

**A REVIEW OF MOBILE SOURCE
EMISSION INVENTORIES IN THE
MID-ATLANTIC REGION**

The **PECHAN**-Avanti Group

**5528-B Hempstead Way
Springfield, VA 22151**

**703-813-6700 telephone
703-813-6729 facsimile**

**3622 Lyckan Parkway
Suite 2002
Durham, NC 27707**

**919-493-3144 telephone
919-493-3182 facsimile**

**2880 Sunrise Blvd.
Suite 220
Rancho Cordova, CA 95742**

**916-852-1794 telephone
916-852-9451 facsimile**

Prepared for:

Mid-Atlantic Regional Air
Management Association
711 West 40th Street, Suite 318
Baltimore, MD 21211-2109

Prepared by:

The Pechan-Avanti Group,
a unit of E.H. Pechan & Associates, Inc.
5528-B Hempstead Way
Springfield, VA 22151

March 2000

Pechan Rpt. No. 00.03.001/9404.000

CONTENTS

	Page
TABLES	v
ACRONYMS AND ABBREVIATIONS	vii
ACKNOWLEDGMENTS	ix
CHAPTER I	
INTRODUCTION AND SUMMARY	1
CHAPTER II	
MOBILE EMISSION ESTIMATION METHODS - MID-ATLANTIC STATE URBAN AREAS	3
CHAPTER III	
HIGHWAY VEHICLE EMISSION ESTIMATION METHODS - COMPARING NET96, SIP, AND OTAG	29
A. OTAG EMISSION ESTIMATES	29
B. NATIONAL EMISSION TRENDS	30
C. OBSERVATIONS	33
D. GENERAL CAVEATS	33
1. Washington, DC	33
2. Charlotte and Raleigh	42
3. Pittsburgh	42
4. Baltimore	42
5. Philadelphia	42
6. Richmond and Norfolk	43
REFERENCES	45

TABLES

	Page
II-1 New Jersey Portion of Philadelphia, PA	5
II-2 Philadelphia, PA	7
II-3 Pittsburgh, PA	9
II-4 Baltimore, MD	11
II-5 Washington, DC	14
II-6 Richmond, VA	17
II-7 Tidewater, VA	18
II-8 Raleigh-Durham, NC	20
II-9 Charlotte, NC	23
II-10 Summary of Mobile Emission Estimation Method Differences	27
III-1 OTAG I/M Program Coverage - Mid-Atlantic States	31
III-2 Philadelphia, PA Highway Vehicle Emissions Comparison	34
III-3 Pittsburgh, PA Highway Vehicle Emissions Comparison	35
III-4 Baltimore, MD Highway Vehicle Emissions Comparison	36
III-5 Washington, DC Highway Vehicle Emissions Comparison	37
III-6 Richmond, VA Highway Vehicle Emissions Comparison	38
III-7 Norfolk-Virginia Beach-Newport News, VA Highway Vehicle Emissions Comparison	39
III-8 Raleigh-Durham, NC Highway Vehicle Emissions Comparison	40
III-9 Charlotte-Gastonia, NC Highway Vehicle Emissions Comparison	41

ACRONYMS AND ABBREVIATIONS

AADT	annual average daily traffic
ADT	average daily travel
BPR	Bureau of Public Roads
CO	carbon monoxide
COG	Metropolitan Washington Council of Governments
DMV	Department of Motor Vehicles
DVRPC	Delaware Valley Regional Planning Commission
EPA	U.S. Environmental Protection Agency
FHWA	Federal Highway Administration
FTP	Federal Test Procedure
HDDT	heavy-duty diesel truck
HDDV	heavy-duty diesel vehicle
HDGV	heavy-duty gasoline vehicle
HDVs	heavy-duty vehicles
HPMS	highway performance monitoring system
I/M	inspection and maintenance
LDDT	light-duty diesel trucks
LDDV	light-duty diesel vehicles
LDGT	light-duty gasoline truck
LDGV	light-duty gasoline vehicle
LDT	light-duty truck
LDV	light-duty vehicle
MARAMA	Mid-Atlantic Regional Air Management Association
MPO	metropolitan planning organization
MSA	metropolitan statistical area
NAPAP	National Acid Precipitation Assessment Program
NET	National Emissions Trends
NO _x	oxides of nitrogen
OTAG	Ozone Transport Assessment Group
OTAQ	Office of Transportation and Air Quality
PAMS	Photochemical Assessment Monitoring Stations
Pechan-Avanti	The Pechan-Avanti Group
PEI	Periodic Emission Inventory
PennDOT	Pennsylvania Department of Transportation
PPAQ	Post-Processor for Air Quality
psi	pounds per square inch
RACT	reasonably available control technology
RMS	Roadway Management System
ROM	Regional Oxidant Model
ROP	rate-of-progress
RVP	Reid vapor pressure
SHA	State Highway Administration
SIP	State Implementation Plan

ACRONYMS AND ABBREVIATIONS (continued)

SJTPO	South Jersey Transportation Planning Organization
SO ₂	sulfur dioxide
tpd	tons per day
VMT	vehicle miles traveled
VOC	volatile organic compound

ACKNOWLEDGMENTS

The report authors acknowledge the contributions of the Mid-Atlantic Regional Air Management Association (MARAMA) member State agency staff in providing information and comments on what is included in this report. Project contacts include the following State agency and Council of Governments staff:

Staff Name	Agency
Mike Clifford	Metropolitan Washington Council of Governments
Arlene Shulman	Pennsylvania Department of Environmental Protection
Bruce Benton	New Jersey Department of Environmental Protection
Bob Stern	New Jersey Department of Environmental Protection
Tom Ballou	Virginia Department of Environmental Quality
Diane Franks	Maryland Department of the Environment
Mohammed Khan	Maryland Department of the Environment
Laura Boothe	North Carolina Department of Environment and Natural Resources
Mark Eastburn	Delaware

Valuable comments on report drafts that have improved the quality of this final report were received from Rob Altenburg (Pennsylvania Department of Environmental Protection), Harvey Michaels (U.S. Environmental Protection Agency [EPA]-Office of Transportation and Air Quality [OTAQ]), and Susan Wierman (the MARAMA Project Director).

CHAPTER I

INTRODUCTION AND SUMMARY

Motor vehicle emission controls are an important part of the State Implementation Plans (SIPs) for attaining and maintaining the ozone standard in the mid-Atlantic Region. Ambient air quality data show measurable impacts of motor vehicle emissions (Main, et al., 1999). This report analyzes mobile source emissions data for major metropolitan areas in the mid-Atlantic Region. It explores the similarities and differences among inventories for metropolitan areas, and it describes differences among various State and national emission inventory estimates. This report identifies important assumptions underlying the calculation of mobile source emissions.

Chapter II of this report compares urban scale emission estimation methods for the eight largest metropolitan areas in the mid-Atlantic Region. Available estimates for these areas for either 1990 or 1996 were evaluated. This review showed that differences in methods of calculating emissions for the areas have a significant influence on highway vehicle emission levels. While some of the inter-city differences represent differences in the vehicle fleet and travel patterns in the areas of interest (registration distributions, trip lengths, etc.) there are also analytical differences in assigning vehicle miles traveled (VMT) among vehicle types, in allocating VMT by roadway type, and in estimating vehicle speeds by roadway type. Estimating vehicle speeds by roadway type is the most important analytical difference in emission rates by area. Methodological differences have evolved for both technical and organizational reasons specific to each State.

In view of the above, it is recommended that there be discussions among the urban areas in this region about highway vehicle emission modeling methods. Regional consistency in all aspects of inventory preparation is not expected, since inter-city differences in vehicle fleet, fuels, and travel patterns will persist, and since local data availability and conformity procedures will also influence methods. However, a common understanding of current methods and an ongoing discussion of future plans would facilitate the use of improved methods as new inventories are developed.

Chapter III summarizes and compares the highway vehicle emission estimates that have been made by States for SIP analyses with those that have been developed for the Ozone Transport Assessment Group (OTAG) modeling and for the EPA National Emission Trends Report. The OTAG emissions data base is important because it was used for the regional strategy analyses performed by that group. The 1996 Trends estimates are similarly important because they are used for many current and upcoming regional modeling exercises. While there were differences among the inventories, there were no consistent biases among the highway vehicle emissions estimates made for SIPs, OTAG, and the Trends data base. Common reasons for observed differences include (1) the way that travel was allocated between passenger cars and light trucks (light truck emission rates are much higher), and (2) differences in methods used to estimate heavy-duty diesel truck (HDDT) emissions. For example, North Carolina adjusted their 1996 SIP emissions

estimates for Charlotte and Raleigh that account for the effects of the heavy-duty diesel vehicle (HDDV) emission control defeat device. No other mid-Atlantic States made the HDDV defeat device adjustment in the SIP estimates included in this report, and excess emissions from the HDDV defeat device are not accounted for in either the OTAG inventory or the Trends inventory. This illustrates how inventories improve as States use new methods or information.

The Chapter III analysis suggests that users of regional emission data bases need to pay attention to the year and daily conditions that were used in developing any motor vehicle emissions data base. The OTAG or current Trends data bases may not be the best available estimates of mobile source emissions for future studies.

CHAPTER II

MOBILE EMISSION ESTIMATION METHODS - MID-ATLANTIC STATE URBAN AREAS

This chapter addresses the mobile source emission estimation methods and results that were used in the major urban areas in the mid-Atlantic States to estimate highway vehicle and associated fuels transport and storage emissions. This analysis was performed through discussions with State air pollution control agency and metropolitan planning organization (MPO) staff who prepared the highway vehicle, storage and transport emission estimates, and by reviewing the reports that were written to document the 1990 SIP Inventories, or the rate-of-progress (ROP) plan, or modeling inventories that have been prepared for years more recent than 1990.

The States and urban areas that were evaluated in this analysis are listed below. The New Jersey and Pennsylvania portions of the Philadelphia ozone nonattainment area are evaluated separately because the emission inventory methods for the two States differ. The other multi-State ozone nonattainment area in the mid-Atlantic Region is Washington, DC. The Metropolitan Washington Council of Governments (COG) prepares the mobile and area source emission estimates for the entire region, so the information for metropolitan Washington, DC is presented as a single, multi-State analysis. The evaluations for Pittsburgh and Philadelphia are similar because Pennsylvania uses consistent emission modeling methods for the urban areas/counties within its borders. The same is true for Richmond and Tidewater in Virginia, as well as for Raleigh-Durham and Charlotte in North Carolina.

1. New Jersey Portion of Philadelphia, PA
2. Philadelphia, PA
3. Pittsburgh, PA
4. Baltimore, MD
5. Washington, DC
6. Richmond, VA
7. Tidewater, VA
8. Raleigh-Durham, NC
9. Charlotte, NC

Following EPA guidance, the States and MPOs used a combination of network models and traffic ground counts in estimating their 1990 and 1996 travel and associated emissions. For the purposes of this study, the best situation is one where an established network model is used to simulate travel behavior on the highway network (for spatial and temporal allocations) with network model estimated VMT verified with measured traffic counts. Network-based transportation models provide more detail on the location, sources, and purposes of travel. These models then allow areas to simulate how future changes in the roadway network, vehicle ownership and occupancy patterns, and other variables will

affect emission related variables such as VMT, the number of trips, time-of-day of travel, and vehicle speeds.

The evaluation performed for this study focused on ten (10) attributes that were determined to be important in estimating travel and in using EPA's MOBILE5 Mobile Source Emission Factor model for the purposes of estimating base year emission rates. With the ultimate emphasis in this study being to compare emissions with nearby ambient monitoring values, some of the attributes that were evaluated, like temporal allocation, were potentially more important than they might be if only the accuracy of total emissions across an entire nonattainment area were of interest. However, most of the attributes were selected to compare the *level of detail* used in the emission calculations among the study areas.

At the time that this report was prepared, the highway vehicle emission estimates represented 1990 conditions for some urban areas, and 1996 conditions for others. As a result, it is difficult to draw definitive conclusions about inter-city differences in emission estimation techniques and effects on emission quantities and volatile organic compound (VOC) versus oxides of nitrogen (NO_x) ratios. However, it appears that the emissions estimation method differences among areas are as significant an influence on highway vehicle emission values as are the control programs that individual areas have adopted, such as reformulated gasoline and inspection and maintenance (I/M) programs. While some of the inter-city differences represent differences in the vehicle fleet and travel patterns in the areas of interest (registration distributions, trip lengths, etc.), there are also analytical differences in assigning VMT among vehicle types, in allocating VMT by roadway type, and in estimating vehicle speeds by roadway type.

Between-city differences in highway vehicle emission rates can be seen by comparing attribute 11 information (in Tables II-1 through II-9) for Philadelphia, PA (Table II-2) and Richmond, VA (Table II-6). The 1996 ozone season daily emission rates in the five county Philadelphia area range from 1.87 to 2.82 grams VOC per mile and from 2.57 to 2.95 grams NO_x per mile. The Richmond, VA area VOC emission rates range from 1.43 to 1.80 grams per mile and the NO_x values from 2.25 to 2.83 grams per mile. Thus, the fleetwide VOC emission rates in the Richmond area are estimated to be 25 to 35 percent lower than the corresponding Philadelphia, PA values. About 10 percent of the VOC difference between these two areas results from the lower Reid vapor pressure (RVP) gasoline in Virginia (7.8 pounds per square inch (psi) compared with 8.7 psi). Some of the remaining difference is attributable to an older fleet in the Philadelphia area and the additional emissions produced by the increased congestion in a larger metropolitan area and the longer trip lengths. However, part of the remaining difference in these emission rates is produced by differences in the analysis techniques % the most important of which is estimating vehicle speeds by roadway type.

Note also that there can be significant variations in emission rates (by county) within a metropolitan area. This can be seen in Table II-5 for the Washington Metropolitan Area where the 1990 VOC emission rate in Montgomery County, MD is 37 percent lower than in the neighboring District of Columbia. For the Photochemical Assessment Monitoring Stations (PAMS) data comparisons, the ratio of VOC to NO_x is also important, and the Montgomery County, MD highway vehicle based ratio of 0.88 to 1.0 presents a different picture than the DC-based ratio of 1.37 to 1.0. Because of the inter-area travel between

**Table II-1
New Jersey Portion of Philadelphia, PA**

Attributes	Description
1. VMT estimation methods	<p>The 1990 Base Year mobile source ozone season emission inventory was based on methods that use highway performance monitoring system (HPMS) data, and vehicle speeds derived from engineering judgment. The subsequent 1996 and 1999 highway vehicle emission estimates use VMT estimates from travel demand models developed by the respective MPO in New Jersey.</p> <p>Of the six New Jersey counties in the Philadelphia-Trenton-Wilmington ozone nonattainment area, two (Cumberland and Salem) are in the South Jersey Transportation Planning Organization (SJTPO), while four (Burlington, Camden, Gloucester, and Mercer) are in the Delaware Valley Regional Planning Commission (DVRPC) planning area.</p> <p>The SJTPO uses a computer model called the Post-Processor for Air Quality (PPAQ) to estimate highway vehicle emissions. The traffic file contains daily VMT estimates for three roadway types for five time periods for each county in the MPO's jurisdiction.</p> <p>The DVRPC uses a slightly different procedure to estimate highway vehicle emissions. First, the travel demand model is used to generate a file that contains daily VMT and vehicle speed estimates. Three MOBILE5 input files are established for each of the three roadway types used in the travel demand model: freeways, arterials, and locals. The DVRPC modeling procedure generates MOBILE5a emission factors for speeds between 3 and 55 miles per hour in one mile per hour increments for use by the model.</p>
2. Assignment of VMT to roadway functional classifications	VMT is tracked separately for three roadway classes: freeways, arterials, and local roads. For the four DVRPC NJ counties in the Philadelphia ozone nonattainment area, the fraction of VMT by roadway type is 30.6 percent freeway, 49.4 percent arterials, and 20 percent local roads.
3. Vehicle speed estimation methods and level of detail	The emission factors used in the emission calculations are stored by roadway type, at one mile per hour speed increments.
4. Registration distribution	Not available.
5. Operating mode estimates	Not available.
6. VMT mix by vehicle type	Not available.

Table II-1 (continued)

Attributes	Description																												
7. Analysis years	1990, 1996, and 1999.																												
8. Temporal resolution	The five time periods used are 24-hour average, overnight (7 p.m. to 6 a.m.), morning rush hour (6 to 9 a.m.), and evening rush hour (4 to 7 p.m.).																												
9. I/M and fuels program modeling assumptions	A two step process is used to estimate I/M program benefits in New Jersey. The first step estimates the emissions from all vehicles as if they were inspected at a centralized, test-only inspection facility. The second step estimates the emissions from all vehicles in the State as if they were inspected at a decentralized, test and repair facility. The emissions are then calculated using a 68 percent factor for centralized inspections and 32 percent for decentralized. Calendar year 1996 emission estimates include the emission benefits of Phase I Federal reformulated gasoline.																												
10. Intra-area geographic differentiation (urban, rural)	Not available.																												
11. Average gram per mile VOC and NO _x emissions a. Fleetwide	<p>1990 emission rates by County for New Jersey counties in the Philadelphia nonattainment area are presented below.</p> <table><thead><tr><th>County</th><th>VOC gm/mile</th><th>NO_x gm/mile</th><th>Carbon Monoxide (CO) gm/mile</th></tr></thead><tbody><tr><td>Cumberland</td><td>1.87</td><td>2.38</td><td>14.7</td></tr><tr><td>Salem</td><td>1.90</td><td>3.41</td><td>17.1</td></tr><tr><td>Burlington</td><td>2.24</td><td>2.49</td><td>14.4</td></tr><tr><td>Camden</td><td>2.37</td><td>2.35</td><td>15.3</td></tr><tr><td>Gloucester</td><td>2.11</td><td>2.52</td><td>13.5</td></tr><tr><td>Mercer</td><td>2.32</td><td>2.45</td><td>15.0</td></tr></tbody></table> <p>Note that Salem County has a higher NO_x emission factor than other counties in this nonattainment area, which suggests that this county has a higher percentage of freeways (and high speed travel) than the surrounding counties, and also a higher percentage of heavy-duty truck travel.</p>	County	VOC gm/mile	NO _x gm/mile	Carbon Monoxide (CO) gm/mile	Cumberland	1.87	2.38	14.7	Salem	1.90	3.41	17.1	Burlington	2.24	2.49	14.4	Camden	2.37	2.35	15.3	Gloucester	2.11	2.52	13.5	Mercer	2.32	2.45	15.0
County	VOC gm/mile	NO _x gm/mile	Carbon Monoxide (CO) gm/mile																										
Cumberland	1.87	2.38	14.7																										
Salem	1.90	3.41	17.1																										
Burlington	2.24	2.49	14.4																										
Camden	2.37	2.35	15.3																										
Gloucester	2.11	2.52	13.5																										
Mercer	2.32	2.45	15.0																										
b. Light-duty vehicles	Not available.																												

**Table II-2
Philadelphia, PA**

Attributes	Description
1. VMT estimation methods	<p>To monitor conditions on the Pennsylvania highway system and to support its management, the Pennsylvania Department of Transportation (PennDOT) developed the Roadway Management System (RMS). RMS is a computerized data base containing about 100,000 records covering each highway segment and section in the state system, plus the Pennsylvania Turnpike. A substantial body of traffic counts are conducted annually, including both HPMS control sections and other counts by MPOs, consultants, and PennDOT. All of this count data is loaded into RMS on a continuing basis, so that RMS contains current annual average daily traffic (AADT) volume estimates on all highway segments.</p> <p>RMS covers virtually all of the freeways, arterials, and collectors in the state, as well as a significant portion of the local streets, and it contains details describing both travel demand and supply characteristics.</p> <p>For the 5 county Philadelphia area, the DVRPC travel demand model was used to reflect network characteristics that affect roadway volumes, VMT, and speeds.</p>
2. Assignment of VMT to roadway functional classifications	<p>Each highway segment in the RMS dataset contains a functional class code that is consistent with and forms the basis for the HPMS VMT accumulation. This functional class code, working with the county and urban/small urban/rural setting code, controlled the accumulation of segment VMT from the SIP RMS data set to produce VMT for each of the MOBILE categories.</p>
3. Vehicle speed estimation methods and level of detail	<p>The speed calculation process requires estimates of hourly traffic volumes on each segment. To support these calculations, the seasonally and daily adjusted traffic volume on each segment was disaggregated to 24 hourly volumes prior to analysis using pattern distribution data. PennDOT has developed typical hourly patterns for each functional class, setting, and region of the state, and the appropriate pattern distribution was selected and applied to the daily volume on each highway segment in the RMS data set to produce hourly traffic volumes.</p>
	<p>Speeds were individually calculated for each roadway segment and hour. VMT and vehicle hours of travel were then accumulated for each cell of the county, urban/small urban/rural setting, roadway functional class, time-of-day matrix; and accumulated VMT was divided by vehicle hours to produce a speed estimate.</p>

Table II-2 (continued)

Attributes	Description																																
4. Registration distribution	Vehicle age distributions are based on the number of registered vehicles in each county. These distributions reflect the percentage of vehicles in the fleet up to 25 years old and are listed by the eight EPA vehicle types. The vehicle age distributions were downloaded from the PennDOT Bureau of Motor Vehicles Registration Data Base in July 1997.																																
5. Operating mode estimates	The default MOBILE operating mode fractions were used, consisting of 20.6 percent for cold starts and 27.3 percent for hot starts.																																
6. VMT mix by vehicle type	1996 RMS roadway truck percentages are used in combination with MOBILE5a default vehicle type percentages to the eight MOBILE vehicle types for each county and functional class combination.																																
7. Analysis years	There were emission estimates made for 1990 and 1996.																																
8. Temporal resolution	MOBILE is run for four time periods (morning and evening peaks, mid-day and night).																																
9. I/M and fuels program modeling assumptions	I/M programs in place during 1990 and 1996 were simulated. I/M programs were in place in the five counties in the Philadelphia ozone nonattainment area in 1990 and 1996. This is a basic I/M program design. The 1996 highway vehicle emission estimates include Phase I Federal reformulated gasoline benefits.																																
10. Intra-area geographic differentiation (urban, rural)	Areas were differentiated as urban, small urban and rural.																																
11. Average gram per mile VOC and NO _x emissions a. Fleetwide	<p>1990 and 1996 emission rates by County for Pennsylvania counties in the Philadelphia nonattainment area are presented below.</p> <table><tr><td></td><td>1990</td><td>1996</td><td>1996</td></tr><tr><td></td><td>VOC</td><td>VOC</td><td>NO_x</td></tr><tr><td><u>County</u></td><td><u>gm/mile</u></td><td><u>gm/mile</u></td><td><u>gm/mile</u></td></tr><tr><td>Bucks</td><td>2.52</td><td>2.20</td><td>2.95</td></tr><tr><td>Chester</td><td>2.00</td><td>1.87</td><td>2.98</td></tr><tr><td>Delaware</td><td>2.54</td><td>2.25</td><td>2.76</td></tr><tr><td>Montgomery</td><td>2.28</td><td>1.89</td><td>2.57</td></tr><tr><td>Philadelphia</td><td>3.56</td><td>2.82</td><td>2.95</td></tr></table>		1990	1996	1996		VOC	VOC	NO _x	<u>County</u>	<u>gm/mile</u>	<u>gm/mile</u>	<u>gm/mile</u>	Bucks	2.52	2.20	2.95	Chester	2.00	1.87	2.98	Delaware	2.54	2.25	2.76	Montgomery	2.28	1.89	2.57	Philadelphia	3.56	2.82	2.95
	1990	1996	1996																														
	VOC	VOC	NO _x																														
<u>County</u>	<u>gm/mile</u>	<u>gm/mile</u>	<u>gm/mile</u>																														
Bucks	2.52	2.20	2.95																														
Chester	2.00	1.87	2.98																														
Delaware	2.54	2.25	2.76																														
Montgomery	2.28	1.89	2.57																														
Philadelphia	3.56	2.82	2.95																														
b. Light-duty vehicles	Not available.																																

**Table II-3
Pittsburgh, PA**

Attributes	Description
1. VMT estimation methods	<p>To monitor conditions on the Pennsylvania highway system and to support its management, PennDOT developed the RMS. RMS is a computerized data base containing about 100,000 records covering each highway segment and section in the state system, plus the Pennsylvania Turnpike. A substantial body of traffic counts are conducted annually, including both HPMS control sections and other counts by MPOs, consultants, and PennDOT. All of this count data is loaded into RMS on a continuing basis, so that RMS contains current AADT volume estimates on all highway segments.</p> <p>RMS covers virtually all of the freeways, arterials, and collectors in the state, as well as a significant portion of the local streets, and it contains details describing both travel demand and supply characteristics.</p> <p>For the 6 county Pittsburgh area, the SWPRPC travel demand model was used to reflect network characteristics that affect roadway volumes, VMT, and speeds.</p>
2. Assignment of VMT to roadway functional classifications	Each highway segment in the RMS dataset contains a functional class code that is consistent with and forms the basis for the HPMS VMT accumulation. This functional class code, working with the county and urban/small urban/rural setting code, controlled the accumulation of segment VMT from the SIP RMS data set to produce VMT for each of the MOBILE categories.
3. Vehicle speed estimation methods and level of detail	The speed calculation process requires estimates of hourly traffic volumes on each segment. To support these calculations, the seasonally and daily adjusted traffic volume on each segment was disaggregated to 24 hourly volumes prior to analysis using pattern distribution data. PennDOT has developed typical hourly patterns for each functional class, setting, and region of the state, and the appropriate pattern distribution was selected and applied to the daily volume on each highway segment in the RMS data set to produce hourly traffic volumes.
	Speeds were individually calculated for each roadway segment and hour. VMT and vehicle hours of travel were then accumulated for each cell of the county, urban/small urban/rural setting, roadway functional class, time-of-day matrix; and accumulated VMT was divided by vehicle hours to produce a speed estimate.

Table II-3 (continued)

Attributes	Description																								
4. Registration distribution	Vehicle age distributions are based on the number of registered vehicles in each county. These distributions reflect the percentage of vehicles in the fleet up to 25 years old and are listed by the eight EPA vehicle types. The vehicle age distributions were downloaded from the PennDOT Bureau of Motor Vehicles Registration Data Base in July 1997.																								
5. Operating mode estimates	The default MOBILE operating mode fractions were used, consisting of 20.6 percent for cold starts and 27.3 percent for hot starts.																								
6. VMT mix by vehicle type	1996 RMS roadway truck percentages are used in combination with MOBILE5a default vehicle type percentages to the eight MOBILE vehicle types for each county and functional class combination.																								
7. Analysis years	There were emission estimates made for 1990 and 1996.																								
8. Temporal resolution	MOBILE is run for four time periods (morning and evening peaks, mid-day and night).																								
9. I/M and fuels program modeling assumptions	I/M programs in place during 1990 and 1996 were simulated. I/M programs were in place in Allegheny County and portions of Beaver, Washington, and Westmoreland counties in 1990. This is a basic I/M program design.																								
10. Intra-area geographic differentiation (urban, rural)	Areas were differentiated as urban, small urban, and rural, as well as by county. Also, three of the counties (Beaver, Washington, and Westmoreland) were differentiated by the portion with versus without I/M.																								
11. Average gram per mile VOC and NO _x emissions a. Fleetwide	<table><tr><th>County</th><th>1996 VOC gm/mile</th><th>1996 NO_x gm/mile</th></tr><tr><td>Allegheny</td><td>2.11</td><td>2.33</td></tr><tr><td>Armstrong</td><td>2.15</td><td>3.01</td></tr><tr><td>Beaver</td><td>1.99</td><td>3.52</td></tr><tr><td>Butler</td><td>1.99</td><td>3.25</td></tr><tr><td>Fayette</td><td>2.22</td><td>3.32</td></tr><tr><td>Washington</td><td>1.92</td><td>3.87</td></tr><tr><td>Westmoreland</td><td>1.91</td><td>3.27</td></tr></table>	County	1996 VOC gm/mile	1996 NO _x gm/mile	Allegheny	2.11	2.33	Armstrong	2.15	3.01	Beaver	1.99	3.52	Butler	1.99	3.25	Fayette	2.22	3.32	Washington	1.92	3.87	Westmoreland	1.91	3.27
County	1996 VOC gm/mile	1996 NO _x gm/mile																							
Allegheny	2.11	2.33																							
Armstrong	2.15	3.01																							
Beaver	1.99	3.52																							
Butler	1.99	3.25																							
Fayette	2.22	3.32																							
Washington	1.92	3.87																							
Westmoreland	1.91	3.27																							
b. Light-duty vehicles	Not available.																								

**Table II-4
Baltimore, MD**

Attributes	Description
1. VMT estimation methods	<p>The 1990 ozone precursor inventory for highway vehicles in the Baltimore nonattainment area, which consists of the City of Baltimore, plus Anne Arundel, Baltimore, Carroll, Harford, and Howard counties, is the hourly, transportation model link-based inventory. Total exhaust emissions were generated using VMT to estimate stabilized emissions and the number of trips to generate cold and hot start offsets. Therefore, emission factors for 100 percent stabilized operation, 100 percent cold start operation, and 100 percent hot start operation were used in the generation of exhaust emission estimates.</p> <p>For event-based emissions, trip data was developed by the transportation modeling group for each of the 631 zones in the transportation modeling network. Trip data was disaggregated based on hourly trip distributions, which varied according to six basic trip types.</p>
2. Assignment of VMT to roadway functional classifications	See number 6 below.
3. Vehicle speed estimation methods and level of detail	The Bureau of Public Roads (BPR) volume-to-capacity relationships were used to estimate hourly vehicle speeds for the transportation-modeling-based inventory work in the nonattainment area.
4. Registration distribution	<p>This was based on the July 1990 Maryland Motor Vehicle Administration's vehicle registration data base as it existed on July 1, 1990. A translation algorithm was developed to place the vehicle registration data as categorized by the MVA into MOBILE5 vehicle categories.</p> <p>Two sets of registration distributions were developed for the state of Maryland. An urban distribution was used for all I/M counties, and a separate rural distribution was used for non-I/M counties. All of the counties in the Baltimore nonattainment area were classified as urban.</p>

Table II-4 (continued)

Attributes	Description
5. Operating mode estimates	Maryland started with the 1990 trip tables by trip purpose. They then applied the data developed for the 1982 ozone SIP revision for the Baltimore area to develop an estimate of hot and cold transient VMT. The result was a new set of operating mode fractions reflecting local patterns of higher cold start and stabilized VMT compared with the MOBILE default operating mode fractions.
6. VMT mix by vehicle type	<p>VMT mix fractions by vehicle type was estimated using vehicle classification counts data collected by the Maryland State Highway Administration (SHA). These vehicle counts include 16 vehicle classifications. To develop VMT fractions for the eight MOBILE5 vehicle types, the state had to develop a translation algorithm to aggregate the 16 SHA vehicle classifications into the eight classifications used by the MOBILE model. Only weekday SHA classification counts were used to generate VMT mixes.</p> <p>Maryland also computed different VMT mixes for each hour of the day by roadway functional classification in order to capture differences in vehicle types traveling during different parts of the day.</p>
7. Analysis years	1990 is the base year. The 1996 periodic emission inventory estimates are being reviewed and will be released shortly.
8. Temporal resolution	Daily and hourly for 1990, but five time period basis from 1993 onwards.
9. I/M and fuels program modeling assumptions	I/M program modeling was based on the program characteristics in 1990. Counties with basic I/M programs then were: Anne Arundel, Baltimore, Carroll, Harford, Howard, Montgomery, Prince Georges, and Baltimore City.
10. Intra-area geographic differentiation (urban, rural)	Counties within the Baltimore ozone nonattainment area were all classified as urban. Counties outside the nonattainment area were considered rural.

Table II-4 (continued)

Attributes	Description
11. Average gram per mile VOC and NO _x emissions a. Fleetwide	<p>1990 ozone nonattainment area values:</p> <p>VOC 2.17 gm/mile NO_x 2.65 CO 19.4</p> <p>Note: The above estimates were calculated from the Baltimore area emission estimates on page 159 of the August 1993 Maryland Department of the Environment report divided by the Table 4-47 VMT (on page 147 of the same report).</p>
b. Light-duty vehicles	Not available.

**Table II-5
Washington, DC**

Attributes	Description
1. VMT estimation methods	<p>Emissions from on-road mobile sources were derived from the Metro COG's travel demand forecasting procedure, which simulates vehicle travel across the region's transportation system. Travel was simulated on all roadways in the region, including both volume and speed of travel for each hour of the day. Not all of the Washington, DC-VA-MD metropolitan statistical area (MSA) is currently covered by the regional transportation model. For outlying parts of the air quality planning area, more manual calculation methods were used, based on locally developed travel estimates.</p> <p>Observed traffic volumes are published each year in either map form, or in book form. These sources were assembled by COG and specific counts at each location in the region were coded, on the order of 12,000 links. One other complicating factor was the fact that most jurisdictions publish average daily travel (ADT) volumes. Only the District publishes average weekday daily travel volumes, which is what the travel modeling process attempts to simulate. Therefore, it was necessary to factor the published ADT counts to develop average weekday daily traffic values. This was accomplished by multiplying by 1.11.</p> <p>Comparisons were made between estimated and observed travel. This showed the model estimated values to be 3.4 percent greater than the observed values. Most jurisdictions compared favorably. Prince William County, VA was the exception as its travel was oversimulated by 19 percent. Modeled estimates were used without adjustment however, as traffic counts made during the 1980s may not have captured the high VMT growth in this county.</p>

Table II-5 (continued)

Attributes	Description
2. Assignment of VMT to roadway functional classifications	Traffic assignment is the modeling process to route vehicle trips onto the facilities represented in the network street system. This is performed at the zone level. To estimate traffic on each facility in a realistic fashion, a capacity restraint procedure is used. This involves assigning successive portions of the trip table and computing congestion levels after each increment of traffic. The procedure uses speed-flow curves associated with each functional classification of facilities. Level of service A is the starting point in the process, i.e., free flow speeds; as traffic is assigned to each facility, speeds decrease and subsequent traffic is routed to other facilities, and an equilibrium state is approached.
3. Vehicle speed estimation methods and level of detail	The emissions post-processor converts daily volumes to hourly volumes as a function of facility characteristics developed from traffic data and speed estimation associated with travel for each hour of the day as a function of volume to capacity ratios applied to speed flows curves for each facility type.
4. Registration distribution	Local registration distributions are used. These were developed at the county-level with a separate distribution used for each county. For all counties, the heavy-duty gasoline vehicle (HDGV) and HDDV registration distributions used were the MOBILE5 defaults.
5. Operating mode estimates	A hybrid modeling approach is used which places cold and start emissions at trip origins, with running emissions estimated to be 100 percent in the hot stabilized mode.
6. VMT mix by vehicle type	Two separate VMT mixes by vehicle type were used in the Wash COG modeling. One VMT mix was used to characterize the urbanized counties within the Washington metro area and the other was used to characterize the ex-urban counties within the Washington metro area. Ex-urban counties are those that did not have an I/M program in 1990. These VMT mixes were obtained from COG's Department of Transportation Planning, and override the default MOBILE5 VMT mix.
7. Analysis years	1990 is the base year inventory. Estimates have also been made for 1996 and 1999 for the ROP plans.
8. Temporal resolution	By hour of the day using transportation planning model estimates of time-of-day travel differences.

Table II-5 (continued)

Attributes	Description																																																								
9. I/M and fuels program modeling assumptions	Basic I/M program parameters were used to estimate 1990 emissions for the counties in the metro area with vehicle inspection programs at that time. I/M programs were modeled in DC, Alexandria, Arlington, Fairfax, Prince William, Montgomery, and Prince George's counties. Enhanced I/M programs were not in place by 1996. If the ROP plan includes enhanced I/M benefits for 1996, then these need to be adjusted for comparison with PAMS data. The 1996 emission estimates include the benefits of Federal Phase I reformulated gasoline.																																																								
10. Intra-area geographic differentiation (urban, rural)	Emission rates differ by urban versus ex-urban area within MD and VA. All of DC is considered urban.																																																								
11. Average gram per mile VOC and NO _x emissions a. Fleetwide	<p>1990 emission rates by County for Metropolitan Washington nonattainment area counties are presented below:</p> <table><tr><td></td><td>VOC</td><td>NO_x</td><td>CO</td></tr><tr><td><u>County</u></td><td><u>gm/mile</u></td><td><u>gm/mile</u></td><td><u>gm/mile</u></td></tr><tr><td>DC</td><td>3.09</td><td>2.25</td><td>23.8</td></tr><tr><td>Montgomery</td><td>1.95</td><td>2.22</td><td>15.4</td></tr><tr><td>Prince Georges</td><td>2.09</td><td>2.22</td><td>16.6</td></tr><tr><td>Arlington</td><td>3.00</td><td>2.24</td><td>22.7</td></tr><tr><td>Alexandria</td><td>3.19</td><td>2.31</td><td>23.2</td></tr><tr><td>Fairfax</td><td>2.21</td><td>2.23</td><td>17.9</td></tr><tr><td>Loudoun</td><td>2.51</td><td>2.70</td><td>18.5</td></tr><tr><td>Prince William</td><td>2.41</td><td>2.56</td><td>20.9</td></tr><tr><td>Frederick</td><td>2.15</td><td>3.18</td><td>24.2</td></tr><tr><td>Charles</td><td>2.37</td><td>2.86</td><td>18.0</td></tr><tr><td>Stafford</td><td>2.43</td><td>3.02</td><td>27.1</td></tr><tr><td>Calvert</td><td>2.63</td><td>2.93</td><td>19.3</td></tr></table>		VOC	NO _x	CO	<u>County</u>	<u>gm/mile</u>	<u>gm/mile</u>	<u>gm/mile</u>	DC	3.09	2.25	23.8	Montgomery	1.95	2.22	15.4	Prince Georges	2.09	2.22	16.6	Arlington	3.00	2.24	22.7	Alexandria	3.19	2.31	23.2	Fairfax	2.21	2.23	17.9	Loudoun	2.51	2.70	18.5	Prince William	2.41	2.56	20.9	Frederick	2.15	3.18	24.2	Charles	2.37	2.86	18.0	Stafford	2.43	3.02	27.1	Calvert	2.63	2.93	19.3
	VOC	NO _x	CO																																																						
<u>County</u>	<u>gm/mile</u>	<u>gm/mile</u>	<u>gm/mile</u>																																																						
DC	3.09	2.25	23.8																																																						
Montgomery	1.95	2.22	15.4																																																						
Prince Georges	2.09	2.22	16.6																																																						
Arlington	3.00	2.24	22.7																																																						
Alexandria	3.19	2.31	23.2																																																						
Fairfax	2.21	2.23	17.9																																																						
Loudoun	2.51	2.70	18.5																																																						
Prince William	2.41	2.56	20.9																																																						
Frederick	2.15	3.18	24.2																																																						
Charles	2.37	2.86	18.0																																																						
Stafford	2.43	3.02	27.1																																																						
Calvert	2.63	2.93	19.3																																																						
b. Light-duty vehicles	Not available.																																																								

**Table II-6
Richmond, VA**

Attributes	Description																																
1. VMT estimation methods	The MINUTP traffic demand model was used for the Richmond area.																																
2. Assignment of VMT to roadway functional classifications	Not available.																																
3. Vehicle speed estimation methods and level of detail	Vehicle speed estimates are as predicted by the MINUTP model by road class for each jurisdiction. Speeds for all road classes not included in the network modeling analysis were developed from data on observed travel conditions.																																
4. Registration distribution	1996 jurisdiction-specific vehicle registration data was used as MOBILE5a input. Note that local registration data was not used for Colonial Heights and Hopewell because it was decided that local data did not accurately reflect the amount of interstate, industrial, or commercial activity in these areas (especially in heavy-duty vehicles [HDVs]).																																
5. Operating mode estimates	Not available.																																
6. VMT mix by vehicle type	Not available.																																
7. Analysis years	The latest emission estimates are for 1996.																																
8. Temporal resolution	Daily.																																
9. I/M and fuels program modeling assumptions	No I/M program was in place during 1996. The 1996 emission estimates include the benefits of Federal Phase I reformulated gasoline.																																
10. Intra-area geographic differentiation (urban, rural)	Not available.																																
11. Average gram per mile VOC and NO _x emissions a. Fleetwide	<p>1996 emission rates by County and independent city are listed below:</p> <table><thead><tr><th></th><th>VOC gm/mile</th><th>NO_x gm/mile</th><th>CO gm/mile</th></tr></thead><tbody><tr><td><u>County</u></td><td></td><td></td><td></td></tr><tr><td>Chesterfield (County)</td><td>1.49</td><td>2.44</td><td>10.6</td></tr><tr><td>Colonial Heights City</td><td>1.48</td><td>2.77</td><td>10.9</td></tr><tr><td>Hanover (County)</td><td>1.43</td><td>2.83</td><td>10.4</td></tr><tr><td>Henrico (County)</td><td>1.54</td><td>2.25</td><td>11.4</td></tr><tr><td>Hopewell City</td><td>1.76</td><td>2.47</td><td>13.3</td></tr><tr><td>Richmond City</td><td>1.80</td><td>2.65</td><td>13.3</td></tr></tbody></table>		VOC gm/mile	NO _x gm/mile	CO gm/mile	<u>County</u>				Chesterfield (County)	1.49	2.44	10.6	Colonial Heights City	1.48	2.77	10.9	Hanover (County)	1.43	2.83	10.4	Henrico (County)	1.54	2.25	11.4	Hopewell City	1.76	2.47	13.3	Richmond City	1.80	2.65	13.3
	VOC gm/mile	NO _x gm/mile	CO gm/mile																														
<u>County</u>																																	
Chesterfield (County)	1.49	2.44	10.6																														
Colonial Heights City	1.48	2.77	10.9																														
Hanover (County)	1.43	2.83	10.4																														
Henrico (County)	1.54	2.25	11.4																														
Hopewell City	1.76	2.47	13.3																														
Richmond City	1.80	2.65	13.3																														
b. Light-duty vehicles	Not available.																																

**Table II-7
Tidewater, VA**

Attributes	Description
1. VMT estimation methods	The MINUTP traffic demand model was used for the Tidewater area.
2. Assignment of VMT to roadway functional classifications	Not available.
3. Vehicle speed estimation methods and level of detail	Vehicle speed estimates are as predicted by the MINUTP model by road class for each jurisdiction. Speeds for all road classes not included in the network modeling analysis were developed from data on observed travel conditions.
4. Registration distribution	1996 jurisdiction-specific vehicle registration data was used as MOBILE5a input. Note that local registration data was not used for Williamsburg because it was decided that local data did not accurately reflect the amount of interstate, industrial, or commercial activity in this area (especially in heavy-duty vehicles).
5. Operating mode estimates	Not available.
6. VMT mix by vehicle type	Not available.
7. Analysis years	The latest emission estimates are for 1996.
8. Temporal resolution	Daily.
9. I/M and fuels program modeling assumptions	No I/M program was in place during 1996. The 1996 emission estimates include the benefits of Federal Phase I reformulated gasoline.
10. Intra-area geographic differentiation (urban, rural)	Not available.
11. Average gram per mile VOC and NO _x emissions	

Table II-7 (continued)

Attributes	Description																																																				
a. Fleetwide	<p>1996 emission rates by County and independent city for the Tidewater/ Hampton Roads ozone nonattainment area are listed below:</p> <table><tr><td></td><td>VOC</td><td>NO_x</td><td>CO</td></tr><tr><td><u>County</u></td><td><u>gm/mile</u></td><td><u>gm/mile</u></td><td><u>gm/mile</u></td></tr><tr><td>Chesapeake City</td><td>1.88</td><td>2.47</td><td>13.9</td></tr><tr><td>Hampton</td><td>1.83</td><td>2.20</td><td>13.8</td></tr><tr><td>James City (County)</td><td>1.48</td><td>2.09</td><td>10.9</td></tr><tr><td>Newport News</td><td>1.71</td><td>2.06</td><td>12.8</td></tr><tr><td>Norfolk</td><td>2.31</td><td>2.72</td><td>17.2</td></tr><tr><td>Poquoson</td><td>2.71</td><td>1.95</td><td>21.8</td></tr><tr><td>Portsmouth</td><td>2.44</td><td>2.55</td><td>18.5</td></tr><tr><td>Suffolk</td><td>2.02</td><td>2.55</td><td>14.7</td></tr><tr><td>Virginia Beach</td><td>1.46</td><td>1.84</td><td>10.8</td></tr><tr><td>Williamsburg</td><td>1.58</td><td>1.83</td><td>12.2</td></tr><tr><td>York (County)</td><td>1.57</td><td>2.07</td><td>11.6</td></tr></table>		VOC	NO _x	CO	<u>County</u>	<u>gm/mile</u>	<u>gm/mile</u>	<u>gm/mile</u>	Chesapeake City	1.88	2.47	13.9	Hampton	1.83	2.20	13.8	James City (County)	1.48	2.09	10.9	Newport News	1.71	2.06	12.8	Norfolk	2.31	2.72	17.2	Poquoson	2.71	1.95	21.8	Portsmouth	2.44	2.55	18.5	Suffolk	2.02	2.55	14.7	Virginia Beach	1.46	1.84	10.8	Williamsburg	1.58	1.83	12.2	York (County)	1.57	2.07	11.6
	VOC	NO _x	CO																																																		
<u>County</u>	<u>gm/mile</u>	<u>gm/mile</u>	<u>gm/mile</u>																																																		
Chesapeake City	1.88	2.47	13.9																																																		
Hampton	1.83	2.20	13.8																																																		
James City (County)	1.48	2.09	10.9																																																		
Newport News	1.71	2.06	12.8																																																		
Norfolk	2.31	2.72	17.2																																																		
Poquoson	2.71	1.95	21.8																																																		
Portsmouth	2.44	2.55	18.5																																																		
Suffolk	2.02	2.55	14.7																																																		
Virginia Beach	1.46	1.84	10.8																																																		
Williamsburg	1.58	1.83	12.2																																																		
York (County)	1.57	2.07	11.6																																																		
b. Light-duty vehicles	Not available.																																																				

**Table II-8
Raleigh-Durham, NC**

Attributes	Description
1. VMT estimation methods	The NC DOT provided data on VMT for six urban and six rural road types. VMT for NC counties were provided by the Statewide Planning Branch of the Division of Highways of the NC DOT. The 1987-1988 VMT for counties in the airshed model domain were obtained from the annual HPMS VMT reported to the Federal Highway Administration (FHWA). NC records AADT for all roads in all functional classifications. However, only 73.8 percent of the local functionally classified road mileage was covered by counts. For links without counts, an ADT of 400 vehicles per day was assumed.
2. Assignment of VMT to roadway functional classifications	A separate VMT mix is provided for each roadway functional class.
3. Vehicle speed estimation methods and level of detail	The speed estimates produced by the NC DOT were estimated by each roadway functional classification using the NC highway speeds report for 1990. A single average speed was assumed for each functional road type.
4. Registration distribution	Because the NC Department of Motor Vehicles (DMV) was not able to provide registration records by age for the in-use fleet, NC accident data was used to estimate the vehicle age distribution by type and age. The accident studies section of NC DOT provided the number, type and age of the vehicles involved in accidents in North Carolina during 1990. Using these data required converting NC DOT's vehicle types to EPA's vehicle categories, and computing registration distributions by vehicle type and age. (Use of data for the entire state might not represent the distributions in the urban areas of interest.)
5. Operating mode estimates	The Federal Test Procedure operating mode fractions were applied in all MOBILE5 simulations (20.6, 27.3, 20.6) These are the MOBILE5 defaults.

Table II-8 (continued)

Attributes	Description
6. VMT mix by vehicle type	<p>Counts taken during 1987-1990 from automatic traffic recording stations and selected HPMS locations were used to determine the percentage of vehicles, by vehicle type, for the different road types. Vehicle types reported by the NC DOT were as follows:</p> <ol style="list-style-type: none">1. Passenger Cars2. Pickups3. Buses4. 2 axle trucks5. 3 axle trucks6. 4 axle trucks7. 4 axle tractor semi-trailer8. 5 axle tractor semi-trailer9. 6 axle tractor semi-trailer10. 5 axle twin11. 6 axle twin12. 7 axle twin
7. Analysis years	1990, 1999, 2005 as well as episode days in 1987 and 1988.
8. Temporal resolution	Daily for 1990, 1999 and 2005. Hourly for urban airshed modeling episode days.
9. I/M and fuels program modeling assumptions	Accident data from 1992 were used to estimate the fraction of vehicles operating in each of the NC counties that were subject to I/M programs. In 1990, only Wake County was subject to an I/M program. This was a CO-only program in the base year. A compliance rate of 95.2 percent was used in 1990 estimates.
10. Intra-area geographic differentiation (urban, rural)	Not available.

Table II-8 (continued)

Attributes	Description																
11. Average gram per mile VOC and NO _x emissions																	
a. Fleetwide	<div>These values are computed for 1988 episode conditions:</div> <table><tr><td><u>County</u></td><td><u>VOC gm/mile</u></td><td><u>NO_x gm/mile</u></td><td><u>CO gm/mile</u></td></tr><tr><td>Durham</td><td>3.18</td><td>4.07</td><td>23.8</td></tr><tr><td>Granville</td><td>2.23</td><td>4.36</td><td>21.0</td></tr><tr><td>Wake</td><td>2.41</td><td>2.63</td><td>16.3</td></tr></table>	<u>County</u>	<u>VOC gm/mile</u>	<u>NO_x gm/mile</u>	<u>CO gm/mile</u>	Durham	3.18	4.07	23.8	Granville	2.23	4.36	21.0	Wake	2.41	2.63	16.3
<u>County</u>	<u>VOC gm/mile</u>	<u>NO_x gm/mile</u>	<u>CO gm/mile</u>														
Durham	3.18	4.07	23.8														
Granville	2.23	4.36	21.0														
Wake	2.41	2.63	16.3														
b. Light-duty vehicles	Not available.																

**Table II-9
Charlotte, NC**

Attributes	Description
1. VMT estimation methods	<p>The NC DOT provided data on VMT for six urban and six rural road types. VMT for NC counties were provided by the Statewide Planning Branch of the Division of Highways of the NC DOT. The VMT for South Carolina counties in the Charlotte NA area were obtained from the SC DOT. The 1987-1988 VMT for counties in the airshed model domain were obtained from the annual HPMS VMT reported to FHWA. NC records annual AADT for all roads in all functional classifications. However, only 73.8 percent of the local functionally classified road mileage was covered by counts. For links without counts, an ADT of 400 vehicles per day was assumed.</p> <p>Note that recent travel demand modeling for the Charlotte Metropolitan area produces a VMT estimate that is significantly higher than was determined from the HPMS data that was used in the 1990 inventory development.</p>
2. Assignment of VMT to roadway functional classifications	A separate VMT mix is provided for each roadway functional class.
3. Vehicle speed estimation methods and level of detail	The speed estimates produced by the NC DOT were estimated by each roadway functional classification using the NC highway speeds report for 1990. A single average speed was assumed for each functional road type.
4. Registration distribution	Because the NC DMV was not able to provide registration records by age for the in-use fleet, NC accident data was used to estimate the vehicle age distribution by type and age. The accident studies section of NC DOT provided the number, type and age of the vehicles involved in accidents in North Carolina during 1990. Using these data required converting NC DOT's vehicle types to EPA's vehicle categories, and computing registration distributions by vehicle type and age. (Use of data for the entire state might not represent the distributions in the urban areas of interest.)
5. Operating mode estimates	The Federal Test Procedure operating mode fractions were applied in all MOBILE5 simulations (20.6, 27.3, 20.6) These are the MOBILE5 defaults.

Table II-9 (continued)

Attributes	Description
6. VMT mix by vehicle type	<p>Counts taken during 1987-1990 from automatic traffic recording stations and selected HPMS locations were used to determine the percentage of vehicles, by vehicle type, for the different road types. Vehicle types reported by the NC DOT were as follows:</p> <ol style="list-style-type: none"> 1. Passenger Cars 2. Pickups 3. Buses 4. 2 axle trucks 5. 3 axle trucks 6. 4 axle trucks 7. 4 axle tractor semi-trailer 8. 5 axle tractor semi-trailer 9. 6 axle tractor semi-trailer 10. 5 axle twin 11. 6 axle twin 12. 7 axle twin
7. Analysis years	1990, 1999, 2005 as well as episode days in 1987 and 1988.
8. Temporal resolution	Daily for 1990, 1999 and 2005. Hourly for urban airshed modeling episode days.
9. I/M and fuels program modeling assumptions	Accident data from 1992 were used to estimate the fraction of vehicles operating in each of the NC counties that were subject to I/M programs. In 1990, only Mecklenburg County was subject to an I/M program. This was a CO-only program in the base year. A compliance rate of 95.2 percent was used in 1990 estimates.
10. Intra-area geographic differentiation (urban, rural)	Not available.

Table II-9 (continued)

Attributes	Description																
11. Average gram per mile VOC and NO _x emissions a. Fleetwide	<div>These values are computed for 1988 episode conditions:</div> <table><tr><td></td><td>VOC</td><td>NO_x</td><td>CO</td></tr><tr><td><u>County</u></td><td><u>gm/mile</u></td><td><u>gm/mile</u></td><td><u>gm/mile</u></td></tr><tr><td>Gaston</td><td>2.15</td><td>2.65</td><td>15.17</td></tr><tr><td>Mecklenburg</td><td>4.12</td><td>4.06</td><td>28.32</td></tr></table>		VOC	NO _x	CO	<u>County</u>	<u>gm/mile</u>	<u>gm/mile</u>	<u>gm/mile</u>	Gaston	2.15	2.65	15.17	Mecklenburg	4.12	4.06	28.32
	VOC	NO _x	CO														
<u>County</u>	<u>gm/mile</u>	<u>gm/mile</u>	<u>gm/mile</u>														
Gaston	2.15	2.65	15.17														
Mecklenburg	4.12	4.06	28.32														
b. Light-duty vehicles	Not available.																

these two jurisdictions, in practice, there is likely to be less of a real emissions difference between these two areas than these figures indicate.

Table II-10 summarizes some of the most important mobile source emission estimation methods differences noted above. These are listed according to the key attributes that were investigated in this study. The gasoline volatility estimates provided in Table II-10 are taken from the recent EPA National Emission Trends Procedures Report (EPA, 1998) in order to provide RVP values that are all from the same time period (summer 1996). Only the Philadelphia and Washington RVPs are measured values. RVP estimates for the other cities are estimated from those in nearby survey cities.

The potential implications of the inter-city highway vehicle emission differences noted above are as follows:

1. SIP planners make decisions about control measure adoption based on the relative share of mobile versus stationary source VOC and NO_x emissions. Analysis method differences that shift these shares compared with other nearby nonattainment areas may produce attainment strategies that have different than intended effects.
2. Many control strategy decisions in the mid-Atlantic States are now made based on regional modeling. Highway vehicle emission differences that are solely the result of analysis method differences add uncertainty to the regional modeling predictions.
3. Comparisons between emissions and ambient ozone precursor estimates are affected by the magnitude and ratio of VOC and NO_x emissions. Both local and metropolitan area emissions data should be used in such comparisons, especially where the fleet composition and allocations of VMT to roadway types differs markedly from county-to-county. (It may not be advisable to use county-level vehicle registration data in metropolitan area emission estimates where there is significant cross county boundary travel.)

The three Type II PAMS sites in the mid-Atlantic States are in Philadelphia, Baltimore, and Washington. While there was PAMS data collected in other urban areas in the mid-Atlantic, these were short-term studies. Therefore, the primary candidates for more detailed study in this analysis were Philadelphia, Baltimore, and Washington. The Pechan-Avanti Group (Pechan-Avanti) recommended that the Baltimore and Washington PAMS sites and emission inventories be the areas for more detailed study for three reasons:

1. The highway vehicle emission estimation methods used in the Baltimore and Washington, DC areas are the most rigorous of the urban areas evaluated.
2. PA and NJ portions of the Philadelphia area are likely to affect pollutant concentrations at the East Lycoming Street PAMS site. With somewhat different emission inventory methods, data handling and results interpretation were likely to be more difficult for the Philadelphia site.
3. The nearby Sun Oil and Tosco Refineries just south of the Philadelphia downtown area may make it difficult to isolate the mobile source signature there.

Table II-10
Summary of Mobile Emission Estimation Method Differences

Attributes	Methods and Analysis Differences
Assignment of VMT among vehicle types	Some areas use MOBILE5 default fractions with separate information for trucks. Others translate State Highway Administration vehicle classifications into MOBILE5 types. Another area used separate urban and rural county vehicle mixes from transportation data. <i>Department of Transportation vehicle type classifications are not always the best for distinguishing cars versus light trucks and gas from diesel trucks.</i>
Allocating VMT by roadway type	This was done by either (1) using different VMT mixes by hour of the day by roadway type; (2) translating traffic counts to AADT estimates; or (3) via the traffic assignment process in the network modeling analysis.
Estimating vehicle speeds by roadway type	Methods vary from using a single average speed for each roadway type to using travel demand model estimated values to using volume-to-capacity ratios and speed versus flow curves for each facility type.
Different gasoline volatility, expressed as RVP	Representative July 1996 RVP values: Pittsburgh, PA 8.5 psi Philadelphia, PA 7.9 Baltimore, MD 7.5 Charlotte and Raleigh, NC 7.6 Washington, DC 7.0 Richmond and Tidewater, VA 7.0

CHAPTER III

HIGHWAY VEHICLE EMISSION ESTIMATION METHODS - COMPARING NET96, SIP, AND OTAG

The purpose of this chapter is to summarize and compare the highway vehicle emission estimates that have been made by the States for rate-of-progress or SIP analyses with those that have been developed for the OTAG modeling and for the EPA National Emissions Trends (NET) Report. Comparisons are made for the same eight metropolitan areas that were examined in Chapter II. These areas are: Philadelphia, PA; Pittsburgh, PA; Baltimore, MD; Washington, DC; Richmond, VA; Tidewater, VA; Raleigh-Durham, NC; and Charlotte, NC. The area definitions used in this analysis are those used in the EPA *Green Book* for classification purposes. Some of these metropolitan areas are ozone nonattainment areas and some are maintenance areas (under the one hour average ozone National Ambient Air Quality Standard).

Highway vehicle emission comparisons are displayed in a series of tables, one per metropolitan area. Both VOC and NO_x emission estimates are provided in these tables. The State Implementation Plan/Rate of Progress Plan emission estimates are the 1996 ozone season daily values estimated by the respective States for these areas. For some areas, these 1996 emission estimates are in published SIP documents, but for others, the emission values are currently unpublished, and were supplied by the States on request. The 1996 NET emission estimates are calendar year 1996 ozone season values. They are from the 1997 NET report. The report itself does not contain metropolitan area emission summaries. The metropolitan area emission summaries were developed from the NET data base, and are also available on the internet at www.pechan.com.

A. OTAG EMISSION ESTIMATES

The primary data source for the OTAG Inventory was the States. Where States were unable to provide data, EPA's 1990 Interim Inventory was used to provide data. The Interim Inventory is a comprehensive county/source level inventory of VOC, NO_x, CO, and sulfur dioxide (SO₂). The Interim Inventory was developed in 1992 by EPA to serve as the emission inventory input file for EPA's Regional Oxidant Model (ROM). For highway vehicles, the primary activity estimator is the FHWA's HPMS. HPMS VMT was allocated to counties using population. Emission factors were estimated using MOBILE5.

During the OTAG process, inputs needed to estimate highway vehicle emissions (VMT and MOBILE5 input files) were collected from the States, instead of the emission estimates themselves. This approach was used because highway vehicle emissions are temperature depending, and the modeling protocols were sophisticated enough to account for geographic and temporal temperature differences during specific modeling episodes. Thus, all OTAG highway vehicle emission estimates are episode-specific.

The MARAMA States that supplied VMT estimates to EPA for use in the OTAG Inventory included New Jersey, Pennsylvania, Delaware, and North Carolina. The 1990 Interim Inventory VMT estimates were used for the other MARAMA States. MARAMA States supplied MOBILE input files for the Pittsburgh, Philadelphia-Wilmington-Trenton, Baltimore, Raleigh-Durham, and Charlotte nonattainment or maintenance areas.

State and area-specific I/M program characteristics were modeled. There are differences in the I/M program parameters for each State, with some States having different programs in their different nonattainment areas. Table III-1 shows which States were modeled with an I/M program, and which programs had an anti-tampering component. All of the programs had annual emission inspections, with the exception of Delaware, Maryland, and Virginia, which had biennial testing. The other important program attribute affecting the emission calculation is whether inspections are performed at test-only versus test-and-repair stations. Test-and-repair programs received only 50 percent of the I/M credit given to a test-only program (using MOBILE5a). States with test-only programs included DC, Delaware, Maryland, and New Jersey. All of the I/M test types were idle tests.

B. NATIONAL EMISSION TRENDS

A short summary of the Trends highway vehicle emission estimation methods is provided herein. A more detailed explanation is available in the National Air Pollutant Emission Trends, Procedures Document, 1900-1996. The most recent version of the Procedures Document is available at the EPA website.

Annual VMT estimates for 1996 were obtained from the FHWA HPMS data base for that year. The data are specified by State, vehicle type, and roadway type. Using population data from the 1990 Census, VMT was allocated to counties. VMT is then apportioned from the HPMS vehicle categories to the eight MOBILE5 vehicle classes using allocations provided by EPA's Office of Mobile Sources.

The resulting annual county-level vehicle and roadway type specific VMT estimates were allocated by month. The monthly allocation was made by first using National Acid Precipitation Assessment Program (NAPAP) temporal allocation factors to go from annual to seasonal. Monthly VMT was then estimated using ratios of the number of days per month to the number of days per season.

MOBILE5b was used to compute 1996 VOC and NO_x emission factors. MOBILE5b inputs included State-level monthly maximum and minimum temperatures, nine vehicle speeds, national vehicle registration distributions, gasoline volatility expressed in terms of in-use RVP, and county-level I/M and oxygenated fuels programs. Hot and cold start percentages are those estimated for the Federal Test Procedure (FTP). For OTAG States that provided such data, Trends included local registration distributions, I/M program characteristics, and summer gasoline RVP estimates.

Table III-1
OTAG I/M Program Coverage
Mid-Atlantic States

State	County	I/M Program?	Anti-tampering Program?
DC	Washington	Yes	No
Delaware	Kent Co	Yes	No
Delaware	New Castle Co	Yes	No
Delaware	Sussex Co	Yes	No
Maryland	Anne Arundel Co	Yes	Yes
Maryland	Baltimore	Yes	Yes
Maryland	Baltimore Co	Yes	Yes
Maryland	Carroll Co	Yes	Yes
Maryland	Harford Co	Yes	Yes
Maryland	Howard Co	Yes	Yes
Maryland	Montgomery Co	Yes	Yes
Maryland	Prince Georges Co	Yes	Yes
New Jersey	Hudson Co	Yes	Yes
New Jersey	Hunterdon Co	Yes	Yes
New Jersey	Mercer Co	Yes	Yes
New Jersey	Middlesex Co	Yes	Yes
New Jersey	Monmouth Co	Yes	Yes
New Jersey	Morris Co	Yes	Yes
New Jersey	Ocean Co	Yes	Yes
New Jersey	Passaic Co	Yes	Yes
New Jersey	Salem Co	Yes	Yes
New Jersey	Somerset Co	Yes	Yes
New Jersey	Sussex Co	Yes	Yes
New Jersey	Union Co	Yes	Yes
New Jersey	Warren Co	Yes	Yes
North Carolina	Mecklenburg Co	Yes	Yes
North Carolina	Wake Co	Yes	Yes
Pennsylvania	Allegheny Co	Yes	No
Pennsylvania	Beaver Co	Yes	No

Table III-1 (continued)

State	County	I/M Program?	Anti-tampering Program?
Pennsylvania	Bucks Co	Yes	No
Pennsylvania	Chester Co	Yes	No
Pennsylvania	Delaware Co	Yes	No
Pennsylvania	Lehigh Co	Yes	No
Pennsylvania	Montgomery Co	Yes	No
Pennsylvania	Northampton Co	Yes	No
Pennsylvania	Philadelphia Co	Yes	No
Pennsylvania	Washington Co	Yes	No
Pennsylvania	Westmoreland Co	Yes	No
Virginia	Alexandria	Yes	Yes
Virginia	Arlington Co	Yes	Yes
Virginia	Fairfax	Yes	Yes
Virginia	Fairfax Co	Yes	Yes
Virginia	Falls Church	Yes	Yes
Virginia	Prince William Co	Yes	Yes

C. OBSERVATIONS

Tables III-2 through III-9 report highway vehicle emissions by vehicle type for the eight mid-Atlantic State urban areas of interest.

D. GENERAL CAVEATS

When comparing NET and OTAG emissions for a given area, note that the OTAG inventory is a 1995 inventory, while the NET is a 1996 inventory. Therefore, an additional year of penetration has occurred in the NET for the Tier 1 emission standards, which would cause the light duty emission factors in the NET to be lower than the corresponding emission factors in OTAG. Also, the NET was calculated using MOBILE5b, while the OTAG inventory was calculated using MOBILE5a. In addition, the NET emissions represent an average 1996 July day, while the OTAG inventory was calculated using the specific conditions that occurred on July 13, 1995.

1. Washington, DC

The Metropolitan Washington COG uses a significant amount of area-specific information in its MOBILE input files. These include registration distributions that vary by county, trip length distributions, diesel sales fractions that vary by county, as well as its control program inputs, including I/M. These inputs were captured in both the OTAG and NET inventories. However, COG also calculates highway vehicle emission inventories using a trip-based methodology in which emission factors are broken down by the cold start, hot start, and stabilized modes and with VOC emission factors broken down by component. This level of detail is not matched in either the OTAG or NET inventories.

In total, the DC SIP emissions match well with the OTAG emissions for VOC and with the NET emissions for NO_x. However, there are large differences between the three inventories for some of the specific vehicle types. The default HDDV emission factors in MOBILE5a are approximately 15 percent less than the default HDDV emission factors in MOBILE5b for model years 1990 and later. The OTAG modeling included corrections to the MOBILE5a HDDV emission factors that essentially mirror the corrections that were made in MOBILE5b. From the description provided with the DC 1996 emissions, it appears that the default MOBILE5a HDDV emission factors were used, which could account for the lower NO_x emissions in the DC SIP column than in either the NET (which used MOBILE5b) or OTAG. The SIP light-duty gasoline vehicle (LDGV) emissions are higher than both the NET and OTAG emissions for both VOC and NO_x. This is likely to be caused by higher LDGV VMT modeled by DC, although a breakdown of the DC SIP VMT was not provided by vehicle type. It appears that the shift from LDGV VMT towards light-duty gasoline truck (LDGT) VMT is not reflected in the DC SIP VMT, as the ratio between the SIP LDGT and LDGV emissions is dominated by the LDGV emissions. The OTAG inventory included about 72 percent of VMT in the LDGV category compared with 60 percent in the NET while LDGT VMT accounts for 21 percent of the OTAG VMT and 33 percent in the NET. These VMT trends are reflected in both the VOC and NO_x emission trends, where the NET LDGV emissions are lower than the OTAG emissions and the NET LDGT emissions are higher than the OTAG emissions.

Table III-2
Philadelphia, PA Highway Vehicle Emissions Comparison

Vehicle Type	VOC Emissions (tons per day [tpd])			NO _x Emissions (tpd)		
	SIP/ROP Inventory	NET96	OTAG	SIP	NET96	OTAG
Light-duty gasoline-powered vehicles (LDGVs)	139.62	130.50	198.52	130.87	145.00	217.92
Light-duty gasoline-powered trucks 1 (LDGT1)	56.54	62.50	23.49	50.03	63.78	25.62
Light-duty gasoline-powered trucks 2 (LDGT2)	32.11	38.95	17.54	25.89	37.58	17.16
Heavy-duty gasoline-powered vehicles (HDGV)	17.40	11.26	5.89	17.91	13.77	9.32
Light-duty diesel-powered vehicles (LDDV)	0.09	0.77	2.41	0.28	1.97	6.24
Light-duty diesel-powered trucks (LDDT)	0.07	0.37	0.31	0.17	0.75	0.69
Heavy-duty diesel-powered vehicles (HDDV)	10.33	11.26	6.38	98.60	84.38	48.02
Motorcycles	5.26	2.67	7.58	0.56	0.58	1.26
Total Highway Vehicle	261.42	258.27	262.12	524.28	347.82	326.23

NOTES: The SIP/ROP 1996 emission estimates in this table include the 5 Pennsylvania counties in the Philadelphia-Wilmington-Trenton ozone nonattainment area and the 6 New Jersey counties. PA highway emission estimates were available by vehicle type. New Jersey provided county-level highway vehicle emission estimates for 1996. The distribution of 1996 highway vehicle emissions by vehicle type was approximated using 1990 emissions distributions provided by the New Jersey Department of Environmental Protection.

**Table III-3
Pittsburgh, PA Highway Vehicle Emissions Comparison**

Vehicle Type	VOC Emissions (tpd)			NO _x Emissions (tpd)		
	SIP/ROP Inventory	NET96	OTAG	SIP	NET96	OTAG
Light-duty gasoline-powered vehicles (LDGVs)	62.54	59.60	116.56	66.29	62.58	99.22
Light-duty gasoline-powered trucks 1 (LDGT1)	25.29	27.99	5.97	25.66	27.49	5.64
Light-duty gasoline-powered trucks 2 (LDGT2)	15.42	18.91	5.55	13.78	16.98	4.71
Heavy-duty gasoline-powered vehicles (HDGV)	7.17	5.98	1.80	10.46	6.79	2.23
Light-duty diesel-powered vehicles (LDDV)	0.05	0.31	1.59	0.18	0.87	4.20
Light-duty diesel-powered trucks (LDDT)	0.04	0.16	0.19	0.11	0.34	0.47
Heavy-duty diesel-powered vehicles (HDDV)	5.08	5.66	1.18	52.14	43.85	9.50
Motorcycles	2.87	1.49	6.66	0.50	0.28	0.79
Total Highway Vehicle	118.46	120.10	139.50	169.12	159.18	126.77

**Table III-4
Baltimore, MD Highway Vehicle Emissions Comparison**

Vehicle Type	VOC Emissions (tpd)			NO _x Emissions (tpd)		
	1996 Periodic Emission Inventory (PEI)	NET96	OTAG	PEI	NET96	OTAG
Light-duty gasoline-powered vehicles (LDGVs)	63.0	43.05	63.26	76.3	56.06	82.64
Light-duty gasoline-powered trucks 1 (LDGT1)	13.7	16.29	12.89	14.8	20.92	15.84
Light-duty gasoline-powered trucks 2 (LDGT2)	13.2	9.85	7.59	10.8	12.63	9.01
Heavy-duty gasoline-powered vehicles (HDGV)	4.0	3.48	3.44	10.3	5.94	6.60
Light-duty diesel-powered vehicles (LDDV)	0.2	0.32	0.40	0.9	0.88	1.09
Light-duty diesel-powered trucks (LDDT)	0.1	0.14	0.08	0.2	0.32	0.18
Heavy-duty diesel-powered vehicles (HDDV)	3.8	3.81	4.49	45.3	31.16	31.32
Motorcycles	2.9	1.14	1.55	0.3	0.28	0.27
Total Highway Vehicle	100.9	78.08	93.69	158.9	128.19	146.96

**Table III-5
Washington, DC Highway Vehicle Emissions Comparison**

Vehicle Type	VOC Emissions (tpd)			NO _x Emissions (tpd)		
	SIP/ROP Inventory*	NET96	OTAG	SIP*	NET96	OTAG
Light-duty gasoline-powered vehicles (LDGVs)	117.07	83.87	107.25	140.77	99.17	129.88
Light-duty gasoline-powered trucks 1 (LDGT1)	13.81	28.51	19.57	15.65	33.67	24.09
Light-duty gasoline-powered trucks 2 (LDGT2)	3.61	24.37	16.32	3.25	25.92	17.14
Heavy-duty gasoline-powered vehicles (HDGV)	8.98	11.17	9.38	14.92	10.88	10.67
Light-duty diesel-powered vehicles (LDDV)	1.64	0.53	0.60	2.80	1.41	1.59
Light-duty diesel-powered trucks (LDDT)	0.00	0.22	0.11	0.00	0.50	0.25
Heavy-duty diesel-powered vehicles (HDDV)	13.04	8.18	7.65	52.62	62.17	58.21
Motorcycles	5.89	2.02	2.51	1.98	0.44	0.45
Total Highway Vehicle	164.03	158.88	163.38	231.99	234.17	242.28

SOURCE: *Lucas, Eulalie, 1996 Emissions by vehicle type for VOC, NO_x, and CO (Memorandum), Metropolitan Washington COG, September 2, 1999.

**Table III-6
Richmond, VA Highway Vehicle Emissions Comparison**

Vehicle Type	VOC Emissions (tpd)			NO _x Emissions (tpd)		
	SIP/ROP Inventory	NET96	OTAG	SIP	NET96	OTAG
Light-duty gasoline-powered vehicles (LDGVs)		22.91	35.45		25.76	36.66
Light-duty gasoline-powered trucks 1 (LDGT1)		8.86	7.29		9.58	7.51
Light-duty gasoline-powered trucks 2 (LDGT2)		8.26	6.57		7.60	5.50
Heavy-duty gasoline-powered vehicles (HDGV)		2.52	2.44		2.53	2.81
Light-duty diesel-powered vehicles (LDDV)		0.13	0.15		0.35	0.43
Light-duty diesel-powered trucks (LDDT)		0.05	0.03		0.12	0.07
Heavy-duty diesel-powered vehicles (HDDV)		1.89	1.98		14.65	15.75
Motorcycles		0.47	0.65		0.10	0.12
Total Highway Vehicle	40.01	45.08	54.57	63.33	60.69	68.83

Table III-7
Norfolk-Virginia Beach-Newport News, VA Highway Vehicle Emissions Comparison

Vehicle Type	VOC Emissions (tpd)			NO _x Emissions (tpd)		
	SIP/ROP Inventory	NET96	OTAG	SIP	NET96	OTAG
Light-duty gasoline-powered vehicles (LDGVs)		39.29	57.46		39.81	60.66
Light-duty gasoline-powered trucks 1 (LDGT1)		15.10	11.51		14.81	11.87
Light-duty gasoline-powered trucks 2 (LDGT2)		14.04	10.45		11.67	8.60
Heavy-duty gasoline-powered vehicles (HDGV)		4.15	3.65		3.61	4.11
Light-duty diesel-powered vehicles (LDDV)		0.22	0.28		0.55	0.72
Light-duty diesel-powered trucks (LDDT)		0.10	0.05		0.19	0.11
Heavy-duty diesel-powered vehicles (HDDV)		2.87	3.11		20.69	21.77
Motorcycles		0.75	0.89		0.15	0.19
Total Highway Vehicle	69.31	76.51	87.39	85.24	91.49	108.02

**Table III-8
Raleigh-Durham, NC Highway Vehicle Emissions Comparison***

Vehicle Type	VOC Emissions (tpd)			NO _x Emissions (tpd)		
	SIP/ROP Inventory**	NET96	OTAG	SIP**	NET96	OTAG
Light-duty gasoline-powered vehicles (LDGVs)	17.11	26.68	32.28	25.50	26.78	36.48
Light-duty gasoline-powered trucks 1 (LDGT1)	12.26	8.78	5.57	16.96	9.17	6.55
Light-duty gasoline-powered trucks 2 (LDGT2)	1.24	6.77	4.08	4.24	6.38	4.27
Heavy-duty gasoline-powered vehicles (HDGV)	0.65	1.71	1.20	3.19	2.63	2.16
Light-duty diesel-powered vehicles (LDDV)	0.03	0.15	0.15	0.14	0.39	0.46
Light-duty diesel-powered trucks (LDDT)	0.01	0.06	0.03	0.04	0.13	0.07
Heavy-duty diesel-powered vehicles (HDDV)	1.98	1.95	1.52	23.90	15.32	11.55
Motorcycles	0.36	0.57	0.60	0.54	0.11	0.12
Total Highway Vehicle	33.64	46.68	45.42	74.51	60.91	61.67

NOTES: *Comparisons include emissions in Durham, Granville, and Wake Counties. This area is somewhat larger than the Raleigh-Durham, NC maintenance area, which only includes a portion of Granville County.

**These are average episodic 1995 weekday emissions.

**Table III-9
Charlotte-Gastonia, NC Highway Vehicle Emissions Comparison***

Vehicle Type	VOC Emissions (tpd)			NO _x Emissions (tpd)		
	SIP/ROP Inventory**	NET96	OTAG	SIP**	NET96	OTAG
Light-duty gasoline-powered vehicles (LDGVs)	21.30	25.95	29.46	29.29	25.88	34.57
Light-duty gasoline-powered trucks 1 (LDGT1)	15.97	8.50	4.96	20.34	8.83	6.05
Light-duty gasoline-powered trucks 2 (LDGT2)	1.68	6.54	3.63	2.21	6.13	3.95
Heavy-duty gasoline-powered vehicles (HDGV)	0.78	1.63	1.04	2.16	2.45	1.94
Light-duty diesel-powered vehicles (LDDV)	0.05	0.15	0.13	0.21	0.38	0.43
Light-duty diesel-powered trucks (LDDT)	0.01	0.06	0.02	0.06	0.13	0.06
Heavy-duty diesel-powered vehicles (HDDV)	2.48	1.79	1.31	35.64	13.93	10.06
Motorcycles	0.44	0.55	0.55	0.16	0.11	0.12
Total Highway Vehicle	42.71	45.17	41.11	90.07	57.84	57.17

NOTES: *Comparison includes emissions for Gaston and Mecklenburg Counties in NC.

**These are average episodic 1995 weekday emissions.

2. Charlotte and Raleigh

The most outstanding difference between the three sets of emission inventories for both Charlotte and Raleigh is the HDDV NO_x category. In both cases, the SIP numbers are significantly higher than either the NET or OTAG numbers. North Carolina has confirmed that NO_x numbers in the emission inventories they provided for this project account for the effects of the NO_x heavy duty diesel defeat device. Excess NO_x emissions from the HDDV defeat device are not accounted for in either the NET or OTAG. Future versions of the NET are expected to incorporate this factor. These tables highlight the importance of including this factor, as it significantly increases both the HDDV NO_x emissions, and total NO_x emissions.

3. Pittsburgh

The VMT used in the Pittsburgh 1996 SIP is very similar in its distribution by vehicle type to that used in the NET. The VMT used for Pittsburgh in OTAG includes 86 percent of the VMT in the LDGV category, 7 percent in the combined LDGT1 and LDGT2 categories, and less than 1 percent in the HDDV category. The OTAG distribution seems skewed, and the historical trend has been to have increases in the light-duty truck (LDT) VMT fractions and decreases in the light-duty vehicle (LDV) fractions since the early 1990s. MOBILE inputs in all three cases are relatively similar.

4. Baltimore

The Baltimore PEI emissions are very close to the OTAG emissions, even at the vehicle type level. Noticeable exceptions include the LDGV NO_x and HDDV NO_x emissions. The lower LDGV NO_x emissions in the PEI may be attributable to an additional model year of Tier 1 emission standards in place in the PEI. The higher HDDV NO_x emissions in the PEI could be accounted for by a significantly different distribution of VMT by roadway type (which is then translated to speed).

Differences between the OTAG and NET inventories appear to be due primarily to a reallocation of LDGV VMT from OTAG to increased LDGT VMT and decreased LDGV VMT in the NET.

5. Philadelphia

As with some of the other areas, the NET and OTAG emission totals for Philadelphia are relatively close. However, when evaluated at the vehicle type level, significant differences appear in the emissions. Both the NET and OTAG emission factors were calculated using essentially identical MOBILE input files. Therefore, the primary source of differences should be the distribution of VMT by vehicle type and/or by roadway type. In the NET, the LDGV category accounts for only 59 percent of total VMT while 80 percent of the Philadelphia VMT in the OTAG inventory is assigned to the LDGV category, while 33 percent of the NET is in the LDGT categories compared with 13 percent in the same categories in the OTAG inventory. In addition, the NET HDDV category contains approximately twice the VMT percentage of the OTAG inventory.

6. Richmond and Norfolk

No SIP or State-supplied emissions were available for the Richmond or Norfolk areas at the vehicle-type level. The NET and OTAG comparisons for both of these areas follow the trend of having some of the VMT that is included in the LDGV category in OTAG shifted to the LDGT categories in the NET, as both areas have lower LDGV emissions and higher LDGT emissions from OTAG to the NET.

REFERENCES

- Main, 1999: Main, Hilary H., et al., "Characteristics of Volatile Organic Compounds in the Mid-Atlantic Region," Sonoma Technology, Inc., Petaluma, CA, prepared for MARAMA, Baltimore, MD, March 1999.
- EPA, 1998: U.S. Environmental Protection Agency, National Air Pollutant Emission Trends, Procedures Document, 1900-1996, EPA-454/R-98-xxx, Office of Air Quality Planning and Standards, Research Triangle Park, NC, May 1998.
- Chapter 4 - 1996 On-Road Mobile Source Emissions Inventories, Commonwealth of Virginia, Department of Environmental Quality - Air Division, Richmond, VA.
- Proposed State Implementation Plan for the Attainment and Maintenance of Ozone National Ambient Air Quality Standards, Meeting the Requirements of the Alternative Ozone Attainment Demonstration Policy, Appendix V: Rate-of-Progress Plan Benefits Calculations, The State of New Jersey, Department of Environmental Protection, October 28, 1996.
- Supplement to the Redesignation Demonstration and Maintenance Plan for the Charlotte/Gastonia Area, North Carolina Department of Environment and Natural Resources, Raleigh, NC, December 1994.
- On-Road Mobile Source Emission VOC Inventory and Forecast, Pennsylvania Air Quality State Implementation Plan, Volume I: Technical Report, Pennsylvania Department of Transportation Air Quality Task Force, October 1993.
- Summary Tabulations of Highway Vehicle VMT and Emissions Inventory and Forecast: For the Philadelphia 5-County Area: Bucks County, Chester County, Delaware County, Montgomery County, Philadelphia County, prepared by Pennsylvania Department of Transportation and Michael Baker Jr., Inc., in cooperation with Garmen Associates for Pennsylvania Department of Environmental Protection, Bureau of Air Quality Control, Revised January 9, 1998.
- Pennsylvania 1996 Emission Inventories of Highway Vehicles -- An Explanation of Methodology, prepared by Michael Baker Jr., Inc. and Garmen Associates, prepared for Pennsylvania Department of Environmental Protection and Pennsylvania Department of Transportation, November 1998.
- 1990 Inventory of Highway Vehicle Emissions for the Baltimore Ozone Nonattainment Area, the Queen Anne's/Kent County Ozone Nonattainment Area, the Cecil County, Maryland Portion of the Philadelphia, Pennsylvania Ozone Nonattainment Area, and the Remainder of the State of Maryland, prepared by the Maryland Department of the Environment, Baltimore, MD, August 23, 1993.

REFERENCES (continued)

Section 3.4 Vehicle Refueling and Related Activities, Delaware Department of Environmental Quality, inventory methods description received January 19, 1999 from Mark Eastburn, Dover, Delaware.

1990 Base Year Emissions Inventory for Stationary Anthropogenic, Biogenic Sources and Highway Vehicle Emissions of Ozone Precursors in the Washington, DC-MD-VA Metropolitan Statistical Nonattainment Area, prepared for the District of Columbia, Maryland, and Virginia by the Metropolitan Washington Council of Governments, September 22, 1993.

Final State Implementation Plan (SIP) Revision, Revision to the SIP to Achieve a Fifteen Percent Reduction in Volatile Organic Compound Emissions, and Revision to the 1990 Base Year Emissions Inventory for Stationary Anthropogenic, Biogenic Sources and Highway Vehicle Emissions of Ozone Precursors for the Washington, DC-MD-VA Nonattainment Area, prepared by Metropolitan Washington Council of Governments for the Department of Consumer and Regulatory Affairs of the District of Columbia, Maryland Department of the Environment, and the Virginia Department of Environmental Quality on behalf of the Metropolitan Washington Air Quality Committee, February 17, 1998.

State Implementation Plan (SIP) Revision for the Attainment and Maintenance of the Ozone National Ambient Air Quality Standards, Meeting the Requirements of the Alternative Ozone Attainment Demonstration Policy - Phase I Ozone SIP Submittal, The State of New Jersey Department of Environmental Protection, December 31, 1996.

Pechan, 1997: E.H. Pechan & Associates, Inc., "Ozone Transport Assessment Group (OTAG) Emissions Inventory Development Report - Volume I: 1990 Base Year Development (Revised Draft)," Durham, NC, prepared for Air Quality Modeling Group, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC, February 1997.

EPA, 1993: U.S. Environmental Protection Agency, "Regional Interim Emission Inventories (1987-1991), Volume I: Development Methodologies," EPA-454/R-93-021a, Research Triangle Park, NC, May 1993.

EPA, 1997: U.S. Environmental Protection Agency, National Air Pollutant Emission Trends, 1900-1996," EPA-454/R-97-011, Office of Air Quality Planning and Standards, Research Triangle Park, NC, December 1997.

EPA, 1998: U.S. Environmental Protection Agency, "National Air Pollutant Emission Trends, Procedures Document, 1900-1996," EPA-454/R-98-xxx, Office of Air Quality Planning and Standards, Research Triangle Park, NC, May 1998.

REFERENCES (continued)

- NJ DEP, 1999: The State of New Jersey Department of Environmental Protection, "Revision to the State Implementation Plan (SIP) for the Attainment and Maintenance of the Ozone National Ambient Air Quality Standards," Revision to the New Jersey 15 Percent Rate of Progress Plan, February 8, 1999.
- VA DEQ: Chapter 4 - 1996 On-Road Mobile Source Emissions Inventories, Commonwealth of Virginia, Department of Environmental Quality - Air Division, Richmond, VA.
- Lucas, 1999: Eulalie Lucas, 1996 Emissions by vehicle type for VOC, NO_x, and CO (memorandum), Metropolitan Washington Council of Governments, September 2, 1999.
- Boothe, 1999: L. Boothe, Motor Vehicle Emissions for Selected Areas, electronic mail, North Carolina Department of Environmental and Natural Resources, September 29, 1999.

