Streamlining Air Quality Models in Alabama

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16. Abstract

This report documents a research project sponsored by the Alabama Department of Transportation (ALDOT) and conducted by the University of Central Florida (UCF) and the University of Alabama at Birmingham (UAB) to develop a user-friendly, Windows version of MOBILE6 and a Windows carbon monoxide (CO) screening model. Both models were developed for use in Alabama-specific applications by the Environmental Technical Section of ALDOT. The models are intended to improve analytical processes at ALDOT and reduce costs by achieving environmental streamlining goals as encouraged by the Federal Highway Administration. The program Alabama MOBILE6 (AM6) is a user-friendly, yet powerful Windows interface to the EPA program MOBILE6.1/6.2. A number of the inputs to this complex model have been pre-programmed, based on guidance from ALDOT. Input is highly visual and easy to accomplish. The Alabama CO screening model (ALCO) utilizes the Environmental Protection Agency's emission factor model MOBILE6 and dispersion model CAL3QHC. These models are built into the screening model and are invisible to the user. A number of the inputs to these complex models have been pre-programmed, based on guidance from ALDOT. Input is highly visual and easy to accomplish. The authors concluded that ALCO successfully incorporates the state of the practice of intersection screening for the state of Alabama, and recommend that ALDOT adopt this model as soon as possible for use in this aspect of air quality modeling in Alabama. The authors concluded that AM6 successfully runs MOBILE6, and makes it easier for people within the state of Alabama to use MOBILE6, while maintaining the flexibility of the program.

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Executive Summary

This report documents a research project sponsored by the Alabama Department of Transportation (ALDOT) and conducted by the University of Central Florida (UCF) and the University of Alabama at Birmingham (UAB) to develop a user-friendly, Windows version of MOBILE6 and a Windows carbon monoxide (CO) screening model. Both models were developed for use in Alabama-specific applications by the Environmental Technical Section of ALDOT. The models are intended to improve analytical processes at ALDOT and reduce costs by achieving *environmental streamlining* goals as encouraged by the Federal Highway Administration.

Microscale CO modeling at intersections is an important aspect of project level analysis for state transportation departments and other agencies (metropolitan planning organizations, counties, etc.) concerned with air quality impacts from vehicles. Current air quality microscale models are often used to predict CO concentrations near intersections and the results can greatly influence decisions on significant highway and land development projects. The use of existing models is not trivial, however, and their use is time consuming and resource intensive, and often requires highly trained personnel. Many intersections within a project area represent no threat to the national ambient air quality standards (NAAQS) and should not require a detailed analysis. By using a screening model, these non-threatening intersections could be precluded from a detailed analysis, thus saving considerable time and money for the ALDOT.

The Environmental Protection Agency (EPA) has developed, maintained, and regularly updated a mobile source emission factor model. The latest version is MOBILE6. On-road motor vehicles are the largest source category in the U.S. for emissions of CO, and a very major source for emissions of VOC and NO_x. The emission factor is a value that represents the average emissions (in grams per vehicle-mile-traveled – g/VMT) of a specific pollutant. The emission factor (EF) is a complex function of many variables, including vehicle speed, type and age, ambient temperature and humidity, gasoline properties, and others. The EF can be multiplied by total VMT in a state or county to produce an emission inventory, or it can be used in combination with a dispersion model to produce a prediction for pollution concentration near a roadway or intersection.

MOBILE6 is a very large FORTRAN program that requires detailed knowledge and training to use. It has hundreds of input options, and in some cases may require thousands of input data. Many of the inputs for MOBILE6 can be pre-programmed with state-specific values, and this was done in this project. An Alabama-specific version of MOBILE6 was created. Halfway through the project, EPA released version 6.1 and 6.2 of MOBILE6, so new code was developed to incorporate those changes as well. Thus, the Alabama MOBILE6 model incorporates EPA's MOBILE6.1 and 6.2.

The program Alabama MOBILE6 (AM6) is a user-friendly, yet powerful Windows interface to the EPA program MOBILE6.1/6.2. A number of the inputs to this complex model have been pre-

programmed, based on guidance from ALDOT. The model is written in Visual Basic but allows MOBILE6.1/6.2, which is written in FORTRAN, to be run from within the model without exiting Windows. AM6 facilitates quick and easy user input, prepares the detailed FORTRAN input file, runs MOBILE6 in FORTRAN, and presents the FORTRAN output file, on-screen for user visual inspection (and printing if desired). Input is highly visual and easy to accomplish.

The Alabama CO screening model (ALCO) utilizes the EPA emission factor model MOBILE6, and the EPA dispersion model, CAL3QHC. These models are built into the screening model and are invisible to the user. A number of the inputs to these complex models have been pre-programmed, based on guidance from ALDOT. The model is written in Visual Basic but allows both MOBILE6 and CAL3QHC, which are written in FORTRAN, to be run from within the model without exiting Windows. ALCO allows for quick and easy user input, prepares the detailed FORTRAN input files, coordinates the running of various FORTRAN subroutines, processes the FORTRAN output files, and presents the results in a simple report format on-screen for user visual inspection (and printing if desired). Input is highly visual and easy to accomplish.

The authors conclude that ALCO successfully incorporates the state of the practice of intersection screening for the state of Alabama, and recommend that ALDOT adopt this model as soon as possible for use in this aspect of air quality modeling in the state of Alabama. The authors conclude that AM6 successfully runs MOBILE6, and makes it easier for people within Alabama to use MOBILE6, while maintaining the flexibility of the program.

Section 1
Introduction

This report documents a research project sponsored by the Alabama Department of Transportation (ALDOT) and conducted by the University of Alabama at Birmingham (UAB) and the University of Central Florida (UCF) to develop a Windows-based interface for MOBILE6 and a Windows-based carbon monoxide (CO) screening model. Both models were developed for use in Alabama-specific applications conducted and overseen by the Environmental Technical Section of ALDOT. The models are intended to improve the analytical process at ALDOT and reduce costs by achieving its *environmental streamlining* goals as encouraged by the Federal Highway Administration[1].

1.1. Background & Problem Statement

The two programs developed under the project have many features in common but are separate programs and are intended to serve separate purposes. Each program builds upon previously developed models to enhance their usability and applicability in Alabama. Each program and associated model is discussed the in following sections of this report.

Federal environmental laws, in particular the National Environmental Policy Act (NEPA) and the Clean Air Act (CAA) and its amendments require that states develop and maintain state-wide emissions inventories as well as conduct project-level air quality analyses of roadway projects to ensure that roadway improvements/construction do not result in violations of the National Ambient Air Quality Standards (NAAQS) for CO. The U.S. Environmental Protection Agency (EPA) and the Federal Highway Administration (FHWA) require the use of the most current air quality analysis tools. The air quality analysis computer models currently approved by the EPA and the FHWA are:

- MOBILE6 for determining vehicle emission factors and developing inventories (USEPA, 2002), and
- CAL3QHC for pollutant dispersion modeling near roadway intersections (USPEA, 1995).

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[1] A description of the FHWA Environmental Streamlining program is available at
http://www.fhwa.dot.gov/environment/strmlng/index.htm

1.1.1. The MOBILE Model

MOBILE is the state of the art in vehicle emissions modeling and the computer model required by EPA and FHWA for vehicle emissions analyses[2]. EPA has developed, maintained, and regularly updates a mobile source emission factor model. The latest version is MOBILE 6.2.

MOBILE6 is a very complex model. It contains (and utilizes) very large databases representing the result of numerous measurement studies of cars, trucks, buses, and motorcycles, covering many ranges of years and operating conditions, and as well as roadway and ambient conditions[3]. Emissions vary as a function of numerous variables, including:

- Vehicle type (small cars, SUVs, heavy trucks, etc);
- Vehicle age (fuel consumption, pollution control technologies, deterioration, etc.);
- Vehicle operating conditions (speed, idling, acceleration, load);
- Roadway conditions (congestion, grade, etc);
- Fuel (gasoline/diesel, RVP, oxygen content, sulfur content); and
- Ambient conditions (temperature, humidity, solar radiation) (USEPA, 2002).

Values for each the above variables must be collected or derived to run MOBILE6. In many cases, however, there are parameters that are common to a particular state (or regions within a state) that can be used as default values to reduce the data collection, input, and processing requirements.

MOBILE6 is used to generate emission factors for the vehicles comprising the vehicle fleet in the analysis area. The emission factor is a value that represents the average emissions, in grams per vehicle-mile-traveled (g/VMT), of a specific pollutant. The emission factor (EF) is a complex function of many variables, including vehicle speed, type and age, ambient temperature and humidity, and gasoline properties. The EF can be multiplied by total VMT in a state or county to produce an emission inventory, or it can be used in combination with a dispersion model to produce a prediction for pollution concentration near a roadway or intersection for project-level analysis.

1.1.2. Project-level Analysis

Microscale CO modeling at intersections is an important aspect of project level analysis for state transportation departments and other agencies (metropolitan planning organizations, counties, etc.) concerned with air quality impacts from vehicles. Current air quality microscale models are often used to predict CO concentrations near intersections and the results can influence decisions on highway and land development projects (Cooper et al., 2004). The use of existing models is not trivial. Their use is time consuming and resource intensive, and often requires highly trained personnel. Many intersections within a project area represent no threat to the NAAQS and should not require a detailed analysis. By using a screening model, these non-threatening intersections could be precluded from a detailed analysis, thus saving considerable time and money for the ALDOT.

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[2] MOBILE is used in all states except California which uses a version developed specifically for the low-emission vehicles sold in California as mandated by state laws. More information on the MOBILE model and particularly MOBILE6 is available from the EPA at http://www.epa.gov/otaq/m6.htm.

[3] The results of these studies constitute the national level defaults included in the MOBILE model.

CAL3QHC is the accepted model for performing project-level CO analyses. It uses vehicle emission factors as generated by MOBILE and a pollutant dispersion methodology to predict CO levels adjacent to the roadway (USPEA, 1995). Use of these models in their original DOS format requires extensive user knowledge and requires independent gathering of numerous values for specific inputs. Analysis of one project can require several weeks or more to gather all the necessary data, develop the input files, run the models, and analyze the output.

1.2. Purpose and Scope

Approximately 25% of the environmental analyses conducted by ALDOT require the use of the MOBILE model. ALDOT estimates that emissions modeling currently requires between 6 and 10 man-hours per analysis. Due to increased model complexity and data needs, some estimates put the time required for a full MOBILE6 analysis to be more than 2 to 4 man-days (ALDOT, 2003). The use of Alabama-specific default values substantially reduces the time required to perform a MOBILE6 analysis (50% -75%) while maintaining accuracy and results representative of conditions in Alabama.

The Environmental Technical Section at ALDOT is currently responsible for conducting and/or overseeing approximately 200 environmental analyses on various roadway improvement projects[4]. The number of environmental documentation projects is expected to increase to between 300 and 400 projects over the next few years. Of the 200 projects currently underway, 50 conformity analyses were required (at $7 - $10k per analysis) to determine whether or not the roadway projects would adversely impact local CO levels (ALDOT, 2003). Most of the intersections within a project impact area, however, do not represent a threat to the NAAQS for CO, and therefore should not require a detailed analysis. The advantage of using a CO screening model is so that these intersections can be "screened out" and precluded from a detailed analysis, thus saving considerable time and money for the performing agency. It was estimated that 75% of the analyses performed by ALDOT could have been satisfied via the use of a screening model as developed herein.

The purpose of the project was to provide ALDOT and others in the State of Alabama with a quick and easy way to run MOBILE6 (for a variety of uses), and a quick and uniform method of screening intersections for potential CO violations. The models will reduce costs for ALDOT (regardless of whether ALDOT personnel or consultants do the work) as less time is required for preparing input files and analyzing intersections that really do not need full analyses.

Furthermore, the screening model and MOBILE6 interface will increase the precision and accuracy of the modeling process by allowing more time to be devoted to the few situations that really need detailed analyses. As is the intention of all of the recent FHWA streamlining initiatives, the results of this project will not only save costs for ALDOT, but will also result in better, more accurate and consistent environmental analyses.

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4 Some of these analyses are conducted in-house by ALDOT personnel and others are performed by consultants under roadway design contracts.

The scope of the project involved two primary efforts:

- The development of an Alabama-specific graphical Windows interface for EPA's latest version of their mobile source emissions model (MOBILE6); and

- The development of an Alabama-specific screening model to help air quality analysts evaluate project-level air quality (CO) impacts near roadways and intersections for federally funded highway projects in Alabama.

The first effort resulted in the development and delivery of a MOBILE6 interface program, a User's manual, and a training course[5]. The MOBILE6 interface program runs within Windows and provides colorful and easy to understand screens for inputting data required by MOBILE6. The program builds a MOBILE6 input file, executes EPA's FORTRAN-based MOBILE model, and displays output and other results.

The second effort resulted in a CO screening model (provided as a self-contained computer software application), a user's manual, and a training course. The screening model incorporates MOBILE6 to generate CO emission factors, and uses CAL3QHC to model the dispersion near roadways. MOBILE6 runs within the screening program and is therefore invisible to the user. User input is kept to a minimum and includes only those parameters deemed critical as determined by joint consultation between the researchers at UCF and UAB, as well as authorized representatives of ALDOT. These include some conservative assumptions that have been pre-programmed into the model. User input is facilitated through a graphical user interface, and the entire program runs within Windows (including the MOBILE6 and CAL3QHC portions). The minimum required user inputs are the *year of analysis*, *speed* and *traffic volume*. All other inputs can be selected by the researchers and modified by the user, if desired. Examples of optional inputs include *temperature, surface roughness, background CO concentration, atmospheric stability, receptor locations* and *intersection configurations*. Some of these inputs can be combined into one user input selection. For example, the user is given a land use choice of *urban, suburban,* or *rural*.

The user chooses one – the land use selection then implies three pre-programmed values: surface roughness, background CO concentration and atmospheric stability. The choice of a location within Alabama influences the selection of ambient temperature. Values for inspection/maintenance and anti-tampering programs, vehicle registration, and fuel parameters (especially Reid Vapor Pressure) can also be pre-programmed with specific Alabama data. The screening model output routine extracts the concentrations from the CAL3QHC output and converts them to one-hour and 8-hour CO concentrations (including pre-selected background concentrations) for each receptor. The results are presented in a concise one-page format, documenting the inputs and the results of the screening test.

1.3. Similar Efforts

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[5] A specific schedule for training courses (e.g., number of sessions, number of participants per session, location) will be determined in conjunction with ALDOT.

UCF has developed CO screening models for Florida, Colorado, and Georgia. Each model has features unique to the needs of each state, but the models have much in common and are quick and easy to use. The unique features of the Florida model include choice of six regions, land use type, speed, traffic volume, year of analysis and receptor locations. The six regions in Florida impact the temperature and values for inspection/ maintenance (I/M) and anti-tampering programs (ATP) (Cooper and Keely, 1999).

The unique features of the Colorado model include choice of regions, speed, traffic volume, year of analysis and intersection type. The region impacts the temperature and I/M and ATPs. The Colorado model offers the user three intersection types: 4-way intersection with two through lanes and one left-turn lane; 4-way intersection with three through lanes and two left-turn lanes; and a 3-way intersection with two approach lanes. The receptor locations are pre-programmed. With the Georgia DOT screening model (still being finalized), UCF added an urban diamond interchange as one of the "intersection" types that can be screened (Cooper and Keely, 2002).

Section 2
Alabama-specific Windows-based MOBILE6 Interface (AM6)

2.1 Introduction to AM6

The program Alabama MOBILE6 (AM6) is intended to make it much easier for users in the state of Alabama to create input files and run the EPA program MOBILE6[6]. The opening screen is shown in Figure 2-1.

Figure 2-1. Alabama MOBILE6 opening screen

With AM6, the user can obtain emission factors (EFs) for emissions inventory calculations or can get EFs for a detailed microscale CO analysis. The MOBILE6 inputs used in ALCO have been previously described, and the default inputs for the various regions of Alabama have been

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[6] Halfway through the project, EPA released version 6.1 and 6.2 of MOBILE6, so new code was developed to incorporate those changes as well. Thus, the Alabama MOBILE6 model incorporates EPA's MOBILE6.1 and 6.2.

tabulated. However, there are many other inputs that may be utilized if so desired. Information about these other inputs is available using the AM6 Help[7] system, which essentially is a significant extract from the EPA MOBILE6 User's Manual[8].

MOBILE6 is a FORTRAN program that runs in DOS, but can be accessed from Windows simply by double clicking the executable *mobile6.exe*. An input file must be created in advance, and depending on the options selected, one or more other data files (also prepared in advance by the user) must be available to the program. The input file follows a specific format, and though it is more flexible than MOBILE5, it is also more complex. MOBILE6 input files contain a mixture of English language commands and numerical data that are input in a mixture of free and fixed format (USEPA, 2002). Input falls into three main groupings:

- the HEADER section, which controls the computer run;
- the RUN section, where data is only entered once and applies to all scenarios modeled specific to the evaluated project; and,
- the SCENARIO section, which allows various scenarios to be evaluated (i.e., individual parameters may be changed). In addition to a few required generic command lines, the only mandatory inputs are temperature, year of analysis and Reid vapor pressure (RVP).

There are many other parameters that can impact emission factors. The user can ignore these parameters and use the defaults built into MOBILE6, or the user can input alternate values. Some of these optional parameters are:

- humidity,
- sunrise/sunset,
- peak sun time,
- speed,
- vehicle registration distribution,
- mileage accumulation,
- fuel parameters,
- vehicle miles traveled (VMT) mix, and
- soak distribution.

Also roadway facility data are input, and are used to adjust the basic emission factors to account for real-world driving conditions on freeways, ramps, arterials, and local streets (USEPA, 2002).

The resulting emission factors can be printed as a descriptive output (standard text-file) or as a database output (e.g., spreadsheet). The database output (without user-specified restrictions) lists the emission factors by hour, vehicle type, and vehicle age for each pollutant on each roadway type. As the output file can be quite large, the user is allowed to limit the results by specifying various commands (USEPA, 2002).

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[7] The AM6 help system is built into the program as done in other windows-based programs.
[8] It is recommended that the user obtain a MOBILE6 user's manual to fully understand how AM6 creates input files and what is required therein.

2.1.1   Windows-based Interface Development and Structure

One of the biggest drawbacks to the MOBILE models over the years has been the fact that they are written in FORTRAN, run in DOS, and are not particularly user-friendly. With the evolution of Windows software and the numerous applications written for it, users are accustomed to "point and click" approaches and are less adept using DOS commands.

Though the MOBILE6 input format is more flexible than previous versions, the many options available can be confusing to new and inexperienced users. MOBILE6 still requires:

- That certain input be in certain sections of the input file;
- numerical inputs fall within a range of acceptable values; and
- alphanumeric inputs be correctly spelled.

These are all areas with the potential for user input errors. The interface developed for ALDOT was designed to detect user input errors and prompt for or suggest appropriate input.

The interface is written in Visual Basic (VB), and presents the user with a number of screens that, depending on user inputs, provide for entry of data and then lead to other screens. On each screen various required and optional inputs to MOBILE6 may be entered. From the open screen, the user can access any other open screen, or the user can proceed step-by-step through the program input by clicking on the NEXT button on each screen. The program does logic and error checking of the data, and creates a properly formatted MOBILE6 input file.

In addition to allowing easier user input, Alabama MOBILE6 also builds the input file and runs MOBILE6 directly from the VB shell. To directly execute EPA's MOBILE6, the MOBILE6 source code was recompiled to remove its interactive data input routine. It was then made a callable subroutine within VB. Once the input selections are complete, the user simply clicks on a screen icon, and the program runs MOBILE6 with the input file was generated. After the program runs, the data can be viewed by a built-in viewer, and then saved to a file or printed.

2.1.2.   Alabama-specific Data

MOBILE6 requires information on local climatological conditions (temperature, humidity, etc.) on which to base emissions estimates. It also requires information such as the time of day in which solar radiation peaks and percent cloud cover (to estimate in-vehicle air conditioning usage) for developing EF for the various vehicles. UAB and UCF worked with ALDOT and the Alabama Department of Environmental Management (ADEM) to divide the State into appropriate climatological regions and identify region-specific values for the climatological data. Based on discussions with meteorologists from ADEM, the State was divided into four climatological regions: Northern Alabama, Central Alabama[9], Southern Alabama, and Coastal

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[9] A separate category including only Jefferson and Shelby Counties was also created due to the Birmingham region's air quality status at the time of the model development. This region is a subset of the Central Alabama region and exhibits identical climatological data.

Alabama. Figure 2-2 is a screenshot from the model that shows how the users selects the region of the State for analysis. A list of the counties in each region is presented in Table 2-1.
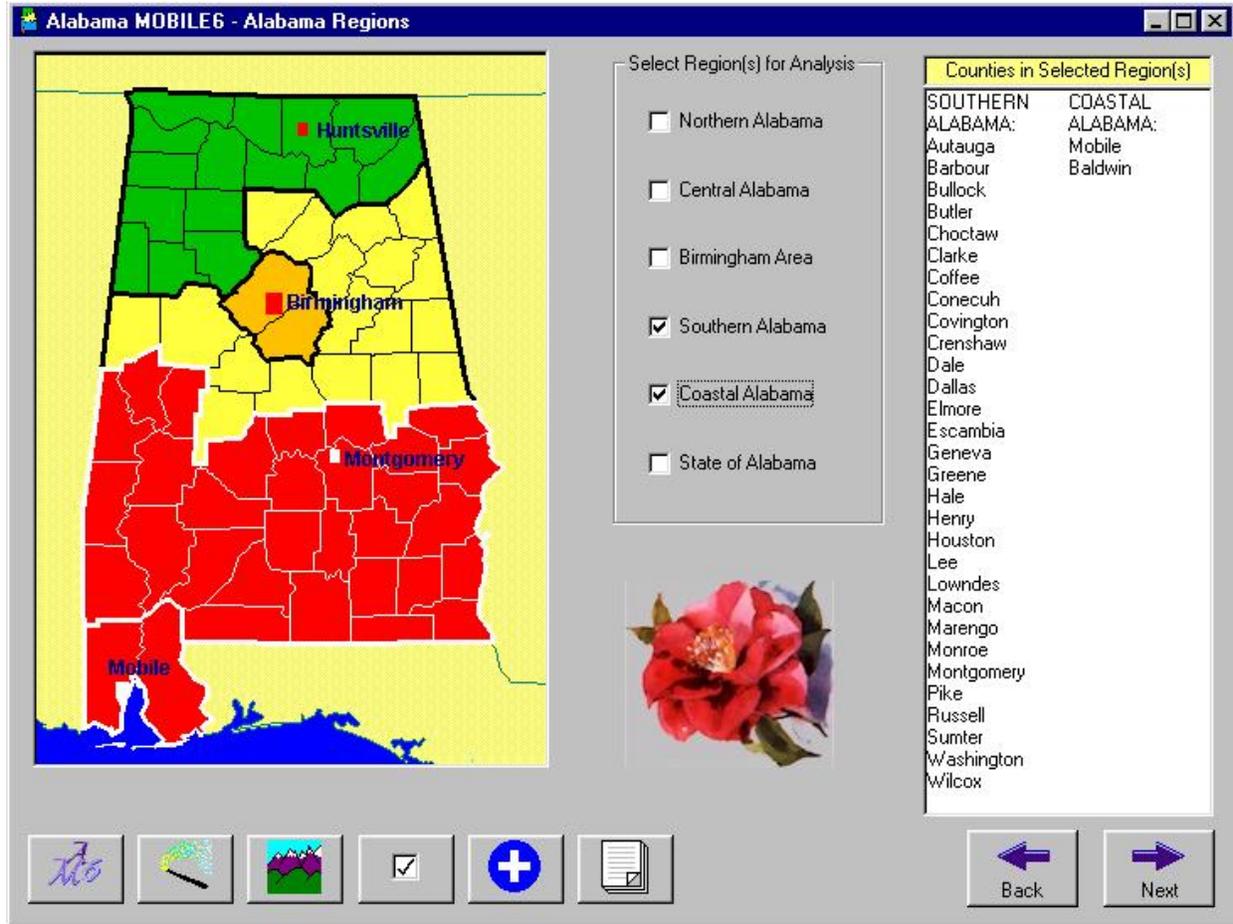

Figure 2-2. Region selection screen

Table 2-1. Counties within the four climatological regions of the State

Region	Counties
Northern	Colbert, Dekalb, Fayette, Franklin, Jackson, Lauderdale, Limestone, Lamar, Lawrence, Madison, Marion, Marshall, Morgan, Walker, Winston
Central	Bibb, Blount, Calhoun, Chambers, Cherokee, Chilton, Clay, Cleburne, Coosa, Etowah, Jefferson, Perry, Pickens, Randolph, Shelby, St. Clair, Talladega, Tuscaloosa, Tallapoosa
Southern	Autauga, Barbour, Bullock, Butler, Choctaw, Clarke, Coffee, Conecuh, Covington, Crenshaw, Dale, Dallas, Elmore, Escambia, Sumter, Geneva, Greene, Hale, Henry, Houston, Lee, Lowndes, Macon, Marengo, Monroe, Montgomery, Pike, Russell, Washington, Wilcox
Coastal	Baldwin, Mobile

All of the region-specific climatological data was assembled for the months comprising the ozone season (May through September) and January[10]. The various climatological data collected and embedded in the AM6 model as region-specific inputs are presented in Tables 2-2 through 2-18.

Table 2-2. Average January peak hour temperatures

Region	Average 7-8 AM Temperature (^{o}F)	Average 5-6 PM Temperature (^{o}F)
Northern	39.3	44.6
Central	43.3	49.4
Southern	44.6	52.9
Coastal	49.4	54.8

Table 2-3. Average January minimum and maximum temperatures

Region	Average Minimum Temperature (^{o}F)	Average Maximum Temperature (^{o}F)
Northern	33.3	51.0
Central	35.0	55.0
Southern	36.9	59.4
Coastal	42.7	62.2

Table 2-4. Average May minimum and maximum temperatures

Region	Average Minimum Temperature (^{o}F)	Average Maximum Temperature (^{o}F)
Northern	58.8	81.1
Central	59.3	82.3
Southern	60.3	84.8
Coastal	63.8	85.7

Table 2-5. Average June minimum and maximum temperatures

Region	Average Minimum Temperature (^{o}F)	Average Maximum Temperature (^{o}F)
Northern	66.7	85.6
Central	67.3	86.5
Southern	68.3	88.8
Coastal	70.6	87.9

Table 2-6. Average July minimum and maximum temperatures

Region	Average Minimum Temperature (^{o}F)	Average Maximum Temperature (^{o}F)
Northern	70.2	90.0
Central	71.4	91.3
Southern	71.4	93.2
Coastal	73.3	91.6

Table 2-7. Average August minimum and maximum temperatures

Region	Average Minimum Temperature (^{o}F)	Average Maximum Temperature (^{o}F)
Northern	68.0	90.0
Central	69.9	90.9
Southern	70.5	93.0
Coastal	73.3	92.2

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10 January data is used in the project-level analyses as maximum CO concentrations are generally associated with colder weather (Cooper, 1987).

Table 2-8. Average September minimum and maximum temperatures

Region	Average Minimum Temperature (^{o}F)	Average Maximum Temperature (^{o}F)
`Northern	61.7	85.6
Central	63.5	86.0
Southern	64.6	86.9
Coastal	68.1	86.7

Table 2-9. Average morning relative humidity

Region	RH (%)					
	January	May	June	July	August	September
Northern	75.5	80.0	84.3	86.0	86.0	82.0
Central	78.2	77.9	83.3	83.8	80.0	79.2
Southern	81.0	81.6	85.2	83.3	84.4	83.6
Coastal	83.5	82.4	85.7	84.2	83.0	86.7

Table 2-10. Average afternoon relative humidity

Region	RH (%)					
	January	May	June	July	August	September
Northern	61.4	51.4	60.7	58.4	54.0	49.1
Central	59.0	55.8	61.5	59.3	54.4	51.1
Southern	56.4	51.0	60.2	56.0	54.3	54.9
Coastal	61.9	55.1	64.1	62.5	57.8	61.6

Table 2-11. Average daily relative humidity

Region	RH (%)					
	January	May	June	July	August	September
Northern	67.6	62.0	69.2	68.0	66.0	60.7
Central	67.3	61.3	69.7	68.4	64.0	61.4
Southern	67.2	62.4	69.7	66.6	65.4	65.9
Coastal	72.5	65.6	72.5	71.4	67.8	71.7

Table 2-12. Average daily cloud cover

Region	RH (%)					
	January	May	June	July	August	September
Northern	2.6	3.3	4.0	3.3	2.4	2.7
Central	6.6	5.5	6.0	5.3	4.8	5.1
Southern	5.4	2.6	3.4	2.6	2.3	3.2
Coastal	5.5	2.6	2.9	1.9	1.7	3.0

Table 2-13. Average January sunrise and sunset times

Region	Sunrise	Sunset
Northern	6:52	5.00
Central	6:50	5:02
Southern	6:45	5:04
Coastal	6:49	5:14

Table 2-14. Average May sunrise and sunset times

Region	Sunrise	Sunset
Northern	4:44	6:43
Central	4:46	6:40
Southern	4:48	6:36
Coastal	4:58	6:40

Table 2-15. Average June sunrise and sunset times

Region	Sunrise	Sunset
Northern	4:34	7:01
Central	4:37	6.57
Southern	4:39	6:53
Coastal	4:50	6:56

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Table 2-16. Average July sunrise and sunset times

Region	Sunrise	Sunset
Northern	4:46	6:58
Central	4:48	6:56
Southern	4:50	6:52
Coastal	5:00	6:55

Table 2-17. Average August sunrise and sunset times

Region	Sunrise	Sunset
Northern	5:08	6:32
Central	5:09	6:31
Southern	5:09	6:28
Coastal	5:19	6:32

Table 2-18. Average September sunrise and sunset times

Region	Sunrise	Sunset
Northern	5:30	5:52
Central	5:30	5:53
Southern	5:29	5:51
Coastal	5:37	5:57

In addition to the climatological data, information was also collected on environmental measures currently in place in the State. It was determined that there were no inspection/maintenance or anti-tampering programs in the State. With respect to fuel composition, the following details were included in AM6:

- Jefferson and Shelby Counties use "summer gas" (RVP = 7.0) during the period from June 1st through September 14th;

- All other counties use gas with an RVP of 9.0 during the period from June 1st through September 14th;

- No restrictions are placed on RVP from September 15th through May 30th – it is "anything goes." Regional defaults were used; and

- ADEM does not regulate sulfur levels.

Other fuel parameters (oxygenated fuel composition, etc.) in AM6 are MOBILE6 defaults. As with another inputs, users are allowed to override any of the preprogrammed values whether default or Alabama-specific.

2.2. Using AM6

In addition to the many Alabama-specific embedded inputs, AM6 requires a minimal number of inputs from the user for each analysis. These inputs are required to describe general parameters and include:

- type of run (inventory or project analysis),
- region of Alabama,
- season (and time of day for a project analysis run),

- calendar year, number of scenarios or increment scenarios, and
- facility type and speed (for project analysis only).

Screenshots of the initial run screen showing the input of the descriptive information are presented as Figures 2-3 and 2-4. The program functions like most Windows-based programs with a menu bar and tool bar to maneuver through the various screens and commands.
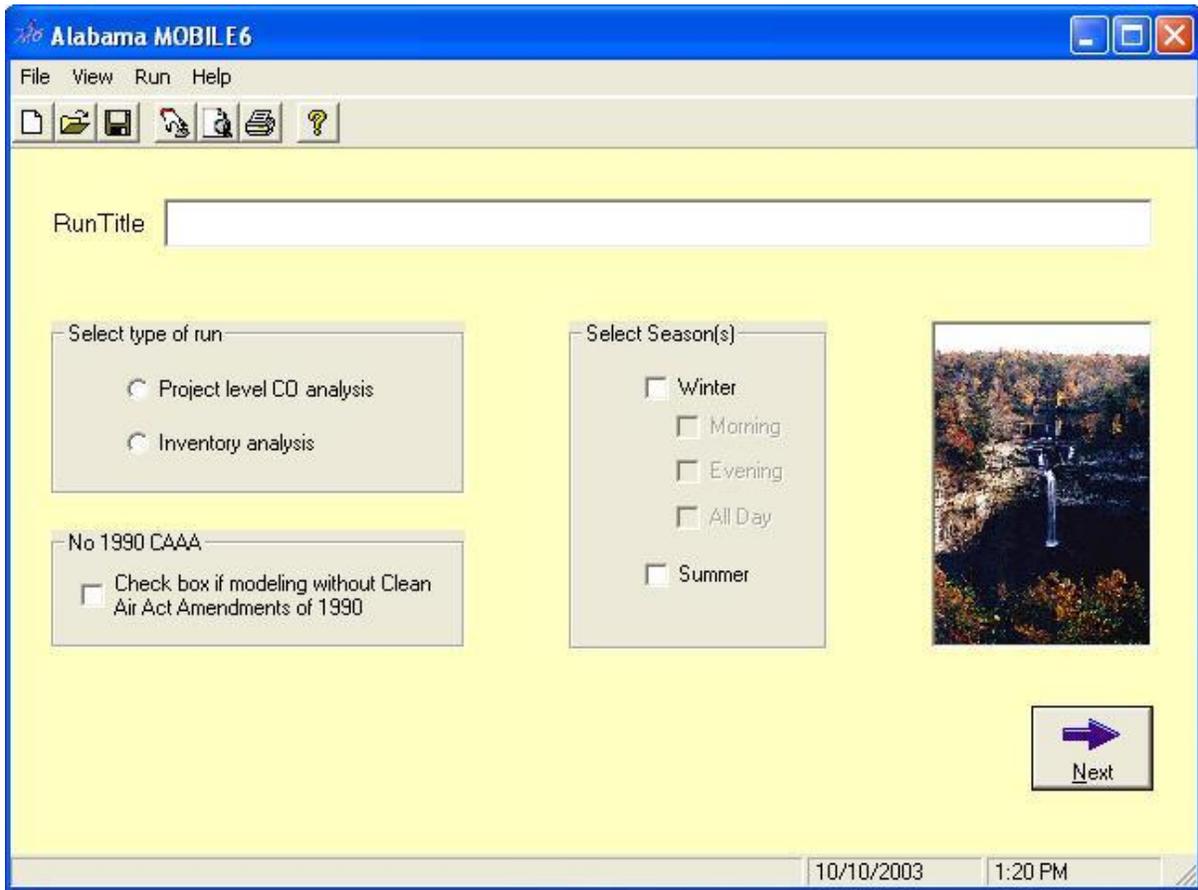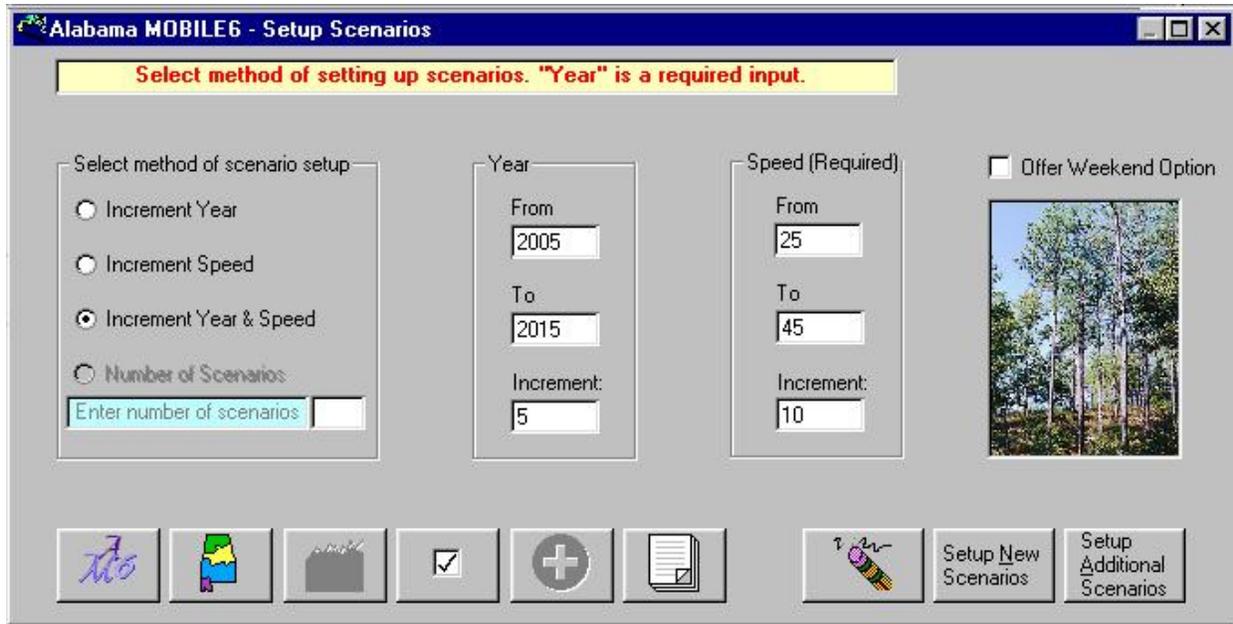

Figure 2-3. AM6 header screen

Figure 2-4. AM6 run control screen

After the opening screen, the user must elect to do an inventory analysis or a project level analysis (Figure 2-3). Then the user steps through the next several screens to select the region (Figure 2-2), the year (Figure 2-4) and other required inputs as needed. To maximize the flexibility of the program, the user is given the opportunity throughout AM6 to accept defaults (either Alabama-specific or national) or import new data. Figure 2-5 is an example of a run scenario input screen. It shows the climatological input data (e.g., minimum temperature, humidity) that was "pulled" into the run scenario as a result of the region selected by the user. At this point in the analysis, the user can accept the Alabama-specific defaults or modify them to fit the needs of the analysis.

Figure 2-5. AM6 Scenario Input Screen

After inputting the regionally-specific information, the user is then prompted to provide transportation-related information. Figure 2-6 shows how the user is prompted to provide inputs to describe the vehicle fleet composition for the region, local trip-making characteristics, etc. Other information that may be input by the user at this time includes environmental-related data, such as whether an inspection/maintenance program exists in the study area, as well as the chemical composition of the fuel(s) used in the region.
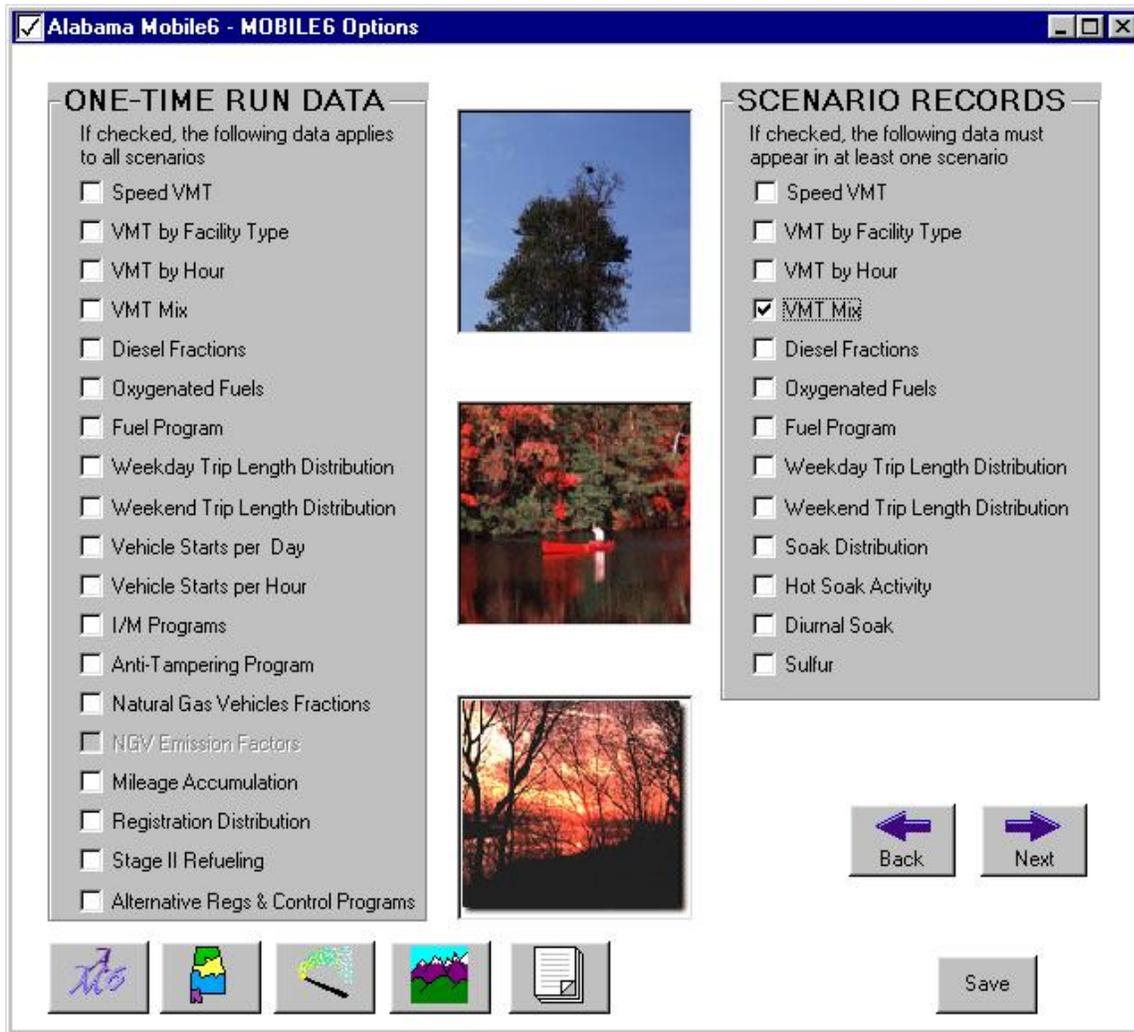
Figure 2-6. Transportation information scenario input screen

Upon electing to input a certain type of data, the user is then given a screen where the data can be: (1) entered manually, (2) read from an external file, or (3) deferred to embedded defaults[11]. A screenshot showing the data input interface is presented as Figure 2-7. The figure is an example of the input screen for describing the composition of the vehicle fleet (fractions of passenger cars, trucks, buses, etc.). The user can manually provide fractions of the fleet corresponding to the various MOBILE6 vehicle classes or can use the "Insert VMT Fractions" button on the left-side of the screen to "call up" default values (national or locally-derived if available).

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11 In some cases, the defaults encountered by the user will be Alabama-specific (e.g., RVP) while many will be national defaults embedded in the MOBILE6 model itself.
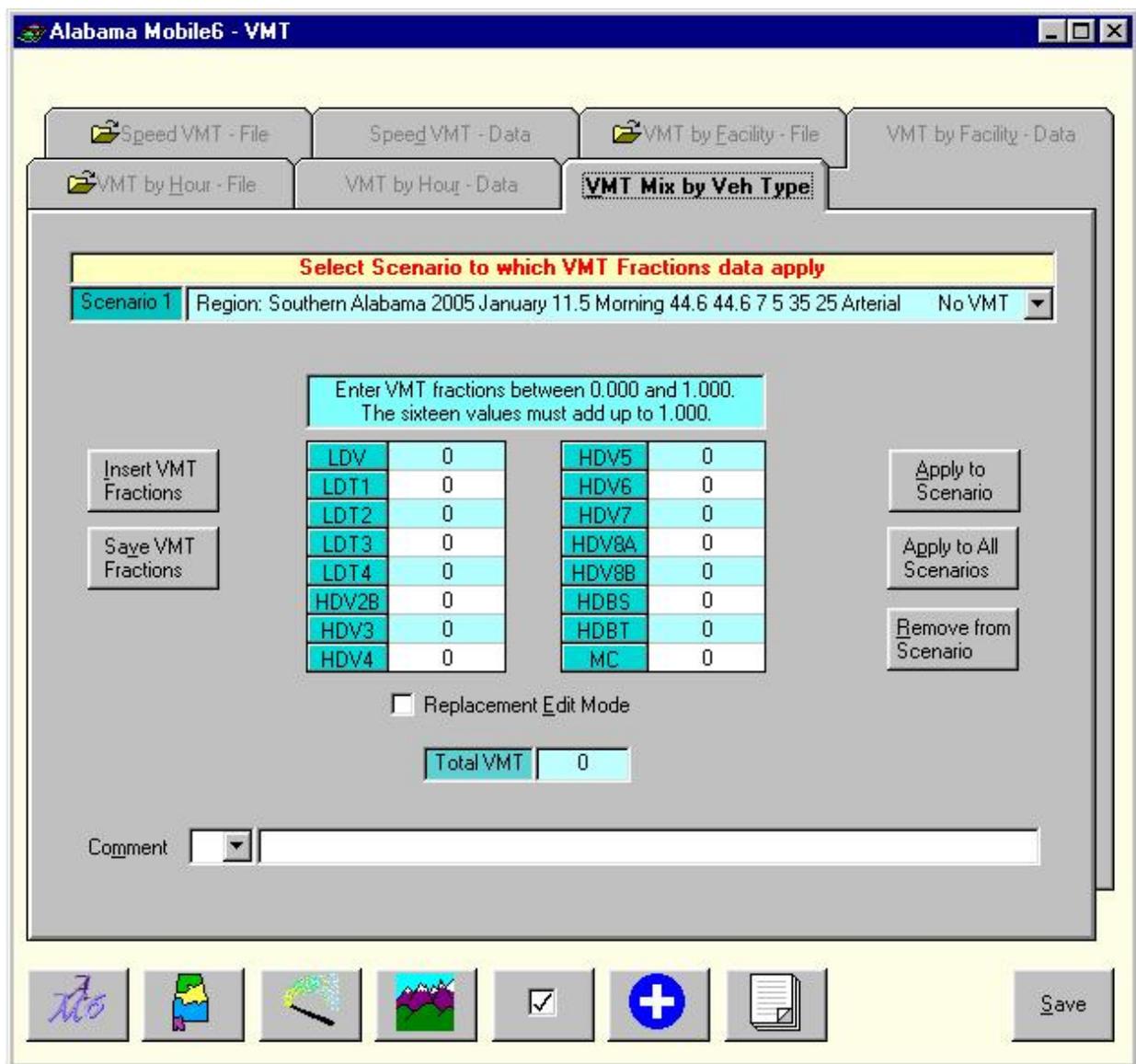
16

Figure 2-7. Sample Transportation-related data input screen

After inputting the required data, the user is allowed to customize the format (text file, spreadsheet, etc.) and content (pollutant type) of the MOBILE6 output[12]. Figure 2-8 shows the output control screen where the user is allowed to specific the details of the output. For details of how to operate within each screen or how to move from one screen to the next, the reader is referred to the AM6 user's manual (Note-contact the Principal Investigator for more information about the user's manual).

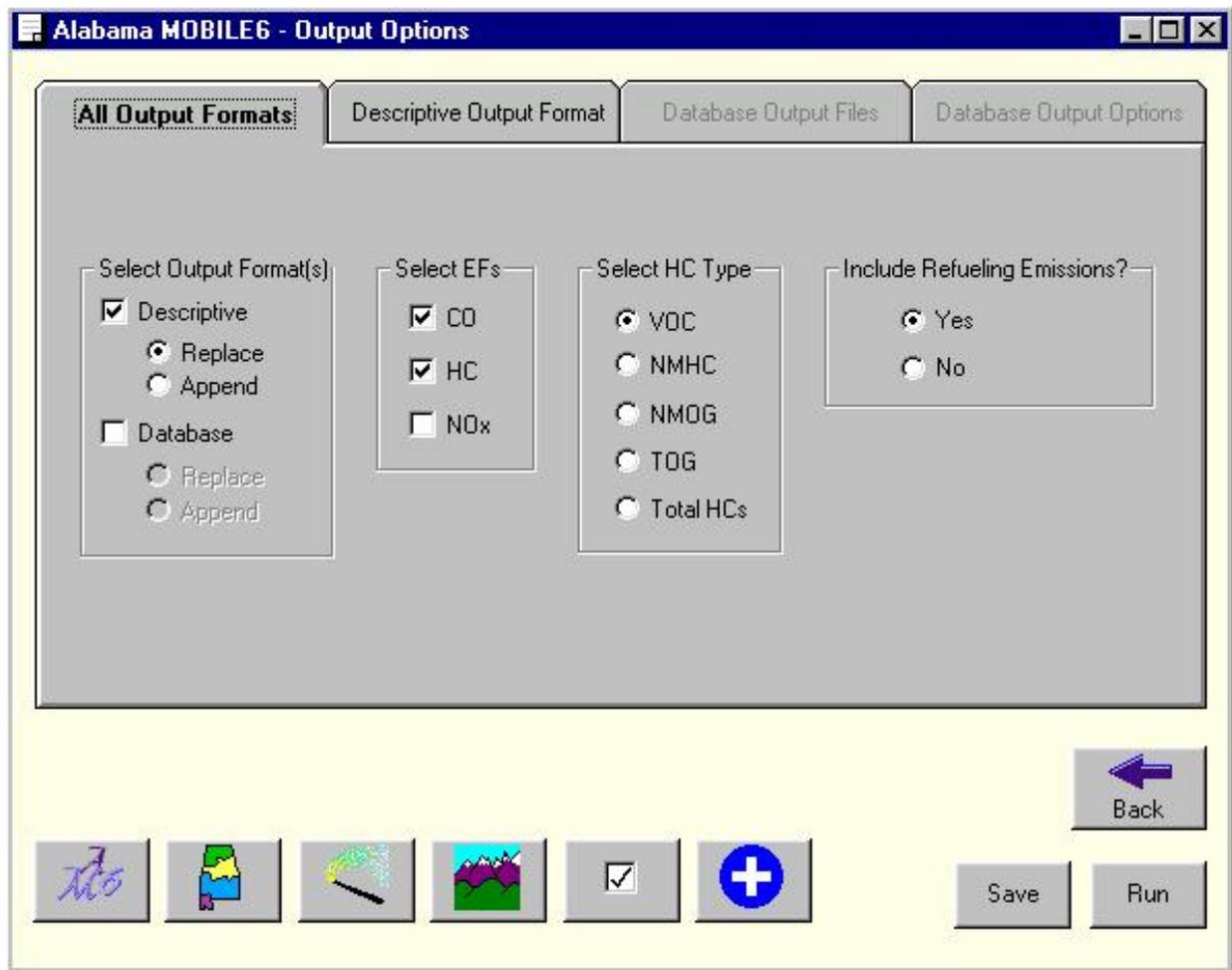12 AM6 does not prohibit the user from using any of EPA's features of MOBILE6.

Figure 2-8. Sample output control screen

Section 3
Alabama CO Screening Model (ALCO)

3.1. Introduction to ALCO

The purpose of the Alabama CO screening model (ALCO) is to provide a quick analysis of an intersection to determine whether the intersection may violate NAAQS – the objective is to quickly eliminate from further consideration those smaller intersections that have no substantial impacts on local CO concentrations. This allows air quality analysts to concentrate their efforts on those locations where projects might have a serious impact on air quality. Screening is intended to be conservative. Thus, intersections which "pass" the screening test will have such low impacts that it is highly unlikely that they could threaten the CO standard. Conversely, projects which "fail" the screening test are those that have potential impacts of such size that they *might* threaten the CO standard. If an intersection passes the screening process, no additional analysis is necessary. If an intersection does not pass the screening test, an additional and more detailed analysis is required. Often, projects that do not pass the screening process may pass a subsequent more-detailed analysis. The opening screen of ALCO is shown in Figure 3-1.

Figure 3-1. Alabama CO screening model opening screen

The intent of a screening model is to provide conservative results, and therefore conservative assumptions are built into the model. Developing a screening model requires identifying information that must be provided by the user and information that can be assumed to remain constant for all analyses (i.e., default values). These needs often vary by state and by regions within a state. To determine which information must be provided by the user and which can be pre-programmed, it is necessary to understand the original models, MOBILE6 and CAL3QHC, embedded in the screening model.

3.1.1. *MOBILE6 and CAL3QHC*

MOBILE was developed by EPA to generate emission factors for on-road mobile sources (e.g., cars, trucks, buses and motorcycles) for use by states for all their mobile source emissions inventory work. The MOBILE models also have been used to develop emission factors for

microscale models (including CAL3QHC) which apply dispersion modeling to predict concentrations near intersections.

CAL3QHC is EPA's preferred dispersion model for predicting CO concentrations near intersections. CAL3QHC determines the CO concentration at user-specified receptors near an intersection for a specified averaging time - usually one hour. It requires the user to input coordinates specifying the intersection geometry and receptor locations. Additional inputs include the surface roughness factor (a function of local land use), signal timing for each approach, traffic volumes for each approach, saturation flow rate for each approach, emission factors for each approach and emission factors for idling. CAL3QHC also requires that the meteorological conditions - wind angle, wind speed and stability class - be specified. All of these parameters, except local land use[13], traffic volumes and emission factors, were pre-set in the screening model (USEPA, 1995).

3.1.2. *Alabama-specific Data*

As described in Section 2, MOBILE6 is a massive FORTRAN program using numerous databases, tables and equations to generate emission factors for specific conditions. There are literally hundreds of input parameters used by MOBILE6 to generate emission factors. Some input parameters, such as calendar year and gasoline RVP, are required for each analysis, yet may vary from project to project. Therefore these must be specified by the user for each analysis. Some parameters are unique to the State of Alabama and while they could be specified by the user, do not vary often (e.g., the range of temperatures in the winter in the Birmingham region). Other parameters have internal national default values which typically remain constant for all runs (e.g., vehicle mix and mileage accumulation rates). When used in a screening model, much time and effort can be saved by pre-determining the values for many of the inputs or default parameters. These inputs may involve dozens and even hundreds of data items, but because they are already specified in the screening model they do not add to the data entry time required for the user. Indeed, the user never sees these detailed input files.

UCF and UAB worked with ALDOT to identify appropriate Alabama-specific default values for use in ALCO. A list of these values is presented in Table 3-1. Traffic volumes and land use are input by the user, and emission factors are extracted automatically by the screening model from MOBILE6. As with AM6 users have the ability to override any defaults, and in the case of intersection geometry and receptor locations, to create new values.

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13 Users are allowed to specify land use. ALCO then assigns a predetermined surface roughness to the chosen land use type.

Table 3-1. Built-in inputs to CO screening model

Input Parameter	Details	Related Model
Reid Vapor Pressure	11.5 psi	MOBILE6
Temperatures	As appropriate for each region	MOBILE6
Surface Roughness	175 cm (Urban), 108 cm (Suburban), 16.7 cm (Rural)	CAL3QHC
Receptor Locations	Refer to discussion	CAL3QHC
Intersection Geometry	Coordinates for 4x4, 6x6, 4x6, T, and Diamond Interchange	CAL3QHC
Signal Cycle	Total cycle length = 120 sec; Red time for left-turning traffic = 105 sec; Red time for through traffic = 75 sec	CAL3QHC
Saturation Flow Rate	1800 vph/lane for intersections; 1900, 1800 and 1600 for diamond interchange	CAL3QHC
Clearance Lost Time	3 seconds	CAL3QHC
Signal Type	Pre-timed	CAL3QHC
Arrival Rate	Worst progression	CAL3QHC
Wind speed	1.0 m/sec	CAL3QHC
Stability Class	Urban & Suburban - D; Rural – F	CAL3QHC
Ambient Background 8-hr CO concentration	Urban - 3.0 ppm; Suburban – 2.0 ppm; Rural - 1.0 ppm	CAL3QHC
Wind Angle Variation Data	360 ° wind angle search in 5-degree increments	CAL3QHC
Total Persistence Factor	0.6	CAL3QHC

3.2. Using ALCO

As the ALCO model is intended for project-specific analyses, it requires a certain amount of project-specific (user-specified) input data. Some of the key user-specified data and attending ALCO screens are presented and described in the following sections. Detailed directions on using ALCO may be found in the user's manual (available upon request to the Principal Investigator).

The Alabama CO Screening model opens with a unique identifying screen (Figure 3-1). From there the user moves to a title screen which allows the user to identify the project and the analyst. From this screen, the next step involves selecting the region in which the project is located. The region identifies climatological factors that affect the emissions factors produced by MOBILE6 and also serve as inputs to ALCO and CAL3QHC (see Section 2.1.2.).

As with AM6, the user is directed through various screens that allow a description of the analysis to be performed. In each of the subsequent screens, several user-selected inputs are required, including the year of analysis, the geometric type of intersection, the speed of vehicles approaching the intersection, the approaching traffic volumes, and receptors. A list of the required user-specified inputs is provided in Table 3-2.

Table 3-2. User-specified inputs to CO screening model

Input Parameter	Limits	Related Model
Project Name	None	MOBILE6/CAL3QHC
Project Location	Northern Alabama, Central Alabama, Southern Alabama, Coastal Alabama	MOBILE6
Year of Analysis	1990-2050	MOBILE6
Cruise Speed	2.5 - 65 mph (roadway speed limit if in doubt)	MOBILE6
Intersection type	4x4, 6x6, 4x6, T, Diamond Interchange	CAL3QHC
Traffic Volume	0 – 9999 vehicles/hour	CAL3QHC
Left-turn Traffic	less than the total traffic volume	CAL3QHC
Receptor Locations	Default plus up to 10 additional receptors	CAL3QHC
Land Use	Urban, Suburban or Rural	CAL3QHC

The CO screening model can be used to analyze CO impacts near an intersection selected by the user. As per the desires of ALDOT, five possible intersection geometries were pre-programmed into the screening model:

1) 6 x 6 - the intersection is a four-way intersection with each leg of the intersection having three through lanes and two left-turn lanes in each direction. The user enters the approaching traffic volume on each leg of the intersection. The user enters the approach speeds, and (for each leg) enters the straight-through plus any right-turning traffic volume, and the left-turning traffic volume separately. For screening purposes the model determines the combination of maximum traffic volumes and lowest speeds to find the worst-case leg, and then applies that amount of traffic and speed on each leg.

2) 4 x 4 - the intersection is a four-way intersection with each leg of the intersection having two through lanes and one left-turn lane. The user enters traffic volumes as described in (1) above. For screening purposes the model assumes that the highest amount of traffic travels on each leg. The user also enters the speeds.

3) 4 x 6 - the intersection is a four-way intersection with both legs of the north/south road having two through lanes and one left-turn lane, while the east/west road has three lanes and two left-turn lanes. The user can mentally rotate the image to apply to any 4 x 6 orientation. Separate speeds and traffic volumes must be entered for the six-lane leg and the 4-lane leg. The model uses the highest 6-lane volume for both 6-lane legs, and the highest 4-lane volume for both 4-lane legs.

4) Tee - this intersection is a three-way intersection with each leg of the intersection having two lanes; one leg of the through road has an extra lane for left-turning traffic. Even though the on-screen image has the through road running "north-south" (e.g., vertically on the screen), the model applies to any tee intersection. The user can simply rotate the image in his or her mind. Also, even though the image is of a multi-lane road, the model can be used for a smaller tee intersection, because with multiple lanes, more cars are bunched near the receptors, producing higher concentrations. For the through road, the user enters the through volume and turning volume for each leg. The model uses the maximum of these two legs. For the road on the stem of the tee, the model uses the actual volumes entered by the user.

5) Diamond interchange - this is actually two intersections where a freeway crosses over an arterial road; it is represented by two-lane ramps exiting a six-lane freeway and intersecting a four-lane arterial; the arterial road also has separate right and left-turn lanes. Traffic volumes must be provided for the ramps, freeway and arterial. Sixteen default receptors are located around the interchange. A 360-degree wind angle search is conducted. The intersections are located approximately 200 feet from the middle of the freeway; the ramps extend approximately 1000 feet from the arterial road. For more details on this or any of the above intersection geometries, please see the User's Manual.

The geometry of each of these intersections is pre-loaded in the screening model, thus saving the user considerable data entry time. The year and speed are required in order for MOBILE6 to determine the emission factor. The approaching traffic volume is used by CAL3QHC to determine total emissions from the roadway segments. For any approach to the intersection, the approaching traffic volume is determined by summing all left-turning, through and right-turning traffic coming from one direction. The model does this for the user for each leg of the intersection to select the largest approach volume. This is a conservative approach which is appropriate for a screening model. Sample intersection input screens are shown for a 4 x 4 intersection and a diamond interchange in Figures 3-2 and 3-3, respectively.
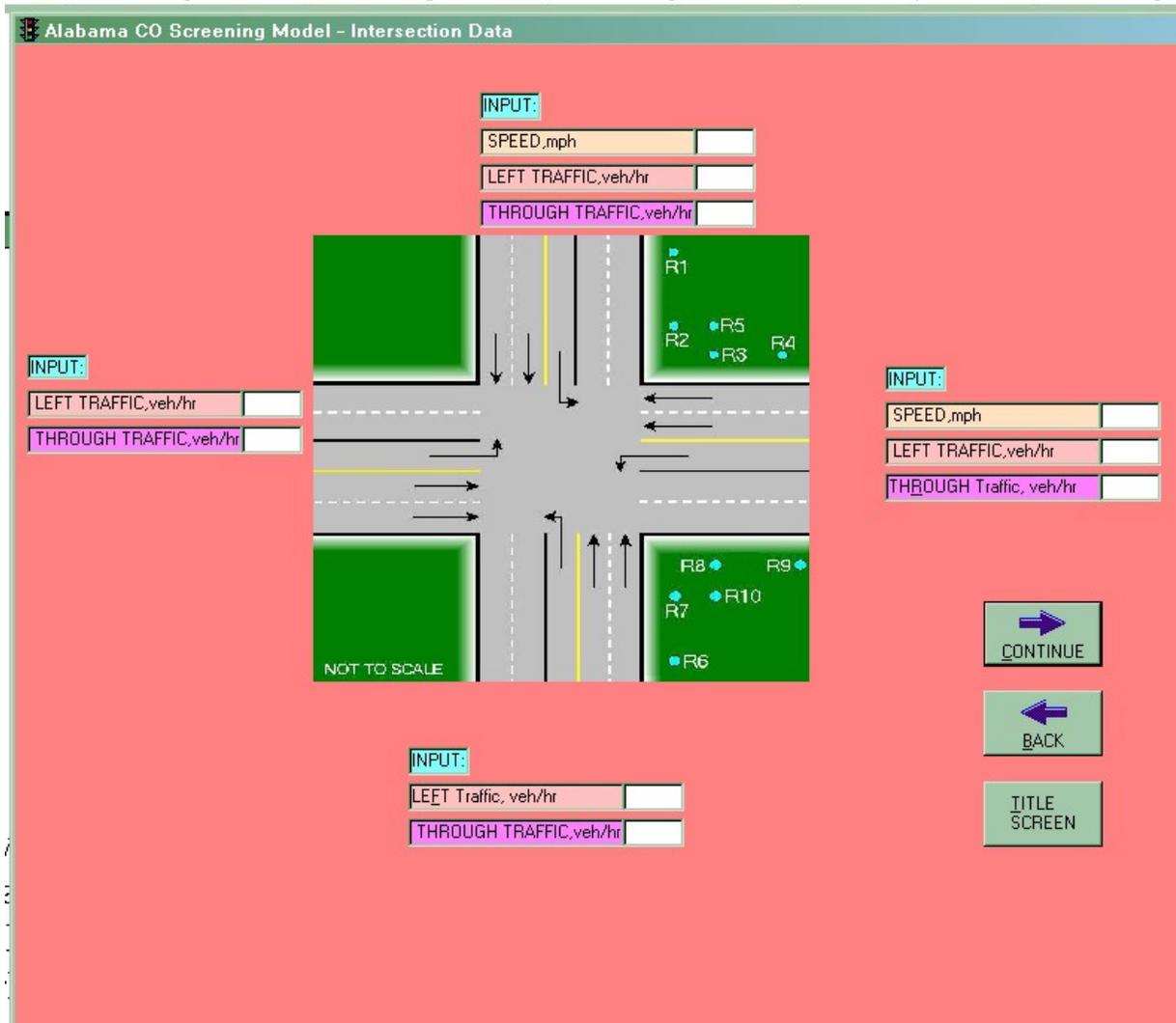

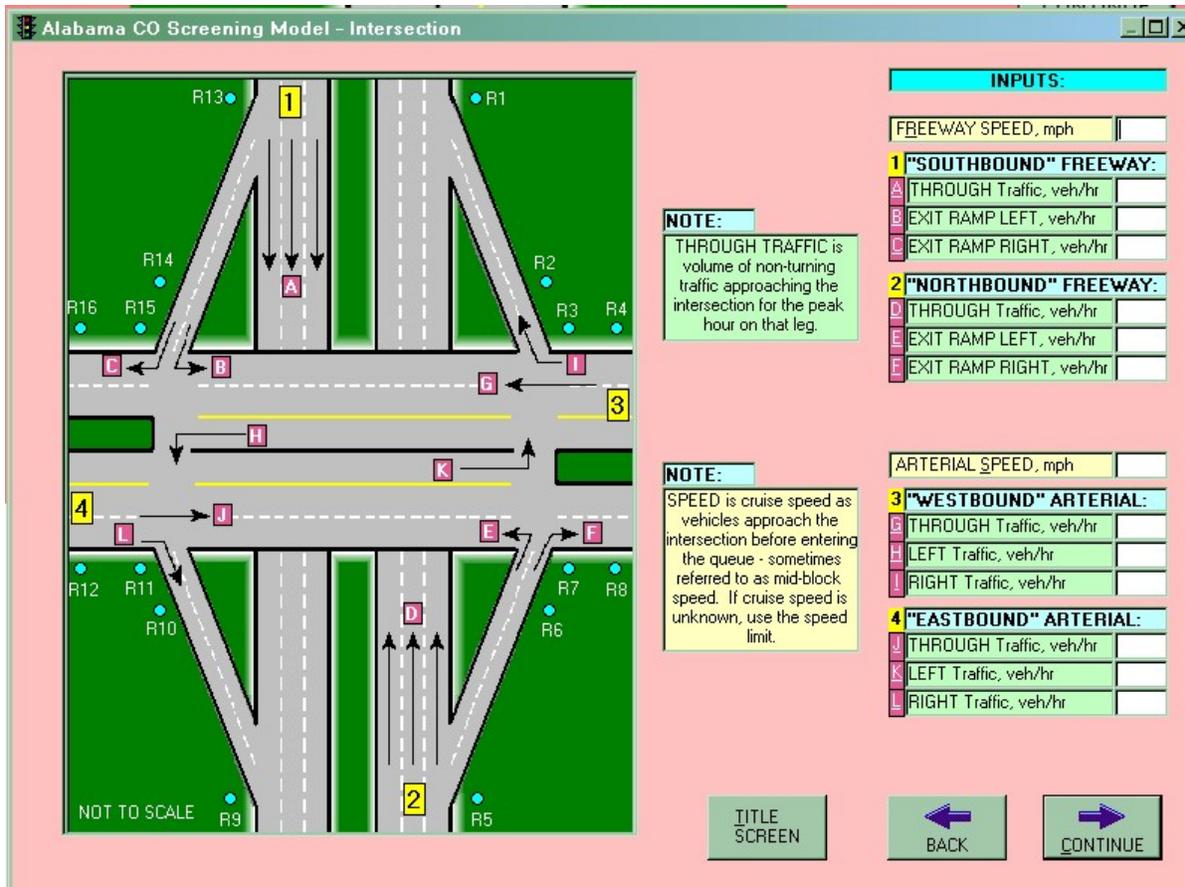**Figure 3-2. Sample 4 x 4 intersection input screen**

Figure 3-3. Sample diamond interchange intersection input screen

To explain further, for the 4 x 4 and the 6 x 6 intersections, the model applies the maximum traffic volume to all four legs. For the 4 x 6 and tee intersections, and the diamond interchange, the model determines the maximum traffic volume for each road type. For example, for the 4 x 6 intersection, the model determines the maximum traffic on the 4-lane arterial, and the maximum traffic on the 6-lane arterial. The maximum traffic on the two 4-lane roadway segments is then used for both 4-lane roadway segments, and the maximum traffic on the two 6-lane roadway segments is then used for both 6-lane roadway segments for calculating the CO concentrations.

The other advantage to this approach is that it creates a symmetrical intersection. A symmetrical intersection allows geometric duplication of the receptors in all quadrants. The distances to the default receptors for all but the diamond interchange are shown in Table 3-3.

Table 3-3. Distances from roadway edges to default receptors

Receptors	Distance in feet from	
	Adjacent Road	**Crossroad**
R1, R6	10	150
R2, R7	10	50
R3, R8	50	10
R4, R9	150	10
R5, R10	50	50

For the diamond interchange, sixteen default receptors are used but they are symmetrical. All receptors are located 10 feet from the edge of the adjacent roadway. Four receptors (numbers 1, 5, 9, and 13) are located at the ends of the on/off ramps. Receptors 2, 6, 10, and 14 are located 10 feet from the on/off ramps and 150 feet from the arterial road. Receptors 3, 7, 11, and 15 are located 10 feet from the arterial road and 50 feet from the on/off ramps. Receptors 4, 8, 12, and 16 are located 10 feet from the arterial road and 150 feet from the on/off ramps. The program automatically increases these distances from the edge of the roadway if the user-input right of way extends farther than 10 feet from the edge of the roadway. The model allows the user to input up to 10 more receptors.

The other inputs that are required for a particular model reflect the specific needs and desires of the State. One such input is land use - urban, suburban or rural. This choice influences the value of the surface roughness parameter in CAL3QHC, and the value of the background CO concentration used in the final calculations. The user selects the land use type and the model automatically selects the appropriate surface roughness and background CO concentration. The background concentrations for the various land uses pro-programmed into ALCO are shown in Table 3-4. Also, ALCO is pre-programmed with a persistence factor of 0.6 but like most parameters can be user-specified if needed.

Table 3-4. Pre-programmed land uses and background CO concentrations

Land Use	Background CO (ppm)
Urban	3.0
Suburban	2.0
Rural	1.0

In less than five minutes, the user can enter all needed data and run the CO screening model. ALCO first creates the MOBILE6 input file. The input file incorporates the user inputs as well as the state-specific inputs that are pre-programmed into the model. Upon completion of the input file, the screening model then runs MOBILE6, scans its output, and extracts the emission factors. Emission factors are determined for idle, 20 mph and other speeds input by the user. A speed of 20 mph is used for all left-turn lanes.

After extracting the emission factors, ALCO automatically builds the CAL3QHC input file. By using predefined intersections, the coordinate system for the intersection is pre-built. The model runs CAL3QHC and then extracts the calculated one-hour CO concentration at each receptor. Because these project-level analyses also require 8-hour CO concentrations, the screening model multiplies the one-hour CO concentrations by a persistence factor (pre-determined by state preference to be 0.60). ALCO adds a background CO concentration (appropriate to the user-selected land use) to each CO concentration predicted from CAL3QHC. The model reads the results of CAL3QHC and incorporates the maximum CO concentration at each receptor into the ALCO output report.

Section 4
Evaluation and Training

Throughout the project, UAB and UCF worked with ALDOT to ensure that the project resulted in software that best met their needs. ALDOT provided input in the development process, and received formal training upon completion of the programs.

4.1. Evaluation

Throughout the development of both models, versions in various stages of completion were evaluated by researchers at UCF and UAB. Versions were also supplied to appropriate ALDOT personnel for evaluation. At the midpoint of the project, UAB demonstrated the format and initial capabilities of AM6 to the ALDOT Environmental Technical Section at their office and solicited their input on program functionality and preferences regarding the Windows-based interface.

Results from both AM6 and ALCO were tested against results from MOBILE6 and CAL3QHC to ensure they generated proper results. In other words, a MOBILE6 input file was generated using AM6. Identical input data was then coded into a text file and then read directly into MOBILE6[14]. As expected, the outputs were identical confirming that AM6 acts only as pre-processor that includes Alabama-specific data, thus saving input time. A similar evaluation was performed using ALCO and CAL3QHC. The ALCO model was tested against the stand-alone, more cumbersome CAL3QHC. The results indicated that ALCO performed as expected and indeed produced more conservative CO concentrations at the selected receptor locations. The results of a comparison between the ALCO results and those obtained using the original MOBILE6/CAL3QHC approach for the analysis of proposed intersection improvements in Houston County, Alabama are presented in Table 4-1.

Table 4-1. Comparison bet6ween ALCO and MOBILE6/CAL3QHC results

Analyses	Predicted concentration (ppm)	
	MOBILE6/CAL3QHC	**ALCO**
2003 1 hr. concentration	3.5	7.7
2003 8 hr. concentration	2.8	4.6
2023 1 hr. concentration	3.0	5.6
2023 8 hr. concentration	2.4	3.3

Table 4-1 clearly indicates that ALCO provides a more conservative estimate of CO concentrations than the original methodology.

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[14] The Alabama-specific data was coded by hand.

4.2. Training

Upon completion of the software development, researchers from UCF and UAB conducted a two-day training course on both programs. The training was intended as a review of MOBILE6 and CAL3QHC and an introduction to AM6 and ALCO. The training was attended by ALDOT personnel from the Environmental Technical Section as well as the Transportation Planning Bureau. Several representatives from the Birmingham Regional Planning Commission were also in attendance along with individuals from ADEM. Additional information about the training materials and agenda may be obtained from the Principal Investigator.

Section 5
Conclusions and Recommendations

AM6 successfully transformed EPA's DOS-based, FORTRAN-language MOBILE6 program into a "point and click" Windows-based model that is accessible to mobile source modelers throughout the State of Alabama. It is very easy to use and contains a number of Alabama-specific default values for certain parameters, yet it retains a wide flexibility to model a variety of cases. The introduction of a graphical input interface increases the speed of use of this program and reduces the possibility of input errors.

CO screening models are much more sophisticated now than in the past, yet they retain their simplicity and speed of analysis. The use of a Windows-based screening model and pre-programmed options for MOBILE6 and CAL3QHC, along with today's faster computers, allows quick and accurate screening of an intersection for possible CO impacts. By using a computerized screening tool, all analysts within the state of Alabama will use consistent techniques, and achieve consistent, conservative results. Much time and effort will be saved by analysts and reviewers. Thus, more attention can be paid to the few intersections that might truly have the potential to cause significant impacts. This will result in a more efficient (*streamlined*) allocation of technical resources that will produce both cost savings and higher quality environmental analyses.

The new Alabama mobile source models exhibit all of the desired qualities in Windows-based interfaces. It is recommended that ALDOT authorize use of ALCO and AM6 for analyzing roadway project-level impacts in Alabama as soon as possible.

Section 6
Acknowledgements

Section 7
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