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Visitor Vehicle Emissions Study
Joshua Tree National Park
Final Report

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EXECUTIVE SUMMARY

As part of a National Park Service (NPS) project to evaluate visitor vehicular emissions in the National Parks, a field study was performed from August 2002 to April 2003. The study was a joint effort between the NPS, the National Park Foundation, and the Volpe National Transportation Systems Center's Environmental Measurement and Modeling Division (Volpe Center). Three parks were studied: Yosemite National Park, Joshua Tree National Park, and Point Reyes National Seashore. This report focuses on the work conducted for Joshua Tree.

The Volpe Center collected vehicular traffic data over a period of four days (November 30 – December 3, 2002) at Joshua Tree. The measured data included vehicle counts, vehicle types (derived from vehicle registration records), and speed profiling (car chase) activities. The data were processed to obtain the necessary inputs for vehicular emissions modeling. One of the key data processing activities involved the development of representative driving cycles from the car chase data.

The Environmental Protection Agency's (EPA) MOBILE6 (Version 6.2) emission factor model was used to develop the main (or "standard") inventories for carbon monoxide (CO), the volatile organic compound (VOC) category of hydrocarbons (HC), nitrogen oxides (NOx), carbon dioxide (CO_2), 2.5-micron particulate matter (PM2.5), and 10-micron particulate matter (PM10). The MOBILE-series models are the standard models promulgated by EPA for various vehicular emissions modeling work, including the development of state implementation plans and conductance of conformity analysis. Average vehicle speeds were used in MOBILE6 for the closest facility type. An alternative approach was also presented using the University of California at Riverside's (UCR) Comprehensive Modal Emissions Model (CMEM). This model and a third, more empirically-based, derivative Meta-Model (based on a speed and acceleration matrix) were used to explicitly model the second-by-second park-specific cycle data.

The resulting inventories showed similar but noticeable differences between the three different methods. The MOBILE6 results were higher (more conservative) for VOC/HC and NOx, but lower for CO. Comparisons to previous studies at other parks showed similar results; they were within a magnitude and, in many cases, much closer. This was due to the similar vehicle miles traveled (VMT) data used in each of the studies.

To conduct further emissions modeling studies (other scenarios) for Joshua Tree, the input data for MOBILE6 and CMEM can be modified by an expert user to reflect various other scenarios. However, it is instead recommended that a simplified methodology using the CMEM Meta-Model be used. This would require the collection of driving cycle data (second-by-second vehicle speeds). As an alternative, when cycle data is not available (or too difficult to obtain), a simplified method using pre-generated MOBILE6 emission factors can also be used.

The Volpe Center's summary report on this project, "Visitor Vehicular Traffic Iimpact Study: Comparison of Traffic Data at Three California National Parks", compares the various traffic data collected at Yosemite, Joshua Tree, and Pt. Reyes. Based on these comparisons, the Volpe Center is recommending that users of the CMEM Meta-Model use the composite CMEM vehicle type distribution presented in the summary report for all California parks, with the possibility of expanding that recommendation for all US parks after further investation, but collect speed and acceleration data separately at individual parks.

1 INTRODUCTION

As part of a National Park Service (NPS) project to evaluate vehicular emissions in the National Parks, a visitor vehicle emissions study was conducted for Joshua Tree National Park. This study was a joint effort between the NPS, the National Park Foundation (NPF), and the Volpe National Transportation Systems Center's Environmental Measurement and Modeling Division (Volpe Center). The goal of this study was two-fold: (1) Develop a park-specific baseline vehicular emissions inventory of carbon monoxide (CO), the volatile organic compound (VOC) category of hydrocarbons (HC), nitrogen oxides (NOx), carbon dioxide (CO_2), 2.5-micron particulate matter (PM2.5), and 10-micron particulate matter (PM10) [NOTE: PM in this document indicates total particulate matter, including exhaust PM (lead, gasoline PM, elemental carbon, organic carbon, and sulfates), brake PM, and tire PM]; and (2) develop a simplified methodology to produce vehicular emissions inventories for varying visitor traffic scenarios. In addition to Joshua Tree, similar studies have been conducted at Yosemite National Park and Pt. Reyes National Seashore with the simplified methods also applied to those parks.

The development of the emissions inventories required the collection of three key datasets concerning visitor vehicles: (1) vehicle counts; (2) vehicle types; and (3) driving patterns within the park. These datasets were used with the Environmental Protection Agency's (EPA's) MOBILE6 (Version 6.2) vehicular emissions model to produce the baseline inventories. MOBILE6 rather than the California-specific emission factor model, EMFAC2002 ("EMFAC" for "Emission Factor"), was used for this study due to the need to keep the methods uniform when analyzing parks outside of California.

In addition to MOBILE6, alternative methods using modal emissions models were developed to provide refined modeling capabilities and results. The University of California at Riverside's (UCR) Comprehensive Modal Emissions Model (CMEM, Version 2.02) was used as the basis for this refined emissions modeling work. A derivative Meta-Model[1] using only the speed and acceleration variables in CMEM was developed to simplify the use of CMEM.

The instructions and recommendations contained herein are not meant to be substituted for any certification procedure or policy utilized by any local, state, or federal government in the generation of any data necessary for the formation of environmental policy.

[1] As used in this context, a "meta-model" is a model developed from the outputs of a parent model (e.g., CMEM) by varying a subset of all the parameters within the parent model.

2 BACKGROUND ON EMISSION FACTOR MODELS

2.1 MOBILE6

MOBILE Version 6.2 ("MOBILE6") is the latest version of the MOBILE-series vehicular emission factor modeling software promulgated by the EPA [EPA 2002]. Typically, states and various local/regional agencies use the model for developing vehicular emissions inventories as a requisite for state implementation plans and conformity analyses.

MOBILE6 was basically developed through emissions measurements using a Federal Test Procedure (FTP) driving cycle with a length of 7.5 miles and a speed averaged over one cycle of 19.6 miles per hour (mph). The basic emission rates derived from these measurements are modified within the model to account for changes in various scenario parameters.

MOBILE6 predicts emission factors (e.g., g/vehicle-mile) for several pollutants such as several HC categories (including VOC), CO, NOx, CO_2, PM2.5, and PM10. The model takes into account various parameters, including vehicle types, temperature, vehicle speeds, inspection/maintenance (I/M) programs, etc., to generate current emission factors. In addition, future scenarios can also be modeled. A basic schematic of the inputs and outputs to the model are shown in Figure 1.

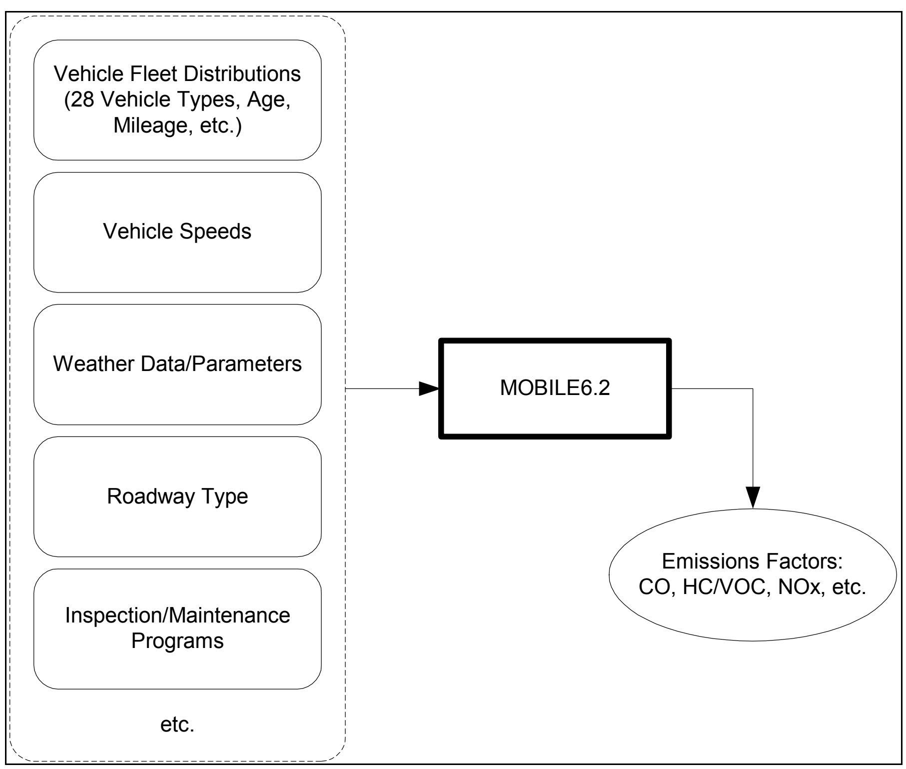

Figure 1. Schematic of the MOBILE6 inputs and outputs

The emission factors from the model are averages for a facility type and provided for up to 28 different vehicle types:

- 1 - LDGV Light-Duty Gasoline Vehicles (Passenger Cars)
- 2 - LDGT1 Light-Duty Gasoline Trucks 1 (0-6,000 lbs. GVWR, 0-3,750 lbs. LVW)
- 3 - LDGT2 Light-Duty Gasoline Trucks 2 (0-6,000 lbs. GVWR, 3,751-5,750 lbs. LVW)
- 4 - LDGT3 Light-Duty Gasoline Trucks 3 (6,001-8,500 lbs. GVWR, 0-5,750 lbs. ALVW)
- 5 - LDGT4 Light-Duty Gasoline Trucks 4 (6,001-8,500 lbs. GVWR, greater than 5,751 lbs. ALVW)
- 6 - HDGV2b Class 2b Heavy-Duty Gasoline Vehicles (8,501-10,000 lbs. GVWR)
- 7 - HDGV3 Class 3 Heavy-Duty Gasoline Vehicles (10,001-14,000 lbs. GVWR)
- 8 - HDGV4 Class 4 Heavy-Duty Gasoline Vehicles (14,001-16,000 lbs. GVWR)
- 9 - HDGV5 Class 5 Heavy-Duty Gasoline Vehicles (16,001-19,500 lbs. GVWR)
- 10 - HDGV6 Class 6 Heavy-Duty Gasoline Vehicles (19,501-26,000 lbs. GVWR)
- 11 - HDGV7 Class 7 Heavy-Duty Gasoline Vehicles (26,001-33,000 lbs. GVWR)
- 12 - HDGV8a Class 8a Heavy-Duty Gasoline Vehicles (33,001-60,000 lbs. GVWR)
- 13 - HDGV8b Class 8b Heavy-Duty Gasoline Vehicles (>60,000 lbs. GVWR)
- 14 - LDDV Light-Duty Diesel Vehicles (Passenger Cars)
- 15 - LDDT12 Light-Duty Diesel Trucks 1and 2 (0-6,000 lbs. GVWR)
- 16 - HDDV2b Class 2b Heavy-Duty Diesel Vehicles (8,501-10,000 lbs. GVWR)
- 17 - HDDV3 Class 3 Heavy-Duty Diesel Vehicles (10,001-14,000 lbs. GVWR)
- 18 - HDDV4 Class 4 Heavy-Duty Diesel Vehicles (14,001-16,000 lbs. GVWR)
- 19 - HDDV5 Class 5 Heavy-Duty Diesel Vehicles (16,001-19,500 lbs. GVWR)
- 20 - HDDV6 Class 6 Heavy-Duty Diesel Vehicles (19,501-26,000 lbs. GVWR)
- 21 - HDDV7 Class 7 Heavy-Duty Diesel Vehicles (26,001-33,000 lbs. GVWR)
- 22 - HDDV8a Class 8a Heavy-Duty Diesel Vehicles (33,001-60,000 lbs. GVWR)
- 23 - HDDV8b Class 8b Heavy-Duty Diesel Vehicles (>60,000 lbs. GVWR)
- 24 - MC Motorcycles (Gasoline)
- 25 - HDGB Gasoline Buses (School, Transit and Urban)
- 26 - HDDBT Diesel Transit and Urban Buses
- 27 - HDDBS Diesel School Buses
- 28 - LDDT34 Light-Duty Diesel Trucks 3 and 4 (6,001-8,500 lbs. GVWR)

2.2 Modal Emissions Modeling

Modal emissions models provide the ability to directly model emissions that are specific to different vehicle operational modes. Depending on its intended use, a modal emissions model could provide emission factors on an aggregate level or on a second-by-second basis for the corresponding speed and acceleration values. One such model for the latter use (second-by-second emissions) is CMEM (Version 2.02) developed by UCR under sponsorship by the National Cooperative Highway Research Program (NCHRP).

CMEM employs a "physical modal modeling approach based on a parameterized analytical representation of emissions production" [Barth 2001]. The six main computational modules in CMEM are: (1) engine power demand, (2) engine speed, (3) fuel/air ratio, (4) fuel-rate, (5) engine-out emissions, and (6) catalyst pass fraction [Barth 2001]. These modules are used to model the "physical phenomena associated with vehicle operation and emissions production" [Barth 2001]. The overall model can be described through the following relationship:

$$\text{Tailpipe Emissions} = FR \times (g_{emission} / g_{fuel}) \times CPF \qquad (1)$$

where FR = Fuel use rate, in g/s, and
CPF = Catalyst pass fraction

The engine power demand module serves as the main interface between the input data and the rest of the modules. The input data are categorized into (1) operating variables and (2) specific vehicle parameters. Examples of operating parameters are road grade, accessory power, and soak time; examples of specific vehicle parameters are vehicle mass, engine displacement, and idle speed of engine [Barth 2001].

CMEM can generate second-by-second modal emission factors as well as aggregated per distance (mile) factors based on a given driving cycle (i.e., speed profile) for CO, HC, and NOx. In addition, fuel flow rates are provided. Unlike MOBILE6, the total emissions of HC are presented rather than as VOC.

The simplest input is a driving cycle with speed information, but other operational data such as acceleration and road grade, along with deviations from the default vehicle parameters, could be used to refine the model work. The vehicle types modeled in CMEM are:

Normal Emitting Cars

- 1 - No Catalyst
- 2 - 2-way Catalyst
- 3 - 3-way Catalyst, Carbureted
- 4 - 3-way Catalyst, FI, >50K miles, low power/weight
- 5 - 3-way Catalyst, FI, >50K miles, high power/weight
- 6 - 3-way Catalyst, FI, <50K miles, low power/weight
- 7 - 3-way Catalyst, FI, <50K miles, high power/weight
- 8 - Tier 1, >50K miles, low power/weight
- 9 - Tier 1, >50K miles, high power/weight
- 10 - Tier 1, <50K miles, low power/weight
- 11 - Tier 1, <50K miles, high power/weight
- 24 - Tier 1, >100K miles

Normal Emitting Trucks

- 12 - Pre-1979 (<=8500 GVW)
- 13 - 1979 to 1983 (<=8500 GVW)
- 14 - 1984 to 1987 (<=8500 GVW)
- 15 - 1988 to 1993, <=3750 LVW
- 16 - 1988 to 1993, >3750 LVW
- 17 - Tier 1 LDT2/3 (3751-5750 LVW or Alt. LVW)
- 18 - Tier 1 LDT4 (6001-8500 GVW, >5750 Alt. LVW)
- 25 - Gasoline-powered, LDT (> 8500 GVW)
- 40 - Diesel-powered, LDT (> 8500 GVW)

High Emitting Vehicles

- 19 - Runs lean
- 20 - Runs rich
- 21 - Misfire
- 22 - Bad catalyst
- 23 - Runs very rich

There are several potential advantages to utilizing CMEM over other statistics-based modal emissions models such as MOBILE6. The micro-scale modeling approach employed in CMEM ensures that it can be used for varying scales of analysis whereas a statistical model may be constrained by the level of detail in the data on which it was developed. The micro-scale analysis capability allows for modeling a wide range of scales since the results can be aggregated for larger scales. CMEM also provides numerous parameters and variables that can be used to refine an analysis such as the addition of road grade information. In addition to these, the physical modeling approach employed in CMEM represents a more realistic and likely a more accurate model. In using the model to develop an overall emissions inventory, CMEM has two potential advantages over MOBILE6: (1) the ability to explicitly model different driving cycles (i.e., other than the FTP cycle); and (2) the ability to take into account road grade data, a significant concern in many National Parks.

CMEM has undergone validation efforts where measured versus modeled emissions were compared. The tests were conducted by running CMEM on several independent driving cycles (i.e., cycles on which CMEM was not developed). In comparing the aggregated measured data (i.e., bag values), excellent agreement was observed with the lowest R^2 value found to be 0.866, and for most tests, the R^2 value higher than 0.95 [Barth 2001]. Tests also generally showed little or no bias for most of the second-by-second tests [Barth 2001].

A disadvantage to using a model of this type is the data requirement. The higher-fidelity nature requires a similarly higher level of input complexity and understanding from the user. Although default parameters can be used, refinements in analyses require the user to provide more data. Data used for other modal emissions analyses may need to be expanded using assumptions as necessary to develop speed, acceleration, road grade, etc. In addition, the model is also limited to light-duty vehicles. Large or heavy-duty vehicles are beyond the scope of the current model (Version 2.02). This is not a concern when modeling visitor vehicular emissions at National Parks because of the negligible fractions of these visitor vehicle types at the parks.

In addition to CMEM, other methods for modeling modal emissions have been developed in the past, including the use of modal multipliers and emission matrices/equations. Both of these methods employ the use of speed and acceleration either to define the various modes (i.e., idle, cruise, acceleration, and deceleration) or as parameters to represent power demand.

Examples of modal multiplier methods include those developed by the Colorado Department of Highways [Griffin 1980] and those employed in the EPA's roadway dispersion model, CALINE4 [Benson 1989]. These methods essentially convert an average emission factor such as a composite MOBILE6 emission factor or a component thereof into an emission factor that represents an acceleration event. While deceleration can also be modeled in this way, it could also be assumed to be similar to cruise (i.e., using average emission factors) for simplicity. By contrast, an emissions matrix or equation would directly provide an emission rate for the specified speed and acceleration combination. If the method/model is in a matrix or lookup table form, varying ranges of speed and acceleration bins could be used. While these methods are limited by the speed and acceleration variables they can take into account, their simplicity allows them to be more usable by a wider community.

3 NATIONAL PARK DESCRIPTION

3.1 Joshua Tree National Park

JOSHUA TREE is located east of Los Angeles, California, in Riverside and San Bernardino Counties. The park features historic landscapes such as the Mojave and Colorado Deserts and the Little San Bernardino Mountains and is famous for its joshua tree orchards, one of which is pictured in Figure 2. There is also a variety of wildlife within the park's boundaries, including coyotes, black-tailed jack rabbits, and bighorn sheep. In 2002, Joshua Tree had 1.1 million visitors. A map of the park is presented in Figure 3.

Figure 2. Joshua tree grove in Joshua Tree National Park

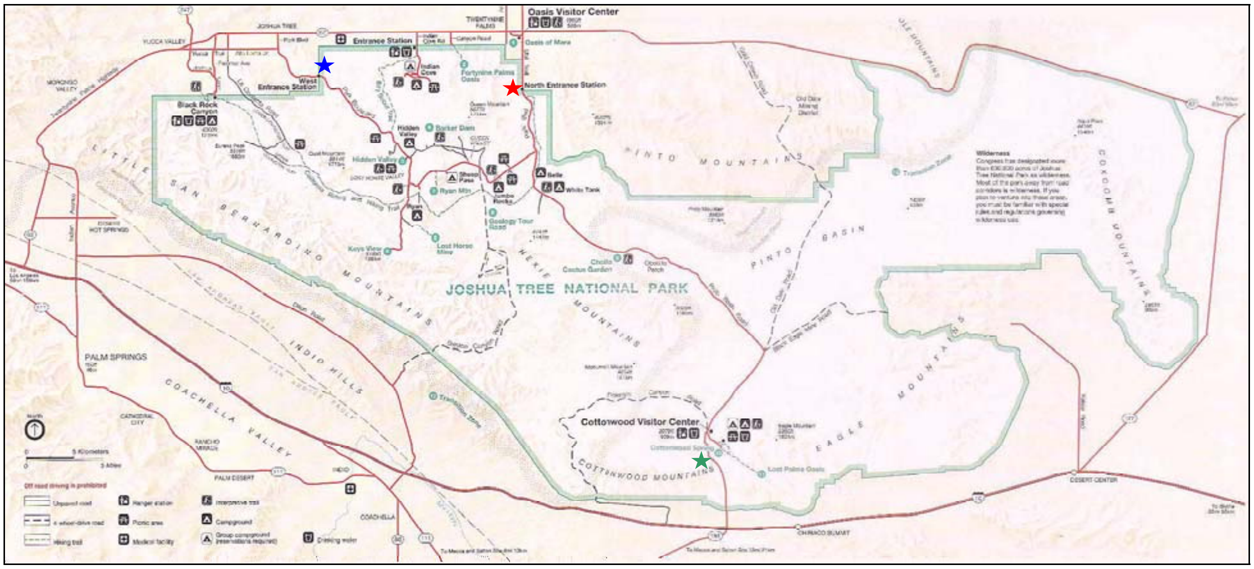

Figure 3. Map of Joshua Tree

On the map in Figure 3, the ★ identifies the Oasis Visitor Center measurement site, the ★ identifies the Park Boulevard measurement site, and the ★ identifies the Cottonwood Visitor Center measurement site.

4 DATA COLLECTION AND EQUIPMENT

Visitor traffic counts along with license plate information and driving patterns were measured at the park. Table 1 shows the basic data collection schedule that was followed.

Table 1. Study measurement schedule at Joshua Tree

Date	Time Slot	# Measurement Sites	# Chase Vehicles
Saturday, November 30, 2002	7:00 – 19:00	3	1
Sunday, December 1, 2002	7:00 – 19:00	3	1
Monday, December 2, 2002	7:00 – 19:00	3	1
Tuesday, December 3, 2002	7:00 – 19:00	3	1

4.1 Measurement Sites

Three measurement sites were set up: Oasis Visitor Center visitor vehicle entrance gate, Park Boulevard visitor vehicle entrance gate, and Cottonwood Visitor Center. At each site, an observer camera was set up with a vantage point close to visitor vehicle travel and beneficial to capturing license plate information. Though the Cottonwood Visitor Center has no entrance gate, a camera was placed there due to the site's proximity to visitor vehicle travel into the park.

4.1.1 Oasis Visitor Center

Vehicles traveling into the park from the north were logged at the Oasis Visitor Center entrance gate. See Figure 4 for a diagram of the Oasis Visitor Center site setup.

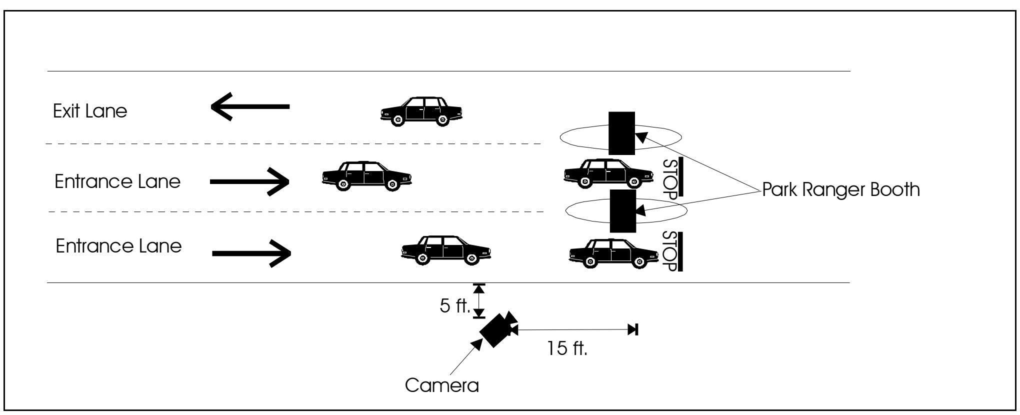

Figure 4. Joshua Tree Oasis Visitor Center measurement site

4.1.2 Park Boulevard

Vehicles traveling into the park from the west were logged at the Park Boulevard entrance gate. The Park Boulevard site setup was very similar to the Oasis Visitor Center site setup pictured in Figure 4.

4.1.3 Cottonwood Visitor Center

Vehicles traveling into the park from the south were logged near the Cottonwood Visitor Center. See Figure 5 for a diagram of the Cottonwood Visitor Center site setup.

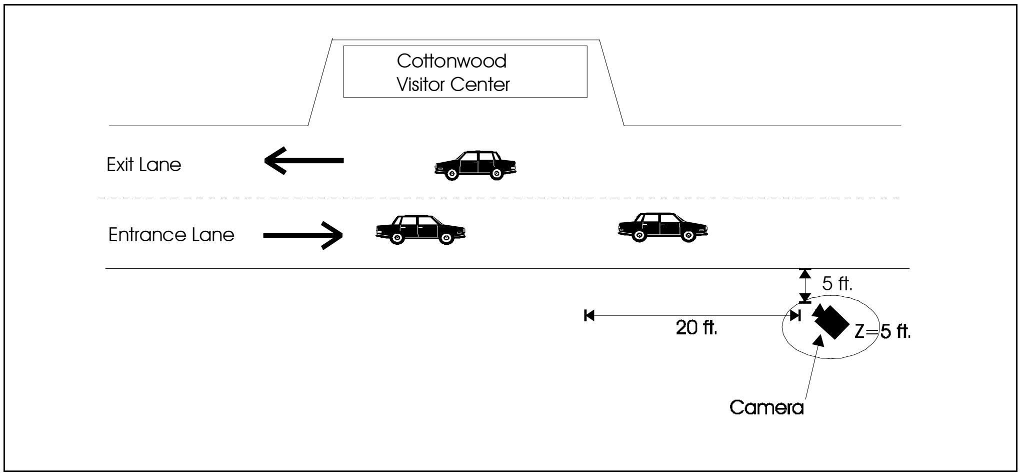

Figure 5. Cottonwood Visitor Center measurement site

4.2 Traffic Counting

A Sony 8 mm Handycam video camera was mounted on a tripod at each measurement site, as in Figure 6, pointed in the direction of traffic traveling into the park. This camera recorded the license plate number and state of each visitor vehicle entering the park.

Figure 6. Video camera at Cottonwood Visitor Center measurement site

The traffic count data from Joshua Tree are quantified in Table 2, including a breakdown of activity by site.

Table 2. Joshua Tree traffic count data.

Oasis, Total Cars Logged	Oasis, CA only	Park Blvd., Total Cars Logged	Park Blvd., CA only	Total Daily Count	Daily CA Count	% CA (%)
548	409	1,302	1,059	1,850[a]	1,468[b]	79.4

[a] 1,616 weekday, 234 weekend
[b] 1,282 weekday, 186 weekend

Of 1,850 total vehicles counted over four days at two Joshua Tree sites, 1,468, or 79.4%, were visitor vehicles registered in the state of California.

Traffic count data from the Cottonwood Visitor Center site have been left out of the tabulation because the high speeds of the vehicles passing before the video camera at the Cottonwood Visitor Center site made it impossible to accurately determine the plate number or state on each vehicle's license plate. Though vehicle make and model could usually be determined for the 647 passbys captured on videotape at this site, these limited data were determined to be unfit for use in the same database with accurate DMV motor vehicle information.

4.3 Vehicle Registration Data

License plate information obtained during the vehicle counting activities was forwarded to the California Department of Motor Vehicles (DMV), which provided printed hardcopies of registration information for each of the vehicles. The registration database included the following parameters:

- vehicle model year
- vehicle make
- body type model
- zip code
- body type
- fuel type
- number of axles
- vehicle weight
- vehicle type
- vehicle body type model
- vehicle class
- last date of registration
- odometer reading

4.4 Visitor Driving Pattern Profiling

To profile visitor driving patterns, the movement of randomly picked visitor vehicles were tracked (profiled) in a chase car. The visitors included a random mixture of the following categories: (1) started outside of the park and ended within the park; (2) started within the park and ended outside of the park; (3) started within the park and ended within the park; (4) started outside of the park and ended outside of the park (i.e., went through the park). In each of these cases, profiles were limited to just those portions of the trip spent within the boundaries of the park. An overview of the visitor vehicle profiling data from Joshua Tree is shown in Table 3.

Table 3. Joshua Tree profiling data.

Date	Total Cars Profiled
Saturday, 11/30	18
Sunday, 12/1	22
Monday, 12/2	16
Tuesday, 12/3	14
All Days	70

The speed and location of the chase car were primarily recorded using the Volpe Center's Global Positioning System (GPS) equipment, as described in Section 4.4.1. Of 70 visitor vehicle profile events performed, 66 were found to contain high-quality time-stamp, latitude, and longitude data for every half-second of the event. Table 4 shows a sample of the higher-quality data from the GPS equipment.

Table 4. Sample vehicle profile data.

FR_TIME	TO_TIME	FR_LAT	FR_LON	TO_LAT	TO_LON
07:14:37.0	07:14:37.5	33.74890883	-115.82403658	33.74892589	-115.82404033
07:14:37.5	07:14:38.0	33.74892589	-115.82404033	33.74893255	-115.82404393
07:14:38.0	07:14:38.5	33.74893255	-115.82404393	33.74894361	-115.82405113
07:14:38.5	07:14:39.0	33.74894361	-115.82405113	33.74895255	-115.82406024
07:14:39.0	07:14:39.5	33.74895255	-115.82406024	33.7489738	-115.82407393
07:14:39.5	07:14:40.0	33.7489738	-115.82407393	33.74899325	-115.82408863
07:14:40.0	07:14:40.5	33.74899325	-115.82408863	33.74899826	-115.82409894
07:14:40.5	07:14:41.0	33.74899826	-115.82409894	33.74900577	-115.82410919
07:14:41.0	07:14:41.5	33.74900577	-115.82410919	33.74901523	-115.82411959
07:14:41.5	07:14:42.0	33.74901523	-115.82411959	33.74902291	-115.82412899
07:14:42.0	07:14:42.5	33.74902291	-115.82412899	33.74902924	-115.82413573
07:14:42.5	07:14:43.0	33.74902924	-115.82413573	33.7490351	-115.82414281

FR_TIME = Time at beginning of half-second time interval
TO_TIME = Time at end of half-second time internal
FR_LON = Longitude (degrees) at beginning of half-second time interval
FR_LAT = Latitude (degrees) at beginning of half-second time interval
TO_LON = Longitude (degrees) at end of half-second time interval
TO_LAT = Latitude (degrees) at end of half-second time interval

4.4.1 Global Positioning System

The GPS consists of a rover unit, which receives satellite signals via a NovAtel receiver, and a laptop computer, which monitors the system through the Volpe Center's Time-

Space-Position-Information (TSPI) software. The GPS equipment collects data continuously at a rate of twice per second [Volpe 2003].

The GPS rover unit was maintained aboard the chase car, shown in Figure 7. The GPS antenna was mounted on the roof of the chase car each day prior to measurements. The NovAtel receiver and a laptop computer containing the TSPI software were installed in the passenger's seat of the chase car just prior to the start of measurements and powered through the chase car's internal electrical system.

Figure 7. Joshua Tree chase car

A distance of approximately 200-300 feet was maintained between the chase car and the visitor vehicle at all times during profiling events. All events began and ended within the boundaries of the park.

4.4.2 Digital Audio Tape

As a backup to the GPS equipment, the chase car was equipped with a dashboard-mounted Sony F-VS3 dynamic microphone and a Sony TCD-D100 DAT Recorder, powered through the chase car's internal electrical system. When the GPS equipment did not receive an acceptable satellite signal, the chase car operator dictated onto DAT tape the location, speed, and behavior of the visitor vehicle.

4.5 Miscellaneous Modeling Data

Various miscellaneous data required to run MOBILE6 were obtained from the vehicular emission factor model, EMFAC2002, which provides California-specific data [CARB 2002]. As shown in Appendix A, the data extracted from the model included:

- Fuel Reid Vapor Pressure (RVP)
- Various inspection/maintenance data

- Fuel program
- Refueling assumptions
- Sulfur content

Specifically, the parameter values that were specific for Riverside County and the month of November 2002 were extracted. Although visitors to Joshua Tree originate from various counties, a county containing part of Joshua Tree National Park (Riverside County) was used because it was assumed that most of the visitors would either originate within or close to this county.

Meteorological data was obtained from various sources, including:

- Atmospheric Temperature [USNO 2003]
- Absolute Humidity [HDS 2002]

5 DATA REDUCTION

The raw traffic count data consist of 8 mm video tapes. The raw visitor vehicle profiling data consist of ASCII text files on 3.5-inch floppy disks, vehicle profiling log sheets, and backup DAT tapes.

5.1 Traffic Count and Vehicle Registration Data

Since 79.4% of the visitor vehicles logged at Joshua Tree were registered in California, it was concluded that neglecting non-California license plate data would be reasonable in developing park fleet characteristics. The license plate information gathered from Joshua Tree was sent by mail to the California DMV for processing. This data was reduced to motor vehicle information through the following steps:

- A Current Record Information request was filed with the DMV [CADMV 2003].
- The DMV sent printed vehicle information records back to the Volpe Center by mail. The DMV could not provide electronic copies of the data without substantial investment by the Volpe Center in antiquated hardware.
- The printed data from the DMV were manually entered into a spreadsheet.
- Each vehicle information record was assigned a MOBILE6 type using the vehicle weight and other categorizing variables.
- Age and mileage information were also extracted from the records.

After filtering out the non-California data records and analyzing (including quality control) the data from the DMV with quality checks, it was determined that out of the total 1,850 Joshua Tree visitor vehicles logged over the four days, 1,165 records were acceptable. Although this is far less than the total, it was still deemed to be a large enough sample to provide representative fleet characteristics. A sample of the 1,165 Joshua Tree vehicle information records are included in Appendix B, complete with the DMV vehicle classification codes, which aided in the translation of vehicles into MOBILE6 and CMEM vehicle types.

5.2 Visitor Vehicle Profiling Data

ArcGIS was used to reduce the raw profile data discussed in Section 4.3 to vehicle speeds. The position information was first plotted to provide visual sanity checks of the data. Figure 8 shows an example of such a plot. The position and time information was used to determine a corresponding vehicle speed for each data point. The half-second data was averaged accordingly into 1-second data for easier modeling.

The speed data was then processed to smooth any spikes (erroneous data points) as exemplified in Appendix C. The resulting data included lists of speeds (speed profiles) for the 66 profiling events.

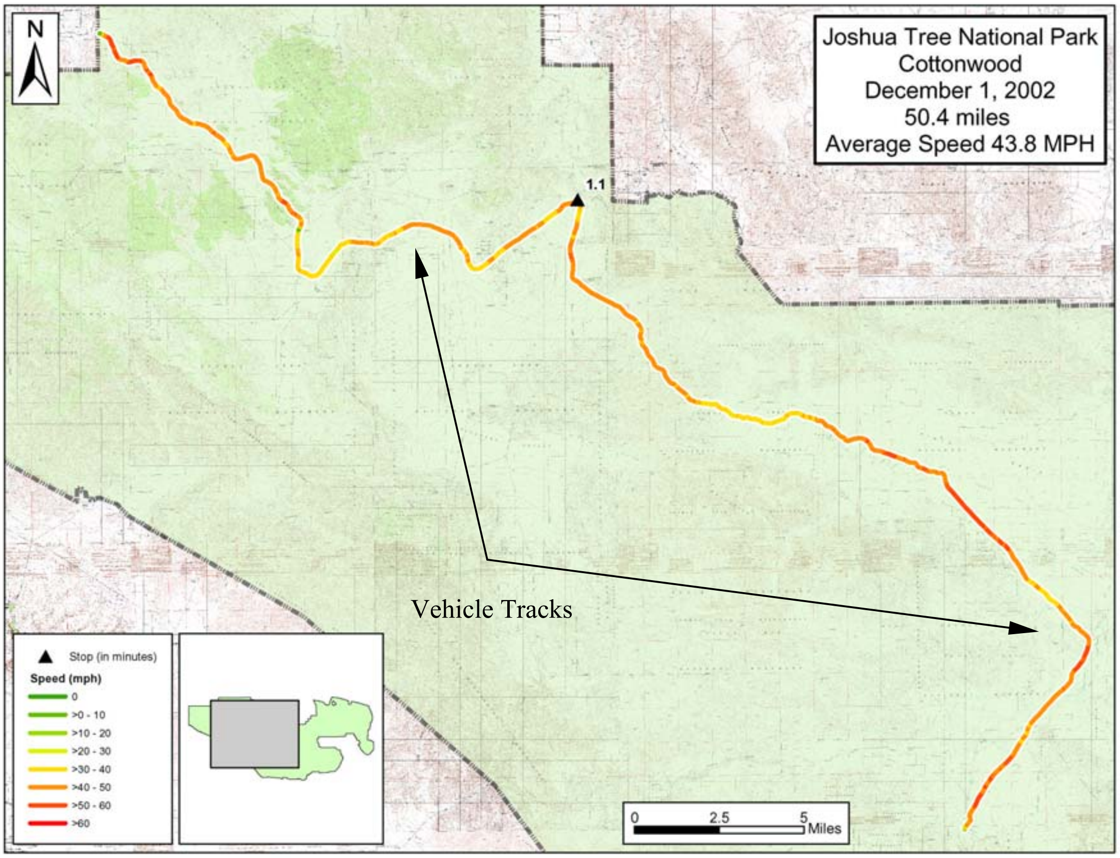

Figure 8. Profile event showing a vehicle traveling through Joshua Tree

6 EMISSIONS INVENTORY DEVELOPMENT METHODOLOGY

Three sets of emissions inventories were developed using MOBILE6, CMEM, and a Meta-Model developed from CMEM outputs. The basic overview of the development is shown in Figure 9.

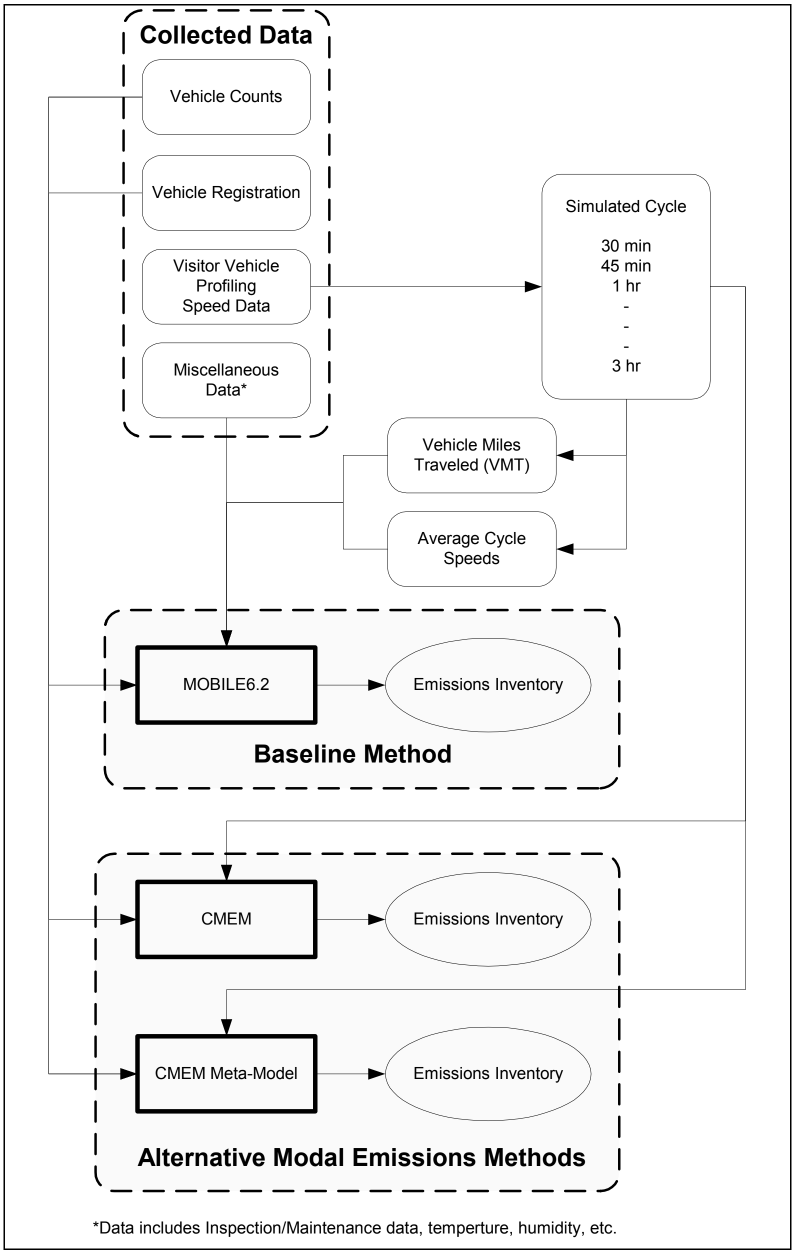

Figure 9. Overview of modeling methods

As shown in Figure 9, the three key common datasets were the vehicle counts, the registration data, and the visitor vehicle driving profile data. The vehicle count data was processed to allow emissions inventories to be developed using a week as a basis. The two days' worth of weekday counts (from Table 2) were scaled and added to the weekend counts (from Table 2) as follows:

[(1616) * 5/2] + 234 = 4274 visitors/week

The vehicle registration data was used to obtain vehicle type fractions for each of the 28 types in MOBILE6 and the 26 types used in CMEM and the CMEM Meta-Model.

In order to provide park-specific speed data to these models, simulated driving cycles (speed profiles) were developed. The development of a cycle began with the identification of discrete movement events in the vehicle profiling data. A movement event was defined as a portion of the speed data that starts with a set of speeds less than or equal to 2.5 mph, continues through subsequent speeds greater than 2.5 mph, and concludes just before speeds of 2.5 mph or lower begin to occur again. One such event is exemplified in Figure 10, where the numbers in the figure represent 1-second samples of vehicle speed.

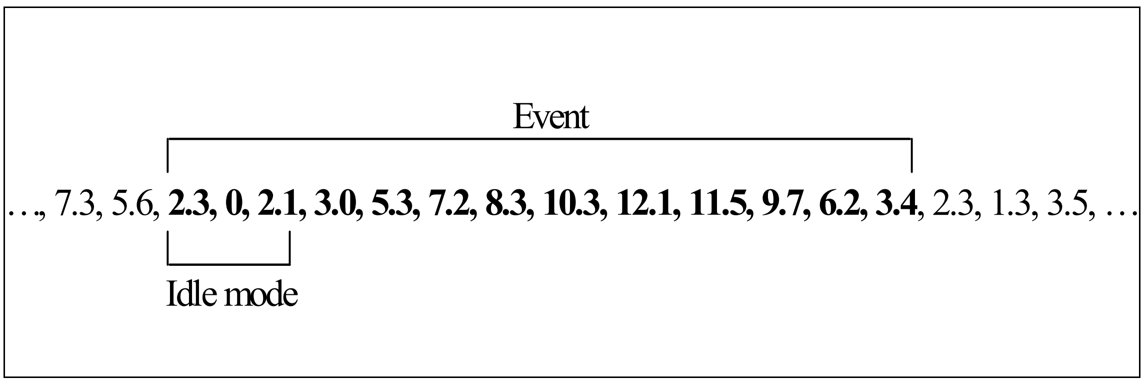

Figure 10. Example movement event

The numbers in bold starting with 2.3 and ending with 3.4 represent an event because 2.3 is the first number equal to or less than 2.5, and 3.4 is the last number in this sequence greater than 2.5. This scheme arbitrarily assigns the idle mode (speeds less than 2.5 mph) to the beginning of the event. A speed of 2.5 mph was chosen for the cutoff between each event because it is effectively used as the cutoff in MOBILE6 for modeling idle emissions. Each of the different modes (idle, acceleration, cruise, and deceleration) is captured in each event to varying degrees: Some modes are clearly defined while others are less distinct and may seem to blend with the others. These events serve as the building blocks for developing a representative park cycle.

A cycle was developed by randomly selecting from the pool of events and attaching the selected events linearly (i.e., end to end) until a desired cycle length was achieved. Since the vehicle profile data were collected by randomly selecting and following park visitors, the cycle developed from this method should be representative of visitor driving patterns in Joshua Tree. Its broader applicability to other parks is still to be determined.

Although speed profiles could be obtained from the vehicle profiling data, the length of time a visitor spends driving in the park could not be determined. Since only continuous visitor activities were captured through car chasing, the total drive times for each visitor could not be deduced. Therefore, cycles were created for a range of different trip lengths:

- 15 min
- 30 min
- 45 min
- 60 min (1 hour)
- 75 min
- 90 min
- 105 min
- 120 min (2 hours)
- 135 min
- 150 min
- 165 min
- 180 min (3 hours)

Pre-generated random numbers were used so that the cycles would be identical (consistent) each time they were created. This also had the effect of causing the shorter cycles to be subsets of the longer cycles. The creation of the longer cycles included the use of the same random numbers used to generate the shorter cycles plus additional random numbers required to fill the rest of the longer cycles' lengths. The average speeds and VMT data for each of these 12 cycles are shown in Table 5.

Table 5. Simulated cycle data

Cycle Length (min)	VMT (miles)	Average Speed (mph)
15	6.8	27.2
30	13.8	27.6
45	24.4	32.5
60 (1 hour)	32.2	32.2
75	32.6	26.1
90	32.6	21.8
105	38.0	21.7
120 (2 hours)	49.7	24.9
135	61.3	27.2
150	71.6	28.6
165	81.9	29.8
180 (3 hours)	91.8	30.6

Although the shorter cycles (e.g., 15 min) are unlikely to be representative of an "average" park cycle length, they were included to show the effects of choosing shorter cycles. Figure 11 shows the results of a Monte Carlo analysis where each of the different cycles was generated randomly (different random numbers) 1,000 times to determine the standard deviation in average cycle speed.

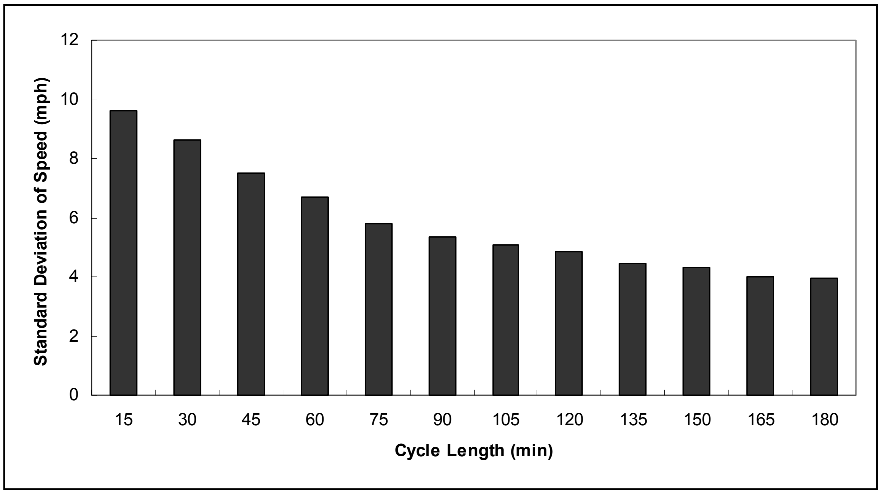

Figure 11. Standard deviation of average speeds per cycle length

These standard deviations indicate that at shorter cycle lengths, there is greater variability in the cycle data, and, hence, greater uncertainty associated with the resulting emissions based on the cycles. Therefore, although emissions inventories have been developed for these shorter-length cycles (less than about 75 min, where the variability begins to level out), they should be used with caution.

To illustrate the significance of the differences between the FTP and the simulated cycles, speed distributions of these cycles were compared. Figure 12 shows the speed distributions for both the FTP cycle and the simulated 1-hour cycle based on 5 mph speed ranges (or bins).

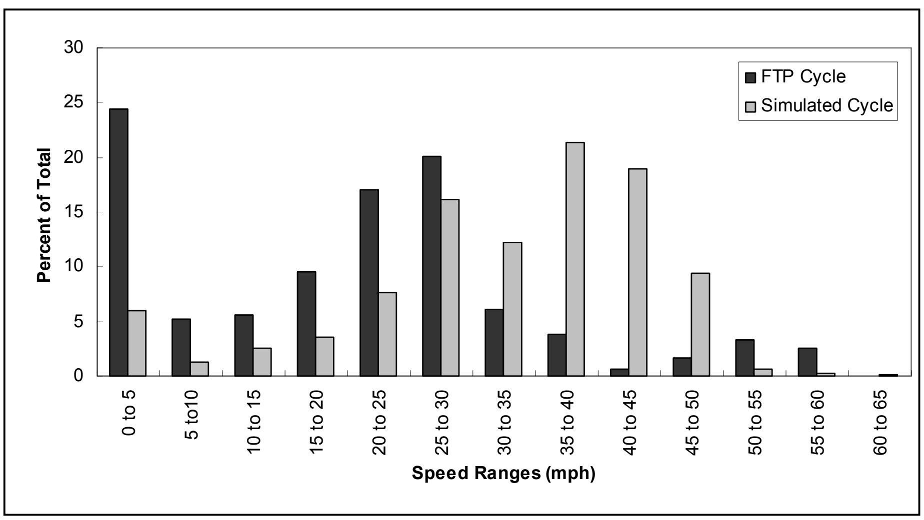

Figure 12. Speed distributions from the FTP and the simulated 1-hour cycle

Figure 12 shows significant differences between the two cycles (i.e., urban versus park driving). This illustrates the greater degree of free-flow movement at higher speeds represented within the park cycle as compared with the urban cycle represented in MOBILE6.

6.1 MOBILE6 Methodology

The MOBILE6 input file was developed using data from the following sources:

- California DMV
- EMFAC mobile emission factor model
- California Air Resources Board (CARB)
- Various miscellaneous sources

The input file was created to allow park-specific modeling of vehicular emissions. Appendix A shows the park-specific data and assumptions used in the input file. The actual input files are shown in Appendix D. Although the data collected generally provided high-fidelity modeling, some assumptions were still necessary. The major assumptions included:

- The use of defaults for the engine-off related parameters (transient effects) such as "Starts per Day" and "Soak Distribution."
- The use of default I/M parameter settings/values from EMFAC. As previously mentioned in Section 4.5, data specific to Riverside County was assumed to be applicable to Joshua Tree because most visitors will either be from or close to this county.
- Although not a part of the input file, an assumption (or approximation) concerning the use of MOBILE6 is that the VMT were based on level roadways. MOBILE6 was developed from cycle data on generally level roadways and cannot reflect the effects of road grades.

Composite emission factors from MOBILE6 were developed for both weekday and weekend scenarios. The output files (modeled results) are shown in Appendix E. Overall composite emission factors were developed by weighting the weekday and weekend emission factors using the vehicle count:

$$EFC = EFCWD*VCFWD + EFCWE*VCFWE \quad (2)$$

Where EFC = Emission factor for an overall composite vehicle type (g/vehicle-mile)
EFCWD = Emission factor for a composite vehicle type for weekday scenario (g/vehicle-mile)
EFCWE = Emission factor for a composite vehicle type for weekend scenario (g/vehicle-mile)
VCFWD = Vehicle count fraction for a weekday = [(1616) * 5/2] / 4274
VCFWE = Vehicle count fraction for a weekend = (234) / 4274

The overall composite emission factors were used with the total vehicle count and VMT entering the park as shown below:

$$TE = EFC * TC * VMT \quad (3)$$

where TE = Total emissions per week (g/week)
TC = Traffic count of all vehicles entering the park (vehicle/week) = 4274/week
VMT = Vehicle miles traveled for a composite vehicle type (miles)

As indicated, a week was used as the basis for the inventories. The inventories could be scaled accordingly to derive emissions for longer time periods (e.g., seasonal, yearly, etc.).

As previously discussed, the inventories were developed for 12 simulated cycles due to an absence of actual VMT data. The actual inventory for Joshua Tree could be determined from interpolating within the emissions results for these 12 cycles. Emissions for CO, VOC, NOx, CO_2, PM2.5, and PM10 were modeled.

6.2 CMEM Methodology

In an attempt to provide a more refined modeling analysis, CMEM was used to develop inventories for CO, HC, and NOx for each of the 12 simulated cycles. These cycles were prepared as a comma-delimited list of second-by-second time, speed, and accelerations. The cycles were assumed to apply to all vehicle types.

Within CMEM, a fleet with all of the 26 vehicle types was created. For each of these vehicle types, default parameters were used. CMEM allows the user to modify the following parameters:

Sload – Secondary load such as AC use in hp
Tsoak – Defines a vehicle's soak (engine-off) time in minutes
Ed – Engine displacement in liters
Masslb – Vehicle mass in lbs
Trlhp – Coast down power in hp
S – Engine speed / vehicle speed in rpm/mph
SH – Specific humidity in grains of H_2O/lb of dry air
Nm – Engine speed in rpm at maximum torque
Qm – Maximum torque in ft-lbs
Zmax – Maximum power in hp
Np – Engine speed in rpm at maximum power
Idle – Idle speed in rpm
ng – Number of gears

The soak (engine-off) times were left unmodified at zero due to a lack of data. Therefore, the only transient conditions were from the idling segments captured as part of the measured cycle data.

Similar to MOBILE6, CMEM can also take into account the effect of age and mileage data, but unlike MOBILE6, it does so through the use of the aforementioned vehicle parameters and the fleet mix, since the 26 vehicle types are a mixture of categories by weight, age, and mileage. The vehicle distributions for CMEM were developed according to the recommended guidelines shown in Appendix F. Although it was possible to base the distributions on the MOBILE6 distributions (with some modifications and assumptions), it was deemed more accurate to use the California DMV data.

Similar to MOBILE6, fleet distributions were developed for both weekday and weekend scenarios. These two sets were combined by weighting them according to their vehicle count fractions as shown:

$$FFi = FFWDi*VCFWD + FFWEi*VCFWE \qquad (4)$$

Where FFi = Weighted fleet fraction for a vehicle type
FFWDi = Weekday fleet fraction for a vehicle type
FFWEi = Weekend fleet fraction for a vehicle type
VCFWD = Vehicle count fraction for a weekday = [(1616) * 5/2] / 4274
VCFWE = Vehicle count fraction for a weekend = (234) / 4274

CMEM provides both second-by-second (g/s) and vehicle-specific aggregated (g/vehicle-mile) emission factors. The aggregated emission factors were used to derive a composite emission factor by using the fleet distribution information as shown:

$$EFC = \sum(EFi * FFi) \qquad (5)$$

Where EFi = Emission factor for a vehicle type (g/vehicle-mile)

Then similar to MOBILE6, Equation 3 was used to calculate total emissions for each pollutant. Since CMEM only models light duty gasoline cars and trucks, diesel and heavy duty vehicles could not be modeled. Leaving out these vehicles was considered acceptable due to their small numbers (less than 1% of the fleet).

In addition to providing modal emission factors, CMEM also provides an advantage over MOBILE6 in being able to model road grade. Although some elevation data was captured through profiling activities at Joshua Tree, they were not used, so as to keep the methods and data uniform with similar studies at other parks (i.e., Yosemite and Pt. Reyes). The elevation data is not of uniform quality among the three parks and is completely missing in the Joshua Tree dataset.

6.3 CMEM Meta-Model Methodology

Since CMEM is a relatively complicated model to run, a simplified method was developed to create a meta-model based on CMEM outputs. Specifically, combinations of speed and acceleration ranges were modeled in CMEM to produce corresponding second-by-second modal emission rates. The speed and acceleration values ranged from 0 to 80 mph and –6 to 6 mph/s, respectively. Each combination of speed and acceleration were fed into CMEM as a set of three records with speed differences that corresponded to the acceleration rate. For example, as shown in Table 6, a speed-acceleration combination of 10 mph and 2 mph/s included points before and after with the differences in speeds equating to an acceleration of 2 mph/s.

Table 6. Speed-acceleration combination example.

Speed (mph)	Acceleration (mph/s)
8	2
10	2
12	2

Only the resulting emission rates for the middle combinations (e.g., 10 mph and 2 mph/s) were used. The additional preceding and trailing points were necessary to minimize any effects of hysteresis and/or forward-looking by the model. The resulting matrix (or lookup table) of emission factors is based on speed, acceleration, and vehicle type. Table 7 shows an excerpt from this matrix.

Table 7. Sample CMEM Meta-Model matrix

Vehicle ID	Speed (mph)	Acceleration (mph/s)	CO (g/s)	HC (g/s)	NOx (g/s)
1	20	2	0.6704	0.0534	0.0166
1	21	2	0.6916	0.0545	0.0175
1	22	2	0.7165	0.0557	0.0185

For non-whole-number speeds and accelerations, interpolations are necessary to use this model. The matrix covers all possible combinations of speed and accelerations by past and present motorized vehicles. Since CMEM already places caps on vehicle performance (i.e., at higher combinations of speed and acceleration), the emissions also have caps. For example, at 45 mph, the emission factors (g/s)[2] for all pollutants will essentially be the same at accelerations greater then 5 mph/s.

Using the same speed and acceleration cycle data used in CMEM, the Meta-Model provided emission factors for each of the cycle data points. Since the emission factors and cycle data points were both based on a 1-second interval, the emission factors were summed and then multiplied by the total number of vehicles to obtain total emissions per week as shown below:

$$TE = \sum(EFs) * TC \qquad (6)$$

where EFs = Composite emission factor for a single cycle data point (g/s)

[2] The conversion factor for grams to tons is 1.1025E-06.

7 EMISSIONS INVENTORIES AND RESULTS

The emissions inventories developed using MOBILE6, CMEM, and the CMEM Meta-Model are shown in Tables 8-13 with corresponding plots in Figures 13-18. As previously discussed, all of these inventories were based on a total Joshua Tree traffic count of 4,274 vehicles per week.

Table 8. CO emissions inventory

Average Cycle Length (min)	VMT (miles)	Average Speed (mph)	CO Emissions (tons/week)		
			MOBILE6	CMEM	CMEM Meta-Model
15	6.8	27.2	0.58	0.15	0.17
30	13.8	27.6	1.17	0.40	0.44
45	24.4	32.5	2.07	0.50	0.80
60	32.2	32.2	2.73	0.80	1.14
75	32.6	26.1	2.77	1.04	1.23
90	32.6	21.8	2.77	1.28	1.31
105	38.0	21.7	3.23	2.29	1.96
120	49.7	24.9	4.22	3.04	2.90
135	61.3	27.2	5.20	3.70	3.80
150	71.6	28.6	6.08	3.97	4.24
165	81.9	29.8	6.95	3.92	4.71
180	91.8	30.6	7.79	3.90	4.96

Table 9. HC emissions inventory

Average Cycle Length (min)	VMT (miles)	Average Speed (mph)	VOC/HC[a] Emissions (tons/week)		
			MOBILE6	CMEM	CMEM Meta-Model
15	6.8	27.2	0.07	0.01	0.01
30	13.8	27.6	0.14	0.02	0.01
45	24.4	32.5	0.24	0.03	0.02
60	32.2	32.2	0.32	0.04	0.03
75	32.6	26.1	0.32	0.05	0.03
90	32.6	21.8	0.32	0.07	0.03
105	38.0	21.7	0.37	0.09	0.04
120	49.7	24.9	0.49	0.10	0.05
135	61.3	27.2	0.60	0.11	0.07
150	71.6	28.6	0.71	0.12	0.07
165	81.9	29.8	0.81	0.13	0.08
180	91.8	30.6	0.90	0.14	0.09

[a]VOC outputs from MOBILE6 were used. CMEM provided HC values.

Table 10. NOx emissions inventory

Average Cycle Length (min)	VMT (miles)	Average Speed (mph)	NOx Emissions (tons/week)		
			MOBILE6	CMEM	CMEM Meta-Model
15	6.8	27.2	0.03	0.01	0.01
30	13.8	27.6	0.06	0.03	0.02
45	24.4	32.5	0.10	0.03	0.03
60	32.2	32.2	0.14	0.04	0.04
75	32.6	26.1	0.14	0.05	0.04
90	32.6	21.8	0.14	0.07	0.04
105	38.0	21.7	0.16	0.09	0.05
120	49.7	24.9	0.21	0.11	0.07
135	61.3	27.2	0.26	0.12	0.09
150	71.6	28.6	0.31	0.13	0.11
165	81.9	29.8	0.35	0.14	0.12
180	91.8	30.6	0.39	0.15	0.13

Table 11. CO_2 emissions inventory

Average Cycle Length (min)	VMT (miles)	Average Speed (mph)	CO_2 Emissions (tons/week)
			MOBILE6
15	6.8	27.2	11.82
30	13.8	27.6	23.98
45	24.4	32.5	42.40
60	32.2	32.2	55.96
75	32.6	26.1	56.66
90	32.6	21.8	56.66
105	38.0	21.7	66.04
120	49.7	24.9	86.37
135	61.3	27.2	106.53
150	71.6	28.6	124.43
165	81.9	29.8	142.33
180	91.8	30.6	159.54

Table 12. PM2.5[a] emissions inventory

Average Cycle Length (min)	VMT (miles)	Average Speed (mph)	PM2.5 Emissions (tons/week)
			MOBILE6
15	6.8	27.2	0.0005
30	13.8	27.6	0.0010
45	24.4	32.5	0.0018
60	32.2	32.2	0.0024
75	32.6	26.1	0.0025
90	32.6	21.8	0.0025
105	38.0	21.7	0.0029
120	49.7	24.9	0.0038
135	61.3	27.2	0.0046
150	71.6	28.6	0.0054
165	81.9	29.8	0.0062
180	91.8	30.6	0.0070

[a] PM indicates Total PM, including exhaust PM (lead, gasoline PM, elemental carbon, organic carbon, and sulfates), brake PM, and tire PM.

Table 13. PM10 emissions inventory

Average Cycle Length (min)	VMT (miles)	Average Speed (mph)	PM10 Emissions (tons/week)
			MOBILE6
15	6.8	27.2	0.0010
30	13.8	27.6	0.0019
45	24.4	32.5	0.0034
60	32.2	32.2	0.0045
75	32.6	26.1	0.0046
90	32.6	21.8	0.0046
105	38.0	21.7	0.0054
120	49.7	24.9	0.0070
135	61.3	27.2	0.0087
150	71.6	28.6	0.0101
165	81.9	29.8	0.0116
180	91.8	30.6	0.0130

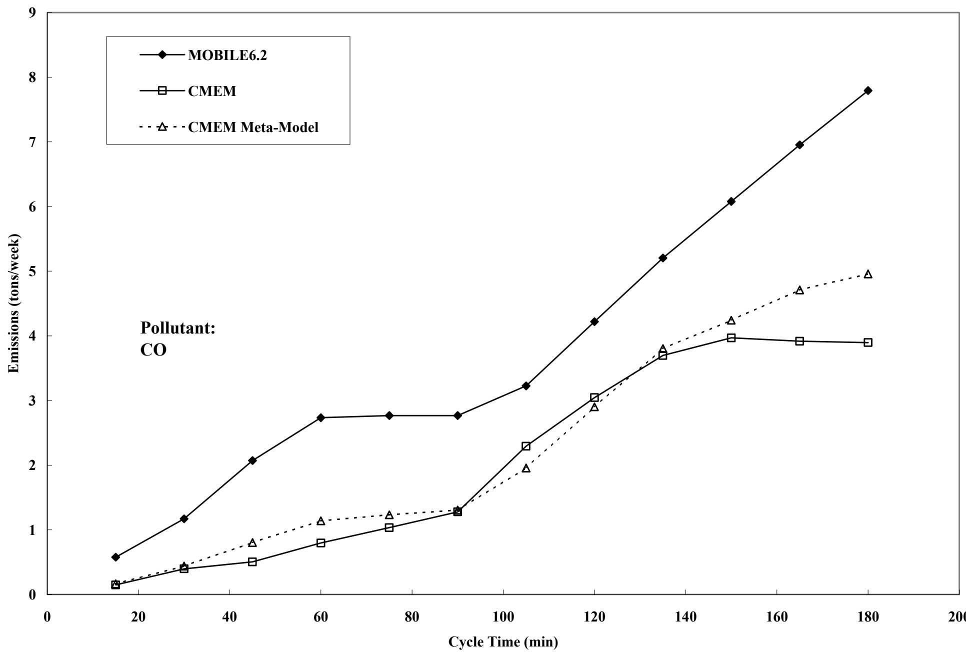

Figure 13. CO emissions plots

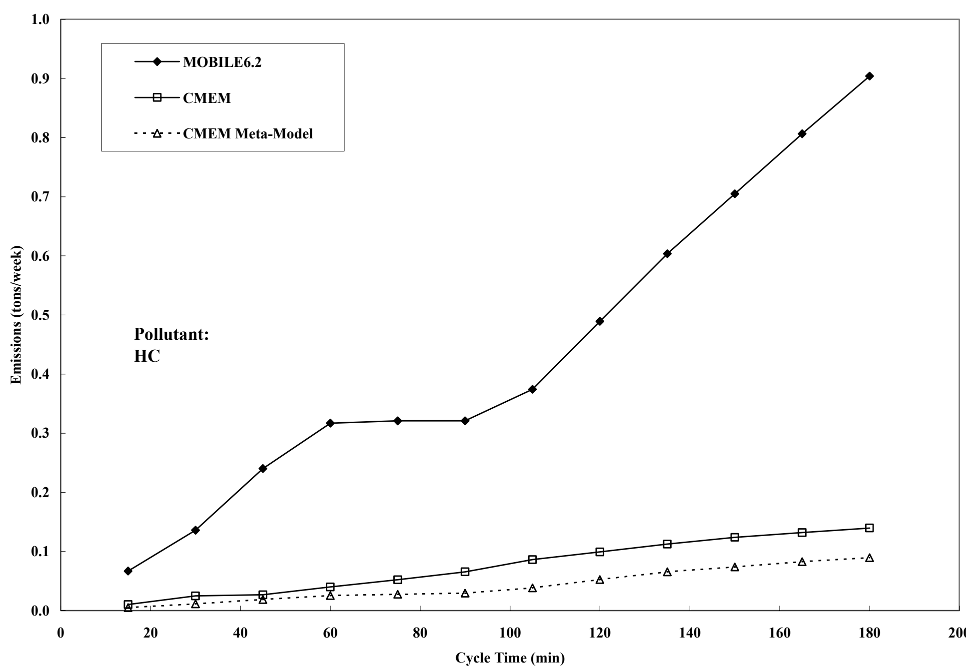

Figure 14. VOC/HC emissions plots

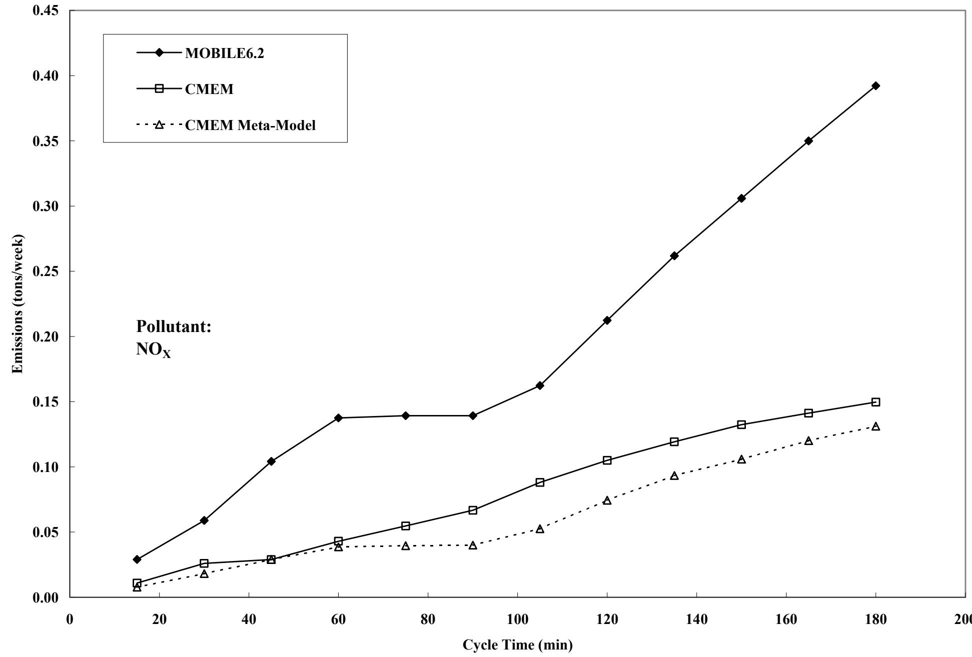

Figure 15. NOx emissions plots

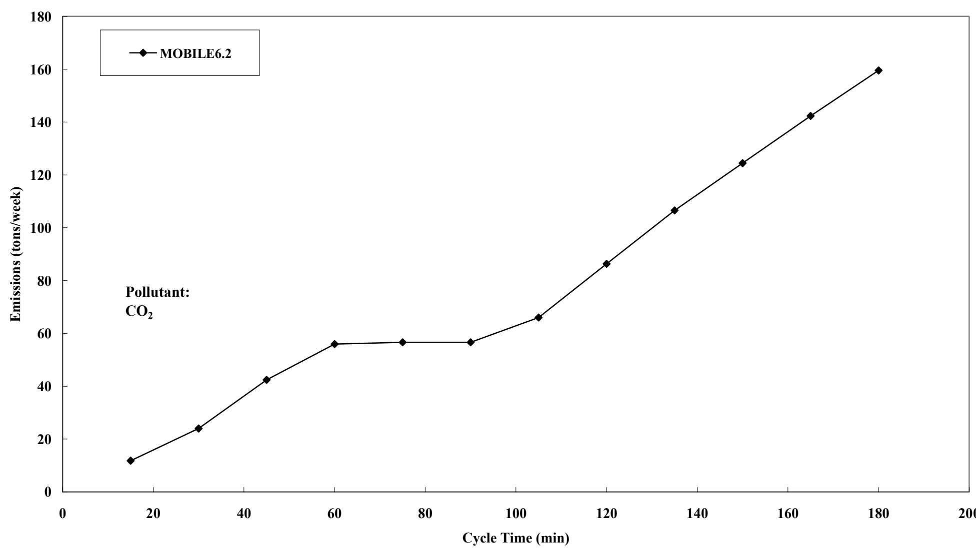

Figure 16. CO_2 emissions plot

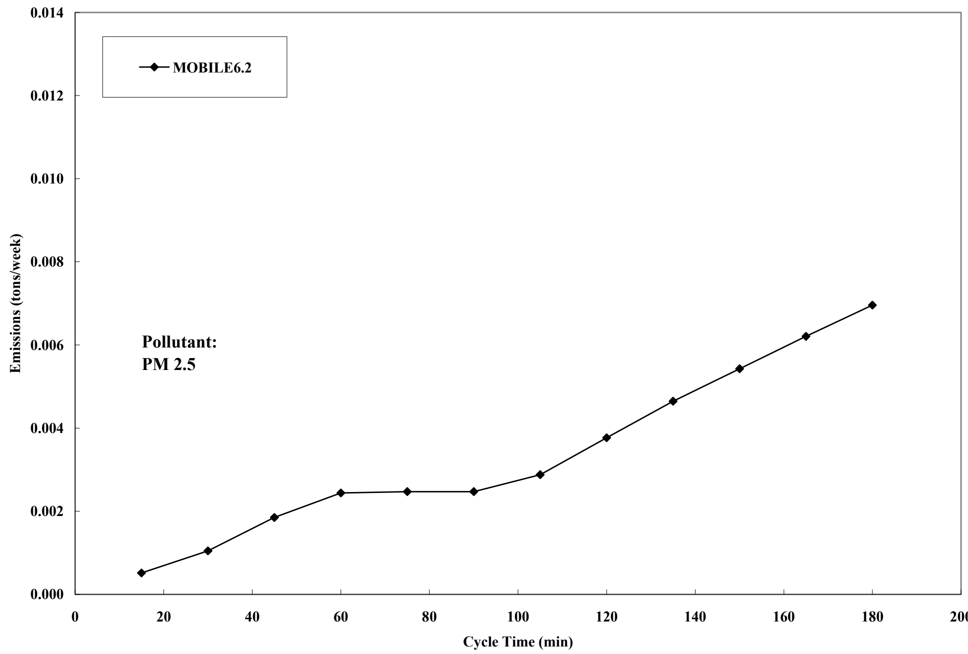

Figure 17. PM2.5 emissions plot

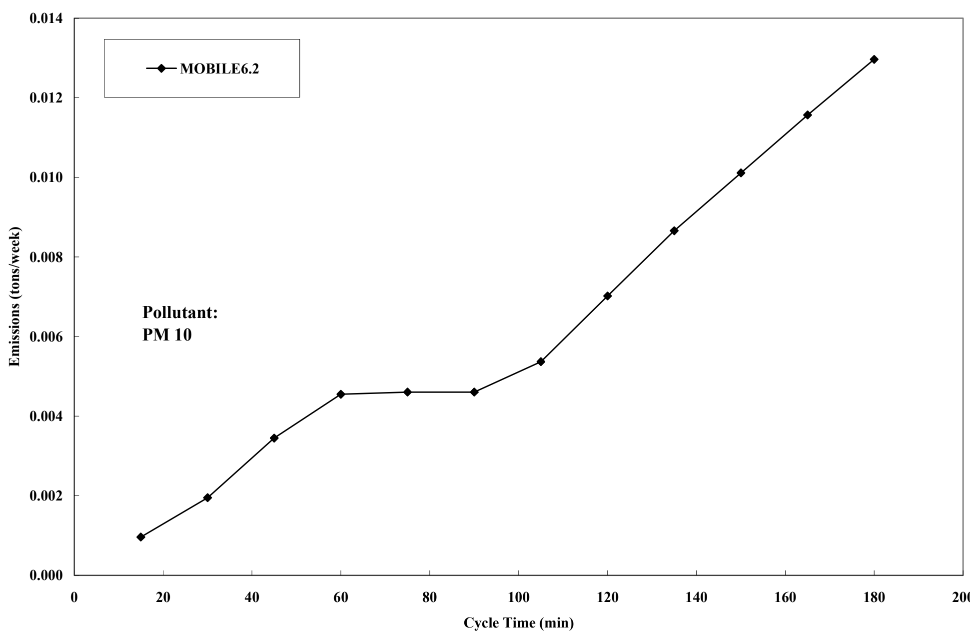

Figure 18. PM10 emissions plot

The inventories and plots show that MOBILE6 predicts CO emissions very similar to CMEM and the CMEM Meta-Model. However, for VOC/HC and NOx, MOBILE6 predicts higher emissions (more conservative) than either of the two modal emissions models. Even with the difference in VOC versus HC, MOBILE6 still produces higher levels. Although the basic inputs to CMEM and the CMEM Meta-Model were the same, the fleet weightings and matrix interpolations caused some noticeable differences between the two approaches. However, the two models produced generally similar results, especially for HC and NOx.

7.1 Comparisons with other Studies

These results are generally consistent with results from earlier studies conducted for other national parks. Table 14 shows a comparison of the inventory results for Joshua Tree, Zion, and Acadia National Parks.

Table 14. Comparison with previous studies

National Park	Model	Emissions (tons/week)			
		CO	VOC/HC	NOx	Source
Joshua Tree[a]	MOBILE6	2.73	0.32	0.14	-
	CMEM	0.91	0.06	0.06	-
	CMEM Meta-Model	1.52	0.04	0.05	-
Zion[b]	MOBILE5	3.70	0.76	0.23	[UCR 2001]
Acadia[c]	MOBILE5	5.17	0.71	1.10	[Volpe 2002]

[a]Based on a cycle length of 60 min.
[b]Derived from monthly values and based on visitor vehicles for 2000. Hydrocarbons were modeled as VOC.
[c]Derived from reduced data not shown in the report. Values are for a scenario in 2000 with shuttle bus usage at the park. Hydrocarbons were modeled as VOC.

The results from the three studies are within a magnitude of each other and much closer in most cases. The main reason for the similarity between these different studies are each park's VMT data, which are similar among all three studies, notwithstanding the fact that the 60 min cycle length for Joshua Tree was chosen somewhat arbitrarily (although reasonably for comparison purposes). If nothing else, these comparisons provide a sanity check to the modeled results.

7.2 Comparisons with other Sources

To provide a basis for understanding the magnitude of these emissions, calculations were performed for a hypothetical power plant operating on a weekly basis. A relatively large 1,000-megawatt (MW) coal-fired power plant is estimated to produce CO emissions of 15.31 tons in a week. This value was derived using the following set of data and assumptions:

- EPA's AP-42 typical emission factor for a typical coal-fired power plant is 0.5 lbs/ton [EPA 2003].
- Assumed a reasonable heating value for coal of 12,000 BTU/lb.
- Assumed an efficiency of 39% for the power plant.

Therefore, the vehicles entering Joshua Tree in a typical week produce approximately 1/10 the amount of CO being emitted by a relatively large power plant. For comparison purposes, a Diablo Canyon (San Luis Obispo, CA) nuclear power plant is similarly rated at 1,136.5 MW while a Contra Costa (near San Francisco) natural gas power plant is rated at a smaller capacity of 359.0 MW [EIA 1996].

8 METHODOLOGY RECOMMENDATIONS

Although all of the input data and assumptions that were used to develop baseline emissions inventories using MOBILE6 (Appendix D) and CMEM are provided in this report, detailed knowledge/experience are required to modify the data to model other scenarios. Therefore, it is recommended that a simplified methodology based on the CMEM Meta-Model be used for further emissions modeling at the park. As discussed in Section 7, the Meta-Model produced results that were comparable to the MOBILE6 results; it was more conservative for CO, but less conservative for VOC/HC and NOx than MOBILE6.

As an alternative (or as a check), a simplified methodology using pre-generated MOBILE6 emission factors could also be used if the data (e.g., second-by-second speeds) required to use the CMEM Meta-Model is not available (or difficult to obtain).

8.1 Simplified Emissions Modeling Using the CMEM Meta-Model

The development of the CMEM Meta-Model is discussed in Section 6.3. The following steps are required to use this method:

1. Obtain a typical second-by-second speed (mph) profile(s). The raw data could actually be courser (e.g., 5-second increments), in which case linear interpolations could be conducted to derive the missing second-by-second speeds.
2. Calculate the corresponding accelerations (mph/s) by assuming zero (0) acceleration for the first point and subtracting the previous speed from the current speed. An example is shown below:

Speed (mph)	Acceleration (mph/s)
0.0	0.0
1.4	1.4 – 0.0 = 1.4
2.7	2.7-1.4 = 1.3
3.5	3.5 – 2.7 = 0.8
etc.	etc.

   Both the speed and acceleration data should be analyzed (cleaned) so that erroneous data are not used.

3. In the “CMEM-Meta-Model-Interpolation-Program” directory in the CD-ROM included with this paper, a set of instructions and a ***Setup.exe*** program has been provided. Double-click this installation program and follow the instructions until the setup is finished. Running the program will present the screen shown in Figure 19:

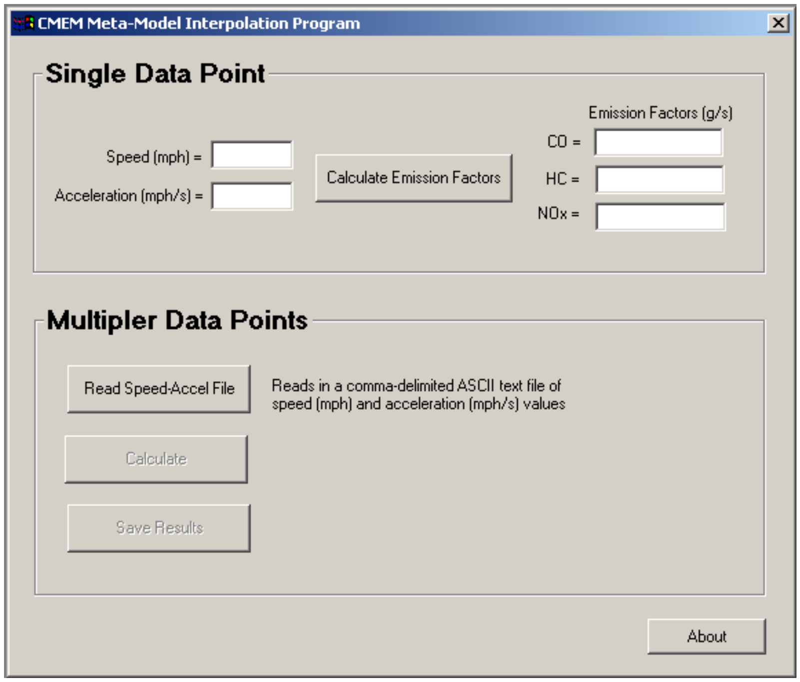

Figure 19. Screenshot of the CMEM Meta-Model interpolation program

The top part of the program allows for the modeling of a single speed and acceleration data point. Enter the desired speed (0 to 80 mph) and acceleration (-6 to 6 mph/s) into the text boxes on the left; then press the ***Calculate Emission Factors*** button to view the resulting emission factors (g/s). The lower part of the program allows for the modeling of many (multiple) speed and acceleration data points. Press the ***Read Speed-Accel File*** button and a dialog box will open asking for the location of a file containing the speed and acceleration data. This file needs to be in a comma-delimited ASCII text formatted file, as shown below, where the first value is the speed (mph) and the second value is the acceleration (mph/s) separated by a comma:

```
0.0,0.0
1.4,1.4
2.7,1.3
3.5,0.8
etc.,etc.
```

Once the data has been read in, the program will indicate the number of data points in the file. Pressing the ***Calculate*** button will begin the interpolation process. A textual indicator next to the button will provide the record position that is currently being analyzed. Once the indicator record position reaches the total number of records, the calculations are complete. Press the ***Save Results*** button to save the results as a comma-delimited ASCII text file. The results will appear in the following format:

Speed ,	Accel ,	HC ,	CO ,	NOx
0.148 ,	0.018 ,	6.08E-04 ,	3.44E-02 ,	2.22E-04
0.2335 ,	0.0855 ,	6.07E-04 ,	3.44E-02 ,	2.37E-04
0.503 ,	0.2695 ,	6.25E-04 ,	3.47E-02 ,	3.82E-04
2.9775 ,	2.4745 ,	1.76E-03 ,	5.75E-02 ,	3.63E-03
6.3735 ,	3.396 ,	2.58E-03 ,	7.23E-02 ,	6.12E-03
etc. ,	etc. ,	etc. ,	etc. ,	etc.

4. Sum the individual second-by-second emission factors (g/s) and multiply by the total traffic count, per equation 6 from Section 6.3 reproduced here:

$$TE = \sum(EFs) * TC \qquad (6)$$

A simple tutorial of this method with example data is provided in Appendix G. The data for this tutorial is contained on the CD-ROM under the "Tutorial" directory.

9 SUMMARY AND RECOMMENDATIONS

9.1 Summary of Study

A field study was performed at Joshua Tree National Park in order to collect data to develop emissions inventories due to visitor vehicles. The collected data included both traffic counts and visitor profiling activities. The traffic count data (along with vehicle license plate information) allowed the development of fleet distributions. The profile data allowed the development of park-specific driving cycles (second-by-second speeds).

The baseline inventories were developed for VOC/HC, CO, NOx, CO_2, PM2.5, and PM10 using EPA's MOBILE6 emission factor model. Average speeds were obtained from the representative park-specific driving cycles. In order to refine the methodology involving MOBILE6, a parallel effort was conducted with the CMEM model developed by UCR. The model provided the ability to directly model second-by-second speed data from representative cycles. A derivative Meta-Model was also developed using the outputs from CMEM by varying just the speed and acceleration parameters. The inventory results showed that CMEM and the Meta-Model were similar to MOBILE6 for CO, but less conservative (lower) for VOC/HC and NOx.

Due to the difficulties associated with using MOBILE6 and CMEM, it was recommended that the simplified method using the CMEM Meta-Model be used for further emissions modeling at Joshua Tree. The Meta-Model requires the use of driving cycle data.

9.2 Recommendations for Further Work

All of the modeling work, including both the CMEM Meta-Model and the MOBILE6 pre-generated emission factors, are based on data from the 2002 to 2003 timeframe. However, they should be applicable for some time into the future because the vehicle type distributions and associated parameters for Joshua Tree will likely stay relatively constant over the next few years. Therefore, these methods and the associated data could be used to develop rough estimates ("first order" approximations) of vehicular emissions for future years.

Rather than developing actual magnitudes for emissions inventories, a better use of these methods would be in determining the change (i.e., percent change) in emissions between two scenarios. In general, there are fewer uncertainties associated with calculating changes (deltas) than there are in predicting a magnitude (or quantity).

In order to keep the methods current, it is recommended that the data used in this study be updated every few years. The exact timeframe will depend on knowledge of the variability of the fleet mix at the park and changes in vehicle emissions standards/technologies.

For future field data collection efforts, it is recommended that elevation (altitude) data also be collected in order to model road grade. This would provide another refinement to the modeling methodology. And although it was not within the scope of this study, atmospheric concentration measurements could also be conducted to help better determine the area's conformity to the National Ambient Air Quality Standards (NAAQS), potential health impacts to visitors, and vehicular contributions to degradation of visibility at the park.

Furthermore, it is recommended that sensitivity studies be conducted in order to better understand the impacts of the various parameters within each of the models. This will help to determine the varying quality of data necessary to run the models and will also allow better use of resources to obtain data.

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APPENDIX A.   MOBILE6 INPUT DATA DESCRIPTIONS

Table A-1. MOBILE6 input data descriptions.

MOBILE6 Parameter	Default	Source	Used for Joshua Tree
input file header	MOBILE6 INPUT FILE, RUN DATA	NA	header written
EVALUATION MONTH	1	calendar	use default
FUEL RVP	NONE	EMFAC	11.0
HOURLY TEMPERATURES	NONE	EMFAC	50.2 52.7 58.6 63.8 66.9 69.4 71.0 71.5 71.3 70.0 66.2 61.4 58.5 56.8 55.5 54.6 53.9 53.1 52.5 51.9 51.4 51.0 50.6 50.3
CALENDAR YEAR	NONE	calendar	2002
POLLUTANTS	HC, CO, NOx	NA	use default
PARTICULATES	NONE	EPA	OK
PARTICULATE EF	EPA national data	EPA	EPA defaults
PARTICLE SIZE	NONE	EPA	2.5, 10
DIESEL SULFUR	NONE	EPA	500 ppm
EXPRESS HC AS "	Volatile Organic Compounds (VOC)	NA	use default
NO REFUELING	do not calculate refueling emissions	EMFAC	write to initiate command
REPORT FILE	inputfilename.txt	NA	weekday report file: JOT_WDAG.TXT, weekend report file: JOT_WEAG.TXT
NO DESC OUTPUT	produce descriptive output	NA	use default
EXPAND EFS	display only 8 vehicle types	NA	use default
EXPAND EXHAUST	display only composite emission factors (running+start)	NA	use default
EXPAND EVAPORATIVE	display only composite evaporative emission factors	NA	use default
DATABASE OUTPUT	do not produce database output	NA	produce database output
DATABASE OPTIONS	specify database content through command line codes	NA	write to initiate command
WITH FIELDNAMES	no not label values in database	NA	label values in database
DATABASE EMISSIONS	report all 8 emission types	NA	use default
DATABASE FACILITIES	report for each facility type	park maps, visits	local
DATABASE VEHICLES	report for 28 vehicle types	CA DMV	OK
DATABASE AGES	report emissions for each of 25 vehicle ages	CA DMV	24, 0
DATABASE HOURS	24 hours	park hours	2, 13
DATABASE YEARS	calendar then going back 25 model years before calendar year	CA DMV	2002, 1978
DAILY OUTPUT	hourly	NA	use default
AGGREGATED OUTPUT	report non-aggregated output	NA	initiate command
EMISSIONS TABLE	inputfilename.TB1	NA	weekday report table: JOT_WDAG.TB1, weekend report table: JOT_WEAG.TB1
ALTITUDE	low altitude	topography map	use default
ABSOLUTE HUMIDITY	75	TRANE software	35.2
CLOUD COVER	zero %	web	use default

PEAK SUN	10 am - 4 pm	web: www.srrb.noaa.gov /surfrad/surfpage.htm	11 1
SUNRISE/SUNSET	6 am - 9 pm	web	7 5
REG DIST	EPA composite US fleet	CA DMV	OK
DIESEL FRACTIONS	EPA composite US fleet	CA DMV	OK
MILE ACCUM RATE	EPA composite US fleet	CA DMV	OK
VMT FRACTIONS	EPA national average data	CA DMV	OK
NGV FRACTION	zero	CA DMV	use default
NGV EF	none	CA DMV	use default
VMT BY FACILITY	EPA national estimates	park visits	all arterial
VMT BY HOUR	EPA national estimates	EMFAC	OK
SPEED VMT	EPA national estimates	Volpe GPS system	data entered into arterial speed bins
AVERAGE SPEED	EPA national estimates	Volpe GPS system	19.6, 2.5, 5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0, 40.0, 45.0, 50.0, 55.0, 60.0, 65.0, 27.2, 27.6, 32.5, 32.2, 26.1, 21.8, 21.7, 24.9, 27.2, 28.6, 29.8, 30.6
STARTS PER DAY	EPA national estimates	NA	use default
START DIST	EPA national estimates	NA	use default
SOAK DISTRIBUTION	EPA national estimates	NA	use default
HOT SOAK ACTIVITY	EPA national estimates	NA	use default
DIURN SOAK ACTIVITY	EPA national estimates	NA	use default
WE DA TRI LEN DI	EPA national estimates	NA	use default
WE EN TRI LEN DI	EPA national estimates	NA	use default
WE VEH US	applies weekday defaults	NA	initiate command in both weekend and weekday input files to better reflect that this is a National Park environment rather than a city environment
STAGE II REFUELING	does not apply Stage II	CARB	initiate command
ANTI-TAMP PROG	no anti-tamper	EMFAC	NA
I/M PROGRAM	no program in place	EMFAC	Riverside Co., California, program 5, subprograms 1 & 2
I/M MODEL YEARS	no program in place	EMFAC	Riverside Co., California, program 5, subprograms 1 & 2
I/M VEHICLES	no program in place	EMFAC	Riverside Co., California, program 5, subprograms 1 & 2
I/M STRINGENCY	no program in place	CARB website	31%
I/M COMPLIANCE	no program in place	CARB website	86%
I/M WAIVER RATES	no program in place	CARB website	1%
I/M CUTPOINTS	no program in place	EMFAC	NA
I/M EXEMPTION AGE	25 years old	EMFAC	use default
I/M GRACE PERIOD	1 year old	EMFAC	4
NO I/M TTC CREDITS	full credit	EMFAC	use default
I/M EFFECTIVENESS	100%	EMFAC	use default
I/M DESC FILE	no program in place	NA	no external file
FUEL PROGRAM	conventional gasoline East	EMFAC	2 S
SULFUR CONTENT	300 ppm	EMFAC	use default
OXYGENATED FUELS	no oxygenate	EMFAC	use default
SEASON	winter if January; summer if July	calendar	2
NO CLEAN AIR ACT	Clean Air Act of 1990 did occur	web	use default
NO DEFEAT DEVICE	EPA national data	EPA	use default
NO NOX PULL AHEAD	EPA national data	EPA	use default
NO REBUILD	EPA national data	EPA	use default
REBUILD EFFECTS	EPA national data	EPA	use default

NO TIER2	EPA national data	EPA	use default
T2 EXH PHASE-IN	EPA national data	EPA	use default
T2 EVAP PHASE-IN	EPA national data	EPA	use default
T2 CERT	EPA national data	EPA	use default
94+LDG IMP	EPA national data	EPA	use default
NO 2007 HDDV RULE	EPA national data	EPA	use default

APPENDIX B. SAMPLE CALIFORNIA DMV REGISTRATION DATA

Table B-1 presents a sample of Joshua Tree motor vehicle records in the California DMV registration database format:

Table B-1. Sample DMV data from Joshua Tree.

License Plate	Year	Make	BTM	ZIP	Type	Power	Veh	Body	Class	Odometer
XXXXXXX	1993	FORD	PK	95387	31	G	32	P	DE	78,974
XXXXXXX	1996	FORD	SV	95405	11	G	12	S	FQ	36
XXXXXXX	1995	WNBGO	MH	95409	11	G	12	J	MV	24,236
XXXXXXX	1992	VOLV	SW	95465	11	G	17	S	DL	87,823
XXXXXXX	1991	SUBA	SW	95501	11	G	12	S	BD	99,509
XXXXXXX	2001	TOYT	PK	95616	31	G	37	P	FS	3,398
XXXXXXX	1988	FORD	SV	95621	11	G	12	S	AJ	NA
XXXXXXX	1995	TOYT	UT	95656	11	G	12	0	FA	40,878
XXXXXXX	1995	NISS	UT	95678	11	G	13	0	CY	66,231
XXXXXXX	1994	NISS	UT	95682	11	G	13	0	CM	100,078
XXXXXXX	2000	MERC	UT	95722	11	G	12	0	DW	42,010
XXXXXXX	1994	GMC	PK	95742	31	D	32	P	JK	155,143
XXXXXXX	1994	NISS	PK	95814	93	G	37	P	AZ	150,378
XXXXXXX	2002	CHEV	4D	95815	11	G	12	0	DT	10
XXXXXXX	1992	ISU	UT	95818	11	G	12	0	AK	117,438
XXXXXXX	1994	ISU	UT	95819	11	G	12	0	DC	48
XXXXXXX	1982	FORD	SD	95823	11	G	17	0	AH	NA
XXXXXXX	2002	HOND	2H	95826	11	G	11	0	EN	71
XXXXXXX	2002	STRN	4D	95826	11	G	12	0	DM	12,580
XXXXXXX	1994	TOYT	PK	95838	31	G	32	P	BE	107,226
XXXXXXX	1998	OLDS	4D	95841	11	G	11	0	HT	10
XXXXXXX	1999	CHEV	UT	95841	11	G	12	0	KJ	48,500
XXXXXXX	1990	TOYT	4D	95945	11	G	12	0	BC	102,000
XXXXXXX	2002	FORD	UT	95966	11	G	12	0	FD	42
XXXXXXX	2002	GMC	UT	95973	11	G	12	0	KT	257
XXXXXXX	1993	DODG	UT	95983	11	G	32	Y	HA	NA
XXXXXXX	1984	FORD	SV	96001	11	G	13	S	AE	NA
XXXXXXX	2001	GMC	PK	96003	31	G	32	P	FZ	40

Figure B-1 presents a list of the DMV classification codes that aided in the determination of MOBILE6 and CMEM vehicle types.

TYPE VEHICLE/VESSEL CODES

The type vehicle/vessel codes indicate whether or not the vehicle/vessel record is new or old, resident or nonresident, and the type of use.

Code	Type
01	Special Equipment—Husbandry, Farm Tractor, Farm Equipment
02	Special Equipment—Mobile
03	Special Equipment—Construction, Cemetery, Logging
04	Prorate ID Commercial/Apportioned Commercial
05	Prorate ID Trailer/Apportioned Trailer
06	Nonresident Temporary Permit—Commercial
07	Nonresident Temporary Permit—Trailer
08	Farm Equipment—Farm Trailer
09	Farm Equipment—Oversize Farm Vehicle, Automatic Bale Wagon, Water Tank
10	Automobile—Horseless Carriage, Historical Vehicle
11	Automobile—New
12	Automobile—Old
13	Automobile—New Nonresident
14	Automobile—New Electric
15	Automobile—Old Electric
16	Automobile—New/Old Nonresident Electric
17	Automobile—Old Nonresident
18	Automobile—New Remanufactured
19	Automobile—Old Remanufactured
20	Motorcycle—Historical Value
21	Motorcycle—New
22	Motorcycle—Old
23	Motorcycle—New Nonresident
24	Motorcycle—New Electric
25	Motorcycle—Old Electric
26	Motorcycle—Old Nonresident
27	Motorcycle—New/Old Nonresident Electric
28	Motorcycle—New Remanufactured
29	Motorcycle—Old Remanufactured
31	Commercial—New
32	Commercial—Old
33	Commercial—New Nonresident
34	Commercial—New Electric
35	Commercial—Old Electric
36	Commercial—New/Old Nonresident Electric
37	Commercial—Old Nonresident
38	Commercial—New Remanufactured
39	Commercial—Old Remanufactured
41	Trailer—New
42	Trailer—Old
43	Trailer—New Nonresident
47	Trailer—Old Nonresident
48	Trailer—New Remanufactured
49	Trailer—Old Remanufactured
51	Prorate Application—Commercial (IRP)
52	Prorate Application—Trailer (IRP)
53	One Way Rental—Commercial (IRP)
61	Off Highway Vehicle—New
62	Off Highway Vehicle—Old
63	Off Highway Vehicle—New Nonresident
64	Off Highway Vehicle—Old Nonresident
65	Moped
68	Off Highway Vehicle—New Remanufactured
69	Off Highway Vehicle—Old Remanufactured
71	Dealer (Leasing/Rental)
72	Manufacturer/Distributor
73	Transporter
74	Dismantler
75	Remanufacturer
81	Vessel—New
82	Vessel—Old
83	Vessel—Nonresident
91	Disabled Person Placard—New
92	Disabled Person Placard—Old
93	Salesman

Figure B-1. CA DMV vehicle classification codes

APPENDIX C. SPEED PROFILE DATA SMOOTHING

The speed data derived from car chase activities was processed through a rigorous quality-check to remove erroneous data points. A criterion of 6.1 mph/s was used as a cap to smooth any data points where the resulting acceleration (between two data points) exceeded this value. The filtering process is exemplified in the following figure:

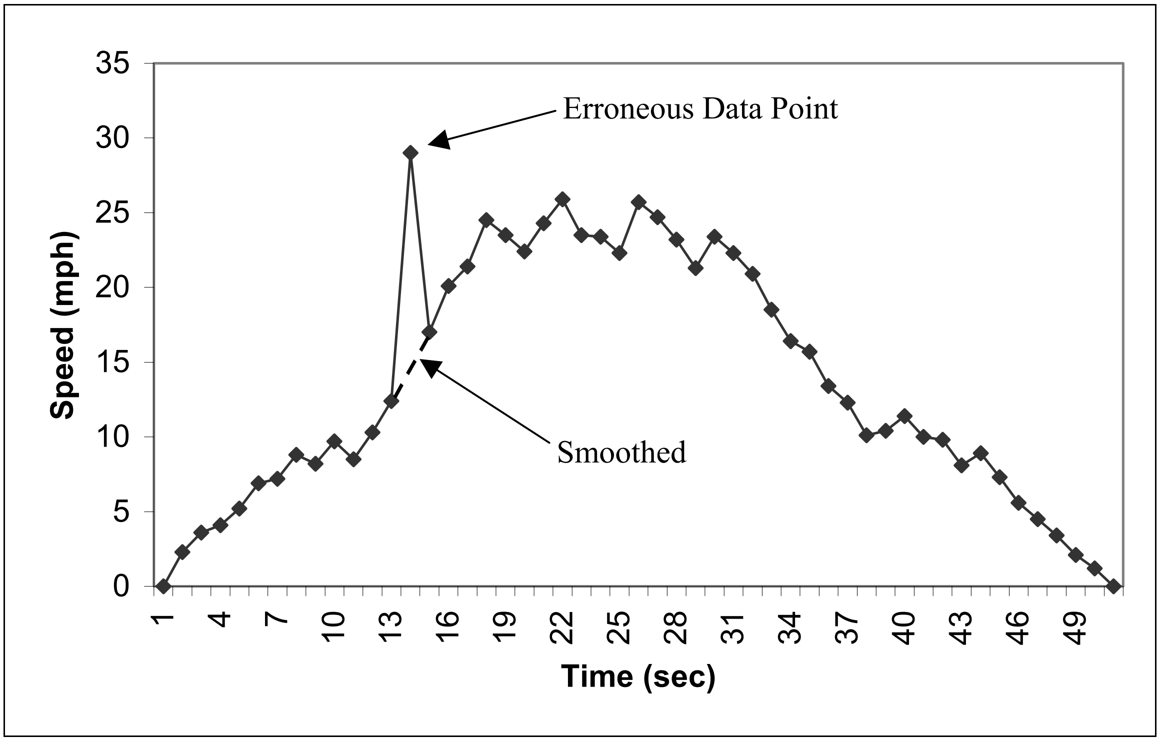

Figure C-1. Sample Time vs. Speed record from Volpe TSPI data

APPENDIX D. MOBILE6 INPUT FILES

Presented below are the main MOBILE6 input and external data files for the Joshua Tree weekday and weekend day measurements.

D.1 Joshua Tree Weekday Input File

(This file is "JOTRWDAY.IN" on the CD-ROM.)

```
MOBILE6 INPUT FILE :

REPORT FILE        : JOT_WDAG.TXT
POLLUTANTS         : HC CO NOX CO2
DATABASE OUTPUT    :
WITH FIELDNAMES    :
DATABASE VEHICLES  : 22212 11111111 1 111 11111111 111
AGGREGATED OUTPUT  :
EMISSIONS TABLE    : JOT_WDAG.TB1
PARTICULATES       :

RUN DATA

NO REFUELING       :

PEAK SUN           : 11 1

SUNRISE/SUNSET     : 7 5

REG DIST           : REGDATA1.D

DIESEL FRACTIONS   :
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000

MILE ACCUM RATE : miledat1.d

VMT FRACTIONS :
0.886 0.054 0.047 0.000 0.013 0.000 0.000 0.000
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000

ABSOLUTE HUMIDITY : 35.2

VMT BY FACILITY : FVMT1.def

VMT BY HOUR : HVMT1.def

STAGE II REFUELING : 89 5 100. 99.

FUEL PROGRAM : 2 S

SEASON : 2

I/M PROGRAM : 1 1974 2040 2 T/O 2500/IDLE

I/M STRINGENCY : 1 31.0

I/M MODEL YEARS : 1 1978 2002

I/M VEHICLES : 1 11111 22222222 1

I/M COMPLIANCE : 1 86.0

I/M WAIVER RATES : 1 1.0 1.0

I/M GRACE PERIOD : 1 4

I/M PROGRAM : 2 1974 2040 2 T/O GC

I/M MODEL YEARS : 2 1978 2002

I/M VEHICLES : 2 22222 22222222 1

I/M COMPLIANCE : 2 86.0

I/M WAIVER RATES : 2 1.0 1.0

I/M GRACE PERIOD : 2 4

I/M PROGRAM : 3 1974 2040 2 T/O ASM 2525/5015 FINAL

I/M STRINGENCY : 3 31.0

I/M MODEL YEARS : 3 1978 2002

I/M VEHICLES : 3 22222 11111111 1

I/M COMPLIANCE : 3 86.0

I/M WAIVER RATES : 3 1.0 1.0

I/M GRACE PERIOD : 3 4

SCENARIO REC : JOTR WEEKDAY DISTRIBUTED SPEED, PS = 2.5

EVALUATION MONTH : 1

FUEL RVP : 11.0

HOURLY TEMPERATURES: 50.2 52.7 58.6 63.8 66.9 69.4 71.0 71.5 71.3 70.0 66.2 61.4
58.5 56.8 55.5 54.6 53.9 53.1 52.5 51.9 51.4 51.0 50.6 50.3

SPEED VMT : SVMT1.def

PARTICULATE EF : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV Pmddr1.CSV Pmddr2.CSV

PARTICLE SIZE : 2.5

DIESEL SULFUR : 500.0

CALENDAR YEAR : 2002

SCENARIO REC : JOTR WEEKDAY DISTRIBUTED SPEED, PS = 10.0

EVALUATION MONTH : 1

FUEL RVP : 11.0

HOURLY TEMPERATURES: 50.2 52.7 58.6 63.8 66.9 69.4 71.0 71.5 71.3 70.0 66.2 61.4
58.5 56.8 55.5 54.6 53.9 53.1 52.5 51.9 51.4 51.0 50.6 50.3

SPEED VMT : SVMT1.def

PARTICULATE EF : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV Pmddr1.CSV Pmddr2.CSV

PARTICLE SIZE : 10.0

DIESEL SULFUR : 500.0

CALENDAR YEAR : 2002

END OF RUN

D.2 Joshua Tree Weekend Input File

(This file is “JOTRWEND.IN” on the CD-ROM.)

```
MOBILE6 INPUT FILE :

REPORT FILE        : JOT_WEAG.TXT
POLLUTANTS         : HC CO NOX CO2
DATABASE OUTPUT    :
WITH FIELDNAMES    :
DATABASE VEHICLES  : 22222 11111111 1 222 11111121 111
AGGREGATED OUTPUT  :
EMISSIONS TABLE    : JOT_WEAG.TB1
PARTICULATES       :

RUN DATA

NO REFUELING       :

PEAK SUN           : 11 1

SUNRISE/SUNSET     : 7 5

REG DIST           : REGDATA2.D

DIESEL FRACTIONS   :
```

```
0.5000 0.0000 0.0000 0.0000 0.0000 0.0000 0.5000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
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0.0000

MILE ACCUM RATE    : miledat2.d

VMT FRACTIONS      :
0.865 0.059 0.060 0.005 0.010 0.000 0.000 0.000
0.000 0.000 0.001 0.000 0.000 0.000 0.000 0.000

ABSOLUTE HUMIDITY  : 35.2

SPEED VMT          : SVMT2.def

VMT BY FACILITY    : FVMT1.def

VMT BY HOUR        : HVMT1.def

STAGE II REFUELING : 89 5 100. 99.

FUEL PROGRAM       : 2 S

SEASON             : 2

I/M PROGRAM        : 1 1974 2040 2 T/O 2500/IDLE

I/M STRINGENCY     : 1 31.0

I/M MODEL YEARS    : 1 1978 2002
```

```
I/M VEHICLES       : 1 11111 22222222 1

I/M COMPLIANCE     : 1 86.0

I/M WAIVER RATES   : 1 1.0 1.0

I/M GRACE PERIOD   : 1  4

I/M PROGRAM        : 2 1974 2040 2 T/O GC

I/M MODEL YEARS    : 2 1978 2002

I/M VEHICLES       : 2 22222 22222222 1

I/M COMPLIANCE     : 2 86.0

I/M WAIVER RATES   : 2 1.0 1.0

I/M GRACE PERIOD   : 2  4

I/M PROGRAM        : 3 1974 2040 2 T/O ASM 2525/5015 FINAL

I/M STRINGENCY     : 3 31.0

I/M MODEL YEARS    : 3 1978 2002

I/M VEHICLES       : 3 22222 11111111 1

I/M COMPLIANCE     : 3 86.0

I/M WAIVER RATES   : 3 1.0 1.0

I/M GRACE PERIOD   : 3  4


SCENARIO REC       : JOTR WEEKEND DISTRIBUTED SPEED, PS = 2.5

WE VEH US          :

EVALUATION MONTH   : 1

FUEL RVP           : 11.0

HOURLY TEMPERATURES: 50.2 52.7 58.6 63.8 66.9 69.4 71.0 71.5 71.3 70.0 66.2 61.4
58.5 56.8 55.5 54.6 53.9 53.1 52.5 51.9 51.4 51.0 50.6 50.3

SPEED VMT          : SVMT2.def

PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV Pmddr1.CSV Pmddr2.CSV

PARTICLE SIZE      : 2.5

DIESEL SULFUR      : 500.0

CALENDAR YEAR      : 2002

SCENARIO REC       : JOTR WEEKEND DISTRIBUTED SPEED, PS = 10.0

WE VEH US          :

EVALUATION MONTH   : 1

FUEL RVP           : 11.0

HOURLY TEMPERATURES: 50.2 52.7 58.6 63.8 66.9 69.4 71.0 71.5 71.3 70.0 66.2 61.4
58.5 56.8 55.5 54.6 53.9 53.1 52.5 51.9 51.4 51.0 50.6 50.3

SPEED VMT          : SVMT2.def

PARTICULATE EF     : PMGZML.CSV PMGDR1.CSV PMGDR2.CSV PMDZML.CSV Pmddr1.CSV Pmddr2.CSV

PARTICLE SIZE      : 10.0

DIESEL SULFUR      : 500.0

CALENDAR YEAR      : 2002
```

```
END OF RUN
```

D.3 Weekday Joshua Tree Mileage Accumulation Rates

(This file is "miledat1.d" on the CD-ROM.)

```
MILE ACCUM RATES
 1 0.01112 0.06368 0.07178 0.10932 0.08591 0.12727 0.14228 0.15060 0.09826 0.14442
   0.00001 0.00001 0.19418 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
   0.00001 0.00001 0.00001 0.00001 0.00001
 2 0.00039 0.00029 0.09411 0.13467 0.18089 0.12939 0.04540 0.04000 0.29424 0.00001
   0.11109 0.10785 0.00001 0.00001 0.00001 0.08068 0.00001 0.00001 0.00001 0.00001
   0.00001 0.00001 0.00001 0.00001 0.00001
 3 0.01949 0.05724 0.08740 0.03854 0.03063 0.16267 0.17652 0.00015 0.32846 0.15795
   0.21799 0.00001 0.13000 0.10849 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
   0.00001 0.00001 0.00001 0.00001 0.06284
 5 0.00108 0.00011 0.00019 0.00001 0.00001 0.36451 0.00022 0.00001 0.19393 0.00001
   0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
   0.00001 0.00001 0.00001 0.00001 0.00001
```

D.4 Weekend Joshua Tree mileage accumulation

(This file is "miledat2.d" on the CD-ROM.)

```
MILE ACCUM RATES
 1 0.01008 0.04625 0.05654 0.08194 0.10933 0.10240 0.12896 0.11682 0.10039 0.12695
   0.13732 0.11805 0.10197 0.12545 0.09815 0.05692 0.09237 0.11759 0.00001 0.09468
   0.00001 0.00001 0.00001 0.00001 0.00001
 2 0.00039 0.00029 0.09411 0.13467 0.18089 0.12939 0.04540 0.04000 0.29424 0.00001
   0.11109 0.10785 0.00001 0.00001 0.00001 0.08068 0.00001 0.00001 0.00001 0.00001
   0.00001 0.00001 0.00001 0.00001 0.00001
 3 0.01949 0.05724 0.08740 0.03854 0.03063 0.16267 0.17652 0.00015 0.32846 0.15795
   0.21799 0.00001 0.13000 0.10849 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
   0.00001 0.00001 0.00001 0.00001 0.06284
 4 0.00098 0.00001 0.00001 0.00532 0.23500 0.00001 0.00017 0.00001 0.00001 0.00001
   0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
   0.00001 0.00001 0.00001 0.00001 0.00001
 5 0.00108 0.00011 0.00019 0.00001 0.00001 0.36451 0.00022 0.00001 0.19393 0.00001
   0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
   0.00001 0.00001 0.00001 0.00001 0.00001
11 0.02363 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
   0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001 0.00001
   0.00001 0.00001 0.00001 0.00001 0.00001
```

D.5 Weekday Joshua Tree Vehicle Age Data

(This file is "REGDATA1.d" on the CD-ROM.)

```
REG DIST
*LDV
 1 0.472 0.076 0.061 0.076 0.053 0.031
   0.046 0.038 0.053 0.031 0.000 0.000
   0.008 0.023 0.000 0.008 0.008 0.000
   0.000 0.000 0.008 0.000 0.000 0.000 0.008
*LDT1
 2 0.250 0.375 0.125 0.000 0.000 0.000
   0.000 0.000 0.125 0.000 0.000 0.000
   0.000 0.000 0.000 0.125 0.000 0.000
   0.000 0.000 0.000 0.000 0.000 0.000 0.000
*LDT2
 3 0.000 0.143 0.143 0.143 0.143 0.000
   0.000 0.143 0.143 0.142 0.000 0.000
   0.000 0.000 0.000 0.000 0.000 0.000
   0.000 0.000 0.000 0.000 0.000 0.000 0.000
*LDT4
 5 0.000 0.000 0.500 0.000 0.000 0.500
```

```
   0.000 0.000 0.000 0.000 0.000 0.000
   0.000 0.000 0.000 0.000 0.000 0.000
   0.000 0.000 0.000 0.000 0.000 0.000 0.000
```

D.6 Weekend Joshua Tree Vehicle Age Data

(This file is "REGDATA2.d" on the CD-ROM.)

```
REG DIST
*LDV
 1 0.270 0.106 0.101 0.093 0.065 0.063
   0.051 0.050 0.040 0.024 0.028 0.027
   0.015 0.013 0.011 0.005 0.009 0.008
   0.003 0.002 0.002 0.001 0.000 0.000 0.013
*LDT1
 2 0.084 0.033 0.117 0.150 0.100 0.050
   0.033 0.017 0.117 0.000 0.017 0.067
   0.033 0.033 0.033 0.033 0.017 0.000
   0.000 0.033 0.000 0.000 0.000 0.000 0.033
*LDT2
 3 0.231 0.131 0.164 0.082 0.049 0.098
   0.033 0.000 0.033 0.016 0.033 0.000
   0.016 0.016 0.000 0.000 0.000 0.000
   0.000 0.049 0.000 0.000 0.000 0.000 0.049
*LDT3
 4 0.400 0.000 0.000 0.200 0.200 0.000
   0.200 0.000 0.000 0.000 0.000 0.000
   0.000 0.000 0.000 0.000 0.000 0.000
   0.000 0.000 0.000 0.000 0.000 0.000 0.000
*LDT4
 5 0.200 0.200 0.200 0.000 0.000 0.000
   0.100 0.000 0.100 0.200 0.000 0.000
   0.000 0.000 0.000 0.000 0.000 0.000
   0.000 0.000 0.000 0.000 0.000 0.000 0.000
*HDV7
11 0.999 0.001 0.000 0.000 0.000 0.000
   0.000 0.000 0.000 0.000 0.000 0.000
   0.000 0.000 0.000 0.000 0.000 0.000
   0.000 0.000 0.000 0.000 0.000 0.000 0.000
```

D.7 Weekday Joshua Tree Speed VMT Data

(This file is "SVMT1.def" on the CD-ROM.)

```
SPEED VMT
2 1  0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 2  0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 3  0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 4  0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 5  0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 6  0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 7  0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 8  0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 9  0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 10 0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 11 0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 12 0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 13 0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 14 0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
```

```
2 15 0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 16 0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 17 0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 18 0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 19 0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 20 0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 21 0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 22 0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 23 0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
2 24 0.0961 0.0099 0.0091 0.0094 0.0155 0.0297 0.0726 0.1514 0.1693 0.1449 0.1240 0.0803
0.0513 0.0365
1 1  0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 2  0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 3  0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 4  0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 5  0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 6  0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 7  0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 8  0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 9  0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 10 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 11 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 12 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 13 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 14 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 15 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 16 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 17 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 18 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 19 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 20 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 21 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 22 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 23 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
1 24 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
0.0000 0.0000
```

D.8 Weekend Joshua Tree Speed VMT Data

(This file is "SVMT2.def" on the CD-ROM.)

```
SPEED VMT
2 1  0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
```

```
2 2  0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 3  0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 4  0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 5  0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 6  0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 7  0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 8  0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 9  0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 10 0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 11 0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 12 0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 13 0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 14 0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 15 0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 16 0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 17 0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 18 0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 19 0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 20 0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 21 0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 22 0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 23 0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
0.0212 0.0041
2 24 0.1052 0.0095 0.0098 0.0124 0.0155 0.0296 0.0530 0.1078 0.1904 0.2240 0.1478 0.0697
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1 1  0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
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1 4  0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
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1 11 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
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1 12 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
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1 13 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
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1 14 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
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1 20 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
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1 22 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
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1 23 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
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1 24 0.0000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.1000 0.0000
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D.9 Weekday *and* Weekend Joshua Tree VMT By Hour Data

(This file is "HVMT1.def" on the CD-ROM.)

```
*
*  Fraction of all vehicle miles traveled by hour of the day.
*  First hour is 6 a.m.
*
      0.0086  0.0368  0.0779  0.0722  0.0436  0.0463
      0.0589  0.0612  0.0603  0.0705  0.0724  0.0747
      0.0836  0.0579  0.0438  0.0323  0.0323  0.0243
      0.0189  0.0104  0.0034  0.0036  0.0016  0.0045
```

D.10 Weekday *and* Weekend Joshua Tree VMT By Facility Data

(This file is "FVMT1.def" on the CD-ROM.)

```
VMT BY FACILITY
* VMT fractions are listed for 28 vehicle classes.
* For each class, 24 sets of values represent the hours of the day.
* For each class and hour, 4 values represent the VMT distribution on
* freeway, arterial, local and ramps--in that order.
 1 0.000  1.000  0.000  0.000
   0.000  1.000  0.000  0.000
   0.000  1.000  0.000  0.000
   0.000  1.000  0.000  0.000
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	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000

	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
17	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
18	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
19	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
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	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
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	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
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	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
20	0.000	1.000	0.000	0.000

	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
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	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
21	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
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	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
22	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
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	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
23	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
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	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
24	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
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	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
25	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
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	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
26	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000

	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
27	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
28	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000
	0.000	1.000	0.000	0.000

APPENDIX E.   MOBILE6 MODELED RESULTS

E.1   Joshua Tree Weekday Report File

```
***************************************************************************
* MOBILE6.2.01 (31-Oct-2002)                                              *
* Input file: JOTRWDAY.IN (file 1, run 1).                                *
***************************************************************************
  M603 Comment:
               User has disabled the calculation of REFUELING emissions.

  M619 Comment:
               User supplied alternate AC input: Peak Sun between 11 AM, and  1 PM.
  M618 Comment:
               User supplied alternate AC input: Sunrise at  7 AM, Sunset at  5 PM.

* Reading Registration Distributions from the following external
* data file: REGDATA1.D
  M614 Comment:
               User supplied diesel sale fractions.

* Reading non-default MILEAGE ACCUMULATION RATES from the following external
* data file: MILEDAT1.D
  M615 Comment:
               User supplied VMT mix.

* Reading Hourly Roadway VMT distribution from the following external
* data file: FVMT1.DEF

  Reading User Supplied ROADWAY VMT Factors

* Reading Hourly VMT distribution from the following external
* data file: HVMT1.DEF
  M601 Comment:
               User has enabled STAGE II REFUELING.

  M616 Comment:
               User has supplied post-1999 sulfur levels.

* Reading ASM I/M Test Credits from ASMDATA.D

* # # # # # # # # # # # # # # # # # # # # # # # # #
* JOTR WEEKDAY DISTRIBUTED SPEED, PS = 2.5
* File 1, Run 1, Scenario 1.
* # # # # # # # # # # # # # # # # # # # # # # # # #

* Reading Hourly, Roadway, and Speed VMT dist. from the following external
* data file: SVMT1.DEF

* Reading PM Gas Carbon ZML Levels
* from the external data file PMGZML.CSV

* Reading PM Gas Carbon DR1 Levels
* from the external data file PMGDR1.CSV

* Reading PM Gas Carbon DR2 Levels
* from the external data file PMGDR2.CSV

* Reading PM Diesel Zero Mile Levels
* from the external data file PMDZML.CSV

* Reading the First PM Deterioration Rates
* from the external data file PMDDR1.CSV

* Reading the Second PM Deterioration Rates
* from the external data file PMDDR2.CSV
  M112 Warning:
               Wintertime Reformulated Gasoline Rules Apply
*** I/M credits for Tech1&2 vehicles were read from the following external
    data file: TECH12.D
  M 48 Warning:
              there are no sales for vehicle class LDDV
  M 48 Warning:
              there are no sales for vehicle class LDDT12
  M 48 Warning:
              there are no sales for vehicle class HDDV2b
  M 48 Warning:
              there are no sales for vehicle class HDDV3
  M 48 Warning:
              there are no sales for vehicle class HDDV4
  M 48 Warning:
              there are no sales for vehicle class HDDV5
  M 48 Warning:
              there are no sales for vehicle class HDDV6
  M 48 Warning:
              there are no sales for vehicle class HDDV7
  M 48 Warning:
              there are no sales for vehicle class HDDV8a
  M 48 Warning:
              there are no sales for vehicle class HDDV8b
  M 48 Warning:
              there are no sales for vehicle class HDDBS
  M 48 Warning:
              there are no sales for vehicle class LDDT34

* Reading Ammonia (NH3) Basic Emissiion Rates
* from the external data file PMNH3BER.D

* Reading Ammonia (NH3) Sulfur Deterioration Rates
* from the external data file PMNH3SDR.D

                    Calendar Year:  2002
                            Month:  Jan.
                         Altitude:  Low
              Minimum Temperature:  50.2 (F)
              Maximum Temperature:  71.5 (F)
                Absolute Humidity:   35. grains/lb
              Fuel Sulfur Content:  129. ppm

              Exhaust I/M Program:  Yes
                 Evap I/M Program:  Yes
```

```
                 ATP Program:  No
            Reformulated Gas:  Yes

          User supplied hourly temperatures.

     Vehicle Type:      LDGV    LDGT12   LDGT34     LDGT     HDGV     LDDV     LDDT     HDDV       MC   All Veh
             GVWR:               <6000    >6000    (All)
                       ------   ------   ------   ------   ------   ------   ------   ------   ------    ------
 VMT Distribution:     0.8860   0.1010   0.0130            0.0000   0.0000   0.0000   0.0000   0.0000    1.0000
Fuel Economy (mpg):      24.1     18.9     14.5     18.3      0.0      0.0      0.0      0.0      0.0      23.2
 ------------------------------------------------------------------------------------------------------------------
Composite Emission Factors (g/mi):
    Composite VOC :     1.967    3.292    1.376    3.074    0.000    0.000    0.000    0.000     0.00     2.093
    Composite CO  :     17.32    41.80    18.46    39.14     0.00    0.000    0.000    0.000     0.00    19.807
    Composite NOX :     0.861    1.338    1.167    1.318    0.000    0.000    0.000    0.000     0.00     0.913
    Composite CO2 :     357.3    443.5    597.4    461.1      0.0      0.0      0.0      0.0      0.0    369.10
 ------------------------------------------------------------------------------------------------------------------

* # # # # # # # # # # # # # # # # # # # # # # # # #
* JOTR WEEKDAY DISTRIBUTED SPEED, PS = 10.0
* File 1, Run 1, Scenario 2.
* # # # # # # # # # # # # # # # # # # # # # # # # #

* Reading Hourly, Roadway, and Speed VMT dist. from the following external
* data file: SVMT1.DEF

* Reading PM Gas Carbon ZML Levels
* from the external data file PMGZML.CSV

* Reading PM Gas Carbon DR1 Levels
* from the external data file PMGDR1.CSV

* Reading PM Gas Carbon DR2 Levels
* from the external data file PMGDR2.CSV

* Reading PM Diesel Zero Mile Levels
* from the external data file PMDZML.CSV

* Reading the First PM Deterioration Rates
* from the external data file PMDDR1.CSV

* Reading the Second PM Deterioration Rates
* from the external data file PMDDR2.CSV
  M112 Warning:
             Wintertime Reformulated Gasoline Rules Apply
  M 48 Warning:
            there are no sales for vehicle class LDDV
  M 48 Warning:
            there are no sales for vehicle class LDDT12
  M 48 Warning:
            there are no sales for vehicle class HDDV2b
  M 48 Warning:
            there are no sales for vehicle class HDDV3
  M 48 Warning:
            there are no sales for vehicle class HDDV4
  M 48 Warning:
            there are no sales for vehicle class HDDV5
  M 48 Warning:
            there are no sales for vehicle class HDDV6
  M 48 Warning:
            there are no sales for vehicle class HDDV7
  M 48 Warning:
            there are no sales for vehicle class HDDV8a
  M 48 Warning:
            there are no sales for vehicle class HDDV8b
  M 48 Warning:
            there are no sales for vehicle class HDDBS
  M 48 Warning:
            there are no sales for vehicle class LDDT34

               Calendar Year:  2002
                       Month:  Jan.
                    Altitude:  Low
         Minimum Temperature:  50.2 (F)
         Maximum Temperature:  71.5 (F)
           Absolute Humidity:   35. grains/lb
         Fuel Sulfur Content:  129. ppm

           Exhaust I/M Program:  Yes
              Evap I/M Program:  Yes
                   ATP Program:  No
              Reformulated Gas:  Yes

          User supplied hourly temperatures.

     Vehicle Type:      LDGV    LDGT12   LDGT34     LDGT     HDGV     LDDV     LDDT     HDDV       MC   All Veh
             GVWR:               <6000    >6000    (All)
                       ------   ------   ------   ------   ------   ------   ------   ------   ------    ------
 VMT Distribution:     0.8860   0.1010   0.0130            0.0000   0.0000   0.0000   0.0000   0.0000    1.0000
Fuel Economy (mpg):      24.1     18.9     14.5     18.3      0.0      0.0      0.0      0.0      0.0      23.2
 ------------------------------------------------------------------------------------------------------------------
Composite Emission Factors (g/mi):
    Composite VOC :     1.967    3.292    1.376    3.074    0.000    0.000    0.000    0.000     0.00     2.093
    Composite CO  :     17.32    41.80    18.46    39.14     0.00    0.000    0.000    0.000     0.00    19.807
    Composite NOX :     0.861    1.338    1.167    1.318    0.000    0.000    0.000    0.000     0.00     0.913
    Composite CO2 :     357.3    443.5    597.4    461.1      0.0      0.0      0.0      0.0      0.0    369.10
 ------------------------------------------------------------------------------------------------------------------
```

E.2 Joshua Tree Weekend Report File

```
***************************************************************************
* MOBILE6.2.01 (31-Oct-2002)                                              *
* Input file: JOTRWEND.IN (file 1, run 1).                                *
***************************************************************************
  M603 Comment:
             User has disabled the calculation of REFUELING emissions.

  M619 Comment:
             User supplied alternate AC input: Peak Sun between 11 AM, and  1 PM.
  M618 Comment:
             User supplied alternate AC input: Sunrise at  7 AM, Sunset at  5 PM.

* Reading Registration Distributions from the following external
```

```
* data file: REGDATA2.D
  M614 Comment:
             User supplied diesel sale fractions.

* Reading non-default MILEAGE ACCUMULATION RATES from the following external
* data file: MILEDAT2.D
  M615 Comment:
             User supplied VMT mix.

* Reading Hourly, Roadway, and Speed VMT dist. from the following external
* data file: SVMT2.DEF

* Reading Hourly Roadway VMT distribution from the following external
* data file: FVMT1.DEF

  Reading User Supplied ROADWAY VMT Factors

* Reading Hourly VMT distribution from the following external
* data file: HVMT1.DEF
  M601 Comment:
             User has enabled STAGE II REFUELING.

  M616 Comment:
             User has supplied post-1999 sulfur levels.

* Reading ASM I/M Test Credits from ASMDATA.D

* # # # # # # # # # # # # # # # # # # # # # # # # #
* JOTR WEEKEND DISTRIBUTED SPEED, PS = 2.5
* File 1, Run 1, Scenario 1.
* # # # # # # # # # # # # # # # # # # # # # # # # #

* Reading Hourly, Roadway, and Speed VMT dist. from the following external
* data file: SVMT2.DEF

* Reading PM Gas Carbon ZML Levels
* from the external data file PMGZML.CSV

* Reading PM Gas Carbon DR1 Levels
* from the external data file PMGDR1.CSV

* Reading PM Gas Carbon DR2 Levels
* from the external data file PMGDR2.CSV

* Reading PM Diesel Zero Mile Levels
* from the external data file PMDZML.CSV

* Reading the First PM Deterioration Rates
* from the external data file PMDDR1.CSV

* Reading the Second PM Deterioration Rates
* from the external data file PMDDR2.CSV
  M112 Warning:
             Wintertime Reformulated Gasoline Rules Apply
*** I/M credits for Tech1&2 vehicles were read from the following external
    data file: TECH12.D
  M 48 Warning:
            there are no sales for vehicle class LDDT12
  M 48 Warning:
            there are no sales for vehicle class HDDV2b
  M 48 Warning:
            there are no sales for vehicle class HDDV3
  M 48 Warning:
            there are no sales for vehicle class HDDV4
  M 48 Warning:
            there are no sales for vehicle class HDDV5
  M 48 Warning:
            there are no sales for vehicle class HDDV6
  M 48 Warning:
            there are no sales for vehicle class HDDV7
  M 48 Warning:
            there are no sales for vehicle class HDDV8a
  M 48 Warning:
            there are no sales for vehicle class HDDV8b
  M 48 Warning:
            there are no sales for vehicle class HDDBS

* Reading Ammonia (NH3) Basic Emissiion Rates
* from the external data file PMNH3BER.D

* Reading Ammonia (NH3) Sulfur Deterioration Rates
* from the external data file PMNH3SDR.D

                   Calendar Year:  2002
                           Month:  Jan.
                        Altitude:  Low
             Minimum Temperature:  50.2 (F)
             Maximum Temperature:  71.5 (F)
               Absolute Humidity:   35. grains/lb
             Fuel Sulfur Content:  129. ppm

             Exhaust I/M Program:  Yes
                Evap I/M Program:  Yes
                     ATP Program:  No
                Reformulated Gas:  Yes

             User supplied hourly temperatures.

Emissions determined from WEEKEND hourly vehicle activity fractions.
```

Vehicle Type: GVWR:	LDGV	LDGT12 <6000	LDGT34 >6000	LDGT (All)	HDGV	LDDV	LDDT	HDDV	MC	All Veh
VMT Distribution:	0.7379	0.1190	0.0077		0.0010	0.1271	0.0073	0.0000	0.0000	1.0000
Fuel Economy (mpg):	24.0	18.8	14.6	18.5	7.5	32.4	17.0	0.0	0.0	23.8
Composite Emission Factors (g/mi):										
Composite VOC :	2.413	2.227	2.036	2.216	1.176	0.125	0.511	0.000	0.00	2.082
Composite CO :	14.90	19.02	18.50	18.99	10.54	0.952	0.973	0.000	0.00	13.539
Composite NOX :	0.917	1.077	1.242	1.087	4.138	0.494	1.294	0.000	0.00	0.891
Composite CO2 :	358.2	454.2	592.9	462.6	1172.6	311.9	594.8	0.0	0.0	368.11

```
* # # # # # # # # # # # # # # # # # # # # # # # # #
* JOTR WEEKEND DISTRIBUTED SPEED, PS = 10.0
* File 1, Run 1, Scenario 2.
* # # # # # # # # # # # # # # # # # # # # # # # # #
```

```
* Reading Hourly, Roadway, and Speed VMT dist. from the following external
* data file: SVMT2.DEF

* Reading PM Gas Carbon ZML Levels
* from the external data file PMGZML.CSV

* Reading PM Gas Carbon DR1 Levels
* from the external data file PMGDR1.CSV

* Reading PM Gas Carbon DR2 Levels
* from the external data file PMGDR2.CSV

* Reading PM Diesel Zero Mile Levels
* from the external data file PMDZML.CSV

* Reading the First PM Deterioration Rates
* from the external data file PMDDR1.CSV

* Reading the Second PM Deterioration Rates
* from the external data file PMDDR2.CSV
  M112 Warning:
             Wintertime Reformulated Gasoline Rules Apply
  M 48 Warning:
            there are no sales for vehicle class LDDT12
  M 48 Warning:
            there are no sales for vehicle class HDDV2b
  M 48 Warning:
            there are no sales for vehicle class HDDV3
  M 48 Warning:
            there are no sales for vehicle class HDDV4
  M 48 Warning:
            there are no sales for vehicle class HDDV5
  M 48 Warning:
            there are no sales for vehicle class HDDV6
  M 48 Warning:
            there are no sales for vehicle class HDDV7
  M 48 Warning:
            there are no sales for vehicle class HDDV8a
  M 48 Warning:
            there are no sales for vehicle class HDDV8b
  M 48 Warning:
            there are no sales for vehicle class HDDBS

                  Calendar Year:  2002
                          Month:  Jan.
                       Altitude:  Low
            Minimum Temperature:  50.2 (F)
            Maximum Temperature:  71.5 (F)
              Absolute Humidity:   35. grains/lb
            Fuel Sulfur Content:  129. ppm

            Exhaust I/M Program:  Yes
               Evap I/M Program:  Yes
                    ATP Program:  No
               Reformulated Gas:  Yes

            User supplied hourly temperatures.

Emissions determined from WEEKEND hourly vehicle activity fractions.
```

Vehicle Type: GVWR:	LDGV	LDGT12 <6000	LDGT34 >6000	LDGT (All)	HDGV	LDDV	LDDT	HDDV	MC	All Veh
VMT Distribution:	0.7379	0.1190	0.0077		0.0010	0.1271	0.0073	0.0000	0.0000	1.0000
Fuel Economy (mpg):	24.0	18.8	14.6	18.5	7.5	32.4	17.0	0.0	0.0	23.8
Composite Emission Factors (g/mi):										
Composite VOC :	2.413	2.227	2.036	2.216	1.176	0.125	0.511	0.000	0.00	2.082
Composite CO :	14.90	19.02	18.50	18.99	10.54	0.952	0.973	0.000	0.00	13.539
Composite NOX :	0.917	1.077	1.242	1.087	4.138	0.494	1.294	0.000	0.00	0.891
Composite CO2 :	358.2	454.2	592.9	462.6	1172.6	311.9	594.8	0.0	0.0	368.11

APPENDIX F. CMEM VEHICLE TYPE CATEGORIZATION GUIDELINES

Figure F-1 shows a CMEM categorization decision tree for light-duty automobiles.

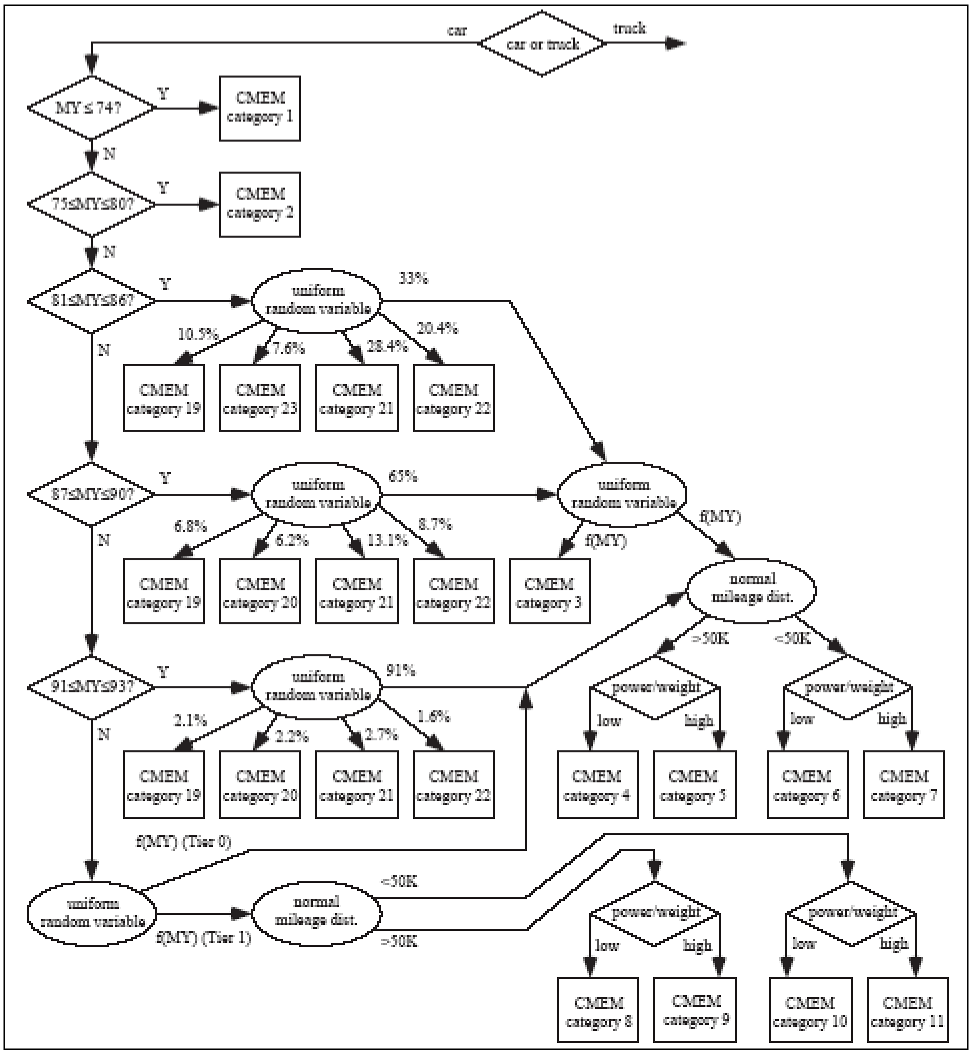


Figure F-1. Light-duty automobile categorization tree

Figure F-2 shows a categorization decision tree for light-duty trucks.

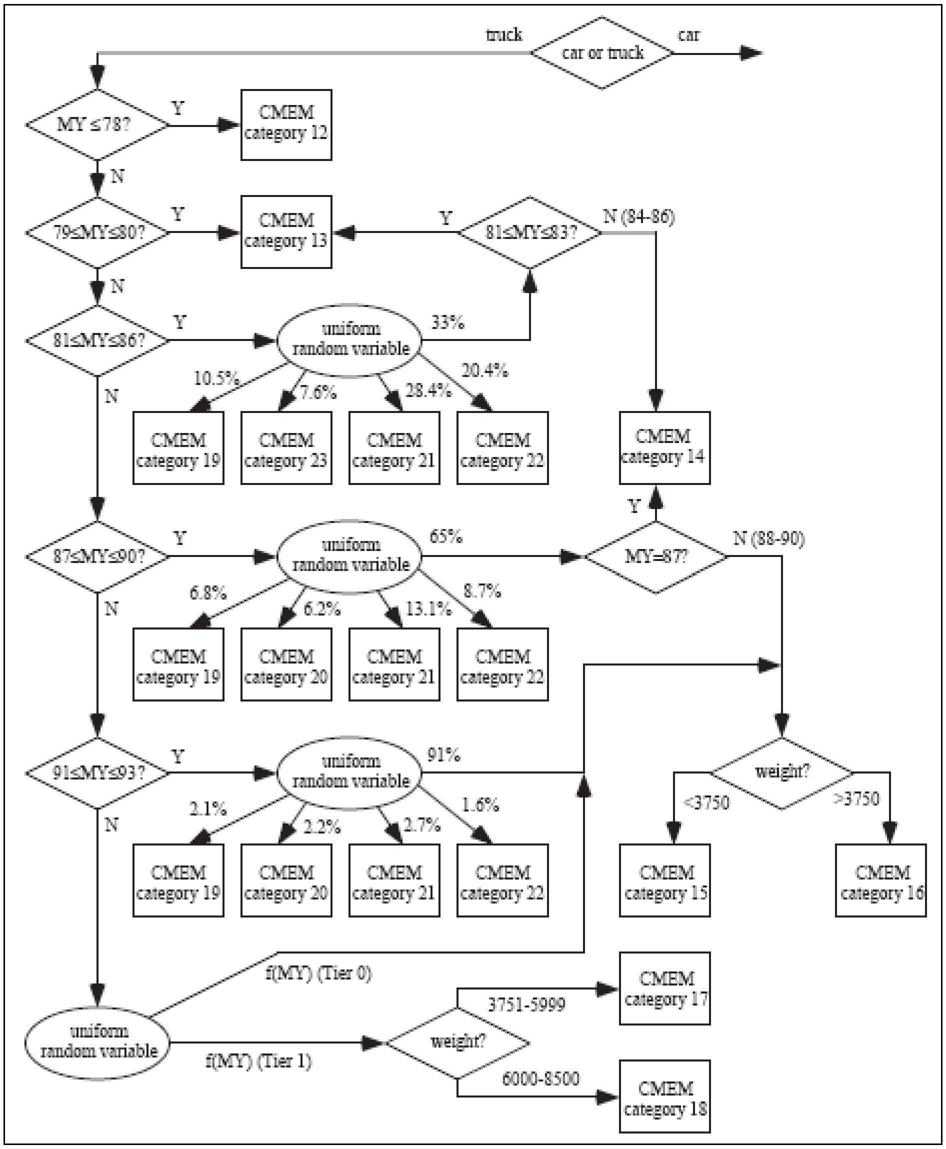


Figure F-2. Light-duty truck categorization tree

APPENDIX G. EXAMPLE TUTORIAL USING THE CMEM META-MODEL

G.1 Modal Emissions Model

This section presents an overview of the CMEM Meta-Model.

Model Requirements The CMEM Meta-Model should be installed on a computer equipped with a Windows 98 or above operating system. To check the operating system of a computer, go to Windows Explorer, My Computer. Right click on My Computer and select Properties. Select the General tab; the operating system will be identified under the header System.

The only data necessary to run the CMEM Meta-Model is a sample of representative speed and acceleration data. Before running the CMEM Meta-Model, create a data directory on the computer's hard drive, for example, **C:\CMEM_META_MODEL**.

This tutorial uses the file ***Sample-Input.txt***, which can be found on the CD-ROM included with this report under the ***Tutorial*** directory. Copy this file onto the hard drive and remember where it was placed. Microsoft Excel also needs to be installed for this tutorial.

Speed/Acceleration Data A park's representative speed and acceleration data should be contained in a text file, as pictured in Figure G-1. A blank text file can be opened in Notepad, standard with Microsoft Windows operating systems, and the data entered there, line-by-line. A text file will end with the "TXT" extension. Using the Windows browser feature, give the file an appropriate name, for example, **PORE_speeds.TXT**, and save it to a folder on the computer's hard drive, for example, **C:\CMEM_META_MODEL**.

The example speed/acceleration input text file provided in the ***Tutorial*** directory and pictured in Figure G-1 contains 51 seconds' worth of speed/ acceleration data, starting at speed 1 = 0 mph and acceleration 1 = 0 mph/s. Note:

- **One second of data is assigned to each line in the text file.**
- For each second of data, the speed and acceleration are separated by a comma.
- Data should be limited to one decimal place.
- Processing is easier if speed data are limited to units of miles per hour (mph): If the speeds are collected at a rate of something other than mph, convert the speeds to mph.
- Processing is easier if acceleration data are limited to units of mph per second (mph/s): If the accelerations are collected at a rate other than mph/s, convert the accelerations to mph/s.
- Accelerations, in mph/s, may be calculated from the one-second speed data by using the following formulas:
    - acceleration 1 = 0
    - acceleration 2 = speed 2 – speed 1

- acceleration 3 = speed 3 – speed 2
- acceleration 4 = speed 4 – speed 3, etc.

- Negative acceleration values represent decelerations.

```
0,0
2.3,2.3
3.6,1.3
4.1,0.5
5.2,1.1
6.9,1.7
7.2,0.3
8.8,1.6
8.2,-0.6
9.7,1.5
8.5,-1.2
10.3,1.8
12.4,2.1
15.1,2.7
17,1.9
20.1,3.1
21.4,1.3
24.5,3.1
23.5,-1
22.4,-1.1
24.3,1.9
25.9,1.6
23.5,-2.4
23.4,-0.1
22.3,-1.1
25.7,3.4
24.7,-1
23.2,-1.5
21.3,-1.9
23.4,2.1
22.3,-1.1
20.9,-1.4
18.5,-2.4
16.4,-2.1
15.7,-0.7
13.4,-2.3
12.3,-1.1
10.1,-2.2
10.4,0.3
11.4,1
10,-1.4
9.8,-0.2
8.1,-1.7
8.9,0.8
7.3,-1.6
5.6,-1.7
4.5,-1.1
3.4,-1.1
2.1,-1.3
1.2,-0.9
0,-1.2
```

Figure G-1. **An example speed/acceleration input text file, 1 s data per line**

For each of these speed and acceleration combinations, the CMEM Meta-Model will calculate emission factors in grams per second (g/s) for Hydrocarbons (HC), Carbon Monoxide (CO), and Nitrogen Oxides (NOx).

Setting Up the Model In the "CMEM-Meta-Model-Interpolation-Program" directory on the CD-ROM, a set of instructions and a ***Setup.exe*** program has been provided. Double-click the ***Setup.exe*** program and follow the instructions until the setup is finished. Running the program will result in the portal screen shown in Figure G-2.

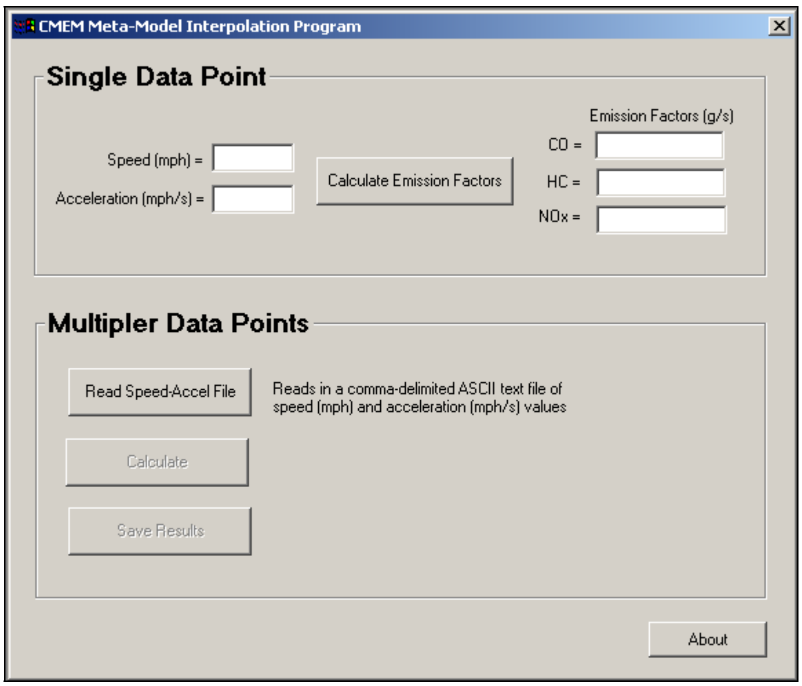


Figure G-2. **Portal screen of CMEM Meta-Model**

This screen represents the only portal screen in the CMEM Meta-Model: All data entry and software commands are executed from here.

Running the Model

The CMEM Meta-Model calculates emission factors in g/s for different speed/acceleration combinations. The model allows the user to calculate emission factors for a single speed/acceleration data point and multiple speed/acceleration data points.

- ***Single Data Point*** In the "Single Data Point" section of the input screen, enter the desired speed in the "Speed (mph) =" box. Enter the desired acceleration in the "Acceleration (mph/s) =" box. Click the ***Calculate Emission Factors*** button. The CO, HC, and NOx emission factors will appear in the "Emission Factors (g/s)" windows.

- ***Multiple Data Points*** The bottom "Multiple Data Points" section is used to read in multiple speed/acceleration data points, stored in the lines of a text file like the one pictured in Figure G-1. At program startup, note that all of the input screen buttons are disabled (grayed-out) except for the ***Read Speed-Accel File*** button. Also note that the textual indicator to the right of the ***Read Speed-Accel File*** button reads: "Reads in a comma-delimited ASCII text file of speed (mph) and acceleration (mph/s) values." This is to remind the user of the format that the input data needs to be in, as discussed in the ***Speed/Acceleration Data*** paragraph of Section G.2 and Figure G-1. Press this ***Read Speed-Accel File*** button, and a "Read Data" dialog box will open. Using the Windows file browser feature, find the desired speed/acceleration data input file on the hard drive, for example, **C:\CMEM_META_MODEL\PORE_speeds.TXT**, and click ***Open***. The dialog box will disappear, and the program will have read in the data contained in the selected text file. The textual indicator to the right of the ***Read Speed-Accel File*** button should have changed to read:

  "Number of records (data points) = 51*"

  This indicates that the data was read in successfully. Note also that the ***Read Speed-Accel File*** button is now disabled (grayed-out) while the ***Calculate*** button is now active. Press the ***Calculate*** button, and the program will automatically conduct the interpolation calculations for each data point contained in the text file. The textual indicator to the right of the ***Calculate*** button indicates which record the interpolations are currently being conducted for. The final reading on the textual indicator should read:

  PROGRESS = 51*

  This means that record 51* was the last record for which the interpolations were conducted. This should always equal the total number of records that were read in. The ***Calculate*** button should now be disabled and the ***Save Results*** button should be active.

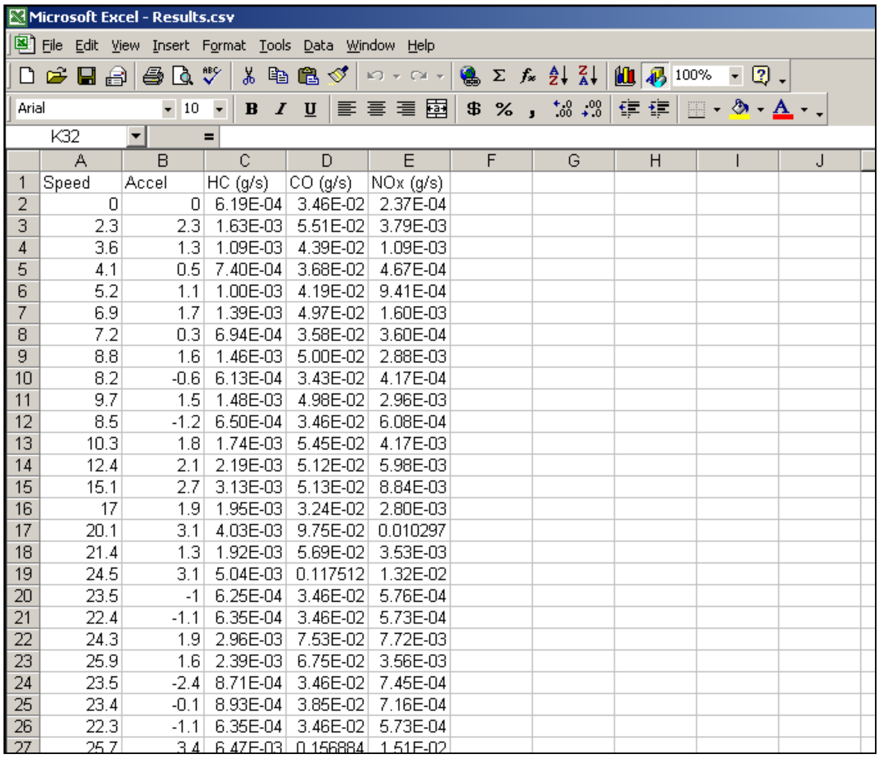
Saving Results Press the ***Save Results*** button, and a ***Save Data*** dialog box will open. Navigate to a suitable location on the hard drive, for example, **C:\CMEM_META_MODEL**, and save the results, using a "CSV" extension and an appropriate filename, for example, **PORE_emissionfactors.CSV**. Click the ***Save*** button, and the dialog box will disappear. The program has saved the CO, HC, and NOx emission factor results in the "CSV" file in a comma-delimited ASCII text format. All of the buttons and textual indicators should have reverted back to their original conditions. This allows the user to process more data as necessary. This ends the use of the "CMEM Meta-Model Interpolation Program."

---

* For however many lines of data there are in the speed/acceleration data input file

G.2 Emissions Inventory

Tabulating Emission Factors Find the "CSV" results file on the hard drive, for example, **C:\CMEM_META_MODEL\PORE_emissionfactors.CSV**. Double-click this file, and it should open in Microsoft Excel. Even though it is a comma-delimited file, its "CSV" extension will be automatically recognized by Excel. In Excel, the data should appear as follows:



	A	B	C	D	E
1	Speed	Accel	HC (g/s)	CO (g/s)	NOx (g/s)
2	0	0	6.19E-04	3.46E-02	2.37E-04
3	2.3	2.3	1.63E-03	5.51E-02	3.79E-03
4	3.6	1.3	1.09E-03	4.39E-02	1.09E-03
5	4.1	0.5	7.40E-04	3.68E-02	4.67E-04
6	5.2	1.1	1.00E-03	4.19E-02	9.41E-04
7	6.9	1.7	1.39E-03	4.97E-02	1.60E-03
8	7.2	0.3	6.94E-04	3.58E-02	3.60E-04
9	8.8	1.6	1.46E-03	5.00E-02	2.88E-03
10	8.2	-0.6	6.13E-04	3.43E-02	4.17E-04
11	9.7	1.5	1.48E-03	4.98E-02	2.96E-03
12	8.5	-1.2	6.50E-04	3.46E-02	6.08E-04
13	10.3	1.8	1.74E-03	5.45E-02	4.17E-03
14	12.4	2.1	2.19E-03	5.12E-02	5.98E-03
15	15.1	2.7	3.13E-03	5.13E-02	8.84E-03
16	17	1.9	1.95E-03	3.24E-02	2.80E-03
17	20.1	3.1	4.03E-03	9.75E-02	0.010297
18	21.4	1.3	1.92E-03	5.69E-02	3.53E-03
19	24.5	3.1	5.04E-03	0.117512	1.32E-02
20	23.5	-1	6.25E-04	3.46E-02	5.76E-04
21	22.4	-1.1	6.35E-04	3.46E-02	5.73E-04
22	24.3	1.9	2.96E-03	7.53E-02	7.72E-03
23	25.9	1.6	2.39E-03	6.75E-02	3.56E-03
24	23.5	-2.4	8.71E-04	3.46E-02	7.45E-04
25	23.4	-0.1	8.93E-04	3.85E-02	7.16E-04
26	22.3	-1.1	6.35E-04	3.46E-02	5.73E-04
27	25.7	3.4	6.47E-03	0.156884	1.51E-02

Figure G-3. **The** PORE_emissionfactors.CSV **file loaded into Microsoft Excel**

Within Excel, immediately save this "CSV" file as an Excel file on the hard drive, for example, **C:\CMEM_META_MODEL\PORE_emissionfactors.xls**. As indicated by the headers, each of the values under the HC, CO, and NOx columns represent emission factors, in g/s. Total emissions for this fictitious driving cycle of 51 speeds and accelerations can be obtained by simply adding each of these individual emission factors as follows:

HC: 6.19E-04 + 1.63E-03 + 1.09E-03 + … + 6.50E-04 = 6.76E-02 g
CO: 3.46E-02 + 5.51E-02 + 4.39E-02 + … + 3.46E-02 = 2.21 g
NOx: 2.37E-04 +3.79E-03 + 1.09E-03 + … + 2.37E-04 = 1.18E-01 g

In Excel, this corresponds to the following formulas:

=sum(C2:C43)
=sum(D2:D43)
=sum(E2:E43)

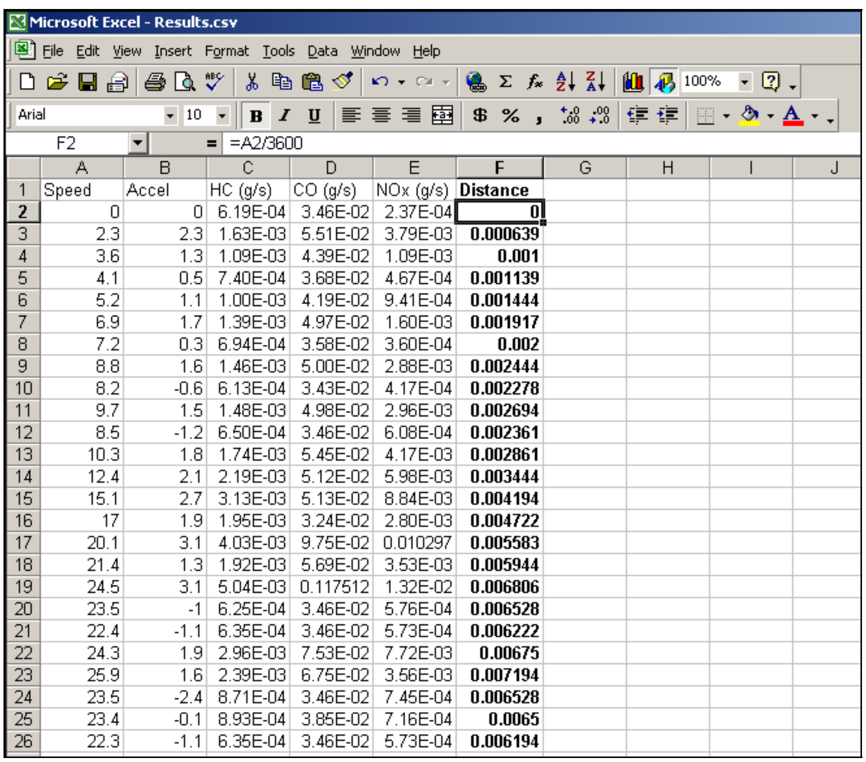
If emissions per mile are necessary (e.g., g/vehicle-mile), then the total distance must be determined. Add an additional "Distance" column to the spreadsheet, and use the following formula to calculate distance for each 1-second time interval in cells ***F2, F3, F4, etc.***:

Distance (mile) = Speed (mph) * (1 hr / 3600 seconds) * 1 second

In Excel, this corresponds to the following formulas:

=A2/3600
=A3/3600
=A4/3600, etc.

The resulting values are shown in Figure G-4.



	A	B	C	D	E	F	G	H	I	J
1	Speed	Accel	HC (g/s)	CO (g/s)	NOx (g/s)	**Distance**				
2	0	0	6.19E-04	3.46E-02	2.37E-04	**0**				
3	2.3	2.3	1.63E-03	5.51E-02	3.79E-03	**0.000639**				
4	3.6	1.3	1.09E-03	4.39E-02	1.09E-03	**0.001**				
5	4.1	0.5	7.40E-04	3.68E-02	4.67E-04	**0.001139**				
6	5.2	1.1	1.00E-03	4.19E-02	9.41E-04	**0.001444**				
7	6.9	1.7	1.39E-03	4.97E-02	1.60E-03	**0.001917**				
8	7.2	0.3	6.94E-04	3.58E-02	3.60E-04	**0.002**				
9	8.8	1.6	1.46E-03	5.00E-02	2.88E-03	**0.002444**				
10	8.2	-0.6	6.13E-04	3.43E-02	4.17E-04	**0.002278**				
11	9.7	1.5	1.48E-03	4.98E-02	2.96E-03	**0.002694**				
12	8.5	-1.2	6.50E-04	3.46E-02	6.08E-04	**0.002361**				
13	10.3	1.8	1.74E-03	5.45E-02	4.17E-03	**0.002861**				
14	12.4	2.1	2.19E-03	5.12E-02	5.98E-03	**0.003444**				
15	15.1	2.7	3.13E-03	5.13E-02	8.84E-03	**0.004194**				
16	17	1.9	1.95E-03	3.24E-02	2.80E-03	**0.004722**				
17	20.1	3.1	4.03E-03	9.75E-02	0.010297	**0.005583**				
18	21.4	1.3	1.92E-03	5.69E-02	3.53E-03	**0.005944**				
19	24.5	3.1	5.04E-03	0.117512	1.32E-02	**0.006806**				
20	23.5	-1	6.25E-04	3.46E-02	5.76E-04	**0.006528**				
21	22.4	-1.1	6.35E-04	3.46E-02	5.73E-04	**0.006222**				
22	24.3	1.9	2.96E-03	7.53E-02	7.72E-03	**0.00675**				
23	25.9	1.6	2.39E-03	6.75E-02	3.56E-03	**0.007194**				
24	23.5	-2.4	8.71E-04	3.46E-02	7.45E-04	**0.006528**				
25	23.4	-0.1	8.93E-04	3.85E-02	7.16E-04	**0.0065**				
26	22.3	-1.1	6.35E-04	3.46E-02	5.73E-04	**0.006194**				

Figure G-4. **The modified** PORE_emissionfactors.xls **file**

Summing the distances will provide the following result:

Total distance = 0 + 0.000639 + 0.001 + … + 0 = 1.89E-01 mile

In Excel, this corresponds to the following formula:

=sum(F2:F43)

Dividing the total emissions by total distance will provide emissions per distance for an average vehicle type:

HC: 6.76E-02 g / 1.89E-01 mile = 0.36 g/vehicle-mile
CO: 2.21 g / 1.89E-01 mile = 11.69 g/vehicle-mile
NOx: 1.18E-01 g / 1.89E-01 mile = 0.62 g/vehicle-mile

In Excel, this corresponds to the following formulas:

=sum(C2:C43)/(sum(F2:F43))
=sum(D2:D43)/(sum(F2:F43))
=sum(D2:D43)/(sum(F2:F43))

Calculating the Emissions Inventory Thus far, complete, representative emission factors have been calculated, in units of g/vehicle-mile. In order to calculate a complete, representative emissions inventory, the emission factors must be multiplied by the representative, park-specific vehicle miles traveled (VMT) and the representative park-specific traffic count.

- ***Representative Vehicle Miles Traveled*** A VMT figure must be calculated for each separate trip length, in miles. The most representative trip length may be the average length of all vehicle trips measured. In its calculation of representative VMT for different trip lengths in each California National Park, the Volpe Center randomly pared individual smaller trips' one-second speed data end-to-end until it had a longer total trip (see companion technical reports for the California parks). For example, for a 3-hour trip, 10,800 seconds' worth of speed data, in mph, were randomly combined to form the larger trip. The average speed, in units of mph, was found for these 10,800 pieces of speed data. Multiplying this average speed by three hours gave the VMT figure, in miles, traveled over the course of that three hours. Suppose the average trip length for a small park is 90 minutes, and the average speed is 24.3 mph. Since 90 minutes is actually 1.5 hours, the VMT is 24.3 mph x 1.5 hours = 36.5 miles. The representative VMT for a trip of 90 minutes is 36.5 miles.

- ***Representative Traffic Count*** A tabulation of all traffic count data for a given number of days yields a total traffic count figure for a park. The Volpe Center counted traffic for two weekdays and two weekend days in each California National Park. The actual traffic count data can be extrapolated to fit a larger or smaller time period. For example, the Volpe Center wanted a traffic count for a representative week in each park, so it extrapolated the four days out to seven days using the following formula:

Representative weekly traffic count =
(2 weekdays traffic count)*2.5 + (2 weekend days traffic count)

This representative weekly traffic count assumes that each vehicle traveled for the amount of time, miles, and at the speed found as part of the calculation of the representative VMT.

- ***Representative Emissions Inventory*** Once the representative VMT and traffic count are found, a park-specific emissions inventory can be calculated. Simply multiply the total emission factor for a given pollutant, in g/vehicle-mile, by the VMT and by the traffic count, and the resulting emissions, in g, will give the user an idea of the emissions over a representative time period in the park being measured. The representative emissions inventory for CO, HC, and NOx, if calculated in the Excel spreadsheet pictured in Figure A-4, should utilize the following formulas:

=(sum(C2:C43)/(sum(F2:F43)))*(cell containing VMT)*(cell containing Traffic Count)
=sum(D2:D43)/(sum(F2:F43))* (cell containing VMT)*(cell containing Traffic Count)
=sum(D2:D43)/(sum(F2:F43))* (cell containing VMT)*(cell containing Traffic Count)

G.3 Conclusion

Because of the science behind CMEM and the Meta-Model, by definition it is expected that the CMEM Meta-Model will provide more representative emissions inventories within a National Park environment, as compared with Federally accepted tools such as MOBILE6. However, the CMEM Meta-Model is not accepted for Federal, state, or local policy or environmental decisionmaking.

If utilized and compared regularly by park personnel, CMEM Meta-Model results can serve to identify for park personnel the effects major changes in driving behavior and vehicle count are having on park emissions of CO, HC, and NOx.

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This Visitor Vehicle Emissions Study was made possible in part by a grant from the National Park Foundation through the generous support of the Ford Motor Company, A Proud Partner of America's National Parks.

Also, this report is part of a series of reports which describes measurements at Yosemite National Park, Joshua Tree National Park, and Pt. Reyes National Seashore and culminates in a comparison of the data measured and air quality results found at the three California parks.

14. ABSTRACT (Maximum 200 words)

The U.S. Department of Transportation, John A. Volpe National Transportation Systems Center (Volpe Center), Environmental Measurement and Modeling Division (Volpe Center), provided technical support to the National Parks Foundation as part of a National Park Service (NPS) project to evaluate vehicular emissions in the National Parks. In December 2002, a Visitor Vehicle Emissions Study was performed at Joshua Tree National Park in order to collect traffic count and vehicle tracking data. This data was processed through the Environmental Protection Agency's (EPA) MOBILE6 modeling software to produce park-specific emission factors. Alternative methods involving modal emissions models were also investigated. Mainly due to their ability to take into account park-specific driving cycles, modal emissions models are likely to provide results that are more appropriate for the National Parks. The report discusses the emissions inventory development methodologies and the corresponding results. For further emissions modeling, a simplified approach using a modal emissions model is recommended.

15. SUBJECT TERMS

national parks, emissions, emissions inventory, MOBILE6, traffic impact, National Park Service, CMEM, modal, modal emissions, Joshua Tree

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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

MASS – WEIGHT (APPROXIMATE)

1 ounce (oz)	=	28 grams (gm)
1 pound (lb)	=	0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp)	=	5 milliliters (ml)
1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup ©	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
1 gallon (gal)	=	3.8 liters (l)
1 cubic foot (cu ft, ft^3)	=	0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] °F	=	y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm)	=	0.04 inch (in)
1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS – WEIGHT (APPROXIMATE)

1 gram (gm)	=	0.036 ounce (oz)
1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

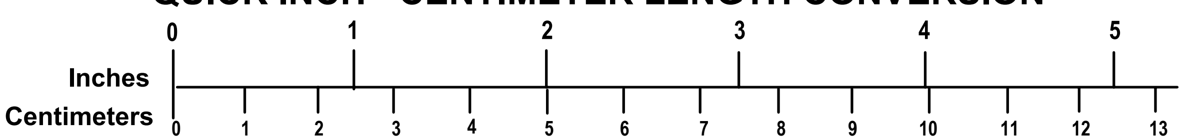
VOLUME (APPROXIMATE)

1 milliliter (ml)	=	0.03 fluid ounce (fl oz)
1 liter (l)	=	2.1 pints (pt)
1 liter (l)	=	1.06 quarts (qt)
1 liter (l)	=	0.26 gallon (gal)
1 cubic meter (m^3)	=	36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)

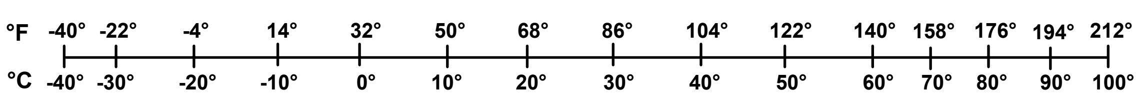
TEMPERATURE (EXACT)

[(9/5) y + 32] °C	=	x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION



For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

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As the nation's principal conservation agency, the Department of the Interior has the responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our parks and historic places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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