

2020 Delaware Ambient Air Monitoring Network Description for Criteria Pollutants



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List of Acronyms

AQS – Air Quality System
CAA – Clean Air Act
CFR – Code of Federal Regulations
CO – carbon monoxide
CSA – combined statistical area
DNREC – Department of Natural Resources and Environmental Control
EPA – Environmental Protection Agency
FEM – Federal Equivalent Method
FRM – Federal Reference Method
lpm – liters per minute
MSA – metropolitan statistical area
NAAQS – National Ambient Air Quality Standards
NO – nitric oxide
NO₂ – nitrogen dioxide
NO_x – nitrogen oxides
O₃ – ozone
PAMS – Photochemical Assessment Monitoring System
Pb - lead
PM_{2.5} – fine particulate matter (2.5 microns)
PM₁₀ – respirable particulate matter (10 microns)
PM_{10-2.5} – coarse particulate matter (PM₁₀ – PM_{2.5})
SLAMS – state and local monitoring stations
SO₂ – sulfur dioxide
SPM – Special Purpose Monitor
UFP – ultrafine particles
WS/WD – wind speed/wind direction



Introduction

In 1970, Congress passed the Clean Air Act that authorized the Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) for pollutants shown to threaten human health and welfare. Primary standards were set according to criteria designed to protect public health, including an adequate margin of safety to protect sensitive populations such as children and asthmatics. Secondary standards were set according to criteria designed to protect public welfare (decreased visibility, damage to crops, vegetation, and buildings, etc.).

Seven pollutants currently have NAAQS: ozone (O₃), carbon monoxide (CO), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), particulate matter less than 10 microns (PM₁₀), particulate matter less than 2.5 microns (PM_{2.5}) and lead (Pb). These are commonly called the "criteria" pollutants. When air quality does not meet the NAAQS, the area is said to be in "nonattainment" with the NAAQS.

Requirements for Monitoring Network Descriptions

In October 2006, the EPA issued final regulations concerning state and local agency ambient air monitoring networks (see 71 FR 61298). These regulations are codified at 40 CFR Part 58 and require periodic assessments of the monitoring networks including the information described below.

§58.10 Annual monitoring network plan and periodic network assessment, Section §58.10 (a) requires for each existing and proposed monitoring site:

- 1) A statement that the operation of each monitor meets the requirements of appendices A, C, D, and E of 40 CFR Part 58, where applicable.
- 2) Proposals for any State and Local Air Monitoring station (SLAMS) network modifications.

Section §58.10 (b) The annual monitoring network plan must contain the following information for each existing and proposed site:

- 1) The Air Quality System (AQS) site identification number.
- 2) The location, including street address and geographical coordinates.
- 3) The sampling and analysis method(s) for each measured parameter.
- 4) The operating schedules for each monitor.
- 5) Any proposals to remove or move a monitoring station within a period of 18 months following plan submittal.
- 6) The monitoring objective and spatial scale of representativeness for each monitor as defined in Appendix D to 40 CFR Part 58.
- 7) The identification of any sites that are suitable and sites that are not suitable for comparison against the annual PM_{2.5} NAAQS as described in §58.30.
- 8) The Metropolitan Statistical Area (MSA), Core Based Statistical Area (CBSA), Combined Statistical Area (CSA) or other area represented by the monitor.
- 9) The identification of required NO₂ monitors as either near-road or area-wide sites in accordance with Appendix D to 40 CFR Part 58.

All proposed changes to SLAMS monitors in the annual monitoring network plans and periodic network assessments are subject to EPA Regional approval according to 40 CFR Part 58.14.



Delaware Ambient Air Monitoring Network Assessment 2020

Executive Summary from Assessment

40 CFR Part 58.10(d) requires Delaware to perform and submit to the EPA Regional Administrator an assessment of the air quality surveillance system every 5 years to determine, at a minimum, if the network meets the monitoring objectives defined in Appendix D of this part, whether new sites are needed, whether existing sites are no longer needed and can be terminated, and where new technologies are appropriate for incorporation in the ambient air monitoring network.

This report serves as Delaware's 2020 assessment under this requirement.

For this 5-Year Monitoring Network Assessment (Assessment), the Division of Air Quality (DAQ) performed a technical review of the data collected in the ambient monitoring network. To conduct this review, DAQ performed the following:

- a. Population data was summarized for all three counties in Delaware. This information was used to determine the appropriateness of monitoring for population exposure.
- b. Meteorological parameters were reviewed to establish upwind / downwind relationships between a monitor site and surrounding emission sources.
- c. Emission inventory summary data was reviewed. This information was used to determine if a monitor is sited appropriately to represent maximum pollution concentrations or specific ambient source impacts quantification.
- d. Historical data collected at each site was reviewed for trends and comparison to the current National Ambient Air Quality Standards. This is helpful to determine if Delaware is achieving air quality improvements and meeting air quality standards.
- e. Site by site correlation analysis was performed using tools supplied by EPA for appropriate monitors. This information is used to determine if information collected at sites is redundant and if the site may be considered for elimination.
- f. A bias calculation was performed to determine impacts that may occur if a monitor is removed from the network.

DAQ evaluated the data from this technical review according to defined performance measures. We also expanded performance measures beyond application of this technical information. Performance measures were organized into the following categories:

- a. Data Criteria
- b. Statistical Criteria
- c. Situational Criteria
- d. Future Needs and Special Considerations

Specific performance measures used in this Assessment are detailed in the Delaware Air Monitoring Network – Current Network Description section. Not all performance measures were applicable to every monitor / site. Based upon the evaluation of these performance measures, DAQ determined the importance (critical, credible, marginal, new site required) of each monitor in the network:

- **Critical sites** are of high value and will be continued.
- **Credible sites** are expected to continue but may not be the design value location at or above the NAAQS.
- **Marginal sites or monitors** are subject for removal or movement.
- **New site required** represent potential areas of investment.

**Network Assessment Results**

The results of this Assessment indicate that the network contains only critical or credible sites. Issues that may impact future network design include new monitoring requirements associated with new or revised NAAQS, aging equipment/maintenance issues, and resource availability. When any future monitoring rules are promulgated, Delaware will work closely with EPA Region 3 to ensure that all new monitoring requirements are met.

The annual network plan for 2020 incorporates the results of the 2020 Assessment. Since all monitors are rated critical or credible, no major changes were recommended for 2020.



Delaware Air Monitoring Network

History of air monitoring in Delaware

Air pollution monitoring in Delaware began in the 1950s, prior to the establishment of the US EPA. The first monitors were simple mechanisms or passive collectors such as dust-fall buckets and tape samplers. These were followed in the 1960s by wet-chemistry instruments, which were soon replaced by more advanced electronic instruments. The addition of computer technology in operating monitoring systems and air pollution data collection in the late 1970s and early 1980s was critical to the development of the core-monitoring network that exists today.

The earliest monitors were placed near pollution sources to measure direct impact of pollution emissions. As ambient air pollution standards became established and monitoring methods standardized, the monitoring network expanded to include monitors in both urban and suburban areas. Monitoring goals shifted to include measuring high pollution concentrations in population centers, detecting trends, and determining compliance with the new national and ambient air quality standards, as well as establishing background levels and measuring pollution transported from areas outside of Delaware.

With the passage of the Clean Air Act in 1970, and the Clean Air Act Amendments in 1990, various control measures implemented by the federal and state governments resulted in major improvements in air quality, particularly regarding major industrial sources. Pollutants of concern today come from a variety of sources including mobile (both on-road and off-road vehicles) sources, large industrial facilities, and smaller industries and business. Delaware continues to use its ambient monitoring network to track changes in air quality across the state and evaluate compliance with ambient air quality standards.

Network Overview

The State of Delaware has established an air monitoring network to determine the ambient levels of the pollutants for which NAAQS have been established. The Delaware Air Monitoring Network consists of the sites and monitors throughout the state, which are listed and described in this document. This network is maintained and operated by the Ambient Monitoring Group of the Division of Air Quality, DNREC.

National Core Monitoring Strategy – NCore

In October 2006 the United States Environmental Protection Agency (EPA) issued final amendments to the ambient air monitoring regulations for criteria pollutants. These amendments are codified in 40 CFR parts 53 and 58. The purpose of the amendments was to enhance ambient air quality monitoring to better serve current and future air quality needs. One of the most significant changes in the regulations was the requirement to establish National Core (NCore) multi-pollutant monitoring stations. These stations provide data on several pollutants at lower detection limits and replace the National Air Monitoring Station (NAMS) networks that have existed for several years. The final network plan was submitted to EPA on July 1, 2009 and the station was fully operational on January 1, 2011.



The NCore Network addresses the following monitoring objectives:

- timely reporting of data to the public through AirNow, air quality forecasting, and other public reporting mechanisms
- support development of emission strategies through air quality model evaluation and other observational methods
- accountability of emission strategy progress through tracking long-term trends of criteria and non-criteria pollutants and their precursors
- support long-term health assessments that contribute to ongoing reviews of the National Ambient Air Quality Standards (NAAQS)
- compliance through establishing nonattainment/attainment areas by comparison with the NAAQS
- support multiple disciplines of scientific research, including; public health, atmospheric and ecological

The NCore sites must measure, at a minimum, PM_{2.5} particle mass using continuous and integrated/filter-based samplers, speciated PM_{2.5}, PM_{10-2.5} particle mass, O₃, SO₂, CO, NO/NO_y, lead, wind speed, wind direction, relative humidity, and ambient temperature.

Each State is required to operate at least one NCore site. The objective is to locate sites in broadly representative urban (about 50 sites) and rural or regional (about 20 sites) locations throughout the country to help characterize urban- and regional-scale patterns of air pollution. Monitoring agencies are encouraged by EPA to collocate NCore sites with existing sites already measuring ozone precursors, air toxics, or PM_{2.5} speciation components. By combining these monitoring programs at a single location, stakeholders can maximize the multi-pollutant information available. This approach not only leverages existing resources but also notably enhances the foundation for future health studies and NAAQS revisions.

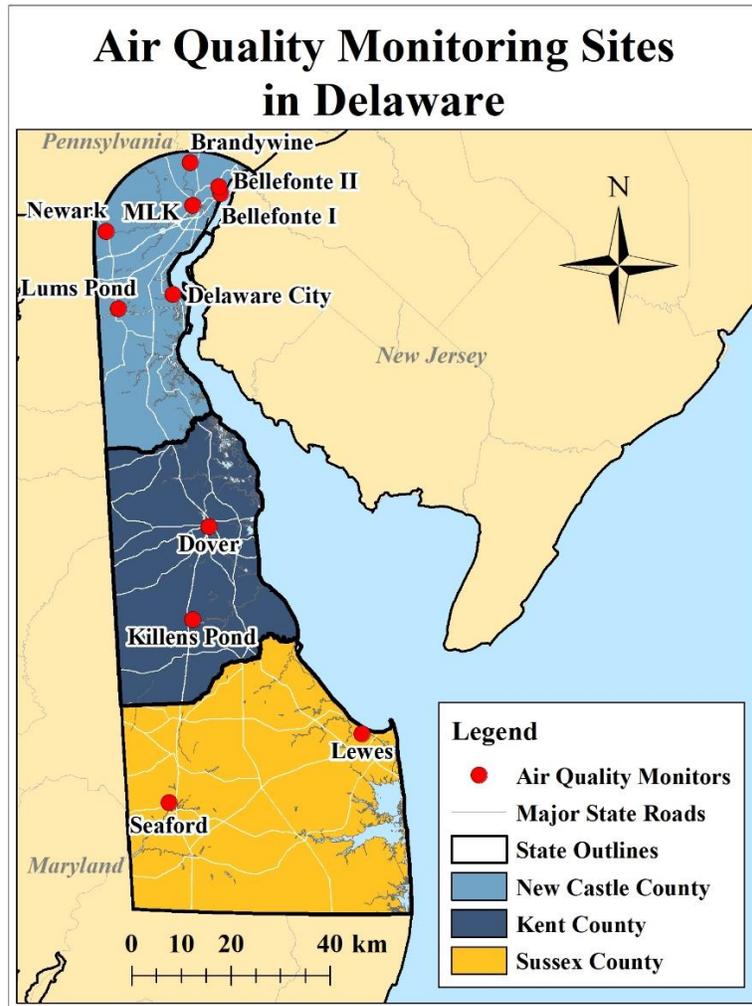
In 2009, EPA provided funding to begin the process of establishing an NCore station in Delaware. After evaluating the existing network, historical data, census data, meteorology, and topography, Delaware's proposal for the existing MLK monitoring site as Delaware's NCore site was accepted by EPA.

Delaware's NCore monitoring, including PM_{coarse}, ozone, and NO_y, became operational on January 1, 2011.



Monitoring Site Network Map and Information

Following is the Delaware ambient air monitoring site network map as of June 2020.



On the following page is a table with summary information on every SLAMS site in Delaware. Information includes site name and AQS ID, active parameters as of June 2020, the date when each monitor began collecting information, the scale of representativeness for each parameter, the monitoring objective, and any other comments relating to the site or monitor. Street address and geographic coordinates are included for each site in Appendix A.

All monitoring sites that are part of a CBSA/MSA meet the minimum monitoring requirements specified in 40 CFR Part 58 Appendix D.

There are no major monitoring site changes from the 2019 Monitoring Plan. Changes to specific monitors are highlighted in yellow.



Monitoring Network Sites and Monitor Information Table

Site Name & AQS ID	Parameter	Start Date	Objective	Comments	
Killens Pond 10-001-0002	O ₃	4/1/1995	General/ Background		
	PM _{2.5}	1/1/1999	General/ Background	Rural site	
	WS/WD	4/1/1995			
Dover 10-001-0003	PM _{2.5}	1/1/1999	Population Exposure	Manual PM _{2.5} FRM To be replaced by continuous FEM	
Brandywine 10-003-1010	O ₃	7/1/1994	Population Exposure	Secondary downwind of Wilmington	
	WS/WD	11/1/2013			
Bellefonte II 10-003-1013	O ₃	4/1/2001	Population Exposure	Primary downwind of Wilmington	
	SO ₂	3/1/2003	Population Exposure		
Bellefonte I 10-003-1003	PM _{2.5}	1/1/1999	Population Exposure	Manual PM _{2.5} FRM To be replaced by continuous FEM	
	SO ₂	1/1/1999	Population Exposure		
	CO	1/1/1999	Population Exposure		
	NO ₂	1/1/2001	Population Exposure/ Maximum Concentration		
	NO _y	1/1/2011	Population Exposure		
	O ₃	1/1/2011	Population Exposure/ NCore		
	MLK 10-003-2004	PM _{2.5}	1/1/1999	Population Exposure/ Maximum Concentration	Urban NCore Site
		PM _{2.5} speciation	6/1/2001	Population Exposure/ NCore	Full PAMS Site Implementation required by summer 2021
		PM ₁₀ (LC) and PM _{coarse}	1/1/2011	Population Exposure/ NCore	
		BC	1/1/2001		
	VOCs	1/1/1999			
	Metals	1/1/2003			
	WS/WD	6/1/2000			
	Temp/RH	1/1/2011			
Newark 10-003-1012	PM _{2.5}	12/15/1999	Population Exposure	Manual PM _{2.5} FRM To be replaced by continuous FEM	



Site Name & AQS ID	Parameter	Start Date	Objective	Comments
Lums Pond 10-003-1007	O ₃	1/1/1992	Upwind Background/ Population Exposure	Rural/suburban, upwind of Wilmington during ozone season
	SO ₂	1/1/2000	General Background/ Population Exposure	
	PM _{2.5}	1/1/1999	Regional Transport/ Population Exposure	
	WS/WD	6/1/2013		
Delaware City (Route 9) 10-003-1008	SO ₂	2/1/1992	Population Exposure/ Source Oriented	Point source dominated site
	PM _{2.5}	6/1/2013	Population Exposure/ Source Oriented	
	WS/WD	5/1/2011		
Seaford 10-005-1002	O ₃	3/1/1990	Population Exposure	
	PM _{2.5}	1/1/1999	Population Exposure	
	WS/WD	5/1/2011	Population Exposure	
Lewes 10-005-1003	O ₃	5/1/1997	Population Exposure	Coastal site
	SO ₂	1/1/2013	Population Exposure	
	WS/WD	6/1/1997		
11 Total Sites – 12 Different Parameters				

N/A – not applicable



Criteria Pollutant Network Description by Parameter

Ozone (O₃)

Ozone is measured by ultraviolet absorption photometry. Air is drawn through a sample cell where ultraviolet light (254 nm wavelength) passes through it. Light not absorbed by the ozone is converted into an electrical signal proportional to the ozone concentration.

Monitoring Requirements

Within an O₃ network, at least one O₃ site for each MSA, or CSA if multiple MSAs are involved, must be designed to record the maximum concentration for that metropolitan area. More than one maximum concentration site may be necessary in some areas. Other types of monitoring sites are needed to determine maximum population exposure, background concentrations, and concentrations being transported into an area (boundary conditions). In Delaware, New Castle County is part of the larger Philadelphia CSA, Kent County is covered by the Dover MSA, and Sussex County is part of the Salisbury MSA.

Number of Ozone SLAMS Sites Required (based on Table D-2 , Appendix D to 40 CFR Part 58, Ozone minimum monitoring requirements)

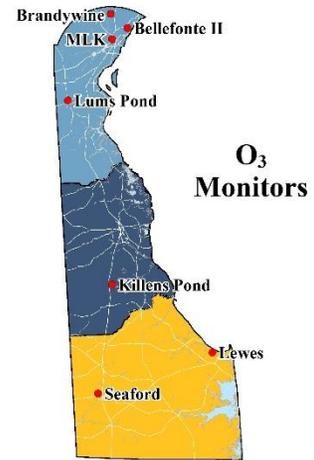
MSA Name	County in Delaware	Population	Delaware Monitors	Total Required Monitors
Philadelphia-Camden Wilmington, PA-NJ-DE-MD	New Castle	6,018,800		3
Dover, DE	Kent	162,310	4	1
Salisbury, MD-DE	Sussex	381,868		1
		197,145	2	
Total in DE			7	4

The appropriate spatial scales for O₃ sites are neighborhood, urban, and regional. Since O₃ requires appreciable formation time, the mixing of reactants and products occurs over large volumes of air, and this reduces the importance of monitoring for small-scale spatial variability.

The prospective maximum concentration monitor site should be selected in a direction from the city that is most likely to observe the highest O₃ concentrations, more specifically, downwind during periods of photochemical activity. Since O₃ levels decrease significantly in the colder parts of the year in many areas, O₃ is required to be monitored only during the “ozone season” as designated in the 40 CFR Part 58 Appendix D, which in Delaware is March 1 through October 31.



Delaware operates seven ozone monitoring sites, including sites for population exposure, background concentrations, upwind and downwind directions for the Wilmington area, and NCore monitoring. Monitoring objectives for each site are included in the detailed site description section of this document. The monitors began operating year-round in 2011 although the official EPA ozone monitoring season for Delaware runs from April through October.



Hourly data is sent to the AirNow website to generate the daily Air Quality Index and to be used in mapping ozone concentrations throughout the region.

Operation of all ozone monitors in Delaware meets the requirements of 40 CFR Part 58 appendices A, C, D, and E as applicable.

Ozone Design Values

The table below shows the most recent (2017 – 2019) design value for each ozone monitor in Delaware. Ozone design values are calculated by taking the 3-year average of the annual 4th maximum daily maximum 8-hr ozone averages. The 8-hr ozone standard established in 2015 is 0.070 ppm.

Ozone 8-hour design values in ppm, 2017 – 2019.

Site	Design Value in ppm
Brandywine (BCSP)	0.069*
Bellefonte II	0.070
Lums Pond	0.068*
Killens Pond	0.065
Seaford	0.065
Lewes	0.063
MLK NCore	0.069
NAAQS	0.070

* One or more years with less than 75% data completeness



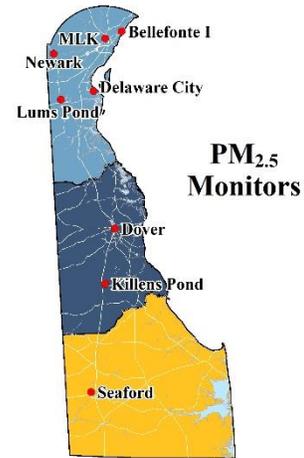
Particulate Matter - Fine (PM_{2.5})

The federal reference method (FRM) monitors for PM_{2.5} operate by drawing air through a specially designed inlet that excludes particles larger than 2.5 microns in diameter. The particles are collected on a Teflon microfiber filter that is weighed to determine the particulate mass.

Monitoring Requirements

State agencies must operate at least the minimum number of required PM_{2.5} sites listed in 40 CFR Part 58 Appendix D Table D-5. These required monitoring stations or sites must be sited to represent community-wide air quality. In addition, the following specific criteria apply:

- (1) At least one monitoring station is to be sited in a population-oriented area of expected maximum concentration.
- (2) For areas with more than one required station, a monitoring station is to be sited in an area of poor air quality.
- (3) Each State shall install and operate at least one PM_{2.5} site to monitor for regional background and at least one PM_{2.5} site to monitor regional transport.



Number of PM_{2.5} SLAMS Sites Required (based on Table D-5, Appendix D to 40 CFR Part 58, PM_{2.5} minimum monitoring requirements)

MSA Name	County in Delaware	Population	Design Value Daily/Annual NAAQS: 35 / 12	Delaware Monitors	Total Required Monitors
Philadelphia-Camden Wilmington, PA-NJ-DE-MD	New Castle	6,018,800	20 / 7.8	4	3
Dover, DE	Kent	162,310	15 / 6.6	2	
Salisbury, MD-DE	Sussex	381,868	16 / 6.8	1	0
Total in DE				7	3

Based on tables available at <http://www.epa.gov/airtrends/values.html>.

Delaware operates more than the minimum number of required PM_{2.5} monitors at seven sites throughout the state. All monitors operate year-round. There is one collocated site at MLK in Wilmington. The normal sampling schedule for the FRM manual method monitors is 24 hours every third day, however, at MLK samples are collected every day.

Operation of all PM_{2.5} monitors in Delaware meets the requirements of 40 CFR Part 58 appendices A, C, D, and E as applicable.



Continuous PM_{2.5}

Delaware operates a designated FEM continuous PM_{2.5} monitor for hourly and 24-hour data at the MLK, Lums Pond, Delaware City, Killens Pond, and Seaford sites. These monitors operate year-round and are collocated with an FRM PM_{2.5} monitor at MLK and Lums Pond.

Correlation of continuous PM_{2.5} FEM data with collocated FRM data:

Under the most recent revisions to the 40 CFR, Part 50, Appendix N data handling requirements, the data capture requirement for annual and daily Design Values is 75% of scheduled samples per quarter. “Creditable” data includes all PM_{2.5} data from scheduled sampling days, valid make-ups and collocated suitable monitors. This data is acceptable for comparison to the annual and daily NAAQS and computations are based on a “combined site record”. “Suitable” monitors are all monitors designated as either FRM or FEM. The PM_{2.5} data from the designated primary monitor is therefore supplemented with the average of daily data from all collocated “suitable” monitors, including continuous FEM monitors, for any missing primary monitor days.

In 2019, Delaware began replacing PM_{2.5} FRM manual method monitors with continuous PM_{2.5} FEM monitors at some sites. The NCore site at MLK in Wilmington will continue to have both FRM and FEM monitors, with the FRM monitor designated as the primary monitor. In order to meet EPA 40 CFR Part 58 appendix A requirements for FEM primary monitor collocation, in 2019 the continuous FEM at Lums Pond was designated as the primary monitor and the FRM maintained at that site as the collocated monitor.

PM_{2.5} Design Values

Below are the design values for PM_{2.5} using 2017 through 2019 data. PM_{2.5} annual design values are calculated using the 3-year average of the respective annual averages. The current annual PM_{2.5} standard is 12 µg/m³. PM_{2.5} daily design values are calculated using the 3-year average of the annual 98th percentile values. The daily PM_{2.5} standard is 35 µg/m³.

Site	Annual Design Value µg/m ³	Daily Design Value µg/m ³
Bellefonte I	7.0	19
MLK NCore	7.8	20
Newark	7.4*	19*
Delaware City (Rt 9)	7.0	17
Lums Pond	7.5	18
Dover	6.2	15
Killens Pond	6.6	15
Seaford	6.8	16
NAAQS	12	35

*At least one year has less than 75% data completeness.

Currently, all Delaware monitors are measuring attainment for both the annual and daily PM_{2.5} standards.



PM_{2.5} Chemical Speciation

Chemical speciation is encouraged at sites where the chemically resolved data would be useful in developing State implementation plans and supporting atmospheric or health effects related studies. The sites in Delaware were established at MLK in Wilmington and Dover in Kent County.

In 2014 EPA completed the process of assessing the national speciation network. The purpose of the assessment was to create a network that is sustainable going forward with the current situation of reduced federal funding by redistributing resources to new or high priorities from those of low-priority or low-benefit. As part of this process, EPA developed a scoring metric to identify existing speciation sites of lower value for defunding, and the Dover site was identified as low-value due to redundancy. Speciation monitoring at the Dover site therefore ended in 2014 in response to termination of support from the EPA. Speciation monitoring continues at the MLK site in Wilmington on a 1-in-three day schedule.

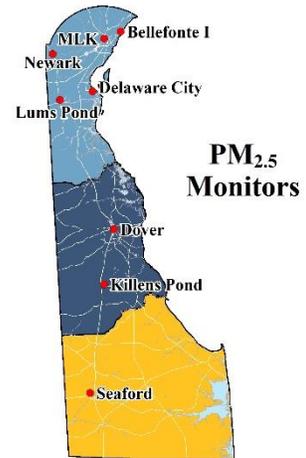


Particulate Matter (PM₁₀)

PM₁₀ is sampled using the federal reference method (FRM) monitor similar to PM_{2.5} that operates by drawing air through a specially designed inlet that excludes particles larger than 10 microns in diameter. The particles are collected on a Teflon microfiber filter that is weighed to determine the particulate mass.

Monitoring Requirements

State, and where applicable local, agencies must operate the minimum number of required PM₁₀ monitoring sites listed in Table D-4 of 40 CFR Part 58 Appendix D. For the Philadelphia-Camden-Wilmington-Newark, PA-DE-MD MSA, the requirements are met by monitors installed in the Philadelphia urban area. No other PM₁₀ monitors are required in Delaware.



Although microscale monitoring may be appropriate in some circumstances, the most important spatial scales to effectively characterize the emissions of PM₁₀ from both mobile and stationary sources are the middle scales and neighborhood scales.

Delaware operates one PM₁₀ monitor at MLK in Wilmington to calculate the PM_{coarse} concentrations; therefore, the PM₁₀ data is reported at Local, not Standard, temperature and pressure for consistency with the PM_{2.5} collocated data.

Particulate Matter (PM_{coarse})

PM_{coarse} is calculated as the difference between concentrations of PM₁₀ and PM_{2.5} at collocated monitors. PM_{coarse} is part of the NCore monitoring at the Wilmington MLK site. Monitoring began on January 1, 2011. There are no ambient air quality standards for PM_{coarse}.

Operation of all PM₁₀ and PM_{coarse} monitors in Delaware meet the requirements of 40 CFR Part 58 appendices A, C, D, and E as applicable.



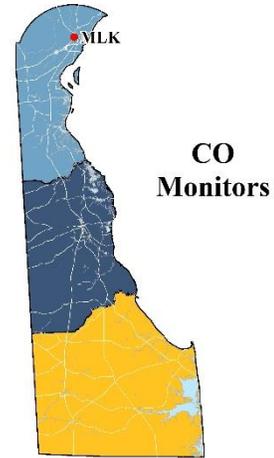
Carbon Monoxide (CO)

Carbon monoxide is measured by infrared absorption photometry. Air is drawn continuously through a sample cell where infrared light passes through it. Carbon monoxide molecules in the air absorb part of the infrared light, reducing the intensity of the light reaching a light sensor. The light is converted into an electrical signal related to the concentration of carbon monoxide in the sample cell.

Monitoring Requirements

EPA revised the minimum number of required CO monitoring sites on August 12, 2011. Since Delaware does not operate a near-road urban monitoring site with a population of 1 million or more and does not have a Photochemical Air Monitoring Site (PAMS), Delaware is only required to monitor CO at its urban NCore MLK monitoring site in Wilmington. For the larger Philadelphia-Camden-Wilmington-Newark, PA-DE-MD MSA, the requirements are met by monitors installed in the urban Philadelphia area.

Operation of the CO monitor at the MLK site meets the requirements of 40 CFR Part 58 appendices A, C, D, and E as applicable. The CO values are well below the ambient standards and close to the minimum detectable limits of the monitor.





Sulfur Dioxide (SO₂)

Sulfur dioxide is measured with a fluorescence analyzer. Air is drawn through a sample cell where it is subjected to high intensity ultraviolet light. This causes the sulfur dioxide molecules in the air to fluoresce and release light. The fluorescence is detected with a photo multiplier tube and converted to an electrical signal proportional to the SO₂ concentration.

Monitoring Requirements

On June 2, 2010, EPA strengthened the primary National Ambient Air Quality Standard (NAAQS) for sulfur dioxide (SO₂). The primary SO₂ standard was revised by establishing a new 1-hour standard at a level of 75 parts per billion (ppb). The new form of the standard is the 3-year average of the 99th percentile of the annual distribution of daily maximum 1-hour average concentrations.

EPA also revised the ambient air monitoring requirements for SO₂. For Delaware, the new standard requires one additional monitoring site be established in Sussex County. This monitor fulfills the requirement for monitoring in the Sussex County portion of the Salisbury metropolitan statistical area (MSA).

On August 10, 2015, the U.S. Environmental Protection Agency initialized requirements for air agencies to monitor or model ambient sulfur dioxide (SO₂) levels in areas with large sources of SO₂ emissions to help implement the 1-hour SO₂ National Air Quality Standard (NAAQS). This final rule established that, at a minimum, air agencies must characterize air quality around sources that emit 2,000 tons per year (tpy) or more of SO₂. Delaware has determined that there are no sources within the state above this threshold emissions total.



EPA also made changes to data reporting requirements for SO₂. State and local agencies are now required to report two data values for every hour of monitoring conducted:

- the 1-hour average SO₂ concentration; and
- the maximum 5-minute block average SO₂ concentration of each hour.

More detailed information on the new SO₂ standard and monitoring requirements can be found on the EPA website at <https://www.epa.gov/newsreleases/epa-retains-national-ambient-air-quality-standards-sulfur-dioxide>

Delaware currently operates four SO₂ monitoring sites in New Castle County, which operate year-round. The fifth site in Sussex County became operational as a SPM in late summer 2012 and a SLAMS on January 1, 2013. Operation of all SO₂ monitors in Delaware meets the requirements of 40 CFR Part 58 appendices A, C, D, and E as applicable.



SO₂ design values for 2017 – 2019: 3-year average of 98th percentile 1-hour averages

Site	Design Value in ppb
Bellefonte II	3 *
MLK NCore	7
Delaware City (Rt 9)	4
Lums Pond	3 *
Lewes	1 *
NAAQS	75

*Does not meet completeness criteria



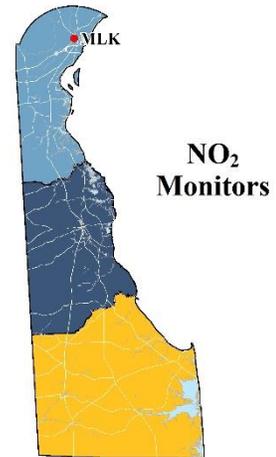
Nitrogen Dioxide (NO₂)

Nitrogen oxides are measured using the chemiluminescence reaction of nitric oxide (NO) with ozone (O₃). Air is drawn into a reaction chamber where it is mixed with a high concentration of ozone from an internal ozone generator. Any NO in the air reacts with the ozone to produce NO₂. Light emitted from this reaction is detected with a photo multiplier tube and converted to an electrical signal proportional to the NO concentration. NO₂ must be measured indirectly. NO_x is measured by passing the air through a converter where any NO₂ in the air is reduced to NO before the air is passed to the reaction chamber. By alternately passing the air directly to the reaction chamber, and through the converter before the reaction chamber, the analyzer alternately measures NO and NO_x. The NO₂ concentration is equal to the difference between NO and NO_x.

Monitoring Requirements

On January 22, 2010, EPA strengthened the health-based National Ambient Air Quality Standard (NAAQS) for nitrogen dioxide (NO₂). EPA set a new 1-hour NO₂ standard at the level of 100 parts per billion (ppb). The form for the 1-hour NO₂ standard is the 3-year average of the 98th percentile of the annual distribution of daily maximum 1-hour average concentrations. EPA also retained, with no change, the current annual average NO₂ standard of 53 ppb.

On March 14, 2013, EPA published revised monitoring requirements for NO₂. Monitoring for NO₂ is now required at near road sites in CBSAs with populations greater than 500,000, in CBSAs with populations greater than 1 million, and at NCore sites. In accordance with the new rule, Delaware is required to monitor NO₂ only at its NCore MLK site in Wilmington. For the larger Philadelphia-Camden-Wilmington-Newark, PA-DE-MD MSA, the requirements are met by monitors installed by the Pennsylvania Department of Environmental Protection (PADEP).



The 2016-2018 one-hour NO₂ design value based on the MLK monitor data is 44 ppb.

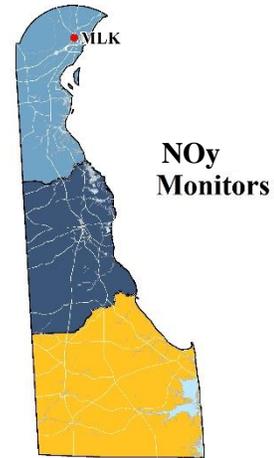
Operation of all NO₂ monitors in Delaware meets the requirements of 40 CFR Part 58 appendices A, C, D, and E as applicable.

More detailed information on the new NO₂ standard and monitoring requirements can be found on the EPA website at <https://www.epa.gov/naaqs/nitrogen-dioxide-no2-primary-air-quality-standards>



Total Reactive Oxides of Nitrogen (NO_Y)

Oxides of Nitrogen are measured using the chemiluminescence reaction of nitric oxide (NO) with ozone (O₃). Air is drawn into a reaction chamber where it is mixed with a high concentration of ozone from an internal ozone generator. Any NO in the air reacts with the ozone to produce NO₂. Light emitted from this reaction is detected with a photo multiplier tube and converted to an electrical signal proportional to the NO concentration. NO_(Diff) must be measured indirectly. NO_Y is measured by passing the air through a converter that is mounted 10 meters from ground level. Reactive Oxides of Nitrogen in the air are reduced to NO in the converter before the air is passed to the reaction chamber. By alternately passing the air directly to the reaction chamber, and through the converter before the reaction chamber, the analyzer alternately measures NO and NO_Y. The NO_(Diff) concentration is equal to the difference between NO and NO_Y.



On January 1, 2011 NO_Y monitoring began at the MLK site as part of the NCore program. Operation of all NO_Y monitors in Delaware meets the requirements of 40 CFR Part 58 appendices A, C, D, and E as applicable.

There are no NAAQS for NO_Y.



Air Toxics Pollutant Monitors

Toxic air pollutants, also called air toxics or hazardous air pollutants are pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects.

As part of the EPA Region III Cooperative Toxic Monitoring Program, Delaware operates one air toxic monitoring station to assess general urban levels. Toxics are sampled every sixth day year-round at the MLK site in Wilmington. The compounds measured are shown in the Monitoring Method table.

The two main classes of air toxics compounds currently monitored in Delaware are volatile organic compounds (VOCs) and heavy metals. VOC samples are collected for 24 hours in canisters with an Entech 1900 canister sampler. The canisters are returned to the Maryland Department of the Environment laboratory for analysis on an Entech/Agilent gas chromatograph mass spectrometer system.

The heavy metals are collected for 24 hours on a total suspended particulate quartz filter, which is sent to the West Virginia Department of Environmental Protection laboratory for analysis using Inductively Coupled Plasma/Mass Spectrometry (ICP/MS). Results of the monitoring are submitted to the national Air Quality System (AQS) database.

Delaware previously included carbonyl monitoring as part of the EPA Region III program but monitoring ended in 2015 due to problems with data quality and aging monitoring equipment. Carbonyl sampling will be included as part of the PAMS Site implementation for 2021, see the next section for more details.

No changes to the program are planned for 2020.



Photochemical Assessment Monitoring System (PAMS) Monitors

The Clean Air Act (CAA) of 1990, Section 182 (c)(1), required the EPA to promulgate rules for enhanced monitoring of O₃, NO_x, and volatile organic compounds (VOCs) for O₃ nonattainment areas based on their classification with the goal of obtaining more comprehensive and representative data on O₃ air pollution.

The following information is taken (and condensed) from the document “PAMS Required Quality Assurance Implementation Plan”, U.S. Environmental Protection Agency, October 2016.

In 2011, the EPA initiated an effort to re-evaluate the PAMS requirements in light of changes in the needs of PAMS data users and the improvements in monitoring technology. The EPA consulted with the Clean Air Science Advisory Committee (CASAC), Air Monitoring and Methods Subcommittee (AMMS) to seek advice on potential revisions to the technical and regulatory aspects of the PAMS program, including changes to required measurements and associated network design requirements. The EPA also requested advice on appropriate technology, sampling frequency, and overall program objectives in the context of the most recently revised O₃ NAAQS and changes to atmospheric chemistry that have occurred over the previous 10 to 15 years in the significantly impacted areas.

Based on the findings of the PAMS evaluation and the consultations with the CASAC AMMS and NACAA MSC, the EPA proposed to revise several aspects of the PAMS monitoring requirements. The current objective of the PAMS air monitoring program is to provide data to evaluate and support the development of air quality models and track trends in ozone precursor concentrations so as to aid ongoing efforts to attain the ozone NAAQS.

Network Design - The first part of the network design change involved EPA requiring PAMS measurements minimally during the PAMS (summer) sampling season, which is June 1 through August 31, at all NCore sites in Core-Based Statistical Areas (CBSAs) with a population of 1,000,000 people or more. The final network design will result in approximately 40 “Required” PAMS sites,

The new regulations specify that the following parameters will be measured at PAMS Required sites:

- **Volatile organic compounds (VOCs)** – It is strongly suggested that all Required PAMS sites take hourly speciated VOC measurements with auto-gas chromatographs (GCs).
- **Carbonyls** - All Required PAMS sites will conduct carbonyl sampling with a frequency of three 8-hour samples on a one-in-three-day basis (~90 samples per PAMS sampling season).
- **Nitrogen Oxides** - All Required PAMS sites must monitor for NO and NO_y (total oxides of nitrogen) in addition to true direct reading NO₂, where the latter must be measured with a cavity attenuated phase shift (CAPS) spectroscopy direct-reading NO₂ instrument or a photolytic-converter NO_x analyzer.
- **Meteorology Measurements** - All Required PAMS sites must measure wind speed and direction, temperature, humidity, atmospheric pressure, precipitation,



solar radiation, ultraviolet radiation, and mixing height. A ceilometer will be used to determine the height of a cloud ceiling or cloud base (mixing height).

As part of the Philadelphia CBSA and OTR Delaware is required to establish a PAMS site at the NCore site in Wilmington (MLK AQS ID 10-003-2004). As part of the PAMS network, the following measurements are required:

1. Hourly speciated VOC measurements with auto-GCs
2. Carbonyl sampling (three 8-hour samples on a one-in-three-day sampling frequency)
3. NO, true NO₂, and NO_y measurements
4. Surface meteorology measurements including mixing height

Based on 40 CFR part 58, Appendix D, state air monitoring agencies are required to begin making PAMS measurements at their NCore location(s) by the amended June 1, 2021 date (Extension granted 12/20/2019). DE DAQ plans to begin making PAMS measurements at the MLK NCore location by June 1, 2021 and will work with EPA to begin measurements on or before the final revised start date for this network.

Planned equipment is included in Appendix A. Purchasing of equipment began in 2017 and is continuing as funding becomes available.



Enhanced Monitoring Program (EMP) - for OTR states

EPA developed a Technical Note “Guidance for Photochemical Assessment Monitoring Stations (PAMS) Required Network Implementation Plans and Enhanced Monitoring Plans (EMPs)” that recommends monitoring organizations submit the EMP by July 1, 2018 along with the annual network plan. The actual regulatory requirement for EMP contained in 50CFR58, Appendix D.5(h) states that “the EMP shall be submitted to the EPA Regional Administrator no later than October 1, 2019” for states in the Ozone Transport Region.

In recognition of EPA's guidance recommending an earlier EMP submittal DE is proposing the following measurements be considered basic elements of the required EMP:

- Year-round NO_x monitoring at Lewes beginning in 2021.

Collection and reporting of these measurements will be contingent on receipt of sufficient additional EPA funding directed specifically towards these EMP activities.



Summary of Changes

Changes from 2019

Following are the changes to the monitoring network in 2019:

- No site changes from 2019.
- Monitor changes:
 - Lums Pond 10-003-1007 FRM PM_{2.5} monitor collocated with continuous FEM PM_{2.5} monitor.
 - MLK NCore 10-003-2004
 - True NO₂ TAPI N500 installed for testing
 - PAMS CAS Auto-GC installed and in testing and training phase

Changes anticipated for 2020-2021

Following are the changes anticipated to occur in 2020:

- Delaware plans to replace the FRM PM_{2.5} monitors with new continuous FEM monitors (Teledyne T-API 640 at 5.0 lpm) at the stand-alone FRM monitor sites:
 - Bellefonte 10-003-1003
 - Newark 10-003-1012
 - Dover 10-001-0003

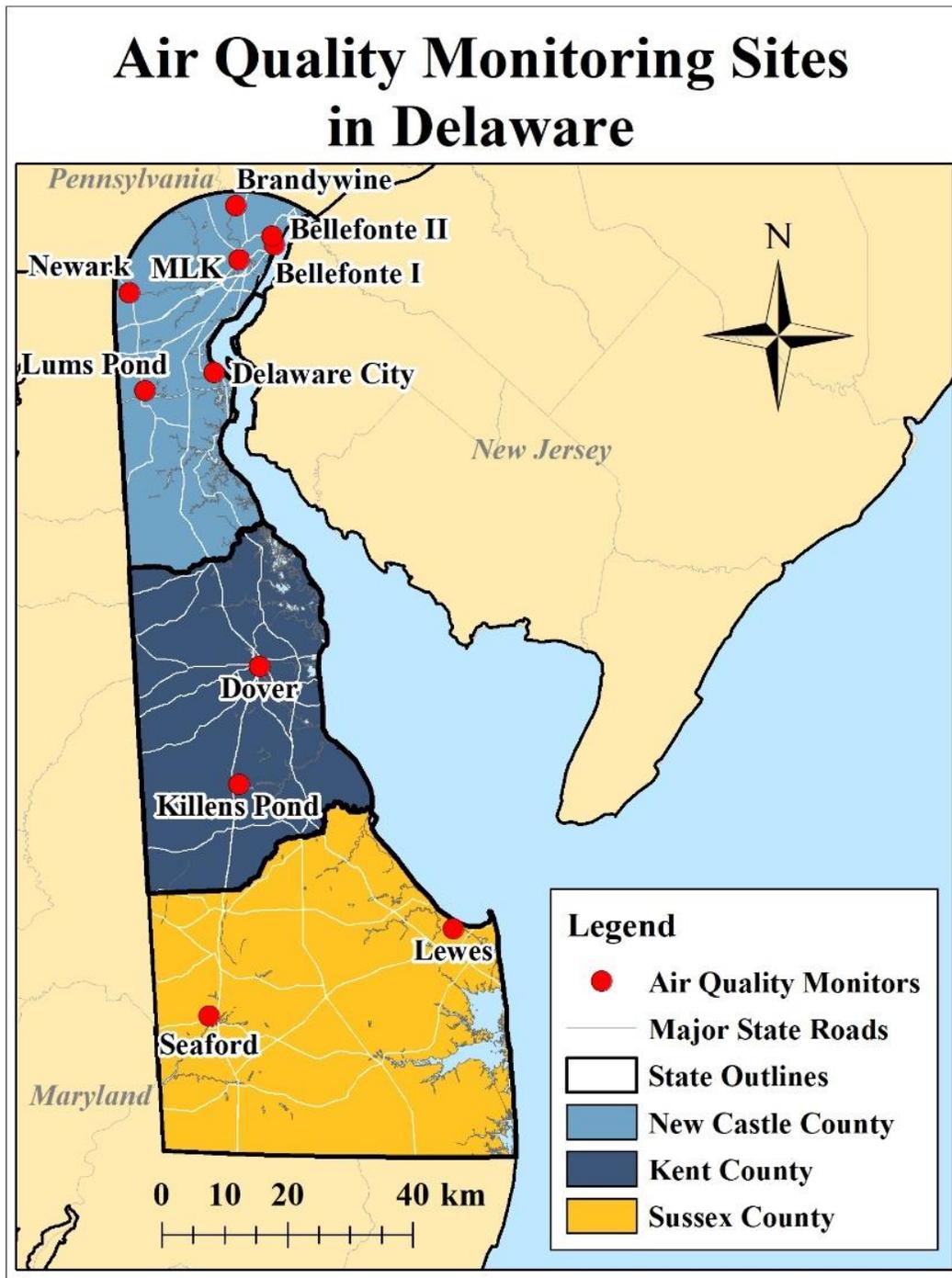
Monitors will be replaced when funding becomes available for the stand-alone monitor enclosures, data acquisition systems, and wireless modem communications.

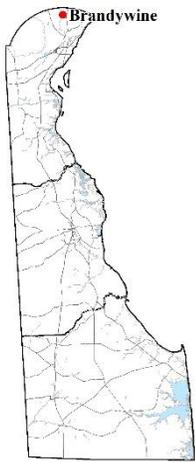
Delaware will continue to comply with all relevant EPA collocation, siting and data handling requirements for the new FEM continuous monitors. FRM monitoring will continue at the NCore site at MLK site 10-003-2004 in Wilmington and the Lums Pond monitoring site 10-003-1007.



Detailed Site Descriptions

The following pages contain additional site-specific information on all active SLAMS monitoring sites in Delaware.





AQS Site ID: 10-003-1010
State: Delaware
County: New Castle
Address: Brandywine Creek State Park, Wilmington

Latitude: 39.8172
Longitude: -75.5639

Spatial Scale: Neighborhood
Area Represented: Philadelphia-Camden-Wilmington,
(MSA) PA-NJ-DE-MD

Year Established: 1994



Monitored Parameters

- O₃** Ozone
- WS / WD** Wind Speed & Direction
- T / Rh** Temperature & Relative Humidity

Site Description

The Brandywine site is located in Brandywine Creek State Park and was established when a secondary downwind site in Claymont was discontinued due to changes in nearby land use and ownership. This is a neighborhood scale site for O₃ monitoring. This site meets all EPA 40 CFR Part 58 App D and E siting criteria.

Monitoring Objectives

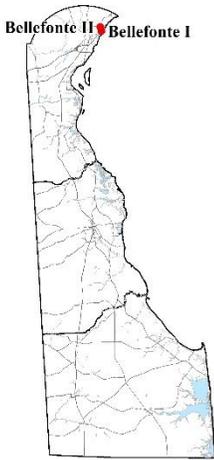
Population exposure, maximum concentration, O₃ NAAQS compliance, and trends.

Planned Changes through 2020

No changes planned.



Site: Bellefonte I (Platform) & II



AQS Site ID: BF I – 10-003-1003
 BF II – 10-003-1013
State: Delaware
County: New Castle
Address: BF I – River Road Park
 BF II – Bellevue State Park

Latitude: BF I – 39.7613
 BF II – 39.7739
Longitude: BF I – -75.4920
 BF II – -75.4965

Spatial Scale: Neighborhood
Area Represented: Philadelphia-Camden-Wilmington,
 (MSA) PA-NJ-DE-MD

Year Established: BF I – 1969
 BF II – 2001



← Bellefonte II

↓ Bellefonte I

Monitored Parameters

Bellefonte I	PM_{2.5}	Particulate Matter: 24-hour (Microns < 2.5)
Bellefonte II	O₃	Ozone
	SO₂	Sulfur Dioxide

Site Description

Bellefonte was originally established in 1969 to monitor O₃ (primary downwind direction from Wilmington) and SO₂. PM_{2.5} was added in 1999. When changing site characteristics began to interfere with ozone monitoring, a new site (Bellefonte II) was established in 2001, less than a mile to the north. The O₃ and SO₂ monitors were relocated to the new site, while the PM_{2.5} monitor remained at the original site to provide data continuity. Both sites meet all EPA 40 CFR Part 58 App D and E siting criteria.

Monitoring Objectives

Monitoring objectives are NAAQS compliance, population exposures, and trends. Bellefonte II is the O₃ maximum downwind concentration site for Wilmington. The SO₂ monitor is sited for general population exposure and trends, with major point sources located to the northeast in Marcus Hook, PA and to the south in Edgemoor.

Planned Changes through 2020

Replace existing PM_{2.5} FRM with new PM_{2.5} FEM at Bellefonte I when resources become available.



Site: MLK NCore (Wilmington)



AQS Site ID: 10-003-2004

State: Delaware

County: New Castle

Address: Justison St. & MLK Blvd., Wilmington

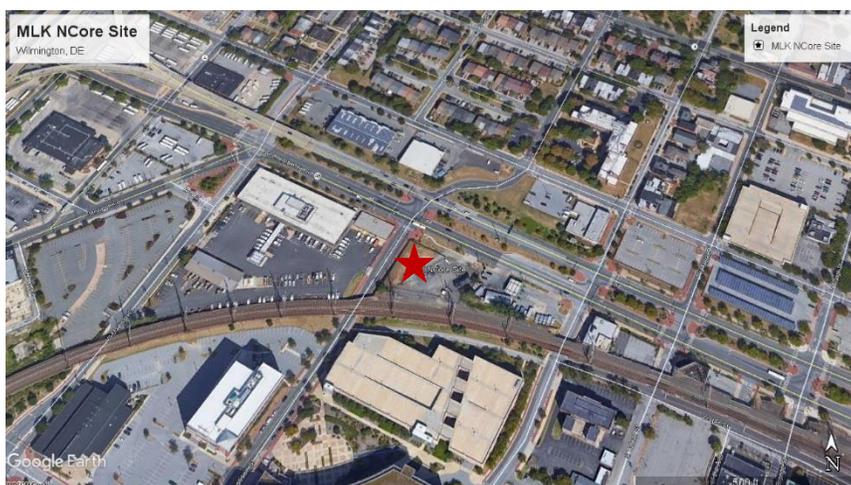
Latitude: 39.7395

Longitude: -75.5575

Spatial Scale: Neighborhood

Area Represented: Philadelphia-Camden-Wilmington,
(MSA) PA-NJ-DE-MD

Year Established: 1999



Monitored Parameters

- O₃** Ozone
- SO₂** Sulfur Dioxide
- CO** Carbon Monoxide
- NO₂** Nitrogen Dioxide
- NO_y** Total Reactive Oxides of Nitrogen
- PM_{2.5}, PM₁₀, PM_{10-2.5}** Particulate Matter: Hourly & 24-hour (Microns < 2.5, 10, & Coarse =10-2.5)
- PM_{2.5} Spec.** Particulate Matter 2.5 Speciation
- WS / WD** Wind Speed & Direction
- T / Rh** Temperature & Relative Humidity

Site Description

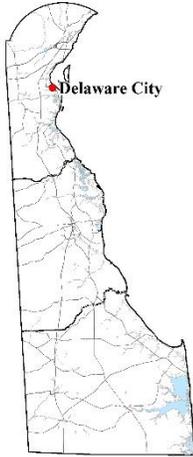
The MLK site is within the city of Wilmington, DE at the intersection of Justison St. and MLK Blvd. It replaced another urban site at 12th and King Streets that had operated at that location for over 20 years and was discontinued due to a change in land ownership. The MLK site is the state National Core (NCore) site and represents urban population exposure to multiple pollution sources. This site meets all EPA 40 CFR Part 58 App D and E siting criteria

Monitoring Objectives

Population exposure, maximum concentration, NAAQS compliance, NCore, and trends.

Planned Changes through 2020

Implementation of the PAMS program by summer of 2021 will require additional equipment including: PAMS Auto GC, Carbonyl Sampler, Ceilometer, Pyrometer, and Tipping Bucket Rain Gauge.



AQS Site ID: 10-003-1008
State: Delaware
County: New Castle
Address: Route 9, Delaware City

Latitude: 39.5777
Longitude: -75.6306

Spatial Scale: Neighborhood
Area Represented: Philadelphia-Camden-Wilmington,
(MSA) PA-NJ-DE-MD

Year Established: 1992



Monitored Parameters

- SO₂** Sulfur Dioxide
- PM_{2.5}** Particulate Matter: Hourly (Microns < 2.5)
- WS / WD** Wind Speed & Direction
- T / Rh** Temperature & Relative Humidity

Site Description

The Delaware City site was established at a location along Route 9 that is between the Delaware City industrial complex and the nearest populated area (Delaware City) in the predominant downwind direction. This site meets all EPA 40 CFR Part 58 App D and E siting criteria.

Monitoring Objectives

This monitoring site is a stationary source-impacted site for SO₂. The monitoring objectives are population exposure, compliance with the NAAQS, and trends.

Planned Changes through 2020

No changes planned.



Site: Newark (Platform)



AQS Site ID: 10-003-1012

State: Delaware

County: New Castle

Address: University of Delaware North Campus, Newark

Latitude: 39.6916

Longitude: -75.7617

Spatial Scale: Neighborhood

Area Represented: Philadelphia-Camden-Wilmington,
(MSA) PA-NJ-DE-MD

Year Established: 1999



Monitored Parameters

PM_{2.5} Particulate Matter: 24-hour (Microns < 2.5)

Site Description

The Newark site is a platform only and was established to understand PM_{2.5} concentrations in the Newark area and potentially transported PM_{2.5} from upwind areas to the west. It is a PM_{2.5} neighborhood scale site. The location is suburban and generally impacted by mobile sources and regional transport. This site meets all EPA 40 CFR Part 58 App D and E siting criteria.

Monitoring Objectives

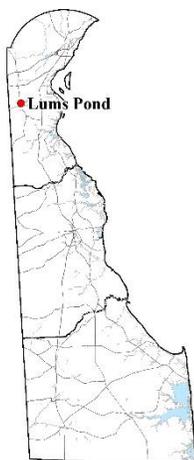
Population exposure, PM_{2.5} NAAQS compliance, regional transport, and trends.

Planned Changes through 2020

Replace existing PM_{2.5} FRM with new PM_{2.5} FEM when resources become available.



Site: Lums Pond

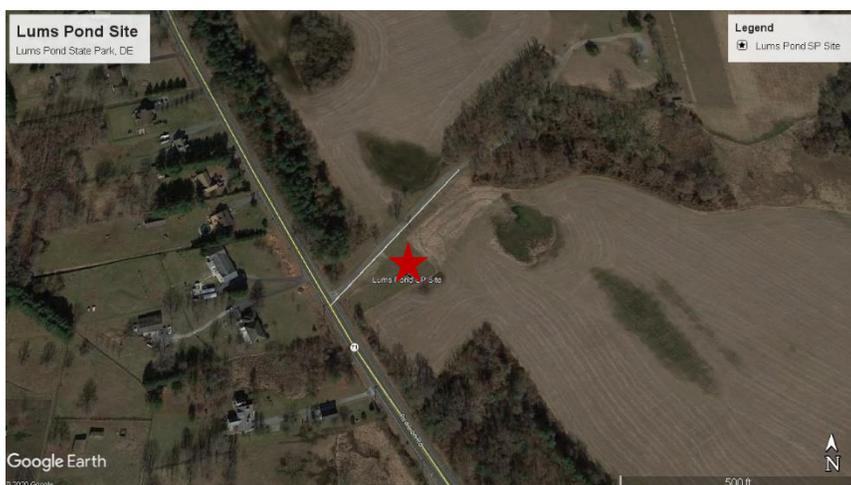


AQS Site ID: 10-003-1007
State: Delaware
County: New Castle
Address: Lums Pond State Park, Bear

Latitude: 39.5513
Longitude: -75.7320

Spatial Scale: Urban
Area Represented: Not in and urban area (MSA)

Year Established: 1991



Monitored Parameters

- O₃** Ozone
- SO₂** Sulfur Dioxide
- PM_{2.5}** Particulate Matter: Hourly & 24-hour (Microns < 2.5)
- WS / WD** Wind Speed & Direction
- T / Rh** Temperature & Relative Humidity

Site Description

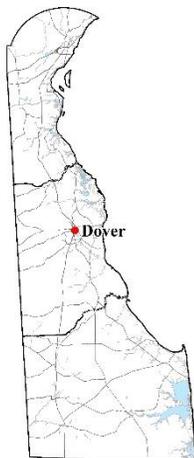
The Lums Pond site was originally neighborhood scale located in a general upwind direction from Wilmington. The scale of representation was changed to Urban (4 – 50 km) to reflect the background and transport monitoring objectives. The immediate area is rural. This site meets all EPA 40 CFR Part 58 App D and E siting criteria.

Monitoring Objectives

The site objectives for O₃ are upwind background for the Wilmington area, population exposure, NAAQS compliance, and trends. This site was originally planned to monitor O₃ transported into Delaware from the Baltimore/Washington area, and continues to serve this purpose. The SO₂ monitor was added in 2000 to detect impacts from major point sources directly to the east. PM_{2.5} monitoring began in 1999 as both a regional transport and general population exposure site, as well as for NAAQS compliance.

Planned Changes through 2020

Replacement of the PM_{2.5} FRM retained to meet collocation with FEM requirements, as resources become available.

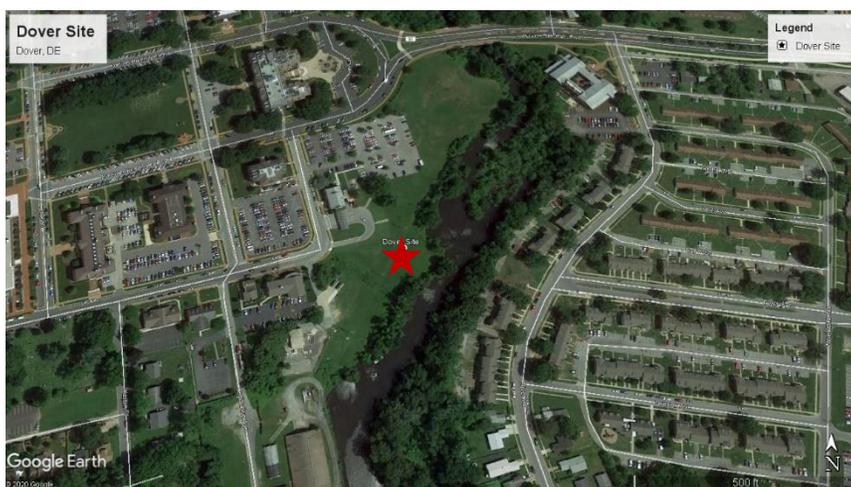


AQS Site ID: 10-001-0003
State: Delaware
County: Kent
Address: Water St., Dover

Latitude: 39.1556
Longitude: -75.5182

Spatial Scale: Neighborhood
Area Represented: Dover
(MSA) DE

Year Established: 1999



Monitored Parameters

PM_{2.5} Particulate Matter: 24-hour (Microns < 2.5)

Site Description

The Dover site is a platform only and was established to understand fine particulate concentrations in the Dover area. It is a neighborhood scale site representative of the Dover MSA impacted by a combination of source types including mobile, large and small point sources. This site meets all EPA 40 CFR Part 58 App D and E siting criteria.

Monitoring Objectives

Population exposure, PM_{2.5} NAAQS compliance, and trends.

Planned Changes through 2020

Replace existing PM_{2.5} FRM with new PM_{2.5} FEM when resources become available.



Site: Killens Pond

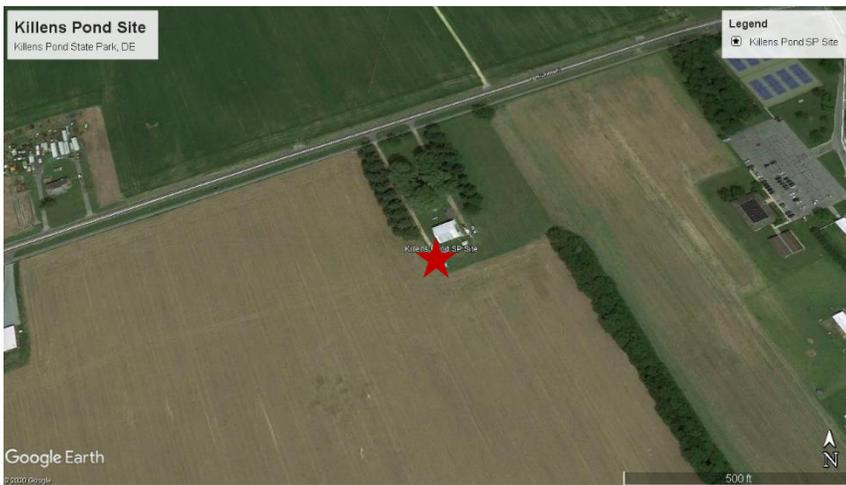


AQS Site ID: 10-001-0002
State: Delaware
County: Kent
Address: Killens Pond State Park, Felton

Latitude: 38.9867
Longitude: -75.5568

Spatial Scale: Urban
Area Represented: Not in an urban area (MSA)

Year Established: 1995



Monitored Parameters

- O₃** Ozone
- PM_{2.5}** Particulate Matter: Hourly (Microns < 2.5)
- WS / WD** Wind Speed & Direction

Site Description

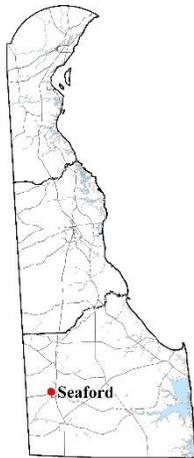
The Killens Pond site is located in a rural area that is part of Killens Pond State Park. It was established to understand background concentrations of O₃ and PM_{2.5}. The scale of representation was changed to Urban (4 – 50 km) to reflect the background monitoring objective. This site meets all EPA 40 CFR Part 58 App D and E siting criteria.

Monitoring Objectives

Background concentrations, NAAQS compliance, and trends.

Planned Changes through 2020

No changes planned.



AQS Site ID: 10-005-1002

State: Delaware

County: Sussex

Address: 350 Virginia Ave., Seaford

Latitude: 38.6539

Longitude: -75.6106

Spatial Scale: Neighborhood

Area Represented: Salisbury,
(MSA) MD-DE

Year Established: 1990



Monitored Parameters

O₃ Ozone
PM_{2.5} Particulate Matter: Hourly (Microns < 2.5)
WS / WD Wind Speed & Direction

Site Description

The Seaford site was originally located to monitor pollutant concentrations in the Seaford area. The original site was located further south, near the Seaford water tower. It was relocated to the present location in 1990 due to deteriorating conditions at the original site. The current site is neighborhood scale and is suburban. The site is impacted by local point sources, mobile sources, and regional transport. This site meets all EPA 40 CFR Part 58 App D and E siting criteria.

Monitoring Objectives

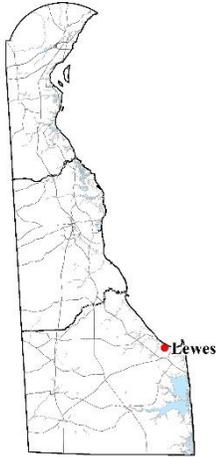
Population exposure, NAAQS compliance, and trends.

Planned Changes through 2020

No changes planned.



Site: Lewes



AQS Site ID: 10-005-1003

State: Delaware

County: Sussex

Address: University of Delaware: College of Earth, Ocean, & Environment - Hugh R. Sharp Campus, Lewes

Latitude: 38.7791

Longitude: -75.1632

Spatial Scale: Neighborhood

Area Represented: Salisbury,
(MSA) MD-DE

Year Established: 1991



Monitored Parameters

- O₃** Ozone
- SO₂** Sulfur Dioxide
- WS / WD** Wind Speed & Direction
- T / Rh** Temperature & Relative Humidity

Site Description

The Lewes site is neighborhood scale established to understand O₃ concentrations in the coastal area where population increases significantly in the summer months. SO₂ was added in 2012 in response to the new SO₂ NAAQS monitoring requirements. It is representative of the coastal Sussex County area. This site meets all EPA 40 CFR Part 58 App D and E siting criteria.

Monitoring Objectives

Population exposure, NAAQS compliance, and trends.

Planned Changes through 2020

No changes planned. A NO_x monitor will be added as part of EMP when implemented.



Monitoring method information

List of Monitor Methods & AQS Codes

Monitoring methods and associated AQS codes used in the Delaware ambient air monitoring network:

Parameter AQS code	AQS Method Code	Method Description/ Analysis Method
O ₃ - 44201	047 – TE 49i 087 – API T400 Teledyne	UV Absorption
SO ₂ - 42401	560 - TE 43i-TLE	UV Fluorescence
CO - 42101	554 – TE 48i-TLE 593 – TAPI Trace CO	Non-dispersive Infrared
NO ₂ - 42602	574 – TE 42i-TL	Chemiluminescence
	599 –TAPI T200 NO, NO _x 600 –TAPI T200 NO ₂	Cavity Attenuated Phase Shift (CAPS) Spectroscopy
	No Method Code Yet-TAPI N500 NO ₂	
NO _y - 42600	674 – TE 42i-Y NO _y	Chemiluminescence
PM _{2.5} - 88101	145 – TE Partisol 2025 VSCC Inlet 236 – Teledyne T640 (continuous)	Gravimetric Continuous broadband spectroscopy
	*PM _{2.5} Speciation – Ions	812 – Met One SASS
*PM _{2.5} Speciation – Metals	811 – Met One SASS	Teflon filter, energy dispersive XRF
*PM _{2.5} Speciation – Carbon	839 – URG 3000N	Quartz filer and cyclone inlet; IMPROVE carbon Thermal Optical Reflectance (TOR) analysis method
PM ₁₀ – 85101 local conditions	127 – TE Partisol 2025 Sequential	Gravimetric
PMcoarse – 86101 PM10-2.5 local conditions	176 – TE Partisol 2025 Sequential Pair	Calculated from paired samplers
Air Toxic – VOCs	150 – SS 6L – Pressurized Canister	Cryogenic pre-concentration: GC/MS
*Air Toxic – Metals	089 – High-Volume TSP	ICP/MS Quartz filters
WS – 61103 WD - 61104	020 – Vaisala vector method	Ultrasonic

* Multiple parameters in this group; see next table for list of compounds.



Parameters with multiple compounds.

Note that all parameter codes can be found online:

https://aqs.epa.gov/aqsweb/documents/codetables/methods_all.html

Group	Compounds
VOCs	Dichlorodifluoromethane, Chloromethane, 1,2-Dichloro-1,1,2,2,tetrafluoroeth, Chloroethene, 1,3-Butadiene, Trichlorofluoromethane, Acetone, Methylene Chloride, 1,1,2-Trichloro-1,2,2-trifluoroethane, 2-methoxy-2-methyl-Propane, Hexane, Chloroform, Tetrahydrofuran, 1,2-Dichloroethane, 1,1,1-Trichloroethane, Benzene, Carbon tetrachloride, Cyclohexane, 1,2-Dichloropropane, Trichloroethene, Heptane, Cis-1,3-Dichloro-1-Propene, Trans-1,3-Dichloro-1-Propene, Toluene, 1,2-Dibromoethane, Tetrachloroethylene, Chlorobenzene, Ethylbenzene, m & p-Xylene, Styrene, 1,1,2,2-Tetrachloroethane, o-Xylene, 1-Ethyl-4-Methylbenzene, 1,3,5-Trimethylbenzene, 1,2,4-Trimethylbenzene, 1,4-Dichlorobenzene
Metals	Arsenic (12103), Cadmium (12110), Chromium (12112), Lead (12128), Manganese (12132), Nickel (12136)
PM _{2.5} Speciation	<p>Ions: Ammonium, Nitrate, Sulfate, Potassium, Sodium</p> <p>Carbon: Elemental carbon (E1 IMPROVE, E2 IMPROVE, E3 IMPROVE, EC IMPROVE TOR, EC IMPROVE TOT) Organic carbon (O1 IMPROVE, O2 IMPROVE, O3 IMPROVE, O4 IMPROVE, OC IMPROVE TOR, OC IMPROVE TOT, OP IMPROVE TOR), OP IMPROVE TOT, TC IMPROVE</p> <p>Metals: Aluminum, Antimony, Arsenic, Barium, Bromine, Cadmium, Calcium, Cerium, Cesium, Chlorine, Chromium, Cobalt, Copper, Europium, Gallium, Gold, Hafnium, Indium, Iridium, Iron, Lanthanum, Lead, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Niobium, Phosphorus, Potassium, Rubidium, Samarium, Scandium, Selenium, Silicon, Silver, Sodium, Strontium, Sulfur, Tantalum, Terbium, Tin, Titanium, Vanadium, Wolfram, Yttrium, Zinc, and Zirconium</p>



Ozone (O₃)

Ozone is measured by ultraviolet absorption photometry. Air is drawn through a sample cell where ultraviolet light (254 nm wavelength) passes through it. Light not absorbed by the ozone is converted into an electrical signal proportional to the ozone concentration.

Sulfur Dioxide (SO₂)

Sulfur dioxide is measured with a fluorescence analyzer. Air is drawn through a sample cell where it is subjected to high intensity ultraviolet light. This causes the sulfur dioxide molecules in the air to fluoresce and release light. The fluorescence is detected with a photo multiplier tube and converted to an electrical signal proportional to the SO₂ concentration.

Carbon Monoxide (CO)

Carbon monoxide is measured by infrared absorption photometry. Air is drawn continuously through a sample cell where infrared light passes through it. Carbon monoxide molecules in the air absorb part of the infrared light, reducing the intensity of the light reaching a light sensor. The light is converted into an electrical signal related to the concentration of carbon monoxide in the sample cell.

Nitrogen Dioxide (NO₂)

- **Chemiluminescence Reaction**

Nitrogen oxides are measured using the chemiluminescence reaction of NO with O₃. Air is drawn into a reaction chamber where it is mixed with a high concentration of ozone from an internal ozone generator. Any NO in the air reacts with the ozone to produce NO₂. Light emitted from this reaction is detected with a photo multiplier tube and converted to an electrical signal proportional to the NO concentration. NO₂ must be measured indirectly.

NO₂ is measured by passing the air through a converter where any NO₂ in the air is reduced to NO before the air is passed to the reaction chamber. By alternately passing the air directly to the reaction chamber, and through the converter before the reaction chamber, the analyzer alternately measures NO and NO_x. The NO₂ concentration is equal to the difference between NO and NO_x.

- **Cavity Attenuated Phase Shift Spectroscopy (CAPS)**

Ambient air is drawn into the true NO₂ analyzer inlet with a vacuum pump. Particulates are removed to prevent deposition of particulate matter (PM) on the analyzer optics. The particulate scrubbed air then enters the sample cell, which includes highly reflective mirrors to produce a considerable path length within the cell. NO₂ in the sampled atmosphere absorbs light at 450 nm. Rather than a traditional absorbance method, where a reduction in intensity of the light to the detector is proportional to concentration, a CAPS monitor uses the average time spent in the cell by the 450-nm light to quantify the NO₂ concentration in the cell. The presence of NO₂ in the cell causes the average time to decrease as the NO₂ concentration increases – due to the absorption. This reduction in time spent in the cell by the 450 nm light absorbed is proportional to the concentration of NO₂ in the sampled atmosphere.



Total Reactive Oxides of Nitrogen (NO_y)

NO_y is measured by the same method as NO_x with the exception that the converter is at the sample inlet mounted 10 meters above ground level instead of at the instrument's reaction chamber. This position is used because the NO_y compounds are too unstable to be measured when taken in through the entire length of the typical ambient air sampling inlet system. Placing the converter at the inlet allows the catalytic reaction to convert most of the NO_y species (approximately 30 nitroxyl compounds) to NO very close to the point where ambient air is sampled. The more stable NO can then be detected as described previously.

Particulate Matter - Fine (PM_{2.5}), PM₁₀, and PM_{coarse}

PM_{2.5} is sampled by drawing air through a specially designed inlet that excludes particles larger than 2.5 microns in diameter. The particles are collected on a Teflon⁷ microfiber filter that is weighed to determine the particulate mass. The normal sampling schedule is 24 hours every third day, however, at one site (Wilmington-MLK) PM_{2.5} samples are collected for 24 hours every day.

PM_{2.5} with the Teledyne T-API 640 continuously measures particulate mass using a light-scattering spectroscopy method.

PM₁₀ samples are collected using the same general method as PM_{2.5} with a specially designed inlet that excludes particles larger than 10 microns in diameter. Samples are collected every third day.

PM_{coarse} is calculated by subtracting the PM_{2.5} concentration from the collocated PM₁₀ concentration for the same day.

PM_{2.5} Speciation

Some of the gravimetric PM_{2.5} monitors are specially equipped to collect PM_{2.5} samples which are later analyzed into concentrations of the samples' chemical constituents or species. MetOne Super SAAS samplers, URG 3000N, and IMPROVE samplers are used for the collection of samples for the chemical speciation of PM_{2.5}. The samplers collect 3 samples simultaneously every third day for a period of 24 hours. These samples are then sent to an EPA contract laboratory for chemical analyses. There are over 50 species consisting of ions, metals and carbon species quantified by the analyses.

VOCs

Air toxics samples are collected for 24 hours in canisters with an Entech 1900 canister sampler on a one in sixth day schedule. A duplicate sample is collected every one in twelve days. The canisters are returned to the Maryland Department of the Environment laboratory for analysis on an Entech/Agilent gas chromatograph mass spectrometer system.

Metals

Metals are collected for 24 hours with a high-volume TSP sampler on a quartz filter. The filter is sent to the West Virginia Division of Air Quality laboratory for analysis using ICP/MS.



Appendix A

PAMS Monitoring Implementation Network Plan - Delaware

Delaware Division of Air Quality (DAQ) plans to operate one Photochemical Assessment Monitoring Stations (PAMS) site in the air monitoring network in 2021, at the Delaware NCore MLK site in Wilmington in accordance with the recently revised monitoring rule (80 FR 65292; October 26, 2015) which requires PAMS measurements June 1 through August 31 at NCore sites that are located in Core-Based Statistical Areas (CBSAs) with populations of 1,000,000 or more.

Network Decision

- The NCore site located at MLK site id 10-003-2004 will serve as the location of the required PAMS site and will measure the following parameters described below. An Inventory of equipment used at the site is provided in Attachment 1.
- ~~We request a waiver from implementing PAMS at an otherwise required NCore site entirely, or to make PAMS measurements at alternative locations such as existing PAMS sites or existing NATTS sites. Rationale for this waiver is provided in Waiver attachment~~

Auto GC Decision

Volatile organic compounds (VOCs) – A complete list of the targeted compounds are found in Table 1.

- We will measure hourly speciated VOC measurements with an auto-gas chromatograph (GC) using the Consolidated Analytical Systems integrated Chromatotec AirmOzone Auto-Gas Chromatograph with Flame Ionization Detection (Auto-GC-FID).
- ~~We request a waiver to allow three 8-hour samples every third day as an alternative to daily hourly speciated VOC measurements at locations (*insert locations*). Rationale for this waiver is provided in Waiver Attachment~~

Meteorology Measurements Decision – Note: EPA is suggesting the use of ceilometers for determining mixing height, however other types of meteorological equipment that provide for an indication of mixing height can be proposed

- Will measure wind direction, wind speed, temperature, humidity, atmospheric pressure, precipitation, solar radiation, ultraviolet radiation, and mixing height. We have elected to use the following instrumentation to measure the parameters described above: *Vaisala WXT520 – WS/WD, Tem, Humidity, Pressure, Precipitation*
Vaisala CL31 – Mixing Height
Kipp & Zonen CUV5 UV Radiometer – UV Radiation
Kipp & Zonen CMP3 Pyranometer – Solar Radiation
- ~~We request a waiver to allow meteorological measurements to be obtained from other nearby sites. Rationale for this waiver is provided in Waiver attachment~~



Other Required Measurements

- **Carbonyls** - Carbonyl sampling at a frequency of three 8-hour samples on a one-in-three day basis (~90 samples per PAMS sampling season) using *ATEC Model 8000-2 Eight Port Carbonyl Sampler with additional Duplicate Channel*. A complete list of the target carbonyl compounds may be found in Table 1. The TO-11A test method, as used in the National Air Toxics Trends (NATTS) program¹ will be used.
- **Nitrogen Oxides** – Will monitor for NO and NO_y (total oxides of nitrogen) in addition to true NO₂. The true NO₂ is required to be measured with a direct reading NO₂ analyzer, cavity attenuated phase shift (CAPS) spectroscopy or photolytic-converter NO_x analyzer. We have elected to use Model *N500 CAPS NO₂ Analyzer* for the true NO₂ measurement. NO and NO_y will be measured using a *Thermo Environmental Instruments 42i-Y Chemiluminescent analyzer*.

Table 1: PAMS Target Compound List

Priority Compounds				Optional Compounds			
1	1,2,3-trimethylbenzene ^a	19	n-hexane ^b	1	1,3,5-trimethylbenzene	19	m-diethylbenzene
2	1,2,4-trimethylbenzene ^a	20	n-pentane	2	1-pentene	20	methylcyclohexane
3	1-butene	21	o-ethyltoluene ^a	3	2,2-dimethylbutane	21	methylcyclopentane
4	2,2,4-trimethylpentane ^b	22	o-xylene ^{a,b}	4	2,3,4-trimethylpentane	22	n-decane
5	acetaldehyde ^{b,c}	23	p-ethyltoluene ^a	5	2,3-dimethylbutane	23	n-heptane
6	acetone ^{c,d}	24	Propane	6	2,3-dimethylpentane	24	n-nonane
7	benzene ^{a,b}	25	propylene	7	2,4-dimethylpentane	25	n-octane
8	c-2-butene	26	styrene ^{a,b}	8	2-methylheptane	26	n-propylbenzene ^a
9	ethane ^d	27	toluene ^{a,b}	9	2-methylhexane	27	n-undecane
10	ethylbenzene ^{a,b}	28	t-2-butene	10	2-methylpentane	28	p-diethylbenzene
11	Ethylene			11	3-methylheptane	29	t-2-pentene
12	formaldehyde ^{b,c}			12	3-methylhexane	30	α/β-pinene
13	Isobutane			13	3-methylpentane	31	1,3 butadiene ^b
14	Isopentane			14	Acetylene	32	benzaldehyde ^c
15	Isoprene			15	c-2-pentene	33	carbon tetrachloride ^b
16	m&p-xylenes ^{a,b}			16	cyclohexane	34	Ethanol
17	m-ethyltoluene ^a			17	cyclopentane	35	Tetrachloroethylene ^b
18	n-butane			18	isopropylbenzene ^b		

Source: Revisions to the Photochemical Assessment Monitoring Stations Compound Target List. U.S. EPA, November 20, 2013

^a Important SOAP (Secondary Organic Aerosols Precursor) Compounds

^b HAP (Hazardous Air Pollutant) Compounds

^c Carbonyl compounds

^d Non-reactive compounds, not considered to be VOC for regulatory purposes

¹ See NATTS Technical Assistance Document for TO-11A method.



Attachment 1 Equipment Inventory

Region	3	
State	Delaware	
AQS ID	10-003-2004	
CBSA	Philadelphia-Camden-Wilmington	
Parameter	Category	Detail
Site	Is the AQS site listed above the expected PAMS Core site?	Yes
	What is the status of the decision for the expected PAMS Core site location (not started, draft, or final)?	Final
	Is there an alternate PAMS Core site location selected?	No
	Identify type of alternative site (existing PAMS, NATTS, etc.)	
	Alternate site AQS ID (if known)	
Mixing Height	Is there an existing functional ceilometer or other similar instrument available for use?	No
	Current location (at future PAMS Core site, at other site, not applicable)	
	Instrument type (ceilometer, radar profiler, etc.)	
	Manufacturer	
	Model	
	Date purchased	
Auto GC	Is there an existing Auto GC available for use?	No
	Current location (at future PAMS Core site, at other site, not applicable)	
	Manufacturer	
	Model	
	Date purchased	
	Does it have a service contract?	
True NO2	Is there an existing true NO2 instrument available for use?	No
	Current location (at future PAMS Core site, at other site, not applicable)	
	Instrument type (photolytic conversion, cavity ringdown, CAPS, etc.)	
	Manufacturer	
	Model	
	Date purchased	
Carbonyls Sampling	Is there an existing sequential carbonyls sampling unit or similar instrument available for use?	No
	Current location (at future PAMS Core site, at other site, not applicable)	
	Instrument type (photolytic conversion, cavity ringdown, CAPS, etc.)	
	Manufacturer	
	Model	
	Date purchased	
Carbonyls Analysis	Does the site currently have a support laboratory for carbonyls or plans to use a support laboratory?	Yes
	Laboratory name	ERG National Contract
	Comments	
Barometric Pressure	Instrument type (aneroid barometer, etc.)	capacitive silicon
	Manufacturer	Vaisala
	Model	WXT 520
	Date purchased	12/2011
	Comments	
UV Radiation	Instrument type (UV radiometer, etc.)	
	Manufacturer	
	Model	
	Date purchased	
	Comments	
Solar Radiation	Instrument type (pyranometer, etc.)	NO
	Manufacturer	
	Model	
	Date purchased	
	Comments	
Precipitation	Instrument type (tipping bucket, weighing, etc.)	Piezoelectrical sensor
	Manufacturer	Vaisala
	Model	WXT 520
	Date purchased	12/2011
	Comments	