MOVES Tools Documentation

prepared for

National Cooperative Highway Research Program

prepared by

Cambridge Systematics, Inc.

with

Eastern Research Group, Inc.

September 2014

www.camsys.com

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1.0 Introduction

This document provides documentation for four tools designed to assist MOVES users with preparing inputs. These tools were developed as part of National Cooperative Highway Research Program (NCHRP) Project 25-38, Inputs for Motor Vehicle Emissions Simulator Model (MOVES). The four tools are:

1. **MOVES Operating Mode Data Import Tool –** Utility program that assists MOVES users in taking vehicle trajectories from a traffic simulation model and converting them to operating mode distributions for input to MOVES. This tool is contained in the file **MOVESOpModeDataImport.zip**.
2. **MOVES Meteorology Data Import Tool –** Utility program that reads the National Climatic Data Center (NCDC) Local Climatological Data (LCD) in ASCII format and carries out most of the steps to convert it to MOVES temperature/relative humidity CSV input format. This tool is contained in the file **LCD_MOVES.zip**.
3. **MOVES Highway Statistics Analysis Tool –** Excel spreadsheet that calculates state-level road type distributions and VMT fractions by HPMS vehicle type, for all 50 states, from data reported by the Federal Highway Administration (FHWA) in the Highway Statistics Series. This tool is contained in the file **MOVES VTRIS & HSS Tools.zip**.
4. **MOVES VTRIS Analysis Tool –** Excel spreadsheet that provides summary tabulations from the 2012 Vehicle Travel Information System (VTRIS), for states reporting classified traffic count data to FHWA. This tool provides sample hour and day of week VMT fractions by state, road type, and vehicle class. This tool is contained in the file **MOVES VTRIS & HSS Tools.zip**.

2.0 MOVES Operating Mode Data Import Tool

2.1 INTRODUCTION

The MOVES Operating Mode Data Import Tool is intended to assist MOVES users in taking vehicle trajectories from a traffic simulation model and converting them to operating mode distributions for input to MOVES. This can assist MOVES users in project-level analysis when detailed information on vehicle activity is available from a traffic microsimulation model. Vehicle trajectories are typically described as second-by-second speed and acceleration profiles. Vehicle trajectories can be input directly to MOVES, but only one trajectory can be entered for each link to represent the "tracer" path of an average vehicle (representing potentially hundreds of vehicles from all 13 source types) on each link. There is a method to overcome this limitation by defining multiple overlapping links with separate source type distributions and drive schedules, but it would be cumbersome to employ this method for hundreds or thousands of individual trajectories that comes from the output of a traffic simulation model. This tool takes the numerous individual vehicle trajectories and creates a single operating mode distribution for each source type on each link to represent the full range of activity that occurs on the link instead of the average vehicle activity.

The tool requires Microsoft.Net Framework to run. Traffic microsimulation models output vehicle trajectories in different file formats. The user is responsible for any pre-processing required to convert the output from their traffic simulation model to the generic format employed in the trajectory input file for this tool. For example, most simulation models have a vehicle type classification scheme different than the 13 MOVES source types. The user will need to figure out the appropriate mapping of vehicle types to provide the trajectory input file with MOVES source types. The user can include an unlimited number of trajectories for individual vehicles in the trajectory input file. The tool processes the trajectories and automatically produces a single operating mode distribution file. These distributions are the fraction of time spent in any of 23 operating mode bins (a combination of vehicle-specific power (VSP) and speed). The tool prepares a file directly usable for MOVES operating mode distribution input in the Project Data Manager.

2.2 REQUIREMENTS

For this application to work, the following software must be installed on the local computer:

- Microsoft Windows 7 (or greater); and
- Microsoft.Net Framework Version 4.0.

2.3 INSTALLATION

The Microsoft.Net Framework is a software component which can be added to the Microsoft Windows operating system. It provides a large body of pre-coded solutions to common program requirements, and manages the execution of programs written specifically for the framework. If necessary, the Microsoft.Net Framework version 4.0 redistributable package can be downloaded directly from the Microsoft web site. Follow the instructions on how to install the package.

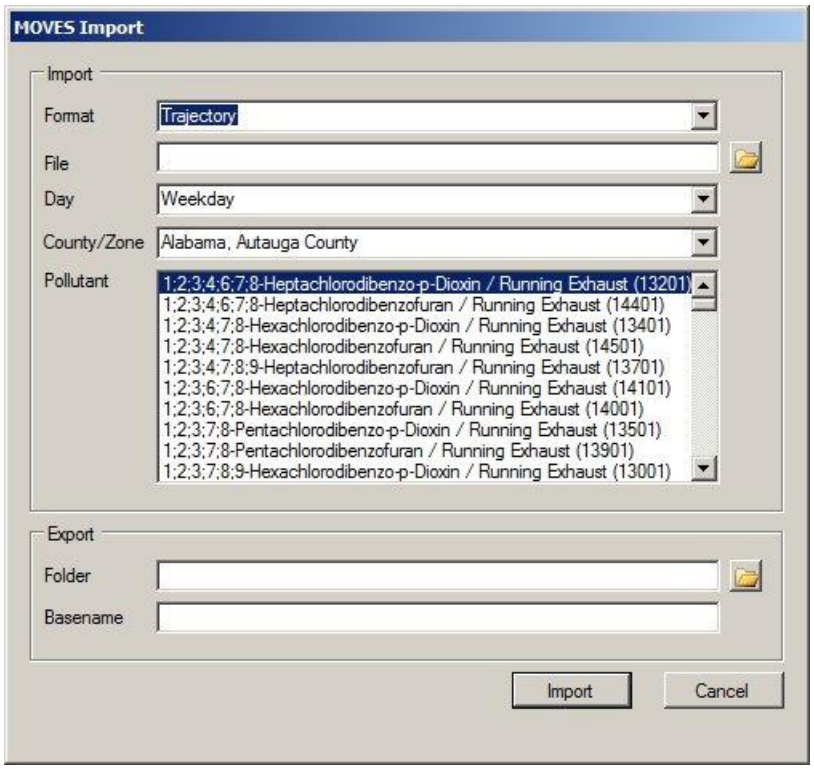
2.4 APPLICATION

To install the application, extract the contents of the "MOVESOpModeDataImport.zip" file to a folder on the computer. This zip file contains several files:

- MOVESDataImport.exe (the application);
- MOVEScounties.csv – U.S. counties in CSV format;
- PollutantProcessAssoc.csv – Pollutant Processes in CSV format; and
- SourceUseType.csv – Source Types in CSV format.

2.5 EXECUTION

To execute the application, double-click the MOVESDataImport.exe file in the installation folder. Once the application is opened, the Import dialog is displayed:



2.6 DATA IMPORT

To import data into the MOVES format:

- Select:
  - The import data format.
  - The CSV file containing the data to import. Click the Browse button to the right of the File textbox to display a File Dialog to allow the file to be selected.
  - Whether the data refers to weekdays or weekends.
  - The County for the data.
  - The Pollutants to reference.
  - The export folder. Click the Browse button to the right of the Folder textbox to display a File Dialog to allow the export folder to be selected.
  - The base name for the MOVES files.
- Click "Import." The import file is processed and validated, and then the data is exported into the MOVES format.

2.7 CSV FILE FORMATS

The MOVES Data Import application uses a number of Comma Separated Value (CSV) files to stored configuration data, the import data and the export data. The format of these CSV files are described below.

Configuration Files

The configuration files are used to populate the import dialog.

MOVESCounties.csv

Stores all of the U.S. counties.

Field	Format	Description
State Name	String	Name of the State
County Name	String	Name of the County
CountyID	Integer	ID for the County
ZoneID	Integer	ID for the Zone

PollutantProcessAssoc.csv

List of the pollutants that can be referenced within MOVES.

Field	Format	Description
PolProcessID	Integer	ID of the Pollutant Process
ProcessID	Integer	ID of the Process
ProcessName	String	Name of the Process
PollutantID	Integer	ID of the Pollutant
PollutantName	String	Name of the Pollutant

SourceUseType.csv

List of the source data types referenced within the Import data. The file distributed with the tool is from the October 30, 2012 version of the MOVES default database. The user can use an updated version of this file if any of the values change in future versions of the MOVES default database.

Field	Format	Description
SourceTypeID	Integer	ID of the Source Type
HPMSVtypeID	Integer	HPMS Vehicle Type ID
SourceTypeName	String	Name of the Source Type
RollingTermA	Double	A coefficient to represent tire rolling resistance
RotatingTermB	Double	A coefficient to represent higher order rolling resistance factors in addition to mechanical rotating friction losses
DragTermC	Double	A coefficient to represent air drag
SourceMass	Double	Represents the average weight of a given source type
FixedMassFactor	Double	The mass used to calculate VSP. For light=duty vehicles it equals the source mass. For heavy-duty vehicles it is a scaling factor roughly equivalent to the average running weight of all heavy-duty vehicles.

Import File

The import data can be provided in a number for formats.

Trajectory

The input file with all information necessary to calculate VSP and create operating mode distribution, including second-by-second speeds from traffic simulation model outputs and link information like length and grade.

Field	Format	Description
LinkID	Integer	ID of the Link
LinkDescription	String	Description of the Link
VehicleID	Integer	ID of the unique vehicle
Time	Integer	Seconds since midnight
Speed	Double	Vehicle speed on the Link (in mph)
Grade	Double	The slope of a roadway link expressed as a percent (vertical distance/lateral distance; 100% grade equals a 45-degree slope).
Length	Double	Length of the Link (in miles)
SourceTypeID	Integer	One of 13 MOVES source type IDs (11-62)
RoadTypeID	Integer	One of 4 MOVES road type IDs (2-5)

Export Files

Multiple files are exported as part of the processing – one file detailing the Link operating modes, and one or more files detailing the average link speed by hour.

Link_Hour_{Basename}_Hour#.csv

Field	Format	Description
LinkID	Integer	ID of the Link
CountyID	Integer	ID of the County
ZoneID	Integer	ID of the Zone
RoadTypeID	Integer	One of 4 MOVES road type IDs (2-5)
LinkLength	Double	Length of the Link (in miles)
LinkVolume	Integer	Number of unique vehicles in the Link within the hour
LinkAvgSpeed	Double	Average vehicle speed on the Link (in mph)
LinkDescription	String	Description of the Link
Length	Double	Length of the Link (in miles)
SourceTypeID	Integer	One of 13 MOVES source type IDs (11-62)
LinkAvgGrade	Double	Average grade of the Link

OP_Mode_{Basename}_Short.csv

Field	Format	Description
SourceTypeID	Integer	One of 13 MOVES source type IDs (11-62)
HourDayID	Integer	Combination of Hour and Day
LinkID	Integer	ID of the Link
PolProcessID	Integer	ID of the Pollutant Process
OPModeID	Integer	ID of the Operating Mode
OPModeFraction	Double	Fraction of the total time in this Operating Mode

3.0 Meteorology Data Import Tool

3.1 INTRODUCTION

This utility program, called LCD-to-MOVES, reads the National Climatic Data Center Local Climatological Data in ASCII format and carries out most of the steps to convert it to MOVES temperature and relative humidity inputs in CSV input format.

The meteorology data for MOVES is contained in the ZoneMonthHour table of the MOVES database. Table 3.1 shows the fields in this table that must be populated with data to complete a MOVES model run:

- **MonthID –** Corresponds to the numeric representation of the month;
- **ZoneID –** Represents the two-digit state FIPS code and three-digit county FIPS code followed by a zero;
- **HourID –** The numeric representation of the hour of the day: hour 1 begins at 12:00 midnight; hour 2 begins at 1:00 a.m., etc.;
- **Temperature –** Average temperature (degrees Fahrenheit); and
- **RelHumidity –** Relative humidity (percent).

Table 3.1 Example of Meteorology Import Template (ZoneMonthHour)

monthID	zoneID	hourID	temperature	relHumidity
1	481410	1	40	42
1	481410	2	40	42
1	481410	3	39	44
1	481410	4	39	44
1	481410	5	38	46
1	481410	6	37	47
1	481410	7	37	48
1	481410	8	38	46
1	481410	9	41	41
1	481410	10	45	37
1	481410	11	48	32
1	481410	12	51	29
1	481410	13	53	27

monthID	zoneID	hourID	temperature	relHumidity
1	481410	14	55	25
1	481410	15	55	24
1	481410	16	55	24
1	481410	17	54	25
1	481410	18	52	28
1	481410	19	49	30
1	481410	20	47	33
1	481410	21	45	35
1	481410	22	44	37
1	481410	23	43	39
1	481410	24	42	40

3.2 REQUIREMENTS, INSTALLATION, AND EXECUTION

This application runs in the Microsoft Windows operating system.

To install the application, extract the contents of the "LCD_MOVES.zip" zip file to a folder on the computer. This zip file contains the following files:

- LCD_To_MOVES.exe (the application), in the "Executable" directory; and
- A set of 12 text (.txt) files in the "Download" directory that are provided as sample meteorological data files.

To execute the application, double-click the LCD_To_MOVES.exe file in the installation folder. Once the application is opened, the Import dialog is displayed.

3.3 DATA IMPORT

To run the application, the user creates a directory, then downloads the 12 monthly LCD files from the NCDC web site, as described in the MOVES Inputs Resource Document, Section 4.8. The user provides the program with the location of these files. The program will, in turn, extract the Summary of the Hour information from the 12 files and output a single 12-month MOVES-ready meteorological input file. The specific steps to run this tool are as follows:

- **Step 1 –** Create a local subdirectory called "Downloads" to store the downloaded LCD data from the NCDC web site.
- **Step 2 –** Obtain 12 months worth of LCD data in ASCII format (*.txt). Follow Steps 1 through 4 from Section 4.8. **Twelve months of data are required**.
- **Step 3 –** Start the program by double-clicking on the executable name in Windows Explorer (Figure 3.1).
- **Step 4a –** Enter the full path to the NCDC LCD Downloads directory in the *LCD Directory* box. It is typically simpler to search for the directory in Windows Explorer, then copy the address and paste into this box (Figure 3.2); **or**
- **Step 4b –** Click "Browse," to open a Windows Explorer session to locate the directory (Figure 3.2). Note: the "Browse" feature actually searches for an individual file. There should be 12 files in the Downloads directory. Any of the 12 files is acceptable (Figure 3.3).
- **Step 5 –** If the program locates the directory, the path will display in the "LCD Directory" text box, and "Directory Exists" will display, denoting the directory has been found (Figure 3.4).
- **Step 6 –** Enter a valid ZoneID (Figure 3.5). The ZoneID represents the two-digit state FIPS code and three-digit county FIPS code, followed by a zero. The entry must follow FIPS code format (between 01001 and 56500), plus the required trailing "0." Leading zeroes are required for state codes 01-09. Note: this does not mean an exact FIPS match is sought, just that the general format be followed. For example, 019999 is considered a valid ZoneID, even though this is an invalid FIPS code (999 is not a valid county code); and, a trailing "9" was entered instead of "0." That said, if the ZoneID does not match the MOVES project ZoneID, the output met file from LCD-to-MOVES will not be accepted when MOVES processing is performed.
- **Step 7 –** If all inputs are valid the "OK" button will be enabled and can be clicked to begin execution (Figure 3.6).
- **Step 8 –** Go to the "Downloads" subdirectory and locate the program output file (LCD_To_MOVES.Output.csv) (Figures 3.7 and 3.8).

Figure 3.1 LCD_To_MOVES Banner

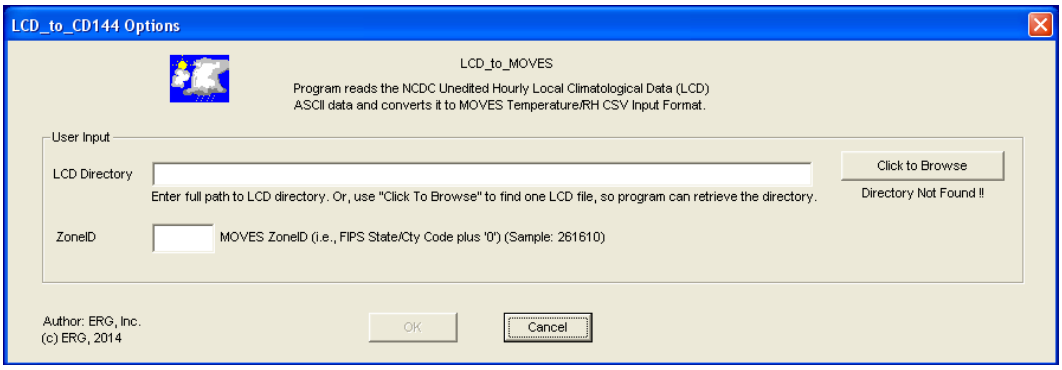


Figure 3.2 LCD-To-MOVES User Input – *Step 1: LCD Directory Options*

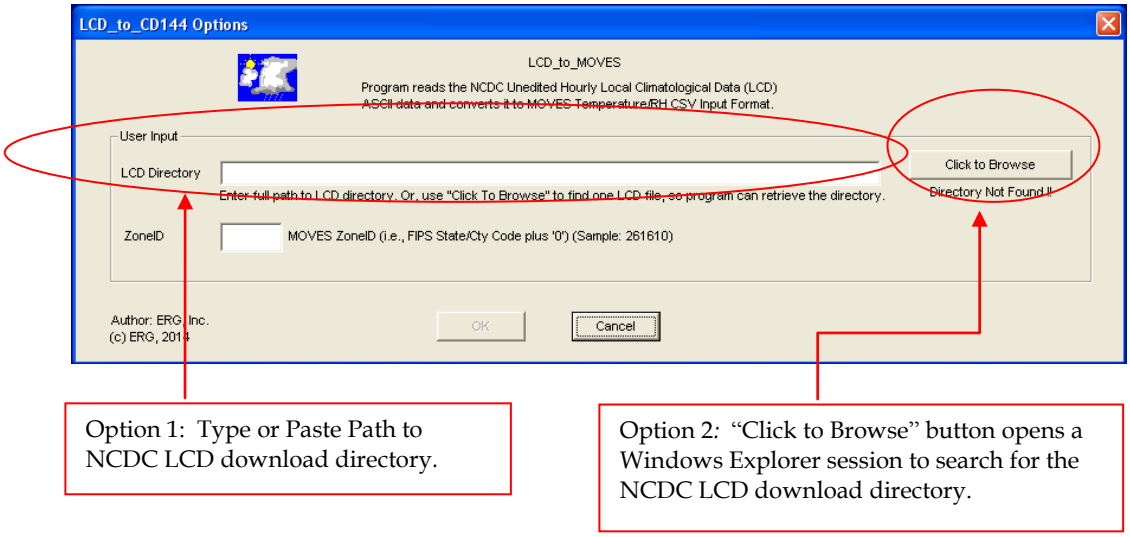
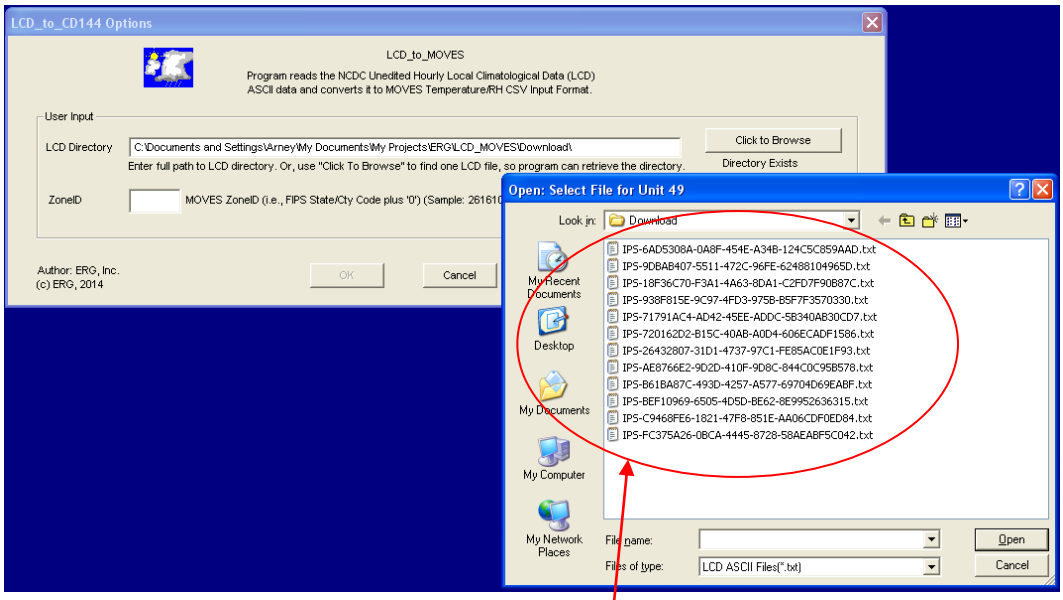
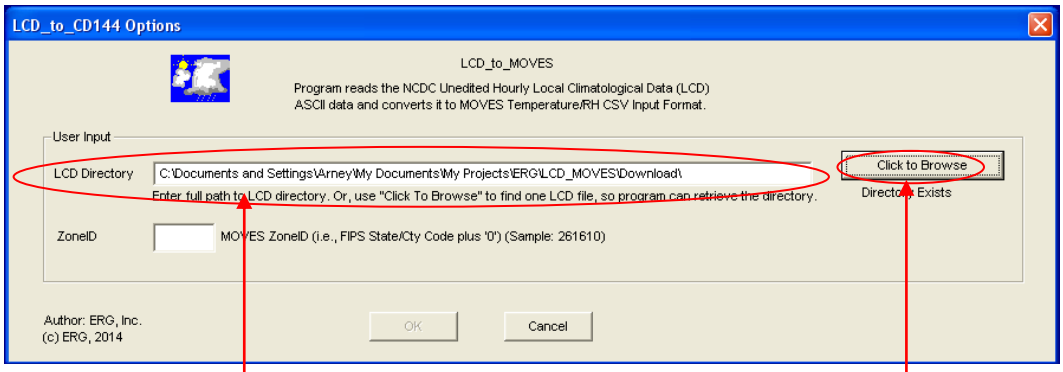


Figure 3.3 Selection of Option 2 (Click to Browse) Example



LCD Directory found. Select one of the files so program can retrieve the directory.

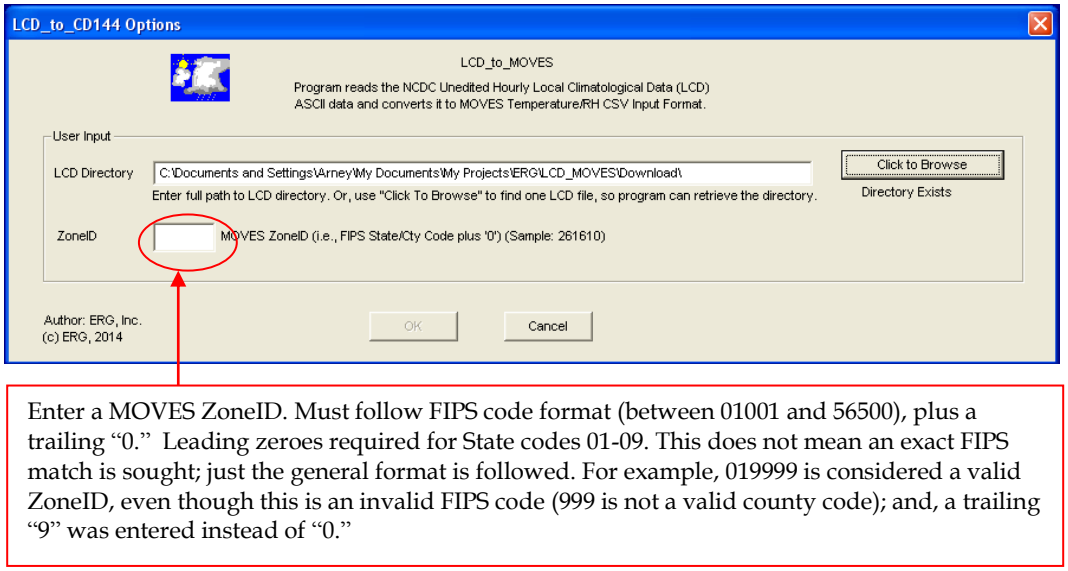
Figure 3.4 Option 2 Browse Successful



Text now reflects path to NCDC LCD files, which was returned during Option 2 "Browse" operation.

"Directory Exists" User-specified path to NCDC LCD files was found.

Figure 3.5 LCD-To-MOVES User Input – *Step 2: ZoneID*



Enter a MOVES ZoneID. Must follow FIPS code format (between 01001 and 56500), plus a trailing "0." Leading zeroes required for State codes 01-09. This does not mean an exact FIPS match is sought; just the general format is followed. For example, 019999 is considered a valid ZoneID, even though this is an invalid FIPS code (999 is not a valid county code); and, a trailing "9" was entered instead of "0."

Figure 3.6 LCD-To-MOVES User Input – *Step 2: ZoneID Successful*

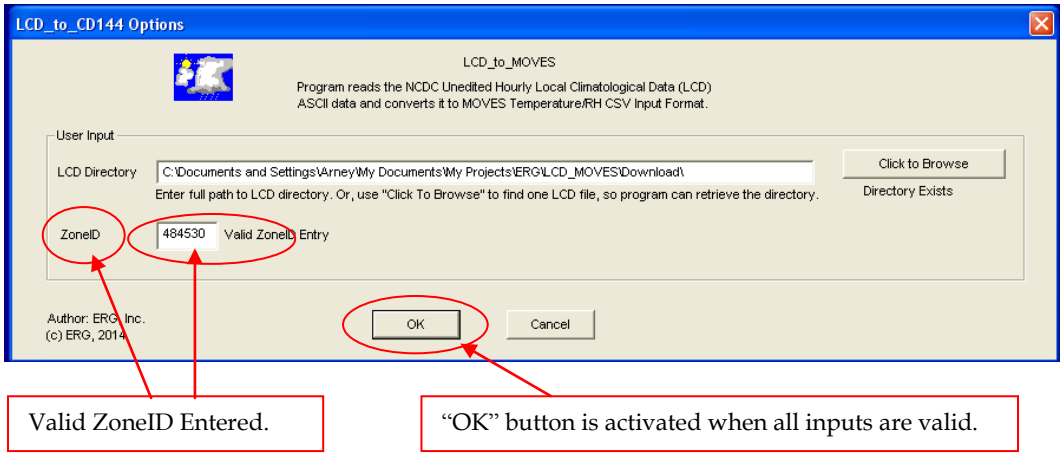


Figure 3.7 NCDC Downloads Directory after Successful LCD-To-MOVES Execution

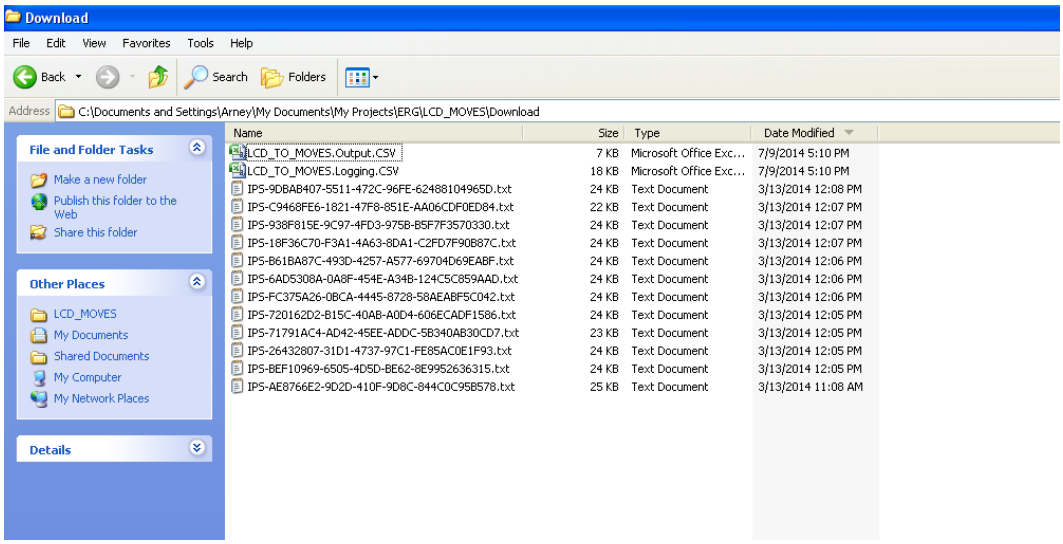
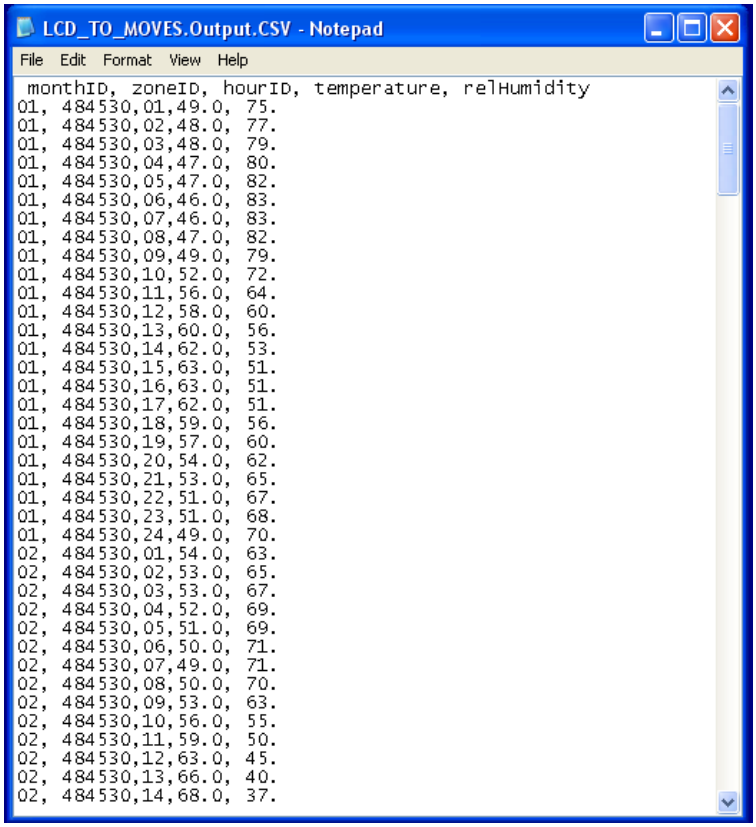


Figure 3.8 Output – MOVES-Ready Meteorological File – *LCD_To_MOVES.Output.CSV*




```
monthID, zoneID, hourID, temperature, relHumidity
01, 484530,01,49.0, 75.
01, 484530,02,48.0, 77.
01, 484530,03,48.0, 79.
01, 484530,04,47.0, 80.
01, 484530,05,47.0, 82.
01, 484530,06,46.0, 83.
01, 484530,07,46.0, 83.
01, 484530,08,47.0, 82.
01, 484530,09,49.0, 79.
01, 484530,10,52.0, 72.
01, 484530,11,56.0, 64.
01, 484530,12,58.0, 60.
01, 484530,13,60.0, 56.
01, 484530,14,62.0, 53.
01, 484530,15,63.0, 51.
01, 484530,16,63.0, 51.
01, 484530,17,62.0, 51.
01, 484530,18,59.0, 56.
01, 484530,19,57.0, 60.
01, 484530,20,54.0, 62.
01, 484530,21,53.0, 65.
01, 484530,22,51.0, 67.
01, 484530,23,51.0, 68.
01, 484530,24,49.0, 70.
02, 484530,01,54.0, 63.
02, 484530,02,53.0, 65.
02, 484530,03,53.0, 67.
02, 484530,04,52.0, 69.
02, 484530,05,51.0, 69.
02, 484530,06,50.0, 71.
02, 484530,07,49.0, 71.
02, 484530,08,50.0, 70.
02, 484530,09,53.0, 63.
02, 484530,10,56.0, 55.
02, 484530,11,59.0, 50.
02, 484530,12,63.0, 45.
02, 484530,13,66.0, 40.
02, 484530,14,68.0, 37.
```

4.0 MOVES Highway Statistics Analysis Tool

4.1 INTRODUCTION

This Microsoft Excel workbook is entitled "MOVES Highway Statistics Analysis Tool.xlsx."

Interactive pivot tables in this workbook provide state-level data for all 50 states that can be used to support the development of two MOVES inputs:

1. Road type distributions by source type; and
2. VMT fractions by HPMS vehicle type.

The sample data in this file may be used if other local data (such as county-level data from traffic counters or a travel demand model) are not available. The data are provided in formats that can be readily adapted to MOVES inputs. However, only six vehicle types can be determined from the data. Data for each HPMS vehicle class may need to be used to represent multiple corresponding MOVES source types in the road type distribution input. For example, the road type distribution for HPMS type 60 (combination trucks) would be used to represent MOVES types 61 and 62 (short-haul and long-haul combination trucks).

Caution should be used in directly applying the VMT fractions observed from traffic counters. In particular, counters have a hard time properly distinguishing type 20 (passenger car) from type 30 (light truck) vehicles. An alternative calculation is provided that breaks down the total type 20 and 30 VMT as reported by state counters by the fraction of each type contained in data embedded in MOVES. The MOVES fractions are based on source type populations (derived from registration data) and average annual miles per vehicle by vehicle type, rather than from traffic counts.

4.2 DATA SOURCE AND UPDATES

The tables are derived from the FHWA Highway Statistics Series, Tables VM-2 (All VMT by State by HPMS Road Class) and VM-4 (Percent of Vehicle Type by State by General Road Type). These were reformatted into the MOVES HPMS vehicle classes and MOVES road types. The most recent Table VM-4 available at the time of creation of this file was for 2010 so the 2010 version of Table VM-2 was also used.

The file is set up such that the user can copy and paste updated VM-2 and VM-4 when available (if provided in the same format) and generate new pivot tables. *The footnotes need to be removed from the state names in the VM tables, and dash texts that indicate zero have to be converted to numeric "0"s.* The worksheet tab **2010 VM-4 Tab A** contains the rural portion of Table VM-4 and the worksheet tab **2010 VM-4 Tab B** contains the urban portion. The worksheet tab **2010 VM-2 Tab A** contains Table VM-2. A hidden tab ("combined and reformatted") contains interim calculations.

4.3 OUTPUT WORKSHEETS

PT Road Type VMT Fractions is the pivot table of road type fractions by HPMS vehicle type. Users can select a state from the drop-down filter in Row 1.

PT VehType VMT Share is the pivot table of VMT by vehicle type. Again, users can select a state from the drop-down filter in Row 1. The statewide total VMT is shown; if applying to a geography other than the state, the percentages by vehicle type should be applied to the total VMT for that geography.

A hidden tab ("Combined and reformatted") contains interim calculations.

5.0 MOVES VTRIS Analysis Tool

5.1 INTRODUCTION

This Microsoft Excel workbook is entitled "VTRIS Analysis Tool.xlsx."

This workbook provides summary tabulations from the 2012 Vehicle Travel Information System (VTRIS),[1] for states reporting classified traffic count data to the FHWA. Tables and charts show:

- VMT hour fractions (percent of VMT in each hour of the day) by state, road type, and vehicle type; and
- VMT day fractions (percent weekday versus weekend) by state, road type, and vehicle type.

The data are provided in formats that can be readily adapted to MOVES inputs. However, only six vehicle types can be determined from the data. Data for each HPMS vehicle class may need to be used to represent multiple corresponding MOVES source types. For example, HPMS type 60 (combination trucks) would be used to represent MOVES types 61 and 62 (short-haul and long-haul combination trucks). The worksheets provide conversions to assist users in creating an input file for the 13 MOVES source types.

Data from 26 states (those reporting classified counts to FHWA) are included in this dataset. However, many states reported only a few stations and data from these dates should be used with caution. Table 4.1 shows the number of stations included in the dataset for each state.

[1] As of this writing, FHWA was considering changing the name of VTRIS to the Traffic Analysis Monitoring System (TAMS).

Table 4.1 Number of Count Stations Included in 2012 VTRIS Dataset

State	Rural Restricted	Rural Unrestricted	Urban Restricted	Urban Unrestricted	Total	Percent of U.S.
Arkansas	10	31	5	5	51	4%
Colorado	12	30	12	8	62	4%
Delaware	0	12	0	5	17	1%
Florida	20	82	44	79	225	16%
Hawaii	0	8	5	28	41	3%
Idaho	2	11	0	3	16	1%
Indiana	13	30	23	12	78	6%
Iowa	0	6	0	0	6	0%
Maine	2	13	0	0	15	1%
Maryland	4	2	2	1	9	1%
Massachusetts	0	0	8	2	10	1%
Minnesota	6	39	7	6	58	4%
Mississippi	12	39	13	15	79	6%
Missouri	14	59	39	4	116	8%
Montana	15	26	0	0	41	3%
Nebraska	6	13	3	6	28	2%
Nevada	4	6	4	2	16	1%
New Hampshire	1	0	3	0	4	0%
New Mexico	3	20	1	0	24	2%
New York	0	0	8	0	8	1%
Ohio	15	42	56	18	131	9%
Pennsylvania	3	19	4	8	34	2%
Rhode Island	1	1	45	1	48	3%
Virginia	46	75	87	73	281	20%
West Virginia	0	2	2	1	5	0%
Wyoming	1	0	0	0	1	0%
Total	**190**	**566**	**371**	**277**	**1,404**	**100%**

5.2 DATA SOURCE

The 2012 VTRIS data were obtained from FHWA Office of Highway Information and Statistics. The data are from classified traffic count stations reporting hourly counts for consecutive 24-hour periods on different days of the week. VTRIS and the data processing procedures are documented more fully in the NCHRP Project 25-38 Final Report. The VTRIS User Guide (including database structures) is available on the FHWA web site, http://www.fhwa.dot.gov/ohim/ohimvtis.cfm.

The worksheet, **12VTRIS HrVOL by FC, State, DOW** contains the raw data. To create these data from the VTRIS data, queries were developed in Microsoft Access to summarize the 10 million records into records of volumes of MOVES Vehicle Types by date, by hour, by state and by MOVES Road Type and to export that information to Excel. The WEEKDAY function was applied to the calendar date to determine the day of the week. The data are not suitable for developing month fractions, since most states did not provide 12-month data. Also, other sources are preferable for developing road type fractions by source type; see the accompanying workbook using data from Highway Statistics.

5.3 OUTPUT WORKSHEETS

PT_Hr is a pivot table to create hour VMT fractions by HPMS vehicle type. Users can select a specific state, set of days of the week (Monday to Friday for weekday, or Saturday/Sunday for weekend), and road type from the menu (pivot table filters) at the top.

Chart_Hr provides the same data in chart format. Users can select state, days of week, and road type from the filters at the top.

PT_HrbyState provides a comparison of VMT hour fractions for all states. However, only one vehicle type can be shown at a time. To show a different vehicle type, users must drag the new vehicle type from the "Choose fields to add…" into the "Values" box in the Pivot Table Field List shown at the right, and remove the old vehicle type from the "Values" box by dragging it into the fields list above.

Chart_HrByState shows the same data in chart format. Again, only one vehicle type can be shown at a time.

PT_DOW allows the user to select a state and road type (from the filters above the table) to show weekday versus weekend VMT fractions.

Notes includes tables showing relevant MOVES ID codes.