# Emission Reduction Calculation Methodologies

## General Instructions

Federal Guidelines require estimates of air emission benefits derived from Congestion Mitigation and Air Quality Improvement (CMAQ) Program projects. Such information should be developed during the development of a region's Transportation Improvement Program (TIP) when projects are prioritized and subsequently selected for inclusion into the TIP. For this reason, air emission data will likely have been developed for most CMAQ projects. However, in the event that such information was not developed, Caltrans and the California Air Resources Board have modified some simplified methodologies provided by the FHWA, and added emission factor tables specific to California that can be used to determine emission benefits. Although not comprehensive, the methodologies address the more common types of CMAQ projects for which air emissions can be determined.

Some projects may not lend themselves to quantitative analysis because of the project's characteristics or because practical experience is lacking to adequately analyze the project. In these cases a qualitative assessment based on a reasoned and logical examination of how the project or program will decrease emissions is acceptable.

In the development of the 1995 CMAQ Annual Report we encourage the use of air emission data developed through local methodologies that are thought to be more accurate; however, in the event the information is not available the methods shown below may be used.

Methods for calculating emission reductions are provided for the following types of projects:

- Bus Purchase for New Service
- Replacement of Old Buses
- Vanpools/Shuttles
- Suburban Carpool Park-and-Ride
- Signal Coordination and Improvements
- High Occupancy Vehicle (HOV) Lanes
- Transportation Management Organizations/Associations (TMOs/TMAs)
- Bicycle Projects
- Pedestrian Projects
- Telecommuting Centers

**Emission Reductions.**
Federal guidance require that emission reductions be estimated and reported in kilograms per day. Estimates should be provided for reactive organic gases (ROG), nitrogen oxides (NOx), carbon monoxide (CO), and fine particulates (PM10). Because some projects relate to work days only, emission reductions for the average work day should be multiplied by 260 work days per year and then divided by 365 to get emission reductions for an average annual day.

**Life of Project.**
Emission factors used to determine emissions are dependent on the life of the project; they decrease over time due to progressively more stringent motor vehicle

emission standards and fleet turnover. Therefore, to make fair estimates of emission reductions, and comparisons of emission reductions related to costs, if so desired, a rough estimate of the useful life of a project is needed. Correspondingly, the emission factor tables, where appropriate, include useful project lives ranging from 5 years to 20 years. For some project types we have suggested useful project lives; for other types you may select what you believe is the useful life the project, up to a maximum of 20 years.

Total emission reductions can be estimated by multiplying average daily emissions by 365 and then by the number of years in the life of the project.

***(Note: The methodologies provided in this document should NOT be used to determine Mobile Source Credits which can be sold or traded. For those procedures, please refer to the Air Resources Board document Mobile Source Emission Reduction Credits Guidelines.***

*Pursuant to California law, motor vehicles, including transit buses, will have to meet progressively more stringent motor vehicle emission standards. Emission reductions associated with the natural turnover of the older fleet to newer, cleaner models play an important role in local clean air plans and are factored into the air emission inventory.*

*Because Mobile Source Credits may be sold or traded, they must* ***go beyond*** *the emission reductions already accounted for in the clean air plans. In contrast, CMAQ moneys are to help implement the transportation measures in the clean air plans. Analyses of CMAQ projects help local decision makers compare one project to another so that priorities can be set for the spending of public moneys.)*

## CMAQ Project Types

**Type 1.** Transit: facilities; vehicles and equipment; operating assistance for new transit service, etc.

**Type 2.** Shared-ride: vanpool and carpool programs, and parking for shared-ride services, etc.

**Type 3.** Traffic flow improvements: traffic management and control services, signalization projects, intersection improvements, and construction or dedication of HOV lanes, etc.

**Type 4.** Demand management: trip reduction programs, transportation management plans, flexible work schedule programs, vehicle restriction programs, etc.

**Type 5.** Pedestrian/bicycle: bikeways, storage facilities, promotional activities, etc.

**Type 6.** I/M, and other TCMs (not covered by the above categories).

**Type 7.** Experimental projects: projects which may not meet the precise eligibility criteria for funding programs, but may show promise in meeting the intended purpose of those programs (see page 9).

# Project Type 1

## Bus Purchase for New Service. *(Suggested Life of Project: 12 years. )*

The emission reduction benefit is the decrease in emissions associated with auto trips replaced by the new bus service after adjusting for the increase in emissions associated with new bus service itself.

To find auto trips replaced, estimate new bus ridership. Then multiply new ridership by 0.5 to determine the number of autos trips replaced. (The 50% reduction is an estimate based on a recent survey of transit riders by Sacramento Regional Transit. Only 64% of riders had a valid drivers license and only 43% claim they could have taken a car instead of transit. Metropolitan Planning Organizations (MPOs) may choose to use a regional number instead of 50%. Bus service specifically targeted at commute travel could assume a higher percentage of auto trips replaced.)

Emissions from auto trips replaced equals the number of trips replaced multiplied by the trip-end emission factor from Table 3 and added to VMT (which equals number of trips multiplied by the average trip length) multiplied by the VMT emission factor. If you do not have the average trip length for your specific project, or the average trip length for your region, you may use 9.0 miles which is the average trip length found in the National Personal Transportation Survey.

Next, calculate emissions associated with the new bus service by multiplying the estimated bus VMT for the new service by the appropriate bus emission factors from Table 1. If the bus is a clean fueled vehicle (methanol, CNG, LNG), be sure to use the alternative fuel factors.

Last, subtract the new bus service emissions from replaced auto trip emissions to get total emissions reduced. Repeat for each pollutant. (Note: Use 200 days per year for school buses and divide by 365 for average annual day.)

**(0.5) (new bus ridership) (auto trip end emiss factor)**
*plus*
**(0.5) (new bus ridership) (aver auto trip length) (auto VMT emiss factor)**
*minus*
**(new bus service VMT) (bus emiss factor)**

## Replacement of Old Buses. *(Suggested Life of Project; 5 years.)*

The emission reductions are the difference between emissions associated with the operation of the old bus minus emissions associated with the new bus. First, estimate average daily VMT for the old bus and multiply by the appropriate VMT factor in Table 1.

Second, multiply the average daily VMT for the new bus by the current emission factor. If the new bus is a clean fueled bus, be sure to use the alternative fueled factors.

Last, subtract the new bus emissions from the old bus emissions to get average daily emission reductions. Repeat for each pollutant.

| **(bus VMT) (old bus emiss factor)** *minus* **(bus VMT) (new bus emiss factor)** |
|---|

## Project Type 2

**Vanpool/Shuttles.** *(Suggested Project Life: 8 years.)*
The emission reduction benefits are a result of trips diverted from auto to van. Calculate emissions related to auto travel minus emissions related to vanpool travel.

To find auto trips diverted, multiply vanpool ridership by 95%. (This is because some vanpool riders may be diverted from transit. According to the Nationwide Personal Transportation Survey, roughly 5% of work trips are made by transit. MPOs may chose to use a region specific number instead of 5%.) Multiply by 2 to account for a round trip.

Next, find emissions related to auto trips by multiplying the number of trips replaced by the vanpool by the average auto trip-end emission factor (Table 3). Add this to the product of the number of auto trips replaced multiplied by the average commute trip length multiplied by the auto VMT emission factor (Table 3). (Note: The length of commute trips replaced by vanpools is usually longer than the regional average commute trip.)

Next, determine the model year of the van and emissions associated with it by multiplying the number of van trips by the average van trip-end emission factor (Table 2), and add van VMT multiplied by VMT emission factor for vans (see Table 2).

Last, subtract van related emissions from the autos-replaced emissions to get air quality benefits. Table 2 gives both “cold trip end” and “hot trip end” factors. To determine van emissions for commuter vans that pick up riders individually (i.e., at their homes), use the “cold trip end” factors from Table 2 as called for in the formula.

For a more continuous shuttle service, nearly all trip starts will be hot starts. Use the “cold trip end” factors for only one or two trips per day and then use the “hot trip end” factors for all remaining trips.

If riders drive to a central location, such as a park and ride lot, there is no change in the number of auto cold starts so there is no need to calculate auto trip end emissions. Simply subtract the van emissions (VMT and trip end) from the auto VMT-related emissions.

**(0.95) (aver daily vanpool riders) (2 trips/day)**
*multiplied by*
**((auto trip end emiss factor) + (commute trip length) (auto VMT emiss factor))**
*minus*
**(aver daily van trips) (van trip end emiss factor)**
*minus*
**(aver daily van VMT) (van VMT emiss factor)**

**Suburban carpool park-and-ride lots.** *(Suggested Life of Project: 20 years. )* The emission reduction benefits are from reduced VMT. First determine number of parking spaces for the new lot, or spaces added to an existing lot, and multiply by 95% to adjust for carpoolers diverted from transit. Estimate the lot utilization rate from monitored data OR assume a 75% lot utilization rate as a default. Parking spaces multiplied by 95%, by 75%, and by 2 work trips/day represents the number of vehicle trips affected.

Next, determine length of average suburban commute trip (VMT), one way. Estimate the average reduction in VMT expected from carpooling OR assume carpooling yields a 2/3 reduction in VMT as a default. Multiply vehicle trips affected by the VMT reduced and by the VMT emission factor in Table 3. Repeat for each pollutant.

**(0.95) (0.75) (parking spaces) (2 trips/day)**
*multiplied by*
**(2/3) (aver trip length) (auto VMT emiss factor) (260 /365)**

(Note: For vanpool programs, see vanpool/shuttle methodology.)

## Project Type 3

**Signal Coordination and Improvements.** *(Suggested Project Life: 5 to 20 yrs)* The emission reductions are a result of the increase in average speed on the affected roadway. Determine the length of roadway (in miles) where signals will be synchronized. For phased projects, use percent of total roadway to be affected by current project(s).

Determine, or estimate, before and after Average Daily Traffic (ADT). Obtain the existing average speed and the predicted average speed after synchronization. This may be determined from "floater car" data, transportation model outputs, volume/capacity ratios and Level of Service (LOS) tables, or other methods. Unless better data is available, post synchronization average speed can be approximated by multiplying the existing speed by 1.15.

Use the fleet emission factor table (Table 4) to determine the emission factors for all pollutants using before and after speeds. To calculate the emissions for existing conditions, multiply appropriate emission factors by ADT and length of roadway. For future conditions, multiply appropriate emission factors by ADT and length of roadway. Subtract the two totals for each pollutant to calculate emissions per pollutant reduced.

**(ADT) (roadway length) (before project emiss speed factor)**
*minus*
**(ADT) (roadway length) (after project emiss speed factor)**

**HOV Lanes.** *(Suggested Project Life: 20 years. )*
The emission reduction benefits are the air pollution emissions associated with auto trips reduced plus additional emission reductions resulting from increased operating speeds.

Estimate the ADT before implementation of the project and ADT after the project for the a.m. peak period. Emissions without the project equal ADT multiplied by the trip-end emission factor for average auto emissions (Table 3) added to VMT (which is ADT multiplied by the average commute trip length) multiplied by the emission factor corresponding to the pre-project average speed (Table 4).

Similarly, estimate emissions for conditions after the project is implemented. Then subtract after-project emissions from before-project emissions to get the emission reduction benefits.

**(pre-project ADT) (auto trip end emiss factor)**
*plus*
**(pre-project ADT) (aver commute trip length) (pre-project emiss speed factor)**
*minus*
**(after project ADT) (auto trip end emiss factor)**
*minus*
**(after project ADT) (aver commute trip length) (after project emiss speed factor)**

## Project Type 4

**TMOs/TMAs.** *(Suggested Project Life: 5 to 20 years. )*
Estimate the number of auto trips and VMT removed from the system. The air quality benefits equal the number of daily trips removed multiplied by the average auto trip end emission factor (Table 3) added to the daily VMT removed multiplied by auto VMT emission factor (Table 3).

**(auto trips removed) (auto trip end emiss factor)**
*plus*
**(auto trips removed) (aver commute trip length) (VMT emiss factor)**

## Project Type 5

**Bicycle projects.** *(Suggested Life of Project: 20 years. )*
The emission reduction benefits are the emissions associated with auto trips replaced by bicycle trips for commute or other non-recreational purposes. The average daily bike traffic for the project can be used to represent the number of

vehicle trips replaced. Use local estimates of daily bike traffic. If no local estimates are available use the optional methodology given below to estimate the

daily bike traffic. Then multiply daily bike traffic (which represents vehicle trips replaced) by emissions per vehicle trip to get total benefits

Emissions from a vehicle trip replaced equals one trip end factor from Table 3 plus the length of an average bike trip multiplied by the VMT factor. Use local estimate for average bike trip length or 1.8 miles (National Personal Transportation Survey).

**(bike traffic) (auto trip end emiss factor)**
*plus*
**(bike traffic) (1.8 miles) (auto VMT emiss factor)**

***OPTIONAL: Method to Determine Daily Bicycle Traffic for Project***

If you do not know average daily bicycle traffic and your city has a relatively high ratio of bike lanes to roads, you may choose to use this method to get a rough estimate for the percentage of total citywide person trips taken by bicycle. The share of bicycle trips increases as the ratio of bike lane miles to arterial and freeway lane mile gets larger.

Step 1. Determine future city miles of bike lanes (or trails) anticipated in a completed bike system as defined in the transportation improvement plan or local bike plan.

Step 2. Determine the city miles of arterials and freeways that will exist when the bicycle system if completed.

Step 3. Calculate the ratio of bicycle lane miles to arterial/freeway miles. This ratio corresponds to the percentage of total person trips taken by bicycle. If the ratio is less than 0.35 use 0.6% as the bicycle mode share of total trips. If ratio is greater than 0.35 use 2% for non-university towns and 6.8% for university towns.

> (Source: This approach is based on Implementing Effective Travel Demand Management Measures, September 1993, prepared by COMSIS Corp. for FHWA & FTA and on work by S.A. Goldsmith. There is a dramatic increase in bike ridership for cities with ratios greater than 0.35.
>
> On the average, the percentage of regional bicycle trips taken for shopping and personal business is the same as for bicycle commuting so the same rate represents all of these trip purposes.)

Step 4. Divide the bicycle trips percentage (from Step 3) by length of bicycle system (from Step 1) to get percentage per bike lane mile.

Step 5. Determine number of total citywide daily person trips and length (miles) of the bicycle project.

Step 6. Multiply percentage of regional bicycle trips per bike lane mile (from Step 4) by the length of the particular bicycle project. Then multiply this result by total citywide person trips (from Step 5) to get average daily bicycle trips for the project.

**Pedestrian projects.** *(Suggested Life of Project: 20 years. )*
These are projects like pedestrian crossings, overcrossings, sidewalks, and paths. The emission reduction benefits of pedestrian projects equals the emissions associated with auto trips replaced by walk trips. Estimate daily foot traffic for the project. Then multiply the number of pedestrian trips (foot traffic) times emissions associated with an auto trip replaced.

Emissions for an auto trip replaced equals one trip end emission factor from Table 3 plus the length of the average walk trip multiplied by the VMT factor. National Personal Transportation Survey gives average walk trip as 0.7 miles.

**(foot traffic) (auto trip end emiss factor)**
*plus*
**(foot traffic) (0.7 miles) (auto VMT emiss factor)**

**Telecommuting Centers.** *(Suggested Life of Project: 5 to 20 years. )*
The emission reduction benefits are the result of employees making fewer work-related trips or driving shorter distances to the telecommute center than they did commuting to their previous worksite. The emission savings equals the sum of emissions reduced for employees who drive to the center plus emissions reduced for employees who use the center and do not drive.

To find the emissions reductions associated with employees who drive to the center, first determine the average number of employees expected to drive to the center each day. Usually employees use the center only one or two days per week. Then multiply by 2 trips/day multiplied by 0.85 (1991 Statewide Travel Survey, regional employees per vehicle rate for major urban areas). The latter factor adjusts for employees who did not drive to work prior to telecommuting. The resulting product yields the average number of vehicle work trips shortened. Then multiply the number of vehicle trips shortened by the difference in the prior average commute distance for the employees and their current average commute distance multiplied by the VMT emission factors from Table 3.

To calculate emissions reduced by employees who do not drive to the center, first multiply (2)(0.85) by the number of these employees to get work day vehicle trips reduced. Multiply vehicle work trips reduced by the prior average commute distance multiplied by the VMT factors in Table 3. Also multiply vehicle trip reduced by the trip end factors from Table 3. Finally, add the VMT benefits and the trip end benefits together.

The total average work day emission reduction benefits are the sum of reductions from employees who drive and who do not drive to the center. Pursuant to the general instructions, multiply by 260 work days to get annual emission reductions and then divide by 365 to get emission reductions per average annual day.

**(0.85) (2) (aver # of employees who drive to center) (auto VMT emiss factor)**
*multiplied by*
**((PRE-proj aver trip length)** *minus* **(AFTER-proj aver trip length))**
*plus*
**(0.85) (2) (aver # of empl who do NOT drive to center) (auto trip end emiss factor)**
*plus*
**(0.85) (2) (aver # of empl who do NOT drive to center)**
*multiplied by*
**(pre-project aver commute trip length) (VMT emiss factor)**

## Project Type 6

Type 6 projects may not have direct relationships to reduced traffic, improved average speeds, transit ridership, etc., thus air quality benefits are not easily calculated. However, air quality benefits may be found in the project's environmental documents, engineering documents, etc. If so, these can be used; if not, professional judgment concerning the estimated number of trips reduced, increased average speed, or increased number of transit riders, etc., may be used. If a quantitative analysis is not feasible a qualitative analysis should be prepared. a

## Project Type 7

The revised Federal CMAQ Guidelines, dated July 13, 1995, added a new category of projects called “Experimental Pilot Projects/Innovative Financing”. These projects may not meet the precise eligibility criteria for Federal and State funding programs, but they may show promise in meeting the intended public purpose of those programs in an innovative way. Depending on the actual project, air emission benefits should be determined by the usual methods, i.e., if feasible actual benefits should be calculated, if not, a qualitative analysis should be prepared.

Prepared by Calrans/CARB
For questions, call
Caltrans @ 916-654-2686

# ***TABLE 1***

## *Bus Emission Factors*

| | | VMT factors in grams/mile | |
|---|---|---|---|
| Pollutant | Year | Diesel Fuel | Compressed Natural Gas (CNG) Liquified Natural Gas (LNG) |
| HC | 1973-83 | 4.2 | NA |
| | 1984+ | 3.7 | 3.7 |
| CO | 1973-83 | 9.9 | NA |
| | 1984+ | 5.3 | 5.3 |
| NOx | Pre-1984 | 30.4 | NA |
| | 1984-90 | 22.5 | NA |
| | 1991-95 | 21.5 | 12.3 |
| PM10 | Pre-1984 | 4.2 | NA |
| | 1984-90 | 3.62 | NA |
| | 1991-93 | 3.14 | 3.07 |
| | 1994-95 | 3.08 | 3.04 |

Notes:

Source: EMFAC7G Draft, Certification and in-use tests. CNG/LNG emission factors are based on limited extended in-use testing and are subject to a larger error band than diesel emission factors.

HC, CO, and NOx are exhaust emissions.

PM10 factors include exhaust, tire wear, and paved road dust. The tire wear and paved road dust portions of the emission factors are based on EMFAC7F1/B7F annual average emissions inventories.

# TABLE 2

## *Average Van/Shuttle Emission Factors*

Methodology: Choose year that best represents the model year of the van/shuttle vehicle.
Multiply the miles traveled by the VMT factor to get emissions in grams.
Estimate number of cold starts and hot starts. Multiply by cold and hot trip end factors.
Add VMT emissions to trip end emissions.

| Model Year | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|
| **ROG** | | | | |
| **vmt (g/mi)** | 0.48 | 0.41 | 0.33 | 0.25 |
| **cold trip end (g/trip)** | 5.05 | 4.78 | 4.44 | 3.74 |
| **hot trip end (g/trip)** | 1.32 | 1.25 | 1.02 | 0.81 |
| **NOx** | | | | |
| **vmt (g/mi)** | 0.86 | 0.82 | 0.75 | 0.66 |
| **cold trip end (g/trip)** | 2.92 | 2.94 | 2.88 | 2.76 |
| **hot trip end (g/trip)** | 1.59 | 1.56 | 1.49 | 1.35 |
| **CO** | | | | |
| **vmt (g/mi)** | 3.58 | 2.97 | 2.49 | 1.75 |
| **cold trip end (g/trip)** | 67.83 | 62.78 | 57.66 | 46.26 |
| **hot trip end (g/trip)** | 14.51 | 12.62 | 11.19 | 8.62 |

| Model Year | 1994 | 1995 | 1996 |
|---|---|---|---|
| **ROG** | | | |
| **vmt (g/mi)** | 0.19 | 0.14 | 0.14 |
| **cold trip end (g/trip)** | 2.97 | 2.59 | 2.34 |
| **hot trip end (g/trip)** | 0.67 | 0.56 | 0.34 |
| **NOx** | | | |
| **vmt (g/mi)** | 0.59 | 0.52 | 0.54 |
| **cold trip end (g/trip)** | 2.64 | 2.51 | 3.33 |
| **hot trip end (g/trip)** | 1.25 | 1.13 | 1.14 |
| **CO** | | | |
| **vmt (g/mi)** | 1.08 | 0.67 | 0.55 |
| **cold trip end (g/trip)** | 34.38 | 27.99 | 19.11 |
| **hot trip end (g/trip)** | 5.87 | 4.45 | 3.12 |

**PM10**
**vmt** 2.38 (all years)

Source: Annual Average Emissions Inventories, EMFAC7F1.1/B7F by Model Year. Includes emissions for light and medium duty trucks. Statewide factors based on average of 3 major urban areas.
VMT factor equals running exhaust plus running losses divided by daily VMT.
Cold trip end factor equals cold starts divided by cold trips plus hot soak divided by all trips.
Hot trip end factor equals hot starts divided by hot trips plus hot soaks divided by all trips.
COLD START OCCURS WHEN VEHICLE IS TURNED OFF FOR OVER ONE HOUR.
PM10 factor includes motor vehicle exhaust, tire wear, and entrained road dust.

# *Table 3*

## *Average Auto Emission Factors*

Methodology: Multiply miles traveled for each year by the VMT factor to get emissions in grams.
Multiply number of trips by the trips factor (trip ends) for each year.
Add VMT emissions to trip end emissions. Do for each pollutant.

| | | Analysis Period | | | |
|---|---|---|---|---|---|
| | | **1-5 Years** (1995-1999) | **6-10 Years** (1995-2004) | **11-15 Years** (1995-2009) | **16-20 Years** (1995-2014) |
| **ROG** | | | | | |
| vmt | (g/mi) | 0.57 | 0.47 | 0.39 | 0.34 |
| Trips | (g/trip) | 5.46 | 4.46 | 3.65 | 3.08 |
| **NOx** | | | | | |
| vmt | | 0.69 | 0.6 | 0.52 | 0.47 |
| Trips | | 2.31 | 2.06 | 1.84 | 1.69 |
| **PM10** | | | | | |
| vmt | | 2.38 (all years) | | | |
| Trips | | NA | | | |
| **CO** | | | | | |
| vmt | | 4.56 | 3.73 | 3.23 | 2.91 |
| Trips | | 56.47 | 46.41 | 38.3 | 32.79 |

Source: Annual Average Emissions Inventories, EMFAC7F1.1/B7F. Includes average statewide emissions for light duty cars and trucks plus motorcycles.

VMT factor equals running exhaust plus running losses divided by daily VMT.
Trips factor equals (cold starts divided by cold trips) plus (hot soaks divided by daily trips).
PM10 factor includes motor vehicle exhaust, tire wear, and entrained road dust.

# ***TABLE 4***
# *Emision Factors by Speed*

## Project Life 1-5 Years

### Average Emission Factors for 1995-1999

**grams/mile**

| mph | ROG | NOx | CO |
|---|---|---|---|
| 5 | 4.18 | 2.91 | 21.89 |
| 10 | 1.93 | 1.72 | 12.43 |
| 15 | 1.15 | 1.46 | 8.58 |
| 20 | 0.83 | 1.29 | 6.62 |
| 25 | 0.67 | 1.19 | 5.44 |
| 30 | 0.56 | 1.15 | 4.63 |
| 35 | 0.48 | 1.16 | 4.05 |
| 40 | 0.42 | 1.22 | 3.65 |
| 45 | 0.37 | 1.34 | 3.45 |
| 50 | 0.35 | 1.52 | 3.51 |
| 55 | 0.37 | 1.78 | 3.97 |
| 60 | 0.49 | 2.12 | 5.94 |
| 65 | 1.02 | 2.55 | 12.39 |

Source: EMFAC7F1.1/B7F, temperature 75 degrees, statewide fleet averages.

## Project Life 6-10 Years

### Average Emission Factors for 1995-2004

**grams/mile**

| mph | ROG | NOx | CO |
|---|---|---|---|
| 5 | 3.73 | 2.36 | 18.05 |
| 10 | 1.69 | 1.59 | 10.36 |
| 15 | 0.99 | 1.35 | 7.16 |
| 20 | 0.70 | 1.19 | 5.52 |
| 25 | 0.56 | 1.10 | 4.52 |
| 30 | 0.47 | 1.06 | 3.85 |
| 35 | 0.40 | 1.07 | 3.37 |
| 40 | 0.35 | 1.12 | 3.05 |
| 45 | 0.31 | 1.23 | 2.89 |
| 50 | 0.30 | 1.40 | 2.95 |
| 55 | 0.32 | 1.63 | 3.35 |
| 60 | 0.42 | 1.93 | 4.91 |
| 65 | 0.84 | 2.33 | 9.95 |

Source: EMFAC7F1.1/B7F, temperature 75 degrees, statewide fleet averages.

# *Table 4 (Continued)*
# *Emission Factors by Speed*

## Project Life 11-15 Years

### Average Emission Factors for 1995-2009

**grams/mile**

| mph | ROG | NOx | CO |
|---|---|---|---|
| 5 | 3.26 | 2.11 | 15.59 |
| 10 | 1.47 | 1.50 | 9.06 |
| 15 | 0.86 | 1.27 | 6.27 |
| 20 | 0.61 | 1.12 | 4.82 |
| 25 | 0.48 | 1.03 | 3.94 |
| 30 | 0.41 | 1.00 | 3.36 |
| 35 | 0.35 | 1.00 | 2.94 |
| 40 | 0.31 | 1.06 | 2.67 |
| 45 | 0.27 | 1.15 | 2.54 |
| 50 | 0.26 | 1.31 | 2.60 |
| 55 | 0.28 | 1.52 | 2.96 |
| 60 | 0.36 | 1.81 | 4.26 |
| 65 | 0.70 | 2.18 | 8.37 |

Source: EMFAC7F1.1/B7F, temperature 75 degrees, statewide fleet averages.

## Project Life 16-20 Years

### Average Emission Factors for 1995-2015

**grams/mile**

| mph | ROG | NOx | CO |
|---|---|---|---|
| 5 | 2.81 | 1.95 | 13.77 |
| 10 | 1.27 | 1.42 | 8.10 |
| 15 | 0.74 | 1.21 | 5.61 |
| 20 | 0.53 | 1.07 | 4.30 |
| 25 | 0.42 | 0.99 | 3.51 |
| 30 | 0.35 | 0.95 | 2.99 |
| 35 | 0.30 | 0.95 | 2.62 |
| 40 | 0.27 | 1.00 | 2.39 |
| 45 | 0.24 | 1.09 | 2.28 |
| 50 | 0.23 | 1.24 | 2.35 |
| 55 | 0.24 | 1.44 | 2.67 |
| 60 | 0.31 | 1.71 | 3.78 |
| 65 | 0.59 | 2.06 | 7.18 |

Source: EMFAC7F1.1/B7F, temperature 75 degrees, statewide fleet averages.

## Table 2A Average Van/Shuttle Emission Factors For CO "Hot Spot" Evaluation

**Methodology:** Choose year that best represents the model year of the van/shuttle vehicle. Multiply the miles traveled by the VMT factor to get emissions in grams. Estimate number of cold starts and hot starts. Multiply by cold and hot trip end factors. Add VMT emissions to trip end emissions.

| **Model Year** | **1990** | **1991** | **1992** | **1993** |
|---|---|---|---|---|
| **CO** | | | | |
| vmt (g/mi.) | 3.58 | 2.97 | 2.49 | 1.75 |
| cold trip end (g/trip) | 67.83 | 62.78 | 57.66 | 46.26 |
| hot trip end (g/trip) | 14.51 | 12.62 | 11.19 | 8.62 |

| **Model Year** | **1994** | **1995** | **1996** |
|---|---|---|---|
| **CO** | | | |
| vmt (g/mi.) | 1.08 | 0.67 | 0.55 |
| cold trip end (g/trip) | 34.38 | 27.99 | 19.11 |
| hot trip end (g/trip) | 5.87 | 4.45 | 3.12 |

**Source:** Annual Average Emissions Inventories, EMFAC7F1.1/B7F by Model Year. Includes emissions for light and medium duty trucks (up to 8500 lbs. Gross Vehicle Weight). Statewide factors based on average of 3 major urban areas. VMT factor equals running exhaust plus running losses divided by daily VMT. Cold trip end factor equals cold starts divided by cold trips plus hot soak divided by all trips. Hot trip end factor equals hot starts divided by hot trips plus hot soaks divided by all trips. COLD START OCCURS WHEN VEHICLE IS TURNED OFF FOR OVER ONE HOUR.

# Table 3A Average Auto Emission Factors For CO "Hot Spot" Evaluation

**Methodology:** Multiply miles traveled for each year by the VMT factor to get emissions in grams. Multiply number of trips by the trips factor (trip ends) for each year. Add VMT emissions to trip end emissions. Do for each pollutant.

| | Analysis Period | | | |
|---|---|---|---|---|
| | **1-5 Years (1995-1999)** | **6-10 Years (1995-2004)** | **11-15 Years (1995-2009)** | **16-20 Years (1995-2014)** |
| **CO** | | | | |
| vmt | 4.56 | 3.73 | 3.23 | 2.91 |
| Trips | 56.47 | 46.41 | 38.3 | 32.79 |

**Source:** Annual Average Emissions Inventories, EMFAC7F1.1/B7F. Includes average statewide emissions for light duty cars and trucks plus motorcycles. VMT factor equals running exhaust plus running losses divided by daily VMT. Trips factor equals (cold starts divided by cold trips) plus (hot soaks divided by daily trips).

# Table 4A Emission Factors by Speed For CO "Hot Spot" Evaluation

## Project Life 1-5 Years

### Average Emission Factors for 1995-1999

**grams/mile**

| mph | CO |
|---|---|
| 5 | 21.89 |
| 10 | 12.43 |
| 15 | 8.58 |
| 20 | 6.62 |
| 25 | 5.44 |
| 30 | 4.63 |
| 35 | 4.05 |
| 40 | 3.65 |
| 45 | 3.45 |
| 50 | 3.51 |
| 55 | 3.97 |
| 60 | 5.94 |
| 65 | 12.39 |

Source: EMFAC7F1.1/B7F, temperature 75 degrees, statewide fleet averages.