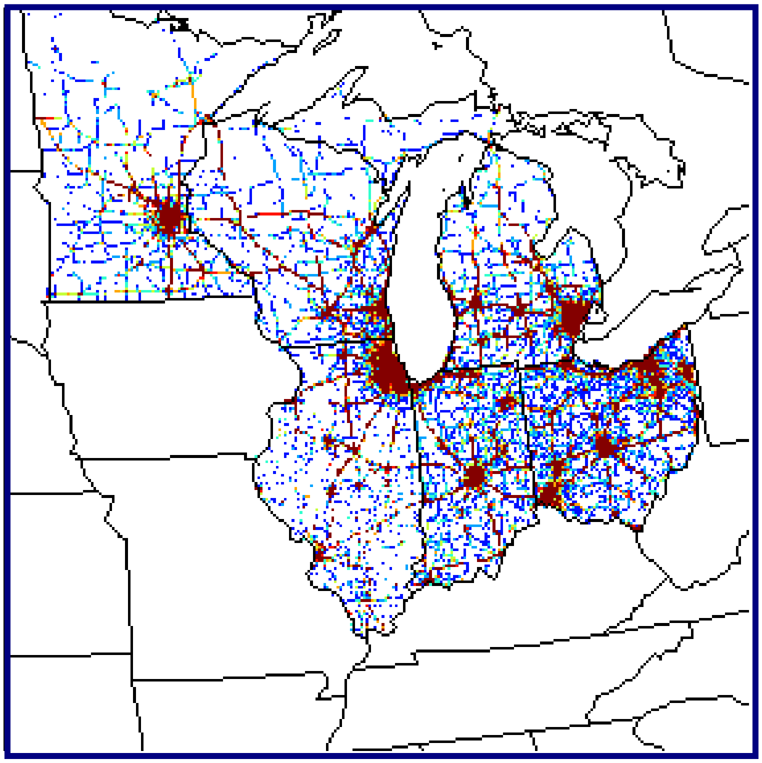
LADCO ON-ROAD EMISSION INVENTORY DEVELOPMENT USING CONCEPT MV



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1. CONSOLIDATED COMMUNITY EMISSIONS PROCESSING TOOL (CONCEPT)

CONCEPT Overview

The Consolidated Community Emissions Processing Tool (CONCEPT) is an emissions processing model that performs the three key features of emissions processing models: temporal allocation of the emissions (to hourly), spatial allocation of the hourly emissions to the grid cells in the modeling domain, and emissions speciation for use in air quality modeling.

The main features of the CONCEPT modeling system are as follows:

- Open Source: Written primarily in PostgreSQL, the software required for running CONCEPT is in the public domain. The model itself is GNU Public License (GPL) compliant and users are encouraged to make additions and enhancements to the modeling system.
- Transparent: The database structure of the model makes the system easy to understand, and the modeling codes themselves are extremely well documented to encourage user participation in customizing the system for specific modeling requirements.
- Quality Control: The CONCEPT model structure and implementation allows for multiple levels of QA analysis during every step of the emissions calculation process. Using the database structures, an emissions modeler can easily trace a process or facility and review the calculation procedures and assumptions for any emissions value. CONCEPT can be run with a variety of debug and QA options that control the number of intermediate tables and reports that are available for the user to review.

The core development software for the CONCEPT system is the PostgreSQL database engine, running on the Red Hat Linux operating system. In addition, the following plug-in packages, all in the public domain, are also required: Perl (to facilitate data input-output from the SQL data base and data reporting); and PostGIS, GEOS and PROJ4 (to facilitate spatial processing).

The CONCEPT emissions model has been developed in a modular fashion, with five primary source category models, and a group of secondary support models that will serve each of the primary models. The major emission source categories are treated as the primary models:

- Area Source;
- Point Source;
- On-road Motor Vehicle, with EPA's MOBILE6 model;
- Non-road Motor Vehicle with the EPA's NONROAD model; and
- Biogenics.

The overall framework architecture and database design were created during the development of the point and area models. During the development process, structural requirements were refined for the unique attributes of the motor vehicle, biogenic, and NONROAD models. The supporting system modules accommodate all of the primary models, as required. The supporting modules are:

- Speciation profile development;
- Spatial surrogate development; and
- Growth & Control with Cost Analysis.

CONCEPT MV code, User's Guide, and related documentation are available on the CONCEPT web site, http://www.conceptmodel.org/.

CONCEPT Motor Vehicle Emissions

A key feature of CONCEPT is that the motor vehicle emissions module (CONCEPT MV) estimates on-road emissions in a more sophisticated and detailed way than any other emissions processing system available.

The CONCEPT MV emissions model estimates and grids link-level emissions using the output from Transportation Demand Models (TDMs). The TDMs typically provide VMT or volume for multi-hour periods, and CONCEPT uses temporal allocation factors and VMT mix fractions to estimate hourly emissions for each vehicle class for each roadway type. Because there are multiple transportation models in use, all with different requirements and inputs/outputs, ENVIRON developed the TDM Transformation Tool, or T3, to process the traffic demand model vehicle types, road networks, and vehicle activity to the file formats required by CONCEPT MV. The primary goals of T3 are to provide an easy mechanism for incorporating TDM model outputs in as "raw" a format as possible, while simultaneously providing a great degree of flexibility in representing the TDM projections in terms acceptable to most air quality models.

EPA's MOBILE6 model is executed within CONCEPT to generate the g/mile (for running emissions) and gram/trip (for trip start and trip ends) emission factors. The emission factors depend on meteorological data (temperature and humidity), which are obtained from MM5 meteorological modeling runs, for every grid cell in the modeling domain. CONCEPT then estimates emissions for each emissions mode by multiplying the activity data (VMT or trips by vehicle class) by the appropriate MOBILE6 emission factors. CONCEPT then speciates the emissions as required for input to an air quality model. The result is an hourly, gridded, speciated inventory ready for input to CMAQ or CAMx air quality models.

Vehicle activity data for CONCEPT come primarily from the T3 pre-processing model. The link-level traffic volume data are typically provided as an average day, in multi-hour periods (e.g., am peak, pm peak, midday, overnight), average day, annual average weekday, or partial day periods. The data are temporally allocated to hourly values for the CONCEPT scenario period. In addition, the activity data are spatially allocated to the model grid since the MOBILE6 emission factors are generated based on gridded meteorological data.

CONCEPT also reads speed data from the input files, and accepts a variety of instructions for adjusting speeds using volume delay functions. Inputs may specify a Bureau of Public Roads (BPR) style adjustment curve, or a detailed lookup table of adjustments. The curve coefficients or adjustment factors may vary by network link, speed, and volume-capacity ratio, which provides a great deal of flexibility in how hourly speeds are calculated.

Most urban transportation modeling networks cover all major roads (interstates, freeways, major arterials), and some lesser roads (minor arterials and collectors). The smallest roads – local roads – are not always covered in transportation models. In CONCEPT, the VMT for local roads can be provided as a county total, and then the emissions are estimated and spatially allocated to grid cells by CONCEPT using a spatial surrogate, such as population. In rural areas not covered by a transportation network, county-level VMT by roadway type, such as HPMS data, can be processed and emissions estimated by CONCEPT in a similar manner.

The steps in CONCEPT MV that are followed to estimate model-ready emissions using the TDM data are as follows:

1. Input QA. CONCEPT imports VMT, trips, volumes, network capacity, speeds, network definition, speed adjustments, and meteorological data and performs QA checks. CONCEPT generates both summary and error reports.

2. Temporal Allocation. TDM data are typically provided for multi-hour periods, e.g., annual average weekday, or am peak/pm peak/off-peak. CONCEPT uses total-volume hourly profiles to split the multi-hour volumes to hourly volumes per link. The total volume temporal profiles are specified by State, roadway type, hour of day, day of week, and month. Temporal allocation is applied to the VMT, volume, capacity, and trips data. The profiles are typically determined from analyses of traffic counter data available from State Departments of Transportation (DOT) and/or local transportation planning agencies.

3. Speed Adjustment. If the user has indicated that speed adjustments are to be applied, CONCEPT calculates the hourly volume-capacity ratios and applies appropriate adjustments to the free-flow speeds for each link to estimate hourly actual speeds. Some networks provide these data as output from their TDM or TDM post-processors, in which case no speed adjustments are performed.

4. Spatial Allocation. MOBILE6 is executed using temperatures and relative humidities from gridded meteorological data (typically from MM5 modeling), so the vehicle activity data must be spatially allocated prior to determining the required MOBILE6 runs. The link-based VMT data are spatially allocated using an overlay of the link network on the model grid. County-based VMT, and TAZ/county based trip data, are allocated to the model grid using spatial surrogates.

5. Application of VMT Mix Profiles. VMT data are split into the eight MOBILE5 vehicle classes used in CONCEPT using vehicle mix profiles provided as input to CONCEPT. The vehicle mix profiles vary by roadway type, month, day of week, and time of day. The vehicle mix profiles are usually determined from analyses of traffic counter data available from State DOT's and/or local transportation planning agencies.

6. Define Required MOBILE6 Runs. MOBILE6 is run for each combination of representative county, minimum and maximum (min/max) temperature combination, calendar year, season (January or July), roadway type, and speed bin. A representative county is one who's M6 inputs are the same as those for a group of counties. The min/max temperature combinations use a user-defined tolerance level so that similar temperature ranges are considered equal. The speeds for which the model is run are also defined with speed bins in the user input. Each MOBILE6 model run uses a single set of 24 hourly values for temperature and relative humidity which is selected from the group of grid cells that match the same specified criteria.

7. Execute MOBILE6. MOBILE6 is executed with the database output; CONCEPT MV uses a customized version of MOBILE6 (developed by Air Improvement Resource [AIR] under contract to LADCO) that includes options for summarizing the database output across model years within each vehicle class, and across the detailed MOBILE6 vehicle classes into the eight MOBILE5 vehicle classes used in CONCEPT. This significantly reduces both the size of the database files and the processing time.

8. Combine Activity Data and Emission Factors. Generally speaking, for each hour of each episode day, for each link in each grid cell, CONCEPT uses the grid cell ID, county, temperature bin, road type, and speed to determine the correct emission factor for each vehicle class, pollutant and (non-start) emission mode. Emissions for each vehicle class, emission type, and pollutant are estimated as the product of the emission factor and the VMT on that link associated with the vehicle class.

9. Speciate the Emissions. CONCEPT MV applies the appropriate speciation profiles by pollutant and emission mode to generate the speciated emissions.

2. DATA SOURCES

LADCO States Transportation Networks

The transportation network data for the larger urban areas within the LADCO region were obtained from state and local transportation planning agencies. In addition to the urban area networks, ENVIRON obtained statewide networks to fill in the major rural roadways throughout the rest of the states.

Table 1 provides some of the basic characteristics of each roadway network. The number of links is the number of links in the network over any time period. The speeds input into CONCEPT indicates the kind of speed information provided by the transportation agency. The volume to capacity ratio cap (V/C cap) is a limit that is set on the volume to capacity ratio for the speed adjustment curve instructions to CONCEPT. This prevents the calculated speeds from being adjusted too severely toward zero. The TDM vehicle classes column describes whether or not there were vehicle class splits in the transportation data. The volume periods column lists the number of temporal periods of the transportation model volume data. The temporal profiles used column indicates which set of temporal profiles were applied to the network data to disaggregate the volume data to hourly values, and then to further break up the volume into the eight MOBILE5 vehicle classes. Finally, the HPMS adjustments applied column indicates whether or not the VMT data were adjusted to match 2005 HPMS values.

It should be noted that the number of links for the statewide networks reported in Table 1 reflect all counties in the state. Those counties that overlap the urban area networks were dropped from the statewide networks so that the emissions would not be double counted in those counties.

The specific details for each of the model years, 2005, 2009, and 2018, are provided in Tables 2, 3, and 4, respectively. These tables list whether or not the network data were adjusted to HPMS values, grown from another network model year, whether or not any additional VMT was added to that reflected in the network data, and additional notes regarding the network.

Table 1. Network descriptions.

Network	Number Links	Speeds Input to CONCEPT	V/C cap	TDM Vehicle Classes	Volume Periods	Temporal Profiles Used	HPMS Adjustments Applied
ILLINOIS							
CATS	33,786	By link by period	2	HD and LD	Provided for 8 time periods	Illinois State	None
ILDOT	303,297	Fixed by road class	none (no speed adjustments done)	Total Volume	One daily total	Illinois State	None
INDIANA							
Indianapolis	7,467	Daily free-flow and congested by link (used congested speed)	none (no speed adjustments done)	Total Volume	One daily total	Illinois State	Conserved adjustment between freeways/other roadway types
INDOT	31,181	Daily free-flow by link	1	Total Volume	One daily total	Illinois State	Conserved adjustment between freeways/other roadway types
NIRPC	9,038	am, pm, off-peak by link	none	Total Volume	am, pm, off-peak	Illinois State	None
MICHIGAN							
MIDOT	9,227	Daily free-flow, congested by link	1	Total Volume	One daily total	Michigan State	Use a single county adjustment for Mason and Mecosta. For all other counties, use conserved adjustment between freeways/other roadway types.
SEMCOG	29,514	Hourly by link	none (hourly speeds provided)	Total Volume -- SEMCOG provided VMT-mix profiles	am, mid-day, pm, off-peak	SEMCOG provided	Used 2005 HPMS adjustment factors provided by SEMCOG.
MINNESOTA							
MN DOT	4,393	Average by road class	none (no speed adjustments done)	Total Volume	One daily total	Minnesota State	Used conserved adjustment on higher facility classes (with the exception of a handful that got county-wide adjustments). Filled in classes 8,9,17,19 with HPMS.
Twin Cities	20,923	By period and link (24 periods)	none (speeds provided are nearly hourly)	Total Volume	24 periods -- preprocessed to fall on the even hours	Minnesota State	Conserved adjustment between freeways/other roadway types

Table 1. Network descriptions (concluded).

Network	Number Links	Speeds Input to CONCEPT	V/C cap	TDM Vehicle Classes	Volume Periods	Temporal Profiles Used	HPMS Adjustments Applied
OHIO							
Akron	11,924	Posted speed by link	0.8	Total Volume	One daily total	Ohio	None
Canton	9,735	Posted speed by link	0.8	Total Volume	One daily total	Ohio	None
Cincinnati	14,747	Free-flow travel time by link	2.4	Total Volume	One daily total	Ohio	None
Dayton	15,136	Free-flow travel time by link	2.4	Total Volume	One daily total	Ohio	None
Cleveland	16,966	Free-flow travel time by link	0.8	Total Volume	One daily total	Ohio	None
Columbus	22,740	Posted speed by link	1.3	Total Volume	One daily total	Ohio	None
Springfield	3,723	Posted speed by link	1.3	Total Volume	One daily total	Ohio	None
Toledo	11,529	Posted speed by link	1.3	Total Volume	One daily total	Ohio	None
Youngstown	9,184	Posted speed by link	0.8	Total Volume	One daily total	Ohio	None
Statewide	50,644	Average of AB and BA speeds by link	1.3	Total Volume	One daily total	Ohio	None
WISCONSIN							
SEWRPC	17,046	Congested and free-flow by link -- applied congested to morning and evening periods	none (no speed adjustments done)	Total Volume	5 periods	Wisconsin State	None. Added 4,513,488 VMT for Collectors.
WIDOT	143,327	Free-flow by link	1.3 (set by Environ)	Light-duty & heavy truck	One daily total	Wisconsin State	Conserved adjustment between freeways/other roadway types

Table 2. Specific network details for modeling 2005.

Network	HPMS Adjustments Applied	Growth	Off-network VMT	Notes
ILLINOIS				
CATS	None	Grown from 2002 using interpolation factors between 2002 and 2010	None	For Saturday and Sunday simulations, the weekday VMT was totaled up over all the time periods in the day so that it would be distributed with a typical weekend day distribution (from the temporal profiles).
ILDOT	None	Grown from 2002 using a compound annual 2% growth rate across the board = 1.06373 (recommended by Sam Long of Illinois EPA).	None	

Table 2. Specific network details for modeling 2005 (continued).

Network	HPMS Adjustments Applied	Growth	Off-network VMT	Notes
INDIANA				
Indianapolis	Conserved adjustment between freeways/other roadway types	The 2005 network growth factors were generated by interpolating between the 2000 and the 2009 network. The growth was applied to the 2000 network.	None	
INDOT	Conserved adjustment between freeways/other roadway types	2005 was grown from 2000 using interpolated county-level growth between 2000 and 2015.	None	
NIRPC	None	None. Used 2005 data provided by NIRPC.	None	For Saturday and Sunday simulations, the weekday VMT was totaled up over all the time periods in the day so that it would be distributed with a typical weekend day distribution (from the temporal profiles).
MICHIGAN				
MIDOT	Use a single county adjustment for Mason and Mecosta. For all other counties, use conserved adjustment between freeways/other roadway types.	Used county-level interpolated growth factors between the 2002 and 2009 data. Grew the 2002 data.	None	
SEMCOG	Used 2005 HPMS adjustment factors provided by SEMCOG.	None. Used 2005 data provided by SEMCOG.	Lower vehicle classes dropped in the link data. Filled in with local VMT provided by SEMCOG. The local VMT is stratified by road class, county, and M5 vehicle class.	
MINNESOTA				
MN DOT	Used conserved adjustment on higher facility classes (with the exception of a handful that got county-wide adjustments). Filled in classes 8,9,17,19 with HPMS.	Grown from 2002 to 2005 using growth factors provided by MNDOT.	Dropped road classes 8, 9, 17, 19 from the network data. They were severely under-represented. Filled in these classes with HPMS data.	

Table 2. Specific network details for modeling 2005 (concluded).

Network	HPMS Adjustments Applied	Growth	Off-network VMT	Notes
MINNESOTA (cont)				
Twin Cities	Conserved adjustment between freeways/other roadway types	Grown from 2000 using factors generated by interpolating county-level VMT between 2000 and 2010 data.	None	For Saturday and Sunday simulations, the weekday VMT was totaled up over all the time periods in the day so that it would be distributed with a typical weekend day distribution (from the temporal profiles). There was no speed correction information for TwinCities, so the standard EPA bpr curve was used. This way T3 would output both a free-flow and congested speed. CONCEPT will use the congested speed as a lower bound on the speed adjustment.
OHIO				
Akron	None	None. Used 2005 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Canton	None	None. Used 2005 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Cincinnati	None	None. Used 2005 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Dayton	None	None. Used 2005 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Cleveland	None	None. Used 2005 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Columbus	None	None. Used 2005 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Springfield	None	None. Used 2005 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Toledo	None	None. Used 2005 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Youngstown	None	None. Used 2005 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	Removed Trumbull County from this network. Added it to the Statewide network.
Statewide	None	Grown from 2002 using factors interpolated between 2002 and 2009 data by county and facility class.	Filled in local roads with HPMS data. The local roads were not present in the link data.	
WISCONSIN				
SEWRPC	None. Add 4,513,488 VMT for Collectors.	Grown from 2002 using growth factors interpolated from 2009 growth factors provided by C. Bovee.	Filled in rural and urban collector VMT with a number provided by WIDOT. Local road VMT is not explicitly modeled.	For Saturday and Sunday simulations, the weekday VMT was totaled up over all the time periods in the day so that it would be distributed with a typical weekend day distribution (from the temporal profiles).
WIDOT	Conserved adjustment between freeways/other roadway types	Grown from 2000 using county-level factors generated by interpolating between 2000 and 2030 data.	None	

Table 3. Specific network details for modeling 2009.

Network	HPMS Adjustments Applied	Growth	Off-network VMT	Notes
ILLINOIS				
CATS	None	Backcasted from 2010 using interpolation factors between 2002 and 2010	None	
ILDOT	None	Grown from 2002 to match county total VMTs provided by Sam Long.	None	
INDIANA				
Indianapolis	The 2005 conserved adjustment between freeways/other roadway types	Used 2009 data provided by Indianapolis	None	Re-mapped the hpms facility classification. Dropped Indianapolis roadway types 0, 43, 44, and 53.
INDOT	Applied the same 2005 conserved adjustment between freeways/other roadway types	2005 was backcasted from 2015 using 2% annual growth for a factor of 0.8858.	None	
NIRPC	None	Backcasted the 2010 data provided by NIRPC using county-level factors interpolated between 2005 and 2010.	None	
MICHIGAN				
MIDOT				
SEMCOG	Used ***revised*** HPMS adjustment factors provided by SEMCOG. These are different from those applied for 2005.	None. Used 2009 data provided by SEMCOG.	Lower vehicle classes dropped in the link data. Filled in with local VMT provided by SEMCOG. The local VMT is stratified by road class, county, and M5 vehicle class.	
MN DOT	Used the same conserved adjustment on higher facility classes (with the exception of a handful that got county-wide adjustments) as was used for 2005. Filled in classes 8,9,17,19 with HPMS.	Used 2009 AADT provided by MNDOT.	Dropped road classes 8, 9, 17, 19 from the network data. They were severely under-represented. Filled in these classes with 2005 HPMS data grown to 2009 with county-level factors.	

Table 3. Specific network details for modeling 2009 (concluded).

Network	HPMS Adjustments Applied	Growth	Off-network VMT	Notes
MINNESOTA				
Twin Cities	Used the same HPMS adjustments as applied for 2005, which was a conserved adjustment between freeways/other roadway types.	Backcasted 2010 data provided by Twincities by 3% across the board.	None	
OHIO				
Akron	None	None. Used 2009 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Canton	None	None. Used 2009 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Cincinnati	None	None. Used 2009 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Dayton	None	None. Used 2009 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Cleveland	None	None. Used 2009 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Columbus	None	None. Used 2009 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Springfield	None	None. Used 2009 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Toledo	None	None. Used 2009 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Youngstown	None	None. Used 2009 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	Removed Trumbull County from this network. Added it to the Statewide network.
Statewide	None	None. Used 2009 data provided by ODOT.	Filled in local roads with 2009 data provided by ODOT. The local roads were not present in the link data.	
WISCONSIN				
SEWRPC	None. Add 4,787,321 VMT for Collectors.	Grown from 2002 using 2009 growth factors provided by C. Bovee.	Filled in rural and urban collector VMT with a number provided by WIDOT. Local road VMT is not explicitly modeled.	
WIDOT	2005 HPMS adjustments applied	Grown from 2000 using county-level factors generated by interpolating between 2000 and 2030 data.	None	

Table 4. Specific network details for modeling 2018.

Network	HPMS Adjustments Applied	Growth	Off-network VMT	Notes
ILLINOIS				
CATS	None	Backcasted from 2020 using interpolation factors between 2020 and 2010	None	
ILDOT	None	Grown from 2002 to match county total VMTs provided by Sam Long.	None	
INDIANA				
Indianapolis	The 2005 conserved adjustment between freeways/other roadway types	Backcasted the 2020 data provided by Indianapolis. VMT diminished across the board by 4%.	None	Re-mapped the hpms facility classification. Dropped Indianapolis roadway types 0, 43, 44, and 53.
INDOT	Applied the same 2005 conserved adjustment between freeways/other roadway types	2005 was backcasted from 2020 using 2% annual growth for a factor of 0.9604.	None	
NIRPC	None	Backcasted the 2020 data provided by NIRPC using county-level factors interpolated between 2010 and 2020.	None	
MICHIGAN				
MIDOT				
SEMCOG	Used ***revised*** HPMS adjustment factors provided by SEMCOG. These are different from those applied for 2005.	None. Used 2018 data provided by SEMCOG.	Lower vehicle classes dropped in the link data. Filled in with local VMT provided by SEMCOG. The local VMT is stratified by road class, county, and M5 vehicle class.	
MINNESOTA				
MN DOT	Used the same conserved adjustment on higher facility classes (with the exception of a handful that got county-wide adjustments) as was used for 2005. Filled in classes 8,9,17,19 with HPMS.	Used 2018 AADT provided by MNDOT.	Dropped road classes 8, 9, 17, 19 from the network data. They were severely under-represented. Filled in these classes with 2005 HPMS data grown to 2018 with county-level factors.	

Table 4. Specific network details for modeling 2018 (concluded).

Network	HPMS Adjustments Applied	Growth	Off-network VMT	Notes
		MINNESOTA (cont)		
Twin Cities	Used the same HPMS adjustments as applied for 2005, which was a conserved adjustment between freeways/other roadway types.	Backcasted 2020 data provided by Twincities by 3% annual growth across the board (6% total).	None	
		OHIO		
Akron	None	None. Used 2018 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Canton	None	None. Used 2018 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Cincinnati	None	None. Used 2018 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Dayton	None	None. Used 2018 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Cleveland	None	None. Used 2018 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Columbus	None	None. Used 2018 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Springfield	None	None. Used 2018 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Toledo	None	None. Used 2018 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	
Youngstown	None	None. Used 2018 data provided by ODOT.	Intrazonal VMT provided by ODOT by county.	Removed Trumbull County from this network. Added it to the Statewide network.
Statewide	None	None. Used 2018 data provided by ODOT.	Filled in local roads with 2009 data provided by ODOT. The local roads were not present in the link data.	
		WISCONSIN		
SEWRPC	None. Add 5,416,584 VMT for Collectors.	Grown from 2002 using 2018 growth factors provided by C. Bovee.	Filled in rural and urban collector VMT with a number provided by WIDOT. Local road VMT is not explicitly modeled.	
WIDOT	2005 HPMS adjustments applied	Backcasted from 2030 using county-level factors generated by interpolating between 2000 and 2030 data.	None	

Table 5 lists the sources of the MOBILE6 inputs for each of the representative counties for each model year. As directed by LADCO, all 2005 REBUILD EFFECTS were set to 0.10; i.e. assuming that 10% of the heavy-duty diesel vehicles (HDDV) required to perform chip reflashing had done so by 2005. This parameter was set to 30% in 2009 and 50% in 2018. Diesel sulfur was set to 43 ppm for all networks in 2009, and 11ppm for all networks in 2018.

Table 5. Agency provided repcounty files.

State	2005	2009	2018	Comments
Illinois	Samuel S Long Illinois EPA	Samuel S Long Illinois EPA	ENVIRON	The 2005 July 15 modeling was completed with DIESEL SULFUR levels set to 40 in the Chicago metro area and 35 down state. This was an error that was corrected to 390 in the metro area and 370 down state (per M Jansen email) for the additional 2005 modeling days. Changed 2009 references of IL07ON to IM07ON (per Sam Long email).
Indiana	ENVIRON	ENVIRON	ENVIRON	2005 based on NMIM.
Michigan	Joan Weidner	Joan Weidner	Joan Weidner	
Minnesota	ENVIRON	ENVIRON	ENVIRON	2005 based on NMIM.
Ohio	William Nichols Ohio EPA	William Nichols Ohio EPA	William Nichols Ohio EPA	
Wisconsin	Chris Bovee Wisconsin Department of Natural Resources	Chris Bovee Wisconsin Department of Natural Resources	Chris Bovee Wisconsin Department of Natural Resources	

HPMS Data

The HPMS county level VMT and speed data were provided to ENVIRON by Alpine Geophysics in SMOKE format. These data were assembled by Alpine for VISTAS modeling and are referred to as the BaseG inventory. In addition to the VMT and speed activity data, MOBILE6 inputs, both general and county specific, were provided. Data were provided for modeling years 2002, 2009 and 2018.

<u>Conversion Methods</u>

ENVIRON pre-processed the data received from Alpine Geophysics in SMOKE format by county and SCC for CENRAP, VISTAS, MANEVU, WRAP, and MRPO regions, to generate speed and VMT by county and SCC in CONCEPT input format.

SCCs accepted by CONCEPT include delineation of the 8 MOBILE5 vehicle classes and 12 HPMS roadway types, for a total of 96 unique SCCs. For some counties, there were more than the 96 standard SCCs in the received data because vehicle types were delineated more finely than the 8 MOBILE5 vehicle types. For counties with more than 96 SCCs, the data were processed such that VMT for those SCCs that are not standard to CONCEPT were mapped to one of the 96 SCCs utilized by CONCEPT. This was accomplished by lumping multiple detailed vehicle classes to the applicable MOBILE5 vehicle class. In order to map speeds from multiple detailed vehicle class SCCs to a CONCEPT input SCC with less detailed vehicle class designations, average speed for the mapped vehicle classes weighted by VMT for the mapped vehicle classes VMT were utilized to estimate speed by SCC for CONCEPT input.

2005 VMT estimates were obtained by linearly interpolating between 2002 and 2009 VMT estimates by county and SCC. Table 6 shows VMT estimates for all years by state.

Table 6. VMT estimates by state (million miles/year).

State	RPO	2002	2005*	2009	2018
ARKANSAS	cenrap	29,179	30,789	32,936	40,116
IOWA	cenrap	31,365	32,854	34,838	41,736
KANSAS	cenrap	28,825	29,871	31,266	38,509
LOUISIANA	cenrap	43,295	44,172	45,340	57,930
MISSOURI	cenrap	60,269	66,564	74,959	82,578
NEBRASKA	cenrap	18,406	19,102	20,059	24,309
OKLAHOMA	cenrap	44,863	46,306	48,248	57,218
TEXAS	cenrap	216,121	228,056	244,014	319,044
ALABAMA	vistas	55,723	58,918	63,178	72,966
FLORIDA	vistas	178,681	193,642	213,590	258,191
GEORGIA	vistas	106,785	114,739	125,343	148,269
KENTUCKY	vistas	50,909	53,948	57,999	78,253
MISSISSIPPI	vistas	36,278	38,309	41,017	46,996
NORTH CAROLINA	vistas	99,119	106,977	117,455	138,854
SOUTH CAROLINA	vistas	47,074	50,534	55,147	65,133
TENNESSEE	vistas	68,313	72,810	78,806	91,774
VIRGINIA	vistas	77,472	82,164	88,419	103,560
WEST VIRGINIA	vistas	19,258	20,188	21,429	24,996
ARIZONA	wrap	52,906	56,471	61,224	72,603
CALIFORNIA	wrap	293,337	307,954	327,443	375,150
COLORADO	wrap	43,214	45,270	48,012	55,400
IDAHO	wrap	14,331	15,067	16,049	18,457
MONTANA	wrap	10,212	10,699	11,348	12,936
NEVADA	wrap	18,614	20,040	21,941	26,424
NEW MEXICO	wrap	23,675	25,010	26,790	31,205
NORTH DAKOTA	wrap	7,372	7,608	7,923	8,816
OREGON	wrap	34,630	36,900	39,927	46,851
SOUTH DAKOTA	wrap	8,717	9,118	9,652	11,034
UTAH	wrap	23,683	25,062	26,901	31,477
WASHINGTON	wrap	54,588	57,575	61,558	71,572
WYOMING	wrap	8,807	9,151	9,611	10,837
CONNECTICUT	manevu	30,996	32,270	33970	36,461
DELAWARE	manevu	8,835	9,181	9642	12,890
DISTRICT OF COLUMBIA	manevu	3,840	4,003	4220	4,194
MAINE	manevu	14,653	14,679	14715	16,998
MARYLAND	manevu	53,758	55,606	58069	72,528
MASSACHUSETTS	manevu	53,231	54,876	57069	56,913
NEW HAMPSHIRE	manevu	13,884	13,825	13747	18,262
NEW JERSEY	manevu	71,666	73,185	75211	82,682
NEW YORK	manevu	140,752	140,306	139712	183,213
PENNSYLVANIA	manevu	104,880	108,134	112473	135,977
RHODE ISLAND	manevu	8,173	8,410	8726	11,366
VERMONT	manevu	7,727	9,059	10834	9,483
Total		**2,814,002**	**2,953,423**	**3,139,408**	**3,713,494**

* Interpolated based on 2002 and 2009 VMT estimates by county and SCC.

Vehicle Age Distribution Data

While reviewing the results of the 2009 modeling, comparing 2009 results to the 2005 results, it was discovered that there were some problems with the CENRAP states MOBILE6 input files. In brief, Sonoma Technology Inc developed county-specific registration distributions and diesel sales fractions (using ERG's VIN decoder) for use in CENRAP's 2002 and 2018 modeling; CENRAP did not model 2009. VISTAS compiled 2009 inputs for all RPO states, and Alpine developed the 2009 MOBILE6 inputs and representative counties setup for the CENRAP states based on the 2002 inputs. In developing those 2009 inputs, the county-specific registration distributions and diesel sales fractions were not carried over. The non-default registration distributions used for the CENRAP states show much older fleets then the MOBILE6 defaults. An older fleet translates into higher emission factors. By using the existing inputs for 2009 (no county specific registration data) the emissions appear to be artificially low in 2009 as compared to 2002 because of the switch from the non-default registration distributions to the MOBILE6 default. The affected states are Iowa, Missouri, Kansas, Arkansas, Oklahoma, Louisiana, and Minnesota.

In developing the CENRAP MOBILE6 inputs, STI used ERG's VIN decoder to generate registration distributions for all light-duty vehicle classes by county (MOBILE6 defaults were used for heavy-duty vehicles) and diesel sales fractions by urban/rural within each of the CENRAP states. Since there is so much variability from county to county, the registration distributions should have been aggregated for groups of counties (or at a minimum urban vs. rural areas); using the county based distributions skews the results and introduces unnecessary variability. MOBILE6 defaults are based on more years of data and apply some smoothing. It would have been preferable to use MOBILE6 default registration distributions for all modeling years rather than the county specific data. However, it was decided, due to budget and time constraints, that the 2009 inputs would be modified to use the same registration distributions as were used in the 2005 (and later 2018) modeling. This was to ensure that we did not arbitrarily introduce a bias across years.

2018 Missing County

Frederick County, Virginia (FIPS=51069) was missing from the 2018 base inventory files. In order to eliminate this ‘hole’ in the 2018 modeling, the Frederick County records were extracted from the 2009 inventory, a growth factor of 1.204 was applied to the VMT and the results were appended to the 2018 Virginia file for processing. The growth factor was derived by reviewing the neighboring Shenandoah County VMT.

Changes to the MOBILE6 Inputs

The representative counties MOBILE6 inputs were primarily derived from the VISTAS inputs provided by Alpine. Two commands were either modified or added to override the MOBILE6 inputs. The commands were DIESEL SULFUR, which specifies the sulfur level of diesel fuel and REBUILD EFFECTS, which specifies the effectiveness rate used to reduce heavy-duty diesel vehicle NOx off-cycle emissions. Table 7 lists the parameters that we used for each of the modeling episodes; these were the same as used in the LADCO states network modeling.

Table 7. MOBILE6 command changes to HPMS inputs.

MOBILE6 Commands	Jan 2005	July 2005	July 2009	July 2018
Diesel Sulfur	280.0 – 500.0[1]	300.0 – 500.0[1]	max(43.0)	11.0
REBUILD	0.10	0.10	0.30	0.50

[1] – these values were specified in the BaseG input files, no modifications were made.

Average Day Meteorology

The meteorology data were provided by LADCO. The data provided included average day files for each month, for each of the three modeling domains; 4km, 12km and 36km grid. The data were downloaded from ftp://ftp.airtoxics.org/emismet/ on 2006 Nov 15. These data were used to generate 'day-specific' files for CONCEPT modeling. The difference between the monthly average files and the 'day-specific' files was simply the episode date. That is, the same met data were used for each July episode day for all three modeling years.

In addition, in order to optimize processing time and reduce disk space requirements, subsets of grid cells were extracted for most of the LADCO transportation networks. Rather than import the entire 4km domain met data, which is almost a 500-megabyte file, for each of the modeling networks only those grid cells covering the transportation network were imported. This was accomplished by developing a Perl script that simply extracted a rectangular subset of cells.

3. ESTIMATING MV EMISSIONS FOR LADCO STATES

The on-road links for the LADCO states as projected by CONCEPT are shown in Figure 1.

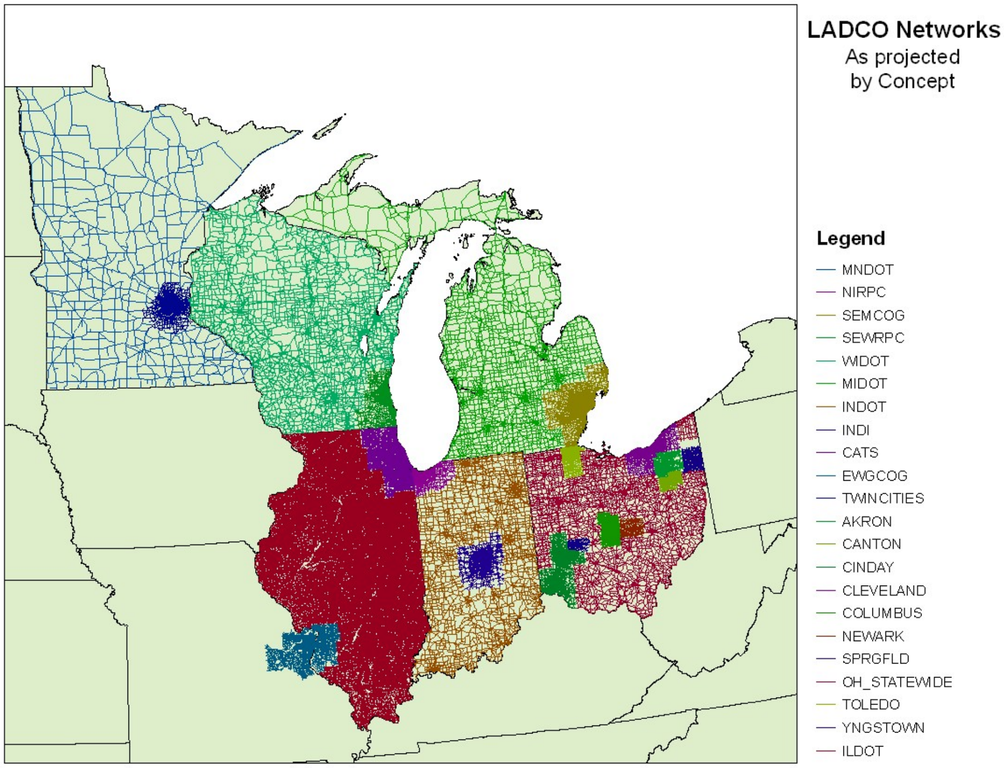

Figure 1. Links in the LADCO states.

The initial step for each network was to process the data through T3 to generate VMT totals by county and facility class. To ensure that the data were correctly interpreted, the T3 VMT totals were sent to each agency for review and approval.

Next, the T3 VMT was compared to the 2005 HPMS data. The goal of this analysis was to flag areas with significantly different county total VMT from that in the HPMS data. The comparison was done for each county by the combined roadway groups freeway and non-freeway. For some of the networks, it was agreed that we would adjust the network VMT by a conserved adjustment factor to bring the VMT totals closer in line with HPMs totals, as listed in Tables 2 through 4. The idea of the conserved adjustment factor is that no network VMT would be adjusted downward unless both the freeway and non-freeway VMT were greater than the HPMS data. If the network VMT from one group were greater than the HPMS VMT, that excess VMT would be moved over to the group short on VMT before calculating the adjustment factors. This way, the overall county adjustment would bring up the network VMT closer to the HPMS county total while respecting the freeway and non-freeway classification of the network data as much as possible. Most of the networks provided average weekday volumes, whereas the 2005 HPMS data were reflective of average daily volumes (i.e., across seven days). In these cases, the HPMS data were adjusted to average weekday using factors generated from the same traffic counter data that was used to create the temporal profiles applied in CONCEPT.

The final T3 VMT data, with all growth and HPMS adjustment factors agreed to, were then fed into CONCEPT. CONCEPT disaggregated the VMT data from the coarser time periods from the transportation demand models into hourly values using total volume temporal profiles. Most of the temporal profiles used for this disaggregation were developed in previous ENVIRON work for LADCO from traffic counter data supplied from the Illinois, Michigan, Minnesota, and Wisconsin DOT's ("LADCO/MPCA Total Volume and Vehicle Classification Temporal Profiles," 2004). SEMCOG and the Ohio DOT provided their own temporal profiles which were re-formatted for CONCEPT. The Illinois profiles were used for Indiana.

Figure 2 provides an example of hourly temporal profiles, Sunday through Saturday, for total VMT. Figure 3 displays an example of hourly temporal profiles, Sunday through Saturday, for vehicle mix.

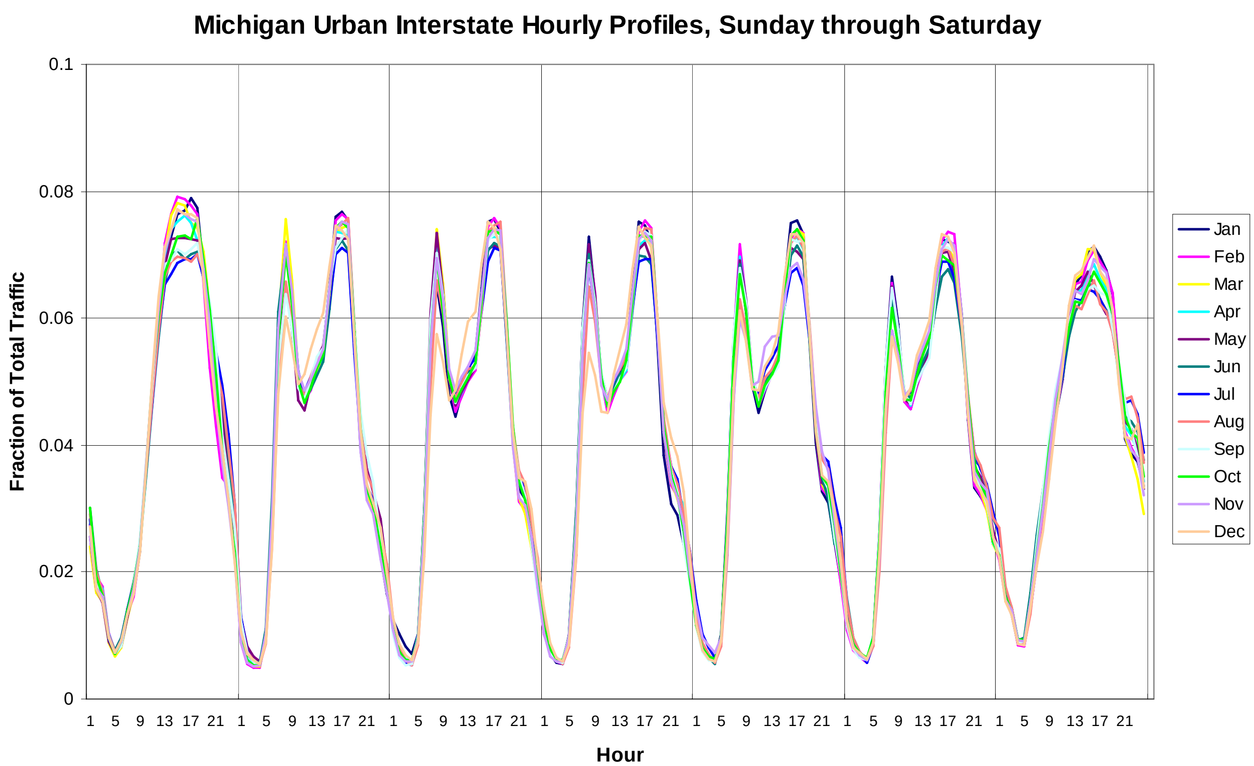

Figure 2. Hourly temporal profiles for total VMT.

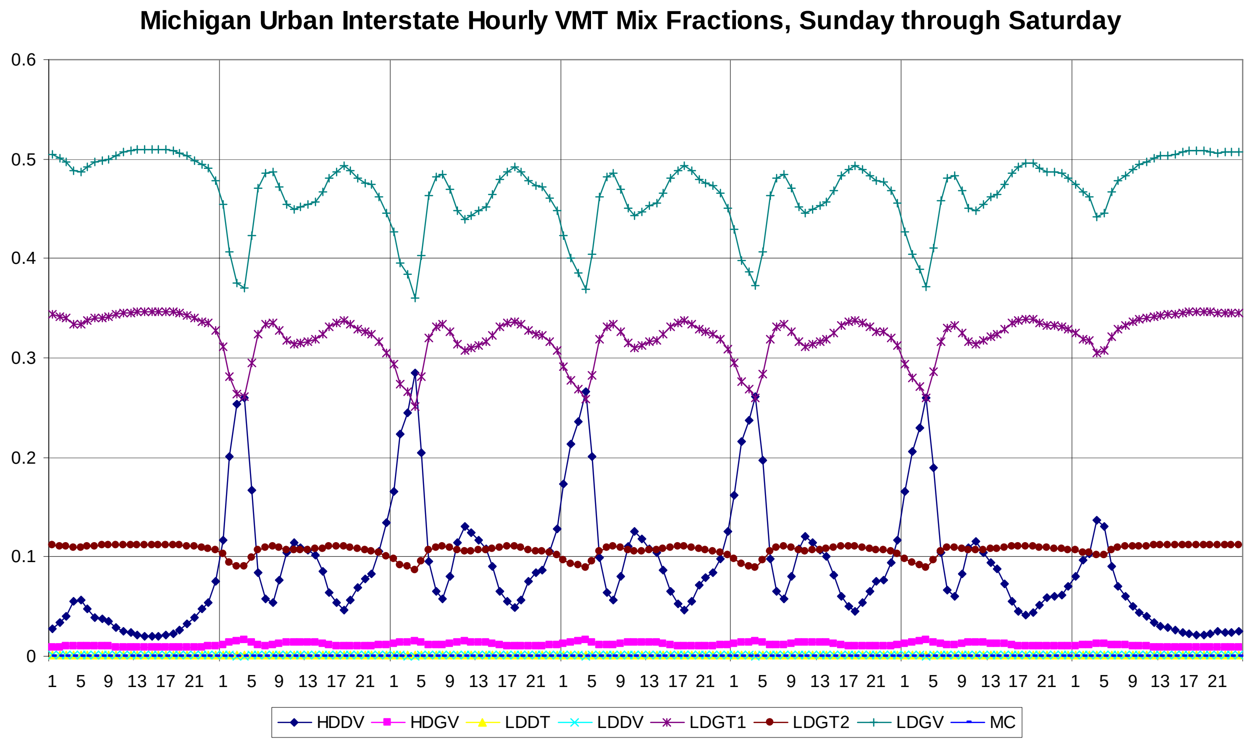

Figure 3. Hourly temporal profiles for vehicle mix.

Modeling Episode Days

A summary of the modeling episode days which were completed for this study are provided in Table 8.

Table 8. Modeling episode day summary.

Year	Month	Date	Day of Week
2005	July	15	Friday
		16	Saturday
		17	Sunday
	January	14	Friday
		15	Saturday
		16	Sunday
2009	July	15	Friday
2018	July	15	Friday

In addition to 2005, 2009, and 2018, ENVIRON also modeled 2008 for the Cincinnati/Dayton area to reflect changes in the Inspection and Maintenance program and fuel RVP. The modeling results were used in a revised State Implementation Plan for the area.

The 2005 and future years CONCEPT modeling followed from earlier 2002 modeling performed for LADCO area networks. Appendix A contains a brief description and results from the 2002 modeling.

For this modeling, the Ohio DOT provided 2008 Transportation model data for their Cincinnati and Dayton networks. The characteristics of the data were the same as that provided for 2005, as shown in Tables 1 and 2. MOBILE6 inputs were changed from what was used for 2005 to reflect the changes in the I/M program and fuel RVP. Three additional changes were made to the MOBILE6 inputs: Ohio DOT provided updated registration distributions; the HDDV chip reflash rate was set to 30% (set by LADCO); and the diesel fuel sulfur level was set to 15 ppm per federal regulation.

Processing

Early on in the modeling process it was determined that transportation networks with a large number of link input records had to be split into pieces in order to optimize the processing time. From our experience PostgreSql simply gets hung up with extremely large data tables. For our purposes we elected to split the IL_CATS, IL_ILDOT, and WI_WIDOT networks. The networks were split as CATS two runs, ILDOT nine runs, and WIDOT four runs.

Each network (or network piece) was set up in a separate directory each with subdirectories: /mv_data, /MOBILE6, /logs, and /output. Table 9 indicates the file types that reside in each subdirectory.

Scripts were developed to automate the CONCEPT MV modeling as much as possible. An initialization script creates the database, defines the scenario, loads CONCEPT MV functions, imports global data (e.g., FIPS codes), imports cross reference data (e.g., rpo_lp speciation profiles), imports the run control file, imports the met data, and generates the spatial grid definition table. A second script imports the MV data, generates the link-grid cross reference table, checks and prepares the MV data for modeling, runs the CONCEPT MV model, and generates the CAMx binary input file. Each of these steps is a call to the CONCEPT execution script which is documented in the CONCEPT User’s Guide.

Following a completed run, the log files were checked for warnings and errors and the output summary reports were reviewed for reasonableness.

Results

Estimated emissions totals by state from the CONCEPT model runs are presented in Table 10 for all modeling years for criteria pollutants CO, TOG, and NOx for Friday runs. Figures 4– 6 present the contribution by state for NOx, TOG, and CO.

Table 9. LADCO networks directory descriptions.

/mv_data	CONCEPT MV on-road data: mobile_ma mobile_ml mobile_mc mobile_mx m6_speed_bins m6_temp_bins m5_vehicle_type_xref repcounty
/MOBILE6	MOBILE6 input files; for example, registration data and CONCEPT generated input and output tables for MOBILE6 (CONCEPT*).
/logs	Run specific log files (mv.log.*project.rundate*) generated from the run scripts. For example, mv.log.semcog_01162005_01.20070731
/output	Run specific output summary reports and 'CAMx' files. For example, camx_mv.semcog_01142005_01.base.out.200514.bin camx_mv.semcog_01142005_01.base.out.200514.gz summary_emiss_by_vmt.semcog_01142005_01.base.txt summary_final.semcog_01142005_01.base.txt summary_hpms.semcog_01142005_01.base.txt summary_m6_runs.semcog_01142005_01.base.txt summary_polid.semcog_01142005_01.base.txt summary_raw.semcog_01142005_01.base.txt summary_spatial.semcog_01142005_01.base.txt summary_speeds.semcog_01142005_01.base.txt summary_vehicle.semcog_01142005_01.base.txt

Table 10. Emissions (TPD) by LADCO state for each modeling year.

Date	State	CO	TOG	NOx
1/14/2005	IL	7,307.39	315.15	851.70
1/14/2005	IN	6,287.21	267.46	630.36
1/14/2005	MI	8,652.32	366.86	827.64
1/14/2005	MN	5,885.72	251.94	482.84
1/14/2005	OH	9,642.99	460.62	1,046.53
1/14/2005	WI	4,797.99	170.84	493.05
1/14/2005 Total		**42,574**	**1,833**	**4,332**
7/15/2005	IL	3,684.33	341.51	748.25
7/15/2005	IN	3,384.94	282.02	541.08
7/15/2005	MI	4,210.29	351.88	721.99
7/15/2005	MN	2,569.08	218.69	380.45
7/15/2005	OH	6,113.40	679.81	933.64
7/15/2005	WI	2,205.97	175.08	457.49
7/15/2005 Total		**22,168**	**2,049**	**3,783**
7/15/2009	IL	2,724.39	259.54	508.33
7/15/2009	IN	2,839.47	234.92	401.90
7/15/2009	MI	3,172.01	269.17	500.86
7/15/2009	MN	2,256.81	206.33	307.49
7/15/2009	OH	4,619.21	423.69	693.50
7/15/2009	WI	1,673.39	119.42	322.10
7/15/2009 Total		**17,285**	**1,513**	**2,734**
7/15/2018	IL	2,022.87	147.55	194.85
7/15/2018	IN	2,217.31	138.40	173.01
7/15/2018	MI	2,434.27	163.51	204.13
7/15/2018	MN	1,799.61	123.09	137.12
7/15/2018	OH	3,361.50	242.54	274.13
7/15/2018	WI	1,255.47	68.44	138.48
7/15/2018 Total		**13,091**	**884**	**1,122**

Emissions modeling results are presented in Table 11 for the Friday modeled in each modeling period by transportation network for criteria pollutants CO, TOG, and NOx. Figures 7 – 9 present the contribution by network for NOx, TOG, and CO. Spatial distribution plots for NOx, TOG and PM2.5 for the 2005 July 15 episode day total daily emissions for the combined transportation networks and local HPMS data are provided in Figures 10 – 12.

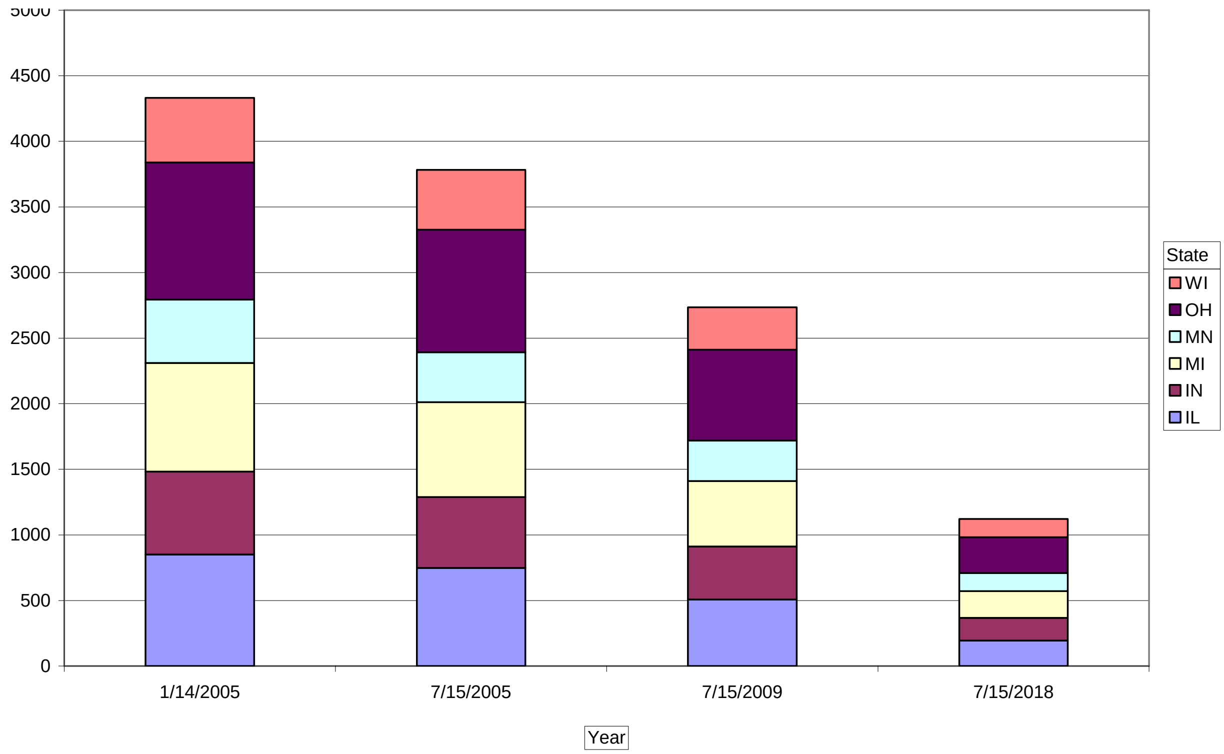

Figure 4. Friday NOx by state by each modeling year.

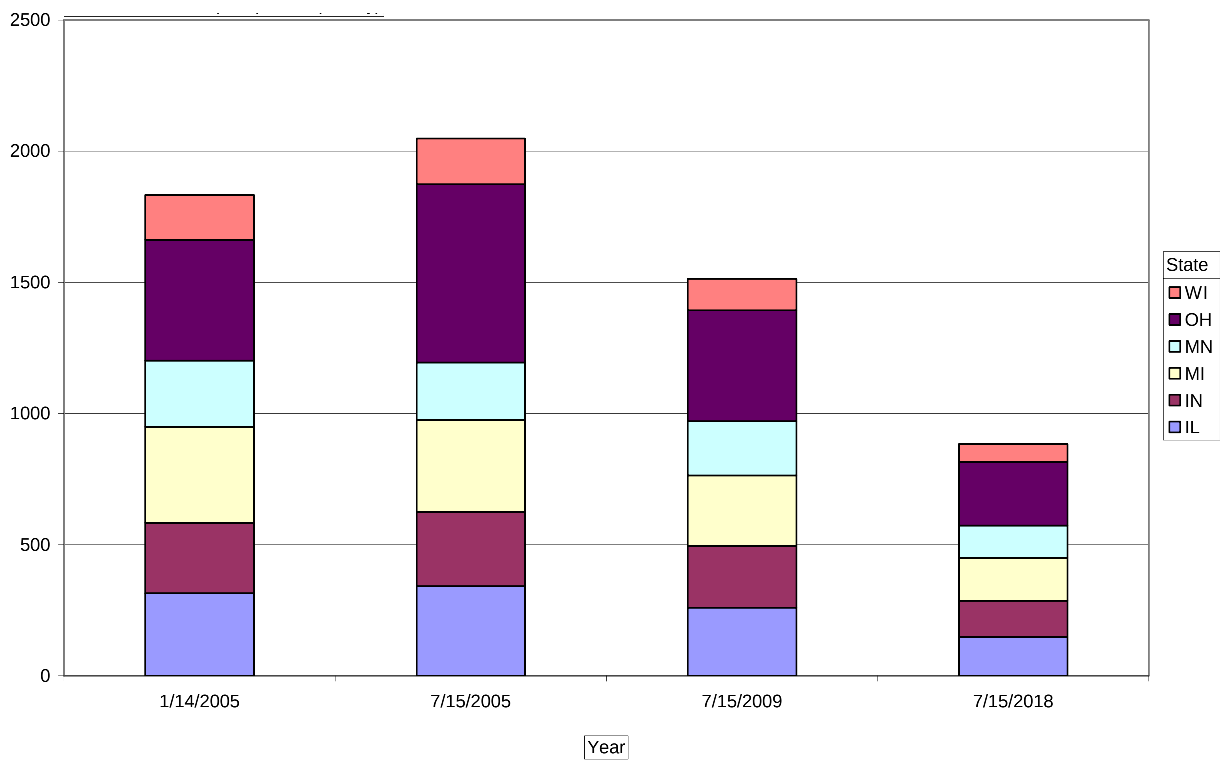

Figure 5. Friday TOG by state by each modeling year.

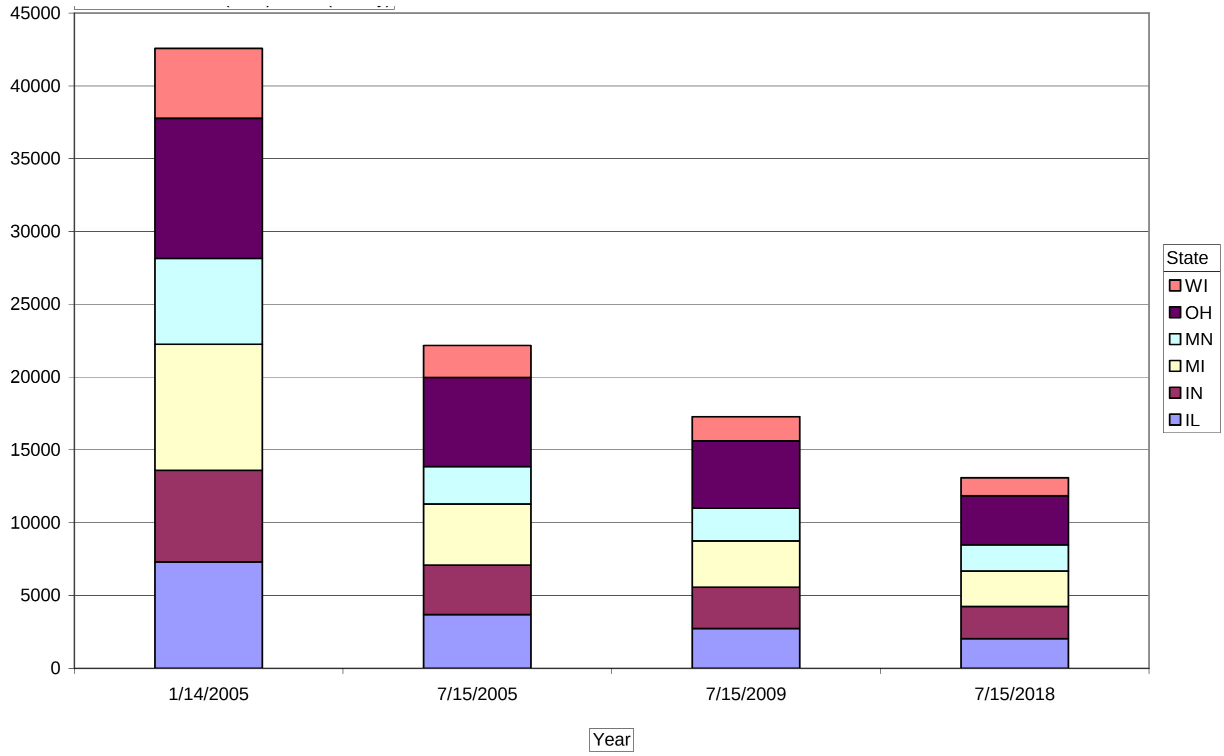

Figure 6. Friday CO by state by each modeling year.

Table 11. Friday emissions (TPD) by network for each modeling year.

Date	State	Network	CO	TOG	NOx
1/14/2005	IL	CATS	3,833.63	146.21	410.05
1/14/2005		ILDOT	3,473.76	168.94	441.65
1/14/2005	IN	INDOT	4,056.21	164.57	398.57
1/14/2005		INDY	1,635.43	78.29	165.91
1/14/2005		NIRPC	595.56	24.60	65.87
1/14/2005	MI	MIDOT	5,380.90	225.67	455.58
1/14/2005		SEMCOG	3,271.43	141.19	372.06
1/14/2005	MN	MMC	2,750.78	112.23	228.57
1/14/2005		MNDOT	3,134.94	139.71	254.26
1/14/2005	OH	AKRON	538.64	23.07	63.40
1/14/2005		CANTON	282.70	15.11	27.59
1/14/2005		CINCI	992.93	43.32	124.71
1/14/2005		CLVLAND	1,184.59	44.92	143.25
1/14/2005		COLUMBUS	1,388.41	68.02	146.69
1/14/2005		DAYTON	508.81	22.42	59.83
1/14/2005		OHIOSW	3,822.07	195.61	387.92
1/14/2005		SPRFLD	101.74	4.23	12.91
1/14/2005		TOLEDO	585.37	31.65	56.65
1/14/2005		YNGTWN	237.74	12.27	23.58
1/14/2005	WI	SEWRPC	1,112.31	43.54	128.76
1/14/2005		WIDOT	3,685.67	127.30	364.29
1/14/2005 Total			**42,574**	**1,833**	**4,332**
7/15/2005	IL	CATS	1,622.20	133.28	348.71
7/15/2005		ILDOT	2,062.13	208.23	399.54
7/15/2005	IN	INDOT	2,273.55	179.27	350.20
7/15/2005		INDY	813.37	78.39	134.46
7/15/2005		NIRPC	298.02	24.36	56.43
7/15/2005	MI	MIDOT	2,839.33	222.27	386.74
7/15/2005		SEMCOG	1,370.96	129.61	335.25
7/15/2005	MN	MMC	1,181.27	102.35	165.41
7/15/2005		MNDOT	1,387.82	116.34	215.04
7/15/2005	OH	AKRON	300.63	25.95	56.22
7/15/2005		CANTON	167.71	17.21	23.74
7/15/2005		CINCI	749.95	115.24	117.32
7/15/2005		CLVLAND	649.78	47.87	124.59
7/15/2005		COLUMBUS	899.54	96.49	127.97
7/15/2005		DAYTON	332.38	40.19	54.32
7/15/2005		OHIOSW	2,461.47	270.56	347.97
7/15/2005		SPRFLD	64.05	6.98	12.04
7/15/2005		TOLEDO	348.94	45.71	49.29
7/15/2005		YNGTWN	138.95	13.61	20.18
7/15/2005	WI	SEWRPC	478.79	40.41	116.64
7/15/2005		WIDOT	1,727.19	134.66	340.85
7/15/2005 Total			**22,168**	**2,049**	**3,783**
7/15/2009	IL	CATS	1,110.98	94.73	216.82
7/15/2009		ILDOT	1,613.41	164.81	291.51
7/15/2009	IN	INDOT	1,863.53	142.89	261.78
7/15/2009		INDY	766.42	74.83	102.26
7/15/2009		NIRPC	209.52	17.20	37.87
7/15/2009	MI	MIDOT	2,173.04	172.69	282.31
7/15/2009		SEMCOG	998.97	96.48	218.55
7/15/2009	MN	MMC	868.67	75.38	113.87
7/15/2009		MNDOT	1,388.14	130.95	193.62
7/15/2009	OH	AKRON	230.47	19.11	40.80
7/15/2009		CANTON	128.41	12.77	17.37
7/15/2009		CINCI	468.49	40.41	81.93
7/15/2009		CLVLAND	445.84	35.68	87.31
7/15/2009		COLUMBUS	681.90	60.75	93.96
7/15/2009		DAYTON	226.78	19.19	37.77
7/15/2009		OHIOSW	2,020.91	193.87	274.84
7/15/2009		SPRFLD	51.87	4.17	9.31
7/15/2009		TOLEDO	259.33	27.74	35.65
7/15/2009		YNGTWN	105.22	9.98	14.54
7/15/2009	WI	SEWRPC	366.83	30.08	81.03
7/15/2009		WIDOT	1,306.56	89.33	241.07
7/15/2009 Total			**17,285**	**1,513**	**2,734**

Date	State	Network	CO	TOG	NOx
7/15/2018	IL	CATS	772.85	49.72	72.83
7/15/2018		ILDOT	1,250.02	97.83	122.02
7/15/2018	IN	INDOT	1,453.53	84.57	112.70
7/15/2018		INDY	608.42	44.26	46.24
7/15/2018		NIRPC	155.36	9.57	14.08
7/15/2018	MI	MIDOT	1,662.11	108.05	126.33
7/15/2018		SEMCOG	772.17	55.46	77.80
7/15/2018	MN	MMC	663.71	44.33	47.90
7/15/2018		MNDOT	1,135.91	78.76	89.21
7/15/2018	OH	AKRON	171.23	11.30	15.32
7/15/2018		CANTON	87.67	6.77	6.85
7/15/2018		CINCI	355.02	24.82	31.70
7/15/2018		CLVLAND	302.84	18.68	27.11
7/15/2018		COLUMBUS	521.80	36.89	40.99
7/15/2018		DAYTON	162.68	11.01	14.20
7/15/2018		OHIOSW	1,466.76	109.99	114.31
7/15/2018		SPRFLD	38.92	2.66	3.54
7/15/2018		TOLEDO	182.95	15.17	14.47
7/15/2018		YNGTWN	71.63	5.26	5.65
7/15/2018	WI	SEWRPC	282.31	16.66	27.99
7/15/2018		WIDOT	973.16	51.78	110.49
7/15/2018 Total			**13,091**	**884**	**1,121**

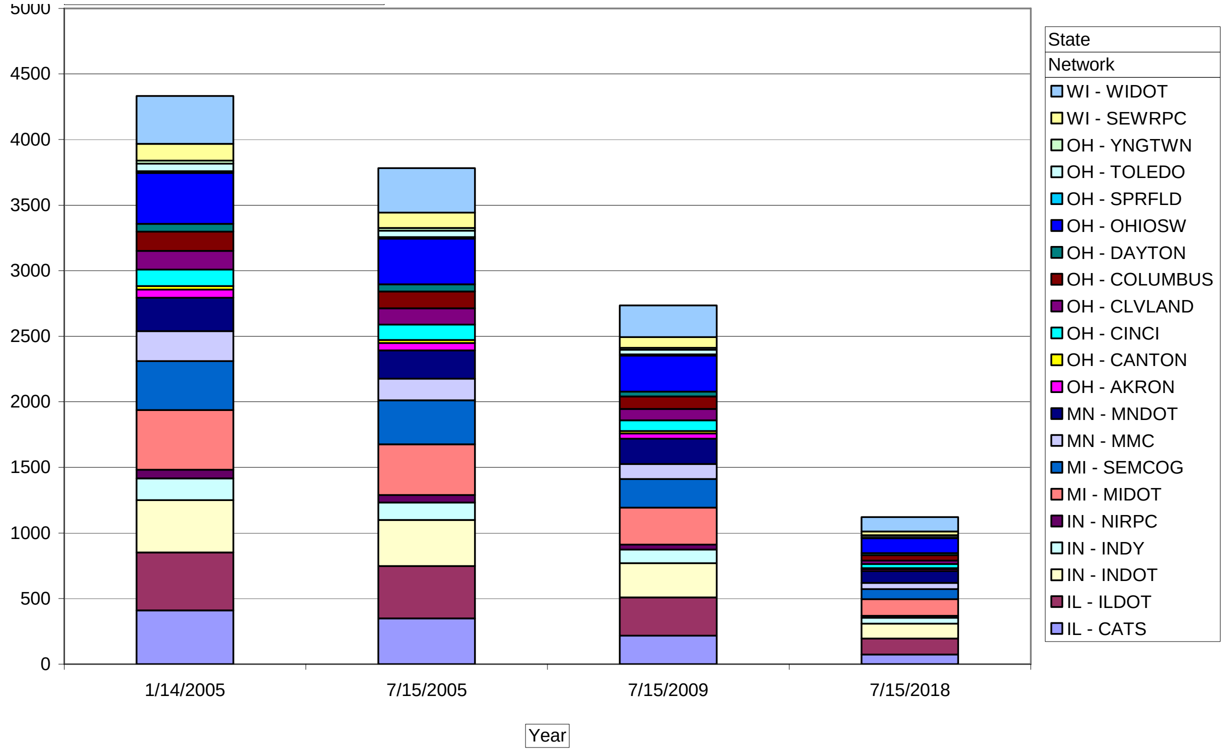

Figure 7. July 15 NOx by network for each modeling year.

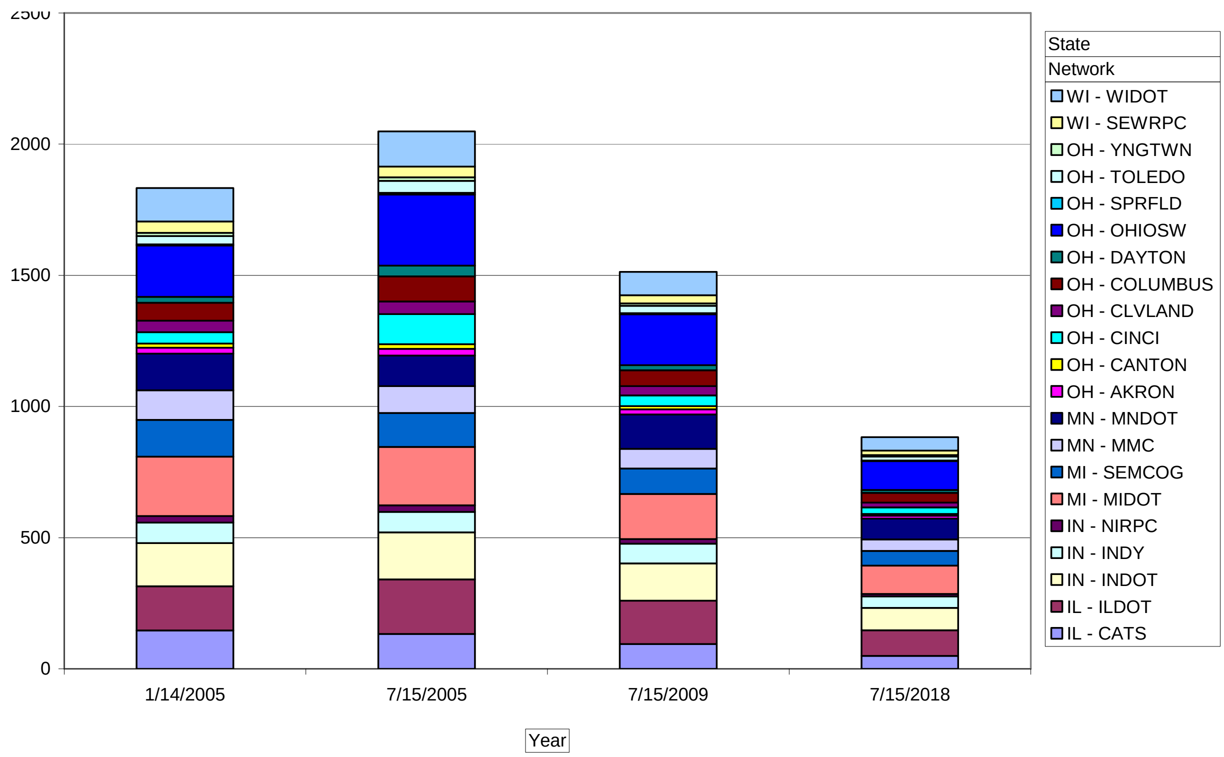

Figure 8. Friday TOG by network for each modeling year.

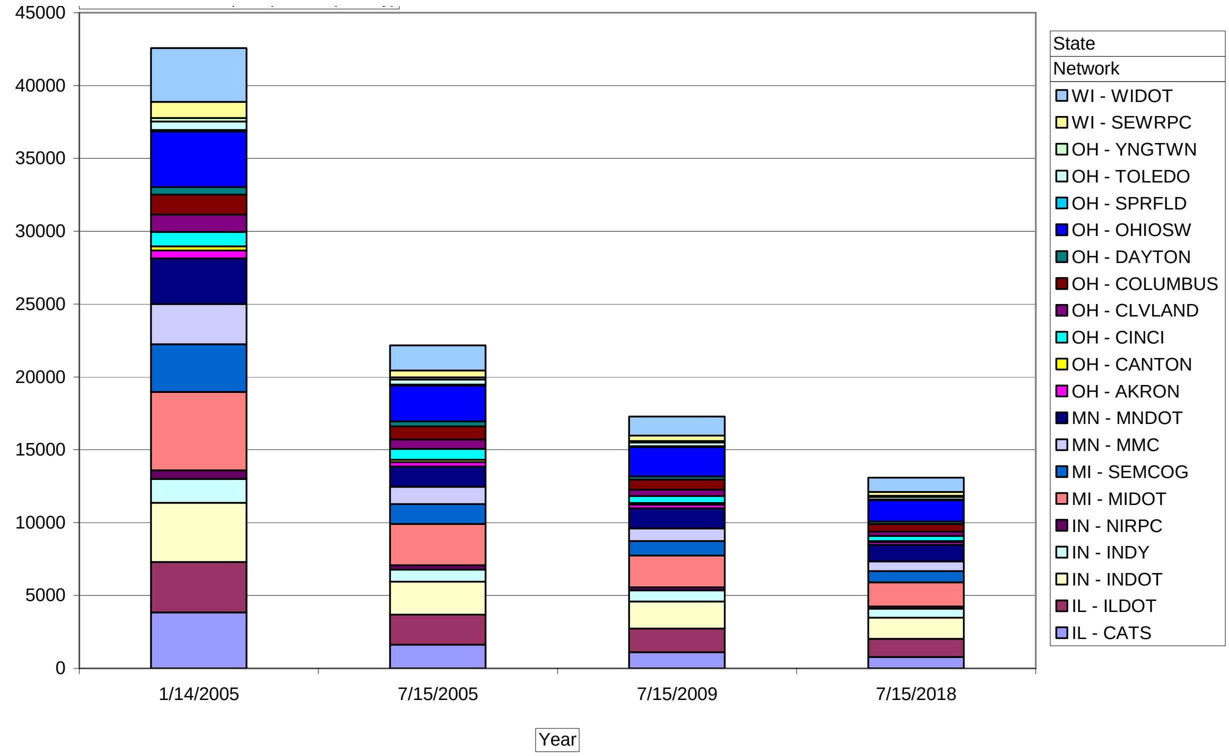

Figure 9. Friday CO by network for each modeling year.

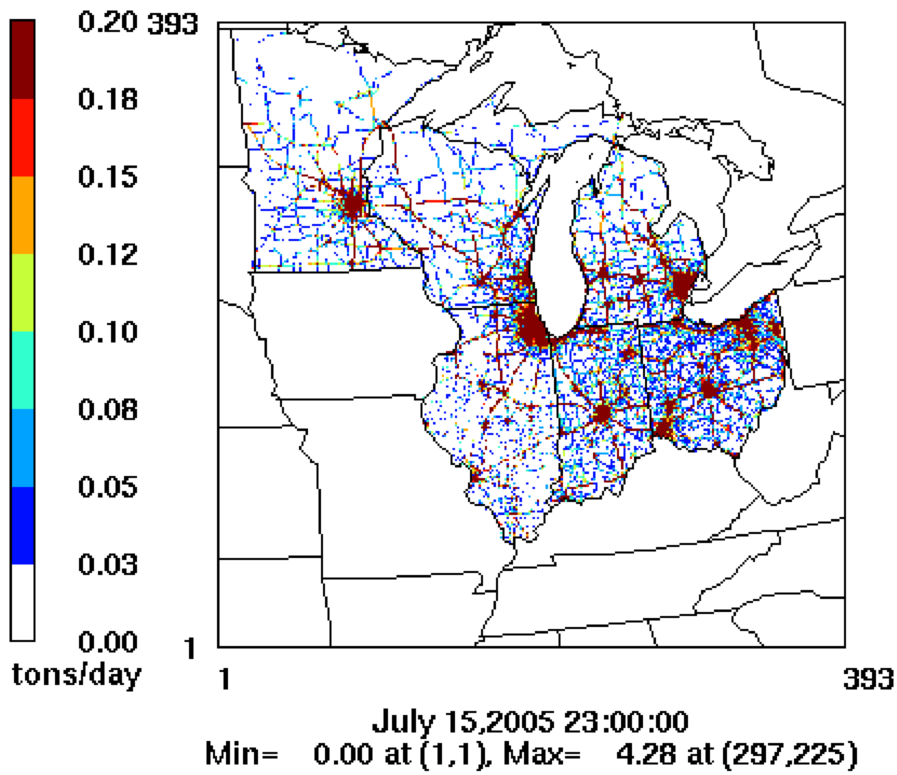

Figure 10. 2005 July 15 daily total NOx spatial distribution for transportation networks.

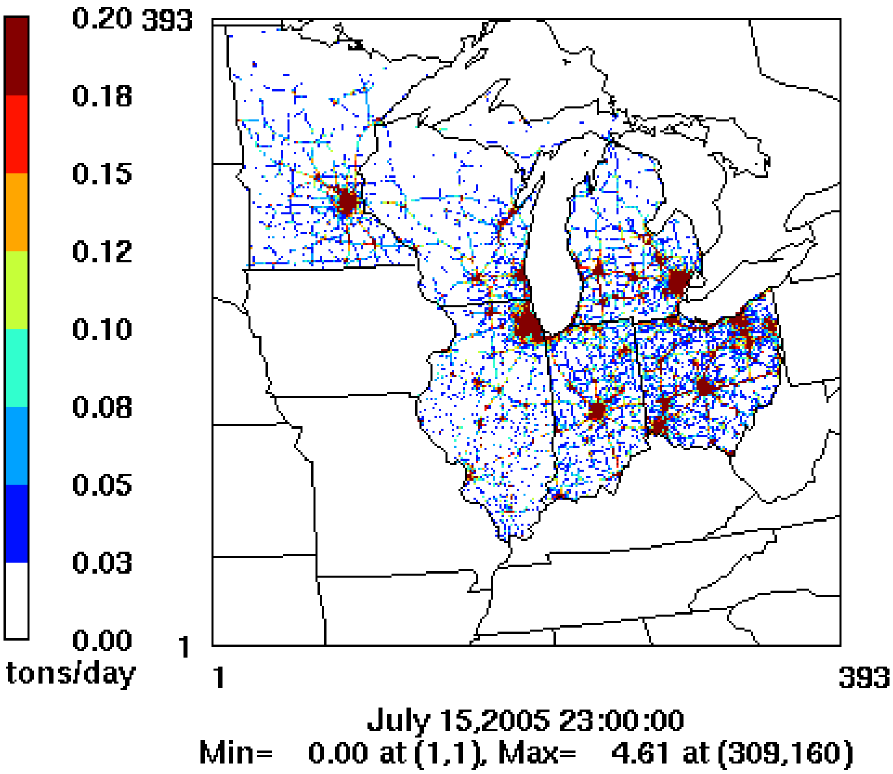

Figure 11. 2005 July 15 daily total TOG spatial distribution for transportation networks.

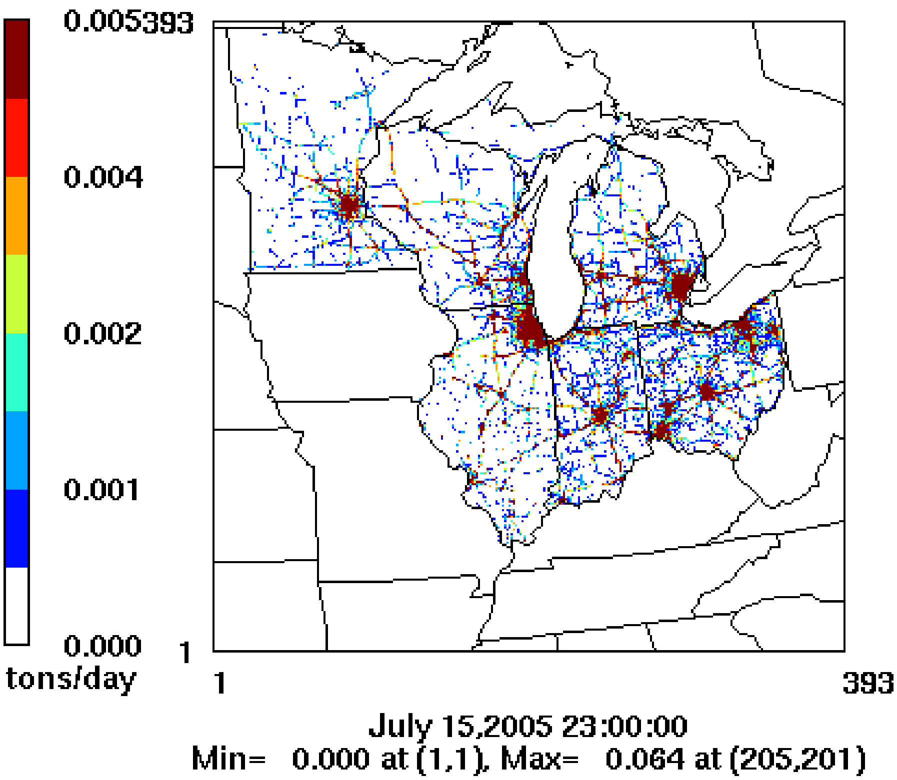

Figure 12. 2005 July 15 daily total PM2.5 spatial distribution for transportation networks.

Single Network Example - SEMCOG Results 2005 July

The Michigan transportation network SEMCOG was selected to demonstrate the comparison between Friday, Saturday, and Sunday on-road emissions for a single network. Figures 13 – 14 present bar charts of total daily emissions (tons) for NOx and TOG respectively. As expected, the weekday Friday NOx emissions are double that of Saturday with a further decline on Sunday. Similarly, TOG emissions decline from Friday to Saturday and again a further decline on Sunday. Figures 15 -16 present hourly distribution of VMT for light-duty gas vehicles and heavy-duty diesel vehicles respectively. Figures 17 -18 present hourly distribution of vehicle mix for Friday and Saturday, respectively.

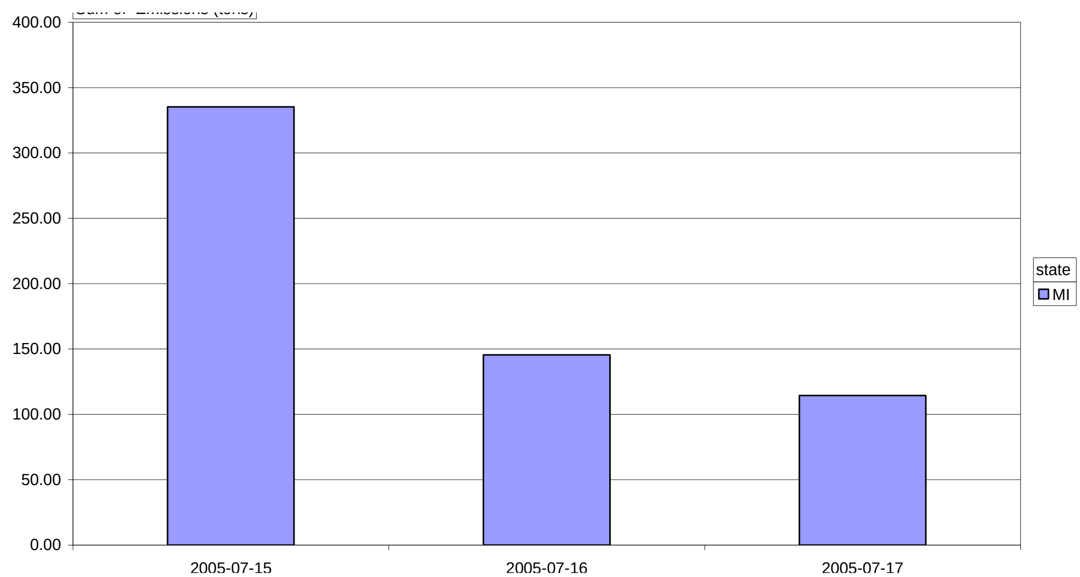

Figure 13. 2005 Friday, Saturday, Sunday NOx Comparison for MI_SEMCOG network.

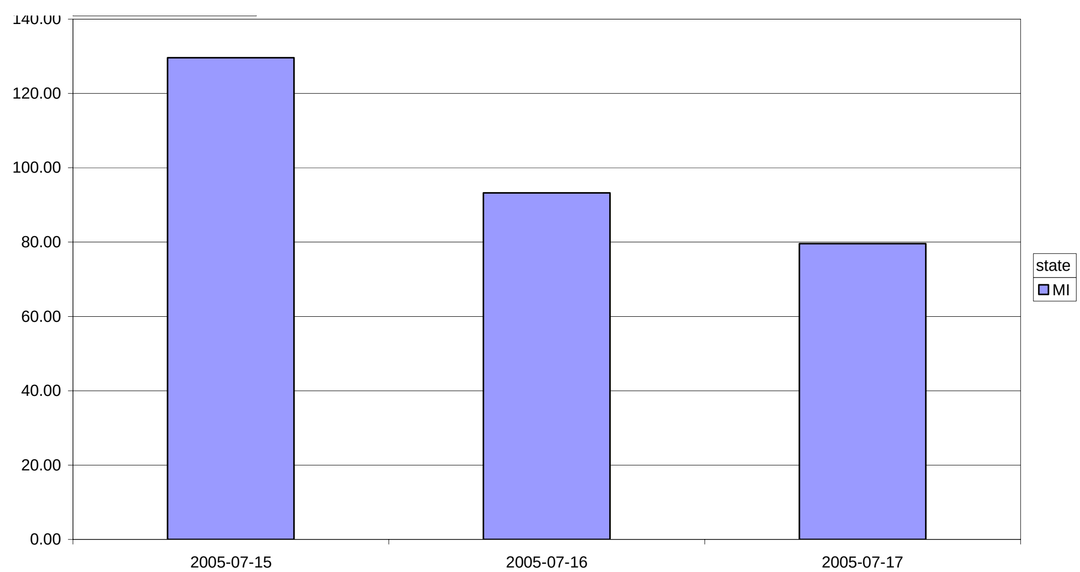

Figure 14. 2005 Friday, Saturday, Sunday TOG Comparison for MI_SEMCOG network.

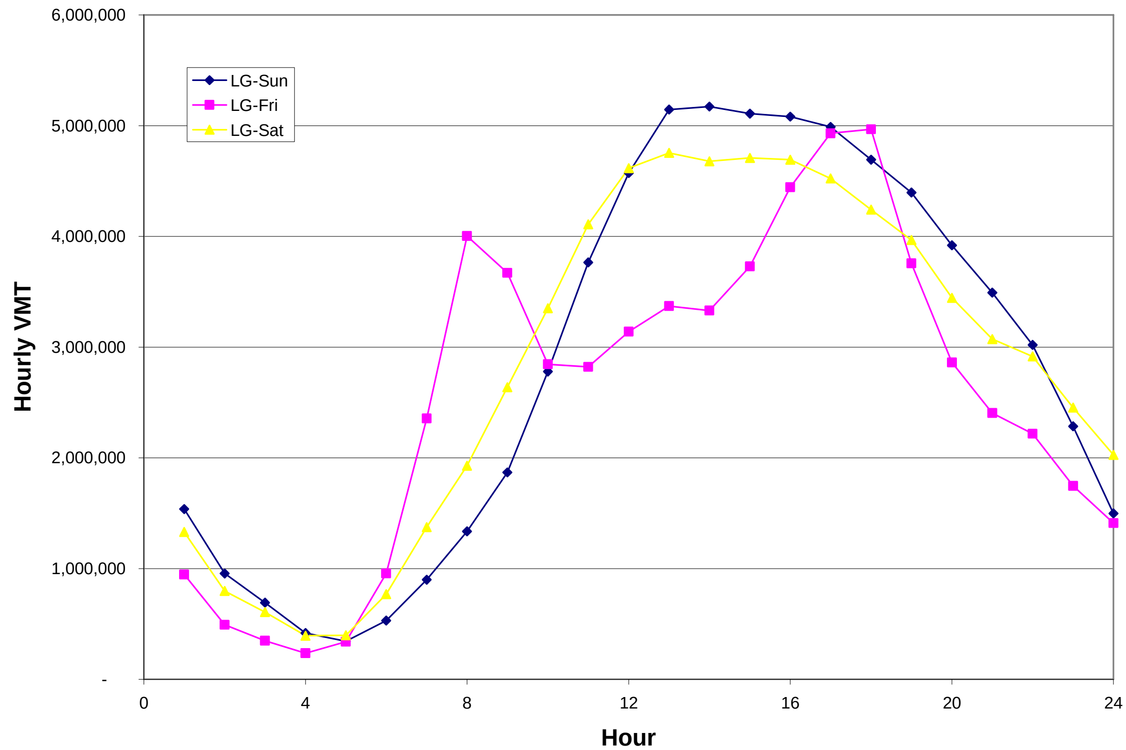

Figure 15. Hourly distribution of light-duty gas vehicles VMT by day.

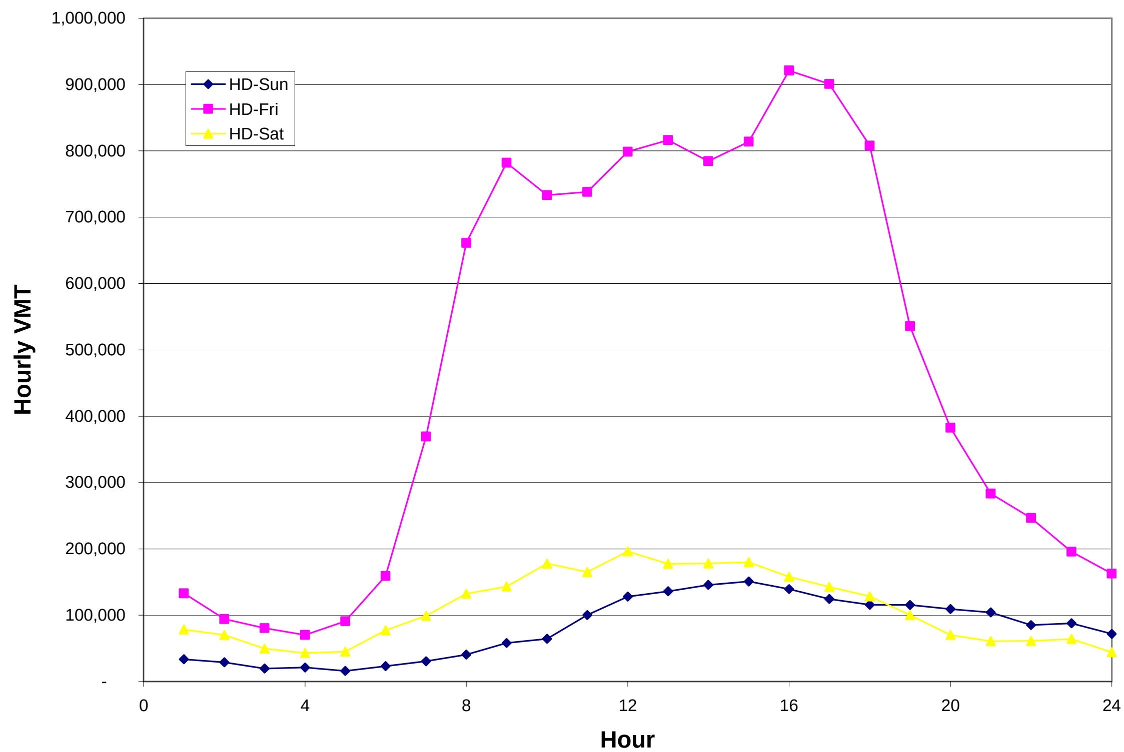

Figure 16. Hourly distribution of heavy-duty diesel vehicles VMT by day.

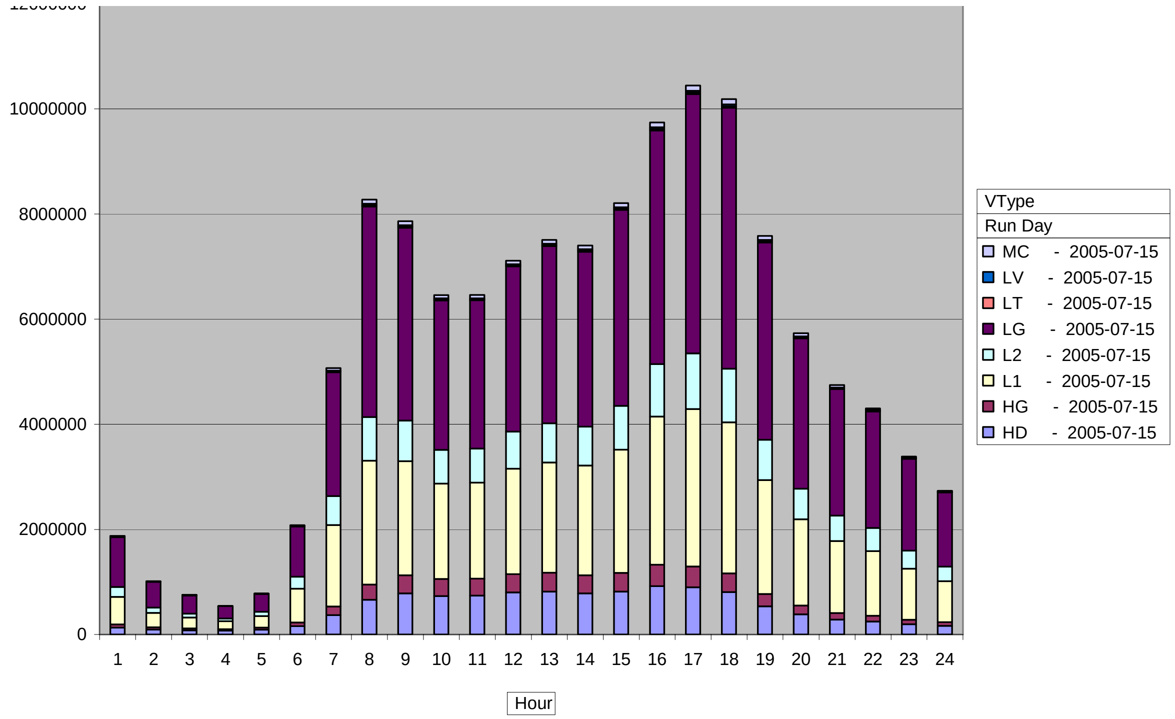

Figure 17. Hourly distribution of VMT Mix for Friday, July 15.

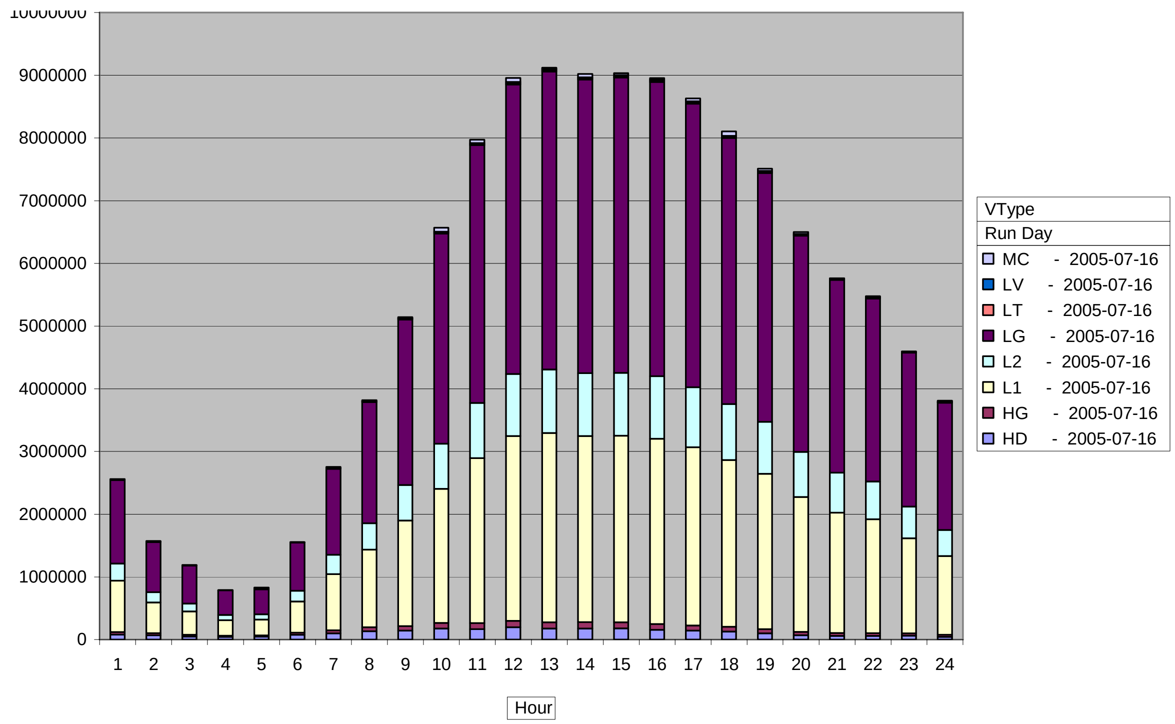

Figure 18. Hourly distribution of VMT Mix for Saturday, July 16.

4. ESTIMATING MV EMISSIONS FOR NON-LADCO STATES USING HPMS DATA

Temporal Profiles

ENVIRON analyzed an extremely large database of detailed traffic counter data by vehicle class, roadway type, and state under contract to EPA[1]. From this work using national databases of vehicle activity maintained by the Federal Highway Administration (FHWA), temporal profiles for on-road sources were developed. The databases used were the FHWA Traffic Volume Trends (http://www.fhwa.dot.gov/policy/ohpi/travel/index.htm) for temporal activity of vehicles, and the FHWA Vehicle Travel Information System (VTRIS) (http://www.fhwa.dot.gov/ohim/ohimvtis.htm) that identifies individual vehicle classes to estimate temporal variation in the vehicle mix.

For month of year profiles the data were aggregated across both roadway types and groups of states; the averaging was volume weighted. The states were grouped as follows:

Northeast: CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT, WV
Southeast: AL, DC, FL, GA, KY, LA, MS, NC, SC, TN, VA
Upper Midwest: IA, MT, ND, SD, WY
Lower Midwest: AR, CO, KS, NE, NM, OK, TX

The hour of day profiles, shown in Figures 19 and 20, are national average profiles developed for use in WRAP modeling. There are separate profiles for light-duty gas vehicles and heavy-duty diesel vehicles for Friday, Saturday and Sunday.

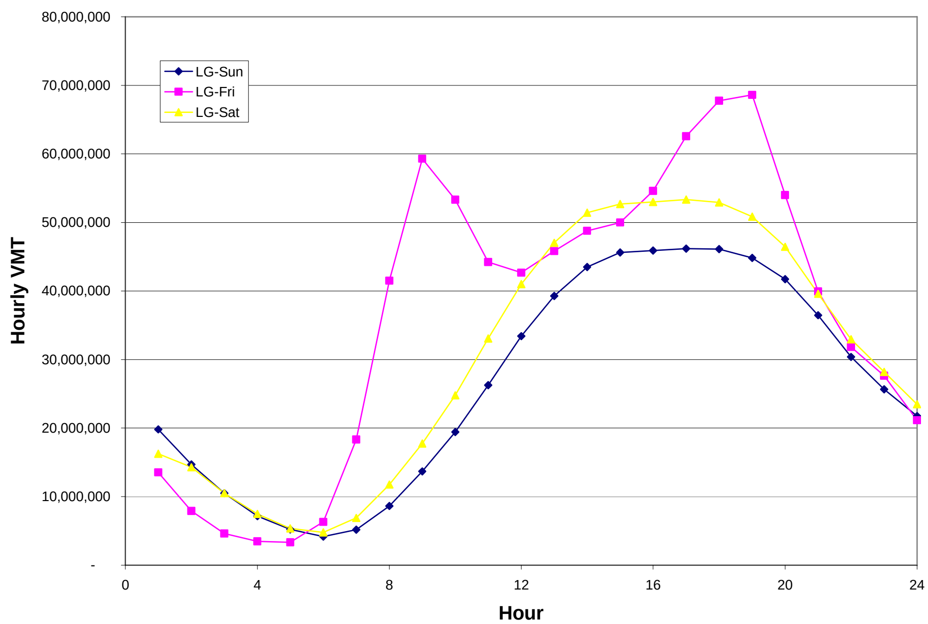

Figure 19. Hourly distribution of light-duty gas vehicles VMT by day.

[1] Lindhjem, C. 2004. "Development Work for Improved Heavy-Duty Vehicle Modeling Capability Data Mining FHWA Datasets Phase II: Final Report", EPA Contract No. 68-C-02-022, Work Assignment No. 2-6, Prepared for: Evelyn Sue Kimbrough, Atmospheric Protection Branch Office of Research and Development U.S. Environmental Protection Agency, September.

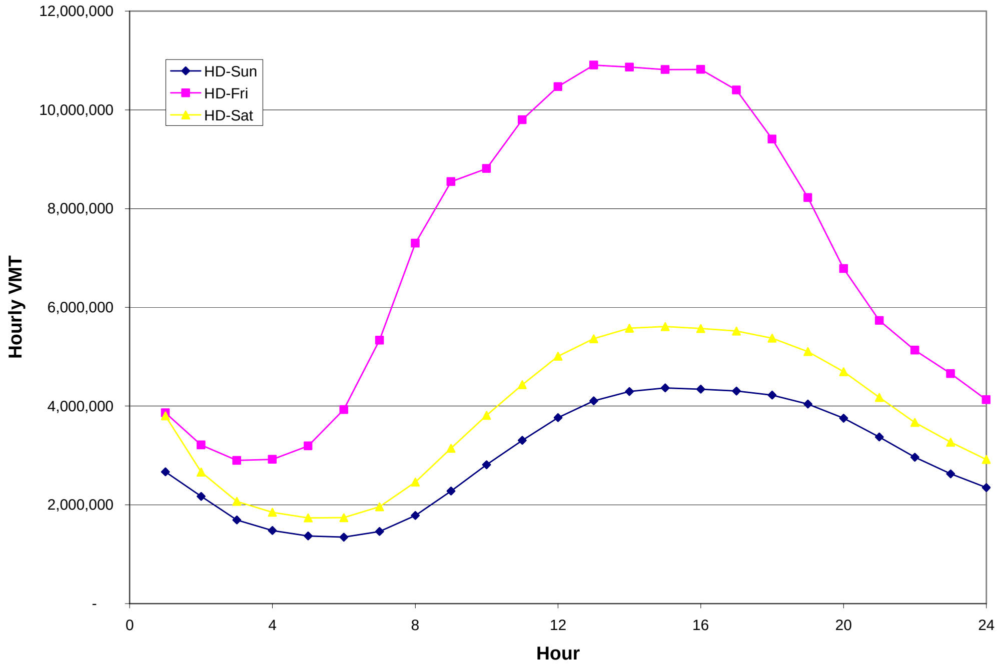

Figure 20. Hourly distribution of heavy-duty diesel vehicles VMT by day.

Modeling Episode Days

The same set of model days were run with the HPMS data as the LADCO networks. The list of modeling episode days can be found in Table 8 above.

As with the LADCO networks it was determined that CONCEPT MV simply got hung when trying to process the HPMS data in large files. Originally the files were split by RPO. This proved to be too time consuming and CONCEPT was not able to handle the vast amount of data. It was decided to split the VMT by state and process each state separately through CONCEPT. In addition, the files were further split between light duty vehicles and heavy duty vehicles to support the different temporal profiles discussed above.

For the 36km modeling domain, which consists of 36 different states, it took approximately 43 hours of computing time to model a single episode day of HPMS VMT data with version 07.1 of the CONCEPT MV code. (Note – it took approximately 70 hours with the previous version of code). The 12km modeling domain, which consists of 20 states, took approximately 35 hours of computing time for a single episode day with version 07.1. Though there are far fewer states in the 12km domain, the finer grid resolution generates far more records by grid cell to process. For example, the state of Iowa, which is completely contained in the 12km modeling domain took approximately 1 hour at 36km resolution and almost 4 hours at 12km resolution.

The most time consuming aspect of the CONCEPT MV modeling is the vast amount of disk I/O required for generating the numerous intermediate database tables that can be used for QA.

Processing Issues

Spatial Surrogates

The HPMS on-road emission estimates were distributed using spatial surrogates. As CONCEPT MV is currently designed to support a single on-road surrogate code, the state data were split between light duty vehicles and heavy duty vehicles. The heavy duty vehicles included both heavy duty diesel (HD) and heavy duty gas (HG). The remaining vehicle classes (LG, L1, L2, LV, LT, MC) were lumped into the light duty file. The light duty vehicles were gridded using spatial surrogate *0.75*total roadway miles + 0.25*total population* (code 255). The heavy duty vehicles were gridded using surrogate *urban primary and rural primary roadway miles* (code 250).

MOBILE6 Processing Runs

The Texas Saturday processing had a problem that required the county VMT to be further split up for processing through CONCEPT MV. The Saturday run simply generated too many MOBILE6 runs. The run id, a sequential number starting at 1, exceeded 999. The current version of MOBILE6 has an output format of "I3" for this run id number being written to the CONCEPT input file. When the run id number exceeds 999 then the output run id is written as "***". Texas had a number of factors that contributed to this large number of runs; 8 different representative counties, a large surface area which would contribute to large differences in temperature data, and two time zones in the state. In addition, for Saturday, the model needed both "Weekday" and "Weekend" MOBILE6 runs because of the multiple time zones. Midnight in CST on Saturday is 11P.M. on Friday in MST. The Texas state VMT was split into six separate files for the Saturday processing

Results for 2005 July 15

Figures 21 - 23 provide spatial distribution plots for NOx, TOG and PM2.5 for the 2005 July 15 episode day for the 36km regional domain HPMS states. These plots clearly show the high density in large urban areas and along major state and interstate highways. Figures 24 - 26 provide spatial distribution plots for NOx, TOG and PM2.5 for the 2005 July 15 episode day of the HPMS states data in the12km domain.

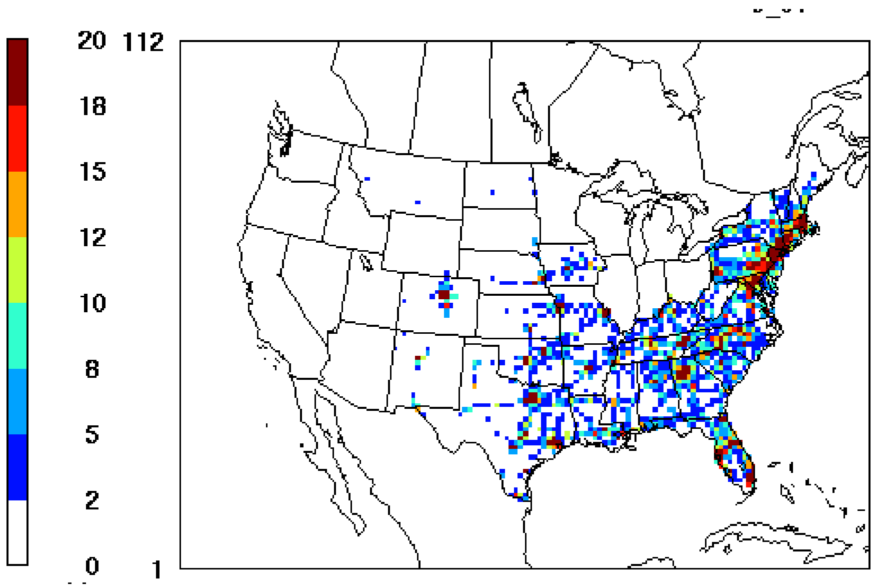

Figure 21. 2005 July 15 daily total NOx spatial distribution for 36km domain of HPMS.

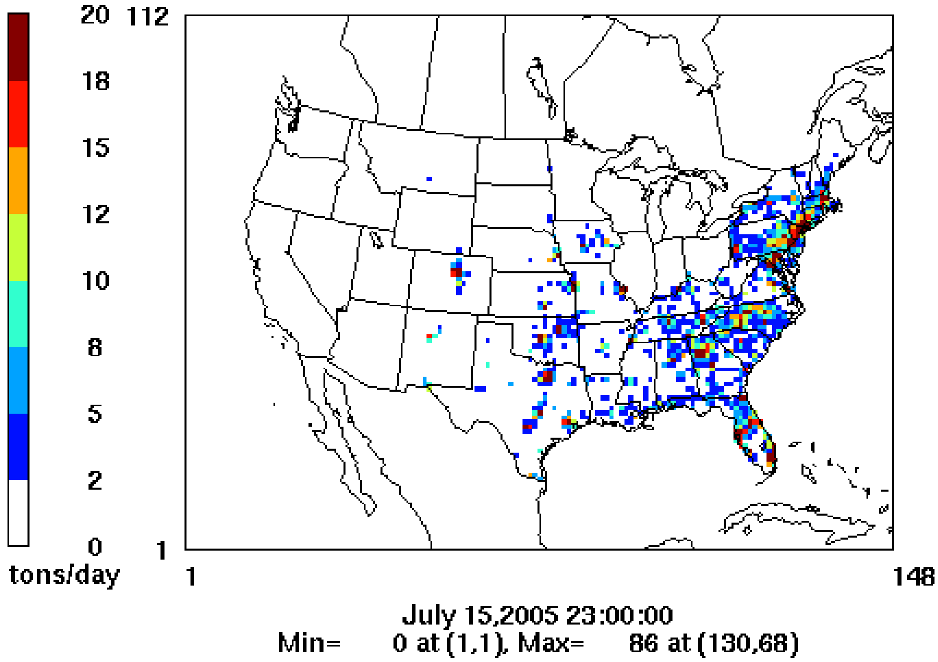

Figure 22. 2005 July 15 daily total TOG spatial distribution for 36km domain of HPMS.

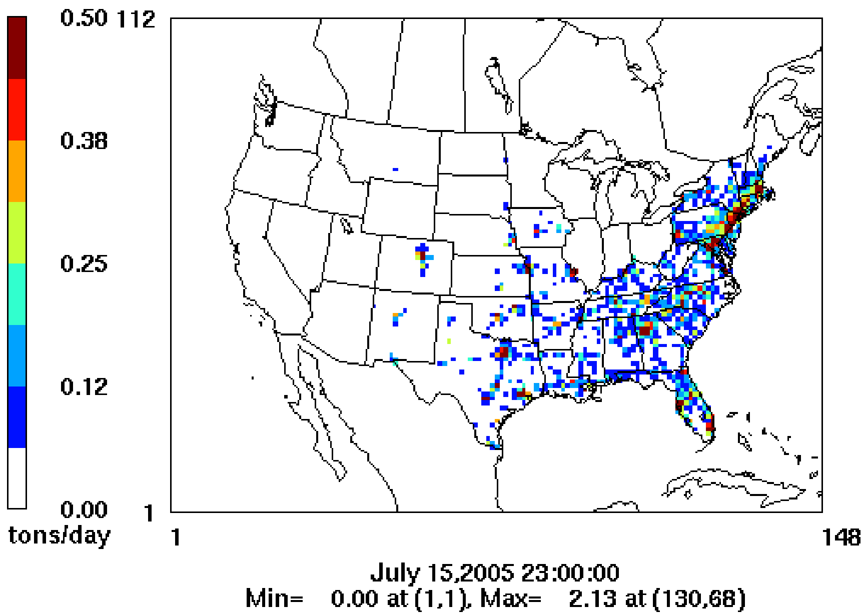

Figure 23. 2005 July 15 daily total PM2.5 spatial distribution for 36km domain of HPMS.

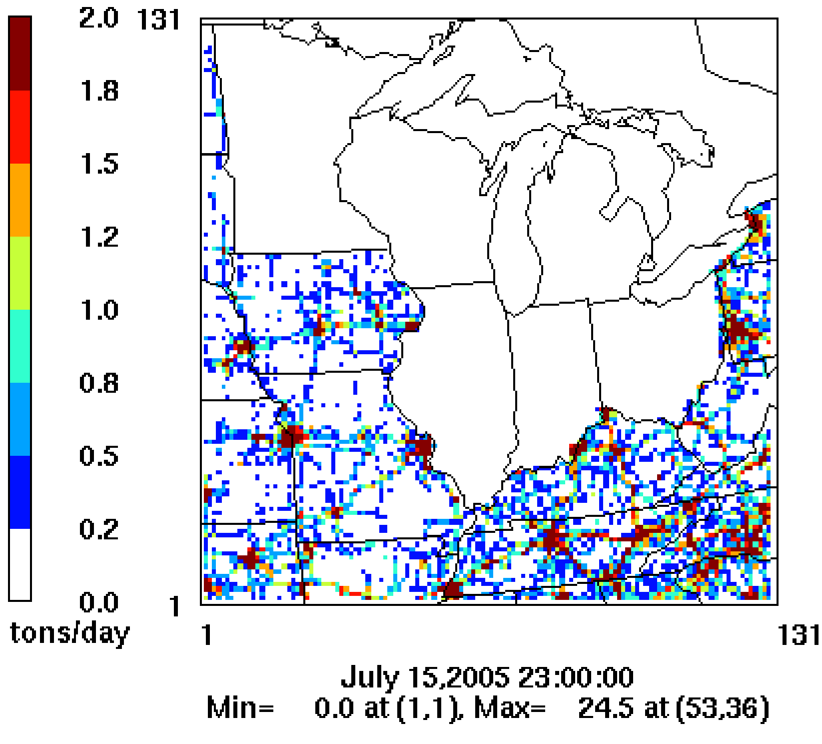

Figure 24. 2005 July 15 daily total NOx spatial distribution for 12km domain of HPMS.

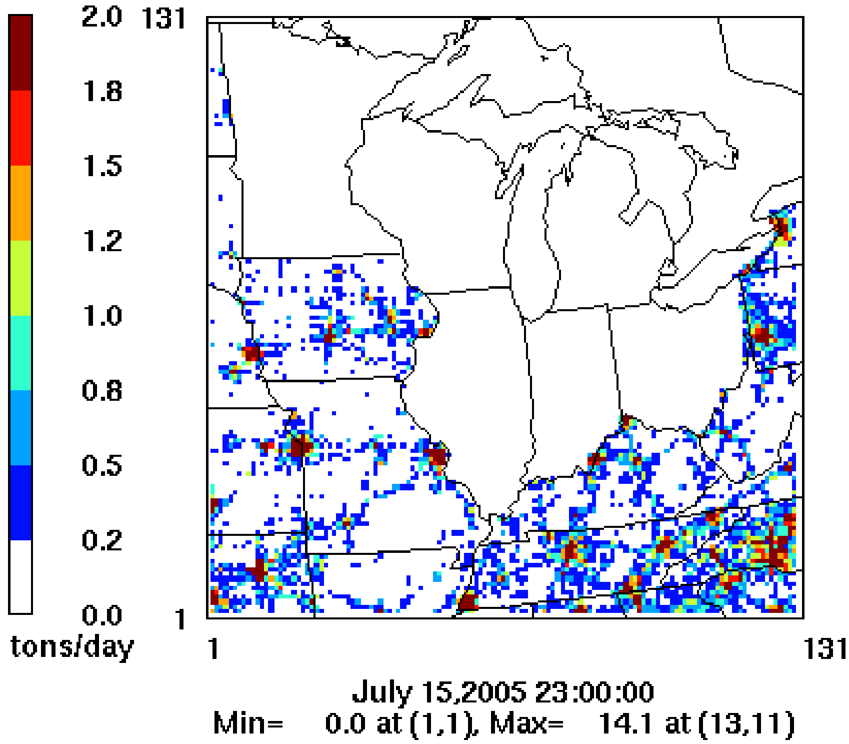

Figure 25. 2005 July 15 daily total TOG spatial distribution for 12km domain of HPMS.

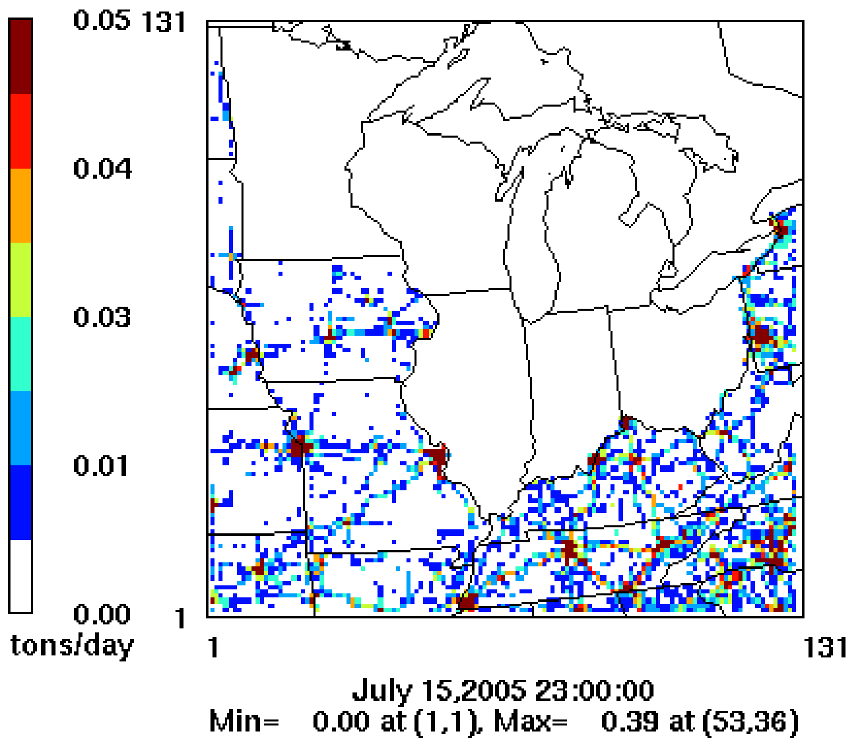

Figure 26. 2005 July 15 daily total PM2.5 spatial distribution for 12km domain of HPMS.

5. QA/QC PERFORMED

In order to verify the validity of the results, a number of graphs and tables were evaluated by ENVIRON to confirm that the results were consistent with activity profiles and MOBILE6 emission factors. As QA performed for networks was different than QA performed for HPMS CONCEPT runs, examples of each type of QA are presented below.

QA/QC for LADCO States Networks

Initial checks were made to compare CONCEPT emissions and VMT output to known estimates. QA/QC checks of overall VMT mix and emissions factors by county for TOG, CO, NOx, and SO_2 were performed for a weekday for each network, for each modeling period. For all time periods, VMT mix was compared to MOBILE6 defaults. For the summer 2005 period, CONCEPT by county emission factor comparisons were made to NMIM model output. For winter 2005, summer 2009 and summer 2018, CONCEPT output emission factors were compared against 2005 CONCEPT output to assess whether changes relative to expected MOBILE6 emission factor changes were reasonable.

Further checks were made by comparing daily output within a modeling period. These checks included daily temporal profile comparisons for MOBILE6 vehicle classes, LDGV, LDGT1, LDGT2, and HDDV. Hourly VMT mix was assessed for each day in a modeling period. Additionally, changes in emissions factors from weekday to weekend days were also assessed for reasonableness. Lastly, overall emissions by day and pollutant were compared.

QA/QC for HPMS Data

Initial checks to compare CONCEPT emissions and VMT output to known estimates were made for HPMS output according to the same procedure as described for a network above. Further HPMS checks to compare activity and emissions among days in the modeling period were made as described above for networks on an RPO by RPO basis (whereas network checks were made on a network by network basis). This allowed ENVIRON to check the validity of HPMS CONCEPT results efficiently given the extent of HPMS emissions output generated.

6. CB05 IMPLEMENTATION

Speciation profiles were developed for carbon-bond 2005 (CB05) and carbon-bond IV (CBIV) as directed by LADCO. The CONCEPT Speciation Module was run to generate the profiles based on EPA's SPECIATE4.0; an Access database application.

The CONCEPT speciate.sql module requires three RPO-formatted input files; rpo_sp, rpo_cl, and rpo_ca. The rpo_sp and rpo_cl files were developed by extracting data from SPECIATE4.0 tables GAS_SPECIE and SPECIE_PROPERTIES, respectively. The results were reformatted to the CONCEPT input requirements with Perl scripts. The rpo_ca files was generated by reformatting the EPA Speciation Tool chemical mechanism definition input files for both CB05 (CB05_24Aug2006_forimport.txt) and CBIV (CBIV_24Aug2006_forimport.txt). The CONCEPT Speciation Module was run twice, once specifying the CB05 chemical mechanism and a second time for CBIV. The Speciation Module outputs the rpo_lp speciation profiles required as input to the CONCEPT MV Module.

As the CONCEPT Speciation Module was designed to only support VOC profiles, due to deadlines, and with agreement from LADCO, the static and PM profiles were taken from ENVIRON's recently completed runs under contract to EPA of the EPA Speciation Tool. These profiles were reformatted for CONCEPT inputs and appended to the rpo_lp profiles generated by the CONCEPT Speciation Module. In addition, in order to match the MOBILE6 output HC the rpo_lp outputs from CONCEPT speciate.sql outputs were edited manually to change VOC to TOG. A final addition to the rpo_lp file included manually defining the new profile, LADM6PMa, to include GASPM25 (90% FCRS, 10% PSO4).

The rpo_cr file, which maps SCC code to speciation profile code, was changed under direction of LADCO from the defaults provided with CONCEPT release to the following: profile codes originally mapped to 1305 through 1308 were changed to reference profile code 8733, and references to 1313 were changed to 3163, and references to M6PMa were changed to LADM6PMa.

APPENDIX A

CONCEPT MV Modeling for LADCO 2002 Networks

CONCEPT MV MODELING FOR LADCO 2002 NETWORKS

The first set of CONCEPT MV runs that ENVIRON performed were for modeling on-road mobile sources for calendar year 2002. ENVIRON obtained transportation demand modeling (TDM) data and MOBILE6 inputs from state and local planning agencies for all of the state and local networks. T3 import routines were written for each of the transportation networks, and the VMT calculated for each networks was verified with the providing agencies.

ENVIRON ran a July weekday 2002 simulation through CONCEPT for each of the networks. During this process, we were able to identify improvements for the CONCEPT motor vehicle emissions model, and troubleshoot issues with the network data, such as proper speed adjustments and vehicle class splits. Many of the improvements for the CONCEPT model were implemented between the time frame of the initial 2002 simulations and the 2005 simulations described in the body of this report.

There were several important changes between the 2002 and 2005 modeling efforts. There were differences in the way the transportation data were treated between the model years for some of the networks. For example, in 2002 there were some networks where the local or intrazonal VMT was calculated using only the VMT from local and centroid connector links in the network, but for 2005 and later years the local and centroid connector links were dropped in favor of county-level total local VMT. In other cases, agencies provided supplemental county-level intrazonal VMT to add in to the 2005 and later years. CONCEPT spatially allocated the county total local and/or intrazonal VMT using a population surrogate. Another change was that for the 2002 modeling effort, we applied HPMS adjustments to the network data when they were provided directly from the transportation modeling agencies; a more complex process for HPMS adjustments was performed for the 2005 and later modeling. Lastly, the 2002 simulations were run with an earlier version of CONCEPT that used CBIV speciation for generating the CAMx-ready modeling files; a later version of CONCEPT was used for the 2005 simulations that included the recently completed CB05 speciation module.

Figure A-1 shows a plot of the 2002 networks links; overall the plot looks very much like the 2005 network links plot shown in Figure 1 in the body of the report, but there were some changes in individual networks.

Figure A-2 and A-3 show some of the modeling results for the 2002 modeling. These plots compare the gram per mile emission factors by county for NOx and TOG, respectively, from the CONCEPT MV runs and run the LADCO Base K emissions files. The comparisons were done on a g/mi basis rather than total emissions as it was expected that the VMT would be different and the g/mi emission factor comparisons remove the effects of differing VMT. Plots similar to this were used as part of the QA process and were helpful in identifying issues with CONCEPT inputs. The g/mi emission factors are expected to be vary from the LADCO Base K emissions for a number of reasons. Key factors in the differences are:

- Updated MOBILE6 inputs were obtained from the state and local agencies for the CONCEPT runs.
- CONCEPT uses gridded temperatures and humidity from MM5 meteorological modeling runs; the Base K runs use fixed met data for each county.
- VMT mix in the LADCO Base K runs are the same for all hours of the day; VMT mix in CONCEPT varies by hour. HDDV VMT fractions in particular vary significantly over the course of the day and have a large effect on NOx emissions.
- CONCEPT uses link-level speeds varying by hour of day; the LADCO Base K county-level MOBILE6 inputs use only one average speed by roadway type for all hours in the day.

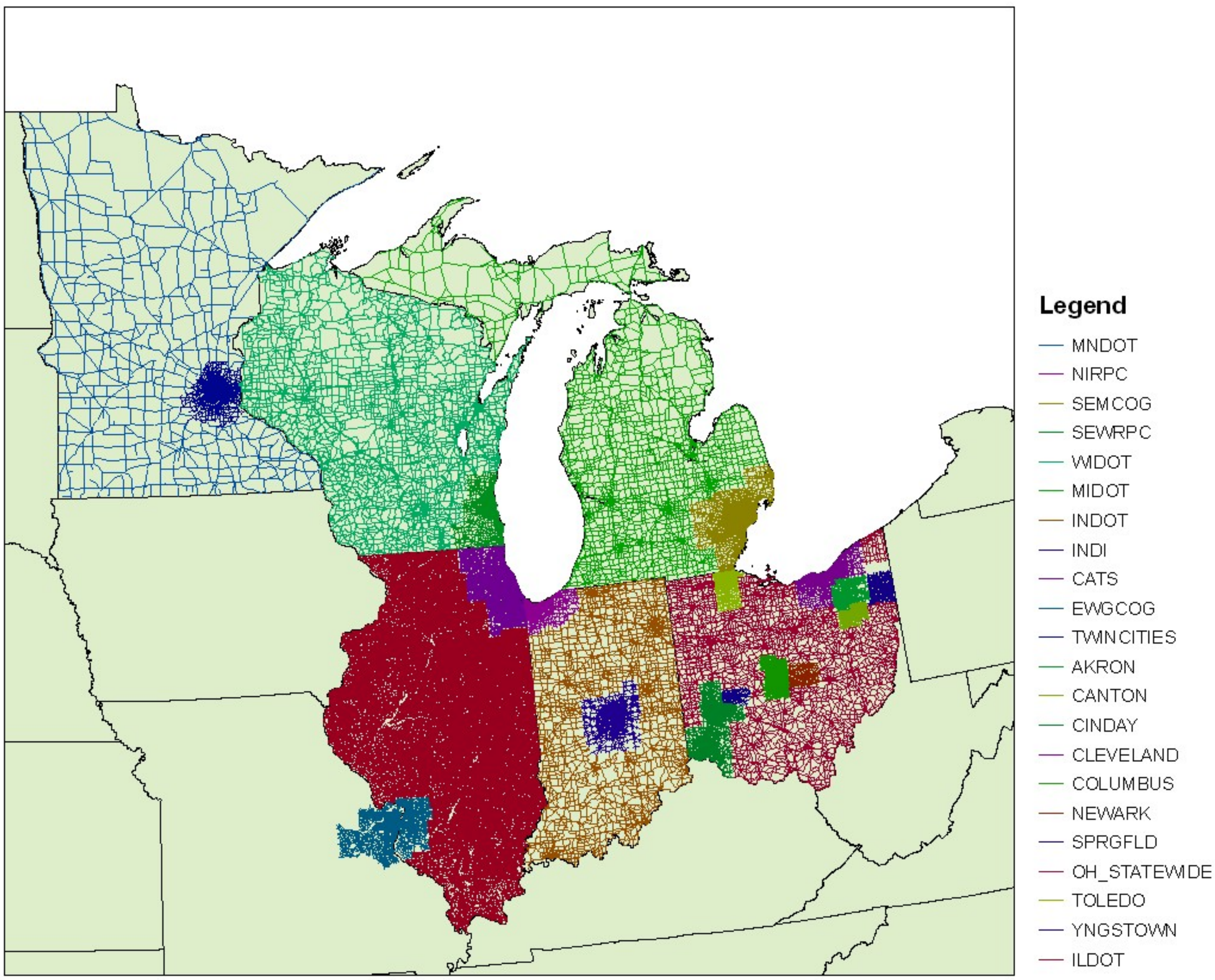

Figure A-1. Roadway links in the 2002 urban and statewide transportation networks.

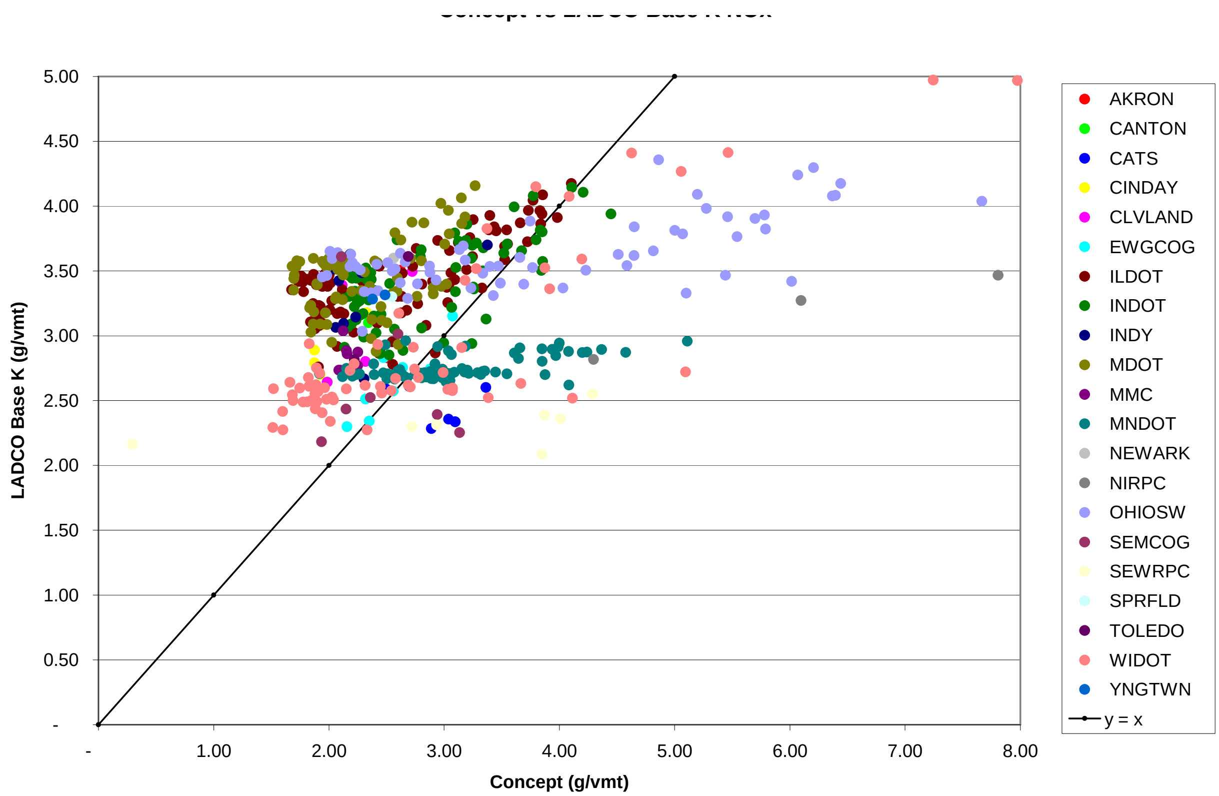

Figure A-2. Comparison of CONCEPT MV and LADCO Base K NOx emission factors

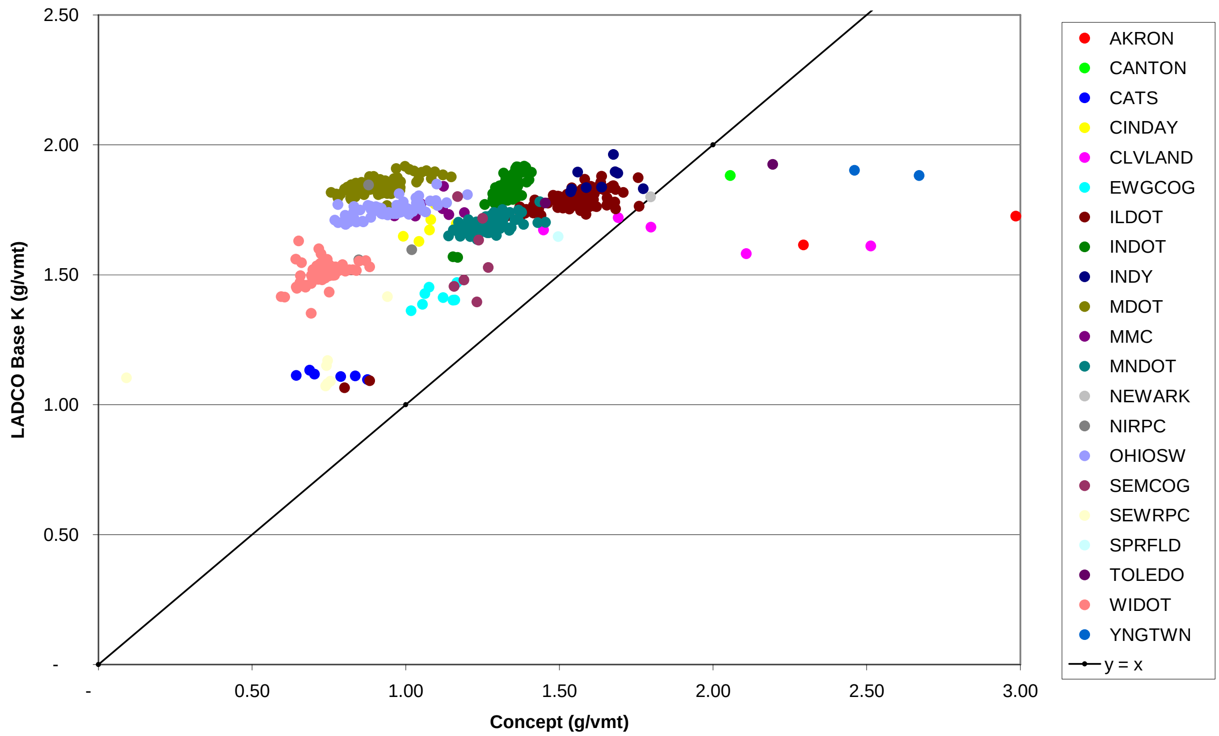

Figure A-3. Comparison of CONCEPT MV and LADCO Base K TOG emission factors