Commonwealth of Pennsylvania
Department of Environmental Protection

Mid-Course Review
for the
Philadelphia One-Hour Ozone Nonattainment Area

January 2005

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Executive Summary

This report was prepared to fulfill a requirement for a mid-course review of progress that EPA established during its approval of the attainment plan for the Philadelphia one-hour ozone nonattainment area [40 CFR Part 52.2037(j)(3)] and to which Pennsylvania Department of Environmental Protection (DEP) committed.

- Air quality in the Philadelphia one-hour ozone nonattainment area should achieve the one-hour National Ambient Air Quality Standard (NAAQS) by the 2005 attainment deadline.
- Pennsylvania has enacted all emission reduction strategies required by the 1990 Clean Air Act Amendments (CAAA) and all volatile organic compound (VOC) and nitrogen oxide (NOx) emission reduction strategies required by the EPA emission reduction shortfall analysis, and has submitted State Implementation Plan (SIP) revisions to EPA for all these strategies.
- Average one-hour ozone design values within the Philadelphia nonattainment area have decreased approximately 18% since the passage of the 1990 CAAA.
- The annual number (count) of total monitor exceedances (one-hour ozone concentration $\geq$ 0.125 ppm) within the Philadelphia nonattainment area has decreased approximately 76% since the 1990 CAAA. The preliminary 2002-2004 one-hour ozone design value for the Philadelphia interstate one-hour ozone nonattainment area is 0.129 ppm, recorded at Fair Hill in Cecil County, MD.
- The highest 2002-2004 one-hour ozone design value in the five-county Philadelphia area is 0.127 ppm at NE Philadelphia Airport in Philadelphia County.
- Only two of the eight monitors in the five-county Philadelphia area have 2002-2004 design values that exceed the one-hour ozone NAAQS.
- Preliminary 2004 ozone season concentration data indicate there were no one-hour ozone exceedances in the Philadelphia interstate nonattainment area. This is the first season this has happened since ozone monitors were installed in the early 1970s.
- The unusually low ozone levels recorded during the 2004 ozone season were, in part, the result of reductions in regional transport. Unusually low summer temperatures and above average precipitation also contributed to this summer's unusually low ozone concentrations.

1.0 Introduction

Why Are We Submitting This Mid-Course Review?

Pennsylvania is responsible for developing revisions to the state implementation plan (SIP) for air quality for the five Pennsylvania counties of the Philadelphia interstate ozone nonattainment area -- Bucks, Chester, Delaware, Montgomery and Philadelphia counties. Pennsylvania submitted its required post-1996 rate of progress and attainment plans to the U.S. Environmental Protection Agency (EPA) in several documents from 1998 through 2001.

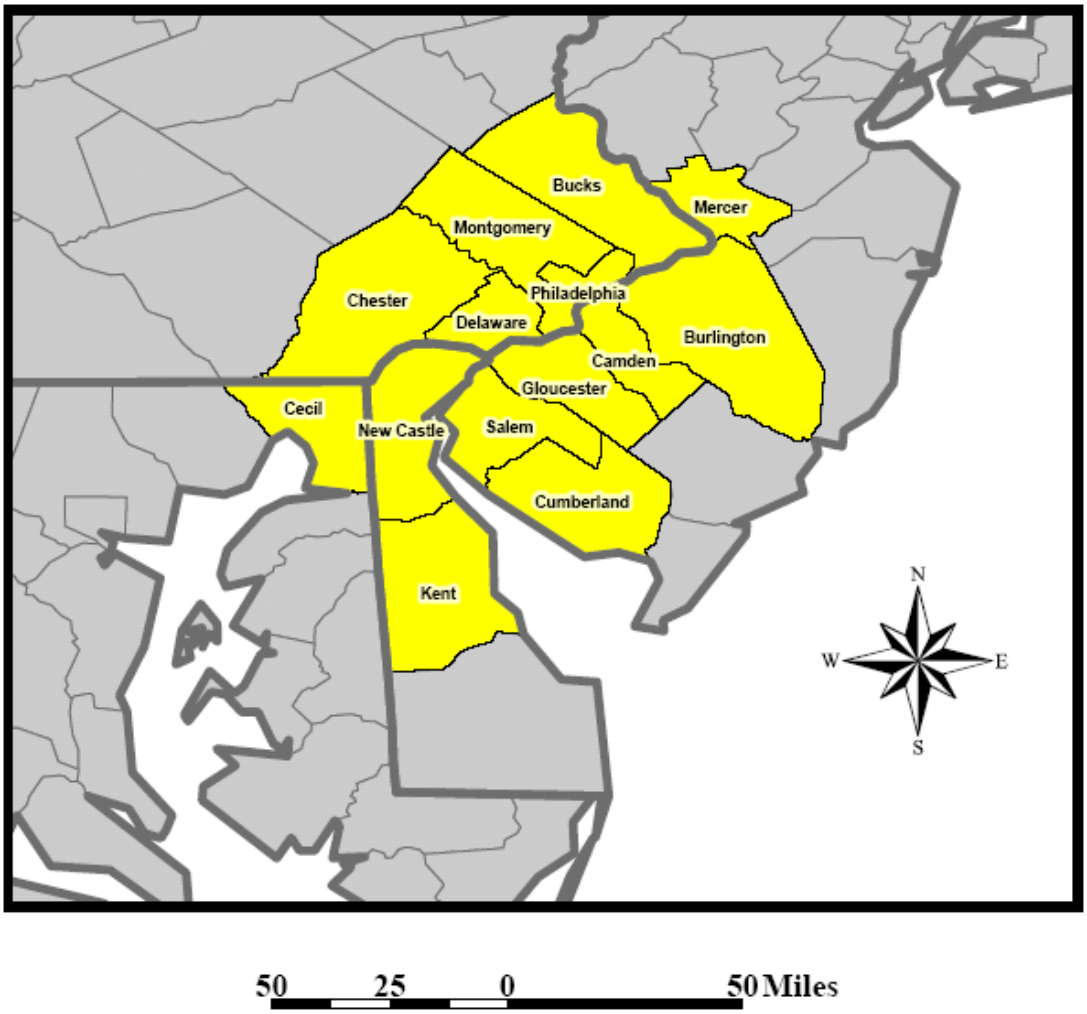
Sections 110 and 181 of the CAAA, 42 U.SC §§ 7410 and 7511, require Pennsylvania to demonstrate that the area will attain the one-hour NAAQS for ozone by 2005. On October 26, 2001, the EPA approved Pennsylvania's One-Hour Ozone Attainment Demonstration for the Philadelphia area [66 FR 54143]. This approval included the EPA's requirement for Pennsylvania to submit a mid-course review [40 CFR Part 52.2037(j)(3)], documenting that the attainment plan was sufficient to attain the standard.

In performing the mid-course review, DEP has generally followed the procedures outlined in EPA's March 28, 2002 memo "Mid-Course Review Guidance for the One-Hour Ozone Nonattainment Areas that Rely on Weight-of-Evidence for Attainment Demonstration."

1.1 Philadelphia One-Hour Nonattainment Area

The Philadelphia one-hour ozone nonattainment area was defined shortly after adoption of the 1990 CAAA. The nonattainment area is comprised of 14 counties: 5 in Pennsylvania, 2 in Delaware, 1 in Maryland and 6 in New Jersey (Figure 1). Table 1 lists all the counties included in the Philadelphia one-hour ozone nonattainment area.

Figure 1. Philadelphia One-Hour Ozone Nonattainment Area



2.0 Emission Control Analysis

The Commonwealth has implemented all emission control programs mandated by the 1990 CAAA in the five-county Pennsylvania portion of the Philadelphia one-hour ozone nonattainment area. Additional control measures have been adopted to address the ozone emission reduction shortfall identified by EPA. All volatile organic compound (VOC) and nitrogen oxide (NOx) emission reduction strategies required to address the shortfall have been adopted by Pennsylvania and the strategies have been submitted to EPA as revisions to the SIP. Emission trends will be summarized in the Trends Analysis section.

Table 1. Philadelphia One-Hour Nonattainment Area

STATE	COUNTY
Delaware	Kent
	New Castle
Maryland	Cecil
New Jersey	Burlington
	Camden
	Cumberland
	Gloucester
	Mercer
	Salem
Pennsylvania	Bucks
	Chester
	Delaware
	Montgomery
	Philadelphia

3.0 Trends Analysis

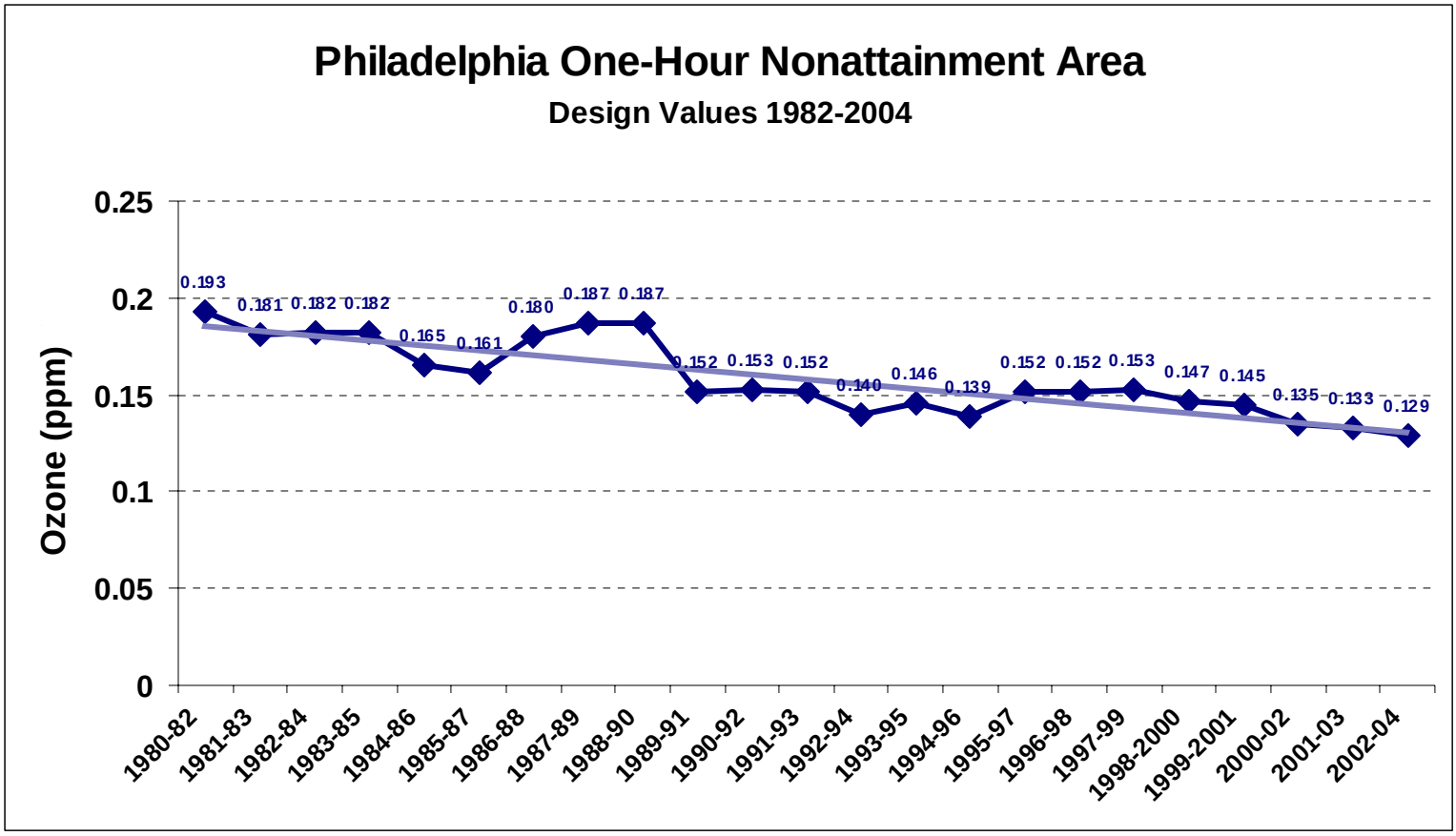
Various trends were analyzed to determine if the Philadelphia one-hour ozone nonattainment area is likely to reach attainment by 2005. A number of analyses were conducted including trends in the region's one-hour ozone design values, monitor exceedances, meteorology, emissions, population, economic activity and individual monitors. Trends were analyzed from 1980 through 2004. One-hour ozone data were extracted from EPA's online AIRS database. Pre-1990 data were then compared to post-1990 data to gauge the effects of emission controls enacted through the 1990 CAAA.

3.1 One-Hour Design Value Trends

Figure 2 displays the one-hour ozone design value for the fourteen-county Philadelphia nonattainment area. This is the maximum monitor design value among all monitors within the Philadelphia one-hour interstate ozone nonattainment area. Only monitors with three years of valid one-hour ozone concentrations are used. Design values do not include one-hour ozone concentrations for July 8th and 9th, 2002. Pennsylvania has flagged this data as an exceptional event due to the influence of the northern Quebec forest fires (see Clark, Jeong and Philbrick, 2003). For consistency all data for these dates were removed from this analysis. Individual states may have made other determinations regarding this event.

One-hour ozone design values in the Philadelphia one-hour ozone nonattainment area have declined substantially. Average design values from 1991-2004 have declined 18% from average design values from 1982-1990 (pre 1990 CAAA).

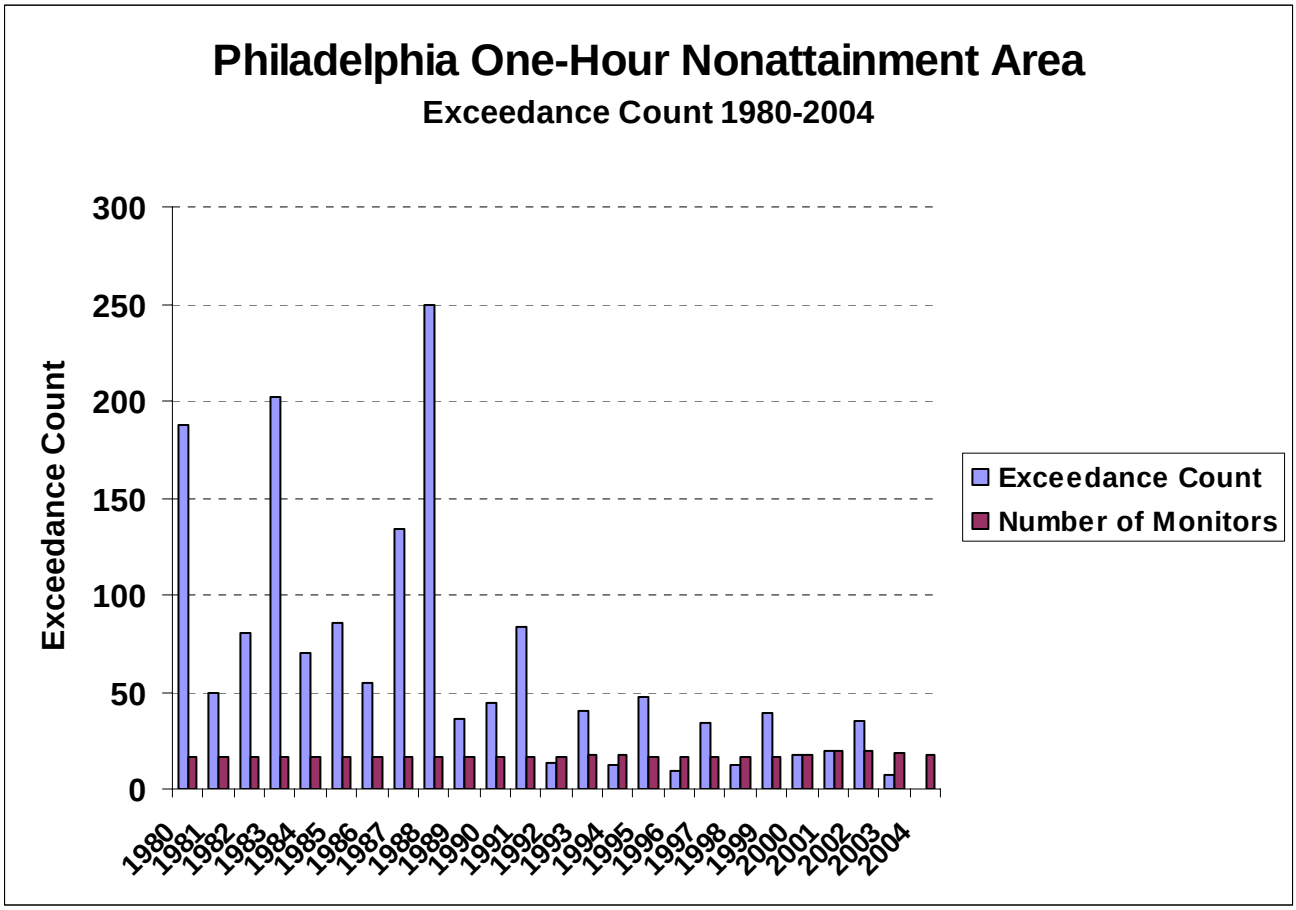
Figure 2. Philadelphia Nonattainment Area One-Hour Design Values



3.2 Monitor Exceedance Count

Trends in the total number of monitor exceedances between 1980 and 2004 are shown in Figure 3. Monitor exceedances occur whenever a monitor's one-hour ozone concentration is equal to or greater than 0.125 ppm. There has been a dramatic decrease in the number of monitored exceedances since 1980. The average number of monitored exceedances from 1991-2004 declined approximately 76% from the average number of exceedances between 1980-90. This decrease cannot be attributed to a decline in the number of monitors in the Philadelphia one-hour ozone nonattainment area since the number of ozone monitors has remained relatively steady, increasing slightly from 16 monitors in 1980 to 18 monitors in 2004. In 2004 there were no exceedances of the one-hour ozone standard in the entire Philadelphia one-hour interstate nonattainment area. This is the first time this has happened since monitoring began in the early 1970s.

Figure 3. Monitored Exceedances Philadelphia One-Hour Nonattainment Area 1980-2004



3.3 Meteorological Trends

Ozone is not emitted directly to the atmosphere, but is formed by photochemical reactions between VOCs and NOx in the presence of sunlight. The long, hot, humid days of summer are particularly conducive to ozone formation, so ozone levels are of general concern during the months of May through September. The primary sources of man-made VOCs and NOx, the ozone precursors, are the evaporation of fuels and solvents (gasoline and consumer products), combustion of fuels (motor vehicles, power plants, and other industries), and chemical and industrial processes.

Correlations can be made between ozone concentrations and meteorological variables such the number of days with temperatures of 90º F or greater, average temperature, amount of precipitation and number of precipitation days. Hot dry summers can produce long periods of elevated ozone concentrations while ozone production can be limited during cool and wet summers.

Meteorological data (May through September) from the Philadelphia International Airport were reviewed to determine relationships between one-hour ozone values and summertime weather conditions. Precipitation totals and the number of days with temperatures 90ºF and above have remained relatively unchanged between 1980 and 2004. Precipitation frequency (number of days with measurable precipitation), however, has increased slightly (see Appendix 2).

There have been a number of unusually warm summers during the 1980-2004 time period. These include 1983, 1988, 1991, 1995, and 2002. Examination of design values and monitor exceedances from these warm summers indicates that both values declined over time. Table 2 lists meteorological data for these unusually warm years along with the average design values for the time periods encompassing the year along with the number of monitor exceedances within the Philadelphia one-hour ozone nonattainment area.

Table 2. Comparison of Warm Summers
Philadelphia International Airport 1980-2004

Year	90ºF days	Precipitation (inches)	Precipitation Days	Avg. Design Value *	Monitor Exceedances
1983	39	13.98	40	0.182	202
1988	49	19.69	48	0.185	250
1991	53	17.43	42	0.152	83
1995	45	10.78	42	0.146	47
2002	45	12.06	34	0.134	35
Station Average	**22.4**	**18.99**	**47.7**		

* Average for year included in the design value calculation. For 1988, the average design value is the average of the 1986-88, 1987-89, 1988-1990 design values.

3.4 Emission Trends

Emission trends from Pennsylvania's recent Rate of Progress Report (Philadelphia SIP, 2004) are summarized in Table 3. There have been significant reductions in emissions of ozone precursors since the 1990 CAAA. NOx and VOC emissions from within the five-county Philadelphia area will have decreased by approximately 35% between 1990 and 2005, Philadelphia's one-hour ozone attainment date. VOC reductions in the five-county Philadelphia area are approximately 40% greater than the NOx reductions.

Table 3. Emissions Rates from Philadelphia ROP Report
NOx and VOC Emissions in Tons Per Day (TPD)
Bucks, Chester, Delaware, Philadelphia and Montgomery Counties

VOC		NOx	
1990	**2005**	**1990**	**2005**
668 tpd	401 tpd	534 tpd	369 tpd
% Reduction	**40.0 %**	**% Reduction**	**30.9%**
Total % VOC and NOx Reduction		**35.9%**	

3.4.1 Emission Reduction Shortfall Measures

In a series of *Federal Register* notices on December 16, 1999 (64 FR 70428), EPA identified an emission reduction shortfall for the Philadelphia-Wilmington-Trenton nonattainment area, and encouraged Pennsylvania to work with the other states in the Ozone Transport Region to eliminate this shortfall. EPA determined that the Philadelphia-Wilmington-Trenton nonattainment area would fall short of its attainment emission level target by amounts equal to 4.5 percent of the 1990 baseline emission inventory for VOC and 0.3 percent of the 1990 baseline emission inventory for NOx. The EPA-derived additional reductions that equate to these percentages are contained in Table 4.

Table 4. Additional Reductions of VOC for Philadelphia-Wilmington-Trenton Nonattainment Area

VOC Reductions (tons/day)	NOx Reductions (tons/day)
62	3

3.4.2 Emission Reductions in the Nonattainment Area

In order to develop new emission reduction measures to close the attainment shortfall, in the Philadelphia-Wilmington-Trenton nonattainment area Pennsylvania cooperated with other states in the Ozone Transport Region to develop five model rules. The Ozone Transport Commission (OTC) coordinated model rule development. The model rules served as the basis for strategies to be considered for adoption by each state in the nonattainment area.

The five model rules and the expected reductions for the Philadelphia-Wilmington-Trenton non-attainment area are listed in Table 5.

Table 5. Volatile Organic Compound (VOC) Emission

Reductions from Model Rules for the Philadelphia-Wilmington-Trenton Nonattainment Area

Model Rule	VOC Reduction Benefit by 2005 (tons/day)
Consumer Products	9
Portable Fuel Containers	5
Architect. & Indust. Maintenance Coatings	19
Mobile Equipment Refinishing	6
Solvent Cleaning Operations	20
Total	**59**

The Pennsylvania-specific versions of the VOC regulations, based on the OTC model rules, have been submitted to EPA as separate SIP revisions. Table 6 lists the VOC regulation numbers and titles, and the expected VOC emission reductions for Bucks, Chester Delaware, Montgomery, and Philadelphia Counties.

To address the NOx emission reduction shortfall in the one-hour ozone nonattainment area, the Commonwealth also participated with the OTC states in the development of a regulation for various classes of small NOx emitting units in the five-county area. On August 17, 2004 the Environmental Quality Board approved the final rulemaking for Small Sources of NOx, Stationary Internal Combustion Engines and Cement Kilns as a revision to 25 *Pa. Code* Chapters 129 and 145. This regulation was published as final rulemaking in the *Pennsylvania Bulletin* [34 Pa.B. 6509] on December 11, 2004 and will require affected sources to implement compliance strategies during the 2005 ozone season. The owners/operators of the boilers, turbines and stationary internal combustion engines subject to the Chapter 129 regulation are expected to reduce NOx emissions by approximately 3 tons per day in the Southeast Pennsylvania Ozone nonattainment area. This level of additional NOx emission reductions fulfills the NOx emission reduction shortfall identified by EPA for the area.

3.5 Populations Trends

Emission reductions have occurred within the one-hour ozone nonattainment area even though there have been significant increases in population. Census data for 1980, 1990 and 2000 were used to determine population trends within the Philadelphia one-hour ozone nonattainment area. Between 1980 and 2000 the fourteen counties that comprise the Philadelphia one-hour ozone nonattainment area grew by 10.4%, adding over half a million people. Population in the Pennsylvania portion of the Philadelphia one-hour ozone nonattainment area population grew by the smallest percentage, approximately 4.5% or 167,000 people. The largest percentage changes occurred in the Maryland and

Delaware portions of the one-hour ozone nonattainment area. Population growth was slightly higher for the 1990-2000 time frame than the 1980-1990 time frame for most of the area except New Jersey.

Table 6. VOC Regulations and Expected Reductions for Pennsylvania Counties

Regulation Number and Title	Expected Benefit by 2005 (tons/day) VOC				
	Bucks	**Chester**	**Delaware**	**Montgomery**	**Philadelphia**
25 Pa. Code Chapter 129 Section 129.63 - Solvent Cleaning	2.78	1.97	2.63	3.42	7.07
25 Pa. Code Chapter 129 Section 129.75 - Mobile Equipment Repair & Refinishing	0.64	0.45	0.60	0.78	1.62
25 Pa. Code Chapter 130 Subchapter A – Portable Fuel Containers	0.56	0.39	0.45	0.78	0.93
25 Pa. Code Chapter 130 Subchapter B – Consumer Products	0.83	0.59	0.78	1.02	2.11
25 Pa. Code Chapter 130 Subchapter C – Architect. & Indust. Maintenance Coatings	1.79	1.26	1.69	2.19	4.54
County Totals	**6.60**	**4.66**	**6.16**	**8.19**	**16.28**
Total VOC Emission Reductions for the Pennsylvania Severe One-Hour Ozone Nonattainment Counties					**41.89**

Note: Totals may not equal the sum of the individual benefits due to rounding.

3.6 Pennsylvania Labor Force Trends

Estimates of the five-county Philadelphia area's labor force provided by the Pennsylvania Department of Labor were examined to determine any trends. The five-county Philadelphia area's estimated labor force increased approximately 16% between 1980 and 2000. This increase is larger than the percentage increase in population between 1980 and 2000 (approximately 4.5%). During the 1980-2000 time period the five-county Philadelphia area's population increased by over 167,000 people while its estimated labor force increased by 257,000 people. Overall the percentage of people in the labor force has increased from approximately 42% in 1980 to approximately 48% in 2000. Bucks, Chester and Montgomery counties had over 50% of their populations in the labor force in 2000.

Most of the increase in the estimated labor force took place between 1980 and 1990 while the bulk of the population increase took place between 1990 and 2000. Economic indicators from the Philadelphia Federal Reserve indicate Pennsylvania's economy expanded during each of these two decades. Labor force expansion during the 1980's, however, appears to be approximately three times greater than that during the 1990s even though economic indices indicate expansion was greater during the 1990's than during the 1980's. This result may reflect changes in worker productivity that took place over the last several decades.

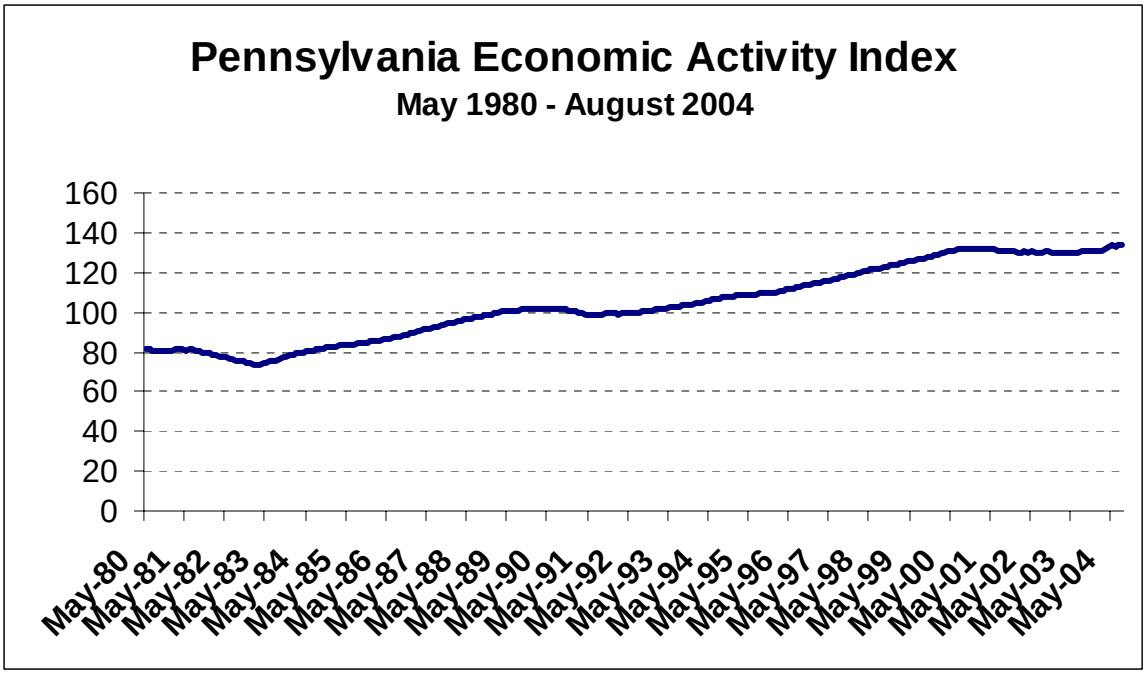
The effects of the five-county Philadelphia area's labor force changes on regional emissions are unknown. Increases in the labor force may affect the total vehicle miles traveled (VMT) in the region. Census and labor force statistics indicate growth is more pronounced in the outer regions of the five-county Philadelphia area, namely Bucks, Chester and Montgomery counties. These differences in growth rates may account for some of the increases in VMT observed over the last few decades. Emissions continue to decrease primarily due to vehicle technology changes through the attainment date and well into the future, based on conformity analyses performed by the Delaware Valley Regional Planning Commission.

3.7 Economic Indicator Trends

Economic indices compiled by the Philadelphia Federal Reserve Bank were examined to gauge economic activity in the region. Emissions are undoubtedly tied to economic activity and would likely increase during periods of robust economic growth and stagnate during periods of recession. The Philadelphia Federal Reserve tracks economic activity in Delaware, New Jersey and Pennsylvania. Figure 4 shows Pennsylvania's economic activity index from May 1980 through August 2004. Periods of heightened economic activity in Pennsylvania occurred during the mid- to late-1980's and mid- to late-1990's. Economic growth slackened in 1983, from 1990-91 and from 2000-03. Rapid increases in economic activity and, hence, increased regional emissions may have contributed to the slight increase in one-hour ozone design values and monitored exceedances in the mid- to late-1990's. Economic activity and its relationship to ozone concentration levels have generally not been considered.

Figure 4. Pennsylvania Economic Indices

Philadelphia Federal Reserve Bank
May 1980 – August 2004



3.8 Pennsylvania Monitor Trends

One-hour ozone trends were analyzed for five Pennsylvania monitors within the Philadelphia one-hour ozone nonattainment area. All five monitors operated during the 1980-2004 time period. Historically, there have been six to nine ozone monitors operating in the five-county Philadelphia area. Currently, there are eight ozone monitors. Only two of the eight monitors in Pennsylvania's portion of the Philadelphia one-hour ozone nonattainment area currently exceed the one-hour standard. They are the Bristol site in Bucks County (0.125 ppm) and the NE Airport site in Philadelphia County (0.127 ppm). These monitored values are close to the preliminary 2004 one-hour design value (Fair Hill, 0.129 ppm) for the entire Philadelphia one-hour ozone nonattainment area. Philadelphia's current design monitor, Fair Hill (MD), is upwind of most of the major emission sources in the nonattainment area. This monitor is likely responding to emissions from the Baltimore nonattainment area.

Table 7 lists current one-hour ozone design values for all monitors in the five-county Philadelphia area. Average design values for 1982-90, 1991-2004 and the percent change are also listed in the table for those monitors with continuous measurements between 1980 and 2004. This cut-off was chosen to gauge the effects of emission controls imposed by the 1990 CAAA. Design values have fallen approximately 12-22% from average pre-1990 CAAA levels.

Table 7. One-Hour Design Values (DV) in the Five-County Philadelphia Area

MONITOR	2004 DV ** (PPM)	AVERAGE 1982-90 DV (PPM)	AVERAGE 1991-2004 DV (PPM)	% CHANGE
NE Airport	0.127	0.153	0.126	-17.6%
Bristol	0.125	0.165	0.134	-18.8%
New Garden	0.124			
Chester	0.123	0.161	0.126	-21.7%
Norristown	0.113	0.140	0.124	-11.9%
Roxboro	0.116	0.154	0.120	-21.3%
Elmwood	0.109			
AMS Lab	0.096			

** Preliminary

Table 8 lists the average number of one-hour exceedances prior to and after passage of the 1990 CAAA. There have been significant reductions in the number of one-hour ozone exceedances at the five monitors in the five-county Philadelphia area. Average one-hour exceedance reductions range from 71-87%.

Table 8. One-Hour Exceedances in the Five-County Philadelphia Area

MONITOR	AVG 1980-90 EXCEEDANCES (PER YEAR)	AVG 1991-2004 EXCEEDANCES (PER YEAR)	% CHANGE
NE Airport	6.5	1.5	-76.9%
Bristol	9.6	2.4	-75.0%
Chester	7.6	1.3	-82.9%
Norristown	4.4	1.3	-70.5%
Roxboro	6.3	0.8	-87.3%

Table 9 lists the changes in yearly peak and 4th high values for the five monitors in the five-county Philadelphia area that had continuous measurements between 1980 and 2004. Pre-1990 CAAA average peak values have decreased at a slightly higher rate than 4th-high values when compared to values for years following the 1990 CAAA.

Table 9. Peak and 4th-High One-Hour Ozone Concentrations
Five-County Philadelphia Area

	PEAK VALUE (PPM)			4TH HIGH (PPM)		
Monitor	Yearly AVG 1980-1990	Yearly AVG 1991-2004	% Change	Yearly AVG 1980-1990	Yearly AVG 1991-2004	% Change
NE Airport	0.153	0.126	-17.6%	0.129	0.109	-15.5%
Bristol	0.176	0.136	-22.7%	0.141	0.118	-16.3%
Chester	0.175	0.129	-26.3%	0.134	0.111	-17.2%
Norristown	0.163	0.127	-22.1%	0.126	0.110	-12.7%
Roxboro	0.164	0.124	-24.4%	0.126	0.105	-16.7%

Overall declines in design values and monitored exceedances for the monitors in the five-county Philadelphia area are similar to declines observed throughout the entire Philadelphia one-hour ozone nonattainment area. Design values have declined approximately 12-22% from pre-1990 levels while monitor exceedances have declined from approximately 71-87%. Peak one-hour and 4th-high values have also declined by approximately 18-26% and approximately 13-17% respectively. These results suggest current emission control programs are resulting in reductions of peak ozone concentrations across the entire Philadelphia one-hour ozone nonattainment area.

4.0 Ozone Transport Analysis

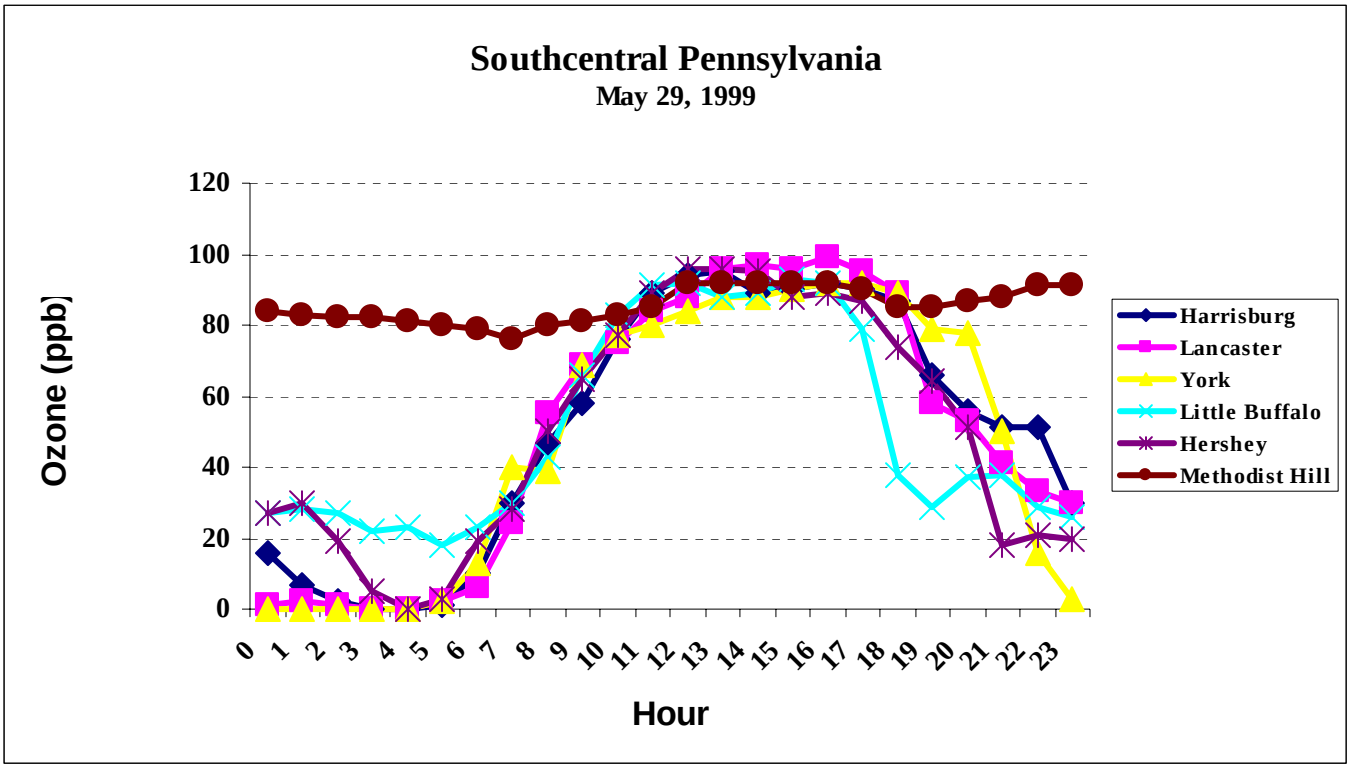
Ozone transport has a significant effect on ozone concentrations within the Philadelphia one-hour ozone nonattainment area. Modeling included in PA DEP's Philadelphia SIP showed that modeled concentrations exceeded the one-hour ozone standard even with all anthropogenic emissions eliminated from the nonattainment area (Aranachalam and Georgopoulos, 1998). Ozone transport is highly variable and gauging the full range of effects on design values, exceedances and peak concentrations is beyond the scope of this report. However, a qualitative assessment on large-scale regional transport, short-term local transport and transport via low-level jets (thin streams of fast-moving air) into the Philadelphia one-hour ozone nonattainment area is made below.

4.1 Regional Ozone Transport Assessment

Large-scale regional transport occurs when ozone concentrates within the lower boundary layer over a wide area of several hundred square miles. These regional-scale ozone plumes become embedded within the large-scale atmospheric flow affecting areas well away from their source regions. Regional plumes are often observed at ozone monitors located in elevated terrain. Ozone from these regional plumes can drift over other areas then mix down to the surface, affecting monitors over a wide area.

Pennsylvania has operated a high-elevation ozone monitor at Methodist Hill on South Mountain in Adams County (elevation 1900 ft) since the mid-1990s. Figure 5 shows what happens when regional plumes enter southcentral Pennsylvania. Ozone concentrations at the high-elevation monitor, Methodist Hill, remain high during the overnight hours. Ozone concentrations at the other monitors remain low until the morning temperature inversion breaks up. Atmospheric mixing taps the regional pool of ozone aloft and ozone concentrations rise rapidly to match those at the high-elevation monitor. This process has also been documented in the Philadelphia region (NEOPS, 2003).

Figure 5. Effect of Regional Ozone Plumes



Unfortunately, Pennsylvania has a limited number of monitoring sites with long records of data to gauge the effects of long-range ozone transport. Ozone data from Perry County's Little Buffalo State Park monitor were used to gauge regional ozone transport. Little Buffalo has a continuous ozone record for the 1980 to 2004 time period. The monitor is isolated from emission sources due to its rural setting and blockage from the Blue Mountain Ridge located south of the monitor.

Changes in design values, exceedances, peak values and 4th-high values were examined over the 1980 and 2004 time period. The analysis was identical to the analysis done for the Philadelphia one-hour ozone nonattainment area monitors. Again the analysis was divided into periods before and after the 1990 CAAA. The results of this analysis as well as the average values for the five-county Philadelphia area are posted in Table 10.

Table 10. Regional Transport Analysis using Little Buffalo

One-Hour Design Values (DV)
Little Buffalo vs. Philadelphia One-Hour Nonattainment Area

Monitor	2004 DV ** (ppm)	Average 1982-90 DV (PPM)	Average 1991-2004 DV (PPM)	% Change
Little Buffalo	0.098	0.117	0.105	-10.3%
Philadelphia	0.129	0.180	0.147	-18.3%

** Preliminary

One-hour Exceedances
Little Buffalo vs. Five-County Philadelphia Area

Monitor	Average 1980-1990 Exceedances (Per year)	Average 1991-2004 Exceedances (Per Year)	% Change
Little Buffalo	1.0	0.0	-100%
Philadelphia	6.5 **	1.5 **	-76.9%

** Average exceedances per monitor (total number of exceedances ÷ number of monitors)

Peak & 4th High One-Hour Ozone Concentrations
Little Buffalo vs. Five-County Philadelphia Area

	Peak Value (PPM)			4th High (ppm)		
Monitor	**Yearly Avg. 1982-1990**	**Yearly Avg. 1991-2004**	**% Change**	**Yearly Avg. 1982-1990**	**Yearly Avg. 1991-2004**	**% Change**
Little Buffalo	0.116	0.107	-7.2%	0.102	0.096	-6.0%
Philadelphia	0.164	0.130	-20.7%	0.130	0.111	-14.6%

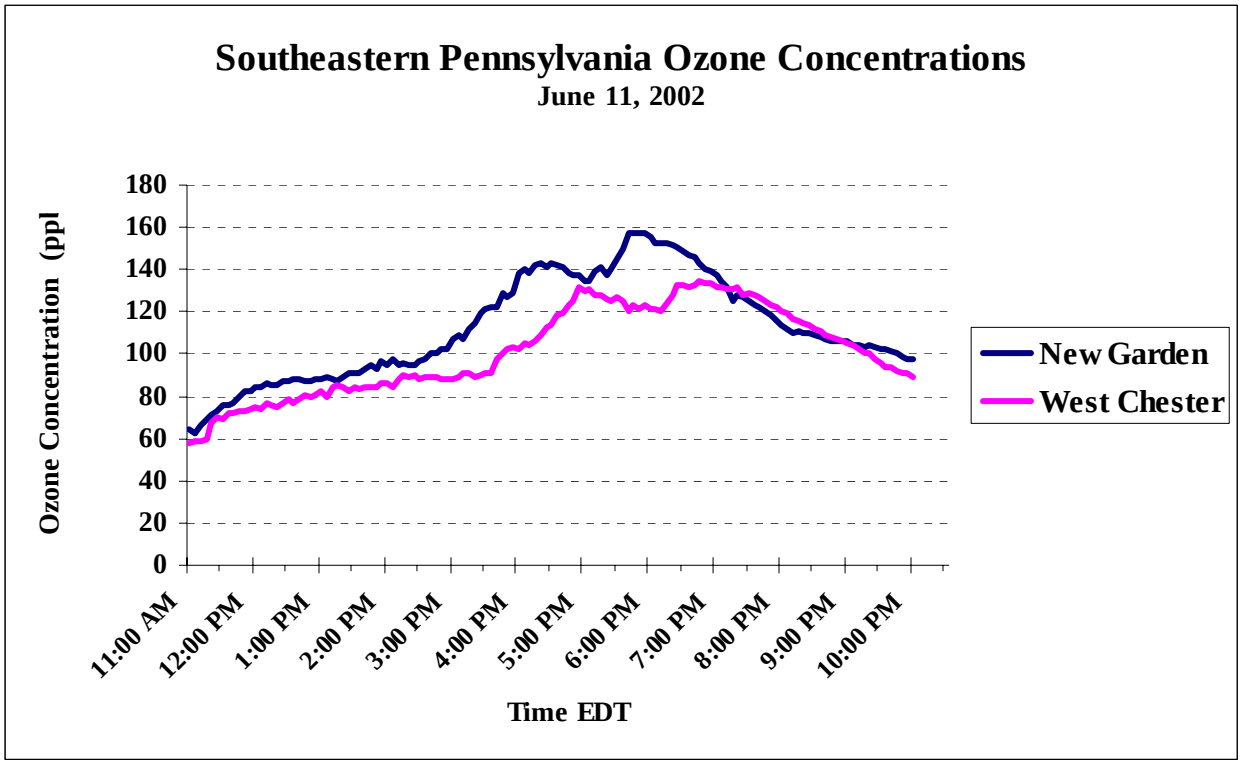
The data from Little Buffalo suggest a small reduction in regional ozone concentrations transported into the Philadelphia one-hour ozone nonattainment area. Much of the reduction observed at Little Buffalo is due to elevated ozone concentrations from one year, 1988. This suggests the 1990-CAAA reductions in regions upwind of Philadelphia have done little to reduce large-scale regional ozone transport.

Preliminary data from the 2004 ozone season indicate that ozone concentrations were the lowest since monitors were installed in the early 1970's. While meteorological factors such as lower than normal temperatures and above average precipitation in the

Philadelphia region may have contributed to lower ozone measurements, a lack of transport into the region also contributed. A brief analysis of the 2004 ozone season is outlined in Appendix 6. Temperatures over much of the Midwest were well below normal. Ozone production in this upwind region was suppressed and, therefore, background concentrations entering eastern Pennsylvania were very low. The 2004 season could be indicative of what the Philadelphia one-hour ozone nonattainment area would experience if regional ozone transport were dramatically reduced.

4.2 Short-Term Local Ozone Transport Assessment

Ozone transport into the Philadelphia one-hour ozone nonattainment area within the lower boundary layer is another important process. Unlike regional transport, local transport occurs over shorter distances and affects a smaller area. This process includes the movement of low-level ozone plumes from the large metropolitan areas in the northeast. Ozone plumes from Baltimore and Philadelphia have been observed migrating downwind. These plumes typically "dissipate" shortly after sunset as fresh NOx emissions react with ozone within these plumes. The "dissipated" ozone plume will re-form downwind the next day when the solar-driven photochemistry resumes. Figure 6 shows the Baltimore ozone plume impacting monitors in southern Chester County forming a "double peak". The second peaks are due to the Baltimore ozone plume as it



travels northeast toward Philadelphia. The second peak at West Chester occurred near sunset. Ozone plumes from Baltimore have been observed moving across southern

Pennsylvania and under ideal conditions reach monitors in the Lehigh Valley well after sunset (Ozone Exceedance Report, 1999).

Ozone plumes can affect design values immediately downwind of large metropolitan areas in the northeast. This explains why design values in Cecil County, MD and southern Chester County are at times higher than any monitors inside the Philadelphia one-hour nonattainment area. Both of these areas are generally upwind of the major emission sources in Philadelphia but downwind of emissions sources in Baltimore.

4.3 Ozone Transport Via Low-Level Jets

Ozone can also be transported in swift-moving low-level jets. Low-level jets form during the overnight hours when radiative cooling "decouples" the earth's surface from the lower portion of the earth's atmosphere. This process removes frictional drag allowing the air to accelerate forming a thin stream of fast-moving air. These jets typically attain speeds of 10-20 m/s (25-45 miles per hour) and are usually located 400-800 meters (1300-2600 feet) above the surface. Low-level jets typically form just after sunset, when skies are clear and synoptic forcing is weak. They usually dissipate shortly after sunrise.

Ozone transported within these low-level jets will mix down to the surface after sunrise. Many of the vertical wind profilers in the Northeast have observed low-level jets during the summer including the North East – Oxidant and Particle Study (NE-OPS) site in northeast Philadelphia County (NE-OPS, 2003, Verghese, et al., 2003, Willitsford et al., 2003). These jets have the potential to move ozone-laden air hundreds of miles during the overnight hours. The nature of low-level jets makes it difficult to quantify their contribution to ozone transport into the Philadelphia one-hour ozone nonattainment area.

5.0 Summary and Conclusion

5.1 Trends Summary

- Average one-hour ozone design values have decreased approximately 18% since the 1990 CAAA.
- Average one-hour ozone monitor exceedances have decreased approximately 76% since the 1990 CAAA.
- The preliminary 2004 one-hour ozone design value is 0.129 ppm at Fair Hill, Maryland. This monitor is considered upwind of the Philadelphia metropolitan area.
- Only two of the eight monitors in the five-county Philadelphia area are violating the one-hour ozone standard: 0.127 ppm NE Airport Philadelphia County, 0.125 ppm Bristol, Bucks County.

- Pennsylvania's most recent Rate of Progress Report for Philadelphia estimates that by 2005 NOx and VOC emissions will have been reduced by approximately 35% from 1990 levels.
- Pennsylvania has enacted all VOC and NOx emission controls required by the 1990 CAAA within the five-county Philadelphia area and implemented all VOC and NOx reductions required under EPA's shortfall measures.
- Population within the Philadelphia one-hour nonattainment area has increased approximately 10%, adding half a million people between 1980 and 2000.
- Pennsylvania's estimated labor force has increased approximately 16% between 1980 and 2000 adding approximately 257,000 people in the five-county Philadelphia area.
- Ozone design values and monitor exceedances are decreasing over time even when weather conditions are favorable for ozone formation (hot and dry summers).
- Increased economic activity in Pennsylvania may be responsible for the slight upswing in one-hour ozone design values in the late-1990s.
- Regional ozone concentrations measured at Little Buffalo State Park in Perry County, PA have shown slight decreases since enactment of the 1990 CAAA.
- Regional ozone transport into the Philadelphia one-hour nonattainment was minimal during the 2004 ozone season. This may have been a factor in the absence of one-hour ozone exceedances during the 2004 ozone season.

5.2 Conclusion

Based on recent one-hour design value trends and emission control programs implemented by the PA DEP, the Philadelphia one-hour nonattainment area will reach compliance by its 2005 attainment date. The primary factor that could delay attainment is ozone transport from outside the Philadelphia one-hour nonattainment area. Meteorological conditions favorable for ozone formation (a hot and dry summer) and/or an upswing in economic activity (increase regional emissions) will also need to be monitored closely.

6.0 References

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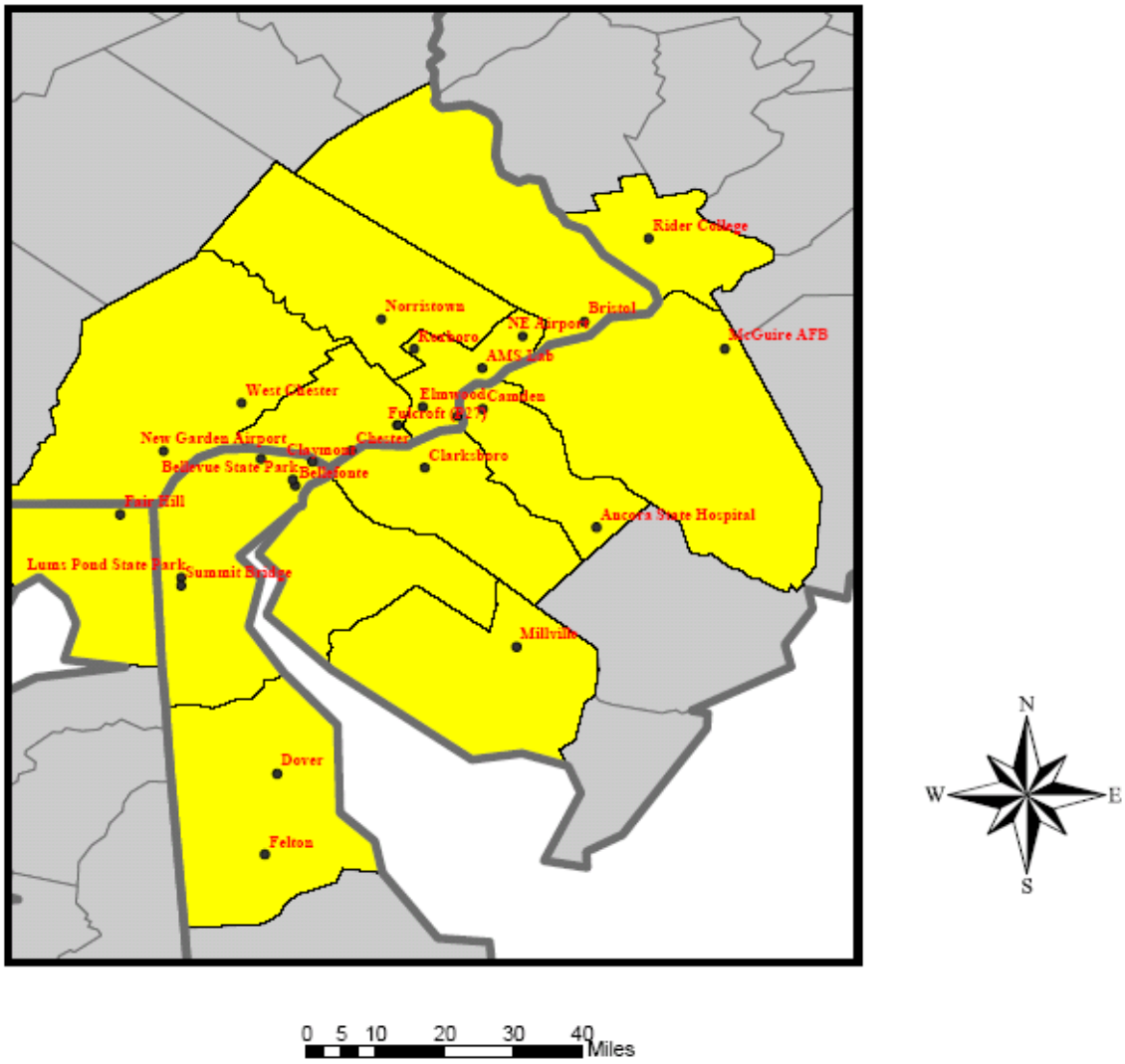
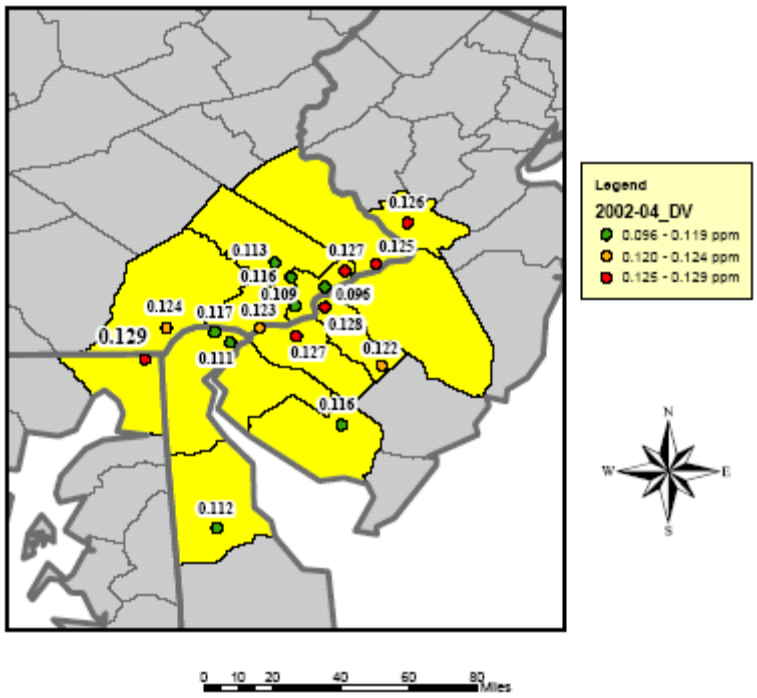
Appendix 1: Map Section

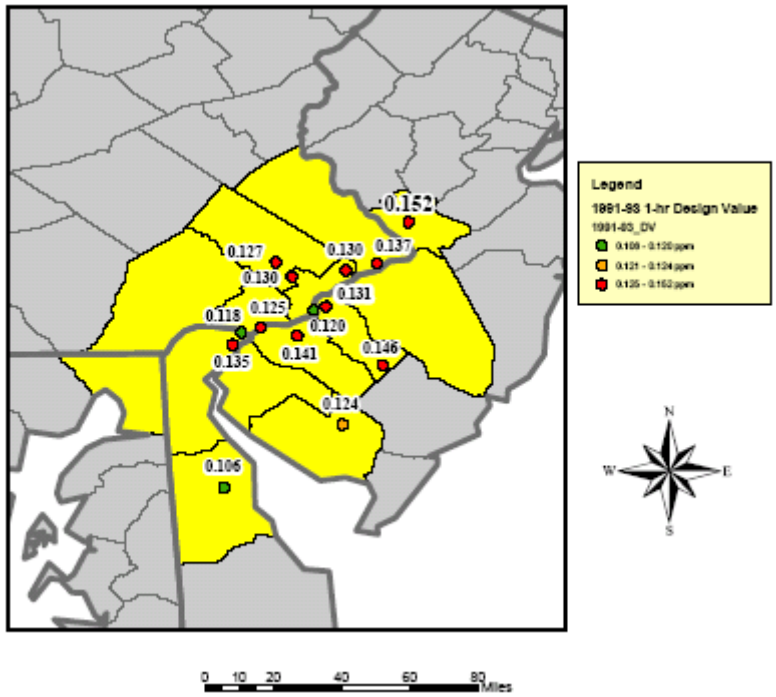
Philadelphia Nonattainment Area Ozone Monitors



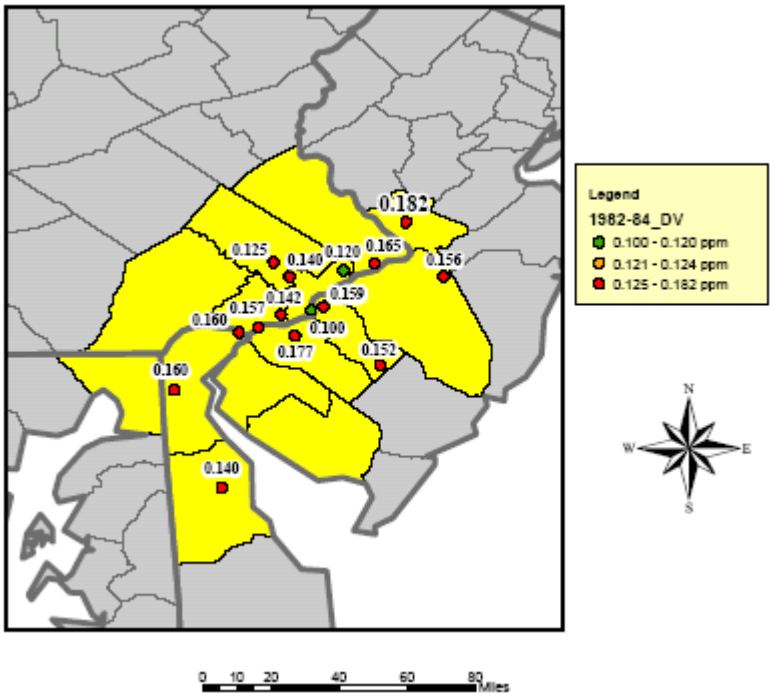
Philadelphia Nonattainment Area One-Hour Preliminary 2004 Ozone Design Values



Philadelphia Nonattainment Area One-Hour 1993 Ozone Design Values

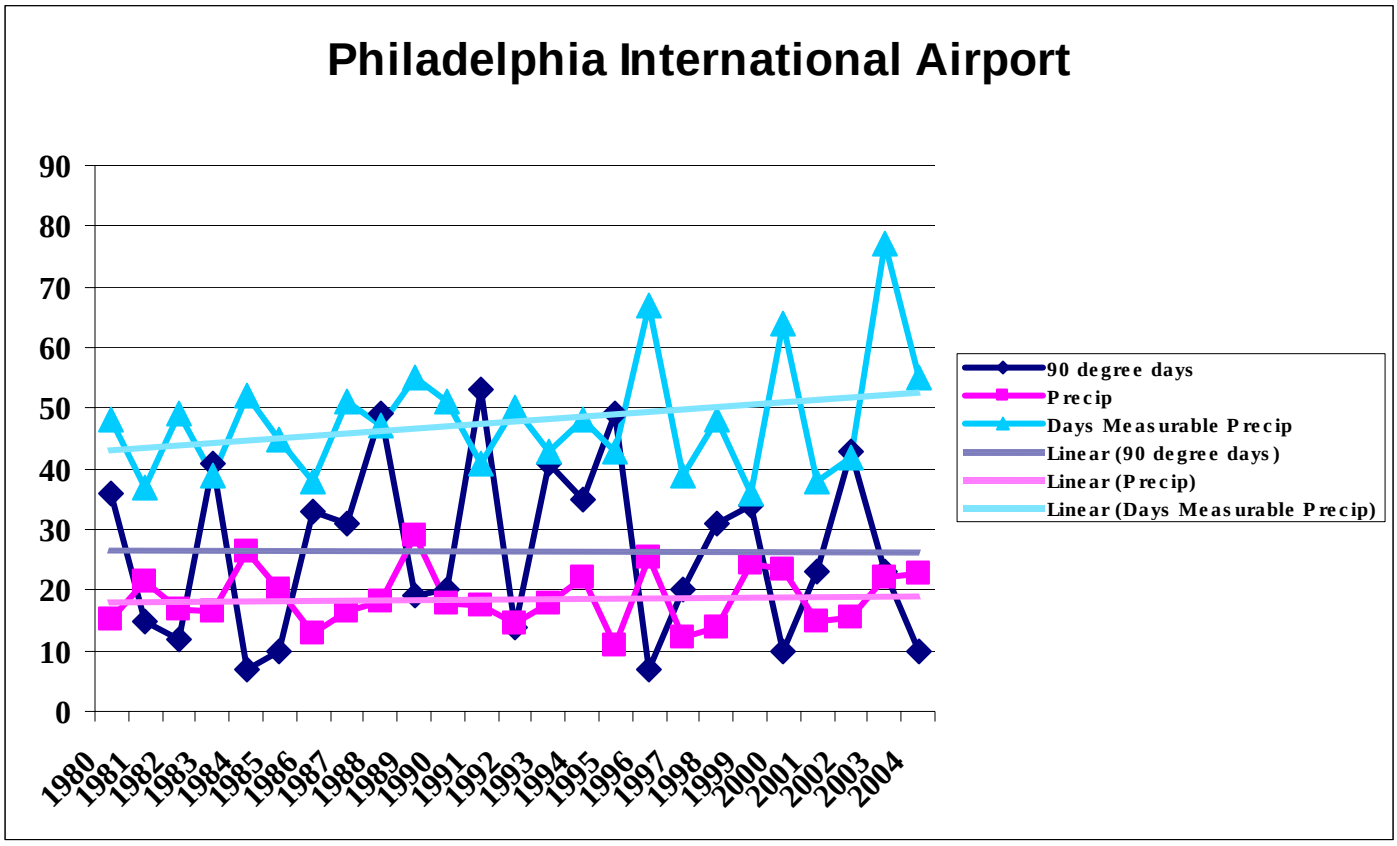


Philadelphia Nonattainment Area One-Hour 1984 Ozone Design Values



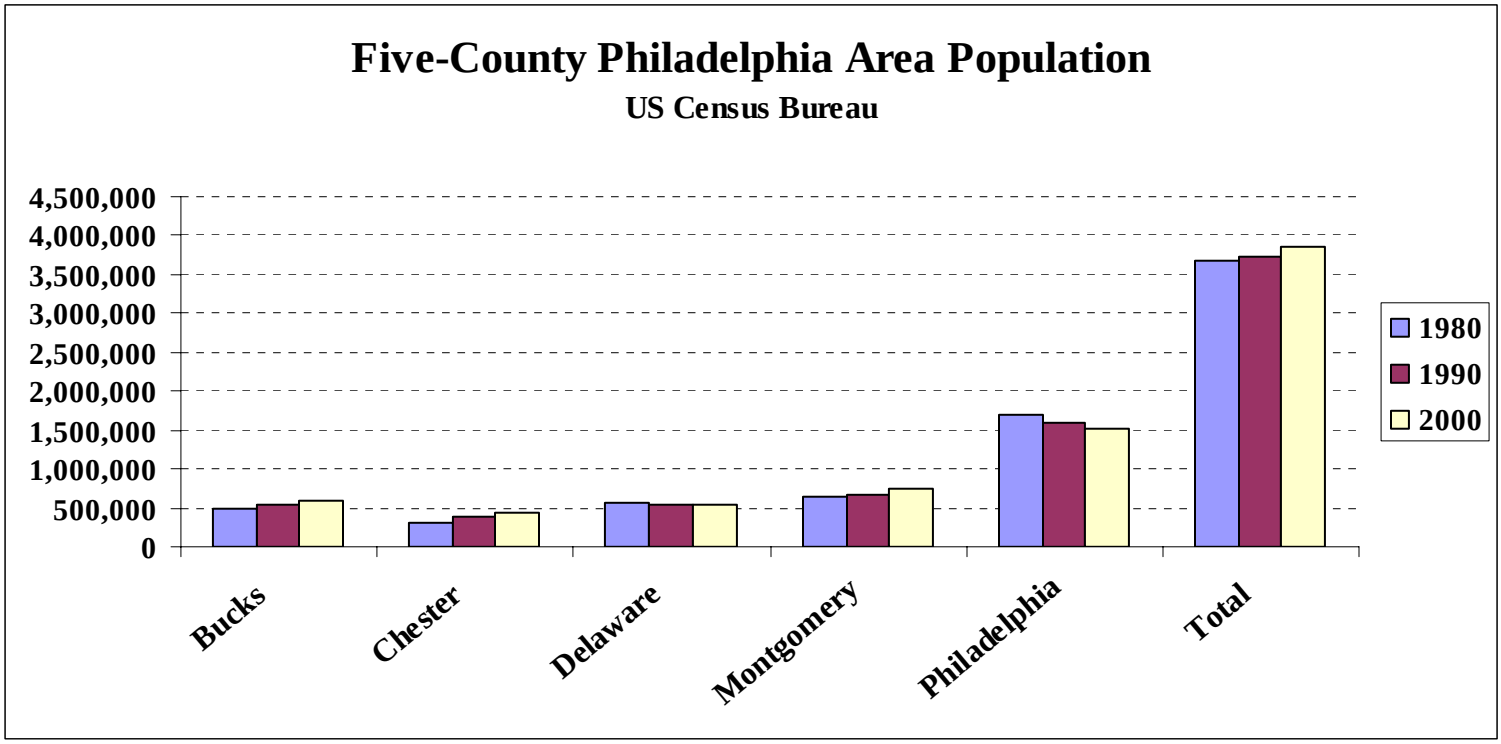
Appendix 2: Meteorological Trends

May - September



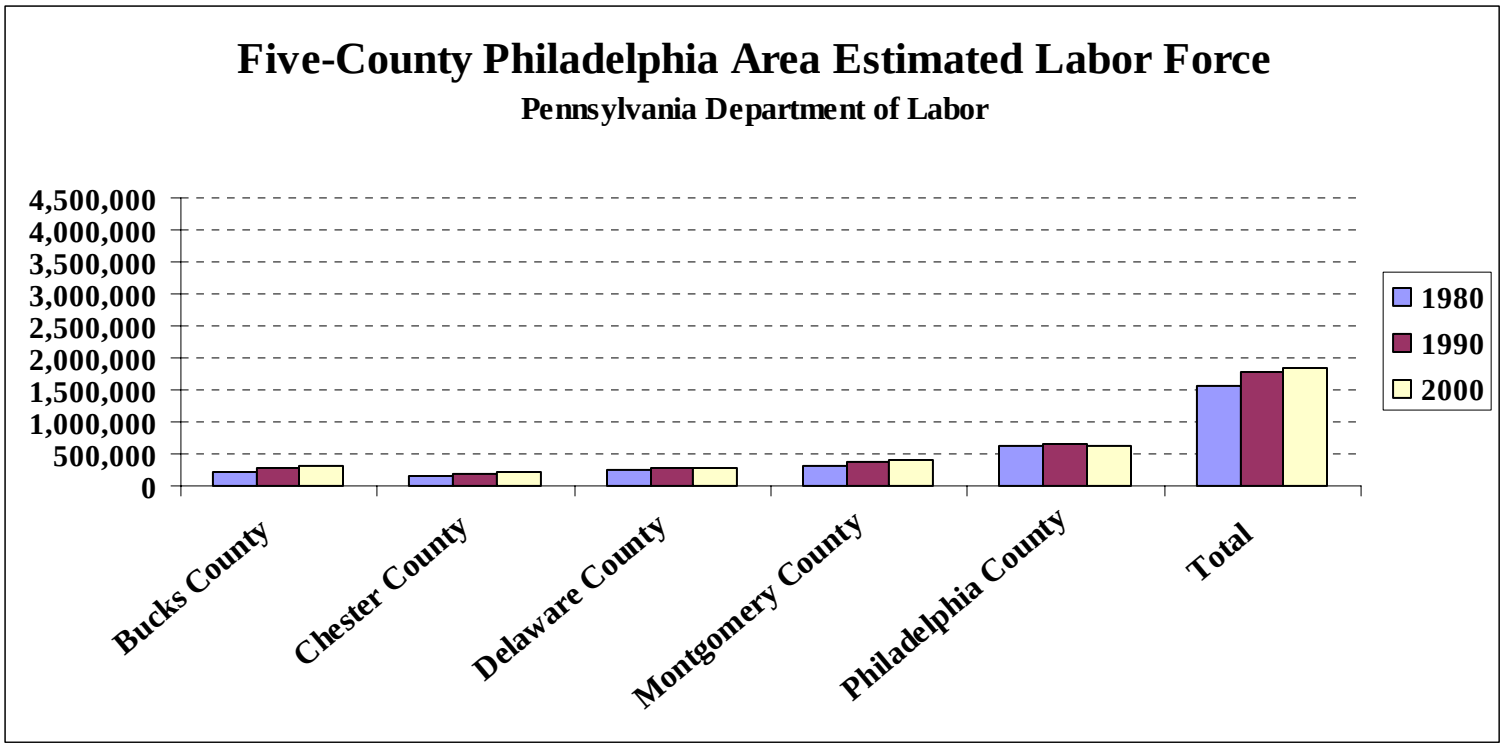
Appendix 3: Population Trends

Five-County Philadelphia Area Population



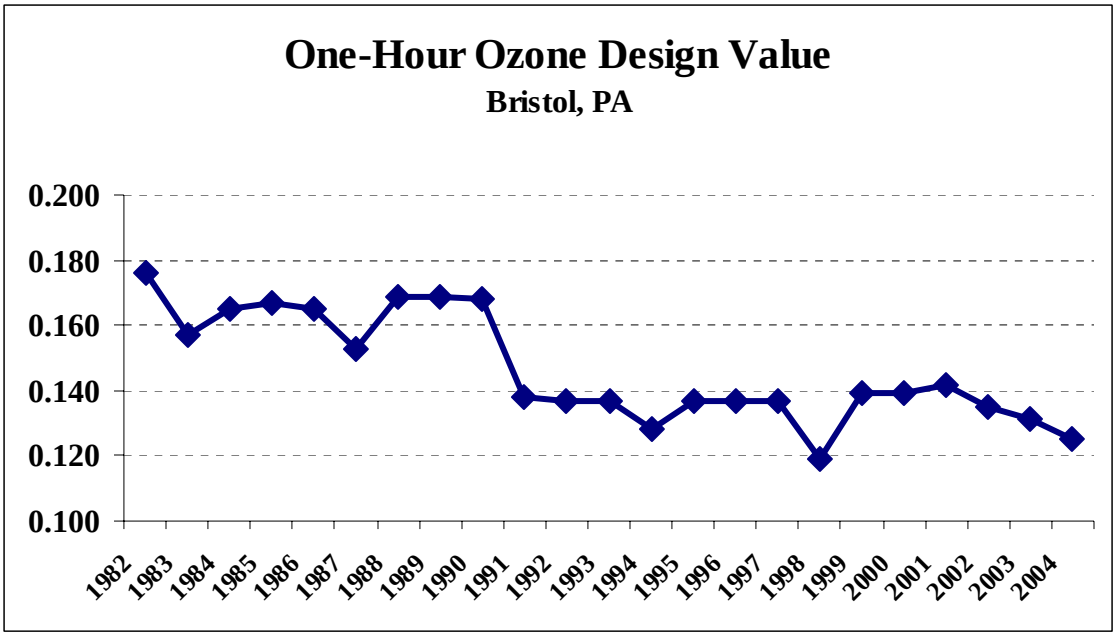
Appendix 4: Estimated Labor Force Trends

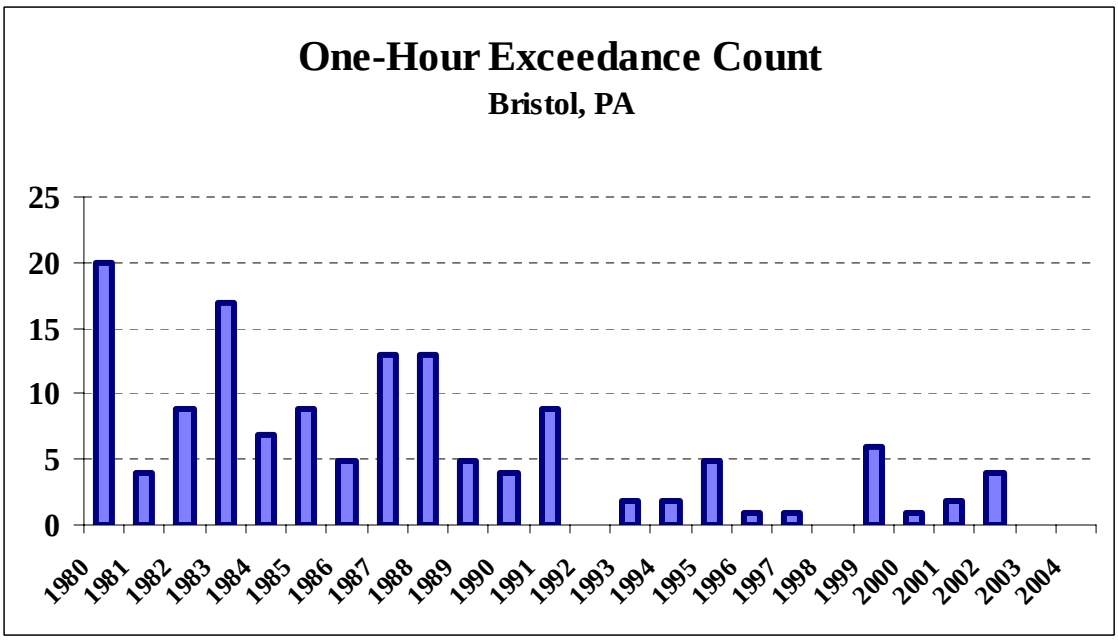
Estimated Labor Force in the Five-County Philadelphia Area



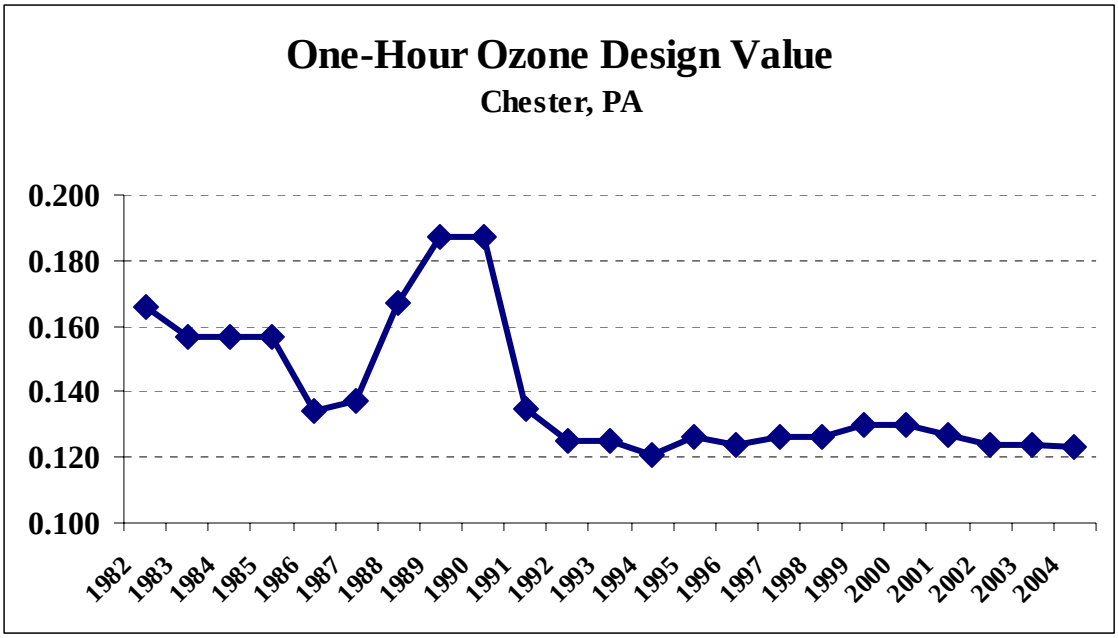
Appendix 5: Pennsylvania Monitor Trends

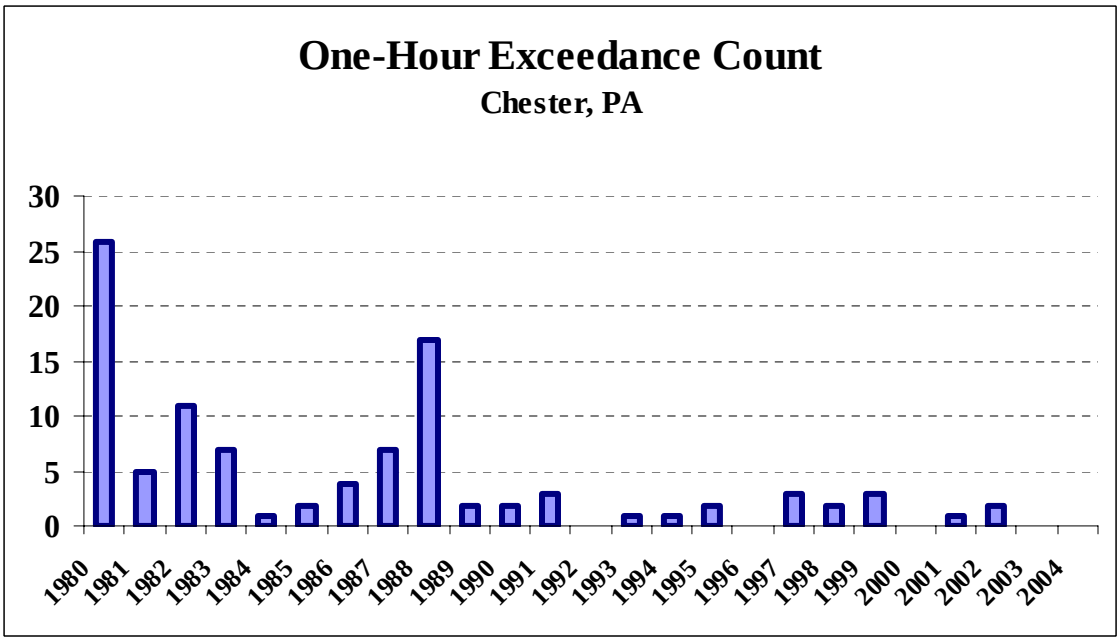
Bristol One-Hour Design Values and Exceedance Counts



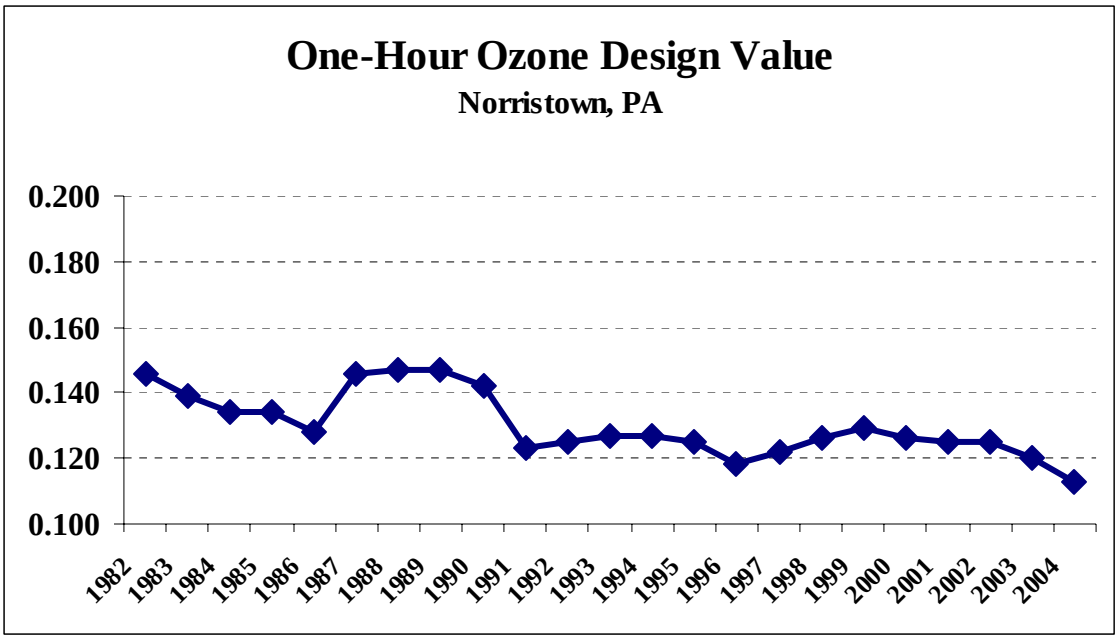


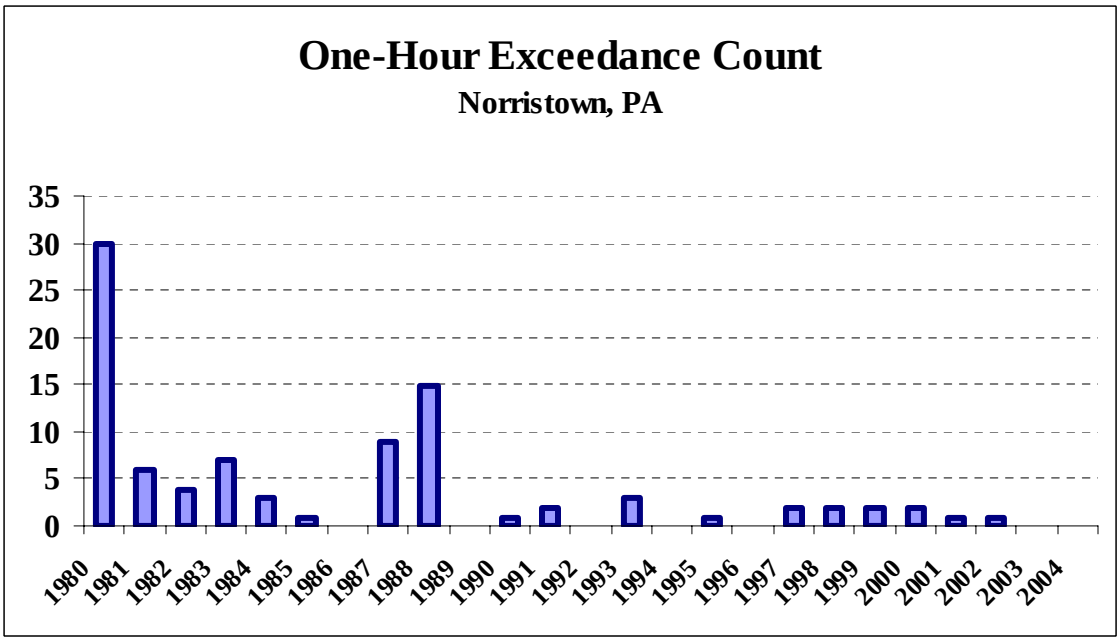
Chester One-Hour Design Values and Exceedance Counts



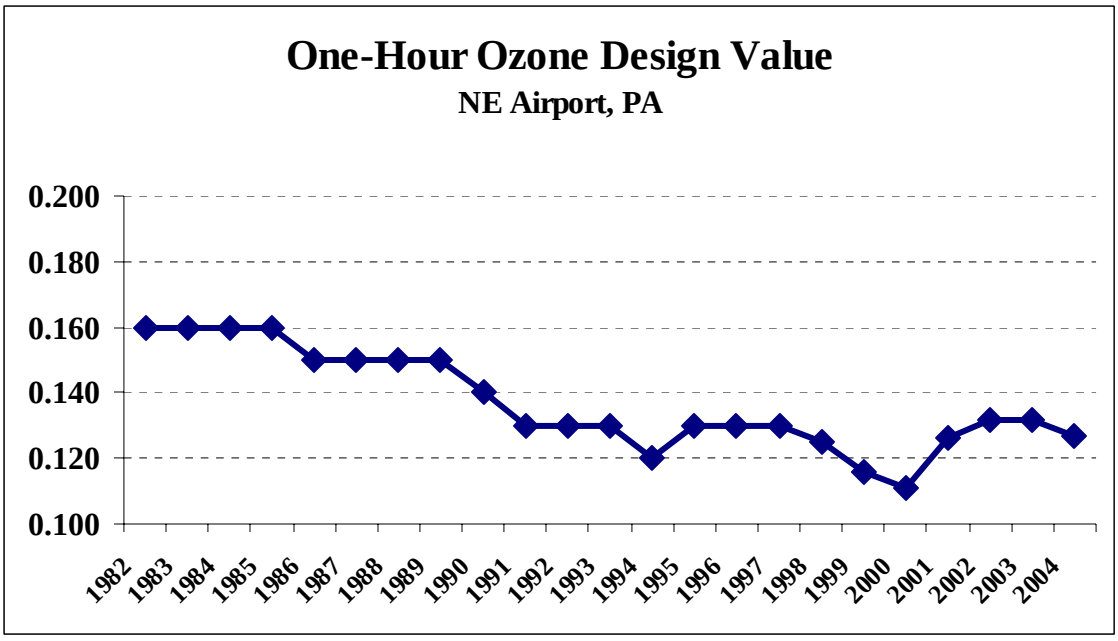


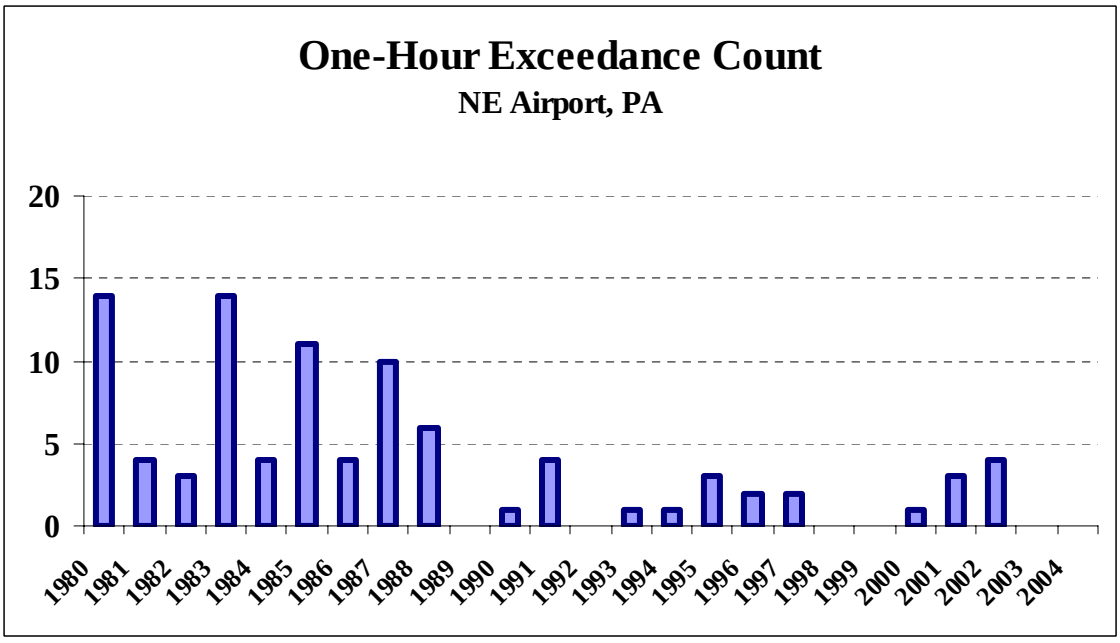
Norristown One-Hour Design Values and Exceedance Counts





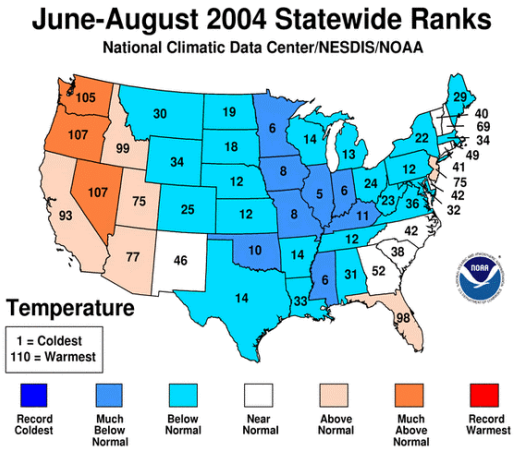
NE Airport One-Hour Design Values and Exceedance Counts

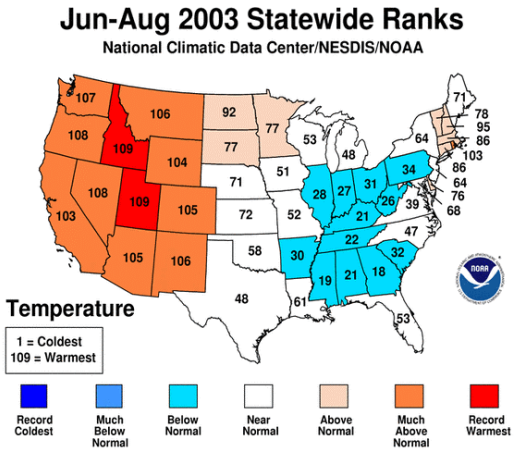


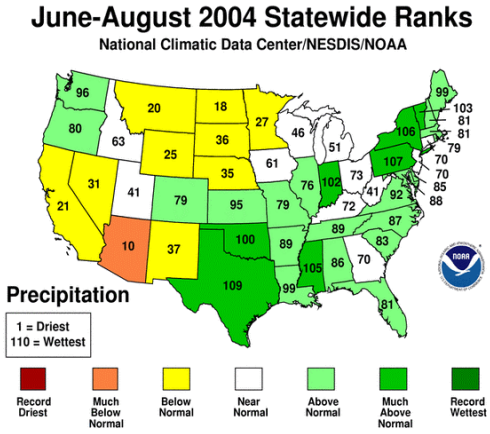


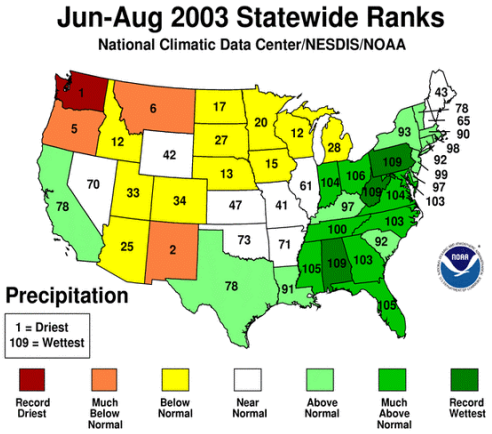
Appendix 6: Summary of the 2004 Ozone Season

The summer of 2004 was characterized by unusually cool temperatures and above average precipitation. Data published by the National Oceanic and Atmospheric Administration (NOAA) indicate much of the Midwest and Mid-Atlantic, with the exception of New Jersey, experienced below average temperatures and above average rainfall. A similar pattern was observed during the 2003 ozone season.









There were no exceedances of the one-hour ozone standard during the 2004 ozone season over the entire Philadelphia one-hour ozone nonattainment area. This has not occurred since ozone monitors were installed in the early 1970s. Unusually cool temperatures and above average rainfall undoubtedly helped reduce ozone concentrations over the Philadelphia nonattainment area by reducing the number days favorable for ozone formation.

While conditions in the Mid-Atlantic were similar for both the 2003 and 2004 ozone seasons, the situation over the Midwest was quite different. The Midwest was much cooler during the 2004 ozone season than the 2003 ozone season. That region is generally upwind of the Philadelphia one-hour nonattainment area. Ozone produced from sources in the Midwest typically drifts over the Mid-Atlantic region increasing background ozone concentrations over Philadelphia. Since temperatures and precipitation over the Midwest inhibited ozone production during the 2004 ozone season, background concentrations entering the Philadelphia region were unusually low. This assessment is verified by looking at 2004 ozone concentrations at Methodist Hill and Little Buffalo State Park. Both sites measured their lowest ozone concentrations since they began operation (Table A6-1) confirming that background concentrations entering the Philadelphia one-hour nonattainment area were unusually low during the 2004 ozone season. Ozone concentrations in 2004 may reflect what would occur if background concentrations (upwind sources) were not affecting the Philadelphia nonattainment area.

Table A6-1. One-Hour Ozone Values for Methodist Hill and Little Buffalo

	Little Buffalo				Methodist Hill			
Year	**Max 1**	**Max 2**	**Max 3**	**Max 4**	**Max 1**	**Max 2**	**Max 3**	**Max 4**
1996	0.096	0.090	0.086	0.085	0.113	0.096	0.092	0.088
1997	0.108	0.103	0.101	0.098	0.120	0.114	0.108	0.100
1998	0.124	0.110	0.102	0.101	0.123	0.120	0.115	0.110
1999	0.111	0.106	0.106	0.103	0.116	0.115	0.106	0.104
2000	0.099	0.099	0.090	0.087	0.101	0.100	0.097	0.088
2001	0.114	0.102	0.097	0.097	0.106	0.104	0.103	0.103
2002	0.118	0.110	0.106	0.098	0.115	0.115	0.114	0.114
2003	0.097	0.095	0.094	0.092	0.110	0.101	0.085	0.085
2004 **	0.081	0.080	0.078	0.078	0.078	0.078	0.078	0.077

** Preliminary

Pennsylvania Ozone Monitor Map