# Commonwealth of Pennsylvania
# Department of Environmental Protection

## Final Air-Quality Modeling Protocol
## For the Annual $PM_{2.5}$ NAAQS

## York Annual $PM_{2.5}$ Nonattainment Area

**October 2007**

Bureau of Air Quality
Pennsylvania Department of Environmental Protection
P.O. Box 8468
Harrisburg, PA 17105-8468
717-787-9495

**www.dep.state.pa.us**

This page left intentionally blank

## Table of Contents



## Table of Figures



## Table of Tables

## 1.0 Overview of York Nonattainment Modeling Demonstration

This section provides background information and describes the basic structure to the $PM_{2.5}$ demonstration that the Pennsylvania Department of Environmental Protection (PA DEP) will undertake. Final modeling guidelines for $PM_{2.5}$ were issued on April 16, 2007 (posted on the U.S. EPA's Support Center for Regulatory Air Modes, SCRAM). This modeling protocol follows the structure outlined in section 12.2 of the U.S. EPA's Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze.

## 1.1 Background and Objectives

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

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.

The U.S. EPA issued the fine particle 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. The U.S. 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 2006 the U.S. EPA lowered the twenty-four hour $PM_{2.5}$ standard to 35 $\mu g/m^3$. Because the nonattainment designations for new twenty-four hour $PM_{2.5}$ standard are not yet in place, the Commonwealth's $PM_{2.5}$ modeling analyses will instead use the1997 twenty-four hour standard (65 $\mu g/m^3$). Final $PM_{2.5}$ SIPs are due in April of 2008.

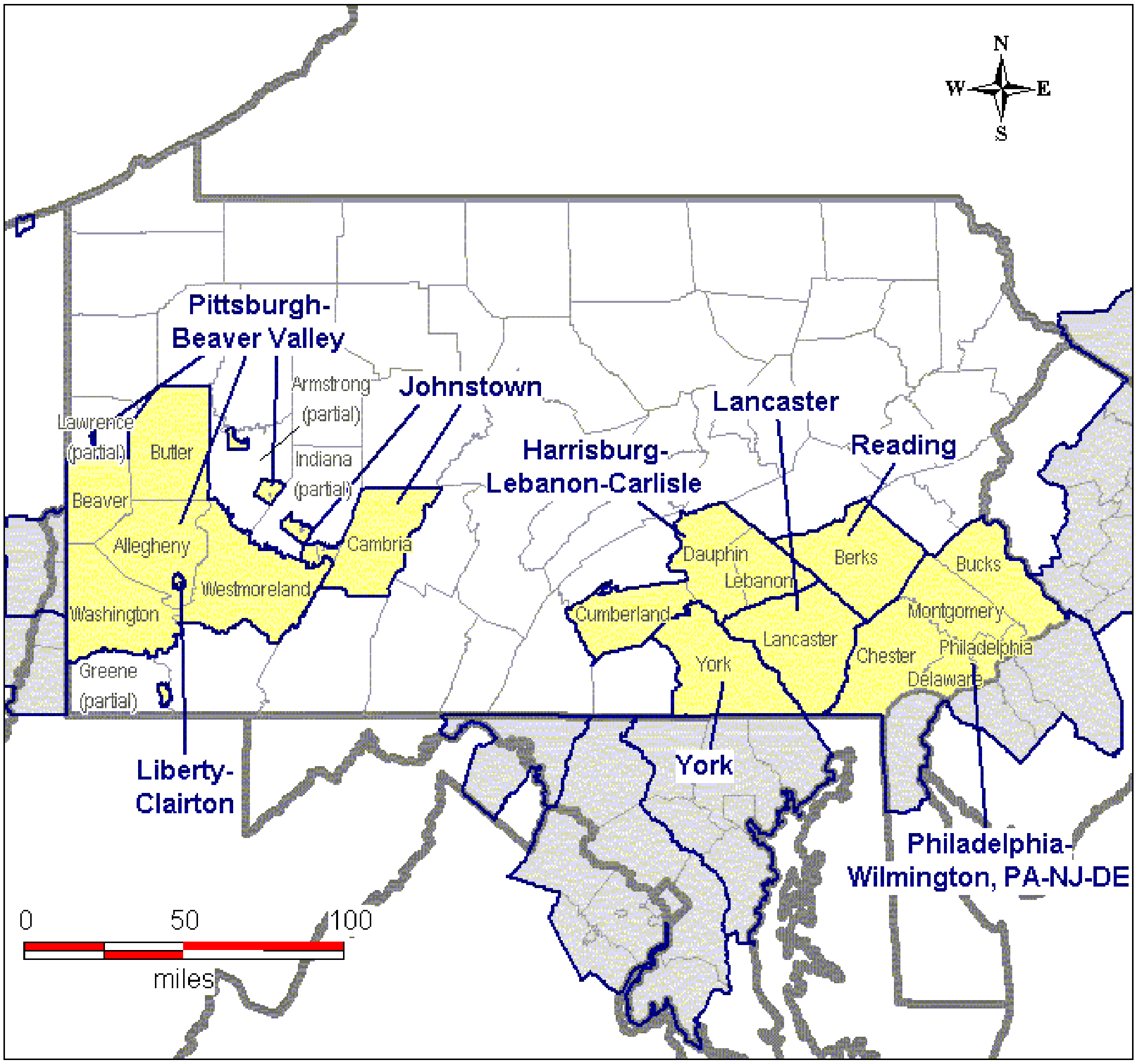
In April 2003, the U.S. EPA issued a memorandum outlining the schedule for designating areas under the $PM_{2.5}$ standard and related guidance on nine factors to consider in identifying nonattainment areas. The Clean Air Act provides for states and tribes to submit designation recommendations to the U.S. EPA, and it requires the U.S. 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 the U.S. 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.

The objective of this protocol is to outline the methods and procedures that will be used to support the modeling demonstration. The Department will take the lead in developing emission control strategies to demonstrate the York County annual $PM_{2.5}$ nonattainment area will reach attainment by the designated attainment date, April 2010 (five years from the final designations).

### 1.2 York Nonattainment Area

The York County $PM_{2.5}$ nonattainment area includes one county (York). Figure 1-1 graphically depicts all of the $PM_{2.5}$ nonattainment areas within Pennsylvania. The York nonattainment area currently violates the U.S. EPA's health-based annual $PM_{2.5}$ standard (15.0 $\mu g/m^3$). York's 2006 annual design value is 16.2 $\mu g/m^3$and its twenty-four hour design value is 36 $\mu g/m^3$. This is below the 1997 twenty-four hour $PM_{2.5}$ standard (65 $\mu g/m^3$). York County will need to demonstrate that it will attain of the annual $PM_{2.5}$ standard by no later than five years from the final designation date of April 5, 2005 (April, 2010).

**Figure 1-1  York Annual $PM_{2.5}$ Nonattainment Area**




There is one monitoring site currently operating in the York County $PM_{2.5}$ nonattainment area. The Department operates several types of $PM_{2.5}$ monitors at York; a Federal Reference Method (FRM) sampler, a $PM_{2.5}$ speciation monitor and a continuous $PM_{2.5}$ monitor. FRM sampling began in January of 1999 and speciated sampling began in April of 2002. Sample frequencies for the York FRM monitor are once every three days (1/3) and once every six days (1/6) for the speciated sampler. The continuous $PM_{2.5}$ monitor has been operational since August of 2004. Measurements from the continuous monitor are generally used for air-quality forecasting purposes and cannot be used to determine attainment status.

### 1.3 York Data Analysis Summary

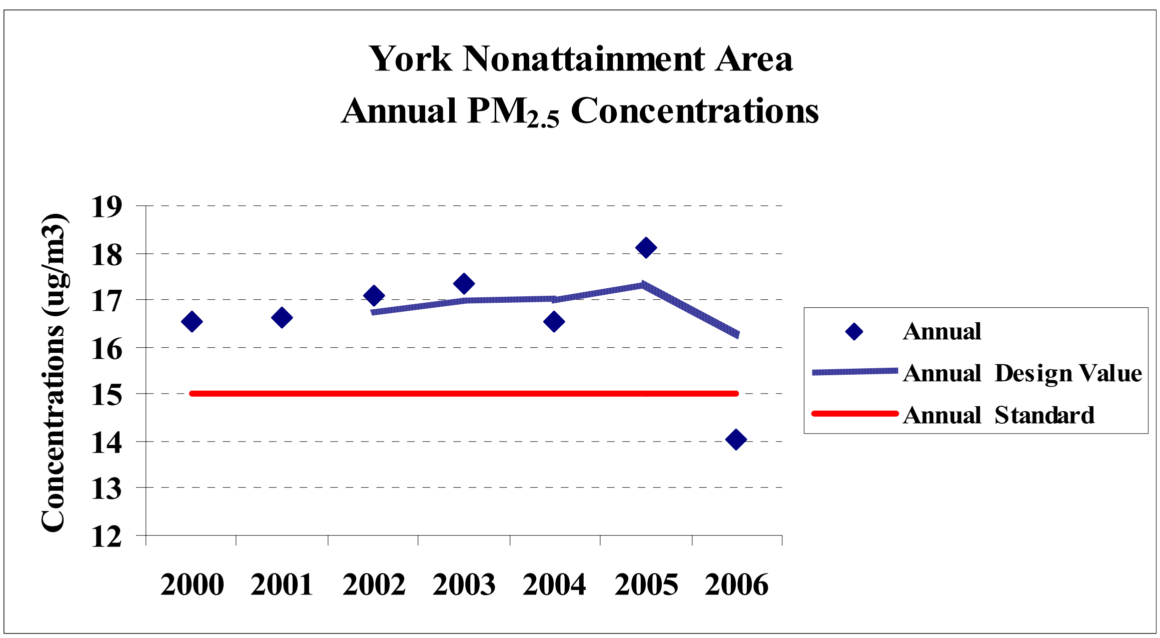
Table 1-1 lists the historic $PM_{2.5}$ concentrations in the York annual $PM_{2.5}$ nonattainment area. Historic FRM data indicate the York annual $PM_{2.5}$ nonattainment area has consistently exceeded the health-based annual $PM_{2.5}$ standard since the Department began sampling (see Figure 1-2).

**Table 1-1 Historic Design Values: York Annual $PM_{2.5}$ Nonattainment Area**

| Year | 98th 24-Hour | 24-Hour Design Value | Annual | Annual Design Value |
|---|---|---|---|---|
| 2000 | | | 16.55 | |
| 2001 | 41.3 | | 16.62 | |
| 2002 | 47.3 | | 17.09 | **16.8** |
| 2003 | 47.0 | 45 | 17.36 | **17.0** |
| 2004 | 35.9 | 43 | 16.54 | **17.0** |
| 2005 | 39.4 | 41 | 18.12 | **17.3** |
| 2006 | 33.2 | 36 | 14.04 | **16.2** |

**Annual standard: 15.0 $\mu g/m^3$ Twenty-four hour standard 65 $\mu g/m^3$**

**Figure 1-2 Annual Design Values: York Annual $PM_{2.5}$ Nonattainment Area**




The Department has reviewed FRM, speciated and continuous $PM_{2.5}$ data within the York annual $PM_{2.5}$ nonattainment area. More detailed analyses are included in Appendices A, B and C. Results from these appendices form the basis of our general conceptual model.

As more analyses are completed in the future, our conceptual model may need to be updated.

A short list of findings is set forth below:

- There is no statistically significant trend in the York monitor's FRM design values (see Appendix B).
- The major components in the speciated data are sulfates, organic carbon, nitrates and ammonium. Component percentages at the York monitor are similar to results from nearby speciated monitors.
- Results from York's continuous TEOM monitor are very similar to the corresponding FRM values indicating results from the continuous monitor are a good reflection of actual concentrations on days when an FRM sample is not collected.
- Additional observations from the York continuous monitor:
  - There is a significant jump in hourly concentrations during the "morning rush" due to increased highway traffic. This jump is less pronounced over the weekend.
  - Overnight concentrations are generally higher than daytime concentrations. This is probably due to local meteorology with overnight emissions "pooling" under the nighttime inversion then mixing away during the day.
  - Weekend concentrations are generally lower than weekday concentrations indicating a strong anthropogenic component.
- The York monitor appears to correlate well with monitors in Harrisburg, York and Reading but less well with nearby monitors in Adams and Perry counties.
- York's fine-particulate concentrations tend to run a bit higher on days when regional loading is low. This suggests "local" sources are affecting the monitor.

### 1.4 Technical Committees

PA DEP staff in consultation with staff from other state agencies will work together to reach decisions regarding technical issues concerning modeling and monitored design values. Any questions or issues that cannot be answered by this group will be forwarded to the appropriate staff in the U.S. EPA Region III.

### 1.5 Participating Organizations

The PA DEP will be the primary developer of the Commonwealth's modeling demonstration. The Allegheny County Health Department will prepare the modeling demonstration for the Liberty-Clarton annual $PM_{2.5}$ nonattainment area in western Pennsylvania. Both agencies maintain periodic contact with one another during the SIP development process. Other organizations involved in developing the Commonwealth's modeling demonstration include the Ozone Transport Commission's (OTC) Modeling

Workgroup, the Mid-Atlantic/Northeast Visibility Union (MANE-VU) and the Northeast States for Coordinated Air Use Management (NESCAUM).

### 1.6 Schedule for Completion

Pennsylvania is currently working with other members of the Ozone Transport Commission's (OTC) Modeling Workgroup to complete the $PM_{2.5}$ modeling demonstration. This modeling demonstration builds on the group's ozone SIP modeling platform. Modeling work should be completed before the end of 2007 to allow adequate time for the states to prepare SIP demonstrations by April 2008.

## 2.0 Model and Modeling Inputs

The modeling demonstration for the York annual $PM_{2.5}$ nonattainment area relies heavily on the OTC SIP quality-modeling platform. Ozone modeling was the primary focus of this effort. This group's interaction with the Mid-Atlantic/Northeast Visibility Union (MANE-VU) and the Northeast States for Coordinated Air Use Management (NESCAUM) allowed it, through the regional modeling centers, to do additional year-round modeling for $PM_{2.5}$ and Regional Haze.

The PA DEP has been an active participant in the OTC's modeling workgroup. The Department provided the necessary emissions files for Pennsylvania sources needed to run the photochemical grid model used in the SIP modeling platform. The following sections provide brief summaries of the OTC modeling study. More detailed information can be found in the OTC documentation produced as part of this modeling analysis. Several of these documents are included in the reference section and in Appendix D.

### 2.1 Selection of Air Quality, Meteorological and Other Model Inputs

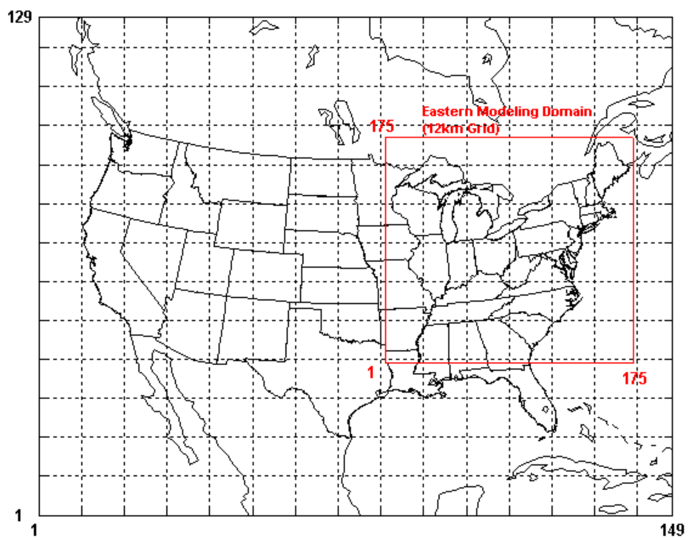
EPA's current guidance does not recommend a particular model or models for use in a SIP attainment demonstration. The OTC modeling committee used the Community Multi-scale Air Quality (CMAQ) photochemical grid model (version 4.5) as part of its SIP modeling platform (OTC Final Modeling Protocol, 2006). CMAQ is a Eulerian grid model capable of simulating air-pollutant concentrations in the atmosphere using mathematical equations to characterize chemical and physical properties.

Meteorological and emission input files must be prepared regardless of which photochemical grid model is used. The regional fine-particulate modeling analysis will encompass an entire year of simulation (2002). This should provide a good variety of episodes to characterize York's annual $PM_{2.5}$ nonattainment.

## 2.2 Modeling Domain

Figure 2-1 shows the modeling domain used by the OTC. A nested-grid approach is used with the lower resolution outer grid providing boundary conditions for a more refined grid covering the area of interest. The modeling domain was chosen to be large enough to properly simulate regional transport. The outer domain boundary is far enough from the inner grid's boundary so that clean-boundary condition assumptions are realistic and probably do not unduly influence concentrations within the inner domain.

**Figure 2-1. OTC Modeling Study Domain**




**Outer grid at 36-kilometer resolution, inner grid at 12-kilometer resolution**

## 2.3 Horizontal and Vertical Grid Resolution

The inner (fine) grid covering the northeast region and the York annual $PM_{2.5}$ nonattainment area has a horizontal grid resolution of 12 km. CMAQ's horizontal grid resolution matches the grid resolution of the meteorological model (MM5). This proposed resolution is within the upper range of the fine-grid resolution size recommended in the US EPA's draft modeling guidance document. The resolution should be adequate to realistically simulate regional air-quality within the York annual $PM_{2.5}$ nonattainment area.

The model's vertical resolution is also in part defined by the vertical resolution of the meteorological model (MM5). The definition of the vertical structure could also have adopted the one-to-one resolution of the meteorological model. However, based upon prior experience, the vertical extent of the model was set around a height of six to eight km.  The number of vertical layers permitted in the model is limited by computational considerations as well as storage limits; too many layers increase the amount of time needed to complete a simulation and the amount of information being stored, processed and exchanged.  Limiting the vertical resolution to a few layers, however, would inherently discard the detailed information provided by the meteorological model.  A compromise solution would be to maintain the high resolution with a one-to-one design of the vertical layers up to approximately one or two km yielding around 7 to 10 levels, followed by a collapse of the MM5 upper layers to around six to eight km to form another six to eight levels.  Thus, under this scenario there would be a total of 13 to 18 layers in the vertical with 7 to 10 levels below two km and the remaining between two and eight km.  It should be noted that the mid-point of layer 1 in this analysis is around 10 m.

### 2.4  Model Initial and Boundary Conditions

The photochemical grid model will be started three days before the start of the analysis period using "clean" conditions across the domain.  Prior experiences have shown that a three-day ramp-up period is sufficient to establish pollutant levels that are encountered in the beginning of an episode.

In prior studies, attempts have been made to include any information that is available from monitors that are near the western and northern boundaries of the modeling domain. For this modeling analysis, similar attempts will be made to obtain pollutant data at the boundaries.  "Clean" conditions, however, will be assumed for the outer model boundaries if reliable data is not available.

### 2.5  Near-Scale Modeling

A near-scale modeling analyses may be necessary if the regional model fails to demonstrate that the York County nonattainment area will meet the health-basted annual $PM_{2.5}$ standard.  In this case, the Department will use a Lagrangian or Gaussian model to examine primary particulate in accordance with applicable guidance.  The approach will be similar to what the Allegheny County Health Department has proposed for its Liberty-Clairton annual $PM_{2.5}$ nonattainment area.

### 2.6  Episode Selection

The OTC modeling study simulated for all of 2002 instead of the episodic approach. This should allow for an adequate analysis of York's annual nonattainment problem since it will include periods of low and elevated fine-particulate concentrations.

Attainment demonstrations have typically been based on a limited number of episodes which are in turn are made up of a limited number of days when pollutant concentrations exceeding the NAAQS.  Episodes are chosen on the basis of peak concentrations and the representativeness of the atmospheric conditions that typically occurred during times of elevated pollutant concentrations. York is violating an annual fine-particulate standard so it is important to consider conditions during the entire year not just episodes when concentrations are high.

Typically computational and resource constraints limited the number of episodes used in a demonstration. Advances in computer capabilities and expanded resources have permitted groups like the OTC modeling group to simulate longer periods of time. The current OTC modeling study has proposed simulating all of 2002 using a regional photochemical grid model. This approach has several advantages. The first advantage being the greater variety of episodes the modeling demonstration can examine. This makes the analysis more robust and increases confidence that emission reductions will be beneficial over a number of atmospheric conditions that lead to elevated fine-particulate concentrations. The second advantage is 2002 coincides with EPA's choice to build the base emission inventory. This coincidence will lead to more confidence in the photochemical model's ability to simulate actual fine-particulate concentrations based on the base inventory (modeled 2002 concentrations will be based on 2002 emissions and compared with actual monitored 2002 concentrations).

## 2.7 Meteorological Model

The meteorological files used in CMAQ were produced using the Pennsylvania State University/National Center for Atmospheric Research **(**PSU/NCAR) mesoscale model more commonly know as MM5. MM5 is a limited-area, nonhydrostatic, terrain-following sigma-coordinate model designed to simulate or predict mesoscale atmospheric circulation. The model is publicly available and has been used for various air-quality modeling studies in the past. Additional information regarding MM5 can be found in Appendix E (OTC Documentation - Meteorological Modeling using Penn State/NCAR 5th Generation Mesoscale Model, MM5).

## 2.8 Emission Inputs

The OTC Modeling Committee also examined two emissions processors (EMS2001 and SMOKE, both using CB4 chemistry) in its prior work and concluded that there are differences between them that could be minimized by forcing the models to use a common speciation and surrogate database. OTC documentation included in Appendix D (Emission Processing for the Revised 2002 OTC Regional and Urban 12 km Base Case Simulations) details on how the emission inventories were built and processed.

For areas with an attainment date of no later than April 5, 2010 for the annual $PM_{2.5}$ NAAQS, the emission reductions need to be implemented no later than the beginning of the 2009. A determination of attainment will likely be based on air-quality monitoring data collected in 2007, 2008, and 2009. Therefore, the year to project future emissions should be no later than the last year of the three-year monitoring period; in this case 2009.

The 2002 base year emissions inventory shall be projected to 2009 using standard emissions projection techniques. 2009 inventories developed by MANE-VU shall be used in the attainment demonstration. The most recently available inventories from other RPOs in the modeling domain will be used.

Emission inventory guidance documents will be followed for developing projection year inventories for point, area, mobile, and biogenic emissions. These procedures address projections of spatial, temporal, and chemical composition change between the base year and projection year.

The control strategies developed for evaluation in the attainment demonstration will be selected by the OTC's Control Strategy Committee. These will be selected from groups of strategies developed by the technical subcommittees responsible for identifying and developing the regulations and/or control measures.

Consideration will be given to maintaining consistency with control measures likely to be implemented by other modeling domains that may be involved in region-wide analysis. Also, technology-based emission reduction requirements mandated by the Clean Air Act will be included in the future year model runs.

### 2.9 Area Examined in the Attainment Demonstration

The York annual $PM_{2.5}$ nonattainment area consists of York County. Three types of fine–particulate monitors operated during 2002; a FRM sampler, a speciated sampler and a continuous monitor. Quarterly relative reduction factors (RRFs) will be calculated using the OTC's modeling results for the York monitor. RRFs have to be determined for each $PM_{2.5}$ component in accordance with the U.S. EPA's modeling guidance document.

The York speciated monitor did not begin operations until April 2002. RRFs for the first quarter will have to be based on a mean first quarter values or some other methodology in accordance with the U.S. EPA modeling guidance document.

Unusual weather conditions contributed to massive fires in the northern portion of Canada's Quebec province in early July 2002. The plume from this fire impacted both fine particulate and ozone concentrations across much of the northeast for several days (Northeast Oxidant and Particle study NE-OPS, 2002). Data (July 6-9, 2002) from the seven monitors in southcentral Pennsylvania including York were invalidated as an "exceptional event" under the U.S. EPA guidelines.

### 2.10 Quality Assurance

All air quality, emissions, and meteorological data will be reviewed to ensure completeness, accuracy, and consistency before proceeding with modeling. Any errors, missing data or inconsistencies, will be addressed using appropriate methods that are consistent with standard practices.

Quality Assurance (QA) activities will be carried out for the various emissions, meteorological, and photochemical modeling components of the modeling study. Emissions inventories obtained from the various Regional Planning Organizations (RPO) will be examined through the use of quality assurance software, algorithms, and plotting routines to check for errors in the emissions estimates. When such errors are discovered, the problems in the input data files shall be corrected.

Emission inventories from the MANE-VU RPO are currently undergoing final preparation and quality assurance tests. The OTC intends to use the most current emission inventory data from the other RPOs that are contained within the modeling domain. The other RPOs may revise their emission inventories after the OTC commences its modeling analysis. These changes will not be incorporated into the OTC's modeling analysis due to time constraints. Emission inventory changes made by the other RPOs are expected to be small and therefore only contribute to minor changes in fine-particulate concentrations within the OTR.

The MM5 meteorological and CMAQ air quality model inputs and outputs will be plotted and examined to ensure accurate representation of the observed data in the model-ready fields, and temporal and spatial consistency and reasonableness. Both MM5 and CMAQ will undergo an operational/scientific evaluation and this will facilitate, among other things, the quality assurance review of the meteorological and air quality modeling procedures. Data sets available to support this quality assurance of the aerometric inputs include the routine synoptic-scale data sets from the NWS 12-hourly rawinsondes and three-hourly surface observations. These data include the horizontal wind components (u and v), temperature (T), and relative humidity (q) at the standard pressure levels, plus sea-level pressure (SLP) and ground temperature (Tg).

The OTC Modeling workgroup has completed several analyses of the MM5 meteorological files used in the group's modeling analysis. Analyses of the MM5 meteorological fields are located in Appendix E. OTC's most resent analysis of MM5 was to examine the effects of different Planetary Boundary Layer (PBL) schemes on the meteorological fields. Three different PBL schemes were examined using meteorological information including temperature, wind speed, wind direct and humidity from over 600 National Weather Service (NWS) and CASTNet (Clean Air Status and Trends Network). MM5 was found to produce meteorological fields that were in general agreement with corresponding observations.

## 3.0 Model Performance Evaluation

A model performance evaluation will be conducted to ensure the regional photochemical model is simulating fine-particulate concentrations in a reasonable fashion. If the regional photochemical model reproduces the fine-particulate components well, then it lends more credibility to the model's ability to simulate fine-particulate concentrations correctly for the control strategy runs.

### 3.1 Ambient Data Base

Model evaluations will need to be completed on all fine-particulate components. Evaluation matrices from the US EPA's draft modeling guidance document will be used. It is important that the regional photochemical model simulate the highest contributing fine-particulate components correctly. In York's case this would be sulfates, nitrates and organic carbon. Results from PA DEP's speciated $PM_{2.5}$ monitor will be used in this analysis.

There are several additional sources of fine-particulate measurements that could be used in the model performance evaluation. These include York's FRM and continuous fine-particulate measurements and results from an acid rain monitoring site near Millersville. Data from the acid rain site is of limited use because the site only started collecting data in November of 2002.

Other performance evaluation measures will have to be developed if the Department has to do additional "near-scale" modeling to demonstrate attainment.

### 3.2 Evaluation Procedures

The U.S. EPA guidance will be used to evaluate model performance. Model $PM_{2.5}$ bias statistics will be developed in accordance with section 18.4.2 of the guidance. These will be used to determine each $PM_{2.5}$ component's bias. Any large bias in York's sulfate, nitrate or organic $PM_{2.5}$ components will be problematic. Initial model results presented at the OTC's modeling committee member's meetings suggest CMAQ simulates sulfate concentrations quite well.

Continuous and FRM data will be used in a relative fashion to determine if there are any temporal biases in the model. These data sets contain more information than the speciated data sets because their collection frequency is greater, once every three days and hourly, versus the once every sixth day for the speciated data.

## 4.0 Attainment Demonstration and other Supplemental Analyses

The modeled $PM_{2.5}$ attainment demonstration consists of analyses that estimate whether selected emissions reductions will result in ambient concentrations that meet the NAAQS, and an identified set of control measures which will result in the required emissions reductions. The attainment demonstration estimates the amount of emission reduction needed to demonstrate attainment by using a modeling attainment test.

Additional analyses may also be performed to indicate that a proposed emission reduction will lead to attainment of the NAAQS. The modeled attainment test predicts whether or not all estimated future annual fine-particulate design values will be less than or equal to the concentration level specified in the NAAQS under meteorological conditions similar to those which have been simulated.

## 4.1 Modeled Attainment Test

The modeled $PM_{2.5}$ attainment test applied at each nonattainment monitor will follow the recommended procedures outline in EPA's modeling guidance document. In order to perform the recommended modeled attainment test, States should divide observed mass concentrations of $PM_{2.5}$ into 6 components[5]:

- mass associated with sulfates ($SO_4$);
- mass associated with nitrates ($NO_3$);
- mass associated with organic carbon (OC);
- mass associated with elemental carbon (EC);
- mass associated with inorganic particulate emissions, excluding primary sulfate and
- nitrate particles (IP);
- unattributed mass (i.e., the difference between measured $PM_{2.5}$ and the sum of the other 5 components) (U).

To apply the test, States must first have run an air quality model at least twice to simulate current emissions and to simulate the net effects of a proposed control strategy and growth projected to two years prior to the required attainment date. The Department will then follow the recommended procedures to develop the appropriate RRFs for each component. For each monitoring site, obtain modeled estimates for 5 of the 6 major components of observed $PM_{2.5}$ (i.e., $SO_4$, $NO_3$, OC, EC and IP). For each 3-month quarter, calculate site (i) and component (j) specific relative reduction factors $(RRF)_{ij}$. The relative reduction factor for component j at a site i is given by the following expression:

$$(RRF)_{ij} = ([C_{j,\ projected}]/[C_{j,\ current}])_I$$

where,

$C_{j,\ current}$ is the quarterly mean concentration predicted at or near the monitoring site with emissions characteristic of the period used to calculate the current design value for annual $PM_{2.5}$ (e.g., 2000-2002);
$C_{j,\ projected}$ is the quarterly mean concentration predicted at or near the monitoring site two years prior to the required attainment date (e.g., 2010 in an area having a 2012 attainment date).

Assume that the relative reduction factor for the sixth previously identified component of observed $PM_{2.5}$ (i.e., "U") is "1.00". Apply each component-specific relative reduction factor to the observed average quarterly mean concentration of the corresponding component, derived in step 1. Add the 6 components to obtain a projected average quarterly mean $PM_{2.5}$ concentration.

## 4.2 Unmonitored Area Analysis

In the event that it is necessary to estimate design values at unmonitored locations within the York annual $PM_{2.5}$ nonattainment area, an "unmonitored area analysis" using model adjusted spatial fields may be performed. The basic steps of this process are as follows:

1. Interpolate ambient design value data to create a set of spatial fields.
2. Adjust the spatial fields using gridded model output gradients (base year values).
3. Apply gridded model RRFs to the model adjusted spatial fields.
4. Determine if any unmonitored areas are predicted to exceed the NAAQS in the future.

The recommended U.S. EPA guidance shall be utilized in the "unmonitored area analysis".

## 4.3 Additional Analyses

Corroboratory evidence shall accompany the model attainment demonstration. The U.S. EPA guidance for supplemental analyses and weight of evidence (WOE) demonstrations shall be followed. Table 1-2 summarizes the U.S. EPA guidelines used to determine if a WOE demonstration is needed.

The weight of evidence submittal, if necessary, shall describe the analyses performed, databases used, key assumptions and outcomes of each analysis, and why the evidence, viewed as a whole, supports a conclusion that the area will attain the NAAQS despite the model predicted future design value, or conversely, demonstrate that reaching attainment is not likely despite passing the model attainment test. WOE analysis performance and type will be dictated by the U.S. EPA's final modeling guidance.

## 5.0 Procedural Requirements

A range of documents will be prepared and referenced during the SIP process. Documents pertaining to the modeling analysis in support of Pennsylvania's SIP for the York annual $PM_{2.5}$ nonattainment area will be made available as soon as practical for all interested parties. Additional documentation for the OTC Modeling Committee as part of its regional modeling analysis will be referenced and included in the documentation.

**Table 1-2 Summary of $PM_{2.5}$ WOE Guidelines (from the U.S. EPA Guidance)**

| Results of Modeled Attainement Test | | Supplemental Analyses |
|---|---|---|
| **Annual $PM_{2.5}$** | **24-Hour $PM_{2.5}$** | |
| **Future Design Value < 14.5 μg/m$^3$, all sites** | **Future Design Value < 62 μg/m$^3$, all sites** | **Basic supplemental analyses should be completed to confirm the outcome of the modeled attainment test** |
| **Future Design Value 14.5 – 15.5 μg/m$^3$, all sites** | **Future Design Value 62 – 67 μg/m$^3$, all sites** | **A weight of evidence demonstration should be conducted to determine if aggregate supplemental analyses support the modeled attainment test** |
| **Future Design Value ≥ 15.5 μg/m$^3$, all sites** | **Future Design Value ≥ 68 μg/m$^3$, all sites** | **More qualitative results are less likely to support conclusion differing from the outcome of the modeled attainment test** |

### 5.1 Reporting

Documents, technical memorandums, and data bases developed in this study will be submitted to all parties for review and subsequent distribution as appropriate. The various work products developed in preceding tasks will be synthesized and integrated to produce a draft Technical Support Document (TSD) that describes the full range of technical and modeling activities performed during the project. This report will contain the essential methods and results of the conceptual model, episode selection, modeling protocol, base case model development and performance testing, future year and control strategy modeling, quality assurance, weight of evidence analyses, and calculation of $PM_{2.5}$ attainment via the U.S. EPA's relative reduction factor (RRF) methodology.

The PA DEP is the responsible agency for conducting and submitting a regional modeling attainment demonstration for June 15, 2009 to the U.S. EPA. All parties will work to establish a suitable outline for the TSD within the framework. A final TSD will be developed after receiving reviewer's comments.

## 5.2 Data Archive and Delivery of Modeling Files

All relevant data sets, model codes, scripts, and related software required by any project participant necessary to corroborate the study findings (e.g., performance evaluations, control strategy runs) will be provided in an electronic format. The Department will be responsible for the archival of all modeling data relevant to this project. Transfer of data may be facilitated through the combination of a project website and the transfer of large databases via overnight mail.

The Department will work with the U.S. EPA Region III staff to develop a full list of deliverables prior to the submittal of the final SIP demonstration.

## 6.0 References


**The Modeling Committee of the Ozone Transport Commission**, *A Modeling Protocol for the OTC SIP Quality Modeling System For Assessment of the Ozone National Ambient Air Quality Standard in the Ozone Transport Region*, March 2006.

**NorthEast Oxidant and Particle Study (NEOPS),** *Final Report to the Commonwealth of Pennsylvania*, July 2003.

**The United States Environmental Protection Agency**, *Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and regional Haze,* April 2007 (EPA –454/B-07-002).

**Mid-Atlantic Regional Air Management Association (MARAMA)**
**A Guide to Mid-Atlantic Regional Air Quality**

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

## Correlation Analysis: Southwest, Southcentral and South East Pennsylvania

# Ozone Transport Commision Documentation

**Ozone Transport Commission**
**Modeling Committee – Meteorological Modeling Analysis**