west virginia department of environmental protection

Appendix C: Berkeley County, WV On-Road Mobile Emissions Inventory Documentation

Promoting a healthy environment.

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On-Road (Highway) Emissions Inventory Documentation for the Berkeley County, West Virginia Portion of the Martinsburg, WV – Hagerstown, MD Nonattainment Area (1997 Annual $PM_{2.5}$ NAAQS)

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May 2013

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Berkeley County, West Virginia $PM_{2.5}$ Non-Attainment Area
On-Road (Highway) Emissions Inventory Documentation
May 2013

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OVERVIEW

This document provides the on-road (highway) mobile source emissions inventory for the Berkeley County, West Virginia portion of the Martinsburg, WV – Hagerstown, MD nonattainment area under the 1997 annual $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS). The inventory was developed using EPA's Motor Vehicle Emission Simulator (MOVES) model. The document includes a summary of the methodology and data assumptions used for the analysis. As shown in Exhibit 1, appendices have been provided with additional detail regarding the MOVES input parameters, vehicle miles of travel (VMT) and emission results for the nonattainment area.

Exhibit 1: Summary of Appendices

Appendix	Title	Description
A	Summary Emission Tables	Provides annual emissions for $PM_{2.5}$, NOx, SO_2, VOC, NH_3 by MOVES process ID, Road Type and Source Type for 2005, 2007, 2017, 2025 and 2040
B	Data Checklist	Provides air quality data checklist
C	MOVES Sample Run Specification	Provides example MOVES data importer (XML) and run specification (MRS) files.

Background:

Berkeley County (West Virginia) and Washington County (Maryland), two of the county jurisdictions in the Hagerstown Eastern Panhandle Metropolitan Planning Organization (HEPMPO), are designated nonattainment for the 1997 annual $PM_{2.5}$ NAAQS. Based on recent monitor readings showing compliance with the standard, a redesignation request and ten-year maintenance SIP is being prepared for the area. This highway inventory supports the SIP by providing estimated highway emissions for the 2005, 2007, 2017 and 2025 analysis years for the Berkeley County, West Virginia portion of the nonattainment area. One or more of the analysis years in the projected inventory may be designated as motor vehicle emission budgets (MVEBs) in support of future regional transportation conformity analyses. The transportation plans and programs for the region must be in conformance with all the provisions in the SIP and demonstrate that forecasted regional vehicle emissions do not exceed the established MVEBs.

The inventory is based on latest planning assumptions including the use of regional planning tools maintained by the HEPMPO, which is the responsible Metropolitan Planning Organization (MPO) for the area. The highway emissions inventory has been estimated using MOVES, EPA's current state-of-the-art tool for estimating emissions from highway vehicles. Compared to previous tools, MOVES incorporates the latest emissions data, more sophisticated calculation algorithms, increased user flexibility, new software design, and additional capabilities. EPA announced the release of MOVES2010 in March 2010 (75 Federal Register 9411), and released a minor revision as MOVES2010a in September 2010. In April 2012, EPA released MOVES2010b to allow users to benefit from several improvements to general model performance. MOVES2010b does not affect the criteria pollutant emissions results of MOVES2010a and therefore is not a new model. Based on the timing of the analysis, this highway emissions inventory utilizes the MOVES2010a model.

Highway Emissions:

Exhibit 2 summarizes the annual highway emissions inventory for the Berkeley County portion of the $PM_{2.5}$ nonattainment area. The inventory includes direct $PM_{2.5}$ (from tailpipe, brake wear and tire wear)

oxides of nitrogen (NOx), sulfur dioxide (SO_2), volatile organic compounds (VOC) and ammonia (NH_3). The emission estimates have been developed using the MOVES2010a emission model and latest planning assumptions. In addition to the required analysis years, test runs were also conducted for the current HEPMPO Long Range Transportation Plan (LRTP) 2040 horizon year. Available data on projects and land use were used to prepare this forecast. The 2040 analysis year has been included to illustrate the potential trends in $PM_{2.5}$ emissions due to the limited impacts of vehicle turnover and technology in that timeframe. These emission trends are considered in the development of final MVEBs and safety margins.

Exhibit 2: Summary of Highway Emissions Inventory

Pollutants	Emissions *(Short Tons/Year)*				
	2005	**2007**	**2017**	**2025**	**2040**
$PM_{2.5}$	199.2	176.5	65.6	39.7	36.9
NOx	5,520	5,005	2,016	1,277	1,142
SO_2	108.8	30.0	9.8	9.9	11.2
VOC	1,472.9	1,378.4	673.4	498.1	442.4
NH3	52.2	51.8	35.8	35.7	40.0

Analysis Methodology:

The analysis methodology and data inputs were developed through interagency consultation and using available EPA guidance documents including:

- *Policy Guidance on the Use of MOVES2010 and Subsequent Minor Revisions for SIP Development, Transportation Conformity, and Other Purposes*, US EPA Office of Air and Radiation, EPA-420-B-12-010, April 2012.
- *Using MOVES to prepare Emission Inventories in State Implementation Plans and Transportation Conformity: Technical Guidance for MOVES2010, 2010a and 2010b.* US EPA Office of Air and Radiation, and Office of Transportation and Air Quality, EPA-420-B-12-028, April 2012.
- *Motor Vehicle Emission Simulator, User Guide for MOVES2010a*, EPA-420-B-10-036, August 2010.

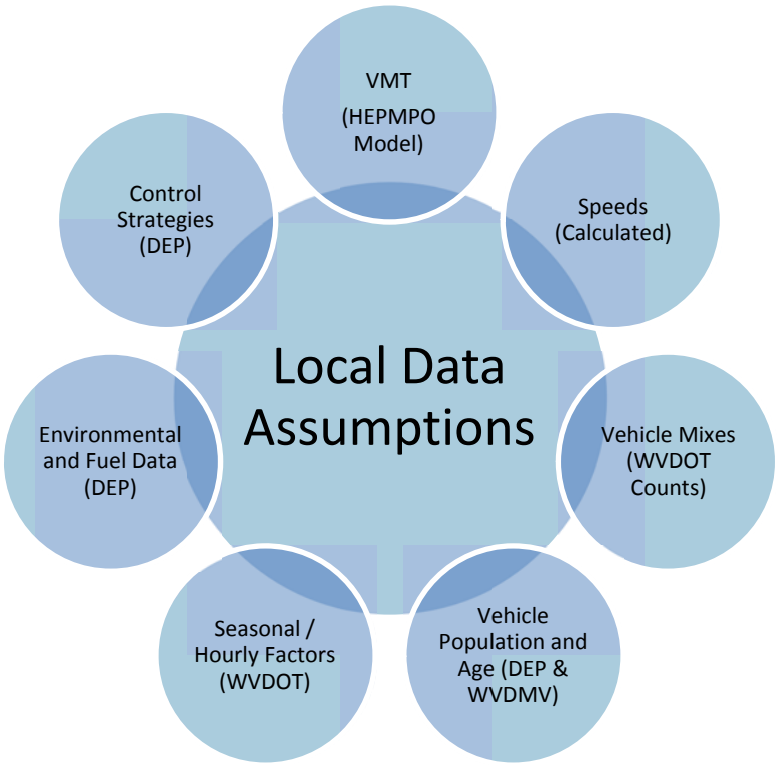
The methodologies used to produce the emission data conform to the recommendations provided in EPA's technical guidance. A mix of local and national default (internal to MOVES2010a) data has been used for this submission. As illustrated in Exhibit 3, local data has been used for the primary data items that have a significant impact on emissions including vehicle miles of travel, vehicle population, congested speeds, vehicle type mix and environmental and fuel assumptions. Local data inputs to the analysis process reflect the latest available planning assumptions using information obtained from the WVDOT, DEP, HEPMPO and other local/national sources.

The analysis methodology used for this inventory is consistent with that planned for future HEPMPO transportation conformity analyses including the upcoming LRTP. This includes the use of the regional travel demand model outputs and custom post-processing software (PPSUITE) to calculate hourly speeds and prepare key traffic input files to the MOVES2010a emission model. PPSUITE 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 MOVES runs and processes MOVES outputs.

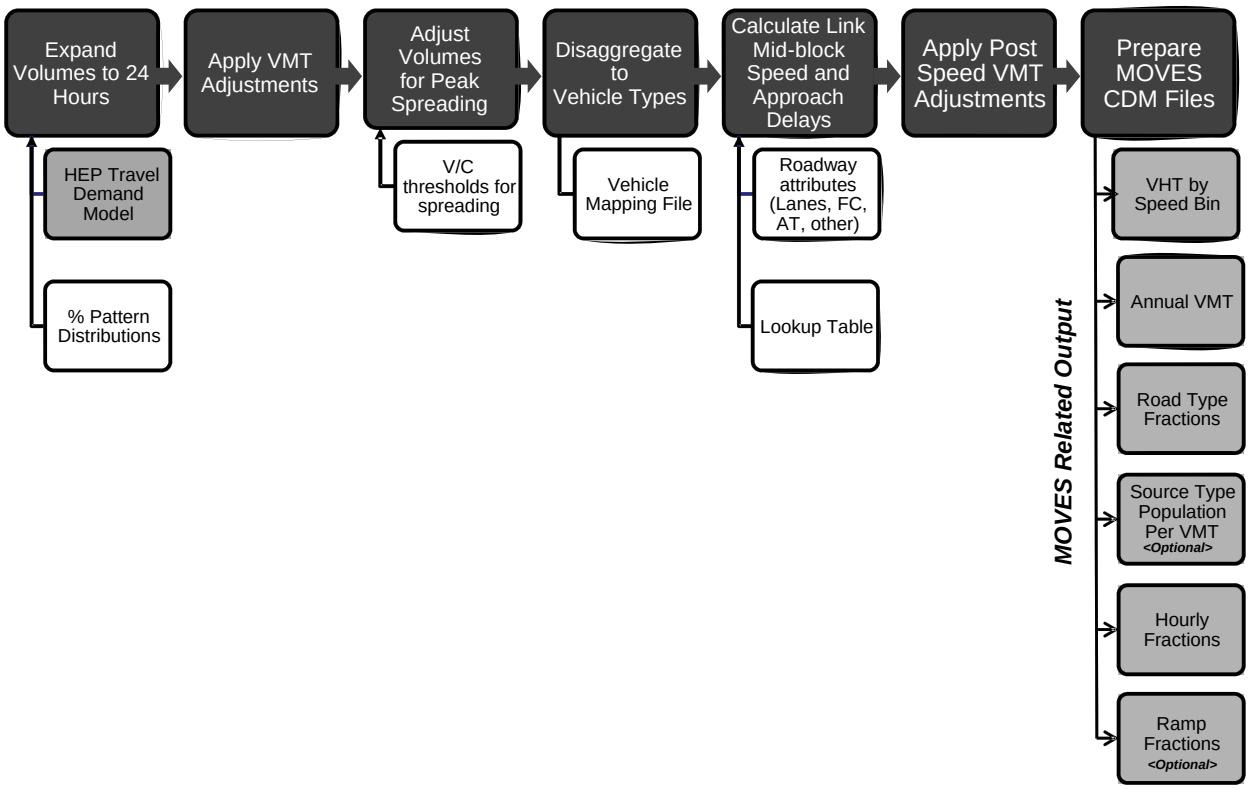
Exhibit 3: Local Data Inputs Used for Emissions Inventory



PPSUITE is a widely used and accepted tool for estimating speeds and processing emissions rates. It is has been used for past SIP highway inventories in Maryland, Pennsylvania, and New Jersey. The software is based upon accepted transportation engineering methodologies. For example, PPSUITE utilizes speed and delay estimation procedures based on planning methods provided in the 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.

The PPSUITE process is integral to producing traffic-related input files to the MOVES emission model. Exhibit 4 summarizes the key functions of PPSUITE within the emission calculation process. Other MOVES input files are prepared external to the PPSUITE software. These include vehicle population, vehicle age, environmental, and fuel input files.

Exhibit 4: Emission Calculation Process



The following sections provide additional detail on the input planning assumptions and analysis methodology including a description of data sources, the role of MOVES default parameters and additional details on the role of PPSUITE in developing the traffic input data files to MOVES.

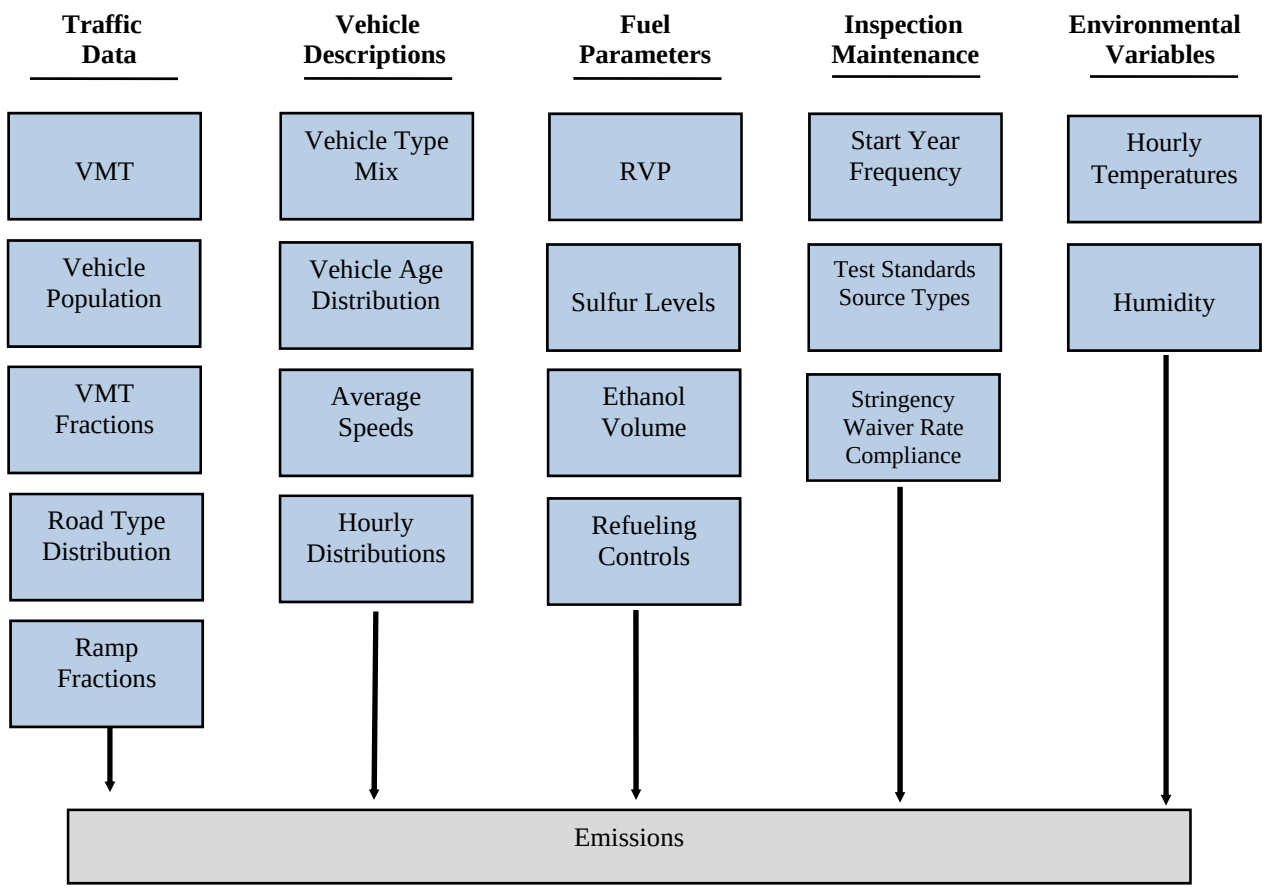
DESCRIPTION OF INPUT DATA

A large number of inputs to MOVES are needed to fully account for the numerous vehicle and environmental parameters that affect emissions. These include traffic flow characteristics, vehicle descriptions, fuel parameters, inspection/maintenance program parameters, and environmental variables as shown in Exhibit 5.

MOVES includes a default national database of meteorology, vehicle fleet, vehicle activity, fuel, and emission control program data for every county; but EPA cannot certify that the default data is the most current or best available information for any specific area. As a result, local data is recommended for use in SIP analyses, where available.

A mix of local and default data is used for this inventory. Local data sources are used for all inputs that have a significant impact on calculated emission rates. These data items are discussed in the following sections.

Exhibit 5: Examples of Key MOVES Input Data



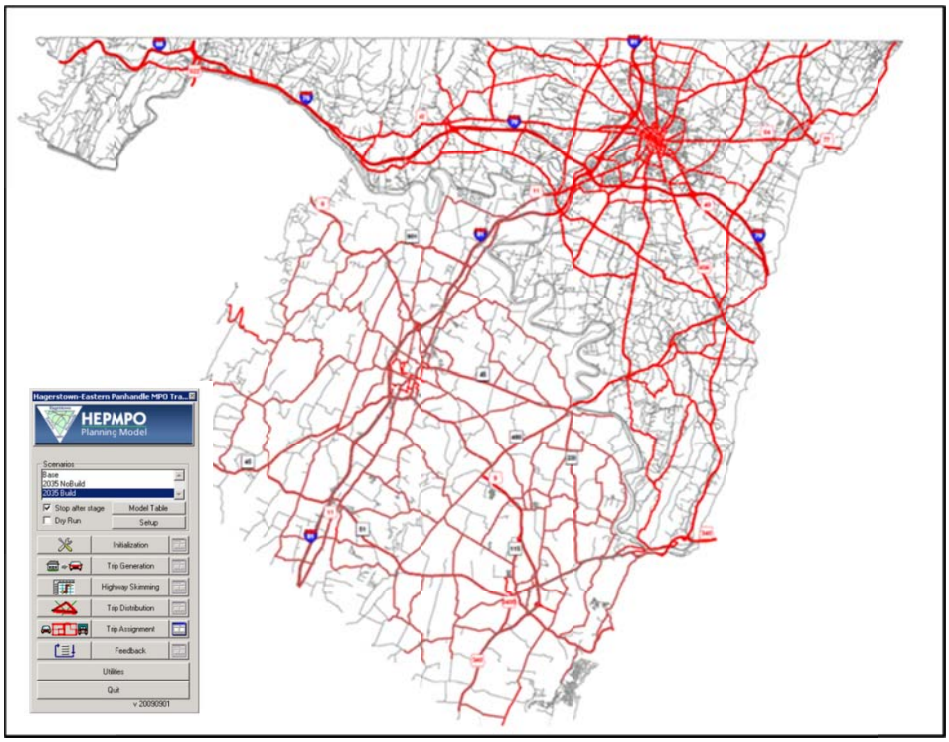
Roadway Data:

The roadway data input to emissions calculations for this inventory is based on information from the HEPMPO regional travel demand model as used for the region's LRTP, Direction2035. The travel model, as illustrated in Exhibit 6, estimates roadway volumes based on input demographic forecasts and expected changes to the transportation roadway network.

The HEPMPO travel demand model follows the basic "four-step" travel demand forecasting process and utilizes the TransCAD software platform. Given the small portion of daily travel carried by the bus system in the Hagerstown and Martinsburg regions, a separate mode choice or transit model is not included. Auto-occupancy factors are used to convert person trips into vehicle trips.

The model is driven by socio-economic and transportation network data. These data include items such as zonal population, households, income, school enrollment, and employment by type for 494 zones defined in the region. Transportation network data includes facility type, length, and speed limit for each of the highway links defined in the region. The highway network database contains attributes for each individual line in the line layer and includes all attributes needed to perform a traffic assignment. The travel model and associated land use inputs used for this inventory were based on the assumptions used for the 2035 LRTP submitted in June 2010.

Exhibit 6: HEP Regional Travel Demand Model



The travel model network and assigned traffic volumes are processed by the PPSUITE post processor to prepare the traffic inputs needed to the MOVES emission model. The following information is extracted from the model for emission calculations:

- lanes
- roadway capacity

- distance
- weekday traffic volume
- area type code
- facility class code

The volumes and distances are used in calculating highway VMT totals for each county. Forecast traffic volumes from the regional travel model are based on the input demographics. Exhibit 7 summarizes the demographics used for the Direction 2035 LRTP and for this emissions inventory. As discussed in the next section, adjustments are needed to convert the traffic volumes (and VMT) to average daily conditions in each month. Additional forecast year demographics needed for this inventory, including 2017 and 2025, were determined through interpolation.

The lane values, capacities, area type, and facility class are important inputs for determining the congestion and speeds for individual highway segments. The PPSUITE processing software allows for many additional variables other than those available in the regional travel model. Using these variables improves the calculation of congested speeds. Such variables include information regarding free-flow speeds, traffic signal and control parameters, and volume-delay functions. This data is determined from lookup tables based on the model link's area type and facility class. Much of the lookup table data was developed from information contained in the Highway Capacity Manual.

Exhibit 7: Demographic Growth Assumptions to the Travel Model

County	Year	Population	Households	Employment
Washington	2008	146,337	57,277	82,377
	2035	199,253	79,913	106,048
	Annual Growth	1.1%	1.2%	0.9%
Berkeley	2008	101,125	41,208	42,702
	2035	140,905	61,808	61,349
	Annual Growth	1.2%	1.5%	1.4%
Jefferson	2008	51,806	20,908	21,489
	2035	79,053	35,624	32,687
	Annual Growth	1.6%	2.0%	1.6%
Region	2008	299,268	119,393	146,568
	2035	419,211	177,345	200,084
	Annual Growth	1.3%	1.5%	1.2%

Other Supporting Traffic Data:

Other traffic data is used to adjust and disaggregate traffic volumes. Key sources used in these processes include the following:

- *HPMS VMT*: According to EPA guidance, baseline inventory VMT computed from the regional model must be adjusted to be consistent with HPMS VMT totals. Although it has some limitations, the HPMS system is currently in use in all 50 states and is being improved under FHWA direction. Adjustment factors are calculated which adjust the travel model VMT to be consistent with the

reported HPMS totals for that year. These factors are applied to all county and facility group combinations within the region. These adjustments are important for accounting for missing local roadway VMT that is not represented within the regional travel model. For historic analysis years (e.g. 2005 and 2007), VMT has been reconciled to match the reported VMT for each of those years.

- *Seasonal Factors*: The travel model produces traffic volumes representing an average weekday. To support the annual emission calculation process, the model travel volumes are adjusted to reflect average annual daily traffic (AADT), an average of all days in the year including weekends and holidays. Seasonal adjustment factors were obtained from the WVDOT. The factors are based on data processing of West Virginia's permanent traffic count stations. The seasonal factors are also used to develop the MOVES daily and monthly VMT fraction files, allowing MOVES to determine the portion of annual VMT that occurs in each month of the year.

- *Hourly Patterns*: Speeds and emissions vary considerably depending on the time of day. Therefore, it is important to estimate the pattern by which roadway volume varies by hour of the day. Pattern data is in the form of a percentage of the daily volumes for each hour. Distributions are provided for all the counties within the region and by each facility type grouping. This data was not directly available from WVDOT but was determined through an assessment of available data in other states. The same factors are also used to develop the MOVES hourly fraction file.

Vehicle Class Data:

Emission rates within MOVES vary significantly by the type of vehicle. The MOVES model produces emissions and rates by thirteen MOVES vehicle source types. However, VMT is input to MOVES by six HPMS vehicle groups. Exhibit 8 summarizes the distinction between each classification scheme.

Exhibit 8: MOVES Source Types and HPMS Vehicle Groups

SOURCE TYPES		HPMS Class Groups	
11	Motorcycle	10	Motorcycle
21	Passenger Car	20	Passenger Car
31	Passenger Truck	30	Passenger/Light Truck
32	Light Commercial Truck	40	Buses
41	Intercity Bus	50	Single Unit Trucks
42	Transit Bus	60	Combination Trucks
43	School bus		
51	Refuse Truck		
52	Single Unit Short-haul Truck		
53	Single Unit Long-haul Truck		
54	Motor Home		
61	Combination Short-haul Truck		
62	Combination Long-haul Truck		

For this regional inventory, vehicle type pattern data was developed for each county and facility class combination based on WVDOT classification counts and internal MOVES defaults. As the first step, WVDOT truck count data was used to develop percentage splits of the total volume to the following vehicle groups:

- autos
- heavy trucks and buses

MOVES default 2008 VMT by HPMS vehicle type (for Berkeley county) were then used to split the above vehicle groups (autos and trucks) into the 6 HPMS vehicle classes needed by MOVES.

The vehicle type percentages are also provided to the capacity analysis section of PPSUITE 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 is accounted for in the speed estimation process by adjusting capacity using information from the Highway Capacity Manual.

Vehicle Ages:

Vehicle age distributions are input to MOVES for each county by the thirteen source types. The distributions reflect the percentage of vehicles in the fleet up to 31 years old. The vehicle age distributions were prepared by DEP based on information obtained from West Virginia Division of Motor Vehicle (WVDMV) 2010 registration data. MOVES default values by analysis year were used for source types 41, 42, 43, 51, 52, 53, 61, and 62, which includes all heavy trucks and buses.

Vehicle Population Data:

The information on the vehicle fleet including the number and age of vehicles impacts forecasted start and evaporative emissions within MOVES. Similar to vehicle ages, MOVES requires the population of vehicles by the thirteen source type categories. The MOVES national default values for calendar year 2010 provided the data for source types 51, 52, 53, 61 and 62. All other light-duty vehicles, buses and motor homes were developed based on WVDMV registration data. This data was processed by DEP based on 2010 registration data.

For the preparation of source type population for other years, the 2010 values were adjusted using growth factors based on historic and forecast population and employment for the region from the Woods and Poole 2012 State Profile. For light-duty vehicles, growth rates were developed based on the population growth in Berkeley County. For heavy trucks, growth rates were determined by selecting the maximum of the population and employment growth for that county.

Environmental and Fuel Data:

Information on environmental, fuel, vehicle technology and other control strategy assumptions were determined based on a review of MOVES2010a default information and other available local data.

Average monthly minimum and maximum temperatures were obtained from the South East Regional Climate Center (SERCC). EPA's MOBILE6.2-MOVES meteorological data convertor spreadsheet (available from http://www.epa.gov/oms/models/moves/tools.htm) was used to prepare the hourly temperature inputs needed for the MOVES model based on the available data. MOVES default humidity values were used for the county.

MOVES default fuel assumptions were updated with the following local data assumptions by season:

- Summer (months 5-10): RVP=10 for E10 fuel; RVP=9 for conventional gasoline
- Winter (months 1,2,12): RVP=14
- Other (months 3,4,11): Uses MOVES default RVP that varies by year

The MOVES defaults included a 29% market share of E10 fuel in 2007 and a 100% market share of E10 fuel in future analysis years.

Other Vehicle Technology and Control Strategy Data:

West Virginia does not have a vehicle inspection maintenance program and there are no state vehicle technology strategies included in the highway emissions inventory. Current federal vehicle emissions control and fuel programs are incorporated into the MOVES2010a software. These include the National Program standards covering model year vehicles through 2016. Modifications of default emission rates are required to reflect the early implementation of the National Low Emission Vehicle Program (NLEV) program in West Virginia. To reflect these impacts, EPA has released instructions and input files that can be used to model these impacts. This inventory utilized the August 2010 version of the files (http://www.epa.gov/oms/models/moves/tools.htm).

ANALYSIS METHODOLOGY

The previous sections have summarized the input data used for computing speeds and emission rates for this highway emissions inventory. This section explains how PPSUITE and MOVES uses that input data to produce emission estimates. Exhibit 9 provides a more detailed overview of the PPSUITE analysis procedure using the available traffic data information described in the previous section.

VMT Preparation:

Producing an emissions inventory with PPSUITE requires a process of disaggregation and aggregation. Data is available and used on a very small scale – individual travel model roadway segments for each of the 24 hours of the day. This data needs to be processed individually to determine the distribution of vehicle hours of travel (VHT) by speed and then aggregated by vehicle class to determine the input VMT to the MOVES emission model. Key steps in the preparation of VMT include:

- *Assemble Travel Model Link VMT* - The HEPMPO regional travel model contains the roadway links, distances and travel volumes needed to estimate VMT. The PPSUITE software processes each link by simply multiplying the assigned travel volume by the distance to obtain VMT. Highway networks for analysis years not available from the past conformity runs are calculated by interpolating VMT from existing networks.

- *Apply Seasonal Adjustments* - PPSUITE takes the travel model average weekday volumes and adjusts the volume to reflect average annual conditions (AADT). The AADT volumes are used in the speed processing routines to determine an average set of congested speeds by hour of the day. The link AADT volumes are assembled by PPSUITE and extrapolated to produce the annual VMT file input to MOVES.

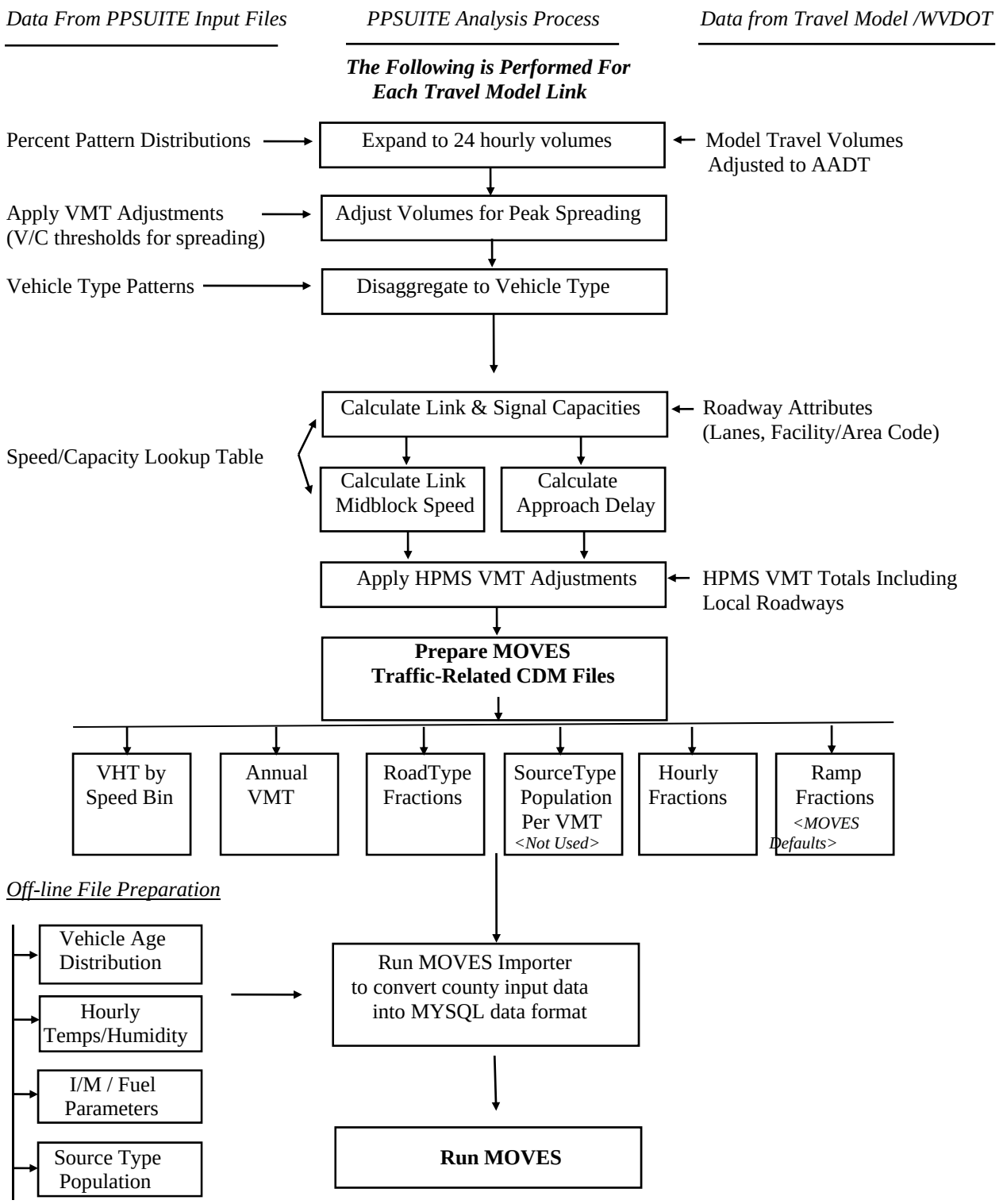
- *Disaggregate to Hours* - After adjusting the link volume to represent AADT, the volume is split to each hour of the day. This allows for more accurate speed calculations (effects of congested hours) and allows PPSUITE to prepare the hourly VMT and speeds for input to the MOVES model.

- *Peak Spreading* - After dividing the daily volumes to each hour of the day, PPSUITE identifies hours that are unreasonably congested. For those hours, PPSUITE 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. This process also helps prevent hours with unreasonably congested speeds that may impact emission calculations.

- *Disaggregation to Vehicle Types* - EPA requires VMT estimates to be prepared by source type, reflecting specific local characteristics. The hourly volumes are disaggregated to the six HPMS MOVES vehicle grouping based on WVDOT vehicle classification count data in combination with MOVES defaults as described in the previous section.

- *Apply HPMS 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 PPSUITE, and are applied to each of the roadway segment volumes. These factors were developed from reported HPMS VMT totals for years 2005, 2007 and 2008. The 2008 factors are applied to future year runs. The VMT added or subtracted to the travel model links assume the speeds calculated using the original volumes for each roadway segment for each hour of the day.

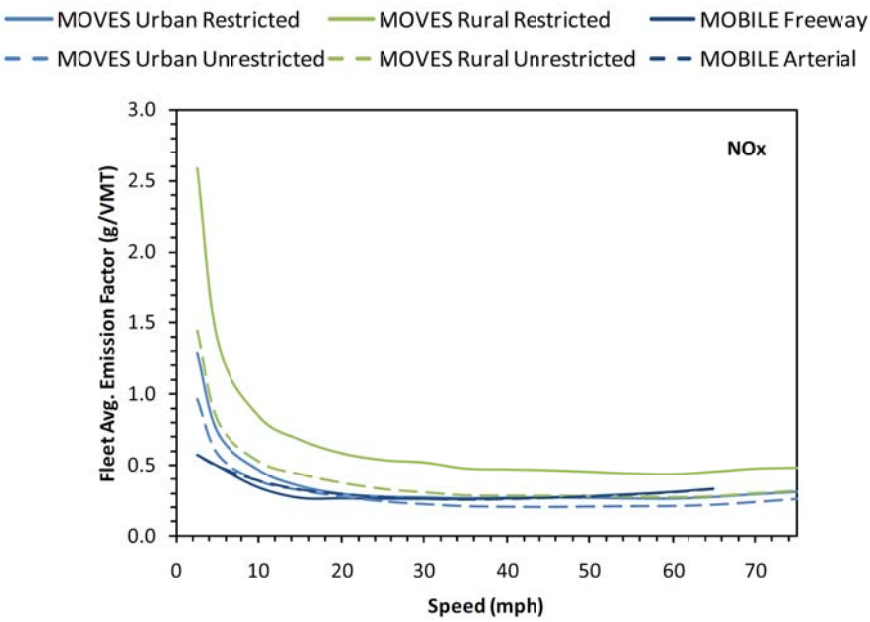
Exhibit 9: PPSUITE Speed/Emission Estimation Procedure



Speed Estimation:

Emissions for many pollutants (including both VOC and NOx) vary significantly with travel speed. While VOCs generally decrease as speed increases, NOx decreases at the low speed range and increases at higher speeds, as illustrated in Exhibit 10.

Exhibit 10: Emission Factor vs. Speed Variances (NOx)



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on, July 2010.

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 road type.

The computational framework used for this analysis meets and exceeds that recommendation. Speeds are individually calculated for each roadway segment and hour and include the estimated delays encountered at signals. Rather than accumulating the roadway segments into a particular road type and calculating an average speed, each individual link hourly speed is represented in the MOVES vehicle hours of travel (VHT) by speed bin file. This MOVES input file allows the specification of a distribution of hourly speeds. For example, if 5% of a county's arterial VHT operates at 5 mph during the AM peak hour and the remaining 95% operates at 65 mph, this can be represented in the MOVES speed input file. For the highway emissions inventory, distributions of speeds are input to MOVES by road type and source type by each hour of the day.

To calculate speeds, PPSUITE 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 area and facility type codes. For areas with known characteristics, values can be directly coded to the 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 characteristics, and other capacity adjustment information used for calculating congested delays and speeds. The result of this process is an estimated average travel time for each hour of the day for each highway segment. The average time multiplied by the volume produces vehicle hours of travel (VHT).

Developing the MOVES Traffic Input Files:

The PPSUITE software is responsible for producing the following MOVES input files during any analysis run:

- VMT by HPMS vehicle class
- VHT by speed bin
- road type distributions
- ramp fractions (Use MOVES defaults)

These files are text formatted files with a *.csv extension. The files are provided as inputs within the MOVES County Data Manager (CDM) and are described below:

- *VMT Input File:* VMT is the primary traffic input that affects emission results. The roadway segment distances and traffic volumes are used to prepare estimates of VMT. PPSUITE performs these calculations and outputs the MOVES annual VMT input file to the County Data Manager (CDM). The annual VMT is computed by multiplying the travel model adjusted AADT by 365 days in a year.

- *VHT by Speed Bin File*: As described in the previous section, the PPSUITE software prepares the MOVES VHT by speed bin file which summarizes the distribution of speeds across all links into each of 16 MOVES speed bins for each hour of the day by road type. This robust process ensures that MOVES emission rates are used to the fullest extent and is consistent with the methods and recommendations provided in EPA's technical guidance.

- *Road Type Distributions*: In MOVES, typical drive cycles and associated operating conditions vary by the type of roadway. MOVES defines five different road types as follows:

  1 Off-Network
  2 Rural Restricted Access
  3 Rural Unrestricted Access
  4 Urban Restricted Access
  5 Urban Unrestricted Access

  For this inventory, the MOVES road type distribution file is automatically generated by PPSUITE using defined equivalencies. The off-network road type includes emissions from vehicle starts, extended idle activity, and evaporative emissions. Off-network activity in MOVES is primarily determined by the Source Type Population input. The remaining distribution among road types is determined by equating the model facility types with each MOVES road type as follows:

  - MOVES Road Type (2) = Rural travel model interstate and ramps
  - MOVES Road Type (3) = All remaining Rural travel model facility types
  - MOVES Road Type (4) = Urban travel model interstate and ramps
  - MOVES Road Type (5) = All remaining Urban travel model facility types

- *Ramp Fractions*: MOVES default Ramp Fraction file (assuming 8% of ramp VMT fraction for both urban and rural links) is used as inputs to MOVES.

MOVES Runs:

After computing speeds and aggregating VMT and VHT, PPSUITE prepares traffic-related inputs needed to run EPA's MOVES2010a software. Additional required MOVES inputs are prepared external to the processing software and include temperatures, I/M program parameters, fuel characteristics, vehicle fleet age distributions and source type population.

The MOVES county importer is run in batch mode. This program converts all data files into the MYSQL formats used by the MOVES model. At that point a MOVES run specification file (*.mrs) is created which specifies options and key data locations for the run. MOVES is then executed in batch mode. A summary of key MOVES run specification settings is shown in Exhibit 11.

Exhibit 11: MOVES Run Specification File Parameter Settings

Parameter	Setting
MOVES Default Database Version	8/26/2010
Scale	COUNTY
Analysis Mode	Inventory
Time Span	12 months Weekday and Weekend 24 hours
Time Aggregation	Hour
Geographic Selection	54003 – Berkeley County
Vehicle Selection	All source types Gasoline, Diesel, CNG
Road Type	All road types including off-network
Pollutants and Processes	All $PM_{2.5}$ categories, NOx, SO_2, VOC, NH_3
Database selection	Early NLEV database
General Output	Units: Emission = grams Distance = miles Time = hours Energy = Million BTU
Output Emissions	Time = Month, Emissions by Process ID, Source Type, and Road Type

MOVES can be executed using either the *inventory* or *rate-based* approaches. For this highway emissions inventory, MOVES is applied using the *inventory-based* approach. Under this method, actual VMT and population are provided as inputs to the model; MOVES is responsible for producing the total emissions for the region. Under the rate-based approach, MOVES would produce emission factors, after which PPSUITE would apply the emission factors to the link data and calculate total regional emissions.

RESOURCES

MOVES model

Modeling Page within EPA's Office of Mobile Sources Website (http://www.epa.gov/omswww/models.htm) contains a downloadable model, MOVES users guide and other information.

Policy Guidance on the Use of MOVES2010 and Subsequent Minor Revisions for SIP Development, Transportation Conformity, and Other Purposes, US EPA Office of Air and Radiation, EPA-420-B-12-010, April 2012.

Using MOVES to prepare Emission Inventories in State Implementation Plans and Transportation Conformity: Technical Guidance for MOVES2010, 2010a and 2010b. US EPA Office of Air and Radiation, and Office of Transportation and Air Quality, EPA-420-B-12-028, April 2012.

Motor Vehicle Emission Simulator, User Guide for MOVES2010a, EPA-420-B-10-036, August 2010.

Traffic Engineering

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

Traffic Trends System Report Module, 2008 Data, State Highway Administration

Highway Vehicle Inventory Glossary

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

AWDT: Average Weekday Daily Traffic.

County Data Manager (CDM): User interface developed to simplify importing specific local data for a single county or a user-defined custom domain without requiring direct interaction with the underlying MySQL database.

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.).

Growth factor: Factor used to convert volumes to future years.

HPMS: Highway Performance Monitoring System

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.

MOVES: The latest model EPA has developed 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.

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

Road Type: Functional code, applied in data management to road segments to identify their type (rural/urban highways, rural/urban arterials, etc.)

Source Type: One of thirteen vehicle types used in MOVES modeling.

VHT: Vehicle hours traveled.

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

APPENDIX A:

Annual VMT and Emission Tables
$PM_{2.5}$ / NOx / SO_2 / VOC / NH_3

Emissions by MOVES Process ID

			PM2.5 Emissions by Emission Process (Tons/Year)				
County	Emission Process	ProcessID	2005	2007	2017	2025	2040
Berkeley	Running Exhaust	1	152.0	133.5	45.6	24.6	21.2
	Start Exhaust	2	11.2	10.3	5.9	4.8	5.0
	Brakewear	9	4.0	4.2	4.9	5.7	7.0
	Tirewear	10	1.8	1.9	2.2	2.5	3.0
	Evap Permeation	11	0.0	0.0	0.0	0.0	0.0
	Evap Fuel Vapor Venting	12	0.0	0.0	0.0	0.0	0.0
	Evap Fuel Leaks	13	0.0	0.0	0.0	0.0	0.0
	Crankcase Running Exhaust	15	25.9	22.6	5.7	1.4	0.2
	Crankcase Start Exhaust	16	0.2	0.2	0.1	0.0	0.0
	Crankcase Extended Idle Exhaust	17	0.7	0.6	0.1	0.0	0.0
	Extended Idle Exhaust	90	3.5	3.1	1.0	0.6	0.5
	Total		**199.2**	**176.5**	**65.6**	**39.7**	**36.9**

			NOX Emissions by Emission Process (Tons/Year)				
County	Emission Process	ProcessID	2005	2007	2017	2025	2040
Berkeley	Running Exhaust	1	4,880.6	4,352.2	1,524.4	857.2	709.9
	Start Exhaust	2	405.2	409.6	248.3	160.0	126.5
	Brakewear	9	0.0	0.0	0.0	0.0	0.0
	Tirewear	10	0.0	0.0	0.0	0.0	0.0
	Evap Permeation	11	0.0	0.0	0.0	0.0	0.0
	Evap Fuel Vapor Venting	12	0.0	0.0	0.0	0.0	0.0
	Evap Fuel Leaks	13	0.0	0.0	0.0	0.0	0.0
	Crankcase Running Exhaust	15	1.7	1.5	0.4	0.1	0.0
	Crankcase Start Exhaust	16	0.0	0.0	0.0	0.0	0.0
	Crankcase Extended Idle Exhaust	17	0.1	0.1	0.0	0.0	0.0
	Extended Idle Exhaust	90	232.2	241.6	242.7	260.0	305.3
	Total		**5,520**	**5,005**	**2,016**	**1,277**	**1,142**

			SO2 Emissions by Emission Process (Tons/Year)				
County	Emission Process	ProcessID	2005	2007	2017	2025	2040
Berkeley	Running Exhaust	1	91.6	26.7	9.2	9.4	10.7
	Start Exhaust	2	1.6	1.0	0.4	0.4	0.4
	Brakewear	9	0.0	0.0	0.0	0.0	0.0
	Tirewear	10	0.0	0.0	0.0	0.0	0.0
	Evap Permeation	11	0.0	0.0	0.0	0.0	0.0
	Evap Fuel Vapor Venting	12	0.0	0.0	0.0	0.0	0.0
	Evap Fuel Leaks	13	0.0	0.0	0.0	0.0	0.0
	Crankcase Running Exhaust	15	13.6	2.1	0.2	0.1	0.1
	Crankcase Start Exhaust	16	0.0	0.0	0.0	0.0	0.0
	Crankcase Extended Idle Exhaust	17	0.3	0.0	0.0	0.0	0.0
	Extended Idle Exhaust	90	1.7	0.2	0.1	0.1	0.1
	Total		**108.8**	**30.0**	**9.8**	**9.9**	**11.2**

			VOC Emissions by Emission Process (Tons/Year)				
County	Emission Process	ProcessID	2005	2007	2017	2025	2040
Berkeley	Running Exhaust	1	470.6	399.9	133.8	81.5	71.0
	Start Exhaust	2	650.8	631.5	321.8	229.0	183.6
	Brakewear	9	0.0	0.0	0.0	0.0	0.0
	Tirewear	10	0.0	0.0	0.0	0.0	0.0
	Evap Permeation	11	37.4	42.5	30.7	21.1	16.7
	Evap Fuel Vapor Venting	12	201.8	191.8	93.4	72.3	62.9
	Evap Fuel Leaks	13	42.2	46.1	56.7	62.8	74.7
	Crankcase Running Exhaust	15	6.9	5.9	1.9	1.0	0.8
	Crankcase Start Exhaust	16	8.6	8.3	4.2	3.0	2.4
	Crankcase Extended Idle Exhaust	17	1.1	1.0	0.3	0.1	0.0
	Extended Idle Exhaust	90	53.3	51.4	30.6	27.4	30.3
	Total		**1,472.9**	**1,378.4**	**673.4**	**498.1**	**442.4**

			NH3 Emissions by Emission Process (Tons/Year)				
County	Emission Process	ProcessID	2005	2007	2017	2025	2040
Berkeley	Running Exhaust	1	52.2	51.8	35.8	35.4	39.1
	Start Exhaust	2	0.0	0.0	0.0	0.0	0.0
	Brakewear	9	0.0	0.0	0.0	0.0	0.0
	Tirewear	10	0.0	0.0	0.0	0.0	0.0
	Evap Permeation	11	0.0	0.0	0.0	0.0	0.0
	Evap Fuel Vapor Venting	12	0.0	0.0	0.0	0.0	0.0
	Evap Fuel Leaks	13	0.0	0.0	0.0	0.0	0.0
	Crankcase Running Exhaust	15	0.0	0.0	0.0	0.0	0.0
	Crankcase Start Exhaust	16	0.0	0.0	0.0	0.0	0.0
	Crankcase Extended Idle Exhaust	17	0.0	0.0	0.0	0.0	0.0
	Extended Idle Exhaust	90	0.0	0.0	0.0	0.4	0.8
	Total		**52.2**	**51.8**	**35.8**	**35.7**	**40.0**

VMT by Road Type

			VMT by Road Type (Miles/Year)				
County	Road Type	RoadTypeID	2005	2007	2017	2025	2040
Berkeley	Off-Network	1	0	0	0	0	0
	Rural Restricted	2	224,258,913	241,692,484	275,813,505	304,167,862	351,430,526
	Rural UnRestricted	3	198,858,080	203,608,102	260,724,922	302,708,961	376,569,731
	Urban Restricted	4	281,127,252	302,981,670	338,712,475	364,756,571	410,313,819
	Urban UnRestricted	5	278,790,371	300,823,841	343,061,377	393,200,960	489,711,212
	Total		**983,034,616**	**1,049,106,097**	**1,218,312,279**	**1,364,834,354**	**1,628,025,288**

Emissions by Road Type

			PM2.5 Emissions by Road Type (Tons/Year)				
County	Road Type	RoadTypeID	2005	2007	2017	2025	2040
Berkeley	Off-Network	1	15.6	14.2	7.2	5.5	5.5
	Rural Restricted	2	55.3	48.8	15.9	7.9	6.3
	Rural UnRestricted	3	20.5	17.5	8.0	5.8	6.2
	Urban Restricted	4	70.5	62.3	20.1	9.9	7.7
	Urban UnRestricted	5	37.4	33.7	14.4	10.6	11.2
	Total		**199.2**	**176.5**	**65.6**	**39.7**	**36.9**

			NOX Emissions by Road Type (Tons/Year)				
County	Road Type	RoadTypeID	2005	2007	2017	2025	2040
Berkeley	Off-Network	1	638	651	491	420	432
	Rural Restricted	2	1,525	1,363	464	255	208
	Rural UnRestricted	3	583	501	205	125	110
	Urban Restricted	4	1,884	1,686	567	306	244
	Urban UnRestricted	5	891	804	290	172	148
	Total		**5,520**	**5,005**	**2,016**	**1,277**	**1,142**

			SO2 Emissions by Road Type (Tons/Year)				
County	Road Type	RoadTypeID	2005	2007	2017	2025	2040
Berkeley	Off-Network	1	3.6	1.3	0.4	0.4	0.5
	Rural Restricted	2	32.7	7.5	2.3	2.3	2.6
	Rural UnRestricted	3	12.1	4.4	1.7	1.8	2.1
	Urban Restricted	4	40.6	9.4	2.8	2.8	3.0
	Urban UnRestricted	5	19.7	7.4	2.6	2.6	3.1
	Total		**108.8**	**30.0**	**9.8**	**9.9**	**11.2**

			VOC Emissions by Road Type (Tons/Year)				
County	Road Type	RoadTypeID	2005	2007	2017	2025	2040
Berkeley	Off-Network	1	888.1	882.0	498.1	380.7	336.0
	Rural Restricted	2	113.5	99.8	35.5	22.2	19.3
	Rural UnRestricted	3	114.0	91.3	34.3	24.4	22.9
	Urban Restricted	4	146.6	128.8	45.0	27.8	23.8
	Urban UnRestricted	5	210.7	176.5	60.4	43.0	40.4
	Total		**1,472.9**	**1,378.4**	**673.4**	**498.1**	**442.4**

			NH3 Emissions by Road Type (Tons/Year)				
County	Road Type	RoadTypeID	2005	2007	2017	2025	2040
Berkeley	Off-Network	1	0.0	0.0	0.0	0.4	0.8
	Rural Restricted	2	12.0	12.0	8.5	8.4	9.1
	Rural UnRestricted	3	10.6	10.1	7.4	7.4	8.5
	Urban Restricted	4	15.0	15.1	10.4	10.1	10.6
	Urban UnRestricted	5	14.6	14.6	9.5	9.5	10.9
	Total		**52.2**	**51.8**	**35.8**	**35.7**	**40.0**

VMT by Source Type

County	Source Type	SourceTypeID	VMT by Source Type (Miles/Year)				
			2005	2007	2017	2025	2040
Berkeley	Motorcycle	11	4,937,094	5,265,623	6,137,224	6,900,452	8,277,709
	Passenger Car	21	469,600,500	500,849,520	583,753,630	656,349,040	787,349,430
	Passenger Truck	31	276,965,490	295,392,260	344,288,990	387,105,510	464,372,060
	Light Commercial Truck	32	48,285,297	51,501,859	60,025,110	67,488,953	80,954,740
	Intercity Bus	41	760,917	842,805	935,909	1,023,383	1,190,919
	Transit Bus	42	212,343	258,656	255,891	308,615	357,075
	School Bus	43	3,062,919	3,217,763	3,744,382	4,108,208	4,775,037
	Refuse Truck	51	933,252	974,281	1,193,865	1,374,695	1,626,861
	Single Unit Short-haul Truck	52	38,186,224	41,092,534	47,826,673	52,931,610	61,575,069
	Single Unit Long-haul Truck	53	5,838,667	6,038,399	5,963,135	6,297,475	7,260,310
	Motor Home	54	695,408	749,912	849,930	930,851	1,058,091
	Combination Short-haul Truck	61	53,166,081	58,063,285	72,209,346	81,779,692	95,254,283
	Combination Long-haul Truck	62	80,390,423	84,859,200	91,128,195	98,235,871	113,973,705
	Total		**983,034,616**	**1,049,106,097**	**1,218,312,279**	**1,364,834,354**	**1,628,025,288**

Emissions by Source Type

County	Source Type	SourceTypeID	PM2.5 Emissions by Source Type (Tons/Year)				
			2005	2007	2017	2025	2040
Berkeley	Motorcycle	11	0.3	0.3	0.3	0.3	0.4
	Passenger Car	21	18.5	17.4	11.7	10.7	12.1
	Passenger Truck	31	18.7	17.2	11.2	10.3	11.7
	Light Commercial Truck	32	4.5	4.1	2.1	1.7	1.8
	Intercity Bus	41	1.0	1.0	0.4	0.2	0.0
	Transit Bus	42	0.2	0.2	0.1	0.0	0.0
	School Bus	43	2.0	1.8	1.0	0.4	0.1
	Refuse Truck	51	0.8	0.7	0.2	0.1	0.1
	Single Unit Short-haul Truck	52	13.6	12.1	3.8	1.8	1.4
	Single Unit Long-haul Truck	53	1.8	1.5	0.5	0.2	0.2
	Motor Home	54	0.2	0.1	0.1	0.0	0.0
	Combination Short-haul Truck	61	53.2	46.4	13.0	5.2	3.6
	Combination Long-haul Truck	62	84.5	73.5	21.3	8.6	5.3
	Total		**199.2**	**176.5**	**65.6**	**39.7**	**36.9**

County	Source Type	SourceTypeID	NOX Emissions by Source Type (Tons/Year)				
			2005	2007	2017	2025	2040
Berkeley	Motorcycle	11	7.1	6.3	4.8	5.2	6.1
	Passenger Car	21	728.2	665.8	275.5	175.9	135.4
	Passenger Truck	31	908.6	859.3	400.4	248.3	201.3
	Light Commercial Truck	32	154.3	149.5	72.0	48.1	46.9
	Intercity Bus	41	20.1	19.6	9.1	4.2	1.7
	Transit Bus	42	4.8	5.1	2.0	1.0	0.5
	School Bus	43	42.2	40.2	21.8	11.1	5.5
	Refuse Truck	51	19.2	16.4	5.1	2.7	2.4
	Single Unit Short-haul Truck	52	311.7	289.3	131.9	98.7	100.8
	Single Unit Long-haul Truck	53	40.1	36.5	16.1	11.8	11.5
	Motor Home	54	5.9	5.8	3.7	2.8	2.5
	Combination Short-haul Truck	61	1,222.0	1,084.2	340.6	170.4	142.7
	Combination Long-haul Truck	62	2,055.6	1,827.0	733.0	497.1	484.5
	Total		**5,520**	**5,005**	**2,016**	**1,277**	**1,142**

			SO2 Emissions by Source Type (Tons/Year)				
County	Source Type	SourceTypeID	2005	2007	2017	2025	2040
Berkeley	Motorcycle	11	0.1	0.1	0.0	0.0	0.1
	Passenger Car	21	12.8	8.7	3.3	3.3	3.8
	Passenger Truck	31	11.4	7.4	2.7	2.6	2.9
	Light Commercial Truck	32	2.6	1.3	0.4	0.4	0.5
	Intercity Bus	41	0.3	0.1	0.0	0.0	0.0
	Transit Bus	42	0.1	0.0	0.0	0.0	0.0
	School Bus	43	0.8	0.1	0.0	0.0	0.0
	Refuse Truck	51	0.4	0.1	0.0	0.0	0.0
	Single Unit Short-haul Truck	52	6.9	1.5	0.5	0.5	0.6
	Single Unit Long-haul Truck	53	1.0	0.2	0.1	0.1	0.1
	Motor Home	54	0.1	0.0	0.0	0.0	0.0
	Combination Short-haul Truck	61	27.2	4.0	1.1	1.2	1.4
	Combination Long-haul Truck	62	45.0	6.4	1.5	1.6	1.9
	Total		**108.8**	**30.0**	**9.8**	**9.9**	**11.2**

			VOC Emissions by Source Type (Tons/Year)				
County	Source Type	SourceTypeID	2005	2007	2017	2025	2040
Berkeley	Motorcycle	11	25.5	28.1	30.8	33.6	39.4
	Passenger Car	21	537.6	498.1	242.7	194.0	176.3
	Passenger Truck	31	622.8	585.5	278.6	192.3	152.5
	Light Commercial Truck	32	85.1	79.8	39.5	24.6	23.4
	Intercity Bus	41	0.6	0.6	0.3	0.1	0.0
	Transit Bus	42	0.2	0.2	0.1	0.0	0.0
	School Bus	43	3.6	3.3	1.6	0.8	0.4
	Refuse Truck	51	0.7	0.6	0.2	0.1	0.1
	Single Unit Short-haul Truck	52	42.7	38.6	18.4	12.2	11.5
	Single Unit Long-haul Truck	53	4.8	4.4	2.2	1.5	1.4
	Motor Home	54	1.4	1.4	0.8	0.5	0.4
	Combination Short-haul Truck	61	38.1	35.2	11.5	4.6	3.1
	Combination Long-haul Truck	62	109.8	102.7	46.7	33.7	34.0
	Total		**1,472.9**	**1,378.4**	**673.4**	**498.1**	**442.4**

			NH3 Emissions by Source Type (Tons/Year)				
County	Source Type	SourceTypeID	2005	2007	2017	2025	2040
Berkeley	Motorcycle	11	0.1	0.2	0.3	0.4	0.5
	Passenger Car	21	27.3	26.8	16.4	15.9	17.1
	Passenger Truck	31	17.2	16.9	11.0	10.4	11.5
	Light Commercial Truck	32	2.5	2.4	1.8	1.7	2.0
	Intercity Bus	41	0.0	0.0	0.0	0.0	0.0
	Transit Bus	42	0.0	0.0	0.0	0.0	0.0
	School Bus	43	0.1	0.1	0.1	0.1	0.1
	Refuse Truck	51	0.0	0.0	0.0	0.0	0.0
	Single Unit Short-haul Truck	52	1.1	1.2	1.3	1.5	1.7
	Single Unit Long-haul Truck	53	0.2	0.2	0.2	0.2	0.2
	Motor Home	54	0.0	0.0	0.0	0.0	0.0
	Combination Short-haul Truck	61	1.5	1.6	2.0	2.3	2.6
	Combination Long-haul Truck	62	2.3	2.4	2.6	3.1	4.1
	Total		**52.2**	**51.8**	**35.8**	**35.7**	**40.0**

APPENDIX B:

Air Quality Data Checklist Summary

Data Item	Inputs Assumptions
MOVES RunSpec	
Scale/Calulation Type	County Scale Inventory Run
Seasonal Analysis	Annual - 12 months including weekdays and weekend (using AADT approach)
Analysis Years	2005, 2007, 2017, 2025, *2040 (for outyear evaluation - optional to evaluate safety margin)*
Pollutants	$PM_{2.5}$, NOx, SO_2, VOC, NH_3
Stage II Refueling Emissions	Not Applicable
Fuel Types	Gasoline, Diesel, CNG
Traffic Data	
Highway Network	Base networks are those used for past HEPMPO LRTP analyses and conformity
	Years not available are calculated by interpolating VMT from existing networks
Seasonal/Daily Adjustments	Factors to develop MOVES daily and monthly VMT fraction files as inputs. Seasonal adjustment factors received from WVDOT.
County HPMS VMT Adjustments	Calculate AADT HPMS adjustments for 2005, 2007 and 2008 (Ensure VMT for past years is consisitent with reported HPMS); HPMS VMT obtained from WVDOT website.
Vehicle Mixes	MOVES VMT required by 6 HPMS vehicle classes. Obtain WVDOT truck count data to determine average truck percentages by functional class; Split model traffic volumes into auto and trucks using these percentages and then use MOVES default VMT distributions for the Charleston region to divide the two vehicle groups (auto and trucks) into MOVES 13 source types, which are recombined to the 6 HPMS vehicle classes.
MOVES Inputs	
Annual VMT	Calculated by PPSUITE from Model network database / seasonal factors / vehicle mapping
Avg. Hourly Speed Distribution	Calculated by PPSUITE (Minimum Speed = 2.5 mph); Based on Model volumes and speed post processing by hour of day.
Road Type Distribution	Calculated by PPSUITE; a RoadType field must be added to the Model network based on FC.
Ramp Fraction	MOVES defaults
Month VMT Fractions	Factors to convert AADT to an average day in each month (Local data or MOVES default). Calculated based on seasonal adjustment factors.
Day VMT Fractions	Based on AADT assumption (i.e. 5/7 & 2/7)
Hour VMT Fractions	Factors to disaggregate daily traffic volumes by hour for different roadway functional classes. Borrow hourly distributions from Washington County, MD.
Source Type Population	2010 Inputs provided by WVDEP --> Adjust/grow to 2005, 2007 and future years by applying factors developed from Woods & Poole population/employment forecast data. (For non-trucks: use population growth. For trucks: maximum of population & employment growth)
Vehicle Age Distribution	Source Types 11, 21, 31, 32 & 54: based on 2010 WV DMV Registration Data; Source Types 41, 42, 43, 51, 52, 53, 61 & 62: use MOVES National Defaults.
Fuel Parameters (Gasoline/Diesel/CNG)	Use MOVES defaults with the following updates to RVP: 1. Summer (months 5 - 10): RVP = 10 for E10 and RVP = 9 for conventional gasoline 2. Winter (months 1, 2, 12): RVP = 14 3. Months 3, 4 & 11: Use MOVES default RVP which varies by year - 10.783 in 2005, 11.339 in 2007, and 12.729 in future years. (Note: MOVES defaults include 29% market share of E10 in 2007 and 100% market share of E10 in future years)
I/M Parameters	No I/M programs
Temperatures/Humidity	Temperatures: Use monthly average Max/Mins provided by WVDEP as inputs to EPA's Mobile6-MOVES converter to develop inputs in MOVES format. Humidity: MOVES defaults
Control Programs	
Early NLEV / CALLEVII	Include EPA provided MOVES override database for early NLEV implementation
California ZEV Program	Not Included

APPENDIX C:

Sample MOVES
Data Importer (XML) Input File
and
Run Specification (MRS) Input FIle

(Sample For 2025: Berkeley County)

MOVES County Data Manager Importer File (MOVESIMPORTER.XML)


```
<moves>
    <importer mode="county" >
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MOVES Run Specification File (MOVESRUN.MRS)


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<engtechid selected="false"/>
<hpclass selected="false"/>
</outputemissionsbreakdownselection>
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    <outputsho value="true"/>
    <outputsh value="true"/>
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    <outputshidling value="true"/>
    <outputstarts value="true"/>
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        <massfactors selected="false" units="Grams" energyunits="Million BTU"/>
    </outputfactors>
    <savedata>
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useParameters No

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</runspec>
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