Commonwealth of Pennsylvania
Department of Environmental Protection

Summary of Pennsylvania's
$PM_{2.5}$ Nonattainment Analysis

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Introduction

This document was created to provide an overview of the Pennsylvania's annual $PM_{2.5}$ nonattainment problem. The document includes monitoring and nonattainment area information that will be useful in developing Pennsylvania's $PM_{2.5}$ attainment demonstrations. Information provided in this report reflects the state of affairs at the time of its preparation.

Purpose

This document will serve the following purposes:

- Identify and describe Pennsylvania's $PM_{2.5}$ nonattainment areas.
- Provide a source document for the Department of Environmental Protection's modeling and attainment demonstrations.
- Provide an overview of $PM_{2.5}$ monitoring data and $PM_{2.5}$ data analysis.
- Facilitate the understanding of what contributes to Pennsylvania's annual $PM_{2.5}$ nonattainment problems and provide a pathway for future analysis.

1.0 Overview of $PM_{2.5}$ Nonattainment Areas in the Commonwealth

This section provides a brief overview of $PM_{2.5}$ health effects, $PM_{2.5}$ attainment status and Pennsylvania's nonattainment areas. Information contained in the section reflects conditions at the time of this report's preparation.

1.1. Background on Fine-Particulate Pollution

Background information on $PM_{2.5}$ included in this section was taken from EPA's website (www.epa.gov/pmdesignations/). This includes basic information on the components and health affects of $PM_{2.5}$.

Particle pollution is a mixture of microscopic solids and liquid droplets suspended in air. This pollution, also known as particulate matter, is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, soil or dust particles, and allergens (such as fragments of pollen or mold spores).

Fine particle pollution or $PM_{2.5}$ describes particulate matter that is less than or equal to 2.5 μm in diameter, approximately 1/30th the diameter of a human hair.

Fine particle pollution can be emitted directly or formed secondarily in the atmosphere. Examples of some of the primary forms of secondary pollutants include:

> Sulfates: These are formed from sulfur dioxide emissions from power plants and industrial facilities.
>
> Nitrates: These are formed from emissions of nitrogen oxides from power plants, automobiles, and other combustion sources.

The chemical composition of particles depends on location, time of year, and weather.

Health studies have shown a significant association between exposure to fine particles and premature death from heart or lung disease. Fine particles can aggravate heart and lung diseases and have been linked to effects such as: cardiovascular symptoms; cardiac arrhythmias; heart attacks; respiratory symptoms; asthma attacks; and bronchitis. These effects can result in increased hospital admissions, emergency room visits, absences from school or work, and restricted activity days. Individuals that may be particularly sensitive to fine particle exposure include people with heart or lung disease, older adults, and children.

1.2 $PM_{2.5}$ Nonattainment Overview

EPA promulgated fine-particle national ambient air quality standards in 1997 after evaluating hundreds of health studies and conducting an extensive peer review process. The annual standard is a level of 15.0 micrograms per cubic meter ($\mu g/m^3$), based on the 3-year average of annual mean $PM_{2.5}$ concentrations. EPA established a twenty-four hour standard of 65 micrograms per cubic meter ($\mu g/m^3$), determined by the 3-year average of the annual 98th percentile concentrations.

In April 2003, EPA issued a memorandum outlining a schedule for designating areas under the $PM_{2.5}$ standard and related guidance on nine factors to consider in identifying nonattainment areas. The Clean Air Act provides for states and tribes to submit designation recommendations to EPA, and it requires EPA to provide time for consultation in cases where the Administrator plans to promulgate a designation that modifies the state or tribal recommendation. On December 17, 2004, EPA published its air quality designations and classifications for the fine particles ($PM_{2.5}$) national ambient air quality standards (NAAQS). These designations became effective on April 5, 2005.

1.3 Anticipated Changes and Schedule

The Commonwealth is responsible for developing State Implementation Plan revisions for its eight (8) annual $PM_{2.5}$ nonattainment areas that demonstrate each nonattainment area will comply with the 1997 $PM_{2.5}$ standards. SIP revisions will be due in April of 2008 demonstrating attainment by April of 2010. The Department is currently developing final modeling protocols for each nonattainment area. These SIP revisions are due to the U. S. EPA's Region III office by September 30, 2007.

In 2006, the U.S. EPA tightened the twenty-four hour $PM_{2.5}$ standard to 35 $\mu g/m^3$. Because the nonattainment designations for the 24-hour $PM_{2.5}$ are not yet in place, the Commonwealth's $PM_{2.5}$ modeling analyses for its April 2008 SIP submittal will use the twenty-four hour standard established in 1997, 65 $\mu g/m^3$. Table 1-1 lists standards established in 1997 along with the current $PM_{2.5}$ standards.

Table 1-1 $PM_{2.5}$ Standards

Date Standard Established	24-Hour	Annual
July 18, 1997	≤ **65** µg/m^3	≤ **15.0** µg/m^3
September 21, 2006	≤ **35** µg/m^3	≤ **15.0** µg/m^3

Timetables for the lower twenty-four hour $PM_{2.5}$ standard established on September 21st, 2006 by the U.S. EPA are as follows:

- States will make recommendations by November 2007 for areas to be designated attainment (meeting the standards) and nonattainment (violating the standards).
- EPA will make designations by November 2009; those designations will become effective in April 2010.
- State Implementation Plan revisions, which outline how states will reduce pollution to meet the standards, will be due three years after designations, in April 2013.
- States must meet the standards by April 2015, with a possible extension to April 2020.

2.0 Monitoring Overview

There are three general types of $PM_{2.5}$ monitors operated in the Commonwealth. These include Federal Reference Method (FRM) monitors, speciation monitors and continuous monitors. Sulfate and Nitrate concentration and deposition information is also collected at various locations across the Commonwealth as part of the Acid Rain Monitoring Program sometimes referred to as Title IV. These measurements could be used to supplement information from $PM_{2.5}$ monitors. This section will give a brief description of each type of monitor and their location.

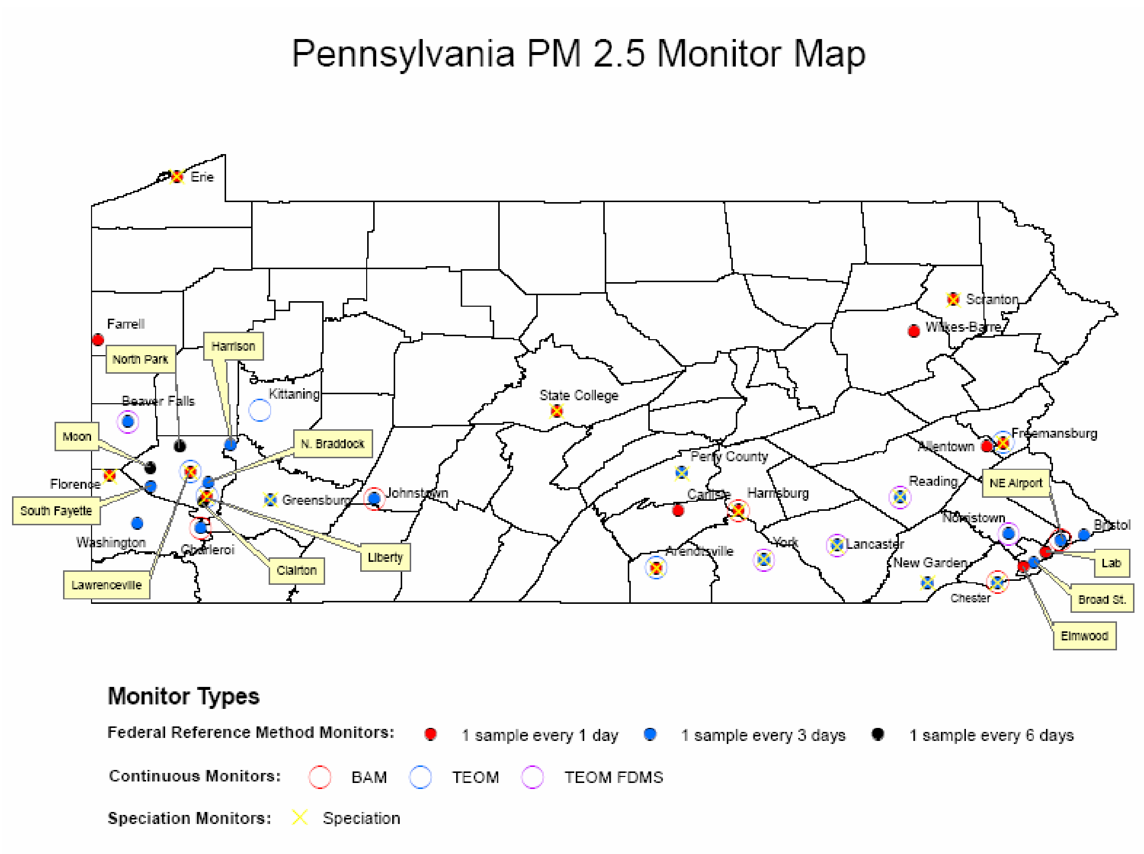
2.1 Monitor Types

Figure 2-1 shows information regarding the $PM_{2.5}$ monitoring network. The Department's annual ambient air-quality reports contain additional information regarding the PA DEP's monitoring network (Pennsylvania Ambient Air Quality Report, 2004).

FRM Monitors

$PM_{2.5}$ concentrations are measured using both discrete (single sample) monitors and continuous real-time instruments. Discrete monitors collect particulate matter on a filter for twenty-four hours. The filter is then collected from the monitor on a set schedule. Depending on the monitoring site and type, department personnel collect filters either once a day (1/1), once every third day (1/3) or once every sixth day (1/6). Collected filters are shipped to a specialized lab to be weighed and analyzed.

Figure 2-1. Pennsylvania $PM_{2.5}$ Monitoring Network



Only the discrete $PM_{2.5}$ sampler is approved by the U.S. EPA as a Federal Reference Method (FRM) for compliance purposes. FRM monitors are maintained at various locations across the Commonwealth by the PA DEP, the Allegheny County Health Department and Philadelphia County's Air Management Services.

Continuous Monitors

There are several manufactures of continuous $PM_{2.5}$ samplers. The analyzer reports one-hour data, which are then used to calculate daily twenty-four hour averages (midnight to midnight), for comparison to the ambient air quality standard. These monitors are used primarily for air-quality forecasting purposes to provide "instantaneous" information since FRM monitors can take weeks to provide results and may not provide information for every day (due to less than 1/1 sampling frequencies).

The PA DEP possesses two types of continuous samplers. These are:

> **Tapered Element Oscillating Microbalance (TEOM) monitor:** a gravimetric instrument that draws ambient air through a filter, constantly weighing the filter and calculating real-time $PM_{2.5}$ concentrations.
>
> **Beta-Attenuation Mass (BAM) sampler:** draws ambient air through a section of filter tape. The filter tape passes between a beta ray source and a beta ray detector. As the particulate mass on the filter increases, the number of beta ray particles transmitted through the filter decreases. So the detector measures the number of beta particles transmitted through the exposed filter tape, and then the instrument calculates the particulate mass using a correlation equation.

Speciation Monitors

Pennsylvania began operating a $PM_{2.5}$ speciation network, consisting of thirteen sampling sites, in April 2002. Speciation is a physical or chemical analysis of the captured particles that provide a first order characterization of the metals, ions, and carbon constituents of $PM_{2.5}$. Knowing the chemical composition of the $PM_{2.5}$ mix is also important for determining sources of pollution. By developing seasonal and annual chemical characterizations of ambient particulates across the Commonwealth, this speciation data will be used to perform source attribution analyses, evaluate emission inventories and air quality models, and support health related research studies and regional haze assessments.

2.2 Other Monitoring Information

The PA DEP, under cooperative agreement with Penn State, has maintained the Pennsylvania Atmospheric Deposition Monitoring Network since 1981. The purpose of this program is to determine how much acid rain is falling in Pennsylvania for environmental assessment purposes. The objectives of this project and subsequent revisions were: (1) to determine the magnitude and distribution of wet atmospheric deposition and associated toxic and nutrient elements in Pennsylvania, (2) to assess their potential environmental impacts, (3) to determine temporal trends in the chemistry of precipitation in the state, (4) to evaluate the influence of local emissions and variations in precipitation volume on wet deposition patterns, (5) to determine the optimum number of sites needed to define spatial variability in atmospheric deposition in Pennsylvania, and (6) to provide a quantitative means of evaluating the effectiveness of present and future air pollution control legislation, such as the Clean Air Act Amendments of 1990, aimed at reducing atmospheric deposition in the United States (Lynch et al., 2005). Figure 2-1 displays the current Acid Rain Monitoring Network.

Precipitation samples are collected once per week and analyzed for pH, sulfate, nitrate, ammonium, chloride, calcium, magnesium, potassium, sodium, and specific conductance.

The PA DEP produces annual reports that are posted on its website. Specific analytical techniques and results can be found in these reports.

Figure 2-2. Pennsylvania's Atmospheric Deposition Monitoring Network

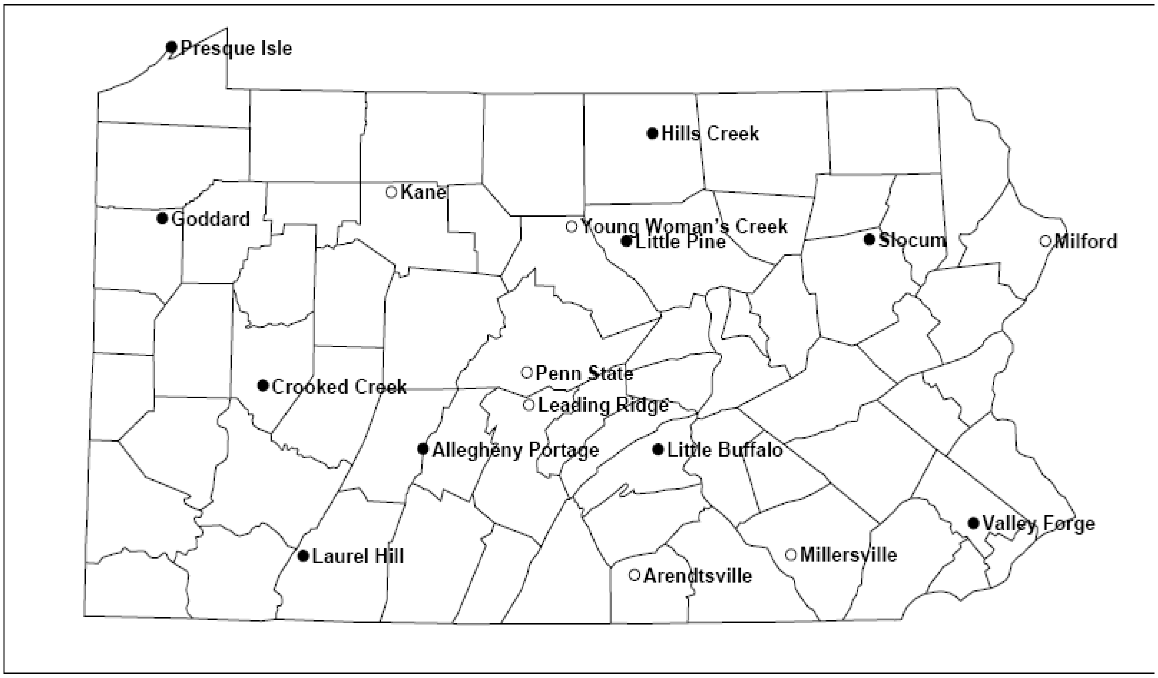


Figure 2-1. Site locations of the 2005 Pennsylvania Atmospheric Deposition Monitoring Network Sites marked with an empty circle are part of the National Atmospheric Deposition Program/National Trends Network (NADP/NTN).

Results for sulfates, nitrates and ammonia could be used to supplement the department's $PM_{2.5}$ monitoring network. Some of the monitoring sites predate the $PM_{2.5}$ monitoring network and could provide trends information that may be useful.

3.0 . Emissions/Control Programs

This section outlines source types that contribute to $PM_{2.5}$ and some of the control programs that help reduce anthropogenic emissions that contribute to fine-particulate pollution.

3.1. Contributing Sources

Design of effective SIP revisions and other regulatory policies requires knowledge of source-receptor relationships that link ambient $PM_{2.5}$ levels with emissions. The design of these strategies is complicated by the importance of secondary aerosol to $PM_{2.5}$. A broad range of anthropogenic and biogenic sources can contribute to local $PM_{2.5}$ concentrations. Primary emissions can come from power plants fired by coal, oil, or gas, diesel- or gasoline-powered transportation, meat cooking, coke plants, biogenics, biomass burning, incineration, and crustal sources. Sources of secondary compounds include power plants, and transportation systems (Pittsburgh Air Quality Study).

3.2. Control Programs

A broad range of emission controls have been implemented under the 1990 Clean Air Act (CAA). Controls on power plants, industrial sources and the mobile source sector have been enacted to control emissions that contribute to ozone, acid rain, particulates and air toxics. These controls, though not specifically designed to control fine particulates, have none the less helped lower direct and secondary fine-particulate emissions. The following sections identify some of these control programs and when they take or took affect. This section provides a general outline of the control programs, what pollutants were controlled and when controls were put in place.

3.2.1 Acid Rain Program (Title IV)

Acid rain causes acidification of lakes and streams and contributes to the damage of trees at high elevations and many sensitive forest soils. Additionally, acid rain accelerates the decay of building materials, paints, statues, and sculptures. Prior to falling to the earth, sulfur dioxide (SO_2) and nitrogen oxide (NO_x) gases and their particulate matter derivatives (sulfates and nitrates) contribute to visibility degradation and harm public health (U.S. EPA Acid Rain site: http://www.epa.gov/acidrain/index.html).

The Acid Rain Program uses a market-based cap and trade mechanism that sets a permanent cap on the total amount of SO_2 that may be emitted by electric power plants nationwide. The first phase of the program began in 1995 and affected a core set of 263 units at 110 mostly coal-burning electric power plants in eastern and Midwestern states. The second phase, which began in 2000, tightened the annual emissions limit imposed on these large, higher emitting plants and also set restrictions on smaller and cleaner plants fired by coal, oil, and gas (U.S. EPA, Cap and Trade: Acid Rain Program Basics). The Acid Rain Program affects existing power generating units greater than 25 megawatts and all new units.

Beginning in 2000, SO_2 emissions from these sources were capped at 9.5 million tons (compared to 1980 emissions of 17.3 million tons), and in 2010, the final annual emissions cap is set at 8.95 million tons. Emissions will reach the cap level after the sizeable allowance bank created by early reductions has been drawn down. At full implementation, the cap cuts SO_2 emissions from power plants to one half of the amount of SO_2 emitted in 1980. The cap ensures that the mandated emissions reductions are achieved and maintained over time.

The Acid Rain Program did not cap NO_x emissions, but instead set emission rate limitations for coal-fired units and allowed companies to develop system-wide compliance strategies with a degree of flexibility. The NO_x program component, also achieved in two phases, requires achievement of a performance standard representing about a 27 percent reduction from 1990 levels.

Figures 3-1 and 3-2 show SO_2 and NO_x emission trends from sources affected by the Acid Rain program. These figures are taken from Lynch et al. (2005). Yearly reports on the Commonwealth's acid rain monitoring program are provided by researched from Penn State, which are funded by the Department (Grant Number ME359494).

Emissions data indicate incremental decreases in SO_2 and NO_x emissions affected by Title IV controls with the largest decrease occurring before most fine-particulate monitoring programs were put in place (~1999). Subsequent incremental emission changes may be too small to be picked up by the current monitoring network.

Figure 3-1. Sulfur dioxide emissions for 1980, 1985, 1990, and 1995 through 2005 from Title IV affected sources of the Clean Air Act Amendments of 1990

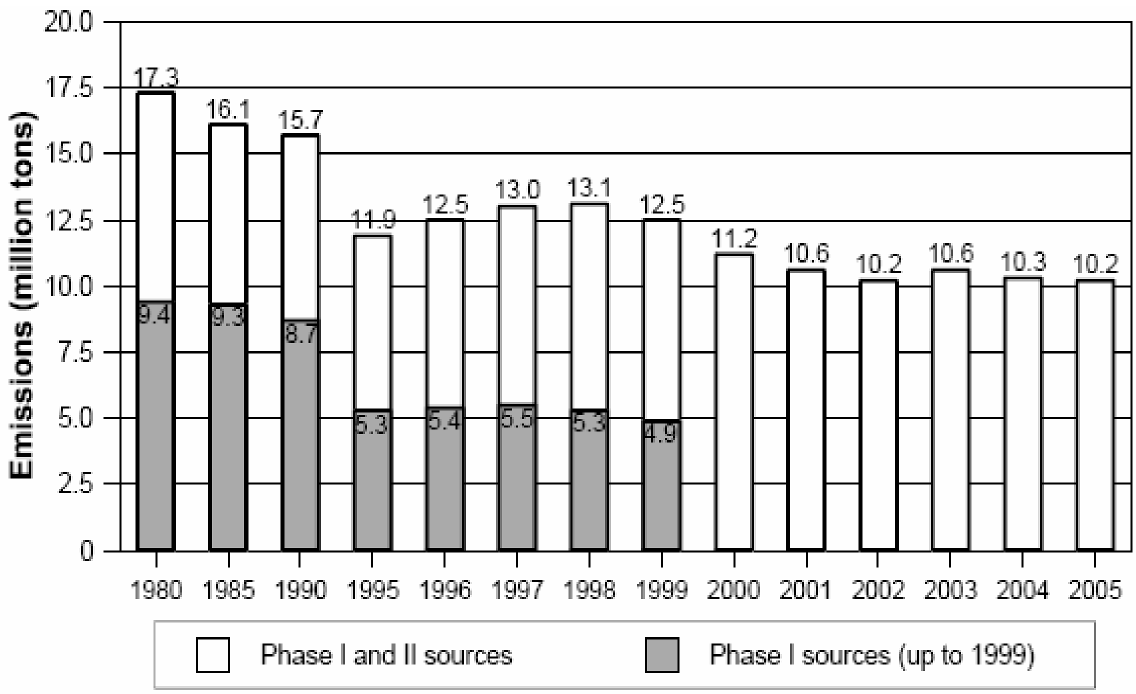
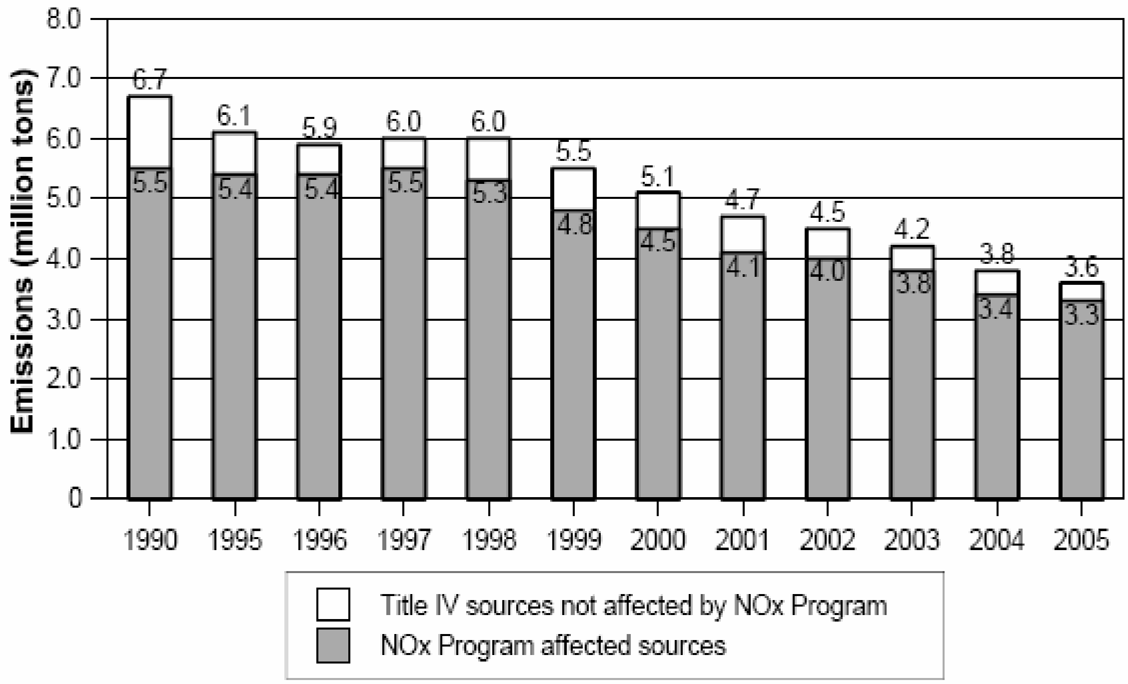


Figure 3-2 Nitrogen oxides emissions for 1990 and 1995 through 2005 from Title IV affected sources of the Clean Air Act Amendments of 1990



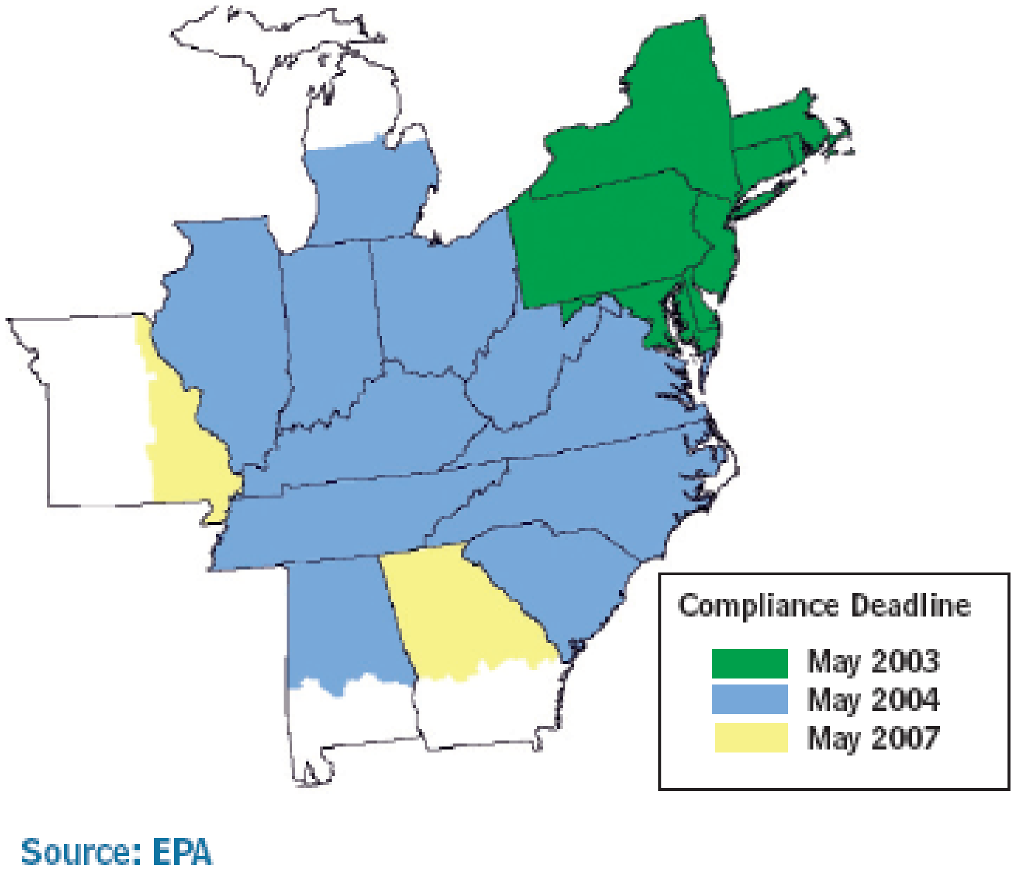
3.2.2 NO_x Budget Trading Program (NO_x SIP Call)

NO_x emissions from large fossil fuel fired power plants have been recognized as significant contributors to ozone formation. The U.S. EPA established the NO_x Budget Trading Program (NBP) to reduce these emissions and help alleviate widespread ozone nonattainment problems across the US. The NBP lead to substantial NO_x controls across the eastern US during the ozone season.

While the NBP was not designed specifically to reduce fine-particulate emission it does limit ozone season NO_x emissions that could lead to formation of nitrates, one of the major components of fine-particulate pollution. Initially, NO_x controls were imposed on fossil fuel-fired electric generating units and large industrial boilers and turbines through an ozone season (May 1 through September 30) in the Northeast under the Ozone Transport Commission's (OTC) NO_x Budget Program. The second phase of the OTC NO_x Budget Program was slated to begin on May 1, 2003, but was superseded by EPA's NO_x SIP Call.

Compliance with the NO_x SIP Call was scheduled to begin in 2003. The OTC states adopted the original compliance date of May 1, 2003, in transitioning to the NO_x SIP Call. In states outside the OTC region, however, litigation delayed the initial deadline until May 31, 2004. For those states, the first compliance period (2004) was for a shorter-than-normal ozone season (see Figure 3-3). In addition, litigation delayed the start date for portions of Georgia and Missouri until 2007.

Figure 3-3 NO_x SIP Call Region, Program Implementation



(From U.S. EPA Report, August 2005)

Collectively, affected NBP industrial units reduced emissions approximately 25 percent from 2003 to 2004, despite the shorter 2004 control period. Emissions from these sources in the full 2004 ozone season were about 40,000 tons, compared to 53,000 tons for the same period in 2003.

3.2.3 Clean Air Interstate Rule (CAIR)

On March 10, 2005, EPA issued the Clean Air Interstate Rule (CAIR). CAIR will permanently cap emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) in the eastern United States. CAIR achieves large reductions of SO_2 and/or NO_x emissions across 28 eastern states and the District of Columbia. When fully implemented, CAIR will reduce SO_2 emissions in these states by over 70 percent and NO_x emissions by over 60 percent from 2003 levels.

Controls will be phased in over the next decade. CAIR Phase I caps will become effective in 2009 (NO_x) and 2010 (SO_2). These caps will be reduced further (Phase II) in 2015. It is expected that some CAIR-affected facilities will put emission reductions in place prior to when the Phase I caps become effective. There are several facilities in the Commonwealth that have already received approval to install Flue-Gas Desufurization (FGD) units that will be operational in the 2008-09 time frame. In addition we expect most CAIR-affected sources to extend their NO_x controls year round further alleviating emissions that contribute to nitrate formation, a significant component of $PM_{2.5}$.

3.2.4 Regional Haze Controls

The regional haze program is designed to improve visibility at 156 national parks and wilderness areas (designated Class I areas) throughout the US. The Regional Haze regulations allow states to develop coordinated strategies and implement programs to make reasonable progress toward the goal of "no manmade impairment" in national parks and wilderness areas by reducing emissions that contribute to haze.

States are required to conduct certain analyses to ensure that they consider the possibility of setting an ambitious reasonable progress goal, one that is aimed at reaching natural background conditions in 60 years. The rule requires States to establish goals for each affected Class I area to 1) improve visibility on the haziest days and 2) ensure no degradation occurs on the clearest days over the period of each implementation plan.

The Regional Haze rule requires States to develop long-term strategies including enforceable measures designed to meet reasonable progress goals. The first long-term strategy will cover 10 to 15 years, with reassessment and revision of those goals and strategies in 2018 and every 10 years thereafter. States strategies should address their contribution to visibility problems in Class I areas both within and outside the State.

Pennsylvania, in partnership with the Mid-Atlantic/Northeast Visibility Union (MANE-VU) member states and tribes, is currently developing its regional haze SIP. This SIP will identify facilities that significantly contribute to visibility impairment at a designated Class I area and are eligible to impose NO_x, SO_2 or particulate controls. Eligibility is limited to facilities in one of 26 source categories that have units installed and operating between 1962 and 1977 with the potential to emit more than 250 tons per year of a visibility impairing pollutant. Additional engineering analyses are conducted to determine if controls are feasible and economical.

Any controls imposed on facilities, as part of the state's regional haze SIP, will reduce $PM_{2.5}$ concentrations in nearby nonattainment areas. Regional haze controls are projected to be installed in 2013.

3.2.5 Mobil-Source Sector Controls

The most common mobile sources of air pollution are motor vehicles, but airplanes, ships, construction equipment and lawn mowers also produce significant amounts of pollutants. Emissions from the mobile-source sector contribute to fine-particulate concentrations through direct emissions and secondary formation from NO_x and SO_2 emissions. A number of emission controls programs have been enacted to lower the mobile-source sector's contribution to fine-particulate pollution. These controls, however, generally affect new equipment so any benefits are tied to "fleet turnover" meaning lower emitting units will eventually replace the older higher emitting units over time. Controls on various mobile sources will therefore be incremental and may not be immediately noticeable in the monitoring data.

3.2.5.1 Light-Duty Vehicles

Light-duty vehicles include all passenger vehicles and light-duty trucks. EPA and Pennsylvania have established emission limits for all new vehicles in this category. Emission standards (hydrocarbon, NO_x and CO limits per mile) have been periodically lowered since the enactment of the Clean Air Act Amendments of 1990. Tighter vehicle emission standards were recently imposed on 2004 and after models. These cleaner vehicles will replace older higher emitting vehicles thus lowering $PM_{2.5}$ emissions along with precursor emission that contribute to fine-particulate concentrations from this fleet category.

Pennsylvania amended the former New Motor Vehicle Control Program (which included the Pennsylvania Clean Vehicles Program) in 2006. The Clean Vehicles Program continues to incorporate the California Low Emission Vehicle Program (CA LEV II) by reference. As amended, the program affects MY 2008 and newer passenger cars and light-duty trucks vehicles less than 8,500 lbs gross vehicle weight rating. 36 *Pa B*. 7424 (December 9, 2006).

3.2.5.2 Heavy-Duty Vehicles

Heavy-duty vehicles include heavy-duty diesel engine trucks and buses. These mobile sources contribute higher direct fine-particulate emissions along with SO_2 and NO_x emissions that contribute to fine-particulate pollution on a higher per vehicle basis than vehicles in the light-duty category.

Again, a number of federal and state programs are lowering emission limits from new heavy-duty vehicles. There are also a number of programs that retrofit controls on older vehicles and attempt to limit idling times. Benefits from these programs are expected to be incremental since they rely heavily on replacing older vehicles with new cleaner ones. NO_x emissions were recently reduced from all 2002 and newer vehicles. Additional NO_x and direct fine-particulate emission reductions are expected from 2007 models with further NO_x reductions expected in model year 2010.

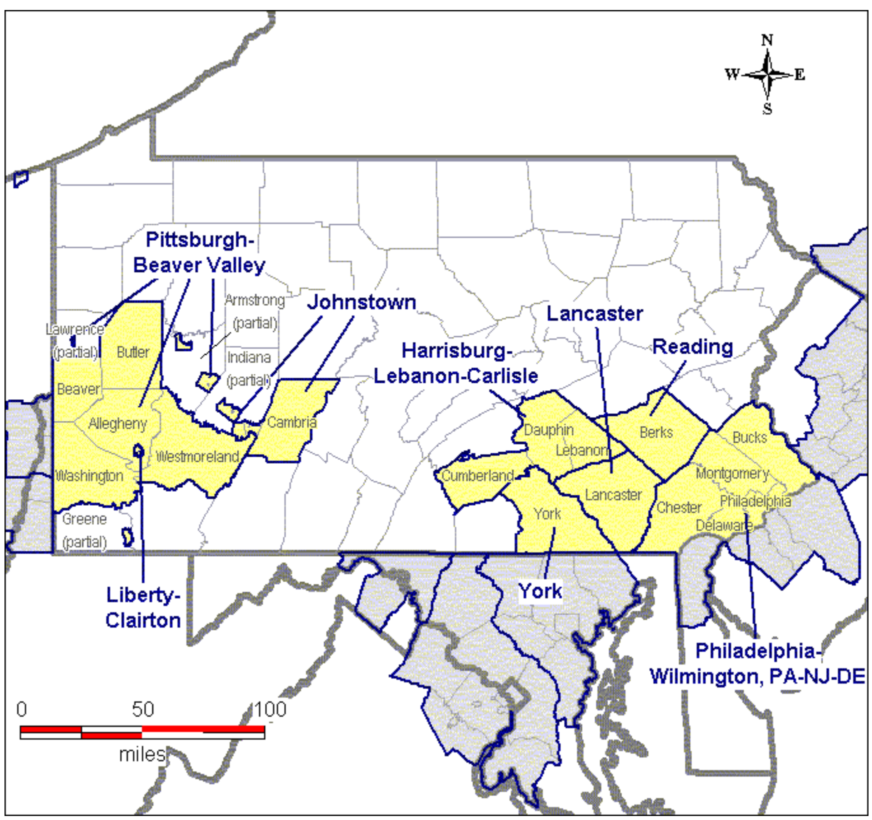
3.2.5.3 Nonroad Sources

This category includes many types of internal combustion engines. These include combustion engines, small-spark ignition, large-spark ignition, marine diesel, marine-spark ignition, recreation vehicle, locomotive and aviation. Emission limits for these types of engines are generally developed on the federal level and have been lowered since the inception of the Clean Air Act Amendments of 1990. Additional fuel-formulation changes have been imposed to help meet these cleaner engine requirements. Most of these emission limits have been established over the last five years and will become fully effective as newer cleaner units replace older units. Again any benefits in the monitoring data from these programs should occur incrementally over time.

4.0 $PM_{2.5}$ Nonattainment Area Analysis

There are currently eight (8) annual $PM_{2.5}$ nonattainment areas in Pennsylvanian. Figure 4-1 depicts the areas, which the U.S. EPA made final on April 2005. The following sections will provide a brief overview of monitor results for each nonattainment area. The Allegheny County Health Department will provide a more detailed analysis for the Liberty-Clairton nonattainment area.

Figure 4-1 Pennsylvania $PM_{2.5}$ Nonattainment Areas



4.1 Pittsburgh-Beaver Valley

Table 4-1 lists the counties and parts of counties included in the Pittsburgh-Beaver Valley $PM_{2.5}$ nonattainment area.

Table 4-1. Pittsburgh-Beaver Valley $PM_{2.5}$ Nonattainment Area

County	Partial County
	Allegheny-**all except City of Clairton, Borough of Glassport, Borough of Liberty, Borough of Lincoln, Borough of Port Vue**
	Armstrong-**only Washington Twp. and Plumbcreek Twp.**
Beaver	
Butler	
	Greene-**only Monongahela Twp.**
	Lawrence-**only Taylor Twp.**
Washington	
Westmoreland	

There are eleven (11) $PM_{2.5}$ monitoring sites in the Pittsburgh-Beaver Valley nonattainment area. These sites are listed in Table 4-2. The table also contains the types of $PM_{2.5}$ monitors operating at each site.

Table 4-2 Pittsburgh-Beaver Valley $PM_{2.5}$ Nonattainment Area Monitors

Federal Reference Method (FRM) Monitors

Site	County	Sample Frequency
Harrison	**Allegheny**	**1/3**
Lawrenceville	**Allegheny**	**1/1**
Moon	**Allegheny**	**1/6**
North Braddock	**Allegheny**	**1/3**
North Park	**Allegheny**	**1/3**
South Fayette	**Allegheny**	**1/3**
Beaver Falls	**Beaver**	**1/3**
Charleroi	**Washington**	**1/3**
Florence	**Washington**	**1/1**
Washington	**Washington**	**1/3**
Greensburg	**Westmoreland**	**1/3**

Figure 4-2 Pittsburgh-Beaver Valley Nonattainment Area Monitors (continued)

Speciated Monitors

Site	County	Sample Frequency
Florence	**Washington**	**1/6**
Greensburg	**Westmoreland**	**1/6**
Lawrenceville	**Allegheny**	**1/6**

Continuous Monitors

Site	County	Type
Beaver Falls	**Beaver**	**TEOM FDMS**
Florence	**Washington**	**TEOM**
Lawrenceville	**Allegheny**	**TEOM**

4.1.1 Pittsburgh-Beaver Valley $PM_{2.5}$ Monitoring Analysis

The following sections provide a brief summary of $PM_{2.5}$ monitoring concentrations within the Pittsburgh-Beaver Valley $PM_{2.5}$ nonattainment area. The $PM_{2.5}$ collected in 2006 generally represents the most recently available data.

FRM Monitoring Analysis:

Table 4-3 summarizes current (2006) annual $PM_{2.5}$ design values for the FRM monitors inside the Pittsburgh-Beaver Valley nonattainment area.

Table 4-3 Pittsburgh-Beaver Valley FRM Annual $PM_{2.5}$ Design Values

Site	**County**	**FRM Annual Design Value µg/m^3**
Harrison (Natrona)	Allegheny	15.0
Lawrenceville (BAPC)	Allegheny	15.2
Moon (Coraopolis)	Allegheny	13.4
North Braddock	Allegheny	16.0
North Park	Allegheny	12.7
South Fayette	Allegheny	12.8
Beaver Falls	Beaver	16.2
Charleroi	Washington	14.9
Florence	Washington	13.1
Washington	Washington	14.4
Greensburg	Westmoreland	15.4

The Pittsburgh-Beaver Valley's most recent (2006) annual $PM_{2.5}$ design values range from a peak of 16.2 µg/m^3 to a low of 12.4 µg/m^3. Only four (4) of the eleven (11) FRM monitors with valid 2006 annual design values exceed the standard; three (3) additional monitors are within 1.0 µg/m^3 of the annual standard. All monitors within the nonattainment area have 24-hour $PM_{2.5}$ design values below the 65 µg/m^3 level established in 1997 by the U.S. EPA.

Table 4-4 shows the overall trends in the $PM_{2.5}$ nonattainment area's annual $PM_{2.5}$ design values. The sampling period is limited to the last several years since the earliest monitors in the region only began operating in 1999.

Table 4-4 Pittsburgh-Beaver Valley FRM $PM_{2.5}$ Design Value Trends

SITE	1999-2001	2000-02	2001-03	2002-04	2003-05	2004-06
Harrison (Natrona)	**16.6**	**16.1**	**15.9**	**15.5**	**15.5**	15.0
Lawrenceville (BAPC)	**16.1**	**15.8**	**15.7**	**15.3**	**15.5**	**15.2**
Moon (Coraopolis)	14.8	14.1	14.9	14.2	14.5	13.4
North Braddock		**16.8**	**16.9**	**16.5**	**16.6**	**16.0**
North Park	13.8	14.3	14.2	13.3	13.6	12.7
South Fayette	14.4	13.5	13.2	12.8	13.5	12.8
Beaver Falls		**16.2**	**16.0**	**15.4**	**16.5**	**16.2**
Charleroi	**15.5**	**15.7**	**15.6**	14.9	**15.1**	14.9
Florence	13.5	13.6	13.7	13.3	13.6	13.1
Washington	**15.2**	**15.2**	15.0	14.5	14.9	14.4
Greensburg	**15.6**	**15.6**	**15.4**	**15.1**	**15.7**	**15.4**

The PA DEP completed an analysis to determine if there were any statistically significant trends in the FRM $PM_{2.5}$ design values. Table 4-5 summarizes the results for the Pittsburgh-Beaver Valley $PM_{2.5}$ nonattainment area. Results were mixed with seven monitors indicating statistically significant trends of varying strength and four monitors with no statistically significant trends noted in the data. A more detailed description of this analysis is included in the Trends Analsysis Section at the end of this document.

Table 4-5. Pittsburgh-Beaver Valley FRM Statistical Analysis

Site	**t-Statistic**	**Trend**
Harrison (Natrona)	9.671	Yes
Lawrenceville (BAPC)	5.151	Yes
North Braddock	4.478	Yes
Washington	3.218	Yes
Charleroi	2.965	Yes
North Park	2.424	Yes
South Fayette	2.359	Yes
Moon (Coraopolis)	1.696	No
Florence	1.523	No
Greensburg	0.713	No
Beaver Falls	0.611	No

Further analysis will be needed to determine why some monitors in the $PM_{2.5}$ nonattainment area appear to have statistically significant trends. . The Pittsburgh-Beaver Valley $PM_{2.5}$ nonattainment area covers a rather large area and has a relatively wide range of design values within it. To see this much variety in the trends and the design values is both interesting and unexpected. At this time, we can only speculate that the variation across the nonattainment area is due to recent changes in local emission sources or possibly it reflects recent controls on the mobile-source sector.

Speciated Monitoring Analysis:

Three speciated monitors operate within the Pittsburgh-Beaver Valley $PM_{2.5}$ nonattainment area. The department operates two of these monitors (Florence and Greensburg) while the Lawrenceville monitor is operated by the Allegheny County Health Department. Results for the Commonwealth's thirteen (13) speciated monitors are contained in the department's annual Ambient Air Quality Reports.

Speciation is a physical or chemical analysis of the captured particles that provide a first order characterization of the metals, ions, and carbon constituents of $PM_{2.5}$. Physical and chemical speciation data can be used to support several areas of study such as:

- Inputs to air quality modeling analyses used to implement the $PM_{2.5}$ standard;
- Indicators to track the progress of air pollution controls;
- Aids to interpret studies linking health effects to $PM_{2.5}$ constituents;
- Aids to understand the effects of atmospheric constituents on visibility impairment; and
- Aids in designing and siting monitoring networks.

$PM_{2.5}$ is composed of a mixture of primary and secondary particles, both having long lifetimes in the atmosphere (days to weeks), traveling long distances (hundreds to thousands of kilometers) and hence, not easily traced back to their individual sources.

Primary particles include soil-related particles such as road dust, construction and agriculture and combustion-related particles. Combustion-related particles come from a variety of sources such as diesel and gasoline vehicles, open burning operations, and utility and commercial boilers. The principle types of secondary aerosols are organics, sulfates and nitrates. Sulfur dioxide, nitrogen oxides and ammonia (ammonium sulfate, ammonium bisulfate, ammonium nitrate) are important precursors to secondary particles.

Knowing the chemical composition of the $PM_{2.5}$ mix is also important for determining sources of pollution. By developing seasonal and annual chemical characterizations of ambient particulates across the nation, this speciation data will be used to perform source attribution analyses, evaluate emission inventories and air quality models, and support health related research studies and regional haze assessments.

Pennsylvania began operating a $PM_{2.5}$ speciation network, consisting of 13 sampling sites, in April 2002. Figure 4-2 show speciation results for the most recent (2005) sample year (Pennsylvania Ambient Air Quality Report, 2005; Allegheny County Health Department Annual Air Quality Report for 2005).

A cursory review of the 2005 data indicates percentages of the two largest $PM_{2.5}$ components are roughly identical (sulfates ~33%, organic carbon ~ 25%) between the three (3) speciated monitors in the Pittsburgh-Beaver Valley nonattainment area. Ammonium and Nitrates are the next most common identified elements within the data. The data indicate secondary components not directly emitted (i.e. sulfates and nitrates) make up a large portion of $PM_{2.5}$ in the Pittsburgh-Beaver Valley nonattainment area.

Figure 4-2. Pittsburgh-Beaver Valley $PM_{2.5}$ Speciation Results

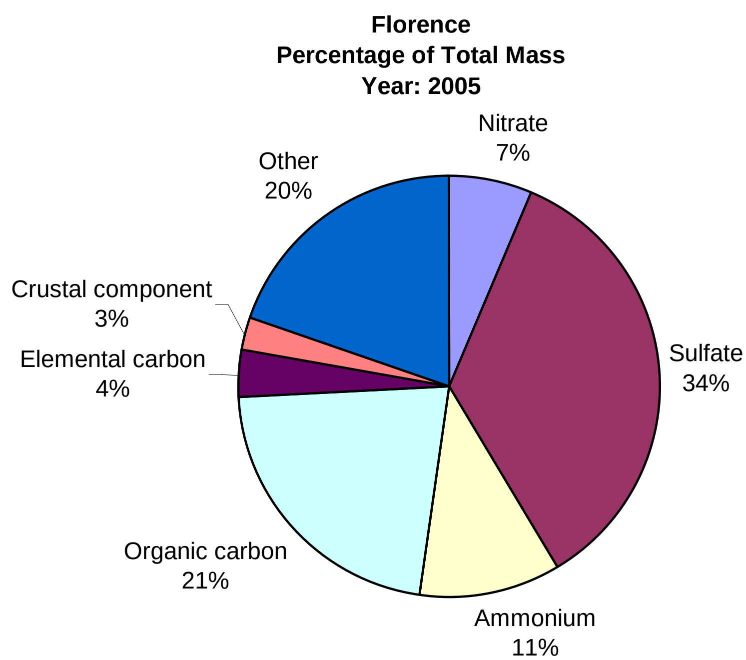
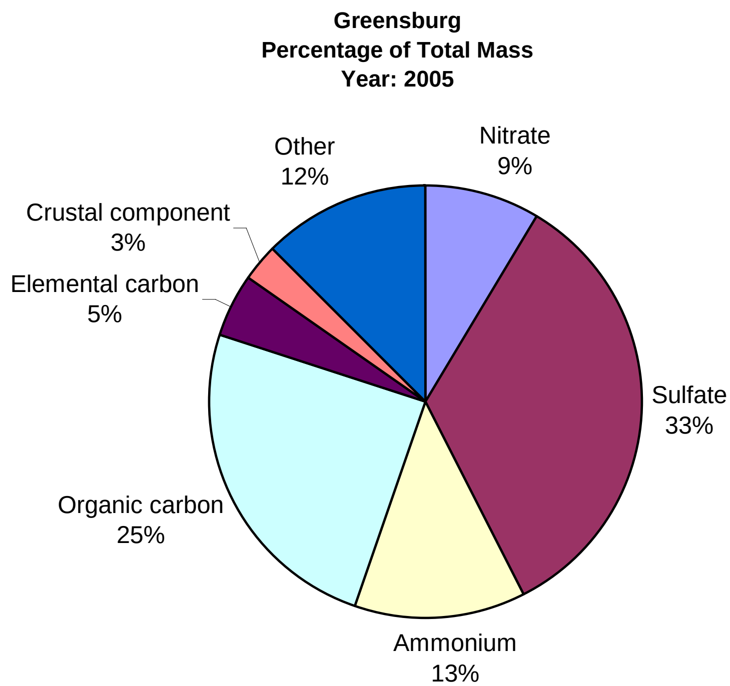
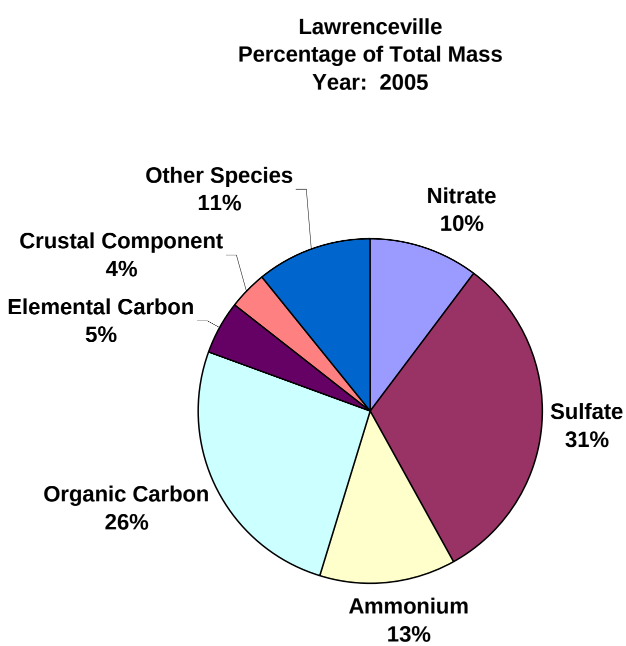


Figure 4-2. (Continued) Pittsburgh-Beaver Valley $PM_{2.5}$ Speciation Results





Continuous Monitoring Analysis:

Three continuous $PM_{2.5}$ monitors operate within the Pittsburgh-Beaver Valley $PM_{2.5}$ nonattainment area. All of the continuous monitors are collocated with a FRM sampler. Continuous $PM_{2.5}$ monitors were installed to give the instantaneous measurements needed for air-quality forecasting purposes. Monitor locations are depicted in Figure 2-1. Table 4-6 lists details on the continuous monitors including manufacturer and date of installation.

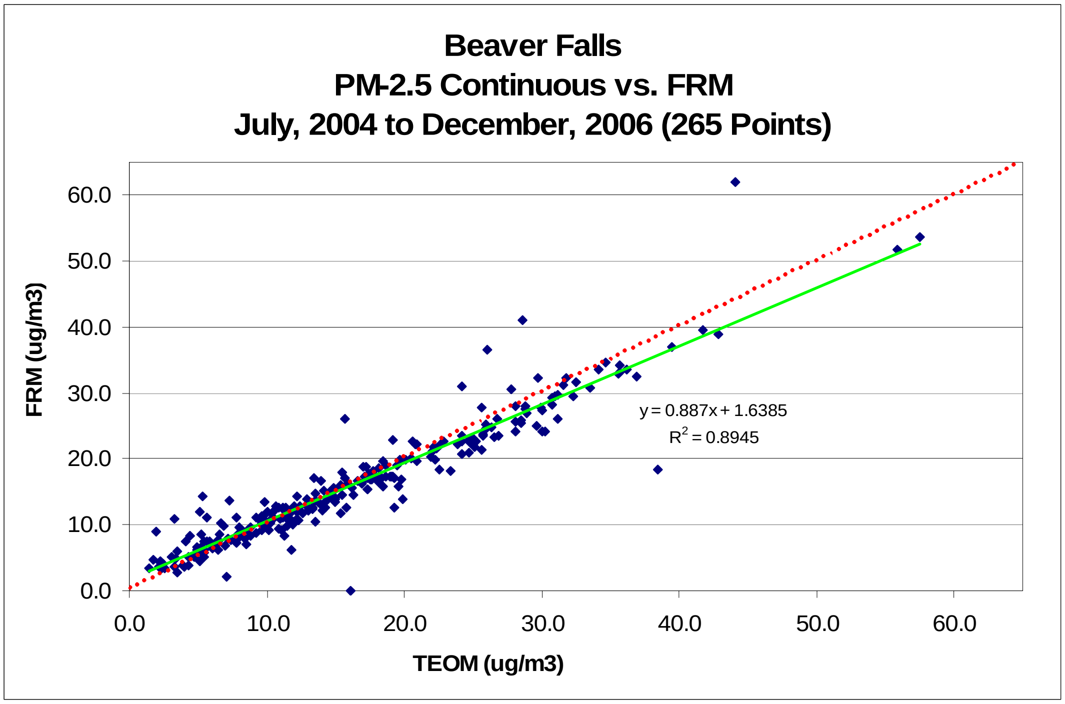
Table 4-6 Pittsburgh-Beaver Valley $PM_{2.5}$ Continuous Monitor Summary

Site	County	Type	Installation Date
Beaver Falls	**Beaver**	**TEOM FDMS**	**July 2004**
Charleroi	**Washington**	**BAM**	**August 2006**
Lawrenceville	**Allegheny**	**TEOM**	**May 2000**

Continuous $PM_{2.5}$ monitoring data can be used in several ways. These include a crosscheck with FRM measurements (on the days a FRM sample is collected) and an analysis of daily patterns in the data.

Figure 4-3 shows the relationship between the FRM data and the corresponding data collected by the continuous monitor at Beaver Falls. The graph indicates there is a good correlation between the measurements from the continuous monitor and the FRM monitor. This is important because it indicates the continuous monitor gives a reasonable estimate of air quality on the days a FRM sample is not taken at Beaver Falls.

Figure 4-3. Beaver Falls: FRM vs. TEOM

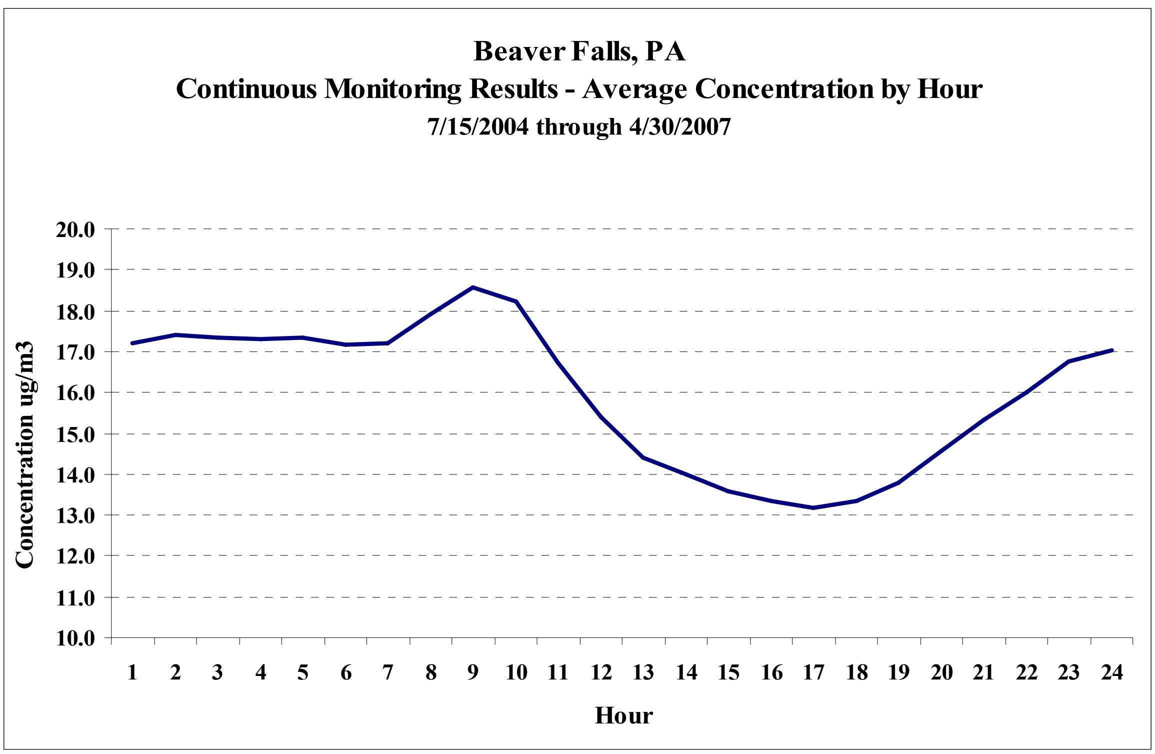


Another analysis that can be done with the continuous monitoring data is to examine average values by hour of collection. This reveals the average daily changes in local $PM_{2.5}$ concentrations at a particular site. Fluctuations in daily $PM_{2.5}$ concentrations are likely the result of local emissions and meteorology.

Figure 4-4 depicts the hourly averaged $PM_{2.5}$ concentrations at the Beaver Falls continuous monitor. All values are averaged for each hour so that there are twenty-four (24) values representing each hour of the day.

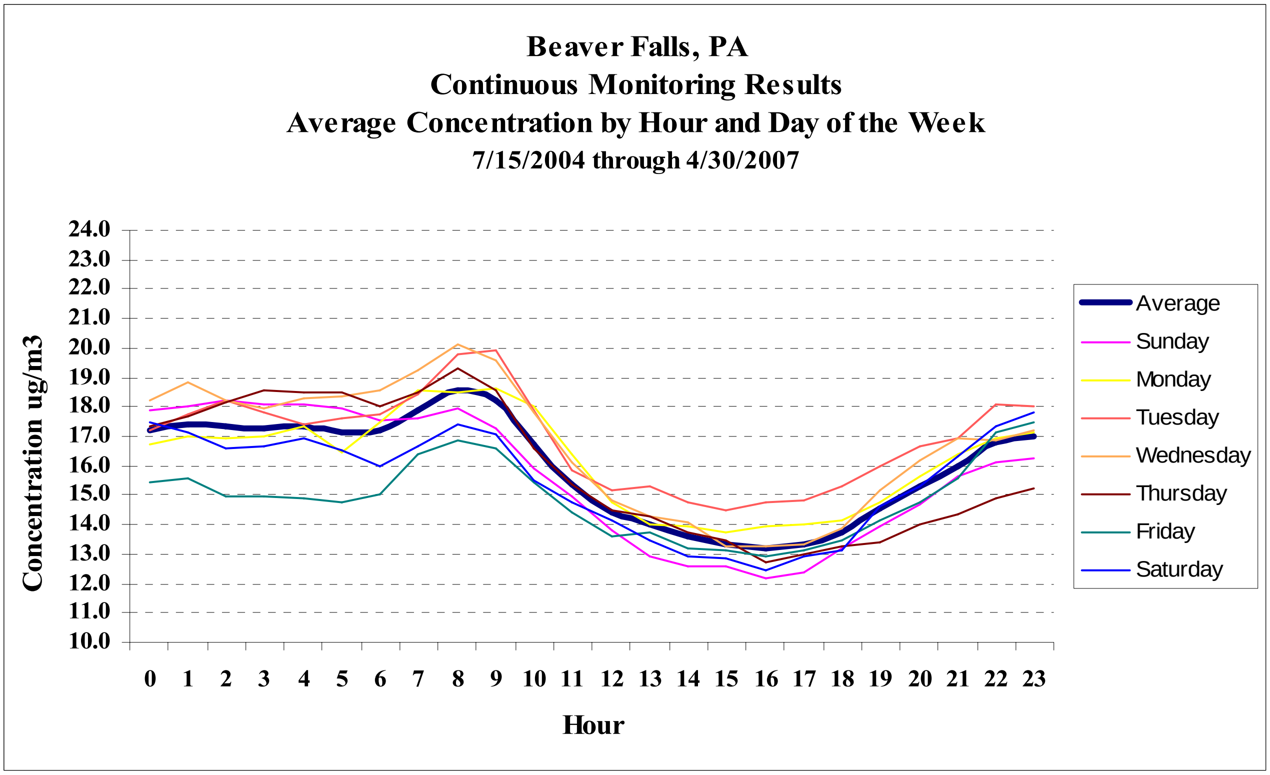
Beaver Falls' $PM_{2.5}$ concentrations tend to be much higher during the overnight hours with a small peak (~1.0 $\mu g/m^3$) occurring during hours eight (8), nine (9) and ten (10). This slight peak probably reflects changes in local traffic patterns due to primary particulate emissions from the mobile-source sector (morning rush). This peak is followed by a general decline in concentrations reflecting meteorological factors (vertical daytime mixing) that help dilute local $PM_{2.5}$ concentrations that had built up overnight within the Beaver River valley.

Figure 4-4. Beaver Falls Continuous Data: Hourly Averages



A further analysis of continuous monitor data from Beaver Falls appears to confirm there is a traffic signal imbedded in the data. Separating the hourly averages by day of the week indicates this morning peak generally disappears over the weekend (see Figure 4-5). The data also indicated $PM_{2.5}$ concentrations tend to run higher on Tuesdays and Wednesdays and lower on Fridays, Saturdays and Sundays.

Figure 4-5. Beaver Falls Continuous Data: Day of Week



The downtown Pittsburgh site (Lawrenceville) shows an even stronger mobile source signature. Figure 4-6 shows the average hourly $PM_{2.5}$ concentrations broken down by day of the week. A bimodal peak is seen in this monitor with elevated $PM_{2.5}$ concentrations observed in the morning and late evening hours corresponding to the morning and afternoon peaks in traffic.

Note that Lawrenceville's $PM_{2.5}$ concentrations are much higher during the weekdays than during the weekends with the weekday concentrations above the monitor average and weekend concentrations below the monitor average. It is also interesting to note the Lawrenceville monitor has a statistically significant trend in its FRM design values while Beaver Falls does not. This may be due to the recent reductions in emissions from the mobile-source sector, which would be more apparent at monitors heavily influenced by local traffic patterns like Lawrenceville.

4.2. Liberty-Clairton $PM_{2.5}$ Nonattainment Area

Table 4-4 lists the municipalities that make up the Liberty-Clairton $PM_{2.5}$ nonattainment area. Additional data analysis may be included in reports generated by the Allegheny County Health Department.

Figure 4-6. Lawrenceville Continuous Data: Day of Week

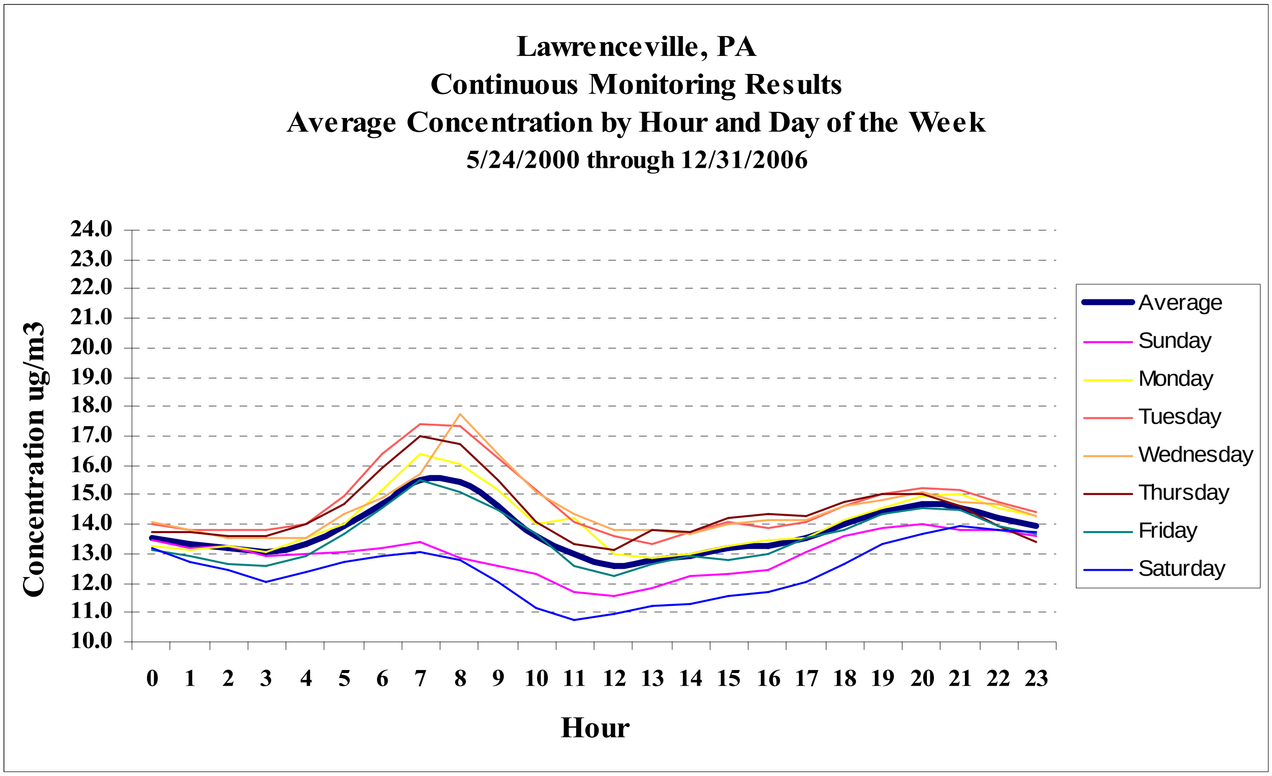


Table 4-7 Liberty-Clairton Nonattainment Area

County	Partial County
	Allegheny-only the City of Clairton, Borough of Glassport, Borough of Liberty, Borough of Lincoln, Borough of Port Vue

There are two monitors in the Liberty-Clairton $PM_{2.5}$ nonattainment area. Both sites are maintained by the Allegheny County Health Department. Information on these two monitoring sites is summarized in Table 4-8.

Table 4-8. Liberty-Clairton Nonattainment $PM_{2.5}$ Area Monitors

Site	Description
Liberty	FRM (1/1), Continuous TEOM, Speciated
Clairton	FRM (1/6)

4.2.1. Liberty-Clairton Monitoring Analysis

The following sections provide a brief summary of $PM_{2.5}$ monitoring concentrations within the Liberty-Clairton nonattainment area. 2006 generally represents the most recently available data. Allegheny County may provide additional data analysis for this nonattainment area.

FRM Monitoring Analysis:

Table 4-9 summarizes current (2006) annual $PM_{2.5}$ design values for the FRM monitors inside the Liberty-Clairton nonattainment area. The Liberty monitor has the highest annual $PM_{2.5}$ design value in the Commonwealth. Note there are significant differences between these two monitors, which are located within a few miles of one another.

Table 4-9 Liberty-Clairton FRM Annual Design Value

Site	County	FRM Annual Design Value $\mu g/m^3$
Liberty	Allegheny	**20.4**
Clairton	Allegheny	14.9

Table 4-10 shows the overall trends in the nonattainment area's annual $PM_{2.5}$ design values. The sampling period is limited to the last several years since the monitors in the nonattainment area only began operating in 1999.

Table 4-10 Liberty-Clairton FRM Annual Design Value Trends

SITE	1999-2001	2000-02	2001-03	2002-04	2003-05	2004-06
Liberty	**20.9**	**21.4**	**21.2**	**20.4**	**20.8**	**20.4**
Clairton	**18.7**	**17.3**	**17.2**	**15.6**	**15.7**	14.9

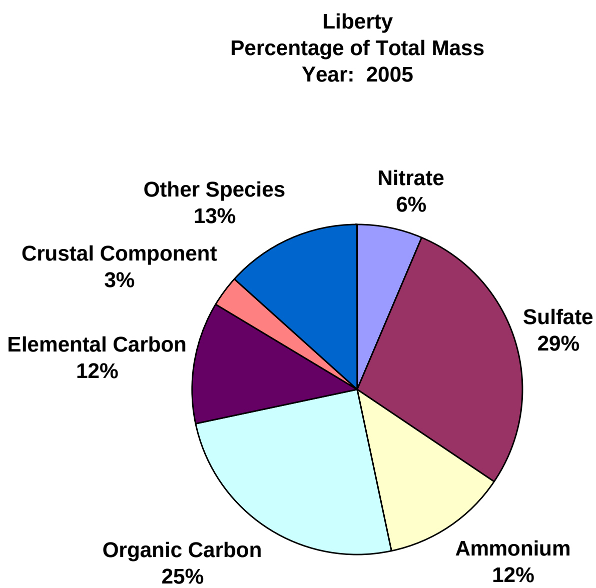
The PA DEP conducted a statistical analysis of the Liberty-Clairton monitors to determine if there were any statistically significant trends in their design values. Our analysis showed that there was a statistically significant trend at the Clairton monitor. No statistically significant trend, however, was found at Liberty. Results of the statistical analysis can be found in the Trends Analsysis Section at the end of this document.

Speciated Monitoring Analysis:

Only one speciated monitor (Liberty) operates in the Liberty-Clairton nonattainment area. Figure 4-7 shows the breakdown of the major $PM_{2.5}$ components at the Liberty monitor for 2005. Additional information regarding the speciated data can be found in the Allegheny County Health Department's Annual Report (2005).

The Liberty speciated components have similar percentages to other speciated monitors in the surrounding Pittsburgh-Beaver Valley nonattainment area. The two largest components are sulfates and organic carbon; both have roughly identical percentages to the surrounding monitors. There is, however, a significant difference in elemental carbon percentage; Liberty has a roughly two to three times higher percentage than the surrounding monitors (12% vs. 4-5%).

Figure 4-7. Liberty $PM_{2.5}$ Speciation Results

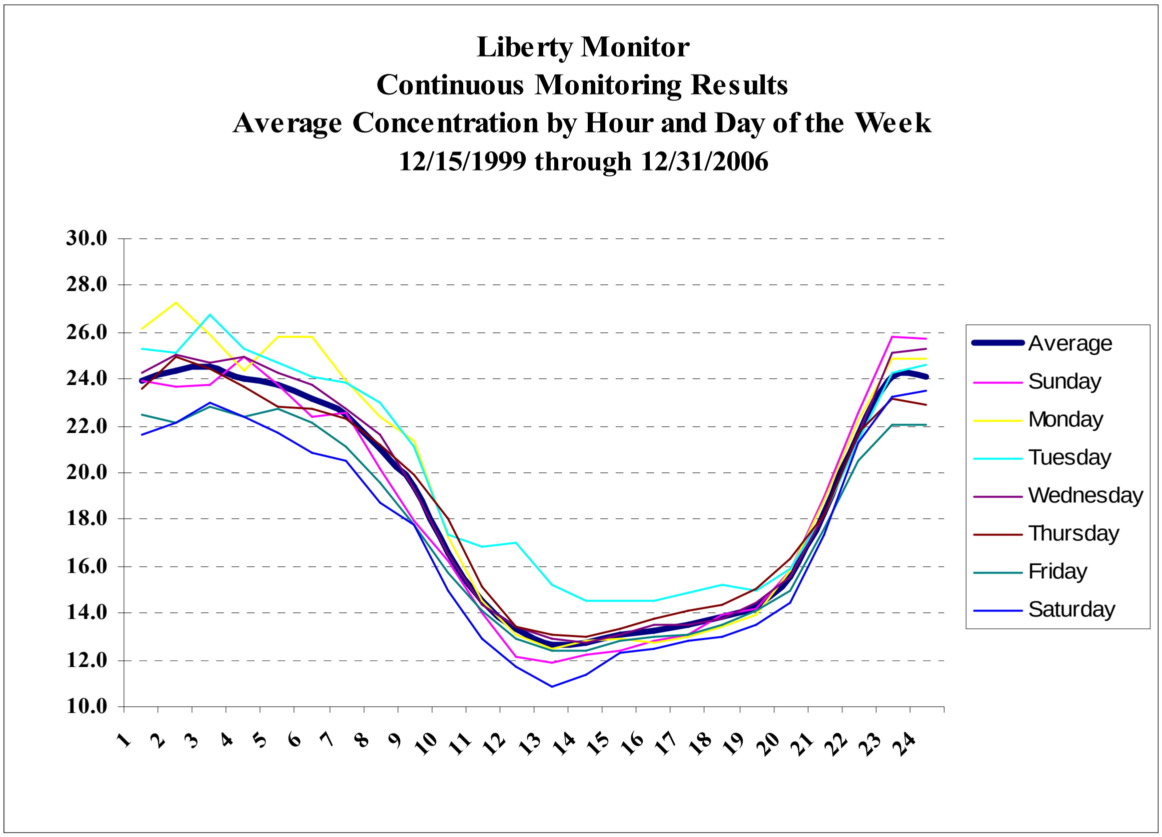


Continuous Monitoring Analysis:

The Allegheny County Health Department operates one continuous monitor in the Liberty-Clairton nonattainment area. A TEOM monitor has been operated at the Liberty site since January of 2000. Figure 4-8 shows the hourly averages for the entire data set. The results indicate on average $PM_{2.5}$ concentrations are typically higher during the overnight hours than during the day. This suggests local emissions are "accumulating" underneath the nighttime inversion then being "diluted" during the day when daytime heating enhances vertical mixing. The difference between the average overnight concentrations and daytime concentrations is significant. Overnight $PM_{2.5}$ concentrations at Liberty are approximately two times greater than during the day.

There does not appear to be a significant traffic signal in the Liberty data like those noted at the Beaver Falls and Lawrenceville sites. This is probably due to the lack of a major highway near the Liberty monitoring site and the heavy influence of local sources on the monitor.

Figure 4-8. Liberty Continuous Data: Day of Week



4.3 Johnstown Nonattainment Area

Table 4-11 lists the county and townships that make up the Johnstown nonattainment area. The nonattainment area consists of the entire county of Cambria and portions of Indiana County.

Table 4-11 Johnstown Nonattainment Area

County	Partial County
	Indiana – only Center Twp, East Wheatfield Twp, West Wheatfield Township, Homer City Borough, Armagh Borough
Cambria	

4.3.1 Johnstown Monitoring Analysis

The following sections provide a brief summary of $PM_{2.5}$ monitoring concentrations within the Johnstown nonattainment area. 2006 generally represents the most recently available data.

The Johnstown monitor is the only monitor in the nonattainment area. The site contains an FRM sampler and a continuous monitor. Table 4-12 summarizes the monitor description.

Table 4-12 Johnstown $PM_{2.5}$ Nonattainment Area Monitor Summary

Site	Description
Johnstown	FRM (1/3), Continuous BAM

FRM Monitoring Analysis:

Table 4-13 lists the Johnstown $PM_{2.5}$ nonattainment area's current (2006) design value. Johnstown's current annual design value, 15.3 μg/m^3**,** is quite close to the annual standard. Table 4-14 shows Johnstown's design value trend. The FRM monitor began operations in 1999. Design values have fluctuated over the last several years, which matches our statistical trend analysis (see Trends Analsysis Section at the end of this document) indicating no firm trend in the data.

Table 4-13 Johnstown FRM Annual Concentrations

Site	County	FRM Annual Design Value μg/m^3
Johnstown	Cambria	**15.3**

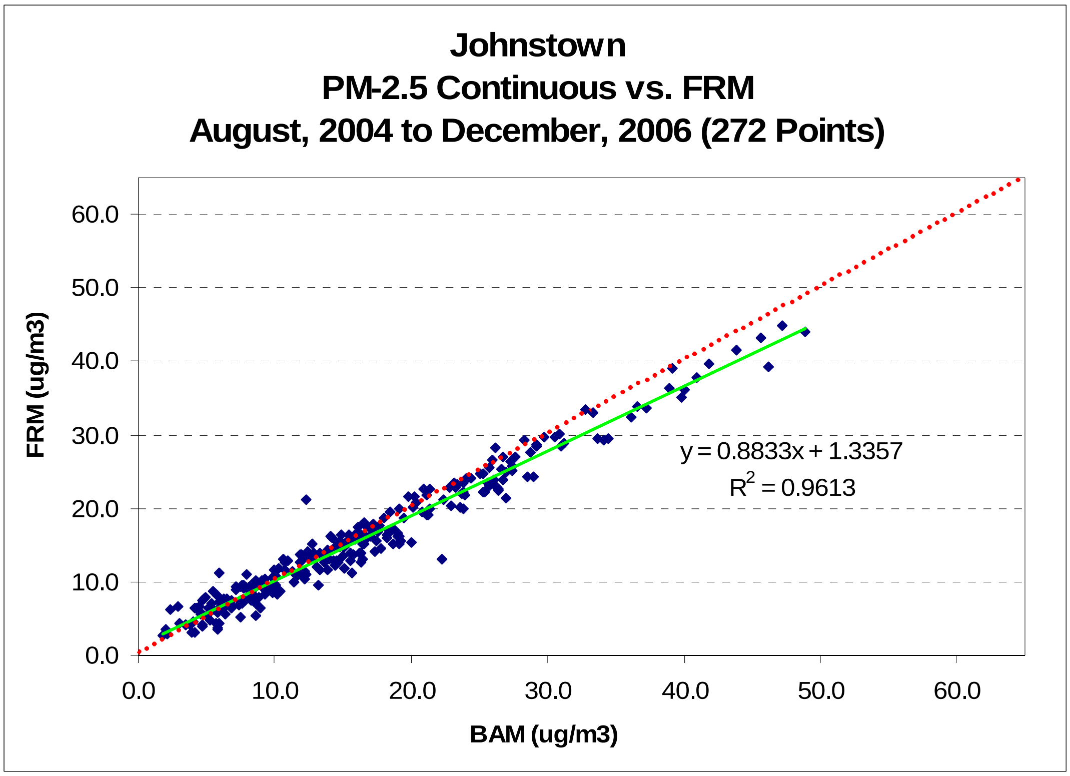
Table 4-14 Johnstown FRM Design Value Trends

SITE	1999-2001	2000-02	2001-03	2002-04	2003-05	2004-06
Johnstown	**15.3**	**15.8**	**15.8**	**15.3**	**15.6**	**15.3**

Continuous Monitoring Analysis:

The Department maintains a continuous monitor at Johnstown in addition to an FRM sampler. The continuous BAM unit began operations in August 2004. Figure 4-9 compares the FRM data and the corresponding BAM data from the Johnstown monitoring site (scatter plot). Results between the continuous and FRM sampler are still quite good indicating the continuous monitor generally reflects actual concentrations as measured by the FRM sampler.

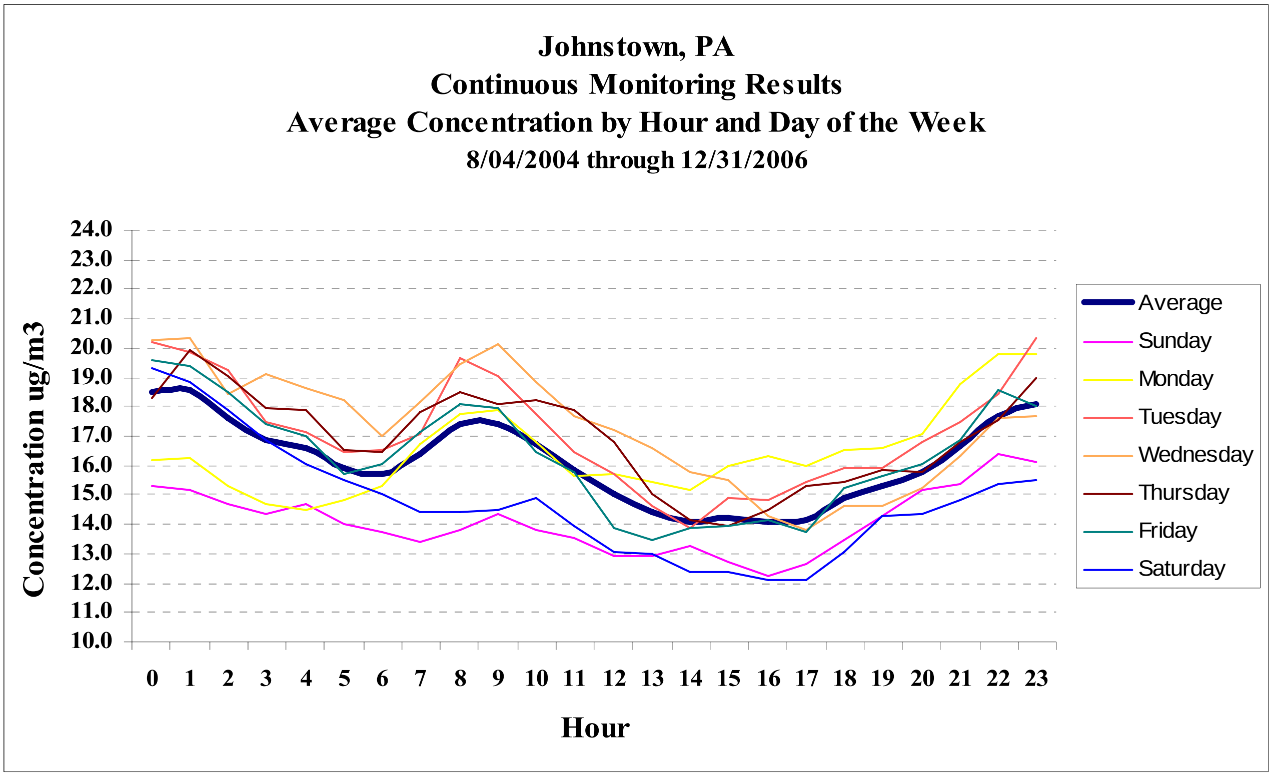
Figure 4-9 Johnstown: FRM vs. TEOM



The continuous monitor provides additional data not available from the FRM monitor. This includes any diurnal patterns, how $PM_{2.5}$ concentrations vary during the day, and any patterns based on day or the week.

Figure 4-10 shows the average daily concentrations by hour and day of the week for the Johnstown BAM unit. Two patterns are apparent in the BAM data. One is a "morning rush hour" signal seen as a peak in $PM_{2.5}$ concentrations centered on hour nine (9). Note that this peak is completely absent during the weekend (Saturday and Sunday). There is also a difference in overall concentrations based on the day of the week. Generally $PM_{2.5}$ concentrations are higher during the weekdays than the weekends (~1-3 $\mu g/m^3$). It's also interesting to note that concentrations, on average, trend upwards about midway through Monday, remain high during the week then decrease to weekend levels early Saturday morning. There is also a general decline in $PM_{2.5}$ concentrations in the early morning hours during the weekday. This information give may be useful in determining which sources are contributing to Johnstown's nonattainment problem.

Figure 4-10. Johnstown Continuous Data: Day of Week



4.4. Harrisburg-Lebanon-Carlisle Nonattainment Area

Table 4-15 lists the counties that make up the Harrisburg-Lebanon-Carlisle nonattainment area. The nonattainment area consists of three counties: Dauphin, Cumberland and Lebanon.

Table 4-15 Harrisburg-Lebanon-Carlisle Nonattainment Area

County	Partial County
Cumberland	
Dauphin	
Lebanon	

4.4.1. Harrisburg-Lebanon-Carlisle $PM_{2.5}$ Nonattainment Area Monitoring Analysis

The following sections provide a brief summary of $PM_{2.5}$ monitoring concentrations within the Harrisburg-Lebanon-Carlisle $PM_{2.5}$ nonattainment area. The 2006 $PM_{2.5}$ data generally represents the most recently available data. Table 4-16 summarizes the types of monitors within the nonattainment area.

Table 4-16. Harrisburg-Lebanon-Carlisle $PM_{2.5}$ Nonattainment Area Monitor Summary

Site	County	Description
Harrisburg	Dauphin	FRM (1/1), Continuous TEOM, Speciated (1/6)
Carlisle	Cumberland	FRM (1/1)

FRM Monitoring Analysis:

Table 4-17 lists the Harrisburg-Lebanon-Carlisle nonattainment area's current (2006) annual design value. The nonattainment area's current value, 15.0 µg/m^3 at Harrisburg, meets the annual $PM_{2.5}$ standard. Annual design values at least one of the two monitors in the nonattainment area exceeded the standard prior to 2006.

Table 4-17. Harrisburg-Lebanon-Carlisle FRM Annual Concentrations

Site	County	FRM Annual Design Value µg/m^3
Harrisburg	Dauphin	15.0
Carlisle	Cumberland	14.4

Table 4-18 shows the design value trend over the last several years. The Harrisburg FRM monitor began operations in 1999 while the Carlisle FRM monitor began operations in 2000. Design values within the nonattainment area have fluctuated over the last several years. Statistical analyses have confirmed this finding neither the Harrisburg nor the Carlisle FRM monitors have a statistically significant trend (see Trends Analsysis Section at the end of this document).

Table 4-18. Harrisburg-Lebanon-Carlisle FRM Annual Design Value Trends

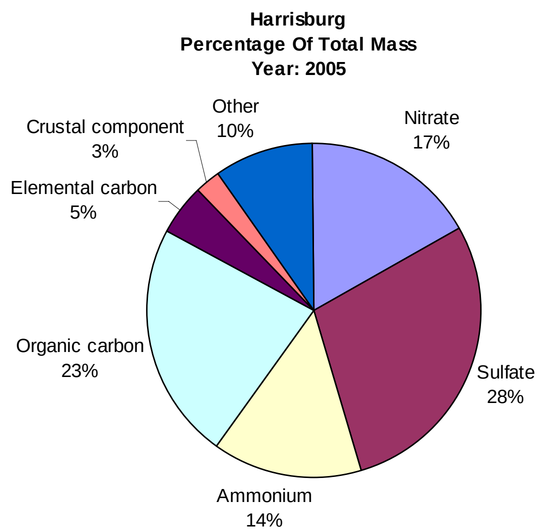
SITE	1999-2001	2000-02	2001-03	2002-04	2003-05	2004-06
Harrisburg	**15.5**	**15.6**	**15.7**	**15.4**	**15.8**	15.0
Carlisle				14.9	**15.1**	14.4

Speciated Monitoring Analysis:

The PA DEP has operated a speciated monitor at the Harrisburg site since April 2002. Speciated samples are collected once every six days (1/6). The filter sample is then sent to a lab for special analysis.

Figure 4-11 shows the results from the most recently available speciated data for the Harrisburg monitor (2005). These results were taken from the PA DEP (2005) Annual Ambient Air-Quality Report. The largest $PM_{2.5}$ components at Harrisburg appear to be sulfate and organic carbon followed by nitrate and ammonium. Percentages of these components appear to be similar to other speciated monitors inside the Commonwealth.

Figure 4-11. Harrisburg $PM_{2.5}$ Speciation Results



Continuous Monitoring Analysis:

The Department has operated a continuous (BAM) unit at the Harrisburg monitoring site since May 2004. This is the only continuous monitor in the nonattainment area and was installed to assist the PA DEP's air-quality forecasters.

A comparison of the FRM and continuous unit is shown in Figure 4-12. The scatter plot indicates the continuous unit tends to yield a higher $PM_{2.5}$ concentration than the FRM sampler. This may be due to the BAM unit's sample methodology. Results between the continuous and FRM sampler are still quite good indicating the continuous monitor generally reflects actual concentrations as measured by the FRM sampler.

Figure 4-12. Harrisburg: FRM vs. BAM

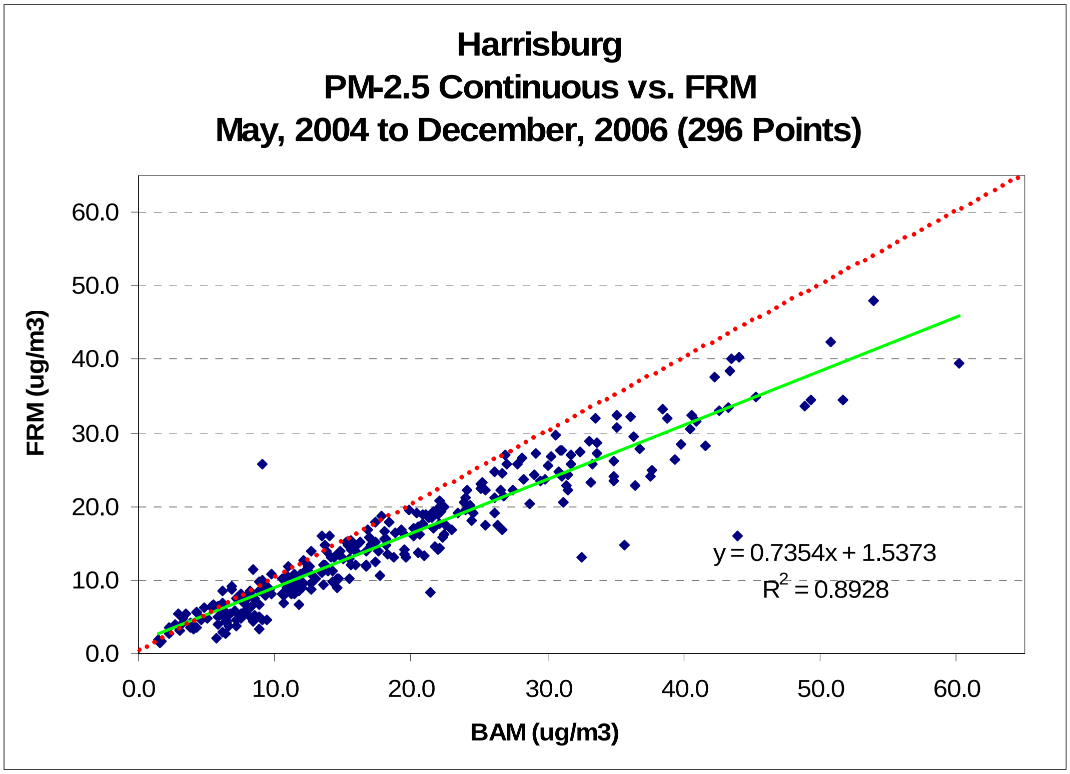
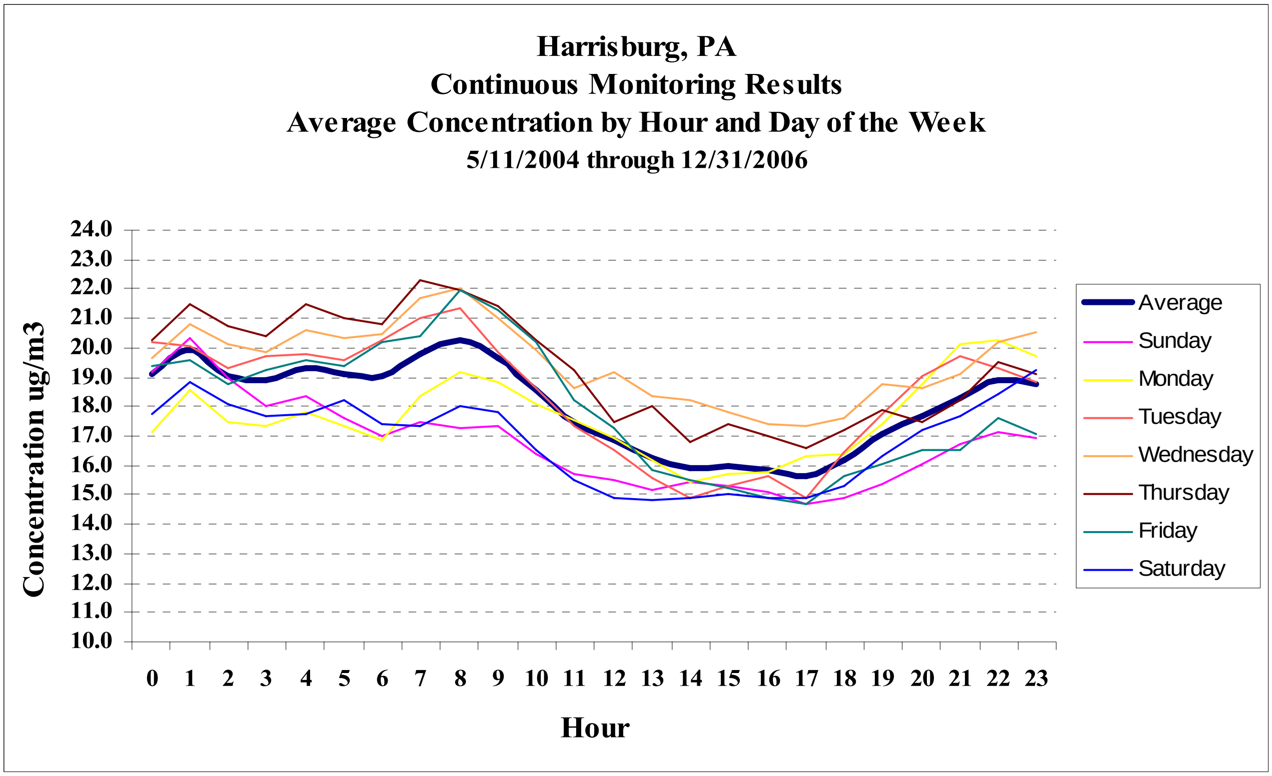


Figure 4-13 shows the average daily concentrations by hour and day of the week for the Harrisburg BAM unit. Several patterns are apparent. The first being $PM_{2.5}$ concentrations tend to run higher overnight than during the day. This is probably due to meteorological conditions (nocturnal inversion trapping local emissions). There is also an apparent "morning rush-hour" signal centered on hour nine (9). This peak is not apparent during the weekend. Also $PM_{2.5}$ concentrations tend to run higher during the workweek (Monday through Friday) with the exception of the early morning hours of Monday. These patterns suggest a strong anthropogenic signal in the $PM_{2.5}$ data.

Figure 4-13. Harrisburg $PM_{2.5}$ Continuous Data: Day of Week



4.5. York $PM_{2.5}$ Nonattainment Area

The York $PM_{2.5}$ nonattainment area includes the entire county of York and is bordered by nonattainment areas to the north, east and south. Adams County (to the west) contains a monitor that meets the annual standard.

4.5.1 York Monitoring Analysis

The following sections provide a brief summary of $PM_{2.5}$ monitoring concentrations within the York nonattainment area. 2006 generally represents the most recently available data. Table 4-19 lists the types of monitors at the York site.

Table 4-19. York $PM_{2.5}$ Nonattainment Area Monitor Summary

Site	County	Description
York	York	FRM (1/3), Continuous TEOM, Speciated (1/6)

FRM Monitoring Analysis:

Table 4-20 lists the York nonattainment area's $PM_{2.5}$ design values from 2001 through 2006. The monitor's current annual design value is 16.2 $\mu g/m^3$, which exceeds the annual $PM_{2.5}$ standard.

Design values within the nonattainment area have fluctuated over the last several years. Statistical analyses have confirmed this finding the York monitor has no statistically significant trend (see Trends Analsysis Section at the end of this document).

Table 4-20. York FRM Annual Design Value Trends

SITE	1999-2001	2000-02	2001-03	2002-04	2003-05	2004-06
York	**16.2**	**16.8**	**17.0**	**17.0**	**17.3**	**16.2**

Speciated Monitoring Analysis:

The PA DEP has operated a speciated monitor at the York site since April 2002. Speciated samples are collected once every six days (1/6). The filter sample is then sent to a lab for special analysis.

Figure 4-14 shows the results from the most recently available speciated data for the York monitor (2005). These results were taken from the PA DEP's 2005 Annual Ambient Air-Quality Report. The largest $PM_{2.5}$ components at York appear to be sulfate and organic carbon followed by nitrate and ammonium. Percentages of these components appear to be similar to other speciated monitors inside the Commonwealth.

Continuous Monitoring Analysis:

The Department has operated a continuous (TEOM) unit at the York monitoring site since August 2004. This is the only continuous monitor in the nonattainment area and was installed in order to assist the PA DEP's air-quality forecasters.

A comparison of the FRM and continuous unit is shown in Figure 4-15. Results between the continuous and FRM sampler are still quite good indicating the continuous monitor generally reflects actual concentrations as measured by the FRM sampler.

Figure 4-14 York $PM_{2.5}$ Speciation Results

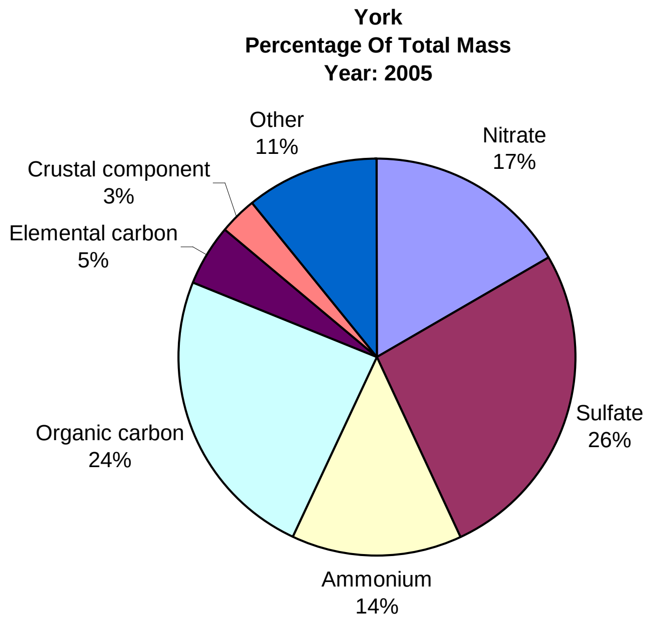


Figure 4-15 York: FRM vs. BAM

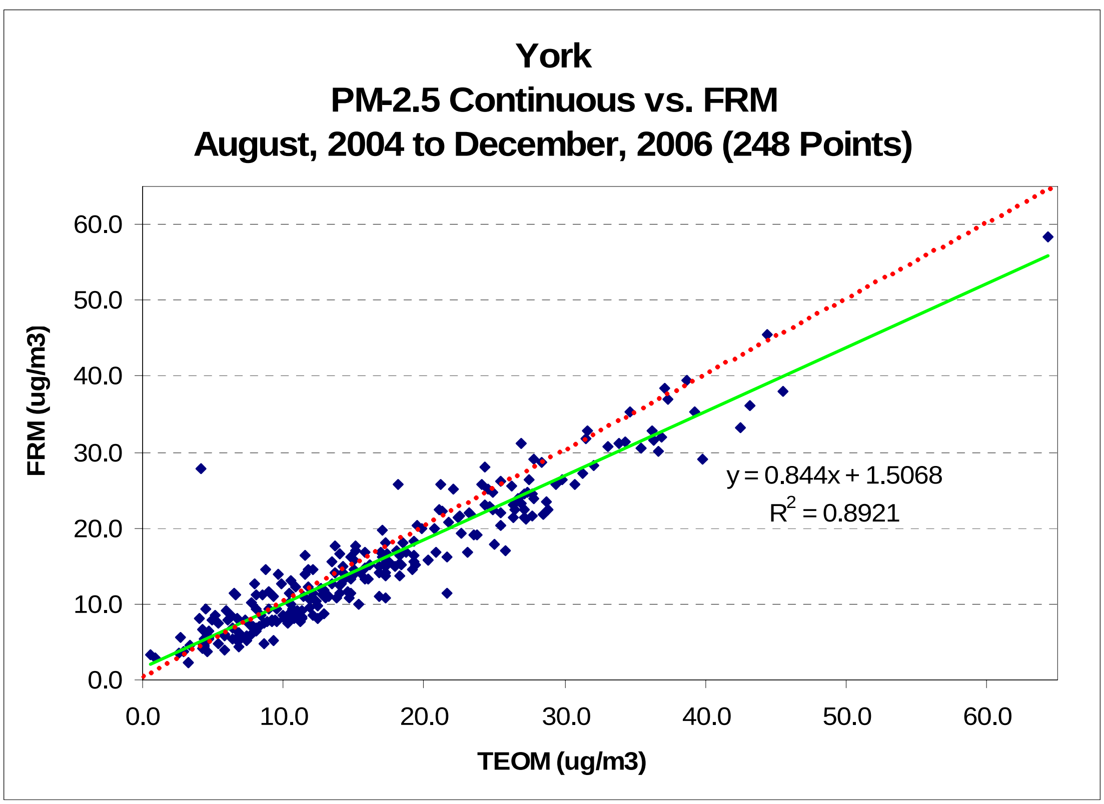
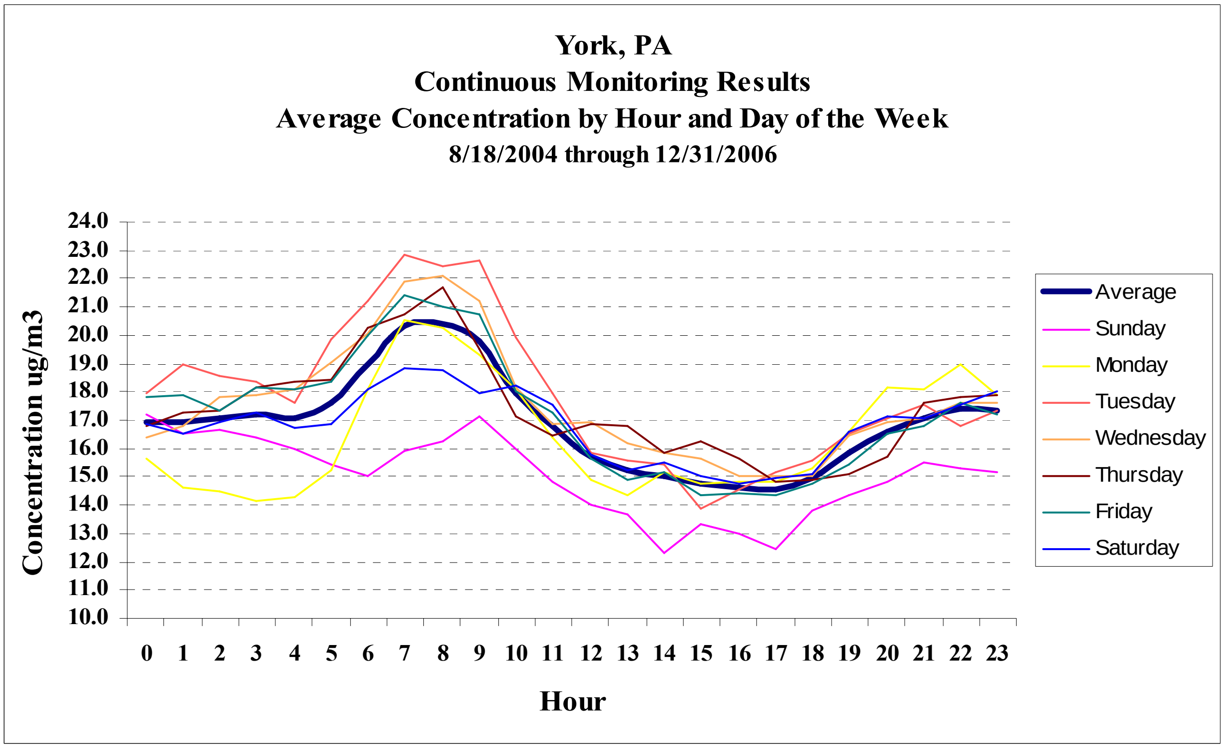


Figure 4-16 shows the average daily concentrations by hour and day of the week for the York TEOM unit. Several patterns are apparent in the data. The first being $PM_{2.5}$ concentrations tend to run higher overnight than during the day. This is probably due to meteorological conditions (nocturnal inversion trapping local emissions). There is also an apparent "morning rush-hour" signal centered on hour eight (8). York's morning peak is one of the largest ones noted in the Commonwealth's continuous monitors (> 3 $\mu g/m^3$). This peak is less apparent over the weekend. York's $PM_{2.5}$ concentrations tend to run higher during the workweek (Monday through Friday) with the exception of the early morning hours of Monday. These patterns suggest a strong anthropogenic signal in the $PM_{2.5}$ data.

Figure 4-16. York Continuous $PM_{2.5}$ Data: Day of Week



4.6 Lancaster Nonattainment Area

The Lancaster nonattainment area includes the entire county of Lancaster. Nonattainment areas surround the county. The Lancaster monitor and the York monitor to the west have the highest annual $PM_{2.5}$ design values in the Commonwealth outside of the Liberty-Clairton nonattainment area near Pittsburgh.

4.6.1 Lancaster Monitoring Analysis

The following sections provide a brief summary of $PM_{2.5}$ monitoring concentrations within the Lancaster nonattainment area. 2006 generally represents the most recently available data. Table 4-21 lists the types of monitors at the Lancaster site.

Table 4-21 Lancaster Nonattainment Area Monitor Summary

Site	County	Description
Lancaster	Lancaster	FRM (1/3), Continuous TEOM, Speciated (1/6)

FRM Monitoring Analysis:

Table 4-21 lists the Lancaster nonattainment area's design values from 2001 through 2006. The monitor's current annual design value is 16.3 $\mu g/m^3$, which exceeds the annual $PM_{2.5}$ standard.

Design values within the nonattainment area have fluctuated over the last several years. Statistical analyses have confirmed this finding the Lancaster monitor has no statistically significant trend (see Trends Analsysis Section at the end of this document).

Table 4-20. Lancaster FRM Annual $PM_{2.5}$ Design Value Trends

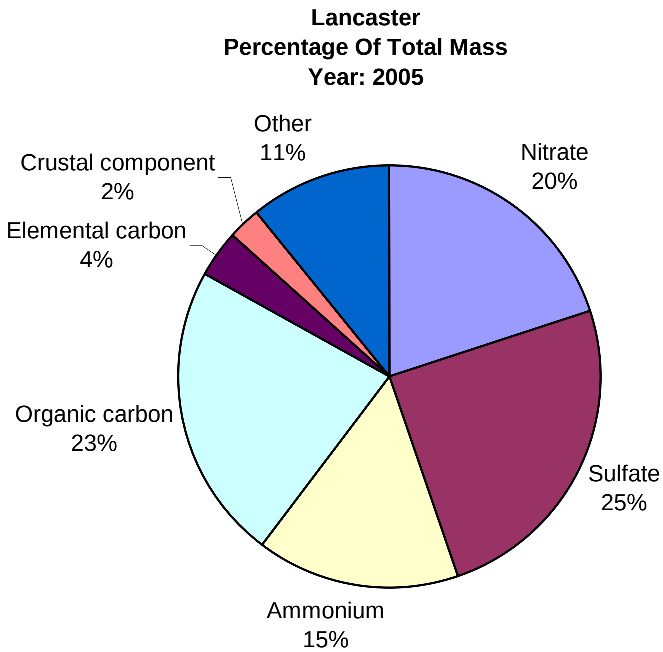
SITE	1999-2001	2000-02	2001-03	2002-04	2003-05	2004-06
Lancaster	**17.0**	**17.2**	**17.0**	**16.8**	**17.5**	**16.3**

Speciated Monitoring Analysis:

The PA DEP has operated a speciated monitor at the Lancaster site since April 2002. Speciated samples are collected once every six days (1/6). The filter sample is sent to a lab for special analysis.

Figure 4-17 shows the results from the most recently available speciated data for the Lancaster monitor (2005). These results were taken from the PA DEP 2005 Annual Ambient Air-Quality Report. The largest $PM_{2.5}$ components at Lancaster appear to be sulfate and organic carbon followed by nitrate and ammonium. Percentages of these components appear to be similar to other speciated monitors inside the Commonwealth.

Figure 4-17 Lancaster $PM_{2.5}$ Speciation Results



Continuous Monitoring Analysis:

The Department has operated a continuous (TEOM) unit at the Lancaster monitoring site since November 2003. This is the only continuous monitor in the nonattainment area and was installed to assist the PA DEP's air-quality forecasters.

A comparison of the FRM and continuous unit is shown in Figure 4-18. Results between the continuous and FRM sampler are still quite good indicating the continuous monitor generally reflects actual concentrations as measured by the FRM sampler.

Figure 4-19 shows the average daily concentrations by hour and day of the week for the Lancaster TEOM unit. Several patterns are apparent in the data. The first being $PM_{2.5}$ concentrations tend to run higher overnight than during the day. This is probably due to meteorological conditions (nocturnal inversion trapping local emissions). There is also an apparent "morning rush-hour" signal centered on hour eight (8). Lancaster's morning peak is somewhat significant, ~2 $\mu g/m^3$. This peak is less apparent over the weekend. Lancaster's $PM_{2.5}$ concentrations tend to run higher during the workweek (Monday through Friday) with the exception of the early morning hours of Monday. These patterns suggest a strong anthropogenic signal in the $PM_{2.5}$ data.

Figure 4-18. Lancaster: FRM vs. BAM

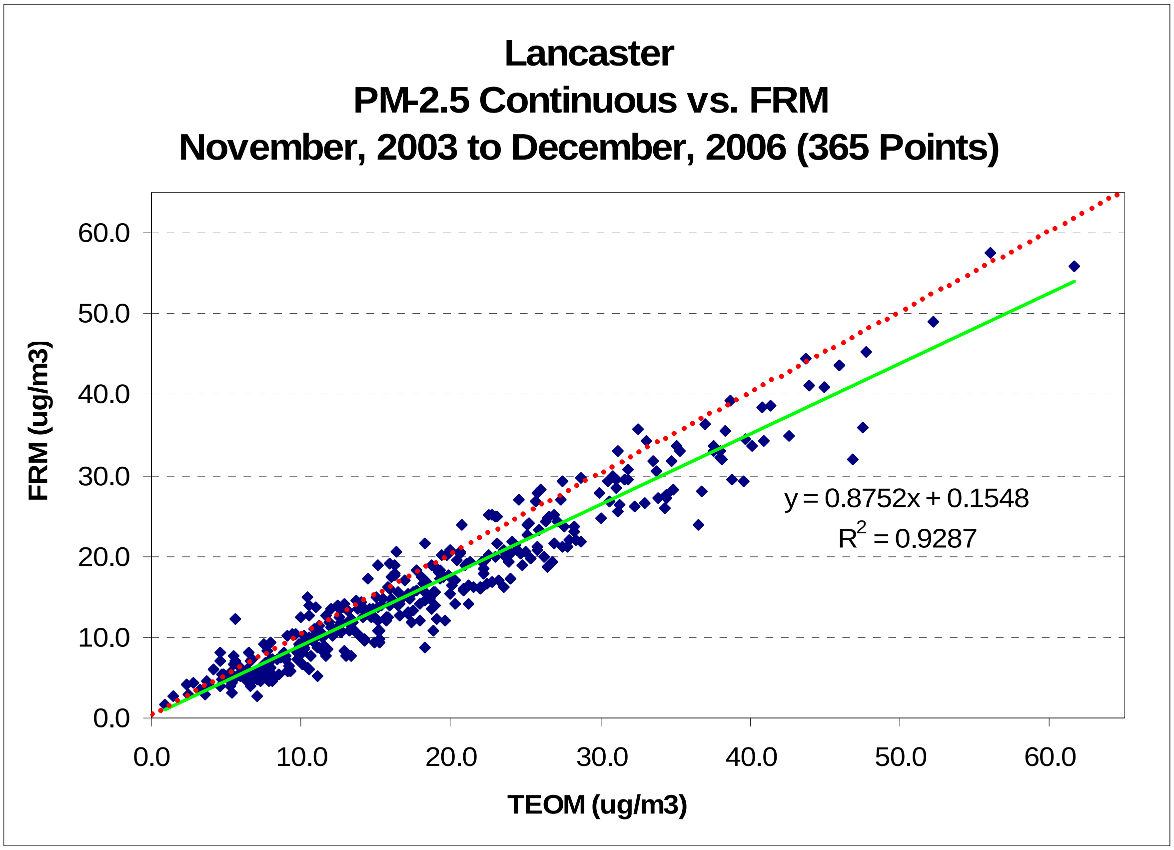
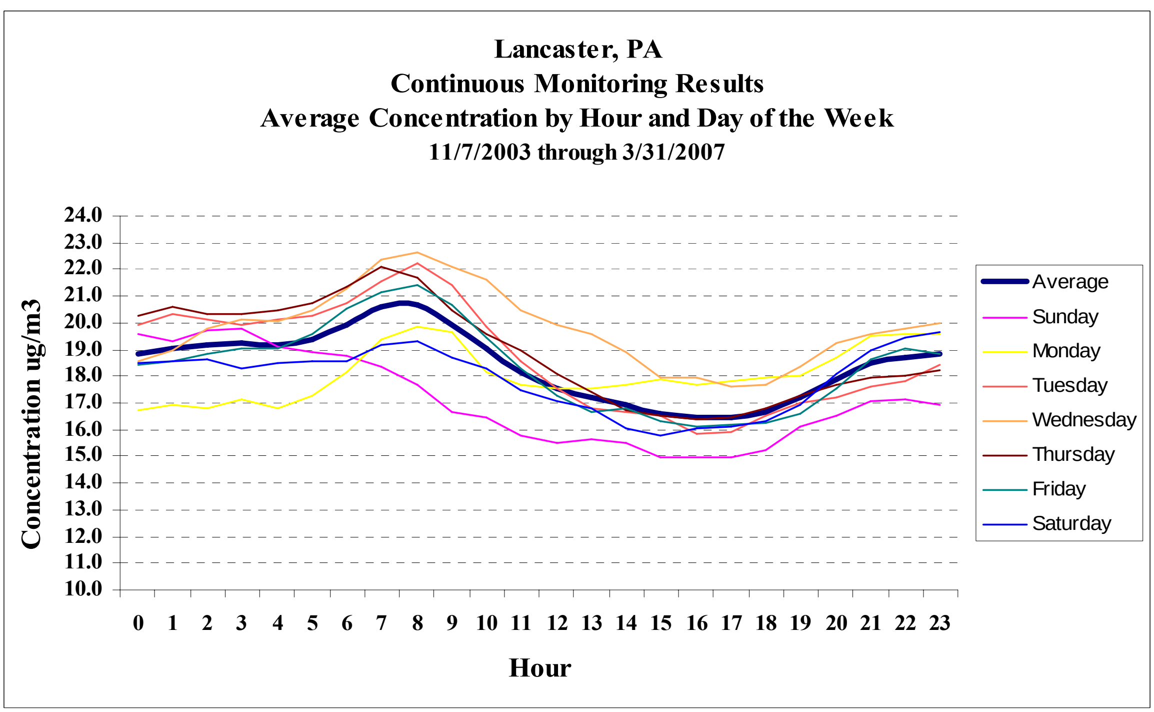


Figure 4-19 Lancaster Continuous $PM_{2.5}$ Data: Day of Week



4.7 Reading $PM_{2.5}$ Nonattainment Area

The Reading $PM_{2.5}$ nonattainment area includes the entire county of Berks. Nonattainment areas surround the county on its western, southern and eastern borders. The monitor in Northampton County, to the northeast, currently meets the annual $PM_{2.5}$ standard.

4.7.1. Reading Monitoring Analysis

The following sections provide a brief summary of $PM_{2.5}$ monitoring concentrations within the Reading nonattainment area. 2005 generally represents the most recently available data. Table 4-21 lists the types of monitors in the Reading nonattainment area.

The Reading monitor was relocated to a permanent site near the Reading Airport (Spaatz Field) in July of 2007. The original site, Reading (UGI), was discontinued due to property leasing issues in May of 2006. A temporary site in the City of Reading was operated until a final leasing agreement was formalized and the new site prepared. An additional FRM sampler, located at the DEP's Reading District Office (RDO) near Tuckerton, was established to determine $PM_{2.5}$ gradients in the region. This site will be maintained until a proper design value can be obtained from the new Reading (Airport) site, though there are pending leasing issues with this site also. A speciation site was added to the Reading (Airport) site in 2007. Thus speciated samples have only been collected in Berks County since 2007.

Table 4-21. Reading Nonattainment Area Monitor Summary

Site	County	Operation	Description
Reading (UGI)	Berks	Discontinued May 2006	FRM (1/3), Continuous TEOM
Reading (Downtown)	Berks	May 2006 through May 2007	FRM (1/3), Continuous TEOM
Reading (Airport)	Berks	July 2007 to present	FRM (1/3), Speciation (1/6), Continuous TEOM
Reading District Office	Berks	August 2005 to present	FRM (1/6)

FRM Monitoring Analysis:

Table 4-22 lists the Reading $PM_{2.5}$ nonattainment area's design values from 2001 through 2005. The nonattainment area's most recent annual design value (2005) is 16.2 $\mu g/m^3$, which exceeds the annual $PM_{2.5}$ standard. If data are combined for the three sites, Berks County's annual design value is estimated to be 15.8 $\mu g/m^3$.

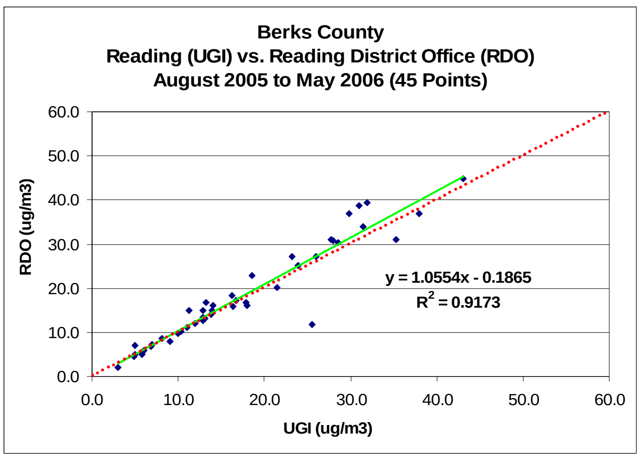
All four monitoring sites in Berks County are within five miles of each other. The scatter plots for the two Reading sites (UGI and Downtown) and the Reading District Office site indicate $PM_{2.5}$ concentrations are very similar to each other (Figure 2-20) suggesting there is a relatively uniform $PM_{2.5}$ gradient in the vicinity of the City of Reading. This result suggests that it may acceptable to combine all of the $PM_{2.5}$ data to generate a design value.

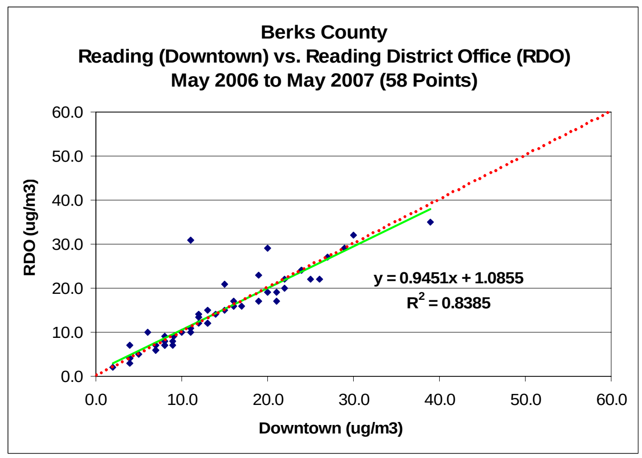
Table 4-22. Reading FRM Annual $PM_{2.5}$ Design Value Trends

SITE	1999-2001	2000-02	2001-03	2002-04	2003-05	2004-06
Reading (UGI)	15.6	16.7	16.4	16.1	16.2	15.8 **

** Combined data

Figure 4-20. $PM_{2.5}$ Scatter Plots for Berks County Monitors





Design values within the nonattainment area have fluctuated over the last several years. Statistical analyses have confirmed this noting the Reading monitor has no statistically significant trend (see Trends Analsysis Section at the end of this document).

Speciated Monitoring Analysis:

A speciation monitor is currently operating at the Reading Airport site that began operations in July 2007. No speciation data was collected in the nonattainment area prior to this date.

Continuous Monitoring Analysis:

A continuous $PM_{2.5}$ TEOM monitor was operated at the Reading UGI site from October 2004 until the site was discontinued in May of 2006. From May 2006 through May of 2007 the monitor was located within the City of Reading limits.

Continuous PM2.5 data from both of these sites is presented even though both data sets are relatively small. Comparing both Reading sites will give some indication of the variability in the data. The old UGI site was located on the southern side of the City of Reading between state route 10 and US 422, a limited access four-lane highway. The temporary site was located at the City of Reading's Maintenance Garage located off of 6th Street. Both sites are approximately two miles apart.

Figure 4-21 compares twenty-four hour averaged $PM_{2.5}$ concentrations collected using the FRM and corresponding TEOM values. Results between the continuous and FRM sampler are still quite good indicating the continuous monitor generally reflects actual concentrations as measured by the FRM sampler.

Figure 4-22 shows the average daily concentrations by hour and day of the week for both the UGI and downtown monitor locations. The daily averages for all days are remarkably similar for both sites despite the differences in location. Both sites exhibit a strong jump in morning $PM_{2.5}$ concentrations (~3.0 µg/m^3) centered on hour eight (8). Both sites also show significant differences in concentrations between weekdays and weekends. Concentrations at both sites tend to be a bit lower over the weekend (Saturday and Sunday) though the UGI site has much higher concentrations on Saturday than the downtown site. This is probably due to traffic pattern differences.

Figure 4-21. Reading (UGI & Downtown) : FRM vs. TEOM

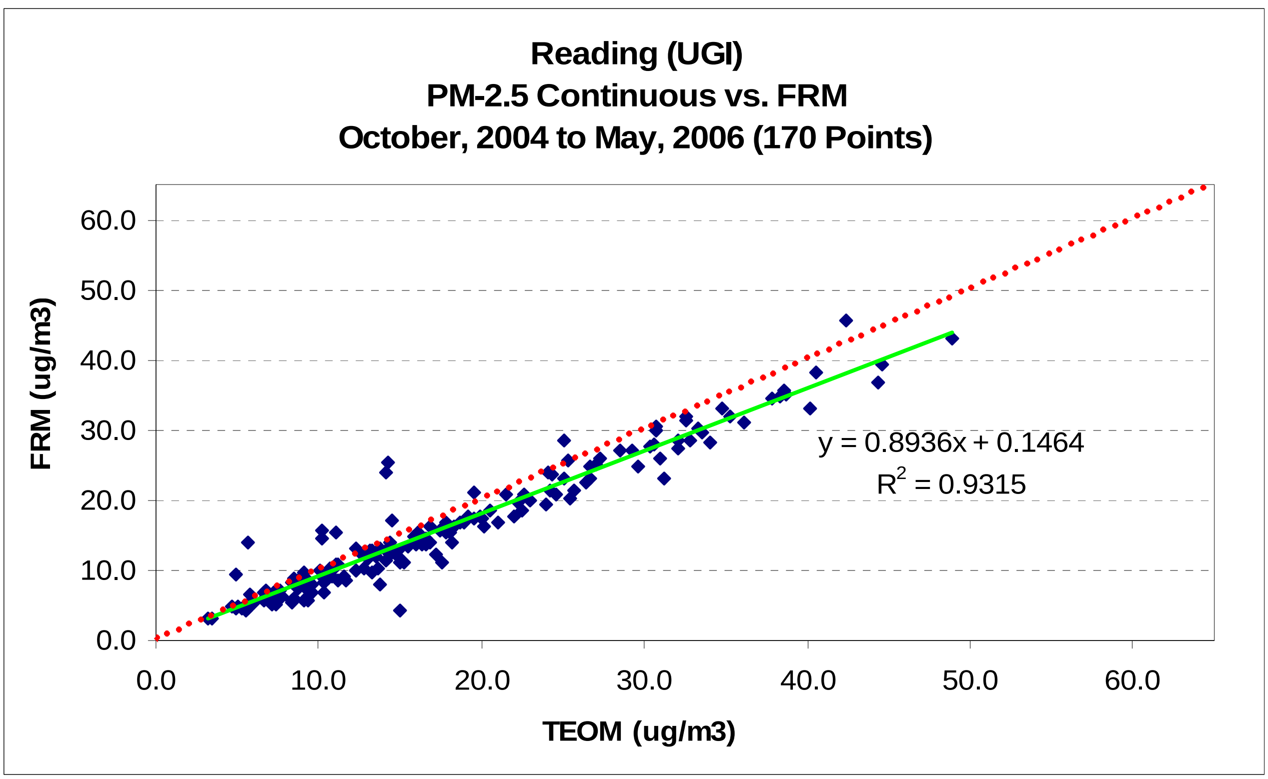


Figure 4-21 Continued

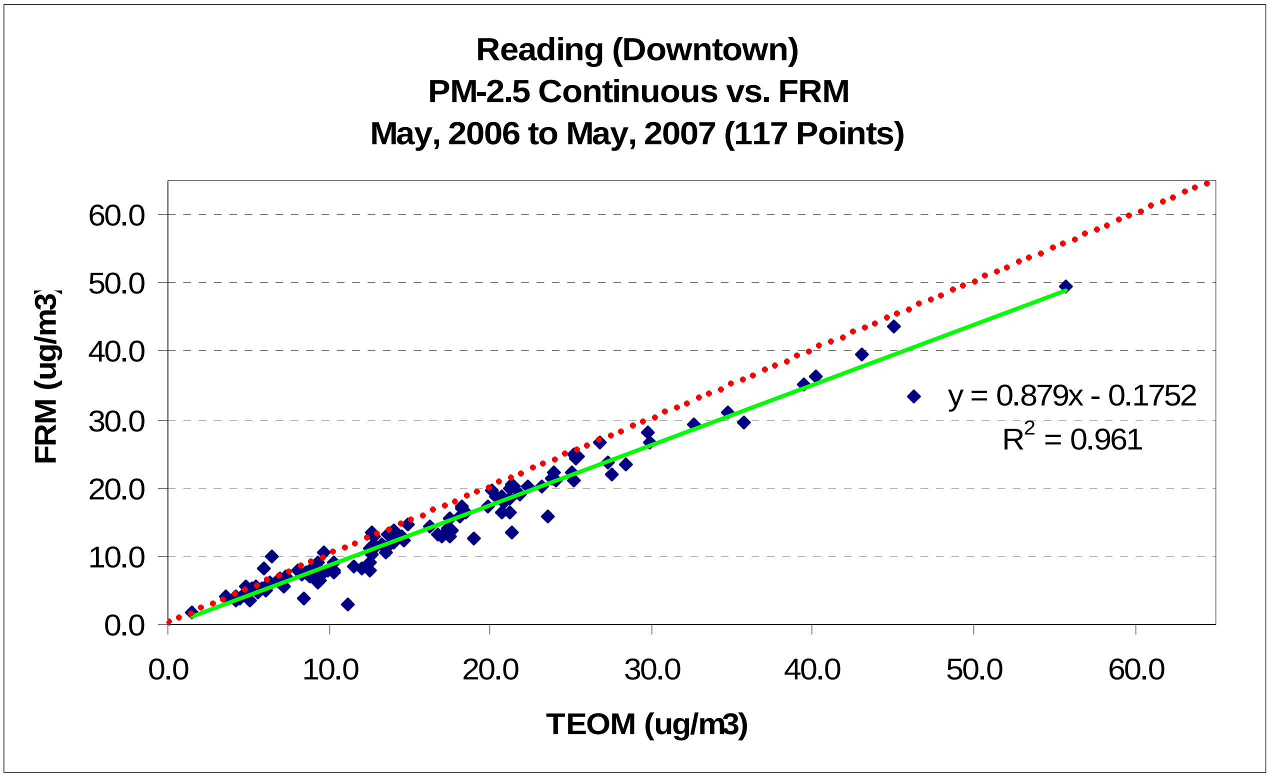
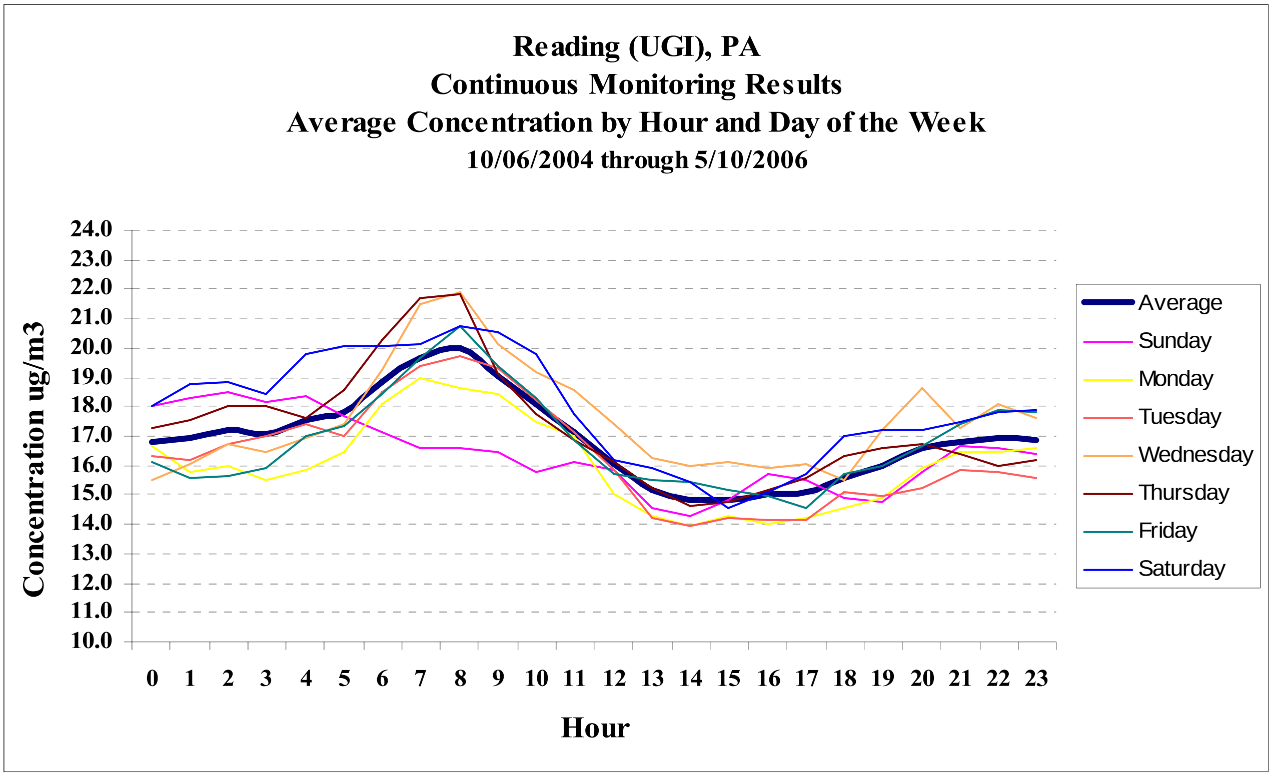
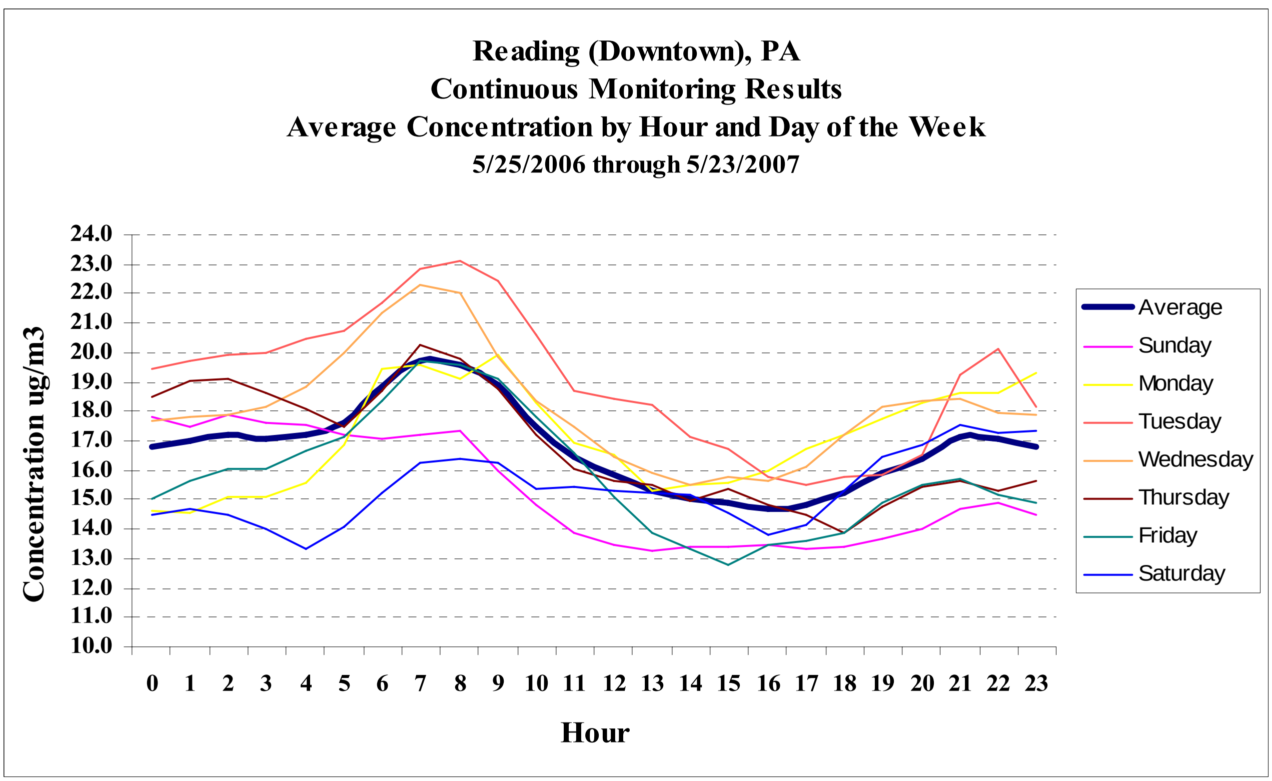


Figure 4-22 Reading (UGI & Downtown) Continuous Data: Day of Week





4.8 Philadelphia-Wilmington, PA-NJ-DE Nonattainment Area

The Philadelphia-Wilmington $PM_{2.5}$ nonattainment area is a multi-state nonattainment area comprised of counties in the states of Pennsylvania, New Jersey and Delaware. Counties are listed in Table 4-23. There are some slight differences between counties included in the annual $PM_{2.5}$ nonattainment area and the corresponding eight-hour ozone nonattainment area with the former including far fewer counties.

Table 4-23. Philadelphia-Wilmington, PA, NJ, DE $PM_{2.5}$ Nonattainment Area

State	County	Partial County
Pennsylvania	**Bucks**	
	Chester	
	Delaware	
	Montgomery	
	Philadelphia	
Delaware	**New Castle**	
New Jersey	**Burlington**	
	Camden	
	Gloucester	

4.8.1 Philadelphia-Wilmington $PM_{2.5}$ Nonattainment Area Monitoring Analysis

The following sections provide a brief summary of annual $PM_{2.5}$ monitoring concentrations within the Philadelphia-Wilmington nonattainment area. Generally only data from monitors inside the Commonwealth of Pennsylvania is included in this analysis. Data from other states in the nonattainment area are included if provided by the appropriate agency.

The 2006 data generally represents the most recently available data. Table 4-24 lists the types of monitors inside the Pennsylvania portion of the Philadelphia-Wilmington nonattainment area.

A total of ten (10) monitoring sites have operated in Pennsylvania's portion of the nonattainment area. Four of these monitors are operated by the department with the remaining six monitors (in Philadelphia County) operated by Philadelphia County's Department of Health, Air-Management Services. Of these ten (10) monitoring sites only eight (8) continued operations into 2006.

Table 4-24. Philadelphia-Wilmington, PA, NJ, DE $PM_{2.5}$ Nonattainment Area Monitors

Federal Reference Method (FRM) Monitors

Site	County	Operation	Sample Frequency
Bristol	Bucks	Since 1999	1/3
New Garden	Chester	Since 2002	1/3
Chester	Delaware	Since 1999	1/3
Norristown	Montgomery	Since 1999	1/3
AMS Lab	Philadelphia	Since 1999	1/1
Roxboro	Philadelphia	2002 - 2004	1/3
Belmont	Philadelphia	1999 - 2005	1/3
NE Airport	Philadelphia	Since 1999	1/1
Broad Street	Philadelphia	Since 1999	1/3 to 1/1 (2006)
Elmwood	Philadelphia	Since 1999	1/1

Speciated Monitors

Site	County	Operation	Sample Frequency
New Garden	Chester	April 2002	1/6
Chester	Delaware	April 2002	1/6
AMS Lab	Philadelphia		1/6
Elmwood	Philadelphia		1/6

Continuous Monitors

Site	County	Operation	Type
Chester	Delaware	Since May 2006	BAMS
Norristown	Montgomery	Since Oct 2003	TEOM FDMS
AMS Lab	Philadelphia	Since May 2006	BAMS
NE Airport	Philadelphia	Since August 2006	BAMS

FRM Monitoring Analysis:

Table 4-25 lists a portion of the Philadelphia-Wilmington $PM_{2.5}$ nonattainment area's design values. The $PM_{2.5}$ nonattainment area's most recent annual design value (2006) is 15.2 $\mu g/m^3$, which exceeds the annual $PM_{2.5}$ standard. Monitoring values for Delaware and New Jersey are also provided in the table. All data was considered for New Jersey regardless of completeness.

Annual design values in Table 4-25 indicate, as of 2006, only one monitor in the Philadelphia-Wilmington nonattainment area exceeds the annual PM2.5 standard. This is tempered by the fact that there are some extended periods of missing data from the 500

Broad Street monitor in Philadelphia County. This monitor was the peak monitor in the nonattainment area at time of designation. We also note that the Chester monitor, the area's current design monitor, has had some interference issues from a nearby local source.

Design values within the nonattainment area have fluctuated over the last several years. Statistical analyses indicate some mixed trends in the Philadelphia-Wilmington nonattainment area (see Trends Analsysis Section at the end of this document). All of the monitors in Philadelphia County and the Norristown monitor appear to be trending downward. The Chester and Bristol monitors do not. Downward trending monitors appear to be in heavy traffic areas and thus may be tracking reductions in mobile source emissions enacted over the last several years.

Table 4-25 Philadelphia-Wilmington FRM Annual $PM_{2.5}$ Design Value Trends

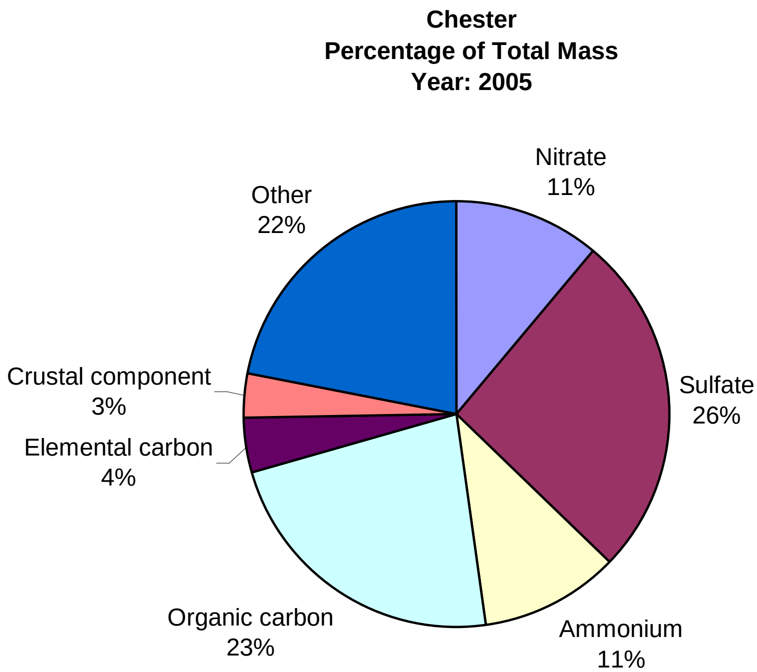
SITE	2000-02	2001-03	2002-04	2003-05	2004-06
Philadelphia AMS	**15.2**	**15.2**	14.4	14.3	13.9
Philadelphia NE	14.3	13.8	13.2	13.0	12.8
Philadelphia Broad St	**16.6**	**16.2**	**15.4**	**15.2**	15.0
Philadelphia Elmwood	**15.1**	14.9	13.6	13.7	13.4
Bristol	14.1	14.3	13.9	13.9	13.2
Chester	**15.5**	**15.3**	15.0	**15.6**	**15.2**
Norristown	14.0	14.1	13.2	12.8	12.2
New Garden	14.6	**15.1**	14.8	**15.2**	14.2
DE Bellefonte	15.0	14.8	14.2	14.3	13.5
DE MLK	**16.3**	**16.0**	15.0	**15.1**	14.8
DE Newark	**15.2**	15.0	14.6	14.6	13.9
DE Lums Pond	13.9	13.6	13.2	13.4	12.8
NJ Camden Lab Primary	14.3	14.7	14.3	14.6	13.3
NJ Pennsauken	14.5	14.0	13.7	13.8	13.3
NJ Gibbstown	14.0	13.5	12.8	13.5	11.9

Speciated Monitoring Analysis

The PA DEP has operated a speciated monitors at the Chester and New Garden sites since April 2002. Additional speciated monitors are located at the Air Management Services lab and Ritner monitor in Philadelphia County. Speciated samples are collected once every six days (1/6). Filter samples are then sent to a lab for special analysis.

Figure 4-23 shows the results from the most recently available speciated data for the Chester and New Garden monitors (2005) operated by the PA DEP and the Lab and Ritner sites operated by Philadelphia County's Department of Health, Air-Management Services. These results were taken from the PA DEP (2005) Annual Ambient Air-Quality Report. Philadelphia County provided the 2005-speciated data for the Lab and Ritner sites. The largest $PM_{2.5}$ components at all the speciated monitors appear to be sulfate and organic carbon followed by nitrate and ammonium. Percentages of these components appear to be similar to other speciated monitors inside the Commonwealth.

Figure 4-23 Philadelphia-Wilmington $PM_{2.5}$ Speciation Results



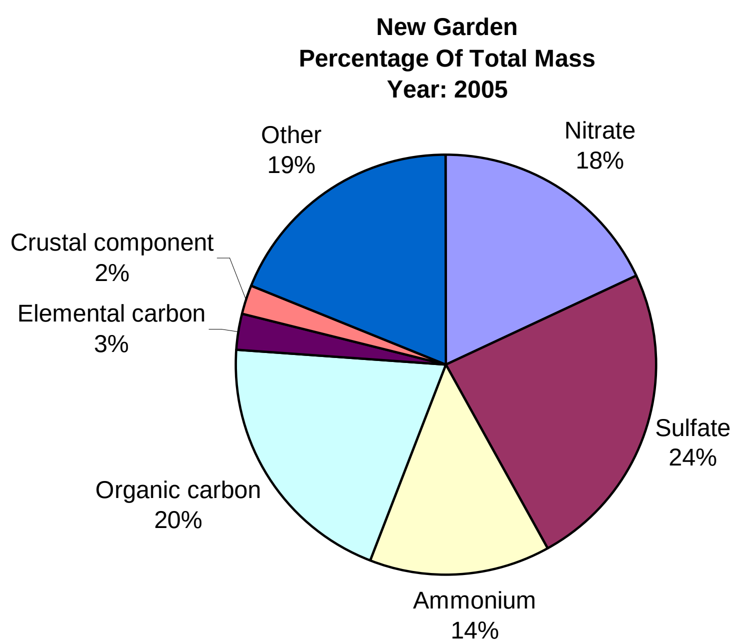
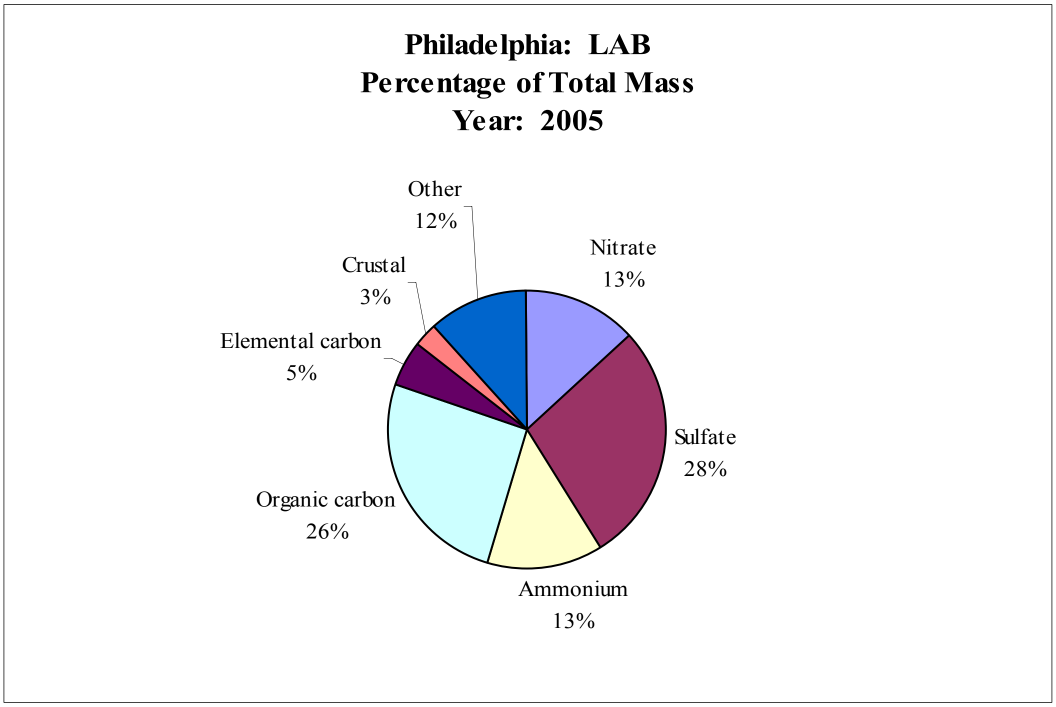
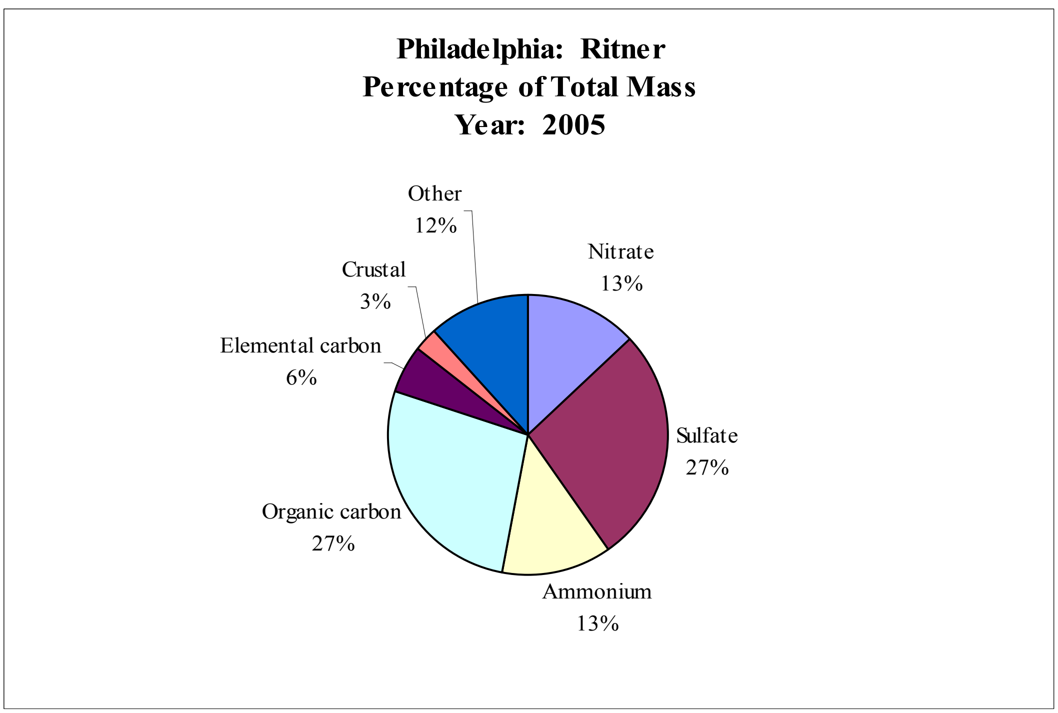


Figure 4-23 continued





Continuous Monitor Analysis:

The Department has operated a continuous (TEOM FDMS) unit at the Norristown monitoring site since October 2003. This continuous monitor was originally installed to assist the PA DEP's air-quality forecasters. Additional continuous monitors have since been installed in the region including a BAMS unit installed at Chester in May of 2006 and two monitors in Philadelphia County also in 2006.

A comparison of Norristown's FRM and continuous unit is shown in Figure 4-24. Results between the continuous and FRM sampler are relatively good though the TEOM FDMS values run consistently higher than the FRM values at Norristown. Nonetheless, the correlation is still pretty good indicating the continuous monitor generally reflects actual concentrations as measured by the FRM sampler.

Figure 4-25 shows the average daily concentrations by hour and day of the week for the Norristown TEOM FDMS unit. Several patterns are apparent in the data. The first being $PM_{2.5}$ concentrations tend to run higher overnight than during the day though the difference is not as large as some of the other monitors in the Commonwealth. This is probably due to meteorological conditions (nocturnal inversion trapping local emissions). There is also an apparent "morning rush-hour" signal centered on hour seven (7). Norristown's morning peak is somewhat significant, ~2 $\mu g/m^3$. This morning peak is generally missing from Saturday and Sunday.

Figure 4-24 Norristown: FRM vs. TEOM

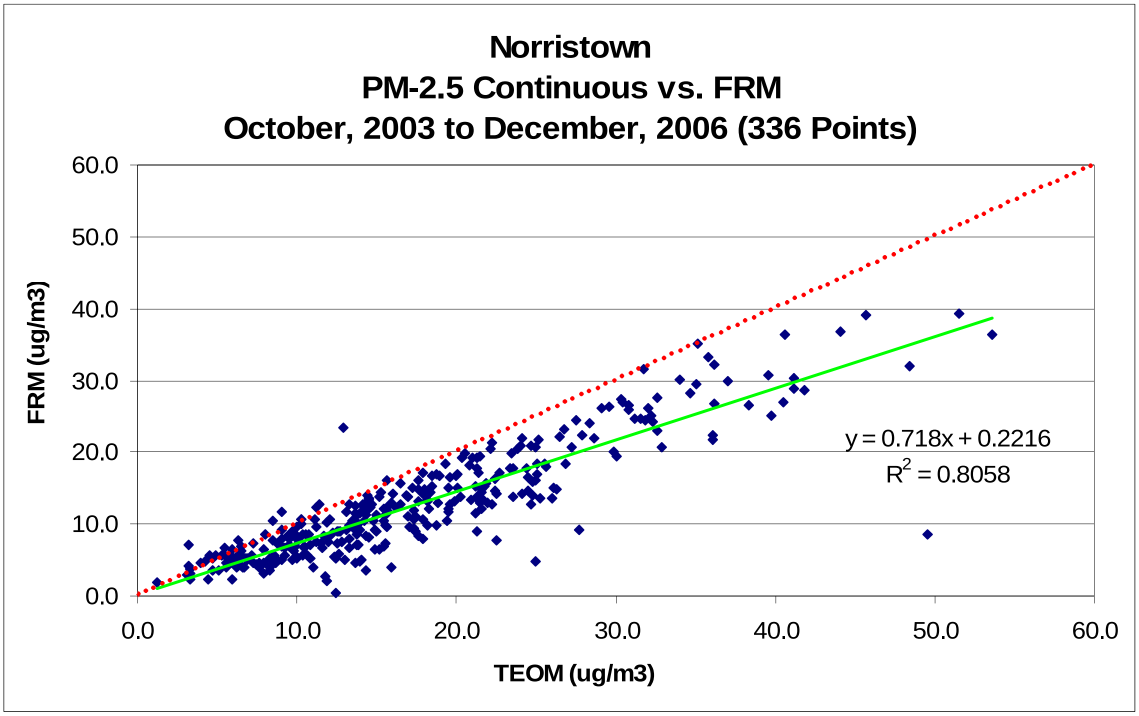
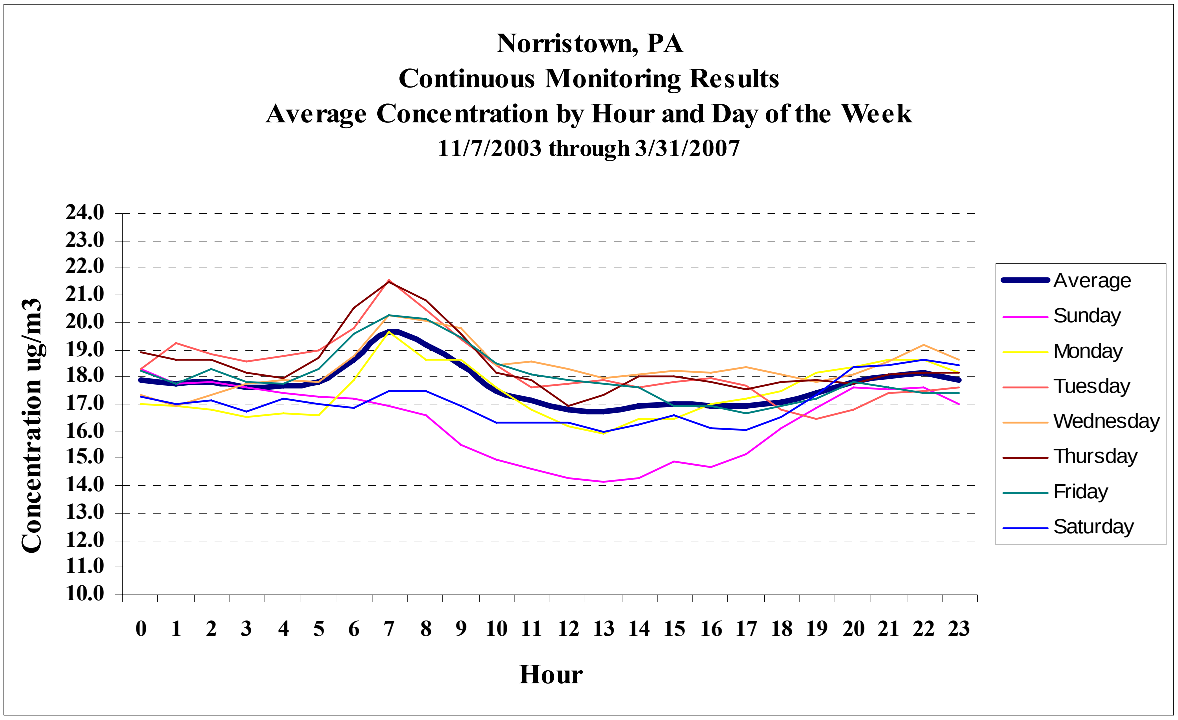


Figure 4-25 Norristown Continuous Data: Day of Week



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Cap and Trade: Acid Rain Program Basics, http://www.epa.gov/airmarkets/cap-trade/docs/arbasics.pdf

Commonwealth of Pennsylvania Department of Environmental Protection Ambient

Air Quality Report, 2004, 2005: http://www.dep.state.pa.us/dep/deputate/airwaste/aq/aqm/aqreport.htm

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Lynch, J.A., Carrick, H, Horner, K.S., Grimm, J.W., **Reductions in Acidic Wet Deposition in Pennsylvania Following Implementation of the Clean Air Act 1995-2005**, 2006.

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Trend Analysis Section

Methodology

This analysis began with 3-year mean $PM_{2.5}$ design value data for each monitor location in Pennsylvania. These data were obtained for six periods over 2001 through 2006, where each given year is the average of that year and the two prior years. (For example, the "2001" data is actually the mean of the 1999–2001 data.)

At each monitor site, a linear regression line was calculated for the design value data using the least squares method. That is, a line described by equation 1 was determined where the slope of the line ($\hat{\beta}_1$) and the y-intercept ($\hat{\beta}_0$) resulted in the lowest possible value for the residual term in equation 2, that is $(y - \hat{y})$.

$$\hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x \tag{1}$$

$$\sum (y - \hat{y})^2 = \sum \left(y - \hat{\beta}_0 - \hat{\beta}_1 x \right)^2 \tag{2}$$

Because data with no trend would necessarily have a slope of zero, that established the null hypothesis as $H_0 : \hat{\beta}_1 = 0$. To determine if the slope is non-zero to a statistically significant degree, the t-test was used for five degrees of freedom ($df = n - 1$) at a 95% confidence ($\alpha = 0.05$). This established a rejection region for the null hypothesis begining at 2.015.

$$t = \frac{\bar{y} - \mu_0}{s/\sqrt{n}} \tag{3}$$

Where the absolute value of t, as calculated by equation 3, exceeds 2.015, we can therefore reject the null hypothesis and assume that there is a statistically significant trend in the data.

Application

For each monitor, t statistics were calculated using the R[1] language. The results at Pennsylvania monitors are summarized in table 1 below. Monitors outside of PA are included in table 2. Sites with a statistically significant trend are listed in bold type.

[1]R: A Language and Environment for Statistical Computing, R Foundation for Statistical Computing (2007), available at http://www.R-project.org.

Table 1: PA Monitors: Results of the analysis

Monitor	t-Statistic	Trend
Allentown	0.64	No
Arendtsville	-0.32	No
Beaver Falls	0.28	No
Bristol	-2.4	Yes
Carlisle	0.58	No
Charleroi	-3.08	Yes
Chester	-0.45	No
Clairton	-3.04	Yes
Coraopolis	-0.98	No
Erie	-2.76	Yes
Farrell	-6.86	Yes
Florence	-1.56	No
Freemansburg	-3.1	Yes
Greensburg	-0.35	No
Harrisburg	-1.08	No
Johnstown	-2.05	Yes
Lancaster	-0.81	No
Liberty	-2.8	Yes
McKees Rocks	1.26	No
Natrona	-7.63	Yes
New Garden	-0.7	No
Norristown	-5.8	Yes
North Braddock	-3.03	Yes
North Park	-4.12	Yes
Perry County	0.36	No
Philadelphia AMS	-5.24	Yes
Philadelphia Belmont	-0.76	No
Philadelphia Broad St	-5.87	Yes
Philadelphia Elmwood	-3.8	Yes
Philadelphia NE	-8.85	Yes
Pittsburgh (BAPC)	-3.45	Yes
Pittsburgh (Gladstone)	-1.62	No
Reading	-3.25	Yes
Scranton	-2.23	Yes
South Fayette	-1.05	No
Springdale	-0.61	No
State College	0.79	No
Washington	-2.02	Yes
Wilkes-Barre	-0.53	No
York	-0.5	No

Table 2: DE and NJ Monitors: Results of the analysis

Monitor	t-Statistic	Trend
DE Lums Pond	-3.57	Yes
DE MLK-a	-4.47	Yes
DE Newark-a	-5.16	Yes
NJ Camden Lab Primary	-1.29	No
NJ Gibstown	-2.6	Yes
NJ Pennsauken	-4.66	Yes