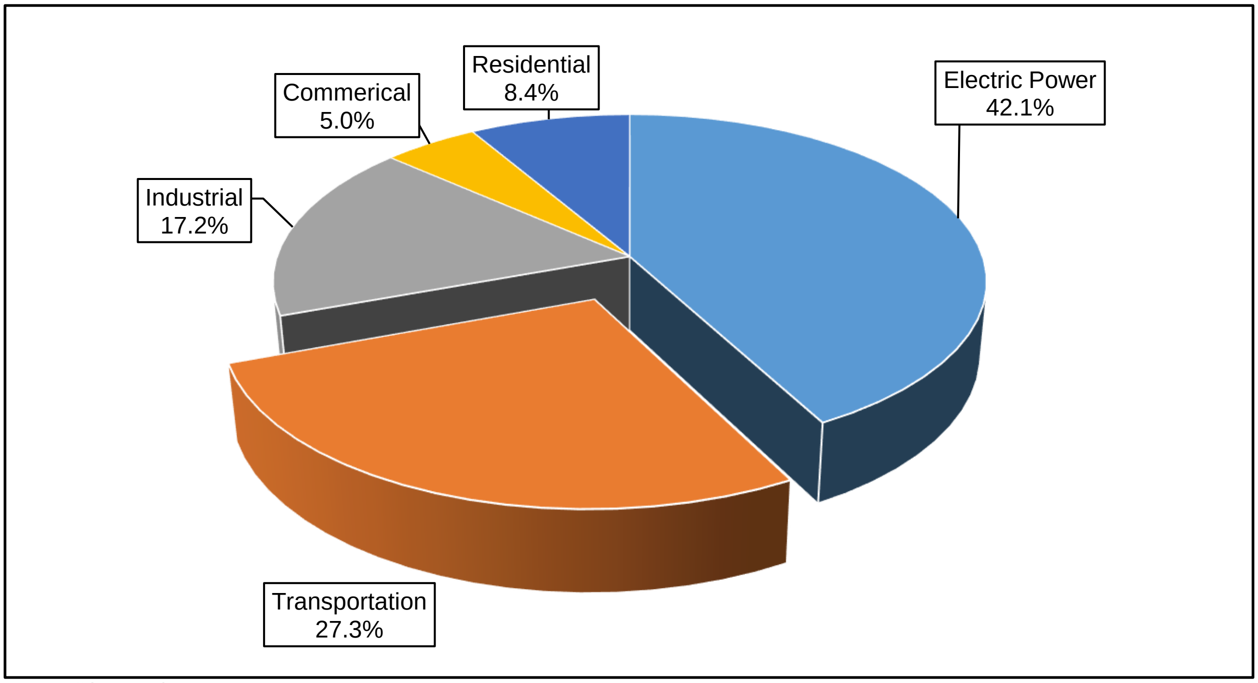


Source: U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2015* (Washington, D.C.: U.S. EPA, 2017), https://www.epa.gov/sites/production/files/2017-02/documents/2017_complete_report.pdf (accessed June 1, 2017).

According to the U.S. Energy Information Agency (EIA), the transportation sector made up 27.3% of total GHGs in Ohio, second only to the electric power industry.[69] Due in large part to Ohio's reliance on coal-fired power plants, this sector makes up a greater share of total GHGs in the state (42.1%) than it does nationally (29.7%).[70] Figure 39 breaks down GHG emissions in Ohio by economic sector.

[69] Energy Information Agency, "State CO_2 Emissions 2014," http://www.eia.gov/environment/emissions/state/ (accessed June 1, 2017).
[70] Ibid.

Figure 39: Share of GHG Emissions by Sector – Ohio



EIA, "State Carbon Dioxide Emissions 2014," http://www.eia.gov/environment/emissions/state/ (accessed June 1, 2017).

GHG emissions from the transportation sector include CO_2, methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons (HFCs). While CO_2, CH_4, and N_2O are emitted from the combustion of fossil fuels, HFCs are released by leaks from and the disposal of vehicle air conditioning units.[71] Each of these gases can store a different amount of heat energy per unit. The relative ability of each GHG to contribute to global warming is known as its global warming potential (GWP). As Table 16 shows, CO_2 makes up the largest share (96.7%) of GHG emissions from the transportation sector in the U.S. Because CO_2 is the most common GHG, officials express GHGs, based upon their GWP, in tons of CO_2 equivalent (TCO_2e).

Table 16: Global Warming Potential of Transportation Sector GHGs

Greenhouse Gas	Global Warming Potential	Percent of Transportation Sector GHG Emissions[a]
CO_2	1	96.66%
CH_4	25	0.09%
N_2O	114	0.75%
HFCs	124 to 14,800[b]	2.50%

[a]This value expresses the range of GWPs for each of the HFCs relevant to the transportation sector.
Source: U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks*.

[71] U.S. EPA, *Fast Facts: U.S. Transportation Sector Greenhouse Gas Emissions 1990-2013* (Washington, D.C.: U.S. EPA, 2015), https://www.epa.gov/sites/production/files/2016-02/documents/420f15032.pdf (accessed June 1, 2017).

6.1 Transportation Sector Greenhouse Gas Emissions in Northeast Ohio

As for both the state of Ohio and the U.S. as a whole, the transportation sector accounts for around one-quarter of total GHG emissions in Northeast Ohio.[72] Transportation sector GHG emissions vary by county. NOACA used U.S. EPA's Motor Vehicle Emissions Simulator (MOVES), version 2014a, to model on-road GHG emissions during 2016 for the five-county NOACA region.

Table 17 displays each county's relative share of emissions, along with its percentage of the region's total population. Regionally, transportation accounted for more than 9.5 $MMTCO_2e$ last year. Unsurprisingly, Cuyahoga County, which has the largest population, has consistently generated more GHGs than any of the four other counties in the area. In 2016, Cuyahoga County accounted for 54.5% of total emissions, lower than its share of the regional population (61.1%). Three of the four other counties generated a lager share of GHGs than its share of regional population; the largest disparity occurred in Medina County, which generated 13% of GHGs but is home to just 8.5% of the population. Figure 40 illustrates the breakdown of GHG emissions by county. Based upon these estimates, Northeast Ohio residents produced 4.6 tons of on-road CO_2e per capita during 2016, below the national average of 4.8. The per capita totals ranged from a low of 4.1 tons per capita in Cuyahoga County to a high of 7.0 tons per capita in Medina County.

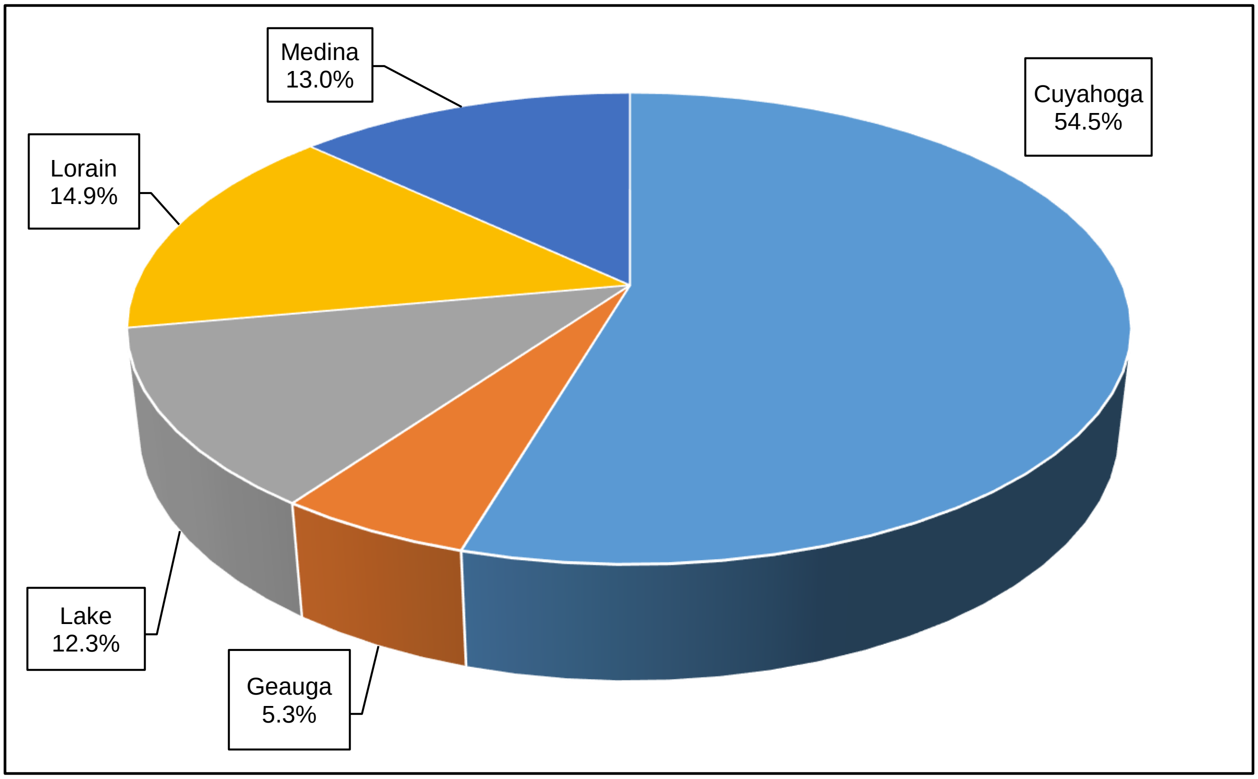
Table 17: Population & On-Road GHG Emissions in Northeast Ohio by County

County	2016 Population[a]	% 2016 Population	2016 GHG Emissions ($MTCO_2e$)[b]	% 2016 GHG Emissions	GHG Tons Per Capita[b]
Cuyahoga	1,258,710	61.1%	5,201,625	54.5%	4.1
Geauga	94,020	4.6%	507,607	5.3%	5.4
Lake	229,266	11.1%	1,168,431	12.3%	5.1
Lorain	304,091	14.8%	1,423,363	14.9%	4.7
Medina	175.543	8.5%	1,236,894	13.0%	7.0
Totals	2,061,630		9,537,920		4.6

[a] U.S. Census Bureau, "2012-2016 American Community Survey 5-Year Estimates."
[b] GHG totals are depicted in metric tons of CO_2e.
Source: NOACA estimates using MOVES2014a.

[72] GreenCityBlueLake Institute (GCBL), *Inventory: Northeast Ohio greenhouse gas emissions* (Cleveland: GreenCityBlueLake, 2012), http://www.gcbl.org/files/resources/ghgfinal2.pdf (accessed June 1, 2017).

Figure 40: Share of On-Road GHG Emissions in Northeast Ohio in 2016 by County



Source: NOACA estimates using MOVES2014a.

Within Northeast Ohio, light-duty vehicles, which include passenger cars and light-duty trucks, such as SUVs, account for the vast majority of transportation sector GHGs (80.5%) and the largest share of vehicles (93.3%) (see Table 18). While medium- and heavy-duty trucks make up just 3.6% of total vehicles, they generate 17.4% of total GHGs. Combined, motorcycles and buses account for just 2% of total on-road GHG emissions.

Table 18: Northeast Ohio On-Road GHG Emissions by Vehicle Type

Vehicle Type	2016 GHG Emissions ($MTCO_2e$)[a]	% 2016 GHG Emissions[b]	% 2016 Vehicle Population
Light-Duty Vehicles	7,678,862	80.5%	93.3%
➢ Passenger Cars	3,077,334	32.3%	49.5%
➢ Light-Duty Trucks	4,601,658	48.2%	43.8%
Motorcycles	30,148	0.3%	2.9%
Buses	165,591	1.7%	0.2%
Medium- and Heavy-Duty Trucks	1,663,320	17.4%	3.6%

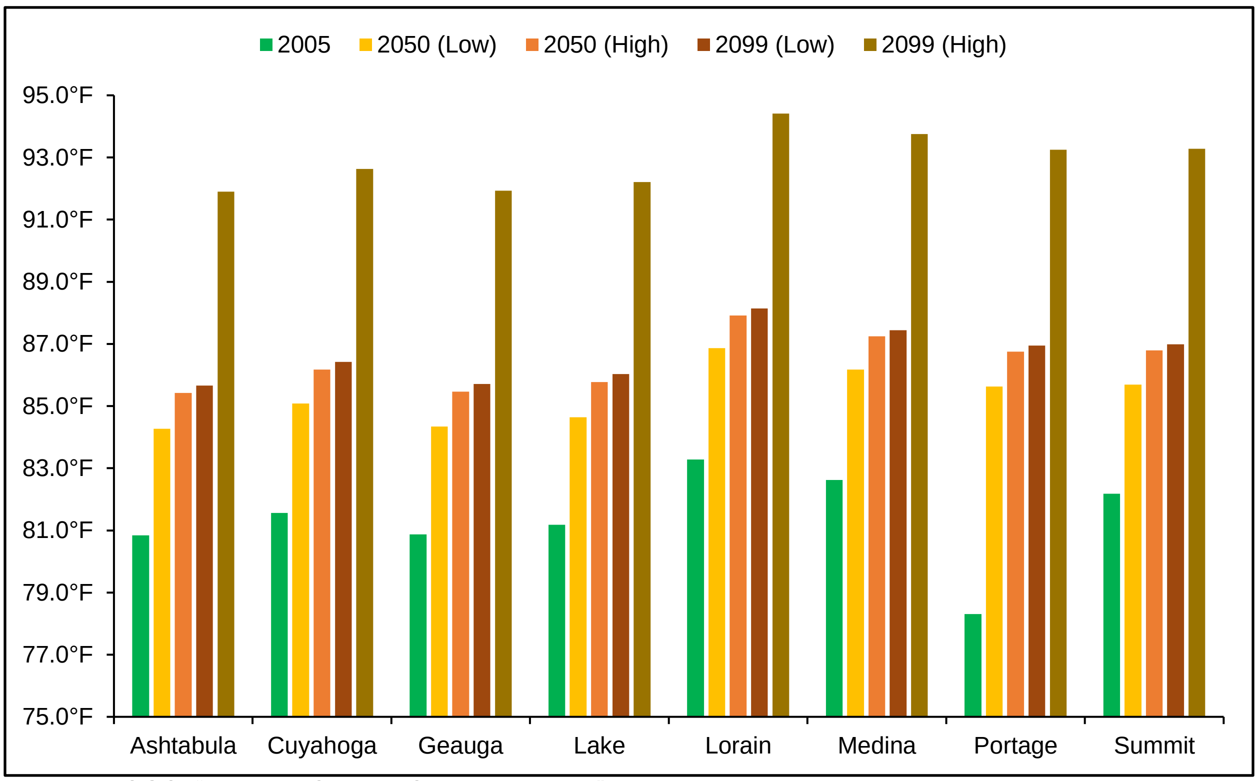
[a]GHG totals are depicted in metric tons of CO_2e.
[a]Values may not total 100% due to rounding.
Source: NOACA estimates using MOVES2014a.

6.2 Impacts of Climate Change on Air Quality in Northeast Ohio

Air pollution can contribute directly to climate change. Multiple criteria air pollutants are also GHGs. Both O_3 and $PM_{2.5}$, which are highly potent GHGs, are known as short-lived climate pollutants, which drive both poor local air quality and global warming. Black carbon (a species of $PM_{2.5}$), for instance, has a GWP of approximately 3,200 over a 20-year period.[73] According to the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO), mitigating these short-lived climate pollutants could reduce future global warming by 0.5°C.[74]

Climate change may, in turn, degrade air quality around the world, including Northeast Ohio. Ground-level O_3 forms most readily on calm, warm summer days. Climate change appears to be making these more common, and it will continue to do so in the coming decades. From 1980-2010, Northeast Ohio experienced roughly nine days per year when ambient air temperatures exceeded 90°F.[75] This number will increase significantly over the next several decades, as the region's maximum annual daily temperature is projected to rise 2.8-4.4°F by 2050 and 5.8-9.7°F by 2099.[76]

Figure 41: Projected Maximum June-August Daily Temperatures by County



Source: USGS, "National Climate Change Viewer," https://www2.usgs.gov/climate_landuse/clu_rd/nccv/viewer.asp (accessed June 1, 2017).

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[73] WHO, *Reducing global health risks*, 29.
[74] UNEP & WMO, *Integrated Assessment of Black Carbon and Tropospheric Ozone* (Nairobi: UNEP & WMO, 2011), http://www.unep.org/dewa/Portals/67/pdf/BlackCarbon_report.pdf (accessed June 1, 2017).
[75] National Oceanic and Atmospheric Administration (NOAA), "NOAA's 1981-2010 Climate Normals," http://www.ncdc.noaa.gov/oa/climate/normals/usnormals.html (accessed June 1, 2017).
[76] Projections are drawn from the U.S. Geological Survey's "National Climate Change Viewer," which produces downscaled climate projections based on global climate models from the IPCC.

These temperature increases will be particularly stark during the summer months (June-August), when O_3 exceedance days are most likely, as shown in Figure 41. Compared to 2005, maximum daily summer temperatures in the eight-county air quality planning area may increase 3.9-5.1°F by 2050 and 5.3-11.6°F by 2099. In the latter, most extreme case, summer temperatures would exceed 92°F on a daily basis. One study projects that Northeast Ohio will experience three to 14 days over 95°F by 2050, a number that may climb to 10-66 by the end of the century.[77] Such increases in summertime air temperatures would make it more likely for ground-level O_3 to form, effectively offsetting some of the benefits of continued emissions reductions. (However, this relationship is not necessarily linear; some research suggests that temperatures above 95°F can actually suppress further ozone formation.[78]) U.S. EPA estimates that climate change may increase daily eight-hour maximum ozone levels by 1-5 ppb in 2030.[79]

The effect of climate change on $PM_{2.5}$ remains more ambiguous. Change in temperature and precipitation patterns will likely contribute to an increase in the frequency and intensity of wildfires in the western U.S., but this outcome is unlikely to affect air quality in Northeast Ohio.[80] The region may see a significant increase in the number of hot, humid summer days, which are conducive to $PM_{2.5}$ formation.[81] Yet, there is currently no consensus on whether climate change will necessarily increase $PM_{2.5}$ levels in the U.S. in the coming decades.

[77] Risky Business Project, *Heat in the Heartland: Climate Change and the Economic Risk in the Midwest* (New York: Risky Business Project, 2015), http://riskybusiness.org/site/assets/uploads/2015/09/RBP-Midwest-Report-WEB-1-26-15.pdf (accessed June 1, 2017).
[78] L. Shen, L.J. Mickley, and E. Gilleland, "Impact of increasing heat waves on U.S. ozone episodes in the 2050s: Results from a multimodel analysis using extreme value theory," *Geophysical Research Letters* 43, no. 8 (2016), 4017-4025.
[79] U.S. Global Change Research Program (USGCRP), *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment* (Washington, D.C.: USGCRP, 2016), 74-75, https://s3.amazonaws.com/climatehealth2016/low/ClimateHealth2016_FullReport_small.pdf (accessed June 1, 2017).
[80] J.S. Melillo, T.C. Richmond, and G.W. Yohe, eds., *Climate Change Impacts in the United States: The Third National Climate Assessment* (Washington, D.C.: U.S. Global Change Research Program, 2014), 177-178, http://nca2014.globalchange.gov/ (accessed June 1, 2017).
[81] Risky Business Project, 13.

7. Conclusion

As this report demonstrates, air quality remains an important issue in Northeast Ohio. While the region's air quality has improved considerably since the passage of the 1970 CAA, with criteria pollutant levels falling by anywhere from 13-72%, portions of the eight-county NOACA air quality planning area remained in nonattainment for one or more of the NAAQS during 2016. Additionally, transportation is a leading source of GHG emissions throughout the region, and its share may become even larger as the region continues to shift away from its reliance on coal for electricity generation.

In its capacity as both the regional air quality and transportation planning agency, NOACA continues to collect information on regional air quality, educate the public on air quality and its linkages to transportation, and strive to increase transportation choice within the region (i.e., reduce single-occupancy vehicle trips). The agency operates or implements a number of programs to serve these goals, such as Gohio Commute, the Commuter Choice Awards, air quality advisories, the Congestion Mitigation for Air Quality Improvement (CMAQ) Program, and the Transportation for Livable Communities Initiative (TLCI). These programs further the agency's vision to build a multimodal transportation system that enhances quality of life in Northeast Ohio. For more information on these programs, visit noaca.org.

For More Information

More criteria pollutant data is available from the following agencies:

- United States Environmental Protection Agency: https://www.epa.gov/outdoor-air-quality-data
- Ohio Environmental Protection Agency: www.epa.ohio.gov/dapc/airohio/index.aspx
- Cleveland Division of Air Quality: http://www.clevelandhealth.org/network/air_quality/air_quality.php
- Akron Regional Air Quality Management District: http://www.araqmd.org/
- Lake County General Health District: https://www.lcghd.org/

NOACA thanks the U.S. EPA, the Ohio EPA, the Cleveland Division of Air Quality, the Akron Regional Air Quality Management District, and the Lake County General Health District for their assistance with this report, as well as for their tireless efforts to collect meaningful, accurate air quality data for Northeast Ohio.

Appendix A: O_3 Exceedance Days 2000-2016

Year	8-Hour Ozone NAAQS	Exceedance Date	No. of Monitors Exceeding the NAAQS	Highest Monitor
2000	**85 ppb**	May 31, 2000	1	93 ppb (Ashtabula)
		June 1, 2000	1	89 ppb (Geauga)
		June 9, 2000	10	106 ppb (Ashtabula)
		June 10, 2000	9	101 ppb (Ashtabula)
		July 13, 2000	2	94 ppb (Summit)
		July 28, 2000	1	87 ppb (Lake)
	Total	**6 days**		
2001	**85 ppb**	May 3, 2001	5	99 ppb (Geauga)
		May 4, 2001	5	92 ppb (Geauga)
		June 13, 2001	5	91 ppb (Cuyahoga)
		June 14, 2001	7	100 ppb (Lake)
		June 15, 2001	1	87 ppb (Geauga)
		June 19, 2001	10	105 ppb (Ashtabula)
		June 26, 2001	1	86 ppb (Ashtabula)
		June 27, 2001	3	102 ppb (Ashtabula)
		June 28, 2001	6	103 ppb (Portage)
		June 29, 2001	4	105 ppb (Ashtabula)
		July 15, 2001	1	94 ppb (Ashtabula)
		July 16, 2001	1	89 ppb (Geauga)
		July 17, 2001	6	101 ppb (Geauga)
		July 18, 2001	4	108 ppb (Summit)
		July 19, 2001	2	87 ppb (Lorain)
		July 20, 2001	2	96 ppb (Geauga)
		July 22, 2001	1	87 ppb (Geauga)
		July 24, 2001	1	87 ppb (Geauga)
		July 31, 2001	3	100 ppb (Summit)
		August 1, 2001	9	102 ppb (Geauga)
		August 2, 2001	2	97 ppb (Geauga)
		August 6, 2001	1	90 ppb (Geauga)
		August 7, 2001	1	92 ppb (Geauga)
		August 9, 2001	1	91 ppb (Lake)
	Total	**24 days**		
2002	**85 ppb**	June 9, 2002	7	99 ppb (Summit)
		June 10, 2002	5	100 ppb (Portage)
		June 11, 2002	3	92 ppb (Ashtabula)
		June 20, 2002	7	104 ppb (Lake)
		June 21, 2002	6	108 ppb (Ashtabula)
		June 22, 2002	9	103 ppb (Lake)
		June 23, 2002	8	107 ppb (Ashtabula)
		June 24, 2002	6	105 ppb (Summit)

Year	8-Hour Ozone NAAQS	Exceedance Date	No. of Monitors Exceeding the NAAQS	Highest Monitor
		June 25, 2002	8	114 ppb (Geauga)
		June 30, 2002	4	96 ppb (Ashtabula)
		July 1, 2002	5	100 ppb (Summit)
		July 4, 2002	1	92 ppb (Ashtabula)
		July 8, 2002	7	117 ppb (Geauga)
		July 13, 2002	3	101 ppb (Summit)
		July 14, 2002	9	103 ppb (Summit)
		July 15, 2002	9	112 ppb (Summit)
		July 17, 2002	10	115 ppb (Lake)
		July 18, 2002	7	103 ppb (Lake)
		July 21, 2002	2	101 ppb (Geauga)
		July 26, 2002	1	87 ppb (Geauga)
		July 31, 2002	3	94 ppb (Lake)
		August 1, 2002	7	115 ppb (Geauga)
		August 4, 2002	5	100 ppb (Lake)
		August 10, 2002	11	115 ppb (Geauga)
		August 11, 2002	9	122 ppb (Geauga)
		August 13, 2002	7	107 ppb (Geauga)
		August 21, 2002	1	90 ppb (Geauga)
		September 7, 2002	3	93 ppb (Lake)
		September 8, 2002	10	110 ppb (Geauga)
		September 9, 2002	9	113 ppb (Lake)
		September 10, 2002	8	104 ppb (Lake)
	Total	**31 days**		
2003	**85 ppb**	June 23, 2003	10	120 ppb (Geauga)
		June 24, 2003	7	123 ppb (Portage)
		June 25, 2003	9	112 ppb (Lake)
		July 3, 2003	8	99 ppb (Ashtabula)
		August 15, 2003	1	93 ppb (Geauga)
		August 20, 2003	1	95 ppb (Geauga)
		August 21, 2003	1	89 ppb (Ashtabula)
		August 25, 2003	1	91 ppb (Geauga)
	Total	**8 days**		
2004	**85 ppb**	May 12, 2004	1	88 ppb (Ashtabula)
		May 13, 2004	1	88 ppb (Ashtabula)
		July 2, 2004	1	87 ppb (Summit)
		July 3, 2004	1	87 ppb (Summit)
		August 2, 2004	2	87 ppb (Geauga)
		August 3, 2004	1	86 ppb (Portage)
	Total	**6 days**		
2005	**85 ppb**	June 7, 2005	2	89 ppb (Ashtabula)
		June 8, 2005	3	103 ppb (Lake)
		June 9, 2005	1	95 ppb (Lake)

Year	8-Hour Ozone NAAQS	Exceedance Date	No. of Monitors Exceeding the NAAQS	Highest Monitor
		June 21, 2005	2	86 ppb (Geauga)
		June 24, 2005	5	94 ppb (Lake)
		June 25, 2005	2	104 ppb (Ashtabula)
		June 26, 2005	3	94 ppb (Medina)
		June 27, 2005	10	118 ppb (Lake)
		June 29, 2005	1	86 ppb (Portage)
		July 10, 2005	6	95 ppb (Ashtabula)
		July 11, 2005	5	101 ppb (Medina)
		July 12, 2005	3	95 ppb (Lake)
		July 20, 2005	2	90 ppb (Geauga)
		August 1, 2005	1	91 ppb (Lake)
		August 2, 2005	2	93 ppb (Portage)
		August 3, 2005	3	89 ppb (Geauga)
	Total	**16 days**		
2006	**85 ppb**	May 29, 2006	1	86 ppb (Ashtabula)
		May 30, 2006	2	99 ppb (Ashtabula)
		June 16, 2006	1	90 ppb (Cuyahoga)
		June 17, 2006	1	99 ppb (Ashtabula)
		July 16, 2006	1	90 ppb (Ashtabula)
	Total	**5 days**		
2007	**85 ppb**	April 22, 2007	1	87 ppb (Cuyahoga)
		May 23, 2007	1	103 ppb (Cuyahoga)
		May 24, 2007	4	95 ppb (Ashtabula)
		May 30, 2007	1	89 ppb (Summit)
		May 31, 2007	3	98 ppb (Ashtabula)
		June 17, 2007	1	90 ppb (Summit)
		June 18, 2007	1	89 ppb (Summit)
		July 10, 2007	1	90 ppb (Ashtabula)
		August 1, 2007	2	92 ppb (Summit)
		August 2, 2007	1	89 ppb (Summit)
		August 28, 2007	1	86 ppb (Summit)
		August 29, 2007	2	92 ppb (Ashtabula)
		September 6, 2007	1	92 ppb (Ashtabula)
	Total	**13 days**		
2008	**75 ppb**	April 18, 2008	5	82 ppb (Geauga)
	New	April 19, 2008	1	78 ppb (Ashtabula)
	NAAQS	May 30, 2008	2	83 ppb (Geauga)
		June 12, 2008	5	83 ppb (Cuyahoga)
		July 7, 2008	1	76 ppb (Lake)
		July 18, 2008	2	81 ppb (Ashtabula)
		July 28, 2008	3	81 ppb (Ashtabula)
		July 29, 2008	5	88 ppb (Cuyahoga)
		August 21, 2008	5	85 ppb (Cuyahoga)

Year	8-Hour Ozone NAAQS	Exceedance Date	No. of Monitors Exceeding the NAAQS	Highest Monitor
		September 2, 2008	4	80 ppb (Medina)
		September 3, 2008	8	92 ppb (Summit)
		September 4, 2008	7	85 ppb (Cuyahoga)
	Total	**12 days**		
2009	**75 ppb**	May 20, 2009	2	79 ppb (Lake)
		May 21, 2009	4	86 ppb (Lake)
		June 25, 2009	3	88 ppb (Lake)
	Total	**3 days**		
2010	**75 ppb**	April 15, 2010	6	87 ppb (Geauga)
		May 27, 2010	3	82 ppb (Summit)
		June 18, 2010	1	79 ppb (Lake)
		July 3, 2010	1	80 ppb (Lake)
		July 4, 2010	2	85 ppb (Ashtabula)
		July 6, 2010	4	88 ppb (Ashtabula)
		July 7, 2010	4	83 ppb (Ashtabula)
		July 8, 2010	6	89 ppb (Lake)
		August 2, 2010	2	81 ppb (Geauga)
		August 9, 2010	2	85 ppb (Lake)
		August 10, 2010	1	77 ppb (Lake)
		August 29, 2010	3	78 ppb (Lake)
		August 30, 2010	4	80 ppb (Lake)
		August 31, 2010	1	78 ppb (Ashtabula)
		October 10, 2010	1	80 ppb (Geauga)
	Total	**15 days**		
2011	**75 ppb**	June 4, 2011	4	86 ppb (Cuyahoga)
		June 6, 2011	2	78 ppb (Cuyahoga
		June 8, 2011	4	87 ppb (Ashtabula)
		June 30, 2011	1	76 ppb (Summit)
		July 1, 2011	5	85 ppb (Summit)
		July 6, 2011	7	90 ppb (Lake)
		July 10, 2011	2	78 ppb (Cuyahoga)
		July 12, 2011	2	78 ppb (Lake)
		July 20, 2011	4	88 ppb (Lake)
		July 21, 2011	1	78 ppb (Lake)
		July 22, 2011	1	82 ppb (Cuyahoga)
		September 1, 2011	1	79 ppb (Lake)
		September 2, 2011	2	80 ppb (Lake)
		September 3, 2011	3	77 ppb (Cuyahoga)
	Total	**14 days**		
2012	**75 ppb**	May 15, 2012	1	76 ppb (Cuyahoga)
		May 19, 2012	5	88 ppb (Cuyahoga)
		May 20, 2012	3	83 ppb (Cuyahoga)

Year	8-Hour Ozone NAAQS	Exceedance Date	No. of Monitors Exceeding the NAAQS	Highest Monitor
		May 21, 2012	3	83 ppb (Cuyahoga)
		May 25, 2012	3	82 ppb (Lake)
		May 28, 2012	1	76 ppb (Cuyahoga)
		June 9, 2012	6	84 ppb (Cuyahoga)
		June 10, 2012	6	93 ppb (Ashtabula)
		June 15, 2012	2	79 ppb (Cuyahoga)
		June 16, 2012	1	76 ppb (Cuyahoga)
		June 20, 2012	3	83 ppb (Cuyahoga)
		June 21, 2012	2	81 ppb (Ashtabula)
		June 28, 2012	11	108 ppb (Lake)
		June 29, 2012	3	82 ppb (Lake)
		July 6, 2012	2	88 ppb (Lake)
		July 7, 2012	7	94 ppb (Cuyahoga)
		July 12, 2012	5	89 ppb (Cuyahoga)
		July 13, 2012	2	76 ppb (Cuyahoga, Lake)
		July 22, 2012	2	77 ppb (Lake)
		July 26, 2012	1	77 ppb (Lake)
		July 31, 2012	1	77 ppb (Lake)
		August 2, 2012	3	87 ppb (Cuyahoga)
		August 3, 2012	5	92 ppb (Lake)
		August 8, 2012	2	76 ppb (Cuyahoga)
		August 24, 2012	5	89 ppb (Lake)
		August 25, 2012	1	78 ppb (Lorain)
	Total	**26 days**		
2013	**75 ppb**	June 21, 2013	4	127 ppb (Cuyahoga)
	Total	**1 day**		
2014	**75 ppb**	April 21, 2014	2	78 ppb (Lake)
		May 26, 2014	2	76 ppb (Lake)
		June 28, 2014	1	79 ppb (Lake)
	Total	**3 days**		
2015	**75 ppb**	May 8, 2015	4	79 ppb (Ashtabula)
		July 29, 2015	1	80 ppb (Geauga)
	Total	**2 days**		
2016	**70 ppb**	April 18, 2016	3	77 ppb (Geauga)
		May 24, 2016	6	82 ppb (Geauga)
		May 25, 2016	5	83 ppb (Lake)
		June 2, 2016	1	72 ppb (Geauga)
		June 10, 2016	2	74 ppb (Cuyahoga)
		June 11, 2016	6	80 ppb (Lake)
		June 19, 2016	1	72 ppb (Lake)
		June 22, 2016	2	73 (Geauga)
		July 7, 2016	2	74 (Lake)

Year	8-Hour Ozone NAAQS	Exceedance Date	No. of Monitors Exceeding the NAAQS	Highest Monitor
		July 12, 2016	1	71 ppb (Lake)
		July 21, 2016	1	74 ppb (Lake)
		July 23, 2016	1	76 ppb (Lake)
		September 22, 2016	1	76 ppb (Geauga)
		September 23, 2016	2	74 ppb (Geauga)
	Total	**14 days**		

Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).

Appendix B: $PM_{2.5}$ Exceedance Days 2007-2016

Year	24-Hour $PM_{2.5}$ NAAQS[1]	Exceedance Date	Number of Monitors Exceeding NAAQS	Highest Monitor (Readings in $\mu g/m^3$)
2007	**35 $\mu g/m^3$**	May 24, 2007	7	42 (Cuyahoga)
		September 6, 2007	9	43 (Lake)
		September 21, 2007	5	41 (Lake)
		December 26, 2007	1	37 (Cuyahoga)
	Total	**4 days**		
2008	**35 $\mu g/m^3$**	January 28, 2008	5	41 (Cuyahoga)
		February 24, 2008	7	44 (Summit)
		March 10, 2008	2	39 (Cuyahoga)
		July 29, 2008	7	40 (Cuyahoga)
		September 3, 2008	1	37 (Cuyahoga)
		September 21, 2008	1	40 (Summit)
	Total	**6 days**		
2009	**35 $\mu g/m^3$**	February 9, 2009	1	37 (Cuyahoga)
	Total	**1 day**		
2010	**35 $\mu g/m^3$**	February 2, 2010	1	35.3 (Summit)
		February 3, 2010	1	36.6 (Summit)
		March 8, 2010	1	35.8 (Summit)
		March 9, 2010	10	52.6 (Cuyahoga)
		July 7, 2010	1	36.9 (Summit)
		August 3, 2010	1	38.9 (Summit)
		October 11, 2010	1	35.1 (Summit)
		November 20, 2010	1	36.3 (Summit)
	Total	**8 days**		
2011	**35 $\mu g/m^3$**	January 6, 2011	1	38 (Cuyahoga)
		September 2, 2011	1	36 (Cuyahoga)
	Total	**2 days**		
2012	**35 $\mu g/m^3$**	May 25, 2012	1	49 (Cuyahoga)
		May 27, 2012	1	37 (Cuyahoga)
		November 9, 2012	1	37 (Cuyahoga)
		November 17, 2012	2	37 (Cuyahoga)
		November 21, 2012	2	46 (Cuyahoga)
	Total	**5 days**		
2013	**35 $\mu g/m^3$**	June 21, 2013	1	43 (Cuyahoga)
	Total	**1 day**		
2014	**35 $\mu g/m^3$**	February 13, 2014	1	37 (Cuyahoga)

	Total	**1 day**		
2015	**35 µg/m³**	March 10, 2015	2	39 (Cuyahoga)
	Total	**1 day**		
2016	**35 µg/m³**	N/A	0	N/A
	Total	**0 days**		

Source: U.S. EPA, "Air Quality System" data, https://www.epa.gov/aqs (accessed June 1, 2017).