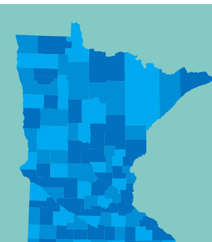
Air quality

June 2023

2024 Air Monitoring Network Plan for Minnesota

MINNESOTA POLLUTION CONTROL AGENCY



Federal Regulation

40 CFR § 58.10 Annual monitoring network plan and periodic network assessment.

(a)(1) Beginning July 1, 2007, the state, or where applicable local, agency shall submit to the Regional Administrator an annual monitoring network plan which shall provide for the documentation of the establishment and maintenance of an air quality surveillance system that consists of a network of SLAMS monitoring stations that can include FRM, FEM, and ARM monitors that are part of SLAMS, NCore, CSN, PAMS, and SPM stations. The plan shall include a statement of whether the operation of each monitor meets the requirements of appendices A, B, C, D, and E of this part, where applicable. The Regional Administrator may require additional information in support of this statement. The annual monitoring network plan must be made available for public inspection and comment for at least 30 days prior to submission to the EPA and the submitted plan shall include and address, as appropriate, any received comments.

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Acronyms, abbreviations, and definitions

AIRNow – air quality forecasting program
Air toxics – suite of parameters that includes VOCs, carbonyls, and metals
AQI – Air Quality Index
AQS – Air Quality System: EPA's repository of ambient air quality data
ARP – American Rescue Plan
BAM – Beta Attenuation Monitor
CAA – Clean Air Act
CAS – Chemical Abstracts Service
CASTNET – Clean Air Status and Trends Network
CBSA – Core Base Statistical Area
CFR – Code of Federal Regulations
Class I area – remote area with pristine air quality
CO – carbon monoxide
Criteria pollutants – the six pollutants regulated by the 1970 Clean Air Act (particulate matter, ozone, nitrogen dioxide, sulfur dioxide, carbon monoxide, and lead)
CSN – Chemical Speciation Network
Design Value – a statistic that describes the air quality status of a given location relative to the level of the National Ambient Air Quality Standards (NAAQS)
DNR – Department of Natural Resources
EPA – U.S. Environmental Protection Agency
FEM – Federal Equivalent Method
FRM – Federal Reference Method
GC/MS – Gas Chromatography/Mass Spectrometry
H_2S – hydrogen sulfide
HAP – Hazardous Air Pollutant
Hg – mercury
HPLC – High Pressure Liquid Chromatography
ICP/MS – Inductively Coupled Plasma/Mass Spectrometry
IMPROVE – Interagency Monitoring of Protected Visual Environments
LADCO – Lake Michigan Air Directors Consortium
MAAQS – Minnesota Ambient Air Quality Standard
MDH – Minnesota Department of Health
MDN – Mercury Deposition Network
MOA – Memorandum of Agreement
MPCA – Minnesota Pollution Control Agency
MSA – Metropolitan Statistical Area
NAAQS – National Ambient Air Quality Standard
NADP – National Atmospheric Deposition Program
NCore – National Core Monitoring Network
NDDN – National Dry Deposition Network
NO – nitric oxide
NO_2 – nitrogen dioxide
NO_x – oxides of nitrogen
NO_y – total reactive nitrogen
NTN – National Trends Network
O_3 – ozone
PAMS – Photochemical Assessment Monitoring Stations
Pb – lead
PM_4 – particulate matter less than 4 microns in diameter

$PM_{2.5}$ – particulate matter less than 2.5 microns in diameter (fine particulate matter)
$PM_{10-2.5}$ – particulate matter between 2.5 and 10 microns in diameter (coarse particulate matter)
PM_{10} – particulate matter less than 10 microns in diameter
ppb – parts per billion by volume
ppm – parts per million by volume
PQAO – Primary Quality Assurance Organization
Primary Standard - NAAQS set to protect public health
QAPP – Quality Assurance Project Plans
QA/QC – Quality Assurance/Quality Control
QMP – Quality Management Plan
Secondary Standard - NAAQS set to protect the environment and public welfare (i.e. visibility, crops, animals, vegetation, and buildings)
SIP – State Implementation Plan
SLAMS – State and Local Air Monitoring Stations
SO_2 – sulfur dioxide
SPM – special purpose monitoring
TO-11A – EPA method for analyzing carbonyls utilizing HPLC
TO-15 – EPA method for analyzing VOCs utilizing GC/MS
TPY – tons per year
TRS – total reduced sulfur
TSP – total suspended particulate matter
U of M – University of Minnesota
UFP – ultrafine particles (particulate matter less than 0.1 microns in diameter)
USDA – United States Department of Agriculture
USDOI – United States Department of the Interior
USG – unhealthy for sensitive groups
VOC – volatile organic compound

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1. Introduction

The Minnesota Air Monitoring Network Plan is an annual report required under the Code of Federal Regulations [40 CFR § 58.10(a)(1)]. The purpose of this plan is to provide evidence that the Minnesota Pollution Control Agency (MPCA) air monitoring network meets current federal monitoring requirements, to detail any changes proposed for the 18 months following publication, to provide specific information on each of the MPCA's existing and proposed monitoring sites, and to provide the opportunity for the public to comment on air monitoring activities conducted by the MPCA. The plan also includes information on known industrial monitoring activities and other air monitoring projects occurring in the state.

The MPCA monitors outdoor air quality throughout Minnesota. The data collected by the MPCA are used for a variety of purposes including monitoring compliance with the National Ambient Air Quality Standard (NAAQS), public reporting of the Air Quality Index (AQI), air quality forecasting, assessing population exposure and risk from air toxics, determining pollution trends, monitoring specific emissions sources, investigating background conditions, and evaluating computer models. Data are also used to address ways to reduce pollution levels.

The MPCA's air quality data are used to determine compliance with NAAQS and Minnesota Ambient Air Quality Standards (MAAQS). In 1970, the Clean Air Act (CAA) established NAAQS for six pollutants known to cause harm to human health and the environment. The CAA requires the MPCA to monitor these pollutants, called criteria pollutants, and report the findings to the U.S. Environmental Protection Agency (EPA). The criteria pollutants are particulate matter, lead, ozone, nitrogen dioxide, sulfur dioxide, and carbon monoxide. The MPCA monitors criteria pollutants to comply with the CAA.

The MPCA also monitors Minnesota's air for other pollutants, called air toxics. Air toxics include a wide range of chemicals that are known or suspected to affect human health. These pollutants do not have federal standards; however, levels found in Minnesota are compared to health benchmarks established by the Minnesota Department of Health (MDH), the EPA, and the State of California.

More information including current air quality, forecasts, tools to explore data from our monitoring network, and this plan can be found on the MPCA website at https://www.pca.state.mn.us/air.

2. Network overview

There are 54 sites for ambient air quality monitoring in Minnesota (Figure 1). This includes five tribal sites, three Interagency Monitoring of Protected Visual Environments (IMPROVE) sites, two Chemical Speciation Network (CSN) sites, one national multi-pollutant monitoring site (NCore), one ozone precursor measurements site (PAMS), and nine National Atmospheric Deposition Program (NADP) sites. In addition to these sites, there is a network of industrial air quality monitors that are owned and operated by the specific industrial facility and adhere to their air permit requirements for monitoring ambient air.

Site location is partly dependent upon population density; therefore, most sites are in the Twin Cities metropolitan area. For the purposes of this report, any sites in the following eight counties considered the Twin Cities metropolitan area: Hennepin, Ramsey, Wright, Anoka, Washington, Dakota, Scott, and Carver. The area that lies outside the Twin Cities metropolitan area is commonly referred to as Greater Minnesota.

The maps included in this plan show sites labeled according to their MPCA, NADP, or IMPROVE site identification numbers, in Greater Minnesota (Figure 1 and Table 2) and in the Twin Cities metropolitan area (Figure 2 and Table 3). Throughout the report, sites are referred to using the site name or the city where the site is located and the MPCA, NADP, or IMPROVE site identification number.

Table 1. Site information for Greater Minnesota sites active in 2023

Site ID	City	Site name	Address/location	LAT	LONG	Year started
27-005-2013	Detroit Lakes	FWS Wetland Management District	26624 N Tower Rd	46.8499	-95.8463	2004
27-007-2304***	Red Lake	Red Lake Nation	24760 Hospital Drive	47.8782	-95.0292	2014
27-017-7417***	Cloquet	Fond du Lac Band	28 University Rd	46.7137	-92.5117	2015
27-021-3410***	Cass Lake	Leech Lake Nation: Cass Lake	200 Sailstar Dr	47.38443	34.60166	2018
27-031-7810***	Grand Portage	Grand Portage Band	27 Store Rd	47.9701	-89.6910	2005
27-035-3204	Brainerd	Brainerd Lakes Regional Airport	16384 Airport Rd	46.3921	-94.1444	2004
27-049-5302	Stanton	Stanton Air Field	1235 Highway 17	44.4719	-93.0126	2003
27-075-0005 MN18* BOWA1**	Ely	Boundary Waters	Fernberg Rd	47.9466	-91.4956	1977
27-083-4210	Marshall	Southwest Minnesota Regional Airport	West Highway 19	44.4559	-95.8363	2004
27-095-3051***	Onamia	Mille Lacs Band	43408 Oodena Dr	46.2052	-93.7594	1997
27-109-5008	Rochester	Ben Franklin School	1801 9th Ave SE	43.9949	-92.4504	1997
27-137-0032	Duluth	Oneota Street	37th Ave W & Oneota St	46.7516	-92.1413	1985
27-137-0034 MN32* VOYA2**	International Falls	Voyageurs NP – Sullivan Bay	Voyageurs National Park - Sullivan Bay	48.4128	-92.8292	2000
27-137-7001	Virginia	Virginia City Hall	327 First St S	47.5212	-92.5393	1968
27-137-7549	Duluth	Michigan Street	1532 W Michigan St	46.7694	-92.1194	1994
27-137-7550	Duluth	U of M - Duluth	1202 East University Circle	46.8182	-92.0894	1998
27-137-7554	Duluth	Laura MacArthur School	720 N Central Ave	46.7437	-92.1660	2012
27-137-7555	Duluth	Waseca Road	Waseca Industrial Rd	46.7306	-92.1634	2001
27-145-3052	Saint Cloud	Talahi School	1321 University Ave SE	45.5497	-94.1335	1998
27-169-9000 GRRI1**	Winona	Great River Bluffs	43605 Kipp Dr	43.9373	-91.4052	2002
MN08*	Hovland	Hovland	(open field)	47.8472	-89.9625	1996
MN16*	Balsam Lake	Marcell Experimental Forest	Marcell Experimental Forest	47.5311	-93.4686	1978
MN23*	Pillager	Camp Ripley	(open field)	46.2494	-94.4972	1983
MN27*	Lamberton	Lamberton	U of M SW Agricultural Research and Outreach Center	44.2369	-95.3010	1979
MN28*	Sandstone	Grindstone Lake	Audubon Center of the North Woods	46.1208	-93.0042	1996
MN99*	Finland	Wolf Ridge	6282 Cranberry Rd	47.3875	-91.1958	1996

*NADP Site ID **IMPROVE Site ID ***Tribal Site

Figure 1. 2023 air quality monitoring sites in Greater Minnesota

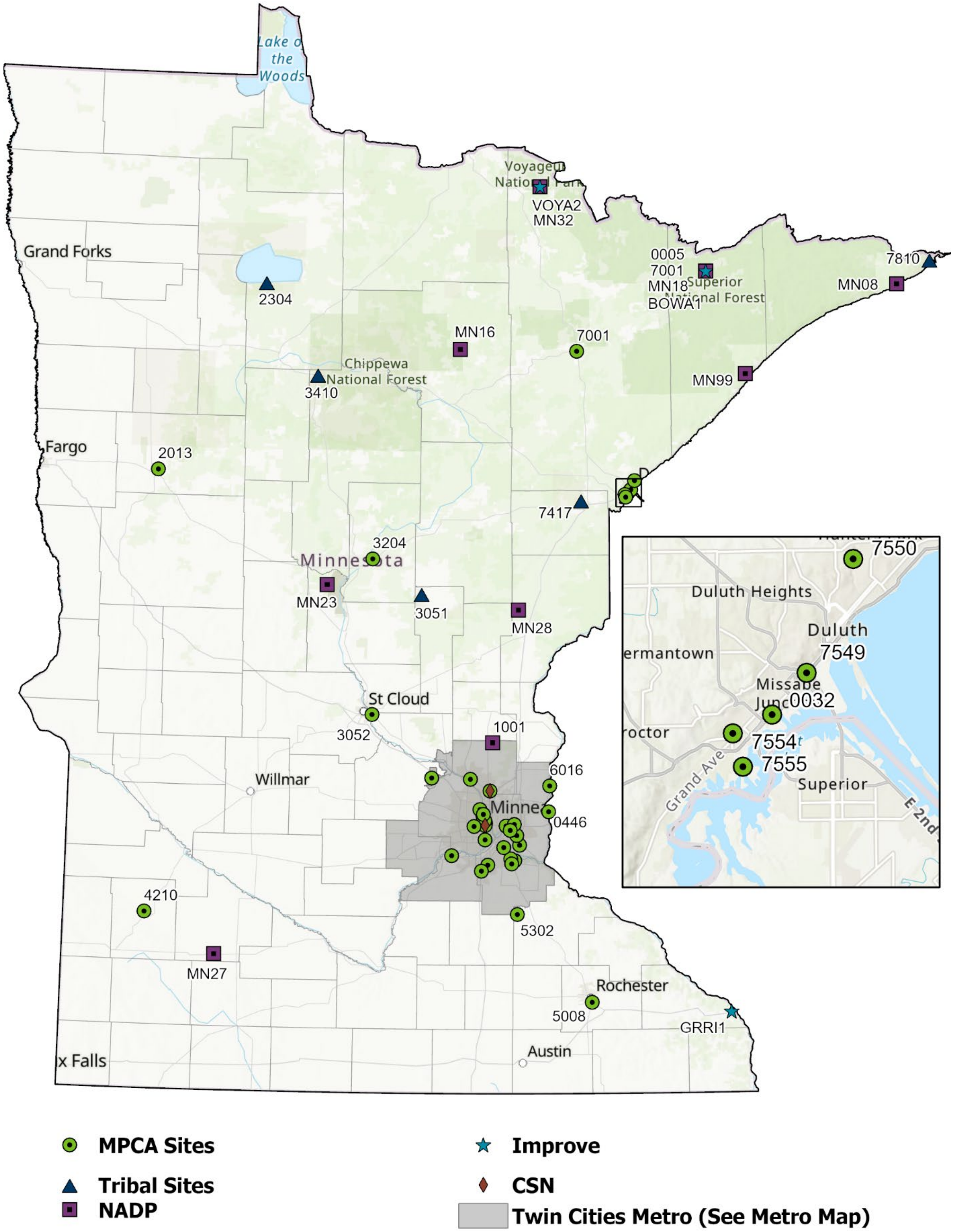
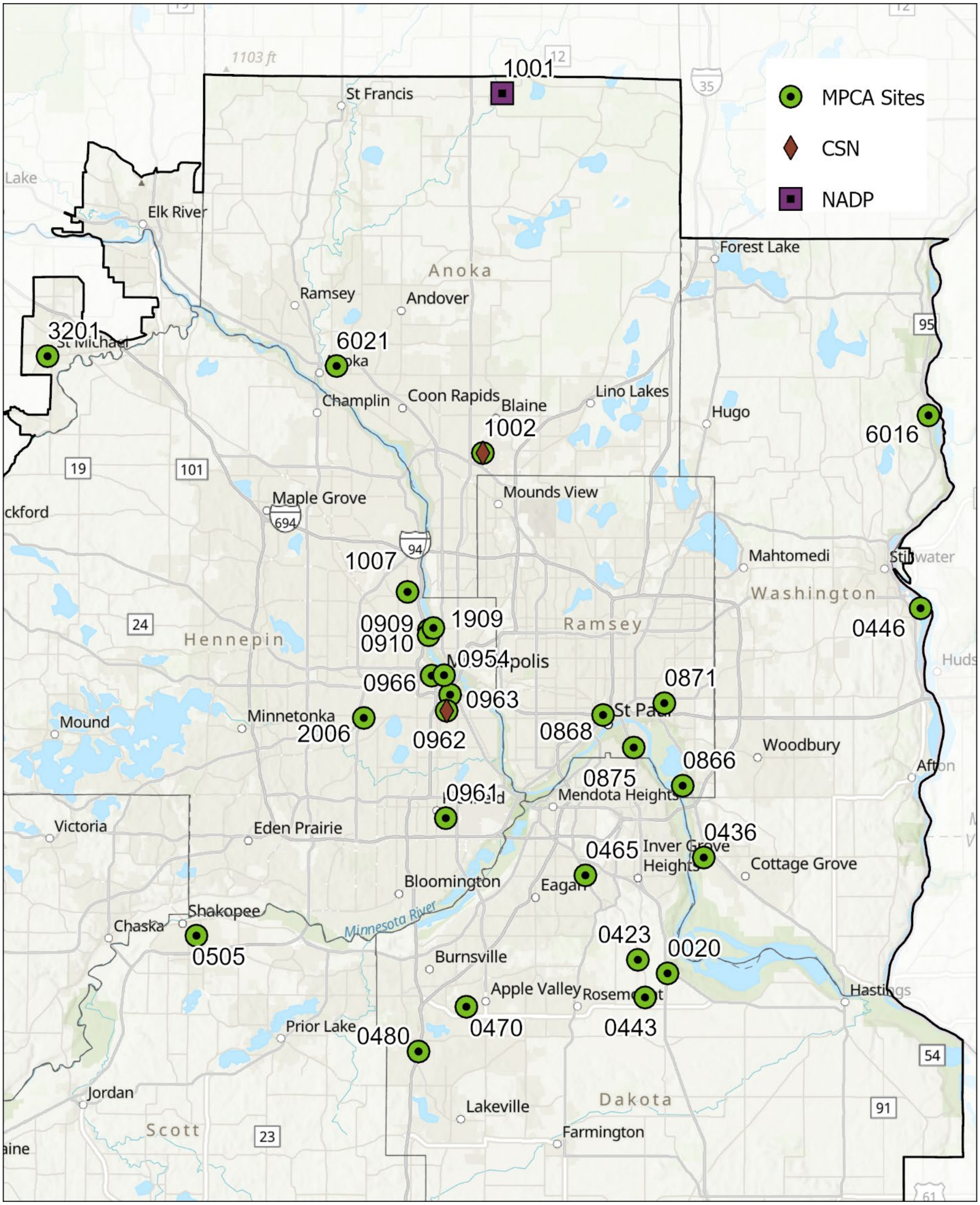


Table 2. Site information for Twin Cities metropolitan area sites active in 2023

Site ID	City	Site name	Address	LAT	LONG	Year started
27-003-1001 MN01*	East Bethel	U of M - Cedar Creek	2660 Fawn Lake Drive NE	45.4018	-93.2031	1979
27-003-1002**	Blaine	Anoka County Airport	2289 Co Rd J	45.1407	-93.2220	1979
27-003-6021	Anoka	Federal Cartridge 6021	900 Bob Ehlen Dr	45.2035	-93.3723	2022
27-037-0020	Rosemount	Flint Hills Refinery 420	12821 Pine Bend Tr	44.7632	-93.0325	1972
27-037-0423	Rosemount	Flint Hills Refinery 423	2142 120th St E	44.7730	-93.0627	1990
27-037-0443	Rosemount	Flint Hills Refinery 443	14035 Blaine Ave E	44.7457	-93.0554	2008
27-037-0465	Eagan	Gopher Resources	Hwy 149 & Yankee Doodle Rd	44.8343	-93.1163	2006
27-037-0470	Apple Valley	Westview School	225 Garden View Dr	44.7387	-93.2373	2000
27-037-0480	Lakeville	Near Road I-35	16750 Kenyon Ave	44.7061	-93.2858	2015
27-053-0909	Minneapolis	Lowry Avenue	3104 N Pacific St	45.0121	-93.2767	2013
27-053-0910	Minneapolis	Pacific Street	2710 N Pacific St	45.0083	-93.2770	2015
27-053-0954	Minneapolis	Arts Center	528 Hennepin Ave	44.9790	-93.2737	1989
27-053-0961	Richfield	Richfield Intermediate School	7020 12th Ave S	44.8756	-93.2588	1999
27-053-0962	Minneapolis	Near Road I-35/I-94	1444 18th St E	44.9652	-93.2548	2013
27-053-0963	Minneapolis	Andersen School	2727 10th Ave S	44.9535	-93.2583	2001
27-053-0966	Minneapolis	City of Lakes Building	309 2nd Ave S	44.9793	-93.2611	2002
27-053-1007	Minneapolis	Humboldt Avenue	4646 N Humboldt Ave	45.0397	-93.2987	1966
27-053-1909	Minneapolis	Bottineau / Marshall Terrace	2522 Marshall St NE	45.0136	-93.2721	2017
27-053-2006	St Louis Park	St. Louis Park City Hall	5005 Minnetonka Blvd	44.9481	-93.3429	1972
27-123-0866	St. Paul	Red Rock Road	1450 Red Rock Rd	44.8994	-93.0171	1997
27-123-0868	St. Paul	Ramsey Health Center	555 Cedar St	44.9507	-93.0985	1998
27-123-0871	St. Paul	Harding High School	1540 East 6th St	44.9593	-93.0359	1998
27-123-0875	St. Paul	West Side	515 Concord St	44.9271	-93.0671	2020
27-139-0505	Shakopee	B.F. Pearson School	917 Dakota St	44.7894	-93.5125	2000
27-163-0436	St. Paul Park	St. Paul Park Refinery 436	649 5th St	44.8473	-92.9956	1989
27-163-0446	Bayport	Point Road	22 Point Rd	45.0280	-92.7742	2007
27-163-6016	Marine on St. Croix	St. Croix Watershed Research Station	St. Croix Trail N	45.1680	-92.7651	2012
27-171-3201	St. Michael	St. Michael Elementary School	101 Central Ave W	45.2092	-93.6690	2003

*NADP Site ID ** NCore site

Figure 2. 2023 air quality monitoring sites in the Twin Cities metropolitan area



2.1 Minimum monitoring requirements

The EPA establishes the minimum number of monitoring sites required to meet national ambient monitoring objectives. The minimum monitoring requirements are codified in Appendix D of 40 CFR Part 58. Minimum monitoring requirements are specific to each individual pollutant (e.g. ozone, $PM_{2.5}$) or are objective-based monitoring networks (e.g. NCore, PAMs). Minimum monitoring requirements typically rely on population and/or air pollution emissions data. Minnesota currently meets all minimum air monitoring requirements. Appendix B provides a detailed description of these requirements.

2.2 Monitoring objectives

When designing an air monitoring network, one of the following six objectives should be considered:

1. Highest concentrations expected to occur in the area covered by the network
2. Representative concentrations in areas of high population density
3. Impact of specific sources on ambient pollutant concentrations
4. General background concentration levels
5. Extent of regional transport among populated areas and in support of secondary standards
6. Welfare-related impacts in the more rural and remote areas

2.3 Site selection

The selection of air monitoring sites is usually based on at least one of the following objectives:

- Determine representative concentrations and exposure in areas of high population density
- Determine highest concentrations in an area based on topography and/or wind patterns
- Judge compliance with and/or progress made towards meeting the NAAQS and MAAQS
- Track pollution trends
- Determine the highest concentrations of pollutants within the state based on the known atmospheric chemistry of specific pollutants and wind patterns
- Determine the extent of regional pollutant transport to and from populated areas
- Determine to what extent major sources impact ambient pollution levels
- Validate control strategies designed to prevent or alleviate air pollution
- Provide a database for research and evaluation of air pollution effects
- Determine general background concentration levels

The exact location of a site is most often dependent on the logistics of the area chosen for monitoring, such as site access, security, and power availability.

2.4 Network scales

The EPA developed a system which specifies an exclusive area, or spatial scale, that an air monitor represents. The goal in establishing air monitoring sites is to correctly match the spatial scale that is most appropriate for the monitoring objective of the site (Table 1). The representative measurement scales are:

- **Micro Scale (10-100 m)** – defines the concentrations in air volumes associated with area dimensions ranging from several meters up to about 100 meters. Measurements on the micro scale typically include concentrations in street canyons, intersections, and in areas next to major emission sources.

- **Middle Scale (100-1,000 m)** – defines the concentration typical of areas up to several city blocks in size, with dimensions ranging from about 100 to 1,000 meters.
- **Neighborhood Scale (1-4 km)** – defines concentrations within some extended area of the city that has relatively uniform land use with dimensions in the one to four kilometers range. Generally, these stations represent areas with moderate to high population densities.
- **Urban Scale (4-50 km)** – defines the overall, citywide conditions with dimensions on the order of 4 to 50 kilometers. This scale represents conditions over an entire metropolitan area, and is useful in assessing citywide trends in air quality.
- **Regional Scale/Background (50-1,000 km)** – usually represents a rural area of reasonably homogeneous geography and extends from tens to hundreds of kilometers.
- **National/Global** – concentrations characterizing the nation and the globe as a whole.

Table 3. Monitoring objectives and appropriate siting scales.

Monitoring objective	Appropriate siting scales
Highest concentration	Micro, Middle, Neighborhood (sometimes Urban)
Population exposure	Neighborhood, Urban
Source impact	Micro, Middle, Neighborhood
General/Background	Urban, Regional (sometimes Neighborhood)
Regional transport	Urban, Regional
Welfare – related	Urban, Regional

3. Quality Assurance/Quality Control program

The purpose of the Quality Assurance/Quality Control (QA/QC) program is to assure the quality of data obtained from the MPCA air monitoring network. The MPCA meets or exceeds the QA requirements defined in 40 CFR Part 58 and all applicable appendices.

The QA/QC program includes, but is not limited to, the following activities:

- Instrument performance audits
- Monitor siting evaluations
- Precision and span checks
- Flow rate audits
- Leak checks
- Data validation
- Bias determinations

For independent quality assurance activities, the MPCA participates in the National Performance Audit Program and the Performance Evaluation Program for criteria pollutant monitoring. Additional inter-laboratory comparisons and proficiency tests are performed periodically for air toxics monitoring.

As the Primary Quality Assurance Organization (PQAO) for ambient air monitoring activities in Minnesota, the MPCA operates under an EPA-approved Quality Management Plan (QMP) and utilizes Quality Assurance Project Plans (QAPP) for each statewide monitoring network. The primary purpose of the QAPP is to provide an overview of the project, describe the need for the measurements, and define QA/QC activities that apply to the project. All other ambient air monitoring initiatives including state, tribal, and industrial projects must have an MPCA-approved monitoring plan for each specific project.

As part of the instrument performance audit, each monitoring site is assessed to ensure that all applicable EPA siting requirements are fully met. This also includes a safety inspection to assure a safe work environment for site operators and staff.

To meet the minimum monitoring requirements for the Minneapolis-St. Paul MN-WI Metropolitan Statistical Area (MSA) and the Lacrosse-Onalaska MN-WI MSA, the MPCA and Wisconsin Department of Natural Resources (DNR) Bureau of Air Management entered into a Memorandum of Agreement (MOA) in January 2011. The MOA formalized the collective agreement between the two States per requirements of 40 CFR Part 58 Appendix D, Section 2(e). The MPCA worked with Wisconsin DNR to update the MOA in 2020. The MPCA reconfirmed with the Wisconsin DNR that all monitoring requirements are currently being met.

4. Environmental Justice

The Minnesota Pollution Control Agency defines environmental justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. This will be achieved when everyone benefits from the same degree of environmental protection and has equal access to the decision-making processes that contribute to a healthy environment.

The MPCA is striving to understand how air pollution may disproportionately affect some communities. Current and continuing efforts to involve and inform communities include issuing several reports and community focused websites with data portals.

- “Air We Breathe” report (https://www.pca.state.mn.us/air/air-we-breathe)
- “Life and Breath” report (https://www.pca.state.mn.us/air/life-and-breath-report)
- North Minneapolis air monitoring project webpage (https://www.pca.state.mn.us/air/north-minneapolis-air-monitoring-project)
- Water Gremlin webpage (https://www.pca.state.mn.us/air/water-gremlin)

The MPCA’s website at https://www.pca.state.mn.us/about-mpca/mpca-and-environmental-justice shares additional information on MPCA’s efforts around environmental justice.

Current efforts

The MPCA considers tribal areas and census tracts with higher concentrations of low-income residents and people of color as areas of increased concern for environmental justice. Three criteria are currently used to define and environmental justice area:

- 50% or more people of color
- At least 40% of people reported income less than 185% of the federal poverty level
- Federally recognized tribal areas

Using this definition, out of 53 statewide monitors, 19 are within one area of environmental concern, 9 are within two overlapping areas, and 3 fall within the boundaries of all three types of environmental justice concern areas (Figure 3 and Figure 4). Overall, 31 of the 53 monitors are in environmental justice areas.

Figure 3: MPCA monitor locations and environmental justice areas of concern of Minnesota.

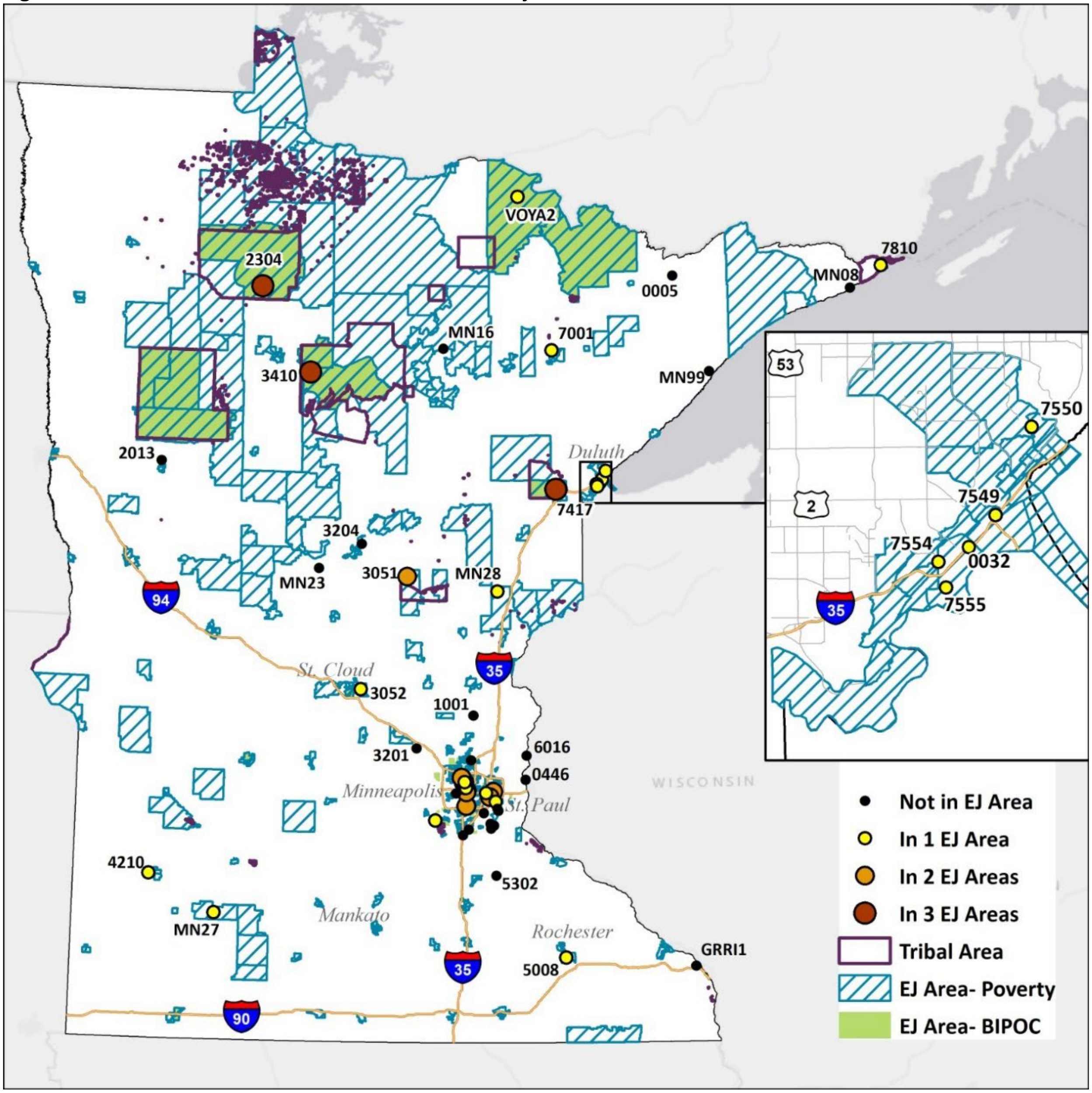
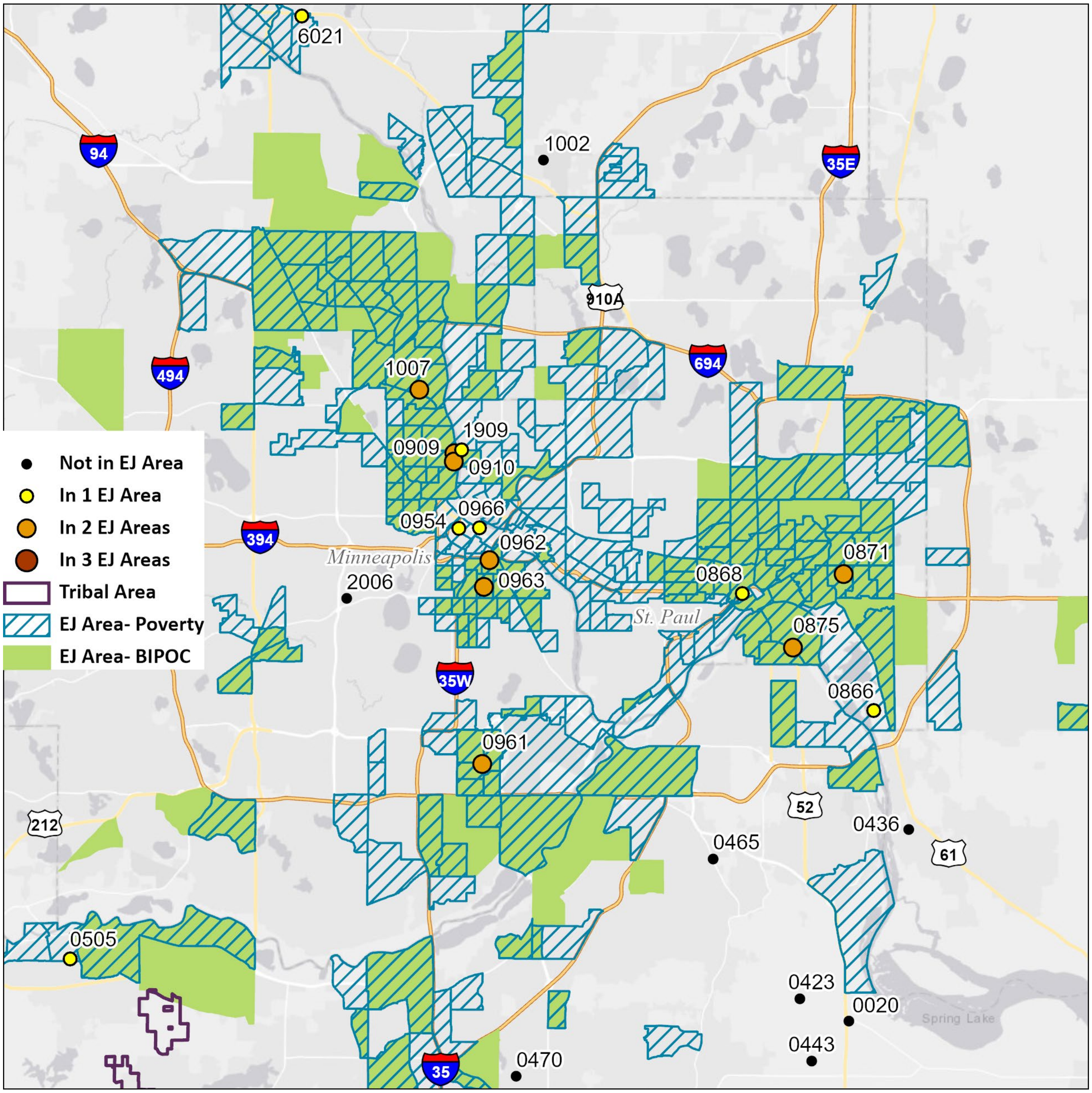


Figure 4: MPCA monitor locations and environmental justice areas of concern in Twin Cities metro.



Future work

As part of MPCA's Assessing Urban Air Quality project (https://www.pca.state.mn.us/air/assessing-urban-air-quality-project), the MPCA placed AQ Mesh air sensors in nearly every zip code in Minneapolis and St. Paul. These sensors allow us to assess air pollution on smaller scales than possible with regulatory air monitors. We continue to look for partnerships to continue to use networks of air sensor such as AQMESH and Purple Air sensors to determine hot spots of air pollution and potentially place SENSIT SPOD VOC sensors to better determine the VOC pollution in the Metro area. Additionally, Photochemical Assessment Monitoring Stations (PAMS) hourly VOC data at our Blaine – Anoka County Airport (1002) monitoring site will be compared to acute health benchmarks, assessing potential air pollution exposure in communities located near these monitors. MNRISKS, MPCA's risk-screening tool, or other similar tools, can also be incorporated into future monitoring network assessments, including the air toxics monitoring network, to ensure environmental justice factors are considered when removing or adding monitors.

Conclusion

The effects of historical and current structural inequities are made clear through the disparities of air pollution health impacts. The MPCA is committed to reducing these disparities and reducing air pollution in areas of environmental justice concern. Through strengthening and fully utilizing our community relationships, increasing our outreach and communication, and being present in these communities, the MPCA continues to work towards the meaningful involvement of those most impacted by air pollution. Through our efforts to incorporate environmental justice in our air monitoring decisions, the MPCA continues to strive for the fair treatment of all people. To explore the MPCA's resources on environmental justice and air pollution, visit the Environmental justice and air webpage at https://www.pca.state.mn.us/air/environmental-justice-and-air.

5. Network assessments

5.1 Regional network assessment

In addition to this air monitoring network plan, the EPA requires states to complete a network assessment every five years. The network assessment provides a detailed evaluation of the regional air monitoring network, including network history, a re-evaluation of the types of pollutants monitored, and an evaluation of the network's objectives and costs. It also includes spatial analyses of ambient air monitoring data and a reconsideration of monitor placement based on changes in land use and population. Under the direction of the Lake Michigan Air Directors Consortium (LADCO), Minnesota has collaborated with other states in our region to develop network assessments in 2010, 2015, and 2020. The results of the Network Assessments can be found on LADCO's website, at https://www.ladco.org/reports/monitoring-reports/.

Some key findings of the 2020 Network Assessment include:

- Criteria pollutant monitoring networks are adequate to meet EPA's minimum monitoring criteria.
- Disinvestment or relocation of existing $PM_{2.5}$ and ozone monitoring sites is very difficult due to stringent EPA criteria for shutdown.
- Using these criteria, amongst all ozone and $PM_{2.5}$ monitors in the state, 12 $PM_{2.5}$ monitors and only one ozone monitor is eligible for disinvestment. All of the $PM_{2.5}$ monitors eligible for disinvestment are outside of Minneapolis. The only ozone monitor eligible for disinvestment is in Duluth (27-137-7550) where $PM_{2.5}$ is also eligible for disinvestment. While these monitors are eligible for disinvestment, we feel these monitors are valuable for spatial and temporal coverage and we do not intend to shut down these monitors at this time.
- Minnesota's criteria pollutant monitoring network is not dense enough to measure neighborhood level disparities in air quality, but we are increasing our use of small air quality sensors to cover gaps in our air monitoring network, especially in areas of environmental justice concern.
- Minnesota's air toxics network is concentrated in the Twin Cities and Duluth due to logistical challenges with transporting samples. Within those areas, the air toxics network is generally representative of the air quality experienced in different neighborhoods. We are expanding our capacity to identify potentially problematic facilities contributing to poor air quality and conduct short-term air monitoring studies to determine if additional action is necessary in these areas.

5.2 Statewide network assessment

Although not required by the EPA or the federal regulations, in the 2022 Ambient Air Monitoring Network Plan, the MPCA committed to re-evaluating Minnesota's air monitoring network using the data from the 2020 Network Assessment. This re-evaluation aims to establish an in-house methodology to quantify monitor values and assess whether there are obvious recommendations (removal, move, and addition) to the existing network.

The internal air assessment team consist of the air assessment section manager in addition to supervisors and members of the ambient air monitoring (AMU), environmental data quality (EDQ), air data analysis (ADA), risk evaluation and air modeling (REAM) units. This membership ensures that stakeholders affected by collection, processing, quality assurance, and analysis are represented.

2021 Internal Criteria Network Assessment

Methodology

The 2020 Regional Network Assessment outcome was used as input for the internal network assessment analysis. The internal network assessment team members discussed and selected the results that should be considered for the analysis. These results include:

- the types/number of pollutants monitored,
- the years monitored,
- the NAAQS exceedance probability ($PM_{2.5}$ and ozone only),
- the correlation coefficients based on nearby monitors ($PM_{2.5}$ and ozone only),
- the spatial analysis factors such as area coverage and population represented by the monitors ($PM_{2.5}$ and ozone only).

The members agreed that some factors should have more weight over others. Each member had the opportunity to experiment with different coefficients for factors contributing to the overall monitor value score. The result of their exercise was captured in a qualitative reflection survey.

Preliminary results and opportunities for improvement

Based on the qualitative survey results taken by the internal network assessment members and group discussions, Table 4 summarizes some of the key findings and conclusions of the 2022 internal network assessment as well as recommendations for future analysis. The results of the future internal network assessments are expected to inform future recommendations for upcoming network plans.

Table 4. Conclusions and Future Recommendations for Internal Network Assessment

Key conclusions/Findings	Recommendations for future analysis
More value should be placed on the number of pollutants monitored rather than the duration of the monitor.	It may be appropriate to consider the monitoring duration in deciding removal suitability, but we may exclude this factor from overall site evaluation as not to "penalize" new sites.
Probability of exceedance based on design value relative to NAAQS is one of the most important factors to consider. This type of assessment was limited to considering $PM_{2.5}$ and ozone.	Future assessment could expand to other criteria pollutants. The values for $PM_{2.5}$ and ozone were based on 2018 design values so the probability of exceedance should be based on most recent available data.
Correlation values were only available for $PM_{2.5}$. Looking at redundancy and possible removal or consolidation would be helpful in planning for future monitoring network.	Future assessment could expand to other criteria pollutants. Before making a removal or consolidation change, a case-by-case comparison against two or more sites would be required. For example, evaluations for consolidation may make sense for the following due to their proximity: • Michigan Street (27-137-7549) and Laura MacArthur School (27-137-7554) • Lowry Avenue (27-053-0909), Pacific Street (27-053-0910), and Bottineau / Marshall Terrace (27-053-1909) Correlation values as well as logistics may inform the possibility to consolidate and remove one to gain efficiency without losing much insight on ambient air concentration in the area.
Several other evaluation factors were identified but not available for analysis in this network assessment.	Future assessment could include: • Environmental Justice considerations, • Resource constraints such as operational and human resource, • Spatial consideration to support baseline data for modeling efforts, • AQI forecasting value, • Sensor placements.

2022-2023 Internal Air Toxics Network Assessment

The MPCA has been monitoring for air toxics since the early 2000 following the legislative studies done around the Twin Cities to measure and understand the risk posed by metals, VOC and carbonyls. Many of the air toxics equipment were set up at the existing criteria pollutant monitoring sites. However, unlike the criteria pollutants, there are no federal requirements to monitor for VOC and carbonyl.

Network assessment team members are evaluating whether the existing air toxics network is purposeful, defensible, and manageable. In the initial phase of the project, members found the workload required to process data in timely fashion is greater than the workforce capacity available. In order to respond to this gap, the MPCA will be reducing the number of samples collected by going from 1-in-6 to 1-in-12 day collection cycle in spring of 2023. This reduced frequency will continue until further decisions are made on the network. To move forward, the project will perform network analysis that would recommend options for changes (removal, move, and addition) to the network. The project expects to have analysis done by spring of 2024.

6. Types of networks

Air monitoring networks are designed to satisfy a variety of purposes, including monitoring compliance with the NAAQS, public reporting of the Air Quality Index (AQI), assessing population exposure and risk from air toxics, determining pollution trends, monitoring specific emissions sources, investigating background conditions, and evaluating computer models. Below are descriptions of the existing monitoring networks in Minnesota.

6.1 State and Local Air Monitoring Stations (SLAMS)

The SLAMS network consists of about 3,500 monitoring sites across the United States. Size and distribution of the sites are largely determined by the needs of state and local air pollution control agencies to meet their respective State Implementation Plan (SIP) requirements and monitoring objectives. Most monitoring sites in Minnesota are part of the SLAMS network. Sites in the SLAMS network may also belong to other monitoring networks, as described below.

6.2 National Air Toxics Trends Stations (NATTS)

The purpose of EPA's National Air Toxics Trends Stations (NATTS) network is to track trends in ambient air toxics levels to facilitate measuring progress toward emission and risk reduction goals. It consists of 27 sites across the U.S. that were established between 2003 and 2008.

There are no NATTS sites in Minnesota; however, we refer to EPA's guidance for the NATTS program for our air toxics sampling, laboratory analyses, data validation, and AQS submittals.

6.3 Air Sensor Program

The Air Sensor Program was implemented in early 2023 as part of the MPCA's commitment to protecting and improving the environment and human health along with improving air quality in population centers and reducing disproportionate impacts from pollution. The Air Sensor Program aims to fill data gaps where regulatory monitoring is not feasible. The program objectives will:

- support existing and new partnerships with communities, educational institutions, and educators,
- locate grants for the program and its partners,
- and store, analyze, and share sensor datasets.

Current efforts involve a partnership with the City of Minneapolis to collect and store data for the deployment of 30 of AQMesh sensors, and with the Minnesota State Mankato to help a few Minneapolis schools with air sensor projects. For questions, please contact air.sensors.mpca@state.mn.us

6.4 Air Quality Index (AQI)

The AQI was developed by the EPA to provide a simple, uniform way to report daily air quality conditions. Minnesota AQI numbers are determined by measurements of six pollutants: fine particles ($PM_{2.5}$), particulate matter (PM_{10}), ground-level ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and carbon monoxide (CO). The AQI values for each pollutant are calculated daily and apply to the respective averaging period. The EPA's NowCast AQI values are updated hourly, and posted on the MPCA's website at https://www.pca.state.mn.us/air/current-air-quality, to help inform the public of current air quality conditions and trends.

The MPCA creates daily forecasts in AQI units for $PM_{2.5}$ and ozone, centered at monitoring locations across the state (Figure 5). There are currently 28 sites in the full AQI network in Minnesota. The Twin Cities monitors are grouped into three forecast locations: Minneapolis-St. Paul, North Metro, and South Metro. Overall, there are 18 forecast locations across the state (Table 6). Daily AQI values are generally the highest for these two pollutants, and are responsible for most poor air quality events in Minnesota.

Figure 5. 2022 fine particle ($PM_{2.5}$) and ozone-monitoring network which serves the AQI forecast system.

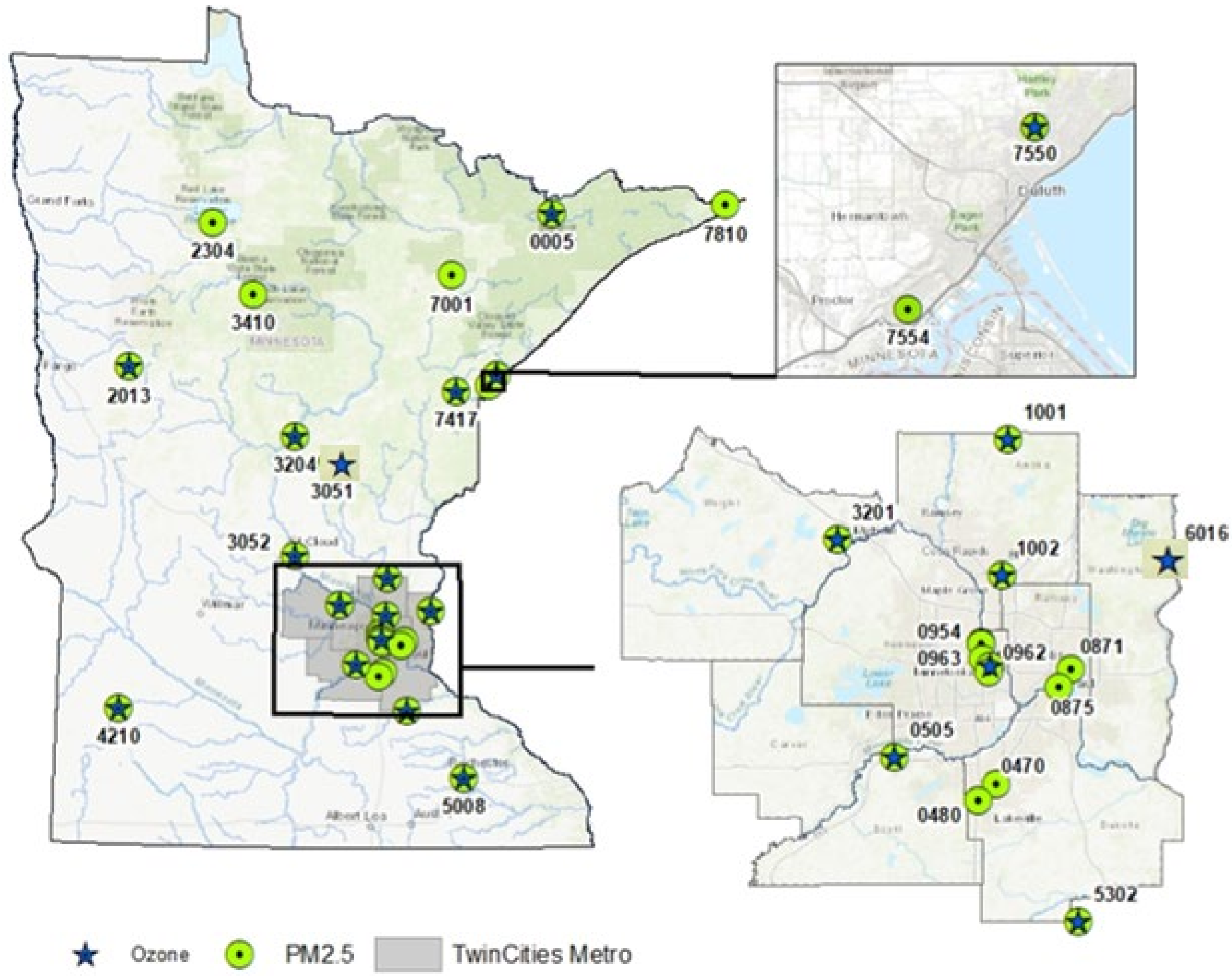


Table 5. Forecast locations and monitors utilized

State area	Forecast location	Monitoring location	Pollutant measured
Metro	Minneapolis-St. Paul	Minneapolis (Near Road) Minneapolis (Anderson School) St. Louis Park St. Paul (Harding High School) St. Paul (Ramsey Health Center)	$PM_{2.5}$, Ozone $PM_{2.5}$ $PM_{2.5}$ $PM_{2.5}$ $PM_{2.5}$
Metro	North Metro	Blaine East Bethel Marine on St. Croix St. Michael	$PM_{2.5}$, Ozone Ozone Ozone $PM_{2.5}$, Ozone
Metro	South Metro	Apple Valley Lakeville Shakopee Stanton	$PM_{2.5}$ $PM_{2.5}$ $PM_{2.5}$, Ozone Ozone
Northwest	Detroit Lakes	Detroit Lakes	$PM_{2.5}$, Ozone
Northwest	Moorhead	Fargo, ND	$PM_{2.5}$, Ozone
Northwest	Red Lake	Red Lake Nation	$PM_{2.5}$
Northeast	Duluth	Duluth (Univ Minn-Duluth)	$PM_{2.5}$, Ozone
Northeast	Ely	Ely	$PM_{2.5}$, Ozone
Northeast	Fond du Lac	Fond du Lac Band (Cloquet)	$PM_{2.5}$, Ozone
Northeast	Grand Portage	Grand Portage Band	$PM_{2.5}$
Northeast	Virginia	Virginia	$PM_{2.5}$
Central	Brainerd	Brainerd	$PM_{2.5}$, Ozone
Central	Leech Lake	Leech Lake Nation (Cass Lake)	$PM_{2.5}$
Central	Mille Lacs	Mille Lacs Band	Ozone
Central	St. Cloud	St. Cloud	$PM_{2.5}$, Ozone
South	Marshall	Marshall	$PM_{2.5}$, Ozone
South	Rochester	Rochester	$PM_{2.5}$, Ozone
South	Winona	La Crosse, WI	$PM_{2.5}$, Ozone

The AQI categories developed by the EPA are green (good), yellow (moderate), orange (unhealthy for sensitive groups or USG), red (unhealthy), purple (very unhealthy), and maroon (hazardous). Each category is assigned a color and corresponds to a different level of health concern (Figure 6). In the past, MPCA offered AQI forecasts for only the Twin Cities and Rochester. Starting June 1, 2017, the MPCA began issuing daily forecasts for the majority of its AQI monitor locations through MPCA's AQI website, the Minnesota Air mobile app, Twitter, and to individuals who have signed up to receive e-mailed forecasts. If it is suspected through forecasting or monitoring that the daily AQI will be over 100, the MPCA will issue an Air Quality Alert to be disseminated by the National Weather Service, GovDelivery, the Minnesota Air mobile app, Twitter, the media, and to individuals who have signed up to receive email alerts. Forecasts and alerts allow the public to be proactive about protecting their health and reducing their own contributions to emissions and exposure to air pollution. At no cost, the public can download the Minnesota Air mobile app and sign up for emailed forecasts and alerts from MPCA's AQI website (https://www.pca.state.mn.us/air/current-air-quality).

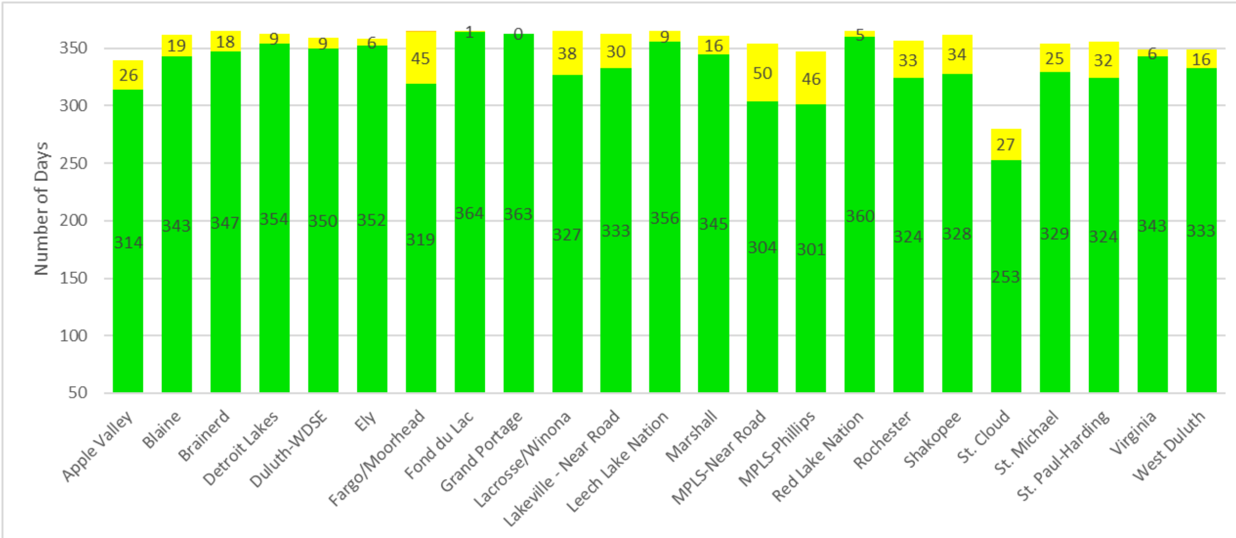
Figure 6. The Air Quality Index categories and respective levels of health concern (from https://airnow.gov).

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

In 2022, across all monitored locations in Minnesota, the majority of days were categorized as green for air quality for both $PM_{2.5}$ and ozone (Figure 7 and Figure 8). Wildfire activity in the Upper Midwest and neighboring Canada was fairly quiet and aided in decreasing the amount of yellow and worse AQI days compared to 2021. The Minneapolis-Near Road, located in the center of the Twin Cities metro, recorded the most yellow AQI days with 50. Most monitors recorded over 220 green ozone days during the official ozone season, which runs from March 1 to October 31. The Twin Cities Metro monitors recorded between 10-19 Yellow AQI days for ozone, with outstate monitors having 12 or fewer yellow AQI days for ozone. In general, a lower number of green AQI days and higher number of yellow and orange days in the Twin Cities is expected, since nitrogen oxides (an ingredient for ozone and $PM_{2.5}$) are more abundant in and around urban areas.

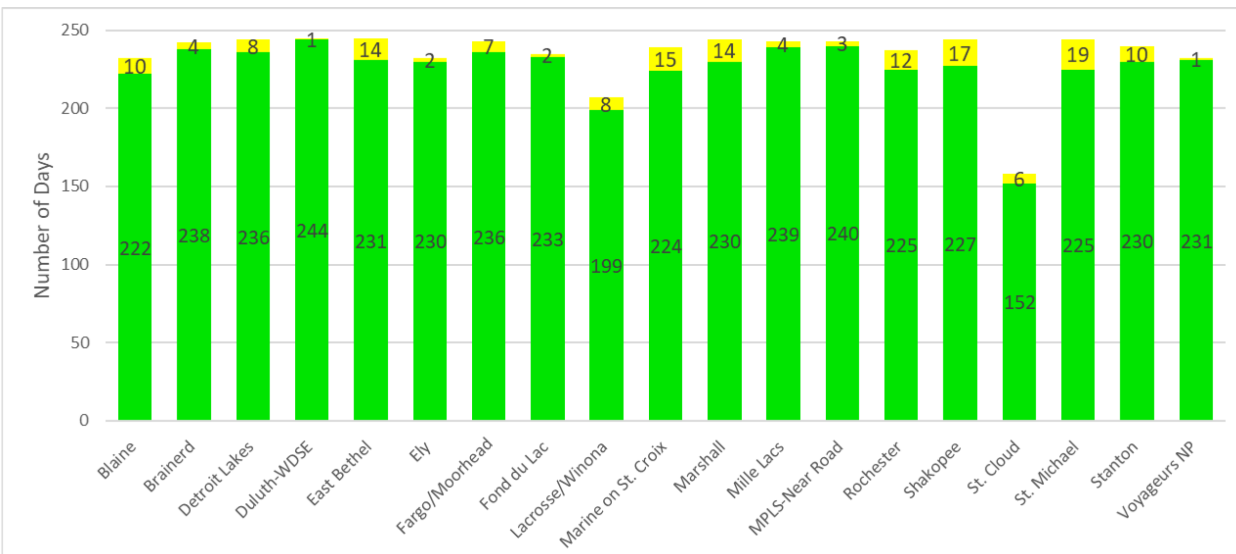
Overall, air quality conditions during 2022 were very similar to recent years with lesser amounts of smoke transport (Figure 9 and Figure 10). Above normal precipitation during the winter and near normal precipitation during the summer throughout most of the region led to reduced wildfire activity. Conditions that favor ozone formation (warm and dry with sunny skies) were also less common. However, wildfire smoke has become an increasingly common occurrence in Minnesota over the last decade. This overall upward trend is expected to continue due to climate change as warmer and drier weather fuels more frequent wildfires across the Canadian provinces and Pacific Northwest region of the U.S.

Figure 7. 2022 daily observed AQI category counts for $PM_{2.5}$ in Minnesota.



*Voyageurs N.P. a non-forecast location

Figure 8. 2022 daily observed AQI category counts for ozone in Minnesota (during the official ozone season from March 1 to October 31).



*Voyageurs N.P. a non-forecast location

Figure 9. Annual statewide $PM_{2.5}$ AQI category counts, 2001-2022.

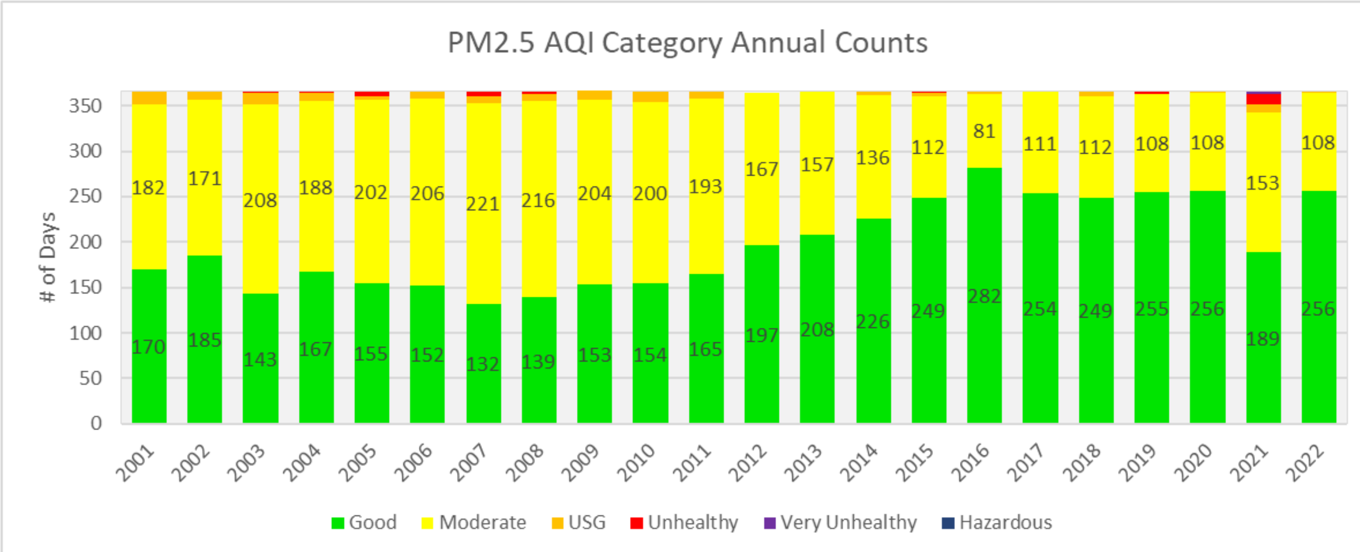
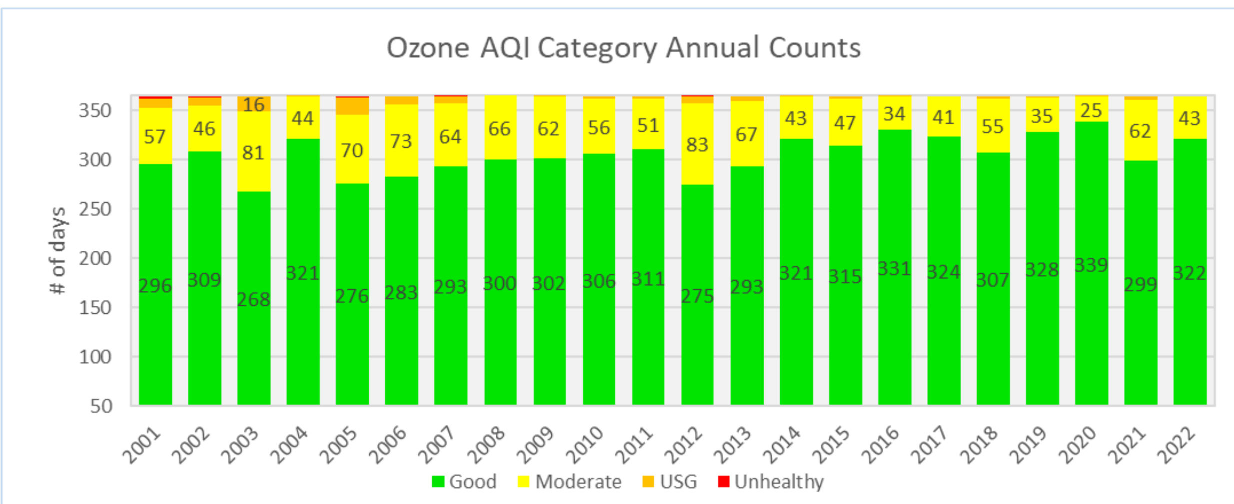
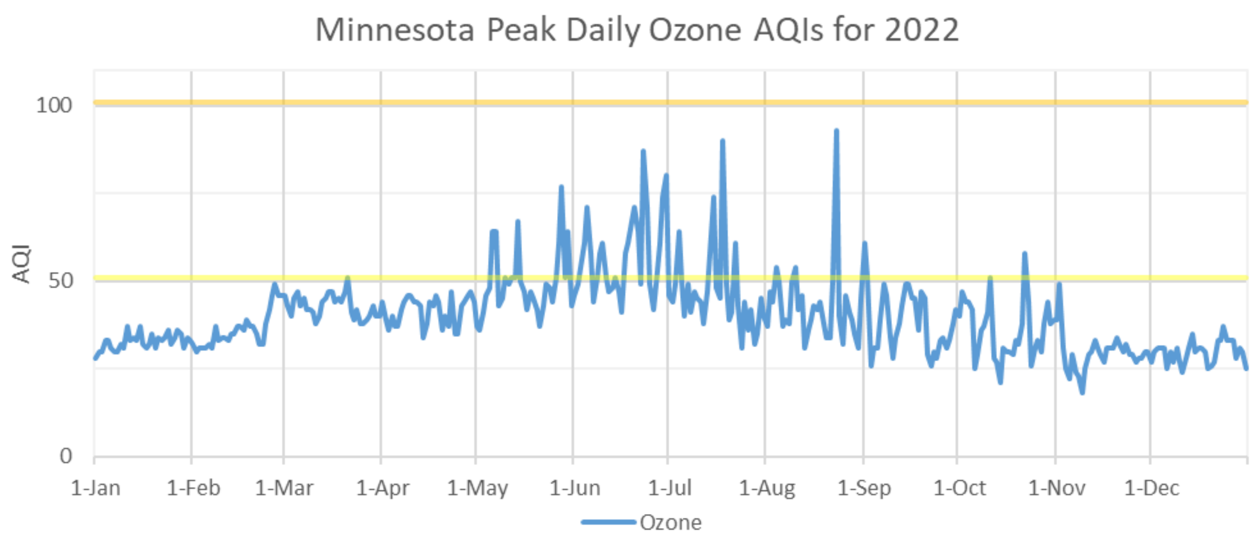


Figure 10. Annual statewide ozone AQI category counts, 2001-2022 (During the official ozone season from March 1 to October 31).



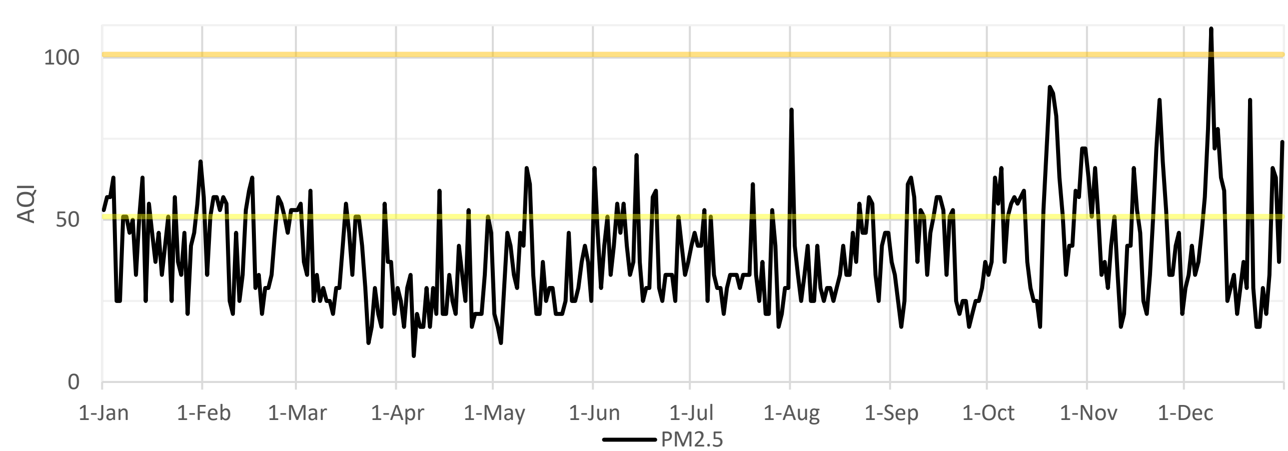
Minnesota did not experience any days with orange or higher ozone AQI measurements in 2022. The weather in Minnesota over the spring and summer of 2022 was generally near normal for temperature, and near normal in most of the state except for an area of dryness in central Minnesota. The highest ozone occurred on August 23, when the AQI reached 90 at East Bethel. The day with the most widespread Yellow or Moderate AQIs for ozone was June 23, when 17 monitors reached Yellow. The higher ozone generally occurred from mid-May to mid-July (see figure 11).

Figure 11. Peak daily ozone AQI for Minnesota in 2022.



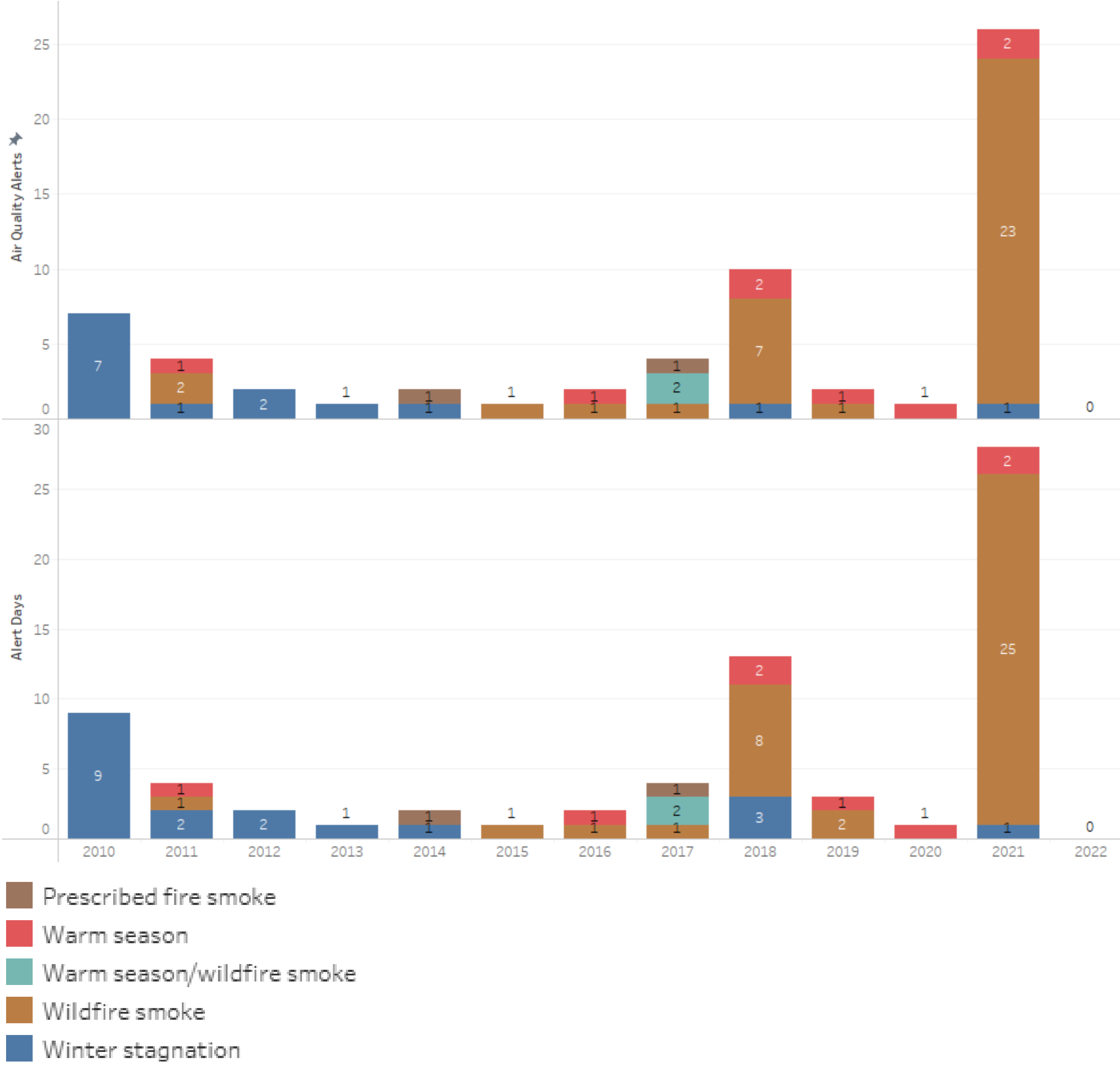
For $PM_{2.5}$, there was only 1 day with an AQI of orange or worse in 2022. The number of yellow or worse AQI days for $PM_{2.5}$ numbered 109, the lowest amount since 2016. Stagnation and nitrate formation was minimal during January to March. Stagnation was more common late in the year and contributed to a single orange AQI day and several yellow days during November and December. Prescribed fire led to a few yellow days during the spring, though the prescribed fire impacts were less in comparison to past years. Wildfire activity in Canada and northeast Minnesota was fairly quiet, a major reason for the lower $PM_{2.5}$ AQIs observed in 2022. Wildfire smoke contributed to yellow AQIs for $PM_{2.5}$ in early June and again in October. The one day spike in early August was an isolated to the Apple Valley monitor with unknown attribution. Figure 12 shows the maximum daily $PM_{2.5}$ for Minnesota in 2022.

Figure 12. Peak daily $PM_{2.5}$ AQI for Minnesota in 2022.



The MPCA did not issue any air quality alerts during 2022. This was the first time since air quality forecasting began in Minnesota where no alerts were issued (Figure 13).

Figure 13. Causes of air quality alerts issued in Minnesota counties, 2010-2022.



In 2023, there are plans to install ozone and fine particulate monitors in Mankato. Once these become operational, the MPCA intends to add Mankato to the list of forecast areas.

6.5 Chemical Speciation Network (CSN)

The CSN network is an EPA effort to gather data on the chemical composition of urban $PM_{2.5}$ and to provide a basic, long-term record of the concentration levels of selected ions, metals, carbon species, and organic compounds found in $PM_{2.5}$. The EPA established this network, which consists of approximately 300 monitoring sites nationwide. CSN data can be useful for assessing trends and developing mitigation strategies to reduce emissions and ambient pollutant concentrations.

The programmatic objectives of the CSN network are:

- Temporal and spatial characterization of aerosols
- Air quality trends analysis and tracking progress of control programs
- Comparison of the urban chemical speciation data set to the rural data collected from the IMPROVE network
- Development of emission control strategies

There are currently two CSN sites in Minnesota, located at the Andersen School (0963) in Minneapolis and at the NCore site in Blaine (1002).

6.6 Interagency Monitoring of Protected Visual Environments (IMPROVE)

The IMPROVE Aerosol Network is a cooperative air quality monitoring effort managed by the IMPROVE Steering Committee with representation from EPA, the National Park Service, U.S. Forest Service, U.S. Fish and Wildlife Service, Bureau of Land Management, the National Oceanic and Atmospheric Administration, several Multi-Jurisdictional Organizations that represent US States, and Arizona DEQ. This program was established in 1985 in response to the 1977 CAA Amendments to aid in developing Federal and State implementation plans for the protection of visibility in Class I areas. Class I areas are national parks overseen by the U.S. Department of the Interior (USDOI) and national forests and wilderness areas overseen by the U.S. Department of Agriculture (USDA). The IMPROVE network comprises 158 monitoring sites network-wide, 110 of which represent visibility conditions in 155 Mandatory Class I areas in the U.S and Virgin Islands. The remaining monitors, separately sponsored by state, regional, tribal and national organizations, do not represent Mandatory Class I areas but expand the spatial coverage for the network.

The objectives of the IMPROVE network are:

- To establish current visibility and aerosol conditions in Class I areas
- To identify chemical species and emission sources responsible for existing man-made visibility impairment
- To document long-term trends for assessing progress towards the national visibility goal
- To, in conjunction with the enactment of the Regional Haze Rule, provide regional haze monitoring that is representative of all visibility-protected Class I areas (where practical)

The IMPROVE monitors collect $PM_{2.5}$ speciation data; thus they are a key component of the EPA's national fine particle monitoring network and are critical to tracking progress related to the Regional Haze Regulations. Minnesota has three IMPROVE Aerosol Network sites shown in Figure 1. The sites are located at Voyageurs National Park (VOYA2, USDOI), near the Boundary Waters Canoe Area Wilderness near Ely (BOWA1, USDA), and Great River Bluffs State Park (GRRI1, Minnesota Department of Natural Resources).

6.7 National Core monitoring (NCore)

In October 2006, the EPA established the National Core (NCore) multi-pollutant monitoring network in its final amendments to the ambient air monitoring regulations for criteria pollutants (codified in 40 CFR Parts

53 and 58). EPA requires each state to have at least one NCore site; there are approximately 75 sites nationwide, mostly in urban areas.

Each NCore site must measure a minimum number of parameters (Table 6).

Table 6. NCore monitoring network site parameters.

Parameter	Comments
$PM_{2.5}$ speciation	Organic and elemental carbon, major ions and trace metals (24 hour average; every 3rd day)
$PM_{2.5}$ FRM mass	24 hr. average at least every 3rd day
Continuous $PM_{2.5}$ mass	1 hour reporting interval; FEM or pre-FEM monitors
$PM_{(10-2.5)}$ mass	Filter-based or continuous
Ozone (O_3)	All gases through continuous monitors
Carbon monoxide (CO)	Capable of trace levels (low ppm and below) where needed
Sulfur dioxide (SO_2)	Capable of trace levels (low ppm and below) where needed
Nitrogen Oxide (NO)	Capable of trace levels (low ppb and below) where needed
Total reactive nitrogen (NO/NO_y)	Capable of trace levels (low ppb and below) where needed
Surface meteorology	Wind speed and direction (reported as "Resultant"), temperature, RH

Each site in the NCore monitoring network addresses the following monitoring objectives:

- Report data on a timely schedule to the public through
  - The AIRNow data reporting website (https://www.airnow.gov/)
  - Air quality forecasting
  - Other public reporting mechanisms
- Support the development of emission strategies through air quality model evaluation and other observational methods
- Track long-term trends of criteria and non-criteria pollutants and their precursors for the accountability of emission strategy progress
- Establish nonattainment/attainment areas via comparison and compliance with the NAAQS
- Support scientific studies ranging across technological, health, and atmospheric process disciplines; support long-term health assessments that contribute to ongoing reviews of the NAAQS
- Support ecosystem assessments, recognizing that national air quality networks benefit ecosystem assessments and, in turn, benefit from data specifically designed to address ecosystem analysis

NCore sites monitor data for multiple parameters (Table 8) because numerous chemical and physical interactions among other pollutants underlie the formation of particulates and ozone, and the formation and destruction of one can influence the creation of the others. Multi-pollutant monitoring benefits health studies, long-term epidemiological studies, source apportionment studies, and air quality modeling.

The MPCA has an NCore site at the Anoka County Airport in Blaine (1002). The Anoka County Airport monitoring station is located approximately 11 miles north of downtown Minneapolis and approximately 15 miles northwest of downtown St. Paul. The site includes monitors for trace-level CO, SO_2, oxides of nitrogen (NO_x), and total reactive nitrogen (NO_y). These pollutants are the predominant products of inorganic combustion, and are the most abundant inorganic elements in the atmosphere. Emissions reductions, mainly from power plants and motor vehicles, have lowered the concentrations of these pollutants in most urban and rural areas; they are precursor gases, however, and they continue to play an important role in the formation of ozone, particulate matter, and air toxics at both local and regional scales. The trace-level data that this site provides helps us understand the role of these pollutants in the environment at levels far below the NAAQS.

6.8 Near road monitoring

Air pollution can be higher close to roadways. The purpose of the near-road network is to measure air pollution levels near heavily trafficked roadways. Near-road air monitoring sites are required to be located within 150 feet of the busiest roadways across the country. As a minimum, near-road monitoring sites are required to measure hourly levels of nitrogen dioxide (NO_2), carbon monoxide (CO), and fine particles ($PM_{2.5}$).

There are two near-road monitoring sites in Minnesota. Minneapolis (0962) is along the I-94 and I-35W freeway commons near downtown Minneapolis. Lakeville (0480) is along I-35, about 20 miles south of the downtowns of Minneapolis and St. Paul. Various parameters are being measured at each of the near-road sites (Table 7).

Table 7. Near-road monitoring parameters.

MPCA Site ID	City name	Site name	$PM_{2.5}$ FEM	TSP and Metals	O_3	NO_x	CO	VOCs	Carbonyls	Other parameters
0962	Minneapolis	Near Road I35/I94	X	X	X	X	X	X	X	Meteorological Data,
0480	Lakeville	Near Road I35	X			X	X			Meteorological Data

The particle counter and black carbon monitors will be removed from the Minneapolis near-road site (27-053-0962) in 2022.

6.9 National Atmospheric Deposition Program (NADP)

Atmospheric deposition is monitored through the NADP Program at over 250 sites, spanning the continental United States, Alaska, Puerto Rico, and the Virgin Islands (http://nadp.slh.wisc.edu/). There are two sub-networks in Minnesota: the National Trends Network (NTN) and the Mercury Deposition Network (MDN), with eight NTN and four MDN sites in Minnesota (see Figure 37).

The NTN network collects weekly precipitation samples for pH, sulfate, nitrate, ammonium, chloride, and base cations (such as calcium and magnesium). This network provides long-term, high-quality data for determining spatial and temporal trends in the chemical composition of precipitation.

The MDN network collects precipitation samples for analysis of total mercury and methylmercury concentrations. The objective is to develop a national database of the weekly concentrations of total mercury in precipitation, along with the seasonal and annual flux of total mercury in wet deposition. Samples are collected weekly and sent to Wisconsin Department of Natural Resource for analysis.

6.10 Photochemical Assessment Monitoring Stations (PAMS)

The PAMS network provides enhanced monitoring of ozone, NO_2, volatile organic compounds (VOCs), and selected carbonyl compounds in ambient air along with monitoring of various meteorological parameters. This is done in order to obtain more comprehensive and representative data on ozone and its precursors. The primary data objectives of the PAMS network include:

- Providing a speciated ambient air database that is both representative and useful in evaluating control strategies and understanding the mechanisms of pollutant transport by ascertaining ambient profiles and distinguishing among various individual VOCs.
- Providing local, current meteorological and ambient data to serve as initial and boundary condition information for photochemical grid models.
- Providing a representative, speciated ambient air database that is characteristic of source emission impacts to be used in analyzing emissions inventory issues and corroborating progress toward attainment.
- Providing ambient data measurements that would allow later preparation of unadjusted and adjusted pollutant trends reports.
- Providing additional measurements of selected criteria pollutants for attainment/nonattainment decisions and to construct NAAQS maintenance plans.
- Providing additional measurements of selected criteria and non-criteria pollutants to be used for evaluating population exposure to air toxics as well as criteria pollutants.

MPCA started taking PAMS measurements at the Blaine NCore location (27-003-1002) on June 1, 2021. Table 8 includes sampling schedules and instruments for each PAMS parameter.

Table 8: PAMS sampling schedules and instrumentation.

Parameter	Duration/Frequency	Sampling schedule	Instrument
Ozone	hourly averages	Year-round	Teledyne T400 series
Wind direction	hourly averages	Year-round	RM Young 200-05103-45 Alpine Wind Monitor
Wind speed	hourly averages	Year-round	RM Young 200-05103-45 Alpine Wind Monitor
Ambient temperature	hourly averages	Year-round	R.M. Young 41382 Temp/RH sensor
Atmospheric pressure	hourly averages	Year-round	R.M. Young 61402 BP sensor
Relative humidity (RH)	hourly averages	Year-round	R.M. Young 41382 Temp/RH sensor
Speciated VOCs	hourly averages	June 1 – August 31	CAS/Chromatatec Auto GC
Carbonyls	three sequential 8-hour average concentrations determined on a 1-in-3 day schedule	June 1 – August 31	ATEC 8000 cartridge sampler
“True” nitrogen dioxide (NO_2)	hourly averages	June 1 – August 31	Teledyne T500U
Precipitation amount	hourly averages	June 1 – August 31	MetOne 370D
Mixing layer height (MLH)	hourly averages	June 1 – August 31	Vaisala CL51
Intensity of solar radiation	hourly averages	June 1 – August 31	Kipp & Zonen SMP10 pyranometer
Intensity of ultraviolet (UV) radiation	hourly averages	June 1 – August 31	Kipp & Zonen SUV5 UV Radiometer

6.11 Industrial monitoring

In Minnesota, air quality permits are required to legally operate certain industrial facilities, to begin construction on new facilities, or to modify certain facilities. Air quality permits contain state and federal requirements aiming to minimize the environmental impact of air emissions from these facilities. Some federal programs specify performance standards for certain types of facilities or processes within a facility. Others address the impact of newly constructed facilities, or modifications to existing facilities, on ambient air quality.

Facilities that are required by state permit to monitor nearby ambient air quality to demonstrate compliance with air quality standards receive assistance from MPCA. This assistance includes siting evaluations, instrument performance audits, and data review. The facilities are responsible for their own data validation and for other QA/QC activities. Data from industrial monitors may be reported to the EPA's Air Quality System (AQS) database when a criteria pollutant is being measured to demonstrate NAAQS compliance.

The following list includes facilities currently monitoring ambient air quality and the parameters being monitored:

- 3M in Maplewood
    - $PM_{2.5}$
- American Crystal Sugar Company in Moorhead, Crookston, and East Grand Forks
    - H_2S, wind speed, wind direction
- Andersen Corporation in Bayport
    - $PM_{2.5}$ and PM_{10}
- ConAgra in Waseca
    - H_2S
- Malt O Meal in Northfield
    - $PM_{2.5}$
- Marvin Windows in Warraod
    - $PM_{2.5}$
- Northshore Mining Company in Silver Bay
    - $PM_{2.5}$, PM_{10}, and TSP
- Southern Minnesota Beet Sugar Cooperative in Renville
    - H_2S, wind speed, wind direction
- Water Gremlin in White Bear Lake
    - VOCs

6.12 Clean Air Status and Trends Network (CASTNET)

CASTNET provides long-term monitoring of air quality in rural areas to determine trends in regional atmospheric nitrogen, sulfur, and ozone concentrations, and deposition fluxes of sulfur and nitrogen pollutants. The objective of the CASTNET network is to evaluate the effectiveness of national and regional air pollution control programs. CASTNET began collecting measurements in 1991 with the incorporation of 50 sites from the National Dry Deposition Network (NDDN), which had been in operation since 1987. CASTNET operates more than 80 regional sites throughout the contiguous United States, Alaska, and Canada. Sites are located in areas where urban influences are minimal (http://epa.gov/castnet).

There are two CASTNET sites in Minnesota. One site, located at Voyageurs National Park (VOYA2), is operated by the National Park Service. The other, in Red Lake (2304), is operated by the Red Lake Nation (Figure 1). The MPCA does not have any role in these CASTNET sites.

7. Parameter networks and equipment

The MPCA monitors different types of measurable air properties, called parameters. The group of sites where a parameter is monitored is referred to as a parameter network. Generally, parameters refer to pollutants such as fine particles or air toxics, but parameters also include non-concentration data such as wind speed and temperature. There are currently 56 sites across Minnesota that are being monitored for various parameters (Table 13 and Table 14), using appropriate methods and equipment (Table 10).

The MPCA monitors the six criteria pollutants established by the 1970 CAA to show compliance with the NAAQS. The criteria pollutants are particulate matter ($PM_{2.5}$ and PM_{10}), lead (Pb), ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO).

Other types of particulate matter are also collected in Minnesota. Total suspended particulate matter (TSP) is monitored to show compliance with Minnesota Ambient Air Quality Standards (MAAQS). Chemical speciation of $PM_{2.5}$ is currently monitored at five sites in Minnesota through the IMPROVE network and CSN. Speciation data are used for trends analysis and to better understand the sources of fine particles.

The MPCA also monitors pollutants that pose a potential risk to human health and the environment but are not regulated by national standards. These pollutants include air toxics, such as VOCs, carbonyls, and metals; acid rain; and mercury (Hg). Acid rain and mercury are monitored across Minnesota through the NADP network.

Compounds containing sulfur are monitored, as they may cause irritation to the eyes, nose, and throat. Hydrogen sulfide (H_2S) is monitored to show compliance with the MAAQS. Total reduced sulfur (TRS), which contains H_2S, is monitored near industrial sources. TRS is used as a conservative measurement to demonstrate compliance with the H_2S MAAQS.

Temperature, wind speed, wind direction, barometric pressure, and relative humidity strongly influence the concentrations and transport of pollutants. Meteorological data are collected at seven sites in the Twin Cities metropolitan area. Meteorological data from other sources near air monitoring stations can also be used to help interpret air quality monitoring data.

Generally, parameters are monitored either continuously or as integrated data, using various methods and equipment (Table 8). Continuous data give incremental readings on a real-time basis, such as every 5 or 15 minutes or every hour. Integrated samples are usually 24-hour averages, collected midnight to midnight once every three days, once every six days, or once every twelve days. Continuous data are collected and analyzed at the site. For integrated data, samples are collected at sites and transported to the MPCA lab for further analysis.

7.1 Site parameter networks

Site parameter networks are groups of sites across the state that monitor the same parameter. Tables 9 and 10 summarize which parameters are measured at sites across Minnesota in 2022. Table 11 summarizes how many sites are in each parameter network.

Table 9. 2023 Site Parameter – Greater Minnesota.

Site ID	City name	Site name	$PM_{2.5}$ FRM	$PM_{2.5}$ FEM	$PM_{2.5}$ Speciation	PM_{10}	TSP and Metals	Ozone	Oxides of Nitrogen	Sulfur Dioxide	Carbon Monoxide	VOCs	Carbonyls	Other parameters
27-005-2013	Detroit Lakes	FWS Wetland Management District		X				X						
27-007-2304***	Red Lake	Red Lake Nation		X										
27-017-7417***	Cloquet	Fond du Lac Band		X				X						
27-021-3410***	Cass Lake	Leech Lake Nation: Cass Lake		X										
27-031-7810***	Grand Portage	Grand Portage Band		X										
27-035-3204	Brainerd	Brainerd Lakes Regional Airport		X				X						
27-049-5302	Stanton	Stanton Air Field						X						
27-075-0005 MN18* BOWA1**	Ely	Boundary Waters		X	X			X						Acid and Hg Deposition, IMPROVE
27-083-4210	Marshall	Southwest Minnesota Regional Airport		X				X						
27-095-3051***	Mille Lacs	Mille Lacs Band						X						
27-109-5008	Rochester	Ben Franklin School		X				X						
27-137-0032	Duluth	Oneota Street				X								Collocated PM_{10}
27-137-0034 MN32* VOYA2**	International Falls	Voyageurs NP – Sullivan Bay			X			X						Acid Deposition, IMPROVE
27-137-7001	Virginia	Virginia City Hall		X		X	X		X	X				
27-137-7549	Duluth	Michigan Street					X					X	X	
27-137-7550	Duluth	U of M - Duluth		X				X						
27-137-7554	Duluth	Laura MacArthur School		X										
27-137-7555	Duluth	Waseca Road					X							Collocated TSP and metals
27-145-3052	Saint Cloud	Talahi School		X				X						
GRRI1**	Winona	Great River Bluffs			X									IMPROVE
MN08*	Hovland	Hovland												Acid Deposition
MN16*	Balsam Lake	Marcell Experimental Forest												Acid and Hg Deposition
MN23*	Pillager	Camp Ripley												Acid and Hg Deposition
MN27*	Lamberton	Lamberton												Acid and Hg Deposition
MN28*	Sandstone	Grindstone Lake												Acid Deposition
MN99*	Finland	Wolf Ridge												Acid Deposition

* NADP Site ID
** IMPROVE Site
*** Tribal monitor

Table 10. 2022 Site parameters – Twin Cities metropolitan area.

Site ID	City name	Site name	$PM_{2.5}$ FRM	$PM_{2.5}$ FEM	$PM_{2.5}$ Speciation	PM_{10}	TSP and Metals	Ozone	Oxides of Nitrogen	Sulfur Dioxide	Carbon Monoxide	VOCs	Carbonyls	Other parameters
27-003-1001 MN01*	East Bethel	Cedar Creek						X						Acid Deposition
27-003-1002	Blaine	Anoka Airport	X	X	X	X[C]	X	X	X[T]	X[T]	X[T]	X	X	[T]NCore trace level gases, $PM_{10-2.5}$, Meteorological Data, CSN, PAMS
27-003-6021	Anoka	Federal Cartridge					X[L]							
27-037-0020	Rosemount	Flint Hills Refinery 420					X		X	X	X	X	X	Collocated TSP and Metals, TRS, Meteorological Data
27-037-0423	Rosemount	Flint Hills Refinery 423					X		X	X	X	X	X	TRS, Meteorological Data
27-037-0443	Rosemount	Flint Hills Refinery 443								X		X	X	
27-037-0465	Eagan	Gopher Resources					X[L]							Collocated TSP and Metals
27-037-0470	Apple Valley	Apple Valley		X			X					X	X	Collocated $PM_{2.5}$ FEM
27-037-0480	Lakeville	Near Road I35		X					X		X			Meteorological Data
27-053-0909	Minneapolis	Lowry Avenue				X[C]	X					X	X	Meteorological Data
27-053-0910	Minneapolis	Pacific Street				X[C]	X							
27-053-0954	Minneapolis	Arts Center								X	X			
27-053-0961	Richfield	Richfield Intermediate School										X	X	
27-053-0962	Minneapolis	Near Road I35/I94		X			X	X	X		X	X	X	Meteorological Data, Collocated VOCs and Carbonyls
27-053-0963	Minneapolis	H.C. Andersen School	X	X	X		X					X	X	CSN
27-053-0966	Minneapolis	City of Lakes				X	X					X	X	
27-053-1007	Minneapolis	Humboldt Avenue					X					X	X	
27-053-1909	Minneapolis	Bottineau / Marshall Terrace				X[C]	X					X	X	
27-053-2006	St. Louis Park	St. Louis Park	X									X	X	Collocated $PM_{2.5}$ FRM
27-123-0866	St. Paul	Red Rock Road				X								Collocated PM_{10}
27-123-0868	St. Paul	Ramsey Health Center	X			X[C]						X	X	
27-123-0871	St. Paul	Harding High School	X	X			X					X	X	Collocated $PM_{2.5}$ FRM
27-123-0875	St. Paul	West Side					X							
27-139-0505	Shakopee	Shakopee		X				X						
27-163-0436	St. Paul Park	St. Paul Park Refinery 436								X		X	X	TRS, Collocated VOCs and Carbonyls
27-163-0446	Bayport	Point Road					X					X	X	
27-163-6016	Marine on St. Croix	Marine on St. Croix						X						
27-171-3201	Saint Michael	Saint Michael		X				X						

*NADP Site ID
[L]Source-oriented Lead
[C]PM_{10} Continuous

Table 11. Number of sites per parameter network in 2023.

	Number of sites in greater Minnesota	Number of sites in the Twin Cities metro area	Total number of sites in Minnesota
All Sites	26	28	54
$PM_{2.5}$ FRM	0	5	5
Continuous $PM_{2.5}$	13	8	21
$PM_{2.5}$ Speciation	3	2	5
PM_{10} Daily	2	2	4
PM_{10} Continuous	0	5	5
TSP and Metals	3	16	19
Ozone	11	6	17
Oxides of Nitrogen	1	5	6
Sulfur Dioxide	1	6	7
Carbon Monoxide	0	6	6
VOCs	1	17	18
Carbonyls	1	17	18

7.2 Methods and equipment

Table 12 lists current methods and equipment used by MPCA. Appendix B of this plan provides tables that describe each monitor's method, scale, objective, and collocation, where required.

Equipment changes

In 2022 and 2023, most of the $PM_{2.5}$ BAM monitors were replaced with Teledyne T640 and T640X monitors. T640 monitors are an FEM for $PM_{2.5}$ while T640X monitors are an FEM for $PM_{2.5}$, PM_{10}, and $PM_{10-2.5}$ simultaneously. When a monitor is designated as FEM, data can be used to demonstrate compliance with the $PM_{2.5}$ NAAQS. Special consideration will be taken regarding the order of replacement and collocation requirements. Details about methods and collocation before and after the transition can be found in Table B6 of Appendix B of this plan.

Most BAM monitors will be replaced with T640 monitors giving us a continuous set of $PM_{2.5}$ data for all continuous $PM_{2.5}$ sites. A T640 monitor will also be added to a new site in Mankato, MN to measure $PM_{2.5}$ to support modeling efforts. Since T640X are an FEM for $PM_{2.5}$, PM_{10}, and $PM_{10-2.5}$, T640X monitors at three sites will give us the following additional benefits:

- Pacific Street (27-053-0910) in Minneapolis will add $PM_{2.5}$ to a site that currently only has PM_{10}
- Marshall (27-083-4210) will add PM_{10} to a site that currently only has $PM_{2.5}$
- NCore (27-003-1002) will replace 2 MetOne BAMs

Table 12. Methods and equipment used for parameter networks in Minnesota.

Parameter	Methods and equipment	Analyzing agency
Acid Deposition	Weekly wet-only precipitation collection	NADP
Carbonyls	HPLC from DNPH tubes collected using ATEC Model 2200 sampler	MPCA
Carbonyls - PAMS	HPLC from DNPH tubes collected using ATEC Model 8000 sampler	MPCA
CO	Infrared Absorption – Teledyne API Models 300E/T300	MPCA
CO trace level	Infrared Absorption – Teledyne API Model T300U	MPCA
H_2S	Honeywell Analytics SPM Flex	MPCA
Mercury Deposition	Weekly wet-only precipitation collection	NADP
Metals	ICP/MS from TSP filters	MPCA
Meteorological Data	Various meteorological sensors	MPCA
NO/NO_y trace level	Chemiluminescence – Teledyne API Model T200U	MPCA
NO_X	Chemiluminescence – Teledyne API Models 200A/T200	MPCA
NO_2	Cavity Attenuated Phase Shift (CAPS) - Teledyne API Model T500U	MPCA
O_3	Ultraviolet Absorption – Teledyne API Models 400E/ T400	MPCA
PM_{10}	Gravimetric – Andersen Hi-Vol samplers	MPCA
PM_{10} Continuous	Beta Attenuation – MetOne Instruments BAM-1020 (Teledyne T640x will be added to the NCore site)	MPCA
$PM_{10-2.5}$	Beta Attenuation – MetOne Instruments BAM-1020	MPCA
$PM_{2.5}$ FEM	Beta Attenuation – MetOne Instruments BAM-1020 FEM	MPCA
	Broadband spectroscopy – Teledyne T640 and T640X	MPCA
$PM_{2.5}$ FRM	Gravimetric – Thermo Partisol-Plus Model 2025 / 2025i $PM_{2.5}$ Sequential Air Sampler	MPCA
$PM_{2.5}$ Speciation - CSN	MetOne Instruments SAAS Speciation Sampler; URG3000N Carbon Samplers	EPA
$PM_{2.5}$ Speciation - IMPROVE	IMPROVE Sampler	IMPROVE
SO_2	Pulsed Fluorescence – Teledyne API Models 100E/T100	MPCA
SO_2 trace level	Pulsed Fluorescence – Teledyne API Model T100U	MPCA
TRS	SO_2 analyzer (pulsed fluorescence) with thermal oxidizer	MPCA
TSP	Gravimetric –High Volume samplers	MPCA
VOCs (24-hour)	GC/MS analysis of samples collected using a ATEC Model 2200 sampler	MPCA
VOCs (hourly)	CAS/Chromatatec Auto GC	MPCA

American Rescue Plan (ARP)

In April of 2022, the MPCA was notified that the EPA was planning to award ARP direct funding to the MPCA to purchase air monitoring equipment. Utilizing one-time funding provided under the American Rescue Plan (ARP) Act, the primary objective of this project is to enhance monitoring of $PM_{2.5}$ or other National Ambient Air Quality Standard (NAAQS) pollutants in and near communities with environmental justice concerns who face disproportionate exposure to these pollutants and health risks which are also associated with increased vulnerability to COVID-19.

The funds may be used to address other considerations in and near communities with environmental justice concerns including upgrading other NAAQS pollutant monitoring sites, upgrading certain NAAQS gas monitors and/or equipment not meeting performance or completeness goals, and other possible PM monitoring investments. Table 13 describes what the MPCA intends to do with the ARP funding. The MPCA has received the ARP funds and is currently in the process of purchasing the equipment.

Table 13: Equipment MPCA will purchase with ARP funding.

AQS Site ID	Site Name	City	Parameter	Upgrade Proposed
27-013-TBD	Mankato	Mankato	Ozone, Continuous $PM_{2.5}$	TAPI T400, T640
27-145-3052	Talahi School	St. Cloud	Ozone	TAPI T400
27-035-3204	Brainerd Lakes Regional Airport	Brainerd	Ozone	TAPI T400
27-137-7550	Duluth U of M	Duluth	Ozone	TAPI T400
27-053-0910	Pacific Street	Minneapolis	Continuous $PM_{2.5}$	TAPI T640X
27-003-1002	Anoka County Airport	Anoka	NO_2	ESC 8872, T700U
27-037-0480	Near Road I-35	Lakeville	NO_2	ESC 8872
27-053-0962	Near Road I-35/I-94	Minneapolis	NO_2	ESC 8872, TAPI T700
27-037-0020	Flint Hills Refinery 420	Rosemount	NO_2	ESC 8872
27-037-0423	Flint Hills Refinery 423	Rosemount	NO_2	ESC 8872
27-137-7001	Virginia City Hall	Virginia	NO_2	ESC 8872, TAPI T700
Statewide	Statewide	Statewide	All Parameters	In house Flow device certification

MPCA also plans to support our tribal partners on new FEM $PM_{2.5}$ projects funded with ARP awards, including serving as their Primary Quality Assurance Organization (PQAO). These projects will provide tribal communities fine particulate data of the same quality and allow them to compare continuous data streams in nearby areas. In addition, the MPCA will support a new ozone site proposed by the Red Lake Nation.

Our tribal partners include:

- Fond Du Lac Band of Lake Superior Chippewa
- Grand Portage Band of Lake Superior Chippewa
- Leech Lake Band of Ojibwe
- Mille Lacs Band of Ojibwe
- Red Lake Nation

8. Criteria pollutants

In 1970, the CAA authorized the EPA to establish standards for six pollutants known to cause harm to human health and the environment; these were given the name criteria pollutants. The CAA requires each state to monitor these pollutants, then to report the findings to the EPA. In Minnesota, the MPCA is responsible for these actions. The criteria pollutants are particulate matter (currently $PM_{2.5}$ and PM_{10}), lead (Pb), ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO).

National Ambient Air Quality Standards

For each of these pollutants, the EPA has developed national ambient air monitoring concentration standards (NAAQS). Primary standards are set to protect public health, while secondary standards are set to protect the environment and public welfare (i.e. visibility, crops, animals, vegetation, and buildings).

The CAA requires the EPA to review the scientific basis of these standards every five years to ensure they are protective of public health and the environment. The EPA website describes the latest updates to the NAAQS, at https://www.epa.gov/criteria-air-pollutants/naaqs-table (Table 14).

Table 14. EPA National Ambient Air Quality Standards (NAAQS).

Pollutant [final rule citation]		Primary/ Secondary	Averaging time	Level	Form
Carbon Monoxide (CO) [76 FR 54294, Aug 31, 2011]		Primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead (Pb) [73 FR 66964, Nov 12, 2008]		Primary and secondary	Rolling 3 month average	0.15 $\mu g/m^3$ (1)	Not to be exceeded
Nitrogen Dioxide (NO_2) [75 FR 6474, Feb 9, 2010] [77 FR 20218, April 3, 2012]		Primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		Primary and secondary	1 year	53 ppb (2)	Annual Mean
Ozone (O_3) [80 FR 65292, Oct 26, 2015]		Primary and secondary	8 hours	0.070 ppm (3)	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM) 78 FR 3086, Jan 15, 2013	$PM_{2.5}$	Primary	1 year	12.0 $\mu g/m^3$	Annual mean, averaged over 3 years
		Secondary	1 year	15.0 $\mu g/m^3$	Annual mean, averaged over 3 years
		Primary and secondary	24 hours	35 $\mu g/m^3$	98th percentile, averaged over 3 years
	PM_{10}	Primary and secondary	24 hours	150 $\mu g/m^3$	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2) [75 FR 35520, Jun 22, 2010] **[84 FR 9866, April 17, 2019]**		Primary	1 hour	75 ppb (4)	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		Secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

(1) In areas designated nonattainment for the Pb standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5 $\mu g/m^3$ as a calendar quarter average) also remain in effect.

(2) The level of the annual NO_2 standard is 0.053 ppm. It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.

(3) Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) O_3 standards additionally remain in effect in some areas. Revocation of the previous (2008) O_3 standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.

(4) The previous SO_2 standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards, and (2) any area for which an implementation plan providing for attainment of the current (2010) standard has not been submitted and approved and which is designated nonattainment under the previous SO_2 standards or is not meeting the requirements of a SIP call under the previous SO_2 standards (40 CFR 50.4(3)). A SIP call is an EPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the required NAAQS.

Air quality design values

A design value is a statistic that describes the air quality status of a given location relative to the level of the National Ambient Air Quality Standards (NAAQS). Design values are defined to be consistent with the individual NAAQS as described in 40 CFR Part 50. They are typically used to designate and classify nonattainment areas, as well as to assess progress towards meeting the NAAQS. Areas of the country where air pollution levels persistently exceed the national ambient air quality standards may be designated "nonattainment." The EPA Green Book (https://www.epa.gov/green-book) provides current information on nonattainment areas by state and pollutant.

Design values are computed and published annually by EPA's Office of Air Quality Planning and Standards and reviewed in conjunction with the EPA Regional Offices. More information can be found at https://www.epa.gov/air-trends/air-quality-design-values.

8.1 Particulate matter

The MPCA monitors four different sizes of particulates: fine particulate matter ($PM_{2.5}$), coarse particulate matter ($PM_{10-2.5}$), PM_{10}, and TSP. $PM_{2.5}$ and PM_{10} are regulated by the NAAQS and TSP is regulated by the MAAQS. There are currently no state or federal air quality standards for $PM_{10-2.5}$.

$PM_{2.5}$ - Fine particulate matter

$PM_{2.5}$ is a chemically and physically diverse mixture of very small particles measuring less than 2.5 microns in diameter. This mixture is comprised of a complex blend of chemicals including ammonium sulfate, ammonium nitrate, particle-bound water, elemental carbon, hundreds or thousands of organic compounds, and inorganic material, including soil and metals.

$PM_{2.5}$ can be inhaled deeply into the lungs, and elevated concentrations of $PM_{2.5}$ are associated with a rise in heart attacks, acute and chronic bronchitis, asthma attacks, and respiratory symptoms. In children, reduced lung function, growth, and increased respiratory illness are also associated with elevated $PM_{2.5}$ concentrations.

There are currently 25 $PM_{2.5}$ sites in Minnesota, 10 of which are in the Twin Cities metropolitan area (Figure 15). Four types of $PM_{2.5}$ monitors are operated in Minnesota: filter-based Federal Reference Method (FRM), Continuous Federal Equivalent Method (FEM), monitors in the Chemical Speciation Network (CSN), and monitors in the IMPROVE network. Monitors classified as FRM or FEM are regulatory-grade monitors, which can be used to demonstrate compliance with the $PM_{2.5}$ NAAQS. Monitors in the CSN and IMPROVE networks are not eligible for regulatory comparisons.

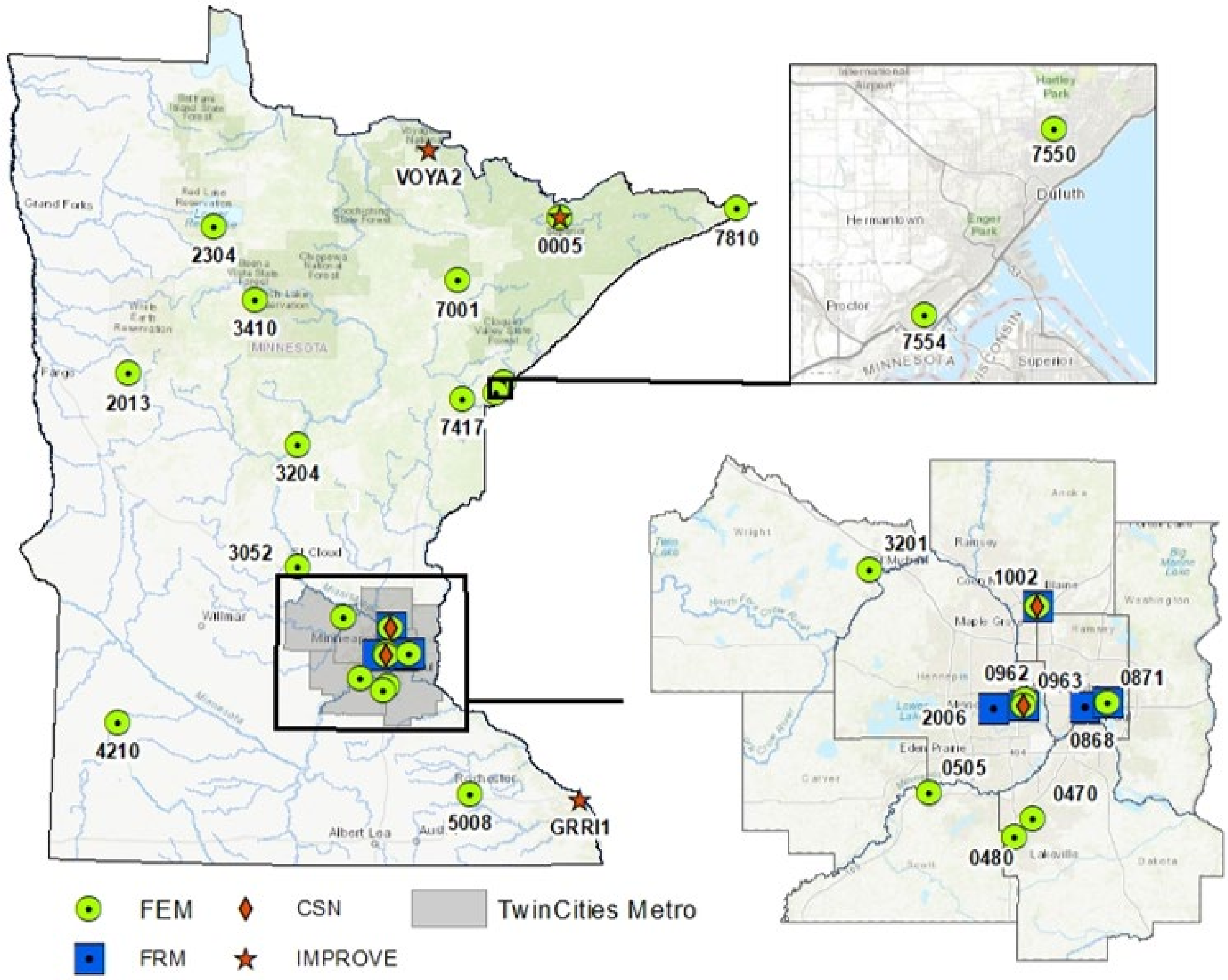
The FRM samplers collect a 24-hour mass sample of $PM_{2.5}$ on Teflon filters. All FRM sites in Minnesota run once every three days. $PM_{2.5}$ data collected using this method are compared to the NAAQS to demonstrate compliance.

The FEM $PM_{2.5}$ monitors operating in Minnesota are continuous mass monitors that collect and report hourly $PM_{2.5}$ concentrations. All continuous $PM_{2.5}$ monitors operating in Minnesota are designated as FEM and can be used to demonstrate compliance with the $PM_{2.5}$ NAAQS. Hourly $PM_{2.5}$ data are also used to calculate the AQI and develop AQI forecasts for Minnesota. Continuous data are reported to the MPCA's AQI website (www.pca.state.mn.us/aqi) and the EPA's AIRNow website (https://airnow.gov/), as well as the Air Quality System (AQS).

CSN and IMPROVE samplers collect 24-hour $PM_{2.5}$ samples once every three days and are analyzed for chemical composition. Speciated parameters and daily $PM_{2.5}$ concentrations are available from both networks. Data from the $PM_{2.5}$ speciation networks are used for trends analysis and to better understand sources and health effects.

In 2023, continuous $PM_{2.5}$ will be added to Pacific Street (27-053-0910) in Minneapolis and to a new site in Mankato. As discussed in the Network Assessment section of this plan, the MPCA will also begin evaluations for potential consolidation of the following sites: Lowry Avenue (27-053-0909), Pacific Street (27-053-0910), and Bottineau / Marshall Terrace (27-053-1909).

Figure 14. 2023 $PM_{2.5}$ monitoring sites in Minnesota.

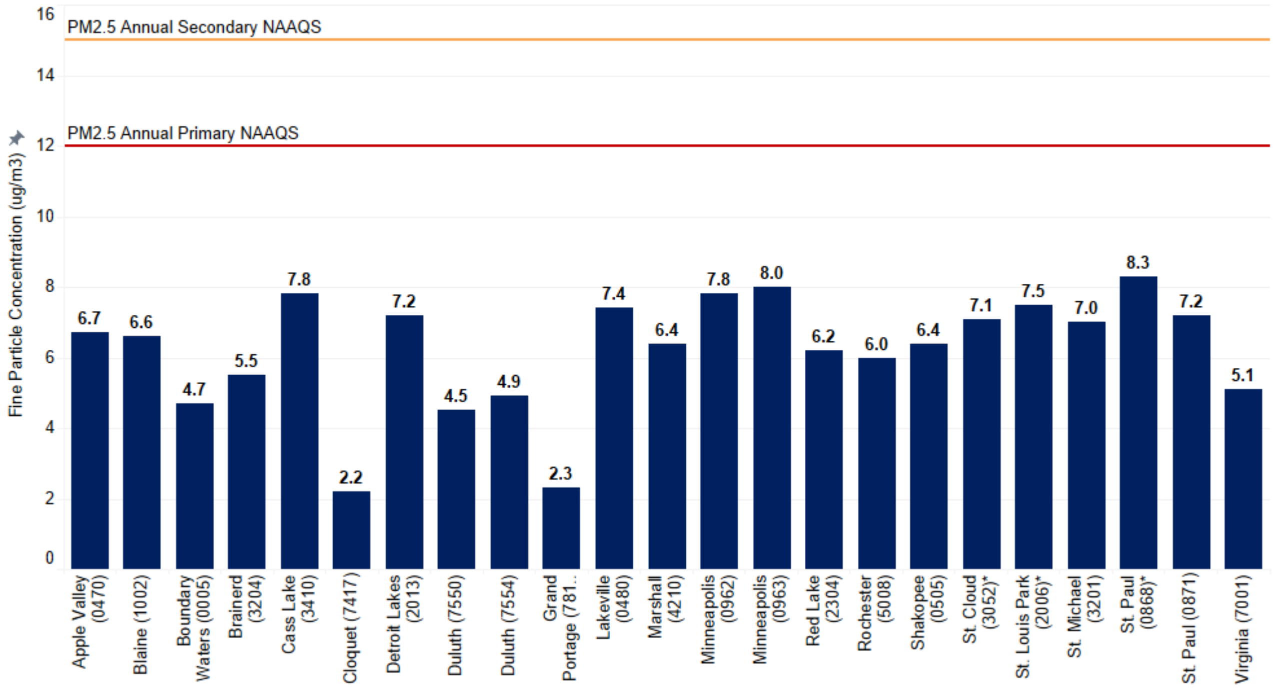


$PM_{2.5}$ Regulatory network overview

The $PM_{2.5}$ regulatory network includes FRM and FEM monitors. Currently, the MPCA operates FRM samplers at five sites and FEM monitors at 21 sites (Figure 15). If a $PM_{2.5}$ FRM monitoring site were lost due to circumstances beyond the MPCA's control, a replacement site would be established if the lost site exceeded the NAAQS or if it is the "design value site" for a particular metropolitan statistical area (MSA). In this case, all possible efforts would be made to find a new site that is physically close to the lost site and has a similar scale and monitoring objective. However, if the "design value site" for that MSA were still operational, the MPCA would not establish a replacement site because the "design value site" would be used to determine compliance with the $PM_{2.5}$ NAAQS.

A given monitoring site meets the annual $PM_{2.5}$ NAAQS if the three-year average of the annual average $PM_{2.5}$ concentration is less than or equal to 12 $\mu g/m^3$. Results from $PM_{2.5}$ monitors in 2020-2022 show Minnesota annual average $PM_{2.5}$ concentrations ranged from 2.2 $\mu g/m^3$ in Cloquet (7417) to 8.3 $\mu g/m^3$ in St. Paul (0868); all below the annual standard of 12 $\mu g/m^3$ (Figure 15).

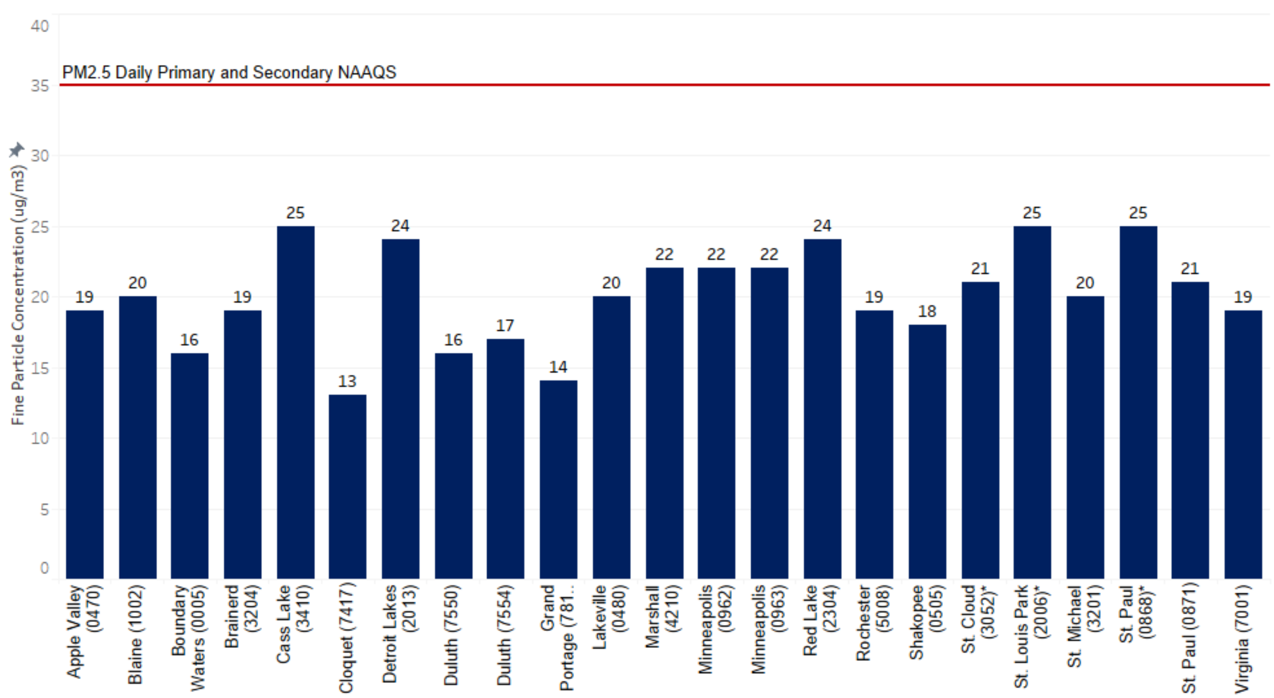
Figure 15. 2022 $PM_{2.5}$ design values compared to the annual NAAQS.



***Site did not meet data completeness criteria**

A site meets the 24-hour NAAQS if the 98th percentile of the 24-hour $PM_{2.5}$ concentrations in a year, averaged over three years, is less than or equal to 35 µg/m³. Results from FEM monitors in 2020-2022 show the 98th percentile of the daily $PM_{2.5}$ averages in Minnesota ranged from 13 µg/m³ in Cloquet (7417) to 25 µg/m³ in St. Paul (0868) and St. Louis Park (2006); all below the 24-hour standard of 35 µg/m³ (Figure 16).

Figure 16. 2022 $PM_{2.5}$ design values compared to the 24-hour NAAQS.



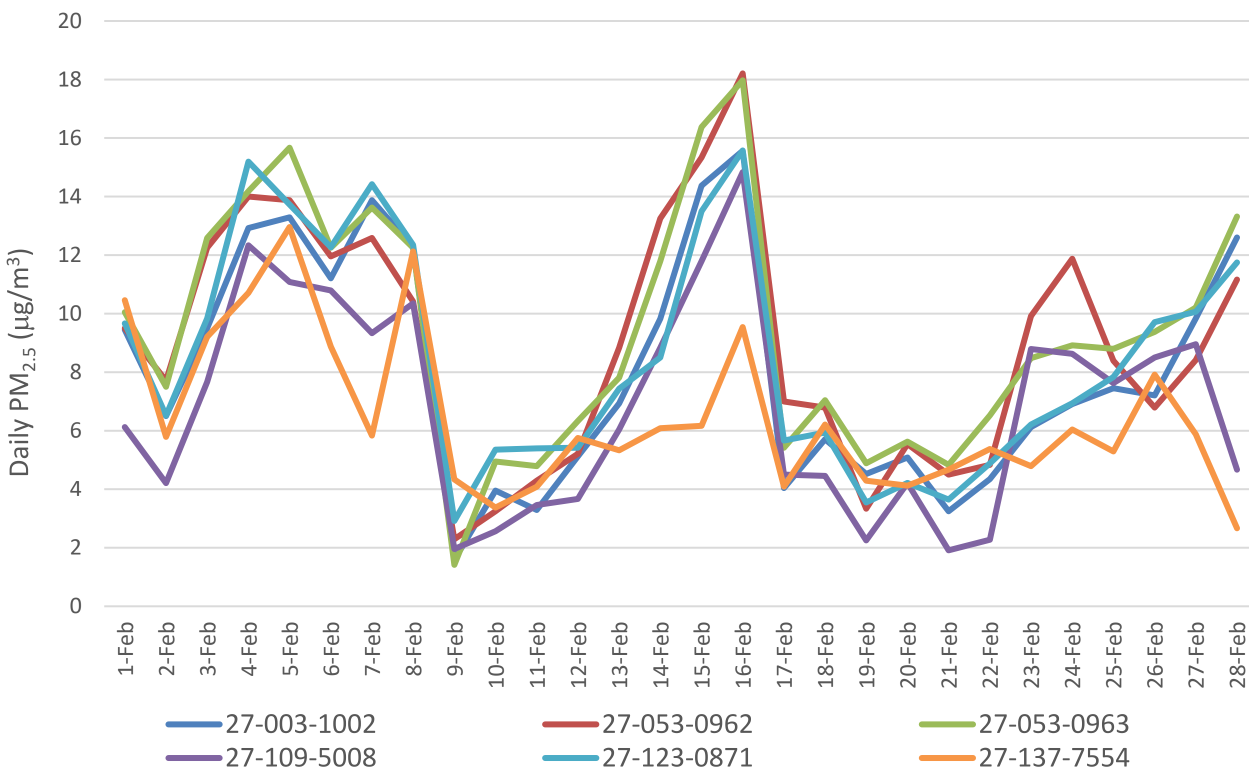
***Site did not meet data completeness criteria**

$PM_{2.5}$ Continuous network

The MPCA currently supports 21 FEM $PM_{2.5}$ sites in Minnesota. In addition to providing NAAQS comparable data, the $PM_{2.5}$ continuous (FEM) data provide two key types of information that are not available from the FRM network. First, continuous data capture high concentration days that might be missed in the one-in-three day FRM sampling schedule. Second, daily monitoring allows for temporal contrasts between sites on an ongoing basis, providing better, more informative comparisons. Additionally, continuous $PM_{2.5}$ monitoring provides hourly data that assist in understanding how concentrations vary throughout the day. Understanding such daily fluctuations helps determine sources of $PM_{2.5}$ and when health risks from fine particles are greatest. Increased understanding of concentrations and risks aids in prioritizing emission reduction efforts.

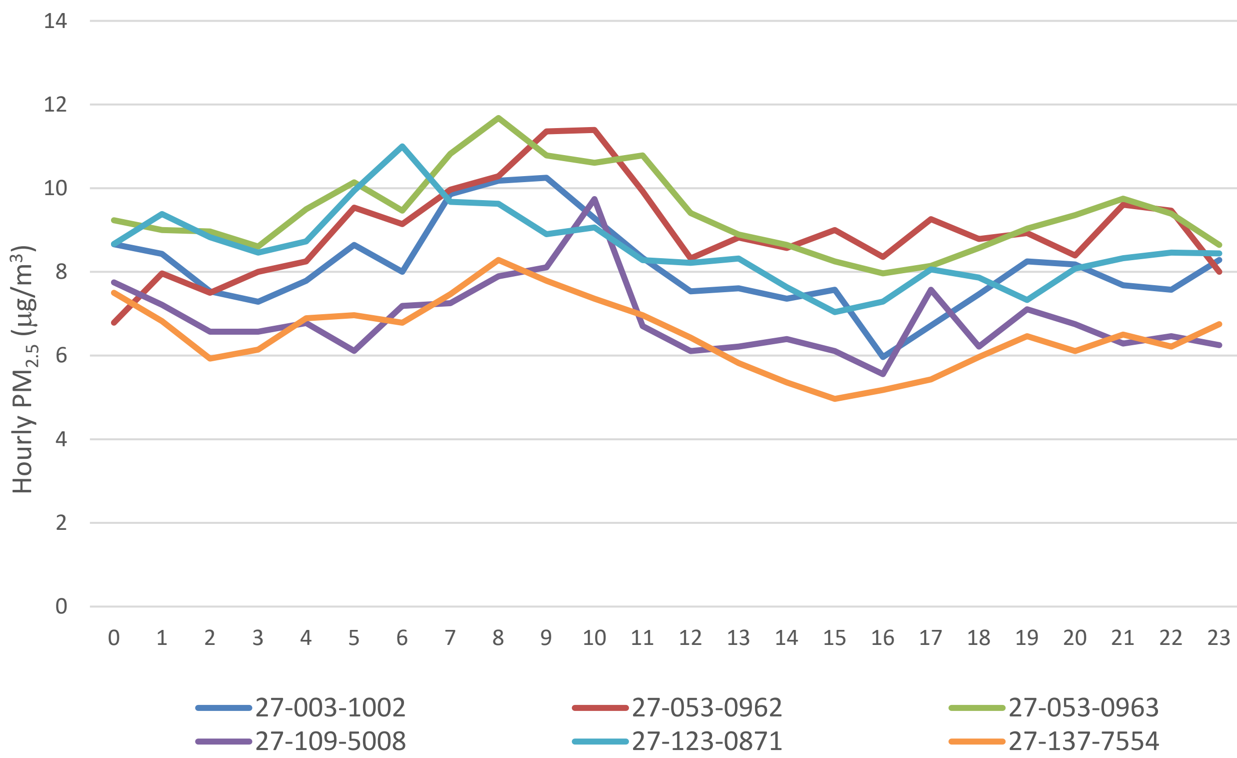
$PM_{2.5}$ is a regional pollutant, with some addition from local sources; therefore, concentrations tend to rise and fall in unison across the state. There is considerable variability between sites, however, even as the general trend stays uniform. Such differences in concentrations tend to be driven by local sources, especially those in closer proximity to large urban areas. Disparities between urban and rural areas demonstrate the effect of man-made emission sources on fine particulate concentrations (Figure 17).

Figure 17. Daily average $PM_{2.5}$ concentrations at several Minnesota sites, February 2022.



$PM_{2.5}$ emissions in urban areas tend to follow a daily pattern (Figure 18). The mid-morning peak concentration results from traffic. As temperatures rise in the day, the atmospheric mixing height increases. This allows for dilution of fine particle concentrations and lowered concentrations throughout the afternoon. Temperatures fall in the evening, lowering the mixing height and trapping the particles, including those emitted during evening rush hour. This results in elevated concentrations throughout the night.

Figure 18. Hourly average $PM_{2.5}$ concentrations at several Minnesota sites, weekdays in February 2022.



$PM_{2.5}$ speciation

Currently, five monitors measure $PM_{2.5}$ chemical speciation in Minnesota. The monitors in Minneapolis (0963) and Blaine (1002) are part of the EPA's CSN (http://www.epa.gov/ttn/amtic/speciepg.html), which focuses on urban locations. The monitors at Voyageurs (VOYA2), Ely (BOWA1), and Great River Bluffs (GRRI1) are part of the IMPROVE network (http://vista.cira.colostate.edu/IMPROVE/), which focuses on visibility issues, primarily in rural locations. Sampling frequency for these sites is once every three days. Samples are analyzed at contracted labs selected by the EPA and the IMPROVE program.

The particulate monitoring portion of the IMPROVE program measures $PM_{2.5}$ for optical absorption, major and trace elements, organic and elemental carbon, and nitrate. CSN monitoring is similar, except that it does not include optical absorption and does include analysis for ammonium.

$PM_{10-2.5}$ – Coarse particulate matter

Coarse particulate matter ($PM_{10-2.5}$) has an aerodynamic diameter ranging from 2.5 to 10 microns. $PM_{10-2.5}$ mass monitoring is required at NCore multipollutant monitoring sites. The MPCA monitors $PM_{10-2.5}$ at the NCore site in Blaine (1002). No additional sites are expected at this time.

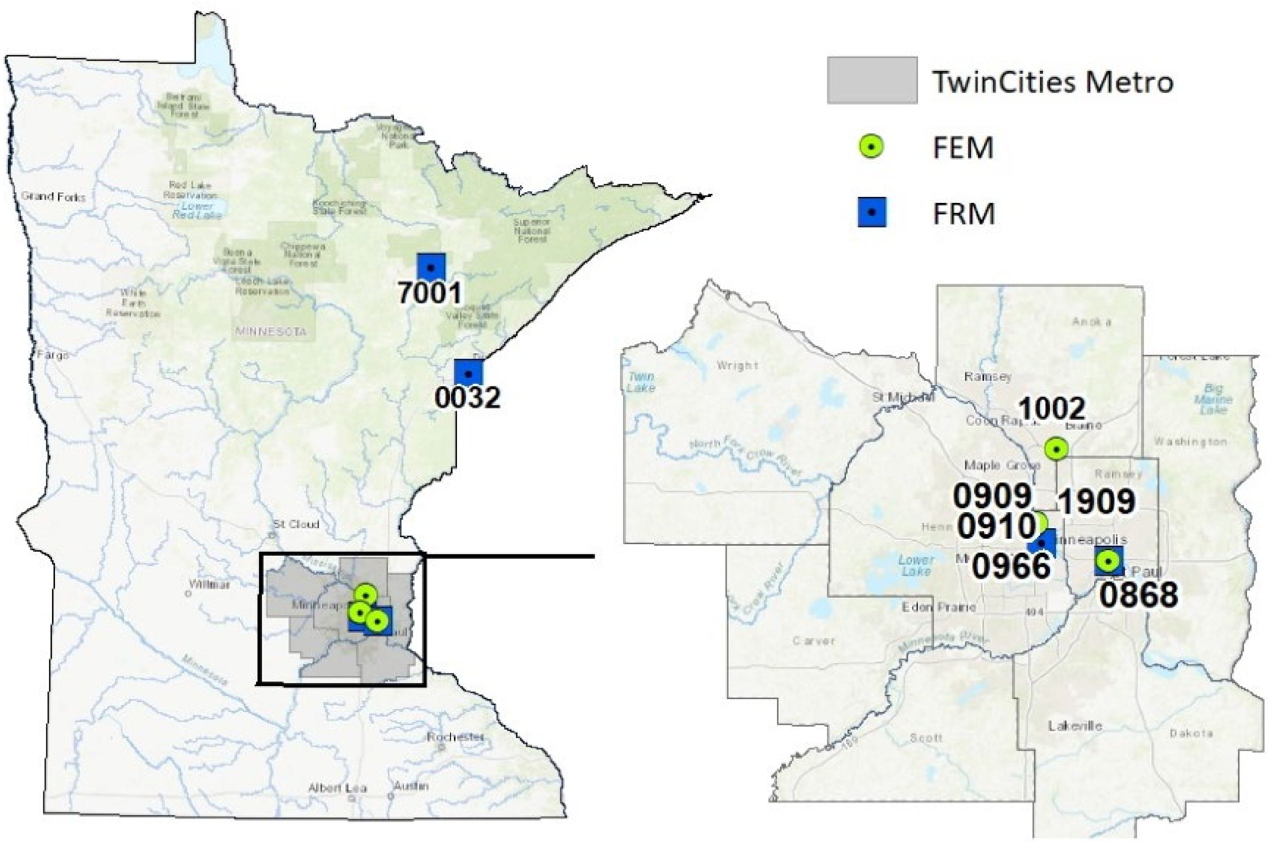
PM_{10}

PM_{10} includes all particulate matter with an aerodynamic diameter equal to or less than 10 microns. Short-term exposure to PM_{10} is linked to hospitalization, even premature death, in people with heart or lung disease. Decreased lung function and increased respiratory symptoms in children are also associated with PM_{10} exposure.

The MPCA currently operates four PM_{10} FRM sites. The FRM method collects mass samples of PM_{10} over a 24-hour period once every six days. There are also continuous PM_{10} FEM monitors that measure hourly PM_{10} concentrations at five sites: St. Paul (0868), Minneapolis (0909), Minneapolis (0910), Minneapolis (1909), and Blaine (1002) (Figure 19). The majority of the PM_{10} monitors are located in the Twin Cities metropolitan area, with additional monitors in Duluth (0032) and Virginia (7001).

In 2023, continuous PM_{10} will be added to Marshall (27-083-4210). As discussed in the Network Assessment section of this plan, the MPCA will begin evaluations for potential consolidation of the following sites: Lowry Avenue (27-053-0909), Pacific Street (27-053-0910), and Bottineau / Marshall Terrace (27-053-1909).

Figure 19. 2023 PM_{10} monitoring sites in Minnesota.

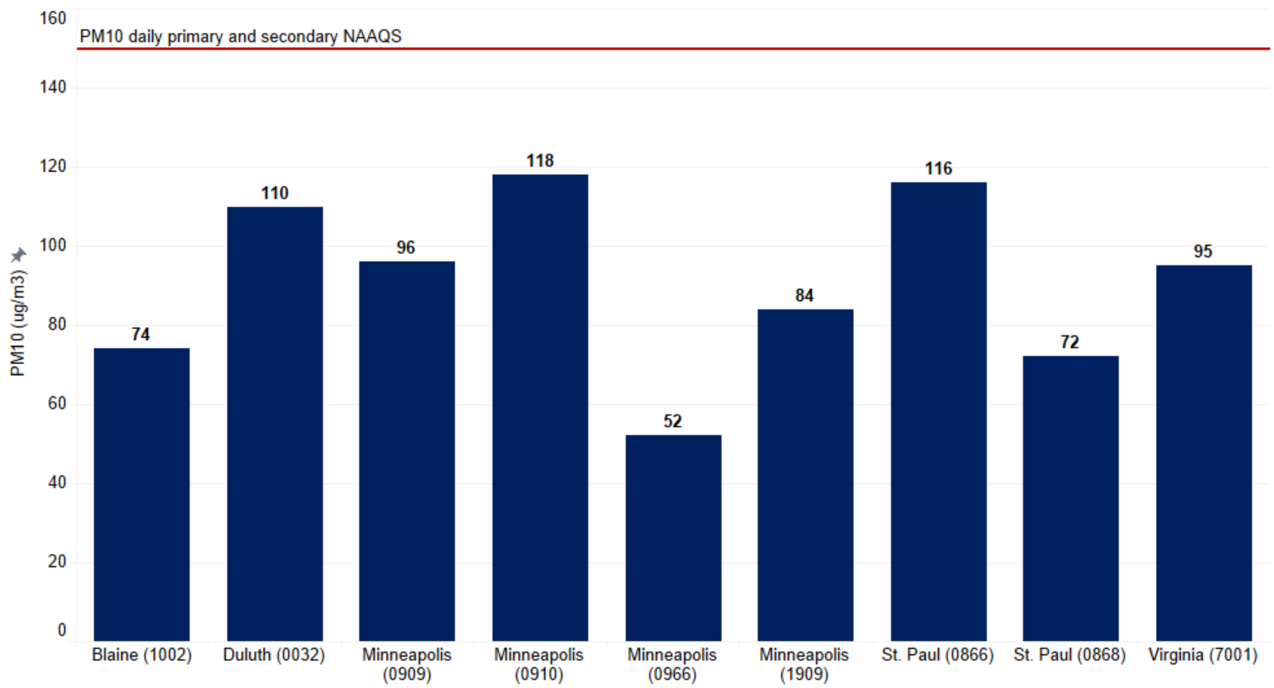


Minnesota currently meets applicable NAAQS for PM_{10} at sites with three years of complete data, collected 2010-2022 (Figure 21). A monitoring site meets the 24-hour PM_{10} NAAQS when the level of 150 $\mu g/m^3$ is not exceeded more than once per year, on average, over three years.

To describe the magnitude of daily PM_{10} measurements, the MPCA reports the daily PM_{10} background concentration, which is calculated following the methodology established in EPA's "PM_{10} SIP Development Guidance" (EPA-450/2-86-001, June 1987, Table 6-1). Depending on the total number of samples collected over a three-year period, the daily PM_{10} background concentration is calculated as the 1^{st}, 2^{nd}, 3^{rd}, or 4^{th}

highest daily PM_{10} concentration measured over three years. Minnesota values ranged from 52 µg/m³ at Minneapolis (0966) to 188 µg/m³ at Minneapolis (0910) in 2022 (Figure 20).

Figure 20. 2022 PM_{10} concentrations compared to the daily NAAQS.



***Site did not meet data completeness criteria**

Total Suspended Particulate matter (TSP)

TSP includes the total mass of particles of solid or liquid matter—such as soot, dust, aerosols, fumes, and mist—found in a sample of ambient air. TSP was one of the original NAAQS pollutants, but was replaced by the PM_{10} standard in 1987. Generally, smaller particles, such as PM_{10} and $PM_{2.5}$, are expected to have greater health impacts than TSP. Today, TSP levels are regulated at the state level by the MAAQS. The MAAQS includes four distinct standards for TSP (Table 15).

Table 15. Minnesota Ambient Air Quality Standards for TSP.

Standard type	Time interval	Level of standard	A monitoring site meets the standard if…
Primary[1]	Daily (24-hour)	260 micrograms per cubic meter	…the annual 2nd highest daily TSP concentration is less than or equal to 260 µg/m³
	Annual	75 micrograms per cubic meter	…the annual geometric mean is less than or equal to 75 µg/m³
Secondary[2]	Daily (24-hour)	150 micrograms per cubic meter	…the annual 2nd highest daily TSP concentration is less than or equal to 150 µg/m³
	Annual	60 micrograms per cubic meter	…the annual geometric mean is less than or equal to 60 µg/m³

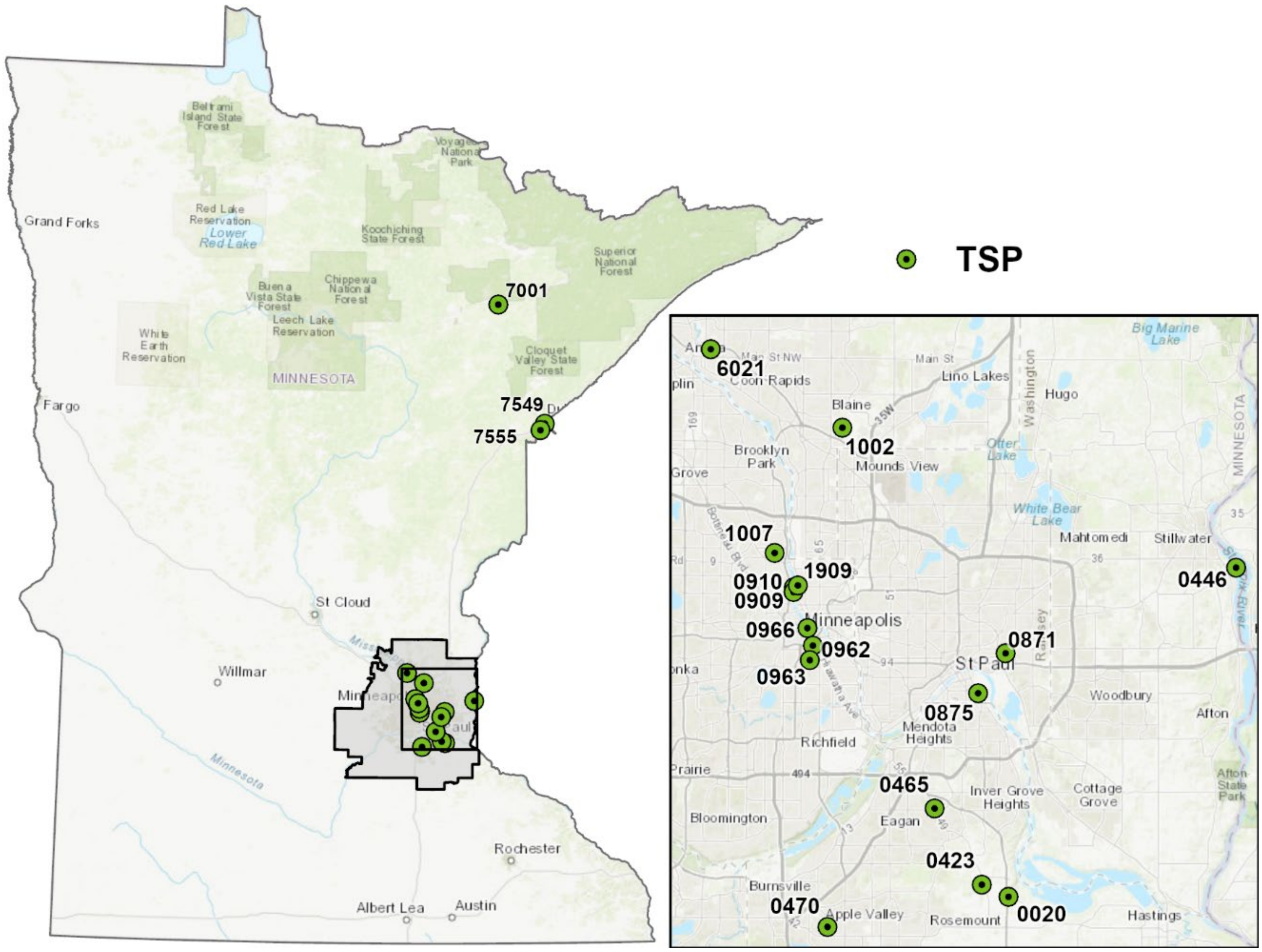
[1]A primary standard is set to protect against human health effects associated with exposure to an air pollutant.
[2]A secondary standard is set to protect against environmental or public welfare effects associated with exposure to an air pollutant.

In addition to TSP, the filters are analyzed for metals as part of the air toxics program, using the ICP/MS method. Metals are discussed further in the air toxics section of this report.

The MPCA currently operates 19 TSP monitoring sites (Figure 21). Mass samples of TSP are collected over a 24-hour period once every six days.

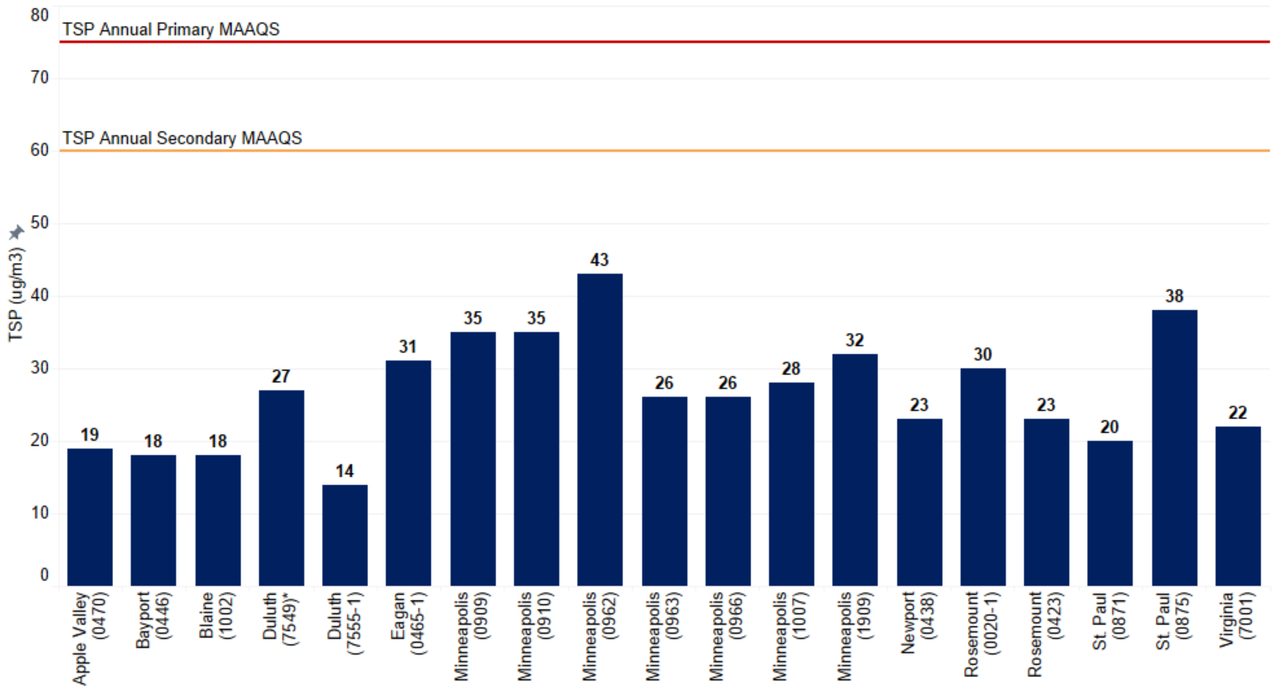
In 2023, a new site will be added near Northern Iron in St. Paul. As discussed in the Network Assessment section of this plan, the MPCA will begin evaluations for potential consolidation of the following sites: Lowry Avenue (27-053-0909), Pacific Street (27-053-0910), and Bottineau / Marshall Terrace (27-053-1909).

Figure 21. 2023 TSP monitoring sites in Minnesota.



In 2022, Minnesota annual TSP averages ranged from 14 µg/m^3 in Duluth (7555-1) to 43 µg/m^3 at Minneapolis (0962) (Figure 22). All sites met the annual primary MAAQS in 2022.

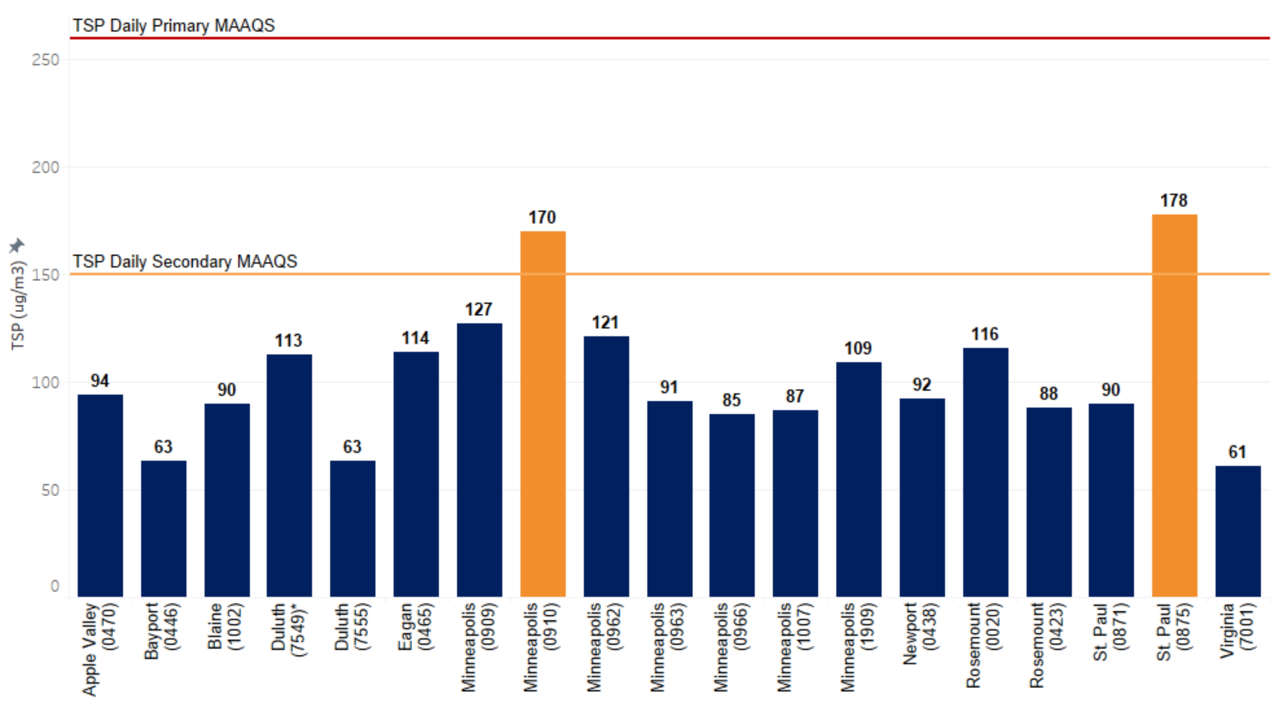
Figure 22. 2022 TSP concentrations compared to the annual primary and secondary MAAQS.



*Site did not meet data completeness criteria

In 2022, daily TSP values in Minnesota ranged from 61 µg/m^3 in Virginia (7001) to 178 µg/m^3 at St. Paul (0875) (Figure 23). St. Paul (0875) and Minneapolis (0910) violated the daily secondary TSP MAAQS; all other sites met the TSP standards.

Figure 23. 2022 TSP concentrations compared to the 24-hour primary and secondary MAAQS.



*Site did not meet data completeness criteria

8.2 Lead (Pb)

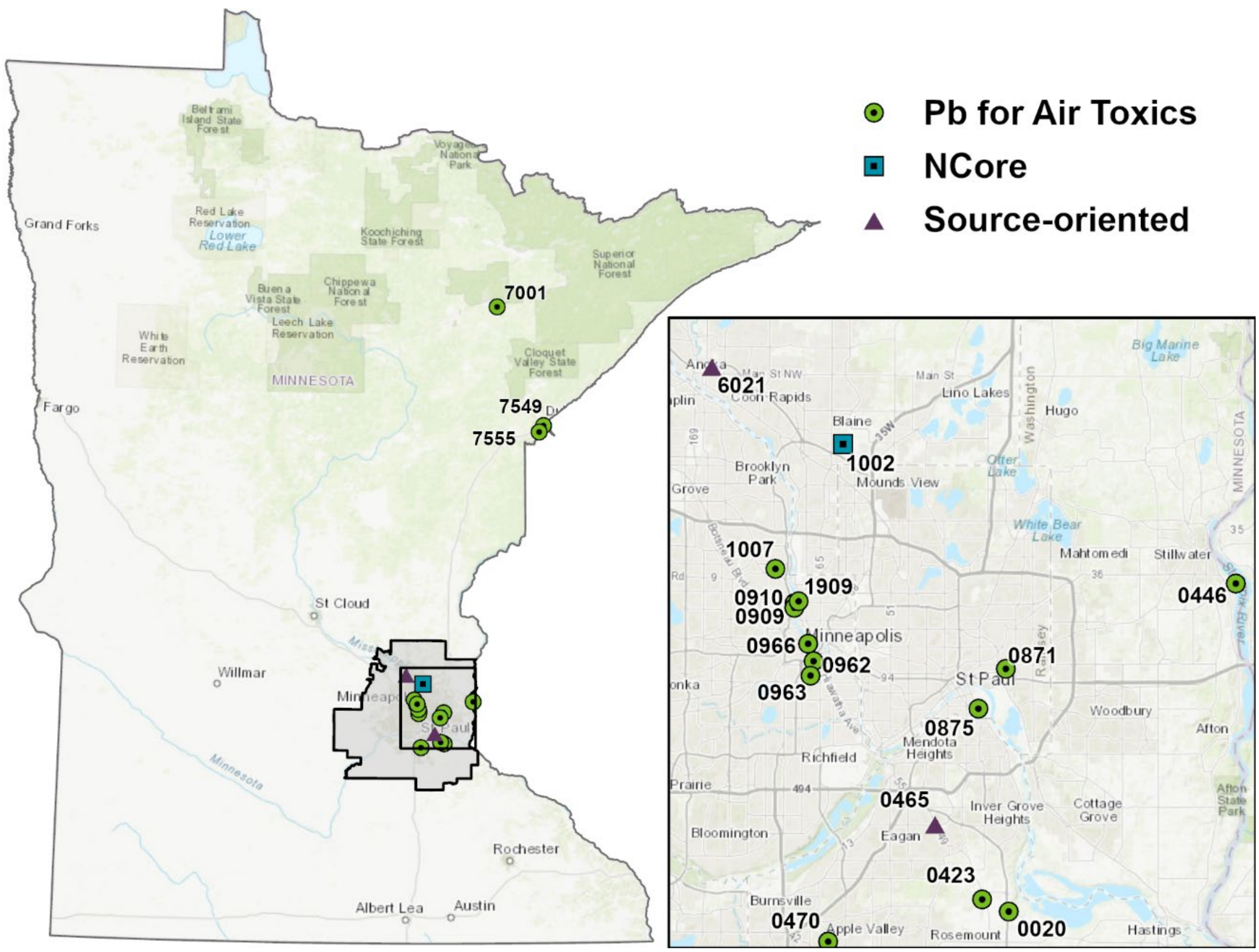
Lead (Pb) is a metal found naturally in the environment, as well as in manufactured products. After lead was removed from gasoline, air emissions and ambient air concentrations decreased dramatically. Currently, metals processing facilities (lead and other metals smelters) and leaded aviation fuel are the primary sources of lead emissions.

Lead emitted into the air can be inhaled directly or can be ingested after it settles onto surfaces or soils. Scientific evidence about the health effects of lead has expanded significantly in the last 40 years. Exposures to low levels early in life have been linked to effects on IQ, learning, memory, and behavior. There is no known safe level of lead in the body.

Elevated levels are also detrimental to animals and to the environment. Ecosystems near sources show many adverse effects including losses in biodiversity, changes in community composition, decreased growth and reproductive rates in plants and animals, and neurological effects in animals.

The MPCA monitors lead at 19 sites, including NCore (1002), two source-oriented monitoring sites: Gopher Resources Corporation in Eagan (0465), Federal Cartridge in Anoka, MN (6021), and 16 sites that are part of our air toxics program (Figure 24). More information on Pb monitoring requirements can be found in Appendix B.

Figure 24. 2023 lead monitoring sites in Minnesota.

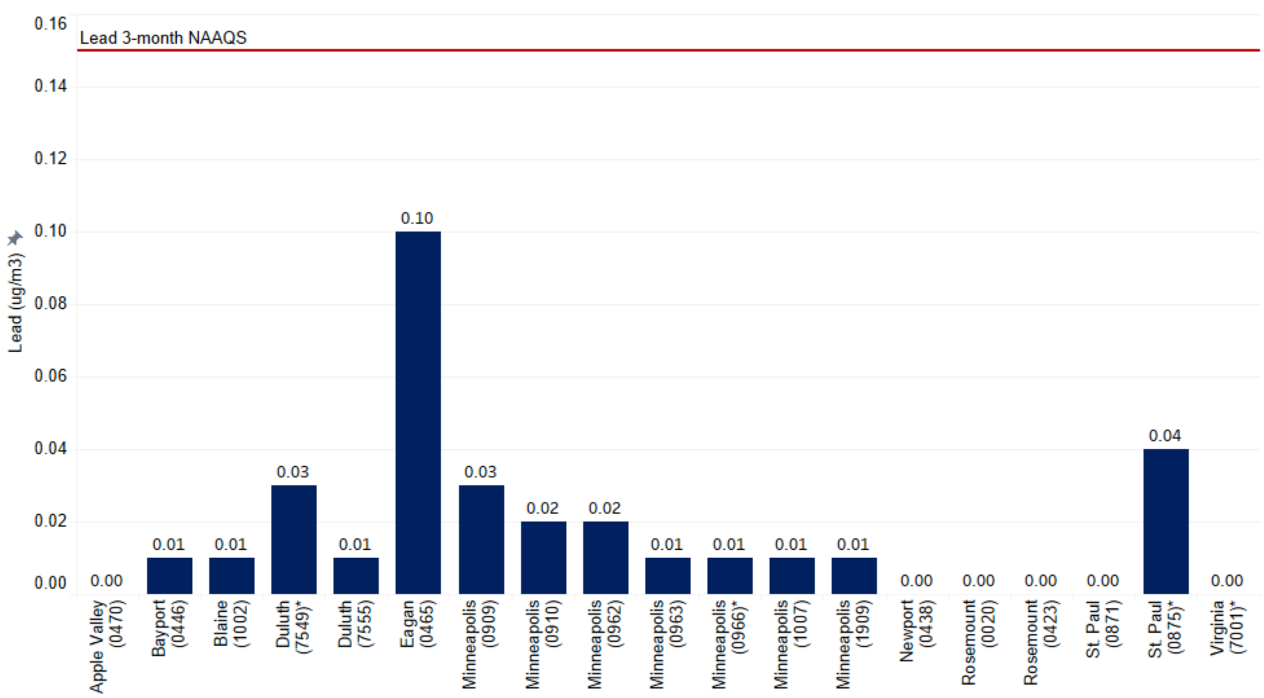


In December 2022, a TSP/metals sampler was deployed near Federal Cartridge in Anoka, MN (27-003-6021)to meet the requirement of Appendix D of 40 CFR Part 58, section 4.5. This requirement identifies there must be one source-oriented SLAMS site located to measure the maximum Pb concentration in ambient air resulting from each non-airport Pb source which emits 0.50 or more tons per year. Federal Cartridge identified emissions above the 0.5 tons Lead on their annually emission inventory for 2019, 2020 and 2021. Preliminary data from Federal Cartridge indicates that the lead NAAQS may be exceeded as of early 2023. Official design values will be added to the Criteria Pollutant Data Explorer (Criteria Pollutant Data Explorer | Tableau Public) in 2023.

In 2023, a new site will be established at Northern Iron in St. Paul. Preliminary lead modeling at Northern Iron indicates high lead levels. Monitoring will be established to confirm preliminary modeling. As discussed in the Network Assessment section of this plan, the MPCA will begin evaluations for potential consolidation of the following sites: Lowry Avenue (27-053-0909), Pacific Street (27-053-0910), and Bottineau / Marshall Terrace (27-053-1909).

All lead monitoring sites in Minnesota met the 2008 lead NAAQS of 0.15 µg/m^3 in 2022 based on the most recent data, which show the three-year maximum 3-month rolling average concentration at monitored sites from 2020-2022. The highest monitored lead design value was 0.10 µg/m^3 in Eagan (0465); the majority of sites were at levels equal to or less than 0.01 µg/m^3 (Figure 25).

Figure 25. 2022 lead design values compared to the 3-month NAAQS.



***Site did not meet data completeness criteria**

8.3 Ozone (O_3)

Ozone is an odorless, colorless gas composed of three oxygen atoms. Ground-level ozone is not emitted directly into the air, but is created through a reaction of NO_x and VOCs in the presence of sunlight.

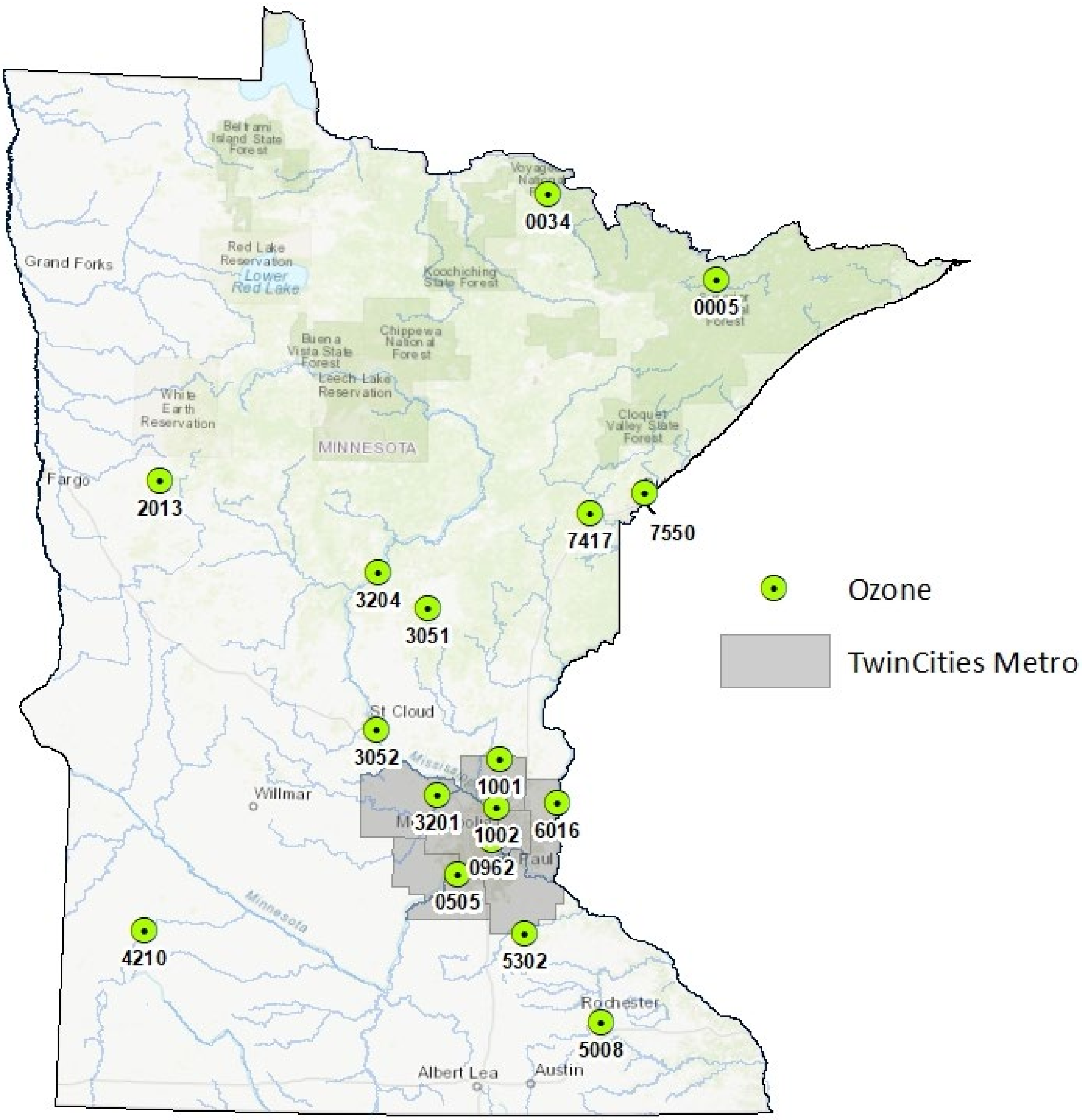
Breathing air containing ozone can reduce lung function and inflame airways, which may, in turn, increase respiratory symptoms and aggravate asthma or other lung diseases. Ozone exposure has also been associated with increased susceptibility to respiratory infections, medication use, doctor and emergency department visits, and hospital admissions for individuals with lung disease. Exposure increases the risk of premature death from heart and lung disease. Children are at increased risk because their lungs are still developing, and they are more likely to have increased exposure since they are often active outdoors.

In addition, cumulative ozone exposure can lead to reduced tree growth, visibly injured leaves, increased susceptibility to disease and damage from insects, and harsher weather. These effects can have adverse impacts on ecosystems, including loss of species and changes to habitat quality and water and nutrient cycles.

MPCA monitors ozone at 17 monitoring sites. An additional monitor, located at Voyageurs National Park (VOYA2), is operated by the National Park Service (Figure 26). Since the MPCA does not have any role in the maintenance or use of this monitor, it is not included in our SLAMS or AQI monitoring networks.

Ozone will be added to a new site in Mankato in 2023.

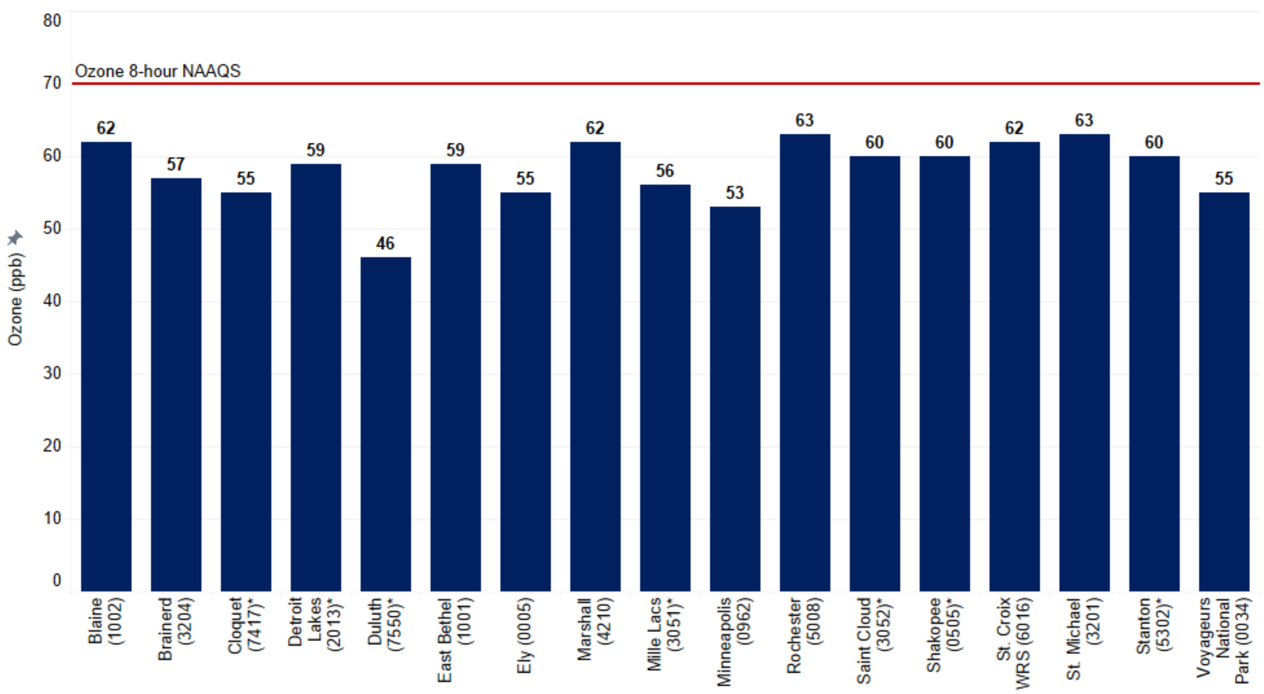
Figure 26. 2023 ozone monitoring sites in Minnesota.



As ozone formation requires high temperatures and sunny conditions, the EPA only requires Minnesota to monitor ozone seasonally. The ozone monitoring season runs from March 1 through October 31 each year. The NCore site in Blaine (1002), at which ozone is monitored year-round, is the only exception to the seasonal monitoring schedule in Minnesota. Additional ozone monitors may periodically operate year-round to support modeling or research. The data collected from ozone monitors are used to determine compliance with the NAAQS and are reported as part of the AQI.

A monitoring site meets the primary ozone NAAQS if the three-year average of the fourth highest daily maximum 8-hour concentration is less than or equal to 70 ppb. From 2020-2022, Minnesota eight-hour averages ranged from 46 ppb in Duluth (7750) to 63 ppb in Rochester (5008) and St. Michael (3201). All sites were below the eight-hour standard (Figure 27).

Figure 27. 2022 ozone design values compared to the 8-hour average NAAQS.



***Site did not meet data completeness criteria**

8.5 Oxides of nitrogen (NO_X)

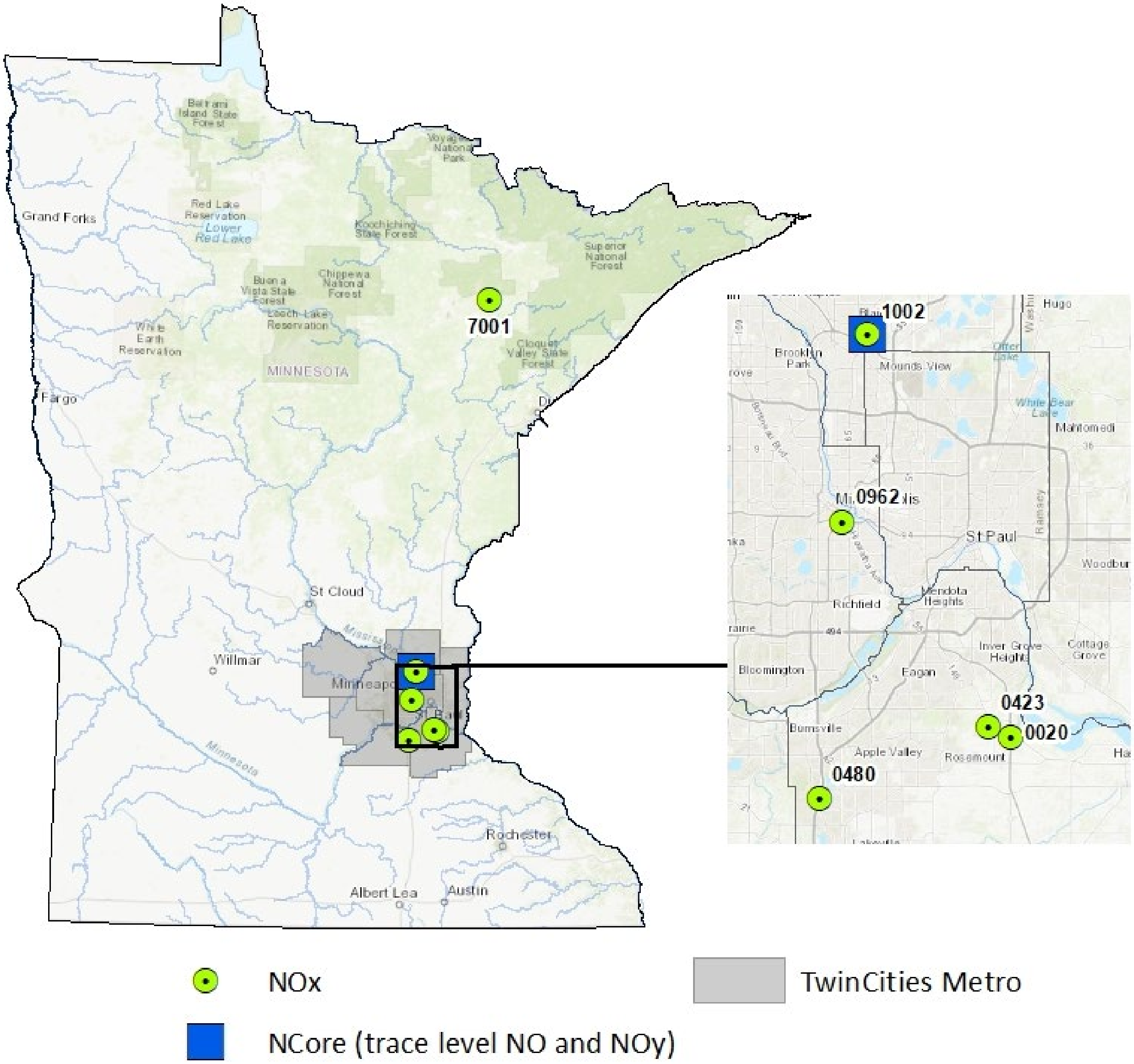
NO_x is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. The two primary components are nitric (nitrogen) oxide (NO) and nitrogen dioxide (NO_2). NO_2 is the federally regulated pollutant; it can often be seen as a reddish-brown layer in the air over urban areas.

NO_x contributes to a wide range of health and environmental effects. NO_2 itself can irritate the lungs and lower resistance to respiratory infections. More importantly, NO_x reacts to form ground-level ozone, $PM_{2.5}$, acid rain, and other toxic chemicals. NO_x can also lead to visibility and water quality impairment due to increased nitrogen loading in water bodies.

Currently, the MPCA monitors NO_2 and NO at six sites in the Minnesota (Figure 28). Trace-levels of NO and NO_y are monitored at the NCore site in Blaine (1002). NO_y, referred to as total reactive nitrogen, consists of NO_x and other nitrogen oxides (e.g. nitric acid, nitrous acid, organic nitrates, and particulate nitrates). This trace-level data will help us understand the role of these pollutants at levels far below the NAAQS.

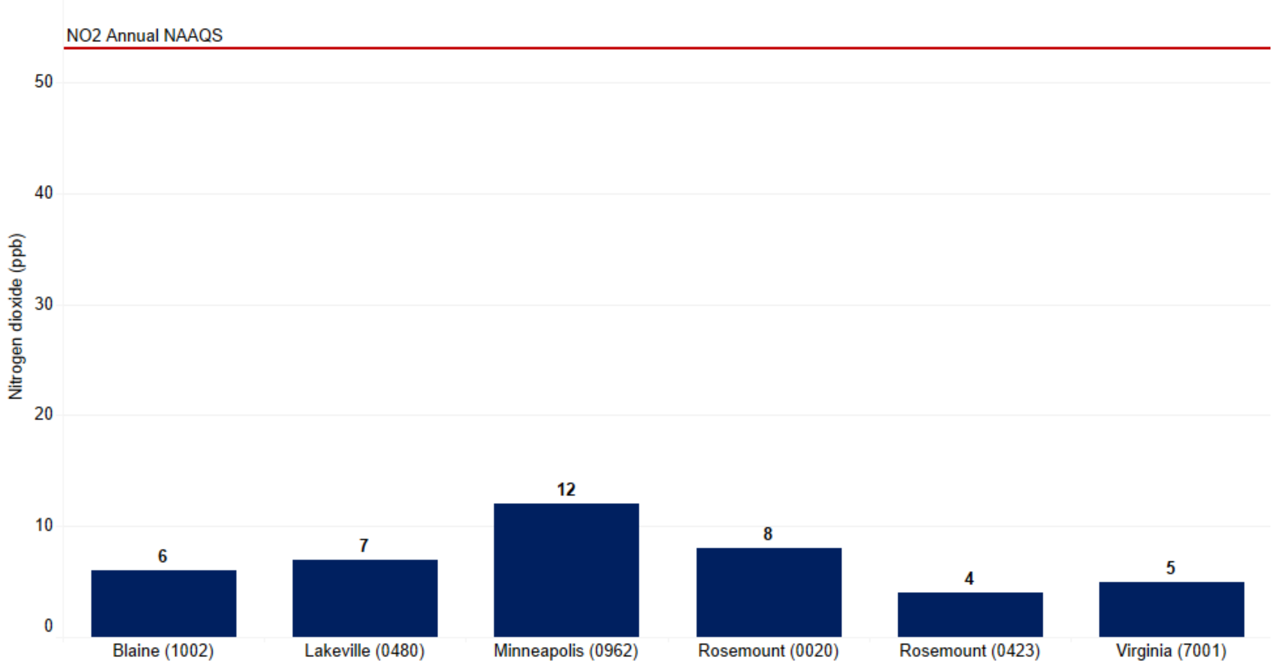
No changes in NO_X monitoring are expected in 2023.

Figure 28. 2023 NO_x monitoring sites in Minnesota.



A monitoring site meets the annual NAAQS for NO_2 if the annual average is less than or equal to 53 ppb. Minnesota averages ranged from 4 ppb at Rosemount (0423) to 12 ppb at the Minneapolis near-road site (0962); therefore, Minnesota met the annual NAAQS for NO_2 (Figure 29).

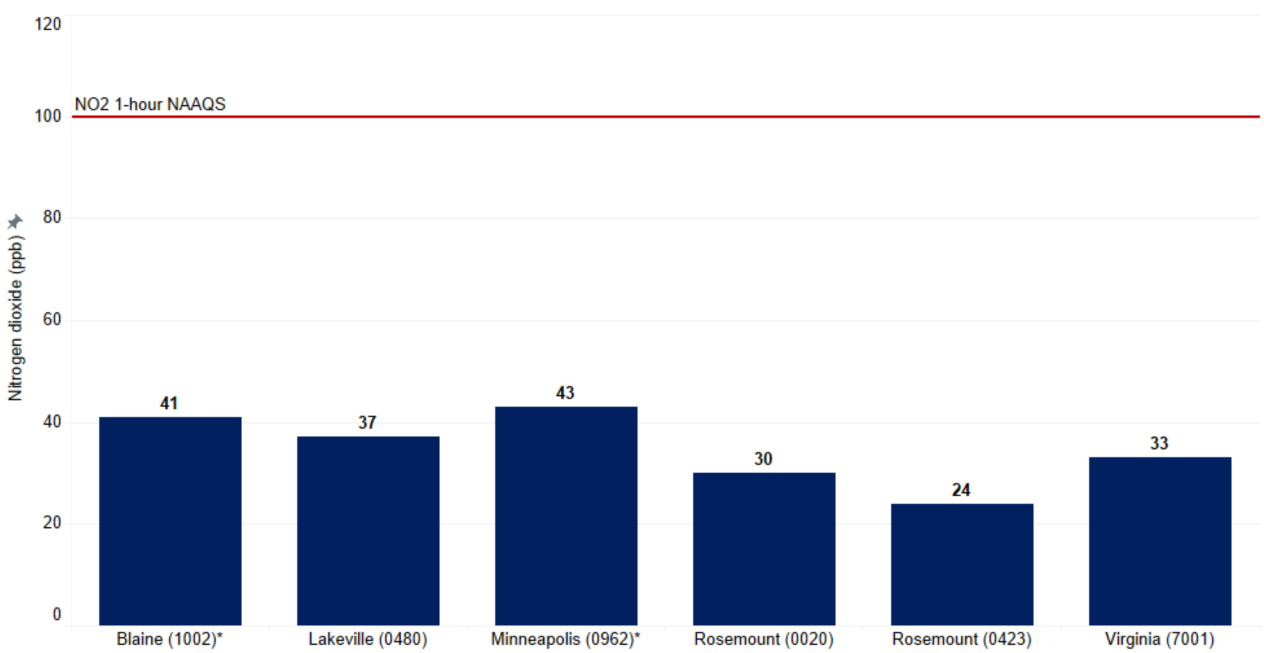
Figure 29. 2022 NO_2 design values compared to the annual NAAQS 2022.



***Site did not meet data completeness criteria**

In addition to the annual standard, there is also a one-hour standard for NO_2. The one-hour NAAQS is intended to protect against adverse health effects associated with short-term exposures to elevated NO_2. To meet this standard, the three-year average of the annual 98th percentile daily maximum one-hour NO_2 concentration must not exceed 100 ppb. Minnesota averages ranged from 24 ppb at Rosemount (0423) to to 45 ppb at Minneapolis (0962); therefore, all sites met the one-hour NAAQS for NO_2 (Figure 30).

Figure 30. NO_2 design values compared to the 1-hour NAAQS.



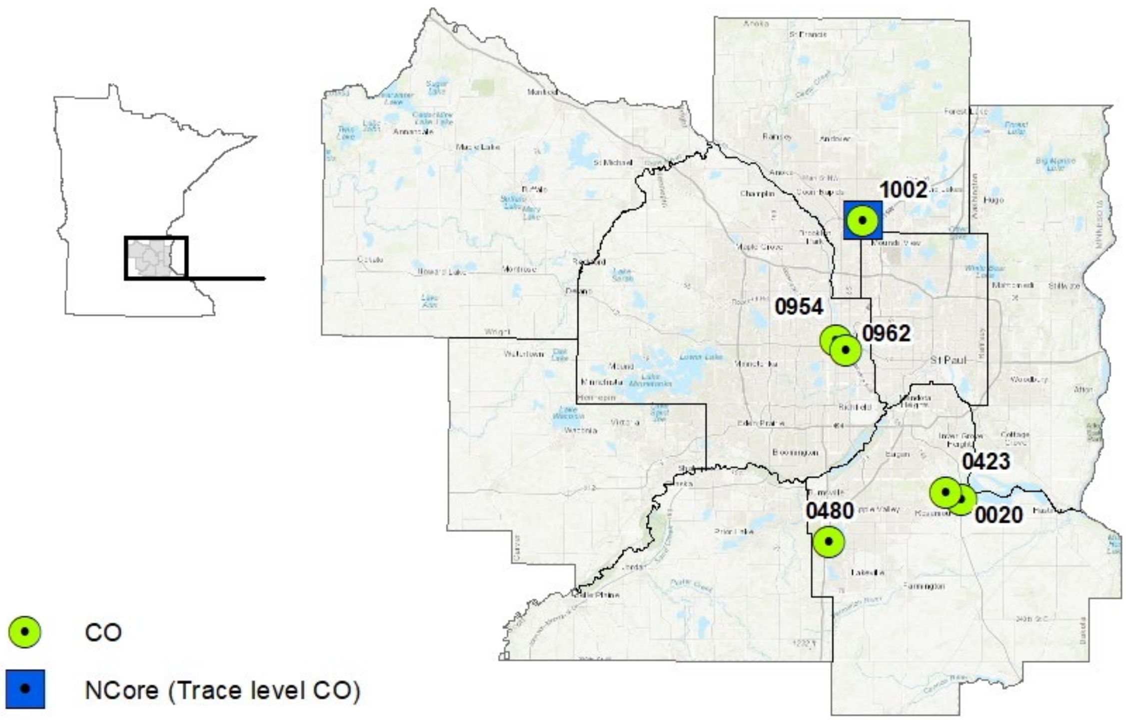
***Site did not meet data completeness criteria**

8.4 Carbon monoxide (CO)

CO is a colorless, odorless, toxic gas formed when carbon in fuels is not burned completely. CO enters the bloodstream and reduces the delivery of oxygen to the body's organs and tissues. Exposure to elevated CO concentrations is associated with vision problems, reduced ability to work or learn, reduced manual dexterity, and difficulty performing complex tasks. Prolonged exposure to high levels can lead to death. Carbon monoxide is also oxidized to form carbon dioxide (CO_2), which contributes to climate change.

The MPCA monitors CO at six sites in Minnesota, all in the Twin Cities metropolitan area (Figure 31). No changes in CO monitoring are expected in 2023.

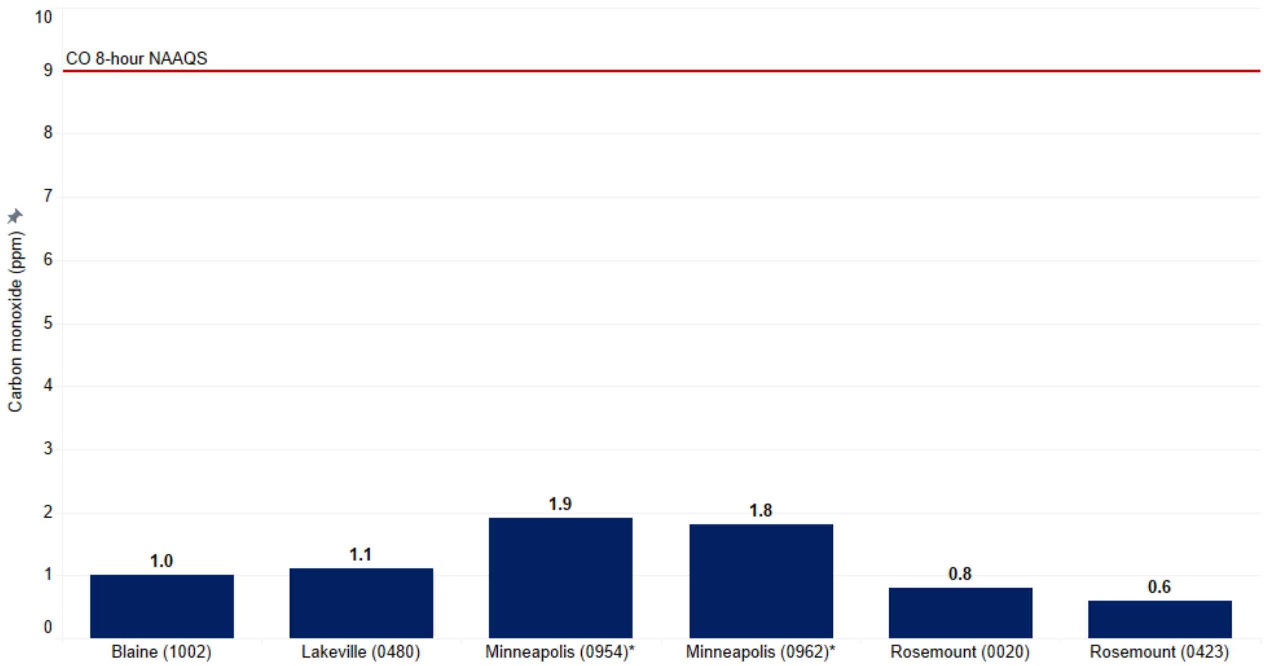
Figure 31. 2023 CO monitoring sites in Minnesota.



CO is monitored on a continuous basis and is reported in hourly increments. Data are used to determine compliance with the NAAQS and are reported as part of the AQI. Trace-level CO at the NCore site in Blaine (1002) also helps us understand the role of CO at levels far below the NAAQS.

Minnesota currently meets applicable eight-hour NAAQS for CO. A monitoring site meets the 8-hour CO NAAQS when the level of 9 ppm is not exceeded more than once per year. A design value is a statistic that describes the air quality status of a given location relative to the level of the National Ambient Air Quality Standards (NAAQS). The design value for CO is evaluated over a two-year period. Specifically, the design value is the higher of each year's annual second maximum, non-overlapping 8-hour average. Minnesota CO design values for 2022 for ranged from 0.6 ppm at the Rosemount site (0423) to 1.9 ppm at Minneapolis (0954) (Figure 32).

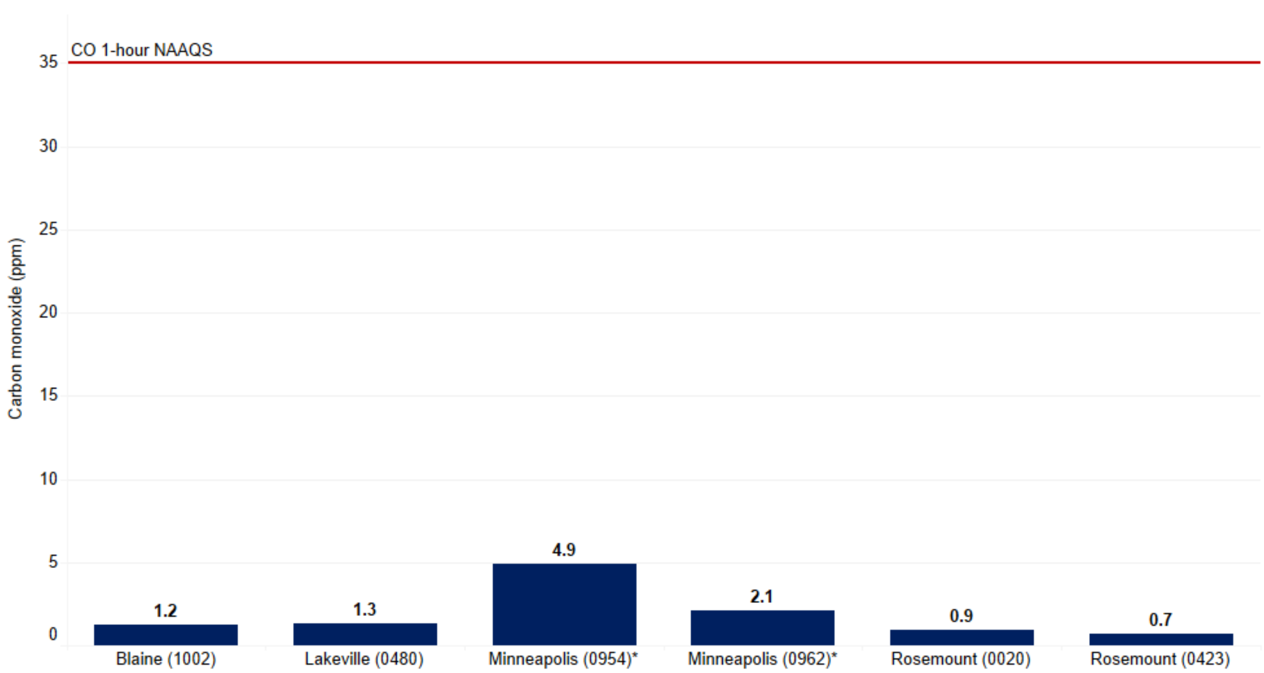
Figure 32. 2022 design values for CO compared to the 8-hour NAAQS.



*Site did not meet data completeness criteria

The one-hour CO NAAQS is met when the level of 35 ppm is not exceeded more than once per year. A design value is a statistic that describes the air quality status of a given location relative to the level of the National Ambient Air Quality Standards (NAAQS). The design value for CO is evaluated over a two-year period. Specifically, the design value is the higher of each year's annual second maximum, non-overlapping 1-hour average. Minnesota values for 2022 ranged from 0.7 ppm at Rosemount (0423) to 4.9 ppm at Minneapolis (0954) (Figure 33).

Figure 33. 2022 CO design values compared to the 1-hour average NAAQS.



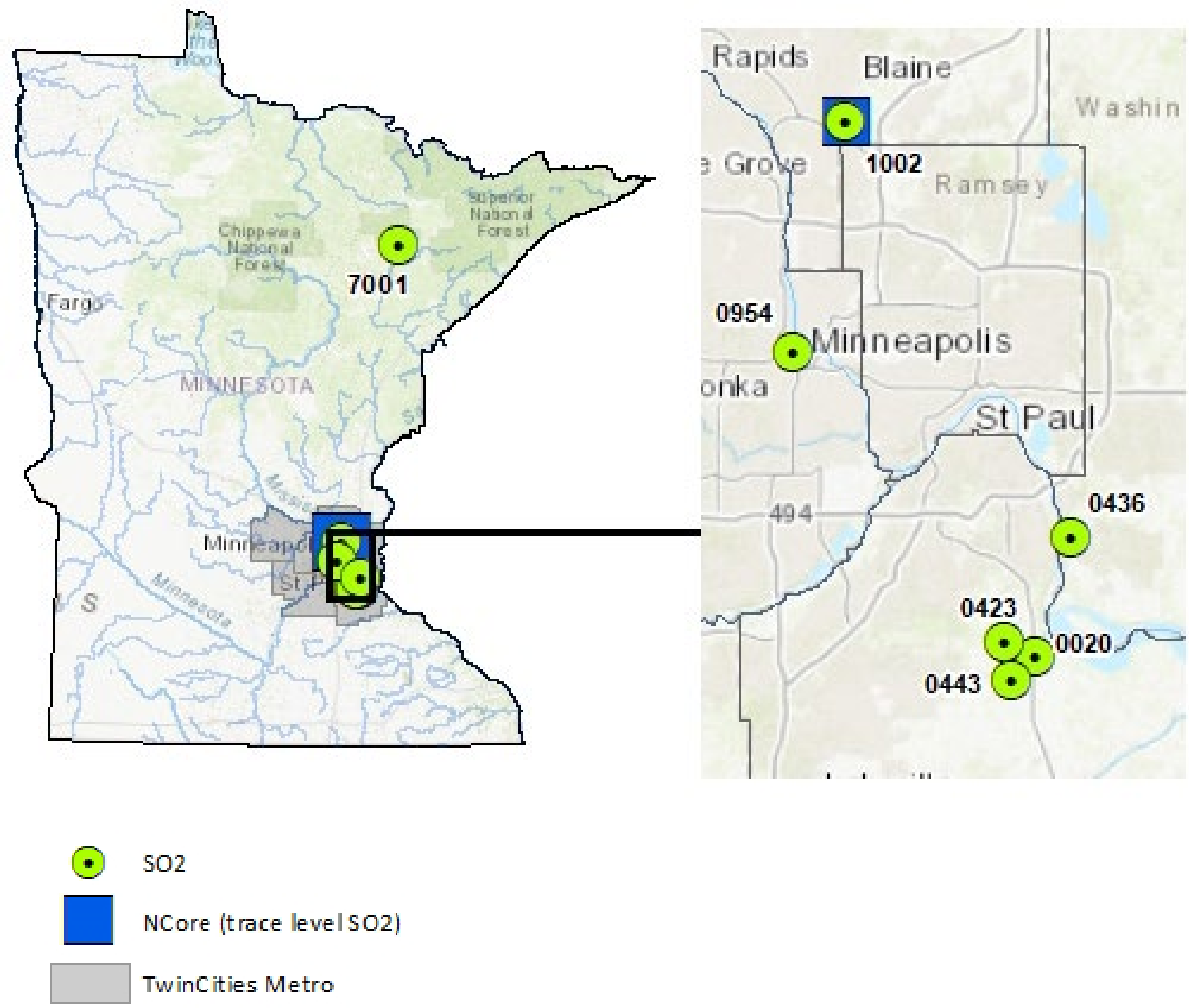
***Site did not meet data completeness criteria**

8.6 Sulfur dioxide (SO_2)

SO_2 belongs to the family of sulfur oxide (SO_x) gases. SO_2 reacts with other chemicals in the air to form sulfate particles. Exposure to SO_2, sulfate aerosols, and $PM_{2.5}$ contribute to respiratory illness, and aggravate existing heart and lung diseases. High levels of SO_2 emitted over a short period, such as throughout the course of a day, can be particularly problematic for people with asthma. SO_2 also contributes to the formation of $PM_{2.5}$, visibility impairment, and acid rain. SO_2 is monitored on a continuous basis; data are reported in hourly increments. Collected data are used to determine compliance with the NAAQS and are reported as part of the AQI. Minnesota currently meets all applicable NAAQS for SO_2; however, continued reductions are sought due to its role in forming $PM_{2.5}$.

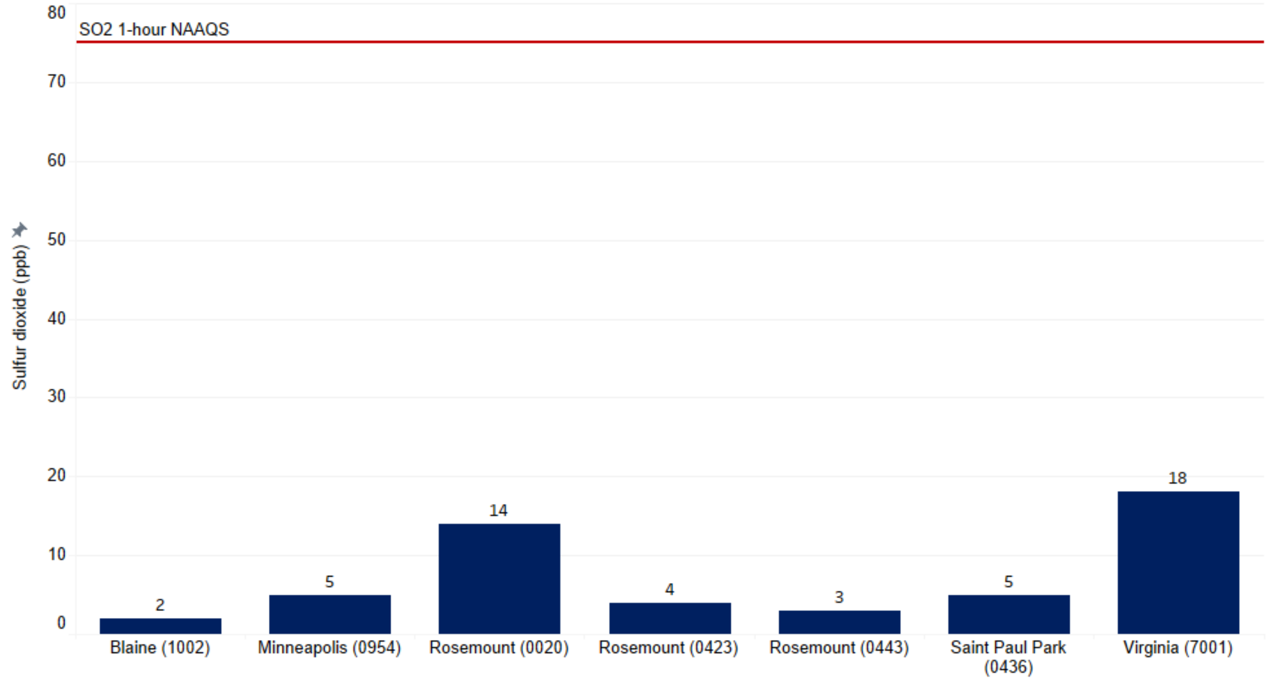
The MPCA monitors SO_2 at six sites in the Twin Cities metropolitan area (Figure 34) and one site in Virginia (7001). Trace level SO_2 at the NCore site in Blaine (1002) will help us understand the role of SO_2 at levels far below the NAAQS. No changes in SO_2 monitoring are expected in 2023.

Figure 34. 2023 SO_2 monitoring sites in Minnesota.



The primary SO_2 NAAQS is a one-hour standard; it is met if the three-year average of the annual 99th percentile daily maximum one-hour SO_2 concentration is less than 75 ppb. Minnesota averages from 2019-2021 ranged from 2 ppb at Blaine (1002) to 20 ppb at Virginia (1007); therefore, all Minnesota sites met the one-hour NAAQS for SO_2 (Figure 35).

Figure 35. 2022 SO_2 design values compared to the 1-hour NAAQS.



***Site did not meet data completeness criteria**

9. Air toxics

The EPA defines air toxics as those pollutants that cause or may cause cancer or other serious health effects, or adverse environmental and ecological effects. Air toxics include, but are not limited to, the 188 Hazardous Air Pollutants (HAPs) specified in the 1990 CAA Amendments (a list of HAPs can be found at http://www.epa.gov/ttn/atw/orig189.html). There are no federal requirements for air toxics monitoring, but the MPCA monitors for a variety of compounds in order to understand potential risks to Minnesota citizens and to track reductions in emissions and concentrations.

The MPCA uses guidelines, called inhalation health benchmarks, to determine risk. Inhalation health benchmarks come from a variety of sources, including the Minnesota Department of Health (MDH) https://www.health.state.mn.us/communities/environment/risk/guidance/air/table.html, the EPA's Integrated Risk Information System (IRIS) https://www.epa.gov/iris; California's Office of Health Hazard Assessment (OEHHA) https://www.oehha.ca.gov/air.html; and EPA's Superfund Program https://www.epa.gov/superfund.

The MPCA monitors three types of air toxics: 57 VOCs, 7 carbonyls, and 10 metals. Samples are collected once every six days, over a 24-hour period. The resulting concentration is a 24-hour average.

9.1 Volatile organic compounds (VOCs) and carbonyls

The MPCA analyzes samples for 57 VOCs (Table 16) and seven carbonyls (Table 17). Samples are analyzed using EPA Compendium Methods TO-15 for VOCs and TO-11A for carbonyls.

The MPCA monitors VOCs and carbonyls at 19 sites in Minnesota (Figure 36). These sites are primarily located in the Twin Cities metropolitan area, with an additional site for VOCs and carbonyls in Duluth (7549).

While there are no changes to the locations where the VOCs and carbonyls are monitored, their sample collection will be reduced from 1-in-6 days to 1-in-12 until further decisions are made to the air toxics network. In 2023, vinyl acetate will be removed from analysis due to inability to identify.

9.2 Metals

The MPCA monitors metals at 19 TSP monitoring sites in Minnesota (Figure 36). These sites are primarily located in the Twin Cities metropolitan area, with additional sites in Virginia (7001) and Duluth (7555 and 7549) (Figure 36). As discussed in the Network Assessment section of this plan, the MPCA will begin evaluations for potential consolidation of the following sites: Lowry Avenue (27-053-0909), Pacific Street (27-053-0910), and Bottineau / Marshall Terrace (27-053-1909).

Metals are extracted from TSP filters and are analyzed using ICP/MS, following an EPA FEM for lead determination (EQL-0710-192). MPCA monitors 10 metals in the state (Table 18).

Figure 36. 2023 Air toxics monitoring sites in Minnesota.

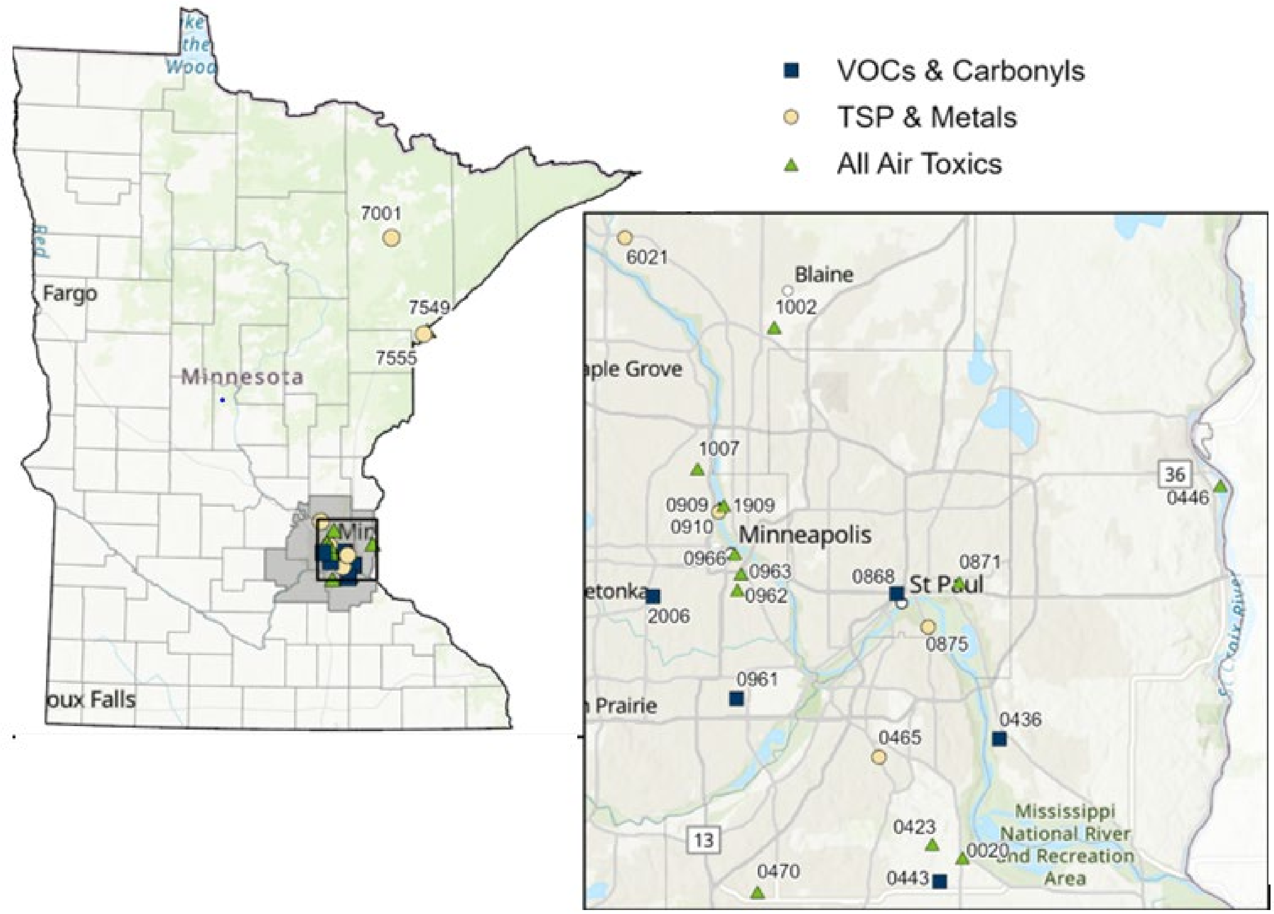


Table 16. VOCs monitored by MPCA in 2023.

Parameter	CAS #	EPA Parameter code
1,1,2,2-tetrachloroethane	79-34-5	43818
1,1,2,3,4,4-Hexachloro-1,3-butadiene	87-68-3	43844
1,1,2-Trichloroethane	79-00-5	43820
1,1-Dichloroethane	75-34-3	43813
1,1-diChloroEthene	75-35-4	43826
1,2,4-Trichlorobenzene	120-82-1	45810
1,2,4-Trimethylbenzene	95-63-6	45208
1,2-Dichloropropane	78-87-5	43829
1,3,5-Trimethylbenzene	108-67-8	45207
1,3-Butadiene	106-99-0	43218
4-Ethyltoluene	622-96-8	45228
Acrolein	107-02-8	43505
Benzene	71-43-2	45201
Benzyl chloride	100-44-7	45809
Bromodichloromethane	75-27-4	43828
Bromoform	75-25-2	46806
Carbon tetrachloride	56-23-5	43804
Chlorobenzene	108-90-7	45801
Chloroform	67-66-3	43803
cis-1,2-Dichloroethene	156-59-2	43839
cis-1,3-Dichloropropene	10061-01-5	43831
Cyclohexane	110-82-7	43248
Dibromochloromethane	124-48-1	43832
Dichlorobenzene (m)	541-73-1	45806
Dichlorobenzene (o)	95-50-1	45805
Dichlorobenzene (p)	106-46-7	45807
Dichlorodifluoromethane (Freon 12)	75-71-8	43823
Dichloromethane	75-09-2	43802
Dichlorotetrafluoroethane (Freon 114)	76-14-2	43208
Ethyl Acetate	141-78-6	43209
Ethyl Chloride	75-00-3	43812
Ethylbenzene	100-41-4	45203
Ethylene dichloride	107-06-2	43815
Ethylene dibromide	106-93-4	43843
Heptane	142-82-5	43232
Hexane	110-54-3	43231
Methyl bromide	74-83-9	43819
Methyl butyl ketone	591-78-6	43559
Methyl chloride	74-87-3	43801
Methyl chloroform	71-55-6	43814
Methyl ethyl ketone	74-83-9	43552
Methyl isobutyl ketone	108-10-1	43560
Methyl methacrylate	80-62-6	43441
Methyl tert-butyl ether	1634-04-4	43372
Styrene	100-42-5	45220
Tetrachloroethene	127-18-4	43817
Tetrahydrofuran	109-99-9	46401
Toluene	108-88-3	45202
trans-1,2-Dichloroethene	156-60-5	43838
trans-1,3-Dichloropropene	10061-02-6	43830
Tribromomethane	75-25-2	43806
Trichloroethene	79-01-6	43824
Trichlorofluoromethane (Freon 11)	75-69-4	43811
Trichlorotrifluoroethane	76-13-1	43207
Vinyl chloride	75-01-4	43860
Xylene (m&p)	108-38-3	45109
Xylene (o)	95-47-6	45204

Table 17. Carbonyls monitored by MPCA in 2023.

Parameter	CAS #	EPA Parameter code
Acetaldehyde	75-07-0	43503
Acetone	67-64-1	43551
Benzaldehyde	100-52-7	45501
Butryaldehyde	123-72-8	43510
Trans-Crotonaldehyde	123-73-9	43516
Formaldehyde	50-00-0	43502
Propionaldehyde	123-38-6	43504

Table 18. Metals monitored by MPCA in 2023.

Parameter	CAS #	EPA Parameter code
Arsenic (As)	7440-38-2	12103
Beryllium (Be)	7440-41-7	12105
Cadmium (Ca)	7440-43-9	12110
Chromium (Cr)	16065-83-1	12112
Cobalt (Co)	7440-48-4	12113
Iron (Fe)	15438-31-0	12126
Lead (Pb)	7439-92-1	14129
Manganese (Mn)	7439-96-5	12132
Nickel (Ni)	7440-02-0	12136
Selenium (Se)	7782-49-2	12154

10. Other parameters and studies

10.1 Atmospheric deposition

Atmospheric deposition is monitored through the NADP. The NADP has two active sub-networks in Minnesota: the National Trends Network (NTN) and the Mercury Deposition Network (MDN).

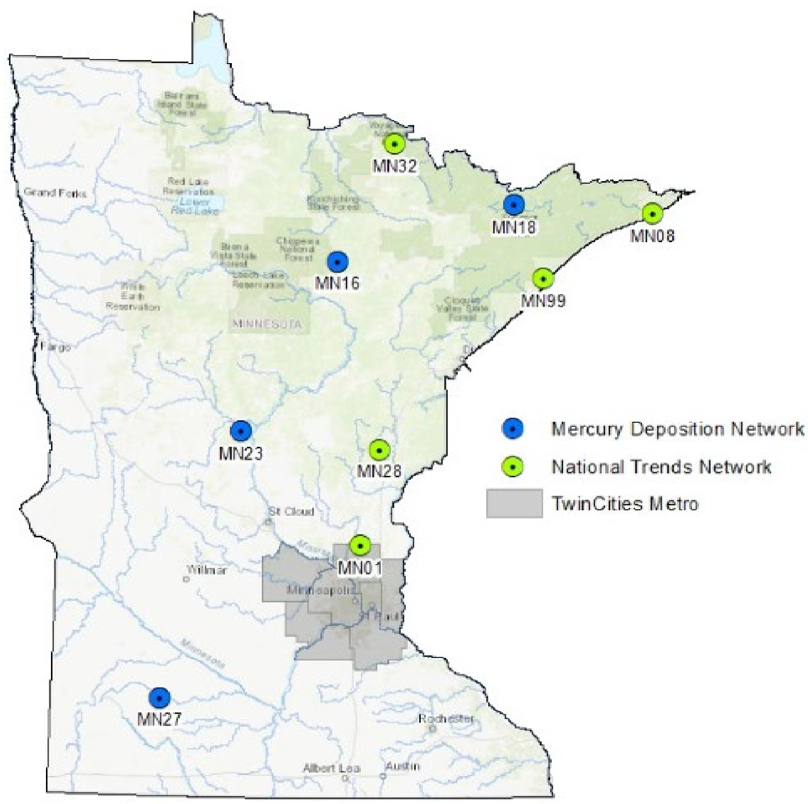
NTN collects weekly precipitation samples for pH, sulfate, nitrate, ammonium, chloride, and base cations (such as calcium and magnesium). NTN provides long-term, high-quality data for determining spatial and temporal trends in the chemical composition of precipitation. MDN collects weekly precipitation samples for analysis of total Hg and methylmercury concentrations. It supports a regional database of the weekly concentrations of Hg in precipitation and the seasonal and annual flux of total Hg in wet deposition.

Minnesota has nine atmospheric deposition sites (Figure 37). No changes are expected for these sites in 2023.

Acid deposition (NTN)

Acid deposition, or acid rain, is monitored as part of the NTN. Acid deposition begins with the burning of fossil fuels (such as coal, gas, or oil) for energy; resulting air pollution contains SO_2 and NO_x. These gases react in the atmosphere to form various acidic compounds. These compounds may be deposited on the Earth by dry deposition, a process where acidic particles or gases settle on, or are absorbed by, plants, land, water, or building materials. The acidic compounds may also be deposited through rain, snow, and cloud water. These pathways are known as wet deposition.

Figure 37. Atmospheric deposition sites in Minnesota.



The MPCA sponsors several monitoring sites that are part of the NADP (http://nadp.slh.wisc.edu/) to monitor acid rain and Hg. The purpose of the network is to collect data on the chemistry of precipitation for monitoring of geographical and long-term trends. The precipitation at each station is collected weekly and is sent to a national contract laboratory where it is analyzed for hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and cations (such as calcium, magnesium, potassium, and sodium).

Mercury (Hg) deposition (MDN)

Widespread mercury contamination of fish is a well-documented problem in Minnesota. The MDH advises people to restrict their consumption of large sport fish from all lakes and rivers. More than 95% of the mercury in Minnesota surface water comes from the atmosphere. In 2007, the EPA accepted Minnesota's mercury total maximum daily load (TMDL) plan that concludes that atmospheric mercury deposition must be reduced by 76% to achieve compliance with aquatic mercury standards.

Mercury is monitored in wet deposition in Minnesota as part of the NADP through the MDN, https://nadp.slh.wisc.edu/networks/mercury-deposition-network/, which began in 1996 and now consists of over 85 sites nationwide. MDN monitors collect weekly samples of precipitation, which are analyzed for total mercury. The objective of the MDN is to provide a nationally consistent survey of mercury in precipitation so that atmospheric loading to surface water can be quantified, and long-term changes can be detected.

Minnesota was on the leading edge of mercury monitoring, establishing four sites as part of the MDN network in 1996, which are still operating. They include Marcell (MN16), Fernberg Road (MN18), Camp Ripley (MN23), and Lamberton (MN27). A site at Mille Lacs (MN22) operated from April 2002 to April 2007. An urban site operated in Blaine (MN98) from February 2008 to 2017. There are currently four MDN sites operating in Minnesota (Figure 37).

In addition to quantifying total mercury, the MPCA also cooperates with the MDN network to measure methylmercury in four-week composite precipitation samples. Only a few of the sites participate in the methylmercury analysis.

The MPCA cooperates with the states of Michigan and Wisconsin to share the use of a trailer equipped with atmospheric mercury monitoring equipment. The equipment includes two Tekran 2537 mercury vapor analyzers, a generator, and a meteorological tower that can record wind speed and direction. The trailer is used to identify local sources of mercury vapor.

10.2 Hydrogen sulfide (H_2S)

H_2S is a flammable, colorless gas that smells like rotten eggs, even at low levels. H_2S occurs naturally in sources such as crude petroleum and natural gas, results from bacterial breakdown of organic matter, and is produced by human and animal wastes. Exposure to low concentrations of H_2S may cause irritation to the eyes, nose, and throat, and may also cause difficulty breathing for some asthmatics. Industrial activities such as food processing, coke ovens, kraft paper mills, petroleum refineries, and confined animal feedlots also emit H_2S.

Minnesota's state standard for H_2S is a 30-minute average of 30 ppb not to be exceeded more than twice in five days, or a 30-minute average of 50 ppb not to be exceeded more than twice per year. H_2S is primarily a concern in the summer, when biological activity is at a peak. The MPCA has monitored several confined animal feedlots and municipal wastewater facilities as a result of odor complaints and health concerns. The MPCA currently oversees industrial monitoring at the Southern Minnesota Beet Sugar Cooperative processing plant in Renville and the American Crystal Sugar processing plants in Moorhead, Crookston, and East Grand Forks, and ConAgra in Waseca.

10.3 Total reduced sulfur (TRS)

TRS consists of the total sulfur from various compounds, including H_2S, methyl mercaptan, dimethyl sulfide, and dimethyl disulfide; SO_2 is not included. Since the majority of TRS is H_2S and the other components are considered to be less toxic than H_2S, TRS can be used as a conservative measure and compared to the H_2S standard. No federal or state standard for TRS is currently available. The MPCA measures TRS at Rosemount sites 0020 and 0423, near the Flint Hills Refinery, and at site 0436 near the St. Paul Park Refining Company in St. Paul Park. Boise White Paper, L.L.C. in International Falls discontinued TRS monitoring in 2015. No changes are planned for the MPCA TRS monitors in 2023.

10.4 Meteorological data

Air pollution concentrations are strongly influenced by atmospheric conditions. Meteorological data can be an important tool for understanding and interpreting concentration data. The MPCA collects hourly wind speed and wind direction data at Rosemount sites 0020 and 0423, near the Flint Hills Resources refinery; site 0909 in North Minneapolis; at the near-road sites in Lakeville (0480) and Minneapolis (0962); and at the NCore site in Blaine (1002). In Blaine, temperature, relative humidity, barometric pressure, solar radiation, rainfall, and mixing layer height are also measured.

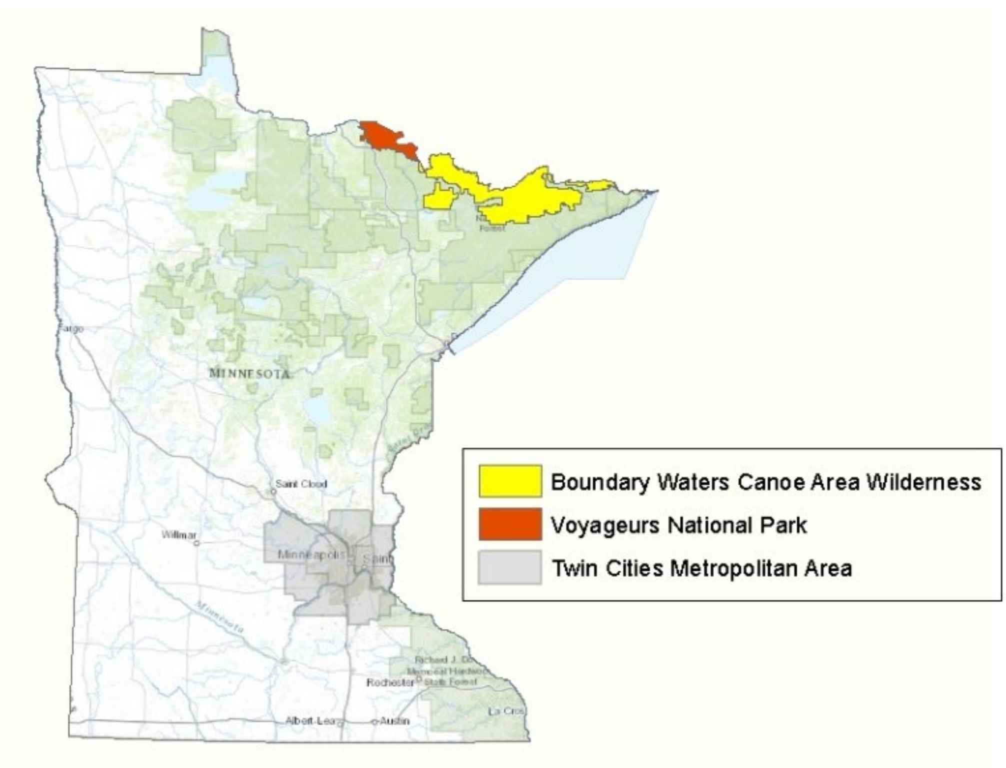
10.5 Visibility

Air pollution can reduce visibility over wide areas, a phenomenon called regional haze. Haze occurs when sunlight encounters fine particles in the air, which absorb and scatter light. Haze-causing pollutants come from a variety of sources, both natural and human-made, including motor vehicles, electric utilities, taconite processing facilities, agricultural activities, and wildfires.

In 1999, the EPA established a regulatory program to reduce haze caused by human-made air pollution at national parks and wilderness (Class I) areas. The goal of the regional haze rule is to achieve natural visibility conditions in Class I areas by 2064, with interim progress goals set every 10 years. The first interim progress goal was set for 2018.

Minnesota has two Class I areas—the Boundary Waters Canoe Area Wilderness and Voyageurs National Park (Figure 38).

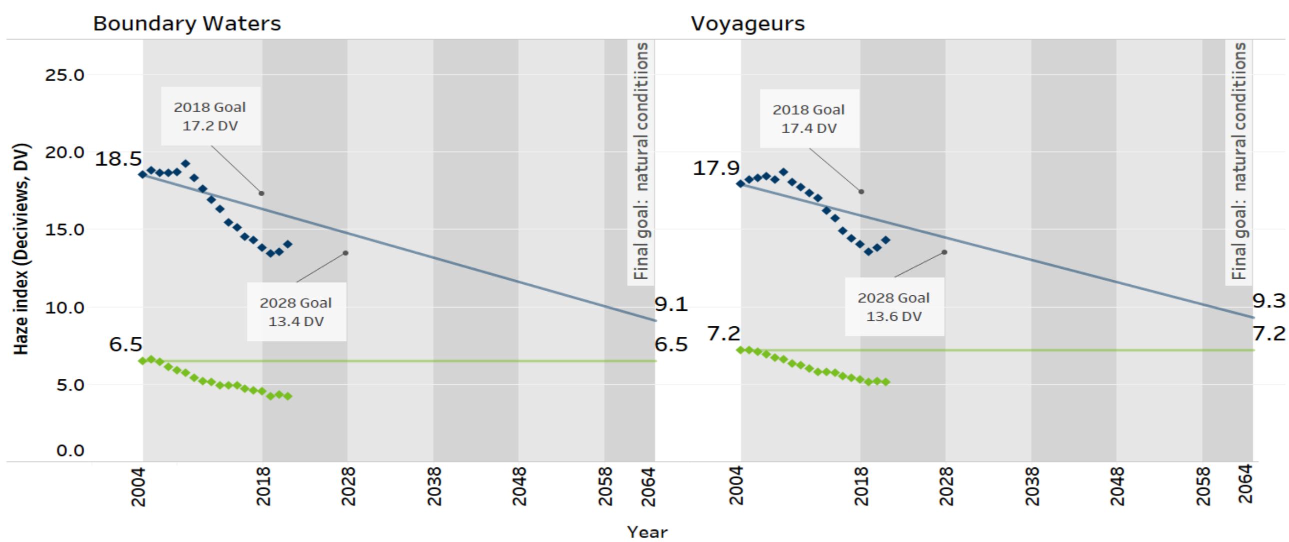
Figure 38. Class I areas in Minnesota impacted by regional haze.



Visibility is calculated from $PM_{2.5}$ species measurements through the IMPROVE Aerosol Network (http://vista.cira.colostate.edu/IMPROVE/). Figure 15 shows the location of Minnesota sites in the network. Minnesota has an IMPROVE site in each of the two Class I areas. An additional site was installed at the Great River Bluffs State Park in southeastern Minnesota to help better understand the regional transport of pollutants that impair visibility into Minnesota from the Southeast.

IMPROVE network $PM_{2.5}$ speciation measurements are mathematically processed to express visibility as a five-year rolling average deciview (dv) value. A human observer is thought to be able to visually perceive a one to two deciview difference in scene appearance. The MPCA aims to see calculated deciview values on the most impaired visibility days reach natural conditions by 2064. Interim goals are set for every ten years. Both the Boundary Waters and Voyageurs sites achieved the 2018 interim goal by 2012. Visibility on the clearest days at both sites has not degraded over time and have actually improved (Figure 39). The MPCA recently established the next interim goal for 2028.

Figure 39. Visibility progress measured at Boundary Waters and Voyageurs (2004-2021) and the estimated interim progress goals for 2018 and 2028.



11. Network changes

Changes to the MPCA Air Monitoring Network are intended to improve the effectiveness of monitoring efforts and to ensure compliance with the EPA National Ambient Air Monitoring Strategy. Some changes are planned well in advance and are detailed in the Network Plan each year. Other changes are a result of legislation, administrative directives, land-use changes, loss of funding, enforcement actions, or are in response to complaints, and cannot be foreseen when this report is created. This section of the document contains all changes that were made in 2023 and the changes that are planned for 2024.

11.1 Proposed and actual changes in 2023

The proposed and actual changes in 2023 are listed in Tables 19 and 20.

1. A new site will be established in Mankato
    - $PM_{2.5}$ and ozone will be measured

Table 19. Proposed changes for 2023.

Site ID	City name	Site name	$PM_{2.5}$ continuous	Ozone
27-013-TBD	Mankato	Mankato	A	A

A = proposed to add

Table 20. Actual changes for 2023.

Site ID	City name	Site name	$PM_{2.5}$ continuous	PM_{10} continuous	TSP/Metals
27-003-6021	Anoka	Federal Cartridge			A
27-083-4210	Marshall	Southwest MN Regional Airport		A	
TBD	Sandstone	Lake Lena	A		
TBD	St. Paul	Northern Iron			A

A = added

- We are currently looking for a site in Mankato and plan to add it in 2024.
- Site 27-003-6021 was established near Federal Cartridge in Anoka.
- Continuous PM_{10} will be added to Marshall
- A new site will be established near Northern Iron in St. Paul.
- A new site by Lake Lena near Sandstone will be established by the Mille Lacs Band of Ojibwe

11.2 Proposed changes for 2024

The MPCA proposes the following changes for 2024:

- We are currently looking for a site in Mankato and plan to add it in 2024.
- As discussed in the Network Assessment section of this plan, the MPCA will begin evaluations for potential consolidation of the following sites: Lowry Avenue (27-053-0909), Pacific Street (27-053-0910), and Bottineau / Marshall Terrace (27-053-1909).

Table 21. Proposed 2024 network changes.

Site ID	City name	Site name	$PM_{2.5}$ continuous	PM_{10} continuous	TSP/ Metals	Ozone	VOCs and Carbonyls	Met* Data
27-013-TBD	Mankato	Mankato	A			A		
27-053-0909	Minneapolis	Lowry Avenue	A, C	C	C		C	C
27-053-0910	Minneapolis	Pacific Street		C	C			
27-053-1909	Minneapolis	Bottineau/ Marshall Terrace		C	C		C	

A = proposed to add
C = potential consolidation

*Meteorological

12. Public inspection period

This plan was available for public inspection from May 23, 2023 through June 22, 2023. The MPCA did not receive any comments during the public inspection period.

In addition to this public inspection period, the public is welcome to comment on our air monitoring activities at any time throughout the year.