ATTACHMENTS

Proposal

Delaware Second Limited Maintenance Plan Under the 2006 24-hr $PM_{2.5}$ National Ambient Air Quality Standard

State Implementation Plan

For the New Castle County Portion of the

Philadelphia-Wilmington, PA-NJ-DE Nonattainment Area for Fine Particles

Submitted To
U.S Environmental Protection Agency

By
Delaware Department of Natural Resources and
Environmental Control

January 1, 2024

[This page is intentionally left blank]

APPENDIX A

FINAL REPORT
to the
Delaware Department of Natural Resources and Environmental Control

Analysis of Speciation Trends Network Data Measured at the State of Delaware

Prepared by

Philip K. Hopke and Eugene Kim

Center for Air Resources Engineering and Science
Clarkson University
Box 5708
Potsdam, NY 13699-5708

January 20, 2005

APPENDIX A

INTRODUCTION

U.S. EPA established Speciation Trends Networks (STN) to characterize $PM_{2.5}$ (particulate matter $\leq$ 2.5 μm in aerodynamic diameter) composition in urban areas and to assist identifying areas out of attainment of the promulgated new national ambient air quality standards for airborne particulate matter. Advanced source apportionment studies for the STN $PM_{2.5}$ measurements are needed for developing effective control strategies for $PM_{2.5}$ as well as for the source-specific community epidemiology to relate adverse health effects to apportioned source contributions. Positive matrix factorization (PMF; Paatero, 1997) has been successfully used to assess ambient $PM_{2.5}$ source contributions in the Arctic (Xie et al., 1999), in Hong Kong (Lee et al., 1999), in Thailand (Chueinta et al., 2000), in Phoenix (Ramadan et al., 2000), in Vermont (Polissar et al., 2001), in three northeastern U.S. cities (Song et al., 2001), in a northwestern U.S. city (Kim et al., 2003a), in Seattle (Kim et al., 2004a), and in Atlanta (Kim et al., 2004b).

The objectives of this project are to identify $PM_{2.5}$ sources and estimate their contributions to $PM_{2.5}$ mass concentrations by analysis of the data measured at the EPA STN sites in the State of Delaware. The PMF derived $PM_{2.5}$ sources and their seasonal trends are discussed. The likely locations of the identified sources are suggested using conditional probability function (CPF) and potential source contribution function (PSCF) analyses.

SAMPLE COLLECTION AND CHEMICAL ANALYSIS

The $PM_{2.5}$ samples analyzed in this project were collected on a one-in-six day schedule at the STN monitoring sites located in Wilmington and Dover, Delaware as shown in Figure 1. The monitoring site in Wilmington is located at Martin Luther King Blvd., about 1 km southwest of downtown, 250 m southeast of the bus depot of the Delaware Transit

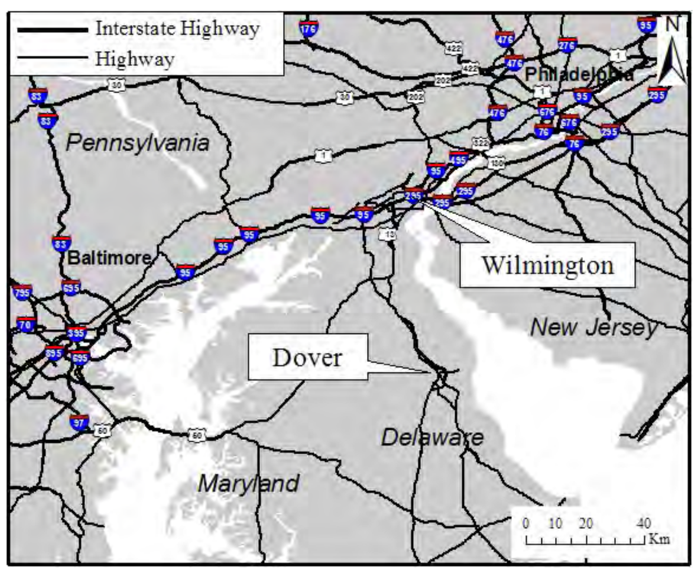


Figure 1. Location of the two STN monitoring sites in Delaware.

Corporation, 3 km northwest of the Port of Wilmington. Interstate highway I-95 and the railroad are closely situated to the west and south of the site, respectively.

The Dover monitoring site is located west of state highways SR1 and Route 13/113. Railroads are situated close to the west of the site. The summary of two monitoring sites are shown in Table 1. Detailed maps of Wilmington and Dover monitoring sites are presented in Figures 2 and 3, respectively. Spiral Aerosol Speciation Samplers (Met One Instruments, Grants Pass, OR) are used at these two sites.

The STN uses multiple analytical laboratories to analyze the samples. There are also differences in the nature of the collected blanks and the treatment of the resulting data. $PM_{2.5}$ samples were collected on Teflon, Nylon, and quartz filters. The Teflon filter was used for mass

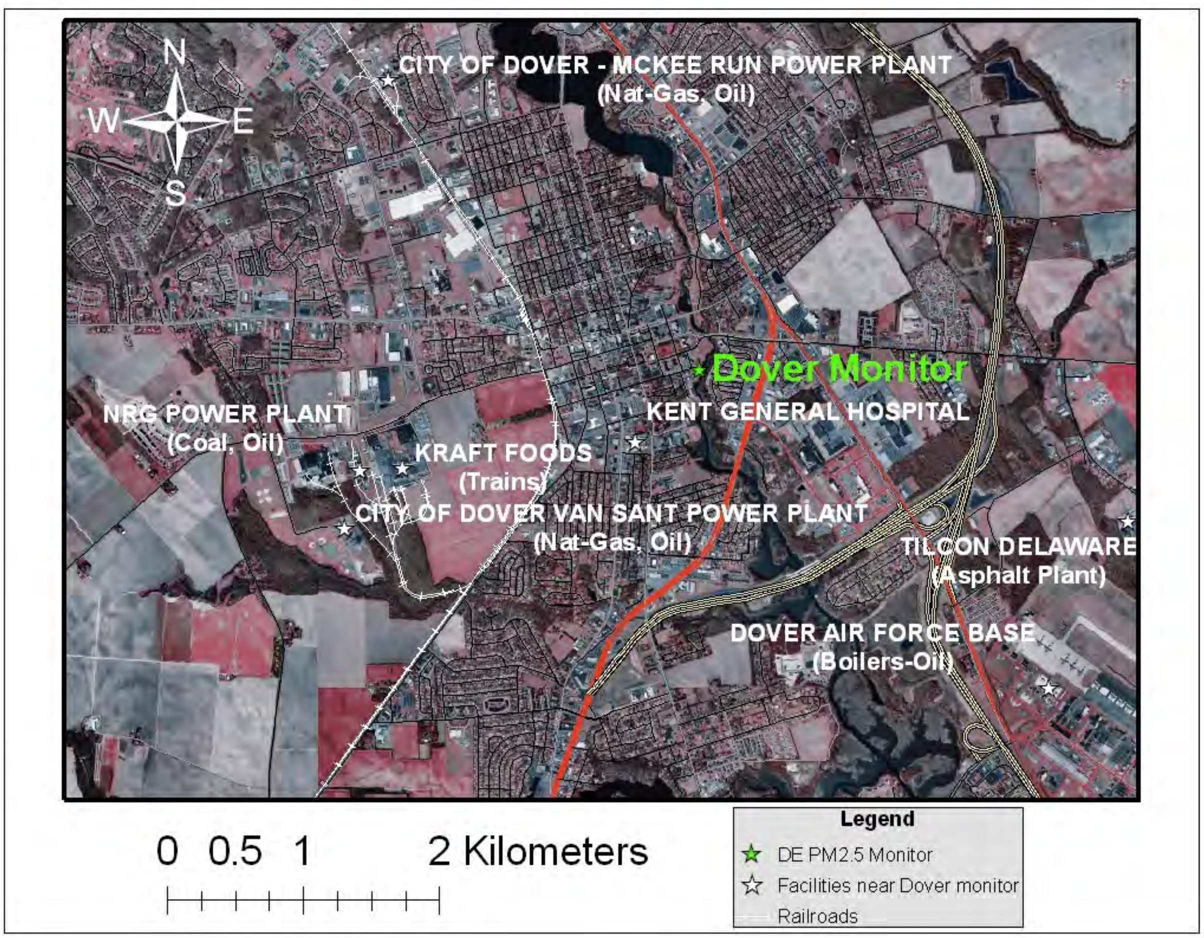


Figure 2. Map of Dover, DE showing the location of the STN site.

concentrations and analyzed via any of five different energy dispersive X-ray fluorescence (XRF) spectrometers for the elemental analysis located in three laboratories: Chester LabNet, Cooper Environmental Services, and Research Triangle Institute (RTI). The Nylon filter is analyzed for sulfate (SO_4^{2-}), nitrate (NO_3^-), ammonium (NH_4^+), sodium (Na^+), and potassium (K^+) via ion chromatography (IC). To minimize the sampling artifacts for NO_3^-, a MgO denuder is included at the upstream of the Nylon filter (Koutrakis et al., 1988; Hering et al., 1999). Two instruments for anions and three instruments for cations in RTI were used for the Nylon filter analyses. The quartz filter was analyzed by one of three instruments at RTI via National Institute for Occupational Safety and Health/Thermal Optical Transmittance (NIOSH/TOT) protocol (Birch et al., 1996) for OC and elemental carbon (EC). Carbon denuders that minimize positive sampling artifact caused by adsorption of gaseous organic materials are not included upstream of the quartz filter in the STN samplers (Gundel et al. 1995; Pankow et al., 2001). None of the reported STN data were blank corrected (RTI, 2004a).

Table 1 Summary of STN sites in Delaware.

AIRS code	Monitoring site	Sampler	Latitude	Longitude	sampling period
100032004	Wilmington, DE	SASS [1]	39.7394	-75.5581	June 2001 - Nov. 2003
100010003	Dover, DE	SASS	39.1550	-75.5181	June 2001 - Nov. 2003

[1] Spiral Aerosol Speciation Sampler

APPENDIX A

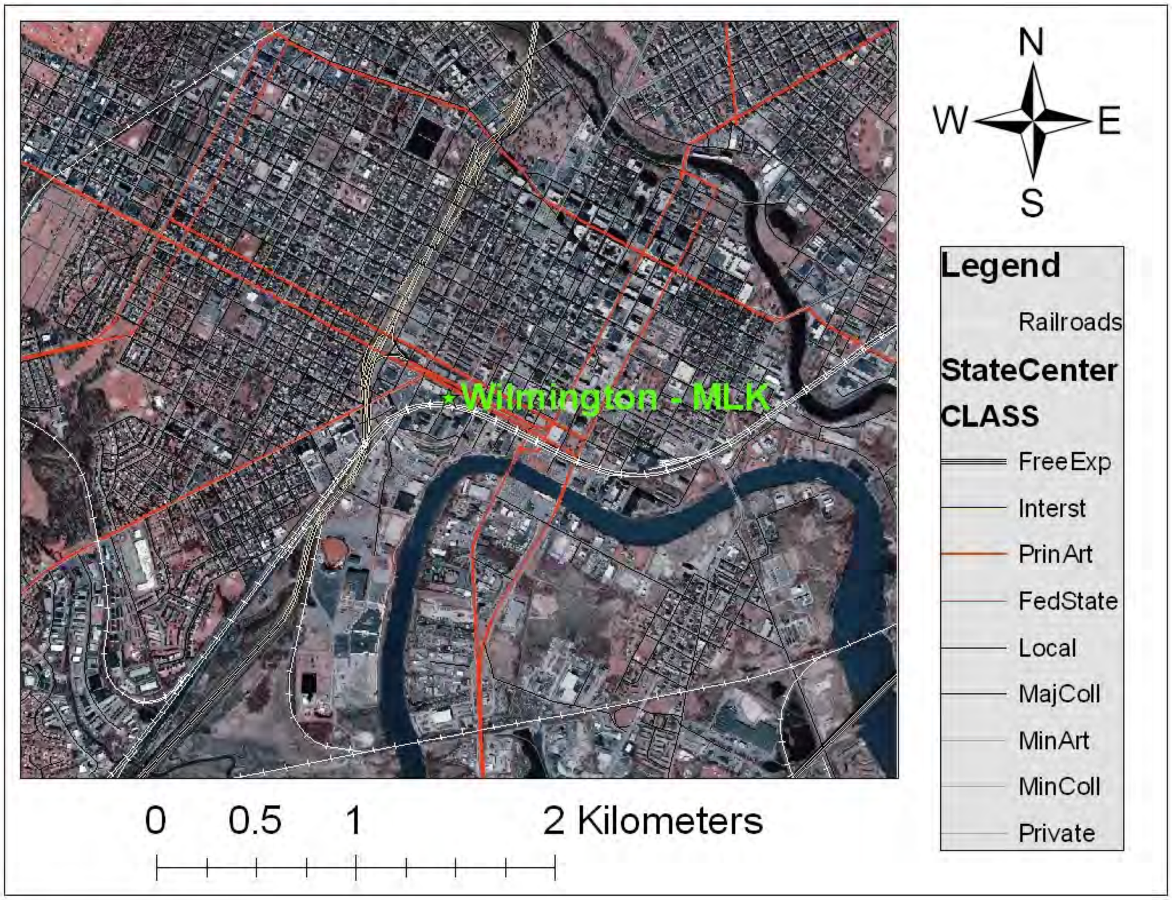


Figure 3. Map of Wilmington, DE showing the location of the STN site.

ESTIMATION OF OC BLANK VALUES

Tolocka et al. (2001) in a comparison study among STN samplers (i.e., Reference Ambient Air Sampler), Federal Reference Method (FRM) sampler, and Versatile Air Pollution Sampler (VAPS) observed that the OC concentration measured by both STN and FRM samplers that did not include carbon denuder at the upstream of quartz filter were consistently higher than the values sampled by VAPS that had a carbon denuder preceding the quartz filter. Since the reported particulate OC concentrations were not blank corrected and there appears to be a positive artifact in the OC concentrations measured by STN samplers, approaches to obtaining an integrated estimate of the OC blank concentrations including trip and field blank as well as OC positive artifact on quartz filter were tested. One of the ways for this estimation is utilizing the intercept of the regression of OC concentrations against $PM_{2.5}$ (Tolocka et al., 2001).

For the OC blank estimation, samples for which $PM_{2.5}$ or OC mass concentrations were not available were excluded. The sample that showed an extreme OC value on July 7, 2002 caused by a Canadian wildfire was excluded from both data sets from Wilminton and Dover. Comparing co-located $PM_{2.5}$ mass concentrations measured by STN and FRM, outliers (June 24 and November 15, 2001 at Wilmington data set) were censored before the regression analyses between STN $PM_{2.5}$ and OC concentrations.

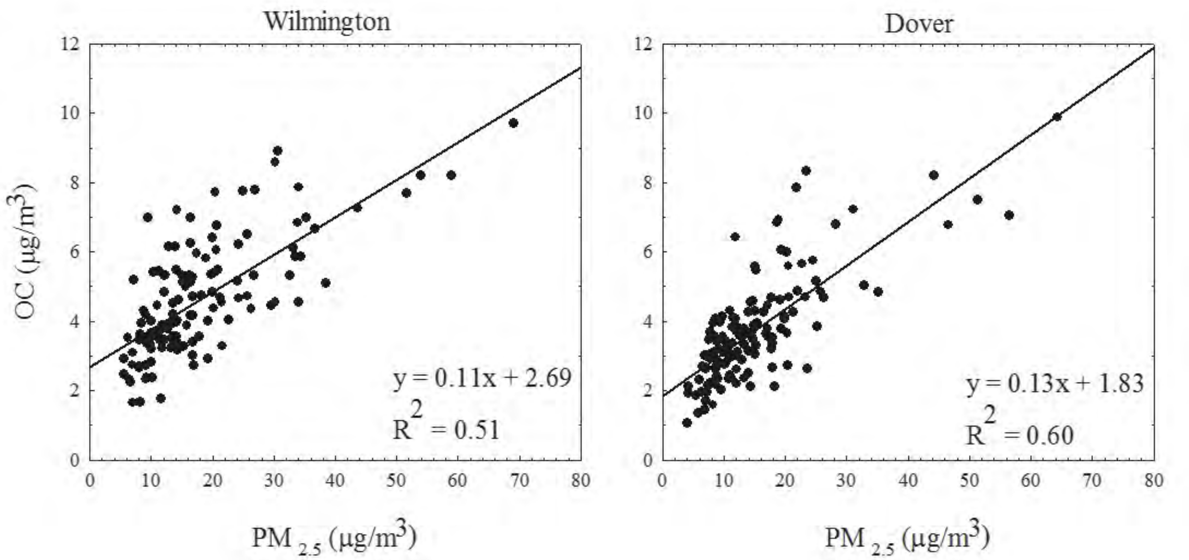


Figure 4. $PM_{2.5}$ versus OC concentration measured at two sites in Delaware.

In Figure 4, $PM_{2.5}$ mass concentrations were compared with OC concentrations for the Wilmington and Dover sites. The intercepts in $PM_{2.5}$ regression against OC concentrations are then considered to be the integrated OC blank concentrations that includes trip blank concentrations as well as positive sampling artifacts by adsorption of gaseous organic matter. The results for the two monitoring sites are summarized in Table 2. For the source apportionment study, the reported STN OC concentrations were blank corrected by subtracting the estimated OC blank concentrations from the measured values.

APPENDIX A

Table 2. Summary of OC blank concentrations estimated from regression of $PM_{2.5}$ mass concentrations against OC concentrations.

Monitoring site	OC blank (µg/m^3)
Wilmington, DE	2.69
Dover, DE	1.83

METHOD DETECTION LIMIT VALUES AND ERROR ESTIMATES

The application of PMF depends on the estimated uncertainties for each of the measured data. The uncertainty estimation based on the analytical uncertainties and laboratory method detection limit (MDL) values provides a useful tool to decrease the weight of missing and below detection limit (BDL) data in these methods. Polissar et al. (1998) suggested a procedure for estimating uncertainties for the PMF study of seven Interagency Monitoring of Protected Visual Environments (IMPROVE) $PM_{2.5}$ speciation data sets, in which data uncertainties and MDL values were well defined. In STN data, various instruments were used to analyze samples and they produce different MDL values and analytical uncertainties. Since prior to July 2003, the STN data were not accompanied by MDL values and uncertainties, it is not possible to identify which instrument was used for the analysis of any particular sample and thus, it is not possible to assign its particular MDL values and uncertainties for that sample. Therefore, a comprehensive set of MDL values and error structures that can be used for source apportionment studies are estimated as described by Kim et al. (2005a).

From the investigation of appropriate MDL values for PMF analyses, the average MDL values among MDL values from five XRF spectrometers (Chester770, Chester771, Cooper, RTI1, RTI2) were selected for this project and presented in Table 3.

A limited set of the XRF analytical uncertainties for thirteen eastern STN sites for samples collected between March 2001 and November 2003 were acquired from the U.S. EPA. The reported analytical uncertainties for S, Si, K, and Fe from the five instruments in three laboratories were compared in Figure 5. Various species, instruments, and laboratories show different analytical uncertainty structures. As can be seen from the Figure 5, the uncertainties are given as fractions of measured mass concentrations. To develop a comprehensive set of errors that could be used for PMF studies across the STN, a general fractional error was estimated by comparing the available measured concentrations and their associated uncertainties. To generate the error structures, the fractional errors that are estimated as a fraction of the measured concentrations are chosen to encompass most of the reported uncertainties as shown by the lines in Figure 5 and to provide the most reasonable PMF solution. The specific values for each element are shown in Table 3. Thus, based on the studies of Polissar et al. (1998), the error structures (s_{ij}) were calculated using the following equation:

$$s_{ij} = \left[MDL_j\right]/3 + k \cdot x_{ij} \qquad (1)$$

where x_{ij} is the jth species concentration measured in the ith sample and the values of k are given in Table 3.

Table 3. Estimated MDL values and fractional uncertainties for the EPA STN data measured at Wilmington and Dover, DE.

Species	Method detection limit (ng/m^3)	Uncertainty (%)
PM_{25}	746.27	7.0
OC	243.78	7.0
EC	243.78	7.0
SO_4^{2-}	12.44	7.0
NH_4^+	16.58	7.0
NO_3^-	8.71	7.0
K^+	13.89	7.0
Na^+	30.06	7.0
Al	16.43	10.0
Sb	22.16	5.0
As	7.07	20.0
Ba	34.65	5.0
Br	1.81	5.0
Cd	10.45	5.0
Ca	5.18	11.0
Ce	52.55	5.0
Cs	24.55	5.0
Cl	8.33	10.0
Cr	1.81	5.0

Co	1.47	10.0
Cu	1.92	5.0
Eu	6.95	5.0
Ga	3.73	5.0
Au	5.90	5.0
Hf	22.03	5.0
In	12.90	5.0
Ir	7.28	5.0
Fe	2.00	5.0
La	41.08	5.0
Pb	4.72	5.0
Mg	23.23	5.0
Mn	2.04	5.0
Hg	4.22	5.0
Mo	6.98	5.0
Ni	1.45	5.0
Nb	4.30	5.0
P	7.58	10.0
K	7.07	10.0
Rb	2.03	5.0
Sm	5.38	5.0
Sc	1.55	5.0
Se	2.46	5.0
Si	12.48	10.0
Ag	9.36	5.0
Na	78.54	10.0
Sr	2.40	5.0
S	10.02	11.0
Ta	14.53	5.0
Tb	5.81	5.0
Sn	18.38	5.0
Ti	3.52	5.0
V	2.34	5.0
W	11.24	5.0
Y	2.93	5.0
Zn	1.98	5.0
Zr	3.60	5.0

APPENDIX A

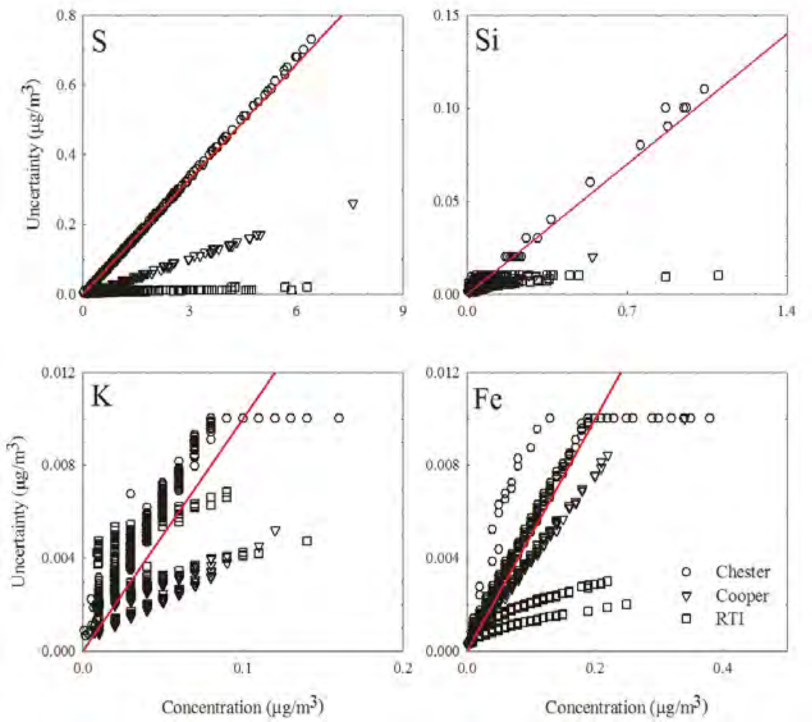


Figure 5. The comparison between measured concentrations and associated uncertainties.

MULTIVARIATE RECEPTOR MODELING

An ambient $PM_{2.5}$ compositional data set of 24-hour integrated samples collected at a STN site in Burlington, VT were analyzed through the application of PMF to examine the estimated error structures and to investigate the appropriate MDL values. The receptor modeling problem can be expressed in terms of the contribution from *p* independent sources to all chemical species in a given sample as follows (Miller et al., 1972; Hopke, 1985),

$$x_{ij} = \sum_{s=1}^{p} g_{is} f_{sj} + e_{ij} \tag{2}$$

where g_{is} is the particulate mass concentration from the *s*th source contributing to the *i*th sample, f_{sj} is the *j*th species mass fraction from the *s*th source, e_{ij} is residual associated with the *j*th species concentration measured in the *i*th sample, and *p* is the total number of independent sources. PMF provides a solution that minimizes an object function, *Q(E)*, based upon uncertainties for each observation (Polissar et al., 1998; Paatero, 1997).

$$Q(E) = \sum_{i=1}^{n}\sum_{j=1}^{m}\left[\frac{x_{ij} - \sum_{s=1}^{p} g_{is} f_{sj}}{u_{ij}}\right]^2 \quad (3)$$

where u_{ij} is an uncertainty estimate in the *j*th constituent measured in the *i*th sample.

There are an infinite number of possible combinations of source contribution and profile matrices to the multivariate receptor modeling problem due to the free rotation of matrices (Henry, 1987). PMF uses non-negativity constraints on the factors to decrease rotational ambiguity. Also, the parameter FPEAK and the matrix FKEY are used to control the rotations (Lee et al., 1999; Paatero et al., 2002). By setting a non-zero values of FPEAK, the routine is forced to add one source contribution vector to another and subtract the corresponding source profile factors from each other and thereby yield more physically realistic solutions. PMF was run with different FPEAK values to determine the range within which the scaled residuals remains relatively constant (Paatero et al., 2002; Kim et al., 2003b). The optimal solution should lie in this FPEAK range. In this way, subjective bias was reduced to a large extent. External information can be imposed on the solution to control the rotation. If specific species in the source profiles are known to be zero, then it is possible to pull down those values towards lower concentration through appropriate settings of FKEY resulting in the most interpretable source profiles. Each element of the FKEY matrix controls the pulling-down of the corresponding element in the source profile matrix by setting a non-zero integer values in FKEY matrix (Lee et al., 1999).

Based on the studies of Polissar et al. (1998), the measured concentrations below the MDL values were replaced by half of the MDL values and their uncertainties were set at 5/6 of the MDL values. Missing concentrations were replaced by the geometric mean of the concentrations and their accompanying uncertainties were set at four times of this geometric mean concentration.

APPENDIX A

For the application of PMF, only samples for which $PM_{2.5}$ or OC mass concentrations were not available were excluded from data set measured at Wilmington and Dover sites. To obtain reasonable model fit, the Canadian wildfire sample on July 7, 2002 in which $PM_{2.5}$ and OC mass concentrations were unusually high was excluded in the source apportionment study. Overall, 21 and 18 % of the original data was excluded from Wilmington and Dover data, respectively. XRF S and IC SO_4^{2-} showed excellent correlations (*slope* = 3.4, r^2 = 0.98 for Wilmington data; *slope* = 3.2, r^2 = 0.96 for Dover data), so it is reasonable to exclude XRF S from the analysis to prevent double counting of mass concentrations. Also, IC Na^+ and IC K^+ were chosen due to the higher analytical precision compared to XRF Na and XRF K. Chemical species that have values more than 90 % below MDL were excluded. Thus, a total of 117 samples and 29 species including $PM_{2.5}$ mass concentrations and a total of 122 samples and 30 species including $PM_{2.5}$ mass concentrations collected between June 2001 and November 2003 were used for the Wilmington and Dover analyses, respectively.

Species that have Signal/Noise (S/N) ratios between 0.2 and 2 were considered weak variables and their estimated uncertainties were increased by a factor of five to reduce their weight in the solution as recommended by Paatero and Hopke (2003). The Nylon filters were contaminated with Na^+ between October 2001 and January 2002 and were reported with error flags (RTI, 2004b). Their estimated uncertainties were increased by a factor of thirty. Summaries of $PM_{2.5}$ speciation data and S/N ratios are provided in Tables 4 and 5.

In these analyses, the measured $PM_{2.5}$ mass concentration was included as an independent variable in the PMF modeling to directly obtain the mass apportionment without the usual multiple regression. The utilization of $PM_{2.5}$ mass concentration as a variable is specified in detail in Kim et al. (2003b)

Finally, to obtain physically reasonable PMF solution, it was necessary to test different numbers of sources and different FPEAK values with the final choice based on the evaluation of the resulting source profiles as well as the quality of the species fits. The global optimum of the PMF solutions were tested by using multiple random starts for the initial values used in the iterative fitting process.

APPENDIX A

CONDITIONAL PROBABILITY FUNCTION ANALYSIS

The conditional probability function (CPF) (Kim et al., 2003b) was calculated to analyze point source impacts from various wind directions using source contribution estimates from PMF coupled with wind direction values measured on site. The same daily fractional contribution was assigned to each hour of a given day to match to the hourly wind data. The CPF is defined as

$$CPF = \frac{m_{\Delta\theta}}{n_{\Delta\theta}} \tag{4}$$

where $m_{\Delta\theta}$ is the number of occurrence from wind sector $\Delta\theta$ that exceeded the threshold criterion, and $n_{\Delta\theta}$ is the total number of data from the same wind sector. In this study, 16 sectors were used ($\Delta\theta$ = 22.5 degrees). Calm winds (< 1 m/sec) were excluded from this analysis due to the isotropic behavior of wind vane under calm winds. From tests with several different percentile of the fractional contribution from each source, the threshold criterion of the upper 25 percentile was chosen to clearly show the directionality of the sources. The sources are likely to be located to the direction that have high conditional probability values.

POTENTIAL SOURCE CONTRIBUTION FUNCTION

To identify the likely locations of the regional sources for the secondary sulfate aerosols, the potential source contribution function (PSCF) (Ashbaugh et al., 1985; Hopke et al., 1995) was calculated using the source contributions estimated from PMF and backward trajectories calculated using the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model (Draxler et al., 2003; Rolph et al., 2003). Five-day backward trajectories starting at height of 500 m above the actual ground level were computed using the vertical mixing model every day producing 120 trajectories per sample. The geophysical region covered by the trajectories was divided into grid cells of 1° × 1° latitude and longitude so that there are an average of 2 trajectory end points per cell. If a trajectory end point of the air parcel lies in the *ij*th cell, the trajectory is assumed to collect $PM_{2.5}$ emitted in the cell. Once the $PM_{2.5}$ is incorporated into the air parcel, it is assumed to be transported along the trajectory to the monitoring site. $PSCF_{ij}$ is the conditional probability that an air parcel that passed through the *ij*th cell had a high concentration upon arrival at the monitoring site defined as

APPENDIX A

$$PSCF_{ij} = \frac{m_{ij}}{n_{ij}} \tag{5}$$

where n_{ij} is the total number of end points that fall in the *ij*th cell and m_{ij} is the number of end points in the same cell that are associated with samples that exceeded the threshold criterion. In this study, the average contribution of each source was used for the threshold criterion. The sources are likely to be located in the area that have high PSCF values.

To minimize the effect of small values of n_{ij} that result in high PSCF values with a high uncertainties, an arbitrary weight function $W(n_{ij})$ was applied to downweight the PSCF values for the cell in which the total number of end points was less than three times the average number of the end points per cell (Hopke et al., 1995; Polissar et al., 2001).

$$W(n_{ij}) = \begin{cases} 1.0 & 8 < n_{ij} \\ 0.7 & 3 < n_{ij} \le 8 \\ 0.4 & 2 < n_{ij} \le 3 \\ 0.2 & 2 \le n_{ij} \end{cases} \tag{6}$$

APPENDIX A

Table 4. Summary of $PM_{2.5}$ species mass concentrations at Wilmington, DE.

Species	Arithmetic mean (ng/m^3)	Geometric mean (ng/m^3)	Minimum (ng/m^3)	Maximum (ng/m^3)	Number of below MDL values (%)	Number of missing values (%)	S/N ratio
$PM_{2.5}$	18539.3	16432.4	5500.0	69100.0	0	0	28.5
OC	2171.4	1540.2	20.0	10310.0	5.1	0	11.3
EC	821.5	752.5	255.0	2260.0	0	0	3.7
S	1819.4	1438.6	312.0	9490.0	0	0	222.6
NH_4^+	2544.0	2003.1	179.0	11400.0	0	0	189.6
NO_3^-	2575.0	1884.3	261.0	10100.0	0	0	379.5
Al	22.8	15.5	1.3	245.0	73.5	0	1.8
Ba	36.6	32.0	0.7	98.1	65.8	0	1.0
Br	3.9	3.2	0.1	12.7	20.5	0	2.3
Ca	35.5	31.4	6.5	90.3	0.0	0	7.4
Cl	35.1	14.3	0.1	344.0	62.4	0	6.6
Cr	1.8	1.4	0.1	5.3	63.2	0	1.0
Cu	13.2	8.9	0.1	95.3	2.6	0	9.8
Fe	112.3	95.0	26.0	437.0	0.0	0	63.6
Pb	5.6	4.3	0.2	41.6	63.2	0	1.3
Mg	26.9	20.5	0.1	213.0	88.9	0	1.0
Mn	3.5	2.7	0.2	15.2	42.7	0	1.9
Ni	4.2	3.3	0.6	13.6	12.8	0	3.2
P	6.6	6.0	0.1	17.9	88.9	0	0.5
K	74.8	64.9	17.1	268.0	70.1	0	3.4
Se	2.1	1.8	0.1	6.5	70.9	0	0.9
Si	78.2	63.6	5.6	496.0	0.9	0	7.9
Na	225.7	141.9	1.0	1610.0	6.0	0.4	11.6
Sr	1.7	1.6	0.1	18.5	88.9	0	0.8
Ta	14.5	12.1	0.9	45.4	76.9	0	0.9
Sn	11.9	11.7	1.4	42.8	82.9	0	0.6
Ti	6.4	4.9	0.2	21.5	29.9	0	2.1
V	7.8	5.9	0.6	27.3	12.8	0	4.0
Zn	12.8	9.0	0.5	98.8	4.3	0	8.8

APPENDIX A

Table 5. Summary of $PM_{2.5}$ species mass concentrations at Dover, DE.

Species	Arithmetic mean (ng/m^3)	Geometric mean (ng/m^3)	Minimum (ng/m^3)	Maximum (ng/m^3)	Number of below MDL values (%)	Number of missing values (%)	S/N ratio
$PM_{2.5}$	15235.2	13344.8	4200.0	64300.0	0	0	24.0
OC	1983.5	1396.3	15.0	8045.0	4.9	0	10.4
EC	467.8	406.9	12.9	1320.0	10.7	0	2.1
S	1599.3	1248.8	359.0	8860.0	0	0	201.1
NH_4^+	1960.9	1445.3	48.1	11800.0	0	0	153.9
NO_3^-	1812.2	1306.5	245.0	8480.0	0	0	279.9
Al	19.6	14.4	0.5	152.0	78.7	0	1.2
Ba	34.9	29.4	0.4	95.8	62.3	0	1.0
Br	3.2	2.6	0.1	8.2	27.9	0	1.8
Ca	33.7	24.4	4.8	240.0	3.3	0	8.7
Ce	28.1	28.5	0.2	99.2	87.7	0	0.5
Cl	23.7	10.6	0.2	348.0	74.6	0	4.6
Cr	1.5	1.2	0.1	9.1	82.8	0	0.9
Cu	3.1	2.0	0.1	12.1	61.5	0	2.0
La	20.6	23.5	0.2	75.8	88.5	0	0.5
Pb	3.5	3.0	0.0	12.3	78.7	0	0.7
Mn	2.0	1.7	0.1	6.7	62.3	0	1.0
Ni	2.2	1.6	0.1	7.9	45.1	0	1.7
K	64.2	57.4	3.1	115.0	70.5	0	2.7
Sc	0.9	0.8	0.1	3.2	86.9	0	0.4
Se	1.9	1.7	0.0	8.6	75.4	0	0.8
Si	82.3	59.7	3.3	554.0	1.6	0	9.2
Na	262.0	161.3	4.2	1650.0	6.6	0	12.8
Sr	1.7	1.5	0.1	9.7	87.7	0	0.7
Ta	12.0	10.4	0.5	50.8	81.1	0	0.8
Sn	12.3	12.0	0.1	56.0	81.1	0	0.7
Ti	4.9	3.7	0.3	25.2	47.5	0	1.7
V	3.3	2.6	0.1	11.2	43.4	0	1.6
Zn	6.8	4.6	0.1	44.9	22.1	0	4.5

APPENDIX A

RESULTS AND DISCUSSION

A variety of factor number solutions were explored for Wilmington and Dover data sets. A nine-source model and a value of FPEAK = 0 provided the most physically reasonable source profiles for the Wilmington data. For the Dover data, six-source model, a value of FPEAK = 0, and a FKEY matrix provided the most reasonable source profiles. For the FKEY matrix, values of all elements were set to zero, except: value of 5 for NH_4^+ in airborne soil. The average source contributions of each source to the $PM_{2.5}$ mass concentrations are provided in Tables 6 and 7.

Table 6. Average source contributions to $PM_{2.5}$ mas concentration at Wilmington, DE.

Sources	Average source contribution (standard error)	
	Mass concentration (µg/m^3)	Percentile (%)
Secondary sulfate	6.97 (0.72)	37.9 (3.9)
Secondary nitrate	3.12 (0.28)	17.0 (1.5)
Gasoline vehicle	2.18 (0.17)	11.9 (0.9)
Oil combustion	1.52 (0.11)	8.3 (0.6)
Railroad	1.10 (0.08)	6.0 (0.4)
Airborne soil	1.09 (0.11)	6.0 (0.5)
Aged sea salt	1.03 (0.11)	5.6 (0.6)
Bus depot	0.79 (0.09)	4.3 (0.5)
Diesel emissions	0.57 (0.06)	3.1 (0.3)

APPENDIX A

Table 7. Average source contributions to $PM_{2.5}$ mas concentration at Dover, DE.

Sources	Average source contribution (standard error)	
	Mass concentration (µg/m^3)	Percentile (%)
Secondary sulfate	7.50 (1.45)	49.6 (9.6)
Gasoline vehicle	2.38 (0.35)	15.8 (2.3)
Secondary nitrate	1.50 (0.30)	9.9 (2.0)
Aged sea salt	1.44 (0.27)	9.5 (1.8)
Diesel emissions	1.19 (0.20)	7.9 (1.3)
Airborne soil	1.11 (0.21)	7.3 (1.4)

In Figure 6, comparisons of the daily reconstructed $PM_{2.5}$ mass contributions from all sources with measured $PM_{2.5}$ mass concentrations shows that the resolved sources effectively reproduce the measured values and account for most of the variation in the $PM_{2.5}$ mass concentrations ($slope$ = 0.95 ± 0.02 and r^2 = 0.95 for Wilmington; $slope$ = 1.04 ± 0.02 and r^2 = 0.94 for Dover). In Figure 7, the averaged seasonal contributions from each source are compared (summer: April - September; winter: October - March). The source profiles, corresponding source contributions, CPF plots, and weekday/weekend variations are presented in Figures 8 - 15.

Secondary sulfate aerosols are represented by its high concentrations of SO_4^{-2} and NH_4^+. Secondary sulfate had the highest source contribution to $PM_{2.5}$ mass concentrations accounting for 38 % (7.0 µg/m^3) and 50 % (7.5 µg/m^3) of the $PM_{2.5}$ mass concentration at Wilmington and Dover, respectively. As shown in Figures 7, 9 and 13, the secondary sulfate factor show strong seasonal variation with higher concentrations in summer when the photochemical activity is highest indicating origination from coal-fired electricity generating plants. When compared to the studies based on Interagency Monitoring of Protected Visual Environments (IMPROVE) data in which PMF separated summer and winter-high secondary sulfate aerosols with seasonal differences of the Se/S concentrations (Kim and Hopke, 2004a, b; Kim et al., 2005b), the Se data were inadequate to permit the winter-high secondary sulfate aerosol to be extracted in this analyses.

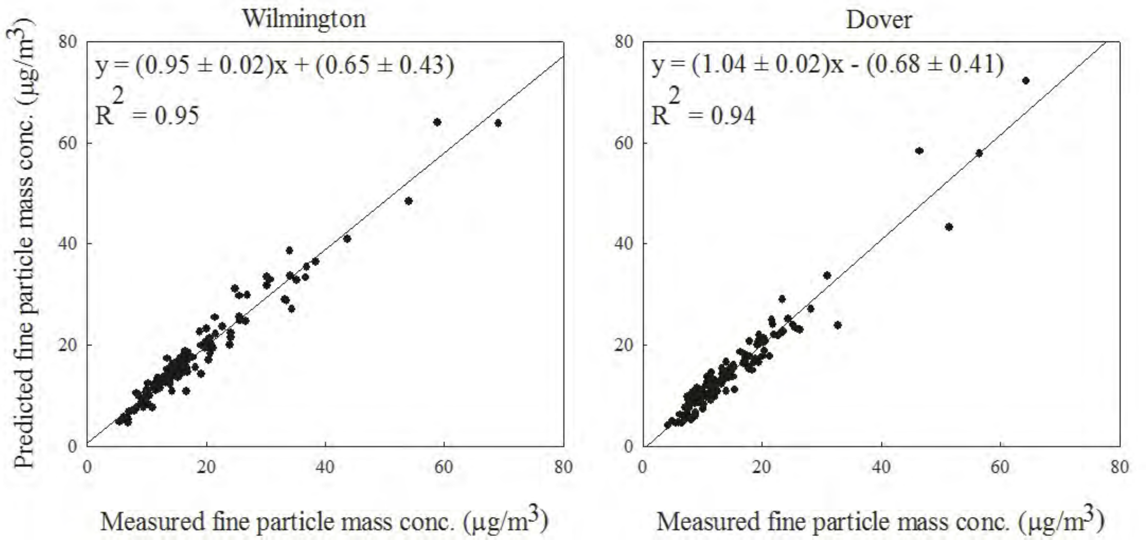


Figure 6. Measured versus PMF predicted $PM_{2.5}$ mass concentrations

In Figures 9 and 13, both monitoring sites were impacted by high concentrations of secondary sulfates aerosols: 48.5 µg/m^3 (Wilmington) and 43.9 µg/m^3 (Dover) on July 19, 2002; 45.8 µg/m^3 (Wilmington) and 51.7 µg/m^3 (Dover) on June 26, 2003. The air mass backward trajectories were calculated for the days with high impacts using the HYSPLIT model starting height of 500 m above sea level using the vertical mixing model. As shown in Figures 16 and 17, the elevated contributions in both Wilmington and Dover were likely to be caused by the regional transport of secondary aerosols from midwestern coal-fired power plants in the Ohio River Valley (Poirot et al., 2001).

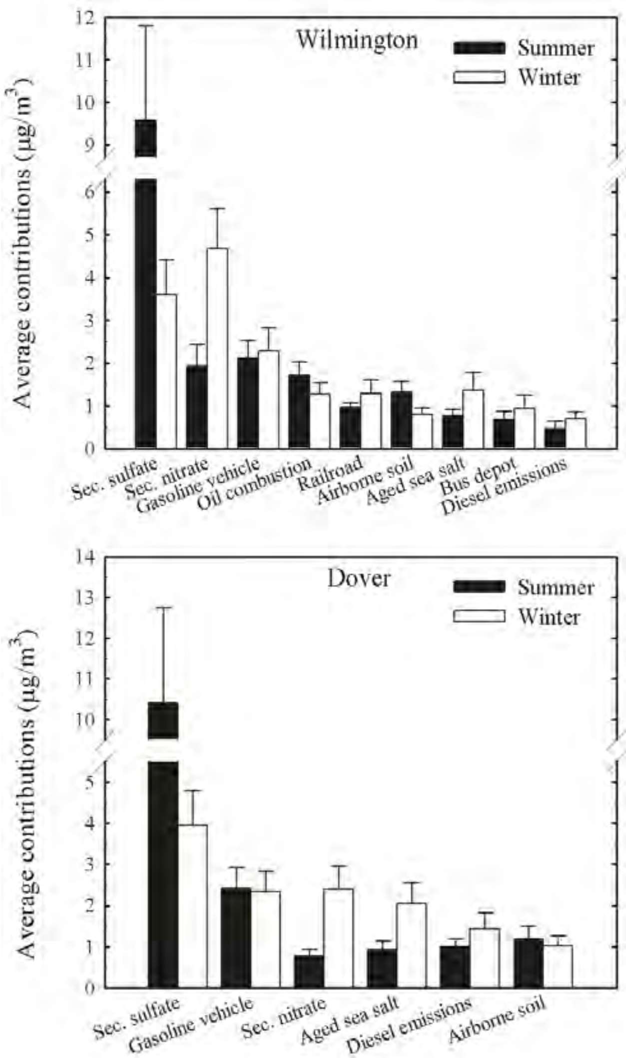


Figure 7. The seasonal comparison of source contributions to $PM_{2.5}$ mass concentration (mean ± 95 % confidential interval)

The PSCF plots for the secondary sulfate aerosol are shown in Figure 18 in which PSCF values are displayed in terms of a color scale. Potential source areas and pathways that give rise to the high contribution to the Wilmington site are located in Mississippi, northern Alabama, Georgia, Tennessee, western South Carolina, and southern Kentucky. These identified areas also include areas where the secondary sulfate aerosols were formed in addition to areas where the sources were located. There remain some potential source areas in the Ohio River Valley as well as St. Louis, MO. The PSCF plot for Dover sites shows high values around southeastern Kentucky, northern Alabama, and the coast of the southern Mississippi, Alabama, and Florida. There are significant petrochemical industries along the coast, but the detailed nature of these source areas is uncertain. There are also areas of potential influence in Georgia.

The prior PSCF analysis for IMPROVE data measured at Washington, DC (Kim and Hopke, 2005c) showed that the high potential areas of the summer and winter-high secondary sulfate aerosols included Ohio River Valley, southern Kentucky, Tennessee, southern Louisiana, Mississippi, and Alabama. The potential source areas of secondary sulfate aerosols contributing Delaware and Washington, DC are very similar, and it confirms our source apportionment studies with STN data.

APPENDIX A

Secondary nitrate aerosol is represented by its high concentration of NO_3^- and NH_4^+. The average contributions of this source to the $PM_{2.5}$ mass concentrations were 3.1 μg/m^3 and 1.5 μg/m^3 at Wilmington and Dover, respectively. This source has seasonal variation with maxima in winter as shown in Figures 7, 9, and 13. These peaks in winter indicate that low temperature and high relative humidity help the formation of nitrate aerosols. Particulate nitrate requires both the formation of HNO_3 from NO_x and the availability of NH_3 from a variety of emissions including animal husbandry, people, and spark-ignition vehicles. Although the CPF plots for both sites show the contributions from Philadelphia, PA and Baltimore, MD, it is likely that the ammonium nitrate arises from a combination of local and regional emissions.

Gasoline vehicle and diesel emissions are represented by high OC and EC, whose abundances differ between these sources (Watson et al., 1994). Gasoline vehicles emissions have high concentration of the OC. In contrast, diesel emissions were tentatively identified on the basis of the high concentration of EC. The CPF plots of gasoline vehicle and diesel emissions at the Wilmington site largely follow a line connecting 60° and 240°. Interstate highway I-95 runs from the southwest to the northeast of the site roughly in the direction indicated by the CPF plots. In addition, the plots indicate some impact from the downtown area located northeast of the site. Gasoline vehicle emissions do not show a strong weekday/weekend variations. In contrast, diesel emissions show weekday-high variations demonstrating that diesel emissions are from heavy-duty vehicles operating more on weekdays.

Another factor with high concentration of OC and EC was identified in Wilmington. It has a high concentration of Cu that might come from the metallic brakes used on large vehicles and has commonly been seen in diesel profiles in other studies (Kim and Hopke, 2004a,b; Kim et al., 2004a,b). The site in Wilmington is near to a bus depot as shown in Figure 2. This source may represent the emissions from the bus depot. The CPF plots of this source indicate impacts from bus depot located west of the site. The bus depot profile does not include Zn and Ca that are often seen in the diesel emissions profiles. These elements appear in the separate diesel emissions profile and may be more strongly related to the on-road trucks moving at higher speed. The bus depot does not show strong weekday/weekend variations as shown in Figure 11.

A third high-EC source was identified in Wilmington that has been tentatively assigned to be a combination of emissions from the nearby railroad and the Port of Wilmington. The main line AMTRAK tracks run parallel to the river to the south of the site, and the passenger terminal is situated southeast of the site. Although a large fraction of the trains are electric powered, there are a number of commuter and AMTRAK trains that use diesel engines. The profile contains a significant Fe concentration that was reported to be the major species emitted by electric trains in Zurich, Switzerland (Bukowiecki et al., 2004). The CPF plot of this source shows the contributions from southwest and southeast where the railroads and the Port of Wilmington are located. Railroad emission shows weekday-high variations. It appears that there may be directional specificity to help resolve multiple point sources of carbonaceous aerosol in Wilmington.

In Figure 14, the CPF plots for gasoline and diesel emissions identified in Dover indicate impacts from the highway junctions located northeast and southeast of the site, and the residential area located south and southwest of the site. The high diesel impact from west and high S concentration in source profile indicate that diesel emissions identified in Dover site are likely to be a combination of emissions from the nearby railroad and on-road diesel vehicles. Gasoline vehicle and diesel emissions do not show strong weekday/weekend variations in the Dover site.

The average $PM_{2.5}$ mass contributions from gasoline vehicle, diesel emissions, bus depot, and railroad were 2.2, 0.6, 0.8, and 1.1 $\mu g/m^3$ in Wilmington, respectively. In Dover, gasoline vehicle and diesel emissions contributed 2.4 and 1.2 $\mu g/m^3$ to $PM_{2.5}$ concentration.

Oil combustion is characterized by carbon fractions, V, and Ni. This source contributes 1.5 $\mu g/m^3$ to the $PM_{2.5}$ mass concentration in Wilmington. As shown in Figure 8, this source profile has large amount of EC reflecting residual oil combustion. This source does not show strong weekday/weekend variations. The CPF plot of this source in Figure 10 points to the northeast and southeast. Previous backward trajectory analyses for the Vermont aerosol study indicated that major sources of oil combustion were located along northeastern urban corridor between Washington, DC and Boston, MA (Polissar et al., 2001). There is a refinery in Delaware City which is south of the site and a large oil-fired power plant within a few km of this site to the south-south east. This plant also burns a significant quantity of coal in addition to residual oil. From the CPF plot, it appears that the Wilmington site is sufficiently close to oil-fired power plant that the plume rarely affects this site. There is a large oil-fired power plant in Salisbury, MD (soutwest) and another moderate sized plant in Dover, DE (south). These sources may contribute to the southerly probabilities. It is also possible that part of these source contributions is actually ship emissions from the direction of the Port of Wilmington. This source shows summer-high seasonal variation that tends to favor an assignment of oil fired power plants.

The airborne soil is represented by Si, Al, and Ca (Watson et al., 2001a, 2001b) contributing 1.1 $\mu g/m^3$ to the $PM_{2.5}$ mass concentration at both Wilmington and Dover sites. Crustal particles could be contributed by roads, construction sites, and wind-blown soil dust. There is a low background of contributions of soil throughout the year that are due to such local sources. There are seasonal variations with higher concentrations in the dry summer season. Prior STN data analysis for Burlington, VT (Kim et al., 2005a) identified the influence of a Saharan dust storm event on July 4, 2002. However, since the samples were not collected between July 1 and 7, 2002, this dust storm event was not identified in this analysis. The elevated contribution of airborne soil on July 19, 2002 and June 26, 2003 at Wilmington shown in Figure 9 were likely related to the regional transport from Midwest noted earlier (also shown in Figures 16 and 17), but could also represent small contributions from intercontinental dust transport. Figure 19 shows the air mass backward trajectories for 20 days, and the likely locations suggest that the elevated contribution on September 11, 2002 at Dover (in Figure 13) was not likely caused by a regional dust storm. There is only a small increase in the soil contribution in Wilmington such that it seems likely that this single high value is the result of a local event.

Aged sea salt is characterized by its high concentration of Na, SO_4^{2-} and NO_3^-. The lack of chlorine in the profile is presumed to be caused by chloride displacement by acidic gases. It also suggests that the particles are aged sea salt and not local road salt. Road salt would be expected to retain its chlorine and would be only seen during the winter months. Aged sea salt accounts for 1.0 and 1.4 $\mu g/m^3$ of the $PM_{2.5}$ mass concentrations in Wilmington and Dover, respectively. This source shows a winter-high seasonal pattern. Although the contaminated Na^+ collected between October 2001 and January 2002 were down-weighted in PMF analyses, the source contributions of aged sea salt in this period were relatively high. Therefore, there is a possibility that this source contribution is still inflated to some degree by this contamination.

APPENDIX A

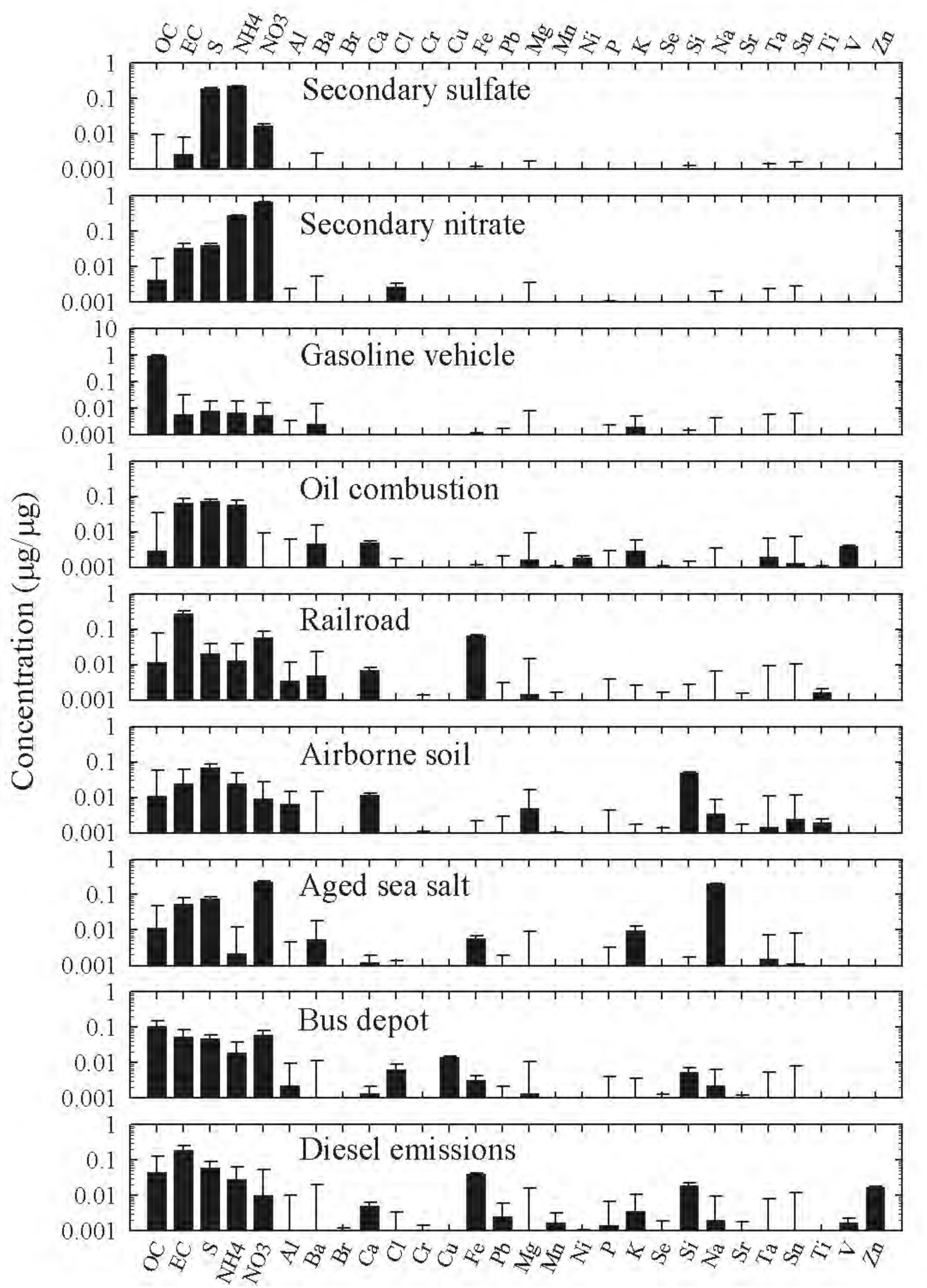


Figure 8. Source profiles deduced from $PM_{2.5}$ samples measured at Wilmington site (prediction ±standard deviation).

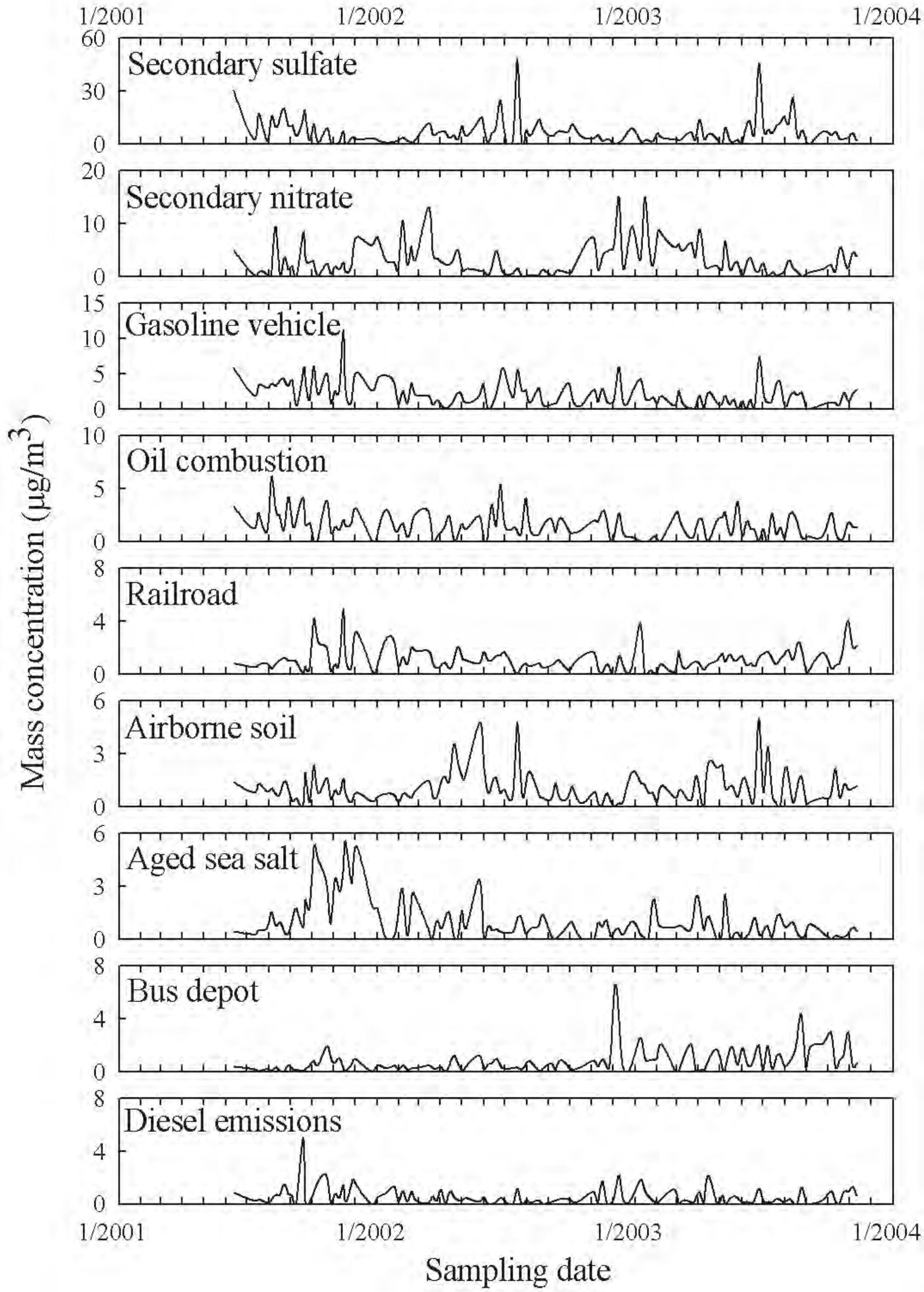


Figure 9. Time series plots of source contributions at Wilmington site.

APPENDIX A

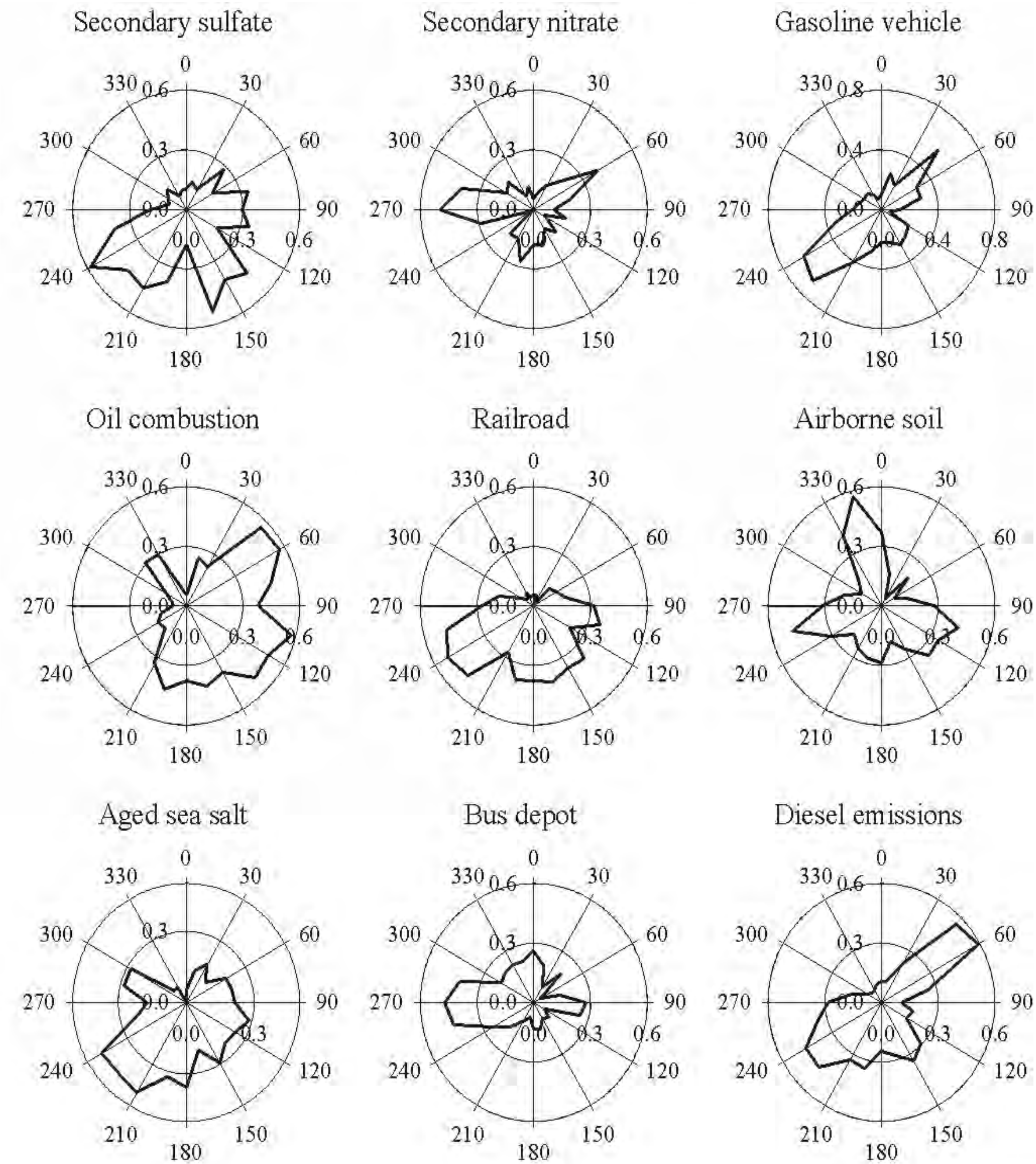


Figure 10. CPF plots for the highest 25 % of the mass contributions at Wilmington site.

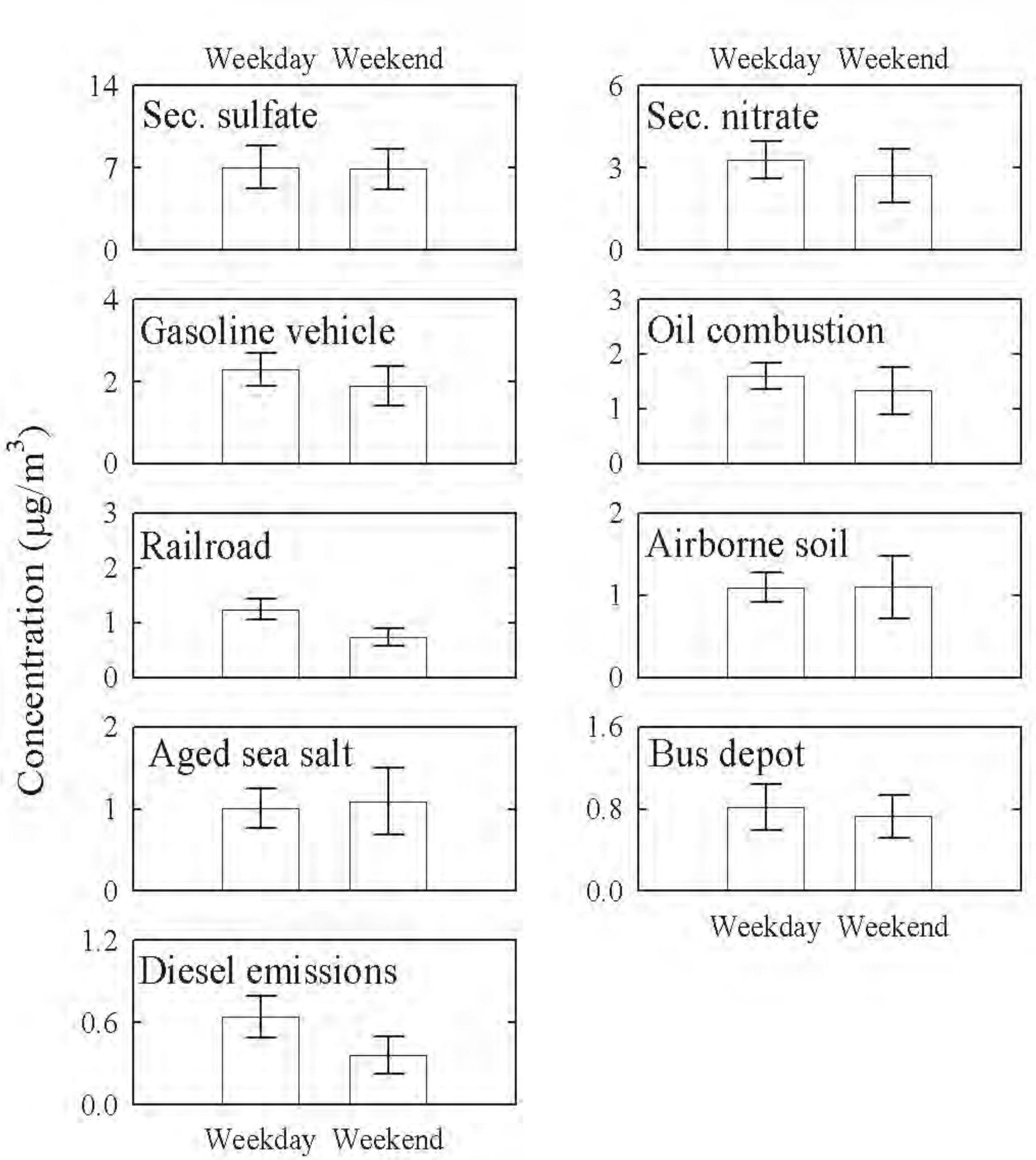


Figure 11. Weekend/weekend variations at Wilmington site.

APPENDIX A

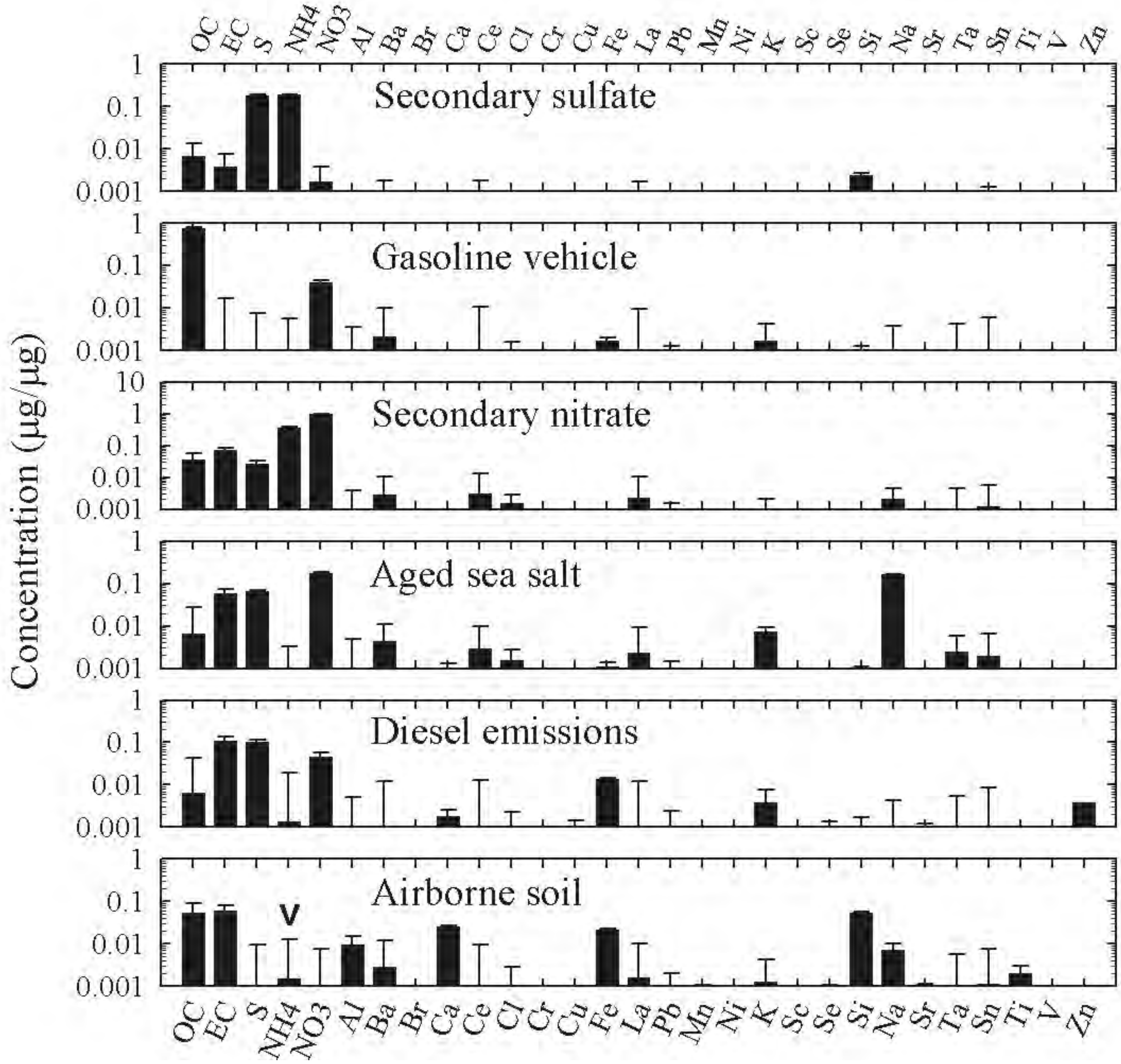


Figure 12. Source profiles deduced from $PM_{2.5}$ samples measured at Dover site (prediction ± standard deviation). The species that was pulled down by FKEY matrix is indicated by arrowhead.

APPENDIX A

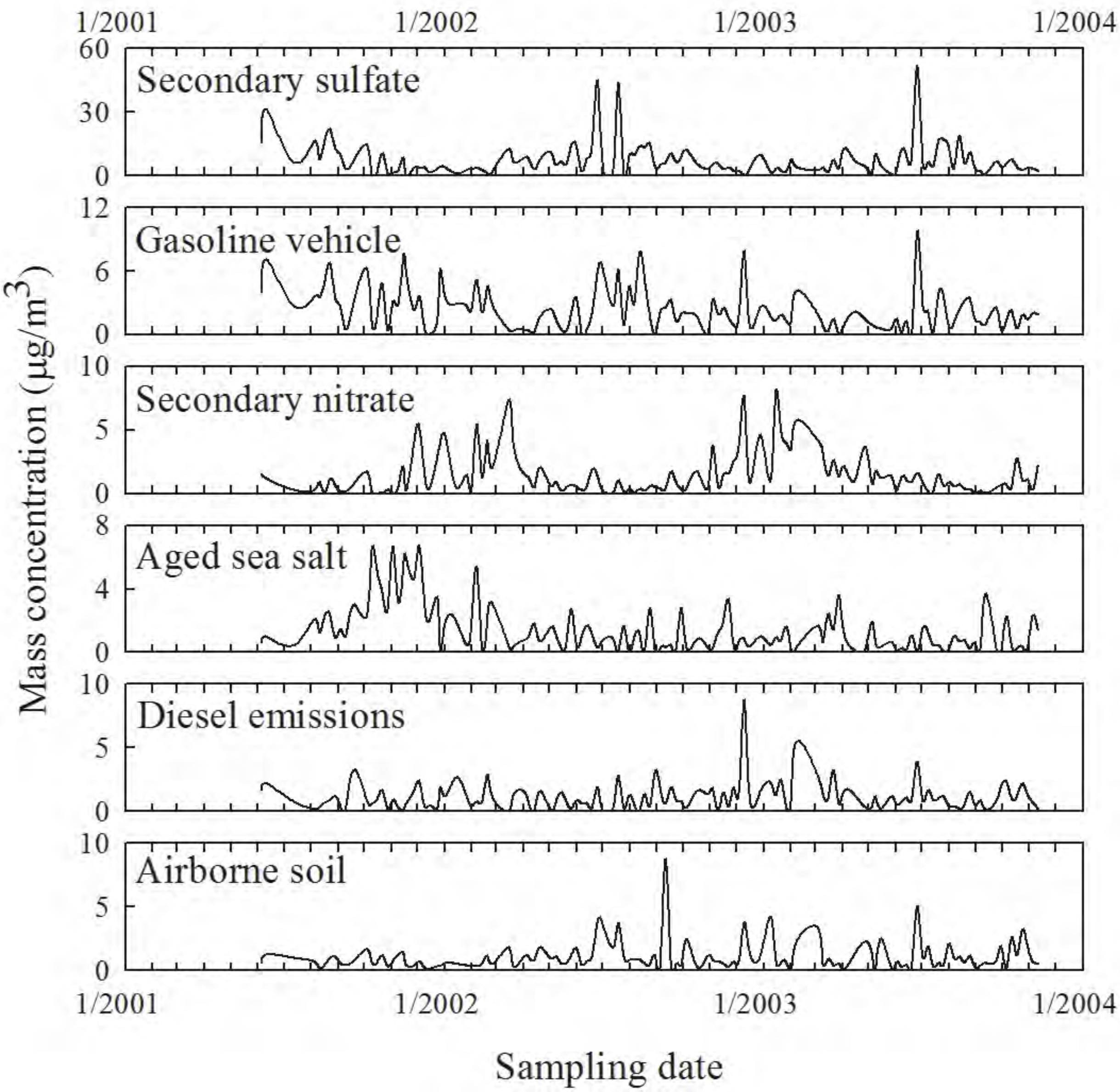


Figure 13. Time series plots of source contributions at Dover site.

APPENDIX A

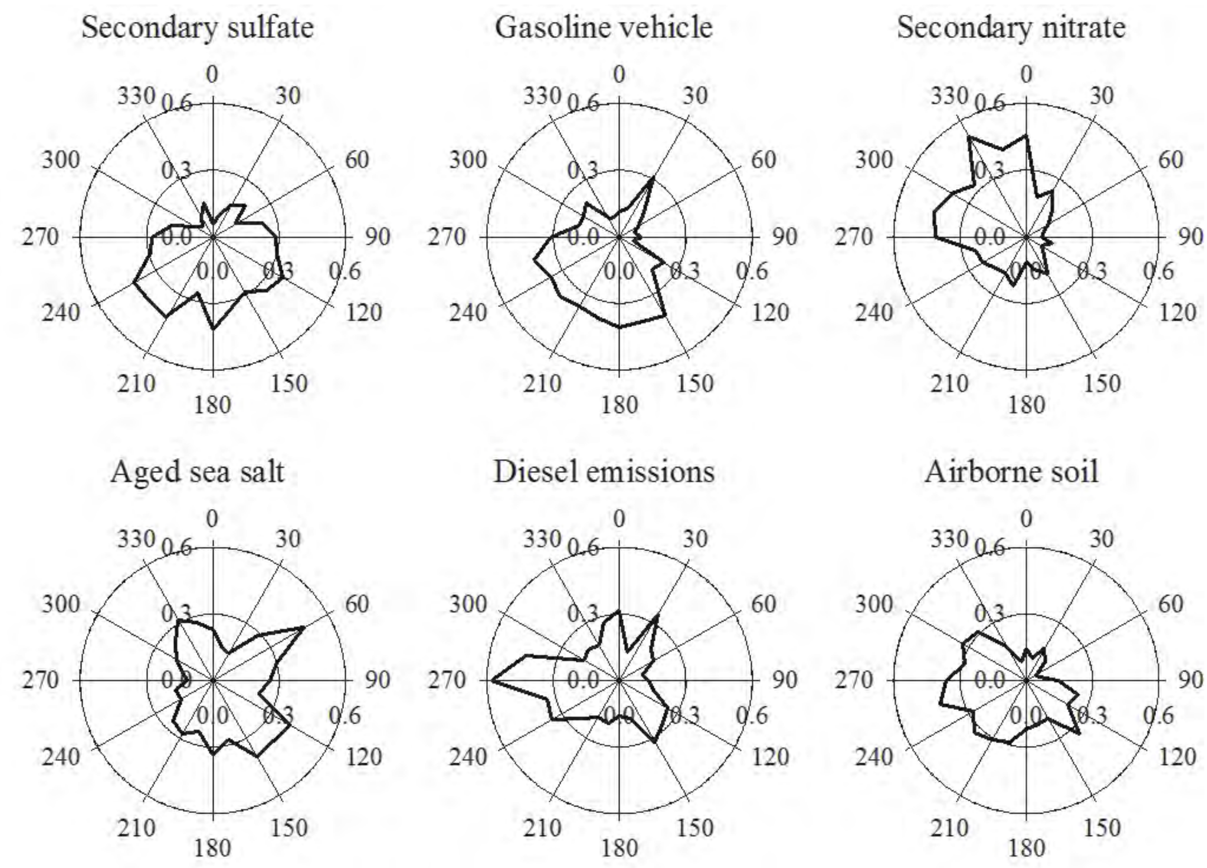


Figure 14. CPF plots for the highest 25 % of the mass contributions at Dover site.

APPENDIX A

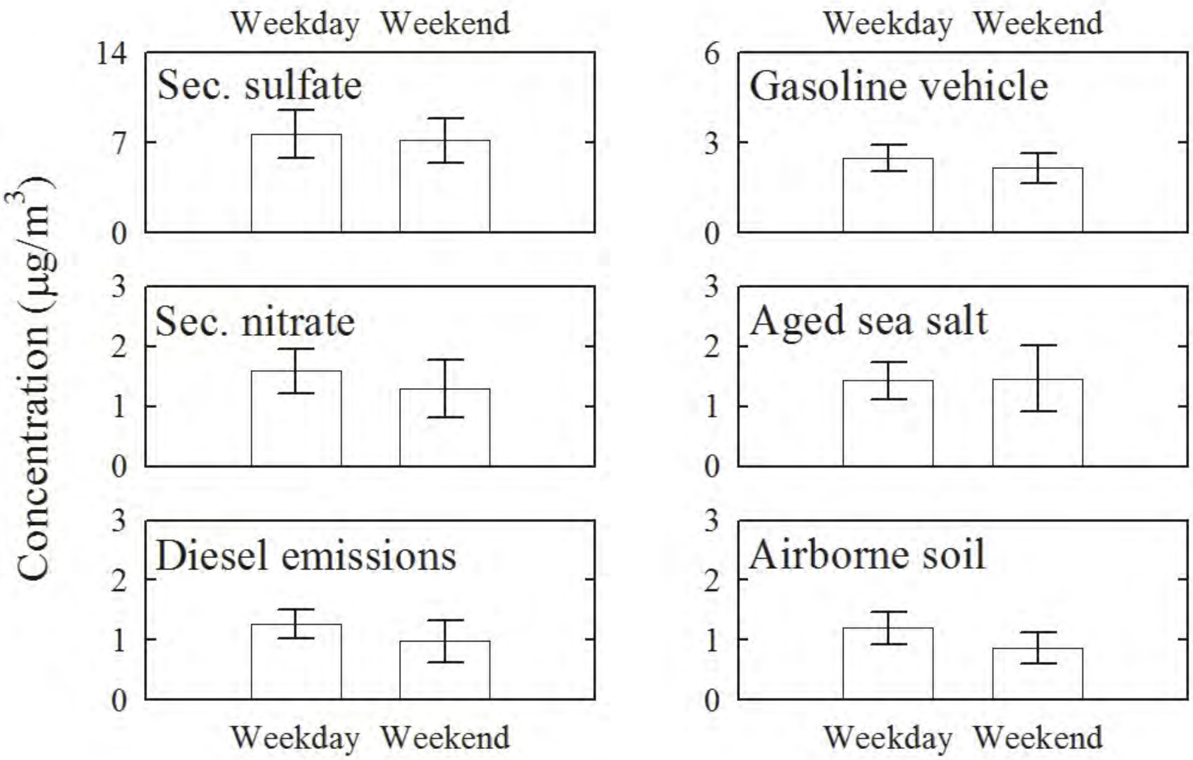


Figure 15. Weekday/weekend variations at Dover site.

APPENDIX A

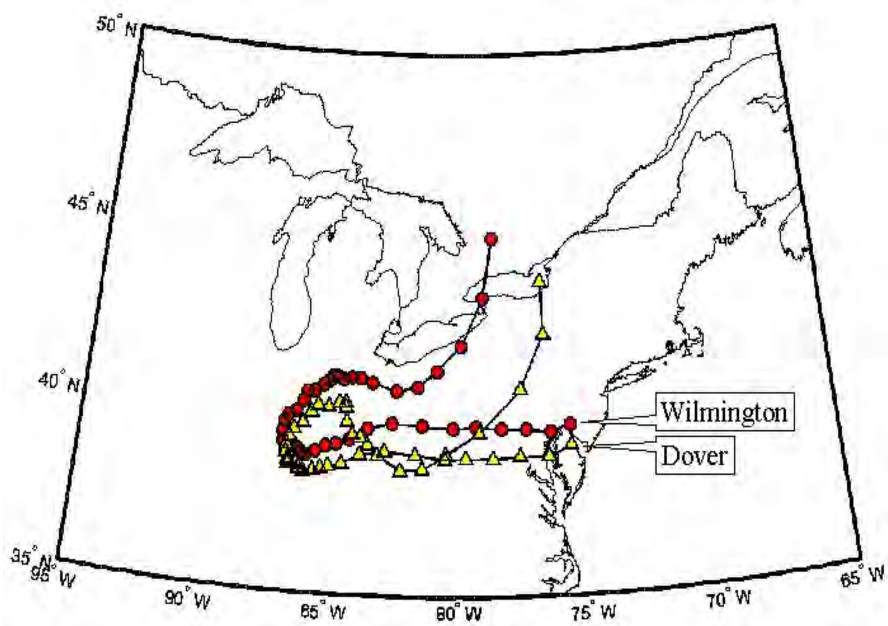


Figure 16. Backward trajectories arriving on July 19, 2002 calculated from NOAA Air Resource Laboratory.

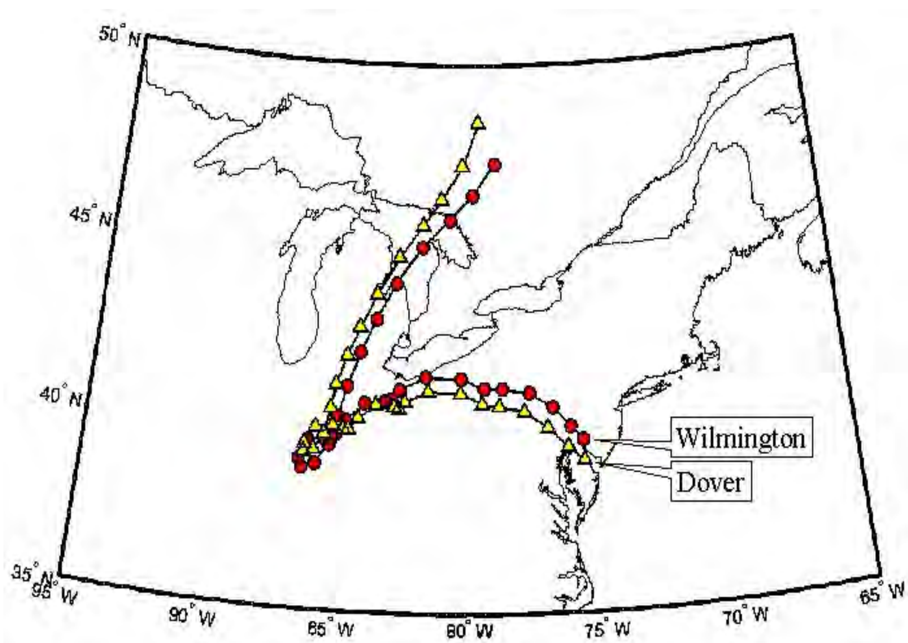


Figure 17. Backward trajectories arriving on June 26, 2003 calculated from NOAA Air Resource Laboratory.

APPENDIX A

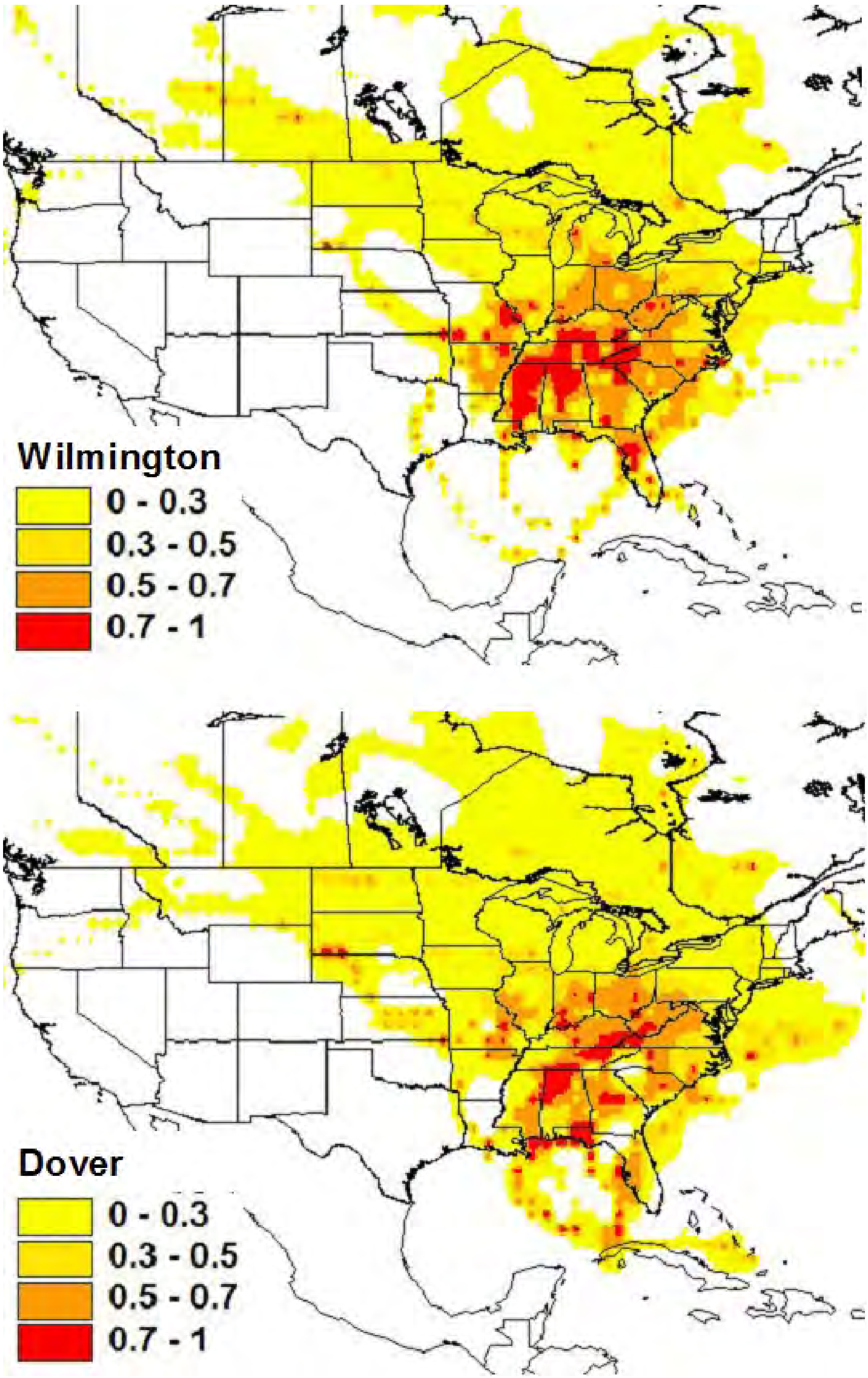


Figure 18. PSCF plots for the secondary sulfate aerosol sources.

APPENDIX A

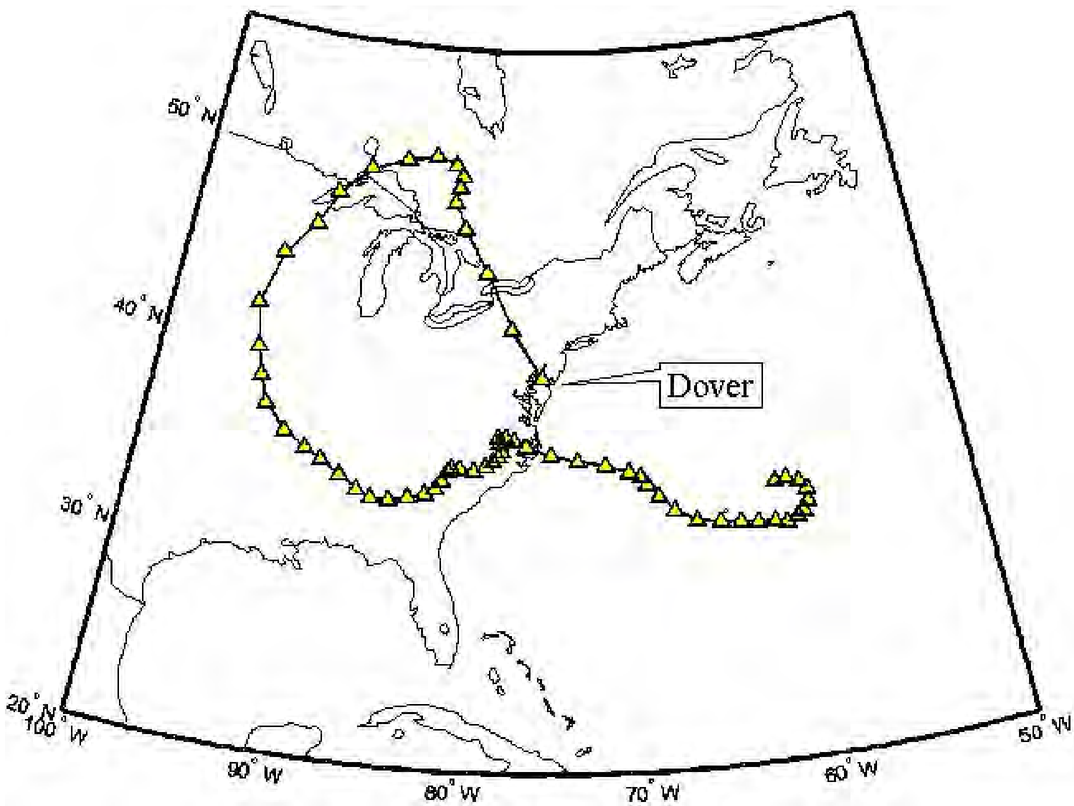


Figure 19. Backward trajectories arriving at Dover, DE on September 11, 2002 calculated from NOAA Air Resource Laboratory.

APPENDIX A

REFERENCES

Ashbaugh, L.L., Malm, W.C., Sadeh, W.Z. A residence time probability analysis of sulfur concentrations at Grand Canyon National Park, Atmospheric Environment, 19(8), 1263-1270, 1985.

Birch, M.E., Cary, R.A. Elemental carbon-based method for monitoring occupational exposures to particulate diesel exhaust; Aerosol Science and Technology 25, 221-241, 1996.

Bukowiecki, N., Hegedus, F., Falkenberg, G., Gehrig, R., Hill, M., Weingartner, E., Baltensperger, U., Highly time resolved elemental ambient concentrations of railway generated aerosols. European Aerosol Conference, Budapest, Hungary, 2004.

Chueinta, W., Hopke, P.K., Paatero, P. Investigation of sources of atmospheric aerosol at urban and suburban residential area in Thailand by positive matrix factorization. Atmospheric Environment 34, 3319-3329, 2000.

Draxler, R.R., Rolph, G.D. HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) Model access via NOAA ARL READY Website (http://www.arl.noaa.gov/ready/hysplit4.html). NOAA Air Resources Laboratory, Silver Spring, MD, 2003.

Gundel, L.A., Lee, V.C., Mahanama, K.R.R., Stevens, R.K., Rau, J.A. Direct determination of the phase distributions of semi-volatile polycyclic aromatic hydrocarbons using annular denuders, Atmospheric Environment, 29, 1719-1733, 1995.

Henry, R.C., Current factor analysis models are ill-posed, Atmospheric Environment, 21, 1815-1820, 1987.

Hering, S., Cass, G. The magnitude of bias in the measurement of $PM_{2.5}$ regression arising from volatilization of particulate nitrate from Teflon Filters, Journal of Air and Waste Management Association, 49, 725-733, 1999.

Hopke, P.K., Receptor modeling in environmental chemistry. John Wiley & Sons, New York, 1985.

Hopke, P.K., Barrie, L.A., Li, S.M., Cheng, M.D., Li, C., Xie, Y.L. Possible sources and preferred pathways for biogenic and non-sea salt sulfur for the high arctic, Journal of Geophysical Research, 100(D8), 16595-16603, 1995.

Kim, E., Larson, T.V., Hopke, P.K., Slaughter, C., Sheppard, L.E., Claiborne, C. Source identification of $PM_{2.5}$ in an arid northwest U.S. city by Positive Matrix Factorization, Atmospheric Research. 66, 291-305. 2003a.

Kim, E., Hopke, P.K., Edgerton, E. Source identification of Atlanta aerosol by Positive Matrix Factorization, Journal of Air and Waste Management Association. 53, 731-739. 2003b.

Kim, E., Hopke, P.K., Larson, T.V., Naydene, N., Lewtas, J. Factor analysis of Seattle fine particles, Aerosol Science and Technology. 38, 724-738, 2004a.

Kim, E., Hopke, P.K., Edgerton, E.S. Improving source identification of Atlanta aerosol using temperature resolved carbon fractions in Positive Matrix Factorization. Atmospheric Environment. 38, 3349-3362, 2004b.

Kim, E., Hopke, P.K. Source apportionment of fine particles at Washington, DC utilizing temperature resolved carbon fractions. Journal of Air and Waste Management Association, 54, 773-785, 2004a.

Kim, E., Hopke, P.K. Improving source identification of fine particles in a rural northeastern U.S. area utilizing temperature resolved carbon fractions. Journal of Geophysical Research, 109, D09204, 2004b.

Kim, E., Hopke, P.K., Qin, Y. Estimation of organic carbon blank values and error structures of the speciation trends network data for source apportionments. Journal of Air and Waste Management Association, 2005a (In submission).

Kim, E., Hopke, P.K., Kenski, D.M., Koerber, M. Sources of fine particles in a rural midwestern U.S. area. Environmental Science and Technology. 2005b (In submission).

Kim, E., Hopke, P.K., Improving source apportionment of fine particles in the eastern U.S. utilizing temperature resolved carbon fractions. Journal of Air and Waste Management Association, 2005c (In submission).

Koutrakis, P., Wolfson, J.M., Slater, J.L., Brauer, M., Spengler, J.D. Evaluation of an annular denuder/filter pack system to collect acidic aerosols and gases, Environmental Science and Technology, 22, 1463-1468, 1988.

Lee, E., Chun, C.K., Paatero, P. Application of Positive Matrix Factorization in source apportionment of particulate pollutants, Atmospheric Environment, 33, 3201-3212, 1999.

Miller, M.S., Friedlander, S.K., Hidy, G.M. A chemical element balance for the Pasadena aerosol, Journal of Colloid and Interface Science, 39, 165-176, 1972.

Paatero, P., Least square formulation of robust non-negative factor analysis, Chemometrics and Intelligent Laboratory Systems, 37, 23-35, 1997.

Paatero, P., Hopke, P.K., Song, X.H., Ramadan, Z. Understanding and controlling rotations in factor analytic models, Chemometrics and Intelligent Laboratory Systems, 60, 253-264, 2002.

Paatero, P., Hopke, P.K. Discarding or downweighting high-noise variables in factor analytic models, Analytica Chimica Acta, 490, 277-289, 2003.

Pankow, J.F., Mader, B.T. Gas/solid partitioning of semivolatile organic compounds (SOCs) to air filters. 3. An analysis of gas adsorption artifacts in measurements of atmospheric SOCs and organic carbon (OC) when using Teflon membrane filters and quartz fiber Filters, Environmental Science and Technology, 35(17), 3422-3432, 2001.

Polissar, A.V., Hopke, P.K., Paatero, P., Malm, W.C., Sisler, J.F. Atmospheric aerosol over Alaska 2. Elemental composition and sources, Journal of Geophysical Research, 103(D15), 19045-19057, 1998.

Polissar, A.V., Hopke, P.K., Poirot, R.L. Atmospheric aerosol over Vermont: Chemical composition and sources, Environmental Science and Technology, 35, 4604-4621, 2001.

Ramadan, Z., Song, X. H., Hopke, P.K., Identification of sources of Phoenix aerosol by positive matrix factorization, Journal of Air and Waste Management Association 50, 1308-1320, 2000.

Rolph, G.D., Real-time Environmental Applications and Display sYstem (READY) Website (http://www.arl.noaa.gov/ready/hysplit4.html). NOAA Air Resources Laboratory, Silver Spring, MD, 2003.

RTI, Quality Assurance Projects Plan Chemical Speciation of $PM_{2.5}$ Filter Samples, http://www.epa.gov/ttn/amtic/files/ambient/pm25/spec/rtiqap.pdf, Research Triangle Park, NC, 2004a.

RTI, Extended Semi-Annual Data Summary Report for the Chemical Speciation of $PM_{2.5}$ Filter Samples Project, RTI/07565/06DS, Research Triangle Park, NC, 2004b.

Song, X.H., Polissar, A.V., Hopke, P.K., Source of fine particle composition in the northeastern

U.S., Atmospheric Environment, 35, 5277-5286, 2001.

Tolocka, M.P., Solomon, P.A., Mitchell, W., Norris, G.A., Gemmill, D.B., Wiener, R.W., Vanderpool, R.W., Homolya, J.B., Rice, J., East versus west in the US: Chemical characteristics of $PM_{2.5}$ during the winter of 1999. Aerosol Science and Technology 34, 88-96, 2001.

Watson, J.G., Chow, J.C., Lowenthal, D.H., Pritchett, L.C., Frazier, C.A., Differences in the carbon composition of source profiles for diesel and gasoline powered vehicles, Atmospheric Environment, 28(15), 2493-2505, 1994.

Watson, J.G., Chow, J.C., Source characterization of major emission sources in the Imperial and Mexicali Valleys along the US/Mexico border; The Science of the Total Environment, 276, 33-47, 2001a.

Watson, J.G., Chow, J.C., Houck, J.E. $PM_{2.5}$ chemical source profiles for vehicle exhaust, vegetative burning, geological material, and coal burning in northwestern Colorado during 1995, Chemosphere, 43, 1141-1151, 2001b.

[This page is intentionally left blank]

Guidance on the Limited Maintenance Plan Option for Moderate $PM_{2.5}$ Nonattainment Areas and $PM_{2.5}$ Maintenance Areas

United States
Environmental Protection
Agency

APPENDIX B

Guidance on the Limited Maintenance Plan Option for Moderate $PM_{2.5}$ Nonattainment Areas and $PM_{2.5}$ Maintenance Areas

Air Quality Policy Division
Air Quality Assessment Division
Office of Air Quality Planning and Standards

Transportation and Climate Division
Office of Transportation and Air Quality

Office of Air and Radiation
U.S. Environmental Protection Agency

United States
Environmental Protection
Agency

EPA-420-B-22-044
October 2022

APPENDIX B

Table of Contents

Section 1: Purpose and Applicability

This document clarifies the EPA's Limited Maintenance Plan (LMP) guidance for $PM_{2.5}$ maintenance plan submissions by state, local, and tribal air agencies.[1] Unless otherwise stated, this guidance applies for any existing $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS) and for any future $PM_{2.5}$ NAAQS.

This $PM_{2.5}$ LMP Guidance applies the attached 2001 *Limited Maintenance Plan Option for Moderate PM_{10} Nonattainment Areas* guidance[2] (PM_{10} LMP Guidance) for $PM_{2.5}$ LMP submissions, except for the specific topics addressed below, where the 2001 guidance is superseded. This document therefore focuses on distinctions specific for $PM_{2.5}$ LMPs. For a broader discussion on LMPs generally, see the PM_{10} LMP Guidance.

Moderate $PM_{2.5}$ nonattainment areas or existing $PM_{2.5}$ maintenance areas meeting the criteria in this guidance may demonstrate maintenance for purposes of Clean Air Act (CAA) section 175A using the method described below. To show that an area is expected to continue to attain the standard for the 10-year maintenance period, this method relies primarily on air quality analyses indicating that there would be a low probability of violating the standard in the future, rather than using air quality modeling or a projection of an area's emissions inventory for a future year. As discussed in the PM_{10} LMP Guidance, an air agency submitting an LMP is not required to submit a future year emissions inventory, but it is still required to submit the other elements of a maintenance plan—an attainment year emissions inventory, provisions for continued operation of the monitoring network, verification of continued attainment, and a contingency plan.[3] Any LMP for a $PM_{2.5}$ area must also meet the applicable requirements of the exceptional events/data modifications, transportation conformity, and general conformity programs, as set forth in relevant implementing regulations for each program. Many of the requirements associated with these programs are described further below.

As noted, the LMP is a tool that allows certain nonattainment and maintenance areas to provide for maintenance under CAA section 175A based on an analysis of current and historical air quality data, rather than modeling or emissions projections. As such, using an LMP to provide for maintenance is not appropriate where an area expects to experience significant emissions growth, or even anticipates that such growth may be possible, during the relevant 10-year maintenance time period. In those situations, in order to meet the statutory requirement to provide for maintenance, the air agency should use the long-standing methods included in a "full maintenance plan" to demonstrate that the area will maintain the NAAQS even considering those projected emissions increases. There are a number of additional considerations that also may be

---

[1] The remainder of this document will refer to "state, local, and tribal air agencies" as either "air agency" or "air agencies."

[2] The *Limited Maintenance Plan Option for Moderate PM_{10} Nonattainment Areas* guidance (including attachments) was issued on August 9, 2001 and can also be found at: www.epa.gov/state-and-local-transportation/2001-limited-maintenance-plan-moderate-pm10-and-attachment.

[3] PM_{10} LMP Guidance at 6-7. *See also Procedures for Processing Requests to Redesignate Areas to Attainment*, September 4, 1992 (Calcagni Memorandum), available at: www.epa.gov/sites/default/files/2016-03/documents/calcagni_memo_-_procedures_for_processing_requests_to_redesignate_areas_to_attainment_090492.pdf.

relevant to whether an LMP is appropriate for a $PM_{2.5}$ area. For example, because of the health risks presented by exposure to $PM_{2.5}$ and possibility of emissions growth,[4] an LMP would likely not be appropriate for the first maintenance plan for a Moderate $PM_{2.5}$ area[5] that includes a major metropolitan area.[6] However, an LMP may be appropriate for an area's first $PM_{2.5}$ maintenance plan in an isolated rural area, or in a smaller metropolitan area where the $PM_{2.5}$ air quality problem is due to a specific source or sources unrelated to on-road transportation emissions and where emissions growth is not anticipated. Areas that have already been redesignated to attainment and are submitting a second maintenance plan under CAA section 175A(b) may be candidates particularly well-suited for an LMP, especially if air quality concentrations in the area have been relatively stable during the first 10-year maintenance period, indicating that emissions growth is unlikely. At a minimum, EPA intends to evaluate information provided by an air agency against the criteria in this guidance and associated regulations to determine whether a $PM_{2.5}$ LMP is appropriate for a given area.

This document is intended solely as guidance. The statutory provisions and EPA regulations discussed in this document contain legally binding requirements. However, this document is not a regulation itself, nor does it change or substitute for statutory provisions and regulations. Thus, it does not impose legally binding requirements on state, local, or tribal agencies or EPA. EPA retains the discretion to consider and adopt approaches on a case-by-case basis that may differ from this guidance, but still comply with the statute and regulations.

Questions about the application of this guidance for specific areas should be addressed to an EPA Regional Office SIP program contact. See this site for a list of Regional Office contacts: https://www.epa.gov/air-quality-implementation-plans/find-regional-contact-air-quality-sipsfipstips.

A copy of this policy guidance can be found at the following websites:

- https://www.epa.gov/pm-pollution/implementation-national-ambient-air-quality-standards-naaqs-fine-particulate-matter
- https://www.epa.gov/state-and-local-transportation/policy-and-technical-guidance-state-and-local-transportation#state

[4] For more information on the health and environmental effects of PM, see www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm.

[5] Consistent with the PM_{10} LMP Guidance, air agencies in Serious $PM_{2.5}$ nonattainment areas should submit maintenance plans that meet EPA's guidance for submission of a full maintenance plan for their first maintenance plan.

[6] A major metropolitan area, for example, could be an area that has an urbanized area population greater than 200,000. (This population threshold is used in other transportation conformity provisions.)

Section 2: Critical Design Value for $PM_{2.5}$

2.1 OVERVIEW

It is important to note that this LMP guidance for $PM_{2.5}$ areas does not include the concept of broadly applicable LMP air quality concentration criteria for the annual and 24-hour $PM_{2.5}$ NAAQS, as was included for the PM_{10} guidance.[7] Rather, this $PM_{2.5}$ LMP Guidance relies on the critical design value (CDV) concept (explained in Appendix A of the PM_{10} guidance), which is used to reflect the unique variability of air quality concentrations for each monitoring site. To be eligible for a $PM_{2.5}$ LMP, the air agency should calculate the site-specific CDV for the monitoring site with the highest design value and all other active monitoring sites with complete data in the relevant nonattainment or maintenance area. The air agency should demonstrate that the average design value (ADV) for each site in the area, based on the most recent 5 consecutive $PM_{2.5}$ design values,[8] does not exceed the associated CDV for each site. If each site in the nonattainment area has an ADV that is less than the CDV, it would demonstrate that the area has $PM_{2.5}$ concentrations that will likely remain below the level of the standard in the future.

CDVs are described in the PM_{10} LMP Guidance as "an indicator of the likelihood of future violations of the NAAQS given the current average design value and its variability." Consistent with the approach described in the PM_{10} LMP Guidance, the CDV calculation for a particular $PM_{2.5}$ monitoring site involves parameters including: 1) the level of the relevant NAAQS; 2) the co-efficient of variation of recent design values; and 3) a statistical parameter corresponding to a 10% probability of exceedance. CDVs are inversely related to the site's design value variability, with higher variability resulting in a lower (or more stringent) CDV. The site's average design value (ADV), calculated from the most recent 5 consecutive design values, is then compared to the CDV. If the ADV is lower than the CDV, then the probability of a future exceedance is less than 10%.

Although the PM_{10} LMP Guidance only included calculations for the PM_{10} CDV, the same procedure has been applied to $PM_{2.5}$ design values by Chu and Paisie in their 2006 evaluation of current $PM_{2.5}$ conditions across the United States.[9] In addition to the conservative "10% probability of exceedance" statistical parameter used in the CDV calculation, decreasing

[7] The broadly applicable LMP air quality concentration criteria included in the 2001 PM_{10} Guidance were 98 µg/m^3 for the 24-hour PM_{10} standard and 40 µg/m^3 for the annual PM_{10} standard. In general, a PM_{10} LMP submission would be approvable if the area average design value (ADV) did not exceed these levels. In Attachment B of the 2001 PM_{10} LMP guidance, these levels are referred to as "margin of safety" values. This $PM_{2.5}$ guidance does not include such national default air quality threshold qualification levels, but instead relies on area-specific critical design values.

[8] Attachment A of the 2001 PM_{10} guidance refers to using "a minimum of five years of data" for calculating the ADV and CDV. EPA recommends that the ADV be calculated using at least five years of design values, each representing a three-year period, because this approach would rely on a more robust dataset. However, we acknowledge that an alternative interpretation may be acceptable, where these variables could be calculated using three years of design values, collectively representing five years of air quality data.

[9] Chu, Shao-Hang and Joseph Paisie, 2006. An evaluation of current $PM_{2.5}$ conditions in the U.S. Atmospheric Environment, Volume 40, Supp. 2, Pages 206-211. www.sciencedirect.com/science/article/abs/pii/S1352231006005723.

concentrations in recent years across much of the United States further reduces the probability of future exceedances.[10,11]

Additionally, to the extent that the air agency is submitting a second 10-year maintenance plan for $PM_{2.5}$, a record showing that the area design value is lower than the CDV, coupled with air quality data demonstrating the area has already been maintaining the NAAQS for at least 8 years, provides EPA with further confidence that the area will continue to maintain the relevant $PM_{2.5}$ standard.

Example Site Calculation: Comparing Average Design Value to the Critical Design Value

The following is an example calculation of the ADV for a single monitoring site in a hypothetical 24-hour $PM_{2.5}$ nonattainment area, and comparison to the site's CDV. In calculating the ADV for a site, EPA recommends using the most recent 5 consecutive 3-year design values to better account for variability of air quality data in a particular location. The air agency should perform this calculation for the site in the area that commonly has the highest design value, and for all other active monitoring sites. Notwithstanding consideration of other factors, the EPA believes it would be appropriate to approve an LMP only when the ADV is less than the associated CDV for each site in the area.

EQUATIONS
Critical Design Value: $CDV = NAAQS / (1+(t_c \times CV))$
Coefficient of Variation: CV = (standard deviation for sample / average design value) = σ/ADV

VARIABLES
NAAQS ($\mu g/m^3$): Level of relevant annual or 24-hour $PM_{2.5}$ NAAQS
t_c (Critical t-value): 1.533[12]

YEARS	**DESIGN VALUES FOR SITE (in $\mu g/m^3$)**
2015-2017	17
2016-2018	14
2017-2019	13
2018-2020	15
2019-2021	18

Avg Design Value (ADV) = 15.4

[10] See https://www.epa.gov/air-trends.
[11] Elizabeth A.W. Chan, Brett Gantt, Stephen McDow, 2018. The reduction of summer sulfate and switch from summertime to wintertime $PM_{2.5}$ concentration maxima in the United States, Atmospheric Environment, Volume 175, 2018, Pages 25-32. www.sciencedirect.com/science/article/pii/S1352231017308166.
[12] The critical t-value of 1.533 is based on an ADV calculation using five consecutive 3-year design values and the one-tail Student's t-distribution at a significance level of 0.10. If only three 3-year design values are used to calculate the ADV, the critical t-value would be 1.886.

CDV CALCULATION

24-hr NAAQS ($\mu g/m^3$)	35
ADV ($\mu g/m^3$)	**15.4**
σ (std. deviation for sample)	2.07

CV = σ/ADV = (2.07 / 15.4) = 0.13
CDV ($\mu g/m^3$) = 35 / (1+(1.533*0.13)) = **29.0**
ADV < CDV? **YES**

2.2 EVENT-INFLUENCED AIR QUALITY DATA

The EPA's Exceptional Events Rule[13] implements CAA section 319(b)(2), which requires the Administrator to promulgate regulations "governing the review and handling of air quality monitoring data influenced by an exceptional event." Pursuant to CAA section 319(b)(3)(B)(iv), the Exceptional Events Rule provides "criteria and procedures for the Governor of a state to petition the Administrator to exclude air quality monitoring data that is directly influenced by exceptional events from use in determinations by the Administrator with respect to exceedances or violations of the national ambient air quality standards [(NAAQS)]." The Rule specifies the types of actions that qualify as "determinations by the Administrator" and therefore must follow the process and requirements in the Exceptional Events Rule, but the Rule also identifies that it may be appropriate to exclude atypical or unrepresentative data for other types of actions that do not qualify as "determinations by the Administrator."

In April of 2019, EPA expanded on this concept by releasing the *Additional Methods, Determinations, and Analyses to Modify Air Quality Data Beyond Exceptional Events (Additional Methods)* guidance, which clarifies the types of regulatory determinations, actions and analyses, including LMPs, for which EPA may consider certain modified air quality monitoring data.[14] The Additional Methods guidance supersedes any related prior approach for data exclusion identified in the 2001 PM_{10} LMP Guidance, and is the appropriate data exclusion guidance to apply in the context of this $PM_{2.5}$ LMP Guidance. Specifically, the *Additional Methods* guidance indicates that atypical or unrepresentative monitoring data could qualify for exclusion for use in calculating air quality design values in support of an LMP submission and any subsequent yearly design value calculations for areas with approved LMPs. The *Additional Methods* guidance identifies that air quality monitoring data above the NAAQS-specific LMP threshold will be treated in a manner analogous to the treatment of exceedance data under the Exceptional Events Rule provided the impacted data otherwise satisfy the general definition and criteria for exceptional events. Because the $PM_{2.5}$ LMP Guidance does not provide a NAAQS-specific LMP threshold, air agencies are strongly encouraged to consult with their EPA Regional office counterparts where exceptional/atypical events-related questions arise in the context of an LMP prior to investing significant resources in developing exceptional events-like analyses.

---

[13] The Exceptional Events Rule was last revised by EPA in 2016. See 81 FR 68216 (Oct. 3, 2016).
[14] *See Additional Methods, Determinations, and Analyses to Modify Air Quality Data Beyond Exceptional Events* (Apr. 4, 2019), available at www.epa.gov/sites/default/files/2019-04/documents/clarification_memo_on_data_modification_methods.pdf.

2.3 AIR QUALITY REVIEW

As is the case for any maintenance plan, the LMP is expected to identify how the air agency intends to track the progress of the maintenance plan. Consistent with the PM_{10} LMP Guidance, an air agency may do its periodic progress tracking by regularly recalculating the ADV (average of 5 consecutive 3-year design values) for all the sites with complete data in the area, and determining if the ADV is still less than the CDV for each site. Under this approach, if the air agency determines that the ADV is not less than the CDV for all sites, the air agency should take appropriate, early action to identify approaches to address the air quality trend and prevent a violation of the NAAQS. Should a violation of the NAAQS occur, EPA may also use its authority under the CAA to take actions necessary to ensure the area comes back into attainment.

Section 3: Transportation Conformity

Transportation conformity is required under CAA section 176(c) (42 U.S.C. 7506(c)) to ensure that federally funded or approved highway and transit activities are consistent with ("conform to") the purpose of the SIP. Conformity to the purpose of the SIP means that transportation activities will not cause or contribute to new air quality violations, worsen existing violations, or delay timely attainment of the relevant NAAQS or any interim milestones.

The transportation conformity regulations (40 CFR Part 93, subpart A) establish criteria and procedures for determining whether metropolitan transportation plans, transportation improvement programs (TIPs), and federally supported highway and transit projects conform to the SIP. These regulations provide for some flexibility when EPA has established an LMP policy for a given NAAQS and pollutant, as explained in a previous EPA transportation conformity rulemaking[15] and the current transportation conformity regulations at 40 CFR 93.109(e). This guidance establishes EPA's LMP policy for the $PM_{2.5}$ NAAQS. The transportation conformity-related portions of the attached PM_{10} LMP Guidance do not apply for $PM_{2.5}$ transportation conformity unless otherwise indicated.

The transportation conformity regulations require that:

> *A limited maintenance plan would have to demonstrate that it would be unreasonable to expect that such an area would experience enough motor vehicle emissions growth for a NAAQS violation to occur.*[16]

As described above, a $PM_{2.5}$ LMP may be submitted for a first and/or second 10-year maintenance plan with documentation that supports the LMP demonstration described under the transportation conformity regulations. The following are examples of how such an LMP demonstration could be developed to address section 93.109(e) of the transportation conformity regulations for a given area:

- As discussed above, an LMP for the first maintenance plan may be appropriate in isolated rural areas or in smaller metropolitan areas where the $PM_{2.5}$ air quality problem is due to a specific source or sources unrelated to on-road transportation emissions (see footnote 6). Therefore, an LMP submission for an area's first maintenance plan should address, in addition to air quality data trends, factors affecting the area's on-road mobile source challenges, including its size, whether it includes a metropolitan planning organization, its main sources of $PM_{2.5}$ emissions, and its historical and projected vehicle miles travelled (VMT).
- As noted in Section 1, an LMP may be particularly appropriate for a second maintenance plan, as the area will have demonstrated attainment of the $PM_{2.5}$ NAAQS for at least 8 years. To meet the requirement in the transportation conformity regulation, i.e., demonstrate that it would be unreasonable to expect that the area would experience enough motor vehicle growth for a NAAQS violation to occur, an LMP submission for

[15] See 69 FR 40063, July 1, 2004.
[16] See 40 CFR 93.109(e).

an area's second maintenance plan should again address the area's $PM_{2.5}$ air quality trends and its historical and projected VMT.

Finally, if emissions of re-entrained road dust have been found to be significant for $PM_{2.5}$ transportation conformity purposes under 40 CFR 93.102(b)(3), e.g., those emissions have been included in regional emissions analyses as part of transportation conformity determinations, then the LMP submission from the air agency should also include an on-road $PM_{2.5}$ emission analysis consistent with the methodology in Attachment B of the PM_{10} LMP Guidance. EPA acknowledges that this on-road emission analysis will not be needed for first or second LMP submissions for most $PM_{2.5}$ areas based on EPA's implementation of the $PM_{2.5}$ NAAQS to date.

If the on-road emissions analysis is necessary, the LMP submission should only include on-road emissions of direct $PM_{2.5}$ (tailpipe, brake wear, tire wear and re-entrained road dust). As discussed in Section 2.1 of this document, the concept of broadly applicable LMP air quality concentration criteria for the annual and 24-hour $PM_{2.5}$ NAAQS ("margins of safety") is not included in this guidance. Therefore, when performing such an onroad emissions analysis, the air agency should use the CDV for the area rather than the "margin of safety." If the onroad $PM_{2.5}$ emissions analysis is required, the air agency must show that for each monitoring site in the area, the ADV plus the on-road emissions growth estimate does not exceed the CDV.

The transportation conformity interagency consultation process must also be used to discuss the development of any LMP submission.[17] EPA Regional SIP and transportation conformity staff will work together and provide technical assistance as needed for this component of the $PM_{2.5}$ LMP.

Where an area has an adequate[18] or approved $PM_{2.5}$ LMP developed under this guidance, a transportation plan or TIP conformity determination would not include a regional emissions analysis for that $PM_{2.5}$ NAAQS.[19] However, transportation plan and TIP conformity determinations that meet applicable requirements continue to be required in these areas (see Table 1 in 40 CFR 93.109). The existing requirement for a regional emissions analysis also continues to apply for any other pollutants or standards for which transportation conformity applies in the area but which are not the subject of an LMP (40 CFR 93.109). In addition, project-level conformity determinations must continue to be completed according to all applicable requirements for federally supported highway and transit projects, including the hot-spot requirements for projects in CO, PM_{10} and $PM_{2.5}$ nonattainment and maintenance areas.[20]

---

[17] *See* 40 CFR 93.105(b).

[18] EPA's adequacy process is described in 40 CFR 93.118(e) and (f) with EPA's adequacy website at: www.epa.gov/state-and-local-transportation/adequacy-review-state-implementation-plan-sip-submissions-conformity.

[19] Per 40 CFR 93.109(e): "Notwithstanding the other paragraphs of this section, an area is not required to satisfy the regional emissions analysis for § 93.118 and/or 93.119 for a given pollutant and NAAQS, if the area has an adequate or approved limited maintenance plan for such pollutant and NAAQS."

[20] See 40 CFR 93.109(e) (providing that, in areas with limited maintenance plans, a "conformity determination that meets other applicable criteria in Table 1 of [40 CFR 93.109(b)] is still required, including the hot-spot requirements for projects in CO, PM_{10}, and $PM_{2.5}$ areas"). See also EPA's guidance for transportation conformity hot-spot analyses available on EPA's website at: https://www.epa.gov/state-and-local-transportation/project-level-conformity-and-hot-spot-analyses.

Section 4: General Conformity

EPA's general conformity regulations do not distinguish between maintenance areas with an approved "full maintenance plan" and those with an approved LMP. Thus, maintenance areas with an approved LMP are subject to the same general conformity requirements under 40 CFR part 93, subpart B, as those covered by a "full maintenance plan." No statements included elsewhere in this guidance or in the PM_{10} LMP Guidance should be construed to require anything less than full compliance with the general conformity program requirements.

Appendix: PM_{10} LMP Guidance (2001)

APPENDIX B

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

AUG 0 9 2001

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

MEMORANDUM

SUBJECT: Limited Maintenance Plan Option for Moderate PM_{10} Nonattainment Areas

FROM: for John O Edwardson
Lydia Wegman, Director
AQSSD (MD-15)

TO: Director, Office of Ecosystem Protection, Region I
Director, Division of Environmental Planning & Protection, Region II
Director, Air Protection Division, Region III
Director, Air, Pesticides & Toxics Management Division, Region IV
Director, Air and Radiation Division, Region V
Director, Air Pesticides & Toxics, Region VI
Director, Air and Toxics Division, Regions VII, IX
Director, Air Program, Region VIII
Director, Office of Air Quality, Region X

I. What is a Limited Maintenance Plan?

This memorandum sets forth new guidance[1] on maintenance plan submissions for certain moderate particulate matter (PM_{10}) nonattainment areas seeking redesignation to attainment (see section IV for further details on qualifying for the policy). If the area meets the criteria listed in this policy the State may submit a maintenance plan at the time it is requesting redesignation that is more streamlined than would ordinarily be permitted. This new option is being termed a limited maintenance plan (LMP)[2].

II. Why is there a need for a limited maintenance plan policy?

Before the U.S. Court of Appeals for the District of Columbia handed down its decision vacating the 1997 PM_{10} national ambient air quality standards (NAAQS)(see American Trucking Associations, et al. v. Environmental Protection Agency (EPA), 175 F.3d 1027 (D.C. Cir. 1999),

[1] This memorandum is intended to provide EPA's preliminary views on how certain moderate PM10 nonattainment areas may qualify to submit a maintenance plan that meets certain limited requirements. Since it represents only the Agency's preliminary thinking that is subject to modification, this guidance is not binding on States, Tribes, the public, or EPA. Issues concerning the applicability of the limited maintenance plan policy will be addressed in actions to redesignate moderate PM10 nonattainment areas under § 107 of the CAA. It is only when EPA promulgates redesignations applying this policy that those determinations will become binding on States, Tribes, the public, and EPA as a matter of law.

[2] Moderate PM_{10} areas that do not meet the applicability criteria of this policy, and all serious PM_{10} nonattainment areas. should submit maintenance plans that meet our guidance for submission of a full maintenance plan as described in the September 4, 1992 memorandum. "Procedures for Processing Requests to Redesignate Areas to Attainment," from John Calcagni, former Director of the Office of Air Quality Planning and Standards (OAQPS) Air Quality management Division to the Regional Air Division Directors (hereafter known as the Calcagni Memo).

we were prepared to make case-by-case determinations that would make the 1987 PM_{10} NAAQS no longer applicable in any area meeting the standards. In taking actions to remove the applicability of the 1987 NAAQS, we would have removed, as well, the nonattainment designation and Clean Air Act (CAA) part D requirements from qualifying areas. As a result of the D.C. Circuit's decision, for areas subject to the 1987 NAAQS, the only route to recognized attainment of the NAAQS and removal of nonattainment status and requirements is formal redesignation to attainment, including submittal of a maintenance plan. Since many areas have been meeting the PM_{10} NAAQS for 5 years or more and have a low risk of future exceedances, we believe a policy that would allow both the States and EPA to redesignate speedily areas that are at little risk of PM_{10} violations would be useful.

III. How did EPA develop the approach used in the LMP option?

The EPA has studied PM_{10} air quality data information for the entire country over the past eleven years (1989-1999) and has determined that some moderate PM_{10} nonattainment areas have had a history of low PM10 design values with very little inter-annual variation. When we looked at all the monitoring sites reporting data for those years, the data indicate that most of the average design values fall below 2 levels, 98 $\mu g/m^3$ for the 24-hr PM_{10} NAAQS and 40 $\mu g/m^3$ for the annual PM_{10} NAAQS. For most monitoring sites these levels are also below their individual site-specific critical design values (CDV). The CDV is an indicator of the likelihood of future violations of the NAAQS given the current average design value and its variability. The CDV is the highest average design value an area could have before it may experience a future exceedance of the NAAQS with a certain probability. A detailed explanation of the CDV is found in Attachment A [3] to this policy which, because of its length, is a separate document accompanying this memorandum.

We believe that the very small amount of variation between the peaks and means in most of the data indicates a very stable relationship that can be reasonably expected to continue in the future absent any significant changes in emissions. The period we assessed provides a fairly long historical record and the data could therefore be expected to have been affected by a full range of meteorological conditions over the period. Therefore, the amount of emissions should be the only variable that could affect the stability in the air quality data. We believe we can reliably make estimates about the future variability of PM_{10} concentrations across the country based on our statistical analysis of this data record, especially in areas where the amount of emissions is not expected to change.

IV. How do I qualify for the LMP option ?

To qualify for the limited maintenance plan option, an area should meet the following applicability criteria. The area should be attaining the NAAQS and the average PM_{10} design

[3] Dr. Shao-Hang Chu's paper entitled "Critical Design Value and Its Applications" explains the CDV approach and is included in its entirety in Attachment A. This paper has been accepted for publication and presentation at the 94th Air and Waste Management Association (A&WMA) Annual Conference in June 2001 in Orlando, Florida.

value [4] for the area, based upon the most recent 5 years of air quality data at all monitors in the area, should be at or below 40 µg/m^3 for the annual and 98 µg/m^3 for the 24-hr PM_{10} NAAQS with no violations at any monitor in the nonattainment area [5]. If an area cannot meet this test it may still be able to qualify for the LMP option if the average design values of the site are less than their respective site-specific CDV.

We believe it is appropriate to offer this second method of qualifying for the LMP because, based on the air quality data we have studied, we believe there are some monitoring sites with average design values above 40 µg/m^3 or 98 µg/m^3, depending on the NAAQS in question, that have experienced little variability in the data over the years. When the CDV calculation was performed for these sites we discovered that their average design values are less than their CDVs, indicating that the areas have a very low probability (1 in 10) of exceeding the NAAQS in the future. We believe it is appropriate to provide these areas the opportunity to qualify for the LMP in this circumstance since the 40 µg/m^3 or 98 µg/m^3 criteria are based on a national analysis and don't take into account each local situation.

The final criterion is related to mobile source emissions. The area should expect only limited growth in on-road motor vehicle PM_{10} emissions (including fugitive dust) and should have passed a motor vehicle regional emissions analysis test. It is important to consider the impact of future transportation growth in the LMP, since the level of PM-10 emissions (especially from fugitive dust) is related to the level of growth in vehicle miles traveled (VMT). Attachment B (below) should be used for making the motor vehicle regional emissions analysis demonstration.

If the State determines that the area in question meets the above criteria, it may select the LMP option for the first 10 year maintenance period. Any area that does not meet these criteria should plan to submit a full maintenance plan that is consistent with our guidance in the Calcagni Memo in order to be redesignated to attainment. If the LMP option is selected, the State should continue to meet the qualifying criteria until EPA has redesignated the area to attainment. If an area no longer qualifies for the LMP option because a change in air quality affects the average design values before the redesignation takes effect, the area will be expected to submit a full maintenance plan.

Once an area selects the LMP option and it is in effect, the State will be expected to recalculate the average design value for the area annually and determine if the criteria used to qualify for the LMP will still be met. If, after performing the annual recalculation of the area's average design value in a given year, the State determines that the area no longer qualifies for the LMP, the State should take action to attempt to reduce PM_{10} concentrations enough to requalify for the LMP. One possible approach the State could take is to implement a contingency measure

[4] The methods for calculating design values for PM_{10} are presented in a document entitled the "PM_{10} SIP Development Guideline", EPA-450/2-86-001, June 1987. The State should determine the most appropriate method to use from this Guideline in consultation with the appropriate EPA Regional office staff.

[5] If the EPA determines that the meteorology was not representative during the most recent five-year period, we may reject the State's request to use the LMP option and request, instead, submission of a full maintenance demonstration.

or measures found in its SIP. If, in the next annual recalculation the State is able to re-qualify for the LMP, then the LMP will go back into effect. If the attempt to reduce PM_{10} concentrations fails, or if it succeeds but in future years it becomes necessary again to address increasing PM_{10} concentrations in the area, that area no longer qualifies for the LMP. We believe that repeated increases in PM_{10} concentrations indicate that the initial conditions that govern air quality and that were relied on to determine the area's qualification for the LMP have changed, and that maintenance of the NAAQS can no longer be assumed. Therefore, the LMP cannot be reinstated by further recalculations of the design values at this point. Once the LMP is determined to no longer be in effect, a full maintenance plan should be developed and submitted within 18 months of the determination.

Treatment of data used to calculate the design values.

Flagged Particulate Matter Data:

Three policies allow PM-10 data to be flagged for special consideration:

- Exceptional Events Policy (1986) for data affected by infrequent events such as industrial accidents or structural fires near a monitoring site;
- Natural Events Policy (1996) for data affected by wildfires, high winds, and volcanic and seismic activities, and;
- Interim Air Quality Policy on Wildland and Prescribed Fires for data affected by wildland fires that are managed to achieve resource benefits.

We will treat data affected by these events consistently with these previously-issued policies. We expect States to consider all data (unflagged and flagged) when determining the design value. The EPA Regional offices will work with the State to determine the validity of flagged data. Flagged data may be excluded on a case-by-case basis depending on State documentation of the circumstances justifying flags. Data flagged as affected by exceptional or natural events will generally not be used when determining the design value. However, in order for data affected by a natural event to be excluded, an adequate Natural Events Action Plan is required as described in the Natural Events policy.

Data flagged as affected by wildland and prescribed fires will be used in determining the design value. If the State is addressing wildland and prescribed fire use with the application of smoke management programs, the State may submit an LMP if the design value is too high only as a result of the fire-affected data.

We are in the process of developing a policy to address agricultural burning. When it is finalized we will amend the LMP option to account for the new policy.

V. What should an LMP consist of?

Under the LMP, we will continue to satisfy the requirements of Section 107(d)(3)(E) of the Act which provides that a nonattainment area can be redesignated to attainment only if the following criteria are met:

1. The EPA has determined that the NAAQS for the applicable pollutant has been attained.
2. The EPA has fully approved the applicable implementation plan under section 110(k).
3. The EPA has determined that the improvement in air quality is due to permanent and enforceable reductions in emissions.
4. The State has met all applicable requirements for the area under section 110 and part D.
5. The EPA has fully approved a maintenance plan, including a contingency plan, for the area under section 175A.

However, there are some differences between what our previous guidance (the Calcagni memo) recommends that States include in a maintenance plan submission and what we are recommending under this policy for areas that qualify for the LMP. The most important difference is that under the LMP the demonstration of maintenance is presumed to be satisfied. The following is a list of core provisions which should be included in an LMP submission. Note that any final EPA determination regarding the adequacy of an LMP will be made following review of the plan submitted in light of the particular circumstances facing the area proposed for redesignation and based upon all available information.

a. Attainment Plan

The State's approved attainment plan should include an emissions inventory (attainment inventory) which can be used to demonstrate attainment of the NAAQS. The inventory should represent emissions during the same five-year period associated with the air quality data used to determine whether the area meets the applicability requirements of this policy (i.e., the most recent five years of air quality data). If the attainment inventory year is not one of the most recent five years, but the State can show that the attainment inventory did not change significantly during that five-year period, it may still be used to satisfy the policy. If the attainment inventory is determined to not be representative of the most recent 5 years, a new inventory must be developed. The State should review its inventory every three years to ensure emissions growth is incorporated in the attainment inventory if necessary.

b. Maintenance Demonstration

The maintenance demonstration requirement of the Act will be considered to be satisfied for the moderate PM_{10} nonattainment areas meeting the air quality criteria discussed above. If the tests described in Section IV are met, we will treat that as a demonstration that the area will maintain the NAAQS. Consequently, there is no need to project emissions over the maintenance period.

c. Important elements that should be contained within the redesignation request

1. Monitoring Network Verification of Continued Attainment

   To verify the attainment status of the area over the maintenance period, the maintenance plan should contain a provision to assure continued operation of an appropriate, EPA-approved air quality monitoring network, in accordance with 40 CFR part 58. This is particularly important for areas using an LMP because there will be no cap on emissions.

2. Contingency Plan

   Section 175A of the Act states that a maintenance plan must include contingency provisions, as necessary, to promptly correct any violation of the NAAQS which may occur after redesignation of the area to attainment. These contingency measures do not have to be fully adopted at the time of redesignation. However, the contingency plan is considered to be an enforceable part of the SIP and the State should ensure that the contingency measures are adopted as soon as possible once they are triggered by a specific event. The contingency plan should identify the measures to be adopted, and provide a schedule and procedure for adoption and implementation of the measures if they are required. Normally, the implementation of contingency measures is triggered by a violation of the NAAQS but the State may wish to establish other triggers to prevent a violation of the NAAQS, such as an exceedance of the NAAQS.

3. Approved attainment plan and section 110 and part D CAA requirements:

In accordance with the CAA, areas seeking to be redesignated to attainment under the LMP policy must have an attainment plan that has been approved by EPA, pursuant to section 107(d)(3)(E). The plan must include all control measures that were relied on by the State to demonstrate attainment of the NAAQS. The State must also ensure that the CAA requirements for PM_{10} pursuant to section 110 and part D of the Act have been satisfied. To comply with the statute, the LMP should clearly indicate that all controls that were relied on to demonstrate attainment will remain in place. If a State wishes to roll back or eliminate controls, the area can no longer qualify for the LMP and the area will become subject to full maintenance plan requirements within 18 months of the determination that the LMP is no longer in effect.

VI. How is Conformity treated under the LMP option?

The transportation conformity rule (40 CFR parts 51 and 93) and the general conformity rule (58 FR 63214; November 30, 1993) apply to nonattainment areas and maintenance areas operating under maintenance plans. Under either conformity rule one means of demonstrating conformity of Federal actions is to indicate that expected emissions from planned actions are consistent with the emissions budget for the area. Emissions budgets in LMP areas may be treated as essentially not constraining for the length of the maintenance period because it is unreasonable to expect that an area satisfying the LMP criteria will experience so much growth during that period of time such that a violation of the PM_{10} NAAQS would result. While this policy does not exempt an area from the need to affirm conformity, it does allow the area to demonstrate conformity without undertaking certain requirements of these rules. For transportation conformity purposes, EPA would be concluding that emissions in these areas need not be capped for the maintenance period, and, therefore, a regional emissions analysis would not be required. Similarly, Federal actions subject to the general conformity rule could be considered to satisfy the "budget test" specified in section 93.158 (a)(5)(i)(A) of the rule, for the same reasons that the budgets are essentially considered to be unlimited.

EPA approval of an LMP will provide that if the LMP criteria are no longer satisfied and a full maintenance plan must be developed to meet CAA requirements (see Calcagni Memo referenced in footnote #2 for full maintenance plan guidance), the approval of the LMP would remain applicable for conformity purposes only until the full maintenance plan is submitted and EPA has found its motor vehicle emissions budgets adequate for conformity purposes under 40 CFR parts 51 and 93. EPA will condition its approval of all LMPs in this fashion because in the case where the LMP criteria are not met and a full maintenance plan is required EPA believes that LMPs would no longer be an appropriate mechanism for assuring maintenance of the standards.

ATTACHMENT A
Critical Design Value Estimation and Its Applications

Shao-Hang Chu
US Environmental Protection Agency
Office of Air Quality Planning and Standards
Air Quality Strategies and Standards Division (MD-15)
Research Triangle Park, NC 27711

ABSTRACT

The air quality design value is the mathematically determined pollutant concentration at a particular site that must be reduced to, or maintained at or below the National Ambient Air Quality Standards (NAAQS) in order to assure attainment. The design value may be calculated based on ambient measurements observed at a local monitor in a 3-year period or on model estimates. The design value, however, varies from year to year due to both the pollutant emissions and natural variability such as meteorological conditions, wildfires, dust storms, volcanic activities etc. In order to investigate certain policy options related to pollution controls it would be desirable to estimate a critical design value above which the NAAQS is likely to be violated with a certain probability.

In this paper, a statistical technique has been developed to estimate a critical design value that is based on the average design value and its variability in the past. The critical design value could be used as a planning tool for regulatory agencies because it is an indicator of the likelihood of future violations of the NAAQS given the current average design value and its variability. The approach is general and could be applied to estimate the critical design value for any pollutant.

As an example, eleven years (1989-1999) of PM10 data nationwide were extracted from the US EPA AIRS database to estimate the PM10 critical design values. The analyses indicate that PM10 design values in the West have much larger inter-annual variability than those in the East as reflected in their much lower critical design values. This, in turn, suggests that the interannual variability in meteorology, wildfires, and dust storms may have played a more significant role in the West, and also this larger variability could be partly explained by the once every six days sampling schedule at most PM10 monitoring sites.

INTRODUCTION

The air quality design value is the mathematically determined pollutant concentration at a particular site that must be reduced to, or maintained at or below the National Ambient Air Quality Standards (NAAQS) in order to assure attainment[1]. The design value may be calculated based on ambient measurements observed at a local monitor in a 3-year period or on model estimates. The detailed calculation of the design values for various criteria pollutants is described in the Appendices of the Code of Federal Regulations[2]. In certain cases, the design value has been used for regulatory purposes to determine whether the local pollutant concentration has violated the National Ambient Air Quality Standard (NAAQS). Most often, however, the design value is used to determine the level of control needed to reduce the pollutant concentration to the NAAQS[3,4,5].

The design value, however, varies from year to year due to both the pollutant emissions and natural variability such as meteorological conditions, wildfires, dust storms, volcanic activities etc. In order to investigate certain policy options related to pollution controls it would be desirable to define a critical design value above which future violations of the air quality standard are likely to occur with a certain probability.

In this paper, an effort has been made to statistically estimate a critical design value based on the average of these yearly design values and their variability in the past. This critical design value is defined in such a way as it is the highest average design value any monitoring site could have before it runs a risk of violating the NAAQS in the future at a certain probability. The technical basis of this estimation approach and its applications will be discussed in the following paragraphs.

CRITICAL DESIGN VALUE ESTIMATION

Our intention is to find a critical design value (CDV) that is the highest possible average design value (ADV) any site could have before it risks a future violation of the standard at a certain probability. First, we try to formulate a relationship among a set of variables involved: such as the CDV, NAAQS, the ADV, the standard deviation of the design values in the past, and a desirable risk factor. We find that if we assume that the design values are normally distributed and the coefficient of variation (CV), which is the ratio of the standard deviation versus the mean of the design values, does not change in the near future, then we can write the relationship as:

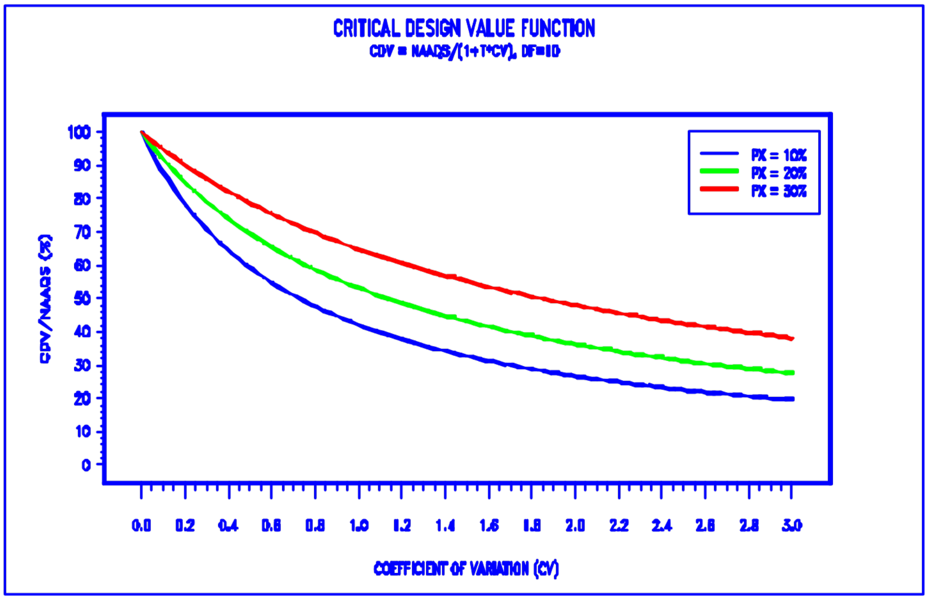
$$CDV = NAAQS/(1+t_c*CV) \qquad (1)$$

Where CDV is the critical design value, CV is the coefficient of variation of the annual design values (the ratio of standard deviation divided by the mean design value in the past), and t_c is the critical t-value corresponding to a probability, c %, of exceeding the NAAQS in the future and the degree of freedom in the estimate to the CV. Equation (1) says that based on the variability of the design values in the past, the probability of any monitoring site with an ADV less than or equal to the CDV to exceed the NAAQS in the future would be no more than c % given the same CV. In other words, the CDV is the highest ADV any monitoring site could have before it may record a future violation of the NAAQS with a certain probability. The percent probability, c, is the chosen risk factor. One can choose either a more, or less, conservative c value depending on how much risk one is willing to take.

The inter-annual variability of the air quality design values at a monitoring site can be estimated from historical data at that station. Using the air quality data in the past, one can calculate the design values for each year. With these design values one can calculate the ADV and its variability in terms of the coefficient of variation (CV). Thus, one can calculate the CDV for any site with a minimum of five years of data.

CHARACTERISTICS OF THE CRITICAL DESIGN VALUE

From equation (1) we see that the CDV is a nonlinear function of the NAAQS of the pollutant, the critical t-value, t_c, and the coefficient of variation, CV, of the design values. The normalized



relationship of the CDV to the product of t_c and CV is shown in figure 1.

Figure 1.

The dependency of CDV on the other two variables can be summarized as:

1. The larger the variability (CV) of the design values in the past, the smaller the CDV will be;
2. The lower the probability of risk for future violations (PX), the lower the CDV will be;
3. If CV=0, i.e., no variability in the design values in the past, then from Figure 1 and Equation (1) we find the highest CDV equal to the NAAQS;
4. As CV increases, the CDV approaches zero;
5. If CV is not zero but $t_c = 0$, then we will also have a CDV equal to the NAAQS, but it will have a 50% chance of violating the standard in the future because $t_c = 0$ corresponds to a probability of 50%.

In Figure 2 we have chosen a risk factor of 10% probability of future violation and plotted two examples using generated data with significantly different variability in the annual PM10 design values. It is intended to illustrate the relationship among design values, ADV, CDV, and the PM10 annual NAAQS of 50 ug/m3. In this example we see that the CDV depends strongly on the inter-annual variability of the design values rather than on their means. Also, from the upper panel of Figure 2 we see that once the ADV is higher than the CDV, the probability of violating the standard will be higher than the risk we have chosen (in this case, it is one out of ten).

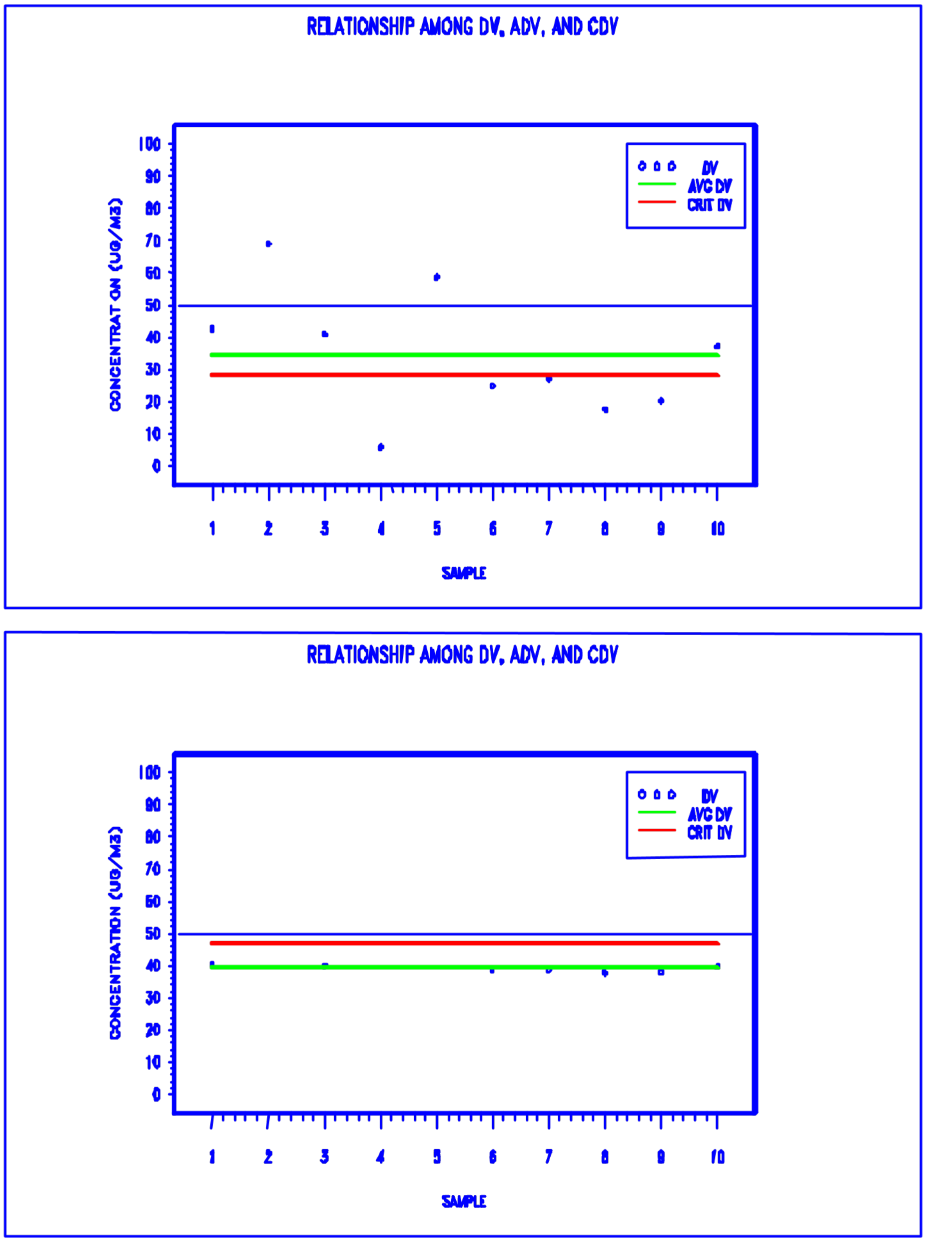


Figure 2.

Contrasting the two panels of Figure 2, we see that whether a site will have a higher or lower risk of violating the NAAQS in the future depends on how much higher or lower the ADV is to the CDV. Thus, unless some drastic change in emissions occurred in the past or should occur in the future, the CDV can be used to assess the likelihood of violating the NAAQS in the future in that area based on normal probability predictions. For this reason, this technique and the estimated

CDV could be used as a planning tool for regulatory agencies to decide whether more or fewer pollutant controls are needed in a specific area.

PM10 CRITICAL DESIGN VALUES AND DISCUSSIONS

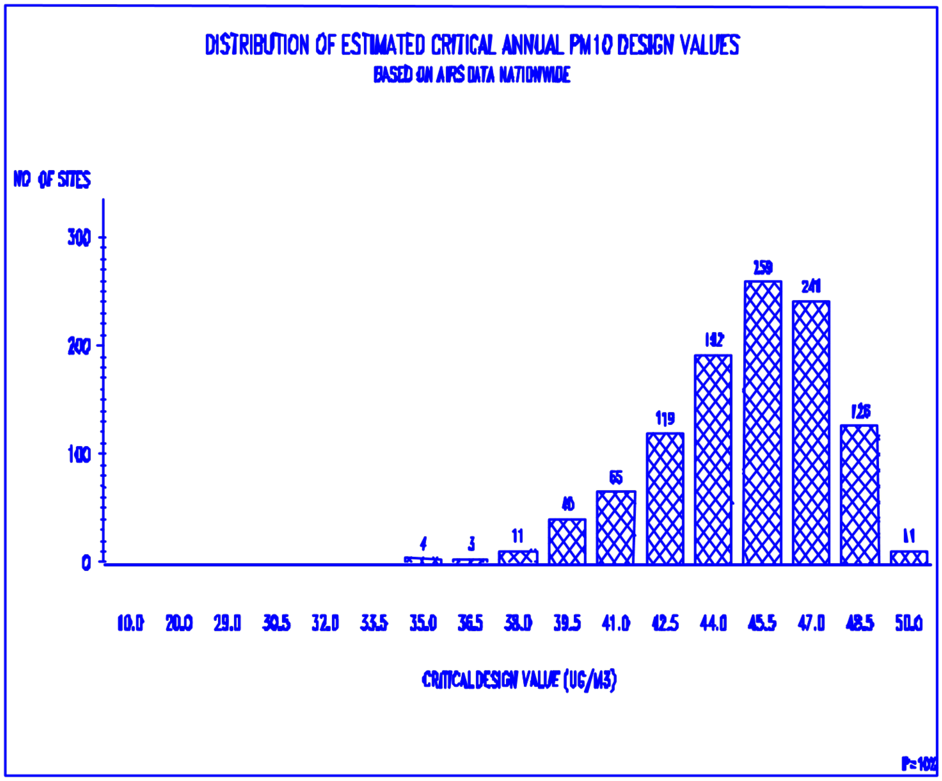
To demonstrate this approach, eleven years (1989-1999) of PM10 data nationwide were extracted from the United States Environmental Protection Agency AIRS database. The annual and 24-hr PM10 design values were calculated following the US EPA Guidance[1]. Then the methodology described in the previous section was applied using a tolerable risk factor of 10% probability of future violation of the NAAQS to calculate the CDVs for all monitor sites with more than five years of valid data. The analyses are discussed and presented in the following figures.

Figure 3 is a frequency distribution of these calculated annual and 24-hr CDVs. We see that the distributions of both the annual and the 24-hr CDVs are skewed to the left with a median annual CDV of 45.3 ug/m3 and a median 24-hr CDV of 123.2 ug/m3. The long tails to the left (low values) suggest that there are places where the inter-annual variability of the design values are quite large. It also suggests that these areas are likely to have a higher probability of violating the standards if they are already in a major PM10 source region with relatively high PM10 concentrations.

In Figure 4 a longitudinal scatter plot of both the ADVs and the CDVs at all sites spanning from Maine to California, was produced to see whether there is a difference from the East to the West. Comparing the differences between these overlaid ADVs and CDVs we see clearly that most of the higher risk areas (i.e., the areas where the ADVs are greater than the CDVs) are in the West and Midwest. The geographical distribution of the CDVs and the actual ADVs are shown in Figures 5 and 6 respectively. For comparison purposes, the ADVs in Figure 6 are color coded to show their probability of future violation of the NAAQS. The probability of future violation of the NAAQS at each site is calculated by inverting the t-values using equation (1).

The East-West difference in CDVs can be explained largely by the fact that the West, in general, has a much larger inter-annual variability of the design values than the East. However, since the anthropogenic emissions in a region usually do not change very much from year to year, the large variability in the inter-annual PM10 design values in the West may be largely attributable to the inter-annual variation in natural conditions such as meteorology, wildfires, dust storms, and volcanic emissions, etc. The higher occurrences of wildfires and dust storms in the West are known to be associated with its much drier climate, meteorological conditions, and topography. Another influencing factor on the inter-annual variability could be related to the sampling frequency of the PM10 data, which for many sites is only once every six days. However, this is more likely in the East because fewer sites are in non-attainment status and thus not required to sample more frequently than once in six days.

APPENDIX B



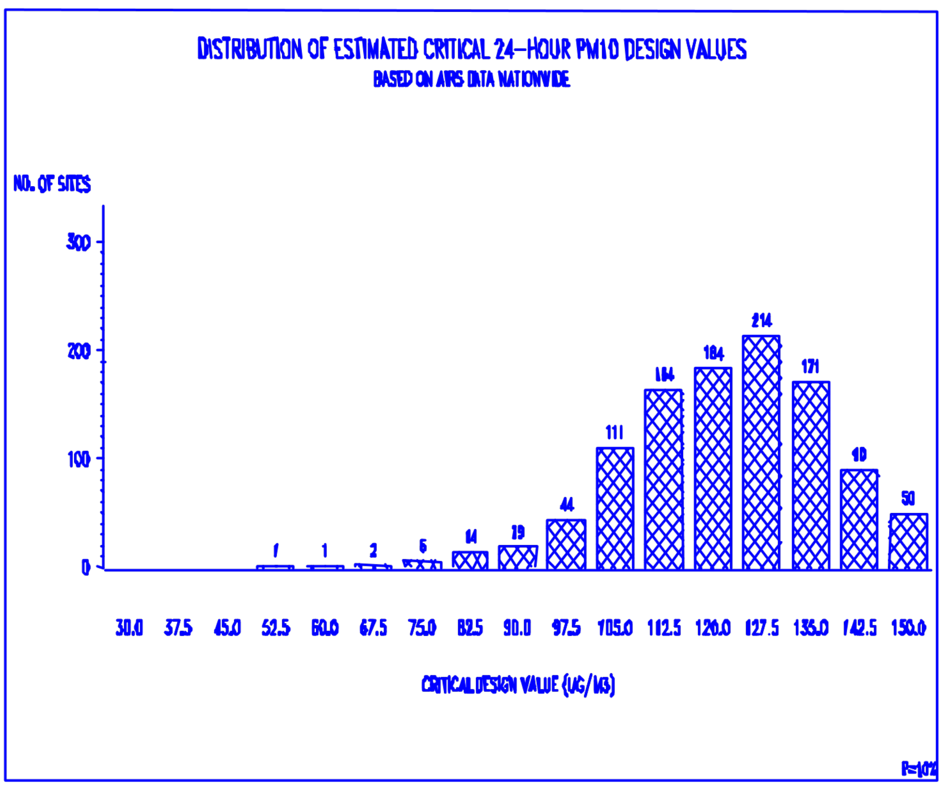
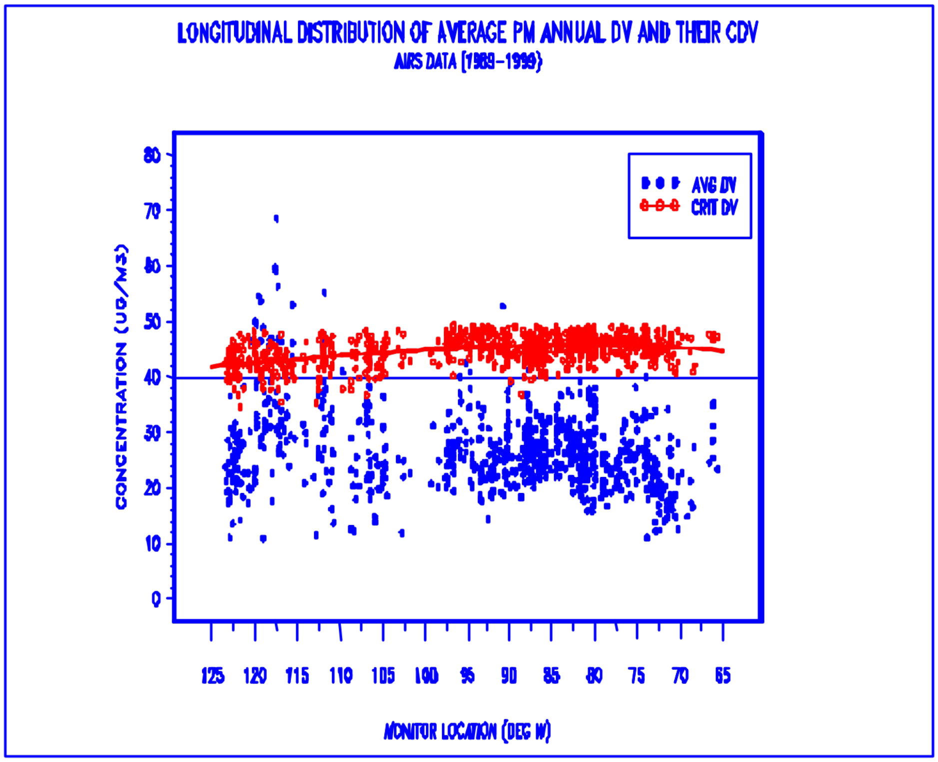


Figure 3.

APPENDIX B



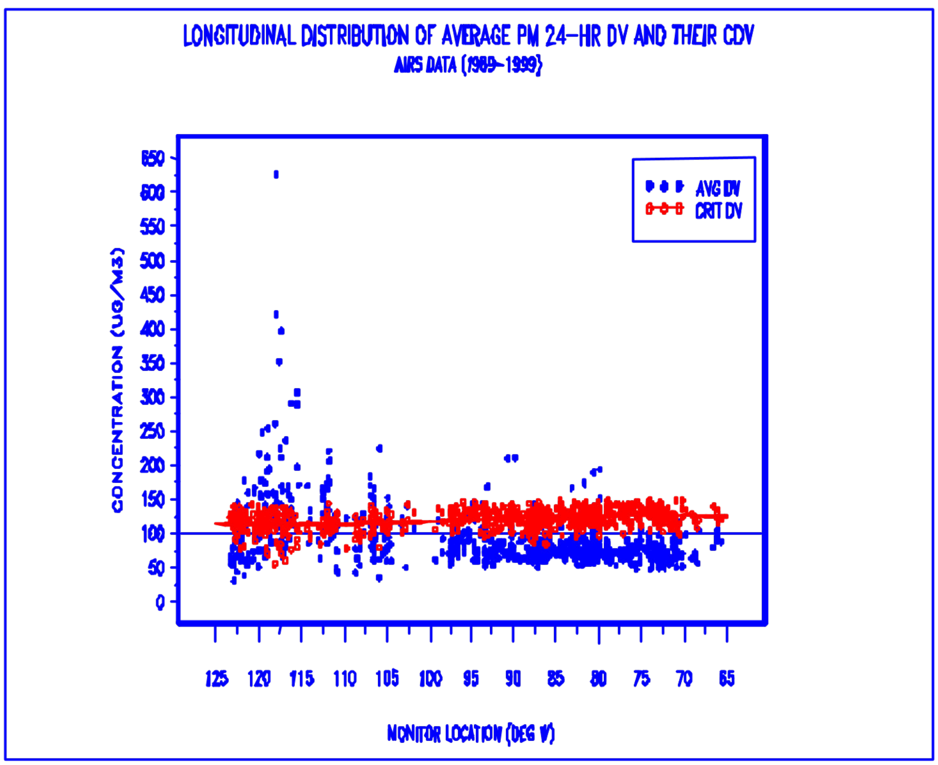
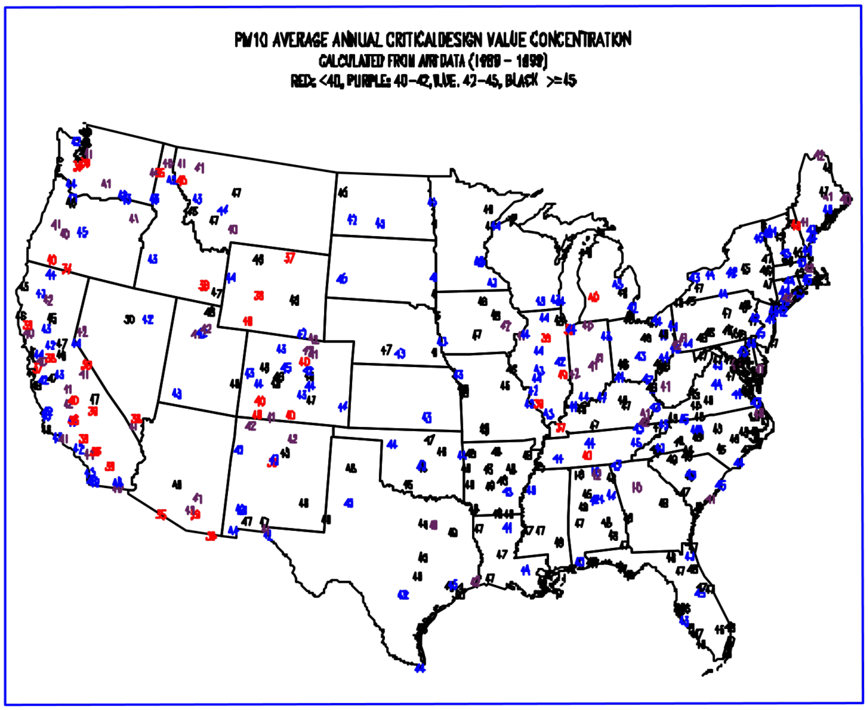


Figure 4.

APPENDIX B



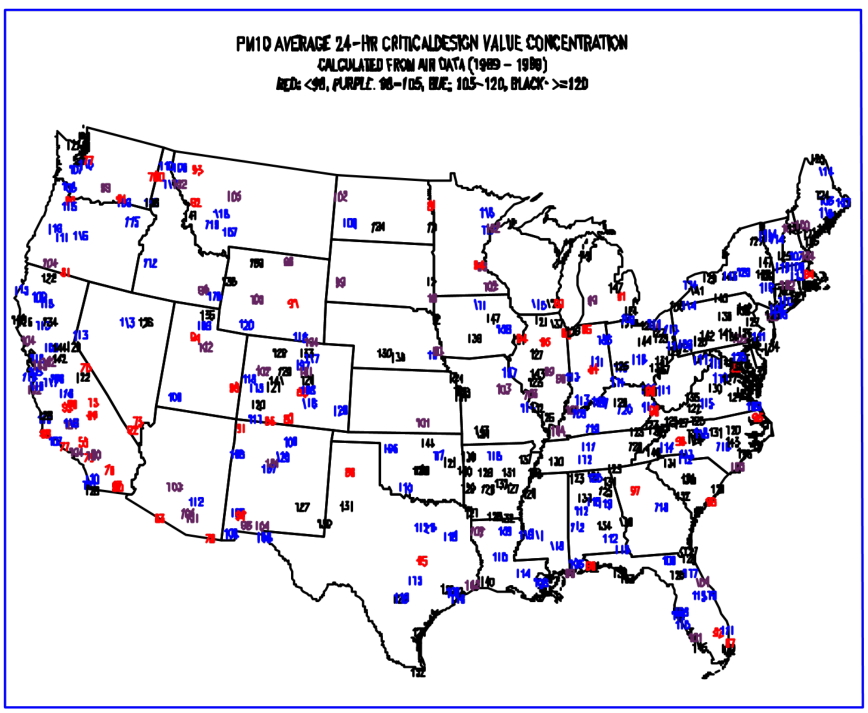
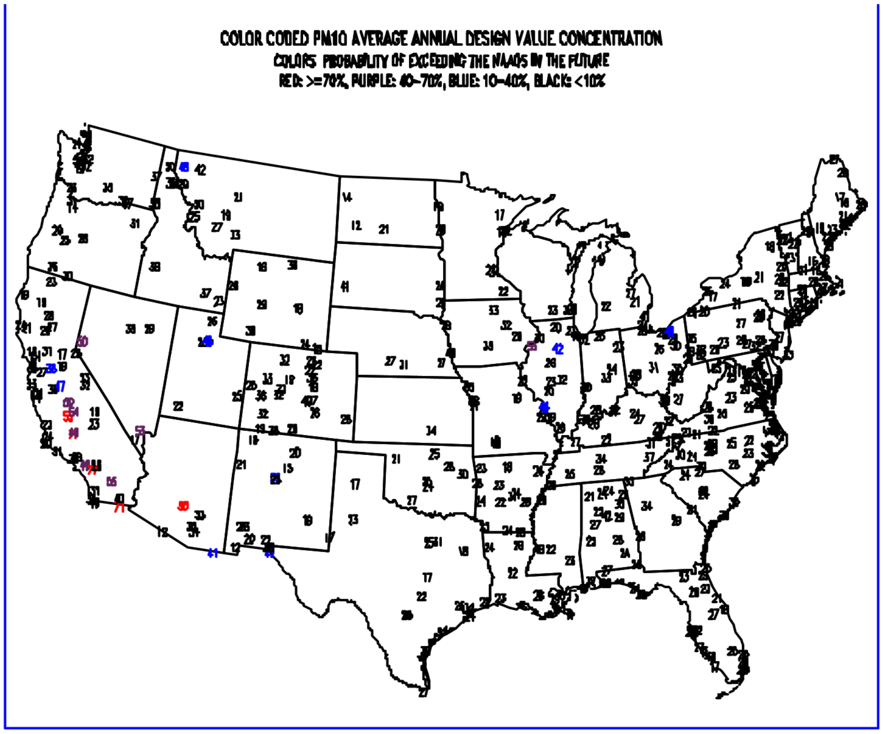


Figure 5.

APPENDIX B



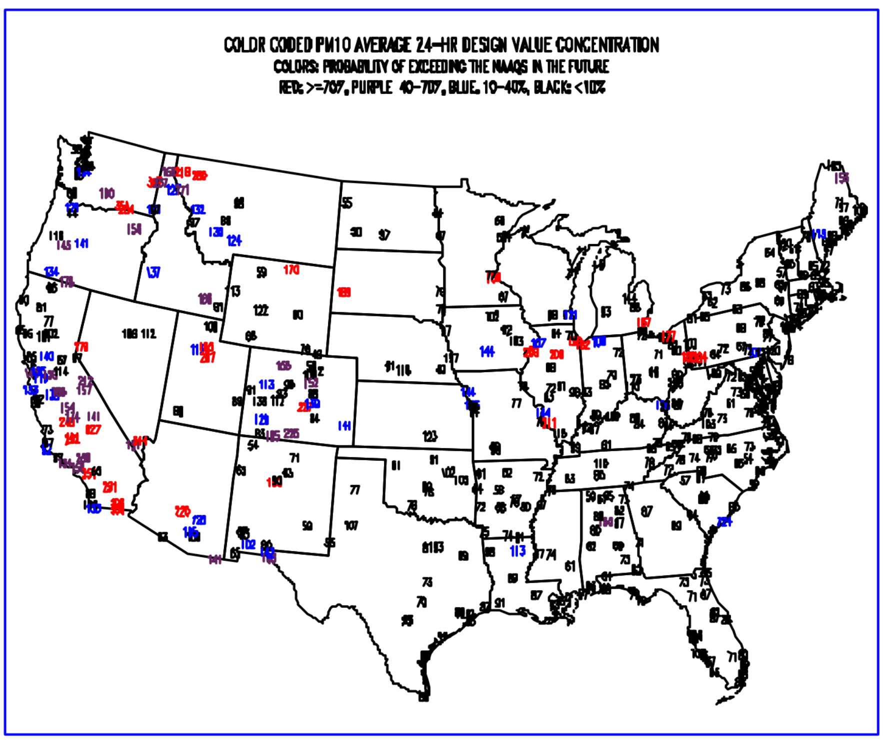


Figure 6.

APPENDIX B

CONCLUSIONS

In this paper a statistical technique has been developed to determine the CDV which is the highest possible average design value any monitoring site could have before it may record a future violation of the NAAQS with a certain probability. The critical design value is calculated based on the average design value and its variability in the past, and it also involves a risk factor of our choice in the estimation. The difference between the ADV and CDV is a good indicator of whether the site is running a higher or lower risk of violating the NAAQS in the future than one is willing to take. Using this approach, one can even predict the probability of violating the NAAQS in the near future at any given site with adequate data length. Thus, this technique could be used as a planning tool for regulatory agencies to assess the risk of future violation of the NAAQS at any monitoring site and to make decisions about emissions controls. Further, since this technique is very general, it can be applied to any pollutant with a minimum of five years of valid data.

As an example, 11 years (1989-1999) of PM10 data were analyzed using this technique. The results suggest that the inter-annual variability of the design values in the West is, on the average, much larger than that in the East, which is reflected in the calculated CDVs. Since anthropogenic emissions in a region usually do not change very much from year to year, the large variability in the inter-annual PM10 design values in the West may be largely attributable to the inter-annual variation in natural conditions such as meteorology, wildfires, dust storms, and volcanic activities, etc. The higher occurrences of wildfires and dust storms in the West are known to be associated with its much drier climate, meteorological conditions, and topography. The once every six days sampling practice of PM10 monitoring may also have some influence on the inter-annual variability of PM10 design values.

FUTURE WORK

Some further studies have been planned which include applying the same technique to other pollutants, and searching for a better estimate of CV in case when significant trend exists in the yearly design values. Since the variance estimate could be affected by an underlying trend and that a better estimate could be made of the CV if the trend and/or serial correlation could be removed from the estimate.

ACKNOWLEDGMENTS

The author would like to give thanks to Dr. Terence Fitz-Simons and Mr. Bill Cox for reading the draft manuscript and their helpful discussions.

REFERENCES

1. US EPA, *PM10 SIP Development Guideline*. EPA-450/2-86-001, US Environmental Protection Agency, Research Triangle Park, NC 27711, 1986.
2. Code of Federal Regulations, *Protection of Environment*, 40 CFR part 50, 1998.
3. US EPA, *Guideline on Air Quality Models (Revised)*. EPA-450/2-78-27 R. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711, 1986.
4. US EPA, *Guideline for the Interpretation of Ozone Air Quality Standards*. EPA450/4-79-003, US Environmental Protection Agency, Research Triangle Park, NC 27711, 1979.
5. Curran, T.C. and W.M. Cox, *Data Analysis Procedures for the Ozone NAAQS Statistical Format*. J. Air Pollution Control Association, 1980.

APPENDIX B

KEYWORDS
Critical design value, design value, inter-annual variability, PM10, probability

ATTACHMENT B:
MOTOR VEHICLE REGIONAL ANALYSIS METHODOLOGY

The following methodology is used to determine whether increased emissions from on-road mobile sources could, in the next 10 years, increase concentrations in the area and threaten the assumption of maintenance that underlies the LMP policy. This analysis must be submitted and approved in order to be eligible for the LMP option.

The following equation should be used:

$$DV + (VMT_{pi} \times DV_{mv}) < MOS$$

Where:

DV = the area's design value based on the most recent 5 years of quality assured data in $\mu g/m^3$

VMT_{pi}= the projected % increase in vehicle miles traveled (VMT) over the next 10 years motor vehicle design value based on on-road mobile portion of the attainment year inventory in $\mu g/m^3$ margin of safety for the

DV_{mv} = relevant PM-10 standard for a given area:
40 $\mu g/m^3$ for the annual standard or 98 $\mu g/m^3$ for the 24-hour standard

MOS =

Please note that DV_{mv} is derived by multiplying DV by the percentage of the attainment year inventory represented by on-road mobile sources. This variable should be based on both primary and secondary PM_{10} emissions of the on-road mobile portion of the attainment year inventory, including re-entrained road dust.

States should consult with EPA regarding the three inputs used in the above calculation, and all EPA comments and concerns regarding inputs and results should be addressed prior to submitting a limited maintenance plan and redesignation request.

The VMT growth rate (VMT_{pi}) should be calculated through the following methods:

1) an extrapolation of the most recent 10 years of Highway Performance Monitoring System (HPMS) data over the 10-year period to be addressed by the limited maintenance plan; and

2) a projection of VMT over the 10-year period that would be covered by the limited maintenance plan, using whatever method is in practice in the area (if different than #1).

Areas where method #1 is the current practice for calculating VMT do not also have to do calculation #2, although this is encouraged. All other areas should use methods #1 and #2, and VMT_{pi} is whichever growth rate produced by methods #1 and #2 is highest. Areas will be expected to use transportation models for method #2, if transportation models are available.

APPENDIX B

Areas without transportation models should use reasonable professional practice.

Examples

1. DV = 80 µg/m^3

   VMT_{pi} = 36%

   DV_{mv} = 30 µg/m^3

   MOS = 98 µg/m^3 for 24-hour PM-10 standard

   80 + (.36 * 30) = 91

   Less than 98 – Area passes regional analysis criterion.

2. DV = 35 µg/m^3

   $VMT^{DV}{}_{mv}{}_{pi}$ = = =25406 µg/m% µg/m3^3 for annual PM-10 standard

   MOS

   35 + (.25 * 6) = 37

   Less than 40 – Area passes regional analysis criterion.

3. DV = 115 g/m^3

   $VMT^{DV}{}_{mv}{}_{pi}$ = = =256098% µgµg/m/m$_3$^{3} for 24-hour PM-10 standard

   MOS

   115 + (.25 * 60) = 130

   More than 98 – Area does not pass criterion. Full section 175A maintenance plan required.

[This page is intentionally left blank]

APPENDIX C

2008 Attainment Year State Implementation Plan Emissions Inventory for $PM_{2.5}$, SO_2 and NO_x

New Castle County, Delaware

F I N A L R E P O R T

Submitted to:

U.S. Environmental Protection Agency

Region 3 – Philadelphia, PA

Prepared by:

Department of Natural Resources & Environmental Control

Division of Air Quality

Emission Inventory Development Program

655 S. Bay Road
Dover, DE 19901

October 2, 2012

APPENDIX C

ACKNOWLEDGEMENTS

Collin O'Mara
Secretary, Department of Natural Resources and Environmental Control

Ali Mirzakhalili, P.E.
Director, Division of Air Quality

Ronald A. Amirikian
Program Manager, Air Quality Planning Branch

Project Manager & Editor

David F. Fees, P.E.
Manager, Emission Inventory Development (EID) Program

Principal Contributors (EID Program)

Marian A. Hitch
Senior Environmental Compliance Specialist

John L. Outten
Senior Environmental Scientist

Jeffrey P. Bendelewski
Engineer

Mark A. Prettyman
Senior Environmental Scientist

The EID Program wishes to acknowledge the assistance of the staff of the Engineering and Compliance Branch within the Delaware Division of Air Quality for their assistance in review of emissions data reported by permitted facilities.

APPENDIX C

TABLE OF CONTENTS

TABLE OF CONTENTS – continued

Page

TABLE OF CONTENTS – continued

LIST OF TABLES

LIST OF TABLES continued

LIST OF FIGURES

APPENDIX C

ACRONYMS & ABBREVIATIONS

ACD	administrative completeness determination
AERR	Air Emissions Reporting Requirements
AMPD	Air Markets Program Data (EPA)
AP-42	Compilation of Air Pollution Emission Factors (EPA)
ARP	Delaware Accidental Release Prevention Program (DNREC)
ATP	Anti-tampering Program
BOC	Bureau of Census
C&D	Chesapeake and Delaware
CARB	California Air Resources Board
CBP	County Business Patterns
CD	compact disk
CDM	county data manager
CDX	central data exchange
CE	control efficiency
CEM	continuous emission monitor
CERS	consolidated emissions reporting schema
CFR	Code of Federal Register
CMV	commercial marine vessel
CNG	compressed natural gas
CO	carbon monoxide
CROMERR	Cross-media Electronic Reporting Rule
DAQ	Delaware Division of Air Quality
DE	Delaware
DE ANG	Delaware Air National Guard
DE ARNG	Delaware Army National Guard
DE DOL	Delaware Department of Labor
DelDOT	Delaware Department of Transportation
DMV	Delaware Division of Motor Vehicles (DelDOT)
DNREC	Department of Natural Resources and Environmental Control
DOE	U.S. Department of Energy
DPC	Delaware Population Consortium
DRBA	Delaware River and Bay Authority
DSWC	Division of Soil and Water Conservation (DNREC)
DVD	digital video disk
DWT	dead weight tonnage
E&C	Engineering and Compliance Branch (DNREC-DAQ)
EDMS	Emissions and Dispersion Modeling System (FAA)
EF	emission factor
EGU	electric generating unit
EIA	Energy Information Administration (DOE)
EID	Delaware Emission Inventory Development Program (DNREC-DAQ)
EIIP	Emission Inventory Improvement Program
EIS	Emission Inventory System
EPA	U.S. Environmental Protection Agency

ACRONYMS & ABBREVIATIONS continued

ERTAC	Eastern Regional Technical Advisory Committee
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FIRE	Factor Information Retrieval System
FP & GC	fuel pressure and gas cap test
GAF	geographic allocation factor
GHG	greenhouse gas
GIS	geographic information system
GSE	ground support equipment
GTM	gross ton-miles
GVWR	gross vehicle weight rating
HAP	hazardous air pollutant
hp	horsepower
HPMS	Highway Performance Monitoring System
IFO	intermediate fuel oil
I/M	Inspection and Maintenance
LEV	low-emission vehicle
LPG	liquefied petroleum gas
LTO	landing/takeoff
MARAMA	Mid-Atlantic Regional Air Management Association
MC	method code (*i*-STEPS)
MMBtu	million British thermal units
MOVES	motor vehicle emission simulator
mph	miles per hour
MY	model year
NAAQS	National Ambient Air Quality Standard
NAICS	North American Industry Classification System
NCC	New Castle County (Delaware)
NCDC	National Climatic Data Center
NEI	National Emissions Inventory
NH_3	ammonia
NLEV	national low emission vehicle
NO_x	oxides of nitrogen
OBD	on-board diagnostics
OGV	ocean-going vessel
OIT	Office of Information Technology (DNREC)
OTR	Ozone Transport Region
pdf	portable document format
PEI	Periodic Emissions Inventory
PM-CON	condensable particulate matter
PM_{10}-FIL	filterable portion of PM_{10}-PRI
$PM_{2.5}$-FIL	filterable portion of $PM_{2.5}$-PRI
$PM_{2.5}$-PRI	particles with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers

ACRONYMS & ABBREVIATIONS continued

PM_{10}-PRI	particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers
ppm	parts per million
POW	Port of Wilmington
psi	pounds per square inch
QA	quality assurance
QC	quality control
R&D	research and development
RE	rule effectiveness
RP	rule penetration
rpm	revolutions per minute
RSZ	reduced speed zone
RVP	Reid vapor pressure
SARA	Superfund Amendments and Reauthorization Act
SCC	source classification code
SEPTA	Southeast Pennsylvania Transportation Authority
SIP	State Implementation Plan
SO_2	sulfur dioxide
SQL	structured query language
TIM	time-in-mode
TPY	tons per year
TRI	Toxics Release Inventory
TV	Title V permit classification
US	United States
USACE	U.S. Army Corps of Engineers
VMT	vehicle miles traveled
VOC	volatile organic compound
XML	extensible markup language

SECTION 1

2008 $PM_{2.5}$, SO_2, AND NO_X INVENTORY OVERVIEW AND SUMMARY

In 2006, the U.S. Environmental Protection Agency (EPA) promulgated a new 24-hour National Ambient Air Quality Standard (NAAQS) for particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers ($PM_{2.5}$). Particles of this size are known as fine particulate matter. EPA established the standard at 35 µg/m^3. The previous 24-hour standard established by EPA in 1997 was set at 65 µg/m^3.

New Castle County was designated non-attainment for the daily $PM_{2.5}$ standard based on 2006-2008 monitoring data. The 35 µg/m^3 24-hour standard went into effect on December 14, 2009, following final non-attainment area boundary designations (EPA, 2009). New Castle County was included in the Philadelphia-Wilmington, PA-NJ-DE non-attainment area with an attainment date of December 14, 2012.

Particulate matter emitted from sources is known as primary particulate emissions. Primary emissions include filterable (PMx-FIL) and condensable (PM-CON) material. Filterable matter can be designated as PM-FIL, PM_{10}-FIL, or $PM_{2.5}$-FIL depending on particle size cut points. PM-CON is always considered smaller than 2.5 micrometers in diameter. The combination of PMx-FIL and PM-CON is known as primary particulate matter, or PMx-PRI. Throughout this report, the use of $PM_{2.5}$ refers to primary fine particulate emissions. Particulate matter is also formed in the atmosphere through reactions that form sulfates and nitrates. These emissions are considered secondary emissions of particulate matter. Sulfur dioxide (SO_2) and oxides of nitrogen (NO_x) contribute to the formation of secondary PM emissions.

The Division of Air Quality (DAQ), within the Delaware Department of Natural Resources and Environmental Control (DNREC) established calendar year 2007 as the base year inventory for the 24-hour $PM_{2.5}$ because (1) 2007 coincides with the three years of ambient monitoring data used to designate New Castle County as part of the Philadelphia non-attainment area, and (2) a 2007 regional inventory had already been prepared for modeling and State Implementation Plan (SIP) purposes. This regional inventory, for which Delaware supplied Delaware-specific data for all source sectors, has undergone extensive quality assurance. Details of how the inventory was developed can be found in the regional report, *Technical Support Document for the Development of the 2007 Emission Inventory for Regional Air Quality Modeling in the Northeast/Mid-Atlantic Region* (MARAMA, 2007).

The DAQ established calendar year 2008 as the attainment year inventory for the 24-hour $PM_{2.5}$ because (1) 2008 coincides with the three years of ambient monitoring data used to demonstrate that New Castle County now attains the 24-hour PM2.5 standard, and (2) 2008 represents a Periodic Emissions Inventory (PEI) reporting year, for which Delaware has prepared a SIP quality inventory based on Delaware-specific data for all sources of criteria pollutants to include $PM_{2.5}$ emissions and emissions of NO_x and SO_2 as precursors to $PM_{2.5}$.

This report documents Delaware's completed 2008 inventory of $PM_{2.5}$ SO2, and NO_x for New Castle County for all sources including the following four major source sectors: stationary point, stationary non-point, on-road mobile, and off-road mobile.

APPENDIX C

1.1 Project Management

The Emission Inventory Development (EID) Program within the Planning Branch of DAQ was responsible for preparing the 2008 PEI for criteria pollutants to include emissions $PM_{2.5}$, SO_2, and NO_x summarized in this report. Internal planning began in September 2008, with focus on the 2008 point source inventory reporting cycle taking place in March/April of 2009.

1.1.1 Project Manager

The overall project manager was David Fees, Managing Engineer for the EID Program. Responsibilities included identifying overall inventory goals, objectives, and deadlines, initiating inventory planning, approving estimation methodologies recommended by staff, reviewing emissions development work, and preparing inventory reports and documentation.

1.1.2 Point Sources Technical Lead

The point source technical planning and review was performed by John Outten, a senior environmental scientist for the EID Program. Responsibilities included:

- Identifying point source inventory goals, objectives, and deadlines;
- Establishing the universe of facilities to inventory;
- Overseeing the development of the survey forms and instructions;
- Providing training and guidance to industry representatives;
- Setting up the on-line electronic reporting system and working with DNREC's Office of Information Technology in preparing the on-line reporting capabilities;
- Performing a technical review of emissions data submitted by facilities;
- Working with facility representatives to correct errors;
- Managing the point source inventory database; and
- Overseeing quality control of point sources data.

1.1.3 Point Sources Support

Support of the point source inventory was performed by Marian Hitch, a senior environmental compliance specialist for the EID Program. Responsibilities included:

- Gathering facility general information on facilities to be surveyed;
- Assisting in developing survey forms and instructions;
- Preparing and mailing reporting packages;
- Receiving and organizing reports submitted by facilities;
- Performing an administrative review of all reports received;
- Tracking reporting status of each facility; and
- Preparing and organizing documentation for the point source inventory.

1.1.4 Non-point and Off-road Sources

Emission estimates of the many non-point and off-road source categories were prepared jointly by Jeffrey Bendelewski, an engineer for the EID program, and Mark Prettyman, a senior environmental scientist for the Planning Branch of DAQ. Their responsibilities included:

- Researching and recommending emission estimation methodologies;
- Defining all simplifying assumptions;
- Obtaining 2008 activity data, current emission factors, and applicable control information
- Using spreadsheets to calculate emissions;
- Downloading and using the EDMS model for developing aircraft emissions;
- Downloading and using the NONROAD model;
- Reviewing emission calculations for accuracy and completeness;
- Preparing report documents; and
- Compiling supporting documentation.

1.1.5 On-road Mobile Sources

Emission estimates of on-road mobile sources were prepared by John Outten, a senior environmental scientist for the EID program. Responsibilities included:

- Downloading the MOVES model;
- Obtaining 2008 vehicle miles traveled (VMT), vehicle registration, and other mobile input data from the Delaware Department of Transportation;
- Obtaining other data for inclusion in the model inputs;
- Preparing the input files for running MOVES;
- Running MOVES and summarizing the model outputs;
- Reviewing emissions for accuracy and completeness;
- Preparing report documents; and
- Compiling supporting documentation.

1.2 Inventory Planning

Calendar year 2008 is a Periodic Emissions Inventory (PEI) year as defined by the Air Emissions Reporting Requirements (AERR) (EPA, 2008). The AERR specifies the emissions data for criteria pollutants that are required to be reported to EPA's National Emission Inventory (NEI). A PEI requires the development of emission estimates from all sources within a state or local area for all criteria pollutants and their precursors. As such, the 2008 inventory can provide the necessary data for the $PM_{2.5}$ 24-hour NAAQS attainment year inventory. While not required, the DAQ also prepared 2008 emission estimates of air toxics and greenhouse gases from all sources.

1.2.1 Inventory Parameters

The inventory parameters defined by the 2008 $PM_{2.5}$ Attainment Year SIP inventory include the following:

- **Inventory year –** 2008;
- **Pollutants –** $PM_{2.5}$, and SO_2 and NO_x as precursors to $PM_{2.5}$ (DNREC, 2012a);
- **Source coverage –** all sources, including point, non-point, mobile, and non-road sources;
- **Spatial resolution –** county level emissions;
- **Geographic coverage –**New Castle County; and
- **Temporal resolution –** annual emissions (DNREC, 2012b).

1.2.2 Data Collection and Management

For all source categories the gathering of local activity data represented a major task spread over many months. For point sources, most facilities reported their emissions through the use of an on-line reporting system. Data entered into the on-line system were transferred to the DAQ *i*-STEPS® database for review and correction.

Microsoft Excel spreadsheets were employed for managing activity data and calculating emissions from stationary non-point sources and some non-road categories. A consistent set of tabs within each source category spreadsheet included activity data, point source data (if applicable, for backouts), emission factors, controls, emission calculations, National Emission Inventory (NEI) input formats, and notes on QA/QC procedures.

On-road mobile source emissions were calculated using the MOVES2010a model. Emissions for most of the non-road vehicles and equipment categories were calculated using the NONROAD2008a model.

Emissions data were transferred from *i*-STEPS® (point sources), from the non-point and non-road spreadsheets, and from the model outputs to staging tables in Microsoft Access databases. These databases were then converted to XML files via the EIS bridge tool, and then transmitted to the EIS via CDX web client by June 1, 2010 to meet the reporting requirements of the AERR.

1.3 Inventory Development

For point sources, the EID Program developed a set of criteria to use in establishing the universe of facilities required to report. These criteria are presented in detail in the point source section of this report. Reporting packages were sent to each facility meeting one or more of the reporting criteria. An extensive amount of review and follow up was performed on the point source data submitted by facilities.

For non-point sources, the first main task involved gathering activity data for each source category. In many cases, these data were obtained from Delaware-specific sources. In some cases the activity data were developed through the allocation of a portion of a national activity dataset (i.e., national off-road equipment populations) to Delaware. Basic demographic data were also used for some source categories and are presented in Table 1-1. Once activity data were obtained, spreadsheets were developed to manage the data and combine the activity data with the selected emission factors to obtain uncontrolled emissions. Finally, for those sources where controls applied, emissions were adjusted to account for control efficiency, rule effectiveness, and rule penetration.

Table 1-1. 2008 Demographic Data for New Castle County

Demographic Parameter	New Castle
Population[a]	528,536
Households[a]	204,630
Land Area (square miles)	439
Annual VMT (million miles)[b]	5,273

[a] DPC, 2009; [b] DelDOT, 2009.

For on-road mobile and off-road equipment, the MOVES and NONROAD models, respectively, were used to develop emissions from these sources. In the use of these models, activity data were included in the model input files. For any type of data used by the model for which Delaware-specific data did not exist, the model used the system defaults. Details about Delaware-specific and default parameters are discussed in the on-road and non-road sections. The models account for controls, some of which reflect controls specific to Delaware.

1.4 Emissions Summary

The following emission summaries present the entire 2008 emission inventory for $PM_{2.5}$, SO_2, and NO_x, for New Castle County broken down by source sector. Throughout this document, annual emissions are reported in tons per year (TPY). The totals may not match the sum of the individual values due to independent rounding.

Table 1-2. 2008 $PM_{2.5}$, SO_2, and NO_x Emissions by Source Sector

Source Sector	Annual Emissions (TPY)		
	$PM_{2.5}$	SO_2	NO_x
Point	1,109	10,576	5,589
Non-point	1,191	402	1,287
Non-road	312	1,067	4,317
On-road	282	94	9,311
All Sectors	**2,894**	**12,139**	**20,504**

Figure 1-1. $PM_{2.5}$ Emissions by Source Sector

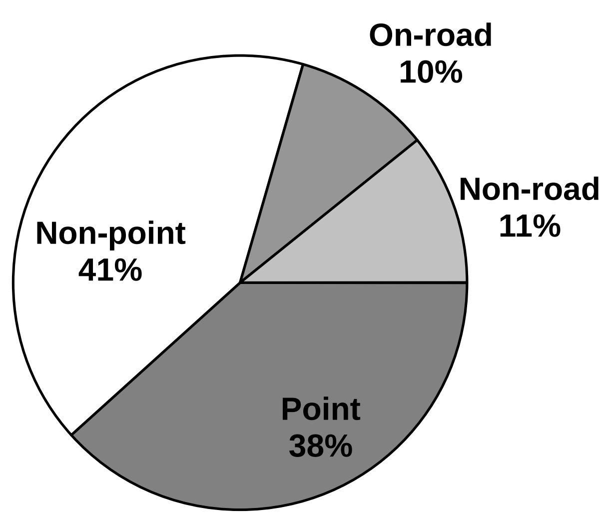


Figure 1-2. SO_2 Emissions by Source Sector

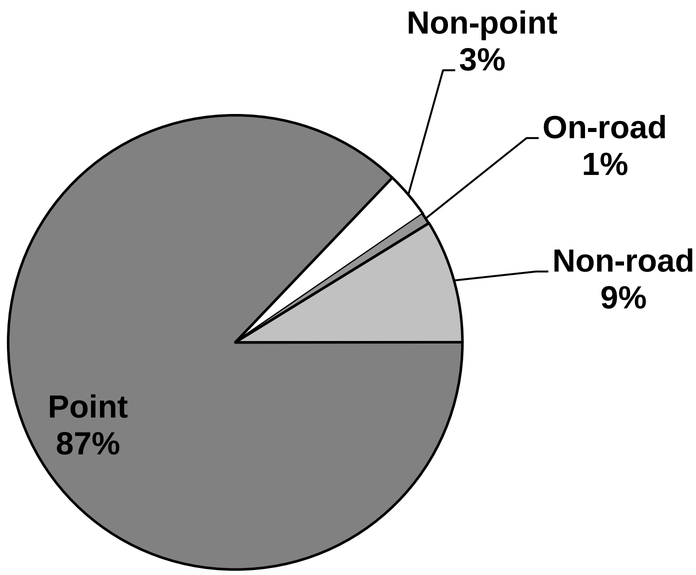
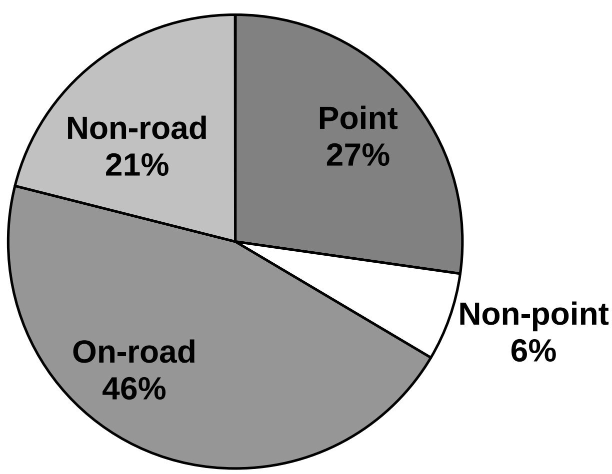


Figure 1-3. NO_x Emissions by Source Sector



1.5 References

DPC, 2009. Delaware Population Consortium Annual Population Projections, downloaded from http://stateplanning.delaware.gov/information/dpc_projections.shtml, October 31, 2009.

DELDOT, 2009. *2008 Estimated VMT by County, by Functional Class, by Rural/Urban Designation*, accessed DelDOT website July 10, 2009, per June 29, 2009 e-mail from Mike DuRoss, DelDOT Planning.

DNREC, 2012a.*"Delaware Redesignation Request and Maintenance Plan Under the 2006 Daily $PM_{2.5}$ National Ambient Air Quality Standard"*, Section 7.2.1, Delaware Department of Natural Resources and Environmental Control, Division of Air Quality, September 2012.

DNREC, 2012b.*"Delaware Redesignation Request and Maintenance Plan Under the 2006 Daily $PM_{2.5}$ National Ambient Air Quality Standard"*, Section 4.1, Delaware Department of Natural Resources and Environmental Control, Division of Air Quality, September 2012.

EPA, 2008. Final Rule: *"Air Emission Reporting Requirements"*, Federal Register – Vol. 73 No. 243 page 76539, December 17, 2008.

EPA, 2009. Final Rule: *"Air Quality Designations for the 2006 24-Hour Fine Particle (PM2.5) National Ambient Air Quality Standards"*, Federal Register – Vol. 74 No. 218 page 58688, November 13, 2009.

SECTION 2

STATIONARY POINT SOURCES

The point source inventory represents facility-specific data for larger stationary sources. Emissions data for all other source categories are reported at the county level. Point sources typically include large industrial, commercial and institutional facilities. Industrial manufacturing facilities comprise the majority of all reporting point sources. The institutional sector includes hospitals, universities, prisons, military bases, landfills, and wastewater treatment plants.

Unlike other source sector emissions which are estimated by DAQ, point source emissions data are submitted to DAQ by the facilities. Emissions are reported at the process level and include both confined (stack) emission points as well as unconfined (fugitive) emission sources. A key aspect of point source data is the inclusion of facility coordinates to accurately allocate emissions spatially within a county for purposes of performing air dispersion modeling.

The planning and execution of the point source inventory was accomplished in the following chronological order:

- Define the purpose of the inventory (defined in Section 1 of this report);
- Establish the reporting criteria and list of facilities to survey;
- Obtain inventory data from facilities;
- Perform administrative and technical review of data received from facilities;
- Seek resubmissions/corrections from facilities based on data review;
- Perform internal data augmentation (for $PM_{2.5}$); and
- Prepare inventory data files, report, and supporting documentation.

Quality control/assurance is not listed in the chronology above since these activities were performed throughout the point source inventory development process. Quality control/assurance efforts are presented throughout this section.

Since there may be overlap between point sources and stationary non-point source categories, one final activity required of the point source inventory staff is to provide point source back out data where appropriate. Point source back out data includes emissions, throughput, or employees, depending on the non-point source category methodology.

2.1 Reporting Criteria

Based on the several purposes of the 2008 inventory (Ozone PEI, $PM_{2.5}$ PEI, HAPs and GHG inventories, as well as the daily $PM_{2.5}$ Attainment Year SIP inventory) the following criteria were established for defining the universe of facilities to be surveyed:

- Facilities that held a Title V permit in 2008;
- Any facility falling into one of the following industry sectors;
  - Hot-mix asphalt plants,

- Electric generating units (EGUs);
- Facilities using anhydrous ammonia as a refrigerant; and
- Chrome plating operations;

- Any facility with emissions greater than 5 TPY for VOCs or 25 TPY for NO_x in 2006 or 2007, as previously reported to the DAQ inventory program; and
- Any facility that may be a significant source of emissions but for which DAQ does not have previous inventory data, or otherwise of particular interest.

2.2 Initial List of Facilities

Once the reporting criteria were established, DAQ point source inventory staff compiled an initial list of facilities to be compared against the reporting criteria. All 133 facilities reporting statewide for the 2005 Periodic Emissions Inventory (PEI) were included in the initial list. All Title V (TV) permitted facilities are required to report emissions each year. The Engineering and Compliance Branch of DAQ provided a list of TV facilities as of the end of 2008, which contained one facility that had not reported for 2005.

The following additional data sources were reviewed to identify facilities that might have met one or more of the reporting criteria:

- Toxics Release Inventory (TRI, SARA 313) – 2006 and 2007 data;
- Hazardous Chemical Inventory (Tier II, SARA 312) – 2007 data;
- Accidental Release Prevention (ARP) Program facility list.

DAQ inventory staff reviewed the two most recent years of TRI data, and found that all facilities within TRI with more than five tons per year air releases of VOC compounds were already included in the initial list. The Tier II data and information from the ARP Program were reviewed mainly to identify facilities that used anhydrous ammonia; however, no additional facilities were added to the initial list as a result of this review.

Through a review of permit and compliance information, and conversations with the permitting group, one new asphalt plant and six other facilities of interest were added to the initial list. The six facilities of interest were either new facilities needing baseline data, or facilities not recently inventoried, but nonetheless with the potential of having significant PM emissions.

The complete initial list included 142 facilities statewide. A spreadsheet was developed by DAQ point source staff containing a record of every facility included on the initial list of facilities. The spreadsheet includes the reason the facility was placed on the initial list. For facilities that were inventoried, the spreadsheet indicates which reporting criteria were met.

2.3 Facilities Inventoried

The facilities on the initial list were evaluated using the reporting criteria established in Section 2.1. TV facilities are required to report regardless of the amount of emissions. Therefore, all 65 TV facilities were included in the final list of point sources. The remaining 77 of the 142 facilities were evaluated against the other reporting criteria. As a result, 20 facilities were dropped from further consideration since no criterion was met.

Four facilities were identified as being closed prior to calendar year 2008. They were City of Lewes EGUs, Industraplate, Spatz Fiberglass and Tilcon-Horsepond Road. Prior to 2008, permits for the City of Seaford's six EGUs had been modified to allow these units to operate only as emergency generators as defined by Delaware Regulation 1144 (DNREC, 2006). Therefore, this facility is no longer included in the point source inventory. One facility, Tilcon-Terminal Avenue, did not operate in 2008, and has since closed permanently.

Three facilities closed during 2008. Attempts were made to contact the companies. In phone conversations with Perma-Flex Rollers and PTFE Compounds, it was determined both facilities did not meet any of the reporting criteria for 2008. PTFE had closed after having minimal operations for the first six months of 2008. In July 2008 the facility moved their operations to New Jersey. The Perma-Flex Rollers site was used primarily for storage and warehousing and had little or no production during 2008. The third facility that closed in 2008, Pepsi Cola Bottling Company, used ammonia refrigeration, which would require reporting; however DAQ was unable to obtain any information related to potential ammonia emissions.

Through a review of emissions data from 2006 and 2007, recently reported TRI air emissions, and inspection reports, eight facilities were determined to not meet either the VOC or NO_x emission thresholds, and thus were not included in the list of facilities to be inventoried.

Two facilities (the Port of Wilmington and VFL Technologies) that were added to the initial list as facilities of interest were not inventoried due to staff resources. DAQ staff did spend considerable time working with the Port of Wilmington to establish a set of stationary and mobile emission units, but due to time constraints, an inventory was not completed by the site. Due to limited resources VFL Technologies was not contacted and did not submit an emissions inventory. VFL closed in 2010.

Finally, in 2007 SPI Polyols was sold to Croda-Uniqema, an adjacent and contiguous Synthetic Minor permitted facility. Starting with 2008, processes and emissions previously associated with SPI Polyols were reported by Croda.

The final list included 122 facilities inventoried statewide. Of these, 58 facilities in New Castle County reported emissions of particulate matter and/or particulate precursors (SO_2, and NO_x) and are included in the 2008 $PM_{2.5}$ Attainment Year SIP inventory.

2.4 Survey Methods

In December 2008, the DAQ point source inventory staff began reviewing survey methods and preparing reporting packages to be e-mailed to each facility to be inventoried. DAQ used two primary methods to gather information from most facilities for the 2008 inventory. Facilities either used an on-line reporting system or submitted activity data reporting forms by e-mail or facsimile. These two methods are described in detail below.

2.4.1 Electronic Reporting

DAQ offers electronic reporting of emissions data through the Internet. For the 2008 reporting cycle, the Terminal Server Satellite ***i***-STEPS® application was updated with the latest FIRE and AP-42 emission factors. Satellite ***i***-STEPS® is capable of calculating emissions based on information supplied on process throughput, operating schedule, and controls. A database specific to each facility was generated based on previously submitted inventories and other information (i.e., permitting files). Information expected to remain the same from year to year was pre-populated in the database, while throughput and emissions data were zeroed out. Facilities were expected to update pre-populated information as necessary and enter 2008 data for fields that were zeroed out.

2.4.2 Activity Data Reporting Forms

Instead of requiring on-line reporting for all facilities, DAQ provides smaller facilities with the option of completing fillable electronic activity data reporting forms that are e-mailed to the facility that can be e-mailed back to DAQ once completed. DAQ used these forms for 2008 to simplify the reporting process. The activity data supplied by facilities (i.e. operating schedule, monthly throughputs), were used by DAQ staff to calculate emissions based on EPA's FIRE emission factors or material balance methodologies.

Activity data reporting forms applicable to the 2008 Attainment Year SIP inventory were developed for the following processes:

- Boilers;
- Stationary diesel engines; and
- Hot-mix asphalt production.

For facilities that used the activity data forms, DAQ already had detailed process and stack information on file.

2.4.3 Other Methods

In a limited number of cases where on-line reporting or the use of the activity data forms was not appropriate or useful, information was obtained from facilities via telephone, e-mail or facsimile. Regardless of the survey methods used to obtain data from facilities, all data were entered into one database within ***i***-STEPS®.

2.5 Data Collection

Reporting packages were sent out in January and February 2009 to facilities identified as meeting one or more of the established reporting criteria.

Table 2.1 provides the number of facilities inventoried by each survey method.

Table 2-1. Inventory Methods

Inventory Method Used	Number of Facilities
On-line reporting	71
Activity data report forms	48
Other methods	3

2.5.1 On-line Reporting

Terminal Server Satellite ***i***-STEPS® software reporting packages were e-mailed to 71 facilities between February 10 and February 18, 2009. The reporting package contained a cover letter, instructions, and an Optical Media Certification Form. Two facilities (Micropore and CPI Packaging) that received reporting packages for on-line submissions were subsequently handled directly through e-mail and facsimile.

The instructions contained information on how to access the Terminal Server Satellite ***i***-STEPS®, user initials and passwords, DAQ contact information, information specific to the 2008 inventory, and a DAQ web page address where additional inventory documents were available. These documents included:

- Emission Inventory Definitions and Structure
- Common Errors
- Useful Web Pages
- Uncontrolled Coal PM_x Factors or Formula
- Calculating PM_{10} and $PM_{2.5}$ Emissions for #4, #5 and #6 Fuel Oils Using EPA FIRE 6.24 Formulas
- Regulated Pollutants
- Web FIRE (Factor Information Retrieval System)
- TANKS Software (EPA, 2005a)
- Emissions Factors / AP 42

A database was customized for each facility based on the process structure previously established for the facility. For new facilities using Satellite ***i***-STEPS®, the reporting structure was created by DAQ point source inventory staff with input from the facility. The database was pre-populated with general information about the facility, as well as a few other data elements not expected to change from year to year, such as stack parameters and design capacity. Other data elements were left blank or zeroed out, such as annual process rate, percent sulfur and ash of fuel burned, operating schedule, throughputs, capture and control efficiencies, and emission estimates.

Generally, it was the large, complex facilities with multiple processes that reported on-line. For facility representatives new to emissions inventory reporting or who had not reported in some time, DAQ inventory staff worked with them to understand the inventory structure. Assistance by phone or e-mail in completing the inventory was offered on an on-going basis for many facilities. Terminal Server Satellite ***i***-STEPS® on-line reporting allowed point source inventory staff to work with a facility simultaneously on-line to resolve any issues a facility may have encountered.

APPENDIX C

The inventory information requested from facilities for the 2008 inventory is described in several EPA publications including *Emission Inventory Requirements for Ozone State Implementation Plans and Emissions Inventory Guidance* (EPA, 1991a) and *Emissions Inventory Improvement Program (EIIP), Volume II* (EPA, 1997). All emissions were reported at the process level. Facilities were required to provide emission calculations and documentation in the Notes window within Terminal Server Satellite ***i***-STEPS® or in writing when submitting their certified emissions.

Terminal Server Satellite ***i***-STEPS® has built-in system checks for out of range values as well as relational errors. Field specific data entry checks were performed by the software at the time the data were entered or when an attempt was made to save the data. The system prompted the user to make the needed corrections. In most cases a record could not be saved until all edit checks were satisfied. System functions and checks include:

- Data can be entered through the use of look-up tables;
- Data entered directly must match information in the look-up table;
- Total percent quarterly throughputs must be between 95 and 101;
- Alpha-numeric checks;
- Enforced relational database integrity;
- Mandatory field alerts;
- Stack assignment check (each process must have an assigned stack); and
- Automated emissions calculations.

Once a facility completed entering its data and information, the user had the ability to run the following reports:

- Group level emissions (facility summary);
- Process unit level emissions summary; and
- Detailed report (contains all entered and calculated data).

Facilities used the three reports to verify data they entered and the emissions reported and/or calculated by the Terminal Server Satellite ***i***-STEPS®. Reports could be displayed to the screen or created as an Adobe Acrobat pdf file which is then automatically e-mailed to the user.

The process summary report provided emissions of each criteria pollutant for each process within an emissions unit. The detailed report lists the data following the Terminal Server Satellite ***i***-STEPS® structure and contains all information that the facility entered as well as information the system used to organize the inventory information or calculate emissions.

The facility summary report tabulates criteria pollutant emissions for each emission unit with a facility total at the bottom. This report also served as the emission certification page and thus contains a signature area for the "Responsible Official". When DAQ received a signed copy of this report, indicating the facility had completed the reporting process, DAQ set the Terminal Server Satellite ***i***-STEPS® to read-only for the facility.

EPA's Cross-Media Electronic Reporting Rule (CROMERR), applies to states that choose to receive reports and documents from facilities through the Internet. The requirements of the rule provide for electronic reporting under authorized state and local government programs, apply to the governmental entities administering the authorized programs, and to facilities that submit data through the Internet to those governmental entities. If on-line reporting is offered by the state, an EPA-approved electronic signature process must be in place. Alternatively, on-line reporting can be followed up by the submission of a certified document (on diskette, compact disk (CD), digital video disk (DVD), facsimile, or paper report) containing the same information that was submitted on-line.

Currently, the DAQ on-line reporting system does not have an approved electronic signature system. Therefore, DAQ is required to receive from reporting facilities a certified document in addition to the data submitted on-line. DAQ has created a detailed report that can be easily created in pdf format for use by a facility as the certified document of their on-line submission. The pdf file can be burned to a CD or DVD and sent to DAQ to meet the CROMERR requirements. A signed Optical Media Certification Form is mailed with the CD or DVD to DAQ.

2.5.2 Activity Data Reporting Forms

Activity data reporting form packages were e-mailed to 48 facilities, from January 13 through January 15, 2009. The reporting packages included a cover letter, general facility information page, and the appropriate activity data reporting form(s) for each facility. Reporting forms were in Microsoft® Word format. The general facility information sheet contained pre-printed general information about the facility. This information included facility name, mailing address, contact name, NAICS codes, and phone and facsimile numbers. Facilities made corrections in the space provided on the facility general information page, added activity information to the activity report forms, and returned these documents via e-mail or facsimile to DAQ.

Assistance in completing the activity reports was offered on an on-going basis. Assistance was provided by telephone and e-mail.

2.6 Inventory Tracking

A log book was maintained to record and track the reporting status of the 119 facilities receiving a reporting package. The log book contained the facility name and identification number, the facility contact, the date the reporting package was e-mailed to the facility, the original due date, an extension date, if given, the date the submission was received by DAQ, and notes regarding phone or e-mail communications with the facility.

In addition to the 2008 inventory log book, a Microsoft® Excel spreadsheet was maintained to track each facility from the initial mailing through all tracking and review steps including the final QA/QC process. Communications with facilities are noted in the spreadsheet, especially when facilities failed to meet their deadlines. All facilities receiving reporting packages supplied either complete on-line submissions, or submitted activity forms via e-mail or facsimile.

APPENDIX C

2.7 Administrative Review

As soon as submissions were received, the review process began. The Administrative Completeness Determination (ACD) was performed as the first step in the review process. The ACD consisted of a one-page checklist which begins the audit trail associated with the review process. The ACD checklist was developed by the DAQ point source inventory staff over many years as a QA/QC tool for ozone SIP inventories. A checklist is completed and maintained in each facility file. An ACD is prepared for all facilities, whether Terminal Server Satellite ***i***-STEPS® or the activity data reporting forms were used to prepare their submission.

2.7.1 Administrative Review of On-line Submissions

The ACD performed on on-line submissions included the following steps:

Review cover letter - Facilities were asked to identify in their cover letter any operational changes and the impact such changes had on emissions. DAQ staff reviewed the cover letter noting any significant changes and highlighted it for future reference.

Emissions comparison - The 2008 facility-wide reported emissions for each criteria pollutant were compared to the most recent periodic emission inventory year which in most cases was 2005. Annual emissions for other years were used when appropriate. Significant differences between the two years were identified, investigated, and documented. Reviewing past and present submissions, process additions and deletions were compared, identified and highlighted for further investigation. If sufficient information was not provided in the cover letter, the facility was contacted to explain the differences.

Accidental releases - Facilities were asked to identify accidental releases either through the assignment of a separate accidental release process or an explanation in their cover letter as to the accounting of the release(s) in their inventory. Throughout 2008, DAQ staff compiled e-mails of accidental releases sent through DNREC's Environmental Release Notification System list server. This information was checked against accidental releases identified in the emission inventory reports. The Delaware City Refinery (Premcor) had the greatest number of reported accidental releases. DAQ requested and received a spreadsheet of detailed accidental release information from the refinery. DAQ compared this information to the release notification information and to emissions reported as accidental releases by the refinery.

Comments Spreadsheet – DAQ developed a Microsoft® Word document to list any data from individual facilities that had significant changes, such as significant decreases or increases in emissions, the reason for the changes in emissions, and a list of issues that needed to be addressed before the QA/QC process could be completed. This information was also listed on the facility's ACD sheet.

Other ACD checks – DAQ staff verified that the emission certification report (facility summary) was signed by the Responsible Official. Any request for confidential business information was forwarded to the DAQ paralegal staff for review. The tracking spreadsheet was updated to include any communications with the facilities and to document when the ACD was completed for each facility and when all issues, if any, were resolved. The completed ACD, cover letter, signed emissions summary page, submitted supporting calculation sheets, notes and other correspondence (i.e., e-mails) were placed in the facility file.

2.7.2 Administrative Review of Activity Data Report Forms

Activity data report form information was used to update facility general information and calculate emissions. Information from the activity reports were entered into the Terminal Server Satellite ***i***-STEPS® database by DAQ staff. The database maintained an audit trail (user ID and date stamp) of data added to the system.

Activity data were used by the database to calculate emissions based on emission factors contained in the database. Fuel combustion throughputs for small boilers and generators were used in this way. Once emissions were estimated for a facility that reported activity data, the 2008 emissions could be compared to data from previous years.

All Title V permitted facilities are required to submit a signed emissions certification report as part of their permit requirements. For those Title V facilities that reported activity data, the DAQ point source inventory staff generated the emissions summary page based on emissions calculated within ***i***-STEPS® and mailed it to the facility for signature by the Responsible Official. The ACD was not complete until the signed emissions summary page was returned to DAQ and the signature verified. The date the emissions summary page was mailed to a facility was documented within the tracking spreadsheet, as well as the due date for receiving the signed document. Finally, the actual date it was received was recorded.

The tracking spreadsheet was updated to include a record of communications with the facilities and to document when the ACD was completed for each facility and when all issues, if any, were resolved. The completed ACD, signed emissions summary page, notes and other correspondence (i.e., e-mails) were placed in the facility file.

2.8 Reported Data and Estimating Emissions

The 2008 stationary point source inventory included all criteria pollutants and their precursors (PM_{10}-PRI, $PM_{2.5}$-PRI, SO_2, NO_x, NH_3, VOC, and CO), all hazardous air pollutants (HAPs), and the six greenhouse gases as defined by the Kyoto Protocol (UN, 1998). For the 2008 $PM_{2.5}$ Attainment Year SIP inventory, only emissions of $PM_{2.5}$, SO_2, and NO_x from New Castle County facilities are included in this report.

If $PM_{2.5}$ emissions were missing, DAQ augmented $PM_{2.5}$ emissions within the point source inventory either by using standard emission factors based on throughput information provided by the facility, or as described in Section 2.11.

Emissions of sulfur dioxide were calculated using FIRE emission factors, except for large units that use CEMs to monitor SO_2. Percent sulfur in the fuel is critical in calculating accurate SO_2 emissions for combustion processes using emission factors. DAQ reviewed and worked with the facilities to resolve any issues associated with the reported percent sulfur.

DAQ required facilities to report data to the process level, identified by an eight-digit Standard Classification Code (SCC). Key data reported included SCC identification, product or fuel throughput, operating schedule, control equipment information (type, capture efficiency and control efficiency), stack parameters (height, diameter, flow rate, velocity and temperature), and emission factors, if FIRE factors were not used. Data collected were consistent with EPA's *Procedures Volume I* (EPA, 1991b), the *Air Emission Reporting Requirements (AERR) – Final Rule* (EPA, 2008), *Emissions Inventory Guidance for Implementation of Ozone and Particulate Matter National Air Quality Standards (NAAQS) and Regional Haze Regulations* (EPA, 2005b) (hereafter referred to as *Emissions Inventory Guidance*), and EIIP documents.

2.8.1 Emission Estimation Methods

Annual emissions could either be calculated within ***i***-STEPS® using uncontrolled emission factors, throughput data, and control data, or outside the system using mass balance, stack tests, or other means. Terminal Server Satellite ***i***-STEPS® allowed for the use of nine emission estimation methods, which are presented in Table 2-2.

Table 2-2. *i*-STEPS® Emission Estimation Methods

***i*-STEPS® Method Code**	**Basis for Emissions Estimate**
1	Stack test data[a]
2	Material balance
3	Use of emission factor outside of ***i***-STEPS® or use of EPA TANKS software
4	Best engineering judgment
5	State or local agency emission factor
6	New construction/not yet operational (zero emissions)
7	Source closed/operation ceased (zero emissions)
8	***i***-STEPS® default emission factor
9	Facility-supplied emission factor

[a] includes Continuous and Predictive Emission Monitoring

Annual emissions are calculated by the database when Method Code (MC) 8 or 9 is designated. The monthly fuel or process throughput rates obtained from the facility are summed to an annual rate and then applied to the relevant emission factor, either the system default (MC8) or one supplied by the facility (MC9). This calculation produces an annual emissions estimate in tons per year. Annual emissions may be calculated outside of ***i***-STEPS® with only the annual emissions entered in ***i***-STEPS®. Annual emissions calculated outside of ***i***-STEPS® are identified in the database by MC1 through MC4. Facilities were asked when deriving annual emissions from stack tests to take into consideration operating conditions during the stack tests, such as load and control efficiency, and be aware when stack test conditions were not representative of operating conditions in 2008.

For MC8 or MC9, emissions are calculated by the database through the use of a default or facility-supplied emission factor using the following equation for pollutant x:

$$E_a = [(Q_a) * (EF_x) * (FP) / 2000] * (1-CE_x)$$

where:

E_a	=	Annual emissions, tons per year
Q_a	=	Annual process throughput
EF_x	=	Emission factor for pollutant x
FP	=	Fuel parameter, such as percent sulfur or ash content
CE_x	=	Overall capture and control efficiency

When a facility chooses MC8 for a process, ***i***-STEPS® automatically selects the emission factor associated with the process SCC and calculates the emissions. For MC9, facilities were required to document facility-supplied emission factors. The emission factor must be documented by the facility or otherwise verified by DAQ. If not, DAQ replaced it with the current ***i***-STEPS® SCC emission factor. Facilities may choose to calculate emissions outside of ***i***-STEPS® and enter the emissions using MC3. If an emission factor is used by the facility to calculate the emissions, the factor must be documented by the facility or otherwise verified by DAQ. If not, DAQ changed the record to an MC8.

2.9 Technical Review of Submitted Data and Information

Once issues from the completeness determination were resolved, the technical review would begin. The technical review was conducted through a series of database queries. The query results were exported to a spreadsheet for ease of review and to compare to previous years' data. The spreadsheets allowed DAQ inventory staff to identify missing, suspicious or conflicting data. Any critical issues were identified and corrected in the database. Questionable data, missing information, and the correction of errors were handled in several ways. When a problem was identified, such as missing data, a typographic error, or other simple errors in the data, a phone call or e-mail to the facility was usually sufficient to resolve and document the issue. Usually no other correspondence was needed.

The following information was included in the technical review:

- General facility information;
- Narrative descriptions of the following: group/point, process, SCC, SCC units, and pollutant;
- Design capacity and standard design capacity units;
- Operating schedule, percent quarterly throughputs, and fuel sulfur and ash content;
- Monthly and annual throughputs provided in the SCC units described;
- Process-level annual emissions for all pollutants for each process;
- Stack ID and parameters;
- Emission calculation method;
- Abatement equipment information, including capture and control efficiencies for each pollutant;
- Calculations and documentation entered by the facility into a Notes field; and
- A summary page of facility-wide annual emissions for each pollutant.

APPENDIX C

There were six general areas of data and information in the technical review, including facility general, group/point (emissions unit), process unit, stack information, process unit controls and process unit emissions. The review of each section is described in detail below.

2.9.1 Facility General

The following facility general information was reviewed: facility name, facility site identification number, mailing address, year of inventory, North American Industry Classification System (NAICS) code, contact person, and phone number. Any missing or questionable information, such as NAICS code or an incorrect inventory year, was noted and resolved. As an example, the NAICS code was compared to a brief description of the facility's business activity supplied by the facility. DAQ had previously determined facility coordinates and thus this information only needed to be updated for newly inventoried facilities.

2.9.2 Group/Point (Emissions Unit)

Group information defines a piece of equipment, a group of related processes, or a particular activity at a facility. Design capacity, and annual and seasonal operating information were reviewed individually and in context with other information in the Emissions Unit spreadsheet.

A description of the equipment or activity is provided along with the design capacity and design capacity units. If the design capacity is missing for combustion equipment, an attempt was made to determine the design capacity of the equipment by reviewing permits or contacting the facility.

The operating schedule was reviewed for missing or inconsistent data. Hours per day and normal daily start and end times were also provided. The annual hours operated is calculated by ***i***-STEPS® from the hours per day, days per week and weeks per year the facility enters into the system. A facility could override this calculated value by entering the actual number of hours operated for the year, if the facility had accurate records.

The percent quarterly throughput was corroborated with operating information. ***i***-STEPS® enforced a range of between 95 and 101 percent for the sum of the four quarterly throughputs. A review of the database indicated that all sums of the quarterly throughputs were within the range of 98 to 101 percent. When necessary, in order to be consistent with the EIS requirements (EPA, 2009), the second quarter (March, April and May) and/or the fourth quarter (September, October and November) percent throughputs were adjusted so the sum of all four quarters would equal 100 percent. The third quarter (summer season) was not adjusted, since it was assumed the facility would have provided an accurate summer season value.

2.9.3 Process Unit

Numerous database queries and spreadsheets were developed to review the process unit level data reported by facilities. The information was reviewed individually and in context with other information in this section and related sections such as the group/emissions unit and stack information. Process unit information includes the process description, stack identifier, Source Classification Code (SCC) and description, percent sulfur and ash (for combustion units), and monthly throughput for most processes. In a limited number of instances only annual throughput was provided.

The process description field is a text field that is used to describe a process in more detail than is defined by the SCC description. A determination was made whether the process description provided by the facility was consistent with the SCC description. As an example, the process description may mention No.6 oil for a piece of combustion equipment; and therefore the SCC description must be for combustion equipment burning No.6 oil.

In most cases monthly throughputs were provided by facilities. ***i***-STEPS® sums the monthly throughputs and stores the value in the annual throughput field. In cases where there were significant changes in the group-level emissions as compared to a previous year, the annual throughputs were compared to previous data. If the comparison of throughput explains the difference in emissions, such as fuel switching, or an increase or decrease in fuel usage, this was noted on the Administrative Completeness Determination page and added to the tracking spreadsheet.

Each SCC has associated standard units as defined by EPA in its master list of SCCs and are contained within ***i***-STEPS®. Facilities are given the option within ***i***-STEPS® to change the units to make them appropriate to the data they are reporting. DAQ staff compared the SCC units as reported by the facility to the standard units. If the two values did not match, DAQ staff determined if the revised units were properly applied in the emission calculations.

2.9.4 Stack Parameters

Stack parameters and associated group and process unit information were reviewed. Each stack has an identification number and description assigned. The stack parameters include height above ground, diameter, exit gas temperature, velocity, and flow rate. If emissions were considered fugitive, then ***i***-STEPS® requires only a stack identification number, a release point type (fugitive) and a height value. A default of ten feet was used for stack height when no fugitive height was provided.

If no stack information was provided for a process unit, DAQ would use information provided for the process in previous years and make the appropriate link within ***i***-STEPS® between the stack and process unit records. If no previous year stack data existed in the database, a stack record was created and linked to the process based on permit file information or subsequent discussions with the facility. During data entry of the process unit record by facilities, Terminal Server Satellite ***i***-STEPS® flashes a warning message, if a stack is not identified for the process.

2.9.5 Process Unit Control Equipment

Control information for controlled processes was reviewed. A control device identification number, ***i***-STEPS® control device code, pollutant-specific capture and control efficiencies, and a description of the abatement equipment were reviewed. Control issues were flagged and resolved, if possible. Particulate, SO_2, and NO_x control devices were evaluated to determine if the control efficiency fell within a range expected for the identified control device.

2.9.6 Process Unit Emissions

Process unit emissions and associated information by pollutant were reviewed. The EIS pollutant code, pollutant name, the emission estimation method code, emission factor, the overall capture and control efficiencies, and annual emissions in tons per year were compiled in spreadsheets. The capture and control efficiencies were compared to the process unit control section. Issues associated with pollutant code or capture and control efficiencies were flagged, investigated, and resolved.

In the review a process was flagged if there was throughput or operating information that indicated a process was operating, but no emissions were provided. If emissions were expected, but not provided, the process unit emissions from the most recent year were checked. Usually, in cases such as this, the facility provided an explanation in the process unit or process emissions Notes field. An example of this would be when CEMs are used for NO_x or SO_2 emissions from combustion sources that utilize more than one type of fuel. All NO_x or SO_2 emissions would be reported under the major fuel burned. The secondary fuel would have a throughput, but no process unit emissions.

2.9.7 A Multi-year Comparison of Facility Level Emissions

A spreadsheet of criteria pollutant facility-wide emissions in tons per year was created for the years 2002 through 2008. Any significant differences in the 2008 emissions compared to the previous years' data were flagged. Fuel switching, production changes, or the addition of controls, were the most common reasons for the observed differences.

2.10 Technical Review Using Database Queries, Reports and Spreadsheets

Numerous database queries, reports and spreadsheets were created to identify information that appeared to be missing, in error or inconsistent with other related information. This included analysis of related operating schedule information.

If an issue initially identified by DAQ or the facility, and subsequently corrected in the ***i***-STEPS® database by DAQ, had a significant impact on the facility's reported total emissions, DAQ requested documentation from the facility acknowledging the change in emissions. The documentation may be in the form of a letter, e-mail, or facsimile from the facility. Title V facilities were required to resubmit a new emissions summary report signed by the Responsible Official.

If issues were unable to be resolved with the facility, DAQ staff updated or modified the information submitted by the facility to the extent needed to develop emission estimates. This usually was acknowledged in correspondence with the facility.

2.11 $PM_{2.5}$ Augmentation of Facility Reported Emissions

To insure $PM_{2.5}$-PRI, $PM_{2.5}$-FIL, and PM-CON were calculated properly for all combustion and non-combustion sources, numerous database queries and spreadsheets were developed to identify missing emissions or inconsistencies between the PM emission estimates for a given process. Missing emissions were determined as follows:

- With the exception of gaseous fuel fired external combustion processes, AP-42 $PM_{2.5}$-FIL and PM-CON emission factors were available for nearly all external combustion processes. If filterable or condensable emissions were not reported by the facility, DAQ staff calculated these emissions using the AP-42 factors.
- For external combustion processes burning gaseous fuels, $PM_{2.5}$-PRI was estimated using factors published in "*Revision of the PM Emissions From Natural Gas Combustion in the Final Version of the 2002 NEI*" (EPA, 2005c) and an EPA Excel file entitled "*Ratios to Adjust PM*" containing SCCs and $PM_{2.5}$-PRI emission factors (EPA, 2005d). If $PM_{2.5}$-PRI was not reported, DAQ staff estimated these emissions using these factors. Specific filterable and condensable factors are currently not available for gaseous fuels.
- If $PM_{2.5}$-PRI was missing, DAQ equated it to the sum of $PM_{2.5}$-FIL and PM-CON;
- In instances where a facility reported only PM_{10} (PRI and/or FIL) DAQ assumed that $PM_{2.5}$ conservatively equaled PM_{10}.

Since primary emissions are the sum of the filterable and condensable components, queries and a spreadsheet were developed to insure that $PM_{2.5}$-PRI matched the sum of its components.

2.12 Review of NO_x and SO_2 Emissions from EGUs and Other Large Sources

In 2002 there were 21 electric generation units (EGUs) in New Castle County. The Madison Street combustion turbine closed in 2004. DAQ staff conducted a review of NO_x and SO_2 emissions for the 20 remaining EGUs in New Castle County. Most of these units report emissions based on continuous emissions monitoring (CEM) data to EPA through their Air Markets Program Data (AMPD) website (EPA, 2010). The website contains emissions data reported to EPA's Acid Rain and NOx Budget Programs. DAQ staff compared AMPD 2008 emissions to emissions reported to DAQ.

There were 18 New Castle County EGUs listed in AMPD that had annual 2008 NO_x and SO_2 emissions that could be compared to annual emissions reported to DAQ. An additional two units reported 2008 emissions for six months (April – September). For those units that only reported six-month emissions, an annual estimate was needed to directly compare to the facility reported value. A NO_x emission factor was calculated in pounds of NO_x emissions per MMBtu using the six-month emission amount divided by the heat content of the fuel listed in AMPD for the six months. Annual emissions were then calculated by applying this factor to the annual fuel heat content reported in ***i***-STEPS®.

There were five additional units (non-EGU) reporting annual emissions under the NO_x Budget Program. These units were located at the Delaware City Refinery (Premcor) and were evaluated using the same methodology as above.
Differences in NO_x emissions reported to DAQ compared to EPA's AMPD data were expected for some units since the Acid Rain Program requires the use of the unit's maximum load value as a default at times when the CEM is not functioning properly. DAQ staff worked with these facilities to determine the best estimate of actual NO_x emissions for the inventory.

2.13 Methods for Correcting Erroneous Data

Questionable data, missing information, and the correction of errors were addressed in several ways. In all cases DAQ maintained a paper or electronic trail of changes made by staff or the facility. When a problem was identified, such as missing data, typographic error, or other simple errors in the data, a phone call or e-mail usually was sufficient to resolve and document the issue. Usually no other correspondence was needed.

If an issue had a significant impact on the facility's initially reported total emissions, DAQ requested documentation from the facility acknowledging the change in the emissions. The documentation may be in the form of a letter, e-mail, or facsimile from the facility. TV facilities were required to resubmit a new emissions summary report signed by the Responsible Official.

For submissions where there were extensive problems, a facility may have been asked to meet with DAQ staff to outline the issues and to develop ways to address the problems. Once issues had been discussed and resolved, the facility may have been asked to resubmit information through the on-line reporting system. DAQ staff would reopen the facility's record within the Terminal Server Satellite ***i***-STEPS® on-line system to allow access for corrections and updates.

If issues were unable to be resolved with the facility, DAQ staff updated or modified the information submitted by the facility to the extent needed to develop emission estimates. This usually was acknowledged in correspondence with the facility.

2.14 Facility Site and Stack Coordinates

Facility and stack coordinates were verified during previous PEI inventories. Coordinates were verified through the use of high-resolution aerial photography that DNREC had previously placed in GIS. Existing site coordinates contained in ***i***-STEPS® were plotted and superimposed on the aerial photography. Staff from the Engineering and Compliance (E&C) Branch met with inventory staff and reviewed the resulting facility locations on the aerial photographs. E&C staff were knowledgeable enough with the layout of the facilities they permit to identify them on the photographs. Based on the permitting engineer's advice, the facility point was moved, if necessary, to place it over the geographic center of emissions activity at the facility. For several facilities, ground reconnaissance was performed to verify a facility's location.

Two New Castle County facilities, Corrado Construction and Micropore, were new to emissions reporting for 2008 and their coordinates were determined using Google Earth.

2.15 Database Management

The 2008 point source inventory database was managed using ***i***-STEPS® for Microsoft® SQL Server 5.0 data management system, associated utilities and applications including the Terminal Server Satellite ***i***-STEPS® on-line system and Microsoft® Access. Microsoft® Access was used to create queries and reports from the SQL tables. After the administrative review and a check of reasonableness of the facility-wide emissions were completed for most facilities, a copy of the

Terminal Server database was produced as an archive of data reported by the facilities. A second database was created as the 2008 production database for purposes of developing the several inventories required for 2008. This database was managed using the Agency ***i***-STEPS®.

DNREC's Office of Information Technology (OIT) provides computer network support and routine database management functions. Joseph Handley, Application Support Project Leader, of the OIT office served as liaison between DAQ inventory staff and OIT. Mr. Handley also helped with user network, Internet connectivity, and firewall issues.

i-STEPS® utilizes relational databases and contains functions and utilities to maintain database integrity. There are field-sensitive look up tables, and data element and record validation routines that ensure valid data and enforce database integrity. The system has a record level audit trail that documents changes made to the records, identifies the user and the date the change was made. In addition, there are comment/note windows for each record where text can be added by the user and DAQ staff to clarify information provided or supply additional documentation.

2.16 Data Submission to EPA's Emissions Inventory System

Emissions Inventory System (EIS) staging tables (EPA, 2009) in Microsoft® Access format were generated from the ***i***-STEPS® database. EIS is the EPA's air emissions inventory data management system. An application developed in conjunction with the Department's Information Technology staff was used to map information in the ***i***-STEPS® database to the EIS staging tables. EPA's EIS Bridge Tool was then used to prepare emissions inventory data in the staging tables for submission to EIS. The EIS Bridge Tool transforms emissions inventory data into CERS XML files.

The XML files were submitted to the EIS QA environment to obtain several feedback reports that would identify errors and issues associated with the submitted files. All significant issues associated with mandatory and necessary fields were reviewed and resolved prior to submission of the XML files to the EIS Production environment. Emissions data submitted to the EIS Production environment are used by EPA to populate the National Emissions Inventory. Production submissions of the 2008 emissions data and facility information were initially made during May 2010 to meet the June 1, 2011 EPA reporting requirement, while final corrections and additions were sent to EIS between December 2010 and January 2011.

2.17 Source Sector Discussions

All New Castle County facilities associated with hot-mix asphalt production and electric generation are included in the 2008 $PM_{2.5}$ Attainment Year SIP point source inventory. Details of these industry sectors are presented below.

2.17.1 Hot-mix Asphalt Plants

Hot-mix asphalt (also known as asphaltic concrete or blacktop) production facilities have been historically tracked and permitted by the Department as point sources. There were five facilities in New Castle County for 2008 and these are all included in the point source inventory. Delaware facilities employ both drum mixer and rotary dryer processes in the production of hot-mix asphalt. The appropriate SCCs were used to identify these processes. In 2008, all New Castle County facilities collectively emitted 12 tons $PM_{2.5}$-PRI, two tons of SO_2, and 13 tons of NO_x.

The activity data forms were used to obtain throughput data from hot-mix asphalt plants. Data from the completed forms were entered into *i*-STEPS® and EPA standard emission factors were used to calculated emissions within *i*-STEPS® based on the SCC provided by the facility. In a few instance emissions were based on stack tests.

Many asphalt plants employ crushing operations powered by diesel engines. The emissions from these diesel engines were estimated based on reported fuel usage and FIRE 6.24 emission factors.

2.17.2 Electric Generating Units (EGUs)

New Castle County EGUs are represented by two large generating stations (Calpine Edge Moor and Calpine Hay Road), three Calpine peaking unit stations, and generators at the Delaware City Refinery (Premcor). In total, there are 20 EGUs located at six facilities in New Castle County included in the point source inventory. EGUs in Delaware include external combustion boilers and combustion turbines. Small diesel generators used by businesses and institutions for emergency backup power and load management are not included in this discussion, and are generally not reported to the point source inventory. 2008 $PM_{2.5}$, SO_2, and NO_x emissions from New Castle County EGUs are presented in Table 2-3. Note that $PM_{2.5}$ emissions given in the following tables represent primary emissions (i.e., filterable plus condensable).

Table 2-3. 2008 $PM_{2.5}$ and Precursor Emissions for New Castle County EGUs

Facility Name	Unit Description	Annual Emissions, TPY		
		$PM_{2.5}$	SO_2	NO_x
Calpine Christiana	Turbine #11	< 1	< 1	1
	Turbine #14	< 1	< 1	1
Calpine Delaware City	Turbine #10	< 1	< 1	1
Calpine Edge Moor	Boiler #3	107	2,011	525
	Boiler #4	242	4,923	1,292
	Boiler #5	11	176	163
	Turbine	< 1	< 1	< 1
Calpine Hay Road	Turbine #1	7	2	65
	Turbine #2	7	2	70
	Turbine #3	7	1	47
	Turbine #5	5	2	7
	Turbine #6	5	2	7
	Turbine #7	5	1	6
Calpine West Substation	Turbine	1	1	1
Delaware City Refinery	Boiler #1	14	9	200
	Boiler #2	11	15	41
	Boiler #3	15	54	254
	Boiler #4	3	11	184
	Turbine #1	28	202	83
	Turbine #2	13	49	47
Total		**479**	**7,463**	**2,994**

Emissions from New Castle County EGUs represent 71% and 54% of the county-wide point source emissions of SO_2 and NO_x, respectively. Most peaking units operate exclusively during the summer to meet periods of high demand. Their operation may coincide with days when air quality is most likely to experience an exceedance of the daily fine particulate standard.

2.17.3 Emissions by Source Sector

Table 2-4 provides New Castle County total $PM_{2.5}$-PRI, SO_2, and $NO_{x,}$ emissions grouped by source sector as defined by the first three digits of the SCC codes assigned to each process.

The source sectors include various combustion and manufacturing processing, material storage and transfer operations, and solid waste disposal. Combustion processes account for the majority of the particulate, SO_2, and NO_x emissions in New Castle County from the point source sector.

Table 2-4. 2008 $PM_{2.5}$ and Precursor Emissions by Industry Sector

SCC	SCC Description	Annual Emissions, TPY		
		$PM_{2.5}$	SO_2	NO_x
101	External Comb. Boilers - Utilities	402	7,199	2,659
102	External Comb. Boilers - Industrial	269	1,120	2,061
103	External Comb. Boilers – Commercial	1	28	51
105	Ex. Comb. Boilers - Space Heaters	< 1	< 1	16
201	Internal Comb. Engines - Utilities	37	12	208
202	Internal Comb. Engines - Industrial	41	252	145
203	Internal Comb. Engines - Commercial	< 1	< 1	4
270	Internal Comb. Engines – Off-road		1	12
301	Chemical Manufacturing	55	78	42
303	Primary Metal Production	56	42	190
304	Secondary Metal Production	< 1		
305	Mineral Products	16	2	13
306	Petroleum Industry	199	1782	164
307	Pulp, Paper and Wood Products	< 1		
308	Rubber and Misc. Plastics Products	< 1	< 1	1
309	Fabricated Metal Products	1		
385	Cooling Tower	15		
399	Misc. Manufacturing	< 1		
402	Surface Coating Operations	7	< 1	5
406	Transport/Marketing of Petrol. Prod.	< 1	< 1	1
501	Solid Waste Disposal - Government	1	7	2
502	Solid Waste Disposal – Comm./Inst.	8	24	11
503	Solid Waste Disposal - Industrial	2	28	4
682	Miscellaneous Processes	< 1		
Statewide Total		**1,109**	**10,576**	**5,589**

2.18 Emissions by Facility

Facility-level annual emissions for the 58 facilities included in the 2008 $PM_{2.5}$ Attainment Year SIP inventory are provided in Tables 2-5. For recent facility name changes, the former name is included in parentheses.

Table 2-5. 2008 $PM_{2.5}$ and Precursor Emissions for New Castle County Facilities

Facility Name	Annual Emissions, TPY $PM_{2.5}$	SO_2	NO_x
A.I. DuPont Hospital	1	25	13
Amtrak Maintenance Facility	< 1	< 1	4
Ashland Research Center (Hercules)	1	9	6
Astrazeneca Pharmaceuticals	< 1	< 1	7
BASF (Ciba Specialty Chemicals)	2	< 1	10
Calpine – Christiana (Conectiv)	< 1	< 1	2
Calpine - Delaware City (Conectiv)	< 1	< 1	1
Calpine - Edge Moor (Conectiv)	360	7,110	1,980
Calpine - Hay Road (Conectiv)	36	10	202
Calpine - West Substation (Conectiv)		1	1
Christiana Hospital	< 1	4	16
Christiana Materials	3	1	3
Chrysler (DaimlerChrysler)	3	24	34
Clean Earth of New Castle	8	24	11
Contractors Materials	2	< 1	2
Corrado Construction	< 1	< 1	1
Croda (Uniqema)	1	7	49
Dassault Falcon Jet	< 1	< 1	1
Delaware City Refinery (Premcor)	446	2,548	2,525
Delaware City Terminal (Premcor)	< 1	< 1	< 1
Del. Correctional Center - Smyrna	< 1	< 1	6
Delaware Recyclable Products	1	28	3
Diamond Materials	5	1	9
DSWA Cherry Island Landfill	1	7	1
DuPont - Chestnut Run	8	140	45
DuPont - Edge Moor	17	17	32
DuPont - Red Lion	< 1	47	13
DuPont Building - Wilmington	3	57	19
DuPont Experimental Station	27	438	156
DuPont Stine-Haskell Lab	1	8	16
E-A-R Specialty Composites	< 1	< 1	1
Eastern Shore Natural Gas – Del City	< 1	< 1	4
Edgemoor Materials	2	< 1	3
Evraz Claymont Steel	64	42	190
FMC	17	< 1	30
Formosa Plastics	26	< 1	25
FP International	< 1	< 1	1
General Motors	7	< 1	25
Honeywell International		< 1	< 1
Johnson Controls Battery	< 1	< 1	3
Kuehne Chemical	< 1	< 1	1
MacDermid	< 1	< 1	3
Magellan Terminals	< 1	5	3
Medal Air Liquide	< 1	< 1	4
Motech Americas (GE Energy)	< 1	< 1	< 1

continued next page

Table 2-5. continued

Facility Name	Annual Emissions, TPY		
	$PM_{2.5}$	SO_2	NO_x
Noramco	< 1	< 1	1
NVF – Yorklyn	< 1	< 1	< 1
Occidental Chemical	< 1	< 1	< 1
Prince Minerals (American Minerals)	< 1	< 1	< 1
Printpack	< 1	< 1	2
Pure Green Industries	< 1	< 1	1
Rohm & Haas Electronic Materials	< 1	< 1	4
St. Francis Hospital	< 1	< 1	4
Sunoco	66	17	83
University of Delaware - Newark	< 1	3	22
Veterans Administration Hospital	< 1	< 1	4
Wilmington Hospital	< 1	< 1	7
Wilmington WWTP	< 1	1	2
New Castle County Total	**1,109**	**10,576**	**5,589**

2.18.1 Sources of $PM_{2.5}$ Emissions

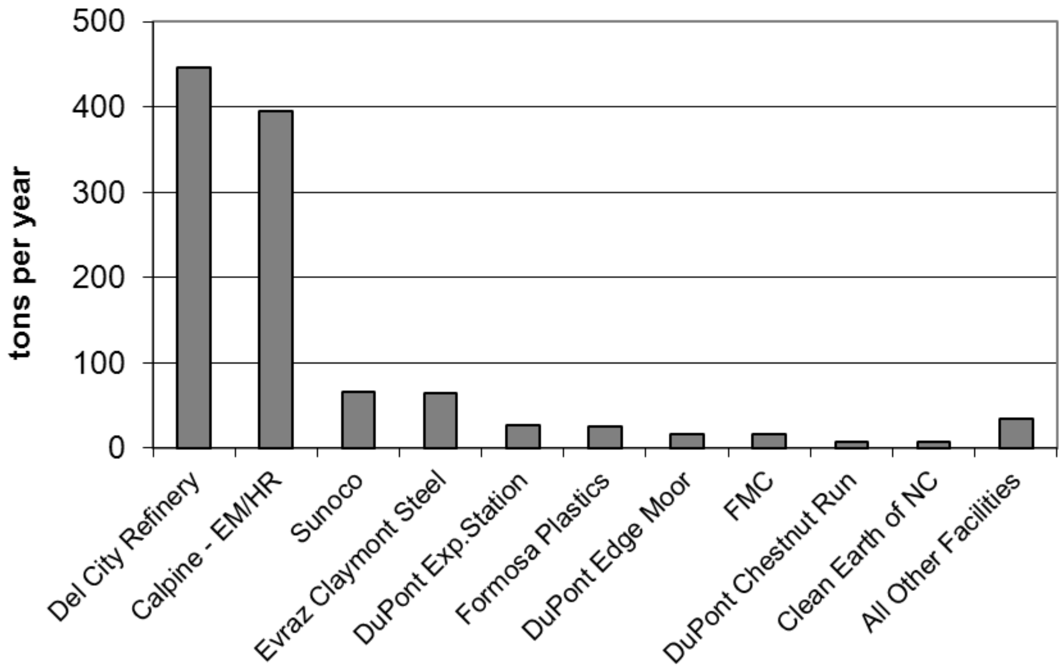
The Delaware City Refinery is the largest source of $PM_{2.5}$-PRI, emitting 446 tons in 2008. 56% of these emissions (263 tons) are associated with the catalytic cracker and coker CO boilers. The Calpine Edge Moor/Hay Road complex is the second largest $PM_{2.5}$-PRI source in Delaware. The coal-fired units at this facility have particulate controls, which have the ability to capture filterable particulates only. Calpine EM/HR emitted 396 tons of $PM_{2.5}$-PRI of which 308 tons were condensables. All other facilities in New Castle County emitted less than 100 TPY of NO_x in 2008.

The top ten $PM_{2.5}$ sources, representing 97% of county-wide annual $PM_{2.5}$ emissions for 2008 from point sources in New Castle County, are presented in Table 2-6 and in Figure 2-1.

Table 2-6. 2008 New Castle County Facility Ranking of $PM_{2.5}$ Annual Emissions

Facility Name	Major Activity	TPY
Delaware City Refinery / Terminal	Petroleum Refinery	446
Calpine – Edge Moor/Hay Road	Electricity Generation	396
Sunoco	Petroleum Refinery	66
Evraz Claymont Steel	Steel Manufacturing	64
DuPont Experimental Station	R&D / Hazardous Waste Incinerator	27
Formosa Plastics	PVC Manufacturing	26
DuPont Edge Moor	Chemical Manufacturing	17
FMC	Chemical Manufacturing	17
DuPont Chestnut Run	Research & Development	8
Clean Earth of New Castle	Contaminated Soil Remediation	8
All Other Facilities		34
County Total		**1,109**

Figure 2-1. 2008 $PM_{2.5}$ Annual Emissions by Facility



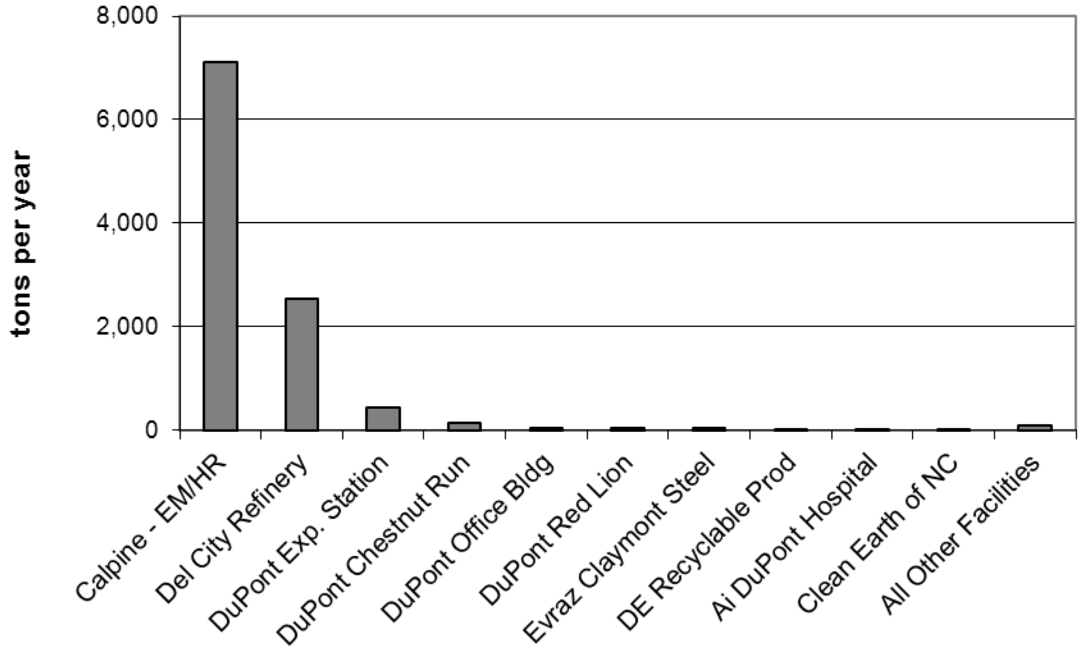
2.18.2 Sources of SO_2 Emissions

The top three facilities account for 96% of the county-wide annual SO_2 emissions from point sources in New Castle County. The top facility, Calpine Edge Moor/Hay Road power plants, burning coal in 2008 to generate electricity, accounted for 67% of county SO_2 emissions. The Delaware City Refinery accounted for another 25% of the county total SO_2 emissions. The third largest source of SO_2 emissions is the DuPont Experimental Station, which utilizes residual oil in its several boilers. The top ten SO_2 sources in New Castle County are presented in Table 2-7 and in Figure 2-2.

Table 2-7. 2008 New Castle County Facility Ranking of SO_2 Annual Emissions

Facility Name	Major Activity	TPY
Calpine Edge Moor/Hay Road	Electricity Generation	7,120
Delaware City Refinery	Petroleum Refinery	2,548
DuPont Experimental Station	R&D / Hazardous Waste Incinerator	438
DuPont Chestnut Run	Research & Development	140
DuPont Building Wilmington	Commercial Building	57
DuPont Red Lion	Chemical Manufacturing	47
Evraz Claymont Steel	Steel Manufacturing	42
Delaware Recyclable Products	Construction Debris Landfill	28
A.I. DuPont Hospital	Health Services	25
Clean Earth of New Castle	Contaminated Soil Remediation	24
All Other Facilities		107
County Total		**10,576**

Figure 2-2. 2008 SO_2 Annual Emissions by Facility



2.18.3 Sources of NO_x Emissions

The largest source of NO_x emissions in New Castle County for 2008 is the Delaware City Refinery. A large majority of emissions (71%) from the refinery come from just a few processes, including the catalytic cracking unit, the fluidized coking unit, and four boilers used for electricity generation. The second largest source of NO_x emissions is the Calpine Edge Moor/Hay Road electric generation complex. The refinery and Calpine EM/HR combined account for 84% of NO_x emissions from point sources in New Castle County.

The top ten NO_x sources, representing 95% of county-wide NO_x emissions for 2008 from New Castle County point sources, are presented in Table 2-8 and in Figure 2-3.

2.19 Closed Facilities

Several facilities included in the 2008 $PM_{2.5}$ Attainment Year SIP inventory have since permanently closed. Table 2-9 presents a list of closed facilities and the month and year operations ceased. For historical context, all New Castle County facilities that reported for 2002 and 2005 that have since closed are also included in Table 2-9.

Table 2-8. 2008 New Castle County Facility Ranking of NO_x Annual Emissions

Facility Name	Major Activity	TPY
Delaware City Refinery	Petroleum Refinery	2,525
Calpine Edge Moor/Hay Road	Electricity Generation	2,182
Evraz Claymont Steel	Steel Manufacturing	190
DuPont Experimental Station	R&D / Hazardous Waste Incinerator	156
Sunoco	Petroleum Refinery	83
Croda	Chemical Manufacturing	49
DuPont Chestnut Run	Research & Development	45
Chrysler	Automobile Assembly	34
DuPont Edge Moor	Chemical Manufacturing	32
General Motors	Automobile Assembly	25
All Other Facilities		268
County Total		**5,589**

Figure 2-3. 2008 NO_x Annual Emissions by Facility

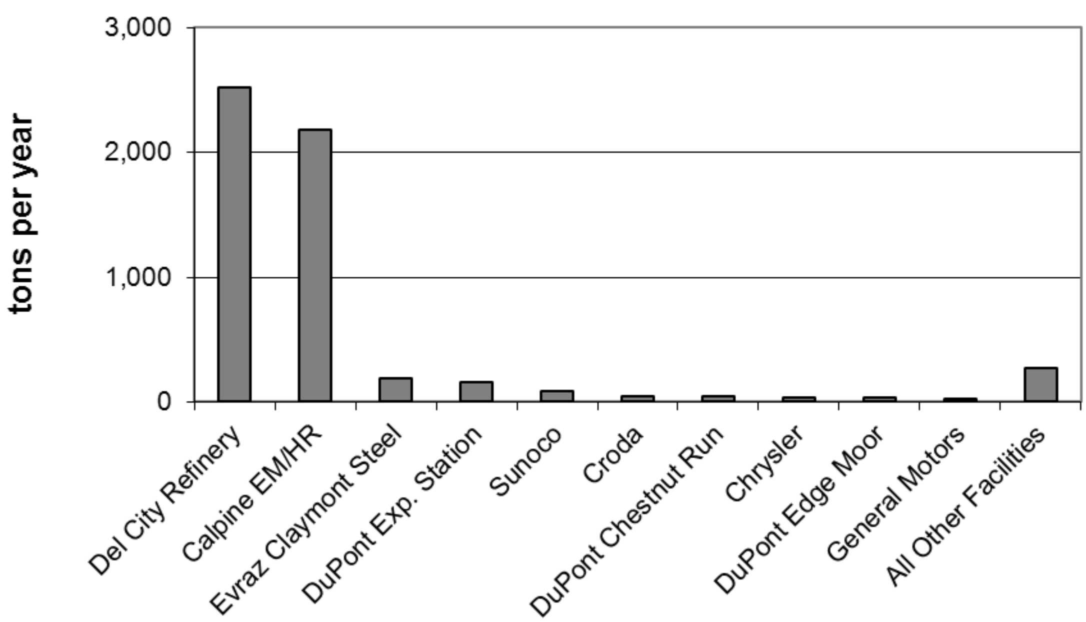


Table 2-9. Reporting Facilities That Have Ceased Operations

Facility Name	Date Closed
Metachem Products	May 2002
Lafarge	November 2002
Westvaco	May 2003
Kaneka	July 2003
VPI Film (VPI Mirrex)	July 2003
Wilmington Piece Dye	September 2003
General Chemical	June 2004
Laidlaw	September 2004
Conectiv - Madison Street	December 2004
Industraplate	March 2005
Ametek	October 2005
Hardcore Composites	January 2006
Spatz Fiberglass	December 2007
PTFE	July 2008
CPI (Unisource)	October 2008
Occidental Chemical	October 2008
Pepsi Cola Bottling	November 2008
NVF Yorklyn	March 2009
Chrysler (DaimlerChrysler)	December 2009
Tilcon – Terminal Avenue	June 2011

2.20 References

DNREC, 2006. *Regulations Governing the Control of Air Pollution*, Regulation No.1144 – Control of Stationary Generator Emissions, Delaware Department of Natural Resources and Environmental Control, Division of Air Quality, Updated to November 2006.

EPA, 1991a. *Emission Inventory Requirements for Ozone State Implementation Plans*, EPA-450/4-91-010, USEPA, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., March 1991.

EPA, 1991b. *Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone*, Volume I: General Guidance for Stationary Sources, EPA-450/4-91-016, USEPA, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., May 1991.

EPA, 1997. *Emissions Inventory Improvement Plan (EIIP), Volume II: Point Sources Preferred and Alternative Methods*, Chapter 1, EPA-454/R-97-004b, USEPA, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., July 1997.

EPA, 2005a. TANKS Version 4.09D, Windows-based computer software program for estimating VOC emissions from storage tanks, 2005.

EPA, 2005b. *Emissions Inventory Guidance for Implementation of Ozone and Particulate Matter National Ambient Air Quality Standards (NAAQS) and Regional Haze Regulations*, EPA-454/R-05-001, USEPA, Emissions Inventory Group Emissions, Monitoring and Analysis Division, Office of Air Quality Planning and Standards, Research Triangle Park, NC, November 2005.

EPA, 2005c. *Revision of the PM Emissions From Natural Gas Combustion in the Final Version of the 2002 NEI*, USEPA, Emissions Inventory Group, Office of Air Quality Planning and Standards, Research Triangle Park, NC, August 2005. ftp://ftp.epa.gov/EmisInventory/2002finalnei/documentation/point/pm_adjustment_2002_nei.pdf

EPA, 2005d. *2002 Final NEI Documentation Containing Ratios to Adjust PM Values for Natural Gas Combustion*, Excel file, Roy Huntley, August 2005., USEPA, Emissions Inventory Group, Office of Air Quality Planning and Standards, Research Triangle Park, NC, August 2005. ftp://ftp.epa.gov/EmisInventory/2002finalnei/documentation/point/augmentation_point/ratios_to_adjust_pmvalues_in_nei_for_naturalgas_combustion082005.xls

EPA, 2008. *Air Emission Reporting Requirements (AERR) – Final Rule*, U.S. Environmental Protection Agency, 40 CFR Part 51, Vol. 73, No 2143, December 17, 2008.

EPA, 2009: *2008 National Emissions Inventory, Emissions Inventory System Implementation Plan, Section 7 Reporting Instruction for Point Emissions,* Revised, August 3, 2009. http://www.epa.gov/ttn/chief/net/neip/index.html.

EPA, 2010. CEM Data for the Acid Rain and NOx Budget Programs, Clean Air Markets Division, http://ampd.epa.gov/ampd/QueryToolie.html, Office of Air and Radiation, USEPA, accessed 2010.

UN, 1998. *Kyoto Protocol to the United Nations Framework Convention on Climate Change*, Annex A, United Nations, 1998.

SECTION 3

STATIONARY NON-POINT SOURCES

Stationary non-point sources represent a large and diverse set of individual emission source categories. A non-point source category is either represented by small facilities too numerous to individually inventory, such as commercial cooking at restaurants and fuel combustion at a variety of small businesses, or is a common activity, such as residential open burning. Emissions from the non-point source categories were estimated at the county level.

3.1 Source Categories

There are a number of non-point source categories which contribute emissions of $PM_{2.5}$, SO_2, and NO_x. These categories can be grouped into several category types. These include:

- **Fuel Combustion –** The combustion of fuels in industrial, commercial, institutional, and residential furnaces, engines, boilers, wood stoves, and fireplaces create emissions of $PM_{2.5}$, SO_2, and NO_x.

- **Open Burning –** Open burning creates emissions of $PM_{2.5}$, SO_2, and NO_x. Open burning categories include trash burning, prescribed burning, burning of land clearing debris, wildfires, and house and vehicle fires.

- **Fugitive Dust –** Primary crustal particulate is created from construction activities, agricultural production, and as a result of vehicle traffic. Fugitive dust is largely coarse material, with only a small percentage being fine particulate.

Individual facilities are typically grouped with other like sources into a source category. Source categories are grouped in such a way that emissions are estimated collectively using one methodology. For the 2008 inventory, the distinction between point and non-point was defined by an annual emission threshold based on recent point source data (see Section 2 for point source criteria). Table 3-1 lists the source categories for which $PM_{2.5}$, SO_2, and NO_x for New Castle County were estimated.

Table 3-1. Non-point Source Categories Inventoried

Agricultural Burning	Residential Construction
Agricultural Production	Residential Fuel Combustion
Commercial Construction	Residential Open Burning
Commercial Cooking	Residential Wood Combustion
Commercial Fuel Combustion	Road Construction
Industrial Fuel Combustion	Structure Fires
Land Clearing Debris Burning	Vehicle Fires
Paved & Unpaved Road Dust	Wildfires
Prescribed Burning	

There were several source categories evaluated, but not included, in the non-point source inventory. These include:

- **Crematories** – While there are at least a dozen human/pet crematories and several laboratory animal incinerators in Delaware, DNREC was unable to locate emission factors for ozone precursors. Emissions from fuels used at these facilities are included in the commercial fuel combustion category.

- **Feed Mills and Concrete Plants -** These industry sectors were considered a source of particulate matter, both from material handling processes and fugitive dust (i.e., storage piles). Several large feed mills in Delaware already met the criteria for reporting as a Title V facility due to combustion emissions from process boilers and grain dryers. The lack of quality emissions data (i.e., emission factors) for feed mills persuaded DAQ from inventorying smaller feed mills. Lack of data was also the reason for not further considering concrete plants.

- **Slash Burning** - No activity for the burning of slash from logging for future silvicultural operations was identified. This was confirmed by the Delaware Division of Forestry. However, recently logged lands are occasionally converted to agriculture. This activity, previously reported as slash burning, is now reported under the land clearing debris burning category.

3.2 Emission Estimation Methodologies and Activity Data

The 2005 Delaware Periodic Emission Inventory served as the starting point for non-point source category selection and methodology development. One new category, agricultural burning, was added to the non-point sector. In 2007 agricultural burning was specifically delineated on the prescribed burning approval application form. This allowed DAQ to track the burning of woody debris specific to agricultural activities separate from other prescribed burning activities and other land clearing debris burning, (the latter is not permitted under Delaware Air Regulation 1113.)

New methods were applied to some existing source categories, and emission factors were updated where available. New methods and emission factors came primarily from current *Emission Inventory Improvement Program, Volume III* documents and documented projects performed by the California Air Resource Board (CARB). Other sources of information included the *Compilation of Air Pollutant Emission Factors, Volume I* (AP-42), the *Factor Information Retrieval System* (FIRE), and several projects performed by the Mid-Atlantic Regional Air Management Association (MARAMA) and EPA.

Emissions from most non-point source categories were estimated by multiplying an indicator of collective activity by a corresponding emission factor. An indicator is any parameter associated with the activity level of a source, such as production, employment, fuel usage, or population that can be correlated with the emissions from that source. The corresponding emission factors are per unit of production, per employee, per unit of commodity consumed, or per capita, respectively. The basic equation that was applied to emission development for most non-point source categories is as follows:

$$Emissions\ (E) = Activity\ Data\ (Q) \times Emission\ Factor\ (EF)$$

If a source category had a regulatory control placed on it at the Federal or State level, the equation expands to the following:

$$E = Q \times EF \times [1 - (CE)(RE)(RP)]$$

where: CE = control efficiency
RE = rule effectiveness
RP = rule penetration

The control efficiency (CE) represents the typical emissions reduction achieved as compared to the otherwise uncontrolled emissions. A control may be a piece of equipment, such as a cyclone used to capture particulates, or it may be an operational control, such as low sulfur fuel.

Rule effectiveness (RE) reflects the ability of the regulatory program to achieve all emissions reductions that could have been achieved by full compliance with the applicable regulations at all sources at all times. If a rule is not being followed by all of the regulated community, then emissions will be higher than would otherwise be if there was 100% compliance. As an example, while the burning of trash is illegal under any circumstances in Delaware, the practice of burning household trash in backyard burn barrels still takes place in many rural areas of the State.

Rule penetration (RP) represents the percent of sources within a source category that are subject to the rule that requires control. As an example, while businesses and developers are prohibited from burning woody debris, Delaware residents may burn small piles of branches and limbs during certain times of the year. Therefore, RP is less than 100%. In the case of the burning of trash or leaves, no person or business is exempt, and thus RP is 100%.

A major portion of the work involved in creating the 2008 non-point source inventory was in collecting activity data for each source category. The activity data gathered was related to the type of emission factors available and, in many cases, obtained from local sources. Surveys, letters, e-mails, and phone calls to individual businesses to obtain representative data for a source category was a technique used for several source categories. The type of activity data and the data source for each category is provided in Table 3-2.

Point source backout was performed for the industrial and commercial fuel combustion categories to avoid double counting of emissions between point and non-point sources. Point source fuel usage was backed out from fuel consumption data obtained from the U.S. Department of Energy's (DOE) Energy Information Administration (EIA).

3.3 2008 Emissions Summary

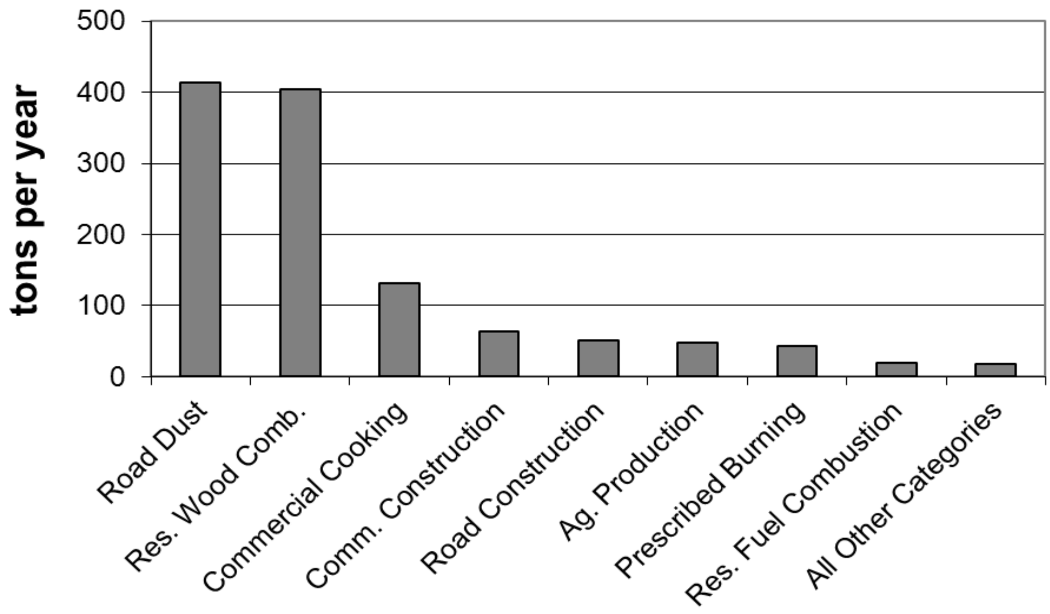
Table 3-3 provides a summary of the 2008 annual (tons per year, TPY) emissions for each non-point source category for New Castle County. The totals may not match the sum of the individual values due to independent rounding.

Table 3-2. Summary of 2008 Non-point Source Activity Data

Source Category	Activity Data	Source of Activity Data
Agricultural Burning	Acreage and vegetation type	DAQ Area Source Compliance Program
Agricultural Production	Planted and harvested crop acreage	Delaware Department of Agriculture
Commercial Construction	Value of construction put in place; construction employment; construction businesses	US Census Bureau County Business Patterns; Delaware Department of Labor
Commercial Cooking	Population	Delaware Population Consortium
Commercial Fuel Combustion	Fuel consumption	DOE Energy Information Admin.
Industrial Fuel Combustion	Fuel consumption	DOE Energy Information Admin.
Land Clearing Debris Burning	Acreage disturbed during road, commercial, and residential construction	DAQ data calculated for the construction dust categories
Paved & Unpaved Road Dust	Vehicle miles traveled	Delaware Department of Transportation
Prescribed Burning	Acreage and vegetation type	DAQ Area Source Compliance Program
Residential Construction	Residential building permits	US Census Bureau
Residential Fuel Combustion	Fuel consumption	DOE Energy Information Admin.
Residential Open Burning	Rural households	US Census Bureau
Residential Wood Combustion	Occupied households	Delaware Population Consortium
Road Construction	Highway capital outlays	Federal Highway Administration
Structure Fires	Number of structures fires	Delaware Fire Marshal and DAQ Area Source Compliance Program
Vehicle Fires	Number of vehicle fires	Delaware Fire Marshal
Wildfires	Acreage and vegetation type	Delaware Division of Forestry

Combustion processes and fugitive dust account for 84% of the direct particulate emissions in New Castle County from the non-point sector. Road dust and residential wood combustion are the two largest non-point source category of direct $PM_{2.5}$. Figure 3-1 presents the top eight $PM_{2.5}$ non-point sources in New Castle County for 2008.

Figure 3-1. 2008 New Castle County $PM_{2.5}$ Emissions by Non-point Source Category



The important precursor pollutants to the formation of secondary fine particulate emissions are SO_2 and NO_x. The non-point sector is a small contributor of these pollutants to the overall county totals. Nearly all of the SO_2 and NO_x emissions result from the combustion of fossil fuels.

Table 3-3. Summary of 2008 New Castle County Emissions from Non-point Sources

Source Categories	$PM_{2.5}$ TPY	SO_2 TPY	NO_X TPY
FUEL COMBUSTION			
Commercial/Institutional	3	16	246
Industrial	3	34	445
Residential Fossil Fuel	20	339	535
Residential Wood	404	8	47
Fuel Combustion Total	**429**	**399**	**1,273**
OPEN BURNING			
Agricultural Burning	4	---	1
Land Clearing Debris Burning	0	---	0
Prescribed Burning	43	3	11
Residential Open Burning	2	< 1	< 1
Structure Fires	3	---	< 1
Vehicle Fires	4	---	< 1
Wildfires	1	< 1	< 1
Open Burning Total	**56**	**3**	**13**
FUGITIVE DUST			
Agricultural Production	48	**---**	**---**
Commercial Construction	63	**---**	**---**
Paved and Unpaved Road Dust	413	**---**	**---**
Residential Construction	2	**---**	**---**
Road Construction	51	**---**	**---**
Fugitive Dust Total	**576**	**---**	**---**
OTHER SOURCES			
Commercial Cooking	131	---	---
Other Sources Total	**131**	**---**	---
NON-POINT SECTOR TOTAL	**1,191**	**402**	**1,287**

SECTION 4

NON-ROAD MOBILE SOURCES

Non-road mobile sources represent a large and diverse set of off-road vehicles and non-stationary equipment. Emission estimates of $PM_{2.5}$, SO_2, and NO_x for this source sector account for exhaust emissions from engine fuel combustion.

4.1 Source Categories

Non-road vehicles and equipment are grouped into four source category types for the purpose of developing emission estimates. These include:

- **Aircraft –** Commercial, military, and private aircraft are considered under this source category.

- **Locomotives –** Commercial line haul and yard locomotives are considered under this source category.

- **Commercial Marine Vessels (CMVs) –** Various types of vessels that navigate the Delaware Bay and River and the Chesapeake and Delaware Canal are included under this source category. Recreational boats are included in the next category.

- **Other Off-road Vehicles and Equipment –** All other off-road emission sources are accounted for through the use of EPA's NONROAD model. The NONROAD model compiles off-road equipment pertinent to Delaware into the following subcategories:

  - Recreational (land-based);
  - Construction;
  - Industrial;
  - Lawn and Garden;
  - Agricultural;
  - Commercial;
  - Logging;
  - Airport Ground Support;
  - Recreational Marine; and
  - Railway Maintenance.

Individual equipment SCCs covered in the NONROAD model are further broken down by the fuel type, including 2-stroke gasoline, 4-stroke gasoline, diesel, liquefied petroleum gas (LPG), and compressed natural gas (CNG).

4.2 Emission Estimation Methodologies

The 2005 Delaware Periodic Emission Inventory served as the starting point for non-road source category selection and methodology development. No new sources were added to Delaware's off-road mobile source inventory. However, new versions of EPA's NONROAD model and the Federal Aviation Administration's (FAA) Emissions and Dispersion Modeling System (EDMS) were used for 2008.

Similar to the estimation of stationary non-point emissions, off-road equipment emissions were estimated by multiplying an indicator of collective activity within the inventory area for a source category by a corresponding emission factor. The indicators of activity for off-road sources include landing and take-offs (LTOs), vessel port-of-calls, time-in-mode (TIMs, which are pertinent to aircraft and CMVs), gross ton miles (locomotives), equipment populations and economic activity (both pertinent to NONROAD equipment) that can be correlated with the emissions from that source. The corresponding emission factors are amount of pollutant (either grams or pounds) per unit of fuel used (locomotives and military/commercial aircraft), per LTO (air taxi and general aviation) or per unit of power output in brake horsepower or kilowatt-hours (NONROAD equipment and CMVs, respectively).

A major portion of the work involved in creating the 2008 non-road source inventory was in collecting activity data for each source category. The activity data gathered was related to the type of emission factors available and, in many cases, obtained from local sources. More information about gathering activity data for each source category is presented below.

There are no point source data that must be backed out of the non-road mobile source sector. Even though larger airports may report as a point source, their reported point source emissions do not include ground support equipment or aircraft engine emissions. Also, aircraft emissions are estimated only for LTOs that take place at a Delaware airport. Emissions from aircraft that transit Delaware airspace are not included in Delaware's inventory.

4.2.1 NONROAD Model Equipment

DAQ used NONROAD2008a to develop 2008 annual emission estimates for New Castle County. Most equipment covered by the NONROAD model is powered by diesel-fueled compression-ignition engines or gasoline-fueled spark-ignition engines. Engines fueled by compressed natural gas (CNG) and liquefied petroleum gas (LPG) engines are also included in the NONROAD model. Table 4-1 lists general SCCs addressed by the NONROAD model. Equipment categories are defined at the 7-digit SCC level (with recreational marine and railway maintenance being exceptions) and specific equipment are defined at the 10-digit SCC level.

To estimate pollutant emissions, the NONROAD model multiplies equipment populations and their associated activity by the appropriate emission factors. Geographic allocation factors (GAFs) are used to distribute national equipment populations to states/counties. These factors are based on surrogate indicators of equipment populations. For example, harvested cropland is the surrogate indicator used in allocating agricultural equipment. A national average engine activity (i.e., load factor times annual hours of use) is used in NONROAD.

To improve the accuracy of the model runs, default inputs were replaced in the NONROAD model option files for select parameters. In the options packet, inputs that can be replaced include: Reid vapor pressure (RVP), temperature, oxygenated fuel weight percent, and fuel sulfur levels. Local activity data inputs, such as equipment populations or activity (e.g., hours of use or load factors), can also replace default values in the model.

Table 4-1. SCCs Addressed by the NONROAD Model

Nonroad SCCs	SCC Descriptions	Nonroad SCCs	SCC Descriptions
2260xxxxxx	2-stroke gasoline engines	2268xxxxxx	CNG engines
2260001xxx	- recreational vehicles	2268002xxx	- construction equipment
2260002xxx	- construction equipment	2268003xxx	- industrial equipment
2260003xxx	- industrial equipment	2268005xxx	- agricultural equipment
2260004xxx	- lawn & garden equipment	2268006xxx	- light commercial equipment
2260005xxx	- agricultural equipment	226801xxxx	- oil field equipment
2260006xxx	- light commercial equipment	2270xxxxxx	Diesel engines
2260007xxx	- logging equipment	2270001xxx	- recreational vehicles
2265xxxxxx	4-stroke gasoline engines	2270002xxx	- construction equipment
2265001xxx	- recreational vehicles	2270003xxx	- industrial equipment
2265002xxx	- construction equipment	2270004xxx	- lawn & garden equipment
2265003xxx	- industrial equipment	2270005xxx	- farm equipment
2265004xxx	- lawn & garden equipment	2270006xxx	- light commercial equipment
2265005xxx	- agricultural equipment	2270007xxx	- logging equipment
2265006xxx	- light commercial equipment	2270008xxx	- airport service equipment
2265007xxx	- logging equipment	2270009xxx	- underground mining equipment
2265008xxx	- airport service equipment	227001xxxx	- oil field equipment
226501xxxx	- oil field equipment	2282xxxxxx	Recreational marine equipment
2267xxxxxx	LPG engines	2285xxx015	Railway maintenance equipment
2267001xxx	- recreational vehicles		
2267002xxx	- construction equipment		
2267003xxx	- industrial equipment		
2267004xxx	- lawn & garden equipment		
2267005xxx	- agricultural equipment		
2267006xxx	- light commercial equipment		
2267008xxx	- airport service equipment		

NONROAD model option files were prepared to account for temperatures and fuel characteristics representative of each county for each of the four seasons (winter, spring, summer, and fall). Temperature and fuel input values for each three-month period (December-February, March-May, June-August, and September-November) were averaged to estimate seasonal values. Minimum, maximum, and average temperatures per month were obtained from the National Weather Service for the New Castle County Airport. Table 4-2 presents a summary of New Castle County temperature and gasoline fuel characteristics data used for each season. A sulfur content of 351 ppm for off-road diesel fuel was used for 2008 based on an EPA recommendation report (EPA, 2009a).

Table 4-2. NONROAD Model Temperature and Fuel Characteristic Input Values by Season for 2008

County	Season	Oxygen Weight %	RVP psi	Gasoline Sulfur ppm	Temperature, °F		
					Minimum	Maximum	Average
New Castle	Summer	3.55	6.82	39	66	86	76
New Castle	Autumn	3.2	8.06	40.67	48	66	57
New Castle	Winter	3.29	10.54	44	30	46	37
New Castle	Spring	3.2	8.06	40.67	44	64	53

DAQ researched the availability of state and county-specific data to improve upon the default equipment populations and GAFs incorporated in the model. DAQ replaced the default equipment population of recreational marine equipment with Delaware-specific data. DAQ used recreational boat registration data provided by the Delaware Division of Fish and Wildlife (DNREC, 2009) to estimate the total recreational marine equipment population in use within Delaware waters. DAQ determined this to be a preferable approach to the NONROAD default approach of a top-down allocation of the national equipment population. However, registration data were not used to allocate recreational marine activity to the county level because residents may register their boats in one county, but use their boats in other parts of the State or neighboring counties.

DAQ updated GAFs for numerous equipment categories. Table 4-3 provides a list of GAFs and the associated equipment populations that use the GAFs that were updated with 2008 Delaware-specific data. For golf carts, DAQ replaced the GAFs based on the number of golf courses in each county with the county total square kilometers of golf courses in each county. DAQ believes that golf cart usage is more directly related to the size of each golf course than to the number of courses that exist in each county. If an equipment population is not identified in Table 4-3, then the model default GAFs were used in the 2008 runs.

Table 4-3. 2008 Delaware-specific Geographic Allocation Factors

Geographic Allocation Factor	Data Source	Equipment Population
Population	DE Population Consortium	
Aircraft NOx emissions	Delaware 2008 inventory	Airport ground support equipment
Dollar value of construction	US Census Bureau and DE DOL	Construction equipment
Harvested acres	DE Department of Agriculture	Agricultural equipment
Area of golf courses	Delaware State Golf Association	Golf carts
Wholesale businesses	BOC County Business Patterns	Commercial equipment
Single and duplex housing	BOC FactFinder website	Residential lawn & garden equipment
Landscaping businesses	BOC County Business Patterns	Commercial lawn & garden equipment
Manufacturing employees	BOC County Business Patterns	Industrial equipment
Snowfall	Weather Warehouse website	Snow blowers and snowmobiles

4.2.2 Aircraft

The aircraft source category includes emissions from commercial, air taxi, general aviation, and military aircraft. These sub-categories are described as follows:

- Commercial aircraft are used for scheduled service transporting passengers, freight, or both;
- Air taxis are used for scheduled service carrying passengers and/or freight, but are smaller aircraft that operate on a more limited basis than the commercial carriers;
- General aviation includes other non-military aircraft used for recreational flying, business, personal transportation, and various other activities; and
- Military aircraft are used by the U.S. military in a wide range of missions.

Airport-specific emissions for all aircraft sub-categories were allocated to the county in which each airport is located. Where there are multiple airports in a given county, the emissions were summed to provide a county-level emissions estimate. Aircraft emissions are reported under the following SCCs:

Table 4-4. SCCs for Aircraft

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2275001000	Mobile Sources	Aircraft	Military Aircraft	Total
2275020000	Mobile Sources	Aircraft	Commercial Aircraft	Total: All Types
2275050000	Mobile Sources	Aircraft	General Aviation	Total
2275060000	Mobile Sources	Aircraft	Air Taxi	Total

DAQ estimated annual aircraft emissions using a combination of airport-specific activity data and Federal Aviation Administration (FAA)/EPA emission factors. Estimating aircraft emissions focuses on the "mixing zone," which has a height (mixing height) equal to the thickness of the inversion layer. Air emissions within this zone are trapped by the inversion layer and ultimately affect ground-level pollutant concentrations. When aircraft are above the mixing zone, emissions tend to disperse and have no ground-level effects. The aircraft operations within the mixing zone are defined by the landing and take-off (LTO) cycle. Each LTO cycle consists of five specific operating modes:

- Approach – aircraft operates in this mode when it approaches the airport on its descent from the mixing height to when it lands on the runway.
- Taxi/idle-in – aircraft operates in this mode when it taxis from the runway to the gate and turns its engines off.
- Taxi/idle-out – this period occurs from engine start-up to take-off as the aircraft taxis from the gate back out to the runway.
- Take-off – this mode is characterized primarily by full-throttle operation that typically lasts until the aircraft reaches between 500 and 1000 feet above ground, which is when engine power is reduced.
- Climb-out – this mode begins right after the take-off mode and lasts until the aircraft passes out of the mixing height.

The operation time in each of these modes is dependent on the aircraft category, local meteorological conditions, and operational considerations at a given airport. The time-in-mode (TIM) for the take-off operating mode is the least variable.

The following are the general steps to be used to estimate aircraft emissions:

- Determine the mixing height to be used to define the LTO cycle;
- Define the fleet make-up for each airport;
- Determine airport activity in terms of the number of LTOs by aircraft/engine type;
- Select emission factors for each engine model associated with the aircraft fleet;
- Estimate the TIM for the aircraft fleet at each airport;
- Calculate emissions based on aircraft LTOs, emission factors for each aircraft engine model, and estimated aircraft TIM; and
- Aggregate the emissions across aircraft.

DAQ contacted the New Castle County and Summit airports to request the number of aircraft LTOs for calendar year 2008 for each of the four aircraft types. Additionally, each airport was requested to provide LTOs by aircraft make and engine type; however this level of detail was not provided by the airports for 2008. DAQ assumed 2008 aircraft were of the same mix of aircraft/engine types as reported for 2002. Table 4-5 provides the LTO data by the four aircraft types for the two airports in New Castle County.

Table 4-5. 2008 LTO Data for New Castle County

Airport	County	Category	LTOs
New Castle County	New Castle	Military	4,618
New Castle County	New Castle	Commercial	488
New Castle County	New Castle	Air Taxi	5,244
New Castle County	New Castle	General Aviation	40,342
Summit	New Castle	General Aviation	34,700

DNREC used these airport-specific LTO data to estimate commercial and military aircraft emissions using FAA's Emissions and Dispersion Modeling System (EDMS), Version 5.1 (FAA, 2008). The model requires detailed inputs on aircraft operation by aircraft and engine type. DNREC matched the aircraft LTO data to the existing aircraft/engine types in EDMS, and used the default EDMS TIM data. A mixing height of 2,300 feet was used for both airports in New Castle County based on an isopleth chart of annual average morning mixing heights for the continental U.S. as provided in EPA's *Procedures* Manual (EPA, 1992). The Delaware Army National Guard (DE ARNG) and the Delaware Air National Guard (DE ANG) operate units at the New Castle County Airport and contribute to the military LTOs at that airport.

EDMS generates emissions for SO_2 and NO_x in tons per year. EDMS does not estimate particulate emissions by aircraft/engine type. As such, DAQ used fleet average $PM_{2.5}$ emission rates applied to total LTOs outside EDMS. The model also generates emissions for ground support equipment (GSE). However, DAQ used the GSE estimates generated from the NONROAD model, so these were subtracted from the EDMS results. EPA fleet average emission factors were applied to the LTO data to estimate annual general aviation and air taxi emissions.

4.2.3 Locomotives

Railroad locomotives are a combustion source of emissions with most significant emissions occurring where there is a concentration of railroad activity (such as a large switch yard). The primary fuel consumed by railroad locomotives is distillate oil (diesel fuel). Locomotives can perform two different types of operations: line haul and yard (or switch). Line haul locomotives generally travel between distant locations, such as from one city to another. Yard locomotives are primarily responsible for moving railcars within a particular railway yard. Locomotive emissions are reported under the SCCs provided in Table 4-6.

For line haul locomotives, DAQ calculated Class I operation emissions separately from Class II/III operations. Line haul locomotive emissions for passenger trains and commuter lines were estimated to be zero since rail service in Delaware (Amtrak and SEPTA) is electric powered. Fuel consumption was used to estimate locomotive engine emissions. Fuel consumption rates are usually known only for the entire interstate operating region, therefore, it is necessary to allocate the total amount of fuel consumed "system-wide" to Delaware and its counties.

Table 4-6. SCCs for Locomotives

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2285002006	Mobile Sources	Railroad Equipment	Diesel	Line Haul Locomotives: Class I Operations
2285002007	Mobile Sources	Railroad Equipment	Diesel	Line Haul Locomotives: Class II/Class III Operations
2285002010	Mobile Sources	Railroad Equipment	Diesel	Yard Locomotives

Line Haul Locomotives – Class I Operations

Norfolk Southern and CSX Transportation operate Class I locomotives within New Castle County. DAQ contacted these companies to obtain estimates of fuel consumption or data to calculate fuel consumption (e.g., gross ton-miles (GTM) and gallons of fuel consumed per GTM).

Norfolk Southern provided GTM data at the county level for each county in Delaware in which they operated. Norfolk Southern provided a fuel consumption index (GTM/fuel consumed) for the system that includes operations in Delaware. CSX provided GTM and fuel consumption data for New Castle County, the only county in which CSX operates in Delaware. The system-wide fuel consumption indices, county-specific GTM, and calculated county-level fuel consumption are provided in Table 4-7.

Table 4-7. 2008 New Castle County Locomotive Fuel Consumption Data for Class I Line Haul Operations

Class I Railroad	Gross Ton Miles (GMT)	System-wide GMT/Gallon Diesel	Fuel Consumed, gallons/year
Norfolk Southern	307,435,000	811.27	377,748
CSX Transportation	683,000,000	886.83	770,161

Line Haul Locomotives – Class II/III Operations

The Maryland & Delaware Railroad is the only Class II/III railroad that operates in New Castle County. The company provided 2008 statewide fuel consumption data. The Maryland & Delaware Railroad operates in New Castle and Sussex Counties. Track miles within each county were used to allocate statewide fuel consumption to each county. The Maryland & Delaware Railroad estimated 3,013 gallons of diesel fuel was used in New Castle County for 2008.

Yard Locomotives

Norfolk Southern, CSX Transportation, and Maryland & Delaware have yard operations within New Castle County. These companies provided the number of locomotives by switchyard location. Table 4-8 provides a summary of switchyard operations and fuel consumption. CSX and Maryland & Delaware provided Delaware-specific fuel consumption for 2008. An average switchyard engine fuel consumption estimate of 32,447 gallons per year was applied based on a recent regional study coordinated through the Eastern Regional Technical Advisory Committee (ERTAC, 2010).

Table 4-8. 2008 Switchyard Activity and Estimated Fuel Consumption

Class I Switchyard	No. of Yard Locomotives	Fuel Consumed, gallons/year
Norfolk Southern	9	292,024
Maryland & Delaware	1	9,640
CSX Transportation	2	120,000

4.2.4 Commercial Marine Vessels

The CMV sector includes many types of vessels, such as large deep-draft vessels, barge towboats, harbor tugs, dredging vessels, ferries, excursion vessels, and commercial fishing vessels. In addition to the numerous vessel types, each vessel type engages in different activities such as hoteling, maneuvering within the port, and cruising.

In its 1999 final rule for commercial marine diesel engines, EPA defined three categories of marine diesel engines based on engine displacement, power and revolutions per minute (rpm) (EPA, 1999a). Table 4-9 presents the definitions for each category.

Table 4-9. U.S. EPA Marine Engine Category Definitions

Category	Displacement per cylinder	Power range (kW)	RPM range
1	disp. < 5 liters and power ≥ 37 kW	37 - 2,300	1,800 - 3,000
2	5 ≤ displacement < 30 liters	1,500 - 8,000	750 - 1,500
3	displacement ≥ 30 liters	2,500 - 80,000	60 - 900

The EPA classifies CMV emissions by fuel type (residual and diesel) and by mode of operation (port and underway). CMVs often burn multiple types of fuel and may burn different fuels for different operating modes or locations (i.e., near ports). DAQ used the port and underway SCCs to characterize the CMV emissions as listed in Table 4-10. The SCC classification is based on the most common type of fuel utilized by the vessel category. Ocean-going vessels (OGV) predominately burn intermediate fuel oil (IFO). DAQ placed emissions from OGVs burning IFO in the residual fuel SCC. This is consistent with how petroleum product sales data are reported by the Energy Information Administration and EPA's classification of fuels (EPA 1999b).

Table 4-10. SCCs for Commercial Marine Vessels

SCC	Descriptor 1	Descriptor 3	Descriptor 6	Descriptor 8
2280002100	Mobile Sources	Marine Vessels, Commercial	Diesel	Port emissions
2280002200	Mobile Sources	Marine Vessels, Commercial	Diesel	Underway emissions
2280003100	Mobile Sources	Marine Vessels, Commercial	Residual	Port emissions
2280003200	Mobile Sources	Marine Vessels, Commercial	Residual	Underway emissions

There are four activity modes for CMV; cruise, reduced speed zone (RSZ), maneuver, and hotel. Underway emissions are estimated as the combined activity of cruise and RSZ modes. Port emissions are estimated as the combined activity of maneuvering and hoteling modes. Emissions from ferries and dredging are considered port emissions since these vessels operate primarily within the port area.

DAQ calculated emissions for ocean-going vessels, towboats, tug-assist vessels, ferries and vessels associated with dredging operations. CMV engine emissions are assumed to be a function of the following:

- Mode of operation,
- Vessel type (bulk carrier, tanker, towboat, etc.);
- Vessel dead weight tonnage (DWT);
- Type of engine (2-stroke, 4-stroke, or steam); and
- Length of waterway segment.

Therefore, DAQ accounted for these variations when estimating CMV activity. The four modes of operation that are performed by vessels are defined below:

Cruise - This mode is assumed to begin 25 miles out from the port breakwater until the vessel reaches the breakwater (EPA, 1999c). The breakwater is located at the mouth of the Delaware Bay. Cruise mode is not applicable to New Castle County.

Reduced Speed Zone (RSZ) - This mode begins at the breakwater and continues until the vessel is one to two nautical miles from the berth or anchorage. The vessel is assumed to have a speed of twelve knots during this mode (EPA, 2009c). This mode is also referred to as transit, and escort for towboats and tug-assist vessels.

Maneuvering - This mode is defined as the time the vessel slows to below four knots until the dock lines are secure. This mode is also referred to as assist mode for tug-assist vessels.

Hoteling - This mode is defined as the time the vessel is at dock. During this mode, the vessel operates auxiliary engines for electrical power.

The waterway segment distances used to estimate activity and to allocate the activity to New Castle County were estimated from the Google Earth website in 2008 by tracing the shipping channel. Segment distances are shown in Table 4-11. The distance South is given to the breakwater at the mouth of the Delaware Bay. The distance north is given to the Delaware-Pennsylvania border. The distance for the C&D Canal East is given from the Delaware-Maryland border to the entrance of the Delaware River (Reedy Point).

The engine activity for each mode is calculated using the following equation:

$$Activity_{mode} = Power \times LoadFactor \times Time_{mode} \times Calls$$

where:

$Activity_{mode}$	=	activity by mode (kilowatt-hours)
Power	=	rated engine power by vessel and engine type (kilowatts)
Load Factor	=	load factor of the engine by vessel type and mode
Time	=	time in mode per call by vessel type (hours)

Calls = number of calls by vessel and engine type

Table 4-11. Waterway Segment Distances for the Delaware River Area

Waterway Segment	Distance (mi.)
Point	**South**
DE/PA Border	83.8
Oceanport	83.3
Port of Wilmington	76.1
Magellan Terminal	75.6
Delaware City Refinery	66.0
C&D Canal	62.6
Latitude 39°30'	57.7
New Castle Co/Kent Co	48.5
Kent Co/Sussex Co	15.9
Point	**North**
Port of Wilmington	7.7
C&D Canal	21.2
Point	**East**
C&D Canal	13.0

This calculation must be performed for both propulsion and auxiliary engines and for each mode. Both propulsion engines and auxiliary engines are operating during cruise, RSZ and maneuvering modes. Only auxiliary engines operate during hoteling. Once the activity is calculated, it is allocated to the county level using county allocation factors.

This approach to calculating activity of CMVs was used for all vessel types except vessels involved in dredging activity. For dredging, the activity data used for emissions calculations was the volume of material dredged. Details on the sources and development of activity data are provided in the following subsections.

Ocean-Going Vessels

DAQ obtained vessel call data for ocean-going vessels (OGVs) during calendar year 2008 from the Marine Exchange for the Delaware River and Bay (ME, 2010). Data were obtained for vessels that called on ports in Delaware, New Jersey and Pennsylvania. The data for the entire port area is required since the majority of vessels pass through Delaware waters en route to other ports. The vessel call data included the vessel name, ship type, DWT, pier, and the date of the call. The ship types calling on the Delaware River Area ports in 2008 are shown in Table 4-12.

Vessels may shift between piers during the same call on the Delaware River area. DAQ adjusted the vessel call data to remove shifts between piers, where possible, to avoid double counting using a methodology recommended by the staff of the Marine Exchange. Data on the engine power and engine type (2-stroke, 4-stroke, and steam) used on OGVs were not available through the Marine Exchange. Therefore, DAQ assigned engine power and engine type based on average engine data obtained from other sources.

For propulsion engines, the average engine power and the engine type were obtained from the EPA report *Commercial Marine Activity for Deep Sea Ports in the United States* (*Deep Sea Ports*) (EPA, 1999c). This report presents data for vessels that called on the Delaware River area ports during calendar year 1996. Note that the Delaware River area includes ports in Delaware, New Jersey and Pennsylvania, which are located on the Delaware River. The number of calls by vessel and engine type is presented for specific DWT ranges. The average engine power is also given.

Table 4-12. Vessel Types Calling on Delaware River Area Ports in 2008

Codes	Main Vessel Type	Additional Vessel Types Included w/ Main Type
BU	Bulk	Chemical (CH), Ore (OR)
CC	Container	Container/Bulk (CB), Part Container (PC)
GC	General Cargo	
MS	Miscellaneous	Cable Ship (CL), Heavy Lift (HL), Livestock (LV), Tall Ship (TS)
PR	Passenger	
RF	Refrigerated Cargo (Reefer)	Container Reefer (CR)
RR	Roll on-Roll off (RORO)	RORO Container (RC)
TA	Tanker	Bulk Oil (BO), Gas Carrier (PG)
VE	Vehicle Carrier	

In order to calculate underway emissions, the number of calls (by vessel type and DWT range) had to be allocated to each port. The ports in Delaware include the Port of Wilmington, Magellan Terminal, Delaware City Refinery, and Oceanport. One port in New Jersey, Bermuda International on Salem Creek, is located adjacent to Delaware. All other ports in New Jersey and all ports in Pennsylvania are located north of the Delaware/Pennsylvania state line. Vessels calling on New Jersey and Pennsylvania ports must be included in underway emission calculations for Delaware since the vessels travel through the Delaware portion of the bay and river.

Table 4-13 presents the assigned propulsion engine power and the number of calls by vessel type, DWT range and engine type for calls on the Delaware River area in 2008. In addition to vessels traveling in the Delaware River Bay and River, 424 OGVs traversed the C&D Canal to or from the Chesapeake Bay.

Towboats and Tug Assists

Towboats are used to transport non-self-propelled vessels, either dry cargo or tanker barges, throughout the Delaware River area, including the C&D Canal. DAQ obtained data on the number of towboat trips during calendar year 2008 from *Waterborne Commerce of the United States* (USACE, 2010a). DAQ subtracted the number of towboat trips for the Port of Wilmington (POW) and the C&D Canal from the number of trips on the Delaware River (PA to the Sea). For towboats traveling to and from the POW and traveling through the C&D Canal, DAQ assumed that half the vessels travel north and the other half travel south to/from the POW and the canal.

In 2008, 13,203 towboat trips transited Delaware waters on the Delaware River, with a trip defined as a one-way passage. 1,184 towboat trips entered or exited the Port of Wilmington, and 3,597 towboat trips transited the C&D Canal.

Table 4-13. Average Propulsion Engine Power and the 2008 Number of Calls for OGVs Calling on the Delaware River Area (DE, NJ and PA)

Code	DWT Range	Engine Type	Power (hp)	Calls	Code	DWT Range	Engine Type	Power (hp)	Calls
BU	< 25,000	2-stroke	9,665	41	RF	15,000-25,000	2-stroke	18,467	72
BU	< 25,000	4-stroke	7,504	6	RR	<15,000	2-stroke	8,280	13
BU	25,000 - 35,000	2-stroke	9,696	85	RR	<15,000	4-stroke	8,553	13
BU	35,000 - 45,000	2-stroke	10,320	56	RR	15,000 - 30,000	2-stroke	12,852	16
BU	> 45,000	2-stroke	16,328	90	RR	>30,000	2-stroke	26,562	0
CC	< 25,000	2-stroke	17,757	126	TA	<30,000	2-stroke	10,008	75
CC	< 25,000	4-stroke	10,898	67	TA	<30,000	4-stroke	7,077	18
CC	25,000 - 35,000	2-stroke	16,327	145	TA	<30,000	Steam	14,646	8
CC	35,000 - 45,000	2-stroke	34,467	117	TA	30,000 - 60,000	2-stroke	12,616	195
CC	> 45,000	2-stroke	30,856	54	TA	30,000 - 60,000	4-stroke	15,360	13
GC	< 15,000	2-stroke	5,784	45	TA	30,000 - 60,000	Steam	15,498	135
GC	< 15,000	4-stroke	3,944	57	TA	60,000 - 90,000	2-stroke	16,026	69
GC	15,000 - 30,000	2-stroke	10,456	30	TA	60,000 - 90,000	4-stroke	14,305	10
GC	15,000 - 30,000	4-stroke	7,536	5	TA	90,000 - 120,000	2-stroke	15,451	302
GC	30,000 - 45,000	2-stroke	12,876	33	TA	90,000 - 120,000	Steam	23,923	7
GC	> 45,000	2-stroke	12,170	2	TA	120,000 - 150,000	2-stroke	23,046	56
MS	< 10,000	2-stroke	3,500	6	TA	> 150,000	2-stroke	25,559	113
MS	< 10,000	4-stroke	11,671	3	TA	> 150,000	Steam	36,324	35
PR	< 5,000	4-stroke	16,108	12	VE	<12,500	2-stroke	11,877	13
PR	5,000 - 10,000	4-stroke	20,776	0	VE	<12,500	4-stroke	13,150	3
PR	5,000 - 10,000	steam	40,649	1	VE	12,500 - 15,000	2-stroke	12,859	30
RF	5,000 - 10,000	2-stroke	9,706	115	VE	12,500 - 15,000	4-stroke	14,770	6
RF	5,000 - 10,000	4-stroke	6,837	20	VE	15,000 - 17,500	2-stroke	13,911	30
RF	10,000 - 15,000	2-stroke	12,500	173	VE	> 17,500	2-stroke	15,224	51
RF	10,000 - 15,000	4-stroke	15,672	3					

Tugs assist OGVs from the shipping channel to its intended berth and then back to the channel when the vessel leaves port. This activity is considered the maneuvering mode for OGVs. Two tugs are typically required to assist an OGV with a DWT greater than 20,000 tons; for smaller OGVs, one tug suffices (EPA, 2009b). The number of tug assists (3,428 in 2008) is directly related to the number of OGVs calling to a Delaware port. Note that a tug assisting a vessel to Bermuda International in New Jersey and the piers at the oil refineries in Marcus Hook, PA will require a tug to pick up the OGV in Delaware waters, thus tug assists are included for these docks. The tug meeting time to the docking time is usually within one hour (Anderson, 2010).

In addition to assisting OGVs to maneuver into port, tugboats escort gas carriers through the Delaware Bay and River (Andersen, 2010). Other vessels typically do not utilize an escort. Tug escort trips are included in the number of towboat trips transiting Delaware waters presented above. DNREC did not estimate emissions from hoteling of towboats and tugs due to lack of activity data.

Vessel speeds, average maneuvering and hoteling time, propulsion and auxiliary engine horsepower ratings, and engine load factors for OGVs, towboats, and tugs were obtained from EPA's *Deep Sea Ports* (EPA, 1999c) and *Preparing Port Emission Inventories* (EPA, 2009b).

For RSZ mode, time-in-mode for each vessel was calculated based on vessel speeds and waterway segment distances provided in Table 4-11.

Dredging

Maintenance dredging is performed routinely on the Delaware River to keep the channels to their required depths. Dredging involves multiple vessels, including dredges, assist tugs, and generator barges that provide additional power. Estimating emissions from dredging vessel engine activity is time-consuming. Therefore, DAQ developed emissions based on the volume of material dredged during calendar year 2008 rather than engine activity in kilowatt-hours.

DAQ obtained the dredging activity data from both the USACE and from within DNREC. The amount of material dredged by USACE contractors was obtained from the USACE report on dredging contracts awarded for the year 2008 (USACE, 2010b). DAQ also contacted the Delaware Division of Soil and Water Conservation to obtain the amount of material dredged by the Division (DSWC, 2010). Table 4-14 presents the estimated amount of material dredged and the type of dredge used. DAQ assumed all the dredging activity is maintenance dredging. New cut dredging results in higher emissions, therefore this assumption may result in lower emission estimates than are actually occurring in the area.

Table 4-14. Material Dredged in the New Castle County Portion of the Delaware River Area during 2008

Project Location	Type of Equipment	Total Material Dredged (cubic yards)
Philadelphia to the Sea	Hydraulic Dredge	732,697
Chesapeake & Delaware Canal	Hydraulic Dredge	600,000
Port of Wilmington	Hydraulic Dredge	650,000
Premcor Berth Maintenance	Hydraulic Dredge	230,000

Ferries

The Three Forts Ferry was identified as the only ferry service in New Castle County. This ferry travels from either Delaware City, DE or Fort Mott, NJ to Fort Delaware located on Pea Patch Island in the Delaware River. Monthly trip count data for the ferry was obtained by contacting the Delaware River & Bay Authority (DRBA, 2010). The Three Forts Ferry made 2,280 one-way trips in 2008. The Delaware River and Bay Authority also provided the engine and time-in-mode data for the Three Forts Ferry.

Spatial Allocation

DAQ developed county allocation factors for CMV activity data based on the location of the activity on the various waterways and length of the waterway segment. In developing county allocation factors, DAQ assumed that from latitude $39^{o}30'$ to 25 miles beyond the mouth of the Delaware Bay, the activity is split evenly between Delaware and New Jersey since the ship channel roughly corresponds to the boundary between the two states. Above latitude $39^{o}30'$, all emissions are allocated to Delaware since the entire breadth of the river is under Delaware's jurisdiction. Allocations were developed for each activity mode, since the activity takes place in different areas depending on the mode.

For OGV maneuvering and hoteling modes, the activity is allocated to the county in which the port is located. All the Delaware ports are located in New Castle County. Therefore, all maneuvering and hoteling activity was allocated to New Castle County.

For the RSZ mode, county allocation factors were developed for the four ports in Delaware (Port of Wilmington, Magellan Terminal, Oceanport, and Delaware City Refinery), Bermuda International in New Jersey, and from the Pennsylvania-Delaware border to the breakwater (PA/DE to the Sea).

Allocating dredging to each county was based on the river miles in each county, and split between Delaware and New Jersey below latitude 39°30'. While the Three Forts Ferry travels to Fort Mott on the New Jersey side of the Delaware River, at that latitude, Delaware’s jurisdictional waters extend the breadth of the river. Therefore, all activity for the Three Forts Ferry was allocated to New Castle County.

4.3 2008 Emissions Summary

Table 4-15 provides a summary of the 2008 annual (tons per year, TPY) New Castle County emissions for aircraft, locomotives, commercial marine vessels, and all equipment emissions estimated using EPA’s NONROAD model. The non-road sector is a significant contributor to $PM_{2.5}$ emissions and emissions of NO_x and SO_2 as precursors to the secondary formation of $PM_{2.5}$ in New Castle County. The totals may not match the sum of the individual values due to independent rounding.

Table 4-15. Summary of 2008 New Castle County Emissions from Non-road Sources in tons/year

Source Categories	$PM_{2.5}$	SO_2	NO_X
NONROAD Model Equipment	148	28	1,676
Aircraft	8	2	13
Locomotives	9	3	239
Commercial Marine Vessels	146	1,034	2,389
NON-ROAD SECTOR TOTAL	**312**	**1,067**	**4,317**

4.4 References

Anderson, 2010: Scott Anderson, Maritime Exchange for the Delaware River and Bay, Philadelphia PA, e-mail to David Fees, DNREC, on March 24, 2010.

DNREC, 2009: Delaware Department of Natural Resources and Environmental Control, Division of Fish and Wildlife, *Delaware Annual Boating Statistics.*

DRBA, 2010: Monthly trips data for the Three Forts Ferry, provided by J. Fred Coldren, Delaware River and Bay Authority, via e-mail to David Fees, DNREC, March 22, 2010.

DSWC, 2010: Brian Kelly, Delaware Division of Soil and Water Conservation, e-mail to David Fees, DNREC, on February 23, 2010.

EPA, 1992: U.S. Environmental Protection Agency, Office of Air and Radiation, *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, EPA-450/4-81-026d (Revised), 1992.

EPA, 1999a: *Final Regulatory Impact Analysis: Control of Emissions from Marine Diesel Engines*. U.S. Environmental Protection Agency, Office of Mobile Sources, Engine Programs and Compliance Division, EPA420-R-99-026, November 1999.

EPA, 1999b: In-Use Marine Diesel Fuel, U.S. Environmental Protection Agency, Office of Mobile Sources, Engine Programs and Compliance Division, EPA 420-R-99-027, August 1999.

EPA, 1999c: *Commercial Marine Activity for Deep Sea Ports in the United States*. U.S. Environmental Protection Agency. Prepared by ARCADIS Geraghty & Miller, Inc. EPA420-R-99-020, September 1999.

EPA, 2009a: *Suggested Nationwide Average Fuel Properties*. Assessment and Standards Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency. EPA-420-B-09-018, April 2009.

EPA, 2009b: *Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories*. U.S. Environmental Protection Agency. Prepared by ICF International, 09-024, April 2009.

ERTAC, 2010. "*ERTAC Rail Emissions Inventory – Part 2: Class I Railyard Switcher Locomotives*", Eastern Regional Technical Advisory Committee, October 2010.

FAA, 2008: Federal Highway Administration, "*Emissions and Dispersion Modeling System (EDMS) User's Manual*", Version 5.1, FAA-AEE-07-01, Revision 5, September 19, 2008.

ME, 2010: "Ship Traffic: Delaware River Ports: 2008" [data files], from Scott Anderson, Maritime Exchange for the Delaware River and Bay, Philadelphia PA, via e-mail to David Fees, Division of Air Quality, DNREC, February 2010.

USACE, 2010a: *Waterborne Commerce of the United States – Calendar Year 2008 – Part 1 Waterways and Harbors Atlantic Coast.* Department of the Army Corps of Engineers, Institute of Water Resources, WR-WCUS-08-1, March 2010.

USACE, 2010b: "U.S. Army Corps of Engineers Dredging Contracts Awarded; Fiscal Year 2008 Awards", U.S. Army Corps of Engineers, information retrieved in 2010 from http://www.iwr.usace.army.mil/ndc/dredge/pdf/awards08.pdf

SECTION 5

ON-ROAD MOBILE SOURCES

The 2008 on-road mobile source inventory is an estimate of vehicle emissions based on actual vehicle miles traveled (VMT) on Delaware roadways in 2008 using EPA's Motor Vehicle Emission Simulator (MOVES) model. Vehicles include passenger cars, light-duty trucks, including sport utility vehicles, heavy-duty trucks, buses, and motorcycles. Emissions were calculated for vehicles fueled by gasoline or diesel. Controls as of 2008 were incorporated into the MOVES model inputs, and thus emissions account for controls. Engine exhaust emissions for $PM_{2.5}$, SO_2, and NO_x, as well as for other criteria pollutants, air toxics, and greenhouse gases were calculated. In addition, particulate matter brake and tire wear emissions were separately calculated. Monthly emissions were calculated by roadway class, vehicle type, and county.

The applicable Standard Classification Codes (SCCs) comprising vehicle type, roadway class, and emission process (exhaust, evaporative, brake wear, and tire wear) are shown in Table 5-1. As an example, the SCC applicable to exhaust emissions from a passenger car fueled by gasoline on an urban interstate would be 220100123X, with the "2201001" indicating that the vehicle is a light-duty gasoline vehicle, the "23" indicating the activity is occurring on an urban interstate, and the "X" indicating that the emissions are exhaust emissions.

Table 5-1. SCCs Included in On-road Mobile Inventory

SCC Digits	Applicable Portion of SCC Code	Portion that SCC Describes	Description
1 - 7	2201001	Vehicle type	Light-duty gasoline vehicles (passenger cars)
1 - 7	2201020	Vehicle type	Light-duty gasoline trucks 1 (0-6,000 lb gross vehicle weight rating [GVWR])
1 - 7	2201040	Vehicle type	Light-duty gasoline trucks 2 (6,001-8,500 lb GVWR)
1 - 7	2201070	Vehicle type	Heavy-duty gasoline vehicles (> 8,500 lb GVWR)
1 - 7	2201080	Vehicle type	Motorcycles (gasoline)
1 - 7	2230001	Vehicle type	Light-duty diesel vehicles (passenger cars)
1 - 7	2230060	Vehicle type	Light-duty diesel trucks (0-8,500 lb GVWR)
1 - 7	2230071	Vehicle type	Class 2b heavy-duty diesel vehicles (8,501-10,000 lb GVWR)
1 - 7	2230072	Vehicle type	Class 3, 4, and 5 heavy-duty diesel vehicles (10,001-19,500 lb GVWR)
1 - 7	2230073	Vehicle type	Class 6 and 7 heavy-duty diesel vehicles (19,501-33,000 lb GVWR)
1 - 7	2230074	Vehicle type	Class 8 heavy-duty diesel vehicles (> 33,000 lb GVWR)
1 - 7	2230075	Vehicle type	Diesel buses
8 - 9	11	Roadway type	Rural interstates
8 - 9	13	Roadway type	Rural other principal arterials
8 - 9	15	Roadway type	Rural minor arterials
8 - 9	17	Roadway type	Rural major collectors
8 - 9	19	Roadway type	Rural minor collectors

Continued next page

Table 5-1. continued

SCC Digits	Applicable Portion of SCC Code	Portion that SCC Describes	Description
8 - 9	21	Roadway type	Rural locals
8 - 9	23	Roadway type	Urban interstates
8 - 9	25	Roadway type	Urban other freeways and expressways
8 - 9	27	Roadway type	Urban other principal arterials
8 - 9	29	Roadway type	Urban minor arterials
8 - 9	31	Roadway type	Urban collectors
8 - 9	33	Roadway type	Urban locals
10	X	Emission process	Exhaust
10	V	Emission process	Evaporative
10	B	Emission process	Brake wear
10	T	Emission process	Tire wear

5.1 Input Data Specific to New Castle County for 2008

The 2008 inventory was the first year that DAQ used the MOVES model to develop on-road mobile emissions. The MOBILE6.2 model was used previously. The MOVES model allows for adjustments to a variety of model inputs, and as such, DAQ, with assistance from the Delaware Department of Transportation (DelDOT), put forth considerable effort in creating a suite of county-specific 2008 input data files. The New Castle County-specific input data types created for the 2008 inventory include VMT (by vehicle and roadway type), vehicle registration data (vehicle populations and age distributions), meteorological data (temperature and relative humidity), average speeds in the form of speed bin fractions (weekday versus weekend and by roadway type), fuel formulations and supply, and inspection and maintenance program specifications. Each of these input data sets are discussed separately below.

5.1.1 Vehicle Miles Traveled (VMT) Data

The activity data used for developing the on-road emission inventory is VMT. DelDOT provided 2008 VMT data by roadway type for New Castle County. DelDOT is required to submit calendar year VMT data annually to the Federal Highway Administration's (FHWA) Highway Performance Monitoring System (HPMS). The VMT is estimated based on data from permanent traffic count stations throughout the county. DelDOT's traffic count program provides daily and seasonal variation data. Additional temporary stations provide shorter-term counts that are expanded with factors derived from appropriate permanent count stations. Counting and expansion activities are consistent with FHWA guidelines. The traffic data submitted to HPMS are considered the most accurate VMT totals for New Castle County.

Since the VMT provided by DelDOT is supplied by HPMS roadway type, the task of creating VMT by MOVES road type fractions only requires mapping the twelve HPMS road types to the four MOVES road types. The road type allocations for New Castle County for 2008 are provided in Table 5-2.

Table 5-2. New Castle County VMT Fractions by Road Type

MOVES Road Type Code	Road Type Description	VMT Fraction by Road Type
2	Rural Restricted Access	0.0000
3	Rural Unrestricted Access	0.1274
4	Urban Restricted Access	0.2813
5	Urban Unrestricted Access	0.5914
Total		**1.0000**

VMT Fractions by Vehicle Type

VMT by vehicle type data are not collected in Delaware, so an alternate procedure was developed using the local registration data in calculating the VMT mixes rather than using the default MOVES VMT distribution by vehicle type. This methodology uses national default MOVES mileage accumulation and diesel sales fraction data in combination with the Delaware county-specific registration data to develop estimates of VMT by vehicle type. The number of vehicles registered in Delaware by model year, vehicle type, and county was multiplied first by the MOBILE6.2 default gasoline or diesel sales fraction corresponding to that vehicle type and model year, and then by the average number of miles accumulated annually by vehicles of the same age and vehicle type in the MOBILE6.2 default mileage accumulation database. This provided an estimate of VMT by vehicle age and vehicle type. These VMT estimates were then summed for all years by vehicle type. The total VMT for each vehicle type was divided by the total calculated VMT to give VMT fractions by vehicle type. Table 5-3 presents the resulting VMT fractions by vehicle type for New Castle County.

Table 5-3. New Castle County VMT Fractions by Vehicle Type

MOVES Vehicle Type Code	Vehicle Description	VMT Fraction by Vehicle Type
11	Motorcycle	0.0072
21	Passenger Car	0.4469
31	Passenger Truck	0.3738
32	Light Commercial Truck	0.1325
41	Intercity Bus	0.0031
42	Transit Bus	0.0011
43	School Bus	0.0018
51	Refuse Truck	0.0003
52	Single Unit Short-haul Truck	0.0078
53	Single Unit Long-haul Truck	0.0007
54	Motor Home	0.0003
61	Combination Short-haul Truck	0.0122
62	Combination Long-haul Truck	0.0123
Total		**1.0000**

APPENDIX C

VMT Temporal Allocations

The MOVES model input files include allocations of VMT by month. Monthly allocation of VMT is accomplished through the use of permanent count station data provided by DelDOT. For 2008, DelDOT provided monthly VMT data from 27 permanent count stations throughout New Castle County. Each month's data for all 27 count station were summed and divided by the sum of the annual VMT recorded by the 27 stations. The monthly VMT fractions created in this way are provided in Table 5-4.

Table 5-4. Monthly VMT Allocation Fractions

Month	VMT Fraction	Month	VMT Fraction
January	0.0795	July	0.0877
February	0.0735	August	0.0905
March	0.0834	September	0.0819
April	0.0859	October	0.0795
May	0.0901	November	0.0784
June	0.0860	December	0.0836

5.1.2 Meteorological Data

Temperature and relative humidity are the meteorological data required for MOVES runs. Hourly data were obtained from the National Climatic Data Center (NCDC, 2010) from data collected at the New Castle County airport. These data were compiled as monthly averages of each hour of the day for input into the MOVES runs.

5.1.3 Fuel Data

The entire State receives Federal reformulated gasoline. However, the fuel parameters vary seasonally as well as by county, based on information from EPA's Reformulated Gasoline Fuel Survey. This survey reports in-use gasoline parameters during winter and summer. New Castle County is well-represented in this survey, as the Philadelphia, PA-Wilmington, DE-Trenton, NJ area is one of the surveyed areas. Thus, it was felt that the parameters obtained from this study could be directly applied for use in the Delaware inventory. Fuel parameters were obtained from the survey for calendar year 2008 and obtained directly from EPA (EPA, 2009) since the Office of Transportation and Air Quality ceased posting such data on their RFG fuel survey data web page after 2006.

The MOVES model has nearly 9,000 choices in its library of fuel formulations. Summertime fuel survey data for 2008 from 21 gasoline stations located in New Castle County were averaged for Reid Vapor Pressure (RVP) to determine the fuel formulation that best matched in-use fuel characteristics in New Castle County. The summer fuel data were applied to the ozone season months of May through September. The summer fuel data were also applied to October as data indicated that fuel formulations are slow to switch to wintertime fuel. The winter fuel data were applied to January, February, and December, based on survey data. Fuel RVP for the remaining months (March, April, and November) were calculated using a straight line interpolation method between summer and winter fuel data. The resulting RVP and sulfur content for New Castle County by month are provided in Table 5-5.

Table 5-5. 2008 Gasoline Fuel Parameters for New Castle County

Months	Reid Vapor Pressure (psi)	Sulfur Content (ppm)
Jan, Feb and Dec	13.4	51.8
Mar, Apr and Nov	10.6	52.4
May - Oct	6.86	53.1

Source: EPA Reformulated Gasoline Survey, 2009.

5.1.4 Vehicle Populations and Age Distributions

Vehicle registration data were obtained from the Delaware Division of Motor Vehicles (DMV). The data are a snapshot of DMV's registration database as of July 1, 2008. The data show the number of vehicles registered by model year for each of the 16 MOBILE6.2 vehicle classes. The 16 vehicle classes were converted to the 13 MOVES vehicle types using a converter provided by EPA. New Castle vehicle populations by MOVES vehicle type are provided in Table 5.6. Vehicle age distribution fractions were developed for each of the 13 vehicle types based on model year. Vehicle 30 years and older were lumped into one fraction.

Table 5-6. 2008 Vehicle Populations for New Castle County

Vehicle Code	Vehicle Type	Number of Vehicles
11	Motorcycle	12,505
21	Passenger Vehicle	244,034
31	Passenger Truck	149,742
32	Light Commercial Truck	49,542
41	Intercity Bus	398
42	Transit Bus	244
43	School Bus	997
51	Refuse Truck	77
52	Single Unit Short-Haul Truck	3,103
53	Single Unit Long-Haul Truck	216
54	Motor Home	390
61	Combination Short-Haul Truck	1,211
62	Combination Long-Haul Truck	917

5.1.5 Vehicle Speeds

The MOVES model represents average vehicle speeds by roadway type through the use of speed bin fractions. There are 16 speed bins with the first representing speeds less than 2.5 miles per hour (mph), with each subsequent bin having a range of 5 mph (i.e., 42.5 mph – 47.5 mph). The final bin represents speeds equal to or greater than 72.5 mph. For 2008, DelDOT provided seasonal speed bin fractions for each of the four MOVES roadway types, for each hour of the day, and for weekday and weekend driving patterns. DelDOT estimated speeds using the Peninsula travel demand model. The model accounts for traffic volumes and variations in travel according to purpose, which impact average speeds. Table 5-7 summarizes the matrix of parameters that results in 12,288 records for speeds in New Castle County.

Table 5-7. 2008 Average Speed Matrix

Parameter	Number of Variables
Season	4
Hour	24
Roadway Type	4
Weekday/Weekend	2
Speed Bins	16

5.1.6 Northeast Ozone Transport Region Low Emission Vehicle Program

Delaware belongs to the Northeast Ozone Transport Region (OTR). The States in this region have adopted a low-emission vehicle program that began with the 1999 model year. The National LEV program (NLEV), which began with the 2001 model year, is the default modeled in MOVES. Therefore, to correctly model the Northeast Ozone Transport Region LEV program in place in Delaware, the early NLEV database was used in the MOVES run specification. The phase-in schedule of the Northeast Ozone Transport Region LEV program is shown in Table 5-8. This phase-in schedule was applied to gasoline-powered passenger cars, passenger trucks, and light commercial trucks under 8,501 GVWR.

Table 5-8. LEV Implementation Schedule in the Northeast OTR

Model Year	Federal Tier I Standards	Transitional LEV Standards	LEV Standards	Tier 2 Standards
1999	30%	40%	30%	
2000		40%	60%	
2001 - 2003			100%	
2004 and later				100%

5.1.7 Inspection and Maintenance (I/M)

The I/M programs for New Castle County include a biennial onboard diagnostic testing program (OBD II) since 2002 for 1996 and later model year vehicles. Vehicle emission computer systems are checked for any diagnostic trouble codes present, a symptom of excess emissions which is a failing result for the vehicle. Older vehicles, starting with model year (MY) 1968, are given a curb idle test (MY 1968-1980) or a two-speed idle test (MY 1981- 1995). A tailpipe probe is inserted for 60 seconds to determine exhaust concentrations of hydrocarbons and carbon monoxide. Depending on the model year, vehicles with an excess emission concentration of either pollutant will fail the test. Older vehicles (MY 1975-1995) are also given a fuel system pressure test (FP) and a gas cap (GC) test. Air pressure is applied to the fuel system from the fuel inlet to the canister. After air pressure has been applied, pressure degradation is monitored.

Vehicles fail the fuel system pressure test if it cannot maintain the equivalent pressure of eight inches of water for up to two minutes after being pressurized to 14.0 ± 0.5 inches of water. A similar pressure test is applied to the vehicle's gas cap.

Table 5-9. New Castle County I/M Program Parameters

Test Type	IDLE	2500/IDLE	FP & GC	OBD I/M
Test Frequency	Biennial	Biennial	Biennial	Biennial
Program Type	Test Only	Test Only	Test Only	Test Only
Model Years	1968-1980	1981-1995	1975-1995	1996-2003
Compliance Factors				
Passenger Vehicle	88.57	94.82	96.00	95.23
Passenger Truck	84.60	89.17	90.24	89.53
Light Comm. Truck	79.20	83.48	84.48	83.82
Vehicles Tested (gasoline only)				
Passenger Vehicle	Yes	Yes	Yes	Yes
Passenger Truck	Yes	Yes	Yes	Yes
Light Comm. Truck (up to 8,500 GVWR)	Yes	Yes	Yes	Yes
School Bus	No	No	No	No
Single Unit Short-Haul Truck	No	No	No	No
Single Unit Long-Haul Truck	No	No	No	No
Refuse Truck	No	No	No	No
Combination Short-Haul Truck	No	No	No	No
Combination Long-Haul Truck	No	No	No	No
Motor Home	No	No	No	No
Intercity Bus	No	No	No	No
Transit Bus	No	No	No	No
Motorcycle	No	No	No	No

5.2 Running the MOVES Model

Running the MOVES model is accomplished through the development of (1) a run specification unique to a particular scenario of interest (2) the County Data Manager (CDM) that contains the various model inputs as described in Section 5.1 of this report, and (3) the form of the desired data output files. Unlike the MOBILE6 model that generated only emission factors that then were matched with the corresponding activity data, such as VMT, to develop emission estimates, the MOVES model, when executed in the Inventory Mode, provides final emissions.

The run specification, or "runspec", is where a user identifies the modeling scale (national, county, or project-level domain), and scenario parameters such as whether to run MOVES in inventory or lookup table mode, geographic boundaries (a county or multiple counties), time spans (year, month(s), hour(s) of the day, weekdays and weekends), fuel types, vehicle types, road types, and pollutants. The runspec is also where input data sets (other than the CDM) are identified. Two input data sets were prepared for 2008 MOVES runs, including the early NLEV program (see Section 5.1.6) and Stage 2 vapor recovery controls. All other inputs are provided in the CDM.

The CDM for New Castle for 2008 included county-specific data for all of the parameters provided in Section 5.1 of this report. Conversely, model default data were used for the following parameters: VMT daily and hourly fractions, ramp fractions, and diesel sales fractions by vehicle type. In addition, speed bin profiles and road type VMT fractions were not vehicle type specific.

The MOVES emissions outputs were specified by county and month at the SCC level (see Table 5-1).

5.3 Controls

All MOVES-recognized on-road control measures known to be in place in Delaware in 2008 were included in the MOVES emission inventory mode modeling. Local control programs include Delaware's I/M program, the Federal reformulated gasoline program, and the Northeast Ozone Transport Region LEV program. The MOVES model internally includes all national control programs, such as the Tier 1 and Tier 2 gasoline fuel and light duty engine emission standards as well as the ultra-low sulfur diesel fuel and heavy duty engine standards.

Two Delaware control programs, the anti-tampering procedures (ATP) performed at the inspections lanes and the anti-idling regulation (DNREC, 2005) were not accounted for in the MOVES runs since the model does not provide for inputting these programs. For the ATP control program, vehicles that are tested are also checked to see if the catalytic converter, gas cap and fuel inlet restrictor are present. Vehicles will fail inspection if any of these devices are missing.

Regulation 1145, Excessive Idling of Heavy Duty Vehicles, is designed to eliminate emissions caused by extending idling. While MOVES delineates emissions processes for extended idling, currently the available control programs within MOVES do not account for anti-idling measures. Delaware currently has no off-model method to determine emission benefits from either ATP or Reg. 1145.

5.4 Results

The $PM_{2.5}$ exhaust emissions are comprised of elemental carbon, organic carbon, and sulfates, while total $PM_{2.5}$ shown in Table 5-10 includes exhaust, brake wear, and tire wear emissions. $PM_{2.5}$ exhaust emissions account for 91.4% of total $PM_{2.5}$ emissions.

Table 5-10. 2008 Annual On-road Mobile Emissions by Vehicle Type for New Castle County

Vehicle Type	Annual Emissions, TPY		
	$PM_{2.5}$	SO_2	NO_x
Light-duty Gasoline Vehicles	49	31	2,188
Light-duty Gasoline Trucks	55	44	3,310
Heavy-duty Gasoline Vehicles	5	4	324
Motorcycles	2	1	40
Light-duty Diesel Vehicles	1	0	11
Light-duty Diesel Trucks	8	1	130
Heavy-duty Diesel Vehicles	142	12	2,879
Total	**282**	**94**	**9,311**

5.5 References

DNREC, 2005: *Regulations Governing the Control of Air Pollution*, Regulation 1145, Delaware Department of Natural Resources and Environmental Control, Division of Air Quality, April 11, 2005.

EPA, 2009: U.S. Environmental Protection Agency, "Reformulated Gasoline Parameters for 2008" spreadsheet containing fuel survey data send via e-mail by Jamiee Dong, Office of Transportation and Air Quality, to Steven Potter, Bureau of Air Management, CT DEM, March 4, 2009.

NCDC, 2009: Annual Climatological Summary, National Climatic Data Center, Asheville, NC, website accessed December 2009.