APPENDIX

Highway Vehicle Emissions Inventories and Forecasts for the Philadelphia Ozone Nonattainment Area

An Explanation of Methodology

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HIGHWAY VEHICLE EMISSION METHODOLOGY

Additions with this SIP revision. The Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements (Tier 2 standards) for passenger cars, light trucks, and larger passenger vehicles will phase in more stringent emission standards starting with the 2004 model year. It affects a broader set of vehicles than the NLEV program. The program will, for the first time, apply the same set of federal standards to all passenger cars, light trucks, and medium-duty passenger vehicles. Light trucks include "light light-duty trucks" (or LLDTs), rated at less than 6000 pounds gross vehicle weight and "heavy light-duty trucks" (or HLDTs), rated at more than 6000 pounds gross vehicle weight). "Medium-duty passenger vehicles" (or MDPVs) form a new class of vehicles introduced by this rule that includes SUVs and passenger vans rated at between 8,500 and 10,000 GVWR. The program thus ensures that essentially all vehicles designed for passenger use in the future will be clean vehicles. Lower sulfur fuel to be available in 2004 ensures the effectiveness of low emission control technologies.

The final rule on Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements ("Tier 2 standards") for passenger cars, light trucks, and larger passenger vehicles was published on February 10, 2000 (65 FR 6698).

Tier 2 benefits for the Philadelphia area were calculated using EPA's MOBILE5 Information Sheet #8 which can be found on EPA's website at http://www.epa.gov/otaq/m5.htm.

Other than the addition of the Tier 2 control strategy, planning assumptions and modeling tools remain consistent with the revised highway budget found adequate by EPA (see http://www.epa.gov/otaq/transp/conform/phil_ltr.pdf).

For the reader's convenience, methodologies from that budget are summarized here. A description of Pennsylvania's highway vehicle emission inventory preparation methodology is also included.

Modeling Methodology and Input Parameters

Two additional control strategies were added in August 1999 to the planning assumptions for the Philadelphia area originally submitted with the Rate Of Progress plans: the new 2004 NOx standard for heavy-duty diesel engines (HDE) and the national low emission vehicle (NLEV) standard for light-duty gasoline-fueled vehicles. The methodology to calculate the NOx benefit of reformulated gasoline (RFG) has been revised slightly based on US EPA guidance released in September 1998.

Heavy-Duty Engines. A new HDE NOx standard was promulgated in October 1997 that combined emission standards of NOx and non-methane hydrocarbons (NMHC) from model year 2004 and later heavy-duty diesel engines used in trucks and buses. Manufacturers of such engines have the choice of certifying their new engines to either a 2.4 g/bhp-hr NMHC plus NOx standard, or to a 2.5 g/bhp-hr NMHC plus NOx standard with a limit of 0.5 g/bhp-hr on NMHC.

In the release of the modeling guidance for the 2004 HDE NOx standard, EPA also updated basic emission rates for model years 1990 and newer HDE. These rates provide a more accurate assessment of HDDV emissions and are included in the MOBILE5b version of the model. However, using version MOBILE5a_H, the emission rates for HDE model years 1990 to 2003 must be added to the base year emission factors using the guidance outlined by EPA. EPA issued guidance on January 30, 1998 on how to incorporate these standards in highway vehicle emission inventories using Mobile 5a. In EPA's analysis of the emission impacts of the new standard and the technologies which are likely to be employed to meet that standard, EPA has deemed it reasonable to model the impact of the combined standard as equivalent to that of a distinct 2.0 g/bhp-hr NOx standard and a 0.5 g/bhp-hr NMHC standard. The guidance has been followed in preparation of this SIP revision.

National Low Emission Vehicle Program. The NLEV program is a voluntary program agreed upon by Pennsylvania, the northeastern states and the auto manufacturers. New cars and light duty trucks up to 6,000 pounds gross vehicle weight will meet tailpipe standards that are more stringent then EPA can mandate prior to model year 2004. These standards will be federally enforced. Pennsylvania submitted a separate SIP revision upon adoption NLEV program regulations (Pennsylvania Code Title 25, Chapter 126). New vehicles meeting the NLEV standard were available in Pennsylvania (and several other northeastern states) with the 1999 model year and available nationally with the 2001 model year. An accurate methodology to quantify NLEV reductions was not available when the Philadelphia SIP was originally submitted in April 1998, but issued MOBILE Information Sheet #6 in July 1998, which has been followed in subsequent Philadelphia area SIPs.

Phase II Reformulated Gasoline. The MOBILE5aH model version does not provide NOx credit for Phase II RFG starting in the year 2000. To calculate the NOx benefit for RFG, MOBILE5b results are used to adjust the emissions results of the MOBILE5aH inventory. Based on EPA guidance, the difference in NOx emissions is divided by the MOBILE5b results without RFG to establish the fractional NOx RFG benefit. The fractional NOx benefit is multiplied by the NOx emissions based on MOBILE5aH to determine the NOx emission benefit from RFG. EPA guidance was provided in September 1998.

A sample calculation is provided below:

Bucks County 2005

MOBILE5aH Emissions Results = 26.02 tpd

MOBILE5b run without RFG = 27.95 tpd

MOBILE5b run with RFG = 26.30 tpd

Difference (5b w/ RFG – w/o RFG) = -1.65 tpd

Fractional NOx Benefit (1.65 / 27.95) = .059

RFG NOx Benefit (MOBILE5aH x .059) = **-1.53 tpd**

PPAQ (Post-Processor for Air Quality). The PPAQ software system has gone through several updates to refine the software and increase its capability and flexibility. The current version is PPAQ3.28. Changes that affect the calculated emissions include the following:

- The diurnal emission calculation procedure now properly allocates diurnal emissions to time periods. This results in small changes in overall diurnal emission quantities.

The other changes to the PPAQ software system do not result in speed or emission calculation changes and instead simply increased the capability and flexibility of the software system.

Technical notes for this SIP revision

US EPA's MOBILE Model. The modeling was performed using EPA's approved MOBILE model, version MOBILE5a_H. The 5a_H version is an enhanced version of MOBILE5a that provides additional emissions credits for hybrid I/M programs and technician training and certification (TTC). The TTC credits are applied to Philadelphia and Pittsburgh areas that have implemented enhanced I/M programs. Pennsylvania requires all inspectors to be certified to perform an emissions inspection.

I/M Credit Data Files. EPA periodically updates their I/M credit files as new cutpoints are established. The new files can be easily downloaded from the EPA OMS or TNN websites. EPA's latest I/M credit data file for Tech IV+ vehicles (1981+ model years) is the IMDATA4.D. This file contains cutpoints for both final and start-up, and one and two mode ASM I/M programs. The single mode ASM5015 final cutpoints were used to represent Philadelphia's PA97 with ASM I/M program. The I/M credit file for Tech I and II vehicles (pre-1981 model years) is TECH12.D

Philadelphia 5-County Area – PA97 with ASM I/M Program. The PA97 with ASM program includes an ASM testing procedure (1981 MY and newer), idle test (1975 – 1980 MY), anti-tampering (1975 and newer MY), full pressure and purge (1981 and newer MY), and the gas cap pressure check (1975 to 1980 MY). All five counties (Bucks, Chester, Delaware, Montgomery and Philadelphia) are included in the program.

Modeling this area requires two scenarios, since the gas cap pressure check cannot be modeled directly with MOBILE. The first scenario is modeled with two I/M programs (one for the idle test for pre-81 model years and the second with ASM for model years 1981 and newer), anti-tampering (1975 and newer), EPA pressure and purge (1981 and newer). In the second scenario, the EPA pressure test is modeled to reflect 1975 and newer model years. This accounts for the gas cap pressure check for 1975 and 1980 vehicles. The resultant emissions are determined by crediting 40% of the pressure check credit using the following equation.

Example: Calculating the Gas Cap Pressure Check

tpd w/ gas cap credit = tpd w/o gas cap – [(tpd w/o gas cap – tpd w/ gas cap) x 40%]

14.41 tpd = 14.65 – (14.65 – 14.05) x 40%

tpd = Tons per Day

Vehicle Age Distributions. Vehicle age distributions are input to MOBILE for each county based on registered vehicles that reflect July 1 summer conditions. 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 updated vehicle age distributions have been acquired for this inventory submission from PennDOT Bureau of Motor Vehicles Registration Database. The modeling utilizes vehicle age distributions from July 1993.

Temperatures. The minimum, maximum and ambient temperatures were provided by the nearest weather station for each of the air quality districts for an average July summer day. These temperatures are the same as those that were used for the 1990 inventories.

INTRODUCTION TO HIGHWAY INVENTORY METHODS

The purpose of this document is to explain how Pennsylvania estimates emissions from highway vehicles for inclusion in its emission inventories and State Implementation Plans.

Overview of Emissions Inventories

Under the Clean Air Act Amendments of 1990, Pennsylvania is required to develop emission inventories for ozone precursors -- volatile organic compounds (VOC) and nitrogen oxides (NOx). A baseline 1990 inventory was required statewide. Two ozone nonattainment areas in Pennsylvania have also been required to achieve US EPA specified minimum percentage reductions in VOC: the seven-county Pittsburgh area and the five-county Philadelphia area. For these areas, projected inventories, both with and without anticipated control strategies, have been prepared for several "milestone" years. Finally, states must develop periodic inventories to "refresh" the 1990 inventory, using updated data and/or estimation methods.

Pennsylvania's inventories generally categorize emissions into four categories:

- highway vehicles
- stationary sources (major industrial, commercial and utility sources)
- area sources (smaller industrial/commercial sources, consumer products)
- nonroad mobile sources (including construction and agricultural equipment, lawn and garden equipment)

Of all of the sources of air pollution, only the emissions of some stationary sources are measured directly and continuously through instrumentation. Emissions from all other sources must be estimated in some fashion, including those from highway vehicles. In their very simplest form, estimates of emissions follow the following pattern:

Emission rate x activity level = emissions per time period (usually day or year)

Most emission rates have been developed by EPA, in cooperation with industry and states, over many years and are compiled and documented in a reference volume, Compilation of Air Pollution Emission Factors (AP-42).

For example, the annual VOC emissions from residential fuel oil heating could be estimated by:

AP-42 emission rate	*x*	*activity level* =	*emissions*
0.713 pounds/gallon	*x*	# dwelling units *x* % using oil *x* # gallons per unit	# pounds of VOC per year

Adding up the products of the emission rates and activity levels for all sources of a given pollutant constitutes the emission inventory for that pollutant.

Highway Vehicle Emission Inventories

Highway vehicles contribute significantly to air pollution, particularly to ground-level ozone, which is the most persistent air pollutant in Pennsylvania. Ozone is not created directly but formed in sunlight from VOCs and NOx. Both VOCs and NOx are emitted from highway vehicles. Pennsylvania's ozone-related emission inventory efforts have been focused on these pollutants.

Obviously, direct measurement of emission levels from all vehicles in use is impossible. In comparison to highway vehicles, estimating residential heating emissions is a fairly simple calculation because there is a constant emission rate and a fairly simple measure of activity. For highway vehicles, however, estimating the emission rate and activity levels of all vehicles on the road during a typical summer day is a complicated endeavor.

If every vehicle emitted the same amount of pollution all the time, one could simply multiply those emission standards (emission rate in grams of pollution per mile) times the number of miles driven (activity level) to estimate total emissions. But, the fact is that emission rates from all vehicles vary over the entire range of conditions under which they operate. These variables include air temperature, speed, traffic conditions, operating mode (started cold? started warm? running already warmed up?) and fuel. The inventory must also account for non-exhaust or evaporative emissions. In addition, the fleet is composed of several generations, types of vehicles and their emission control technologies, each of which performs differently. This requires that the composition of the fleet (vehicle ages and types) must also be included in the estimation algorithm.

In order to estimate both the rate at which emissions are being generated and to calculate vehicle miles traveled (activity level), Pennsylvania examines its road network and fleet to estimate vehicles activity. For ozone-related inventories, this is done for a typical summer (July) weekday. Not only must this be done for a baseline year, but it must also be projected into the future. This process involves a large quantity of data and is extremely complex.

Computer models have been developed to perform these calculations by simulating the travel of vehicles on the Commonwealth's roadway system. These models then generate emission rates (also called emission factors) for different vehicle types for area-specific conditions and then combine them in summary form. The "area-specific conditions" include vehicle and highway data, plus control measure characteristics and future year projections of all variables.

MOBILE. The heart of the highway vehicle emission calculation procedure is EPA's highway vehicle emission factor model, MOBILE. This is a FORTRAN program that calculates **average** in-use fleet emission factors for ozone precursors for each of eight categories of vehicles under various conditions affecting in-use emission levels (e.g., ambient temperatures, average traffic speeds, gasoline volatility) as specified by the model user. MOBILE produces the "emission rates" referred to in the previous section.

The model was first developed as MOBILE1 in the late 1970s, and has been periodically updated to reflect the collection and analysis of additional emission factor data over the years, as well as changes in vehicle, engine and emission control system technologies, changes in applicable regulations, emission standards and test procedures, and improved understanding of in-use emission levels and the factors that influence them. Pennsylvania is currently using MOBILE5a_H as approved by EPA.

PPAQ. Pennsylvania also uses the Post Processor for Air Quality (PPAQ), which consists of a set of programs that perform the following functions:

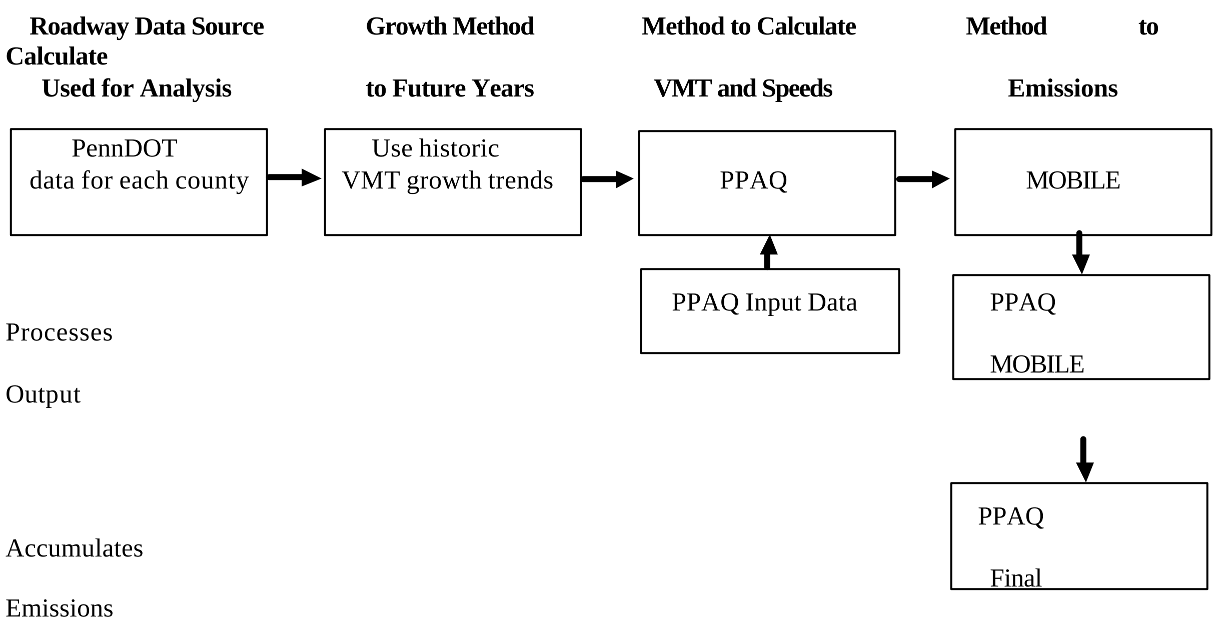
- Analyzes highway operating conditions
- Calculates highway speeds
- Compiles vehicle miles of travel (VMT) and vehicle type mix data
- Prepares MOBILE runs
- Calculates emission quantities from output MOBILE emission rates and accumulated highway VMT.

PPAQ has become a widely used and accepted tool for estimating speeds and processing MOBILE emission rates. It is currently being used for the New York City region, for the north and south New Jersey regions, and in other states including Louisiana, Virginia, and Indiana. The software is based upon accepted transportation engineering methodologies. For example, PPAQ utilizes speed and delay estimation procedures based on planning methods provided in the 1994 Highway Capacity Manual, a report prepared by the Transportation Research Board (TRB) summarizing current knowledge and analysis techniques for capacity and level-of-service analyses of the transportation system.

These two computer programs interact as shown in Exhibit 1.

Exhibit 1

Emission Calculation Process for Pennsylvania



WHERE DOES PENNSYLVANIA OBTAIN ITS DATA?

Data Used in MOBILE

Two major types of information are written into the MOBILE model by EPA: basic emission rates and travel weighting rates. EPA's Office of Mobile Sources obtains this information from a number of sources, including its new vehicle certification program, in-use vehicle random sample studies and special studies (including information from some state I/M programs). For more information on MOBILE, a users guide and various documents (as well as the model itself) are available through EPA's website (http://www.epa.gov/OMSWWW/models.htm).

Basic emission rates are those which are produced under very standardized conditions. The model then modifies (corrects and/or weights) these rates based on other model or input parameters. Rates are incorporated for model year and vehicle type. MOBILE also calculates an assumed amount of increase in emissions as vehicles accumulate mileage.

In addition to exhaust emissions, evaporative VOC emission sources from gasoline-powered vehicles are also included[1]:

- diurnal emissions (evaporated gasoline emissions generated by the rise in temperature over the course of a day when the vehicle is not being driven),
- hot soak emissions (evaporated gasoline emissions occurring after the end of a vehicle trip, due to the heating of the fuel, fuel lines, fuel vapors),
- running loss emissions (evaporated gasoline emissions occurring while a vehicle is driven, due to the heating of the fuel and fuel lines),
- resting loss emissions (small but continuous seepage and minor leakage of gasoline vapor through faulty connections, permeable hoses and other materials in the fuel system).

Evaporative emissions are very dependent on temperature and fuel volatility as well as vehicle model year.

Travel Weighting Fractions. Research has found that newer cars tend to be driven more. The model reflects this, using state-specific vehicle age distributions from registration data. The model also contains assumptions about trips per day and miles per day by age of the vehicle. This is important for exhaust emissions because these emissions are greater when the vehicle is not warmed up (cold start). Also, this information helps characterize evaporative emissions.

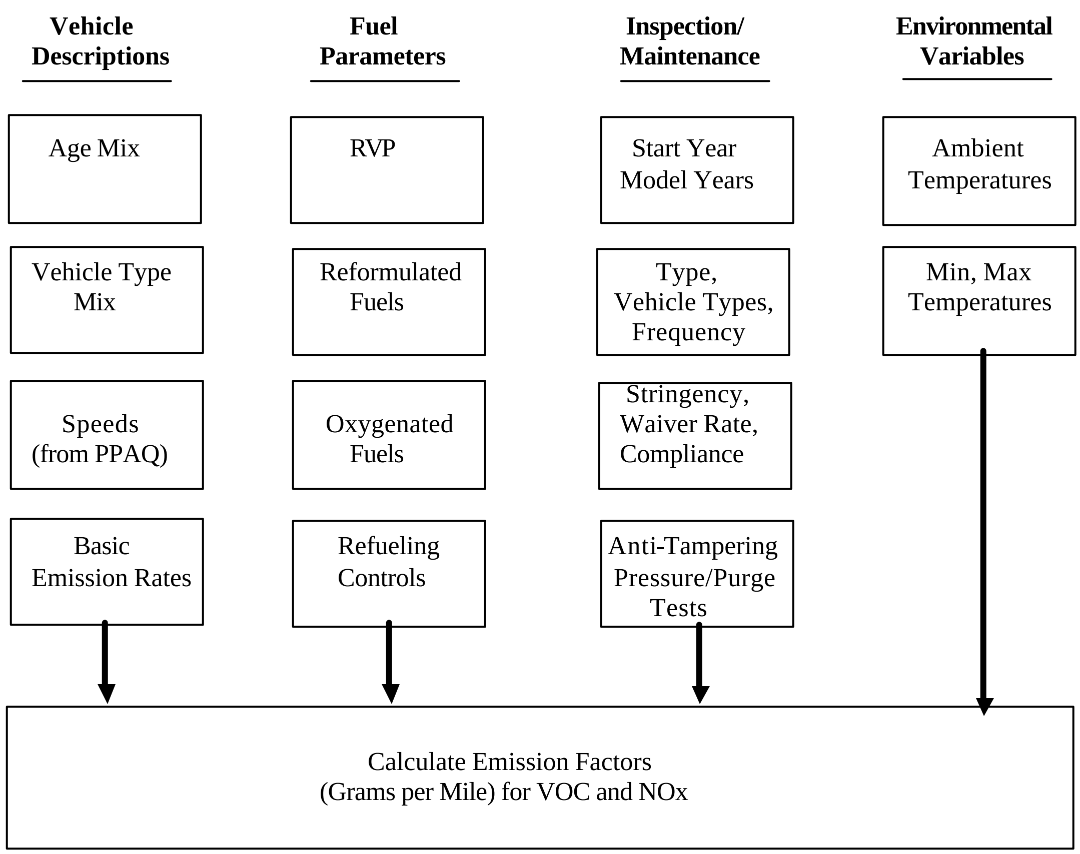
[1] Some states use MOBILE to estimate refueling emissions (gasoline vapor emissions generated by the refueling of vehicles, where in the absence of controls the vapor in the vehicle fuel tank is displaced by the incoming liquid fuel and released to the atmosphere). Pennsylvania handles these emissions in the area source inventory.

What Are The Necessary Data Inputs to MOBILE?

A large number of inputs to MOBILE are needed to fully account for the numerous vehicle and environmental parameters that affect emissions including traffic flow characteristics (as determined from the PPAQ software), vehicle descriptions, fuel parameters, inspection/maintenance program parameters, and environmental variables as shown in Exhibit 2. With some input parameters, MOBILE allows the user to choose default values, while others require area-specific inputs.

Exhibit 2

MOBILE Inputs



For an emissions inventory, area specific inputs are used for all of the inputs shown in Exhibit 2 except for the basic emission rates, which are MOBILE defaults. In addition, Pennsylvania uses MOBILE default cold and hot start fractions (20.6 and 27.3 percent). A vehicle will generate more emissions when it is first operated (cold start). It generates emissions at a different rate when it is stopped and then started again within a short period of time (hot start). Cold/hot start fractions reflect what percent of the VMT was accrued after a cold start and after a hot start.

Vehicle Descriptions. Vehicle age distributions are input to MOBILE for each county based on registered vehicles reflecting July 1 summer conditions. These distributions are obtained from PennDOT's Bureau of Motor Vehicle Registration Database. Vehicle Type Mix is calculated by PPAQ from algorithms using a combination of MOBILE default percentages and PennDOT truck percentages from roadway data. (See also the discussion of Vehicle Type Pattern Data in the next section.) Speeds are discussed extensively in the next section.

Fuel Parameters. The same vehicle will produce different emissions using a different type of gasoline. Fuel control strategies can be powerful emission reduction mechanisms. An important variable in fuels for VOC emissions is its evaporability, measured by Reid Vapor Pressure.

MOBILE allows the user to choose among conventional (used in most of Pennsylvania), federal reformulated (now used in the Philadelphia area), oxygenated (not used in Pennsylvania) and low Reid Vapor Pressure (RVP) gasolines (used in the Pittsburgh area starting in 1998). Pennsylvania chooses the MOBILE inputs appropriate to the year and control strategy for the area being modeled.

MOBILE also allows users to calculate refueling emissions -- the emissions created when vehicles are refueled at service stations. Pennsylvania includes refueling emissions in its area source inventory and not in its highway vehicle inventory. However, that calculation uses a grams per gallon emission rate generated by MOBILE.

Vehicle Emission Inspection/Maintenance (I/M) Parameters. MOBILE allows users to vary inputs depending on the I/M program in place for the area or, of course, choose "no I/M program." The inputs include:

- program start year
- stringency level (failure rate) and pass/fail standards or "cutpoints"
- first and last model years subject to the program
- waiver rates
- compliance rates
- program type (test-only, test-and-repair, etc.)
- frequency of inspection (annual, biennial)
- vehicle type coverage
- test type (idle, loaded, etc.)
- technician training program

Some cutpoints (the emissions at which vehicles are failed) are contained in MOBILE, while others must be put in by the model user. Pennsylvania uses the parameters specific for the geographic area and year for which the modeling is being performed.

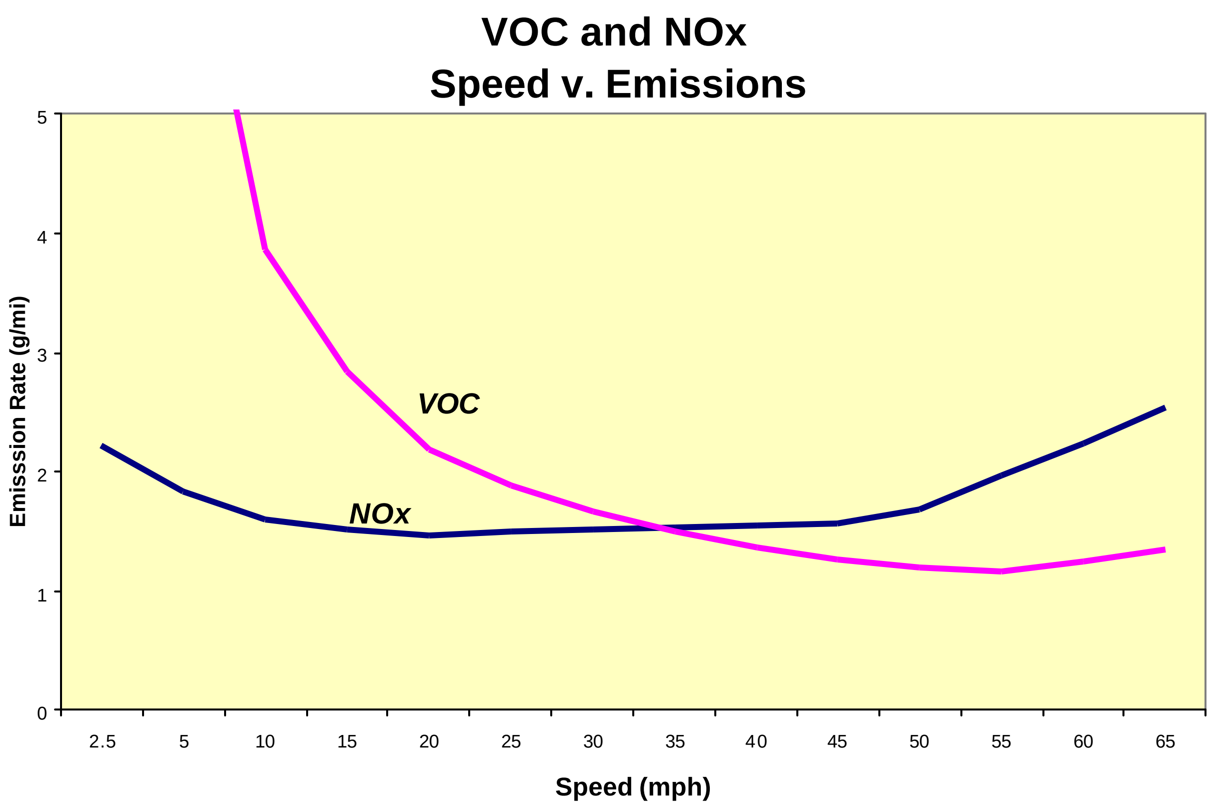
Environmental Variables. Evaporative emissions are influenced significantly by the temperatures of the surrounding air. Minimum, Maximum, and Ambient temperatures have been compiled for each county based on information from EPA's CHIEF bulletin board reflecting airport temperatures on emission violation days.

Emission and Speed Relationships

Of all the user-supplied input parameters, perhaps the most important is vehicle speed. Emissions of both VOC and NOx vary significantly with speed, but the relationships are not linear, as shown in Exhibit 3. While VOCs generally decrease as speed increases, NOx decreases only at the low speed range and increases steeply at higher speeds.

To obtain the best estimate of vehicle speeds, Pennsylvania uses the PPAQ set of programs, whose primary function is to calculate speeds and to organize and simplify the handling of large amounts of data needed for calculating speeds and for preparing MOBILE input files.

Exhibit 3



PPAQ can also provide a link between transportation and air quality models, enabling models like MOBILE to take advantage of the wealth of information generated by transportation models in a form which is relevant for air quality. Transportation models are presently used in the Philadelphia and Pittsburgh areas and are being incorporated into the transportation planning process in other metropolitan areas in the Commonwealth.

Roadway Data

The roadway data input to emissions calculations for Pennsylvania uses information from the Roadway Management System (RMS) maintained by PennDOT's Bureau of Planning and Research. PennDOT obtains this information from periodic visual and electronic traffic counts. RMS data is dynamic since it is continually reviewed and updated from new traffic counts and field visits conducted by PennDOT. Information on roadways included in the National Highway System is reviewed at least annually, while information on other roadways is reviewed at least biennially.

Periodically, a current "snapshot" of the RMS database is taken and downloaded to provide an up-to-date record of the Commonwealth's highway system for estimating emissions.

The RMS database contains all state highways, including the Pennsylvania Turnpike, divided into segments approximately 0.5 miles in length. These segments are usually divided at important intersections or locations where there is a change in the physical characteristics of the roadway (e.g. the number of lane changes). There are approximately 99,000 state highway segments for the 67 Pennsylvania counties contained in the RMS. Each of these segments contains an abundance of descriptive data, but only the following information is extracted for emission calculations:

- Lanes
- Distances
- Volumes in Average Annual Daily Traffic (AADT)
- Truck percentages
- PennDOT urban/rural classifications
- PennDOT functional class codes

RMS volumes and distances are used in calculating highway VMT totals for each county. As discussed in the next section, adjustments are needed to convert the volumes to an average July weekday. Lane values are an important input for determining the congestion and speeds for individual highway segments. Truck percentages are used in the speed determination process and are used to split volumes to individual vehicle types used by the MOBILE software.

Pennsylvania classifies its road segments by function, as well as whether it is located in an urban, small urban or rural area, as indicated below in Exhibit 4. The PennDOT urban/rural (UR) and functional classes (FC) are important indicators of the type and function of each roadway segment. The variables provide insights into other characteristics not contained in the RMS data that are used for speed and emission calculations. In addition, VMT and emission quantities are aggregated and reported using both UR and FC codes.

Exhibit 4

PennDOT Classification Scheme: Urban/Rural Codes and Functional Class Codes

Urban/Rural Code	1=Rural 2=Small Urban 3=Urban	
Functional Class	Rural Functional Classes Used For Rural Areas	Urban Functional Classes Used For Small Urban and Urban Areas
	1=Rural Freeway	11=Urban Freeway
	2=Rural Other Principal Arterial	12=Urban Expressway
	6=Rural Minor Arterial	14=Urban Principal Arterial
	7=Rural Major Collector	16=Urban Minor Arterial
	8=Rural Minor Collector	17=Urban Collector
	9=Rural Local	19=Urban Local

Note: Functional Classes 3,4,5,10,13,15,18 are not currently used in PennDOT's RMS database

Additions and Adjustments to Roadway Data

Before the RMS data can be used by PPAQ for speed and emission calculations, several adjustments and additions must be made to the roadway data.

1990 HPMS Adjustments: According to EPA guidance, baseline inventory VMT computed from the RMS highway segment volumes must be adjusted to be consistent with Highway Performance Monitoring System (HPMS) VMT totals. The HPMS VMT reported for Pennsylvania is a subsystem of the RMS established to meet the data reporting requirements of the Federal Highway Administration (FHWA) and to serve as PennDOT's official source of highway information. Although it has some limitations, the HPMS system is currently in use in all 50 states and is being improved under FHWA direction.

The HPMS VMT totals are developed from the data contained in the RMS database at the time of reporting and serves as a "snapshot" of the RMS data for a particular year. Since the RMS database does not contain many local roads, a separate procedure is used by PennDOT to estimate total local VMT for the HPMS system. HPMS VMT summaries are prepared each year and reported by PennDOT urban/rural and functional class codes. The VMT contained in the HPMS reports are considered to represent average annual daily traffic (AADT).

Although the HPMS VMT and the roadway data used for an inventory emissions analysis are both based on data from the RMS system, differences do exist between them and include the following. First, the HPMS and inventory roadway data are "snapshots" of the RMS data taken at different times. Since the RMS is dynamic, changing constantly due to new data, differences will result between the data used for calculating HPMS VMT totals and the inventory data used for an emissions analysis. Second, local estimates of HPMS VMT are obtained through alternative procedures developed by PennDOT. However, the emissions inventory makes use of those few local roads contained in the RMS system. To account for such differences, adjustment factors are calculated and used to adjust the inventory roadway data to the reported HPMS VMT totals submitted to FHWA.

Adjustment factors are calculated which adjust the 1990 RMS VMT to be consistent with 1990 HPMS totals. These factors are developed for each county, urban/rural code, and functional class combination and are also applied to all future year runs. Adjustments for the "higher" functional classes (e.g. Freeway, Arterials - major routes) were very close to 1.000 since HPMS VMT is derived from RMS information, and the only difference in the data is that the "snapshot" for the emission calculations is taken at a different time than for the HPMS. "Lower" classes (e.g. local roads) require greater adjustment since a large part of the local system is not under state jurisdiction and is not in the RMS database. There is, of course, a significant amount of local road mileage in the state. It is assumed that those local streets that are in RMS are representative of all local streets in their area with respect to volume and speed, so that roadway mileage adjustment is appropriate.

The adjustment factors calculated above are applied by PPAQ during each run. The factors developed for the 1990 volumes are also used for any future year runs.

Seasonal Adjustments to Volumes: The RMS contains AADT volumes that are an average of all days in the year including weekends and holidays. An ozone emission analysis, however, is based on a typical July weekday. Therefore, those volumes must be seasonally adjusted. Seasonal factors were developed for each functional class and urban/rural code based on yearly count information prepared by PennDOT's Bureau of Planning and Research. These factors are applied to the existing RMS AADT volumes to produce the July volumes.

Additional Network Information: The PPAQ software system allows for many additional variables other than those available in the RMS database. Using these variables improves the ability of Pennsylvania to incorporate real roadway conditions into its estimates. The variables include information regarding signal characteristics and other physical roadway features that can affect a roadway's calculated congested speed. PPAQ's ability to estimate congested speeds by road segment improves Pennsylvania's emissions inventories because of the overwhelming role speed plays in emission rates. If specific information regarding these variables is known or obtained for areas, this information can be appended to the RMS database. Otherwise, default values are assumed based on information provided by the PPAQ input speed/capacity lookup data as described below.

Speed/capacity lookup data provides PPAQ with initial (free-flow with no congestion) speeds and capacities for different urban/rural code and functional class groupings. The initial speeds and capacities are used by PPAQ in determining the final congested speed for each roadway segment. Speeds can also be greatly impacted by signals and other roadway features. As a result, this data provides default signal densities (average number of signals per mile for different functional classes) as well as default values for variables that determine the decay of speed with varying levels of congestion. As discussed above, values from the speed/capacity data can be overridden for specific links by directly coding values to the roadway database segments. The speed capacity data was developed from a combination of sources including the following:

- Information contained in the 1994 Highway Capacity Manual
- PennDOT information on speeds and signal densities
- Engineering judgment

24-hour Pattern Data: Speeds and emissions vary considerably depending on the time of day (because of temperature) and congestion. Therefore, it is important to estimate the pattern by which roadway volume varies by hour of the day. The 24-hour pattern data provides PPAQ with information used to split the daily roadway segment volumes to each of the 24 hours in a day. Pattern data is in the form of a percentage of the daily volumes for each hour. Distributions are provided for each county and functional class grouping. This data was developed from 24-hour count data compiled by PennDOT's Bureau of Planning and Research, according to the process in Procedures for Adjusting Traffic Count Data, 1991.

Vehicle Type Pattern Data: Basic emission rates may differ by vehicle type. These types are listed below in Exhibit 5.

Exhibit 5

MOBILE Vehicle Types

1.	LDGV	- Light-Duty Gasoline Vehicles
2.	LDGT1	- Light-Duty Gasoline Trucks (<6,500 lbs)
3.	LDGT2	- Light-Duty Gasoline Trucks (<8,500 lbs)
4.	HDGV	- Heavy-Duty Gasoline Vehicles (>8,500 lbs)
5.	LDDV	- Light-Duty Diesel Trucks (<8,500 lbs)
6.	LDDT	- Light-Duty Diesel Trucks (<8,500 lbs)
7.	HDDV	- Heavy-Duty Diesel Vehicles (>8,500 lbs)
8.	MC	- Motorcycles

MOBILE summary reports by vehicle type are also useful in knowing what kinds of vehicles generate emissions. The vehicle type pattern data is used by PPAQ to divide the hourly roadway segment volumes to the eight MOBILE vehicle types. Similar to the 24-hour pattern data, this data contains percentage splits to each vehicle type for every hour of the day. The vehicle type pattern data was developed from several sources of information:

- Hourly distributions for trucks and total traffic compiled by PennDOT's Bureau of Planning and Research, according to Procedures for Adjusting Traffic Counts, 1991
- PennDOT truck percentages from the RMS database
- MOBILE default vehicle type breakdowns

The vehicle type pattern data is developed for each county and functional class combination. First, RMS truck percentages are averaged for all roadways within a county, functional class grouping. Using this percentage data, the total roadway volume for any segment could be divided to both auto and truck vehicle type categories. However, these percentages do not yet enable volumes to be divided to each of the eight MOBILE vehicle types. As a result, MOBILE default vehicle type breakdowns are then used to divide the auto and truck percentages, calculated above, to each specific MOBILE vehicle type. PennDOT hourly distributions for trucks and total traffic are then used to create vehicle type percentage breakdowns for each hour of the day.

Vehicle Type Capacity Analysis Factors: Vehicle type percentages are provided to the capacity analysis section of PPAQ to adjust the speeds in response to trucks. That is, a given number of larger trucks take up more roadway space than a given number of cars, and this must be accounted for in the model. Capacity is adjusted based on the factors provided in this data. Values are developed from information in the 1994 Highway Capacity Manual and are specific to the various facility types.

Producing Future Year Volumes

Growth factors are used to project future highway volumes from the volumes provided in the RMS database. Separate factors are derived for each county and highway functional class from an analysis of historic HPMS growth trends, coupled with estimates of population and employment growth from the U.S. Department of Commerce's Bureau of Economic Analysis (BEA). The factors are then applied to base year traffic volumes on each highway segment in the RMS network database.

The Pittsburgh and Philadelphia regions, however, use a different approach for determining future year volumes, since the larger metropolitan areas are required to use more sophisticated projection methods for transportation planning. These areas currently have traffic forecasting models in place as required by US Department of Transportation; VMT estimates for base and future years are obtained from the model runs. From these VMT estimates, growth factors are prepared which are then applied to the RMS database volumes similar to other regions in Pennsylvania.

SPEED/EMISSION ESTIMATION PROCEDURE

The previous sections have summarized the input data used for computing speeds and emission rates for Pennsylvania. This section explains how PPAQ and MOBILE use that input data to produce emission estimates. Exhibit 6 on the following page summarizes PPAQ's analysis procedure used for each of the 99,000 highway segments in the state.

Producing an emissions inventory with PPAQ requires a process of disaggregation and aggregation. Data is available and used on a very small scale -- individual ½ mile roadway segments 24 hours of the day. This data needs to first be aggregated into categories so that a reasonable number of MOBILE scenarios can be run, and then further aggregated and/or re-sorted into summary information that is useful for emission inventory reporting.

Volume/VMT Development

Before speeds can be calculated and MOBILE run, volumes acquired from RMS must be adjusted and disaggregated. Such adjustments include factoring to future years, seasonal adjustments, and disaggregating daily volumes to each hour of the day and to each of the eight MOBILE vehicle types.

Future Year Volumes: The RMS database contains up-to-date current year volumes. However, to conduct a future year analysis, these volumes must be factored to the year being analyzed. Growth factors have been prepared based on historic HPMS trends coupled with population and employment forecasts for each county, urban/rural area code, and functional class grouping. These growth factors are applied to the base year RMS volumes to obtain future year estimates that can be utilized by PPAQ.

Example:

A typical freeway link in the RMS database is I-80 segment 2500 in Luzerne County, Pennsylvania. This link has an urban/rural code=1 which indicates the link is in a rural area, and a functional class=1 indicating a rural freeway. The average annual daily traffic (AADT) from the RMS database for this link in 1990 is 12,077 vehicles/day.

Growth factors have been developed to factor the 1990 volume to future years. For example, to factor the 1990 volume to the year 2002, a factor of 1.282 has been developed for Luzerne County rural freeways.

2002 volume = 12,077 vehicles/day x 1.282 = 15,483 vehicles/day

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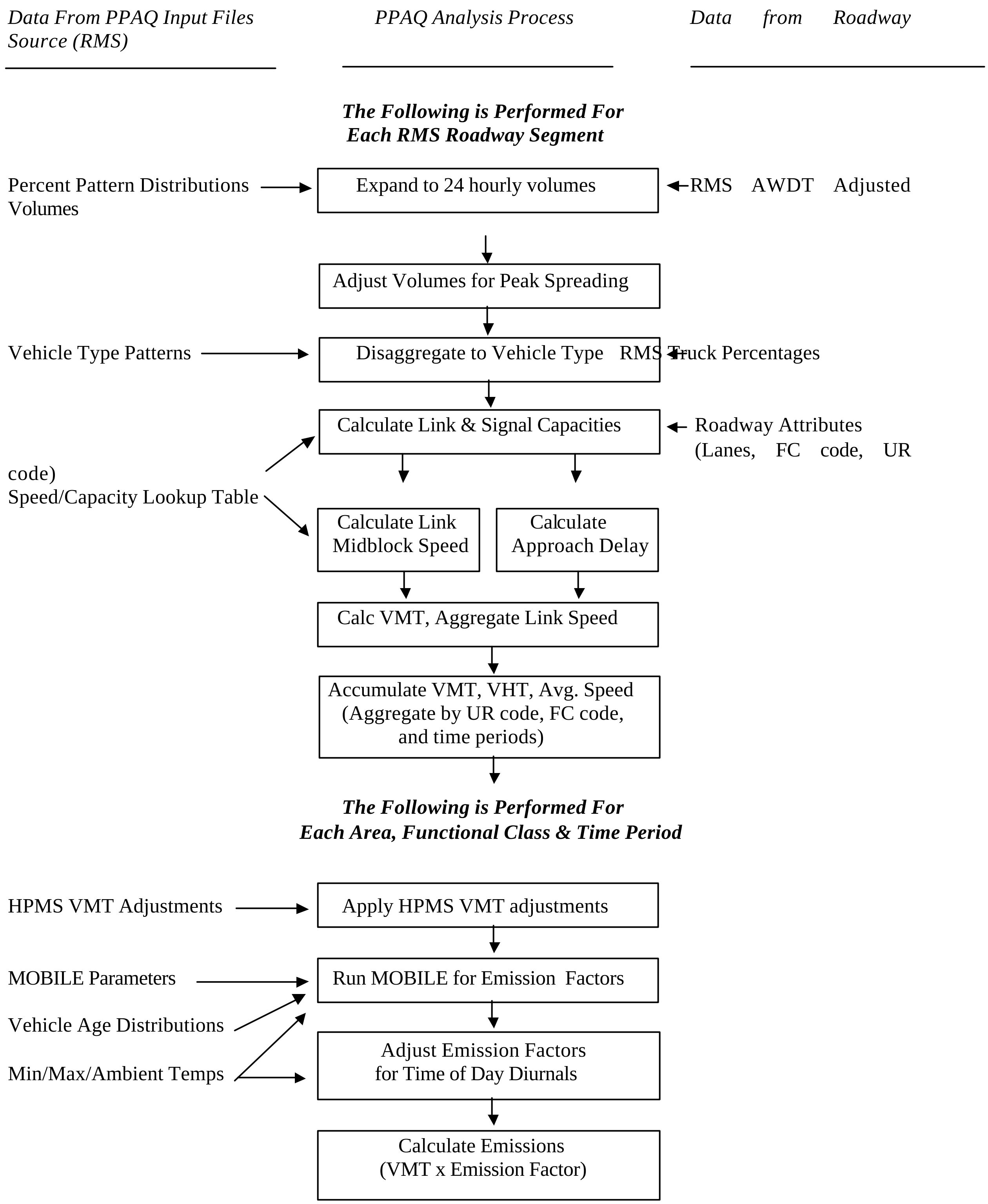
Exhibit 6

PPAQ Speed/Emission Estimation Procedure



Seasonal Adjustments: PPAQ takes the input daily volumes from RMS which represent AADT and seasonally adjusts the volumes to an average weekday in July. This adjustment utilizes factors developed for each functional class and urban/rural code. VMT can then be calculated for each link using the adjusted weekday volumes.

Example:

Again, assume the rural freeway link: I-80 segment 2500 in Luzerne County, Pennsylvania. The average annual daily traffic (AADT) for this link in 1990 is 12,077 vehicles/day.

Seasonal factors have been developed for urban/rural code and functional class combinations. For an urban/rural code=1 and a functional class=1, the factor to convert from AADT to an average weekday in July is = 1.15

Average Weekday July Volume = 12,077 x 1.15 = 13,889 vehicles/day

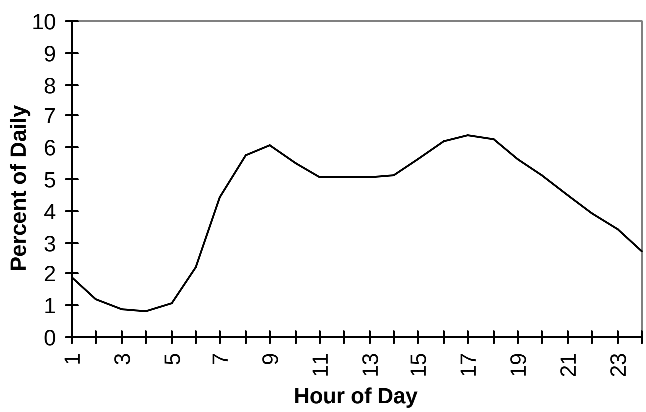
Total VMT (daily) for this link is calculated as volume x distance. The distance of this link as obtained from RMS is 0.286 miles.

1990 VMT = 13,889 vehicles/day x 0.296 miles = 41,111 vehicle-miles / day

Disaggregation to 24 Hours: After seasonally adjusting the link volume, the volume is split to each hour of the day. This allows for more accurate speed calculations (effects of congested hours) and allows PPAQ to aggregate VMT and speeds to different time periods for purposes of running MOBILE scenarios and reporting emissions.

Example:

To support speed calculations and emission estimates by time of day, the July weekday volume is disaggregated to 24 hourly volumes. Temporal patterns were previously developed from PennDOT count data and input to PPAQ. For the I-80 rural freeway link with morning peak volumes similar to evening peak hours (neutral), the following temporal pattern is applied:



Using the I-80 segment for 1990, typical hourly volumes which result include:

8-9 a.m. 6.0% x (41,111 vehicle miles/ 0.296mi.) = 833 vehicles/hour (vph)

12-1 p.m. 5.0% x (41,111 vehicle .miles/ 0.296mi.) = 694 vph

5-6 p.m. 6.3% x (41,111 vehicle miles/ 0.296mi.) = 875 vph

After dividing the daily volumes to each hour of the day, PPAQ identifies hours that are overly congested. For those hours, PPAQ then spreads a portion of the volume to other hours within the same peak period, thereby approximating the "peak spreading" that normally occurs in such over-capacity conditions.

Disaggregation to Vehicle Type: EPA requires VMT estimates to be prepared by vehicle type, reflecting specific local characteristics. As a result, for Pennsylvania's emission inventory, the hourly volumes are disaggregated to the eight MOBILE vehicle types based on count data assembled by PennDOT.

Example:

Disaggregation of the total I-80 volume (by hour) to the various vehicle types would include the following:

Total Volume 8-9 am = 833 vph

Vehicle Type Volume 8-9 am:

LDGV	54.1%	451 vph
LDGT1	19.7%	164 vph
LDGT2	13.8%	115 vph
HDGT	2.7%	22 vph
LDDV	2.3%	19 vph
LDDT	1.8%	15 vph
HDDV	4.8%	40 vph
MC	0.8%	7 vph

Speed/Delay Determination

EPA recognizes that the estimation of vehicle speeds is a difficult and complex process. Because emissions are so sensitive to speeds, it recommends special attention be given to developing reasonable and consistent speed estimates; it also recommends that VMT be disaggregated into subsets that have roughly equal speed, with separate emission factors for each subset. At a minimum, speeds should be estimated separately by roadway functional class. The computational framework used for this analysis meets and exceeds that recommendation: Speeds are individually calculated for each roadway segment and hour and incorporate the delays encountered at signals. VMT and vehicle hours of travel (VHT) are then accumulated for each cell of the county/functional class/time of day matrix; accumulated VMT is divided by VHT to produce the cell's average speed.

To calculate speeds, PPAQ first obtains initial capacities (how much volume the roadway can serve before heavy congestion) and free-flow speeds (speeds assuming no congestion) from the speed/capacity lookup data. As described in previous sections, this data contains default roadway information indexed by the urban/rural code and functional class. For areas with known characteristics, values can be directly coded to the RMS database and the speed/capacity data can be overridden. However, for most areas where known information is not available, the speed/capacity lookups provide valuable default information regarding speeds, capacities, signal densities and characteristics, and other capacity adjustment information used for calculating congested delays and speeds.

Example:

The speed/capacity lookup table is used to obtain important data used for link speed calculations. For the I-80 link with an urban/rural code = 1 (rural) and a functional class = 1 (freeway), the lookup table provides information including the following:

freeflow speed = 65 mph
capacity = 1800 vph per lane
number of signals = 0

This information is used along with the physical characteristics of the roadway to calculate the delay (including congestion) to travel this link during each hour of the day:

For example: The I-80 link is calculated to have a travel time, including delay of 17.76 seconds for the 8-9am hour

Total travel time, in vehicle hours, for the 8-9am hour is calculated as:

VHT (8-9am) = 17.76 seconds x 833vph / 3600 sec/hr = 4.12 vehicle hours

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The result of this process is an estimated average travel time for each hour of the day for each highway segment. The average time can be multiplied by the volume to produce vehicle hours of travel (VHT).

HPMS and VMT Adjustments

Volumes must also be adjusted to account for differences with the HPMS VMT totals, as described previously. VMT adjustment factors are provided as input to PPAQ, and are applied to each of the roadway segment volumes. These factors were developed from 1990 data; however, they are also applied to any future year runs. The VMT added or subtracted to the RMS database assumes the speeds calculated using the original volumes for each roadway segment for each hour of the day.

Example:

Using the Luzerne County I-80 rural freeway link example, the daily assigned volume is adjusted to account for reconciliation with the HPMS VMT. RMS VMT (in AADT) for Luzerne County rural freeways totals 962,559 vehicle miles in 1990. HPMS VMT (in AADT) as supplied by PennDOT and reported to FHWA totals to 990,088 vehicle miles for the rural freeways. A factor is developed by dividing the HPMS VMT by the RMS VMT:

HPMS adjustment factor for Luzerne County rural freeways = 990,088 / 962,559 = 1.029

This factor is held constant in all future years. As an example, this adjustment is made to the
I-80 freeway link VMT for the 8-9am hour after speed calculations are made, and produces the final July weekday VMT for this hour used for Ozone runs.

I-80 Link VMT (8-9am) = 833vph x 0.296 miles x 1.029 = 254 vehicle miles

VMT and Speed Aggregation

While highway volumes, vehicle mixes, and speeds are calculated on the basis of individual highway segments and hours, this data is far too disaggregate to apply directly to MOBILE. Therefore, PPAQ has been set up to automatically accumulate VMT and VHT by larger geographic areas, highway functional class, and time periods as shown in Exhibit 7.

Exhibit 7

VMT/VHT Aggregation Scheme

County			67 entries
Urban/Rural Code	1=Rural 2=Small Urban 3=Urban		18 entries
Functional Class	1=Rural Freeway 2=Rural Other Principal Arterial 6=Rural Minor Arterial 7=Rural Major Collector 8=Rural Minor Collector 9=Rural Local	11=Urban Freeway 12=Urban Expressway 14=Urban Principal Arterial 16=Urban Minor Arterial 17=Urban Collector 19=Urban Local	
Time Periods	AM Peak Period (7:00 to 10:00 AM) Midday (10:00 AM to 4:00 PM) PM Peak Period (4:00 to 6:00 PM) Night (6:00 PM to 7:00 AM)		4 entries
			4,824 potential combinations

Geographic aggregation is performed by urban, small urban, and rural areas of each county. Functional class aggregation is according to PennDOT's eighteen standard functional classes, respecting urban, small urban and rural definitions. Time period aggregation is according to AM peak, PM peak, Midday, and Night as defined in Exhibit 6. For an individual county, this creates a potential for 72 possible combinations, each of which becomes an input MOBILE scenario. This allows each MOBILE scenario to represent the actual VMT mix, speed, and potentially cold/hot start fraction for that geographic / highway / time combination. Altogether then, there are potentially 4,824 combinations for which speeds and VMT are computed and emissions are calculated with MOBILE.

Once all links are processed and VMT and VHT accumulated, average speeds are calculated for each cell of the accumulation matrix by dividing VMT by VHT. This speed is then input to the MOBILE scenario as the average speed for that cell.

Example:

The hourly VMT and VHT quantities are accumulated into a matrix of VMT and VHT for each combination of county, urban/rural code, functional class, and time period.

For this example, Luzerne County rural freeways during the morning peak period (7-10am) will carry 155,904 vehicle miles of travel, and will involve 2,399 vehicle hours of travel. Dividing the accumulative VMT by the cumulative VHT produces the average operating speed for this cell:

Average speed = VMT / VHT = 155,904 / 2,399 = 64.9 mph

Thus the Luzerne County rural freeways will operate at an average speed of 65.0 mph during the morning peak period. Overall, on a 24-hour basis the total VMT for Luzerne rural freeways will be 1,148,251 vehicle miles, and the average travel speed will be 65.0 miles per hour.

MOBILE Emissions Run

After computing speeds and aggregating VMT and VHT, PPAQ prepares input files to be run in EPA's MOBILE program which is used to produce VOC and NOx emission factors in grams of pollutant per vehicle mile. The process uses an unmodified version of the MOBILE program that was obtained directly from EPA.

The MOBILE input file prepared by PPAQ contains the following:

- MOBILE template containing appropriate parameters and program flags
- Temperature data specific to the county being run
- Vehicle age data for the county being run
- Scenario data - contains VMT mix, average speeds specific to scenario as produced by PPAQ

Example:

A MOBILE input file is created by PPAQ for Luzerne County. This file contains separate scenarios for each urban/rural code, functional class, and time period combination. A scenario represents a separate MOBILE run with different emission factors calculated and output for each run.

For this example, Luzerne County rural freeways during the morning peak period (7-10am) will be run as a scenario. Specific data including temperature data, vehicle mix data, and speeds are supplied by PPAQ for this morning period scenario.

Time of Day and Diurnal Emissions

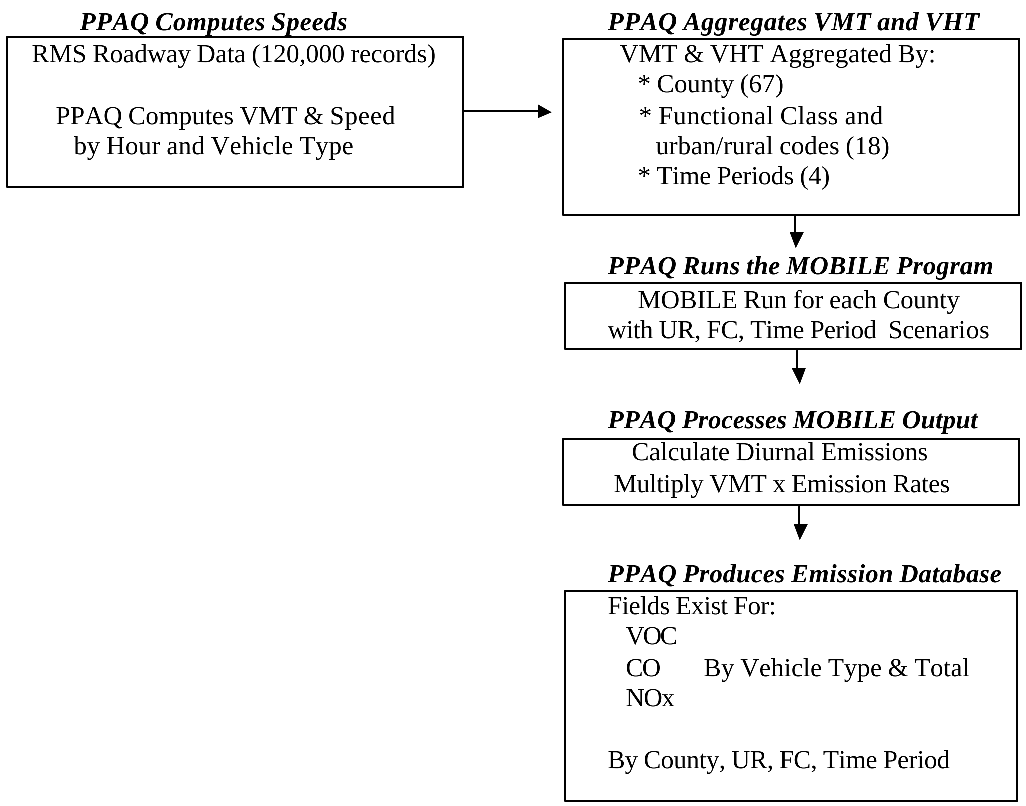
The highway system VMT and speeds are aggregated according to four time periods. Because diurnal emissions are calculated by MOBILE on the basis of 24-hour minimum-to-maximum temperatures, special processing is needed to accurately estimate the emissions component by allocating daily diurnal emissions to the various time periods. This is done within the computational process by adjusting the emission factors for each time period to correctly account for that time period's share of the daily diurnal emissions.

Process MOBILE Output

After MOBILE has been run, PPAQ processes the MOBILE output files and compiles the emission factors for each scenario. Using the above methodology, it allocates daily diurnal emissions to each of the time periods. Using the MOBILE emission factors, PPAQ calculates emission quantities by multiplying the emission factors by the aggregated VMT totals. PPAQ then produces an emissions database summarizing VMT, VHT, VOC, and NOx emissions as shown in Exhibit 8.

Exhibit 8

Summary of PPAQ's Methodology in Producing Emissions Summary



Example:

Luzerne County rural freeways during the morning peak period (7-10am) were run as a scenario in MOBILE. Based on the input information, MOBILE outputs emission factors by vehicle type for this scenario as shown below:

Composite Emission Factors (grams/mile) from MOBILE output

Vehicle Type:	LDGV	LDGT1	LDGT2	HDGT	LDDV	LDDT	HDDV	MC
VOC:	1.22	1.86	2.42	3.68	0.36	0.54	1.13	4.53
NOX:	2.41	3.16	3.66	7.14	1.84	4.15	5.84	8.71

PPAQ reads these emission factors from the MOBILE output file and multiplies them by the Luzerne County morning peak period rural freeway VMT to obtain emission totals for this scenario. (Note: emissions shown in kg/day which is converted to tons/day in SIP narratives)

PPAQ computes emissions as follows for this scenario:

			Emission Factors (g/mi)			**Emissions (kg/day)**	
Veh Type	**VMT**		**VOC**	**NOX**		**VOC**	**NOX**
LDGV	84,344	x	1.22	2.41	=	102.9	203.3
LDGT1	30,713	x	1.86	3.16	=	57.1	97.1
LDGT2	21,515	x	2.42	3.66	=	52.1	78.7
HDGT	4,209	x	3.68	7.14	=	15.5	30.1
LDDV	3,586	x	0.36	1.84	=	1.3	6.6
LDDT	2,806	x	0.54	4.15	=	1.5	11.6
HDDV	7,483	x	1.13	5.84	=	8.5	43.7
MC	1,248	x	4.53	8.71	=	5.7	10.9
Total	155,903					244.6	482.0

The emissions for this scenario are reported and stored in an output database file which contains a record for each scenario with fields containing VMT, VHT, VOC emissions, and NOX emissions. Fields exist for each vehicle type and for the total of all vehicle types as shown below.

Reported by Vehicle Type 1-8 and Total --- Repeated for VHT,HC,NOX

Cnty	**UR**	**FC**	**Time**	**VMT1**	**VMT2**	**VMT3**	**VMT4**	**VMT5**	**VMT6**	**VMT7**	**VMT8**	**VMTtot**
Luze	1	1	AM	84,344	30,713	21,515	4,209	3,586	2,806	7,483	1,248	155,903
				VHT1	**VHT2**	**VHT3**	**VHT4**	**VHT5**	**VHT6**	**VHT7**	**VHT8**	**VHTtot**
				1,298	473	331	65	55	43	115	19	2,399
				VOC1	**VOC2**	**VOC3**	**VOC4**	**VOC5**	**VOC6**	**VOC7**	**VOC8**	**VOCtot**
				102.9	57.1	52.1	15.5	1.3	1.5	8.5	5.7	244.6

NOXtot	NOX1	NOX2	NOX3	NOX4	NOX5	NOX6	NOX7	NOX8
482.0	203.3	97.1	78.7	30.1	6.6	11.6	43.7	10.9

RESOURCES

MOBILE model

Modeling Page within EPA's Office of Mobile Sources Website (http://www.epa.gov/omswww/models.htm) contains a downloadable model, MOBILE users guide and other information. It also contains documents relating to the next version of MOBILE (MOBILE6) expected in 1999.

"AP-42" document, "Compilation of Air Pollutant Emission Factors, Volume II: Mobile Sources," as updated by Supplement A (January 1991), available in hard-copy only. This material is also in the process of being revised and updated. Contact AP-42 Project, Test and Evaluation Branch, EPA, 2565 Plymouth Road, Ann Arbor, MI 48105.

Highway Vehicle Emission Estimates (June 1992) and *Highway Vehicle Emission Estimates II* (May 1995) discusses how EPA obtains data for MOBILE and some of the shortcomings in earlier models. Similar discussions of the present version's shortcomings are discussed in papers available at the website.

"MOBILE5, Information Sheet #5, Inclusion of New 2004 NOx Standard for Heavy-Duty Diesel Engines in MOBILE5a and MOBILE5b Modeling," US EPA, January 30, 1998.

"MOBILE5, Information Sheet #6, Effects of the New National Low Emission Vehicle Standard for Light-Duty Gasoline Fueled Vehicles," US EPA, July 1998.

"MOBILE5, Information Sheet #7, NOx Benefits of Reformulated Gasoline Using MOBILE5a," US EPA, September 1998.

Traffic Engineering

1994 Highway Capacity Manual, Transportation Research Board, presents current knowledge and techniques for analyzing the transportation system.

Procedures for Adjusting Traffic Count Data, 1991 edition, Pennsylvania Department of Transportation, Bureau of Planning and Research

Traffic Data Collection and Factor Development Report, 1996 Data, Pennsylvania Department of Transportation, Bureau of Planning and Research.

Highway Vehicle Inventory Glossary

AADT: Average Annual Daily Traffic, average of ALL days.

AWDT: Average Weekday Daily Traffic

Basic emission rates: MOBILE emission rates based on the applicable Federal emission standards and the emission control technologies characterizing the fleet in various model years.

Cold start: parameter in MOBILE that accounts for additional emissions resulting from a cold-started engine.

Diurnals: the pressure-driven evaporative HC emissions resulting from the daily increase in temperature

Emission rate or factor: expresses the amount of pollution emitted per unit of activity. For highway vehicles, usually in grams of pollutant emitted per mile driven.

FC: Functional code, applied in data management to road segments to identify their type (freeway, local, etc.)

Fuel volatility: The ability of fuel components to evaporate, thus entering the atmosphere as pollution. Fuel volatility is usually measured as Reid Vapor Pressure (RVP) in pounds per square inch. The lower the RVP, the less volatile the fuel.

Growth factor: Factor used to convert volumes to future years

HPMS: Highway Performance Monitoring System, PennDOT's official source of highway information and a subset of RMS.

I/M: Vehicle emissions inspection/maintenance programs ensure that vehicle emission controls are in good working order throughout the life of the vehicle. The programs require vehicles to be tested for emissions. Most vehicles that do not pass must be repaired.

MOBILE: The model EPA has developed and which Pennsylvania uses to estimate emissions from highway vehicles.

Pattern data: Extrapolations of traffic patterns (such as how traffic volume on road segment types varies by time of day, or what kinds of vehicles tend to use a road segment type) from segments with observed data to similar segments.

Program flag: In MOBILE, a numeric code which tells the program such things as how data will be provided by user (or whether default will be used) or how to tailor outputs.

PPAQ: Post-Processor for Air Quality, a set of programs that estimate speeds and processes MOBILE emission rates.

RMS: Roadway Management System, a database maintained by PennDOT from traffic counts and field visits

Scenario: a MOBILE run with a specific set of geographical, time period, highway facility and control strategy assumptions.

Segment: (referred to as link) division of roadway in the PennDOT Roadway Management System. Usually represents 0.5 mile segments of roadway.

UR: Urban/rural code, applied in data management to identify whether a road segment is urban, small urban or rural.

VHT: vehicle hours traveled.

VMT: vehicle miles traveled. In modeling terms, it is the simulated traffic volumes times link length.

Vehicle Type: One of eight types, distinguished primarily by fuel type and/or weight, used in MOBILE modeling.

APPENDIX C

SUMMARY TABLES
AND
DOCUMENTATION FOR
PHILADELPHIA HIGHWAY
VEHICLE INVENTORIES