APPENDIX F

Example Mobile Source Input and Output Calculation Files for the Louisville Area

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A complete copy of the MOVES modeling documentation: including input and output calculation files will be provided electronically upon request.

APCD Technical Documentation for Using EPA Motor Vehicle Emission Simulator (MOVES) 2010 to Develop Mobile Source Emissions May 2011

KIPDA supplied Louisville Metro Air Pollution Control District (LMAPCD) VMT data for Jefferson and Bullitt Counties, Kentucky, and Clark and Floyd Counties, Indiana, using its Travel Demand Forecasting Model (TDFM). LMAPCD then input this data, along with other local data, into the MOVES model to produce the data for development of the SIP Motor Vehicle Emission Budgets (MVEB's). Emissions for the small area of Madison Township in Jefferson County, Indiana were calculated separately with MOVES by INDOT and were included in the final emission totals.

KIPDA TRAVEL DEMAND MODEL

The KIPDA travel demand model is a mathematical model which relates travel to the transportation system and basic socioeconomic information. The domain of the model is a study area which includes the Louisville (KY-IN) Metropolitan Planning Area. The Louisville (KY-IN) Metropolitan Planning Area consists of Clark and Floyd counties, and 0.1 square miles in Harrison County, IN, and Bullitt, Jefferson, and Oldham counties, KY. This area is divided into 807 smaller units called traffic analysis zones.

SIP MVEB development was initiated in January, 2010. As of that date, the KIPDA regional travel demand model had been last updated and calibrated during 2005. This update established 2000 as the new base year for the model. The model update utilized the information incorporated into the travel model during previous updates, in particular, information from the 2000 Census and the 2000 KIPDA Household Travel Survey. During the update, the model parameters were adjusted such that the model output matched within reason, three main calibration criteria based on measured data. These criteria were: (1) daily VMT for all highway facilities except local roads for the region; (2) the distribution of trip lengths (duration in time); and (3) highway traffic volumes crossing the Ohio River screen-line. The result of the update was a travel model that replicated travel in the Louisville area for 2000. The subsequent 2011 update and calibration of the TDFM (setting 2007 as a base year) was initiated after work for the $PM_{2.5}$ Redesignation SIP had begun and, therefore, could not be incorporated into the MOVES model runs.

The KIPDA travel demand model uses the standard four steps of modeling: trip generation, trip distribution, mode choice, and trip assignment. In addition, it considers travel by vehicles entering, leaving, and crossing the study area. These types of trips are known as external-internal, internal-external, and external-external, respectively. The internal ends of these trips are determined by the methods described below for internal-internal travel. The external ends are determined from the volume of traffic crossing the study area boundary at any of the 48 external stations.

Trip generation is the process of determining the number of unlinked trip ends - called productions and attractions - and their spatial distribution based on socioeconomic variables such as households and employment. Trip rates used to define these relationships were derived from the travel data collection efforts described above. This information was supplemented by use of the *National Cooperative Highway Research Program Report #365* and the Institute of

Transportation Engineers' *Trip Generation Report*. The KIPDA travel demand model uses three internal-internal trip purposes and uses different trip rates for each. Internal-internal trips are those that have both ends inside the modeling domain. The three purposes are home-based work, home-based other, and non home-based. Trip distribution is the process of linking the trip ends thereby creating trips that traverse the area.

The KIPDA travel model uses a gravity model to link all trips except the external-external ones. The gravity model is based on the principle that productions are linked to attractions as a direct function of the number of attractions of a zone and as an inverse function of the travel time between zones. This inverse function of travel time is used to generate parameters called friction factors that, in turn, direct the gravity model. The friction factors used in the gravity model were developed as part of the calibration effort performed during the model update.

Mode choice is the process used to separate the trips that use transit from those which use automobiles. It is also used to separate the auto drive-alone trips from auto shared-ride trips. In some previous KIPDA travel demand models, mode choice was based primarily on information provided by the *TARC Travel Forecasting Study*. In that model, the user's benefit or utility was calculated for each mode based on zonal socioeconomic characteristics and the cost and time of the trip using the various modes. A nested *Logit* model was used to determine the probability of the trip being made by each of the modes. This probability was then multiplied by the number of trips between zones to determine the number of trips by each mode.

For transit data the results of the 2004 TARC on-board survey was used to supplement the previous information. This was deemed acceptable for several reasons. The primary reason was that the transit network envisioned by *Horizon 2030* is essentially the same as the existing one. In addition, the number of total trips from the two models was similar. Therefore, the use of the transit trip information from previous travel models did not change significantly the proportion of trips allocated to transit. Finally, the proportion of trips utilizing transit is less than 2% of the total trips. So small differences in the number of transit trips should provide a negligible effect on overall travel.

Trip assignment is the process used to determine which links of the network a trip will use. Several assignment schemes may be used. Two of the more common schemes are All-or-Nothing (AON)--in which all trips between two zones follow the shortest time path--and Stochastic--in which trips between two zones may be assigned to several paths based on their impedances or travel times. It is not uncommon for travel models to use several assignment schemes in sequence to converge to a better assignment. A sequence commonly used involves using several AONs with the traffic volumes reported at the end of each scheme being a weighted average of the volumes from the most recent scheme and the volumes from the previous schemes. A capacity restraint provision is used to adjust travel times between assignment schemes. This sequence is called an equilibrium assignment. The KIPDA travel model uses an equilibrium assignment which converges when the change in system-wide travel time over successive iterations is estimated to be within 0.1 percent of the minimum (optimal) value or less.

The output from the KIPDA travel model is in the form of a series of links with each link having certain associated data such as number of lanes, capacity, facility type, area type, functional class, and volume. This data allows for the calculation of other link information such as VMT.

The VMT can be calculated as the product of the volume of traffic using a link times the distance of the link.

Adjustment Factors for Travel Model Output

The VMT and speeds from the travel demand model were adjusted before being used in the calculation of regional emissions. The purpose of these adjustments was to reconcile the model output with travel estimates from other sources, such as the Highway Performance Monitoring System (HPMS) estimates of VMT. To perform this adjustment, factors were developed for the year of the HPMS or other estimates and applied to model output for other years.

The outputs of the travel demand model were compared to estimates of speed based on: (1) the equations of the Highway Economic Reporting System (HERS) and (2) the use of data from the Automatic Continuous Traffic Recorders (ATRs) of the Kentucky Transportation Cabinet (KYTC). The HERS equations were used to estimate speeds on 402 sections of urban roadways for five functional classifications. The speeds from these roadway sections were used to determine the average speed for each of five functional classes. The speeds used in the travel model were also averaged for each urban functional class. The speed adjustment factor for each urban functional class was calculated as the ratio of the average speed using the HERS equations to the average speed using the travel model data.

The KYTC ATR data was used to estimate speeds on 84 sections of rural roadways for four functional classifications. The speeds from these roadway sections were used to determine the average speed for each of four functional classes. The speeds used in the travel model were also averaged for each rural functional class. The speed adjustment factor for each rural functional class was calculated as the ratio of the average speed using the ATR data to the average speed using the travel model data.

The procedures described above produced speed adjustment factors for all functional classes except rural minor collectors and rural and urban local roads and ramps. (Ramps are not officially a separate functional class, but the speed behavior of traffic on ramps is not expected to be like that of any other functional class. Therefore, the ramps were treated as a separate "functional class.") There was not sufficient data to estimate speeds for the roadways of these classes. For the rural minor collectors and rural and local roads, the speed adjustment factor of the next higher functional class was used. For ramps, the speeds in the travel model were used without adjustment (i.e. the speed adjustment factor for ramps = 1).

MOVES

The following table (Table 1) summarizes the MOVES specifications for the runs used to produce data for the four Louisville Metro area counties to develop SIP PM2.5 MVEB's. VMT data for the runs was supplied by KIPDA's TDFM. The summary reflects the format of the MOVES input panels, in addition to the 13 input files that the County Database Manager (CDM) requires. A complete collection the CDM local input files, as well as the specification files, input databases, and output databases is included separately, along with sample MySQL script and a linked excel workbook. The file *Documentation_main.docx* lists the contents of the folders. MOVES was run in the inventory mode ("calculation type" in the "Scale" input panel) in order to provide the quickest and most accurate emission totals, given the data development schedule requirements.

MOVES RunSpecs: PM2.5 Redesignation SIP MVEB data; Louisville, KY PM2.5 Area

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MOVES RunSpec Parameter	Settings / Assumptions
MOVES Version 2010a, MOVES default database 20100830	
Analysis Years Run	2002, 2009, 2012, 2020, 2030; post-process interpolated to 2005, 2008, 2015, 2025
Scale	County, Emission Inventory mode
Time Span	Time aggregation = Hour; 12 months; All hours of day; weekdays & weekends
Meteorology	All 12 months were input, representing (historical) average annual temperatures and humidity for each month. Local temperature and humidity data was collected from NOAA weather stations in Louisville by APCD. Hourly distributions were then propagated using the EPA MOBILE6-MOVES conversion workbook customized by APCD, and used for all four counties.
Geographic Bounds	2 Indiana counties (Clark, Floyd), 2 Kentucky counties (Bullitt, Jefferson) - all run separately and for each analysis year. The small area in Madison Township, Jefferson Co., IN was calculated by IDEM (contracted - using MOVES with assistance and data supplied by APCD).
Vehicles/Equipment	All source types, gasoline and diesel; CNG population was set to 0 for transit buses using the AFV input file.
Fuel Supply Formulations	From most recent (2006) EPA data as well as IAC agreement for each county. Jefferson Co, KY: RFG, Clark & Floyd Co.'s IN: RVP, Bullitt Co., KY: conventional
I/M Programs	2005 runs for Floyd and Clark Co., IN; otherwise none for any county (last active was 2002 (KY) and 2006 (IN)).
Vehicle Populations & Age Distributions	Local county vehicle registration was used to derive vehicle populations and age distributions for Bullitt & Jefferson Counties (KY); 2002 VIN-decoded registration data supplied by IDEM was used for Floyd & Clark Counties (IN); pass-through heavy duty vehicle population and age distribution was developed using national data. MOBILE6 formatted data was converted using the EPA MOBILE6-MOVES converter workbooks, customized by APCD.
Vehicle VMT	Vehicle VMT was derived from earlier MOBILE6 modeling work, which used MOBILE6 default mileage accumulation rates and FHWA 1997 VMT. Fleet VMT mixes in MOBILE6 input format were then converted using the EPA MOBILE6-MOVES converter workbooks, customized by APCD.
VMT Distributions	Monthly=default, Hourly Profile=default, Road Type=data from KIPDA's TDFM (converted from MOBILE6 format), Speed=data from KIPDA's TDFM (converted from MOBILE6 format),

Ramp Fractions	Specific to each county from KIPDA supplied data.
Road Type	All road types including off-network
Pollutants and Processes	NOx, All $PM_{2.5}$ categories, SO_2, Total Energy Consumption
Strategies	Modified AVFT strategy file to reflect 0% CNG buses in the transit fleet
General Output	Units= grams, joules and miles
Output Emissions	Time = annual; Location = county; onroad inventory emission totals by process and pollutant.
Advanced Performance	none

Table 1: MOVES input summary

LMAPCD executed the MOVES runs to produce the onroad emissions data, and also post-processed the data to calculate the emission totals by county. Totals were calculated by using MSExcel workbooks that were linked to exported Excel files produced with the MySQL browser – part of the MOVES 2010a installation suite of programs – which operated on SQL MOVES output databases created for each run. Inputs were formatted for the MOVES CDM by making use of the EPA conversion workbooks, customized by APCD for easier 'cut and paste' transference. Only VMT input data was supplied by KIPDA's TDFM (and converted from MOBILE6 format to MOVES CDM input records). LMAPCD maintains a 'suite' of data with the most recent local data for its *APCD Mobile Suite*. This was used as a source for the MOVES runs required for the MVEB data (*Mobile Suite version g6*). For the Indiana Counties (Clark and Floyd) two sets of runs were made to provide data using both the older '2004' Indiana fleet data (actually 2002 fleet data, updated in 2004), and the new, but as yet not quality assured 2009 Indiana fleet data. *To date, the older (2002) Indiana fleet data was used in development of the SIP MVEB's.*