CO Florida 2012

FDOT Intersection Air Quality (CO) Screening Model

(FDOT Contract No. BDK78 TWO 98501)

Final Report
to
Florida Department of Transportation

Project Officer
Mr. Mariano Berrios

by

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METRIC CONVERSION TABLE

Symbol	When you know	Multiply by	To find	Symbol
ft	feet	0.305	meters	m
mi	miles	1.609	kilometers	km
in	inches	25.4	centimeters	cm
m	meters	3.28	feet	ft
km	kilometers	0.621	miles	mi
cm	centimeters	0.472	inches	in

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16. Abstract

A new model has been developed for assessing air quality (CO) impacts near Florida roads and intersections. This new model replaces CO Florida 2004, the previous version of Florida's carbon monoxide (CO) screening model for intersections. It updates the screening model to incorporate emission factors produced from the U.S. environmental protection agency's (EPA) MOtor Vehicle Emission Simulator version 2010a (MOVES2010a). Separate emission factors have been developed for each of the seven geographical Florida Department of Transportation (FDOT) districts in Florida. In addition, this new model includes more geometric orientations of previous intersection types and adds a tollbooth option. Additional receptors have been added for each intersection type, and a 360° wind search is included in 5° increments. This version of the CO screening model also includes images from Florida's state parks to add visual interest.

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EXECUTIVE SUMMARY

In order to ensure that a proposed highway transportation project will not adversely impact air quality, a CO air quality modeling study must be done. A large number of motor vehicles idling near or traveling through a large intersection, in concert with adverse meteorological conditions, can produce concentrations of CO near that intersection that may exceed federal air quality standards. Federal Highway Administration (FHWA) and Florida Department of Transportation (FDOT) rules require that state or federal roadway projects be assessed for potential air quality impacts via a project-level CO analysis. A computerized screening model can save much time and effort for each intersection that is analyzed. Considering all the intersections that must be analyzed in any given year, a screening model saves much money for FDOT (either via saved employee time, or through reduced consultant fees).

For several years, FDOT has used a computerized screening model (COFL2004) to assess potential CO impacts. By the end of 2010 (when the new EPA emissions model [MOVES] was introduced), COFL2004 had grown outdated. FDOT contracted with the University of Central Florida (UCF) to develop a replacement for COFL2004.

The research team (Dr. David Cooper and Mr. Mark Ritner), undertook this project and completed it in within the allotted time and within budget. The product – COFL2012 – is a much enhanced version of the previous model. It includes (1) the latest version of CAL3QHC2, (2) emission factor (EF) look-up tables developed through many runs of MOVES2010a - EPA's latest motor vehicle emissions model, (3) seven geographic regions corresponding to the seven FDOT Districts, (4) twelve intersection types, each with more receptors than before, (5) 360° wind angle coverage in 5° increments, and (6) the selection and programming of many aesthetically pleasing photographs and graphics depicting various regions of Florida. The new model remains easy to use, and because of the increased accuracy of MOVES2010a, produces CO concentrations that are slightly lower than those predicted from the older model for similar scenarios.

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LIST OF ABBREVIATIONS

Acronym	Meaning
CO	carbon monoxide
COFL2012	CO Florida 2012
EF	emission factor
EPA	United States Environmental Protection Agency
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
GUI	graphical user interface
MOVES	Motor Vehicle Emission Simulator
MPF	meteorological persistence factor
ppm	parts per million
RVP	Reid vapor pressure
TPF	total persistence factor
UCF	University of Central Florida
VPF	vehicle persistence factor

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CHAPTER 1. INTRODUCTION

1.1 Statement of Objectives

The main objective of this project was to develop a replacement for the outdated air quality screening model, COFL2004. The new model had to utilize the latest versions of EPA-approved software for detailed mobile source air quality modeling: MOVES2010a for emissions and CAL3QHC2 for dispersion. Other objectives were that the new model had to work in Windows, be quick and easy to use, be adaptable to many different types of intersections, be applicable to all the various FDOT districts, and be aesthetically pleasing to use.

1.2 Reasons for a Screening Model

In federal or state roadway projects, intersections affected by the project must be analyzed for CO impacts. Large intersections may have significant impacts and must be assessed using the latest EPA- and FHWA-approved software (such as MOVES2010a and CAL3QHC2). A valid computerized screening model is one that incorporates the latest software, is quick and easy to use, and is one that screens all intersection types.

A screening model works for all intersections by using conservative assumptions and built-in inputs to run a quick analysis of a closely related "standardized" intersection in order to make a "worst-case" assessment. If the worst-case model does not predict a violation of standards, then it is safe to assume that a more detailed realistic model will not predict a violation either. The big advantage of the screening model is that it can be done very quickly compared with a detailed approach (minutes vs days). Keely and Cooper discussed the advantages of computerized screening models for project-level analysis.[1]

If an intersection passes the screening test, nothing further needs to be done; if the intersection fails the screening test, then a more detailed assessment is required. A detailed assessment requires using actual intersection and receptor geometry, actual traffic predictions for all legs of the intersection, and running MOVES2010a and CAL3QHC2 independently, and this may take several person-weeks of effort for one complicated intersection. Several states now have screening models, some of which were developed by the research teams at UCF. These states include Florida, Colorado, Georgia, and Alabama. Both EPA and FHWA have accepted these screening models for use in the air quality impact assessment process.

1.3 Description of COFL2012

Under the contract with FDOT, work began on COFL2012 in April 2011. Written in Visual Basic using Microsoft Visual Studios 2010, the final version of the new model executes within a few minutes with minimal user input, and produces CO predictions for a variety of intersection types. These intersection types include four-way intersections, tee intersections, freeway diamond interchanges, and tollbooths. COFL2012 adds more flexibility and more features than the old screening model, but remains very quick and easy to use. The new model has many beautiful and significant photos and graphics for the state of Florida. For COFL2012, the dispersion modeling is performed (as with COFL2004) using an embedded CAL3QHC2 model with pre-set FDOT-approved input scenarios and parameters appropriate to screening analysis. The emission factors (EFs) utilized in CAL3QHC2, however are now compiled in look-up tables that have been generated through many runs of MOVES2010a. A new report page has been designed to let the user view all the inputs and outputs on one-page.

The program opens with an introductory screen that identifies the model and version number. A different state-significant photo loads each time that COFL2012 is run. Upon a user click, the title screen appears allowing the input of the project title, facility name, analyst's name, year, and type of land use. It should be noted that when the user selects the land use choice the model automatically inserts the appropriate values of the following parameters into the CAL3QHC2 input file: CO background concentration, surface roughness parameter, and atmospheric stability class.

On the next screen, a map of Florida appears which is divided into FDOT districts. The user clicks on a district and the computer automatically selects and loads the table of emission factors unique to that district from a text file. Another screen then comes up that lets the user choose the type of intersection, which is followed by a screen for the input of traffic volumes and speeds unique to the scenario being modeled. The mostly pre-built CAL3QHC2 files are then completed automatically, requiring no further user input, thus providing increased accuracy but maintaining ease of use for the user.

1.4 Assumptions Built into COFL2012

Any screening model must incorporate a number of assumptions. The assumptions should be conservative but realistic. The combination of many conservative (but realistic) assumptions will lead to an extremely conservative model without being completely unrealistic. One example of this is the temperature. A colder temperature gives a higher emission factor for CO. We selected the average January minimum temperature for each district, based on historical meteorological data. Complete sets of the assumptions and default input values are included in the tables presented later in this report.

1.5 MOVES2010a

MOVES2010a (MOtor Vehicle Emissions Simulator, version 2010a) is a computer program designed by the EPA to estimate air pollution emissions from mobile sources. The newest version was released in 2011, and MOVES2010a replaced the EPA's previous emissions model for on-road mobile sources, MOBILE6.2.

COFL2012 uses look-up tables for EFs which were generated though many runs of MOVES2010a. Because COFL2012 accesses these values directly, it runs quicker than COFL2004, which ran MOBILE6.2 in the background. In addition, because COFL2012 has incorporated the latest, EPA-required mobile source emission model, it is inherently more up-to-date than COFL2004. The user inputs for MOVES that were employed in the development of the COFL2012 EF look-up tables are detailed in Tables 1 and 2.

CO emissions are most critical in winter months and are sensitive to ambient temperature. Because temperatures vary significantly in different areas of Florida during the winter, it is more accurate to divide the state into regions to account for these temperature variations. The six geographical regions which were utilized in COFL2004 and previous Florida CO-based screening models were replaced in COFL2012 with the seven geographical districts defined by FDOT. For the MOVES2010a runs, each district was represented by a geographically central county as summarized in Table 1.

Indirectly, the analyst also selects other MOVES input parameters (such as temperature, RVP, and vehicle fleet mix) when selecting one of the seven districts (project location) within Florida. Because of these built-in district-specific default values, COFL2012 may only be applied to projects in Florida.

Table 1. MOVES General Inputs for Idle and Cruise Emission Factors

Input Tab	**Input Value**
Description	***** User Input *****
Scale Domain/scale Calculation type	 Project Inventory
Time Spans Time aggregation level Year of evaluation Month of evaluation Days of evaluation Evaluation hour	 Hour ***** User Input ***** January Weekdays 7:00-8:00 a.m.
Geographic Bounds Evaluation county	FDOT district 1 = DeSoto County FDOT district 2 = Union County FDOT district 3 = Calhoun County FDOT district 4 = Martin County FDOT district 5 = Seminole County FDOT district 6 = Collier County FDOT district 7 = Pasco County
Vehicles/Equipment On Road Vehicles	 All applicable gasoline and diesel vehicles
Road type	Urban unrestricted access
Pollutants and Processes	CO running exhaust, CO running crankcase exhaust

(***This table is continued next page)***

Table 1. (cont.)

Input Tab	Input Value
Manage Input Data Set Database	***** User Input *****
Strategies	Default inputs
Output Mass units Energy units Distance units Activity Output emissions	 Grams Joules Miles Distance traveled, population Emission process
Scenarios Calendar year Approach speed Left-turn speed Right-turn speed	 ***** User Input ***** ***** User Input ***** 20 mph 15 mph

Table 2. MOVES Project Data Manager Inputs for Idle and Cruise Emission Factors

Input Tab	Input Value
I/M Programs	n/a
Generic	n/a
Age Distribution	MOVES national default inputs
Fuel	MOVES county-specific default inputs
Meteorological Data	MOVES county-specific default inputs
Link Drive Schedules	n/a
Off-Network	n/a
Operating Mode Distribution	n/a
Links	See Table 3
Link Source Types	See Table 4

Tables 3 and 4 that follow provide examples of the "Links" and "Link Source Type" spreadsheets that were used in the MOVES2010a runs that produced the COFL2012 EF look-up tables.

Table 3. Example "Links" Spreadsheet for MOVES Runs, DeSoto County

Link ID	County ID	Zone ID	Road Type ID	Link Length	Link Volume	Link Average Speed	Link Desc.	Link Average Grade
1	12027	120270	5	1	1	0		0
2	12027	120270	5	1	1	5		0
3	12027	120270	5	1	1	10		0
4	12027	120270	5	1	1	15		0
5	12027	120270	5	1	1	20		0
6	12027	120270	5	1	1	25		0
7	12027	120270	5	1	1	30		0
8	12027	120270	5	1	1	35		0
9	12027	120270	5	1	1	40		0
10	12027	120270	5	1	1	45		0
11	12027	120270	5	1	1	50		0
12	12027	120270	5	1	1	55		0
13	12027	120270	5	1	1	60		0
14	12027	120270	5	1	1	65		0

Table 4. Example” Link Source Type” Spreadsheet for MOVES, DeSoto County

Link ID	Source Type ID	Source Type Hour Fraction	Source Type Description
1	11	0.034	Motorcycle
1	21	0.580	Passenger Car
1	31	0.293	Passenger Truck
1	32	0.049	Light Commercial Truck
1	41	0.003	Refuse Truck
1	42	0.001	Single Unit Short-Haul Truck
1	43	0.004	Single Unit Long-Haul Truck
1	51	0.000	Motor Home
1	52	0.010	School Bus
1	53	0.001	Transit Bus
1	54	0.001	Intercity Bus
1	61	0.010	Combination Short-Haul Truck
1	62	0.014	Combination Long-Haul Truck

*Note: The Source Type ID’s and Hour Fractions are copied identically for Link ID’s 1-14

1.6 CAL3QHC2

CAL3QHC2 runs each time that COFL2012 runs. Most inputs are pre-set default values with only a few inputs to be determined by the analyst. Again, this feature simplifies the analyst's job, yet retains the accuracy of CAL3QHC2. CAL3QHC2 inputs are identified in Tables 5 and 6. The CAL3QHC2 data required to be entered into COFL2012 are the project title, facility name, the intersection type, and the peak-hour traffic approach volumes.

CAL3QHC2 requires that an intersection be defined and its coordinates be input. Because this is a screening model and to save significant time for the user, several standard intersection geometries have been pre-defined. COFL2012 includes the choice of twelve pre-defined intersection configurations. The coordinate system for each has been developed and is internal to the program; the analyst has *no need* to input any real coordinates.

Table 5. CAL3QHC2 Input Parameter Values - Pre-set and User Input

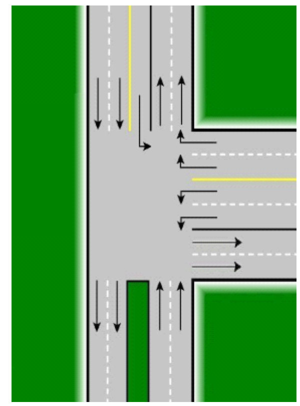
Input	Values
Job title	***** User Input *****
Averaging time	60 minutes
Surface roughness Z_o	
Urban	175. cm
Suburban	108. cm
Rural	10. cm
Settling and deposition velocity	0 and 0
Number & location of receptors (See Table 6 for specifics)	Default
Receptor height	6 ft for all receptors
<u>*Queue links*</u>	
Source height	0
Number of travel lanes in queue	Dependent on Intersection type selected
	12 ft/lane x #lanes
Mixing zone width	120 sec
Average signal cycle length	See Table 7
Average red time	3 sec
Clearance lost time	***** User Input *****
Traffic volume	MOVES Look-up tables
Idle emission factor	1600 vph/lane
Saturation flow rate – arterial	1500 vph/lane
Saturation flow rate – off ramps	pre-timed
Signal type	average progression
Arrival rate	

(***This table is continued next page)***

Table 5. (cont.)

Input	Values
Free flow links	
Traffic volume	***** User Input *****
Emission factor	MOVES Look-up tables
Source height	0
Mixing zone width	12 ft/lane x #lanes + 20 ft
Meteorology	
Wind speed	1.0 m/s
Wind angle	360° search
Wind angle variation data	by 5°
Stability class	
urban	D
suburban	D
rural	E
Mixing height	1000 m
Ambient background CO (8-hr)	
urban	3.0 ppm
suburban	2.0 ppm
rural	1.0 ppm
Other Considerations	
Total persistence factor	0.6
% Left turn	15
(except Tee intersections; see Table 6)	

Table 6. Example Tee Intersection Traffic Volume Distribution: East Tee

Approach Leg	Traffic Volume Distribution	East Tee Graphic
South Bound	Through – 85%	
	Left-turning – 15%	
West Bound	Left-turning – 50%	
	Right-turning – 50%	
North Bound	Through – 75%	
	Right-turning – 25%	

In COFL2012, the user inputs the traffic volumes for each approach, and the program selects the worst-case (volume and speed) for each direction and applies that volume to both legs in that direction. The analyst simply inputs the peak-hour *approach* volumes and speeds. The model assumes appropriate turning movements for each type of intersection. For conservatism, these through and left-turning traffic volumes are duplicated for each approach of the intersection, and are used to calculate departures. The intersection signal timings that were used in the model are given in Table 7.

Table 7. Intersection Signal Red Times* Used in COFL2004

4-way Intersections	East Tee Intersection	E-W Freeway Diamond Interchange
Thru lanes – 60 sec Left-turn Lanes – 90 sec	South bound leg: Thru lanes – 40 sec Left-turn lane – 80 sec	Off ramps: Left-turn lane – 90 sec Right-turn lane – 80 sec
	West bound leg: Left-turn lane – 80 sec Right-turn lane – 40 sec	West intersection: Eastbound lanes – 60 sec Westbound thru – 30 sec Left-turn lane – 90 sec
	North bound leg – 80 sec	East intersection: Westbound lanes – 60 sec Eastbound thru – 30 sec Left-turn lane – 90 sec

*Note: 120 second total signal cycle time

The methodology described above makes the model more conservative than reality, as befits a screening model, which was also the case with COFL2004. However, unlike COFL2004, COFL2012 uses more receptors, and they are located in all four quadrants in order to capture the worst-case CO concentration. These receptor coordinates are documented in Table 8. Also, the wind directions are searched by 5 degrees throughout the whole compass to ensure finding the highest CO concentrations. Due to the greater speed of modern PCs, it is no longer necessary to "cut corners" to save computer time during the analysis.

The outputs of CAL3QHC2 are one-hour CO concentrations excluding the background CO concentration. For air quality analyses, it is necessary to convert the one-hour CO concentrations to eight-hour CO concentrations by multiplying by a total persistence factor (TPF) as shown in the following equations. Also, appropriate CO background concentrations are added:

$$CO_{1\text{-hr}} = CO_{CAL3QHC2} + \text{background } CO_{1\text{-hr}} \quad (1)$$

$$\text{Background } CO_{1\text{-hr}} = \text{Background } CO_{8\text{-hr}} / TPF \quad (2)$$

$$CO_{8\text{-hr}} = CO_{CAL3QHC2} \times TPF + \text{background } CO_{8\text{-hr}} \quad (3)$$

where: $CO_{1\text{-hr}}$ = the total one-hour CO concentration, ppm
$CO_{8\text{-hr}}$ = the total eight-hour CO concentration, ppm

Conservative background CO concentrations for Florida are used by COFL2012, namely 3, 2, or 1 ppm for urban, suburban, or rural land uses, respectively. The total persistence factor used in COFL2012 is 0.6 in order to convert a modeled worst-case 1-hour CO concentration into a modeled worst-case 8-hour CO concentration. The TPF reflects the fact that the specified worst-case atmospheric conditions and peak-hour traffic conditions will not remain constant at these worst-case values for eight continuous hours. The receptor coordinates listed in Table 8 are relative to the intersection origins as shown in Figures 1-3.

Table 8. Example Receptor Locations (X,Y,Z), units in feet

Receptor	4X4 Intersection	EW Freeway Diamond	EW Freeway Tollbooth
1	(40,180,6)	(46,361,6)	(-2000,68,6)
2	(40,80,6)	(46,261,6)	(-1250,68,6)
3	(40,40,6)	(46,166,6)	(-500,116,6)
4	(80,40,6)	(336,116,6)	(-150,116,6)
5	(180,40,6)	(1036,46,6)	(-50,116,6)
6	(180,-40,6)	(1036,-46,6)	(50,116,6)
7	(80,-40,6)	(336,-116,6)	(150,116,6)
8	(40,-40,6)	(46,-166,6)	(500,116,6)
9	(40,-80,6)	(46,-261,6)	(1250,68,6)
10	(40,-180,6)	(46,-361,6)	(2000,68,6)
11	(-40,-180,6)	(-46,-361,6)	(2000,-68,6)
12	(-40,-80,6)	(-46,-261,6)	(1250,-68,6)
13	(-40,-40,6)	(-46,-166,6)	(500,-116,6)
14	(-80,-40,6)	(-336,-116,6)	(150,-116,6)
15	(-180,-40,6)	(-1036,-46,6)	(50,-116,6)
16	(-180,40,6)	(-1036,46,6)	(-50,-116,6)
17	(-80,40,6)	(-336,116,6)	(-150,-116,6)
18	(-40,40,6)	(-46,166,6)	(-500,-116,6)
19	(-40,80,6)	(-46,261,6)	(-1250,-68,6)
20	(-40,180,6)	(-46,361,6)	(-2000,-68,6)

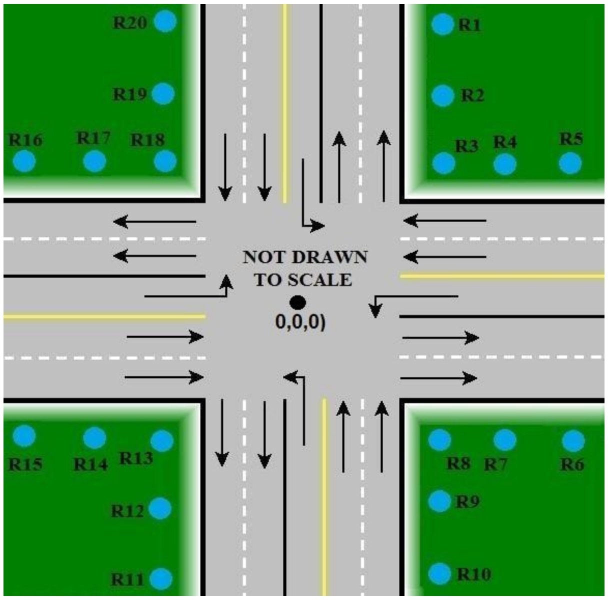


Figure 1. 4X4 Intersection

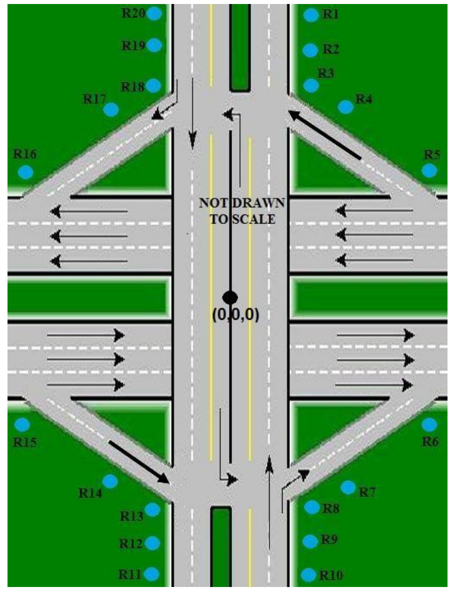


Figure 2. E-W Freeway Diamond

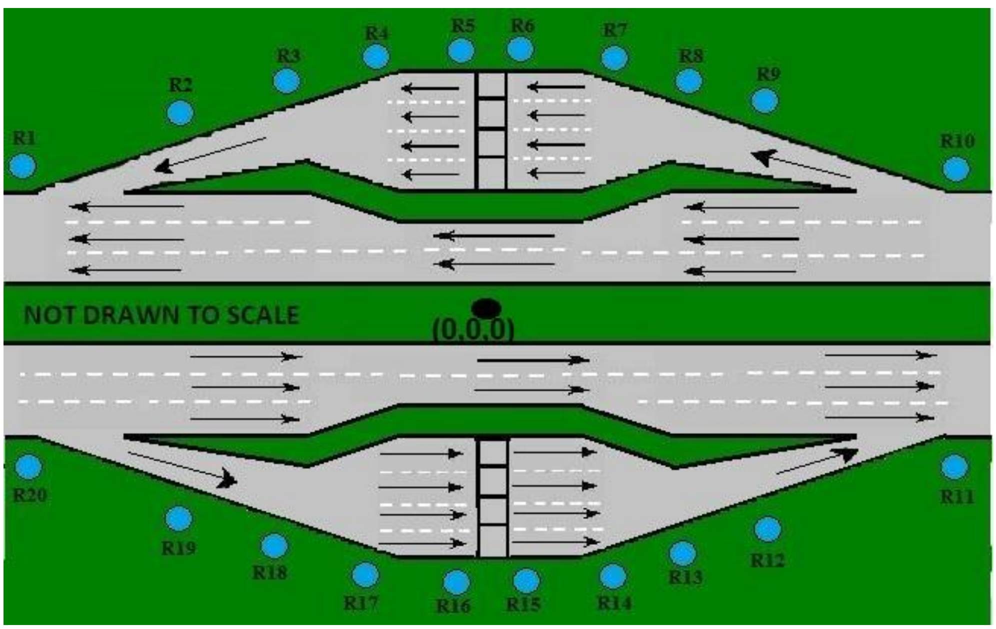


Figure 3. E-W Freeway Tollbooth

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CHAPTER 2. COMPARISON OF COFL2012 WITH COFL2004

2.1 Differences in Models

The old model, COFL2004, was very easy to use but went out of date and lacked accuracy once EPA released MOVES2010a (to replace MOBILE6). Also, COFL2004 lacked flexibility in that it didn't offer multiple geographic orientations of each type of intersection, which COFL2012 now does (e.g., for tee intersections). In addition, COFL2012 includes and receptors in all four quadrants of each intersection, thus eliminating the need to prompt users to enter additional receptors. Also, COFL2012 includes a new tollbooth scenario.

COFL2012 remains easy to use and has increased accuracy in that it includes EFs developed using MOVES2010a. COFL2012 can be used to model projects out to the year 2050. It has more intersection types, more receptors, and 360° wind coverage in 5° increments. The COFL2012 intersection configuration options are shown in Figure 4. COFL2012 has also incorporated Florida-county specific vehicle fleet information, thus making it more accurate than using national default values.

Both models are Windows-based programs, and are easy to use. The outputs of both models show the modeled one-hour and calculated eight-hour CO concentrations at each receptor; including the background concentrations for the specified land use type. COFL2012 offers the user the option to print run results directly or save as a text file that can be opened with a text viewer or word processing program.

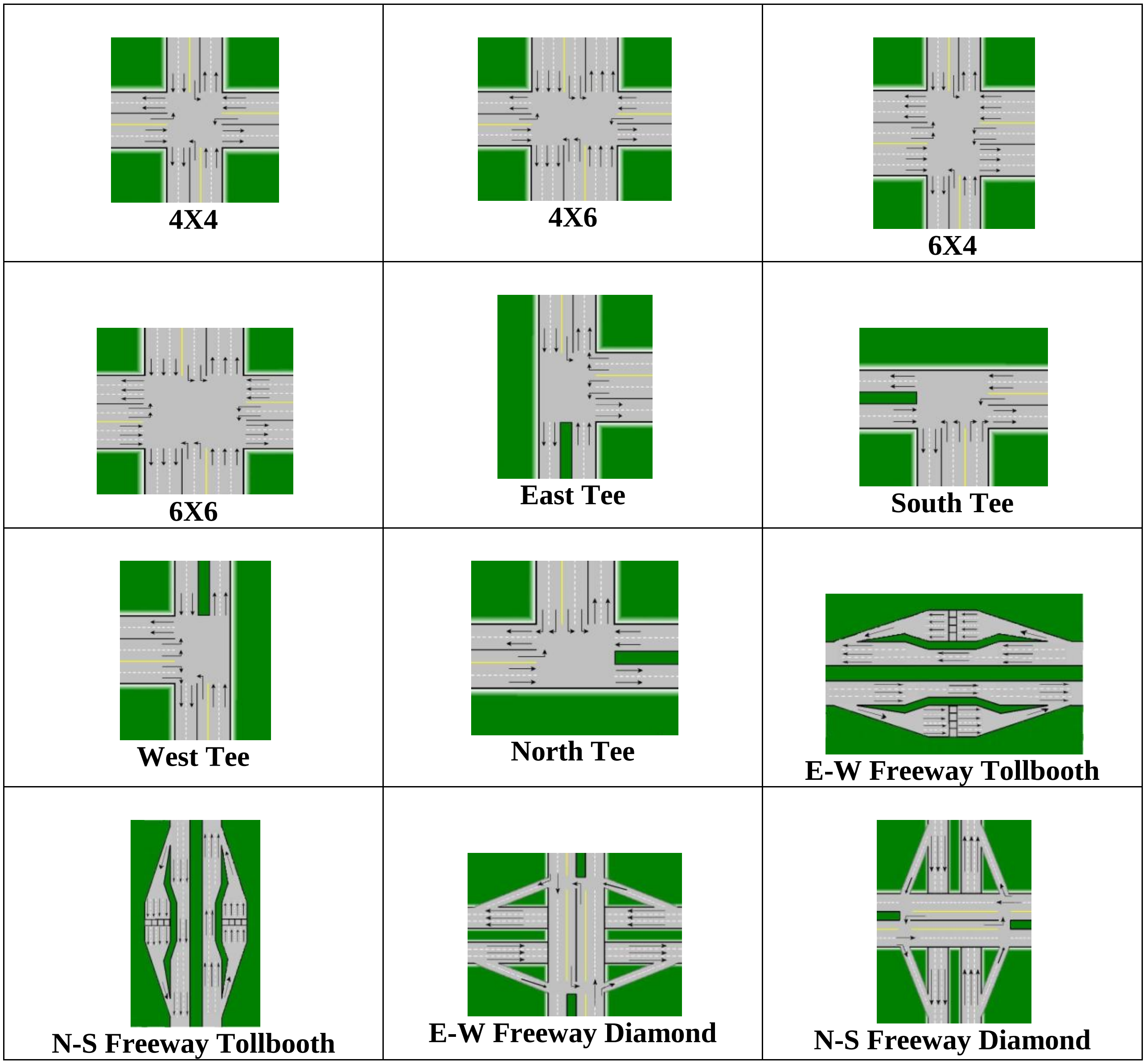

Figure 4. COFL2012 Intersection Configuration Options

A significant improvement in COFL2012 is the inclusion of the effects of acceleration on the CO emissions produced by on-road vehicles. The average speed approach used in MOVES for determining "cruise" EFs simulates real-world driving that includes moderate decelerations and accelerations, while producing an average cruise speed. This approach does not, however, consider the significant increase in emissions that comes from the harder acceleration that occurs when a vehicle accelerates from a complete stop to a cruise speed.

COFL2012 has incorporated the acceleration from a complete stop consideration into the model via the use of EF multipliers. The multipliers serve as correction factors to estimate the average EF under steady acceleration as a multiple of the EF at terminal cruise speed. The multipliers were developed by making multiple MOVES runs using the Link Drive Schedule approach, rather than the Average Speed Approach. Table A-1 in the Appendix provides an example of the link drive schedule spreadsheet that served as the basis of these MOVES runs. For detailed information on this method, see the MOVES2010a User Manual.[4] Each link provides an average EF (in grams per mile) across the link distance under constant acceleration to a final cruise speed, e.g., 0-15 mph, 0-20 mph, etc. The multiple runs of MOVES were then used to create equations for the multipliers as a function of speed and project year. Note that for the freeway diamond on-ramps, a 2% grade was employed (and “2s” replace the “0s” in the Grade % column in Table 12 in the Appendix). Table 9 presents a summary example of multipliers under level (0% grade) and inclined (2% grade) acceleration conditions, and shows the much higher EFs for vehicles that are accelerating hard compared with vehicles that are cruising smoothly at one speed.

Table 9. Example of Multiplier Calculations

Terminal Speed (mph)	Acceleration (mph/s)	% Grade	EF Free Flow (g/mile)	EFAccel (g/mile)	Multiplier
40	6	0	4.41	62.4	14.2
50			4.16	62.6	15.0
60			4.28	52.3	12.2
40	6	2	4.41	66.4	15.1
50			4.16	66.6	16.0
60			4.28	55.6	13.0

2.2 Differences in Results: COFL2012 vs COFL2004

The results of the CO screening tests using these two models are different for many reasons, the main one being that MOVES2010a is being used instead of MOBILE6.2. For CO emissions, MOVES2010a produces much lower CO emissions factors than MOBILE6.2 did, reflecting the reality the fact that cars are even less polluting than was predicted by MOBILE6.2.[2,3] Offsetting the much lower cruise and idle CO EFs to some extent is the fact that COFL2012 has tried to model the effects of acceleration via the use of EF multipliers as previously discussed. Because of the many new intersection configurations offered in COFL2012, it is hard to compare the two models side by side, but in general, the CO concentrations predicted by COFL2012 are slightly lower than those predicted by COFL2004. These lower “worst-case” concentrations mirror observations that cars are now cleaner than in the past, as evidenced by declining monitored CO concentrations nationwide.

As an example to illustrate the differences, both models were run for a 4 x 4 intersection for the year 2015 and 2025 for two different traffic volumes. In both cases the region was Central Florida, the land use was urban, and the approach speed was 45 mph. The results are shown in Table 10. As can be seen, the CO concentrations from COFL2012 are lower than those from COFL2004. The lower emission factor predictions simply reflect the fact that cleaner cars are now available that emit much less CO than before, and that MOVES2010a models that fact better than MOBILE6.2. This comparison demonstrates that COFL2004 (with MOBILE6.2) was over-predicting future CO impacts, and that COFL2012 is a more accurate model for use in CO screening of Florida intersections.

Table 10. Comparison of Results for one Intersection* COFL 2012 vs COFL2004

	Highest 8-hour CO Concentration Predicted, ppm			
Highest Traffic Volume	Year 2015		Year 2025	
Peak hour flow, vph	COFL2004	COFL2012	COFL2004	COFL2012
1500	5.5	4.6	5.1	4.1
3000	7.0	5.8	6.4	5.2

*Note: Analysis of a 4x4 central Florida urban intersection with arterial speed = 45 mph

CHAPTER 3. USE OF THE NEW MODEL

Once EPA officially implements MOVES as the official mobile source model for conformity purposes, COFL2012 should be used for every air quality analysis of roadway projects in the state of Florida. It probably can be used starting immediately, but if FDOT so desires, COFL2004 can continue to be used for now. The use of either screening model will save considerable time and expense for analysts by quickly eliminating from further consideration a large percentage of the intersections analyzed each year.

The model is very easy to use. From the "Start Programs" menu on the PC or the desktop shortcut, the user selects "CO Florida 2012." The opening screen appears and the user clicks "Continue," and then follows the self-explanatory screens in sequence.

With all data entered, COFL2012 extracts the relevant EFs from the table of MOVES EFs for the project FDOT district. The EF extraction occurs almost instantaneously, and these values are then incorporated into a CAL3QHC2 input file. Next, the model continues its analysis using CAL3QHC2. The black DOS screen will appear for a few seconds while CAL3QHC2 runs, followed by a brief pause as COFL2012 retrieves the pertinent results from the CAL3QHC2 output file ("outcal3qhc.out") COFL2012 extracts the 1-hour concentrations calculated by CAL3QHC2 at the various receptors, adds the appropriate 1-hr background concentration, and also converts these data to 8-hour concentrations (including background) utilizing a total persistence factor (TPF) of 0.6.

After the model finishes extracting and converting the concentrations, it creates a 1-page summary report which is displayed on the results screen. The bottom of the screen indicates whether or not the run has passed the screening criteria (did not exceed either the 1-hour (35 ppm) or the 8-hour (9 ppm) CO ambient air concentration standards). A detailed description of each screen and the input options available to the user is presented in the COFL2012 User's Guide (published as a separate document).

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CHAPTER 4. CONCLUSIONS AND RECOMMENDATIONS

This project was finished on time and on budget. The new model uses the latest EPA-approved software (MOVES2010a and CAL3QHC2), allows for analysis of twelve intersection configurations, provides more receptors than the older model, incorporates 360° wind coverage in 5° increments, covers each of the seven FDOT Districts, and includes many aesthetically pleasing photographs and graphics depicting various regions of Florida. It operates quickly and easily from within Windows, and is accessible and understandable to anyone who needs to do this task. It is concluded that this new model achieves the goals of this project for FDOT, will perform well for FDOT and others for intersection analyses within the state of Florida, and will save FDOT a considerable amount of time, effort, and money throughout the next several years.

It is noted that the Visual Basic code for COFL2012 was written to allow easy future modification or upgrades in MOVES. The EF look-up tables are the only link to MOVES, and were incorporated within external text files that may be updated as future versions of MOVES become available. There will be no need to make any changes to the actual COFL2012 program to achieve such an update. A macro-enabled Microsoft Excel workbook, *EFTableGenerator.xlsm* has been included in the program companion documentation folder. The workbook provides an easy way to update the COFL2012 EF look-up text files in the proper format. Instructions for the use of the workbook are included on the first tab of the spreadsheet.

It is recommended that FDOT immediately begin to use this model, and that they place it on their web site for free downloading by interested individuals. They should remove the older model (COFL2004), as well as any copies of the interim version of COFL2012 that were supplied previously in this project.

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APPENDIX

Table A-1. Example Link Drive Schedule for Acceleration

Link ID	Second ID	Speed (mph)	Grade (%)
1	0.00	0	0
1	0.17	1	0
1	0.33	2	0
1	0.50	3	0
1	0.67	4	0
1	0.83	5	0
1	1.00	6	0
1	1.17	7	0
1	1.33	8	0
1	1.50	9	0
1	1.67	10	0
1	1.83	11	0
1	2.00	12	0
1	2.17	13	0
1	2.33	14	0
1	2.50	15	0
2	0.00	0	0
2	0.17	1	0
2	0.33	2	0
2	0.50	3	0
2	0.67	4	0
2	0.83	5	0
2	1.00	6	0
2	1.17	7	0
2	1.33	8	0
2	1.50	9	0
2	1.67	10	0
2	1.83	11	0
2	2.00	12	0
2	2.17	13	0
2	2.33	14	0
2	2.50	15	0
2	2.67	16	0
2	2.83	17	0
2	3.00	18	0
2	3.17	19	0
2	3.33	20	0
3	0.00	0	0
3	0.17	1	0
3	0.33	2	0
3	0.50	3	0
3	0.67	4	0
3	0.83	5	0
3	1.00	6	0
3	1.17	7	0
3	1.33	8	0
3	1.50	9	0
3	1.67	10	0
3	1.83	11	0
3	2.00	12	0
3	2.17	13	0
3	2.33	14	0
3	2.50	15	0
3	2.67	16	0
3	2.83	17	0
3	3.00	18	0
3	3.17	19	0
3	3.33	20	0
3	3.50	21	0
3	3.67	22	0
3	3.83	23	0
3	4.00	24	0
3	4.17	25	0

(***This table is continued next page)***

Link ID	Second ID	Speed (mph)	Grade (%)
4	0.00	0	0
4	0.17	1	0
4	0.33	2	0
4	0.50	3	0
4	0.67	4	0
4	0.83	5	0
4	1.00	6	0
4	1.17	7	0
4	1.33	8	0
4	1.50	9	0
4	1.67	10	0
4	1.83	11	0
4	2.00	12	0
4	2.17	13	0
4	2.33	14	0
4	2.50	15	0
4	2.67	16	0
4	2.83	17	0
4	3.00	18	0
4	3.17	19	0
4	3.33	20	0
4	3.50	21	0
4	3.67	22	0
4	3.83	23	0
4	4.00	24	0
4	4.17	25	0
4	4.33	26	0
4	4.50	27	0
4	4.67	28	0
4	4.83	29	0
4	5.00	30	0

Link ID	Second ID	Speed (mph)	Grade (%)
5	0.00	0	0
5	0.17	1	0
5	0.33	2	0
5	0.50	3	0
5	0.67	4	0
5	0.83	5	0
5	1.00	6	0
5	1.17	7	0
5	1.33	8	0
5	1.50	9	0
5	1.67	10	0
5	1.83	11	0
5	2.00	12	0
5	2.17	13	0
5	2.33	14	0
5	2.50	15	0
5	2.67	16	0
5	2.83	17	0
5	3.00	18	0
5	3.17	19	0
5	3.33	20	0
5	3.50	21	0
5	3.67	22	0
5	3.83	23	0
5	4.00	24	0
5	4.17	25	0
5	4.33	26	0
5	4.50	27	0
5	4.67	28	0
5	4.83	29	0
5	5.00	30	0
5	5.17	31	0
5	5.33	32	0
5	5.50	33	0
5	5.67	34	0
5	5.83	35	0

(***This table is continued next page)***

Link ID	Second ID	Speed (mph)	Grade (%)
6	0.00	0	0
6	0.17	1	0
6	0.33	2	0
6	0.50	3	0
6	0.67	4	0
6	0.83	5	0
6	1.00	6	0
6	1.17	7	0
6	1.33	8	0
6	1.50	9	0
6	1.67	10	0
6	1.83	11	0
6	2.00	12	0
6	2.17	13	0
6	2.33	14	0
6	2.50	15	0
6	2.67	16	0
6	2.83	17	0
6	3.00	18	0
6	3.17	19	0
6	3.33	20	0
6	3.50	21	0
6	3.67	22	0
6	3.83	23	0
6	4.00	24	0
6	4.17	25	0
6	4.33	26	0
6	4.50	27	0
6	4.67	28	0
6	4.83	29	0
6	5.00	30	0
6	5.17	31	0
6	5.33	32	0
6	5.50	33	0
6	5.67	34	0
6	5.83	35	0
6	6.00	36	0
6	6.17	37	0
6	6.33	38	0
6	6.50	39	0
6	6.67	40	0

Link ID	Second ID	Speed (mph)	Grade (%)
7	0.00	0	0
7	0.17	1	0
7	0.33	2	0
7	0.50	3	0
7	0.67	4	0
7	0.83	5	0
7	1.00	6	0
7	1.17	7	0
7	1.33	8	0
7	1.50	9	0
7	1.67	10	0
7	1.83	11	0
7	2.00	12	0
7	2.17	13	0
7	2.33	14	0
7	2.50	15	0
7	2.67	16	0
7	2.83	17	0
7	3.00	18	0
7	3.17	19	0
7	3.33	20	0
7	3.50	21	0
7	3.67	22	0
7	3.83	23	0
7	4.00	24	0
7	4.17	25	0
7	4.33	26	0
7	4.50	27	0
7	4.67	28	0
7	4.83	29	0
7	5.00	30	0
7	5.17	31	0
7	5.33	32	0
7	5.50	33	0
7	5.67	34	0
7	5.83	35	0
7	6.00	36	0
7	6.17	37	0
7	6.33	38	0
7	6.50	39	0
7	6.67	40	0
7	6.83	41	0
7	7.00	42	0
7	7.17	43	0
7	7.33	44	0
7	7.50	45	0

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Link ID	Second ID	Speed (mph)	Grade (%)
8	0.00	0	0
8	0.17	1	0
8	0.33	2	0
8	0.50	3	0
8	0.67	4	0
8	0.83	5	0
8	1.00	6	0
8	1.17	7	0
8	1.33	8	0
8	1.50	9	0
8	1.67	10	0
8	1.83	11	0
8	2.00	12	0
8	2.17	13	0
8	2.33	14	0
8	2.50	15	0
8	2.67	16	0
8	2.83	17	0
8	3.00	18	0
8	3.17	19	0
8	3.33	20	0
8	3.50	21	0
8	3.67	22	0
8	3.83	23	0
8	4.00	24	0
8	4.17	25	0
8	4.33	26	0
8	4.50	27	0
8	4.67	28	0
8	4.83	29	0
8	5.00	30	0
8	5.17	31	0
8	5.33	32	0
8	5.50	33	0
8	5.67	34	0
8	5.83	35	0
8	6.00	36	0
8	6.17	37	0
8	6.33	38	0
8	6.50	39	0
8	6.67	40	0
8	6.83	41	0
8	7.00	42	0
8	7.17	43	0
8	7.33	44	0
8	7.50	45	0
8	7.67	46	0
8	7.83	47	0
8	8.00	48	0
8	8.17	49	0
8	8.33	50	0

Link ID	Second ID	Speed (mph)	Grade (%)
9	0.00	0	0
9	0.17	1	0
9	0.33	2	0
9	0.50	3	0
9	0.67	4	0
9	0.83	5	0
9	1.00	6	0
9	1.17	7	0
9	1.33	8	0
9	1.50	9	0
9	1.67	10	0
9	1.83	11	0
9	2.00	12	0
9	2.17	13	0
9	2.33	14	0
9	2.50	15	0
9	2.67	16	0
9	2.83	17	0
9	3.00	18	0
9	3.17	19	0
9	3.33	20	0
9	3.50	21	0
9	3.67	22	0
9	3.83	23	0
9	4.00	24	0
9	4.17	25	0
9	4.33	26	0
9	4.50	27	0
9	4.67	28	0
9	4.83	29	0
9	5.00	30	0
9	5.17	31	0
9	5.33	32	0
9	5.50	33	0
9	5.67	34	0
9	5.83	35	0
9	6.00	36	0
9	6.17	37	0
9	6.33	38	0
9	6.50	39	0
9	6.67	40	0
9	6.83	41	0
9	7.00	42	0
9	7.17	43	0
9	7.33	44	0
9	7.50	45	0
9	7.67	46	0
9	7.83	47	0
9	8.00	48	0
9	8.17	49	0
9	8.33	50	0
9	8.50	51	0
9	8.67	52	0
9	8.83	53	0
9	9.00	54	0
9	9.17	55	0

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Link ID	Second ID	Speed (mph)	Grade (%)
10	0.00	0	0
10	0.17	1	0
10	0.33	2	0
10	0.50	3	0
10	0.67	4	0
10	0.83	5	0
10	1.00	6	0
10	1.17	7	0
10	1.33	8	0
10	1.50	9	0
10	1.67	10	0
10	1.83	11	0
10	2.00	12	0
10	2.17	13	0
10	2.33	14	0
10	2.50	15	0
10	2.67	16	0
10	2.83	17	0
10	3.00	18	0
10	3.17	19	0
10	3.33	20	0
10	3.50	21	0
10	3.67	22	0
10	3.83	23	0
10	4.00	24	0
10	4.17	25	0
10	4.33	26	0
10	4.50	27	0
10	4.67	28	0
10	4.83	29	0
10	5.00	30	0
10	5.17	31	0
10	5.33	32	0
10	5.50	33	0
10	5.67	34	0
10	5.83	35	0
10	6.00	36	0
10	6.17	37	0
10	6.33	38	0
10	6.50	39	0
10	6.67	40	0
10	6.83	41	0
10	7.00	42	0
10	7.17	43	0
10	7.33	44	0
10	7.50	45	0
10	7.67	46	0
10	7.83	47	0
10	8.00	48	0
10	8.17	49	0
10	8.33	50	0
10	8.50	51	0
10	8.67	52	0
10	8.83	53	0
10	9.00	54	0
10	9.17	55	0
10	9.33	56	0
10	9.50	57	0
10	9.67	58	0
10	9.83	59	0
10	10.00	60	0

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Link ID	Second ID	Speed (mph)	Grade (%)
11	0.00	0	0
11	0.17	1	0
11	0.33	2	0
11	0.50	3	0
11	0.67	4	0
11	0.83	5	0
11	1.00	6	0
11	1.17	7	0
11	1.33	8	0
11	1.50	9	0
11	1.67	10	0
11	1.83	11	0
11	2.00	12	0
11	2.17	13	0
11	2.33	14	0
11	2.50	15	0
11	2.67	16	0
11	2.83	17	0
11	3.00	18	0
11	3.17	19	0
11	3.33	20	0
11	3.50	21	0
11	3.67	22	0
11	3.83	23	0
11	4.00	24	0
11	4.17	25	0
11	4.33	26	0
11	4.50	27	0
11	4.67	28	0
11	4.83	29	0
11	5.00	30	0
11	5.17	31	0
11	5.33	32	0

Link ID	Second ID	Speed (mph)	Grade (%)
11	5.50	33	0
11	5.67	34	0
11	5.83	35	0
11	6.00	36	0
11	6.17	37	0
11	6.33	38	0
11	6.50	39	0
11	6.67	40	0
11	6.83	41	0
11	7.00	42	0
11	7.17	43	0
11	7.33	44	0
11	7.50	45	0
11	7.67	46	0
11	7.83	47	0
11	8.00	48	0
11	8.17	49	0
11	8.33	50	0
11	8.50	51	0
11	8.67	52	0
11	8.83	53	0
11	9.00	54	0
11	9.17	55	0
11	9.33	56	0
11	9.50	57	0
11	9.67	58	0
11	9.83	59	0
11	10.00	60	0
11	10.17	61	0
11	10.33	62	0
11	10.50	63	0
11	10.67	64	0
11	10.83	65	0

(***This table is continued next page)***

REFERENCES

[1] Keely, Debra K. and Cooper, C. David. "The Advancement of CO Screening Models," a paper presented at the 1999 Annual Meeting of the Air & Waste Management Association, St. Louis, Missouri, June 20-25, 1999.

[2] Cooper, C. D. and Keely, Debra K. “Using MOBILE6.2 to Get Emission Factors for a Microscale CO Analysis,” a paper presented at the 95th Annual Conference of the Air & Waste Management Association, Baltimore, Md, June 24-27, 2002.

[3] Cooper, C. David. “A Comparison of MOBILE6.2 with MOBILE5A, and the Effects on Predicted CO Emission Factors used in Project Level Analysis,” a paper presented at the Annual Meeting of the Florida Air & Waste Management Association, Jupiter Beach, Florida, September 15-17, 2002.

[4] U.S. Environmental Protection Agency, "Motor Vehicle Emission Simulator (MOVES) User Guide for MOVES2010a," 2010.