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The Southeastern Local Air Pollution Control Agencies
Southeastern States Air Resource Managers, Inc.

2007 MOVES2010a On-road Mobile Source Emissions Factors for the Southeastern Modeling Analysis and Planning (SEMAP) States

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1.0 INTRODUCTION

The Southeastern Modeling Analysis and Planning (SEMAP) group requested the development of on-road mobile source emissions factors for SEMAP states using the latest version of MOVES2010 (OTAQ, 2010a, 2010b) and EPA's MOVES/SMOKE interface tool (EPA, 2010). Though the original proposal called for the development of on-road mobile source emissions factors for a 2007 base year and up to three future years, this document details how on-road mobile source emissions factors were estimated for a 2007 base year.

1.1 The Motor Vehicle Emissions Simulator (MOVES)

MOVES2010 is the U.S. EPA's next generation mobile source emissions model. An important feature of MOVES2010 is that a user can choose between two options to model on-road mobile source emissions: (1) the Inventory calculation, which estimates emission rates in terms of total quantity of emissions for a given time period, and (2) the Emission Rate calculation, which estimates emission rates in terms of grams/mile (i.e., on-network driving) and grams/vehicle/hour (i.e., off-network idling, starts, refueling, parked, and vapor venting). For purposes of the proposed study, the second option (i.e., Emission Rate calculation) was used.

The first rendition of the model was MOVES2010a. The study team used MOVES2010a for the entire project, though MOVES2010b did become available about three-quarters of the way through the study. Based on assurances from EPA's Office of Transportation and Air Quality (OTAQ) that the emissions factors between the two versions of MOVES were identical, SEMAP decided that it was best to proceed with the use of the first release of the model instead MOVES2010b since input file development for MOVES2010a had already progressed significantly and to avoid any potential delays resulting from transitioning to the newest MOVES version. All future references to MOVES2010 in this document thus refer to MOVES2010a. During the course of the project, the study team collaborated with project team members from the northeast United States, who were also running MOVES2010a for their purposes, and with OTAQ staff responsible for the development of MOVES. As the current study effort really turned out to be one of the first real-world applications of the MOVES modeling system, the work involved a substantial shakedown of the MOVES modeling system. Thus, as a result of the collaborative effort, we were able to jointly identify, verify, and offer suggestions on how to correct errors encountered while running the MOVES modeling system.

The approach to run MOVES2010 for SMOKE was based on "representative" counties in order to avoid duplicate, time consuming runs of MOVE2010. Counties that shared the same fuel parameters, fleet age distribution, and inspection/maintenance (I/M) programs, among other factors, were grouped together and a MOVES2010 run was made for a single, representative county. During SMOKE modeling of the on-road mobile source sector, the MOVES2010 emissions rates for this representative county were applied to all counties in the county group. Each representative county was modeled at a range of speeds and temperatures to produce emission rate lookup tables (grams/mile or grams/vehicle/hour). The approach allowed any county with unique distributions of vehicle miles traveled (VMT), vehicle population, roadway speed, and grid cell temperatures to be modeled in SMOKE without having to rerun MOVES2010.

1.2 MOVES/SMOKE INTERFACE TOOL

OTAQ, through contractor support, has developed the MOVES/SMOKE Interface Tool to facilitate the process of using MOVES to create on-road mobile source emissions estimates for use in air quality modeling. The MOVES/SMOKE Interface Tool is comprised of scripts that automate the proper use of the Emission Rate calculations. The SMOKE-MOVES tool provides three major functions: (1) Meteorological data preprocessor; (2) MOVES2010 model processor; and (3) SMOKE model processor.

The Meteorological data preprocessor (MET4MOVES) prepares spatially and temporally averaged temperatures and relative humidity data to set up the meteorological input conditions for MOVES2010 and SMOKE using the Meteorology-Chemistry Interface Processor (MCIP) output files. The MOVES2010 model processor creates data input files (i.e., runspec) for use in MOVES2010 that specifies the characteristics of the particular scenario to be modeled, and it reformats the resulting MOVES2010 emission rates lookup tables that are suitable for input to SMOKE. The SMOKE postprocessor (MOVESMRG) estimates emissions from on-road mobile sources based on MOVES2010-based emission rate lookup tables and meteorology data from MET4MOVES.

For purposes of the proposed study, the study team did not run MOVESMRG. Instead, we provided the outputs from MET4MOVES and the MOVES2010 model processor to SEMAP for their use in running MOVESMRG. SEMAP then provided the study team with the SMOKE reports from which we developed the emissions estimates summaries.

2.0 COMPONENTS OF THE STUDY

There were five distinct components to this effort:

- Perform relative humidity (RH) and Reid vapor pressure (RVP) sensitivity experiments;
- Estimate MOVES and SMOKE meteorology;
- Estimate on-road mobile source emissions factors using MOVES2010a;
- Estimate on-road mobile source emissions using SMOKE; and
- Prepare on-road mobile source emissions estimates summaries from SMOKE reports.

The study team (AMEC Environment & Infrastructure, Inc. and Alpine Geophysics, LLC) conducted all aspects of this project except for the effort required to estimate on-road mobile source emissions using SMOKE, which was conducted by the University of North Carolina. A brief summary is provided for each component here and is more fully discussed within the body of this report, with the exception of the component to estimate on-road mobile source emissions using SMOKE.

2.1 RH and RVP Sensitivity Experiments

MOVES2010a requires as input the choice of fuel modeling seasons. The modeling seasons are chosen based on information such as the fuel characteristics and meteorology. At the time the project started, MOVES was just being introduced to the modeling community, and it was unclear how sensitive the model would be to variations in these data. As such, SEMAP decided to conduct two sensitivity experiments involving two of the parameters: relative humidity (RH) and Reid vapor pressure (RVP); to determine how sensitive MOVES emissions estimates were to these parameters.

2.2 Estimate MOVES and SMOKE Meteorology

MOVES and SMOKE require estimates of RH and ambient temperature for each group of counties associated with a representative county by fuel season. The estimates of RH and ambient temperature for use in MOVES2010a and SMOKE were prepared using the MET4MOVES component of the SMOKE-MOVES Integration Tool (EPA, 2010).

2.3 Estimate Emissions Factors Using MOVES2010a

The study team developed the following six files based on information received from SEMAP:

- Fuel formulation;
- Fuel supply;
- VMT;
- Inspection and Maintenance (I/M) program;
- Age distribution; and
- Vehicle population.

These data coupled with the meteorology were input to MOVES2010a, which produced the on-road mobile source emissions factors. The input data and the on-road mobile source emissions factors were subjected to quality assurance review by the study team, the SEMAP QA contractor (ENVIRON), and representatives from the SEMAP states.

2.4 Estimate Emissions Using SMOKE

This component was performed by researchers at the University of North Carolina (UNC). Please refer to other documentation in regards to the details of performing this component of the study.

2.5 Prepare Emissions Estimates Summaries from SMOKE Reports

Researchers at UNC provided SMOKE reports to the study team for use in our efforts to summarize the on-road mobile source emissions estimates. The study team developed Excel workbooks with Visual Basic for Applications (VBA) scripting to facilitate the ingestion of the SMOKE reports. Further, VBA scripts were developed to prepare a number of standard report summaries as well as to provide a limited ad-hoc reporting capability so that a user of the Excel workbooks could prepare their own report summaries from the SMOKE reports.

3.0 RELATIVE HUMIDITY (RH) AND REID VAPOR PRESSURE (RVP) SENSITIVITY EXPERIMENTS

MOVES2010a requires the identification of fuel seasons for purposes of generating emissions factors. Fuel seasons should be chosen such that the groupings have similar fuel characteristics and meteorology. Because the MOVES modeling system was just being introduced to the modeling community at the start of this study, it was not clear how the choice of fuel season might impact the MOVES2010a results. SEMAP judged that the two critical inputs to the choice of how fuel seasons were chosen were the RH and RVP. Using default data supplied with the MOVES modeling system, MOVES2010a was run in emissions inventory mode for an April and May 2007 weekday to estimate emissions (tons/day) for CO, NO_X, VOC, SO_2, PM_{10}, and $PM_{2.5}$. MOVES2010a was also run using data supplied by the SEMAP states that was used in-lieu of the MOVES2010a default data for the same period and pollutants.

The RH sensitivity simulations included the following:

- For April 2007, Mecklenburg County, NC;
  a. Base simulation at 48.98% relative humidity fixed for all hours of the day,
  b. Simulation using national defaults (this was for comparison purposes to estimates derived using the SEMAP states-supplied data),
  c. Four sensitivity simulations at $\pm$5% RH and $\pm$10% RH added to the base simulation,
- For May 2007, Mecklenburg County, NC;
  a. Base simulation at 55.37% relative humidity fixed for all hours of the day,
  b. Simulation using national defaults (this was for comparison purposes to estimates derived using the SEMAP states-supplied data), and
  c. Four sensitivity simulations at $\pm$5% RH and $\pm$10% RH added to the base simulation.

The results of the RH runs were compiled into an Excel workbook (on the data disk semap/rh_rvp_sensitivity_experiments/37119_2007_04_ozone_emissions_estimates_RH_comparison.xls). The exhaust, evaporative, and total emissions estimates for CO, NO_X, VOC, SO_2, PM_{10}, and $PM_{2.5}$ are compiled in the "RH Emissions Summary" worksheet for both gasoline and diesel fueled vehicles. Further, the percent change in emissions estimates due to a $\pm$5% and $\pm$10% change in RH from the base simulation (i.e., 49.98% RH for April 2007 and 55.37% RH for May 2007) were provided. The choice of $\pm$5% and $\pm$10% RH ranges were made by SEMAP and reflect a gross range of RH changes seen across the year. A summary of the emissions estimates changes is as follows:

- For diesel and gasoline VOC, SO_2, PM_{10} and $PM_{2.5}$, the emissions differences due to $\pm$10% RH change are non-existent (PM_{10} and $PM_{2.5}$ are not affected by changes in RH) or negligible (SO_2 has less than a 0.01 tons/day difference in emissions which equates to less than a 1% difference in emissions, and VOC has less than a 0.20 tons/day difference in emissions which equates to less than a 1% difference in emissions whether they are evaporative or exhaust);
- For diesel CO, the emissions differences are negligible due to a $\pm$10% RH change (CO has less than a 0.20 tons/day difference in emissions which equates to about a 1% difference in emissions);
- For gasoline CO, the emissions differences are small due to a $\pm$10% RH change (though CO has about a 8 tons/day swing in emissions due to $\pm$10% RH change, this equates to less than $\pm$1.6% overall difference in the emissions);

- For diesel NO_X, a $\pm$5% RH change results in about a $\pm$0.50 tons/day change in the emissions which equates to about $\pm$1.5% change in the emissions. At a $\pm$10% RH change, NO_X emissions change by about $\pm$1.0 tons/day which equates to about $\pm$3% change in the emissions.
- For gasoline NO_X, a $\pm$5% RH change results in about a $\pm$0.75 tons/day change in the emissions which equates to about $\pm$1.5% change in the emissions. At a $\pm$10% RH change, NO_X emissions changes show a non-linear response in May 2007 with the range of -0.90 tons/day to +1.7 tons/day change and a more linear response in April 2007 with a $\pm$1.5 tons/day change, which equates to roughly $\pm$3% of the base emissions.

For diesel and gasoline VOC, CO, SO_2, PM_{10} and $PM_{2.5}$, a $\pm$5% RH change or even a $\pm$10% RH change results in emissions changes that will likely not impact the air quality modeling results. However, for NO_X a $\pm$5% RH change, diesel and gasoline NO_X emissions estimates change by $\pm$1.25 tons/day ($\pm$1.35% -- note that an increase in RH results in a decrease in NO_X).

The RVP sensitivity simulations included the following:

- For April 2007, Mecklenburg County, NC;
  a. Base simulation at 48.98% RH and RVP of 13.5 psi (ran during RH simulation),
  b. Two sensitivity simulations where RVP is set to 15.0 psi and 9.0 psi,
- For May 2007, Mecklenburg County, NC;
  a. Base simulation at 55.37% RH and RVP of 9.0 psi (ran during RH simulation), and
  b. Two sensitivity simulations where RVP is set to 13.5 psi and 7.8 psi.

The choice of the RVP range was made by SEMAP and reflects the range of RVPs that are seen the fuels across the SEMAP states. The results of the RVP runs were compiled into the attached Excel workbook on the data disk semap/rh_rvp_sensitivity_experiments/37119_2007_04_ozone_emissions_estimates_RVP_comparison.xls). The exhaust, evaporative, and total emissions estimates for CO, NO_X, VOC, SO_2, PM_{10}, and $PM_{2.5}$ are compiled in the "RH Emissions Summary" worksheet for gasoline fueled vehicles as diesel is not affected by RVP. Although results for April 2007 with RVP values of 15.0, 13.5, and 9.0 psi and for May 2007 with RVP values of 13.5, 9.0 and 7.8 psi are compiled in the Excel workbook, the focus is only on a summary of the comparison for April 2007 between RVP values of 15.0 and 13.5 psi and for May 2007 between RVP values of 9.0 and 7.8 psi as those are the RVP values of interest for the fuel seasons of concern. A summary of the emissions estimates changes is as follows:

- For April 2007 for RVP change of 15.0 psi to base 13.5 psi;
  a. Exhaust VOC, SO_2, PM_{10}, and $PM_{2.5}$ have negligible (VOC) or no change (SO_2, PM_{10}, $PM_{2.5}$) due to a change in RVP,
  b. CO emissions decrease with decreasing RVP by 25% (~160 tons/day) of the base CO emissions,
  c. NO_X emissions decrease with decreasing RVP by about 2% (~1 ton/day) of the base NO_X emissions,
  d. Evaporative VOC emissions decrease with decreasing RVP by about 50% (~15 tons/day) of the base evaporative VOC emissions,

e. Total VOC emissions decrease with decreasing RVP by about 28% (~15 tons/day) of the base total VOC emissions,

- For May 2007 for RVP change of base 9.0 psi to 7.8 psi;
  a. Exhaust VOC, SO_2, PM_{10}, and $PM_{2.5}$ have negligible (VOC) or no change (SO_2, PM_{10}, $PM_{2.5}$) due to a change in RVP,
  b. CO emissions decrease with decreasing RVP by 1.3% (~6 tons/day) of the base CO emissions,
  c. NO_X emissions decrease with decreasing RVP by about 1.3% (~1 ton/day) of the base NO_X emissions,
  d. Evaporative VOC emissions decrease with decreasing RVP by about 12% (~2 tons/day) of the base evaporative VOC emissions, and
  e. Total VOC emissions decrease with decreasing RVP by about 5% (~2 tons/day) of the base total VOC emissions.

The greatest impact to emissions occurs in the RVP change from 15.0 psi to 13.5 psi with CO and VOC exhibiting definite sensitivity. There is less of an impact to CO and VOC emissions when the RVP changes from 9.0 psi to 7.8 psi. However, in both cases NO_X has about a 1.0 ton/day sensitivity which may be important for modeling and policy purposes.

Though the results of the experiments indicate that there are important sensitivities to changes in RH and RVP and thus multiple fuel season definitions may be in order, SEMAP determined that a summer (i.e., May through September) and winter (January through April and October through December) were sufficient for the purposes of the study especially given the significant processing times that are necessary to run MOVES2010a.

4.0 ESTIMATE MOVES AND SMOKE METEOROLOGY

4.1 DATA INPUTS

MOVES2010a and SMOKE require estimates of ambient temperature and relative humidity. The MET4MOVES component of the SMOKE-MOVES Integration Tool (EPA, 2010) was used to facilitate the preparation of the MOVES2010a and SMOKE meteorological data sets.

MET4MOVES requires the following primary inputs:

- Representative county cross-reference;
- Fuel month cross-reference;
- Gridded surrogates; and
- Meteorology-Chemistry Interface Processor (MCIP) data sets.

The representative county-cross reference file was prepared based on information that was supplied by SEMAP (Boylan, 2010). Table 4-1 lists the names of the representative counties and the number of counties assigned to the representative counties. The 926 counties for the SEMAP states were assigned to one of the 39 representative counties. The complete assignment details can be found in the SMOKE data files (i.e., mcref_semap_SS_2007.txt where SS is the state abbreviation) located on the data disk in the directory semap/edss/data_semap/ge_dat/mcref_files.

Table 4-1. Names of representative counties by state and the number of counties assigned to the representative counties.

State	Representative County	FIPS Code	Number of Counties Assigned
Alabama	Jefferson	01073	2
	Montgomery	01101	65
Florida	Escambia	12033	62
	Hillsborough	12057	2
	Miami-Dade	12086	3
Georgia	Barrow	13013	7
	Chatham	13051	114
	Floyd	13115	25
	Fulton	13121	13
Kentucky	Bullitt	21029	1
	Fayette	21067	114
	Jefferson	21111	1
	Kenton	21117	3
	Oldham	21185	1
Mississippi	Hinds	28049	82
North Carolina	Cumberland	37051	40
	Davidson	37057	1
	Duplin	37061	52
	Forsyth	37067	1
	Guilford	37081	1
	Mecklenburg	37119	2
	Orange	37135	1
	Wake	37183	2
South Carolina	Spartanburg	45083	46
Tennessee	Davidson	47037	1
	Fayette	47047	2
	Hamilton	47065	1
	KNO_X	47093	7

State	Representative County	FIPS Code	Number of Counties Assigned
	Madison	47113	66
	Marion	47115	1
	Putnam	47141	7
	Rutherford	47149	4
	Shelby	47157	1
	Sullivan	47163	5
Virginia	Albemarle	51003	107
	Henrico	51087	7
	Prince William	51153	10
	York	51199	11
West Virginia	Kanawha	54039	55

The fuel month cross-reference file was prepared based on information supplied by SEMAP (Boylan, 2010). Two fuel seasons, summer (i.e., May through September) and winter (January through April and October through December), were assigned to each representative county. The contents of these data sets can be viewed in the files semap/edss/data_semap/ge_dat/fuelmonth_semap_SS.txt where SS is the state abbreviation.

The gridded surrogates were provided as part of the SMOKE distribution. As recommended in the User's Guide (EPA, 2010), surrogates 100 (i.e., population) and 240 (i.e., total road miles) were used to derive the representative county meteorology by fuel season. The master surrogate data set can be found in semap/edss/data_semap/ge_dat/ SRGDESC.MOVES.NC, which points to the actual surrogate files semap/edss/data_semap/ge_dat/Srg_12km_MOVES_SEMAP/USA_100_NOFILL.txt and semap/edss/data_semap/ge_dat/Srg_12km_MOVES_SEMAP/USA_240_FILL.txt.

The MCIP data sets were provided by UNC for each day in 2007. The UNC-supplied MCIP data files were post processed to reduce their considerable size to something that was more manageable. The post-processed MCIP data sets contain only the ambient temperatures at two meters, the pressure, and the water vapor mixing ratio (a surrogate for RH) from the first layer of the modeling domain. The actual MCIP data sets can be found in the directory semap/edss/data_semap/met with the naming nomenclature of METCOMBO_2007DDD where DDD is the Julian day of the file. All MCIP files are in netCDF structures.

4.2 DATA OUTPUTS

MET4MOVES produces three output data files:

- SMOKE-ready meteorological data file;
- MOVES-ready meteorological file; and
- Log file.

The SMOKE-ready meteorological data set contains the temperature and relative humidity estimates by county, fuel season month, and calendar month necessary for input to SMOKE. The MOVES-ready meteorological data set contains the average relative humidity and twenty-four hourly temperature estimates by representative county, fuel season month, and temperature profile necessary for input to MOVES. The log file contains runtime and error messages from a MET4MOVES run and is useful for diagnosing problems should they occur. Examples of the meteorological data sets generated by MET4MOVES for this study can be found in semap/edss/data_semap/met_out/12k. The MOVES-ready files are named MOVES_12km_2007001-2007365_??.txt, and the SMOKE-ready files are named SMOKE_12km_2007001-2007365_??.txt where ?? is the two letter state abbreviation.

4.3 RUN SCRIPTS

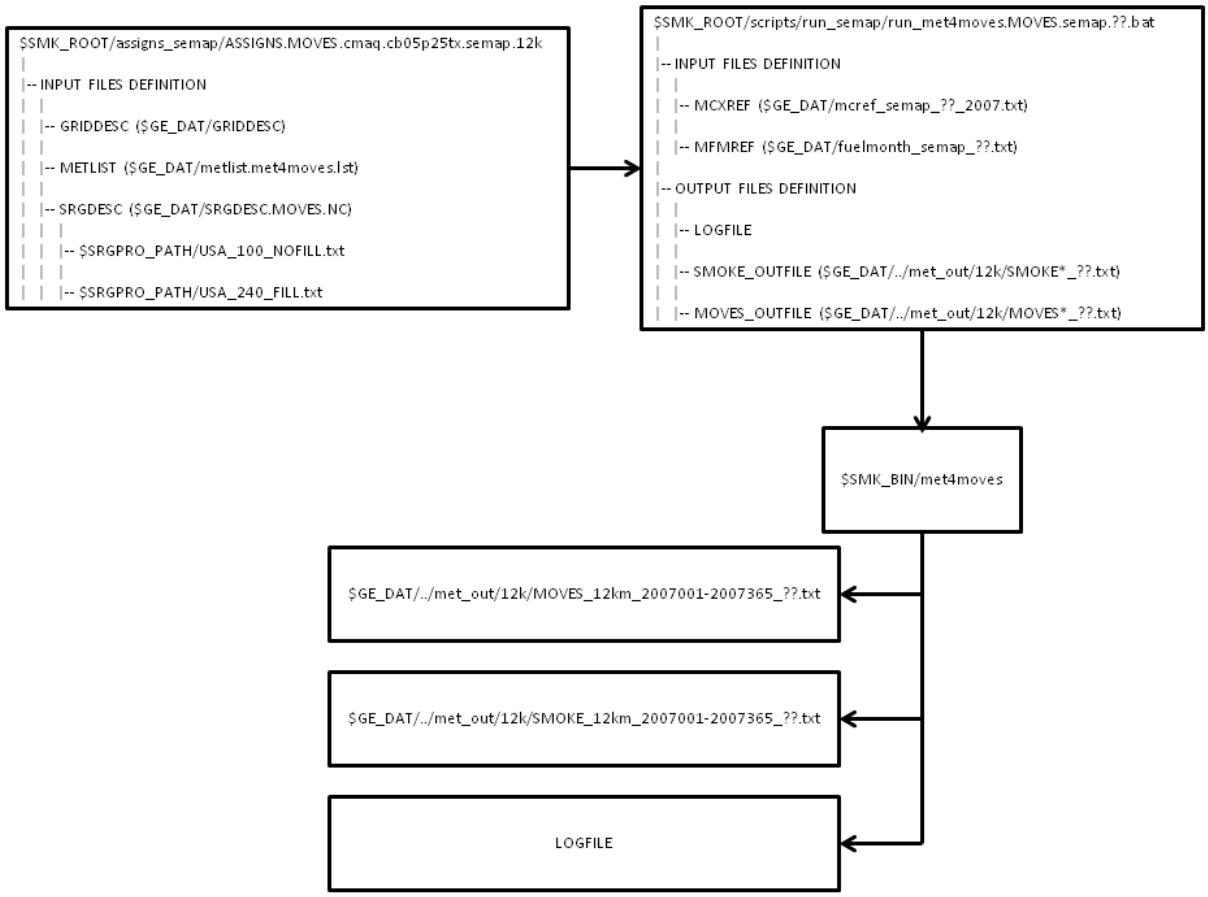
MET4MOVES is run through Linux C-shell command scripts. Figure 4-1 provides an overview of the script names and the primary input and output definitions that are required. Before the user can run these scripts, the scripts must be modified to accommodate the directory structure of the user's computer platform. The scripts to run MET4MOVES are located in the directory semap/edss/subsys/smoke/scripts/run_semap and have the naming convention of run_met4moves.MOVES.semap.??.bat where ?? is the two letter state abbreviation. The following command is an example of how to run the script for Alabama:

% ./run_met4moves.MOVES.semap.AL.bat

This command will produce copious output so it may advisable to capture this output to log files, which can be viewed at the user's convenience:

% (./run_met4moves.MOVES.semap.AL.bat > LOG) >& LOG.error

Figure 4-1. Overview of the C-shell scripts to run MET4MOVES. ?? in the file names refer to the two letter state abbreviation.



5.0 ESTIMATE EMISSIONS FACTORS USING MOVES2010A

5.1 DATA INPUTS

The study team prepared MOVES2010a input files for thirty-nine (39) representative counties in the SEMAP domain for two fuel seasons (i.e., winter and summer) for the 2007 base year. The input files were prepared for use with the emissions rate calculation mode of MOVES2010a.

The effort included converting default MOBILE6.2 inputs to MOVES2010a inputs using the MOBILE6 to MOVES2010 conversion tools (OTAQ, 2010c). We also integrated MOVES2010a input files that were developed by a variety of organizations from the SEMAP states.

For each representative county, the following six files were prepared for input to the MOVES2010a modeling system:

- Fuel formulation;
- Fuel supply;
- VMT;
- Inspection and Maintenance (I/M) program;
- Age distribution; and
- Vehicle population.

MOVES2010a also requires the following input data files, the development of which is described Chapter 4:

- Representative county cross-reference;
- Fuel month cross-reference; and
- MOVES-ready meteorology.

The six files that were developed during this component of the study were based on multiple exchanges of information between representatives from the SEMAP states and the study team. Each file went through multiple iterations before a final set of data files was prepared for each of the thirty-nine representative counties. The formats of these files are described in EPA (2010).

The fuel formulation file contains the characteristics of each fuel, gasoline and diesel, used in the representative county including such parameters as RVP, fuel sulfur content, and ethanol content. The fuel supply file identifies the specific fuel used during each month of the year and the market share that fuel has for each representative county. The VMT file defines the annual VMT by major vehicle category for each representative county. The I/M program file defines the inspection and maintenance program characteristics for each representative county that was in effect during 2007. If no I/M program was in existence, this file is empty. The age distribution file contains the fraction of vehicles by vehicle category and model year that comprise the fleet for the base year (i.e., 2007) and the prior thirty years. The vehicle population contains the vehicle counts for each of the thirteen MOVES vehicle categories.

The input data files can be found on the data disk in the directory semap/smoke_moves_input/?? where ?? is the two letter state abbreviation. The naming convention for the input files is as follows (where SS is the two digit state code [e.g., 01 for Alabama] and CCC is the three digit county code [e.g., 073 for Jefferson County]):

- SSCCC_FuelFormulation.csv;
- SSCCC_FuelSupply.csv;
- SSCCC_HPMSVTypeVMT.csv;
- SSCCC_IMCoverage.csv;
- SSCCC_sourceTypeAgeDistribution.csv; and
- SSCCC_sourceTypePopulation.csv.

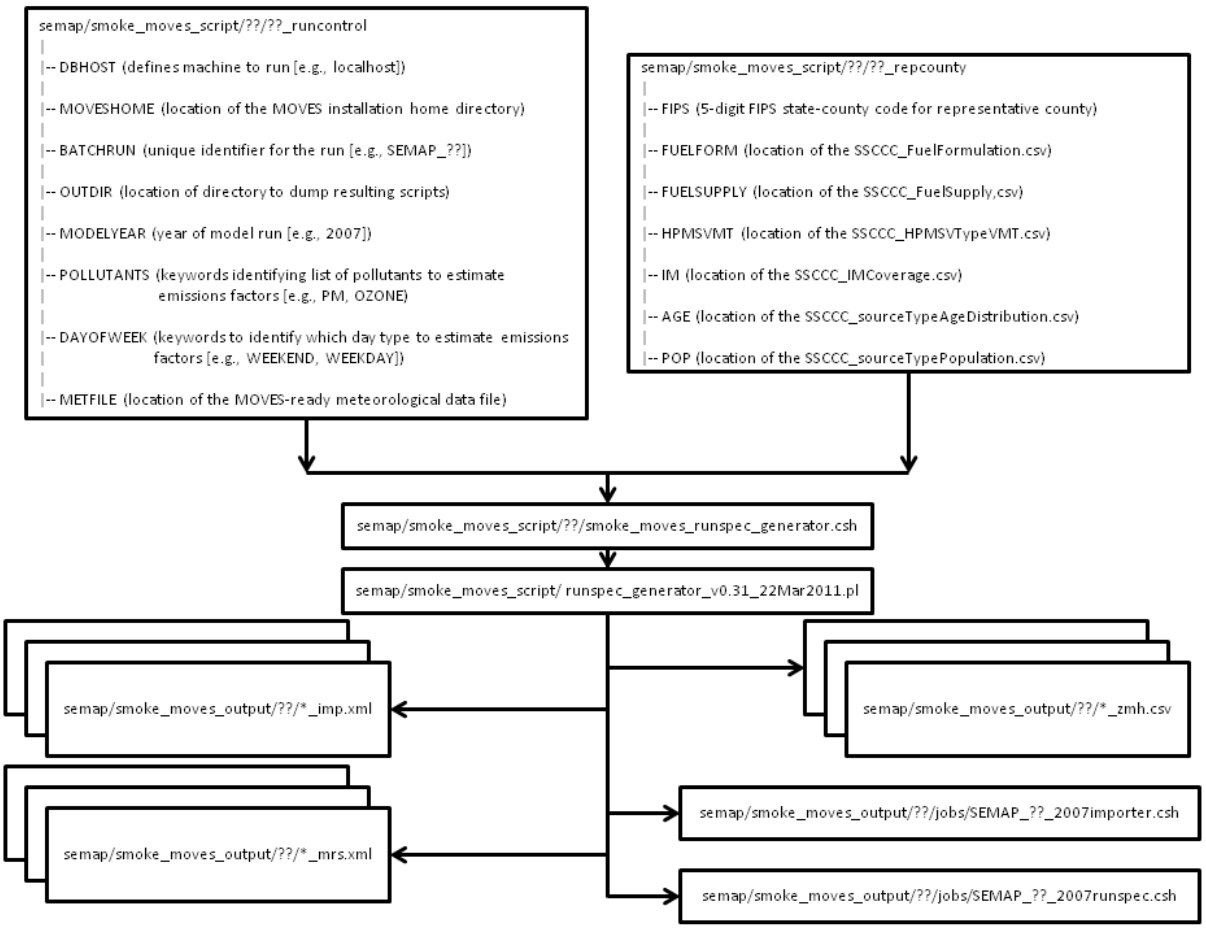
5.2 QUALITY ASSURANCE OF THE MOVES INPUTS

The MOVES data input files were delivered to the SEMAP quality assurance contractor and representatives from the SEMAP states for review and comment. Though the review of the MOVES data input files was expected to take only two or three iterations, in the end, many iterations were required over the course of some fifteen months before the MOVES data input files were completely correct. This was due in part to problems with the MOVES2010a modeling system itself, in part because the SEMAP states had evolving needs that required changes to the data, and in part due to issues with the study team not initially fully understanding how MOVES2010a ingested data.

5.3 MOVES DATA IMPORT AND RUN SPECIFICATION SCRIPTS

MOVES2010a requires that XML script files be constructed in order to run the modeling system. The SMOKE-MOVES Integration Tool (EPA, 201) provides the perl script tools necessary to create the XML scripts to import the data files described in Section 5.1 and the XML scripts to run the MOVES2010a modeling system. Figure 5-1 provides an overview of the data inputs and scripts that are necessary to construct the XML files necessary to run the MOVES2010a modeling system.

Figure 5-1. Overview of the data inputs and C-shell scripts used to construct the MOVES2010a modeling system data import XML and run specification XML scripts. ?? in the file names refer to the two letter state abbreviation. SSCCC in the file names refer to the five digit state-county FIPS identifier for the representative county.



For each representative county, the study team built the two input files ??_runcontrol and ??_repcounty. Further, the study team built the C-shell script smoke_moves_runspec_generator.csh to help automate the process of constructing the XML scripts. The perl script runspec_generator_v0.31_22Mar2011.pl was the most recent script that was available in the SMOKE-MOVES Integration Tool at the time this project was proceeding.

In order to run the C-shell script to construct the XML files suitable to run the MOVES2010a modeling system, the user must modify the two input files, ??_runcontrol and ??_repcounty, to conform to the layout of his/her computational platform. The C-shell script is run as follows:

% source smoke_moves_runspec_generator.csh

The output of this is a set of XML data importer scripts, XML run specification scripts, C-shell scripts, and CSV files, which are output to the directories specified in Figure 5-1. The CSV files represent the MOVES-formatted meteorology that is utilized by the XML data importer scripts.

Though the SMOKE-MOVES Integration Tool prepares the necessary C-shell scripts to run the XML files, the result of the effort has all representative counties being run on one platform. In order to spread the MOVES2010a runs over multiple machines so that the runs are computationally more

efficient, the study team split the SEMAP_??_2007importer.csh and SEMAP_??_2007runspec.csh C-shell scripts into multiple C-shell scripts – one for each representative county; hence, there exist thirty-nine importer C-shell scripts and thirty-nine run specification C-shell scripts that could be run in parallel on thirty-nine different computational cores. The naming convention used to identify the split C-shell scripts is as follows:

- SSCCC_importer_MACHINE_CORE.csh; and
- SSCCC_runspec_MACHINE_CORE.csh.

Where SSCC is the five digit FIPS state-county code, MACHINE is the name of the computational platform, and CORE identifies the surrogate upon which CPU that the C-shell script is to run on the MACHINE.

5.4 QUALITY ASSURANCE OF THE MOVES XML AND C-SHELL SCRIPTS

The MOVES XML and C-shell scripts were delivered to the SEMAP quality assurance contractor and representatives from the SEMAP states for review and comment. Fortunately, the review of the MOVES XML and C-shell scripts took only two iterations. OTAQ, the developer of the MOVES modeling system, released at least two new versions of the SMOKE-MOVES Integration Tool run specification perl scripts which were used to repeat the development of the MOVES XML and C-shell scripts descried in Section 5.3.

5.5 RUNNING MOVES2010A

After the XML and C-shell scripts were constructed, it was possible to actually run the MOVES2010a modeling system. The first step to running the modeling system was to import the data described in Section 5.1. Importing of the data was performed by executing the following command, one each for the thirty-nine files on the appropriate MACHINE and CORE:

% (source SSCCC_importer_MACHINE_CORE.csh > LOG) >& LOG.error

The method of running the C-shell script in this manner allowed the capture of the copious output that was generated during the import of data into the MOVES2010a MySQL data bases, which the user can view at his/her leisure and was useful for diagnosing problems when they arose.
After all thirty-nine C-shell importer scripts were run, the effort to generate the actual on-road mobile source emissions factors was performed. This was accomplished by running the following command, one each for the thirty-nine files on the appropriate MACHINE and CORE:

% (source SSCCC_runspec_MACHINE_CORE.csh > LOG) >& LOG.error

The method of running the C-shell script in this manner allowed the capture of the copious output that was generated during the generation of on-road mobile source emissions factors that were stored in the MOVES2010a MySQL data bases, which the user can view at his/her leisure and was useful for diagnosing problems when they arose.

5.6 DATA OUTPUTS

All MOVES2010a input data bases, which resulted from running the C-shell importer scripts, were stored in MySQL data bases. There are hundreds of input data bases per representative county as this is a necessary requirement of the MOVES2010a modeling system so that the range of meteorological conditions were captured. All MOVES2010a emissions factors that were created by running the C-shell run specification scripts were stored in MySQL data bases, one per representative county for a total of thirty-nine MySQL output data bases. Each MySQL input and output data base contained multiple data tables. Descriptions of the contents of the MOVES2010a MySQL data bases can be found in OTAQ (2010a). The resulting MOVES2010a input MySQL data bases were archived on the data disk in the directory semap/2007_MOVES_MySQL_inputs/??

where ?? is the two letter state identifier. Similarly, the resulting MOVES2010a output MySQL data bases were archived on the data disk in the directory semap/2007_MOVES_MySQL_outputs/?? where ?? is the two letter state identifier.

5.7 GENERATION OF THE SMOKE-READY EMISSIONS FACTORS

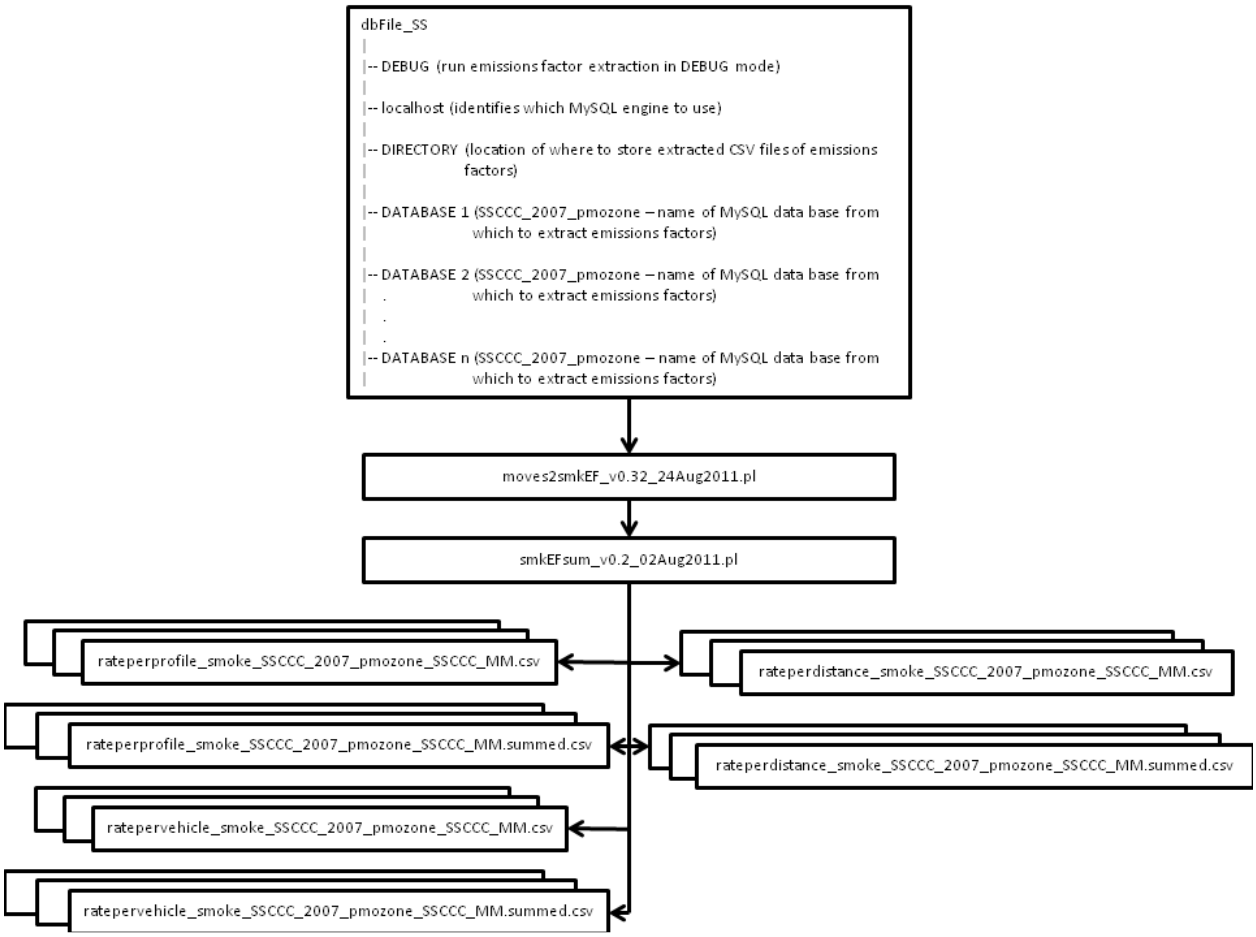
Until this point, all modeling was performed on Linux machines. Due to unresolved difficulties in getting the emissions factors extracted from the Linux based MySQL output data bases using the perl scripts supplied with the SMOKE-MOVES Integration Tool (EPA, 2010), all MySQL output data bases were transported to a Windows platform where these difficulties were nonexistent.

Figure 5-2 provides an overview of the input file and the perl script that was used to extract the emissions factors from the MySQL output data bases to create the SMOKE-ready emissions factors files. The study team built the dbFile_SS, where SS is the two digit state FIPS code, which contained the necessary information to run the SMOKE-MOVES Integration Tool (EPA, 2010) extraction perl scripts – moves2smkEF_v0.32_24Aug2011.pl and smkEFsum_v0.2_02Aug2011.pl. The perl script to extract the MOVES2010a emissions factors from the MySQL output data bases was run as follows:

% perl moves2smkEF_v0.32_24Aug2011.pl –output all dbFile_SS.inp

where SS is the two digit FIPS state identifier. The output of this perl script was the SMOKE-ready emissions factors and was stored in multiple CSV files.

Figure 5-2. Overview of the SMOKE-MOVESIntegration perl script and input file that was necessary to extract the emissions factors from the MOVES2010a MySQL output data bases. SS in the file names refer to the two digit state FIPS identifier. SSCCC in the file names refer to the five digit state-county FIPS identifier for the representative county. MM in the file names refer to the two digit fuel month identifier.



5.8 QUALITY ASSURANCE OF THE MOVES OUTPUT EMISSIONS FACTORS

Excel workbooks with VBA scripts were developed to assist in review of the MOVES2010a emissions factors. The workbooks are located on the data disk in the directory semap/moves_emissions_factors_qa. Users must be familiar with the VBA scripting language in order to utilize these workbooks to facilitate review of other MOVES2010a emissions factors. These example workbooks contain the CSV files as described in Section 5.7 for the states of Alabama and North Carolina (e.g., worksheet tab 'rateperdistance_smoke_37051_200'). After the CSV files have been loaded into a worksheet, a VBA script was run to generate graphics of the emissions factors for each SCC. The graphics provided a quick means of reviewing the thousands of emissions factors that were estimated. These workbooks were delivered to representatives of the SEMAP states and the SEMAP quality assurance contractor for review.

Figure 5-3 provides an example of the running exhaust VOC rate per distance emissions factors (g/mile) for the 2007 winter season for light duty diesel vehicles on urban interstates for Mecklenburg County, North Carolina by temperature and speed bin. Figure 5-4 provides an example of the crankcase start exhaust VOC rate per vehicle emissions factors (g/vehicle/hour) for the 2007 winter

season for light duty gasoline vehicles on all road types for Jefferson County, Alabama by hour and temperature.

Figure 5-3. Running exhaust VOC rate per distance emissions factors (g/mile) for the 2007 winter season for light duty diesel vehicles on urban interstates for Mecklenburg County, North Carolina by temperature and speed bin.

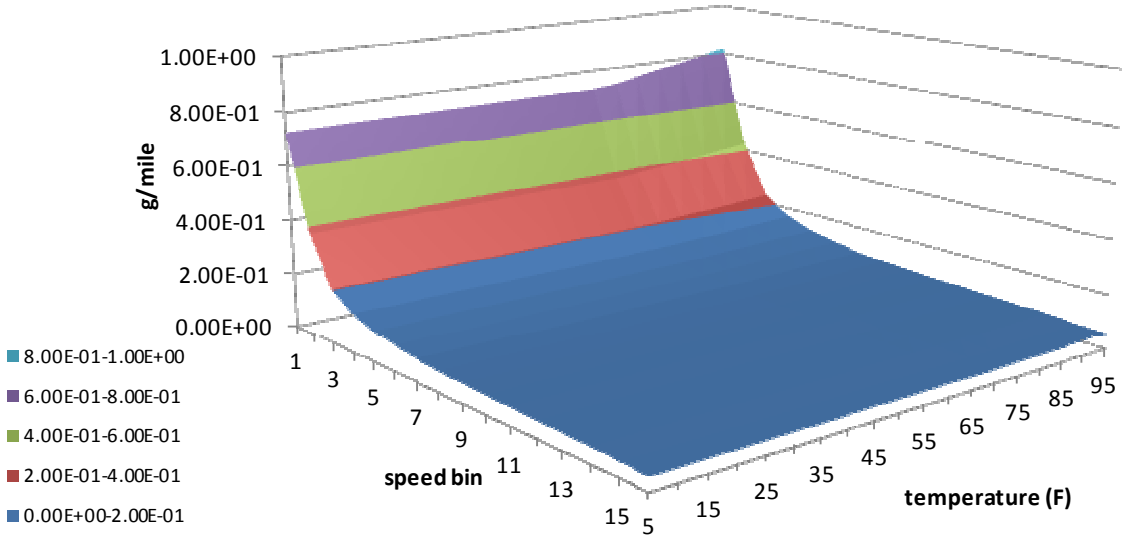
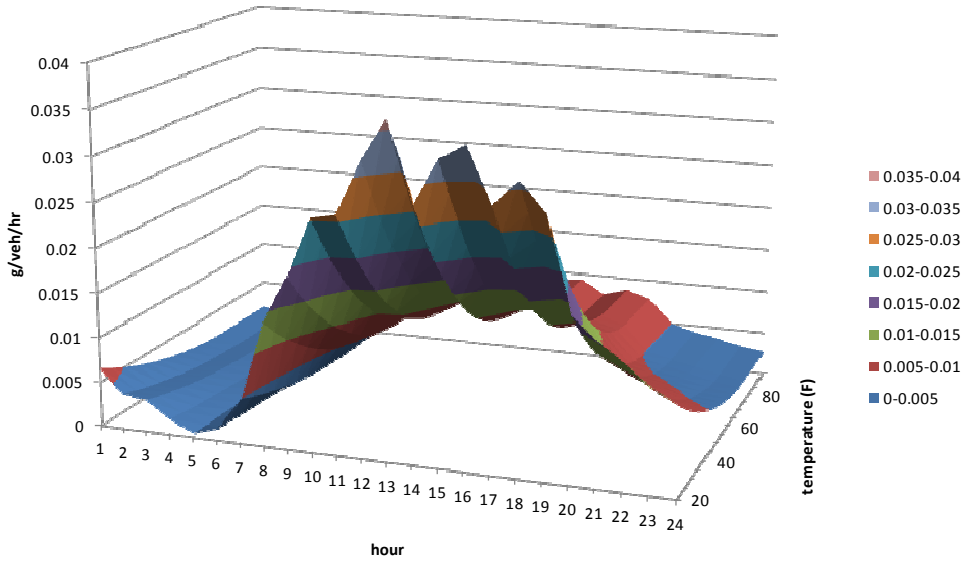


Figure 5-4. Crankcase start exhaust VOC rate per vehicle emissions factors (g/vehicle/hour) for the 2007 winter season for light duty gasoline vehicles on all road types for Jefferson County, Alabama by hour and temperature.



As was expected with any new modeling system, issues were found in the initial stages of running the MOVES2010a modeling system in regards to the emissions factors it estimated. The graphics provided a quick means to identify the issues from which corrections were made to the input data, and through the help of the MOVES developers, from which corrections were made to the MOVES2010a modeling system. Indeed, OTAQ, the developer of the MOVES modeling system, continued to make corrections to MOVES2010a as late as the first quarter of 2012.

Once the emissions factors had been approved by SEMAP, they were delivered to researchers at the UNC for their use in estimating on-road mobile source emissions using SMOKE. The data that were delivered to UNC are contained on the data disk in the directory semap/moves2smoke_windows. The naming convention of the zip archives that were delivered to UNC was ??_2007_MOVES2010a_corrected.zip where ?? is the two letter state abbreviation. These archives also contain the input data files and perl scripts described in Figure 5-2.

6.0 DEVELOPMENT OF THE EMISSIONS ESTIMATES REPORTS

Researchers at UNC delivered to the study team the SMOKE reports that were output by the SMOKE modeling system. In order to better utilize these data, Excel workbooks with VBA scripts were developed to ingest the SMOKE reports, prepare standard reports, and provide the capability to the user to develop some limited ad-hoc reports. The Excel emissions summary workbooks can be found on the data disk in the directory semap/smoke_emissions_summaries. There is one Excel workbook for each SEMAP state.

6.1 OVERVIEW OF WORKSHEETS

The SMOKE emissions summary Excel files are macro-enabled workbooks that contain the on-road emissions estimates summaries from the SMOKE emissions reports from UNC. Each workbook contains the following worksheets:

- State Summary Report Def - contains information used by an embedded Excel macro to build the emissions estimates summary by state for the major vehicle classifications (State Summary report)
- County Summary Report Def - contains information used by an embedded Excel macro to build the emissions estimates summary by state and county for the major vehicle classifications (State Summary report)
- Ozone Season Day Report Def - contains information used by an embedded Excel macro to build the emissions estimates summary by state for the major vehicle classifications (State Summary report)
- User Poll List - contains the list of pollutants to include in each report
- SCC - contains a list of SCCs and their description
- AttLookUp - this is a scratch worksheet used by embedded macros
- Month?? – monthly summary of the all the SMOKE reports that UNC provided where ?? is month of the year (tons/month)
- State Summary - contains the annual emissions summary for the state (tons/year)
- State SCC Summary – contains the annual emissions summary for the state by SCC (tons/year)
- County Summary - contains the annual emissions summary by state-county (tons/year)
- County SCC Summary – contains the annual emissions summary by state-county and SCC (tons/year)
- Annual State Report Summary - contains the annual emissions estimates summary by major vehicle category by state (tons/year)
- Annual County Report Summary - contains the annual emissions estimates summary by major vehicle category by state and county (tons/year)
- Ozone Season Day Summary - contains the emissions estimates summary for an average ozone season day by major vehicle category by state (tons/day)

6.2 OVERVIEW OF EMBEDDED VBA MACROS

The workbook has the following embedded macros (press Alt-F8) to see a list of these macros:

- CreateUserReportGroupByStateCounty - this macro creates a report based on user-defined parameters. Example worksheets that contain the user-defined parameters include:

  - State Summary Report Def;
  - County Summary Report Def;
  - Ozone Season Day Report Def
- DeleteSheet - a macro to delete a worksheet
- EmissionsByCounty - macro that creates the summaries contained in:
  - County Summary;
  - County SCC Summary
- EmissionsByState - macro that creates the summaries contained in:
  - State Summary;
  - State SCC Summary
- ImportSMOKEReports - macro to import the SMOKE reports

If the user desires to rerun the reporting macros (i.e., EmissionsByState, EmissionByCounty, or CreateUserReportGroupByStateCounty), the workbook has to have the macros enabled (which is done when the user specifies such when the workbook is first opened). The user then needs to press Alt-F8 to get a list of report macros to run, select the report macro, and press run.

For the report macro CreateUserReportGroupByStateCounty, the system will ask for the name of the worksheet (e.g., State Summary Report Def; County Summary Report Def; Ozone Season Day Report Def) that contains the information to generate the user-defined report. The system will also ask if the user wants to aggregate the pollutants. If the user responds “Yes," the system will use the chemical list from Column B of the User Poll List worksheet. If the user responds "No," the system will use the chemical list from Column A of the User Poll List worksheet.

For the report macros EmissionsByState and EmissionsByCounty, The system will ask if the user wants to aggregate the pollutants. If the user responds "Yes," the system will use the chemical list from Column B of the User Poll List worksheet. If the user responds "No," the system will use the chemical list from Column A of the User Poll List worksheet.

6.3 USER POLL LIST WORKSHEET

The User Poll List worksheet has two columns. The chemicals in Column A name all the pollutants that exist in the UNC data sets and the order that the chemicals are to be reported in the Month01 through Month12 worksheets. Column B lists the reduced set of "aggregated" chemicals and the order that they are to appear in summary reports. The embedded macros use Column A or Column B based on the user's response to whether to aggregate the chemicals (use Column B) or not to aggregate the chemicals (use Column A).

The chemicals in Column B can be used to aggregate other values into a single value. In the current worksheet, NO_X is estimated as 1.533*NO + NO2. Another example how this aggregation can be applied would be to make an entry in Column B for PM_{10} as follows:

PM_{10}=PMC+PMFINE

In order for this to appear in the reports, the user would have to rerun the macros as discussed in Section 6.2

6.4 USER-DEFINED REPORTS

The worksheets -- State Summary Report Def; County Summary Report Def; and Ozone Season Day Report Def -- contain information that is used by the embedded macro "CreateUserReportGroupByStateCounty " to prepare emissions estimates summary reports. In order to run the macro, certain cells need to be populated by the user as follows:

- C1 - name of the report (a worksheet is created with this name and can be no longer than 31 characters -- an Excel limitation).
- G1 - keyword STATE or COUNTY (STATE indicates that the macro will estimate the emissions for the entire state; COUNTY indicates that the macro will estimate the emissions by state-county combination).
- C2, D2, E2, ..., N2 - the names of the Month?? worksheets to use in compiling the emissions estimates report.
- C3 - units of the emissions estimates (e.g., tons/day).
- C4 - emissions divisor (this divisor [d] is applied to all emissions estimates [e] in the form of [e] divided by [d]. for example, if you wanted an annual average day emissions estimate, in Cells C2 through N2 you would list Month01, Month02, ..., Month12 and in Cell C4 you would enter 365.
- A5, B5, C5, ..., n - category names for the grouped SCCs.
- A6, A7, A8, ... n - for each category listed in A5, B5, C5, and so on, the list B6, B7, B8, ... n of SCCs that are to be included in the grouping. If a "?" is specified in the SCC sequence, it is treated as a wildcard thus matching any value in that position. For any SCC that is not captured, the system will report these emissions estimates under the "Other" category and will list these SCCs on the report definition worksheet.

6.5 EXECUTION SPEED OF MACROS

The embedded macros do take time to run depending on the complexity of the report that is being generated. On a four-core Windows 7 machine, with each CPU operating at 2.4GHz, it takes roughly sixty minutes each for the EmissionsByState and EmissionsByCounty macros to run to completion. For the example user-defined reports included in the workbooks, the CreateUserReportGroupByStateCounty macro takes anywhere from thirty minutes to seventy-five minutes to run.

In each case, the status bar, which is located in the lower left-hand corner of the Excel screen, indicates the worksheet, state/county, SCC, and chemical that the macro is currently summarizing. If at some point the user decides to run an embedded macro and the status bar does not change every five or ten seconds, it is highly likely that Excel has locked up and will need to be restarted. Therefore, it is imperative that as the user completes each task with each workbook, that the workbook be saved.

6.6 EMISSIONS ESTIMATES SUMMARIES

Summaries of the annual, SEMAP state-wide emissions estimates were prepared. Table 6-1 shows the annual on-road mobile source emissions estimates by state for the on-network and off-network contributions by pollutant for gasoline fueled vehicles. Table 6-2 shows the annual on-road mobile source emissions estimates by state for the on-network and off-network contributions by pollutant for diesel fueled vehicles. Table 6-3 shows the annual on-road mobile source emissions estimates by state for the on-network and off-network contributions by pollutant for gasoline and diesel fueled vehicles. Table 6-4 shows the annual on-road mobile source emissions estimates by state and vehicle category. Table 6-5 shows the ozone season day on-road mobile source emissions

estimates by state and vehicle category. Figure 6-1 shows the percent contribution by state and fuel to the annual on-road mobile source emissions estimates.

Table 6-1. Annual on-road mobile source emissions summary by state and network from gasoline fueled vehicles (tons/year).

State	Network	CO	NO_X	VOC-EVP	VOC-EXH	VOC-TOT	SO2	NH3	PM25 EXH	PM25 BRAKE	PM25 TIRE	PM25-TOT	PM10 EXH	PM10 BRAKE	PM10 TIRE	PM10 -TOT
AL	Off	387,407	25,615	11,619	33,446	45,065	52	-	327	-	-	327	355	-	-	355
	On	497,401	71,523	6,603	19,439	26,042	1,173	2,703	779	382	106	1,266	846	1,458	440	2,744
	State Total	884,807	97,138	18,222	52,885	71,106	1,225	2,703	1,106	382	106	1,593	1,201	1,458	440	3,099
FL	Off	809,843	76,911	41,592	82,665	124,257	137	-	584	-	-	584	634	-	-	634
	On	1,694,406	235,921	24,613	60,164	84,777	4,157	9,329	1,873	1,368	323	3,563	2,034	5,225	1,347	8,606
	State Total	2,504,249	312,832	66,205	142,830	209,034	4,295	9,329	2,457	1,368	323	4,147	2,668	5,225	1,347	9,240
GA	Off	609,671	51,131	20,688	59,619	80,307	177	-	665	-	-	665	723	-	-	723
	On	1,244,981	173,157	15,373	53,539	68,912	5,567	5,144	1,793	609	165	2,566	1,947	2,325	687	4,959
	State Total	1,854,653	224,288	36,061	113,158	149,220	5,744	5,144	2,458	609	165	3,232	2,670	2,325	687	5,682
KY	Off	340,582	19,073	7,523	27,367	34,890	42	-	360	-	-	360	391	-	-	391
	On	345,203	52,819	4,188	12,254	16,442	758	2,075	703	209	65	977	763	798	273	1,834
	State Total	685,785	71,892	11,711	39,621	51,332	800	2,075	1,062	209	65	1,337	1,154	798	273	2,225
MS	Off	251,279	16,132	7,913	20,609	28,522	32	-	203	-	-	203	221	-	-	221
	On	255,223	38,788	3,293	8,777	12,070	651	1,703	394	161	55	610	428	614	230	1,273
	State Total	506,503	54,920	11,206	29,385	40,592	683	1,703	598	161	55	814	649	614	230	1,494
NC	Off	904,378	39,809	24,160	58,037	82,197	94	-	743	-	-	743	807	-	-	807
	On	1,174,460	144,496	9,681	35,874	45,555	2,098	4,879	1,982	372	134	2,488	2,152	1,420	560	4,132
	State Total	2,078,838	184,305	33,840	93,912	127,752	2,192	4,879	2,725	372	134	3,231	2,959	1,420	560	4,939
SC	Off	296,250	18,735	8,552	22,732	31,283	42	-	221	-	-	221	240	-	-	240
	On	427,817	56,305	4,450	13,519	17,969	999	2,189	585	248	71	904	635	947	294	1,877
	State Total	724,067	75,041	13,001	36,251	49,252	1,041	2,189	806	248	71	1,124	875	947	294	2,116
TN	Off	518,448	28,711	17,466	36,796	54,262	66	-	450	-	-	450	489	-	-	489
	On	646,534	87,701	5,780	19,630	25,410	1,290	3,096	1,012	211	77	1,300	1,099	807	321	2,227
	State Total	1,164,983	116,412	23,246	56,426	79,671	1,356	3,096	1,462	211	77	1,750	1,588	807	321	2,716
VA	Off	643,629	33,501	15,388	51,011	66,399	64	-	708	-	-	708	769	-	-	769
	On	522,601	76,084	7,917	17,137	25,054	1,030	3,884	1,328	244	104	1,676	1,442	933	434	2,809
	State Total	1,166,230	109,585	23,305	68,148	91,453	1,093	3,884	2,036	244	104	2,384	2,211	933	434	3,578
WV	Off	181,756	8,379	3,399	12,392	15,791	22	-	174	-	-	174	189	-	-	189
	On	166,960	22,464	1,604	5,195	6,800	371	833	328	82	26	436	356	313	109	779
	State Total	348,716	30,843	5,004	17,587	22,591	393	833	503	82	26	611	546	313	109	968
SEMAP	Off	4,943,243	317,997	158,299	404,674	562,973	728	-	4,436	-	-	4,436	4,817	-	-	4,817
	On	6,975,587	959,259	83,502	245,528	329,030	18,094	35,836	10,776	3,885	1,126	15,787	11,703	14,842	4,695	31,240
	Total	11,918,830	1,277,256	241,801	650,202	892,003	18,822	35,836	15,212	3,885	1,126	20,223	16,520	14,842	4,695	36,057

Table 6-2. Annual on-road mobile source emissions summary by state and network from diesel fueled vehicles (tons/year).

State	Network	CO	NO_X	VOC-EVP	VOC-EXH	VOC-TOT	SO2	NH3	PM25 EXH	PM25 BRAKE	PM25 TIRE	PM25-TOT	PM10 EXH	PM10 BRAKE	PM10 TIRE	PM10 -TOT
AL	Off	5,448	10,117	-	2,320	2,320	12	0	190	-	-	190	196	-	-	196
	On	19,195	65,412	-	3,652	3,652	272	120	3,986	96	22	4,104	4,109	367	90	4,566
	State Total	24,643	75,530	-	5,971	5,971	284	120	4,176	96	22	4,294	4,305	367	90	4,762
FL	Off	12,015	20,460	-	4,894	4,894	28	0	496	-	-	496	511	-	-	511
	On	49,187	165,643	-	8,968	8,968	829	347	9,490	291	56	9,837	9,783	1,112	234	11,130
	State Total	61,202	186,103	-	13,863	13,863	857	347	9,986	291	56	10,333	10,294	1,112	234	11,641
GA	Off	7,530	13,051	-	3,009	3,009	16	0	250	-	-	250	258	-	-	258
	On	47,208	159,498	-	8,686	8,686	647	271	9,912	239	48	10,199	10,218	912	202	11,332
	State Total	54,738	172,549	-	11,694	11,694	663	271	10,162	239	48	10,449	10,476	912	202	11,590
KY	Off	4,667	9,086	-	2,038	2,038	10	0	157	-	-	157	162	-	-	162
	On	13,559	52,447	-	2,513	2,513	211	97	2,806	49	14	2,868	2,892	186	58	3,137
	State Total	18,226	61,533	-	4,551	4,551	222	97	2,963	49	14	3,026	3,055	186	58	3,299
MS	Off	4,380	8,054	-	1,848	1,848	10	0	170	-	-	170	175	-	-	175
	On	14,493	54,251	-	2,667	2,667	227	106	3,012	50	15	3,078	3,106	192	63	3,361
	State Total	18,873	62,305	-	4,514	4,514	237	106	3,182	50	15	3,248	3,280	192	63	3,536
NC	Off	12,244	24,555	-	5,568	5,568	28	0	444	-	-	444	458	-	-	458
	On	19,890	71,809	-	3,744	3,744	314	174	3,639	47	20	3,706	3,751	181	81	4,014
	State Total	32,134	96,364	-	9,312	9,312	342	174	4,083	47	20	4,150	4,209	181	81	4,472
SC	Off	3,599	6,724	-	1,542	1,542	8	0	122	-	-	122	126	-	-	126
	On	17,809	62,715	-	3,229	3,229	264	114	3,640	89	18	3,748	3,753	341	77	4,171
	State Total	21,408	69,439	-	4,771	4,771	272	114	3,763	89	18	3,870	3,879	341	77	4,297
TN	Off	4,964	9,482	-	2,147	2,147	11	0	170	-	-	170	175	-	-	175
	On	27,718	122,910	-	4,995	4,995	490	226	5,777	57	27	5,861	5,956	218	112	6,285
	State Total	32,682	132,392	-	7,142	7,142	501	226	5,947	57	27	6,031	6,131	218	112	6,461
VA	Off	3,188	5,333	-	1,201	1,201	7	0	122	-	-	122	126	-	-	126
	On	19,493	81,825	-	3,644	3,644	329	157	3,930	55	21	4,006	4,051	210	86	4,348
	State Total	22,681	87,159	-	4,845	4,845	335	157	4,052	55	21	4,128	4,177	210	86	4,473
WV	Off	3,308	7,168	-	1,562	1,562	8	0	116	-	-	116	120	-	-	120
	On	5,558	21,957	-	1,052	1,052	87	42	1,174	19	6	1,199	1,210	74	24	1,308
	State Total	8,865	29,125	-	2,614	2,614	95	42	1,290	19	6	1,315	1,330	74	24	1,428
SEMAP	Off	61,342	114,033	-	26,129	26,129	138	0	2,238	-	-	2,238	2,307	-	-	2,307
	On	234,110	858,467	-	43,148	43,148	3,670	1,654	47,366	993	246	48,606	48,829	3,794	1,028	53,651
	Total	295,453	972,499	-	69,277	69,277	3,808	1,654	49,604	993	246	50,844	51,137	3,794	1,028	55,959

Table 6-3. Annual on-road mobile source emissions summary by state and network from gasoline and diesel fueled vehicles (tons/year).

State	Network	CO	NO_X	VOC-EVP	VOC-EXH	VOC-TOT	SO2	NH3	PM25 EXH	PM25 BRAKE	PM25 TIRE	PM25-TOT	PM10 EXH	PM10 BRAKE	PM10 TIRE	PM10-TOT
AL	Off	392,855	35,732	11,619	35,765	47,384	64	0	517	-	-	517	551	-	-	551
	On	516,595	136,935	6,603	23,090	29,694	1,445	2,823	4,765	478	127	5,370	4,955	1,825	530	7,310
	State Total	909,450	172,668	18,222	58,856	77,078	1,509	2,823	5,282	478	127	5,887	5,506	1,825	530	7,861
FL	Off	821,857	97,371	41,592	87,559	129,151	165	0	1,080	-	-	1,080	1,146	-	-	1,146
	On	1,743,593	401,565	24,613	69,133	93,746	4,987	9,676	11,362	1,659	379	13,400	11,816	6,337	1,582	19,735
	State Total	2,565,451	498,935	66,205	156,692	222,897	5,151	9,676	12,442	1,659	379	14,480	12,962	6,337	1,582	20,881
GA	Off	617,202	64,183	20,688	62,628	83,316	193	0	915	-	-	915	980	-	-	980
	On	1,292,189	332,655	15,373	62,225	77,598	6,214	5,416	11,705	848	213	12,765	12,165	3,238	888	16,291
	State Total	1,909,391	396,837	36,061	124,853	160,914	6,407	5,416	12,620	848	213	13,681	13,145	3,238	888	17,271
KY	Off	345,249	28,160	7,523	29,405	36,928	53	0	517	-	-	517	553	-	-	553
	On	358,762	105,266	4,188	14,767	18,955	969	2,172	3,508	258	79	3,845	3,656	985	331	4,971
	State Total	704,011	133,425	11,711	44,172	55,883	1,022	2,172	4,026	258	79	4,363	4,209	985	331	5,524
MS	Off	255,659	24,186	7,913	22,456	30,369	42	0	373	-	-	373	396	-	-	396
	On	269,716	93,039	3,293	11,443	14,737	877	1,809	3,407	211	70	3,688	3,534	807	294	4,634
	State Total	525,375	117,225	11,206	33,899	45,106	920	1,809	3,780	211	70	4,061	3,929	807	294	5,030
NC	Off	916,622	64,364	24,160	63,606	87,766	122	0	1,187	-	-	1,187	1,265	-	-	1,265
	On	1,194,351	216,305	9,681	39,618	49,299	2,412	5,053	5,621	419	154	6,194	5,903	1,601	641	8,146
	State Total	2,110,972	280,670	33,840	103,224	137,064	2,534	5,053	6,808	419	154	7,381	7,168	1,601	641	9,411
SC	Off	299,849	25,460	8,552	24,274	32,826	50	0	343	-	-	343	366	-	-	366
	On	445,626	119,020	4,450	16,748	21,198	1,263	2,303	4,225	337	89	4,652	4,388	1,288	371	6,047
	State Total	745,475	144,480	13,001	41,022	54,023	1,313	2,303	4,568	337	89	4,994	4,754	1,288	371	6,413
TN	Off	523,412	38,193	17,466	38,943	56,409	77	0	621	-	-	621	664	-	-	664
	On	674,253	210,611	5,780	24,624	30,404	1,780	3,322	6,789	268	104	7,161	7,054	1,025	433	8,512
	State Total	1,197,665	248,804	23,246	63,567	86,813	1,857	3,322	7,409	268	104	7,781	7,719	1,025	433	9,177
VA	Off	646,816	38,835	15,388	52,212	67,600	70	0	830	-	-	830	894	-	-	894
	On	542,095	157,909	7,917	20,781	28,698	1,358	4,041	5,258	299	125	5,682	5,494	1,143	520	7,157
	State Total	1,188,911	196,744	23,305	72,992	96,297	1,429	4,041	6,088	299	125	6,512	6,388	1,143	520	8,051
WV	Off	185,064	15,547	3,399	13,955	17,354	30	0	291	-	-	291	309	-	-	309
	On	172,517	44,421	1,604	6,247	7,852	458	875	1,502	101	32	1,635	1,566	387	133	2,087
	State Total	357,581	59,968	5,004	20,202	25,205	487	875	1,793	101	32	1,926	1,876	387	133	2,397
SEMAP	Off	5,004,586	432,030	158,299	430,803	589,102	866	0	6,674	-	-	6,674	7,124	-	-	7,124
	On	7,209,697	1,817,725	83,502	288,677	372,179	21,763	37,490	58,142	4,879	1,372	64,393	60,532	18,636	5,723	84,892
	Total	12,214,283	2,249,755	241,801	719,480	961,281	22,629	37,490	64,816	4,879	1,372	71,067	67,657	18,636	5,723	92,016

Table 6-4. Annual on-road mobile source emissions summary by state and vehicle category (tons/year).

State	Category	CO	NO_X	VOC-EVP	VOC-EXH	VOC-TOT	SO2	NH3	PM25 EXH	PM25 BRAKE	PM25 TIRE	PM25-TOT	PM10 EXH	PM10 BRAKE	PM10 TIRE	PM10-TOT
AL	LDGV	308,556	39,989	8,526	18,583	27,109	602	1,621	471	167	60	698	512	639	249	1,399
	LDGT1	344,599	34,831	5,311	21,184	26,494	377	686	397	121	27	546	432	463	113	1,008
	LDGT2	118,354	11,965	1,825	7,278	9,102	130	236	137	42	9	188	148	159	39	346
	HDGV	106,231	10,094	1,315	5,362	6,677	111	149	90	52	9	150	97	197	38	333
	MC	7,068	259	1,245	479	1,724	5	11	11	0	0	11	12	0	1	13
	LDDV	24	80	-	7	7	1	0	6	0	0	7	6	1	0	7
	LDDT	328	486	-	65	65	2	2	31	1	0	31	31	2	1	35
	HDDV	24,148	74,730	-	5,885	5,885	281	118	4,126	95	21	4,242	4,254	362	89	4,705
	BUSES	143	234	-	15	15	1	0	13	0	0	14	14	1	0	16
	State Total	909,450	172,668	18,222	58,856	77,078	1,509	2,823	5,282	478	127	5,887	5,506	1,825	530	7,861
FL	LDGV	1,165,545	155,634	40,230	64,227	104,457	2,269	5,944	1,365	669	195	2,229	1,482	2,555	814	4,851
	LDGT1	866,109	104,419	13,777	50,203	63,979	1,373	2,325	724	477	87	1,287	786	1,820	364	2,970
	LDGT2	349,727	40,252	6,152	22,123	28,274	478	799	278	164	30	472	302	625	125	1,052
	HDGV	102,620	11,865	1,167	4,917	6,084	161	235	67	58	10	135	73	223	42	337
	MC	20,248	662	4,880	1,360	6,240	13	26	23	0	1	24	25	1	3	29
	LDDV	239	482	-	66	66	2	1	83	1	0	84	86	3	1	89
	LDDT	1,885	2,716	-	336	336	9	6	155	3	1	158	160	10	2	172
	HDDV	57,365	176,595	-	13,213	13,213	824	331	9,377	277	54	9,708	9,667	1,059	223	10,949
	BUSES	1,713	6,311	-	247	247	21	9	370	11	2	383	382	41	8	431
	State Total	2,565,451	498,935	66,205	156,692	222,897	5,151	9,676	12,442	1,659	379	14,480	12,962	6,337	1,582	20,881
GA	LDGV	588,537	69,139	15,807	39,760	55,568	2,121	2,267	967	191	71	1,229	1,050	731	295	2,076
	LDGT1	767,539	95,064	11,667	45,339	57,005	2,192	1,763	914	247	56	1,217	993	943	234	2,170
	LDGT2	365,564	46,099	5,346	20,925	26,271	1,082	884	440	123	28	591	478	469	117	1,064
	HDGV	117,805	13,391	1,440	6,066	7,505	328	217	117	48	9	174	128	182	39	348
	MC	15,208	595	1,802	1,069	2,871	22	14	19	0	0	20	21	1	2	24
	LDDV	41	115	-	13	13	1	0	16	0	0	16	16	1	0	18
	LDDT	1,039	1,439	-	204	204	6	6	100	2	1	102	103	7	2	112
	HDDV	51,873	166,257	-	11,181	11,181	642	258	9,760	228	46	10,035	10,062	872	192	11,126
	BUSES	1,786	4,738	-	297	297	14	7	286	8	2	296	295	32	7	334
	State Total	1,909,391	396,837	36,061	124,853	160,914	6,407	5,416	12,620	848	213	13,681	13,145	3,238	888	17,271
KY	LDGV	253,054	29,550	5,799	15,649	21,448	389	1,218	460	95	37	592	499	363	156	1,018
	LDGT1	271,656	27,417	3,406	15,873	19,279	263	577	392	76	19	486	426	289	77	792
	LDGT2	79,701	7,620	970	4,460	5,430	80	157	110	18	5	133	120	69	21	210
	HDGV	75,889	7,112	771	3,346	4,116	65	116	92	20	4	117	100	77	19	196
	MC	5,485	193	764	294	1,058	3	8	9	0	0	9	10	0	1	10
	LDDV	15	47	-	5	5	0	0	4	0	0	4	4	0	0	5
	LDDT	178	272	-	39	39	1	1	18	0	0	18	18	1	0	20
	HDDV	17,912	60,986	-	4,494	4,494	220	95	2,929	48	14	2,991	3,020	184	57	3,260
	BUSES	121	228	-	14	14	1	0	12	0	0	13	13	1	0	14
	State Total	704,011	133,425	11,711	44,172	55,883	1,022	2,172	4,026	258	79	4,363	4,209	985	331	5,524

Table 6-4. (continued)

State	Category	CO	NO_X	VOC-EVP	VOC-EXH	VOC-TOT	SO2	NH3	PM25 EXH	PM25 BRAKE	PM25 TIRE	PM25-TOT	PM10 EXH	PM10 BRAKE	PM10 TIRE	PM10-TOT
MS	LDGV	213,453	28,659	5,491	11,941	17,432	438	1,249	307	101	40	448	334	385	166	885
	LDGT1	222,004	21,007	3,522	13,825	17,348	200	378	228	49	13	290	248	188	53	488
	LDGT2	14,572	1,379	231	908	1,139	13	25	15	3	1	19	16	12	3	32
	HDGV	53,165	3,755	779	2,517	3,295	30	46	43	8	2	53	47	29	8	84
	MC	3,309	120	1,183	195	1,378	2	5	4	0	0	4	5	0	0	5
	LDDV	113	389	-	32	32	3	2	28	1	0	29	29	3	1	34
	LDDT	564	831	-	114	114	4	4	53	1	0	55	55	3	1	60
	HDDV	17,636	59,216	-	4,278	4,278	224	98	3,000	47	14	3,060	3,092	178	58	3,329
	BUSES	559	1,870	-	91	91	6	3	101	2	1	103	104	8	2	114
	State Total	525,375	117,225	11,206	33,899	45,106	920	1,809	3,780	211	70	4,061	3,929	807	294	5,030
NC	LDGV	533,163	47,517	13,084	26,813	39,896	745	1,995	748	113	56	916	812	432	232	1,476
	LDGT1	1,022,227	87,755	13,341	45,835	59,175	909	1,843	1,258	161	49	1,468	1,366	615	206	2,186
	LDGT2	352,587	30,877	4,508	15,606	20,115	324	659	440	58	18	516	478	220	74	772
	HDGV	144,284	17,376	885	4,524	5,409	200	353	250	40	11	301	272	153	47	471
	MC	26,577	781	2,022	1,134	3,157	13	28	29	0	0	30	32	1	2	34
	LDDV	134	315	-	54	54	2	1	55	0	0	55	56	1	1	58
	LDDT	868	1,268	-	178	178	6	7	93	1	0	94	96	5	2	102
	HDDV	30,443	93,628	-	9,010	9,010	331	165	3,880	45	19	3,944	4,000	172	78	4,250
	BUSES	688	1,153	-	69	69	4	2	56	1	0	57	57	3	1	62
	State Total	2,110,972	280,670	33,840	103,224	137,064	2,534	5,053	6,808	419	154	7,381	7,168	1,601	641	9,411
SC	LDGV	260,091	29,266	6,621	13,634	20,254	441	1,169	347	95	35	478	377	364	148	889
	LDGT1	287,913	29,417	3,527	14,470	17,997	388	667	291	99	23	413	317	377	95	789
	LDGT2	106,943	11,163	1,276	5,246	6,522	151	260	111	39	9	158	120	147	37	304
	HDGV	59,943	4,905	664	2,436	3,101	56	81	45	15	3	64	49	58	13	121
	MC	9,177	290	914	465	1,379	6	13	11	0	0	11	12	0	1	13
	LDDV	19	64	-	5	5	1	0	5	0	0	5	5	1	0	6
	LDDT	336	508	-	66	66	2	2	31	1	0	32	32	2	1	35
	HDDV	20,467	66,849	-	4,600	4,600	263	109	3,607	85	18	3,710	3,719	326	73	4,118
	BUSES	586	2,018	-	100	100	6	3	120	3	1	124	124	12	2	138
	State Total	745,475	144,480	13,001	41,022	54,023	1,313	2,303	4,568	337	89	4,994	4,754	1,288	371	6,413
TN	LDGV	394,567	38,209	12,192	22,688	34,880	481	1,331	549	66	32	647	597	251	135	983
	LDGT1	494,334	52,166	6,335	22,151	28,486	590	1,209	601	98	30	729	652	376	126	1,154
	LDGT2	169,330	17,853	2,173	7,595	9,769	202	413	206	34	10	250	224	128	43	395
	HDGV	93,538	7,768	1,113	3,443	4,556	76	126	91	14	4	108	98	52	15	165
	MC	13,213	416	1,432	548	1,981	7	16	15	0	0	16	17	0	1	18
	LDDV	91	338	-	24	24	3	2	24	1	0	25	24	2	1	28
	LDDT	22	37	-	8	8	0	-	2	-	-	2	2	-	-	2
	HDDV	32,040	130,331	-	7,028	7,028	493	222	5,834	55	26	5,915	6,014	209	109	6,332
	BUSES	529	1,685	-	83	83	5	2	88	2	0	90	91	6	2	99
	State Total	1,197,665	248,804	23,246	63,567	86,813	1,857	3,322	7,409	268	104	7,781	7,719	1,025	433	9,177

Table 6-4. (concluded)

State	Category	CO	NO_X	VOC-EVP	VOC-EXH	VOC-TOT	SO2	NH3	PM25 EXH	PM25 BRAKE	PM25 TIRE	PM25-TOT	PM10 EXH	PM10 BRAKE	PM10 TIRE	PM10-TOT
VA	LDGV	598,031	66,894	13,931	32,698	46,629	816	3,258	1,332	185	86	1,604	1,447	708	359	2,515
	LDGT1	327,314	24,760	4,693	20,920	25,613	159	368	406	33	10	449	441	127	43	610
	LDGT2	168,614	12,757	2,418	10,777	13,194	82	189	210	17	5	232	228	65	22	315
	HDGV	62,787	4,856	715	3,233	3,948	33	58	74	9	2	84	80	33	9	121
	MC	9,485	318	1,548	520	2,068	4	11	14	0	0	15	16	0	1	17
	LDDV	86	264	-	29	29	2	1	31	0	0	31	32	2	1	34
	LDDT	562	879	-	135	135	4	4	55	1	0	56	57	2	1	60
	HDDV	19,973	79,351	-	4,349	4,349	309	142	3,614	47	18	3,680	3,726	179	77	3,982
	BUSES	2,060	6,664	-	332	332	20	10	352	7	2	361	363	27	7	397
	State Total	1,188,911	196,744	23,305	72,992	96,297	1,429	4,041	6,088	299	125	6,512	6,388	1,143	520	8,051
WV	LDGV	103,227	10,280	1,907	5,337	7,244	160	424	168	31	13	212	183	119	54	356
	LDGT1	183,906	14,607	2,063	9,630	11,693	158	279	242	35	9	287	263	134	38	435
	LDGT2	43,824	4,173	446	2,055	2,501	52	95	65	12	3	80	71	46	13	129
	HDGV	13,112	1,647	57	359	416	20	30	21	4	1	25	22	14	4	41
	MC	4,648	136	530	207	737	2	5	6	0	0	7	7	0	0	8
	LDDV	23	58	-	11	11	0	0	7	0	0	7	8	0	0	8
	LDDT	115	180	-	25	25	1	1	12	0	0	12	13	1	0	14
	HDDV	8,474	28,126	-	2,539	2,539	91	40	1,231	18	5	1,255	1,269	70	23	1,362
	BUSES	252	761	-	39	39	2	1	39	1	0	40	41	3	1	44
	State Total	357,581	59,968	5,004	20,202	25,205	487	875	1,793	101	32	1,926	1,876	387	133	2,397
SEMAP	LDGV	4,418,223	515,137	123,588	251,328	374,917	8,462	20,475	6,714	1,714	625	9,053	7,292	6,546	2,608	16,446
	LDGT1	4,787,601	491,444	67,641	259,430	327,070	6,609	10,095	5,453	1,396	323	7,172	5,922	5,332	1,348	12,602
	LDGT2	1,769,215	184,137	25,345	96,972	122,317	2,593	3,717	2,012	508	118	2,639	2,185	1,942	494	4,621
	HDGV	829,375	82,768	8,907	36,201	45,108	1,080	1,412	890	266	56	1,212	966	1,018	233	2,217
	MC	114,416	3,771	16,320	6,271	22,592	77	136	143	1	3	147	155	5	12	172
	LDDV	785	2,153	-	245	245	15	8	258	4	1	263	266	14	6	286
	LDDT	5,897	8,615	-	1,169	1,169	36	32	549	9	3	560	566	35	11	611
	HDDV	280,332	936,069	-	66,576	66,576	3,677	1,578	47,359	945	235	48,539	48,822	3,611	980	53,414
	BUSES	8,439	25,662	-	1,287	1,287	80	36	1,438	35	7	1,480	1,482	134	31	1,648
	Total	12,214,283	2,249,755	241,801	719,480	961,281	22,629	37,490	64,816	4,879	1,372	71,067	67,657	18,636	5,723	92,016

Table 6-5. Ozone season day on-road mobile source emissions summary by state and vehicle category (tons/day).

State	Category	CO	NO_X	VOC-EVP	VOC-EXH	VOC-TOT	SO2	NH3	PM25 EXH	PM25 BRAKE	PM25 TIRE	PM25-TOT	PM10 EXH	PM10 BRAKE	PM10 TIRE	PM10-TOT
AL	LDGV	810.0	112.9	25.2	46.5	71.7	1.7	4.6	1.0	0.5	0.2	1.7	1.1	1.8	0.7	3.6
	LDGT1	915.8	97.5	15.9	55.0	70.9	1.1	2.0	0.8	0.3	0.1	1.3	0.9	1.3	0.3	2.5
	LDGT2	313.8	33.4	5.5	18.9	24.3	0.4	0.7	0.3	0.1	0.0	0.4	0.3	0.4	0.1	0.9
	HDGV	276.6	26.7	3.8	14.0	17.8	0.3	0.4	0.2	0.1	0.0	0.3	0.2	0.5	0.1	0.8
	MC	17.5	0.6	3.7	1.3	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LDDV	0.1	0.2	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LDDT	1.0	1.4	-	0.2	0.2	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1
	HDDV	67.1	193.6	-	15.9	15.9	0.8	0.3	11.3	0.3	0.1	11.6	11.6	1.0	0.2	12.9
	BUSES	0.4	0.6	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	State Total	2,402.2	466.8	54.2	151.8	206.0	4.3	8.0	13.8	1.3	0.4	15.5	14.3	5.1	1.5	20.9
FL	LDGV	3,244.6	441.6	108.2	176.6	284.9	6.6	16.8	3.5	1.9	0.6	6.0	3.8	7.2	2.3	13.3
	LDGT1	2,398.5	296.0	37.2	139.0	176.1	4.0	6.6	1.9	1.3	0.2	3.5	2.0	5.2	1.0	8.2
	LDGT2	946.0	112.7	16.5	60.6	77.0	1.4	2.2	0.7	0.5	0.1	1.2	0.8	1.7	0.4	2.9
	HDGV	274.7	32.1	3.1	13.4	16.6	0.5	0.6	0.2	0.2	0.0	0.4	0.2	0.6	0.1	0.9
	MC	50.5	1.7	12.6	3.7	16.3	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1
	LDDV	0.7	1.3	-	0.1	0.1	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.0	0.0	0.2
	LDDT	5.4	7.4	-	0.8	0.8	0.0	0.0	0.4	0.0	0.0	0.4	0.4	0.0	0.0	0.5
	HDDV	159.6	467.1	-	36.2	36.2	2.3	0.9	25.7	0.8	0.1	26.6	26.5	2.9	0.6	30.0
	BUSES	4.7	16.6	-	0.7	0.7	0.1	0.0	1.0	0.0	0.0	1.0	1.0	0.1	0.0	1.2
	State Total	7,084.8	1,376.5	177.6	431.0	608.6	14.8	27.3	33.6	4.6	1.1	39.4	35.0	17.8	4.4	57.2
GA	LDGV	1,742.2	221.9	44.7	106.4	151.0	10.6	6.5	2.1	0.5	0.2	2.8	2.2	2.1	0.8	5.2
	LDGT1	2,416.8	293.2	33.1	133.0	166.2	11.0	5.0	2.0	0.7	0.2	2.9	2.2	2.7	0.7	5.5
	LDGT2	1,162.4	141.8	15.1	62.0	77.1	5.4	2.5	1.0	0.3	0.1	1.4	1.0	1.3	0.3	2.7
	HDGV	361.8	39.8	4.0	18.0	21.9	1.6	0.6	0.2	0.1	0.0	0.4	0.3	0.5	0.1	0.9
	MC	48.7	2.0	5.0	3.5	8.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	LDDV	0.1	0.3	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LDDT	3.1	4.0	-	0.6	0.6	0.0	0.0	0.3	0.0	0.0	0.3	0.3	0.0	0.0	0.3
	HDDV	144.2	431.2	-	30.4	30.4	1.8	0.7	26.7	0.6	0.1	27.5	27.5	2.4	0.5	30.4
	BUSES	4.9	12.2	-	0.8	0.8	0.0	0.0	0.8	0.0	0.0	0.8	0.8	0.1	0.0	0.9
	State Total	5,884.2	1,146.5	101.9	354.6	456.5	30.6	15.4	33.1	2.4	0.6	36.1	34.4	9.1	2.5	46.0
KY	LDGV	585.4	81.0	17.6	35.7	53.3	1.1	3.5	0.8	0.3	0.1	1.2	0.9	1.0	0.4	2.4
	LDGT1	668.4	75.4	10.4	39.8	50.2	0.7	1.7	0.7	0.2	0.1	1.0	0.7	0.8	0.2	1.8
	LDGT2	193.6	21.0	3.0	11.2	14.1	0.2	0.4	0.2	0.1	0.0	0.3	0.2	0.2	0.1	0.5
	HDGV	185.7	18.5	2.3	8.5	10.8	0.2	0.3	0.2	0.1	0.0	0.2	0.2	0.2	0.1	0.4
	MC	12.3	0.5	2.4	0.8	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LDDV	0.0	0.1	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LDDT	0.5	0.7	-	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	HDDV	49.4	157.5	-	12.1	12.1	0.6	0.3	8.0	0.1	0.0	8.2	8.3	0.5	0.2	8.9
	BUSES	0.3	0.6	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	State Total	1,695.6	355.3	35.6	108.1	143.8	2.9	6.2	10.0	0.7	0.2	10.9	10.4	2.8	0.9	14.1

Table 6-5. (continued)

State	Category	CO	NO_x	VOC-EVP	VOC-EXH	VOC-TOT	SO2	NH3	PM25 EXH	PM25 BRAKE	PM25 TIRE	PM25-TOT	PM10 EXH	PM10 BRAKE	PM10 TIRE	PM10-TOT
MS	LDGV	569.7	80.8	16.2	30.7	46.9	1.3	3.6	0.7	0.3	0.1	1.1	0.7	1.1	0.5	2.3
	LDGT1	575.3	58.1	10.6	36.0	46.6	0.6	1.1	0.5	0.1	0.0	0.6	0.5	0.5	0.1	1.2
	LDGT2	37.7	3.8	0.7	2.4	3.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	HDGV	134.3	9.9	2.3	6.5	8.8	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.2
	MC	7.9	0.3	3.6	0.5	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LDDV	0.3	1.1	-	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1
	LDDT	1.7	2.3	-	0.3	0.3	0.0	0.0	0.1	0.0	0.0	0.1	0.2	0.0	0.0	0.2
	HDDV	48.9	152.6	-	11.5	11.5	0.6	0.3	8.2	0.1	0.0	8.4	8.5	0.5	0.2	9.1
	BUSES	1.5	4.8	-	0.2	0.2	0.0	0.0	0.3	0.0	0.0	0.3	0.3	0.0	0.0	0.3
	State Total	1,377.3	313.6	33.3	88.2	121.5	2.6	5.2	10.0	0.6	0.2	10.8	10.4	2.3	0.8	13.5
NC	LDGV	1,156.5	128.8	34.7	63.4	98.1	2.2	5.7	1.5	0.3	0.2	2.0	1.6	1.2	0.7	3.5
	LDGT1	2,459.1	238.6	35.6	118.8	154.3	2.6	5.3	2.5	0.5	0.1	3.1	2.8	1.7	0.6	5.1
	LDGT2	851.4	83.8	12.0	40.6	52.6	0.9	1.9	0.9	0.2	0.1	1.1	1.0	0.6	0.2	1.8
	HDGV	359.2	44.8	2.4	12.4	14.8	0.6	1.0	0.5	0.1	0.0	0.6	0.5	0.4	0.1	1.1
	MC	56.0	1.9	5.1	3.0	8.2	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1
	LDDV	0.3	0.8	-	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.2	0.2	0.0	0.0	0.2
	LDDT	2.6	3.5	-	0.5	0.5	0.0	0.0	0.3	0.0	0.0	0.3	0.3	0.0	0.0	0.3
	HDDV	84.8	241.2	-	24.5	24.5	0.9	0.5	10.6	0.1	0.1	10.8	10.9	0.5	0.2	11.6
	BUSES	1.9	2.9	-	0.2	0.2	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.0	0.0	0.2
	State Total	4,971.8	746.4	89.9	263.3	353.2	7.3	14.4	16.7	1.2	0.4	18.3	17.5	4.5	1.8	23.8
SC	LDGV	643.5	80.6	18.2	34.4	52.7	1.3	3.3	0.7	0.3	0.1	1.1	0.8	1.0	0.4	2.3
	LDGT1	739.0	81.4	9.7	38.2	48.0	1.1	1.9	0.6	0.3	0.1	1.0	0.7	1.1	0.3	2.0
	LDGT2	275.2	30.8	3.5	13.9	17.4	0.4	0.7	0.2	0.1	0.0	0.4	0.3	0.4	0.1	0.8
	HDGV	147.0	12.8	1.8	6.3	8.1	0.2	0.2	0.1	0.0	0.0	0.1	0.1	0.2	0.0	0.3
	MC	21.0	0.7	2.4	1.3	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LDDV	0.1	0.2	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LDDT	1.0	1.4	-	0.2	0.2	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1
	HDDV	56.8	172.8	-	12.5	12.5	0.7	0.3	9.9	0.2	0.0	10.2	10.2	0.9	0.2	11.3
	BUSES	1.6	5.2	-	0.3	0.3	0.0	0.0	0.3	0.0	0.0	0.3	0.3	0.0	0.0	0.4
	State Total	1,885.1	385.9	35.7	107.1	142.8	3.8	6.5	12.0	0.9	0.3	13.2	12.5	3.6	1.0	17.1
TN	LDGV	820.5	102.5	33.4	52.3	85.7	1.4	3.8	1.0	0.2	0.1	1.3	1.1	0.7	0.4	2.2
	LDGT1	1,210.5	142.2	17.5	57.8	75.4	1.7	3.5	1.2	0.3	0.1	1.5	1.3	1.1	0.4	2.7
	LDGT2	412.6	48.4	6.0	19.8	25.8	0.6	1.2	0.4	0.1	0.0	0.5	0.4	0.4	0.1	0.9
	HDGV	214.5	20.1	3.0	8.7	11.8	0.2	0.3	0.2	0.0	0.0	0.2	0.2	0.1	0.0	0.4
	MC	27.5	1.0	3.9	1.5	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LDDV	0.3	0.9	-	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1
	LDDT	0.1	0.1	-	0.0	0.0	0.0	-	0.0	-	-	0.0	0.0	-	-	0.0
	HDDV	88.5	337.7	-	19.0	19.0	1.4	0.6	16.0	0.1	0.1	16.2	16.5	0.6	0.3	17.3
	BUSES	1.4	4.4	-	0.2	0.2	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.0	0.0	0.3
	State Total	2,775.8	657.2	63.8	159.5	223.3	5.3	9.4	19.1	0.8	0.3	20.1	19.8	2.9	1.2	23.9

Table 6-4. (concluded)

State	Category	CO	NO_x	VOC-EVP	VOC-EXH	VOC-TOT	SO2	NH3	PM25 EXH	PM25 BRAKE	PM25 TIRE	PM25-TOT	PM10 EXH	PM10 BRAKE	PM10 TIRE	PM10-TOT
VA	LDGV	1,442.5	182.3	39.9	77.7	117.6	2.4	9.3	2.5	0.5	0.2	3.3	2.7	2.0	1.0	5.8
	LDGT1	737.3	66.4	13.5	50.3	63.8	0.5	1.1	0.7	0.1	0.0	0.8	0.8	0.4	0.1	1.2
	LDGT2	379.1	34.1	7.0	25.9	32.8	0.2	0.5	0.4	0.0	0.0	0.4	0.4	0.2	0.1	0.6
	HDGV	142.7	12.5	2.0	7.8	9.9	0.1	0.2	0.1	0.0	0.0	0.2	0.1	0.1	0.0	0.2
	MC	20.6	0.8	4.3	1.3	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LDDV	0.2	0.7	-	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1
	LDDT	1.6	2.3	-	0.3	0.3	0.0	0.0	0.2	0.0	0.0	0.2	0.2	0.0	0.0	0.2
	HDDV	54.8	205.9	-	11.7	11.7	0.9	0.4	9.9	0.1	0.1	10.1	10.2	0.5	0.2	10.9
	BUSES	5.6	17.3	-	0.9	0.9	0.1	0.0	1.0	0.0	0.0	1.0	1.0	0.1	0.0	1.1
	State Total	2,784.4	522.4	66.7	175.9	242.6	4.1	11.5	14.8	0.8	0.4	16.0	15.5	3.2	1.5	20.2
WV	LDGV	212.8	27.7	5.5	11.7	17.2	0.5	1.2	0.3	0.1	0.0	0.4	0.3	0.3	0.2	0.8
	LDGT1	401.0	39.4	6.0	23.1	29.1	0.5	0.8	0.4	0.1	0.0	0.5	0.4	0.4	0.1	0.9
	LDGT2	100.5	11.3	1.3	5.1	6.4	0.1	0.3	0.1	0.0	0.0	0.2	0.1	0.1	0.0	0.3
	HDGV	31.2	4.2	0.2	1.0	1.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	MC	9.4	0.3	1.5	0.5	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LDDV	0.1	0.1	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	LDDT	0.3	0.5	-	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	HDDV	23.3	72.8	-	6.9	6.9	0.3	0.1	3.4	0.1	0.0	3.4	3.5	0.2	0.1	3.7
	BUSES	0.7	2.0	-	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.1
	State Total	779.3	158.3	14.5	48.5	63.0	1.4	2.5	4.4	0.3	0.1	4.8	4.6	1.1	0.4	6.0
SEMAP	LDGV	11,227.7	1,460.0	343.6	635.4	979.0	29.0	58.3	14.1	4.9	1.8	20.8	15.4	18.5	7.4	41.3
	LDGT1	12,521.8	1,388.2	189.5	691.1	880.6	23.7	28.8	11.3	4.0	0.9	16.2	12.3	15.1	3.8	31.2
	LDGT2	4,672.2	521.1	70.5	260.2	330.7	9.8	10.6	4.2	1.4	0.3	5.9	4.5	5.5	1.4	11.4
	HDGV	2,127.7	221.4	25.0	96.6	121.6	3.7	3.9	1.8	0.7	0.2	2.6	1.9	2.8	0.6	5.3
	MC	271.3	10.0	44.6	17.4	61.9	0.3	0.4	0.3	0.0	0.0	0.3	0.3	0.0	0.0	0.4
	LDDV	2.2	5.7	-	0.5	0.5	0.0	0.0	0.7	0.0	0.0	0.7	0.7	0.0	0.0	0.8
	LDDT	17.4	23.7	-	3.0	3.0	0.1	0.1	1.5	0.0	0.0	1.5	1.5	0.1	0.0	1.7
	HDDV	777.2	2,432.3	-	180.5	180.5	10.3	4.3	129.6	2.6	0.6	132.8	133.6	9.9	2.7	146.2
	BUSES	23.0	66.5	-	3.4	3.4	0.2	0.1	3.9	0.1	0.0	4.1	4.1	0.4	0.1	4.5
	Total	31,640.4	6,128.9	673.2	1,888.1	2,561.3	77.1	106.4	167.5	13.7	3.9	185.0	174.4	52.3	16.1	242.8

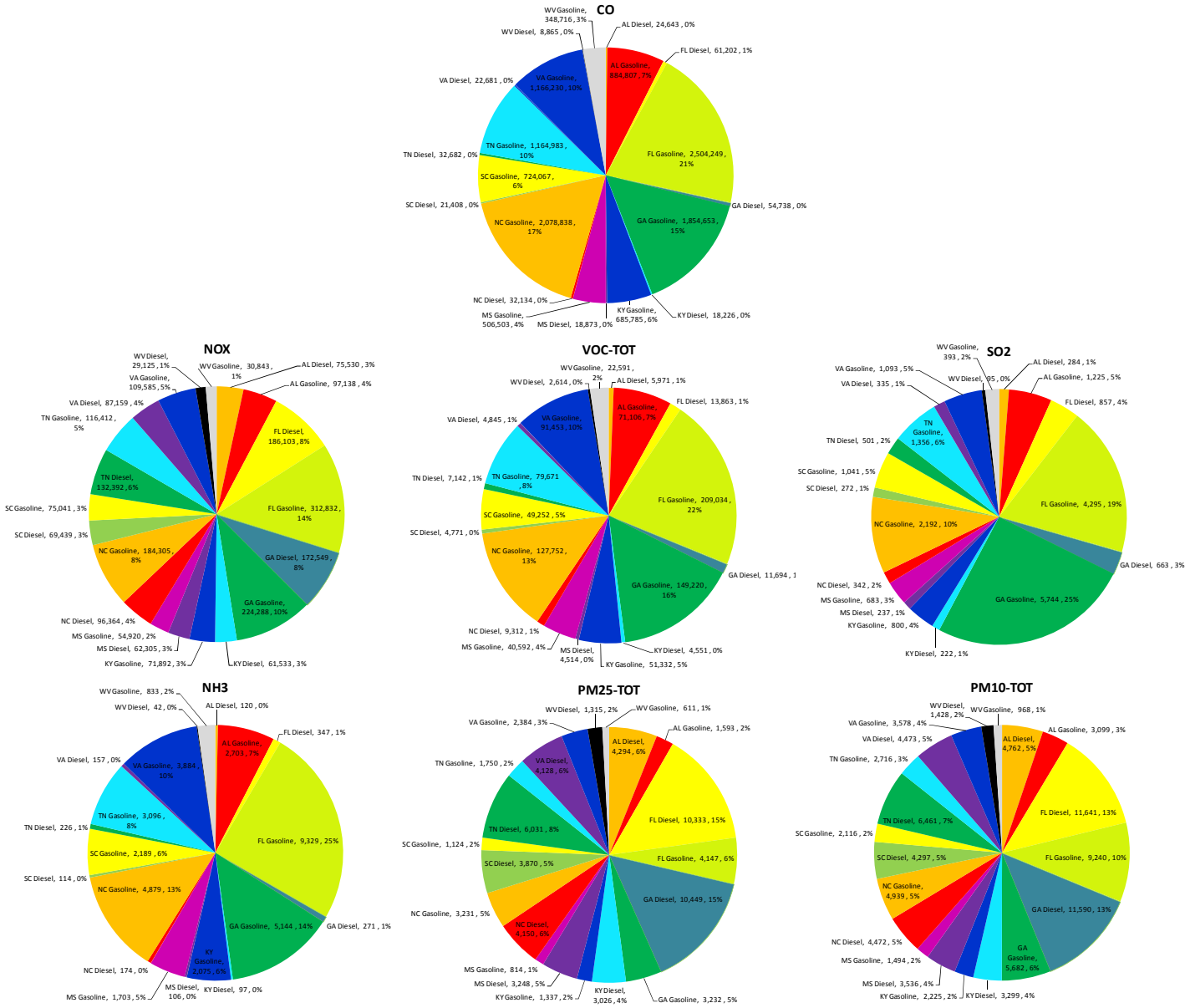


Figure 6-1. Percentage contribution by state and fuel to annual on-road mobile source emissions estimates.

7.0 DATA DISK

A data disk containing an archive of the information developed during the study was prepared. The contents of the archive are described in Table 7-1.

Table 7-1. Description of data disk archive for the SEMAP 2007 MOVES2010a study.

semap	(directory)
|-- 2007_MOVES_MySQL_inputs	MySQL input data base archives of MOVES2010a runs
|-- 2007_MOVES_MySQL_outputs	MySQL output data base archives of MOVES2010a runs
|-- edss	(directory) SMOKE files files for use with MET4MOVES
| |-- data_semap	(directory)
| | |-- ge_data	(directory)
| | | |-- fuelmonth_semap_??.txt	Fuel month cross-reference file for use in MET4MOVES and MOVES2010a
| | | |-- mcref_semap_??_2007.txt	Representative county cross-reference file for use in MET4MOVES and MOVES2010a
| | | |-- GRDDESC	Standard SMOKE grid definition file used by MET4MOVEs
| | | |-- SRGDESC.MOVES.NC	Standard SMOKE spatial surrogates definition file used by MET4MOVES
| | | |-- Srg_12km_MOVES_SEMAP	(directory) containing standard SMOKE spatial surrogates used by MET4MOVES
| | | |-- metlist.met4moves.lst	File containing list of netCDF MCIP files for use by MET4MOVES
| | |-- inventory	(directory)
| | | |-- MOVES_2007	(directory)
| | | | |-- mobile	(directory) files for use by UNC in SMOKE modeling
| | | | |-- onroad_dat	(directory) files for use by UNC in SMOKE modeling
| | |-- met	(directory) containing netCDF MCIP files for MET4MOVES (referenced by metlist.met4moves.lst)
| | |-- met_out	(directory)
| | | |-- 12k	(directory) containing output from MET4MOVES (SMOKE and MOVES compatible met data sets)
| | |-- run_MOVES_2007	(directory)
| | | |-- static	(directory)
| | | | |-- logs	(directory) containing diagnostic log files output by MET4MOVES
| |-- subsys	(directory)
| | |-- smoke	(directory)
| | | |-- assigns_semap	(directory)
| | | | |-- ASSIGNS.MOVES.cmaq.cb05p25tx.semap.12k	SMOKE ASSIGNS file used by MET4MOVES
| | | |-- scripts	(directory)

```
|   |   |   |   |
|   |   |   |   |-- run_met4moves.MOVES.semap.??.bat        C-shell scripts to run MET4MOVES
|
|-- moves2smoke_windows                                     (directory) containing MOVES2010a emissions factors archives delivered to UNC.
|                                                                       Also contains Windows-based scripts to extract MOVES2010a emissions
|                                                                       factors from MySQL output data base archnives.
|
|-- moves2moke_linux                                        (directory) containing example scripts and results from running emissions factor
|                                                                       extraction procedures on a linux platform (still in testing mode).
|
|-- moves_emissions_factors_qa                              (directory) containing example Excel workbooks with VBA macros to ingest
|                                                                       MOVES2010a emissions factors and develop consolidated graphics for
|                                                                       QA purposes.
|
|-- rh_rvp_sensitivity_experiments                          (directory) containing Consolidated Excel workbooks summarizing RH and RVP
|                                                                       MOVES2010a sensitivity experiments.
|
|-- smoke_moves_input                                       (directory) containing the MOVES2010a data inputs developed during the study.
|   |
|   |-- ??                                                  (directories) one directory per state
|   |   |
|   |   |-- SSCCC_FuelFormulation.csv                       MOVES2010a fuel formulation input file
|   |   |
|   |   |-- SSCCC_FuelSupply.csv                            MOVES2010a fuel supply input file
|   |   |
|   |   |-- SSCCC_HPMSVTypeVMT.csv                          MOVES2010a annual VMT input file
|   |   |
|   |   |-- SSCCC_IMCoverage.csv                            MOVES2010a I/M input file
|   |   |
|   |   |-- SSCCC_sourceTypeAgeDistribution.csv             MOVES2010a mode year age distribution input file
|   |   |
|   |   |-- SSCCC_sourceTypePopulatin.csv                   MOVES2010a vehicle population count input file
|   |   |
|   |   |-- MOVES_12km_2007001-2007365_??.txt               MOVES2010a meteorological input file (replicated from met_out/12k)
|   |   |
|   |   |-- SMOKE_12km_2007001-2007365_??.txt               SMOKE meteorological input file (replicated from met_out/12k)
|
|-- smoke_moves_input_qa                                    (directory) MOVES2010a input QA results
|   |
|   |-- ??                                                  (directories) one directory per state
|
|-- smoke_moves_output                                      (directory) containing SMOKE-MOVES Integration Tool Run Specification Generator
|   |                                                                   results
|   |
|   |-- ??                                                  (directories) one directory per state
|   |   |
|   |   |-- dummy*csv                                       Standard SMOKE-MOVES Integration Tool files
|   |   |
|   |   |-- *imp.xml                                        MOVES2010a XML data import scripts from SMOKE-MOVES Integration Tool
|   |   |                                                   Run Specification Generator
|   |   |
|   |   |-- *mrs.xml                                        MOVES2010a XML run specification scripts from SMOKE-MOVES Integration
|   |   |                                                   Tool Run Specification Generator
|   |   |
|   |   |-- *.csv                                           MOVES2010a compatible meteorological file from SMOKE-MOVES Integration
```

```
|   |   |                                                 Tool Run Specification Generator
|   |   |
|   |   |-- jobs                                          (directory)
|   |   |   |
|   |   |   |-- SEMAP_??_2007importer.csh                 MOVES2010a C-shell data importer script from SMOKE-MOVES Integration
|   |   |   |                                             Tool Run Specification Generator
|   |   |   |
|   |   |   |-- SEMAP_??_2007runspec.csh                  MOVES2010a C-shell eun specification script from SMOKE-MOVES Integration
|   |   |   |                                             Tool Run Specification Generator
|   |   |   |
|   |   |   |-- SSCCC_importer_MACHINE_CORE.csh           C-shell script to run MOVES2010a data import on a specific MACHINE and CORE
|   |   |   |
|   |   |   |-- SSCCC_runspec_MACHINE_CORE.csh            C-shell script to run MOVES2010a run specification on a specific MACHINE and CORE
|
|-- smoke_moves_script                                    (directory) SMOKE-MOVES Integration Tool scripts to generate MOVES2010a XML and
|   |                                                                 C-shell scripts
|   |
|   |-- ??                                                (directories) one directory per state
|   |   |
|   |   |-- ??_repcounty                                  Representative county definition file for SMOKE-MOVES Integration Tool
|   |   |
|   |   |-- ??_runcontrol                                 Run control file for the SMOKE-MOVES Integration Tool
|   |   |
|   |   |-- smoke_moves_runspec_generator.csh             C-shell script to run the SMOKE-MOVES Integration Tool
|   |
|   |-- runspec_generator_v0.31_22Mar2011_early_NLEV.pl   SMOKE-MOVES Tool Integration perl script for NLEV states (used only for VA)
|   |
|   |-- runspec_generator_v0.31_22Mar2011.pl              SMOKE-MOVES Tool Integration perl script
```

8.0 Conclusion

EPA's Motor Vehicle Emissions Simulator (MOVES) version 2010a was used in an on-road mobile source emissions modeling study for thirty-nine representative counties in ten SEMAP states. There were five distinct components to the effort:

- Perform relative humidity (RH) and Reid vapor pressure (RVP) sensitivity experiments;
- Estimate MOVES and SMOKE meteorology;
- Estimate on-road mobile source emissions factors using MOVES2010a;
- Estimate on-road mobile source emissions using SMOKE; and
- Prepare on-road mobile source emissions estimates summaries from SMOKE reports.

The purpose for conducting the sensitivity experiments was to determine how responsive the modeling system was to changes in RH and RVP, the results of which were used to help guide the choice of fuel seasons to model. It was found that for diesel and gasoline VOC, CO, SO_2, PM_{10} and $PM_{2.5}$, a $\pm$5% RH change or even a $\pm$10% RH change results in emissions changes that will likely not impact the air quality modeling results. However, for NO_X in a typical county, a $\pm$5% RH change resulted in diesel and gasoline NO_X emissions estimates changing by $\pm$1.25 tons/day ($\pm$1.35% -- note that an increase in RH results in a decrease in NO_X). Further, it was discovered that the greatest impact to emissions occurs in an RVP change from 15.0 psi to 13.5 psi with CO and VOC exhibiting definite sensitivity. There is less of an impact to CO and VOC emissions when the RVP changes from 9.0 psi to 7.8 psi. However, in both cases NO_X has about a 1.0 ton/day sensitivity in a typical county, which may be important for modeling and policy purposes.

Using the MET4MOVES component of the SMOKE-MOVES Integration Tool, estimates of RH and ambient temperature for use in MOVES2010a and SMOKE were prepared. The two important inputs to MET4MOVES were the fuel month cross-reference file and the representative county cross-reference file, both which were developed jointly by the study team and SEMAP.

Six additional MOVES2010a input files were developed by the study team based on information provided by SEMAP:

- Fuel formulation;
- Fuel supply;
- VMT;
- Inspection and Maintenance (I/M) program;
- Age distribution; and
- Vehicle population.

These data coupled with the meteorology were input to MOVES2010a, which produced the on-road mobile source emissions factors. The on-road mobile source emissions factors were subjected to quality assurance review by the study team, the SEMAP QA contractor (ENVIRON), and representatives from the SEMAP states. The emissions factors and attendant data were delivered to researchers at UNC who ran SMOKE to estimate on-road mobile source emissions.

Researchers at UNC provided SMOKE reports to the study team for use in summarizing the on-road mobile source emissions estimates. The study team developed Excel workbooks with VBA scripting to facilitate the ingestion of the SMOKE reports. Further, VBA scripts were developed to prepare a

number of standard report summaries as well as to provide a limited ad-hoc reporting capability so that a user of the Excel workbooks can prepare his/her own report summaries from the SMOKE reports. Various tabular and graphical reports were prepared for use by SEMAP.

9.0 REFERENCES

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