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Implications of the Implementation of the MOBILE6 Emissions Factor Model on Project-Level Impact Analyses Using the CAL3QHC Dispersion Model

Final Report

August 2004

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August 2004

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Office of Natural and Human Environment

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04-045

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Executive Summary

Emission factor models, specifically EPA's MOBILE series of models, are critical to assessing the emissions and air quality ramifications of transportation strategies, programs and projects. They serve as the underlying analytic tool for the development and evaluation of mobile source emissions in State Implementation Plans (SIPs), conformity determinations, and project-level impact analyses. As such, changes in these emission factor models will directly impact project-level analyses.

The increased flexibility in specifying inputs to MOBILE6[1] has allowed the inclusion of facility functional classes, increased number of vehicle classifications and improvements in emission estimates that are now based more characteristically on trip starts and length. However, most of the improvements in MOBILE6 have been directed at improving regional emission estimates, not project-specific estimates. Thus, the changes in MOBILE6 may inadvertently undermine the validity of the project-level assessment procedures. The implication of how the application of MOBILE6 will affect project-level analyses has not been explored. It is anticipated that the project-level analyst will require additional guidance and resources in selecting MOBILE6 modeling options.

Across the country, most Metropolitan Planning Organizations' (MPOs) and state Departments' of Transportation (DOTs) staff have begun to use MOBILE6 in project-level dispersion modeling. As a result, a goal for this project was to inform practitioners in the transportation community about the most critical and sensitive input parameters to MOBILE6 affecting project-level transportation and air quality analyses so that resulting transportation decisions are improved*.* The results of this project provide transportation planners with information that can help them develop cost effective strategies for using MOBILE6 in project-level dispersion analyses and to help design mitigation strategies when hotspot modeling is needed.

The CAL3QHC roadway intersection model is typically employed to determine potential air quality impacts for project-level analysis. CAL3QHC uses both an idle emission factor and an appropriate emission factor based on each link's free flow speed. The recent changes incorporated in MOBILE6 may produce changes in the idle and free-flow speed emission rates. Because these two emission rates are the input parameters for CAL3QHC, the modeling output may be different using MOBILE6 versus earlier versions of MOBILE.

Overall the study explores how the use of MOBILE6 impacts project-level analyses. The study is divided into three main components addressing the following three questions:

- *How will changes in MOBILE6 impact project-level results?*
- *How will changes in MOBILE6 affect the process for project-level analysis?*
- *Will changes in MOBILE6 significantly impact screening assessment procedures?*

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[1] All MOBILE6 simulations done in this study used the version publicly available in September 2003, known as MOBILE6.2, which was the version available at the beginning of the study. In late November 2003, EPA released a new version of MOBILE6.2, called MOBILE6.2.03 (version dated September 24, 2003). This newer version was adjusted to account for effects of Tier2 and the National Low Emission Vehicle program standards. A comparison between the version used in this study and the newly released version showed that in all cases the newer version of the model produced lower CO emission rates. This implies that the results found in this study are conservative, in that they underestimate the emission reduction effects estimated in the latest version of MOBILE6 (6.2.03) in comparison to MOBILE5.

MOBILE6 Impact on Project-Level Results

A review of the MOBILE6 changes that may impact project-level analysis suggest that ten emission change scenarios will be of primary interest to the project-level analyst in assessing the difference between using MOBILE5 and MOBILE6. These scenarios reflect both typical applications and/or potential changes from national distributions and anticipate significant impacts to carbon monoxide (CO) emission factors. Findings show that, in 2005, MOBILE6 produces lower emission factors than MOBILE5 at low speeds (between idle and 19.5 mph) across all temperatures and for all scenarios. This trend is reversed for higher speeds. For 2035, MOBILE6 emission factors are lower than the corresponding MOBILE5 emission factors for all scenarios, including higher speeds. Thus, for the earlier years, MOBILE6 will always estimate lower emission rates than MOBILE5 for low speeds, but higher emission rates for higher speeds. For later years, MOBILE6 will always provide lower emission rates than MOBILE5.

To assess the validity of the CAL3HC model, comparisons are made between the emission factor models MOBILE4.1 and MOBILE5, which was used in the model evaluation and selection study. The idle emissions decrease significantly when using MOBILE6.2, relative to either MOBILE5 or MOBILE4.1, while moving emissions increase. Historically, analyses of roadway intersections have found that high concentrations are a result of large queue emissions and hence, the idle emission factor. This tradeoff in emissions will likely impact the CAL3QHC model by lowering concentrations in most situations where queue length is important. Since the model performance evaluation of CAL3QHC in the Route 9a model validation study tended to underpredict emissions for all intersections evaluated, one would expect model bias to increase. However, this prediction somewhat contrasts with the other more recent major study, NCHRP25-6, which suggested that MOBILE6.2 will improve model performance relative to its evaluation based on using MOBILE5. Some of this difference may be the result of changes in engine technology since these evaluation studies were based on pre-1990 and pre-1995 vehicles. It is possible that differences between the two MOBILE models may be considerably different for a newer fleet of vehicles. If, however, today's fleet is analogous to the NCHRP's pre-1995 fleet, then the use of the MOBILE6.2 model in project-level analysis will likely improve model performance.

With the release of MOBILE6, EPA recommended that, because nearly all emissions are hot-stabilized, the model's emission factor estimates should be used without adjustment for start fraction, except for special modeling situations (such as parking lots) which may require the modeling of the effects of engine starts. ICF has identified additional locations under which start emissions should be considered. For each of these locations, a methodology has been identified for estimating start emission characterizations. In general, these methods use a combination of historical survey data in combination with an estimate of facility size to estimate the number of starts. In addition to borrowing results from these studies, several alternative methods are discussed for collecting data to characterize soak distribution for project-specific locations. These methods are relatively inexpensive to implement relative to a fully instrumented vehicle study.

Implementation of MOBILE6 will affect the results of project-level analysis. An assessment is made using the CAL3QHC model for a typical high volume freeway and high volume intersection. Modeling is performed for a variety of emission scenarios representing the expected range of differences between MOBILE5 and MOBILE6 models for the base year of

2005 and a future year of 2035. In addition, the impact of start emissions are assessed for an urban and a suburban intersection for several levels of service, assuming that a fourth of the vehicles arriving are in start mode.

For the high volume freeway scenario, MOBILE6 produces higher concentrations than MOBILE5 for 2005, while in 2035, MOBILE6 is more comparable to MOBILE5, but produces higher concentrations at lower temperatures. Thus, application of MOBILE6 for freeways in the near future years coupled with high traffic volumes and high background concentrations may present problems not currently demonstrated with MOBILE5. For the suburban intersection scenarios, MOBILE6 produces lower ambient CO concentration values for every combination than does MOBILE5. For the central business district (CBD) intersection, too, the concentrations produced by the MOBILE6 model are always lower than those from MOBILE5. For the start scenarios, both the urban and suburban intersections show problems achieving the eight-hour CO standard. For 2035, the urban intersection meets the eight-hour standard, but the suburban intersection does not. In all cases, these exceedances are associated with the high idle emissions factors associated with start emissions. Thus, intersections with high start fractions and high volumes appear to have the potential for exceeding the CO standard.

MOBILE6 Impact on the Process for Project-Level Analysis

Use of MOBILE6 has the potential to affect the process through which project-level analysis is performed. Potential changes include the need for additional information; local or state procedures, including estimating background concentration; and impacts on mitigation strategies. For those agencies using mostly default values, no additional effort has been found in applying the MOBILE6 model, while those developing location-specific input indicated that additional effort is needed to develop inputs to the model. Almost all state agencies contacted indicated that more time is required to complete project-level analyses using MOBILE6 compared to using MOBILE5, ranging from several hours to 40 hours. Most states have also found that future background concentrations of CO should be lowered as a result of MOBILE6's strong downward CO emission trends and estimates of regional vehicle miles traveled (VMT) growth. As a result, a number of locations have, or are looking at, adopting new procedures for determining future background CO levels. For intersection modeling using MOBILE6, areas will need to change their "worst case" modeling receptors from being intersection-based to using a mid-block location. For mitigation, the traditional approach of increasing intersection capacity to achieve higher average speeds may result in overall emission increases.

MOBILE6 Impact on Screening Assessment Procedures

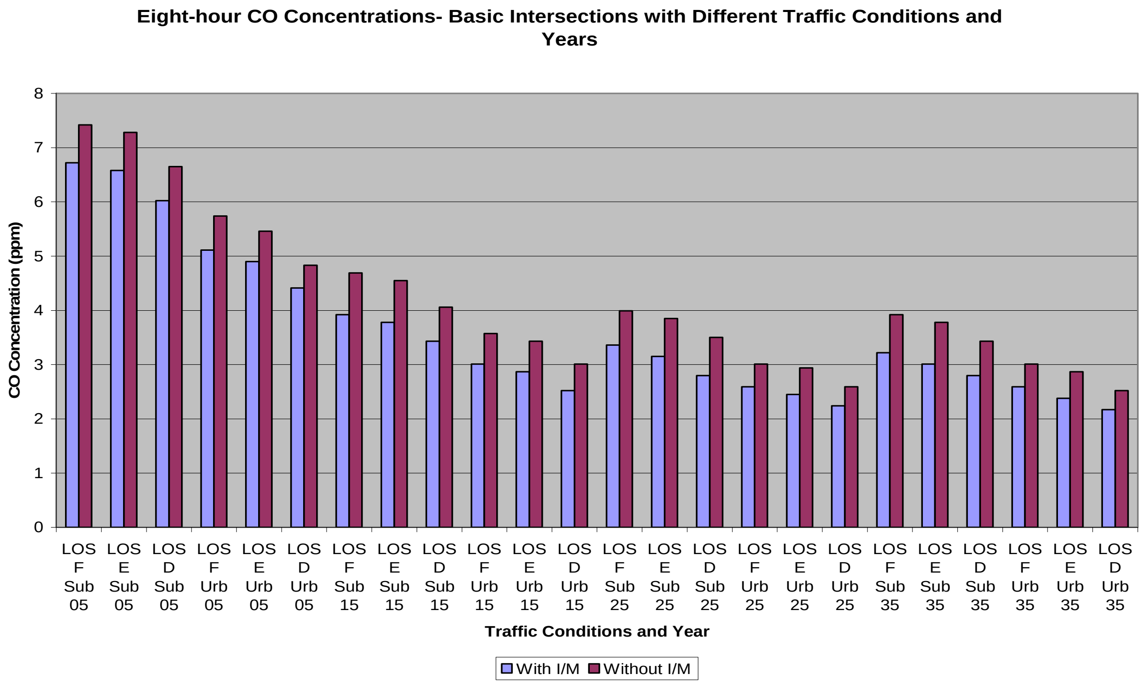
Use of MOBILE6 has the likely potential to affect the screening assessment procedures for project-level analysis. This study identifies current efforts in revising screening-level procedures, as well as develops an approach for setting a threshold screening-level procedure. In addition, the study identifies limitations in the applicability of the screening approach.

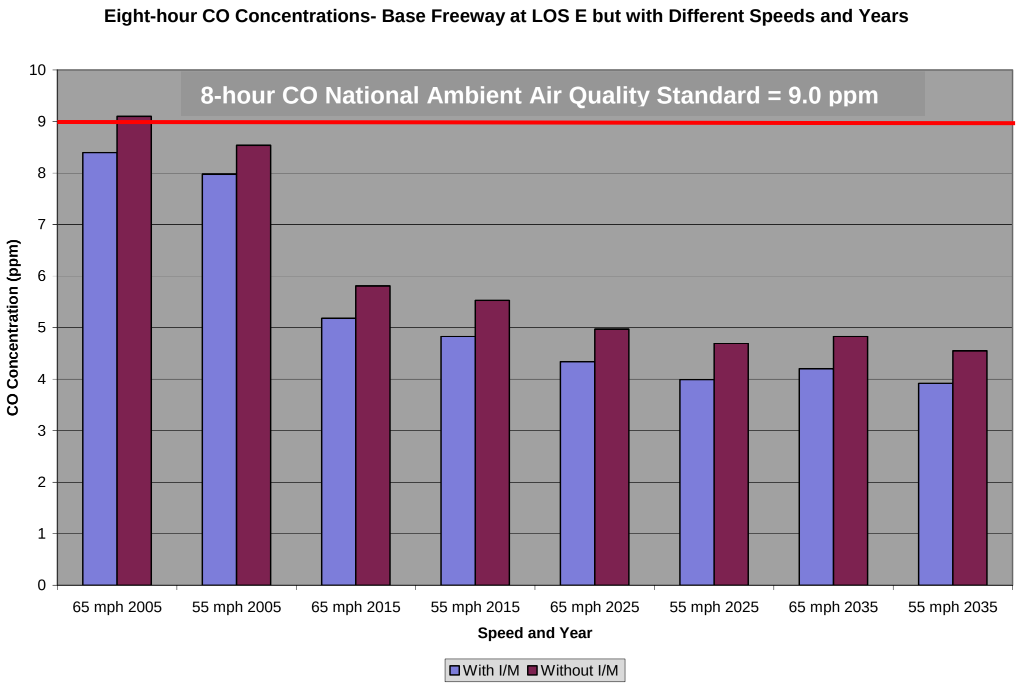
The assessment finds limited potential for the CO National Ambient Air Quality Standards (NAAQS) violations for project-level studies under most typical conditions. In the past, level of service (LOS) C has been widely used as a screening threshold to reduce the need for detailed modeling. Due to the changes from MOBILE 5 to MOBILE6, the relative role of cruise emissions has increased, while the idle emission factors have been substantially reduced. As shown in ES-1, detailed modeling can likely be excluded for both intersection and freeway locations with

LOS E or better under a wide variety of conditions, especially when looking beyond the near-term period (2015 or later). It was also observed that, for a freeway operating at LOS E, modeling results suggest the potential for higher CO levels than at an intersection operating at LOS F. Thus, freeway scenarios should be examined, along with intersections, in setting a screening threshold assessment procedure. Results also show that, for intersections, the corner receptors no longer exhibit the highest concentration.

The applicability of this screening approach is dependent on the circumstances of a given project and how closely they resemble typical conditions. Several exceptions to these typical conditions have been identified. These include: locations in very close proximity to very high volume freeways; locations with an extraordinary rate of start emissions, such as near a park and ride lot or CBD parking garage; a fleet much older than the national default age distribution; and locations with an unusually high background concentration. These type cases will need to be examined on a case-by-case basis. Nevertheless, it appears likely that the vast majority of typical projects will not require detailed modeling if the traffic analysis indicates that all signalized intersections and freeway sections will operate at LOS E or better.

Figure ES-1. Maximum CO Concentrations Near Typical Intersections and Freeways Using MOBILE6





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1. Summary of Objectives of Study

The release of MOBILE6[2] marked an important milestone in making available additional facility functional classes, increased number of vehicle classifications and improvements in emission estimates, now based principally on trip starts and length. However, the implication of how these and other changes will affect project-level analyses has not been explored. It is anticipated that the project-level analyst will require additional guidance in selecting MOBILE6 modeling options. In addition, most of the improvements in MOBILE6 have been directed at improving regional emission estimates, not project-specific estimates. Thus, the changes in MOBILE6 may inadvertently undermine the validity of the project-level assessment procedures.

The study has been designed to provide further insight on the implications of the use of MOBILE6 in project-level analysis. The project has three major objectives:

- Inform practitioners in the transportation community about the most critical and sensitive input parameters in MOBILE6 affecting project-level transportation and air quality analyses.
- Identify under what conditions the use of MOBILE6 may lead to project-level problems and identify possible approaches to developing necessary inputs.
- Identify potential screening threshold procedures for project-level studies.

The principal findings from the study can be briefly summarized as:

- Application of MOBILE6 for freeways in the near future years coupled with high traffic volumes and high background concentrations may present problems not currently demonstrated with MOBILE5.
- Intersections with high start fractions and high volumes appear to have a strong potential for exceeding the carbon monoxide (CO) standard.
- Intersection modeling will need to change “worst case” modeling receptors from intersection-based to using a mid-block location. For mitigation, the traditional approach of increasing intersection capacity to achieve higher average speeds may result in overall emission increases.
- It appears likely that detailed modeling can be excluded for both intersection and freeway locations with level of service (LOS) E or better under a wide variety of conditions, especially when looking beyond the near-term period (2015 or later).
- Potential problem locations requiring detailed modeling still remain. These sensitive locations include: locations in very close proximity to very high volume freeways; locations with an extraordinary rate of start emissions, such as near a park-and-ride lot or central business district (CBD) parking garage; a fleet much older than the national default age distribution; and locations with an unusually high background concentration.

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[2] All MOBILE6 simulations done throughout this study used the version publicly available in September 2003, known as MOBILE6.2, which was the version available at the beginning of the study. In late November 2003, EPA released a new version of MOBILE6.2, called MOBILE6.2.03 (version dated September 24, 2003). This newer version was adjusted to account for effects of Tier2 and the National Low Emission Vehicle program standards. A comparison between the version used in this study and the newly release version showed that in all cases the newer version of the model produced lower CO emission rates. This implies that the results found in this study are conservative, in that they underestimate the emission reduction effects estimated in the latest version of MOBILE6 (6.2.03) in comparison to MOBILE5.

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2. Project Approach and Discussion

2.1. Background

Emission factor models are the underlying analytic tool for the development and evaluation of mobile source emissions in State Implementation Plans (SIPs), conformity determinations, and project-level impact analyses. As such, changes in these emission factor models will directly impact project-level analyses. The increased flexibility in specifying inputs to MOBILE6 gives the analyst increased capabilities to provide site-specific detail, but comes at the expense of additional resources needed in gathering and developing the additional data.

The MOBILE series of models have been developed using a fleet-wide average emission rate determined from individual vehicle type emission rates for each vehicle class and the fractions of vehicle miles traveled (VMT) for each vehicle class. This makes the models suitable for regional-scale modeling, but less appropriate for project-level analysis where site-specific real-time fleet emissions are needed. EPA has recognized this limitation and is conducting research in developing a more appropriate model for project-level analysis. However, until EPA develops an alternative, project-level analyses will need to be conducted using MOBILE6. Hence, the current need to evaluate MOBILE6 for project-level analyses.

Across the country, many Metropolitan Planning Organizations' (MPOs) and state Departments' of Transportation (DOTs) staff are familiar with the strengths and weaknesses of previous versions of EPA's MOBILE model. However, most have just begun using MOBILE6 and have limited familiarity with the model for use in project-level dispersion modeling.[3] Therefore, one goal of this project was to inform practitioners in the transportation community about the most critical and sensitive input parameters in MOBILE6 affecting project-level transportation and air quality analyses so that resulting transportation decisions are improved. The results of this project provide transportation planners with information that can help them develop cost effective strategies for using MOBILE6 in project-level dispersion analyses and design mitigation strategies when hotspot modeling is needed.

The CAL3QHC roadway intersection model is typically employed to determine potential air quality impacts for project-level analysis. CAL3QHC uses both an idle emission factor and an appropriate emission factor based on each link's free flow speed. In determining the appropriate CO emission factor using MOBILE6, input parameters could reflect such site-specific factors as: fleet mix, age distribution, facility type, air conditioning usage, start distributions, soak time, starts per day, temperature, inspection and maintenance (I/M) program, fuel (% oxygenate), reid vapor pressure, weekday versus weekend, and vehicle speed distribution. How CAL3QHC will respond to these MOBILE6 emission factors will depend on how these parameters change the idle and free-flow speed emission rates inputted to CAL3QHC. This study examines how the most important of these parameters affect the CAL3QHC results.

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[3] For example, use of MOBILE6 may show higher emissions at intersections near a park-and-ride lot compared to previous MOBILE versions due to more explicit recognition of cold starts under certain conditions.

2.2. Approach and Analysis

This study explores how the use of MOBILE6 impacts project-level analyses. The study is divided into three main components addressing the questions:

- *How will changes in MOBILE6 impact project-level results?*
- *How will changes in MOBILE6 affect the process for project-level analysis?*
- *Will changes in MOBILE6 significantly impact screening assessment procedures?*

The first question is addressed through exploration and investigating of the following topics:

- The base emission rate changes from MOBILE5 to MOBILE6 will impact project-level analyses.
- The changes in MOBILE6 will impact the validity of CAL3QHC.
- The emissions will change for characterizing start situations for starts per day, start distribution and soak distribution.
- The changes in MOBILE6 will impact CAL3QHC results.
- The changes in MOBILE6 will impact typical high-end project-level applications.

The second question is addressed through exploration and investigation of the following topics:

- Investigate the need for additional efforts to develop new model inputs.
- Investigate if the worst case condition remains the same when using MOBILE6.
- Investigate if mitigation approaches remain the same when using MOBILE6.
- Investigate the level of effort required to prepare MOBILE6 model inputs.

The third question is addressed through model applications for the following topics:

- Develop an approach for setting threshold screening-levels based on MOBILE6.
- Determine limitations and applicability of this threshold screening approach.

2.2.1. Impacts from the use of MOBILE6 in Project-Level Analysis

2.2.1.1 Base Emission Rate Changes from MOBILE5 to MOBILE6

Various studies on emission model runs conducted within EPA have indicated that MOBILE6 usually provides different emission factors than the MOBILE5 model. This is due to a variety of differences in model characteristics, such as updated information on in-use deterioration rates, new technologies (e.g., on-board diagnostics), updated emission base emission rates, and incorporation of new regulations.

A number of changes in MOBILE5 to MOBILE6 make it more complicated to directly compare outputs between the two models. For example, in MOBILE5, specification of a single average speed would return a composite emission rate that represents the best estimate of cumulative emissions for vehicle operations over the course of a driving cycle, such as the Federal Test Procedure (FTP) driving cycle. In MOBILE6, emission factors by speed are specified by facility type. Thus an appropriate facility type must be matched to each speed to provide the best comparison.

MOBILE6 contains a number of changes relative to the MOBILE5 version. These changes can be broadly classified as follows:

- Vehicle age distribution
- Vehicle fleet mix distribution
- Inspection/Maintenance programs
- Base emission rate equations
- Treatment of starting vs. running emissions
- Treatment of vehicle speed on different highway facilities
- Fuel corrections
- Evaporative emissions
- Air conditioning and acceleration effects
- Emission Factors for PM exhaust and selected air toxics
- Gasoline sulfur effects on catalysts.

Because of these many changes between the two versions of MOBILE and the fact that many transportation agencies use national default values for a large number of the input variables, the baseline comparison between the two versions of the MOBILE model uses national default values for both models. In many cases, results between the models may be different because of more up-to-date information used internally in MOBILE6. Thus, two types of comparisons have been performed: 1) to identify CO emission factor changes as a result of switching models for a baseline (national default) and 2) to identify changes that would most likely be seen by the transportation air quality analyst in applying MOBILE6 for a project-level analysis.

2.2.1.1.1. MOBILE5 and MOBILE6 Using National Defaults for a Set of Project-Level Vehicle Speeds and Temperatures

A comparison between MOBILE5 and MOBILE6[4] models was made applying national default values for a base year, 2005, and 30-years in the future, 2035. The scenarios were performed over a range of ambient temperatures: 0, 10, 20, 30, 40, 50, 60, 70, 80 and 90 ºF and a range of speeds: idle (0), 3.4, 7.1, 12.1, 19.5 and 35.9 miles per hour (mph). These speeds were selected based on the driving cycles used in MOBILE5 based on statistical analysis of emissions testing from the eight driving cycles used internally within MOBILE5 that are used to calculate speed-specific emissions. MOBILE6 has a similar makeup, but uses slightly different driving cycles, although the lowest two speeds are identical. To provide a direct comparison, the same speeds used in MOBILE5 were used in the MOBILE6 simulations.

Base input files were prepared for both models using national defaults. An I/M program was defined for the base case with the following specifications:

- Model years for the start of the programs: 1985 and 2015, respectively
- Stringency level: 24%
- Waiver rate: 15%
- Compliance range: 85%
- Biennial program, computerized inspection and repair
- Covering LDGV, LDGT1, LDGT2, LDGT3 and LDGT4
- I/M test type: 2500/idle and on-board diagnostics (OBD) inspection option. OBD inspection option was used in MOBILE6 for vehicle model years 1996 to 2035.

Other general specifications for the base file were as follows:

- Low altitude
- RVP of 9.5
- Default absolute humidity for MOBILE6 (75 grains/pound)
- No refueling program or oxygenated gasoline program.

MOBILE6 does not directly model idle emissions. The MOBILE6 User Guide recommends that idle emissions be estimated from modeling the 2.5 mph speed bin and then multiplying over the hour to provide a grams/hour emission rate. This approach was used to determine the idle emission rate from MOBILE6.

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[4] All MOBILE6 simulations done throughout this study used the version publicly available in September 2003, known as MOBILE6.2, which was the version available at the beginning of the study. In late November 2003, EPA released a new version of MOBILE6.2, called MOBILE6.2.03 (version dated September 24, 2003). This newer version was adjusted to account for effects of Tier2 and the National Low Emission Vehicle program standards. A comparison between the version used in this study and the newly release version showed that for most national default fleets in 2005 that LDGV, LDGT12 had about 8% lower emissions for all speeds with the new version of the model, while LDGT34 and LDDV had only a 1-3% reduction. These effects changed in later years, by 2035 LDGV vehicles show a 5-8% decrease, LDGT12 and LDGT34 show a 16-22% decrease, and LDDV a 9% decrease. This implies that the results found in this study are, in general, conservative, in that they underestimate the emission reduction effects estimated in the latest version of MOBILE6 (6.2.03) in comparison to MOBILE5.

Tables A.1.1 through A.1.6 are presented in Appendix A with the CO emissions factors for MOBILE5 and MOBILE6 for each of the temperature/average speed combinations for 2005 and 2035, as well as percentage changes relative to MOBILE5 based on the formula:

$$\%Change = \frac{(EF_{MOBILE6} - EF_{MOBILE5})}{EF_{MOBILE5}}$$

These results are referred to as the base case scenarios and are discussed as part of the project-level scenarios presented in the following section.

2.2.1.1.2. MOBILE5 and MOBILE6 Comparison for Project-level Scenarios

A review of the MOBILE6 changes that may impact the project-level analysis suggested that the scenarios described below will be of primary interest to the project-level analyst in assessing the change between using MOBILE5 and MOBILE6. These selected scenarios reflect both typical applications and/or potential changes from national distributions with anticipated significant impacts on CO emission factors. The emphasis has been placed on light-duty gasoline vehicle and trucks as they are the largest category of vehicle types, have significant differences in CO emission rates between vehicles and light-duty trucks, and have historically been the largest contributor to CO emissions. The scenarios evaluated were:

- Without I/M Program (2005/2035)
- Shift of ±3 years in the average age fleet distribution for light-duty vehicles and trucks (2005/2035)
- Increase and decrease the 2005 light-duty vehicle fleet percentage by 30% from the 2005 national default, for MOBILE6
- Increase and decrease the 2035 light-duty vehicle fleet percentage by 30% from the 2035 national default, for MOBILE6.

For the first scenario, without an inspection and maintenance program, new input files were created without I/M programs for each of the years to model. These results are shown in Appendix A in Tables A.2.1, A.2.2, and A.2.3 for year 2005 and A.2.4, A.2.5, and A.2.6 for year 2035.

For the shift of plus and minus three years in the average fleet distribution for light-duty vehicles and trucks, the following steps were followed:

1. National default registration distributions for MOBILE5 and MOBILE6 were obtained for all vehicle types.
2. For light-duty vehicles and trucks only, the average age distribution was calculated for the year in which the median value (50%) is found in the accumulated fleet distribution. That year was considered to be the average age of the fleet. For light-duty vehicles and MOBILE5 that was around 6 years. For MOBILE6 and light-duty vehicles that age was around 7 years.
3. Once the average age was found, the fleet was made three years younger or older by altering the distribution in a way that, while keeping original proportions between years, the average age of the fleet distribution would be three years newer or older. For example, for

light-duty vehicles and MOBILE5, a fleet three years younger should have the same sum of accumulated vehicle fractions for the first three years of the distribution as it previously had for the first 6 years, and the same sum in the remaining 22 years as it previously had for the last 19 years. In order to do that, the sum of the fractions for the first 6 years was subtracted from the sum of the fractions of the first three years. That difference was then summed to each of the fractions in the first three years by multiplying that difference by the proportion of the vehicle fraction of each of the years with respect to the three years. This can be expressed mathematically in the general expression:

$$NewDist_{year\,1-3} = Distribution_{year\,1-3} + \left(\sum_{i=1}^{6} Distribution_{yeari} - \sum_{i=1}^{3} Distribution_{yeari}\right) * \frac{Distribution_{year\,1-3}}{\sum_{i=1}^{3} Distribution_{yeari}}$$

Equation 1. Calculation of New Distribution for Three-Years-Newer Fleet, First 3 Years

For the last 22 years of the new distribution a similar procedure was followed but the difference was set between the last 19 years of the distribution and the last 22 years of the distribution:

$$NewDist_{year4-25} = Distribution_{year4-25} + \left(\sum_{i=7}^{25} Distribution_{yeari} - \sum_{i=4}^{25} Distributiony_{yeari}\right) * \frac{Distribution_{year2-25}}{\sum_{i=4}^{25} Distribution_{yeari}}$$

Equation 2. Calculation of New Distribution for Three-Years-Newer Fleet, Last 22 Years

To age the fleet three years, the distribution for the first 9 years was changed following a similar procedure.

4. The new registration distributions were incorporated directly into MOBILE5. For MOBILE6, two new external registration distribution files were prepared – one for the light-duty vehicles and the other for light-duty-trucks. The other vehicle types used the national defaults. These changes in age distribution are illustrated in Figure 2.2.1 through 2.2.3 for MOBILE6 for the three year shifts and for the national default for light-duty vehicles, light-duty truck type 1 or 2, and light-duty truck type 3 or 4. Similar patterns are seen for MOBILE5. The resulting emission factors and percentage changes are shown in Appendix A, Tables A.3.1, A.3.2 and A.3.3 for 2005 and A.3.4, A.3.5 and A.3.6 for 2035 for the three- year-newer fleet. The results for the three- years-older fleet are shown in Appendix A in Tables A.4.1, A.4.2 and A.4.3 for 2005 and A.4.4, A.4.5 and A.4.6 for 2035.

Figure 2.2.1. Cumulative Frequency Distributions of Light-duty Vehicles as Used in MOBILE6

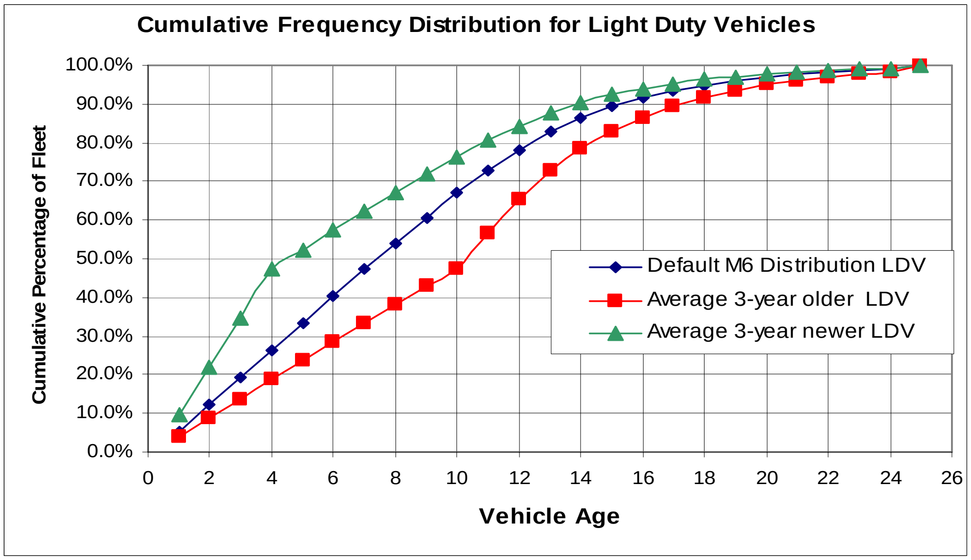


Figure 2.2.2. Cumulative Frequency Distributions of Light-duty Trucks (Type 1 or 2) as Used in MOBILE6.

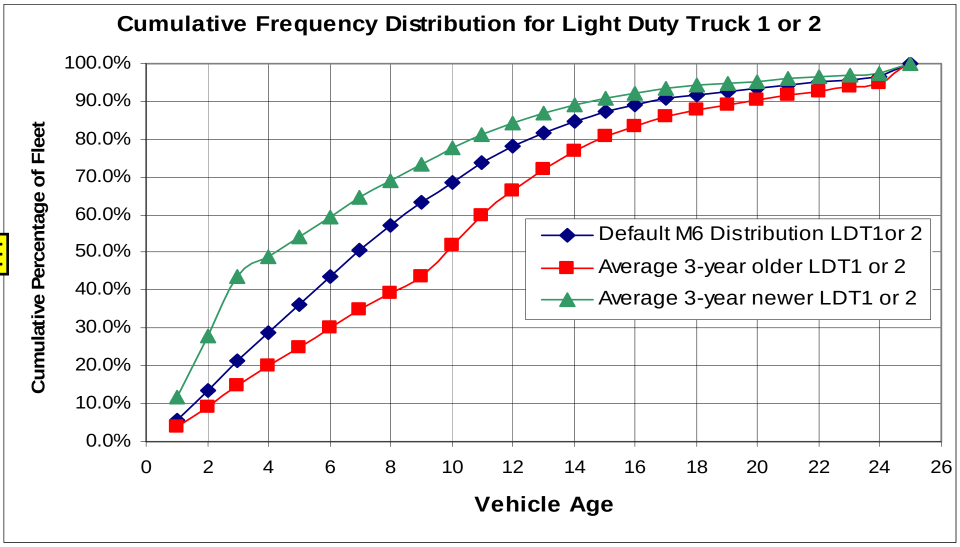
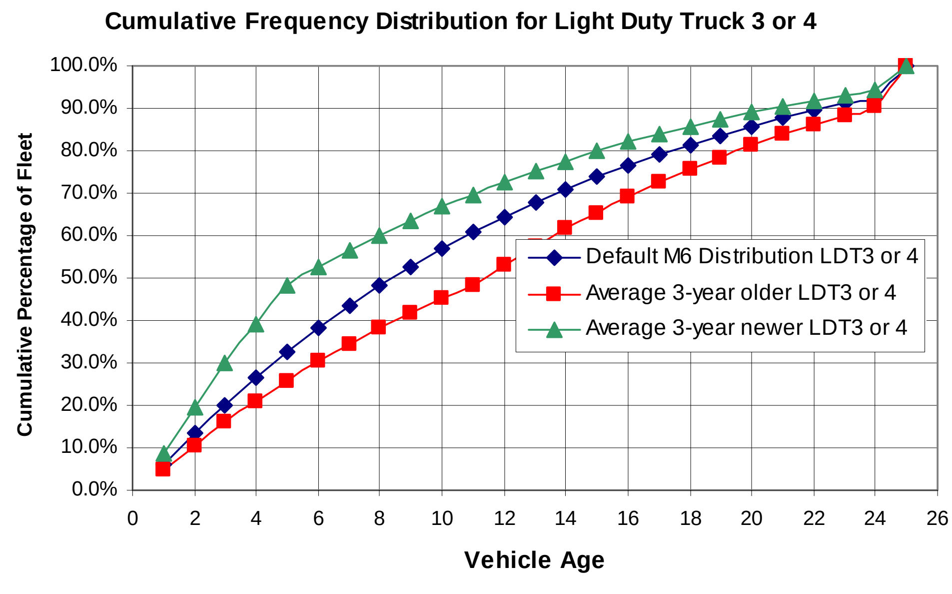


Figure 2.2.3. Cumulative Frequency Distributions of Light-duty Trucks (Type 3 or 4) as Used in MOBILE6.



The two final scenarios involved changing the vehicle fleets mix. Neither model allows for the direct modification of the vehicle fractions within the model. In order to modify the fleet distribution, the vehicle miles fraction, which defines the fractions of miles traveled for each vehicle type in the vehicle fleet, is adjusted.

National default VMT fractions were used for each of the years to increase or decrease the proportion of light-duty vehicles in the fleet. To increase the light-duty vehicle percentage in the fleet by 30%, the corresponding VMT fraction for light-duty vehicles for each of the years was increased by 30% (see equation 3). The other fractions were proportionally decreased as indicated in equation 4.

$$VMT_{new_{LDV}} = 1.30 * VMT_{old_{LDV}}$$

Equation 3. Calculation of VMT Fraction Increased by 30% for Light-duty Vehicles

$$VMT_{new_{other}} = VMT_{old_{other}} + \left(1 - \left(\sum_{LDV} VMT_{new_{LDV}} + \sum_{Other} VMT_{old_{other}}\right)\right) * \frac{VMT_{old_{other}}}{\sum_{other} VMT_{old_{other}}}$$

Equation 4. Calculation of New VMT Fractions for Vehicles Other Than Light-duty Vehicles

Similarly, the VMT fraction was decreased by 30%, as follows:

$$VMT_{new_{LDV}} = 0.70 * VMT_{old_{LDV}}$$

Equation 5. Calculation of VMT Fraction Decreased by 30% for Light-duty Vehicles

The other fractions were increased also using Equation 4.

The new VMT fractions were input to both MOBILE5 and MOBILE6. The resulting emission factors and percentage changes can be found in Appendix A, Tables A.5.1, A.5.2 and A.5.3 for 30% decrease in the light-duty vehicle (LDV) fraction in 2005; in Tables 5.4, 5.5 and 5.6 for 30% decrease in 2035; in Tables A.6.1, A.6.2 and A.6.3 for 30% increase in 2005; and in Tables A.6.4, A.6.5 and A.6.6 for a 30% increase in 2035.

2.2.1.1.3. Discussion of Results

For the 2005 base case files, the percentage changes are negative for all temperatures and for all speeds from idle to 19.5 mph, indicating the emission factors calculated by MOBILE5 for those speeds are larger than those calculated by MOBILE6. Also, higher speeds correspond with lower percentage changes. The negative percentage change decreases for low temperatures (0-20 ºF), increases over medium temperatures (30-60 ºF for speeds idle to 3.4 mph and 30-70 ºF for speeds 7.1 to 19.5 mph) and decreases again for high temperatures (70-90 ºF for speeds idle to 3.4 mph and 80-90 ºF for speeds 7.1 to 19.5 mph), but the change is small. Percentage changes are positive for the higher speed, 35.9 mph, indicating larger MOBILE6 factors than MOBILE5 factors. For this speed, there is an initial increase in the percent change for low temperatures (0-10 ºF), a decrease for medium to medium-high temperatures (20 to 70 ºF) and a final increase for the higher temperatures (80-90 F). In summary, there is a clear trend showing that MOBILE5 has larger emission factors for lower speeds and that MOBILE6 has larger emission factors for higher speeds.

For the 2035 base case, the trends are very similar to the 2005 base case; however, now all of the percentage changes are negative, indicating that MOBILE5 emission factors are larger are larger than MOBILE6 factors for all the speed and temperature combination[illegible]odeled. The changes are also larger than those seen for 2005, but similar to the 2005 results, percent changes decrease with increasing speed. Changes with increasing temperature are larger than those for 2005, but still small. Overall, these results show that, by 2035, MOBILE6 emission factors for even the higher speeds are lower than MOBILE5 emission factors.

For the no inspection and maintenance program for the 2005 scenario, the emission factors for both MOBILE5 and MOBILE6 increase with respect to the base, as expected. The percentage change values are similar to, but slightly lower than, those calculated for the corresponding base case scenario at low speeds. For speeds higher than 12.1 mph, the changes become slightly larger. With the application of similar I/M programs, MOBILE6 factors do not decrease as much as the corresponding MOBILE5 factors.

For the 2035 scenario with no I/M program, the percentage changes are lower than the corresponding percentage changes for the base case with inspection and maintenance for all speed and temperature combinations. Also, the difference is slightly larger. The difference between the base MOBILE5 and MOBILE6 emission factors is lower for 2005 than the difference for MOBILE6.

For the three- year-newer average fleet distribution for 2005, the emission factors are lower for both models, with MOBILE5 and MOBILE6 generally showing a 20% lower emission rate. The trends for the percentage changes between the two versions of the emission factor models are similar to those observed for the base case (with I/M). Notice that, in this case, the percentage change with increasing years for speeds between idle and 19.5 mph decreases more than for the base case, and the differences grow larger as the speed increases. Also, for the larger speed of 35.9 mph, the percentage change increases significantly, around 5-10%, with respect to the base case for all temperatures. This trend indicates that both MOBILE5 and MOBILE6 integrate the change in the average fleet distribution for light-duty vehicles and trucks in a similar manner. For 2035, the trend is similar to the trend observed for 2005, with the exception of the larger speed, 35.9 mph. For that speed the percent change for 2035 is negative, and the trend of increasing difference with increasing temperature continues up to 80 ºF.

For the 2035 three- year-older average fleet distribution for light-duty vehicles and trucks, the emission factors for MOBILE5 and MOBILE6 are higher, typically by about 20%, than those of the base case (with I/M). The trends for the percentage changes between the two versions of the emission factor models are similar to that observed for the base case. For the higher speed, 35.9 mph, the percentage changes are higher than the base case; the others behave similarly to the base case. There is also a small increase in the percentage change with respect to the base case, and that difference increases with increasing speed. This shows that by 2035, the emission factors for MOBILE6 decrease more than the MOBILE5 emission factors do, indicating that MOBILE6 projects that significant improvement in emission reductions will continue after 2005, while MOBILE5 does not. For 2035, the trend of increasing difference with increasing temperature continues up to 80 ºF, which is similar to what was seen with the three- year-newer fleet.

For the 30% decrease in the light-duty vehicles VMT fraction for 2005, the emission factors increase only a few percent in value with respect to the base case. Thus, differences in fleet composition appear to have minimal impact on emissions. The percentage changes between the two versions of the emission factor models are large and generally decrease as the speed increases. However, the 35.9 mph speed scenario is an exception, in which the percentage change decreases significantly with respect to the base case. The trend with respect to the temperature is relatively constant. For the 30% decrease in the light-duty vehicles VMT fraction for 2035, the trend for the percent changes is similar to that explained for 2005. The differences in the percent changes for this scenario with respect to the corresponding base case scenario are slightly larger than those observed for 2005; however, they do decrease with increasing average speed.

For the 30% increase in the light-duty vehicles VMT fraction for 2005, the emission factors increase only a few percent in value with respect to the base case. Again differences in fleet composition appear to have minimal impact on emissions. The percentage changes between the two versions of the emission factor models are large and generally decrease as the speed increases. The 35.9 mph speed scenario is, again, an exception, in which the percent change increases significantly with respect to the base case. For 2035, the trend is similar to the trend observed for 2005. For temperature, both 2005 and 2035 show decreasing emissions with increasing temperature, however MOBILE6.2 shows a more rapid decrease in emissions with increasing temperature than MOBILE5. This same trend is also found in the other scenarios.

In summary the major findings from this two model comparison are:

- For 2005, there is a clear trend that the MOBILE5 emission factors are higher for lower speeds, while at speeds greater than 30 mph, the MOBILE6 emission factors are higher. However, by 2035, the MOBILE6 emission factors for even the higher speeds are lower than MOBILE5 emission factors.
- For 2005, both MOBILE5 and MOBILE6 integrate changes in the average fleet distribution for light duty vehicles and trucks in a similar manner. However, by 2035, the emission factors for MOBILE6 decrease more than the MOBILE5 emission factors, indicating that MOBILE6 continues to show improvement in emission factor reductions after 2005.
- Both MOBILE5 and MOBILE6 models have minimal sensitivity in overall emission factor rates to changes in fleet composition, regardless of the year.

2.2.1.2 MOBILE6 Impact on the Validity of CAL3QHC

Two studies have performed extensive monitored-to-modeled comparison of the CAL3QHC model. The first study, “Evaluation of CO Intersection Modeling Techniques Using a New York City Database” (Sigma Research, 1992), is the older study, with traffic and air concentration data collected in 1989. The study also used the then current emission factor model, MOBILE4.1. This study formed the basis for EPA’s selection of the CAL3QHC model as the preferred guideline model for project-level analysis. The second study is NCHRP25-6, “Intersection Air Quality Modeling,” which is a mid-1990s study, which used MOBILE5 emission factor model for three intersections in Tucson, Arizona; Denver, Colorado; and Sterling, Virginia. A review of how the CAL3QHC performed in these two studies and how the use of MOBILE6 will impact CAL3QHC’s validity is discussed below.

2.2.1.2.1. Application of the MOBILE4.1 Emission Factor Model in CAL3QHC Using the New York City Model Evaluation Database

The MOBILE4.1 model analysis was limited to the three least complex intersections with the best quality data. These three intersections were #1 - West and Chambers, #2 - 34th Street and 8th Avenue and, #5 - 12th Street and 34th Avenue. For all three intersections, the observed and CAL3QHC predicted values paired in time and location showed underpredictions with an average difference of 2.2, 2.8 and 2.6 parts per million (ppm), respectively. Similar results were found for all three intersections events paired only in time. For the 25 highest observed and predicted CO concentrations paired only by each intersection, the CAL3QHC results showed systematic underpredictions ranging between 2.7 to 5.0 ppm.

The fractional bias is a measure of the model’s ability to simulate observed concentrations during the highest observed periods. The fractional bias (FB) is defined as

$$\mathrm{FB} = 2\left[\frac{OB - PR}{OB + PR}\right]$$

where OB and PR refer to the averages of the observed and predicted highest 25 values matched by rank for each intersection. A positive value of the fractional bias means the model is underpredicting. CAL3QHC has a positive value for all three intersections, but is within a factor of two of the observed concentration. The ambient conditions most important for regulatory applications are those which lead to the highest concentrations. These were categorized in the New York City study as wind speed less than 6 mph and neutral or stable atmospheric conditions. Under these conditions, the CAL3QHC model was found to predict values to within 50% at all three intersections, but systematically low. In combination across all three intersections, CAL3QHC was found to be the best performing of the intersection models tested. Thus, the overall finding for the CAL3QHC model was a general underprediction bias, but at higher concentrations, results were generally within a factor of 2. Under meteorological conditions favorable for high CO concentrations, CAL3QHC was found to be within 50% of the observed concentration, but again biased low for all three intersections.

2.2.1.2.2. Application of the MOBILE5 Emission Factor Model in CAL3QHC Using the NCHRP 25-6 Database

Three high-volume, suburban intersections in Tucson, Virginia and Denver were intensively monitored – fourteen locations at the Tucson intersection and 20 locations at the Denver and Sterling, Virginia, intersections. Seven random days of data were selected for simulation and comparison from the twelve-week winter monitoring period. The periods selected for evaluation were all weekday periods where complete traffic volumes and meteorological data were available for full 24-hour periods. The Tucson intersection was monitored in early 1994, and the Virginia and Denver intersections were monitored during the 1994-1995 winter period.

For the Denver and Virginia intersections, the observed and CAL3QHC predicted values (using MOBILE5) paired in time and location showed overpredictions with an average difference of 3.0 and 1.6 ppm, respectively. The Tucson intersection showed an underprediction of 0.6 ppm. For the 25 highest observed and predicted CO concentrations paired only by each intersection, the CAL3QHC results showed overpredictions of 5.6 and 5.5 ppm for the Denver and Virginia intersections, respectively. The Tucson intersection showed the reverse outcome, with an average underprediction bias of 5.5 ppm. Similar biases were found with the fractional bias for the top 25 observed concentrations. However, only the Denver intersection was, on average, within a factor of two of the observed concentrations.

The three intersections were multilane intersections, and all had high total traffic volumes. Both the Denver and Virginia intersections were dominated by flow volumes in particular directions. The Tucson intersection was evenly balanced between the north-south and east-west direction. This balance in traffic flow and signal cycle timing resulted in the CAL3QHC model predicting minimal queue lengths and concentrations being dominated by the moving emissions. CAL3QHC queue lengths for Denver and Virginia were large because of the unbalanced flow volumes and signal cycle timing, with a resulting overpredicition in concentration dominated by the idle emissions from excessive queue lengths.

Based on the findings in Section 2.2.1.1, application of the MOBILE6 model will likely improve the CAL3QHC model performance for Tucson, as moving emissions will increase, leading to higher predicted concentrations and a better match to monitored values. For Denver and Virginia, the contribution from idle will decrease, reducing the overprediction bias, resulting in improved model performance.

2.2.1.2.3. MOBILE4.1 versus MOBILE6.2 Emission Factor Comparison for Future Applications of the MOBILE6 Model for CAL3QHC

Emission factors from the mobile emission factor models are used as input for the roadway intersection model, CAL3QHC. This model was selected as the preferred roadway intersection model by EPA based on the Route9a evaluation study, using the then current model, MOBILE4.1, as input to CAL3QHC, for three key intersections located in Manhattan (Sigma Research Corporation, 1992). It is therefore important to determine how changes between MOBILE4.1 and MOBILE6.2 may have changed as a result of improved understanding of emissions. Studies have shown that CAL3QHC model simulation results are usually driven by queue length and number of lanes (queue density) for overcapacity conditions. CAL3QHC uses an internal queuing algorithm to estimate queue length. Queue emissions result from emissions produced while idling. In most cases, the highest CO concentrations occurred during overcapacity situations. Thus, the question of principal interest is how have idle emissions changed between the two versions of the model.

Based on a review of the "Evaluation of MOBILE Vehicle Emission Model" conducted by Sierra Research in 1994 to help in determining the most significant changes between MOBILE4.1 and MOBILE5 and the more recent studies on MOBILE5 and MOBILE6, as well as the efforts conducted in Section 2.2.1.1, **the input variables found likely to have had the most significant changes in the CO emission factors between MOBILE4.1 and MOBILE6.2 models are the start fraction and temperature**. Fuel volatility effects are only important for VOC emissions.

To assess these levels of changes, a base emission scenario was modeled using MOBILE4.1 and MOBILE6.2 based on the parameters used in the Route 9A studies which are summarized as:

- Inspection and maintenance program, as follows:
  - Start year 1982
  - Pre-1981 stringency rate of 30%
  - First model-year covered 1960
  - Last model-year covered 2020
  - Waiver rate for pre-1981 vehicles of 0%
  - Waiver rate for1981 and newer vehicles of 0%
  - Compliance rate of 75%
  - Inspection type manual decentralized
  - Inspection frequency annual
  - Vehicles covered LDGV, LDGT1, LDGT2, HDGV
  - Idle test type for 1981 and later model years.
- Anti-tampering program, as follows:
  - Start year 1984
  - First model-year covered 1960
  - Last model-year covered 2020
  - Vehicles covered LDGV, LDGT1, LDGT2, HDGV
  - Test type decentralized

  - Frequency annual
  - Compliance rate 75%
  - Air pump system disablements, yes
  - Catalyst removals, yes
  - Fuel inlet restrictor disablements, no
  - Tailpipe lead deposit test, no
  - EGR disablement, yes
  - Evaporative system disablement, no
  - PCV system disablements, yes
  - Missing gas caps, no
  - Cold start percentage 20.6%
  - Ambient temperature of 40 ºF
  - Fuel volatility of 11.9 pounds per square inch (psi).

Four different scenarios were evaluated in comparison to the base simulation using the two emission factor models. These scenarios were:

- Percentage cold start of 3% (minimum value found at any hour during the Route9a study).
- Percentage cold start of 26% (maximum value found at any period during the Route9a study).
- Ambient temperature of 90 ºF (maximum temperature during the study period).
- Ambient temperature of 10 ºF (minimum temperature during the study period).

The Route9a study was conducted in 1989, and the then current New York City registration distributions and mileage accumulation rates were used. National default vehicle mixes were used in both emission factor models. Emission factors were estimated for idle, 20 and 30 mph average speeds. The latter are used to examine what the impacts may be at intersection where queue densities may be low or if idle emissions have been significantly reduced in MOBILE6.

2.2.1.2.4. Discussion of Results

Tables 2.2.1.1, 2.2.1.2 and 2.2.1.3 present the results of the models sensitivity test for idle, 20 and 30 mph average speed conditions for the base case and four sensitivity scenarios.

For the base case, the composite CO emission factor calculated for idling by MOBILE6.2 is much lower, 56% lower, than the factor estimated by MOBILE4.1. For 20 and 30 mph average speeds, the emission factor estimated by MOBILE6.2 is higher than MOBILE4.1 by 36% and 103%, respectively. This represents an important shift in emission contribution at intersections. Emissions from idle will typically now contribute 56% less with MOBILE6.2, and moving emissions will typically increase by 36% or more.

For the percent start modification scenario, MOBILE6.2 was held constant using the MOBILE6.2 national default engine soak times as EPA guidance states. Nearly all emissions are hot-stabilized, and unless it is a special modeling situation (such as a parking lot) which may require modeling of the effects of engine starts, it is strongly suggested to use the emission factors from MOBILE6.2 without any special adjustment for starts since MOBILE6.2 already includes vehicle idling in proportion to normal driving. Only intersection #1 from the Route9a study was near a parking facility, but the parking lot was reported to be relatively small, so no adjustments were made to MOBILE6.2. On the other hand, MOBILE4.1 was applied following the guidance developed specifically for this model, which suggests the user should use the site-specific estimate of the cold start fraction as input. In the Route9a study, the lowest and highest surveyed cold start percentages were 3.4% and 26%, respectively. These were used to define the lower- and upper- range in the estimated emission rates when using MOBILE4.1. For the idle condition, the lower-range for MOBILE4.1 yields similar results to MOBILE6.2, while the upper-range doubles the emissions. For the 20 to 30 mph average speeds, the change in the emission factor for the lower-range is much lower than for the base case, but with a smaller difference for the upper-range. This suggests that applying MOBILE6.2 for intersections that have been characterized as having a low percentage of start emissions, as is now the current understanding, as input to MOBILE4.1 will result in little change in idle emissions, but nearly double the contribution from moving emissions.

For the temperature range scenarios, the 90 ºF temperature has almost no effect on the MOBILE4.1 emission factor, while the MOBILE6.2 factor increased by 60%. The overall effect is to narrow the differences for the base case between the two versions of the emission factor model. For the moving emissions, the changes are much smaller, with MOBILE6.2 showing slightly larger emission factors. For the 10 ºF ambient temperature scenario, the emission factors calculated by both models increased with respect to the base case. In the case of MOBILE6.2, the idling factor increased by 36%, while the MOBILE4.1 factor increased 55%, resulting in a difference of about a factor of 2 between the two models. For the 20 and 30 mph moving scenarios, both models increased emissions, resulting in the relative differences remaining about the same, with MOBILE6.2 having the higher emission factors. Overall, for the cold temperature conditions, MOBILE6.2 will typically reduce idle emission contribution by 50% and increase moving emissions by 37%. The results indicate that MOBILE6.2 is less sensitive to cold temperatures and more sensitive to warm temperatures than MOBILE4.1.

Overall, the idle emissions decreased significantly for MOBILE6.2, while moving emissions increased. Historically, analyses of roadway intersections have found that high concentrations are a result of large queue emissions and hence, the idle emission factor. The tradeoff in emissions seen here will likely impact the CAL3QHC model by lowering concentrations in most situations where queue length is important. Since the model performance evaluation of CAL3QHC in the Route 9a study had a positive fractional bias (underprediction) for all three intersections, the model bias will likely increase using MOBILE6.2. However, this somewhat contrasts with the NCHRP25-6 study results, which suggest that MOBILE6.2 will improve model performance relative to its evaluation based on using MOBILE5 . Some of this difference may be the result of changes in engine technology since these evaluation studies were based on pre-1990 and pre-1995 vehicles. It is possible that differences between the two MOBILE models may be considerably different for a newer fleet of vehicles. If, however, today’s fleet is analogous to the NCHRP’s pre-1995 fleet, then the use of the MOBILE6.2 model in project-level analysis will likely improve model performance.

Table 2.2.1.1. New York Route9A: MOBILE4.1 and MOBILE6.2 Idle Emission Factors (g/hr)

	Base	Lower-range of start activity	Upper-range of start activity	Tmax = 90 F	Tmin = 10 F
MOBILE4.1	554.70	359.40	624.56	531.77	852.22
MOBILE6.2	310.68	310.68*	310.68*	494.75	424.45
MOBILE4.1 – MOBILE6.2	244.02	48.72	313.88	37.03	427.77

Table 2.2.1.2. New York Route9A:MOBILE4.1 and MOBILE6.2 20 mph Emission Factors (g/mi)

	Base	Lower-range of start activity	Upper-range of start activity	Tmax = 90 F	Tmin = 10 F
MOBILE4.1	30.72	21.40	34.06	30.65	45.72
MOBILE6.2	41.88	41.88*	41.88*	47.89	62.48
MOBILE4.1 – MOBILE6.2	-11.16	-20.47	-7.82	-17.24	-16.76

Table 2.2.1.3. New York Route9A:MOBILE4.1 and MOBILE6.2 30 mph Emission Factors (g/mi)

	Base	Lower-range of start activity	Upper-range of start activity	Tmax = 90 F	Tmin = 10 F
MOBILE4.1	19.20	13.53	21.22	19.34	28.52
MOBILE6.2	38.96	38.96*	38.96*	43.70	58.95
MOBILE4.1 – MOBILE6.2	-19.77	-25.43	-17.75	-24.36	-30.43

* *Emissions rate held constant based on MOBILE6.2 formulation, which assumes that nearly all emissions are hot-stabilized unless strongly influenced by a nearby start location.*

2.2.1.3 Emission Changes for Characterizing Start Situations, Starts per Day, Start and Soak Distributions

With the release of MOBILE6, EPA recommended that, in most instances, the model's emission factor estimates should be used without adjustment for start fraction, since nearly all emissions are hot-stabilized, unless the location is near a parking garage or shopping center with a large number of starts. In this section, ICF investigated under what circumstances a user may want to account for start emissions and identify possible approaches for estimating start fraction for a variety of settings. In locations where start emissions may be important, the potential impact on project-level results may be significant.

The emission rate of a gasoline-fueled vehicle will be at its lowest rate when the engine and catalyst are at their full operational temperature. When the engine temperature and catalyst are not fully warmed up, inefficiencies in combustion and catalytic conversion result in higher emission rates. The elevated emissions, which are a combination of fuel enrichment and increased engine and transmission friction, are termed "cold start" emissions. Cold start emissions are of particular concern, as a large proportion of total mobile source emissions are due to vehicles being driven under cold start conditions (TRL, 2000). The length of time a vehicle has been parked influences the temperature of the engine and catalyst on restart and hence, the cold start emission rate. Vehicles restarted shortly after being stopped are characterized as "hot starts" and have much lower emission rates.

In the 1970s, the introduction of the catalytic converter into the vehicle fleet shifted the focus on high CO emission rates to the time period before the catalyst was fully functional. During this time and into the 1980s, bag 1 of the FTP cycle, the first 505 seconds (s), was used to define the cold start emission profile (Midurski and Castaline, 1977). Since that time, improved capabilities to measure second-by-second emissions, as well as improved combustion technology using fuel injection and on-board diagnostics, have reduced engine warm-up time leading to a shorter cold start emission period. Most recent studies, by measuring second-by-second emission rates, have now characterized the cold start emission period as the first 200 s following a 4-hour or longer period since the engine was last started (Boulter, 1997; Laurikko, 1996; and Singer et al., 1998; Rakaha et al., 2003).

2.2.1.3.1. Start Emissions Characterization

The three parameters that define the average start emissions for a region are

- The number of starts per day,
- Start distribution over the day, and
- Soak distribution.

For project-specific locations, the key parameter is the soak distribution, the length of time parked before the start, which defines the much higher cold start emission rate versus the much lower hot start emission rate. Both the start distribution over the day and the number of starts per day are important for region-wide estimates of total CO emissions, but are much less important to defining the emissions at a project-specific location. As a result, the two primary objectives for start characterizations were to develop estimates for soak distributions for a variety of potential high emission ("hot spot") locations and investigate potential methods for collecting site-specific data. A secondary objective was to gather information on the number of starts per day and start distribution for a subregion, as it may be useful for regional analysis or providing localized background concentrations.

A list of potential high start emission locations was developed for this investigation. Seven locations were identified where a high percentage of start emissions could be potentially found at a nearby intersection. The seven locations are

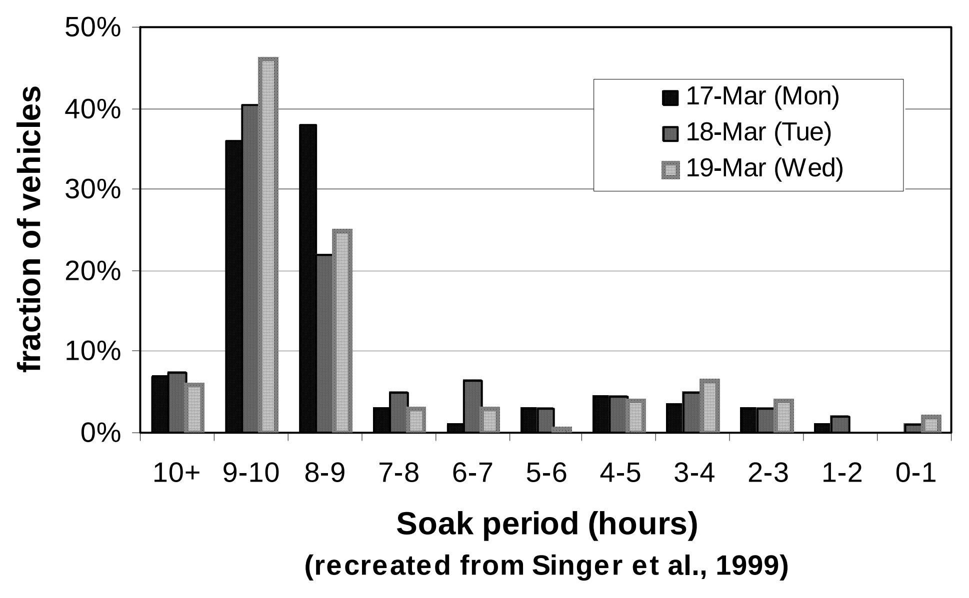
- A commuter parking garage during PM peak
- A shopping center
- A hospital
- A university/college
- A park-and-ride lot (bus or light rail transit)
- A railway station
- A general residential area during AM peak.

Other locations were considered, such as a theme park or amusement center, but were eliminated because start departures were not generally clustered during a particular period. Each of these seven locations/settings has sufficient differences in their soak distribution to warrant separate discussion.

Commuter Parking Garage

Vehicle activity levels were monitored at a three-level underground parking garage located in an office building at a CBD location in March 1997 (Singer et al., 1999). The second and third levels are used as employee only parking and only their activity levels were investigated. Two three-weekday periods were studied with similar results found for the soak distribution. Figure 2.2.4 shows the soak distribution for the vehicles parked in the CBD garage. The figure shows that over 90% of the vehicles were in cold start mode upon departure. Driving in the garage averaged approximately 41 s for the second floor parking and an additional 39 s for the third floor parking, which required travel through the second floor and a ramp. This would allow most vehicles to reach a nearby intersection and still be in start mode. This soak distribution is likely transferable to other CBD parking locations; however, some adjustments may be needed for in-time garage travel distances, which might limit the number of vehicles reaching nearby intersections in start mode. Appendix B contains a listing of the soak distribution input file formatted for MOBILE6, “soakdst.d,” for the CBD garage soak distribution as translated from Figure 2.2.4.

Figure 2.2.4. Distribution of Soak Times for Vehicles Parked in a CBD Garage



Shopping Center

Estimates of vehicle activity at shopping centers were made from the national survey studies, *Parking Generation*, 2nd Edition publication conducted by the Institute of Transportation Engineers (ITE) (ITE, 1987)[5] and the Urban Land Institute's *Parking Requirements for Shopping Centers* (ULI, 2000). The soak distributions can be estimated by first estimating the potential parking capacity. The number of vehicles parked at a peak hour is based on the type of shopping center, ranging from a neighborhood to a super regional center. The busiest hour of parking demand falls between 1:00 and 3:00 pm on a Saturday. The ITE Study provides a mathematical expression between the gross square footage (X) of the retail center and the number of parked cars (P) as:

$$\mathrm{Ln}\,(P) = 1.261\,\mathrm{Ln}\,(X) - 0.365$$

This equation provides an estimate of the parking demand. However, this relationship is based on survey data for the average Saturday. The ULI report identified the 20th highest hour of parking demand based on 1997 survey data and found results generally about 10% higher than given by the above expression. While the parking reports do not estimate parking duration, they do estimate that the peak parking demand occurs between 1:00-2:00 pm and that about 20% of all parking is condu[illegible]d by employees (ULI, 2000). The best estimate of the duration comes from TRL Report No. 469 (Green and Boulter, 2000), in which they surveyed vehicle activity for parking duration at a supermarket and golf course. Figure 2.2.2 shows the parking duration for a supermarket and golf course only. The supermarket parking duration distribution would best represent the neighborhood center (30,000 to 100,000 sq. ft.) and community center (100,000 to 350,000 sq. ft.), while generally longer shopping durations, characteristic of the time for a round of golf, would be anticipated for the regional (400,000 to 800,000 sq. ft.) and super centers (>800,000 sq. ft.). However, to apply the supermarket soak distributions to a shopping center, each hour should be proportionality reduced to account for the 20% of parking accomplished by employees and the 9-10 hour parking period should be increased for the 20% of employee parking. The total number of vehicles leaving the parking facility and the subsequent percentage of starts reaching nearby intersections can then be estimated based on the peak parking demand and the estimated soak distribution. Appendix B contains the soak distribution input file formatted for MOBILE6, "soakdst.d", for the "supermarket" profile adjusted for employee parking and the "golf course only" as translated from Figure 2.2.5.

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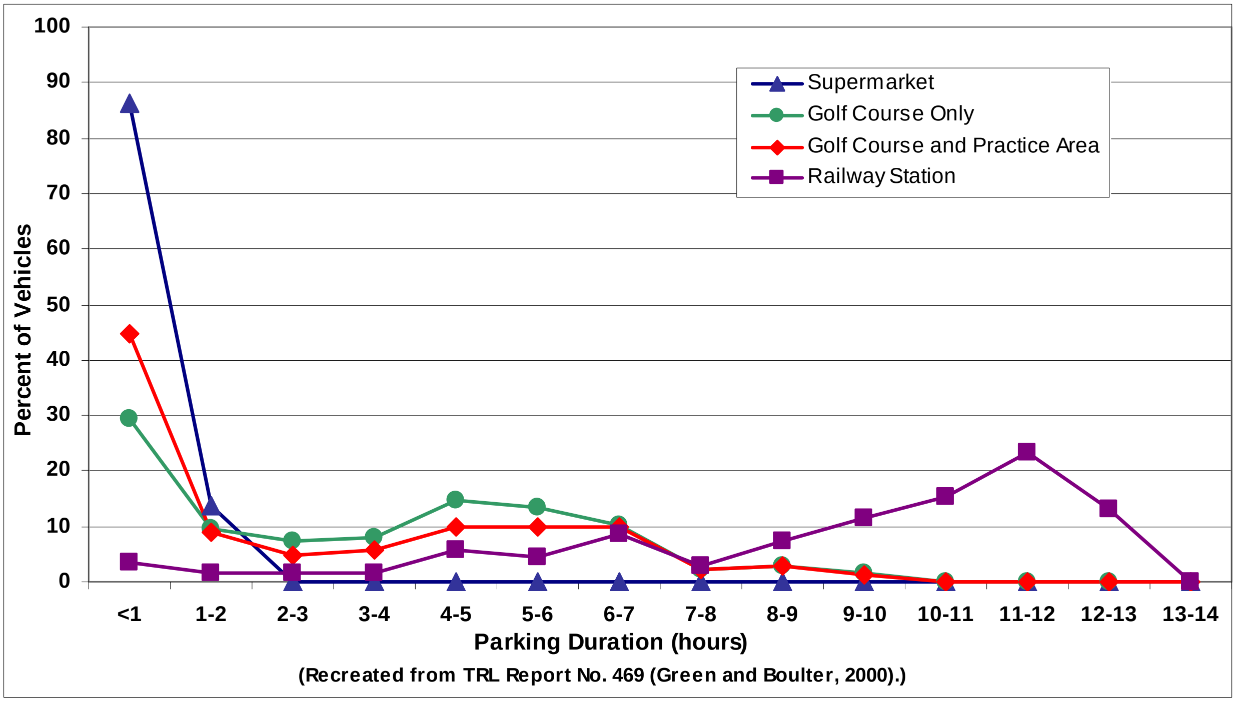
[5] Some revision to these estimates may occur later this year with the anticipated release in late 2004 of the *2004 Parking Generation* manual by the Institute of Transportation Engineers.

Figure 2.2.5. Percentage of Vehicles Parking Duration Distribution



Hospitals

Estimates of vehicle activity at hospitals were made from the national survey study, *Parking Generation*, 2nd Edition, conducted by the Institute of Transportation Engineers (ITE) (ITE, 1987). The soak distributions can be estimated by first estimating the potential parking capacity. The ITE study provides a mathematical expression between the number of beds (X) of the hospital and the number of parked cars (P) as:

$$\text{Ln}\,(P) = 0.95\,\text{Ln}\,(X) + 0.81$$

This equation provides an estimate of the parking demand. The peak parking demand coincided with the mid-morning and mid-afternoon hours associated with employee shift change overlap. However, no survey data was available to estimate the parking duration distribution, and no appropriate surrogate distribution appeared readily available in the literature. The 2004 *Parking Generation* manual update may contain some additional information to help in estimating park duration distribution.

Universities

Estimates of vehicle activity at universities may be made from the national survey study, *Parking Generation*, 2nd Edition, conducted by the Institute of Transportation Engineers (ITE) (ITE, 1987). However, the 1987 survey only contains data from a single university and cannot be considered representative of most situations. Thus, at this time no reliable estimate can be made on parking duration distribution at universities. It is anticipated that the 2004 ITE *Parking*

Generation manual will contain much more data for various sizes and locations of universities and be able to define the peak parking periods.

Park-and-Ride Lots

Vehicle inbound and outbound activity levels were monitored at seven park-and-ride lots for light rail transit in two different years in the City of Calgary, Canada (population 708,000), serving primarily the central business district (Kok, et al., 1994). The soak distributions can be estimated using the PM peak hour volume and assuming that approximately 45% of the travel is CBD-oriented, home-based work trips. The trip generation equations were developed from all seven of the park-and-ride lots and can be expressed mathematically as an expression between the number of parking stalls (X) for the lot and the number of trips (T) as:

$$T = 0.62\,(X) - 32$$

Of these trips, on average, 83% were outbound. Therefore, for example, a 1,500 park-and-ride lot would be estimated to generate (0.62*1500-32)*0.83*0.45 = 335 start vehicles during the PM peak. It is anticipated that these results would be transferable to US cities and could be applied as long as the home-based work trips fraction is readily available.

Railway Station

Green and Boulter (2000) studied a commuter-oriented railway station parking lot from data collected during December 1998 and February 1999. They observed two peaks in parking duration. A primary peak centered on the 11-12 hour, and a secondary peak occurred at parking duration hour 6-7. The hour-by-hour railway station parking distribution is presented in Figure 2.2.5. This soak distribution is likely transferable to other railway station locations; however, additional information on the number of vehicles using the parking lot would be needed to apply to other locations.

General Residential Areas

In some areas, high CO concentrations have been found to be associated with the general startup of residential area emissions. A household travel behavior survey conducted in Anchorage, Alaska, based on travel logs of some 1,548 households found that the AM peak (6-9 AM) for the general residential area had 51% of the starts associated with parking periods of over 12 hours and 73% of all peak AM starts having an eight-hour or longer soak (Municipality of Anchorage, 1993). This high start distribution could be used as a conservative first estimate for areas where no travel log surveys have been conducted.

2.2.1.3.2. Starts per Day and Start Distribution

In addition to the soak distribution, some literature was found on starts per day and start distribution, which may be useful for sub-regional analyses. While not specific to project-level analysis, this information may be useful in preparing background concentration levels, particularly in regions where the background concentration is high and where only moderate project-level activity levels may lead to potential CO violations.

The primary information on starts per day and start distribution is from the vehicle-instrumented study sponsored by EPA for Baltimore, Maryland, and Spokane, Washington. An alternative approach developed by Everett and Sacs (2001) uses a more economical approach employing a simple electronic data logger. In this study, done in the mid-sized city of Knoxville, Tennessee, the data logger was connected through the cigarette lighter of a vehicle and allowed to record whether the engine was on or off on a second-by-second basis. Data was collected from some 377 vehicles from 200 households during weekdays over a three-month period.

Analysis of the collected data from the Knoxville study showed that Knoxville had about 1.5 fewer starts per day than Baltimore or Spokane experienced for both weekday and weekend days. It was surmised that this difference was due to differences in study area characteristics. For start distribution results, the weekdays were found to be similar to those found in Baltimore and Spokane, except that no 3 PM peak was found in Knoxville. It is believed that this peak is associated with the pickup and transport of children from school. Weekend start distributions in Knoxville were the same as Baltimore and Spokane.

2.2.1.3.3. Methods for Collecting Project-Specific Start and Soak Distribution

In addition to a review of the available literature, methods were reviewed on collecting data on soak distribution using approaches other than fully instrumented vehicles. The primary focus was directed to collecting data for project-specific soaks, with extended capabilities to determine start information.

Parking Studies

One approach applicable to parking facilities is to collect information on parking activities. For example, for a commuter-dominated parking garage, the number of vehicles entering and exiting the facility may be recorded during AM and PM peaks. Departure and arrival times for each vehicle may be matched via license to determine length of time vehicles were parked. Vehicle trip times and lengths while in the parking facility may be recorded via stopwatch during AM and PM peak periods. Measurements made using this approach over a three-day period found similar results for each day (Singer, et. al, 1998). This suggests that a one-day sample may be sufficient in other applications. The approach also provides details on the trip time through the garage and the fraction of vehicles exiting in start mode since individual licenses are matched between entering and exiting. This approach can be extended to other garages, but it is imperative to carefully measure time spent in the garage following engine start-up before exiting to the street.

Remote Sensing

Another suitable technique is remote sensing, which uses open-path reflection of infrared radiation off the road surface to see the functioning state of the catalyst (Stedman, 2002 and Rendahl et al, 2003). By measuring other vehicle parameters, including vehicle speed, acceleration, mass and road slope, and additional emissions of water vapor and carbon dioxide (CO_2) the technique can distinguish between the three conditions leading to high CO emitting conditions:

- “Hard acceleration”
- “Gross emitter”—a malfunctioning catalyst
- Start mode.

If the catalyst is operating properly, the operating temperature will be high (this is inferred through measurement of the water vapor and CO_2), and if acceleration or road slope is high, then the vehicle is in “hard acceleration”. If the catalyst operating temperature is low and emissions are high, then the vehicle is in start or has a malfunctioning catalyst. By measuring the other pollutants, ammonia, acetylene, ethylene and the ratio of total hydrocarbon to methane, the catalyst’s operating state can be determined.

The advantage of this remote sensing technique is that it would provide direct information on start fraction at the precise location of interest. The limitation with the method is that it has not been fully developed and tested and needs two to four infrared sensors to collection the emission measurements.

Travel Demand Models

In addition, travel demand models may be used to provide sub-regional (not site-specific) estimates of soak distribution (Allen and Davies, 1993). This may be useful in estimating concentrations in areas with high CO background concentrations. Within a travel demand model, assignments may be made based on the start duration for each type of travel (e.g., home to work) and travel analysis zone. The number of start trips may be summed separately in the travel model output, with the resulting final assignment giving the percentage of vehicles on a link in start mode. This approach would have the added benefit of reducing the linear growth in emissions with increased VMT if growth increased through increased travel distances.

Simple Instrumented Vehicles

While not specific to a project-level analysis, a relatively inexpensive instrumented vehicle approach using an electronic data logger, at an approximate cost of $100 each, can be used to collect regional or sub-regional level (traffic analysis zone) data on vehicle starts, start distribution and soak distribution. The inexpensive data logger simply measures whether the vehicle is on or off and time stamps those events. By analyzing the duration between starts and by designing a representative household survey sample, a local estimate of the soak distribution may be made (Everett et. al, 2001). Analysis of the data collected can also provide information on the number of starts per day and the start distribution. If sufficient number of vehicles are instrumented at a sub-regional level, e.g. at the travel analysis zone, then characterization of the local soak distribution can also be estimated.

2.2.1.4 Impact of CAL3QHC Results by Examination of Typical High-End Project-Level Applications

In this section, an assessment is made on how the implementation of MOBILE6 will affect the results of project-level analysis through the modeling of changes in CO concentration from a typical high volume freeway segment and a typical high volume intersection while migrating from the MOBILE5 to MOBILE6 emissions model. Analysis involved the application of the CAL3QHC and CALINE3 dispersion models for a variety of emission scenarios, representing the expected range of differences between MOBILE5 and MOBILE6 models. Each of the scenarios was run for a base year of 2005 and a future year of 2035. In addition, the impact of start emissions was made for an urban and a suburban intersection for several levels of service where a high number of start emissions are possible (e.g., parking garages and park-and-ride lots).

2.2.1.4.1. Changes in CO Concentrations in Migrating from MOBILE5 to MOBILE6

Air quality modeling was performed using the emissions changes identified in section 2.2.1.1 as the most likely to affect the simulated ambient concentrations of CO at the project-level. This effort was performed for three settings (urban intersection, suburban intersection and freeway); two years (2005 and 2035); and six emission scenarios, with emissions factors determined from both the MOBILE5 and MOBILE6 emissions models; and for three levels of service. For each of these combinations, a pair of emission factors was selected that showed the most significant differences between these two emission factor models for a given temperature and speed.

Three scenarios for dispersion modeling were prepared to assess the CO concentration changes: one suburban intersection, one urban intersection, and one freeway segment. Each of the simulations was applied for the peak traffic period with worst case screening meteorology to determine the maximum one-hour concentration. In all cases, it was assumed that settling and deposition velocities were zero.

The **freeway setting** occurred on a six-lane freeway (one link of three lanes in each direction), each lane about 12 feet in width, with a 12-foot median. Each link had a total mixing width of 56 feet, a length of 10,000 feet, and was at grade level. The freeway was oriented in a north-south direction, with four receptors located at the north-south midpoint of the link and at distances of 50, 100, 200, and 500 feet from, and perpendicular to, the freeway edge. All receptors were placed at a height of 1.8 meters (breathing level height). Worst case meteorology was applied, a near parallel wind direction (south-southwesterly wind at 190º) at 1 meter per second (m/s), with D stability. The surface roughness length was 175 centimeters (cm) (suburban), and the mixing height sas 1 kilometer (km). All emissions source heights were set at ground level. Traffic was divided evenly across all lanes, with a peak flow of 1,620 vehicles per lane per hour. Modeling was performed with CALINE3, the same dispersion module as CAL3QHC, but without the queuing algorithm.

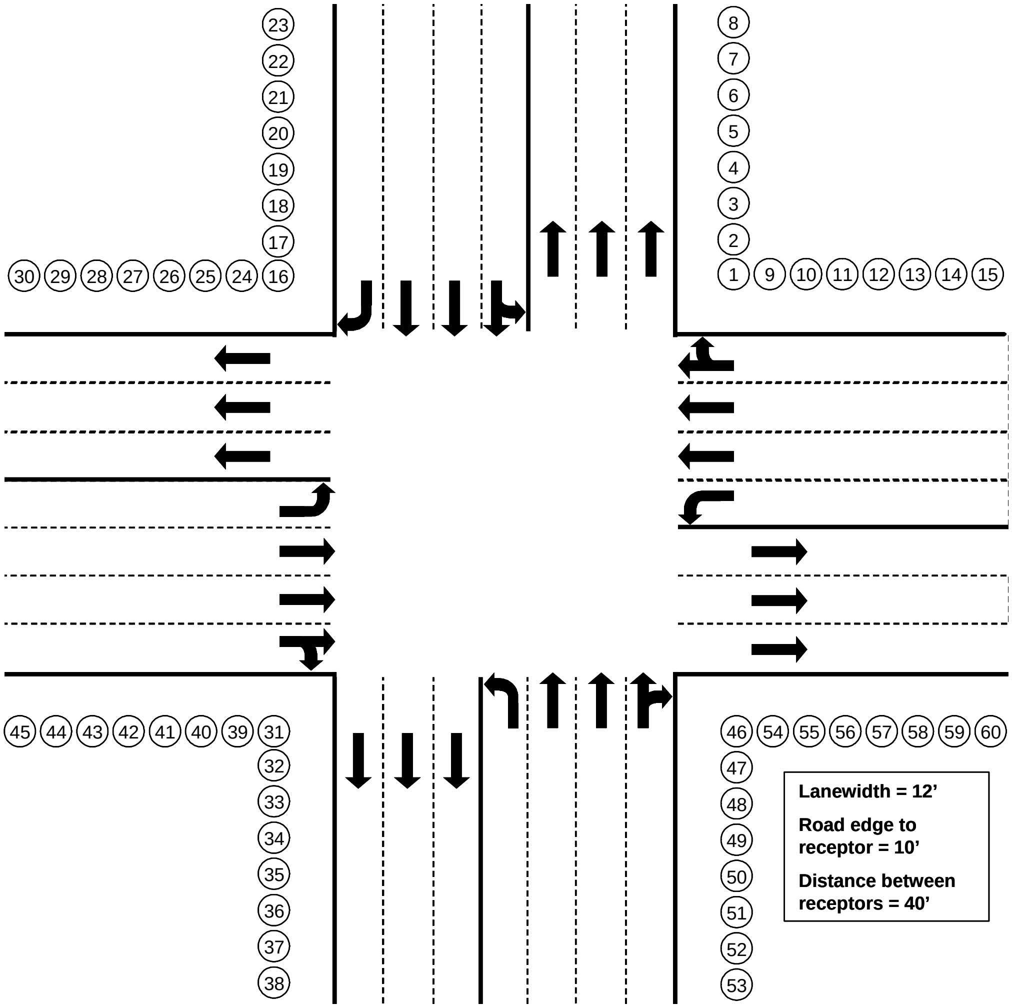
The **CBD intersection** simulations occurred at a four-legged, symmetric intersection. Each of the four links corresponds to a principal compass direction, with each having two approach lanes, two departure lanes and a single left-turn bay. The approach lanes and the turn bay are queued, with the flow and signalization different for each of the three levels of service (D, E, and F). The signal type was set as actuated and the arrival rate as average. All lanes were 12 feet wide and at grade level. The total mixing width of each approach to the intersection was 44 feet. Sixty receptors were located symmetrically around the intersection, 15 in each quadrant. Receptor numbers 1, 16, 31, and 46 were located at the corners of the intersection, with receptors 1-15 in the NE quadrant, 16-30 in the NW quadrant, 31-45 in the SW quadrant, and 46-60 in the SE quadrant of the intersection (see Figure 2.2.6). All receptors were located parallel to the edge of the links, 10 feet from the roadway edge, at a height of 1.8 meters and with 40 feet (2.5 car lengths) of spacing between them. The surface roughness was 321 cm (urban), and the mixing height was 1 km. Worst case screening meteorology was assumed, with wind speeds of 1 m/s; D stability; and wind direction varying between 0º and 350º, inclusive, incremented at 10º. Although the total traffic volume varied by level of service, in all cases, 15% of the vehicles turned left, 80% went straight through and 5% turned right. Traffic volume by approach, as well as the signal cycle and average red time length, is given in Table 2.2.1.4. The saturation traffic flow for the intersection was 1,800 vehicles per hour per lane. Clearance lost time was 3.0 s for left turn queues and 3.5 s for through and right turns. All queues had an average rate of progression. All modeling was performed with CAL3QHC.

Table 2.2.1.4. Traffic Operations for Urban and Suburban Intersections

Modeling Scenario	Approach Volume (veh/hr)	Average Red Time Length (s)		Control Delay Per Vehicle (s/veh)	Conservative Level of Service (LOS)	Cycle Length(s)
		Left	Right/Through			
Suburban LOS D	1100	87.9	72.1	56.4	D	100
Suburban LOS E	1300	122.8	97.2	84.9	E	140
Suburban LOS F	1400	128.7	98.8	103.9	F	145
Urban LOS D	800	97.8	76.7	52.1	D	110
Urban LOS E	1000	117.5	87.0	87.1	E	130
Urban LOS F	1100	136.0	98.5	114.6	F	150

The **suburban intersection** simulations were set up similar to the CBD intersection. The main difference between the two settings is that the suburban intersection has three approach lanes, three departure lanes, and one turn lane in each direction. The total mixing width of each approach is 56 feet. The placement of the receptors relative to the roadway edge was the same as for the CBD intersection. The surface roughness was 175 cm (suburban), and the mixing height was 1 km. Traffic volume and signalization varied by level of service, but the same fractions for turning left, going straight and turning right were used as for the suburban intersection as were used for the CBD intersection. The saturation traffic flow was 1,800 vehicles per hour per lane. Clearance lost time was 3.0 s for left turn queues and 3.5 s for through and right turns. All queues had an average rate of progression. The same worst case screening meteorology and concentration averaging time were assumed in this scenario as were used for the urban intersection.

Figure 2.2.6. General Intersections and Receptor Layout



2.2.1.4.2. Simulated Emissions

Six scenarios for emissions calculations were identified to create “incremental” emissions factors that were used in the air quality modeling for the MOBILE5 to MOBILE6 change comparison. These were the same scenarios as described in Section 2.2.1.1.2:

- Base case with an inspection and maintenance program.
- Base case without an inspection and maintenance program.
- Shift to a three-years-newer average age fleet distribution for light-duty vehicles and trucks.
- Shift to a three-years-older average age fleet distribution for light-duty vehicles and trucks.
- Decrease the light-duty vehicle VMT fraction by 30% from the national default.
- Increase the light-duty vehicle VMT fraction by 30% from the national default.

Each of the scenarios above was used as input to create "incremental" emission factors for both the base (2005) and future (2035) years (note that in scenarios 5 and 6, above, the fraction is relative to the appropriate year), using both MOBILE5 and MOBILE6. For each of these 24 combinations, two pairs of idle and mobile emissions factors were chosen that represented the largest differences (i.e., the "incremental" emissions) between the emission models as a function of temperature and speed combinations[6] (for the freeway modeling, only moving emissions factors were included). Each of these combinations was then run through each of the three model settings. For both the urban and suburban intersection settings, the pairs of emission factor values used were:

- Idle and moving for 10°F and 35.9 mph.
- Idle and moving for 70°F and 19.5 mph.

For the freeway modeling exercise, the emissions values used were:

- Moving at either 0°F (year 2005) or 10°F (year 2035) and 48.3 mph[7].
- Moving at either 70°F (year 2005) or 80°F (year 2035) and 48.3 mph.

In addition to the tests performed above, another suite of CAL3QHC model runs were made to test the effects of cold start emissions on ambient concentrations of CO in migrating to the MOBILE6 emissions model. These additional runs were done in order to evaluate the potential for exceedances of the eight-hour CO standard for situations with heavy cold start emissions. The same 3 x 3 suburban and 2 x 2 urban intersection settings were used for these simulations as for the comparisons described above, but only LOS D was explored for each of the intersections. Real-world examples of these types of intersections include locations near an urban parking lot or a suburban park and ride-discharging traffic during the afternoon traffic volume peak on a cold winter afternoon. The emissions factors used in these simulations were created with the MOBILE6 model, producing cold start only and hot-stabilized idle only emission factors[8]. Three emission factor values were incorporated into the dispersion model for two temperature scenarios: cold start idle emissions, hot-stabilized idle emissions and running emissions. Idle emissions input to the model were determined from the cold start and hot-stabilized idle values by assuming that one-fourth of the vehicles were in cold start mode, i.e., within the first 200 s of ignition, while three-fourths of the vehicles were assumed hot-stabilized. This ratio was kept constant in all simulations. For these simulations, the suburban intersection was modeled at a temperature of 10 ºF and the urban intersection at a temperature of 20 ºF.

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[6] This results in some cases where future-year temperature/speed combinations maximum "increment" is different than the base year.

[7] This relatively low freeway speed was chosen as representative of a typical congested freeway condition. It should also be noted that for MOBILE6, CO emission factors increase with speed after 35 mph. Thus the 48.3 mph emission factor is about equivalent to the 20 mph emission rate; 65 mph is equivalent to the 12 mph emission rate.

[8] Cold start emissions were simulated in MOBILE6 by setting all soak times to 720 minutes. Hot-stabilized emissions had all soak times set to 10 minutes.

2.2.1.4.3. Air Quality Modeling Results

For the **freeway modeling**, the emissions factors for the various scenarios described above were applied in the CALINE3 dispersion model. The outputs for each of the six scenarios, two temperature pairs, and two years were compared for the two emissions models at each of the four receptors. The concentration changes, along with the emissions change for each of the scenarios is given in Table 2.2.1.5. Note that negative percent changes indicate that MOBILE5 values are higher than MOBILE6.

Table 2.2.1.5. Percent Change in 1-Hour CO Concentration from the Freeway Modeling

Scenario	Year	Temp (F)	Change in Moving EF (M6-M5) (g/mi)	Average M6-M5 Concentration Change Across All Receptors (%)	M6-M5 Peak CO Change at 50 ft (ppm)	M6-M5 Peak CO Change at 100 ft (ppm)	M6-M5 Peak CO Change at 200 ft (ppm)	M6-M5 Peak CO Change at 500 ft (ppm)
1	2005	0	20.60	124.1%	4.70	3.29	2.13	0.99
1	2005	70	5.98	79.5%	1.37	0.96	0.62	0.29
1	2035	10	3.20	24.1%	0.73	0.51	0.33	0.15
1	2035	80	-0.66	-9.8%	-0.15	-0.11	-0.07	-0.03
2	2005	0	21.90	121.0%	5.00	3.50	2.27	1.05
2	2005	70	6.56	79.6%	1.50	1.05	0.68	0.31
2	2035	10	4.60	31.7%	1.05	0.74	0.48	0.22
2	2035	80	0.19	2.5%	0.04	0.03	0.02	0.01
3	2005	0	18.50	141.3%	4.23	2.96	1.91	0.89
3	2005	70	5.31	90.1%	1.21	0.85	0.55	0.25
3	2035	10	3.50	32.7%	0.80	0.56	0.36	0.17
3	2035	80	-0.25	-4.7%	-0.06	-0.04	-0.03	-0.01
4	2005	0	23.90	120.1%	5.46	3.82	2.47	1.14
4	2005	70	6.95	76.8%	1.59	1.11	0.72	0.33
4	2035	10	2.90	18.7%	0.66	0.46	0.30	0.14
4	2035	80	-1.08	-13.6%	-0.25	-0.17	-0.11	-0.05
5	2005	0	19.60	111.4%	4.48	3.13	2.03	0.94
5	2005	70	5.64	70.0%	1.29	0.90	0.58	0.27
5	2035	10	2.30	16.4%	0.53	0.37	0.24	0.11
5	2035	80	-0.95	-13.3%	-0.22	-0.15	-0.10	-0.05
6	2005	0	21.60	138.5%	4.93	3.45	2.24	1.03
6	2005	70	6.42	91.9%	1.47	1.03	0.66	0.31
6	2035	10	4.10	32.8%	0.94	0.66	0.42	0.20
6	2035	80	-0.34	-5.4%	-0.08	-0.05	-0.04	-0.02

The **urban (CBD) intersection** was simulated using the CAL3QHC model, as described above. The results of the simulations are shown in Table 2.2.1.6, which gives the changes in emissions factors between the MOBILE5 and MOBILE6 models, as well as the corresponding changes in peak ambient CO concentrations for each of the scenarios. Unlike the freeway modeling, the results are not presented at each of the receptors since the intersection is symmetric and there are too many receptors to show in one table. Instead, only the peak concentration from the full array of receptors is presented. It should be noted that the location of the peak was not always the same between the two emissions models, although, in cases where the locations were different, the concentration differences were typically small and/or occurred symmetrically about the intersection.

Table 2.2.1.6. Ambient 1-Hour CO Concentration and Emissions Changes for the Urban Intersection Modeling

Scenario	Year	LOS	Pair	Temp (F)	Change in Idling EF (M6-M5)/M5	Change in Moving EF (M6-M5)/M5	% Change in Ambient CO Concentration (M6-M5)/M5	Change in Ambient CO Concentration (M6-M5) (ppm)
1	2005	D	1	10	-56.7%	46.5%	-42.7%	-4.7
1	2005	E	1	10	-56.7%	46.5%	-39.7%	-4.6
1	2005	F	1	10	-56.7%	46.5%	-38.7%	-4.6
1	2035	D	1	10	-79.3%	-21.3%	-69.3%	-7.0
1	2035	E	1	10	-79.3%	-21.3%	-68.8%	-7.5
1	2035	F	1	10	-79.3%	-21.3%	-66.7%	-7.4
1	2005	D	2	70	-56.5%	-37.6%	-50.8%	-3.2
1	2005	E	2	70	-56.5%	-37.6%	-49.3%	-3.4
1	2005	F	2	70	-56.5%	-37.6%	-50.0%	-3.6
1	2035	D	2	70	-79.7%	-70.2%	-75.4%	-4.6
1	2035	E	2	70	-79.7%	-70.2%	-75.4%	-4.9
1	2035	F	2	70	-79.7%	-70.2%	-76.1%	-5.1
2	2005	D	1	10	-55.4%	44.2%	-42.5%	-5.1
2	2005	E	1	10	-55.4%	44.2%	-39.1%	-5.0
2	2005	F	1	10	-55.4%	44.2%	-37.4%	-4.9
2	2035	D	1	10	-76.1%	-17.3%	-67.9%	-7.6
2	2035	E	1	10	-76.1%	-17.3%	-65.3%	-7.7
2	2035	F	1	10	-76.1%	-17.3%	-64.5%	-7.8
2	2005	D	2	70	-55.2%	-37.4%	-50.7%	-3.5
2	2005	E	2	70	-55.2%	-37.4%	-50.0%	-3.8
2	2005	F	2	70	-55.2%	-37.4%	-48.7%	-3.8

Scenario	Year	LOS	Pair	Temp (F)	Change in Idling EF (M6-M5)/M5	Change in Moving EF (M6-M5)/M5	% Change in Ambient CO Concentration (M6-M5)/M5	Change in Ambient CO Concentration (M6-M5) (ppm)
2	2035	D	2	70	-75.9%	-66.3%	-71.2%	-4.7
2	2035	E	2	70	-75.9%	-66.3%	-72.6%	-5.3
2	2035	F	2	70	-75.9%	-66.3%	-72.0%	-5.4
3	2005	D	1	10	-55.6%	57.0%	-38.4%	-3.3
3	2005	E	1	10	-55.6%	57.0%	-35.9%	-3.3
3	2005	F	1	10	-55.6%	57.0%	-33.7%	-3.2
3	2035	D	1	10	-78.4%	-14.9%	-69.5%	-5.7
3	2035	E	1	10	-78.4%	-14.9%	-64.0%	-5.5
3	2035	F	1	10	-78.4%	-14.9%	-64.4%	-5.6
3	2005	D	2	70	-55.1%	-34.3%	-52.0%	-2.6
3	2005	E	2	70	-55.1%	-34.3%	-47.2%	-2.5
3	2005	F	2	70	-55.1%	-34.3%	-43.6%	-2.4
3	2035	D	2	70	-78.6%	-68.1%	-74.5%	-3.5
3	2035	E	2	70	-78.6%	-68.1%	-74.5%	-3.8
3	2035	F	2	70	-78.6%	-68.1%	-75.5%	-4.0
4	2005	D	1	10	-56.1%	45.4%	-41.5%	-5.4
4	2005	E	1	10	-56.1%	45.4%	-40.4%	-5.7
4	2005	F	1	10	-56.1%	45.4%	-38.5%	-5.5
4	2035	D	1	10	-80.1%	-24.7%	-70.6%	-8.4
4	2035	E	1	10	-80.1%	-24.7%	-70.1%	-8.9
4	2035	F	1	10	-80.1%	-24.7%	-69.2%	-9.0
4	2005	D	2	70	-56.1%	-37.3%	-50.7%	-3.8
4	2005	E	2	70	-56.1%	-37.3%	-51.2%	-4.2
4	2005	F	2	70	-56.1%	-37.3%	-50.6%	-4.3
4	2035	D	2	70	-80.6%	-71.5%	-76.8%	-5.3
4	2035	E	2	70	-80.6%	-71.5%	-76.6%	-5.9
4	2035	F	2	70	-80.6%	-71.5%	-76.3%	-6.1
5	2005	D	1	10	-56.7%	40.7%	-42.9%	-4.8
5	2005	E	1	10	-56.7%	40.7%	-39.8%	-4.7
5	2005	F	1	10	-56.7%	40.7%	-38.8%	-4.7

Scenario	Year	LOS	Pair	Temp (F)	Change in Idling EF (M6-M5)/M5	Change in Moving EF (M6-M5)/M5	% Change in Ambient CO Concentration (M6-M5)/M5	Change in Ambient CO Concentration (M6-M5) (ppm)
5	2035	D	1	10	-79.4%	-24.9%	-71.2%	-7.4
5	2035	E	1	10	-79.4%	-24.9%	-69.1%	-7.6
5	2035	F	1	10	-79.4%	-24.9%	-67.9%	-7.6
5	2005	D	2	70	-56.3%	-37.9%	-52.3%	-3.4
5	2005	E	2	70	-56.3%	-37.9%	-48.6%	-3.4
5	2005	F	2	70	-56.3%	-37.9%	-49.3%	-3.6
5	2035	D	2	70	-79.5%	-70.3%	-75.4%	-4.6
5	2035	E	2	70	-79.5%	-70.3%	-75.4%	-4.9
5	2035	F	2	70	-79.5%	-70.3%	-76.5%	-5.2
6	2005	D	1	10	-56.7%	52.6%	-43.5%	-4.7
6	2005	E	1	10	-56.7%	52.6%	-38.6%	-4.4
6	2005	F	1	10	-56.7%	52.6%	-37.1%	-4.3
6	2035	D	1	10	-79.1%	-17.1%	-68.7%	-6.8
6	2035	E	1	10	-79.1%	-17.1%	-68.2%	-7.3
6	2035	F	1	10	-79.1%	-17.1%	-66.1%	-7.2
6	2005	D	2	70	-56.6%	-37.3%	-50.0%	-3.1
6	2005	E	2	70	-56.6%	-37.3%	-47.8%	-3.2
6	2005	F	2	70	-56.6%	-37.3%	-48.6%	-3.4
6	2035	D	2	70	-79.8%	-70.0%	-76.7%	-4.6
6	2035	E	2	70	-79.8%	-70.0%	-77.8%	-4.9
6	2035	F	2	70	-79.8%	-70.0%	-76.1%	-5.1

The **suburban intersection** was also simulated with the CAL3QHC model for the settings described above. The results of the simulations are shown in Table 2.2.1.7, which gives the relative changes in emissions factors between the MOBILE5 and MOBILE6 models, as well as the corresponding changes in peak ambient CO concentrations for each of the scenarios. The same caveats regarding location for the urban intersection also apply here.

Table 2.2.1.7. Ambient 1-Hour CO Concentration and Emissions Changes for the Suburban Intersection Modeling

Scenario	Year	LOS	Pair	Temp (F)	Change in Idling EF (M6-M5)/M5	Change in Moving EF (M6-M5)/M5	% Change in Ambient CO Concentration (M6-M5)/M5	Change in Ambient CO Concentration (M6-M5) (ppm)
1	2005	D	1	10	-56.7%	46.5%	-41.1%	-6.0
1	2005	E	1	10	-56.7%	46.5%	-40.1%	-6.3
1	2005	F	1	10	-56.7%	46.5%	-40.7%	-6.6
1	2035	D	1	10	-79.3%	-21.3%	-70.4%	-9.5
1	2035	E	1	10	-79.3%	-21.3%	-70.7%	-10.4
1	2035	F	1	10	-79.3%	-21.3%	-69.3%	-10.4
1	2005	D	2	70	-56.5%	-37.6%	-51.2%	-4.3
1	2005	E	2	70	-56.5%	-37.6%	-50.5%	-4.7
1	2005	F	2	70	-56.5%	-37.6%	-51.1%	-4.8
1	2035	D	2	70	-79.7%	-70.2%	-75.9%	-6.0
1	2035	E	2	70	-79.7%	-70.2%	-76.5%	-6.5
1	2035	F	2	70	-79.7%	-70.2%	-76.4%	-6.8
2	2005	D	1	10	-55.4%	44.2%	-40.3%	-6.4
2	2005	E	1	10	-55.4%	44.2%	-39.5%	-6.8
2	2005	F	1	10	-55.4%	44.2%	-40.1%	-7.1
2	2035	D	1	10	-76.1%	-17.3%	-67.1%	-10.0
2	2035	E	1	10	-76.1%	-17.3%	-66.5%	-10.7
2	2035	F	1	10	-76.1%	-17.3%	-65.9%	-10.8
2	2005	D	2	70	-55.2%	-37.4%	-50.5%	-4.7
2	2005	E	2	70	-55.2%	-37.4%	-50.0%	-5.0
2	2005	F	2	70	-55.2%	-37.4%	-49.0%	-5.0
2	2035	D	2	70	-75.9%	-66.3%	-72.4%	-6.3
2	2035	E	2	70	-75.9%	-66.3%	-71.6%	-6.8
2	2035	F	2	70	-75.9%	-66.3%	-71.4%	-7.0
3	2005	D	1	10	-55.6%	57.0%	-41.4%	-4.8

Scenario	Year	LOS	Pair	Temp (F)	Change in Idling EF (M6-M5)/M5	Change in Moving EF (M6-M5)/M5	% Change in Ambient CO Concentration (M6-M5)/M5	Change in Ambient CO Concentration (M6-M5) (ppm)
3	2005	E	1	10	-55.6%	57.0%	-38.4%	-4.8
3	2005	F	1	10	-55.6%	57.0%	-37.2%	-4.8
3	2035	D	1	10	-78.4%	-14.9%	-68.8%	-7.5
3	2035	E	1	10	-78.4%	-14.9%	-69.0%	-8.0
3	2035	F	1	10	-78.4%	-14.9%	-68.6%	-8.3
3	2005	D	2	70	-55.1%	-34.3%	-48.5%	-3.2
3	2005	E	2	70	-55.1%	-34.3%	-51.4%	-3.7
3	2005	F	2	70	-55.1%	-34.3%	-50.7%	-3.8
3	2035	D	2	70	-78.6%	-68.1%	-73.8%	-4.5
3	2035	E	2	70	-78.6%	-68.1%	-75.0%	-5.1
3	2035	F	2	70	-78.6%	-68.1%	-75.0%	-5.4
4	2005	D	1	10	-56.1%	45.4%	-41.7%	-7.3
4	2005	E	1	10	-56.1%	45.4%	-40.4%	-7.6
4	2005	F	1	10	-56.1%	45.4%	-38.5%	-7.4
4	2035	D	1	10	-80.1%	-24.7%	-72.3%	-11.5
4	2035	E	1	10	-80.1%	-24.7%	-69.6%	-11.9
4	2035	F	1	10	-80.1%	-24.7%	-69.9%	-12.3
4	2005	D	2	70	-56.1%	-37.3%	-51.0%	-5.1
4	2005	E	2	70	-56.1%	-37.3%	-49.1%	-5.3
4	2005	F	2	70	-56.1%	-37.3%	-47.8%	-5.4
4	2035	D	2	70	-80.6%	-71.5%	-76.6%	-7.2
4	2035	E	2	70	-80.6%	-71.5%	-77.0%	-7.7
4	2035	F	2	70	-80.6%	-71.5%	-76.9%	-8.0
5	2005	D	1	10	-56.7%	40.7%	-41.6%	-6.2
5	2005	E	1	10	-56.7%	40.7%	-41.0%	-6.6
5	2005	F	1	10	-56.7%	40.7%	-41.2%	-6.8

Scenario	Year	LOS	Pair	Temp (F)	Change in Idling EF (M6-M5)/M5	Change in Moving EF (M6-M5)/M5	% Change in Ambient CO Concentration (M6-M5)/M5	Change in Ambient CO Concentration (M6-M5) (ppm)
5	2035	D	1	10	-79.4%	-24.9%	-71.7%	-9.9
5	2035	E	1	10	-79.4%	-24.9%	-71.3%	-10.7
5	2035	F	1	10	-79.4%	-24.9%	-69.9%	-10.7
5	2005	D	2	70	-56.3%	-37.9%	-49.4%	-4.2
5	2005	E	2	70	-56.3%	-37.9%	-51.6%	-4.9
5	2005	F	2	70	-56.3%	-37.9%	-51.0%	-4.9
5	2035	D	2	70	-79.5%	-70.3%	-75.9%	-6.0
5	2035	E	2	70	-79.5%	-70.3%	-77.0%	-6.7
5	2035	F	2	70	-79.5%	-70.3%	-75.3%	-6.7
6	2005	D	1	10	-56.7%	52.6%	-41.3%	-5.9
6	2005	E	1	10	-56.7%	52.6%	-38.6%	-5.9
6	2005	F	1	10	-56.7%	52.6%	-40.3%	-6.4
6	2035	D	1	10	-79.1%	-17.1%	-70.1%	-9.4
6	2035	E	1	10	-79.1%	-17.1%	-70.1%	-10.1
6	2035	F	1	10	-79.1%	-17.1%	-68.7%	-10.1
6	2005	D	2	70	-56.6%	-37.3%	-50.6%	-4.1
6	2005	E	2	70	-56.6%	-37.3%	-51.6%	-4.7
6	2005	F	2	70	-56.6%	-37.3%	-50.5%	-4.7
6	2035	D	2	70	-79.8%	-70.0%	-75.9%	-6.0
6	2035	E	2	70	-79.8%	-70.0%	-76.5%	-6.5
6	2035	F	2	70	-79.8%	-70.0%	-77.3%	-6.8

For the start emission scenario, both the suburban and urban intersections were simulated with the CAL3QHC dispersion model for the 2005 base and 2035 future years using LOS D signalization and traffic flow values. Worst case meteorology was included in the simulations, as described above, but the temperatures were taken as 10 ºF for the suburban and 20 ºF for the urban intersection, conditions that are conducive to high CO concentrations. Specific intersection parameters are given in Table 2.2.1.8, and results for each of the combinations of year and intersection scenario are shown in Table 2.2.1.9. In Table 2.2.1.9, the hourly peak CO concentrations have been reduced to an eight-hour average concentration by use of a 0.7 persistence factor for comparison to the 9 ppm eight-hour air quality standard. Background concentration was assumed to be zero.

Table 2.2.1.8. Intersection Parameters Used for Start Modeling

Year	Setting	Temp (F)	Idle EF (g/hr)	Mobile EF (g/mi)	total flow (vh/hr)	Left Turn V/C	Left Turn Queue Length	Through V/C	Through Queue Length
2005	Urban	20	728.98	28.5	800	1.05	8.4	0.76	7.3
2035	Urban	20	393.38	14.2	800	1.05	8.4	0.76	7.3
2005	Suburb	10	832.5	32.4	1100	1.31	26.3	0.77	6.2
2035	Suburb	10	450.98	16.1	1100	1.31	26.3	0.77	6.2

Table 2.2.1.9. Peak Ambient CO Concentrations from Start Modeling

Year	Setting	Worst Case Peak Hourly Conc (ppm)	8-hr value (ppm)	Increment above/below 8-hour standard (ppm)
2005	Urban	16.8	11.8	2.8
2035	Urban	9	6.3	-2.7
2005	Suburb	26	18.2	9.2
2035	Suburb	13.9	9.7	0.7

As can be seen from Table 2.2.1.5, the total moving emissions at 48.3 mph, as used in the freeway modeling, in all scenarios ranges from about -14% to about 140%. In the majority of cases, MOBILE6 has larger emissions factor values than MOBILE5. For 2005 only, MOBILE6 was greater than MOBILE5 in all cases, with a minimum difference of about 70% and an average difference of about 103%. The 2035 MOBILE6 scenarios show an average increase of only about 10%. Other than some small rounding off, the relative concentration change at the receptors is equivalent to the relative emissions changes, as expected. Also, at increasing distance from the freeway, the ambient concentration differences diminish. At 50 feet from the freeway edge, the ambient concentration changes ranged from about 1.2 to about 5.5 ppm for the various 2005 scenarios. For the 2035 scenarios, the ambient concentration changes at 50 feet from the freeway edge ranged from about –0.25 to about 1.1 ppm. For both years, the high temperature ambient concentration change was significantly less than the low temperature change. For the two base cases (Scenario 1), the low temperature values both show increases in migrating from MOBILE5 to MOBILE6, as does the 2005 high temperature value, but the 2035 high temperature value shows a slight decrease. Generally, low temperature base year simulations show a large increase in peak concentration in migrating from MOBILE5 to

MOBILE6, with changes of about 4 ppm or more at 50 feet and 0 ºF, followed by 2005 simulations at higher temperatures with changes of about 1 ppm at 50 feet and 70 ºF.[9] Low temperature future year simulations show smaller concentration increases, with values ranging between 0.5 and 1 ppm at 10 ºF, while high temperature future year simulations typically showed small concentration decreases. In all cases, MOBILE6 produced higher concentrations than MOBILE5 for 2005, while in 2035, MOBILE6 was more comparable to MOBILE5, but produced higher concentrations for lower temperatures. Thus, application of MOBILE6 for freeways in the near future years coupled with high traffic volumes and high background concentrations, could demonstrate potential problems in meeting the CO standard.

As shown by Table 2.2.1.6 for the **suburban intersection** scenarios, MOBILE6 produced lower ambient CO concentration values for every combination than did MOBILE5. The difference in the worst case ambient concentrations over all the scenarios ranged from about -0.3 to about -12 ppm (full range of about 40% to about 80 % reductions). For the base scenario (Scenario 1), the differences were fairly central to the range as a whole, with about 4-6 ppm for the base year, 2005, and about 6-10 ppm for the future year, 2035. These differences in concentration are more correlated with the change in idling emissions than with the change in moving emissions across the various scenarios and levels of service. While idling emissions are always lower in the MOBILE6 model than in MOBILE5, the moving emissions alternate having larger and smaller values across the scenarios. Note that for the suburban intersection, the volume to capacity ratio ranged from about 1.3 to about 1.5 for the left turn lane and about 0.77 to about 0.79 for the right turn-through queue.

For the **CBD intersection**, too, the concentrations produced by the MOBILE6 model were always lower than those from MOBILE5, ranging from 34% to about 78%. The same general trends observed for the suburban intersection also hold for the CBD intersection. The volume-to-capacity ratio for the turn lanes range from about 1.0 to about 1.5 and for the right turn-through queues, from about 0.76 to about 0.86 for the urban intersection. The overall reductions in ambient concentration are somewhat less than for the suburban intersections.

For the start scenarios, both the urban and suburban cases showed reductions of about 47% in 2035 for the peak CO concentrations over the base year, 2005. For 2035, the 1-hour peak values are about 9 and 14 ppm for the urban and suburban intersections, respectively. For 2005, the one-hour peak values are about 17 and 26 ppm. In all cases, the colder, suburban intersection showed higher concentrations than its urban counterpart. For comparison to the eight-hour CO standard, these values were adjusted to an eight-hour concentration value using the persistence factor of 0.7. Of the simulated intersections, only the urban intersection in the 2035 future year was not in exceedance of the eight-hour standard. In all cases, these exceedances are associated with the high idle emissions factors associated with the high number of starts. Thus, intersections with high start fractions appear to have the potential for exceeding the CO standard, given high traffic volumes and low temperatures.

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[9] These 2005 concentration increases would be about 20% higher at higher speeds (65mph) if the same level of traffic volume was possible.

2.2.2. Changes in MOBILE6 Impacting the Process for Project-Level Analysis

Use of MOBILE6 has the potential to affect the process in which project-level analysis is performed. The potential process-impacting effects may be organized into three subject areas:

- Need for Additional Information and Additional Agencies.
- Affect on Local or State Procedures Including Background.
- Impact on Mitigation Strategies.

These three areas are explored primarily through interviews conducted during the study. A total of 24 individuals affiliated with state DOTs, MPOs and researchers/consultants who have experience working with MOBILE6 on project-level analyses were interviewed. These interviewees represented a total of 14 groups conducting project-level analysis, nine state DOTs/MPOs, two groups responsible for facilitating project-level process and three researchers/consultants. The nine state DOTs/MPOs interviewed were: New York, Illinois, Alaska, Washington, Utah, New Mexico, Montana, Colorado and Florida. Results from these interviews are summarized in the attached document. Interview questions and a summary of the interview results are provided in Appendix C and D, respectively.

2.2.2.1 Need for Additional Information and Additional Agencies

The need to gather added information and involve additional agencies to conduct project-level analysis as a result of using MOBILE6 varies from state to state. Some states have found no additional information or agency involvement is necessary (generally these are the states using the defaults provided by the model), while other states have found there are additional needs and in several cases, some significant additional effort (e.g., one agency quoted that as much as 100% more information is required). There is approximately an equal split between agencies indicating that MOBILE6 required more data and additional agency contact and those that said that little or no additional resources were required. For those agencies requiring additional contact and coordination, most were local air pollution control districts or MPOs and in one case, a state energy agency. These agencies cited the need for additional agencies because they were making use of a number of the MOBILE6 options for which they had previously relied upon national defaults.

Agencies also commented that additional information was needed on model sensitivity to changes in inputs relative to MOBILE5. Several state agencies requested that a statistical analysis of model sensitivity be performed for vehicle mix, vehicle distribution and vehicle class.

Almost all state agencies contacted indicated that more time was required to complete project-level analysis using MOBILE6 compared to using MOBILE5, ranging from several hours to 40 hours. It was generally agreed that this would decrease over time and with practice.

2.2.2.2 Affect on Local or State Procedures Including Background

Most state agencies reported that use of MOBILE6 has not had a direct change on their procedures for project-level analysis. However, a number of consultants and researchers indicated that changes were seen in the data collection process, which included gathering additional facility-specific data and assessing the need for start specifications. For example, previously in New York City, specific percentages were used for particular neighborhoods. The new procedures drafted for New York City will use the same emission factors for *all* New York City neighborhoods.

Most states have also found that future background concentrations of CO should be lowered as MOBILE6's downward CO emission trends are, for most locations, larger than the regional VMT growth. As a result, a number of locations have, or are looking at, adopting new procedures for determining future background CO levels. For example, New York state is switching from the relatively common approach of calculating background CO concentrations using a three-year average of local CO monitoring data to a roll forward technique.

Several researchers and consultants reported that, based on their experience working with MOBILE6.2, areas will need to change their "worst case" modeling receptors from intersection-based to a mid-block location. This is caused by MOBILE6's higher speed emission factors, coupled with much lower emission factors for near idle conditions, which leads to shifting the maximum CO concentration away from the intersection corners where idle emissions are most dominate.

Other comments noted by state agencies and researchers that affect the applicability of MOBILE6.2 in project-level analysis is the limitation of the tool for the modeling of freeway ramps, as the user cannot change the model's average speed from the national average default freeway ramp speed of 34.6 mph.

2.2.2.3 Impact on Mitigation Strategies

States have reported that use of MOBILE6 appears to have had an impact on CO mitigation strategies. In some cases, the use of the model in place of MOBILE5 has eliminated the need for a mitigation strategy, as the intersections no longer appeared to have problems. However, the traditional approach of increasing intersection capacity to achieve higher average speeds, given today's vehicle emission control technology, will no longer reduce overall CO emissions, but may actually increase emissions.

More studies are needed to better quantify possible benefits derived from adopting certain CO mitigation strategies, (e.g., what are optimal emissions mitigation strategies and scenarios for a given location?) Historically, one key strategy in most CO mitigation plans was to reduce idle emissions. Studies that can identify which mitigation strategy would work best to reduce CO emissions given a certain set of local conditions (e.g., high altitude, high volume, narrow streets, etc.) are highly desirable. For example, one researcher suggested that optimizing signal timing will have to be restudied to better understand the possible CO mitigation benefits.

2.2.3 Changes in MOBILE6 Impacting Screening Assessment Procedures

Use of MOBILE6 has the likely potential to affect the screening assessment procedures for project-level analysis. The potential processes and resulting needs that may affect these procedures may be organized into three subject areas:

- Identification of Efforts to Date Suggesting the Need for Revised Screening-Level Procedures.
- Development of an Approach for Setting a Threshold Screening-Level Procedure.
- Limitations and Applicability of this Threshold Screening Approach.

These three areas are explored first through interviews conducted during this study, followed by an investigation into air quality screening procedures based on MOBILE6 and CAL3QHC simulations.

2.2.3.1 Identification of Efforts to Date Suggesting the Need for Revised Screening-Level Procedures

All of the state agencies interviewed base their screening assessment procedures on the transportation conformity rule, which requires a project-level analysis for federally funded projects in CO nonattainment and maintenance areas. This approach is extended to all projects, including state- or privately funded projects, as well as projects needing an assessment under the National Environmental Policy Act (NEPA). The conformity rule requires that a quantitative analysis, (e.g., using CAL3QHC) is required for projects: 1) in or affecting locations identified in the state implementation plan (SIP) as sites of potential or actual violations of the CO National Ambient Air Quality Standards (NAAQS); 2) affecting intersections that are at or will be at LOS[10] D or worse; or 3) affecting intersections identified in the SIP as having the three highest volumes or three worst levels of service in the nonattainment or maintenance area. Five of the nine state agencies use a modification of the LOS C screening approach (that is LOS C passes screening) which consists of LOS and traffic volume thresholds. Four of the nine state agencies use LOS C only, but several are looking at revisiting this procedure in light of MOBILE6. Three of the nine agencies are updating their screening procedures because of MOBILE6 changes. A more extensive review of these procedures is presented by Houk and Claggett in an FHWA paper, *Survey of Screening Procedures for Project-Level Conformity Analyses.*

In Illinois, new pre-screening analyses have been developed for use with MOBILE6. The new procedure features “cut-off” criteria that are built into the analysis, which are based on the worst case inputs and the distance to a receptor.

New York City has modified its screening method procedure because of MOBILE6. The selection of modeling receptors has changed from an intersection location to a mid-block location.

Researchers and consultants recommend that state agencies revisit the current screening procedures, as MOBILE6 coupled with CAL3QHC does not yield the same results. Some of the key differences that may affect the current screening procedures include: speed curves exhibiting

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[10] This refers to the classification of signalized intersection operations based on procedures in the Highway Capacity Manual. The ratings go from LOS A, with little delay, to LOS F, with an average delay over 80 s per vehicle.

increased emissions following a low point around 30-35 mph, idle emission decreases and moving emission increases and a shift in worst case receptor concentration towards mid-block.

2.2.3.2 Development of an Approach for Setting a Threshold Screening-Level Procedure

To examine the potential for CO air quality violations for project-level settings, an investigation was performed for a combination of levels of service D, E and F; two intersection configurations; and one freeway configuration for two speeds and two dispersion settings (urban and rural). The modeling was performed using the MOBILE6 emission factors for the years 2005, 2015, 2025 and 2035.

For the two generalized intersections, one represented the intersection of two streets with three lanes plus a left turn bay on every approach. This was assumed to be in a suburban setting. The second was the intersection of streets with two lanes plus a left turn bay on each approach, and it was assumed to be in an urban setting. In addition, concentrations were also determined for sites in proximity to a six-lane freeway. These are a subset of the configurations, as described in Section 2.2.1.4.1

Three traffic conditions were developed for each intersection, representing LOS D, E, and F. Signal operations were estimated assuming a total of four phases, allowing for separate operation of the left turns and the through movement (along with right turns) of each roadway. It was assumed that 15% of the approach volume was turning left. Receptors were located at each corner, ten feet off each roadway, with seven more spaced at 40 feet along each leg of the intersection, for a total of 60 sites.

The freeway was assumed to have a narrow right-of-way, with a total width of 96 feet between the outside edges of the travel lanes. With an assumed volume of 2,000 vehicles per hour per lane, the highway would be operating at LOS E. The average speed based on the highway capacity manual estimate was 55 mph. Receptors were placed at an assumed right-of-way line, 78 feet from the center line (30 feet from the nearest travel lane), with additional sites located at 80, 180 and 480 feet from the nearest travel lane.

These general modeling scenarios were intended to represent typical “worst case” conditions. A practical range of vehicle volumes was developed and then classified by LOS. Signal operations for intersections were estimated using the Highway Capacity Software (HCS), and vehicle speeds on freeways were evaluated also using HCS. In both cases, common assumptions were applied (e.g., lane widths of 12 feet).

For intersections, current EPA guidance suggests that locations operating at LOS C or better will not require detailed analysis. The results of this review of MOBILE6 continue to illustrate that concentrations increase with decreasing levels of service, even though intersections at LOS C or better were not analyzed. This outcome can be attributed to the increase in the density of vehicles and duration of queues (the cause and the effect) as one moves from LOS D to LOS F. A higher condition (e.g., LOS A) can be expected to have freer flow and hence, higher speeds, but as shown on Figure 2.2.7 and 2.2.8, emissions start to increase only slightly at higher approach speeds and only after 35 mph. The slight increase in emission factor will be more than offset by the lower vehicle volumes resulting in overall lower emissions compared to the cases of LOS D to LOS F presented here.

Figure 2.2.7. 2005 MOBILE6.2 CO Emission Factors versus Average Speed

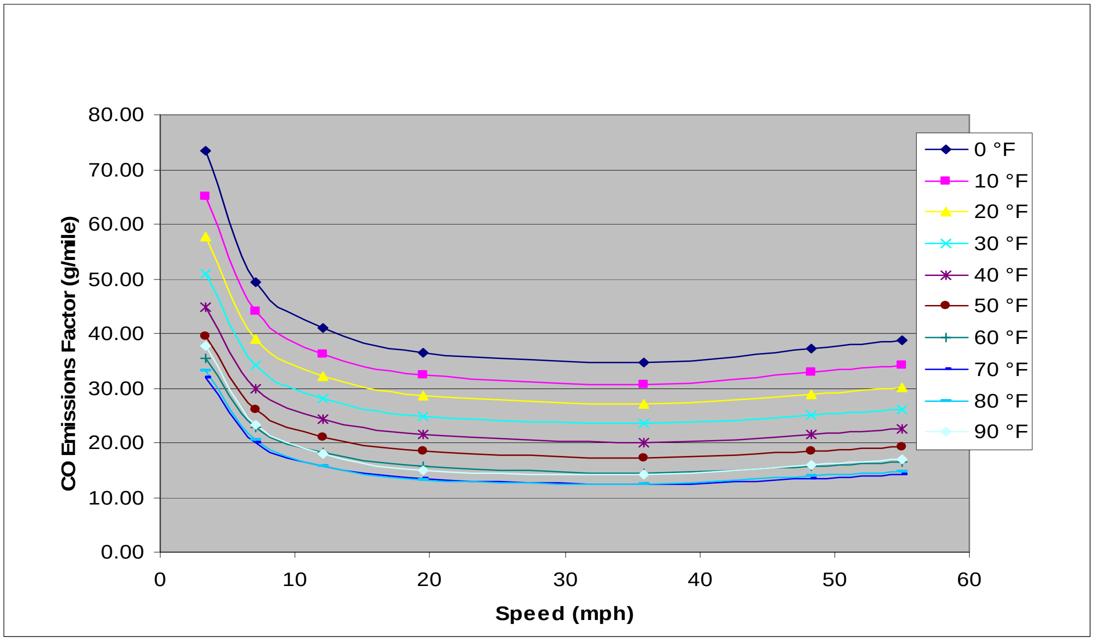
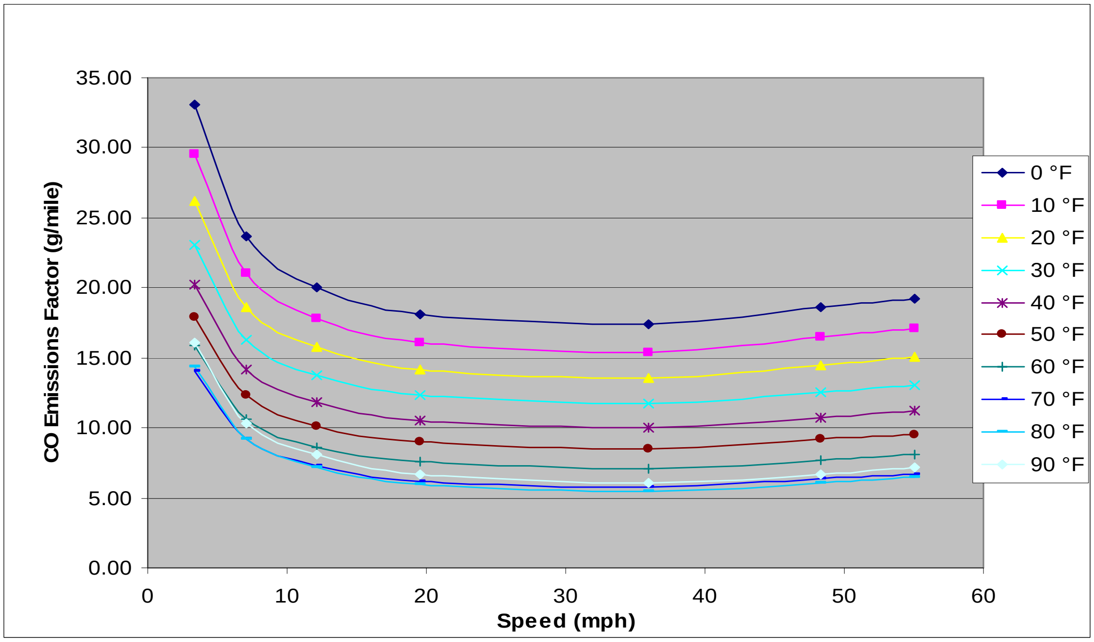


Figure 2.2.8. 2035 MOBILE6.2 CO Emission Factors versus Average Speed



For freeways, the assumed conditions (including 2,000 vehicles per hour per lane) result in LOS E, with a computed speed of 55 mph. This “worst case” scenario has been extended by also considering the same volume with a speed of 65 mph, which has a greater emission rate. This case would represent very aggressive drivers. Using the same typical assumptions, HCS assessments of LOS A, B or C indicates flows of 333, 667, or 1,333 vehicles per hour per lane, respectively, with average speeds of 67 mph. Therefore, the emission rates at a higher LOS would be equivalent to the “aggressive driver” LOS E assumption in this analysis, but the number of vehicles and therefore, the overall emissions would be substantially reduced.

General results of the CAL3QHC modeling effort are summarized in Figure 2.2.9. The values shown represent the highest predicted eight-hour CO concentration in the vicinity of the intersection assuming a persistence[11] factor of 0.7 to estimate the adjustment from the one-hour to the eight-hour concentrations. For the intersection, the location of the maximum concentration varied from the corner to a more mid-block location, but the location at the nearest receptor to the right-of-way always had the highest freeway concentration. The overall modeling approach applied the typical worst case assumptions. A wind speed of 1 m/s was evaluated at every wind angle in 10° increments. An atmospheric stability class of D was used with a mixing height of 1,000 meters and an ambient temperature of 10°F. MOBILE6 was applied using national default values to represent typical conditions.

The results shown are based on a background concentration of zero. In some states, location-specific monitoring data is used, and as discussed in the previous section, a rollback technique may be used for future CO background concentration estimates. However, these values must be considered carefully since, in many cases, the measurements represent both regional background and local traffic conditions. An FHWA guidance document (1986) suggested that a background concentration of 1 ppm would be appropriate for rural settings, and 2 to 3 ppm would be typical in urban areas. These estimates appear to be reasonable estimates of today’s typical urban and rural CO background values, as EPA’s most recent trend data (http://www.epa.gov/airtrends/carbon.html, USEPA, 2003) shows that, for 2002, the national average 2nd highest high eight-hour average CO concentration is around 3 ppm (likely a typical urban setting) and the lowest 2nd highest high eight-hour average CO concentration is around 1.5 ppm (likely a rural setting). Additionally, as a first approximation, it is suggested that for screening purposes attainment areas assume a background concentration of 3 ppm. Non-attainment and maintenance areas should use previously developed methods for establishing background concentrations.

When looking at the values reported in Figure 2.2.9, the highest predicted eight-hour concentration is slightly above 9.0 ppm for traffic traveling at 65 mph on a freeway in 2005 in an area without an I/M program. This would imply a potential violation of CO NAAQS (9.0 ppm) at this level of service in the near-term. For this case, a more refined modeling approach using hour-by-hour traffic and meteorology would be recommended. Assuming a “worst case” background concentration of 3 ppm, the implication is that a project-level eight-hour concentration of 6 ppm or less is needed to satisfy the eight-hour NAAQS.

The results displayed in Figure 2.2.9 indicate a limited potential for violations of the NAAQS at typical locations in the near-term, and by 2015, the potential effectively disappears. An interesting feature in Figure 2.2.9 is that the freeway scenario operating at LOS E has the

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[11] This factor takes into account variations in traffic and meteorological conditions between the 1 and 8-hour averaging periods.

potential for higher CO levels than an intersection operating at LOS F. This implies that the freeway scenario should be examined, along with intersections, in setting a screening threshold assessment procedure.

Results from modeling also showed that, for intersections, the corner receptor no longer has the highest concentration; the greatest concentration is now typically found about 200 feet behind the front of the queue. In both the intersection and freeway cases, the benefits of I/M programs are limited (on the order of 20% or less), but improvements due to fleet turnover between 2005 and 2035 are substantial (on the order of 50%), with most of that improvement in the first ten years. This latter effect reflects the introduction of today's technology into the remaining portion of the fleet.

To more fully asses the applicability of this screening approach to the more extreme roadway settings, two additional roadway configurations were evaluated. The intersection was expanded to consist of two five-lane approaches and included a dual left-turn lane, four through lanes, and a right-turn lane for each approach. A ten-lane freeway was also evaluated. As with the previous case, this freeway was assumed to have a narrow right-of-way. However, concentrations at the right-of-way site (30-feet from the nearest travel lane) and a site 80 feet from the nearest travel lane (approximately 150 feet from the center line) have been shown in Figure 2.2.10. As with the earlier modeling runs, nearly all of the predicted levels are below 6 ppm, excluding modeling runs for 2005 and the sites near freeway rights-of-way.

The current data has been presented with an "open format" since it includes no background concentration. This value will vary depending on the guidance a given state might provide or the nature of the location (e.g., rural or urban). Although the modeling was performed for one-hour periods, the figures have been converted to eight-hour estimates using an assumed persistence factor of 0.7. Again, different states might suggest different values for this adjustment, but the eight-hour standard is more susceptible to being exceeded; therefore, the 0.7 persistence factor-adjusted results are shown in the figures.

Because application of the results of this study might vary by state, it is not possible to propose a universal screening policy at this stage. However, it appears that a straight-forward screening based on the LOS will be a practical approach to future air quality evaluations. Some states have used LOS C as an initial screening assessment and then applied a quantitative approach (e.g., simplified modeling or "look-up" tables) if a lower LOS was found. The current analysis indicates that a relatively low LOS (LOS E) will still meet the air quality standards in most cases, and it is unlikely that a proposed project would be advanced if it were not expected to improve operations. In terms of project-level studies, this approach would be similar for an attainment or a nonattainment area.

As with other screening methods, it will be important to develop an appropriate set of disclaimers. The assumptions applied in this study attempted to identify "worst case" assumptions that would address a wide range of projects. Still, it was determined that rare settings and conditions might lead to air quality concerns, for example, an urban intersection in close proximity to a parking garage or a site with limited offset from a high-volume freeway. Nevertheless, LOS alone might have wide applicability as a screening tool for project-level air quality assessments.

2.2.3.3 Limitations and Applicability of this Threshold Screening Approach

This assessment indicates that the potential screening threshold for project-level studies would, for most typical conditions, rarely require the need for a detailed analysis with CAL3QHC. In the past, LOS C has been widely used as a screening threshold to reduce the need for detailed modeling. If there were no signalized intersections associated with a project where the operations would be classified as LOS D or worse, then it was determined that there would be no air quality impacts. Due to the changes from MOBILE 5 to MOBILE6, the relative role of cruise emissions has increased, while the idle emission factors have been substantially reduced. Based on the assessment completed in this study, it appears likely that detailed modeling can be excluded for both intersection and freeway locations with LOS E or better under a wide variety of conditions, especially when looking beyond the near-term period (2015 or later).

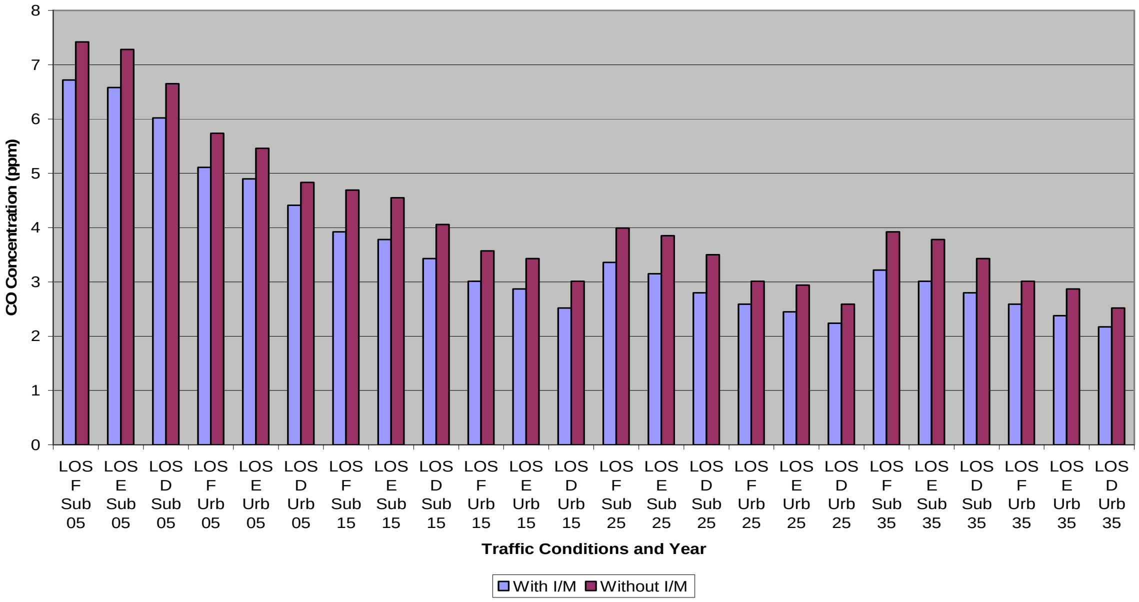
The applicability of this screening threshold is dependent on the circumstances of a given project and how closely they resemble the “normal” conditions used and the other assumptions applied here. This effort has focused on applying a reasonable worst case condition that would capture the vast majority of real-world conditions. However, several exception type cases can be noted:

- Locations in very close proximity to very high volume freeways.
- Location with an extraordinary rate of cold start emissions, such as near a park and ride lot or CBD parking garage.
- A much older fleet than the national default age distribution.
- An unusually high background concentration.

These type cases would need to be examined on a case-by-case basis. Nevertheless, it appears likely, based on the modeling efforts shown, that the vast majority of typical projects will not require detailed modeling if the traffic analysis indicates that all signalized intersections and freeway sections will operate at LOS E or better.

Figure 2.2.9. Maximum CO Concentrations near Typical Intersections and Freeways

Eight-hour CO Concentrations- Basic Intersections with Different Traffic Conditions and Years



Eight-hour CO Concentrations- Base Freeway at LOS E but with Different Speeds and Years

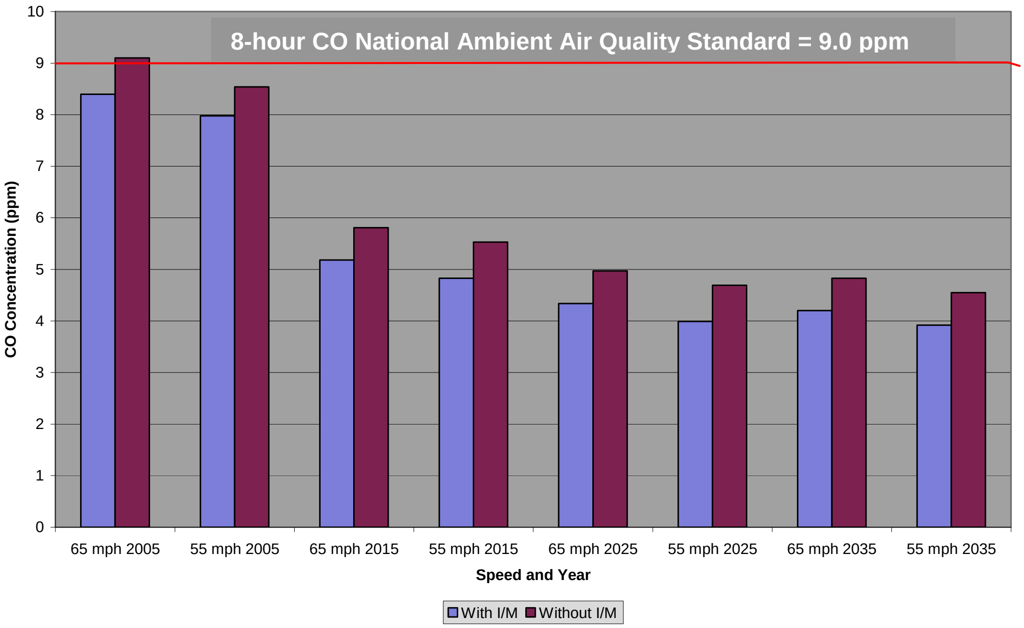
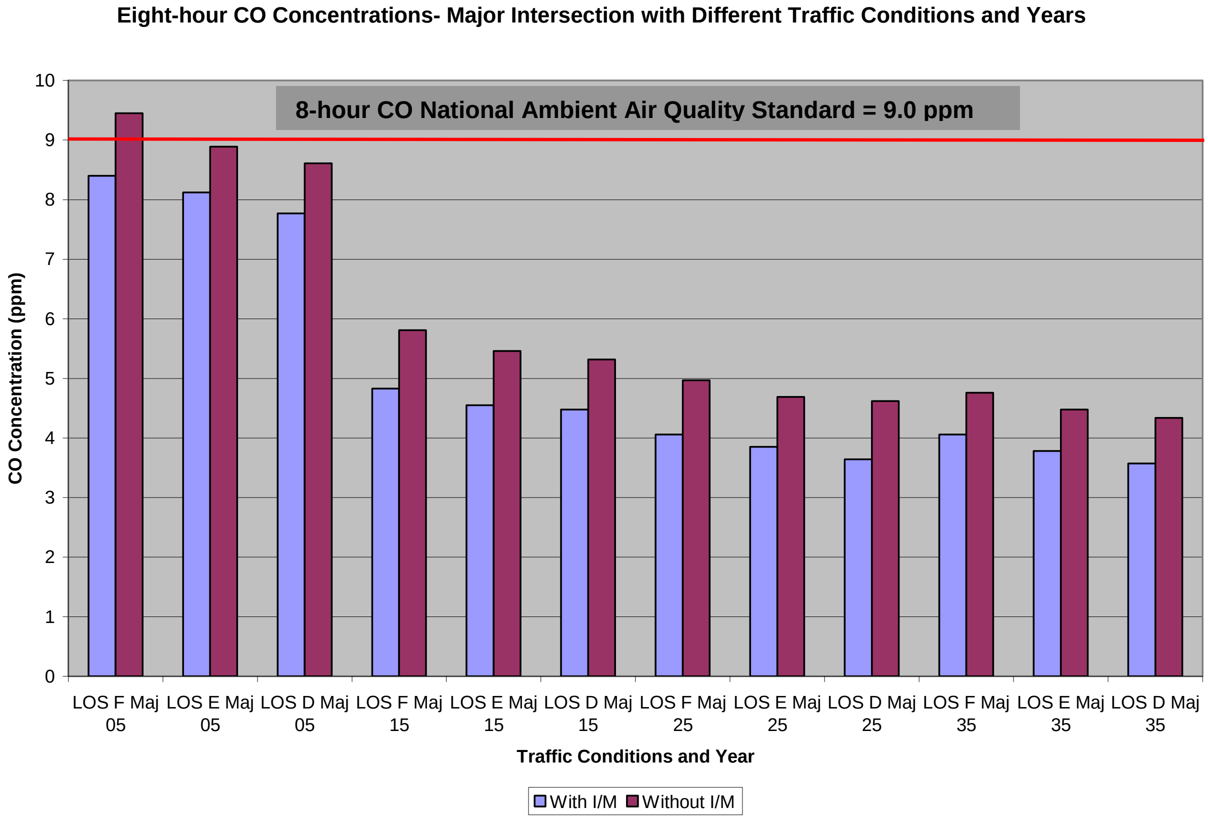
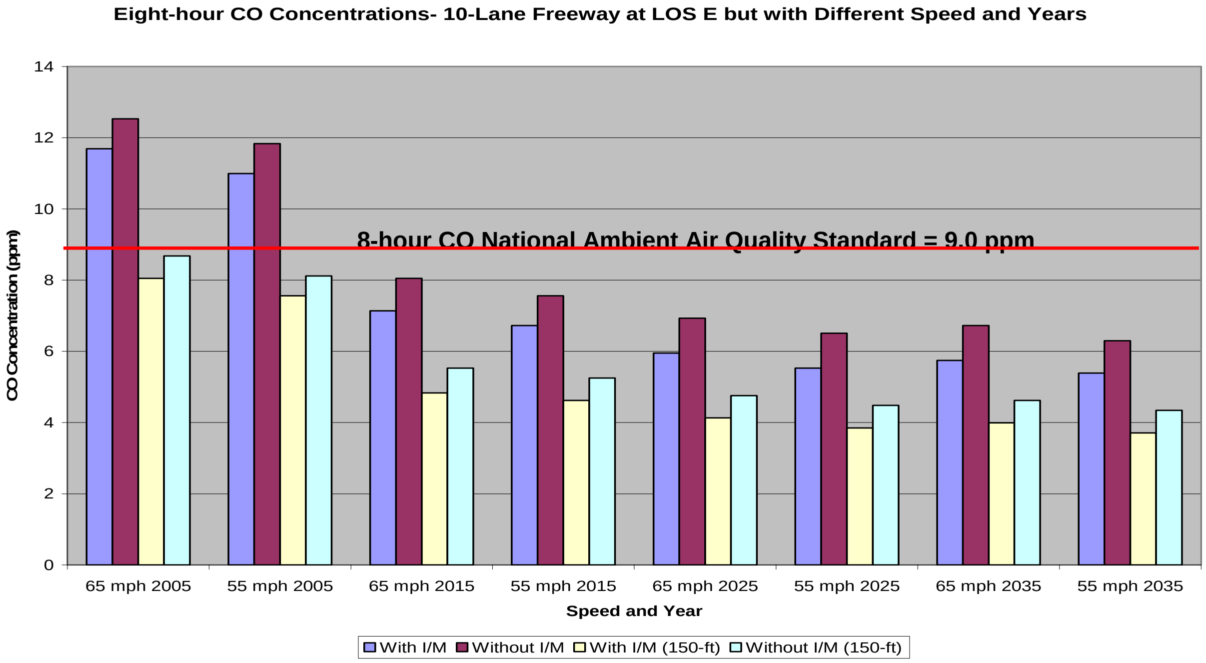


Figure 2.2.10. Maximum CO Concentrations near Major Intersections and Freeways





3. Summary of Findings

As a result of this study, a number of useful insights have been developed on the impact of MOBILE6 on project-level analysis. Summarized in this section are the most critical and sensitive input parameters, along with the identification of methods to develop key inputs, if needed. In addition, a screening-level procedure for project-level studies using MOBILE6 is discussed.

3.1. Key Findings from MOBILE5 versus MOBILE6 Model Comparison

A review of the MOBILE6 changes relevant to the impact on project-level analysis suggested that ten scenarios, described below, will be of primary interest to the project-level analyst in assessing the change between using MOBILE5 and MOBILE6. These scenarios reflect both typical applications and/or potential changes from national distributions with anticipated significant impacts on CO emission factors. The scenarios evaluated were:

- Without an inspection and maintenance (I/M) program (2005/2035).
- Shift of ±3 years in the average age fleet distribution for light-duty vehicles and trucks (2005/2035).
- Increase and decrease the 2005 light-duty vehicle fleet percentage by 30% from the 2005 national default for MOBILE6.
- Increase and decrease the 2035 light-duty vehicle fleet percentage by 30% from the 2035 national default for MOBILE6.

For 2005, MOBILE6 produces lower emission factors than MOBILE5 at low speeds (between idle and 19.5 mph) across all temperatures and scenarios. This trend reverses for higher speeds. For 2035, MOBILE6 emission factors are lower than the corresponding MOBILE5 emission factors for all scenarios, including higher speeds. Thus, for the earlier years, MOBILE6 will always estimate lower emission rates than MOBILE5 for low speeds, but higher emission rates for higher speeds. For later years, MOBILE6 will always provide lower emission rates than MOBILE5.

For I/M changes, both models behave in a similar manner. The shift of three years in the average fleet distribution is treated in a similar manner by both MOBILE5 and MOBILE6 in both 2005 and 2035. For the 30% shift in the light-duty vehicle VMT fraction for 2005 and 2035, MOBILE5 is slightly more influenced by the shift in fleet than is MOBILE6.

For all scenarios, MOBILE6 factors change less rapidly as a function of speed than the corresponding MOBILE5 factors. For the scenarios assessed, the largest changes between MOBILE5 and MOBILE6 are the scenarios with shifts in the average age fleet distribution for light-duty vehicles and trucks with differences of up to 57% lower in the 2005 MOBILE6 emissions and 80% lower in 2035.

3.2. MOBILE6 Impact on CAL3QHC Validity

Two studies have performed extensive monitored-to-modeled comparison of the CAL3QHC model. The first study, "Evaluation of CO Intersection Modeling Techniques Using a New York City Database" (Sigma Research, 1992), was conducted in 1989 and used the MOBILE4.1 emission factor model. This study formed the basis for EPA's selection of the CAL3QHC model as the preferred guideline model for project-level analysis. The second study is NCHRP25-6, "Intersection Air Quality Modeling," which is a mid-1990s study, which used the MOBILE5 emission factor model for three intersections in Tucson, Arizona; Denver, Colorado; and Sterling, Virginia.

CAL3QHC was evaluated for three key intersections all located in Manhattan. Studies have shown that CAL3QHC model simulation results are usually driven by queue length and number of lanes (queue density) for overcapacity conditions. Queue emissions result from idling. In most cases the highest CO concentrations occurred during overcapacity situations. Thus, the focus for the validation study was on how idle emissions have changed between the two versions of the model.

Overall, the idle emissions decreased significantly for MOBILE6.2, relative to either MOBILE5 or MOBILE4.1, while moving emissions increased. Historically, analyses of roadway intersections have found that high concentrations are a result of large queue emissions and hence, the idle emission factor. This tradeoff in emissions will likely impact the CAL3QHC model by lowering concentrations in most situations where queue length is important. Because the model performance evaluation of CAL3QHC in the Route 9a study tended to underpredict for all three intersections, the model bias will likely increase. However, this somewhat contrasts with the NCHRP25-6 study results which suggest that MOBILE6.2 will improve model performance relative to its evaluation based on using MOBILE5. Some of this difference may be the result of changes in engine technology since these evaluation studies were based on pre-1990 and pre-1995 vehicles. It is possible that differences between the two MOBILE models may be considerably different for a newer fleet of vehicles. If however, today's fleet is analogous to the NCHRP's pre-1995 fleet then the use of the MOBILE6.2 model as input to CAL3QHC for project-level analysis will likely improve model performance.

3.3. MOBILE6 Impact on Characterizing Start Emissions

With the release of MOBILE6, EPA recommended that, in most instances, the model's emission factor estimates should be used without adjustment for start fraction since nearly all emissions are hot-stabilized, unless the location is near a parking garage, shopping center or similar facility with a large number of start emissions. Additional locations have been identified under which start emissions should be considered. These locations are:

- A commuter parking garage during PM peak
- A shopping center
- A hospital
- A university/college
- A park-and-ride lot (bus or light rail transit)
- A railway station
- A general residential area during AM peak.

For each of these locations a methodology has been identified for estimating start emission characterizations. In general, these methods use a combination of historical survey data in combination with an estimate of facility size to estimate the number of starts. In addition to borrowing results from these studies, several alternative methods have been presented for collecting data to characterize soak distribution for project-specific locations. These methods are relatively inexpensive to implement relative to a fully instrumented vehicle study.

3.4. MOBILE6 Impact on Project-level Results

Implementation of MOBILE6 will affect the results of project-level analysis. An assessment was made using the CAL3QHC model for typical high volume freeways and high volume intersections. Modeling was performed for a variety of emissions scenarios representing the expected range of differences between MOBILE5 and MOBILE6 models for the base year of 2005 and a future year of 2035. In addition, an assessment was made on the impact of start emissions for an urban and a suburban intersection for several levels of services, assuming that one-fourth of the vehicles arriving are in start mode.

Six scenarios for emissions calculations were developed to create “incremental” emissions factors that were used in the air quality modeling for the MOBILE5 to MOBILE6 change comparison. These were the same scenarios used in the MOBILE5 to MOBILE6 comparison. Each scenario was applied for 2005 and 2035 for a set of temperature and speeds and for an urban and suburban setting.

For the high volume freeway scenario, MOBILE6 produced higher concentrations than MOBILE5 for 2005, while in 2035, MOBILE6 was more comparable to MOBILE5, but produced higher concentrations at the lower temperatures. Thus, application of MOBILE6 for freeways in the near future years coupled with high traffic volumes and high background concentrations may present problems not currently demonstrated with MOBILE5.

For the suburban intersection scenarios, MOBILE6 produced lower ambient CO concentration values for every combination than did MOBILE5, ranging from 40% to 80% reductions. For the CBD intersection, too, the concentrations produced by the MOBILE6 model were always lower than those from MOBILE5, ranging from 34% to about 78% lower. The overall reductions in ambient concentration are somewhat less than for the suburban intersections. For the high number of start scenarios, both the urban and suburban intersections showed problems achieving the eight-hour CO standard. For 2035 the urban intersection meets the eight-hour standard, but the suburban intersection did not. In all cases, these exceedances are associated with the high idle emission factors associated with a high number of starts. Thus, intersections with a high number of start fractions and high volumes appear to have the potential for exceeding the CO standard.

3.5. MOBILE6 Impact on the Process of Project-level Analysis

Use of MOBILE6 has the potential to affect the process in which project-level analysis is performed. The potential processes may affect the need for additional information and local or state procedures, including estimates for background concentration and impacts on mitigation strategies. These three areas were explored primarily as a result of the interviews conducted during the study. A total of 24 individuals affiliated with state DOTs, MPOs and researchers/consultants who have experience working with MOBILE6 on project-level analyses were interviewed.

For those agencies using mostly default values no additional effort was found in applying the MOBILE6 model, while those developing location-specific input indicated that additional effort was needed to develop inputs to the model. Almost all state agencies contacted indicated that more time was required to complete project-level analysis using MOBILE6 compared to using MOBILE5, ranging from several hours to 40 hours. Most states have also found that future background concentrations of CO should be lowered as a result of MOBILE6's strong downward CO emission trends and estimates of regional VMT growth. As a result, a number of locations have, or are looking at, adopting new procedures for determining future background CO levels. For intersection modeling using MOBILE6, areas will need to change their "worst case" modeling receptors from intersection-based to a mid-block location. For mitigation, the traditional approach of increasing intersection capacity to achieve higher average speeds may result in overall emission increases.

3.6. MOBILE6 Impact on Screening-Level Procedure

Use of MOBILE6 has the likely potential to affect the screening assessment procedures for project-level analysis. This study has identified current efforts in revising screening-level procedures, as well as developing an approach for setting a threshold screening-level procedure. Also, this study has identified limitations in the applicability of the screening approach.

All of the state agencies interviewed base their screening assessment procedures on the transportation conformity rule which requires a project-level analysis for federally funded projects in CO nonattainment and maintenance areas. The conformity rule requires that a quantitative analysis, (e.g., using CAL3QHC) is required for projects: 1) in or affecting locations identified in the state implementation plan (SIP) as sites of potential or actual violations of the CO NAAQS, 2) affecting intersections that are at or will be at LOS[12] D or worse or 3) affecting intersections identified in the SIP as having the three highest volumes or three worst levels of service in the nonattainment or maintenance area. Most agencies use a modification of the LOS C screening approach (that is LOS C passes screening) which consists of LOS and traffic volume thresholds. Others use LOS C only. Several agencies are considering revising the procedure in light of MOBILE6, while three agencies are updating their screening procedures because of MOBILE6. In general, it is recommended that state agencies revisit their current screening procedures as MOBILE6 coupled with CAL3QHC does not yield the same results. Some of the key differences which may affect the current screening procedures include: speed curves exhibiting increased emissions following a low point around 30-35 mph, idle emission decreases and moving emission increases and a shift in worst case receptor concentration towards mid-block.

To examine the potential for CO air quality violations for project-level settings, an analysis was performed for a combination of levels of service D, E and F; two high volume, thee-lane approach intersection configurations; and a high volume, six-lane freeway for two speeds and

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[12] This refers to the classification of signalized intersection operations based on procedures in the Highway Capacity Manual. The ratings go from LOS A, with little delay, to LOS F, with an average delay over 80 s per vehicle.

two dispersion settings (urban and rural). The modeling was performed using the MOBILE6 emission factors for the years 2005, 2015, 2025 and 2035. MOBILE6 was applied using national default values to represent typical conditions.

Results suggest a limited potential for violations of the NAAQS at typical high volume locations in the near-term, and by 2015, the potential essentially disappears. However, both freeway and intersection scenarios show the potential for CO violations in 2005, assuming typical background concentrations. Also, modeling results suggest the potential for higher CO levels at a freeway operating at LOS E than at an intersection operating at LOS F. Thus, freeway scenarios should be examined, along with intersections, in setting a screening threshold assessment procedure. Results also show that, for intersections, the corner receptors no longer exhibit the highest concentration; the greatest concentrations are now typically found about 200 feet behind the front of the queue.

To more fully asses the applicability of this screening approach to the most extreme roadway settings, two additional roadway configurations were evaluated. The intersection was expanded to consist of two five-lane approaches, and the freeway was expanded to ten lanes. Results showed that nearly all of the predicted levels are below the CO NAAQS, with the exception of the near-term (2005 modeling runs) and in 2015, only locations in the very near freeway right-of-way.

Overall, this assessment found limited potential for the CO NAAQS violations for project-level studies under most typical conditions. In the past, LOS C has been widely used as a screening threshold to reduce the need for detailed modeling. Due to the changes from MOBILE 5 to MOBILE6, the relative role of cruise emissions has increased, while the idle emission factors have been substantially reduced. It appears likely that detailed modeling can be excluded for both intersection and freeway locations with LOS E or better under a wide variety of conditions, especially when looking beyond the near-term period (2015 or later).

The applicability of this screening approach is dependent on the circumstances of a given project and how closely they resemble the “normal” conditions. This analysis focused on applying a reasonable worst case condition that would capture the majority of real-world conditions. However, several exceptions can be noted: locations in very close proximity to very high volume freeways; locations with an extraordinary rate of start emissions, such as near a park and ride lot or CBD parking garage; a fleet much older than the national default age distribution; and locations with unusually high background concentrations. These type cases would need to be examined on a case-by-case basis. Nevertheless, it appears likely that the vast majority of typical projects will not require detailed modeling if the traffic analysis indicates that all signalized intersections and freeway sections will operate at LOS E or better.

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4. Recommendation of Best Practices

Based on the work done in this study, a set of general recommendations or best practices has been developed. These suggested practices represent the general consensus among current practitioners and results presented earlier in the study. These suggested practices should complement or enhance existing guidance for project-level analysis when using the MOBILE6 model.

4.1. Inputs to MOBILE6 Most Critical for Project-level Analysis

The practitioner should attempt to specify the local I/M program in with as many details as possible. Applicable details include: the model years for the program, the stringency level, waiver rate, compliance rate, inspection frequency, vehicle covered and type of test. Where multiple I/M programs exist within a local area (e.g., multiple state programs), the practitioners should attempt to estimate the fraction of vehicles participating in each program at the location of the project-level analysis and develop a weighted emission rate.

Information should be developed specific to the local fleet age distribution and mileage accumulation (i.e., the local registration distribution data), as this data may have significant changes in the emission rate. If the registration data is not representative of what the on-road fraction is at the project location, adjustments should be made for the outside fleet through local surveys.

It is recommended that the practitioner coordinate with other agencies involved early in the process of air quality assessment. In particular, coordination should be made with the department of motor vehicle registration for local registration data and the air quality management agency to ensure consistency with the state implementation plan.

4.2. Recommendations on Local Screening-Level Assessment Procedures

Before applying the CAL3QHC model in a screening-level analysis, it is recommended that the agency review the current procedures to assure that the project is assessing the potential worst case conditions. This may be accomplished by following these procedures:

- Closely examine the speed assumptions in the screening procedure in light of the changes in MOBILE6 due to minimum emission rates at 30-35 mph for speed curves, much lower idle emission rates and increased moving emission rates.
- If the project includes a roadway segment (e.g., freeway) and an intersection setting, examine both, as the freeway setting may show higher concentrations than the intersection.
- In applying the intersection model, place receptors at mid-block locations away from the corners of the intersection, as these are more likely to show the highest concentrations.
- Strongly consider estimating the future background concentration based on an estimate of the regional VMT growth and MOBILE6 emission factor for the future year and then scaling from the current background concentration.

4.3. Recommendations on Exceptions to Screening-Level Assessment

For certain project-level settings it may be necessary to examine the use of MOBILE6 default assumptions or general model input procedures. The practitioner should consider the following questions when deciding on the appropriateness of the default or general model inputs:

- Will the project setting experience a higher than typical start fraction? Is the projected location in the nearby vicinity of parking garage(s), regional shopping center(s) or large park-and-ride lot(s) for public transportation? If so, consider adjusting the MOBILE6 model inputs to characterize these higher emission rates.
- Consider adjustments for project settings where the local fleet is suspected of being much older and/or having a higher proportion of light-duty vehicles than the proposed registration distribution.

4.4. Revisiting current mitigation strategies

It is recommended that historical strategies for CO mitigation be revisited in light of the changes with MOBILE6. In particular, the practitioner should consider the applicability of

- Increasing the roadway capacity to achieve higher speeds. With the use of MOBILE6, this may lead to increased overall emission rates at the intersection and increased concentrations.
- Optimizing the signal cycle timing. With the use of MOBILE6, this may have negative impacts on air quality if speeds are increased and the moving emissions are the dominant contributor to the maximum concentration.

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Appendices

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Appendix A:
MOBILE5 versus MOBILE6 Comparison Tables

Table A.1.1. 2005 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

Base Case with Inspection and Maintenance Program

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	-56.83%	-56.67%	-56.58%	-56.58%	-56.68%	-56.85%	-57.07%	-56.45%	-53.86%	-50.86%
3.4	-54.29%	-54.13%	-54.08%	-54.16%	-54.41%	-54.83%	-55.41%	-55.24%	-52.91%	-49.93%
7.1	-45.42%	-45.25%	-45.34%	-45.73%	-46.49%	-47.75%	-49.50%	-50.73%	-49.10%	-46.01%
12.1	-35.29%	-35.12%	-35.33%	-36.03%	-37.29%	-39.37%	-42.26%	-44.73%	-43.49%	-40.02%
19.5	-23.97%	-23.78%	-24.12%	-25.11%	-26.88%	-29.80%	-33.87%	-37.65%	-36.83%	-33.01%
35.9	46.40%	46.43%	45.34%	42.90%	38.80%	32.34%	23.54%	16.03%	18.90%	27.27%

Table A.1.2. 2005 Carbon Monoxide Composite Emission Factor for Mobile 5b at Different Ambient Temperatures and Average Speeds

Base Case with Inspection and Maintenance Program

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	521.95	461.54	408.01	360.41	317.89	284.12	256.88	231.11	227.36	242.69
3.4	160.45	141.98	125.60	111.04	98.03	87.70	79.36	71.47	70.36	75.13
7.1	90.65	80.30	71.12	62.96	55.67	49.88	45.20	40.78	40.18	42.92
12.1	63.22	55.98	49.57	43.87	38.77	34.73	31.46	28.37	27.94	29.83
19.5	48.02	42.48	37.57	33.20	29.29	26.19	23.69	21.33	20.98	22.38
35.9	23.68	20.96	18.55	16.41	14.50	12.98	11.75	10.59	10.42	11.12

Table A.1.3. 2005 Carbon Monoxide Composite Emission Factor for Mobile 6 at Different Ambient Temperatures and Average Speeds

Base Case with Inspection and Maintenance Program.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	225.32	199.99	177.15	156.49	137.72	122.61	110.27	100.64	104.91	119.26
3.4	73.34	65.13	57.68	50.90	44.69	39.61	35.38	31.99	33.13	37.62
7.1	49.47	43.96	38.88	34.17	29.79	26.06	22.83	20.09	20.45	23.17
12.1	40.91	36.32	32.06	28.06	24.31	21.05	18.16	15.68	15.79	17.89
19.5	36.51	32.37	28.50	24.86	21.42	18.39	15.67	13.30	13.25	14.99
35.9	34.67	30.70	26.97	23.45	20.12	17.17	14.51	12.28	12.39	14.16

Table A.1.4. 2035 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

Base Case with Inspection and Maintenance Program.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	-79.50%	-79.30%	-79.18%	-79.14%	-79.20%	-79.37%	-79.63%	-79.68%	-78.85%	-77.65%
3.4	-77.90%	-77.70%	-77.61%	-77.64%	-77.81%	-78.14%	-78.62%	-78.95%	-78.25%	-77.02%
7.1	-72.39%	-72.21%	-72.23%	-72.47%	-72.98%	-73.86%	-75.08%	-76.25%	-75.90%	-74.52%
12.1	-66.81%	-66.64%	-66.75%	-67.18%	-68.01%	-69.40%	-71.33%	-73.28%	-73.21%	-71.62%
19.5	-61.01%	-60.83%	-61.00%	-61.61%	-62.74%	-64.63%	-67.26%	-70.20%	-70.86%	-69.41%
35.9	-21.52%	-21.28%	-21.80%	-23.24%	-25.81%	-29.97%	-35.69%	-42.29%	-44.41%	-41.99%

Table A.1.5. 2035 Carbon Monoxide Composite Emission Factor for Mobile 5b at Different Ambient Temperatures and Average Speeds

Base Case with Inspection and Maintenance Program.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	483.35	426.72	376.78	332.59	293.33	262.51	237.97	214.83	211.53	224.95
3.4	149.80	132.34	116.94	103.31	91.20	81.69	74.12	66.98	65.98	70.16
7.1	85.67	75.77	67.04	59.31	52.44	47.05	42.76	38.71	38.16	40.55
12.1	60.48	53.48	47.31	41.85	36.99	33.18	30.15	27.29	26.89	28.58
19.5	46.51	41.09	36.31	32.08	28.32	25.37	23.02	20.81	20.49	21.77
35.9	22.12	19.55	17.29	15.28	13.50	12.10	10.98	9.93	9.78	10.39

Table A.1.6. 2035 Carbon Monoxide Composite Emission Factor for Mobile 6 at Different Ambient Temperatures and Average Speeds

Base Case with Inspection and Maintenance Program.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	99.09	88.33	78.46	69.38	61.00	54.15	48.48	43.65	44.74	50.27
3.4	33.11	29.51	26.18	23.10	20.24	17.86	15.85	14.10	14.35	16.12
7.1	23.65	21.05	18.62	16.33	14.17	12.30	10.66	9.19	9.20	10.33
12.1	20.07	17.84	15.73	13.73	11.83	10.15	8.65	7.29	7.21	8.11
19.5	18.14	16.10	14.16	12.32	10.55	8.97	7.54	6.20	5.97	6.66
35.9	17.36	15.39	13.52	11.73	10.01	8.47	7.06	5.73	5.44	6.03

Table A.2.1. 2005 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

Without Inspection and Maintenance Program.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	-55.52%	-55.38%	-55.31%	-55.33%	-55.45%	-55.62%	-55.83%	-55.19%	-52.59%	-49.60%
3.4	-53.11%	-52.97%	-52.93%	-53.03%	-53.29%	-53.69%	-54.22%	-53.99%	-51.63%	-48.65%
7.1	-44.81%	-44.65%	-44.74%	-45.12%	-45.84%	-47.01%	-48.62%	-49.67%	-47.95%	-44.87%
12.1	-35.32%	-35.16%	-35.36%	-36.01%	-37.19%	-39.12%	-41.77%	-43.96%	-42.60%	-39.19%
19.5	-24.76%	-24.57%	-24.88%	-25.79%	-27.44%	-30.13%	-33.87%	-37.36%	-36.65%	-33.16%
35.9	44.08%	44.15%	43.17%	40.92%	37.13%	31.17%	23.10%	16.05%	18.43%	25.96%

Table A.2.2. 2005 Carbon Monoxide Composite Emission Factor for Mobile 5b at Different Ambient Temperatures and Average Speeds

Without Inspection and Maintenance Program.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	570.12	504.02	445.60	393.76	347.58	311.15	281.99	254.45	250.75	267.57
3.4	175.10	154.89	137.03	121.18	107.06	95.91	86.99	78.57	77.47	82.69
7.1	98.86	87.53	77.52	68.64	60.72	54.47	49.47	44.75	44.16	47.15
12.1	68.98	61.06	54.06	47.85	42.32	37.95	34.45	31.15	30.73	32.80
19.5	52.46	46.39	41.03	36.26	32.02	28.68	26.00	23.47	23.13	24.67
35.9	25.85	22.87	20.24	17.91	15.83	14.19	12.87	11.63	11.47	12.24

Table A.2.3. 2005 Carbon Monoxide Composite Emission Factor for Mobile 6 at Different Ambient Temperatures and Average Speeds

Without Inspection and Maintenance Program.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	253.60	224.90	199.12	175.88	154.86	138.09	124.56	114.02	118.89	134.85
3.4	82.10	72.85	64.49	56.91	50.01	44.42	39.82	36.15	37.47	42.46
7.1	54.56	48.45	42.84	37.67	32.89	28.87	25.42	22.52	22.99	25.99
12.1	44.61	39.59	34.94	30.62	26.58	23.11	20.06	17.46	17.64	19.95
19.5	39.47	34.99	30.82	26.91	23.24	20.04	17.19	14.70	14.65	16.49
35.9	37.24	32.97	28.98	25.23	21.70	18.61	15.84	13.50	13.58	15.41

Table A.2.4. 2035 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

Without Inspection and Maintenance Program.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	-76.34%	-76.10%	-75.94%	-75.86%	-75.87%	-75.95%	-76.08%	-75.91%	-74.74%	-73.29%
3.4	-74.82%	-74.59%	-74.45%	-74.43%	-74.54%	-74.77%	-75.10%	-75.17%	-74.12%	-72.65%
7.1	-69.58%	-69.35%	-69.30%	-69.47%	-69.88%	-70.59%	-71.60%	-72.42%	-71.68%	-70.07%
12.1	-64.24%	-64.01%	-64.03%	-64.35%	-65.04%	-66.21%	-67.83%	-69.35%	-68.86%	-67.06%
19.5	-58.68%	-58.43%	-58.50%	-58.96%	-59.90%	-61.51%	-63.75%	-66.26%	-66.71%	-65.29%
35.9	-17.66%	-17.25%	-17.55%	-18.69%	-20.85%	-24.41%	-29.34%	-35.05%	-36.72%	-34.36%

Table A.2.5. 2035 Carbon Monoxide Composite Emission Factor for Mobile 5b at Different Ambient Temperatures and Average Speeds

Without Inspection and Maintenance Program.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	531.99	469.56	414.62	366.12	323.14	289.61	263.11	238.17	234.92	249.82
3.4	164.76	145.51	128.58	113.62	100.36	90.02	81.85	74.16	73.17	77.81
7.1	94.12	83.21	73.61	65.14	57.62	51.76	47.13	42.77	42.22	44.87
12.1	66.45	58.74	51.96	45.97	40.66	36.51	33.24	30.16	29.76	31.63
19.5	51.16	45.18	39.93	35.28	31.17	27.96	25.42	23.03	22.72	24.14
35.9	24.31	21.48	18.99	16.79	14.84	13.31	12.11	10.98	10.83	11.51

Table A.2.6. 2035 Carbon Monoxide Composite Emission Factor for Mobile 6 at Different Ambient Temperatures and Average Speeds

Without Inspection and Maintenance Program.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	125.88	112.20	99.75	88.38	77.97	69.65	62.93	57.39	59.35	66.73
3.4	41.49	36.98	32.85	29.05	25.56	22.72	20.38	18.42	18.94	21.28
7.1	28.64	25.50	22.60	19.89	17.36	15.22	13.39	11.80	11.95	13.43
12.1	23.77	21.14	18.69	16.39	14.21	12.34	10.69	9.24	9.27	10.42
19.5	21.14	18.78	16.57	14.48	12.50	10.76	9.22	7.77	7.56	8.38
35.9	20.02	17.77	15.66	13.65	11.74	10.06	8.56	7.13	6.85	7.55

Table A.3.1. 2005 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

3-Years-Newer Average Age Fleet Distribution for Light-duty Vehicles and Trucks.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	-55.81%	-55.63%	-55.53%	-55.50%	-55.56%	-55.66%	-55.80%	-55.09%	-52.41%	-49.38%
3.4	-52.86%	-52.69%	-52.63%	-52.71%	-52.94%	-53.33%	-53.87%	-53.67%	-51.29%	-48.26%
7.1	-42.66%	-42.51%	-42.62%	-43.05%	-43.88%	-45.22%	-47.08%	-48.47%	-46.90%	-43.74%
12.1	-31.34%	-31.21%	-31.49%	-32.27%	-33.67%	-35.93%	-39.07%	-41.90%	-40.83%	-37.29%
19.5	-18.89%	-18.75%	-19.18%	-20.30%	-22.26%	-25.47%	-29.93%	-34.27%	-33.75%	-29.87%
35.9	57.15%	57.04%	55.71%	52.91%	48.31%	41.14%	31.37%	22.44%	24.42%	32.79%

Table A.3.2. 2005 Carbon Monoxide Composite Emission Factors for Mobile 5b at Different Ambient Temperatures and Average Speeds

3-Years-Newer Average Age Fleet Distribution for Light-duty Vehicles and Trucks.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	411.60	364.23	322.05	284.31	250.39	223.06	200.66	179.35	175.72	187.60
3.4	126.85	112.34	99.41	87.85	77.45	69.08	62.21	55.67	54.59	58.31
7.1	71.94	63.79	56.53	50.04	44.20	39.49	35.63	31.96	31.37	33.52
12.1	50.24	44.54	39.46	34.91	30.82	27.53	24.83	22.25	21.84	23.32
19.5	38.16	33.79	29.89	26.40	23.27	20.74	18.67	16.70	16.36	17.46
35.9	18.75	16.61	14.71	13.00	11.47	10.24	9.23	8.27	8.11	8.66

Table A.3.3. 2005 Carbon Monoxide Composite Emission Factors for Mobile 6 at Different Ambient Temperatures and Average Speeds

3-Years-Newer Average Age Fleet Distribution for Light-duty Vehicles and Trucks.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	181.90	161.60	143.22	126.52	111.28	98.90	88.69	80.55	83.63	94.97
3.4	59.79	53.15	47.09	41.54	36.45	32.24	28.69	25.79	26.59	30.17
7.1	41.25	36.68	32.44	28.49	24.81	21.63	18.85	16.47	16.66	18.86
12.1	34.49	30.64	27.03	23.64	20.45	17.64	15.13	12.93	12.92	14.63
19.5	30.95	27.45	24.16	21.04	18.09	15.46	13.08	10.98	10.84	12.24
35.9	29.46	26.08	22.90	19.89	17.02	14.45	12.12	10.12	10.09	11.49

Table A.3.4. 2035 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

3-Years-Newer Average Age Fleet Distribution for Light-duty Vehicles and Trucks.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	-78.55%	-78.35%	-78.23%	-78.20%	-78.25%	-78.40%	-78.62%	-78.63%	-77.73%	-76.46%
3.4	-76.73%	-76.55%	-76.47%	-76.51%	-76.68%	-77.02%	-77.50%	-77.81%	-77.05%	-75.74%
7.1	-70.54%	-70.39%	-70.44%	-70.73%	-71.29%	-72.24%	-73.55%	-74.83%	-74.47%	-72.98%
12.1	-64.29%	-64.16%	-64.32%	-64.83%	-65.75%	-67.27%	-69.37%	-71.55%	-71.55%	-69.85%
19.5	-57.78%	-57.64%	-57.89%	-58.59%	-59.86%	-61.93%	-64.82%	-68.11%	-68.92%	-67.37%
35.9	-15.03%	-14.90%	-15.58%	-17.26%	-20.12%	-24.71%	-31.02%	-38.43%	-40.94%	-38.36%

Table A.3.5. 2035 Carbon Monoxide Composite Emission Factors for Mobile 5b at Different Ambient Temperatures and Average Speeds

3-Years-Newer Average Age Fleet Distribution for Light-duty Vehicles and Trucks.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	385.09	340.26	300.49	265.04	233.32	207.98	187.40	167.87	164.46	174.84
3.4	119.50	105.67	93.39	82.46	72.67	64.85	58.50	52.47	51.44	54.67
7.1	68.48	60.63	53.67	47.47	41.91	37.47	33.87	30.45	29.88	31.74
12.1	48.33	42.79	37.87	33.48	29.55	26.42	23.87	21.46	21.05	22.35
19.5	37.11	32.82	29.01	25.62	22.58	20.15	18.18	16.31	15.98	16.97
35.9	17.68	15.65	13.84	12.23	10.78	9.63	8.69	7.81	7.65	8.13

Table A.3.6. 2035 Carbon Monoxide Composite Emission Factors for Mobile 6 at Different Ambient Temperatures and Average Speeds

3-Years-Newer Average Age Fleet Distribution for Light-duty Vehicles and Trucks.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	82.62	73.66	65.41	57.79	50.74	44.93	40.06	35.87	36.63	41.16
3.4	27.80	24.78	21.98	19.37	16.94	14.90	13.16	11.64	11.80	13.26
7.1	20.17	17.95	15.86	13.90	12.03	10.40	8.96	7.67	7.63	8.58
12.1	17.26	15.33	13.51	11.78	10.12	8.65	7.31	6.11	5.99	6.74
19.5	15.67	13.90	12.22	10.61	9.06	7.67	6.40	5.20	4.97	5.54
35.9	15.03	13.32	11.68	10.12	8.61	7.25	6.00	4.81	4.52	5.01

Table A.4.1. 2005 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

3-Years-Older Average Age Fleet Distribution for Light-duty Vehicles and Trucks.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	-56.25%	-56.09%	-56.00%	-56.01%	-56.12%	-56.33%	-56.63%	-56.11%	-53.66%	-50.73%
3.4	-53.81%	-53.64%	-53.59%	-53.68%	-53.93%	-54.39%	-55.03%	-54.95%	-52.76%	-49.85%
7.1	-45.25%	-45.06%	-45.12%	-45.50%	-46.25%	-47.52%	-49.31%	-50.61%	-49.15%	-46.17%
12.1	-35.16%	-34.95%	-35.13%	-35.79%	-37.03%	-39.11%	-42.01%	-44.55%	-43.53%	-40.22%
19.5	-23.70%	-23.45%	-23.74%	-24.68%	-26.40%	-29.31%	-33.38%	-37.27%	-36.76%	-33.19%
35.9	45.30%	45.45%	44.50%	42.20%	38.25%	31.93%	23.26%	15.55%	17.55%	25.19%

Table A.4.2. 2005 Carbon Monoxide Composite Emission Factors for Mobile 5b at Different Ambient Temperatures and Average Speeds

3-Years-Older Average Age Fleet Distribution for Light-duty Vehicles and Trucks.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	623.42	551.04	487.04	430.25	379.65	339.70	307.70	277.48	273.39	291.83
3.4	191.12	169.03	149.50	132.16	116.72	104.52	94.75	85.52	84.31	90.02
7.1	107.50	95.17	84.26	74.57	65.94	59.13	53.67	48.52	47.87	51.13
12.1	74.75	66.15	58.55	51.81	45.79	41.05	37.25	33.65	33.19	35.44
19.5	56.66	50.09	44.28	39.12	34.53	30.91	28.01	25.26	24.89	26.56
35.9	28.21	24.96	22.08	19.53	17.25	15.46	14.02	12.66	12.48	13.32

Table A.4.3. 2005 Carbon Monoxide Composite Emission Factors for Mobile 6 at Different Ambient Temperatures and Average Speeds

3-Years-Older Average Age Fleet Distribution for Light-duty Vehicles and Trucks.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	272.73	241.97	214.28	189.26	166.58	148.33	133.46	121.78	126.69	143.79
3.4	88.28	78.37	69.39	61.22	53.77	47.67	42.61	38.53	39.82	45.14
7.1	58.86	52.29	46.24	40.64	35.45	31.03	27.21	23.96	24.34	27.52
12.1	48.47	43.04	37.98	33.26	28.84	25.00	21.60	18.66	18.75	21.19
19.5	43.23	38.34	33.77	29.47	25.42	21.85	18.66	15.85	15.74	17.74
35.9	40.99	36.30	31.91	27.77	23.85	20.39	17.28	14.63	14.67	16.68

Table A.4.4. 2035 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

3-Years-Older Average Age Fleet Distribution for Light-duty Vehicles and Trucks.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	-80.32%	-80.11%	-79.99%	-79.95%	-80.03%	-80.21%	-80.50%	-80.60%	-79.84%	-78.69%
3.4	-78.79%	-78.59%	-78.49%	-78.52%	-78.69%	-79.03%	-79.54%	-79.89%	-79.25%	-78.08%
7.1	-73.57%	-73.37%	-73.37%	-73.59%	-74.08%	-74.94%	-76.14%	-77.30%	-77.01%	-75.71%
12.1	-68.27%	-68.08%	-68.16%	-68.56%	-69.35%	-70.69%	-72.56%	-74.46%	-74.43%	-72.94%
19.5	-62.78%	-62.57%	-62.71%	-63.28%	-64.36%	-66.18%	-68.72%	-71.54%	-72.19%	-70.82%
35.9	-25.03%	-24.72%	-25.17%	-26.50%	-28.94%	-32.94%	-38.45%	-44.79%	-46.84%	-44.56%

Table A.4.5. 2035 Carbon Monoxide Composite Emission Factor for Mobile 5b at Different Ambient Temperatures and Average Speeds

3-Years-Older Average Age Fleet Distribution for Light-duty Vehicles and Trucks.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	566.25	499.63	441.08	389.48	343.82	308.35	280.46	254.24	251.02	266.99
3.4	175.38	154.84	136.79	120.87	106.79	95.86	87.25	79.17	78.19	83.16
7.1	100.18	88.55	78.32	69.30	61.31	55.11	50.24	45.65	45.11	47.95
12.1	70.72	62.50	55.27	48.90	43.26	38.87	35.43	32.19	31.80	33.80
19.5	54.43	48.06	42.46	37.52	33.15	29.76	27.09	24.58	24.27	25.80
35.9	25.86	22.84	20.19	17.85	15.78	14.17	12.90	11.71	11.57	12.29

Table A.4.6. 2035 Carbon Monoxide Composite Emission Factors for Mobile 6 at Different Ambient Temperatures and Average Speeds

3-Years-Older Average Age Fleet Distribution for Light-duty Vehicles and Trucks.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	111.45	99.36	88.27	78.08	68.68	61.02	54.68	49.31	50.61	56.89
3.4	37.19	33.15	29.42	25.96	22.76	20.10	17.86	15.92	16.22	18.23
7.1	26.48	23.58	20.86	18.30	15.89	13.81	11.99	10.36	10.37	11.65
12.1	22.44	19.95	17.60	15.37	13.26	11.39	9.72	8.22	8.13	9.15
19.5	20.26	17.99	15.83	13.78	11.82	10.07	8.47	7.00	6.75	7.53
35.9	19.39	17.19	15.11	13.12	11.21	9.50	7.94	6.47	6.15	6.82

Table A.5.1. 2005 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

30% Decrease in Light-duty Vehicles VMT Fraction.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	-56.89%	-56.69%	-56.57%	-56.53%	-56.57%	-56.67%	-56.81%	-56.32%	-54.23%	-51.73%
3.4	-54.49%	-54.29%	-54.21%	-54.25%	-54.45%	-54.79%	-55.26%	-55.20%	-53.35%	-50.87%
7.1	-46.16%	-45.97%	-46.02%	-46.37%	-47.05%	-48.18%	-49.75%	-50.98%	-49.77%	-47.19%
12.1	-36.46%	-36.26%	-36.43%	-37.05%	-38.20%	-40.10%	-42.72%	-45.09%	-44.22%	-41.29%
19.5	-25.49%	-25.25%	-25.51%	-26.38%	-27.98%	-30.65%	-34.36%	-37.94%	-37.45%	-34.18%
35.9	40.61%	40.66%	39.67%	37.41%	33.61%	27.69%	19.65%	12.57%	14.72%	21.85%

Table A.5.2. 2005 Carbon Monoxide Composite Emission Factors for Mobile 5b at Different Ambient Temperatures and Average Speeds

30% Decrease in Light-duty Vehicles VMT Fraction.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	531.47	469.94	415.52	367.19	324.08	289.77	262.03	235.83	232.10	248.11
3.4	163.82	144.99	128.33	113.54	100.34	89.83	81.33	73.31	72.21	77.23
7.1	93.20	82.61	73.24	64.92	57.49	51.58	46.80	42.28	41.70	44.61
12.1	65.03	57.62	51.07	45.24	40.05	35.91	32.56	29.40	28.98	30.99
19.5	49.26	43.58	38.56	34.09	30.11	26.94	24.38	21.95	21.61	23.08
35.9	24.68	21.85	19.35	17.13	15.15	13.57	12.30	11.09	10.93	11.68

Table A.5.3. 2005 Carbon Monoxide Composite Emission Factors for Mobile 6 at Different Ambient Temperatures and Average Speeds

30% Decrease in Light-duty Vehicles VMT Fraction.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	229.13	203.51	180.45	159.62	140.74	125.55	113.17	103.01	106.24	119.75
3.4	74.56	66.28	58.77	51.94	45.71	40.61	36.39	32.84	33.69	37.94
7.1	50.18	44.63	39.53	34.82	30.44	26.72	23.51	20.72	20.94	23.56
12.1	41.32	36.73	32.46	28.48	24.75	21.51	18.65	16.15	16.17	18.20
19.5	36.71	32.58	28.72	25.10	21.68	18.68	16.00	13.62	13.52	15.19
35.9	34.70	30.74	27.03	23.54	20.24	17.33	14.71	12.49	12.54	14.23

Table A.5.4. 2035 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

30% Decrease in Light-duty Vehicles VMT Fraction.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	-79.65%	-79.42%	-79.26%	-79.18%	-79.20%	-79.31%	-79.48%	-79.49%	-78.71%	-77.59%
3.4	-78.17%	-77.94%	-77.82%	-77.81%	-77.93%	-78.19%	-78.58%	-78.85%	-78.18%	-77.03%
7.1	-73.04%	-72.84%	-72.82%	-73.01%	-73.46%	-74.23%	-75.32%	-76.36%	-75.98%	-74.66%
12.1	-67.77%	-67.57%	-67.63%	-68.00%	-68.74%	-69.98%	-71.71%	-73.45%	-73.29%	-71.74%
19.5	-62.22%	-61.99%	-62.10%	-62.61%	-63.61%	-65.31%	-67.67%	-70.32%	-70.83%	-69.38%
35.9	-25.28%	-24.96%	-25.35%	-26.60%	-28.87%	-32.59%	-37.71%	-43.63%	-45.38%	-43.03%

Table A.5.5. 2035 Carbon Monoxide Composite Emission Factors for Mobile 5b at Different Ambient Temperatures and Average Speeds

30% Decrease in Light-duty Vehicles VMT Fraction.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	488.10	430.56	379.91	335.15	295.44	264.19	239.23	215.72	212.22	225.69
3.4	151.88	134.10	118.45	104.62	92.34	82.68	74.97	67.70	66.64	70.86
7.1	87.56	77.44	68.53	60.64	53.65	48.14	43.75	39.61	39.02	41.46
12.1	61.94	54.77	48.46	42.87	37.91	34.01	30.90	27.97	27.54	29.26
19.5	47.59	42.03	37.12	32.79	28.95	25.92	23.50	21.23	20.89	22.19
35.9	22.98	20.30	17.95	15.86	14.01	12.56	11.40	10.30	10.14	10.77

Table A.5.6. 2035 Carbon Monoxide Composite Emission Factors for Mobile 6 at Different Ambient Temperatures and Average Speeds

30% Decrease in Light-duty Vehicles VMT Fraction.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	99.31	88.60	78.79	69.76	61.44	54.67	49.09	44.24	45.18	50.57
3.4	33.16	29.58	26.28	23.22	20.38	18.03	16.06	14.32	14.54	16.27
7.1	23.61	21.04	18.63	16.37	14.24	12.40	10.80	9.37	9.37	10.51
12.1	19.96	17.76	15.69	13.72	11.85	10.21	8.74	7.43	7.36	8.27
19.5	17.98	15.97	14.07	12.26	10.53	8.99	7.60	6.30	6.09	6.79
35.9	17.17	15.24	13.40	11.64	9.97	8.47	7.10	5.81	5.54	6.14

Table A.6.1. 2005 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

30% Increase in Light-duty Vehicles VMT Fraction.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	-56.82%	-56.69%	-56.64%	-56.68%	-56.82%	-57.07%	-57.39%	-56.63%	-53.51%	-50.00%
3.4	-54.14%	-54.00%	-53.98%	-54.11%	-54.41%	-54.92%	-55.61%	-55.32%	-52.48%	-48.97%
7.1	-44.68%	-44.53%	-44.65%	-45.09%	-45.92%	-47.31%	-49.25%	-50.47%	-48.40%	-44.76%
12.1	-34.08%	-33.93%	-34.19%	-34.96%	-36.33%	-38.61%	-41.78%	-44.35%	-42.71%	-38.67%
19.5	-22.41%	-22.27%	-22.69%	-23.79%	-25.72%	-28.92%	-33.37%	-37.34%	-36.17%	-31.78%
35.9	52.64%	52.66%	51.48%	48.86%	44.48%	37.46%	27.82%	19.86%	23.52%	33.28%

Table A.6.2. 2005 Carbon Monoxide Composite Emission Factors for Mobile 5b at Different Ambient Temperatures and Average Speeds

30% Increase in Light-duty Vehicles VMT Fraction.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	512.90	453.52	400.83	353.90	311.92	278.65	251.89	226.51	222.74	237.41
3.4	157.22	139.07	122.96	108.62	95.78	85.61	77.43	69.67	68.53	73.06
7.1	88.15	78.02	69.03	61.02	53.86	48.18	43.61	39.28	38.66	41.22
12.1	61.42	54.36	48.08	42.50	37.50	33.54	30.35	27.33	26.89	28.67
19.5	46.79	41.38	36.58	32.30	28.48	25.45	23.01	20.70	20.35	21.68
35.9	22.70	20.08	17.76	15.69	13.84	12.38	11.20	10.08	9.91	10.57

Table A.6.3. 2005 Carbon Monoxide Composite Emission Factors for Mobile 6 at Different Ambient Temperatures and Average Speeds

30% Increase in Light-duty Vehicles VMT Fraction.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	221.48	196.43	173.82	153.32	134.68	119.64	107.33	98.24	103.55	118.72
3.4	72.10	63.97	56.58	49.84	43.67	38.60	34.37	31.13	32.56	37.28
7.1	48.76	43.28	38.21	33.51	29.13	25.39	22.13	19.46	19.95	22.77
12.1	40.49	35.91	31.64	27.64	23.88	20.59	17.67	15.21	15.41	17.58
19.5	36.31	32.17	28.28	24.62	21.15	18.09	15.33	12.97	12.99	14.79
35.9	34.65	30.65	26.90	23.36	20.00	17.01	14.31	12.08	12.25	14.08

Table A.6.4. 2035 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

30% Increase in Light-duty Vehicles VMT Fraction.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	-79.28%	-79.12%	-79.03%	-79.04%	-79.15%	-79.39%	-79.73%	-79.83%	-78.95%	-77.66%
3.4	-77.55%	-77.39%	-77.33%	-77.40%	-77.63%	-78.03%	-78.61%	-79.00%	-78.27%	-76.95%
7.1	-71.64%	-71.49%	-71.54%	-71.84%	-72.42%	-73.41%	-74.79%	-76.10%	-75.77%	-74.32%
12.1	-65.71%	-65.58%	-65.74%	-66.25%	-67.18%	-68.73%	-70.87%	-73.05%	-73.08%	-71.44%
19.5	-59.62%	-59.50%	-59.75%	-60.47%	-61.75%	-63.85%	-66.76%	-70.01%	-70.85%	-69.38%
35.9	-17.21%	-17.07%	-17.74%	-19.41%	-22.30%	-26.96%	-33.36%	-40.74%	-43.25%	-40.77%

Table A.6.5. 2035 Carbon Monoxide Composite Emission Factors for Mobile 5b at Different Ambient Temperatures and Average Speeds

30% Increase in Light-duty Vehicles VMT Fraction.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	477.09	421.58	372.55	329.08	290.40	260.12	236.09	213.39	210.32	223.62
3.4	147.26	130.18	115.09	101.71	89.80	80.49	73.09	66.11	65.17	69.28
7.1	83.54	73.91	65.39	57.84	51.12	45.86	41.69	37.74	37.22	39.56
12.1	58.85	52.06	46.05	40.73	36.00	32.29	29.35	26.57	26.20	27.84
19.5	45.31	40.06	35.42	31.30	27.64	24.77	22.50	20.35	20.05	21.31
35.9	21.21	18.75	16.58	14.66	12.95	11.61	10.55	9.54	9.41	10.00

Table A.6.6. 2035 Carbon Monoxide Composite Emission Factors for Mobile 6 at Different Ambient Temperatures and Average Speeds

30% Increase in Light-duty Vehicles VMT Fraction.

	Temperature in Degree F									
Speed(mph)	0	10	20	30	40	50	60	70	80	90
Idle	98.85	88.05	78.13	68.99	60.55	53.62	47.87	43.05	44.28	49.95
3.4	33.06	29.44	26.09	22.98	20.09	17.68	15.63	13.88	14.16	15.97
7.1	23.70	21.07	18.61	16.29	14.10	12.19	10.51	9.02	9.02	10.16
12.1	20.18	17.92	15.78	13.75	11.81	10.10	8.55	7.16	7.05	7.95
19.5	18.30	16.22	14.25	12.37	10.57	8.95	7.48	6.10	5.85	6.53
35.9	17.56	15.55	13.64	11.81	10.06	8.48	7.03	5.66	5.34	5.92

Figure A.1.1. 2005 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

Base Case with I/M Program

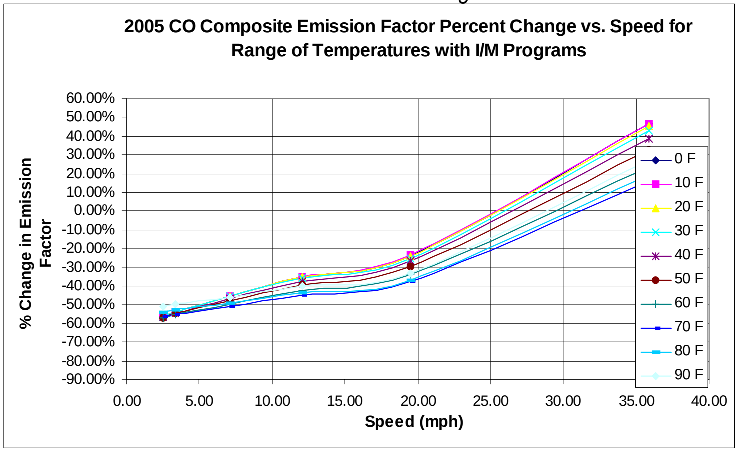

Figure A.1.2. 2005 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 5b at Different Ambient Temperatures and Average Speeds

Base Case with I/M Program

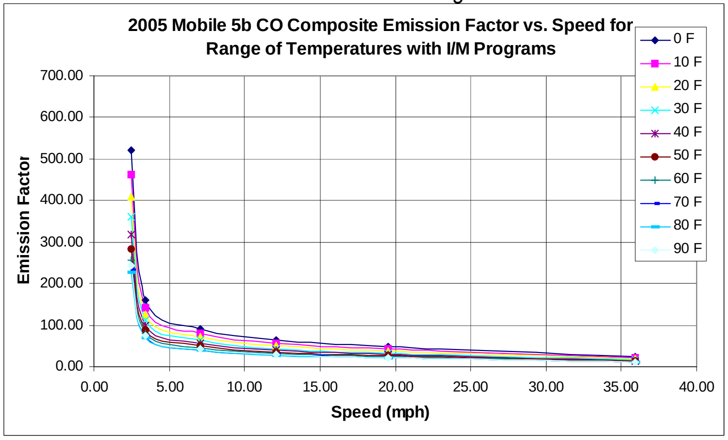

Figure A.1.3. 2005 Carbon Monoxide Composite Emission Factor for Mobile 6 (g/mi) at Different Ambient Temperatures and Average Speeds. Base Case with I/M Program

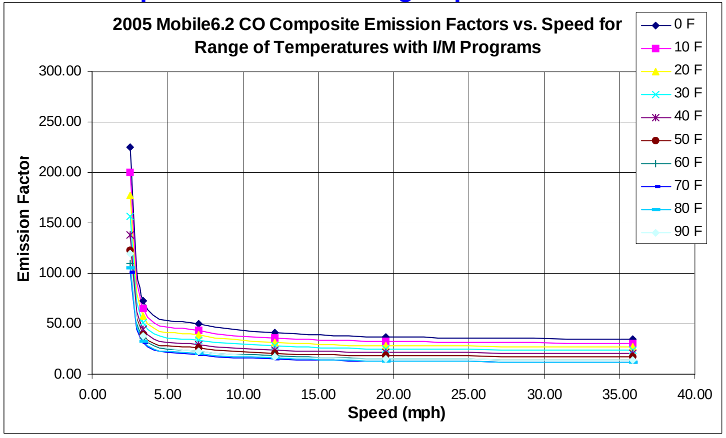

Figure A.1.4. 2035 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

Base Case with I/M Program.=

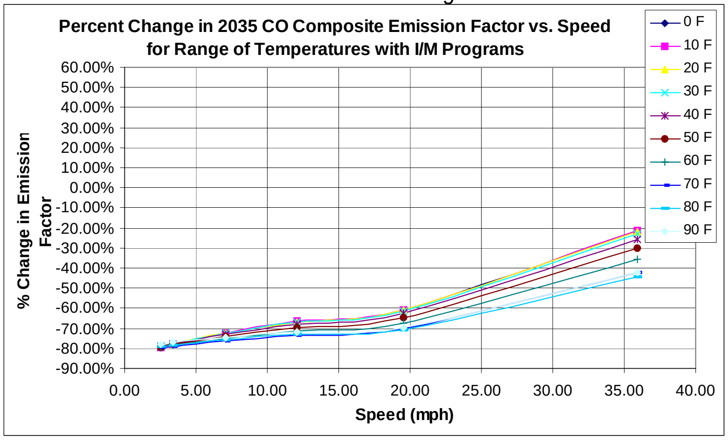

Figure A.1.5. 2035 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 5b at Different Ambient Temperatures and Average Speeds

Base Case with I/M Program

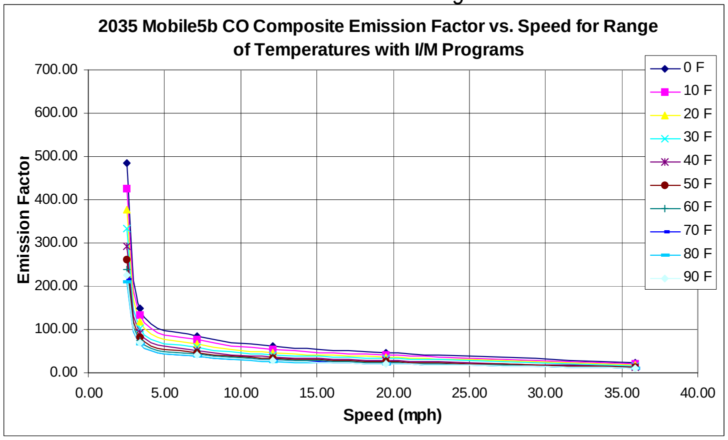

Figure A.1.6. 2035 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 6 at Different Ambient Temperatures and Average Speeds

Base Case with I/MProgram

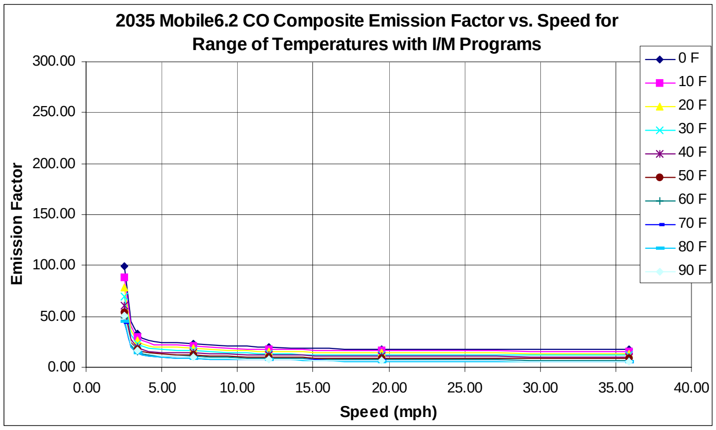

Figure A.2.1. 2005 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

Without I/M Program.

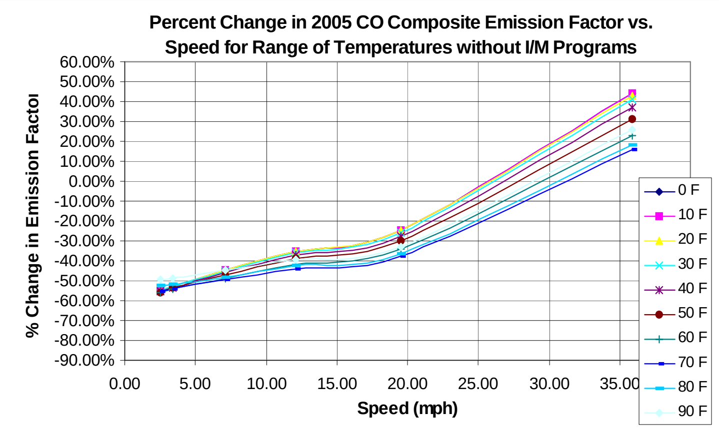

Figure A.2.2. 2005 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 5b at Different Ambient Temperatures and Average Speeds

Without I/M Program.

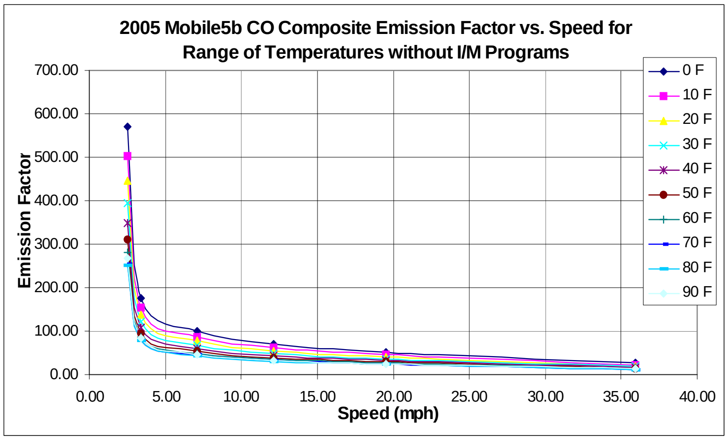

Figure A.2.3. 2005 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 6 at Different Ambient Temperatures and Average Speeds

Without I/M Program.

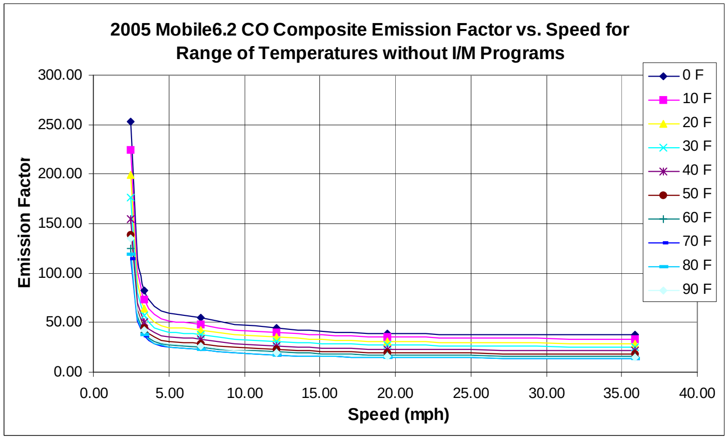

Figure A.2.4. 2035 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

Without /M Program

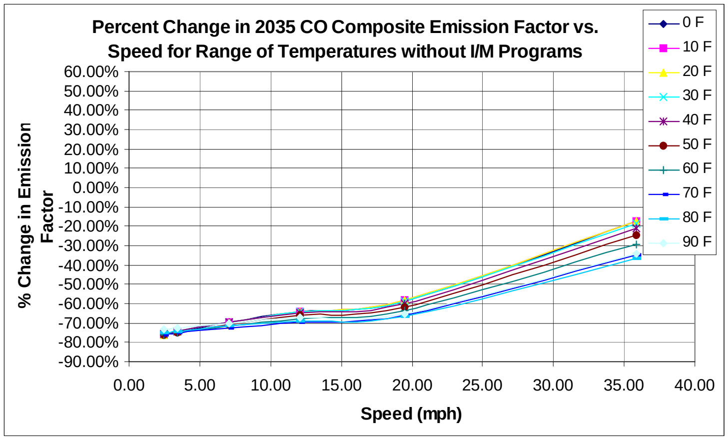

Figure A.2.5. 2035 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 5b at Different Ambient Temperatures and Average Speeds

Without I/M Program.

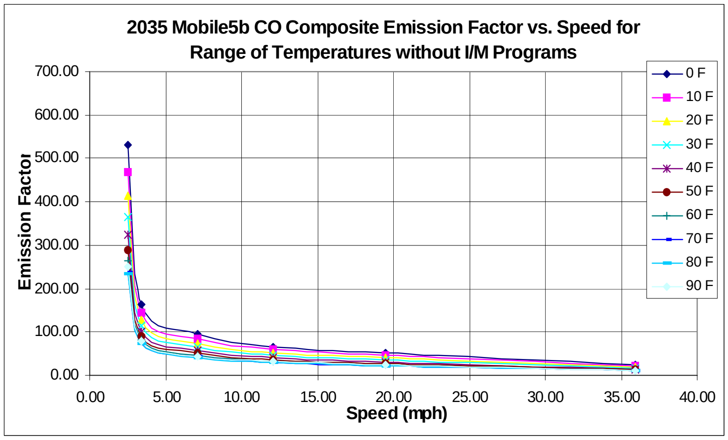

Figure A.2.6. 2035 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 6 at Different Ambient Temperatures and Average Speeds

Without I/M Program.

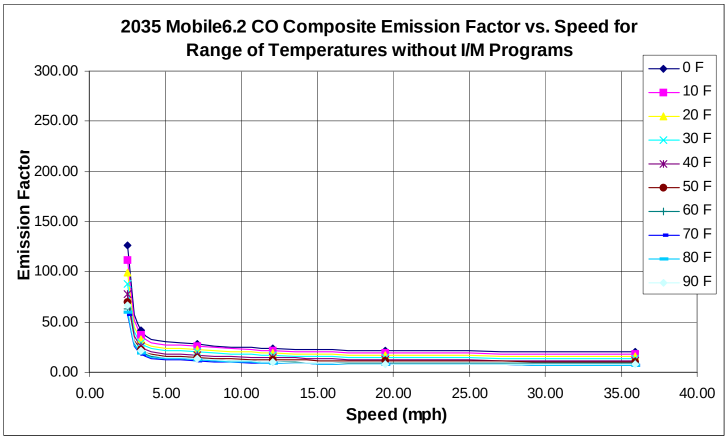

Figure A.3.1. 2005 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

3 Years Newer Average Age Fleet Distribution

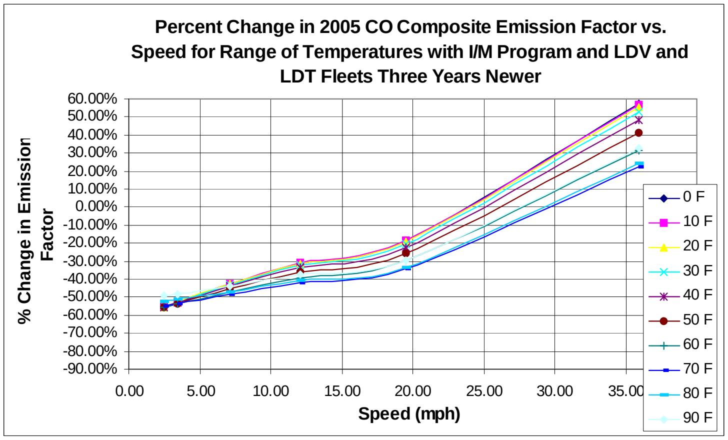

Figure A.3.2. 2005 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 5b at Different Ambient Temperatures and Average Speeds

3 Years Newer Average Age Fleet

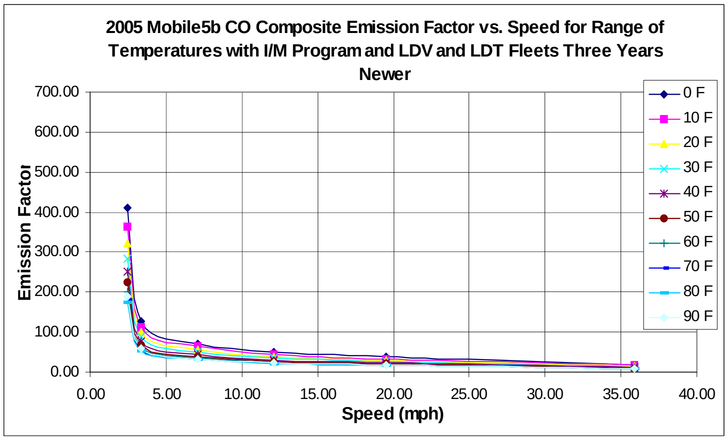

Figure A.3.3. 2005 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 6 at Different Ambient Temperatures and Average Speeds

3 Years Newer Average Age Fleet

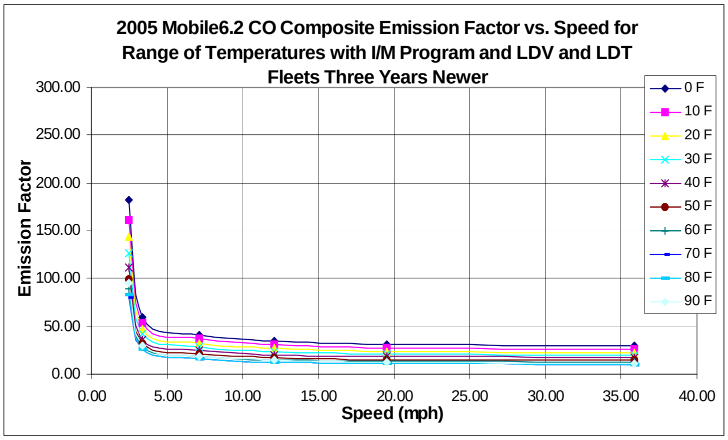

Figure A.3.4. 2035 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

3 Years Newer Average Age Fleet.

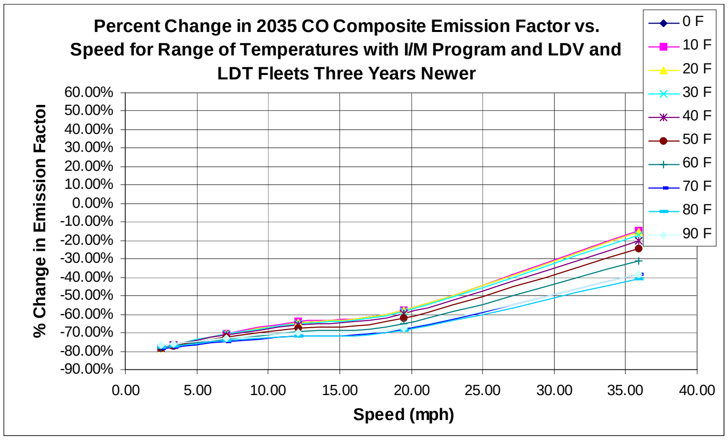

Figure A.3.5. 2035 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 5b at Different Ambient Temperatures and Average Speeds

3 Years Newer Average Age Fleet.

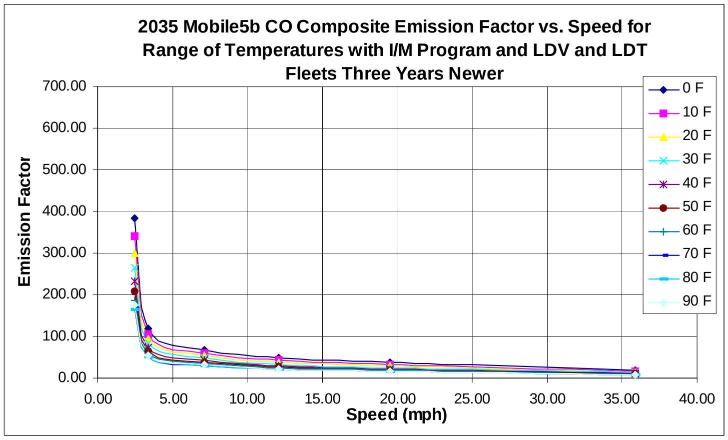

Figure A.3.6. 2035 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 6 at Different Ambient Temperatures and Average Speeds

3 Years Newer Average Age Fleet.

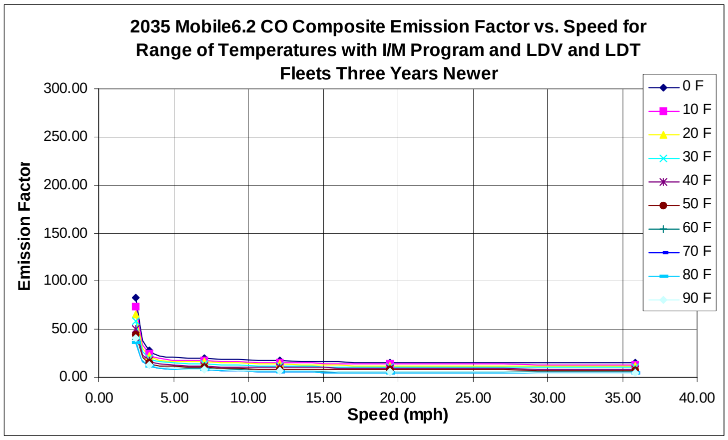

Figure A.4.1. 2005 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

3 Years Older Average Age Fleet.

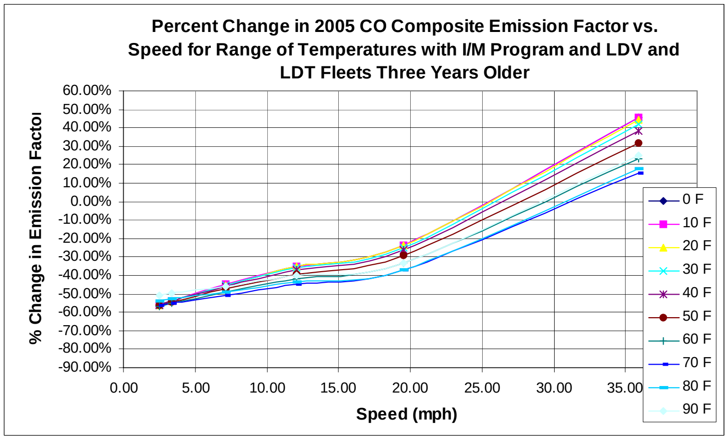

Figure A.4.2. 2005 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 5b at Different Ambient Temperatures and Average Speeds

3 Years Older Average Age Fleet.

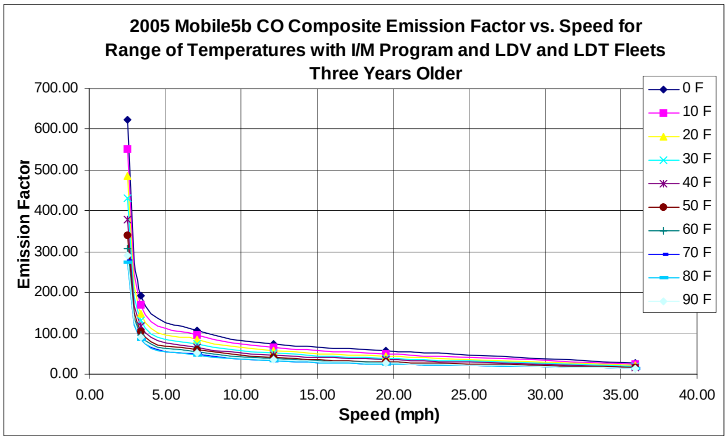

Figure A.4.3. 2005 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 6 at Different Ambient Temperatures and Average Speeds

3 Years Older Average Age Fleet.

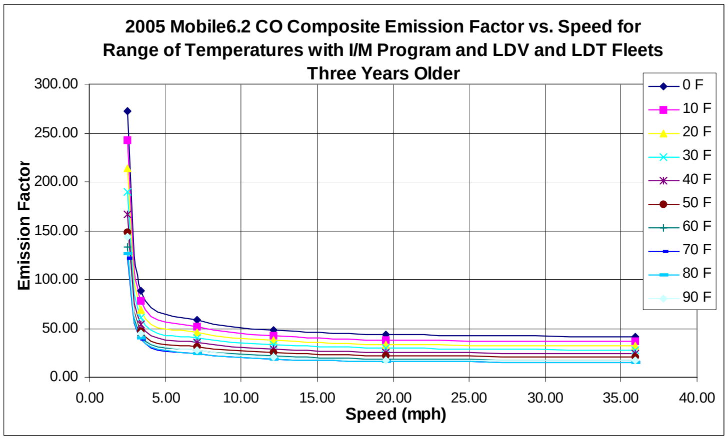

Figure A.4.4. 2035 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

3 Years Older Average Age Fleet.

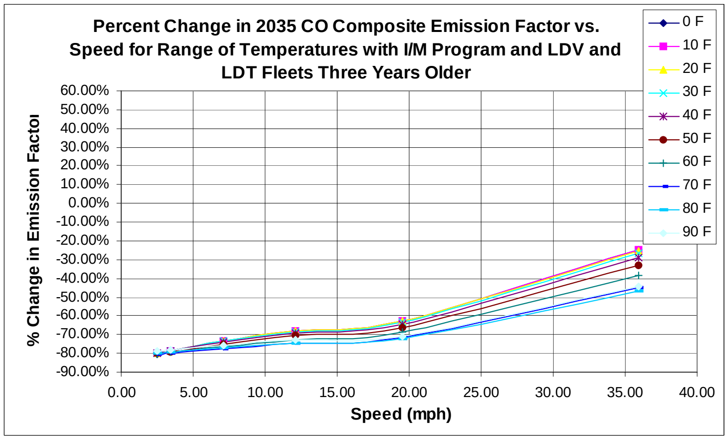

Figure A.4.5. 2035 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 5b at Different Ambient Temperatures and Average Speeds

3 Years Older Average Age Fleet..

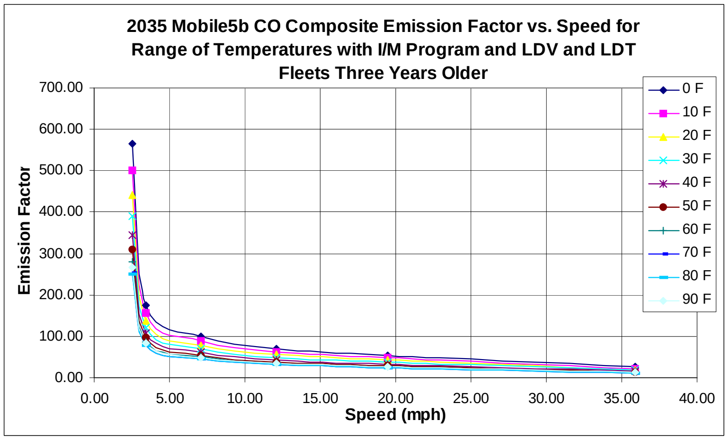

Figure A.4.6. 2035 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 6 at Different Ambient Temperatures and Average Speeds

3 Years Older Average Age Fleet.

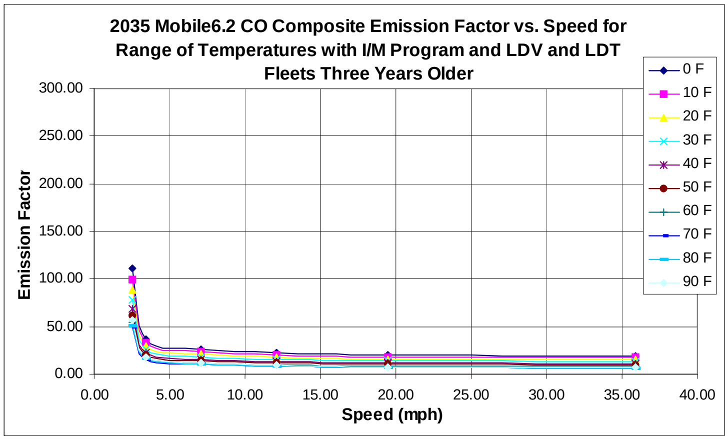

Figure A.5.1. 2005 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

30% Decrease in LDV VMT Fraction.

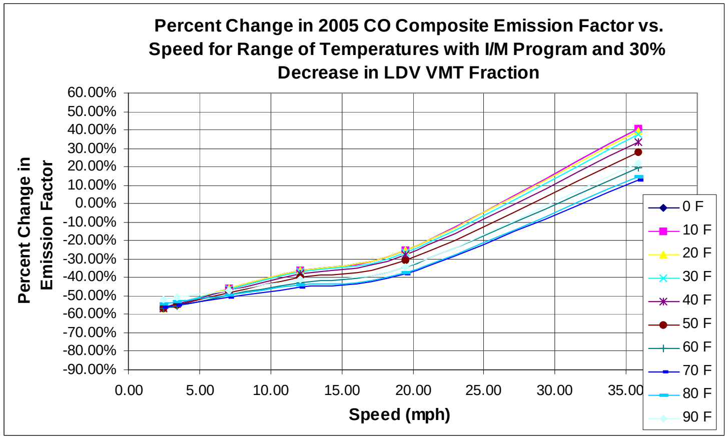

Figure A.5.2. 2005 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 5b at Different Ambient Temperatures and Average Speeds

30% Decrease in LDV VMT Fraction.

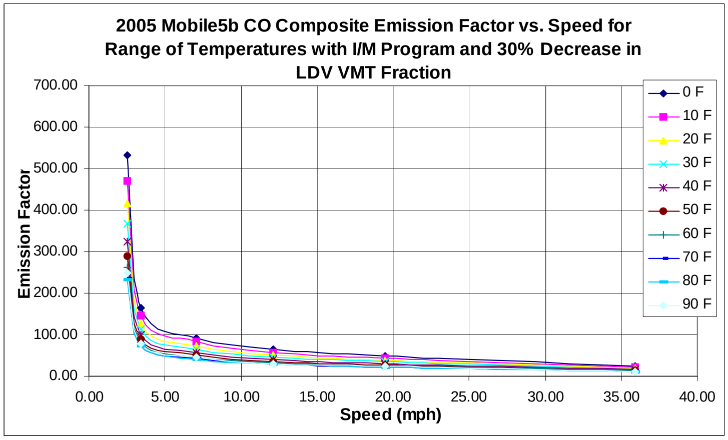

Figure A.5.3. 2005 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 6 at Different Ambient Temperatures and Average Speeds

30% Decrease in LDV VMT Fraction.

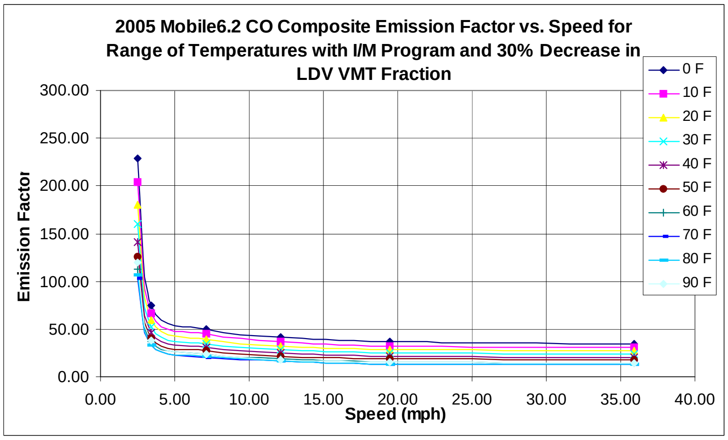

Figure A.5.4. 2035 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

30% Decrease in LDV VMT Fraction.

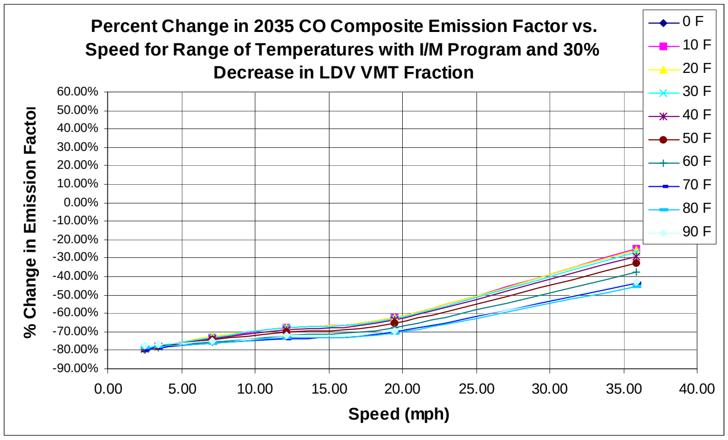

Figure A.5.5. 2035 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 5b at Different Ambient Temperatures and Average Speeds

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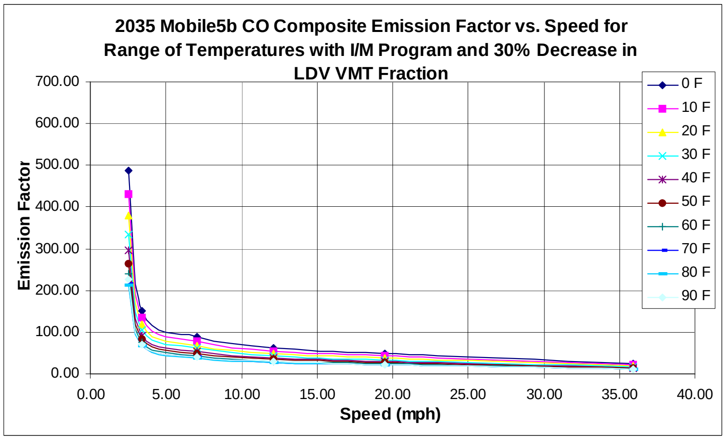


Figure A.5.6. 2035 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 6 at Different Ambient Temperatures and Average Speeds

30% Decrease in LDV VMT Fraction.

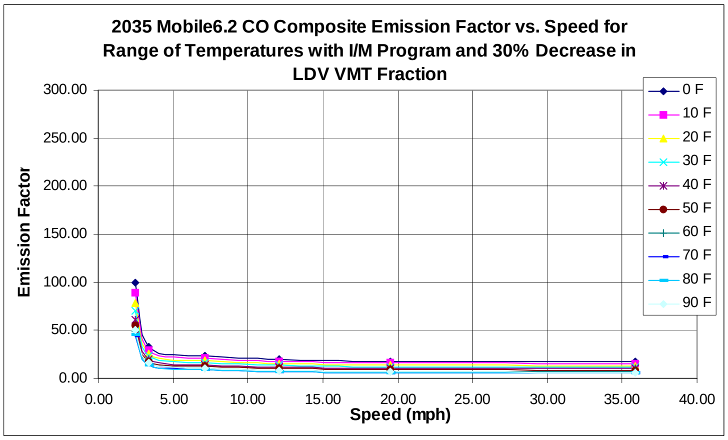


Figure A.6.1. 2005 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

30% Increase in LDV VMT Fraction.

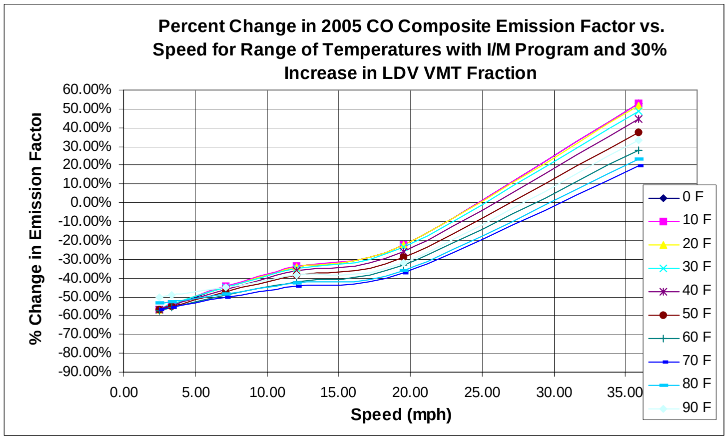


Figure A.6.2. 2005 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 5b at Different Ambient Temperatures and Average Speeds

30% Increase in LDV VMT Fraction.

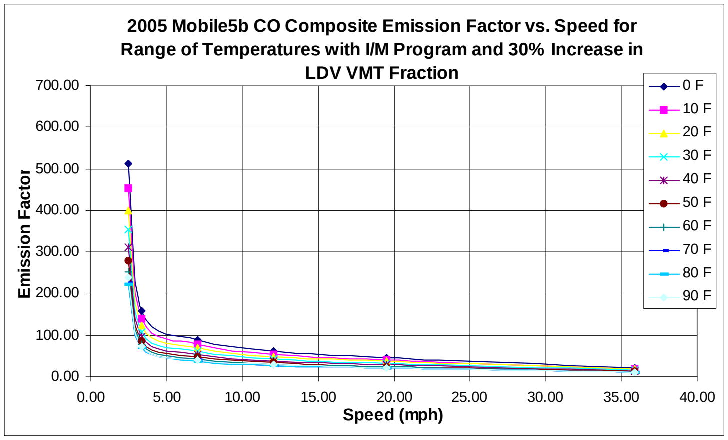


Figure A.6.3. 2005 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 6 at Different Ambient Temperatures and Average Speeds

30% Increase in LDV VMT Fraction.

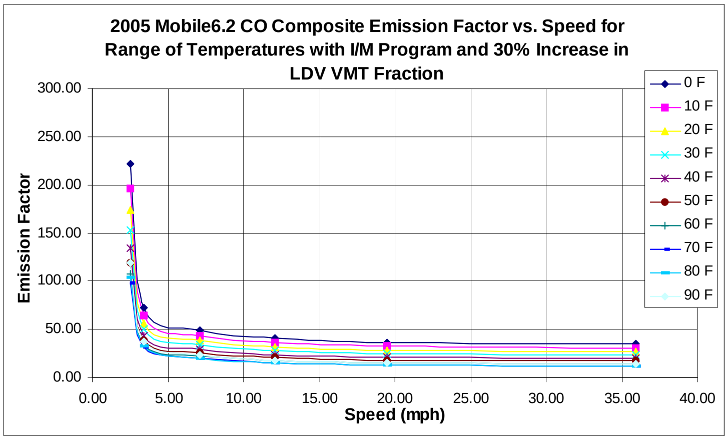


Figure A.6.4. 2035 Carbon Monoxide Composite Emission Factor % Change at Different Ambient Temperatures and Average Speeds

30% Increase in LDV VMT Fraction.

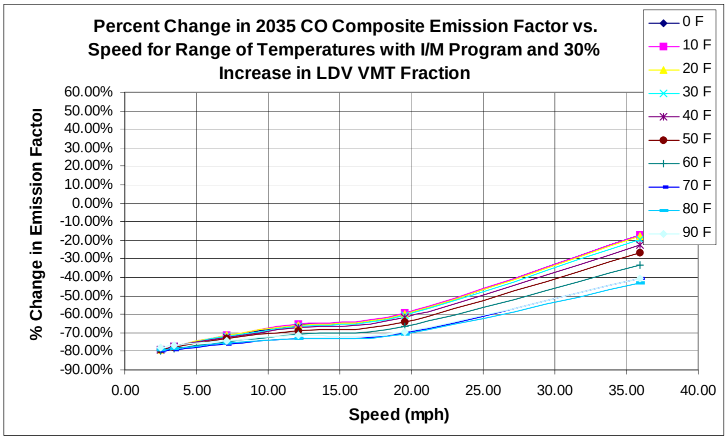
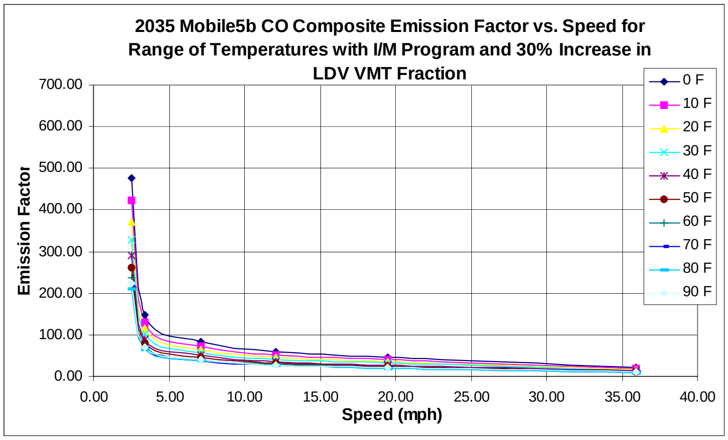


Figure A.6.5. 2035 Carbon Monoxide Composite Emission Factor (g/mi) for Mobile 5b at Different Ambient Temperatures and Average Speeds

30% Increase in LDV VMT Fraction.



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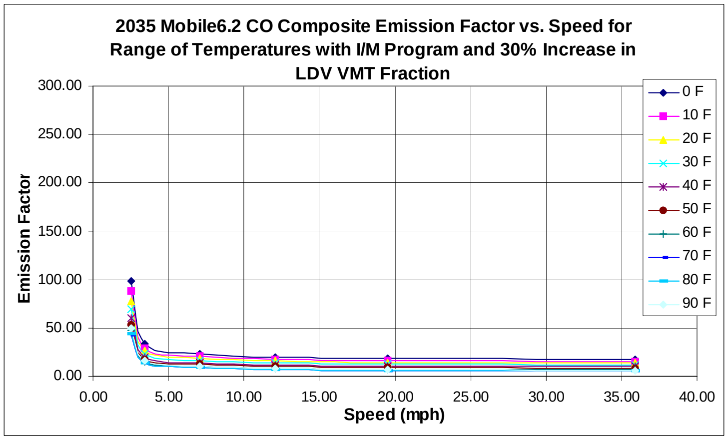

Appendix C:
Interview Questions

How Use of MOBILE6 Has Changed Results Relative to MOBILE5

General

- Does your agency perform the MOBILE6 modeling necessary for project-level analyses, or is this modeling performed by consultants, the State air agency, or some other party?
- Do you have thresholds or a screening procedure to determine when hotspot modeling is necessary for a project, or do you rely on the default LOS C threshold in the conformity rule?
- What are your "worst case" conditions for your location/practice/research? For instance, what would you use in your screening analysis for temperature, starts, background, and persistence factors?

Vehicle Fleet Characteristics

- Have you made use of the more specific vehicle fleet characteristics options in MOBILE6 [e.g., have you used local data on vehicle age, registration distribution, mileage accumulation, alternative diesel sales fraction, or natural gas vehicle fractions]? If so, how have these changes impacted the resulting emission factors relative to what you would have found if you only used MOBILE5? Will you use different vehicle fleets for different projects in your area, and what criteria would you base this on? *[If they have made use of specific vehicle fleet characteristic changes then proceed with the remaining questions in this section.]*
  - Have you gathered local data for the 28 individual vehicle types used in the MOBILE6 fleet characteristics commands? Or have you alternatively mapped the MOBILE5 categories to MOBILE6? If so, how did you decide on the mapping? Did you use the methodology in the MOBILE6 Technical Guidance?
  - Are you making use of the registration distribution capability in MOBILE6 for any of the 16 composite vehicle types for the 25-year vehicle age distributions? If so, which vehicle types and why these? How did you gather the data on vehicle type and age? In particular how are you handing the heavy-duty gasoline vehicle registration that is now composed of 8 types, whereas MOBILE5 only had 1?
  - Are you making use of the 14 composite vehicle type diesel fraction splits for the 25-year vehicle ages? If so, for which vehicles and why these? How did you gather the data on diesel fraction splits by age?
  - Are you making use of the r natural gas vehicle fractions?
  - Are you specifying annual mileage accumulation rates for any of the 28 individual vehicle types? If so, which vehicles and why these? How did you gather the information on mileage accumulation?
  - If you are using local registration data to establish vehicle class distributions, do you account for corridor-to-corridor variability or external traffic passing through the study area?

Vehicle Activity

- Have you made use of local vehicle activity options (i.e., VMT fleet mix by vehicle type, VMT distribution by hour, VMT Distribution by facility type, VMT by speed distribution, and average speed in MOBILE6)? If so, how have these changes impacted the resulting emission factors relative to what you would have found if you only used MOBILE5? *[If they have made use of specific vehicle activity changes then proceed with the remaining questions in this section]*
  - Are you basing your project-level studies on vehicle classification counts (VMT fleet mix) within the project area? How many categories are distinguished in your counts?
  - How are you projecting traffic counts to future study years on existing roadways or onto proposed facilities? How are you establishing the fleet characteristics (VMT fleet mix) for these future cases (i.e., are you using the same fleet characteristics for future cases as the present)?
  - Are you specifying local vehicle miles traveled by vehicle type for each of the 16 composite vehicle types? If so, which vehicles and why these? How did you gather the information on vehicle type? Are you using the MOBILE6 User Guide suggested mapping?
  - Are you specifying local vehicle miles traveled by the specific facility type in the project-level analysis? By each hour of the day? Or using peak hour? If so, which facilities and why these?
  - Are you specifying local vehicle miles traveled by speed for the two facility types that allow speed variations? If so, which facilities did you specify and why these?
  - How do you gather the information on the 14 speed distributions? By facility? By time of day? Are you using the MOBILE5 speeds to create MOBILE6 speeds by facility types as suggested in Appendix F of the MOBILE6 User Guide?
  - Do you use a locally developed estimate of speed for the “local” and “ramp” facility types, or do you rely on the MOBILE6 defaults? How do you account for speeds other than the default?
  - Is your standard practice to use the “Average Speed” command in the project-level analysis to calculate emission factors as a function of vehicle speed for the two facility types that allow speed variations?

Operating Modes

- Have you made use of local operating mode options (i.e., starts per day, start distribution, soak time distribution, weekend/weekday trip length distribution and weekend vs. weekday activity) in MOBILE6? If so, how have these changes impacted the resulting emission factors relative to what you would have found if you only used MOBILE5? *[If they have made use of specific operating mode changes then proceed with the remaining questions in this section]*
  - Are you using local start emissions in your project-level analysis even in light of EPA’s recommendation[13] that the calculation of idling emissions at intersections not include any effects from engine starts? Does your practice for including or not including start

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[13] EPA, 2002. “Technical Guidance Use of MOBILE6 for Emission Inventory Preparation”, EPA/OTAQ, January 2002, pg. 42.

emissions vary by location of the project? (See examples from Task 5 of the SOW.) If so, are you relying on the model's default assumptions on start activity (starts per day, start distribution, soak distribution) or using local data?

  - If you are using local data, how did you determine the number of starts per day for the up to 18 individual vehicle classes affected by starts per day? Did you differentiate between weekday and weekend starts? If so, how did you determine this?
  - If you are using local data for start emissions, how did you determine the hourly start distribution? How did you collect this information for use in the model? How did you use it in the model? Does it differ between weekday and weekend? If so, how did you determine this?
  - If you are using local data for start emissions, are you providing project-level specific vehicle soak distributions? If so, how do they differ from the national default? How did you determine the hourly soak distributions for the 70 soak duration values? Do you differentiate between weekday and weekends?
  - Are you making use of the weekend/weekday trip length distribution or the weekend vs. weekday activity in your project-level analyses? If so, how?

External Conditions

- Have you made use of the expanded meteorological conditions options (i.e., min/max temperature and hourly temperature) in MOBILE6? If so, how have these changes impacted the resulting emission factors relative to what you would have found if you only used MOBILE5? *[If they have made use of the expanded meteorological condition options, then proceed with the two questions in this section]*
  - Are you making use of the hourly temperature feature in MOBILE6? Do you use the max/min temperature parameter and specify the same temperature?
  - How local are your temperature data (e.g., County level), and what is the source of the data? [Note, areas subject to conformity should be using temperature data consistent with that used for the regional emissions analysis, per section 93.123(c)(3) of the conformity rule, which in turn should be consistent with the data used to develop the SIP emissions budgets (93.122(a)(6)). If areas subject to conformity are using project-specific temperature data that differ from the SIP inputs, then we will ask the reason, and ask if this was cleared through the interagency consultation process.

State Programs

- Are you making use of the ability of MOBILE6 to incorporate up to seven different exhaust and evaporative emission I/M programs on calculated emission factors? If so, how many are you using? How do you determine the appropriate mix for the project location? Are there features not available in MOBILE6 I/M options that you would like to see? If so, what are they and why are they important?

Fuels

- Are you making use of any of the new MOBILE6 capabilities for RVP specification, as well as lower bound range for RVP specification in your project-level analysis? Are you using the "splash" blend capability for alcohol-based oxygenates? Have you estimated how these capabilities have affected project-level emissions? Are there features not available in MOBILE6 fuel options that you would like to see? If so, what are they and why are they important.

General Impacts

- Have you found changes in idle emission rates as a result of the changes you have adopted for use with MOBILE6? If so, can you provide an estimate of the change in the idle emission rate, as well as the implementing change used in MOBILE6?
- How would you characterize your "worst case" events for project-level analysis in your region? What are the associated parameters for those conditions (i.e., meteorological conditions, traffic operations, fuel mix, temperature, etc.)?

How Use of MOBILE6 Has Changed the Project-level Process

- Has the use of MOBILE6 required a need to gather additional information? If so, how much additional resources/time is needed to perform a typical MOBILE6 analysis? Will this effort require less time/fewer resources as the user gains more familiarity with MOBILE6?
- Has the use of MOBILE6 led to the need to involve additional agencies in preparing model inputs? For example, is additional information now needed from air agencies on fuel programs, I/M, meteorology? Department of motor vehicle registration on vehicle fleet and age distribution? Have other processes of preparing inputs been affected by the use of MOBILE6?
- Has the application of MOBILE6 affected procedures unique to any additional state or local requirements for project-level analyses?
- Has the change to MOBILE6 caused your screening procedures to be reassessed? If so, how have they changed? Are trigger levels now higher or lower than with MOBILE5? For example, has MOBILE6 changed the traffic volume trigger screening-levels?
- Has the use of MOBILE6 had any impact on possible CO mitigation strategies? If so, how has it changed the strategies?
- Has the use of MOBILE6 caused you to revisit how you've estimated present and future background carbon monoxide concentration? What is your procedure for estimating present and future background concentration, and if it was modified due to MOBILE6, how has it changed?

Appendix D:
Interview Summary Table

Background Questions			Has M6 Changed Analysis Process?			Has M6 Changed Results of Project-level Analysis		
Q1 Do you use M6 for Project-level analysis?	Q2 Is hotspot modeling based on thresholds or LOS C?	Q3 What are your worst case conditions?	Q4 Need for additional information	Q5 Need to involve additional agencies	Q6 Affect on state/ local procedures	Q7 Change in estimate for present/ future back-ground CO due to M6	Q8 Reassessed screening procedures due to M6	Q9 Impact on CO mitigation strategies
State DOT, EPA, DEP, APCD								
• All respondents in which a full interview was conducted use Mobile 6 in project-level analysis. • Most use consultants with some of the M6 work done by APCD or state enviro agency. • M6 is better designed for area wide analysis (such as inventories, mesoscale analysis) rather than the microscale analysis. • Many questions related to applicability of M6 for project-level analysis.	• Five of the nine agencies use a modification of the LOS C screening procedures consisting of LOS and volume thresholds. • Four of the nine agencies use LOS C, but two indicate revising this procedure	• Most agencies use peak hour traffic volumes • Most use a persistence factor (p.f.) of 0.7; however the range was from 0.72 to 0.57 depending on local data used to develop p.f. • Most agencies use January average temperatures, these may be refined to county or locally specific temperatures • .Background CO is determined in various ways – no consistent approach - statewide uniform value, varying values across the state, local monitoring data, roll forward, and SIP modeling • For CAL3QHC modeling follow EPA roadway intersection guidance	• M6 allows optional inputs/local data. About half the agencies would like to develop these inputs • This additional information requires more survey and statistical analysis assessment primarily for: • vehicle mix distribution and; vehicle class • Would like to see sensitivity test of the model and impacts of the inputs. • Other half of agencies did not see the need for additional information—using national defaults	• About half the agencies indicated that additional contact and coordination was needed with APCD, MPO, and energy departments • The other half of the agencies indicated that the same agencies are needed as with M5 • The need for additional contact were those agencies making use of the M6 options which had previously relied on national defaults	• Most agencies responded that M6 has had no change on their state and local procedures • A few cited the need for expanded coordination throughout the process to get local data for each analysis	• In general agencies have not found that M6 has caused any change to the present background concentration. • Several agencies are looking to possibly use M6 for future year emissions which will impact the roll forward or trends to estimate future background concentration.	• Six of the nine agencies report no changes to the screening procedures. • Three agencies are updating the screening procedures to incorporate M6 inputs.	• Most agencies felt it was to earlier to tell the impact on mitigation strategies. However, one agency strongly suspects that one intersection which had previously shown a problem with M5 requiring mitigation will no longer be the case when using M6.

Background Questions			Has M6 Changed Analysis Process?			Has M6 Changed Results of Project-level Analysis		
Q1 Do you use M6 for Project-level analysis?	Q2 Is hotspot modeling based on thresholds or LOS C?	Q3 What are your worst case conditions?	Q4 Need for additional information	Q5 Need to involve additional agencies	Q6 Affect on state/ local procedures	Q7 Change in estimate for present/ future back-ground CO due to M6	Q8 Reassessed screening procedures due to M6	Q9 Impact on CO mitigation strategies
Researchers/.Consultants								
• Three researchers were interviewed which heavily use M6 for project-level analysis. • All three researchers use it in private consulting projects for project-level analysis.	• All three researchers use a screening approach, but these are tied to the particular state or local agency. • Trigger requirement varies state by state, agency by agency. 1) Project related volume increases over no-build scenario is usual determining factor. 2) Some agencies first look at LOS D, E, and F, and then at volume increases. 3) Delay increases over no-build are also used	• Temperature determination is either based on average temperature of top 10 CO readings during last 3 years, or the one used for current SIP, or specified by state as January climate average. • M6 default values used for base traffic, with exception for project specific generated outbound trips (i.e. out of parking lots or buildings) • Persistence factors are usually based on top 10 eight-hour/ one-hour CO measurements during last 3 years or specified by state • CO background are specified by state	• Amount of additional information is generally small (i.e. roadway type, mileage accumulation), • However, if all M6 features are employed the additional information required are extensive • At first, M6 is more time consuming to prepare input files, since VMT fractions, soak distributions, and other parameters are not as simple as M5. However, once done a few times, the process becomes simpler.	• Same agencies as used in M5 applications are needed.	• In general impacts were seen in the data collection process, application to facility specific types, and in the hot/cold start specifications	• Many states just use average monitoring concentration of last three years for background levels. • Many states are recalculating M6 with future backgrounds levels using the roll forward technique.	• Yes, researches saw the need to revisit screening procedures as M6 coupled with CAL3QHC does not produce same results • Much smaller differences between cold start and hot-stabilized. • Speed curves for CO are U-shaped with lowest point around 30-35 mph. • Idle emissions play much smaller role when compared to moving (cruise) emissions. • Worstcase modeling receptors change from intersection to mid block • An interchange or non-signalized intersection can have higher CO impacts than a signalized intersection	• Increasing capacity to achieve higher speeds is no longer desirable and won't solve problems. • Optimizing signal timing will have to be studied further to better quantify possible benefits