REVISED

Methodology for Evaluating Congestion Mitigation and Air Quality Improvement Projects

Maricopa Association of Governments

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INTRODUCTION

The purpose of the Congestion Mitigation and Air Quality Improvement (CMAQ) Program is to provide federal funding for projects and programs designed to assist nonattainment and maintenance areas in complying with the National Ambient Air Quality Standards. In addition, final federal guidance for the CMAQ Program, effective April 28, 1999, indicates that Metropolitan Planning Organizations (MAG, for the Maricopa region) need to develop procedures for assessing emission reduction benefits for proposed CMAQ projects. In accordance with this guidance, MAG distributed this revised methodology for interagency consultation and for MAG modal committee review during July, 2001. The methodology was revised in August, 2001 in response to comments received. The response to comments on the methodology for evaluating CMAQ projects is provided in the Appendix.

Among the comments received on the draft methodology, one reviewer recommended use of more project and site-specific data in the CMAQ methodologies, while another inferred that the CMAQ data to be supplied by member agencies was too extensive. To balance these disparate views, the 2001 CMAQ methodology provides options for local input, while striving to keep the overall data requirements from being overly complex and burdensome. In general, agencies submitting CMAQ-eligible projects may provide local data to replace MAG default values in any of the methodologies, as long as there is supporting written documentation. The values to be substituted and the documentation (i.e., output of traffic engineering model; a city-specific survey) must be submitted to MAG with the project request for CMAQ funding.

Each year MAG programs available CMAQ funds. As part of the programming process, jurisdictions are requested through the MAG Management Committee, Transportation Review Committee, and MAG modal committees, to submit requests for federally funded projects. Guidance on projects eligible for CMAQ funding is provided in Section IX of the Draft FY 2003-2007 MAG Transportation Improvement Program Guidance Report, June 2001. Following the submittal of project requests, MAG will evaluate the CMAQ projects for possible inclusion in the Transportation Improvement Program. The MAG modal committees will be furnished with the CMAQ assessment, along with the Congestion Management System rating system score, for project evaluation purposes. It is anticipated that the recommendations from the MAG modal committees will be forwarded to the Transportation Review Committee for programming consideration.

The CMAQ assessment may be in the form of a quantitative analysis resulting from the methodologies or a qualitative evaluation. CMAQ guidance allows a qualitative evaluation to be made when a quantitative analysis is not possible. Qualitative assessments may be based on a reasonable review of how a project or program will decrease emissions. Proposed projects which are not quantified using the methodologies will be assessed based on a comparison with committed control measures found in the Revised MAG 1999 Serious Area Carbon Monoxide Plan for the Maricopa County Nonattainment Area and the Revised MAG 1999 Serious Area Particulate Plan for PM-10 for the Maricopa County Nonattainment Area. Committed transportation control measures identified in the air quality plans receive priority in project programming. In addition, if a different type of project is proposed, a new methodology to evaluate the project may be developed, if possible.

The methodologies for quantifying the emission reduction benefit and cost-effectiveness of typical CMAQ-funded projects are described below. In general, the methodologies involve the estimation of daily emission reductions, expressed as the sum of carbon monoxide (CO), total organic gases (TOG), and particulate matter less than ten microns in diameter (PM-10), expressed in kilograms per day, and the cost-effectiveness of each project, measured in CMAQ and total dollars per metric ton of total emissions reduced. It is important that the CMAQ emission reductions for committed control measures be as consistent as possible with the Serious Area Plans when emission reduction credit is taken. It should be noted that some projects do not reduce PM-10 emissions and, in these cases, only CO and TOG emissions will be considered. In other cases, only PM-10 emissions are reduced by a potential project and CO and TOG will be excluded from the calculation of total emissions. In quantifying total emission reductions, CO emission reductions will be divided by a factor of seven to normalize the effect of significantly higher CO emission rates, compared with TOG and PM-10 emission rates. It is important to note that if a proposed project combines two project types (i.e. paving a dirt road and adding a bicycle lane), the combined impact of the two portions of the project will be used to estimate the impact of the project.

The cost-effectiveness of a project will be calculated by dividing the annualized project cost, in terms of CMAQ dollars requested and total dollar cost, by the annual total emission reduction benefit in metric tons. The project cost will be annualized by amortizing the CMAQ funds requested and total cost for the project over the expected effectiveness period (project life) using a five percent discount rate. A five percent discount rate represents the opportunity cost of using public dollars to fund a project, versus investing the same public funds in a certificate of deposit earning five percent per year over the life of the project.

The Environmental Protection Agency (EPA) MOBILE5a and PART5 emission models will be run to estimate CO, TOG, and PM-10 emission factors for 2010 and 2015. The emission factors for 2010 will be used to estimate the impact of each project with a life expectancy of ten years or less. The emission factors for 2015 will be used to estimate the impact of each project with a life expectancy greater than ten years. All CO runs (winter scenario) with MOBILE5a will assume an average January temperature of 50 degrees Fahrenheit. All TOG runs (summer scenario) with MOBILE5a will assume an average July temperature of 90 degrees Fahrenheit. Temperature is not an input to PART5, which is used to estimate PM-10 emission factors. Therefore, the composite total CO, TOG, and PM-10 emission reductions produced by this analysis will not reflect either an annual average or any particular season. Emission factors will be estimated for a range of speeds in two mile per hour increments. Interpolation between these emission factors will be used to estimate emission factors for speeds falling between the two mile per hour increments. The average speed of area-wide traffic will be assumed to be 30 miles per hour, unless specified otherwise.

The sections below discuss the specific methodologies and assumptions to estimate emission reduction benefits and cost-effectiveness for typical CMAQ projects. The following project categories are addressed: Bus Projects, Bicycle and Pedestrian Facilities, Paving Projects, PM-10 Certified Street Sweepers, Traffic Flow Improvements, Intersection Improvements (including Roundabouts), Vanpool Vehicles, Rideshare Programs, Trip Reduction Program, Ozone Education Program, Telework Program, Teleconferencing, and High Occupancy Vehicle Facilities. The general approach for calculating cost-effectiveness was derived from the California Air Resources Board report, Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, 1999 Edition, August 1999. Other assumptions obtained from this report and other sources are noted below.

The methodology for each project category is divided into three sections. The first section describes the modeling methodology, the modeling assumptions, and default assumptions. The second lists the data that are requested from the entity proposing the project. If any of the necessary data are not provided, default assumptions will be used. The third section provides the formulas used in the analyses. Data from the first and second sections will be input to the formulas to estimate the emission reduction and cost-benefit of the proposed projects. At least one example calculation is provided for each project type.

The methodologies described below were developed in response to federal guidance (FHWA, 2000) requiring the quantification of emission reductions for proposed CMAQ projects. Other potential project benefits such as human health, safety, land use, and congestion mitigation impacts are not addressed. It is also important to reiterate that emissions reduction and cost-effectiveness are not the only factors considered in evaluating and selecting candidates for CMAQ funding.

BUS PROJECTS

"Alternative Fuels for Fleets" and "Expansion of Public Transportation Programs" are committed control measures in the MAG 1999 Serious Area CO and PM-10 Plans. "Alternative Fuels for Fleets" reduces CO, TOG, and PM-10 emissions by replacing diesel-powered buses with buses powered by alternative fuels. "Expansion of Public Transportation Programs" reduces CO, TOG, and PM-10 emissions by reducing the total vehicle miles of travel (VMT) driven by passenger automobiles.

Replacement of Diesel Buses with Alternative Fuel Buses

The MOBILE5a and PART5 models will be run to estimate the base emission factors (***BEF***) for 1993 model year transit buses (categorized as heavy duty diesel vehicles in MOBILE5a and buses in PART5) for 2015. These emission factors will be adjusted to reflect alternatively fueled buses using data from the U.S. Department of Energy National Alternative Fuel Hotline Heavy Duty Diesel Vehicle and Engine Resource Guide, October 1998. Table 1 in the DOE guide estimates certification standards ($\boldsymbol{CERT_{DIE}}$) for current generation buses (1996 EPA-certified). Table 4 in the DOE guide includes certification standards ($\boldsymbol{CERT_{ALT}}$) for the only liquefied natural gas (LNG) engine type which fits in the current buses used in the Phoenix area (DDC 50G). The base emission factors estimated by MOBILE5a and PART5 in unit of grams per mile will be reduced by the ratio of the certification standards (in grams per brake horsepower-hour) for the 1996 EPA buses and the buses with the LNG DDC 50G engine. The DOE certification standards will not be used directly, because units of grams per mile were not available.

It will be assumed that a bus travels 36,000 miles per year and operates 240 days per year. This assumption results in a bus traveling 150 miles per working day (***miles***).

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding***.
- ***Total Funding***.

Formulas:

$$\textit{Adjusted Emission Factor } (\boldsymbol{AEF}) = \left(\frac{BEF_{CO} * \frac{CERT_{ALT}}{CERT_{DIE}}}{7}\right) + \left(BEF_{PM} * \frac{CERT_{ALT}}{CERT_{DIE}}\right) + \left(BEF_{TOG} * \frac{CERT_{ALT}}{CERT_{DIE}}\right)$$

where: $CERT_{ALT}$ = the certification standard for an alternative fuel bus engine
$CERT_{DIE}$ = the certification standard for a diesel fuel bus engine
BEF = the base emission factor for each pollutant

$$\textit{Daily Emissions Reduction} = (\boldsymbol{miles}) * \left[\left(\frac{BEF_{CO}}{7} + BEF_{TOG} + BEF_{PM}\right) - \boldsymbol{AEF}\right] * \frac{1}{1000} * 0.66 = \frac{kilograms}{day}$$

where: 0.66 = factor to convert 240 operating days to 365 days per year
miles = the daily miles traveled by the bus
BEF = the base emission factor for each pollutant

$$\textit{Capital Recovery Factor } (\boldsymbol{CRF}) = \frac{(1+i)^{\boldsymbol{life}}\,(i)}{(1+i)^{\boldsymbol{life}} - 1}$$

where: i = discount rate of 5 percent
life = effectiveness period of 12 years (from CARB Report)

$$\textit{Cost-Effectiveness of CMAQ Funding} = \frac{\boldsymbol{CRF} * \boldsymbol{CMAQ\ Funding} * 1000}{\textit{Daily Emissions Reduction} * 365} = \frac{dollars}{metric\ ton}$$

$$\textit{Cost-Effectiveness of Total Cost} = \frac{\boldsymbol{CRF} * \boldsymbol{Total\ Cost} * 1000}{\textit{Daily Emissions Reduction} * 365} = \frac{dollars}{metric\ ton}$$

______where:_ ***CMAQ Funding*** = the CMAQ funding requested for the project
___________________***Total Cost*** = the total cost of the project

Purchase of an Alternative Fuel Bus **EXAMPLE**

A city proposes to purchase an alternative fuel bus to replace an existing diesel-powered bus. The cost of the alternative fuel bus is $320,000. The city proposes to pay $32,000 and requests $288,000 of CMAQ funding. It is assumed that the bus travels 150 miles per working day.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding*** = $288,000.
- ***Total Cost*** = $320,000.

Calculations:

$$\textit{Adjusted Emission Factor } (\boldsymbol{AEF}) = \left(\frac{7.9 * \frac{2.3}{15.5}}{7}\right) + \left(0.43 * \frac{0.01}{0.05}\right) + \left(1.6 * \frac{0.6}{1.3}\right) = 0.99$$

$$\textit{Daily Emissions Reduction} = (150) * \left[\left(\frac{7.9}{7} + 0.43 + 1.6\right) - 0.99\right] * \frac{1}{1000} * 0.66 = 0.21 \ \frac{\textit{kilograms}}{\textit{day}}$$

$$\textit{Capital Recovery Factor } (\boldsymbol{CRF}) = \frac{(1+0.05)^{12} * (0.05)}{(1+0.05)^{12} - 1} = 0.1128$$

$$\textit{Cost-Effectiveness of CMAQ Funds} = \frac{0.1128 * 288{,}000 * 1000}{0.21 * 365} = 423{,}828 \ \frac{\textit{dollars}}{\textit{metric ton}}$$

$$\textit{Cost-Effectiveness of Total Cost} = \frac{0.1128 * 320{,}000 * 1000}{0.21 * 365} = 470{,}920 \ \frac{\textit{dollars}}{\textit{metric ton}}$$

<u>New Bus Service</u>

Bus service on new routes and increased frequency on existing bus routes provide a new level of service and result in reduced automobile vehicle miles of travel. The daily emissions reduction attributable to the new service will be estimated based on the difference between the emissions from the automobile trips replaced by transit and the sum of the bus emissions from the new service and automobile emissions from people driving to reach transit.

The automobile VMT replaced (***VMT_{REP}***) by the new transit service will be estimated based on the fraction of riders on the bus who drove to their destination prior to introduction of the new bus service (***F_1***). This fraction will be multiplied by total bus riders and the average trip length replaced by the bus service (***trip $length_1$***). The VMT replaced by bus trips will be multiplied by the 2015 automobile emission factors from MOBILE5a and PART5 to estimate the automobile emissions from trips replaced by transit.

The emissions from the bus itself are equal to the number of miles driven daily by the bus multiplied by the exhaust plus fugitive dust emission factors from the bus. Exhaust emission factors for transit buses will be estimated using data from the U.S. Department of Energy National Alternative Fuel Hotline Heavy Vehicle and Engine Resource Guide, October 1998. These emission factors, expressed in units of grams per brake horsepower hour will be converted to grams per mile by multiplying by a factor of 4.2. In addition to the exhaust emission factors from buses, a PART5 fugitive dust emission factor will be included in the net emission factor estimated for buses. It will be assumed that a bus travels 36,000 miles per year and operates 240 days per year. This assumption results in a bus traveling 150 miles per working day (***VMT_{BUS}***).

The automobile VMT added (***VMT_{ADD}***) by people driving to reach the new transit service will be estimated based on the fraction of riders on the bus who drive to transit (***F_2***). This fraction will be multiplied by total bus riders and the average trip length to reach transit (***trip $length_2$***). The VMT added by automobile trips to reach transit will be multiplied by the 2015 cold start automobile emission factors from MOBILE5a and PART5 to estimate the automobile emissions added by trips to reach transit. The cold start emission factors are used because it is assumed that the average trip length to reach transit is two miles.

Inputs Required from Entity Requesting CMAQ Funds:

•***CMAQ Funding***.
•***Total Funding***.
•Fraction of riders who previously drove to their destination (***F_1***). For example, if 75 of 100 bus riders drove vehicles to their destination before introduction of the new bus, F_1 would equal 0.75. Default = 0.5 (CARB).
•Fraction of riders who drive to reach transit (***F_2***). For example, if 50 of 100 riders of the new bus drive to reach the bus, F_2 would equal 0.50. Default = 0.1 (1995 On-Board Origin and Destination Study).
•Average length of trip from home to destination (***trip $length_1$***). Default = 9 miles (CARB).
•Total daily ridership of each new bus (***R***). For example, if the new bus is expected to carry 400 people per day, *R* would equal 400. Default = 307 (Valley Metro).
•Average length of trip from home to transit (***trip $length_2$***). Default = 1.2 miles (Valley Metro).

Formulas:

$$\text{Auto VMT Replaced } (\boldsymbol{VMT_{REP}}) = R * F_1 * \text{trip length}_1$$

where: R = the ridership on the bus per operating day
F_1 = the fraction of riders on the bus who previously drove
trip length$_1$ = the average trip length replaced for each rider who previously drove

$$\text{Auto Emissions Replaced } (\boldsymbol{AUTO_{REP}}) = \boldsymbol{VMT_{REP}} * \left(\frac{BEF_{CO}}{7} + BEF_{TOG} + BEF_{PM}\right) * \frac{1}{1000} * 0.66 = \frac{kilograms}{day}$$

where: $\mathbf{VMT_{REP}}$ = the automobile travel replaced by bus service
BEF = the automobile base emission factor for each pollutant
0.66 = factor to convert 240 operating days to 365 days per year

$$\text{Bus Emissions } (\boldsymbol{BUS}) = \left[\left[\left(\frac{CERT_{CO}}{7} + CERT_{TOG} + CERT_{PM}\right) * 4.2\right] + BEF_{DUST}\right] * VMT_{BUS} * \frac{1}{1000} * 0.66 = \frac{kilograms}{day}$$

where: *CERT* = the certification standard for each pollutant
4.2 = the conversion factor for grams per brake horsepower hour certification standard to grams per mile
BEF_{DUST} = emission factor for dust reentrained by the bus
VMT_{BUS} = the daily bus VMT
0.66 = factor to convert 240 operating days to 365 days per year

$$\text{Auto VMT added } (\boldsymbol{VMT_{ADD}}) = R * F_2 * \text{trip length}_2$$

where: R = the ridership on the bus per operating day
F_2 = the fraction of riders who drive to transit
trip length$_2$ = the average trip length driven to transit

$$\text{Auto Emissions Added } (\boldsymbol{AUTO_{ADD}}) = \boldsymbol{VMT_{ADD}} * \left(\frac{BEF_{CO}}{7} + BEF_{TOG} + BEF_{PM}\right) * \frac{1}{1000} * 0.66 = \frac{kilograms}{day}$$

where: $\mathbf{VMT_{ADD}}$ = the VMT added as a result of trips made to reach transit
BEF = the cold start automobile emission factor for each pollutant
0.66 = factor to convert 240 operating days to 365 days per year

$$Daily\ Emissions\ Reduction = \boldsymbol{AUTO_{REP}} - \boldsymbol{BUS} - \boldsymbol{AUTO_{ADD}} = \frac{kilograms}{day}$$

$$Capital\ Recovery\ Factor\ (\boldsymbol{CRF}) = \frac{(1+i)^{\boldsymbol{life}}\ (i)}{(1+i)^{\boldsymbol{life}} - 1}$$

where: i = discount rate of 5 percent
life = effectiveness period of 12 years (from CARB Report)

$$Cost\text{-}Effectiveness\ of\ CMAQ\ Funding = \frac{\boldsymbol{CRF} * \boldsymbol{CMAQ\ Funding} * 1000}{Daily\ Emissions\ Reduction * 365} = \frac{dollars}{metric\ ton}$$

$$Cost\text{-}Effectiveness\ of\ Total\ Cost = \frac{\boldsymbol{CRF} * \boldsymbol{Total\ Cost} * 1000}{Daily\ Emissions\ Reduction * 365} = \frac{dollars}{metric\ ton}$$

where: ***CMAQ Funding*** = the CMAQ funding requested for the project
Total Cost = the total cost of the project

Operation of New Bus Service — EXAMPLE

A city proposes to purchase an alternative fuel bus to start a new bus route. The cost of the alternative fuel bus is $320,000. The city proposes to pay $32,000 and requests $288,000 of CMAQ funding. It is assumed that the bus travels 150 miles per working day. Over the life of the bus, it is expected to carry an average of 307 people per day.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding*** = $288,000.
- ***Total Cost*** = $320,000.
- Fraction of riders who previously drove to their destination ($\boldsymbol{F_1}$) = 0.5.
- Fraction of riders who drive to reach transit ($\boldsymbol{F_2}$) = 0.1.
- Average length of trip from home to destination ($\boldsymbol{trip\ length_1}$) = 9 miles.
- Total daily ridership of the new bus (***R***) = 307.
- Average length of trip from home to transit ($\boldsymbol{trip\ length_2}$) = 1.2 miles.

Calculations:

$$Auto\ VMT\ Replaced\ (\boldsymbol{VMT_{REP}}) = 307 * 0.50 * 9 = 1381.5$$

$$Auto\ Emissions\ Replaced\ (\boldsymbol{AUTO_{REP}}) = 1381.5 * (\frac{4.65}{7} + 0.78 + 1.39) * \frac{1}{1000} * 0.66 = 2.58\ \frac{kilograms}{day}$$

$$Bus\ Emissions\ (\boldsymbol{BUS}) = [[(\frac{2.3}{7} + 0.6 + 0.01) * 4.2] + 13.2] * 150 * \frac{1}{1000} * 0.66 = 1.70\ \frac{kilograms}{day}$$

$$Auto\ VMT\ added\ (\boldsymbol{VMT_{ADD}}) = 307 * 0.1 * 1.2 = 36.8$$

$$Auto\ Emissions\ Added\ (\boldsymbol{AUTO_{ADD}}) = 36.8 * (\frac{16.09}{7} + 1.54 + 1.39) * \frac{1}{1000} * 0.66 = 0.13\ \frac{kilograms}{day}$$

$$Daily\ Emissions\ Reduction = 2.58 - 1.70 - 0.13 = 0.75\ \frac{kilograms}{day}$$

$$Capital\ Recovery\ Factor\ (\boldsymbol{CRF}) = \frac{(1 + 0.05)^{\mathbf{12}} * (0.05)}{(1 + 0.05)^{\mathbf{12}} - 1} = 0.1128$$

$$Cost\text{-}Effectiveness\ of\ CMAQ\ Funding = \frac{(0.1128) * (288{,}000) * 1000}{(0.75) * 365} = 118{,}672\ \frac{dollars}{metric\ ton}$$

$$Cost\text{-}Effectiveness\ of\ Total\ Cost = \frac{(0.1128) * (320{,}000) * 1000}{(0.75) * 365} = 131{,}858\ \frac{dollars}{metric\ ton}$$

BICYCLE AND PEDESTRIAN FACILITIES

"Encouragement of Bicycle Travel" and "Development of Bicycle Travel Facilities" are committed control measures in the MAG 1999 Serious Area CO and PM-10 Plans. Bicycle facilities have the potential to reduce commute and other non-recreational trips. Bicycle paths are facilities which are physically separated from motor vehicle traffic. Bicycle lanes are striped for preferential or exclusive use of bicycles. CO, TOG, and PM-10 emission reductions occur when bicycle trips replace single occupant vehicle trips.

"Encouragement of Pedestrian Travel" is also a committed control measure in the MAG 1999 Serious Area CO and PM-10 Plans. Pedestrian facilities provide or improve pedestrian access. Emissions are reduced when vehicle trips are replaced by walking.

The CO, TOG, and PM-10 emission factors will be calculated based on a twenty-year project life for bicycle and pedestrian paths, a fifty-year project life for overpasses and underpasses, a ten-year project life for bicycles lanes on roads that do not have a curb and gutter, and a twenty-year project life for bicycle lanes on roads that have a curb and gutter. The annual average daily traffic (AADT) estimates for the nearest parallel arterial will be provided by the entity requesting CMAQ funding for the project. The following formulas will be used to calculate the annual emission reductions and cost-effectiveness of using CMAQ dollars to fund bicycle and pedestrian facilities. These formulas were derived from the CARB report, Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, 1999 Edition, August 1999.

MOBILE5a will be run assuming a speed of 30 miles per hour to estimate CO and TOG base emission factors ($\boldsymbol{BEF_{CO}}$ and $\boldsymbol{BEF_{TOG}}$). Since it is assumed that bicycle/pedestrian trips replace vehicle trips that are four miles or less, the cold start emission factor will be used for all vehicle trips replaced by bicycle/pedestrian trips. Evaporative emissions from the hot engine at the end of each trip will be estimated for TOG ($\boldsymbol{BEF_{END\ TOG}}$). PART5 will be run to estimate the base emission factors for PM-10 ($\boldsymbol{BEF_{PM}}$).

The number of vehicle trips replaced by bicycle or pedestrian trips will be estimated based on the annual average daily traffic on the nearest parallel arterial to the bicycle/pedestrian path. The AADT on the road will be converted to an estimate of vehicle trips reduced using the adjustment factors from Table 1. The adjustment factors are dependent upon the length of the bicycle/pedestrian project and the AADT on the road parallel to the bicycle/pedestrian project. Given the relative importance of bridges and underpasses that connect bicycle/pedestrian paths, the adjustment factor used for bridges and underpasses will be based on the sum of the lengths of the two paths connected.

Estimates of the vehicle VMT reduced will be based on the average number of vehicle trips reduced multiplied by the following assumed trip lengths. Consistent with assumptions in MAG transportation modeling concerning pedestrian trips to transit centers, a pedestrian trip distance of ½ mile will be assumed. Based on data in Bicycle Demand and Benefit Model (Alta Transportation Consulting, April 2000) an average bicycle trip length of four miles will be assumed. For multi-use paths, it will be assumed that half of the trips are bicycle and half are pedestrian. Therefore, an average trip length of 2.25 miles will be assumed for multi-use paths.

Table 1. Adjustment Factors*

ANNUAL AVERAGE DAILY TRAFFIC (AADT)	LENGTH OF PROJECT (one direction)	**ADJUSTMENT FACTOR (*A*)**
AADT ≤ 12,000 vehicles per day	≤ 1 mile	0.0019
	> 1 mile and ≤ 2 miles	0.0029
	> 2 miles	0.0038
12,000 < AADT≤ 24,000 vehicles per day	≤ 1 mile	0.0014
	> 1 mile and ≤ 2 miles	0.0020
	> 2 miles	0.0027
AADT > 24,000 vehicles per day	≤ 1 mile	0.0010
	> 1 mile and ≤ 2 miles	0.0014
	> 2 miles	0.0019

* Data adapted from Methods to Find Cost-Effectiveness of Funding Air Quality Projects (CARB 1999)

The usefulness of a bicycle/pedestrian path is also dependent upon its location. Usage estimates for bicycle/pedestrian paths will take into consideration the number of activity centers near the proposed bicycle/pedestrian path. The credit for activity centers along a bicycle/pedestrian path is shown in Table 2.

Table 2. Activity Center Credits*

Examples of Activity Centers: bank, church, hospital or HMO, park and ride, office park, post office, public library, shopping area or grocery store, schools, university or junior college.		
Number of activity centers	**Credit (C)**	
	Within ½ mile	Within ¼ mile
at least three	0.0005	0.001
more than three but less than seven	0.001	0.002
seven or more	0.0015	0.003

* Data adapted from Methods to Find Cost-Effectiveness of Funding Air Quality Projects (CARB 1999)

Inputs Required from Entity Requesting CMAQ Funds:

•***CMAQ Funding***.

•***Total Cost***.
•Annual average daily traffic (***AADT***) on the nearest parallel arterial.
•Number of activity centers (i.e. bank, church, hospital, HMO, light rail station, park and ride lot, office park, post office, public library, shopping area, grocery store, university or junior college) within ¼ mile and ½ mile of the bicycle/pedestrian project.
•Length of bicycle/pedestrian path (for a bridge/underpass; the combined length of the paths connected by the bridge/underpass).
•If a bicycle lane is on a road with or without curb and gutter. If the road does not include a curb and gutter, does it have a Maricopa edge and is the pavement in the bicycle lane at least as thick as the rest of the road.

Formulas:

$$\textit{Auto Trips Reduced } (\boldsymbol{ATR}) = (\boldsymbol{AADT}) * (\boldsymbol{A} + \boldsymbol{C})$$

where: ***A*** = the adjustment factor from the preceding table
C = the activity center credit from the preceding table
AADT = the annual average daily traffic on the nearest parallel arterial

$$\textit{Automobile VMT Reduced } (\boldsymbol{AVR}) = (\boldsymbol{ATR}) * (\boldsymbol{trip\ length})$$

where: ***trip length*** = the length of a bicycle trip is assumed to be 4.0 miles and the length of a pedestrian trip is assumed to be 0.5 miles. For a multi-use path, it is assumed that the average trip length is 2.25 miles

$$\textit{Daily Emissions Reduction} = [[\boldsymbol{ATR} * BEF_{END\ TOG}] + [\boldsymbol{AVR} * (\frac{BEF_{CO}}{7} + BEF_{TOG} + BEF_{PM})]] * \frac{1}{1000} = \frac{kilograms}{day}$$

where: ***BEF*** = the base emission factor in cold start mode for each pollutant
$\boldsymbol{BEF_{END\ TOG}}$ = the base trip end emission factor for TOG (hot soak)

$$\textit{Capital Recovery Factor } (\boldsymbol{CRF}) = \frac{(1+i)^{\boldsymbol{life}}\ (i)}{(1+i)^{\boldsymbol{life}} - 1}$$

where: *i* = discount rate of 5 percent
life = effectiveness period of 20 years for bicycle and pedestrian paths; 50 years for an overpass or underpass; 10 years for bicycle lane on road without curb/gutter; 15 years for a striped bicycle lane on a road without curb/gutter but with a Maricopa edge and pavement on the bicycle path at least as thick as the remainder of road; 20 years for bicycle lane on road with curb/gutter.

$$Cost\text{-}Effectiveness\ of\ CMAQ\ Funding = \frac{(\boldsymbol{CRF}) * (\boldsymbol{CMAQ}\ Funding) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

$$Cost\text{-}Effectiveness\ of\ Total\ Cost = \frac{(\boldsymbol{CRF}) * (\boldsymbol{Total}\ Cost) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

where: ***CMAQ Funding*** = the CMAQ funding requested for the project
Total Cost = the total cost of the project

Bicycle and Pedestrian Facilities **EXAMPLE**

A city proposes a 1.5 mile long bike lane at a total cost of $650,000 where $65,000 will be paid for with local funds. The lane is on an arterial with an estimated annual average daily traffic (**AADT**) of 18,000 vehicles per day. There are three activity centers (a grocery store, a library, and a park and ride) less than ¼ mile from the path. There are four additional activity centers (two office parks, a church, and a post-office) between ¼ and ½ mile from the path for a total of seven activity centers within ½ mile.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding***=$585,000.
- ***Total Cost***.=$650,000.
- Project length (***miles***)=1.5 miles.
- Annual average daily traffic (***AADT***) on nearest parallel arterial = 18,000.
- Activity centers within ¼ mile=3 OR Activity centers within ½ mile =7.
- Project is on a road with a curb and gutter.

Calculations:

The primary Adjustment Factor (**A**) is calculated from Table 1. From Table 1, the adjustment factor for a path adjacent to a roadway with between 12,000 and 24,000 and between one and two miles in length is 0.0020. The Activity Center Credit (**C**) is calculated from Table 2. There are two choices of activity center credit for this project, since there are three activity centers within one quarter mile (0.001) and seven centers within one half mile (0.0015). The higher value, 0.0015, is chosen.

$$Auto\ Trips\ Reduced\ (\boldsymbol{ATR}) = (18{,}000) * (0.0020 + 0.0015) = 63\ \frac{trips}{day}$$

$$Automobile\ VMT\ Reduced\ (\boldsymbol{AVR}) = (63) * (4) = 252\ \frac{vehicle-miles}{day}$$

$$Daily\ Emissions\ Reduction = [[63 * 0.43] + [252 * (\frac{13.45}{7} + 1.5 + 1.38)]] * \frac{1}{1000} = 1.24\ \frac{kilograms}{day}$$

$$Capital\ Recovery\ Factor\ (\boldsymbol{CRF}) = \frac{(1+0.05)^{20} * (0.05)}{(1+0.05)^{20} - 1} = 0.0802$$

$$Cost-Effectiveness\ of\ CMAQ\ Funds = \frac{(0.0802) * (585{,}000) * 1000}{(1.24) * 365} = 103{,}661\ \frac{dollars}{metric\ ton}$$

$$Cost-Effectiveness\ of\ Total\ Cost = \frac{(0.0802) * (650{,}000) * 1000}{(1.24) * 365} = 115{,}179\ \frac{dollars}{metric\ ton}$$

PAVING PROJECTS

"Reduce Particulate Emissions from Unpaved Roads and Alleys," "Reduce Particulate Emissions from Unpaved Shoulders on Targeted Arterials," "Paving, Vegetating and Chemically Stabilizing Unpaved Access Points Onto Paved Roads (Especially Adjacent to Construction/Industrial Sites)," and "Curbing, Paving or Stabilizing Shoulders on Paved Roads (Includes Painting Stripe on Outside of Travel Lane)" are committed control measures in the Revised MAG 1999 Serious Area PM-10 Plan. Paving projects are effective in reducing PM-10 and therefore, represent potential candidates for CMAQ funds. Typical projects requesting CMAQ funds are for paving unpaved shoulders, curbs and gutters, unpaved roads, and unpaved access points. These projects will be assumed to reduce PM-10, but not CO or TOG.

Consistent with the methodology used in the Particulate Control Measure Feasibility Study (MAG, 1997), projects involving the paving of unpaved shoulders and/or curbs and gutters will be assumed to reduce roadway PM-10 emissions by 50 percent. Assuming that the average non-freeway paved road emission factor is 1.1 grams per vehicle mile, controlling an uncontrolled shoulder will reduce emissions by 0.55 grams per vehicle mile. The Serious Area PM-10 Plan assumed an unpaved road emission rate of 573.91 grams per vehicle mile of travel (***BEF***) and a paved road emission rate of 1.573 grams per vehicle mile of travel (***AEF***) on low ADT roads. The difference between the paved and unpaved emission rates (i.e. 572 g/vmt) represents the reduction in PM-10 emissions due to paving of unpaved roads. As in the Serious Area PM-10 Plan, paving unpaved access points will be assumed to reduce emissions by 41 grams per access point per day. If the number of access points to be paved is not supplied, it will be assumed that eight access points were paved per project mile.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding***.
- ***Total Cost***.
- Project length (***miles***).
- Annual average daily traffic (***AADT***) for paving unpaved roads or controlling shoulders.
- The number of access points to be paved (***access points***) - if paving unpaved access points.
- **Whether or not the project includes curb and gutter or Maricopa edge and equal pavement thickness (for paving shoulders)**

Formulas:

<u>For Paving Unpaved Shoulders/Curbs and Gutters</u>:

$$\text{Daily Emissions Reduction} = \left(0.55 \frac{\text{grams}}{\text{vehicle mile}}\right) * (\textbf{miles}) * (\textbf{AADT}) * \frac{1}{1000} = \frac{\text{kilograms}}{\text{day}}$$

where: ***miles*** = the length of the project
AADT = the average annual daily traffic

<u>For Paving Unpaved Roads</u>:

$$\text{Daily Emissions Reduction} = (\textbf{BEF} - \textbf{AEF}) * (\textbf{miles}) * (\textbf{AADT}) * \frac{1}{1000} = \frac{\text{kilograms}}{\text{day}}$$

where: ***miles*** = the length of the road
AADT = the annual average daily traffic on the road to be paved
BEF = the emission factor for travel on an unpaved road
AEF = the emission factor for travel on a paved road

<u>For Paving Unpaved Access Points</u>:

$$\text{Daily Emissions Reduction} = \left(41 \frac{\text{grams}}{\text{access point} - \text{day}}\right) * (\textbf{access points}) * \frac{1}{1000} = \frac{\text{kilograms}}{\text{day}}$$

where: ***access points*** = the number of access points to be paved

For All Paving Projects:

$$Capital\ Recovery\ Factor\ (\mathbf{CRF}) = \frac{(1+i)^{life}\ (i)}{(1+i)^{life} - 1}$$

where: i = discount rate of 5 percent
life = effectiveness period of 20 years (10 years for paving an unpaved road without curb and gutter, **15 years for paving an unpaved road without curb and gutter but including Maricopa edge and equal or greater pavement thickness on shoulder as remainder of road**)

$$Cost\text{-}Effectiveness\ of\ CMAQ\ Funding = \frac{(\mathbf{CRF}) * (\mathbf{CMAQ}\ Funding) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

$$Cost\text{-}Effectiveness\ of\ Total\ Cost = \frac{(\mathbf{CRF}) * (\mathbf{Total}\ Cost) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

where: ***CMAQ Funding*** = the CMAQ funding requested for the project
Total Cost = the total cost of the project

Paving Unpaved Roads (no curb/gutter) EXAMPLE

A city proposes to pave a 1.5 mile unpaved road which currently has 150 trips per day. The project will not include the addition of curb and gutter **and does not have a Maricopa edge**. Therefore, the project life will be 10 years. The cost of paving the road is $150,000. The city proposes to pay $15,000 and requests $135,000 of CMAQ funding.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding*** = $135,000.
- ***Total Cost*** = $150,000.
- Project length (***miles***) = 1.5 miles.
- Annual average daily traffic (***AADT***) on unpaved road = 150.

Calculations:

$$Daily\ Emissions\ Reduction = (573.91 - 1.573) * (1.5) * (150) * \frac{1}{1000} = 128.8\ \frac{kilograms}{day}$$

$$\textit{Capital Recovery Factor } (\textbf{\textit{CRF}}) = \frac{(1+0.05)^{10} * (0.05)}{(1+0.05)^{10} - 1} = 0.1295$$

$$\textit{Cost-Effectiveness of Total Cost} = \frac{(0.1295) * (150{,}000) * 1000}{(128.8) * 365} = 413 \frac{\textit{dollars}}{\textit{metric ton}}$$

$$\textit{Cost-Effectiveness of CMAQ Funding} = \frac{(0.1295) * (135{,}000) * 1000}{(128.8) * 365} = 372 \frac{\textit{dollars}}{\textit{metric ton}}$$

Paving Unpaved Roads (adding curb/gutter) EXAMPLE

A city proposes to pave a one-mile unpaved road which currently has 150 trips per day. The project will include the addition of curb and gutter. Therefore, the project life will be 20 years. The cost of paving the road and adding curb and gutter is $500,000. The city proposes to pay $50,000 and requests $450,000 of CMAQ funding.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding*** = $450,000.
- ***Total Cost*** = $500,000.
- Project length (***miles***) = 1 mile.
- Annual average daily traffic (***AADT***) on unpaved road = 150.

Calculations:

Calculate the daily emissions reduction from paving the unpaved road

$$\textit{Daily Emissions Reduction} = (573.91 - 1.573) * (1) * (150) * \frac{1}{1000} = 85.9 \frac{\textit{kilograms}}{\textit{day}}$$

Calculate the daily emissions reduction from adding the curb and gutter

$$\textit{Daily Emissions Reduction} = (0.55 \frac{\textit{grams}}{\textit{vehicle mile}}) * (1) * (150) * \frac{1}{1000} = 0.083 \frac{\textit{kilograms}}{\textit{day}}$$

$$\textit{Capital Recovery Factor } (\textbf{\textit{CRF}}) = \frac{(1+0.05)^{20} \ * \ (0.05)}{(1+0.05)^{20} - 1} = 0.0802$$

$$\textit{Cost-Effectiveness of CMAQ Funding} = \frac{(0.0802) * (450{,}000) * 1000}{(85.9 + 0.083) * 365} = 1{,}151 \ \frac{\textit{dollars}}{\textit{metric ton}}$$

$$\textit{Cost-Effectiveness of Total Cost} = \frac{(0.0802) * (500{,}000) * 1000}{(85.9 + 0.083) * 365} = 1{,}278 \ \frac{\textit{dollars}}{\textit{metric ton}}$$

Paving Unpaved Access Points EXAMPLE

A city proposes to pave unpaved access points on two miles of road. The project life will be 20 years. The cost of paving the access points is $325,000. The city proposes to pay $32,500 and requests $292,500 of CMAQ funding.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding*** = $292,500.
- ***Total Cost*** = $325,000.
- Project length (***miles***) = 2 miles.
- Access points to be paved (***access points***) assume 8 per mile.

Calculations:

$$\textit{Daily Emissions Reduction} = \left(\frac{41 \textit{ grams}}{\textit{access point-day}}\right) * (16) * \frac{1}{1000} = 0.656 \ \frac{\textit{kilograms}}{\textit{day}}$$

$$\textit{Capital Recovery Factor } (\textbf{\textit{CRF}}) = \frac{(1+0.05)^{20} \ (0.05)}{(1+0.05)^{20} - 1} = 0.0802$$

$$\textit{Cost-Effectiveness of CMAQ Funding} = \frac{(0.0802) * (292{,}500) * 1000}{(0.656) * 365} = 97{,}972 \ \frac{\textit{dollars}}{\textit{metric ton}}$$

$$\textit{Cost-Effectiveness of Total Cost} = \frac{(0.0802) * (325{,}000) * 1000}{(0.656) * 365} = 108{,}858 \ \frac{\textit{dollars}}{\textit{metric ton}}$$

PM-10 CERTIFIED STREET SWEEPERS

"PM-10 Efficient Street Sweepers" is a committed control measure in the Revised MAG 1999 Serious Area PM-10 Plan. Street sweepers certified in accordance with South Coast Air Quality Management District Rule 1186 reduce PM-10 on paved roads, which reduces PM-10 reentrainment by vehicles traveling on the road. Therefore, the purchase of PM-10 certified street sweepers is eligible for CMAQ funds. Emission reductions for PM-10 certified street sweepers will be addressed as three separate components: the reduction in reentrained dust from vehicles traveling on the roadways cleaned by the sweeper, the reduction in dust from the actual sweeping process, and, where appropriate, the reduction in tailpipe emissions for sweepers using alternative fuels. These components will be combined to determine the total emissions reduction associated with a PM-10 certified street sweeper. Each component is described in a separate section below.

Reduced Reentrained Dust from Vehicles Traveling on Roadways. This emission reduction will be based on a comparison of the emissions from the base silt loading on a paved road after using a conventional sweeper versus emissions from the reduced silt loading attributable to a PM-10 certified street sweeper. The reduced silt loading results in lower emissions of reentrained dust from vehicles traveling on the road. Emission reductions for this component will only be calculated for PM-10.

The emission factor for reentrained dust varies depending upon how often a street is swept. It will be assumed that requested PM-10 certified street sweepers use the same sweeping schedule as the conventional street sweepers that they replace. Based on the Most Stringent PM-10 Control Measure Analysis (MAG, 1998), it will be assumed that the silt loading on a street returns to its initial level eight days after the street is swept by a PM-10 efficient street sweeper and three days after being swept by a conventional sweeper. Data from that report also indicate that the PM-10 certified street sweepers reduce the initial silt loading by 80 percent (i.e. the silt loading is reduced to 20 percent of the initial level), while conventional sweepers reduce the initial silt loading by 30 percent. The schedule listed in the Most Stringent PM-10 Control Measure Analysis for percent of initial silt loading at varying days after PM-10 efficient sweeping is as follows: day of sweeping - 20 percent, 1 day after - 30 percent, 2 days after - 40 percent, 3 days after - 50 percent, 4 days after - 60 percent, 5 days after - 70 percent, 6 days after - 80 percent, 7 days after - 90 percent, and eight days or more after - 100 percent of initial silt loading. Similarly, the silt loading at varying days after sweeping with a conventional street sweeper is as follows: day of sweeping - 70 percent, 1 day after - 80 percent, 2 days after - 90 percent, and 3 days or more after - 100 percent of initial silt loading.

The paved road emission factor for reentrained dust is exponentially related to the silt loading. Therefore, the change in emission factor with time after sweeping does not follow the same linear relationship as shown for silt loading. The emission factors for freeways and non-freeways are listed below at various days following street sweeping. Based on sweeping frequency, these emission factors will be combined to create a weighted average emission factor as shown in the emission factor formulas below. Separate weighted emission factors will be estimated to reflect the impact of sweeping with PM-10 certified street sweepers versus conventional street sweepers. The difference between these two emission factors is the incremental change that is achieved when replacing a conventional street sweeper with a PM-10 certified street sweeper.

Emission factor as a function of days after sweeping with a PM-10 certified street sweeper		
	Freeway	Non-freeway
initial (for all days where k ≥ 9)	0.163 g/VMT	1.10 g/VMT
day of sweeping (k=1)	0.057 g/VMT	0.39 g/VMT
1 day after sweeping (k=2)	0.075 g/VMT	0.50 g/VMT
2 days after sweeping (k=3)	0.090 g/VMT	0.61 g/VMT
3 days after sweeping (k=4)	0.104 g/VMT	0.70 g/VMT
4 days after sweeping (k=5)	0.117 g/VMT	0.79 g/VMT
5 days after sweeping (k=6)	0.129 g/VMT	0.87 g/VMT
6 days after sweeping (k=7)	0.141 g/VMT	0.95 g/VMT
7 days after sweeping (k=8)	0.152 g/VMT	1.03 g/VMT
8 days after sweeping (k=9)	0.163 g/VMT	1.10 g/VMT

Emission factor as a function of days after sweeping with a conventional street sweeper		
	Freeway	Non-freeway
initial (for all days where k ≥ 4)	0.163 g/VMT	1.10 g/VMT
day of sweeping (k=1)	0.129 g/VMT	0.87 g/VMT
1 day after sweeping (k=2)	0.141 g/VMT	0.95 g/VMT
2 days after sweeping (k=3)	0.152 g/VMT	1.03 g/VMT
3 days after sweeping (k=4)	0.163 g/VMT	1.10 g/VMT

Reduced Emissions During the Sweeping Process. The reduction in PM-10 from the actual sweeping process will be based upon the estimate that a PM-10 certified street sweeper entrains 0.05 pounds per mile less PM-10 than a conventional sweeper during the sweeping process (CARB, 1999). For this analysis, the emissions reduction is converted to the units of kilograms per vehicle mile, for a resulting emission reduction factor of 0.023 kilograms per vehicle mile traveled by the PM-10 certified sweeper. This estimate will be combined with the estimate of miles traveled per day by the street sweeper to produce a total reduction in emissions in kilograms for an average day. Emission reductions for this component will only be calculated for PM-10.

Reduced Exhaust Emissions from Alternative Fuel PM-10 Certified Sweepers. For PM-10 certified street sweepers which run on alternative fuels, the reduction in exhaust emissions from the alternatively fueled engines will be derived in a manner consistent with the CMAQ methodology used for the Replacement of Diesel Buses with Alternative Fuel Buses. The same adjusted emission factor derived for buses in that methodology will be applied to the alternative fuel PM-10 certified street sweepers. Emission reductions for this component include exhaust emissions of carbon monoxide, total organic compounds, as well as PM-10.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding***.
- ***Total Cost***.
- Annual average daily traffic (***AADT***) per lane on streets to be swept by each requested sweeper.
- Lane miles (***miles***) of street to be swept per cycle by each requested sweeper.
- Sweeping cycle length (***time***) per lane mile (i.e. each lane mile is swept once every 14 days).
- If the street sweeper is used primarily on freeways or non-freeways.

Formulas:

Reduced Reentrained Dust from Vehicles Traveling on Roadways:

Emission factor for roads swept with PM-10 certified street sweepers:

$$Emission\ Factor\ (\boldsymbol{PEF}) = \frac{\sum_{k=1}^{\boldsymbol{time}} (PM\text{-}10\ certified\ emission\ factor)_k}{\boldsymbol{time}}$$

Emission factor for roads swept with conventional street sweepers:

$$Emission\ Factor\ (\boldsymbol{CEF}) = \frac{\sum_{k=1}^{\boldsymbol{time}} (conventional\ emission\ factor)_k}{\boldsymbol{time}}$$

where:

(PM-10 certified emission factor)$_k$ = the emission factor on day k from the table that lists emission factors reflecting the impact of PM-10 certified street sweepers

(conventional emission factor)$_k$ = the emission factor on day k from the table that lists emission factors reflecting the impact of conventional street sweepers

time = number of days in the sweeping cycle

$$\textit{Daily Emissions Reduction for Vehicle Reentrainment} = (\textbf{\textit{miles}}) * (\textbf{\textit{AADT}}) * (\textbf{\textit{CEF}} - \textbf{\textit{PEF}}) * \frac{1}{1000} = \frac{\textit{kilograms}}{\textit{day}}$$

<u>Reduced Emissions During the Sweeping Process:</u>

$$\textit{Daily Emissions Reduction for the Sweeping Process} = (\textbf{\textit{miles}}) * (0.023) * \frac{1}{\textbf{\textit{time}}} = \frac{\textit{kilograms}}{\textit{day}}$$

<u>Reduced Exhaust Emissions from Alternative Fuel PM-10 Certified Sweepers:</u>

$$\textit{Daily Emissions Reduction for Alternative Fuel Sweepers} = (\textbf{\textit{miles}}) * (1.4\ \textit{grams}) * \frac{1}{\textbf{\textit{time}}} * \frac{1\ \textit{kilogram}}{1000\ \textit{grams}} = \frac{\textit{kilograms}}{\textit{day}}$$

where: ***miles*** = lane miles of street to be swept per cycle by each requested sweeper
AADT = annual average daily traffic per through lane mile on streets to be swept by each requested sweeper
0.023 = kilograms per mile reduction in reentrained dust from the sweeping process itself.
1.4 grams= reduction in exhaust emissions per vehicle mile (as calculated using the CMAQ methodology for the Replacement of Diesel Buses with Alternative Fuel Buses where 1.4 grams = 0.21 kilograms per day / 150 vehicle miles per day).

$$\textit{Capital Recovery Factor } (\textbf{\textit{CRF}}) = \frac{(1+i)^{\textbf{\textit{life}}}\,(i)}{(1+i)^{\textbf{\textit{life}}} - 1}$$

where: i = discount rate of 5 percent
life = effectiveness period of 8 years

$$\textit{Cost-Effectiveness of CMAQ Funding} = \frac{(\textbf{\textit{CRF}}) * (\textbf{\textit{CMAQ}}\ \textit{Funding}) * 1000}{(\textit{Daily Emissions Reduction}) * 365} = \frac{\textit{dollars}}{\textit{metric ton}}$$

$$\textit{Cost-Effectiveness of Total Cost} = \frac{(\textbf{\textit{CRF}}) * (\textbf{\textit{Total}}\ \textit{Cost}) * 1000}{(\textit{Daily Emissions Reduction}) * 365} = \frac{\textit{dollars}}{\textit{metric ton}}$$

______where:_ ***CMAQ Funding*** = the CMAQ funding requested for the project
___________________***Total Cost*** = the total cost of the project

<u>PM-10 Certified Street Sweepers EXAMPLE</u>

A city proposes to purchase a PM-10 certified street sweeper to replace an existing broom street sweeper. The cost of the sweeper is $150,000. The city proposes to pay $15,000 and requests $135,000 of CMAQ funding. The sweeper will be used on non-freeway roads with 2000 average daily trips per through lane. Each lane mile of street will be swept once every 14 days. During this 14-day cycle, 700 lane miles of road will be swept using the street sweeper. The street sweeper is powered with conventional diesel fuel.

Inputs Required from Entity Requesting CMAQ Funds:

CMAQ Funding = $135,000.
Total Cost = $150,000.
Average daily trips per through lane on roads to be swept (***ADT***)= 2000 vehicles/day.
Lane miles of road swept per cycle (***miles***) = 700 miles.
Number of days in the sweeping cycle (***time***) = 14 days.

Calculations:

$$\boldsymbol{PEF} = \frac{0.39 + 0.50 + 0.61 + 0.70 + 0.79 + 0.87 + 0.95 + 1.03 + (6 * 1.10)}{(14)} = 0.89$$

$$\boldsymbol{CEF} = \frac{0.87 + 0.95 + 1.03 + (11 * 1.10)}{(14)} = 1.07$$

$$\textit{Daily Emissions Reduction for Vehicle Reentrainment} = (700) * (2000) * (1.07 - 0.89) * \frac{1}{1000} = 252 \frac{kilograms}{day}$$

$$\textit{Daily Emissions Reduction for the Sweeping Process} = (700) * (0.023) * \frac{1}{14} = 1.2 \frac{kilograms}{day}$$

$$\boldsymbol{CRF} = \frac{(1 + 0.05)^8 * (0.05)}{(1 + 0.05)^8 - 1} = 0.1547$$

$$\textit{Cost-Effectiveness of CMAQ Funds} = \frac{(0.1547) * (135,000) * 1000}{(253.2) * 365} = 226 \frac{dollars}{metric\ ton}$$

$$Cost-Effectiveness\ of\ Total\ Cost = \frac{(0.1547)*(150{,}000)*1000}{(253.2)*365} = 251\ \frac{dollars}{metric\ ton}$$

TRAFFIC FLOW IMPROVEMENTS

"Coordinate Traffic Signal Systems," "Develop Intelligent Transportation Systems," and "Reduce Traffic Congestion at Major Intersections" are committed control measures in the MAG 1999 Serious Area CO and PM-10 Plans. These measures reduce CO and TOG emissions by reducing vehicle idling time and increasing speeds on roadways. The following types of traffic flow improvement projects are candidates for CMAQ funding: traffic signal coordination, Intelligent Transportation Systems (ITS), Freeway Management System (FMS), and intersection improvements.

Traffic Signal Coordination

The following formulas will be used to calculate the daily CO and TOG emission reductions and cost-effectiveness of using CMAQ dollars to fund traffic signal coordination projects. These formulas were derived from the CARB report, Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, 1999 Edition, August 1999.

The ADT and speed before project implementation will be provided by the entity requesting the CMAQ funds. The speed after project implementation will be derived from the CARB report, Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, 1999 Edition, August 1999. (See Table 3). Using the baseline traffic speed, MOBILE5a will be run to estimate the base emission factors for CO and TOG (BEF_{CO} and BEF_{TOG}). The data in Table 3 corresponding to the category of improvement will be used to estimate the traffic speed after project implementation. MOBILE5a was run to estimate the adjusted emission factors for CO and TOG (AEF_{CO} and AEF_{TOG}) that correspond to the estimated speeds. The PART5 model will not be used, because speed changes do not significantly impact PM-10 emissions. It will be assumed that traffic signal coordination provides no benefit on weekend days.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding***.
- ***Total Cost***.
- Length of project (***miles***).
- Current average weekday traffic (***ADT***).
- Pre-improvement traffic speed.
- The category into which the proposed project may be classified (see Table 3).

Table 3. "After" Traffic Signal Coordination Speeds

Category	Before Condition	After Condition	Increase in Speed
one	Non-interconnected, pre-timed signals with old timing plan	Advanced computer-based control	25 percent
two	Interconnected, pre-timed signals with old timing plan	Advanced computer-based control	17.5 percent
three	Non-interconnected signals with traffic-actuated controllers	Advanced computer-based control	16 percent
four	Interconnected, pre-timed signals with actively managed timing	Advanced computer-based control	8 percent
five	Interconnected, pre-timed signals with various forms of master control and various qualities of timing plans	Optimization of signal timing plans. No change in hardware	12 percent
six	Non-interconnected, pre-timed signals with old timing plan	Optimization of Signal Timing Plans	7.5 percent

Formulas:

$$\textit{Daily Emissions Reduction} = (\textbf{\textit{miles}}) * (\textbf{\textit{ADT}}) * [(\frac{BEF_{CO}}{7} + BEF_{TOG}) - (\frac{AEF_{CO}}{7} + AEF_{TOG})] * \frac{1}{1000} * \frac{250}{365} = \frac{kilograms}{day}$$

where: 250/365 = the conversion from weekdays to annual days
miles = the length of the project
ADT = the average weekday traffic
BEF = base emission factor for each pollutant reflecting pre-project speed
AEF = adjusted emission factor for each pollutant reflecting post-project speed

$$\textit{Capital Recovery Factor } (\textbf{\textit{CRF}}) = \frac{(1+i)^{life}\,(i)}{(1+i)^{life} - 1}$$

where: i = discount rate of 5 percent
life = effectiveness period of 5 years (from CARB report)

$$\textit{Cost-Effectiveness of CMAQ Funding} = \frac{(\textbf{\textit{CRF}}) * (\textbf{\textit{CMAQ}}\ \textit{Funding}) * 1000}{(\textit{Daily Emissions Reduction}) * 365} = \frac{dollars}{metric\ ton}$$

$$Cost-Effectiveness\ of\ Total\ Cost = \frac{(\mathbf{CRF}) * (\mathbf{Total}\ Cost) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

where: ***CMAQ Funding*** = the CMAQ funding requested for the project
Total Cost = the total cost of the project

Traffic Signal Coordination EXAMPLE

A city proposes to install a system that synchronizes the traffic lights on three miles of street. The city will be replacing non-interconnected signals having traffic-actuated controllers with an advanced computer-based control system. The cost of the system is $475,000. The city proposes to pay $50,000 and requests $425,000 of CMAQ funding. The existing mean speed on the street is 34 miles per hour. Based on the project fitting in category three of Table 3, it is estimated that the speed on the road will be increased to 39.4 miles per hour. The ADT on the road was estimated to be 10,000.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding*** = $425,000.
- ***Total Cost*** = $475,000.
- Length of project (***miles***) = 3.
- Average weekday traffic (***ADT***).
- Pre-improvement traffic speed = 34 miles per hour.
- The category into which the proposed project may be classified (see Table 3) = category 3.

Calculations:

$$Daily\ Emissions\ Reduction = (3) * (10{,}000) * [(\frac{6.07}{7} + 0.88) - (\frac{5.07}{7} + 0.79)] * \frac{1}{1000} * \frac{250}{365} = 4.78\ \frac{kilograms}{day}$$

$$Capital\ Recovery\ Factor\ (\mathbf{CRF}) = \frac{(1+0.05)^5 * (0.05)}{(1+0.05)^5 - 1} = 0.2310$$

$$Cost-Effectiveness\ of\ CMAQ\ Funds = \frac{(0.2310) * (425{,}000) * 1000}{(4.78) * 365} = 56{,}270\ \frac{dollars}{metric\ ton}$$

$$Cost-Effectiveness\ of\ Total\ Cost = \frac{(0.2310) * (475{,}000) * 1000}{(4.78) * 365} = 62{,}890\ \frac{dollars}{metric\ ton}$$

Intelligent Transportation Systems

The installation of Intelligent Transportation Systems (ITS) alerts drivers concerning congestion incidents. This permits more efficient rerouting of traffic and increases vehicle speeds which, in turn, reduces CO and TOG emissions. Emission factors will be calculated for vehicle operating speeds before and after the incident management and congestion mitigation provided by ITS. The estimated vehicle miles of travel (VMT) on the roadway impacted by incident management will be multiplied by the change in emission factors for CO, TOG, and PM-10 to estimate kilograms reduced per weekday in the mid-year of the ITS project life.

The Governor's Alternative Transportation System Task Force (ATSTF, 1996) estimated that two congested miles ($\boldsymbol{D_s}$) per vehicle per congestion incident on freeways and arterials could be avoided by using ITS. Re-routing of vehicles was estimated to increase average vehicle trip length by 0.6 miles ($\boldsymbol{D_x}$) on non-congested arterials. The emissions from the extra distance driven will be subtracted from the emission reduction due to the increased speed. The difference represents the overall reduction in emissions per vehicle per incident.

The Governor's Alternative Transportation System Task Force estimated that the average congestion incident affects 9,960 vehicles (***V***) and that an arterial experiences an average of 1.5 incidents per 5 weekdays. It will be assumed that there are 0.075 incidents per mile per weekday (***incidents***). MOBILE5a will be run to estimate the onroad CO and TOG emissions in grams per mile at the following vehicle speeds: a congested freeway - 23.9 mph ($\boldsymbol{BEF_f}$), an uncongested freeway - 33.3 mph ($\boldsymbol{AEF_f}$), a congested arterial - 20 mph ($\boldsymbol{BEF_a}$), and an uncongested arterial - 30.3 mph ($\boldsymbol{AEF_a}$). Based on these assumptions, the vehicle which is re-routed to avoid arterial congestion emits less pollution than a vehicle which makes the shorter trip at lower speeds.

Inputs Required from Entity Requesting CMAQ Funds:

•***CMAQ Funding.***
•***Total Cost***.
•Length of project (***miles***).

Formulas:

$$\textit{Extra Emissions Per Incident } (X) = (D_x) * \left(\frac{AEF_{a\,CO}}{7} + AEF_{a\,TOG} + AEF_{a\,PM}\right) * (V)$$

where: $\boldsymbol{D_x}$ = the extra distance driven to avoid congestion
$\boldsymbol{AEF_a}$ = the emission factor for an arterial at the uncongested speed
V = the number of vehicles involved per incident

$$\textit{Emissions Saved } (S) = (D_s) * \left(\left(\frac{BEF_{a\,CO} + BEF_{f\,CO}}{7}\right) + BEF_{a\,TOG} + BEF_{f\,TOG} - \left(\frac{AEF_{a\,CO} + AEF_{f\,CO}}{7}\right) - AEF_{a\,TOG} - AEF_{f\,TOG}\right) * (V)$$

where: D_s = the miles of congestion avoided
BEF = the emission factor at the congested speed
AEF = the emission factor at the uncongested speed
V= the number of vehicles involved per incident

$$Daily\ Emissions\ Reduction = (\boldsymbol{incidents}) * (\boldsymbol{S} - \boldsymbol{X}) * (\boldsymbol{miles}) * \frac{1}{1000} * 0.91 = \frac{kilograms}{day}$$

where ***incidents*** = the number of incidents per mile per day
miles = the number of miles included in the project
0.91 = the factor for converting weekday ADT to average annual daily traffic

$$Capital\ Recovery\ Factor\ (\boldsymbol{CRF}) = \frac{(1+i)^{\boldsymbol{life}}\ (i)}{(1+i)^{\boldsymbol{life}} - 1}$$

where: *i* = discount rate of 5 percent
life = effectiveness period of 10 years

$$Cost\text{-}Effectiveness\ of\ CMAQ\ Funding = \frac{(\boldsymbol{CRF}) * (\boldsymbol{CMAQ}\ Funding) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

$$Cost\text{-}Effectiveness\ of\ Total\ Cost = \frac{(\boldsymbol{CRF}) * (\boldsymbol{Total}\ Cost) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

where: ***CMAQ Funding*** = the CMAQ funding requested for the project
Total Cost = the total cost of the project

Intelligent Transportation Systems **EXAMPLE**

A city proposes to install ITS to three miles of road. The cost of the project is $600,000. The city proposes to pay $60,000 and is requesting $540,000 in CMAQ funding.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding*** = $540,000.
- ***Total Cost*** = $600,000.

•Length of project (***miles***) = 3.

Calculations:

$$\textit{Extra Emissions Per Incident } (\boldsymbol{X}) = (0.6) * (\frac{7.04}{7} + 0.96 + 1.39) * (9{,}960) = 20{,}054$$

$$\textit{Emissions Saved } (\boldsymbol{S}) = (2) * (\frac{11.30 + 9.39}{7} + 1.29 + 1.14 - \frac{7.04 + 6.24}{7} - 0.96 - 0.89) * (9{,}960) = 32{,}640$$

$$\textit{Daily Emissions Reduction} = (0.075) * (32{,}640 - 20{,}054) * (3) * \frac{1}{1000} * 0.91 = 2.58 \ \frac{\textit{kilograms}}{\textit{day}}$$

$$\textit{Capital Recovery Factor } (\boldsymbol{CRF}) = \frac{(1 + 0.05)^{10} * (0.05)}{(1 + 0.05)^{10} - 1} = 0.1295$$

$$\textit{Cost-Effectiveness of CMAQ Funds} = \frac{(0.1295) * (540{,}000) * 1000}{(2.58) * 365} = 74{,}259 \ \frac{\textit{dollars}}{\textit{metric ton}}$$

$$\textit{Cost-Effectiveness of Total Cost} = \frac{(0.1295) * (600{,}000) * 1000}{(2.58) * 365} = 82{,}510 \ \frac{\textit{dollars}}{\textit{metric ton}}$$

Freeway Management System

The Freeway Management System (FMS) reduces emissions by informing motorists of potential problems which might impede traffic flow and reduce vehicle speeds. The methodology developed by Sierra Research and described in the document, Feasibility and Cost Effectiveness of New Air Pollution Control Measures Pertaining to Mobile Sources was followed in evaluating the emission reduction impact of adding centerline miles of freeway to the FMS. Sierra Research estimated that each freeway mile of FMS would result in a reduction of 35.20 kilograms of CO per day (***CO reduction***) and 2.84 kilograms of TOG per day (***TOG reduction***). The combined reduction (***CR***) in grams per mile per day will be multiplied by the miles of freeway added to estimate CO and TOG emission reductions in kilograms per day. Since this measure reduces emissions by increasing speeds, PM-10 emissions changes due to this measure will not be calculated.

Inputs Required from Entity Requesting CMAQ Funds:

•***CMAQ Funding***.
•***Total Cost***.

•Length of project (***miles***).

Formulas:

$$\textit{Combined Reduction } (\boldsymbol{CR}) = \frac{\textbf{\textit{CO reduction}}}{7} + \textbf{\textit{TOG reduction}}$$

where: ***CO reduction*** = the CO emission reduction per day estimated by Sierra Research
TOG reduction = the TOG emission reduction per day estimated by Sierra Research

$$\textit{Daily Emissions Reduction} = \textbf{\textit{miles}} * \boldsymbol{CR} * 0.91 = \frac{\textit{kilograms}}{\textit{day}}$$

where: ***miles*** = the length of the project
0.91 = the factor for converting weekday ADT to average annual daily traffic

$$\textit{Capital Recovery Factor } (\boldsymbol{CRF}) = \frac{(1+i)^{\textbf{\textit{life}}}\,(i)}{(1+i)^{\textbf{\textit{life}}} - 1}$$

where: *i* = discount rate of 5 percent
life = effectiveness period of 10 years

$$\textit{Cost-Effectiveness of CMAQ Funding} = \frac{(\boldsymbol{CRF}) * (\textbf{\textit{CMAQ}}\ \textit{Funding}) * 1000}{(\textit{Daily Emissions Reduction}) * 365} = \frac{\textit{dollars}}{\textit{metric ton}}$$

$$\textit{Cost-Effectiveness of Total Cost} = \frac{(\boldsymbol{CRF}) * (\textbf{\textit{Total}}\ \textit{Cost}) * 1000}{(\textit{Daily Emissions Reduction}) * 365} = \frac{\textit{dollars}}{\textit{metric ton}}$$

where: ***CMAQ Funding*** = the CMAQ funding requested for the project
Total Cost = the total cost of the project

ADOT proposes to add an additional three miles of freeway to the freeway management system. The cost of the project is $3,345,000. ADOT proposes to pay $334,500 and requests $3,010,500 in CMAQ funding.

Inputs Required from Entity Requesting CMAQ Funds:

- Funding dollars (***Funding***) = $3,010,500.
- Length of project (***miles***) = 3.

Calculations:

$$\textit{Combined Reduction } (\boldsymbol{CR}) = \frac{35.2}{7} + 2.84 = 7.87$$

$$\textit{Daily Emissions Reduction} = 3 * 7.87 * 0.91 = 21.5 \ \frac{kilograms}{day}$$

$$\textit{Capital Recovery Factor } (\boldsymbol{CRF}) = \frac{(1+0.05)^{10} * (0.05)}{(1+0.05)^{10} - 1} = 0.1295$$

$$\textit{Cost-Effectiveness of CMAQ Funding} = \frac{(0.1295) * (3{,}010{,}500) * 1000}{(21.5) * (365)} = 49{,}679 \ \frac{dollars}{metric\ ton}$$

$$\textit{Cost-Effectiveness of Total Cost} = \frac{(0.1295) * (3{,}345{,}000) * 1000}{(21.5) * (365)} = 55{,}199 \ \frac{dollars}{metric\ ton}$$

INTERSECTION IMPROVEMENTS

Intersection improvements include projects which add left or right turn lanes or construct roundabouts to improve traffic flow. These improvements reduce vehicle delay and idling emissions. If an entity requesting CMAQ funds provides the total weekday or peak period vehicle delay before and after the intersection improvement, based on traffic operations modeling, or the average morning and evening peak period queue lengths before the intersection improvement, based on recent traffic counts, then this data will be utilized in estimating the emission reductions.

Otherwise, the vehicle delay associated with the addition of a second or third turn lane will be calculated using average queue lengths ($\boldsymbol{Q_{am}}$,$\boldsymbol{Q_{pm}}$) for the morning (7 to 9 a.m.) and evening (4 to 6 p.m.) peak periods in the adjacent turn lane before the improvement. Similarly, the delay at an intersection where a right or left turn lane will be added and there currently is none (i.e. the adjacent lane accommodates both right and through or left and through movements) will be calculated using the morning and evening peak period queue lengths ($\boldsymbol{Q_{am}}$,$\boldsymbol{Q_{pm}}$) for the adjacent through lane and the average turning movement percent (***TM***) before the improvement. If one turn lane is added, it will be assumed that vehicle delay will be reduced (***RF***) by 40 percent. If two lanes are added, ***RF*** will equal 70 percent. For roundabouts, it will be assumed that either one or two new turn lanes are added, depending upon the design capacity. If delay reduction data from traffic operations modeling or queuing data from traffic counts are not provided by the requestor, the AM and PM peak period queue lengths for each intersection will be derived from the 1998 MAG Regional Congestion Study. If improvements are proposed for an intersection not included in the Congestion Study, the queue lengths will be obtained from the Study for an intersection with similar traffic characteristics. The total reduction in AM and PM peak period vehicle delay at the intersection will be multiplied by a factor of 2.05 to account for congestion reduction during off-peak, as well as, peak hours. An idling emission factor for 2015 will be applied to determine the emission reduction benefit of the intersection improvement. This methodology assumes that reductions in weekday delay are the principal source of emission reductions attributable to an intersection improvement.

MOBILE5a and PART5 will be run to estimate the average idle onroad emission factors of CO, TOG, and PM-10 for 2015 ($\boldsymbol{BEF_{CO}}$, $\boldsymbol{BEF_{TOG}}$, and $\boldsymbol{BEF_{PM}}$). As recommended in the MOBILE5a Information Sheet #2, the idle emission factor will be estimated by running the model at 2.5 miles per hour and converting the resulting emission factor in grams per mile to grams per hour, using 2.5 miles per hour. The same methodology will be used in applying PART5.

Inputs Required from Entity Requesting CMAQ Funds:

•***CMAQ Funding***.
•***Total Cost***.

And optionally:

•Modeled reduction in total weekday or am and pm peak period vehicle hours of delay due to the improvement (***R***); or
•Recent counts of average queue lengths in the adjacent lane during the am and pm peak periods before the improvement ($\boldsymbol{Q_{am}}$,$\boldsymbol{Q_{pm}}$).

Formulas:

When a second or third turn lane is added to an existing turn lane:

$$Daily\ Emissions\ Reduction = (\boldsymbol{RF}) * 2.05 * (\boldsymbol{Q_{am}} + \boldsymbol{Q_{pm}}) * (\frac{\boldsymbol{BEF_{CO}}}{7} + \boldsymbol{BEF_{TOG}} + \boldsymbol{BEF_{PM}}) * \frac{250}{365} * \frac{1}{1000} = \frac{kilograms}{day}$$

When a turn lane is added, where one did not exist:

$$\textit{Daily Emissions Reduction} = (\boldsymbol{RF}) * 2.05 * (\boldsymbol{Q_{am}} + \boldsymbol{Q_{pm}}) * (\boldsymbol{TM}) * (\frac{\boldsymbol{BEF_{CO}}}{7} + \boldsymbol{BEF_{TOG}} + \boldsymbol{BEF_{PM}}) * \frac{250}{365} * \frac{1}{1000} = \frac{\textit{kilograms}}{\textit{day}}$$

where: 2.05 = the ratio of total average weekday delay per vehicle to the average delay per vehicle during the a.m. and p.m. peak periods
250/365 = factor to convert from an average weekday to average annual day
$\boldsymbol{Q_{am}}$ = average queue length for the turning movement in the a.m. peak period before the improvement
$\boldsymbol{Q_{pm}}$ = average queue length for the turning movement in the p.m. peak period before the improvement
RF = the delay reduction factor
TM = the average turning movement percent
BEF = the base idling emission factors for each pollutant

$$\textit{Capital Recovery Factor } (\boldsymbol{CRF}) = \frac{(1+i)^{life}\,(i)}{(1+i)^{life} - 1}$$

where: *i* = discount rate of 5 percent
life = effectiveness period of 20 years

$$\textit{Cost-Effectiveness of CMAQ Funding} = \frac{(\boldsymbol{CRF}) * (\boldsymbol{CMAQ}\ \textit{Funding}) * 1000}{(\textit{Daily Emissions Reduction}) * 365} = \frac{\textit{dollars}}{\textit{metric ton}}$$

$$\textit{Cost-Effectiveness of Total Cost} = \frac{(\boldsymbol{CRF}) * (\boldsymbol{Total}\ \textit{Cost}) * 1000}{(\textit{Daily Emissions Reduction}) * 365} = \frac{\textit{dollars}}{\textit{metric ton}}$$

where: ***CMAQ Funding*** = the CMAQ funding requested for the project
Total Cost = the total cost of the project

Additional Turning Lanes **EXAMPLE**

A city proposes to add second left turn lanes westbound and northbound and a dedicated right turn lane eastbound at an intersection. The cost of the project is $2,000,000. The city proposes to pay $200,000 and requests $1,800,000 of CMAQ funding.

Inputs Required from Entity Requesting CMAQ Funds:

•***CMAQ Funding*** = $1,800,000.
•***Total Cost*** = $2,000,000

The city does not provide an estimate of the total reduction in weekday or peak period vehicle hours of delay based on traffic operations modeling or the peak period queue lengths for adjacent lanes, based on recent traffic counts. Therefore, the data in Table 4 is obtained from the 1998 MAG Regional Congestion Study for the intersection to be improved.

Table 4. Queue Lengths for Turning Movements at the Intersection Before Improvements

		Left Turn			Thru/Right Turn
Approach	Time Period	Queue Length	Approach	Time Period	Queue Length
East	7-8 a.m.	9.90	West	7-8 a.m.	20.00
East	8-9 a.m.	9.50	West	8-9 a.m.	11.00
East	4-5 p.m.	8.54	West	4-5 p.m.	14.18
East	5-6 p.m.	9.38	West	5-6 p.m.	20.69
South	7-8 a.m.	9.34			
South	8-9 a.m.	8.84			
South	4-5 p.m.	9.00			
South	5-6 p.m.	9.76			

•For the additional westbound left turn lane, Q_{am} = 19.40 and Q_{pm} = 17.92 (from Table 4).
•For the additional northbound left turn lane, Q_{am} = 18.18 and Q_{pm} = 18.76 (from Table 4).
•For the new eastbound right turn lane, Q_{am} = 31.00 and Q_{pm} = 34.87 (from Table 4), and the average right turning movement percentage, TM = 15%.

Calculations:

For the additional westbound left turn lane:

$$\textit{Daily Emissions Reduction} = (0.40) * 2.05 * (19.40 + 17.92) * (\frac{99.25}{7} + 14.48 + 0.80) * \frac{250}{365} * \frac{1}{1000} = 0.617 \frac{\textit{kilograms}}{\textit{day}}$$

For the additional northbound left turn lane:

$$\textit{Daily Emissions Reduction} = (0.40) * 2.05 * (18.18 + 18.76) * (\frac{99.25}{7} + 14.48 + 0.80) * \frac{250}{365} * \frac{1}{1000} = 0.611 \frac{\textit{kilograms}}{\textit{day}}$$

For the new eastbound right turn lane:

$$Daily\ Emissions\ Reduction = (0.40) * 2.05 * (31.00 + 34.87) * (0.15) * (\frac{99.25}{7} + 14.48 + 0.80) * \frac{250}{365} * \frac{1}{1000} = 0.163\ \frac{kilograms}{day}$$

Total vehicle delay reduced on an average weekday due to the addition of the three new lanes would be 68.99 hours. The total daily emissions reduction would be 1.391 kilograms/day.

$$Capital\ Recovery\ Factor\ (\boldsymbol{CRF}) = \frac{(1 + 0.05)^{20} * (0.05)}{(1 + 0.05)^{20} - 1} = 0.0802$$

$$Cost-Effectiveness\ of\ CMAQ\ Funds = \frac{(0.0802) * (1{,}800{,}000) * 1000}{(0.617 + 0.611 + 0.163) * 365} = 284{,}333\ \frac{dollars}{metric\ ton}$$

$$Cost-Effectiveness\ of\ Total\ Cost = \frac{(0.0802) * (2{,}000{,}000) * 1000}{(0.617 + 0.611 + 0.163) * 365} = 315{,}925\ \frac{dollars}{metric\ ton}$$

Roundabout EXAMPLE

ADOT proposes to build a roundabout at a freeway interchange. Traffic operations modeling performed by ADOT engineers indicates that the roundabout will reduce average vehicle delay by 120 hours per average weekday. The cost of the project is $2,200,000. ADOT proposes to pay $200,000 and requests $2,000,000 of CMAQ funding.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding*** = $2,000,000.
- ***Total Cost*** = $2,200,000

Since the requestor has provided the modeled estimate of vehicle delay for an average week day (***R***), this value will be substituted for **RF**, **2.05,** $\mathbf{Q_{am}}$, $\mathbf{Q_{pm}}$, and **TM** in the equations above.

$$Daily\ Emissions\ Reduction = 120 * (\frac{99.25}{7} + 14.48 + 0.80) * \frac{250}{365} * \frac{1}{1000} = 2.421\ \frac{kilograms}{day}$$

$$Capital\ Recovery\ Factor\ (\boldsymbol{CRF}) = \frac{(1+0.05)^{20} * (0.05)}{(1+0.05)^{20} - 1} = 0.0802$$

$$Cost\text{-}Effectiveness\ of\ CMAQ\ Funds = \frac{(0.0802) * (2{,}000{,}000) * 1000}{(2.421) * 365} = 181{,}517\ \frac{dollars}{metric\ ton}$$

$$Cost\text{-}Effectiveness\ of\ Total\ Cost = \frac{(0.0802) * (2{,}200{,}000) * 1000}{(2.421) * 365} = 199{,}668\ \frac{dollars}{metric\ ton}$$

VANPOOL VEHICLES

"Encouragement of Vanpooling" is a committed control measure in the MAG 1999 Serious Area CO and PM-10 Plans. Vanpools reduce emissions by decreasing the total vehicle miles of travel (VMT) for commute trips.

Valley Metro indicates that a vanpool vehicle travels 66 miles (on average - round trip) per day on 255 commute days per year. This is equal to 16,830 commute miles annually per van. Valley Metro estimates that the average vanpool carries nine people, including the driver. It will be assumed that each vanpool passenger drives an average of three miles round trip to access the vanpool, which reduces the daily commute miles saved to 63 per passenger. This reduction accounts for passengers driving (park-and-ride) or being dropped off (kiss-and-ride) to join the vanpool or the vanpool driver picking up and dropping off passengers. It will also be assumed that the average vehicle occupancy for commute trips by all modes is 1.2 (RPTA, 2001). Based on these assumptions, 16,830 miles per van (***vanpool miles***) will replace 121,125 ***commute miles*** per year. Therefore, each vanpool reduces automobile VMT by 104,295 miles annually and each vanpool mile replaces approximately 7.2 commute miles.

The MOBILE5a and PART5 models will be run for 2010 to estimate the average commute trip onroad emissions of CO, TOG, and PM-10 ($\boldsymbol{BEF_{CO\ AUTO}}$, $\boldsymbol{BEF_{TOG\ AUTO}}$, and $\boldsymbol{BEF_{PM\ AUTO}}$) in grams per mile. The equivalent emission factor for light-duty gas trucks, LDGT2, ($\boldsymbol{BEF_{CO\ VAN}}$, $\boldsymbol{BEF_{TOG\ VAN}}$, and $\boldsymbol{BEF_{PM\ VAN}}$), which includes most full size vans, will also be estimated using MOBILE5a. The emission factor for vans will reflect the midpoint of their life (i.e. it will be assumed that they are two years old). The emission factors will be multiplied by the appropriate miles of travel to estimate commute and vanpool emissions. The difference between the commute and vanpool emissions represents the net emission reduction benefit of vanpools.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding***.
- ***Total Cost***.

Formulas:

$$Auto\ Emissions\ (\boldsymbol{AE}) = (\boldsymbol{commute\ miles}) * (\frac{BEF_{CO\ auto}}{7} + BEF_{TOG\ auto} + BEF_{PM\ auto})$$

where: ***commute miles*** = the commute miles replaced by the vanpool each year
BEF = the base emission factors for each pollutant

$$Vanpool\ Emissions\ (\boldsymbol{VE}) = (\boldsymbol{vanpool\ miles}) * (\frac{BEF_{CO\ van}}{7} + BEF_{TOG\ van} + BEF_{PM\ van})$$

where*:* ***vanpool miles*** = the miles driven annually by a van used for a vanpool
BEF = the base emission factors for a van for each pollutant

$$Daily\ Emissions\ Reduction = (\boldsymbol{AE} - \boldsymbol{VE}) * \frac{1}{1000} * \frac{1}{365} = \frac{kilograms}{day}$$

where: 1/365 = factor to convert annual emissions to daily emissions

$$Capital\ Recovery\ Factor\ (\boldsymbol{CRF}) = \frac{(1+i)^{\boldsymbol{life}}\ (i)}{(1+i)^{\boldsymbol{life}} - 1}$$

where: *i* = discount rate of 5 percent
life = effectiveness period of 4 years

$$Cost\text{-}Effectiveness\ of\ CMAQ\ Funding = \frac{(\boldsymbol{CRF}) * (\boldsymbol{CMAQ}\ Funding) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

$$Cost\text{-}Effectiveness\ of\ Total\ Cost = \frac{(\boldsymbol{CRF}) * (\boldsymbol{Total}\ Cost) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

where: ***CMAQ Funding*** = the CMAQ funding requested for the project
Total Cost = the total cost of the project

Vanpool Vehicles **EXAMPLE**

RPTA proposes to purchase a fifteen-passenger van to be used in a vanpool. The cost of the van is $25,000. RPTA requests $25,000 of CMAQ funding. It is assumed that the vanpool will have a driver and eight passengers.

Inputs Required from Entity Requesting CMAQ Funds:

• ***CMAQ Funding*** = $25,000.
• ***Total Cost*** = $25,000.

Calculations:

$$\textit{Auto Emissions } (\textbf{\textit{AE}}) = 121{,}125 * (\frac{6.34}{7} + .82 + 1.392) = 377{,}633\ \frac{grams}{year}$$

$$\textit{Vanpool Emissions } (\textbf{\textit{VE}}) = 16{,}830 * (\frac{4.65}{7} + .34 + 1.33) = 39{,}286\ \frac{grams}{year}$$

$$\textit{Daily Emissions Reduction} = (377{,}633 - 39{,}286) * \frac{1}{1000} * \frac{1}{365} = 0.93\ \frac{kilograms}{day}$$

$$\textit{Capital Recovery Factor } (\textbf{\textit{CRF}}) = \frac{(1+0.05)^4 * (0.05)}{(1+0.05)^4 - 1} = 0.2820$$

$$\textit{Cost-Effectiveness of CMAQ Funding} = \frac{(0.282)*(25{,}000)*1000}{(0.93)*365} = 20{,}769\ \frac{dollars}{metric\ ton}$$

RIDESHARE PROGRAMS

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$$\textit{Cost-Effectiveness of Total Cost} = \frac{(0.282)*(25{,}000)*1000}{(0.93)*365} = 20{,}769\ \frac{dollars}{metric\ ton}$$

Rideshare Program Incentives" and "Preferential Parking for Carpools and Vanpools" are committed control measures in the MAG 1999 Serious Area CO and PM-10 Plans. Ridesharing in carpools and vanpools reduces emissions by decreasing the total vehicle miles of travel (VMT) for commute trips. MAG programs CMAQ funding for the Regional Rideshare Program operated by RPTA and partial funding for the Capitol Rideshare Program conducted by the Arizona Department of Administration.

Based on TDM surveys conducted in 1999-2001 for RPTA, an average of 15 percent of all work trips are made by carpools and vanpools. The average trip length of commute trips by all modes is during this period was 12.6 miles and the average vehicle occupancy, 1.2 (RPTA, 2001).

The MOBILE5a and PART5 models will be run for 2010 to estimate the average commute trip onroad emissions of CO, TOG, and PM-10 (BEF_{CO}, BEF_{TOG}, and BEF_{PM}) in grams per mile. The emission factors will be multiplied by the reduction in vehicle miles of travel (***AVR***) to estimate the emissions benefit of ridesharing.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding***.
- ***Total Cost***.
- Percent of carpooling/vanpooling participation attributable to the Regional Rideshare Program ***(P)***.

Formulas:

$$\textit{Auto VMT Reduced } (\boldsymbol{AVR}) = \frac{\mathbf{.15} * \boldsymbol{W} * \boldsymbol{P}}{\mathbf{1.2}} * \mathbf{12.6}$$

where: ***.15*** = 1999-2001 average percent of total commute trips by carpool/vanpool (Table 15, RPTA, 2001)
W = daily home-based work person trips = 1.6 * total employment in Maricopa County for CMAQ funding request year (MAG trip attraction equation)
P = percent of carpooling/vanpooling attributable to the Regional Rideshare Program
1.2 = average vehicle occupancy for all modes (derived from Table 15, RPTA, 2001)
12.6 = 1999-2001 average commute trip length by all modes (Table 52, RPTA, 2001)

$$\textit{Daily Emissions Reduction} = \boldsymbol{AVR} * \left(\frac{BEF_{CO}}{7} + BEF_{TOG} + BEF_{PM}\right) * \frac{1}{1000} * \frac{250}{365} = \frac{\textit{kilograms}}{\textit{day}}$$

where: 250/365 = factor to convert from an average weekday to average annual day

$$\textit{Capital Recovery Factor } (\boldsymbol{CRF}) = \frac{(1+i)^{\boldsymbol{life}}\,(i)}{(1+i)^{\boldsymbol{life}} - 1}$$

where: i = discount rate of 5 percent
life = program period of 1 year

$$\textit{Cost-Effectiveness of CMAQ Funding} = \frac{(\boldsymbol{CRF}) * (\boldsymbol{CMAQ}\ \textit{Funding}) * 1000}{(\textit{Daily Emissions Reduction}) * 365} = \frac{\textit{dollars}}{\textit{metric ton}}$$

$$\textit{Cost-Effectiveness of Total Cost} = \frac{(\boldsymbol{CRF}) * (\boldsymbol{Total}\ \textit{Cost}) * 1000}{(\textit{Daily Emissions Reduction}) * 365} = \frac{\textit{dollars}}{\textit{metric ton}}$$

where: ***CMAQ Funding*** = the CMAQ funding requested for the project
Total Cost = the total cost of the project

Regional Rideshare Program **EXAMPLE**

RPTA requests $594,000 in FY 2002 CMAQ funds for the Regional Rideshare Program and indicates that the Regional Rideshare Program is responsible for 10 percent of employee participation in carpooling and vanpooling. Based on projections adopted by the MAG Regional Council in June 1997, the total employment for Maricopa County in 2002 is estimated to be 1,561,027.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding*** = $594,000.
- ***Total Cost*** = $594,000.
- ***P*** = 10%.

Calculations:

$$\textit{Auto VMT Reduced } (\boldsymbol{AVR}) = \frac{.15 * (1.6 * 1{,}561{,}027) * .10}{1.2} * 12.6 = 393{,}379$$

$$\textit{Daily Emissions Reduction} = 393{,}379 * \left(\frac{6.34}{7} + .82 + 1.392\right) * \frac{1}{1000} * \frac{250}{365} = 840\ \frac{\textit{kilograms}}{\textit{day}}$$

$$Capital\ Recovery\ Factor\ (\boldsymbol{CRF}) = \frac{(1+0.05)^1 * (0.05)}{(1+0.05)^1 - 1} = 1.05$$

$$Cost-Effectiveness\ of\ CMAQ\ Funding = \frac{(1.05)*(594{,}000)*1000}{(840)*365} = 2{,}034\ \frac{dollars}{metric\ ton}$$

$$Cost-Effectiveness\ of\ Total\ Cost = \frac{(1.05)*(594{,}000)*1000}{(840)*365} = 2{,}034\ \frac{dollars}{metric\ ton}$$

TRIP RED UCTION PROGRAM

"Trip Reduction Program" is a committed control measure in the MAG 1999 Serious Area CO and PM-10 Plans. The Trip Reduction Program requires employers with 50 or more employees at a work site in Area A to achieve target reductions in single occupant vehicle (SOV) trips through use of alternate transportation modes. Alternate transportation modes include carpooling, vanpooling, taking the bus, bicycling, and walking. Reductions in SOV trips due to telecommuting or compressed work schedules also qualify for credit in the trip reduction program. The program reduces emissions by decreasing the total vehicle miles of travel (VMT) for commute trips.

The Maricopa County Trip Reduction Program (TRP) maintains detailed information on participating organizations and their employees. The TRP indicates that 35 percent of employees work for TRP organizations and 21 percent of the commute trips taken by these employees is by alternate modes (or the commute trip is eliminated, in the case of telecommuting and compressed work weeks). In addition, the average commute trip length for TRP employees is 12.7 miles each way and the average vehicle occupancy for TRP commute trips by all modes is 1.145.

The MOBILE5a and PART5 models will be run for 2010 to estimate the average commute trip onroad emissions of CO, TOG, and PM-10 ($\boldsymbol{BEF_{CO}}$, $\boldsymbol{BEF_{TOG}}$, and $\boldsymbol{BEF_{PM}}$) in grams per mile. The emission factors will be multiplied by the reduction in vehicle miles of travel ($\boldsymbol{AVR}$) to estimate the emissions benefit of the Trip Reduction Program.

Inputs Required from Entity Requesting CMAQ Funds:

•***CMAQ Funding***.
•***Total Cost***.
•Percent of alternate mode use attributable to the Trip Reduction Program ***(P)***.

Formulas:

$$Auto\ VMT\ Reduced\ (\boldsymbol{AVR}) = \frac{\mathbf{.21} * \boldsymbol{W} * \mathbf{.35} * \boldsymbol{P}}{\mathbf{1.145}} * \mathbf{12.7}$$

where: ***.21*** = the percent of work trips in TRP organizations using alternate modes, including telecommuting and compressed work schedules (from TRP data)
W = daily home-based work person trips = 1.6 * total employment in Area A in the CMAQ funding request year (from MAG trip generation equation)
.35 = percent of employees working for a TRP organization with at least 50 employees (from TRP data)
P = percent of alternate mode use attributable to the Trip Reduction Program
1.145 = average vehicle occupancy for all modes (from TRP data)
12.7 = average commute trip length by all modes (from TRP data)

$$Daily\ Emissions\ Reduction = \boldsymbol{AVR} * \left(\frac{BEF_{CO}}{7} + BEF_{TOG} + BEF_{PM}\right) * \frac{1}{1000} * \frac{250}{365} = \frac{kilograms}{day}$$

where: 250/365 = factor to convert from an average weekday to average annual day

$$Capital\ Recovery\ Factor\ (\boldsymbol{CRF}) = \frac{(1+i)^{\boldsymbol{life}}\ (i)}{(1+i)^{\boldsymbol{life}} - 1}$$

where: *i* = discount rate of 5 percent
life = program period of 1 year

$$Cost\text{-}Effectiveness\ of\ CMAQ\ Funding = \frac{(\boldsymbol{CRF}) * (\boldsymbol{CMAQ}\ Funding) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

$$Cost\text{-}Effectiveness\ of\ Total\ Cost = \frac{(\boldsymbol{CRF}) * (\boldsymbol{Total}\ Cost) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

where: ***CMAQ Funding*** = the CMAQ funding requested for the project
Total Cost = the total cost of the project

Trip Reduction Program — EXAMPLE

Maricopa County requests $910,000 in FY 2002 CMAQ funds for the Trip Reduction Program. The Arizona Department of Environmental Quality contributes $948,000 to the program. The County indicates that the share of alternative mode use attributable to the Trip Reduction Program is 25 percent. Based on projections adopted by the MAG Regional Council in June 1997, the total employment for Maricopa County in 2002 is expected to be 1,561,027. Area A includes the most populous areas of Maricopa County, as well as the Apache Junction and Queen Creek areas of Pinal County. Therefore, it is assumed that the employment in Area A will approximate the Maricopa County level of 1.56 million employees in 2002.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding*** = $910,000.
- ***Total Cost*** = $1,858,000.
- ***P*** = 25%.

Calculations:

$$Auto\ VMT\ Reduced\ (\boldsymbol{AVR}) = \frac{.21 * (1.6 * 1{,}560{,}000) * .35 * .25}{1.145} * 12.7 = 508{,}710$$

$$Daily\ Emissions\ Reduction = 508{,}710 * (\frac{6.34}{7} + .82 + 1.392) * \frac{1}{1000} * \frac{250}{365} = 1{,}086\ \frac{kilograms}{day}$$

$$Capital\ Recovery\ Factor\ (\boldsymbol{CRF}) = \frac{(1+0.05)^1 * (0.05)}{(1+0.05)^1 - 1} = 1.05$$

$$\text{Cost-Effectiveness of CMAQ Funding} = \frac{(1.05) * (910{,}000) * 1000}{(1{,}086) * 365} = 2{,}411 \ \frac{\text{dollars}}{\text{metric ton}}$$

$$\text{Cost-Effectiveness of Total Cost} = \frac{(1.05) * (1{,}858{,}000) * 1000}{(1{,}086) * 365} = 4{,}922 \ \frac{\text{dollars}}{\text{metric ton}}$$

O

ZONE EDUCATION PROGRAM

"Areawide Public Awareness Programs" is a committed control measure in the MAG 1999 Serious Area CO and PM-10 Plans. Past Air Quality Education Programs have been conducted during the winter months for CO and PM-10 and the summer months for ozone. These educational and outreach efforts focus on encouraging the public to reduce single occupant vehicle (SOV) travel, especially during periods of high measured concentrations, called pollution "alerts." Air Quality Educational Program messages are communicated through the news media, television and radio spots, posters, and the Internet. During pollution alerts, residents are encouraged to take alternate modes, such as carpools, vanpools, buses, bicycles, or walking. Telecommuting and compressed work schedules are also encouraged. These programs reduce emissions primarily by decreasing the total vehicle miles of travel (VMT) for commute trips.

Based on TDM surveys conducted in 1999-2001 for RPTA, an average of 26.7 percent of commute trips by persons not employed at home were taken by an alternate mode, including telecommuting and compressed work schedules. The average trip length of commute trips by all modes for 1999-2001 was 12.6 miles (RPTA, 2001).

The MOBILE5a and PART5 models will be run for 2010 to estimate the average commute trip onroad emissions of CO, TOG, and PM-10 (BEF_{CO}, BEF_{TOG}, and BEF_{PM}) in grams per mile. The emission factors will be multiplied by the reduction in vehicle miles of travel (***AVR***) to estimate the emissions benefit of the Clean Air Campaign.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding***.
- ***Total Cost***.
- Percent of alternate mode use attributable to the Clean Air Campaign ***(P)***.
- Number of work days during the Clean Air Campaign ***(N)***.

Formulas:

$$\textit{Auto VMT Reduced } (\boldsymbol{AVR}) = \frac{\mathbf{.267} * \boldsymbol{W} * \boldsymbol{P}}{\mathbf{1.2}} * \mathbf{12.6}$$

where: ***.267*** = 1999-2001 average percent of trips by employees using alternate modes, including telecommuting and compressed work schedules (Table 21, RPTA, 2001)
W = daily home-based work person trips = 1.6 * total employment in Maricopa County for CMAQ funding request year (MAG trip attraction equation)
P = percent of alternate mode use attributable to the Clean Air Campaign
1.2 = average vehicle occupancy (derived from Table 15, RPTA, 2001)
12.6 = 1999-2001 average commute trip length by all modes (Table 52, RPTA, 2001)

$$\textit{Daily Emissions Reduction} = \boldsymbol{AVR} * \left(\frac{BEF_{CO}}{7} + BEF_{TOG} + BEF_{PM}\right) * \frac{1}{1000} * \frac{\boldsymbol{N}}{\mathbf{365}} = \frac{kilograms}{day}$$

where: N/365 = factor to convert from a campaign work day to an average annual day

$$\textit{Capital Recovery Factor } (\boldsymbol{CRF}) = \frac{(1+i)^{life}\,(i)}{(1+i)^{life} - 1}$$

where: *i* = discount rate of 5 percent
life = program period of 1 year

$$\textit{Cost-Effectiveness of CMAQ Funding} = \frac{(\boldsymbol{CRF}) * (\boldsymbol{CMAQ}\ Funding) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

$$\textit{Cost-Effectiveness of Total Cost} = \frac{(\boldsymbol{CRF}) * (\boldsymbol{Total}\ Cost) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

______where:_ ***CMAQ Funding*** = the CMAQ funding requested for the project
___________________***Total Cost*** = the total cost of the project

RPTA requests $300,000 in FY 2002 CMAQ funds for the Summer Ozone Program and indicates that the share of alternative mode use attributable to the Summer Ozone Education Program is 10 percent. Based on projections adopted by the MAG Regional Council in June 1997, the total employment for Maricopa County in 2002 is estimated to be 1,561,027. The number of work days during the FY 2002 summer campaign is 83.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding*** = $300,000.
- ***Total Cost*** = $300.000.
- ***P*** = 10%.
- ***N*** = *83.*

Calculations:

$$\textit{Auto VMT Reduced } (\boldsymbol{AVR}) = \frac{.267 * (1.6 * 1{,}561{,}027) * .10}{1.2} * 12.6 = 700{,}214$$

$$\textit{Daily Emissions Reduction} = 700{,}214 * (\frac{6.34}{7} + .82 + 1.392) * \frac{1}{1000} * \frac{83}{365} = 496 \ \frac{\textit{kilograms}}{\textit{day}}$$

$$\textit{Capital Recovery Factor } (\boldsymbol{CRF}) = \frac{(1+0.05)^1 * (0.05)}{(1+0.05)^1 - 1} = 1.05$$

$$\textit{Cost-Effectiveness of CMAQ Funding} = \frac{(1.05) * (300{,}000) * 1000}{(496) * 365} = 1{,}740 \ \frac{\textit{dollars}}{\textit{metric ton}}$$

$$\textit{Cost-Effectiveness of Total Cost} = \frac{(1.05) * (300{,}000) * 1000}{(496) * 365} = 1{,}740 \ \frac{\textit{dollars}}{\textit{metric ton}}$$

TELEWORK PROGRAM

"Encouragement of Telecommuting, Teleworking and Teleconferencing" is a committed control measure in the MAG 1999 Serious Area CO and PM-10 Plans. The program encourages employers to set up and institutionalize telecommuting options for employees. The program provides consulting services to implement or expand corporate telecommuting programs, including advice on information technology and telecommunications connectivity. The current outreach effort targets CEOs of companies to obtain top level commitment. The program also aims to increase general public awareness of telecommuting via TV programs, press releases, and advertisements in corporate publications. The Telework Program reduces emissions by decreasing the total vehicle miles of travel (VMT) for commute trips.

Based on averages for 2000-2001 from RPTA TDM surveys, 7.5 percent of all persons not employed at home telecommute at least one day per week and the average number of days they telecommute is 2.55. The average trip length of commute trips by telecommuters is 19.0 miles (RPTA, 2000a). The MOBILE5a and PART5 models will be run for 2010 to estimate the average commute trip onroad emissions of CO, TOG, and PM-10 ($\boldsymbol{BEF_{CO}}$, $\boldsymbol{BEF_{TOG}}$, and $\boldsymbol{BEF_{PM}}$) in grams per mile. The emission factors will be multiplied by the reduction in vehicle miles of travel (***AVR***) to estimate the emissions benefit of the Telework Program.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding***.
- ***Total Cost***.
- Percent of telecommuting attributable to the Telework Program ***(P)***.

Formulas:

$$\textit{Commute Trips Avoided } (\boldsymbol{CTA}) = \frac{\mathbf{.075} * \boldsymbol{W} * \mathbf{2.55}}{\mathbf{1.2} * \mathbf{5}}$$

$$\textit{Auto VMT Reduced } (\boldsymbol{AVR}) = \boldsymbol{CTA} * \boldsymbol{P} * \mathbf{19.0}$$

where: ***.075*** = 2000-2001 average percent of employees telecommuting at least one day per week (Table 21, RPTA, 2000b and Table 21, RPTA, 2001)
W= daily home-based work person trips = 1.6 * total employment in Maricopa County in the CMAQ funding request year (from MAG trip generation equation)
2.55 = 2000-2001 average telecommuting participation in days/week (Table 21, RPTA, 2000b and Table 16, RPTA, 2001)
1.2 = average vehicle occupancy (derived from Table 15, RPTA, 2001)

5 = number of work days per week
P = percent of telecommuting attributable to the Telework Program
19.0 = average one-way commute trip length in miles for telecommuters (Table 4, RPTA, 2000a)

$$Daily\ Emissions\ Reduction = \boldsymbol{AVR} * \left(\frac{BEF_{CO}}{7} + BEF_{TOG} + BEF_{PM}\right) * \frac{1}{1000} * \frac{250}{365} = \frac{kilograms}{day}$$

where: 250/365 = factor to convert from an average weekday to average annual day

$$Capital\ Recovery\ Factor\ (\boldsymbol{CRF}) = \frac{(1+i)^{\boldsymbol{life}}\ (i)}{(1+i)^{\boldsymbol{life}} - 1}$$

where: *i* = discount rate of 5 percent
life = program period of 1 year

$$Cost-Effectiveness\ of\ CMAQ\ Funding = \frac{(\boldsymbol{CRF}) * (\boldsymbol{CMAQ}\ Funding) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

$$Cost-Effectiveness\ of\ Total\ Cost = \frac{(\boldsymbol{CRF}) * (\boldsymbol{Total}\ Cost) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

where: ***CMAQ Funding*** = the CMAQ funding requested for the project
Total Cost = the total cost of the project

Telework Program **EXAMPLE**

RPTA requests $300,000 in FY 2002 CMAQ funds for the Telework Program. RPTA indicates that the share of telecommuting attributable to the Telework Program is 20 percent. Based on projections adopted by the MAG Regional Council in June 1997, the total employment for Maricopa County in 2002 is estimated to be 1,561,027.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding*** = $300,000.
- ***Total Cost*** = $300,000.
- ***P*** = 20%.

Calculations:

$$\textit{Commute Trips Avoided } (\boldsymbol{CTA}) = \frac{.075 * (1.6 * 1{,}561{,}027) * 2.55}{1.2 * 5} = 79{,}612$$

$$\textit{Auto VMT Reduced } (\boldsymbol{AVR}) = 79{,}612 * .20 * 19.0 = 302{,}526$$

$$\textit{Daily Emissions Reduction} = 302{,}526 * \left(\frac{6.34}{7} + .82 + 1.392\right) * \frac{1}{1000} * \frac{250}{365} = 646 \frac{\textit{kilograms}}{\textit{day}}$$

$$\textit{Capital Recovery Factor } (\boldsymbol{CRF}) = \frac{(1+0.05)^1 * (0.05)}{(1+0.05)^1 - 1} = 1.05$$

$$\textit{Cost-Effectiveness of CMAQ Funding} = \frac{(1.05)*(300{,}000)*1000}{(646)*365} = 1{,}336 \frac{\textit{dollars}}{\textit{metric ton}}$$

$$\textit{Cost-Effectiveness of Total Cost} = \frac{(1.05)*(300{,}000)*1000}{(646)*365} = 1{,}336 \frac{\textit{dollars}}{\textit{metric ton}}$$

TELECONFERENCING

"Encouragement of Telecommuting, Teleworking and Teleconferencing" is a committed control measure in the MAG 1999 Serious Area CO and PM-10 Plans. Teleconferencing reduces emissions by decreasing the vehicle miles of travel (VMT) associated with trips to and from meetings. The Maricopa Association of Governments is sponsoring a teleconferencing pilot project to interconnect the cities and towns in Maricopa County, as well as provide training and support activities associated with teleconferencing, in order to reduce vehicle trips and VMT.

The MOBILE5a and PART5 models will be run for 2010 to estimate the average onroad emissions of CO, TOG, and PM-10 (BEF_{CO}, BEF_{TOG}, and BEF_{PM}) in grams per mile. The emission factors will be multiplied by the reduction in vehicle miles of travel (***AVR***) to estimate the emissions benefit of teleconferencing.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding***.
- ***Total Cost***.
- Number of vehicle trips reduced by teleconferencing in a year ***(ATR)***.
- Average trip length of vehicle trips reduced by teleconferencing ***(TL)***.

Formulas:

$$\textit{Auto VMT Reduced } (\boldsymbol{AVR}) = \boldsymbol{ATR} * \boldsymbol{TL}$$

where: ***ATR*** = average annual vehicle trips reduced by teleconferencing project
TL = average trip length of vehicle trips reduced

$$\textit{Daily Emissions Reduction} = \boldsymbol{AVR} * \left(\frac{BEF_{CO}}{7} + BEF_{TOG} + BEF_{PM}\right) * \frac{1}{1000} * \frac{1}{365} = \frac{kilograms}{day}$$

where: 1/365 = factor to convert annual emissions to daily emissions

$$\textit{Capital Recovery Factor } (\boldsymbol{CRF}) = \frac{(1+i)^{life}\,(i)}{(1+i)^{life} - 1}$$

where: *i* = discount rate of 5 percent
life = effectiveness period of 5 years

$$Cost-Effectiveness\ of\ CMAQ\ Funding = \frac{(\boldsymbol{CRF}) * (\boldsymbol{CMAQ}\ Funding) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

$$Cost-Effectiveness\ of\ Total\ Cost = \frac{(\boldsymbol{CRF}) * (\boldsymbol{Total}\ Cost) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

where: ***CMAQ Funding*** = the CMAQ funding requested for the project
Total Cost = the total cost of the project

Teleconferencing **EXAMPLE**

MAG requests $920,000 in FY 2002 CMAQ funds for teleconferencing equipment. MAG estimates that the number of vehicle trips eliminated annually by the teleconferencing program is 20,000 and the average trip length of the eliminated trips is 15 miles.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding*** = $920,000.
- ***Total Cost*** = $920,000.
- ***ATR*** = 20,000.
- ***TL*** *= 15.*

Calculations:

$$Auto\ VMT\ Reduced\ (\boldsymbol{AVR}) = 20{,}000 * 15 = 300{,}000$$

$$Daily\ Emissions\ Reduction = 300{,}000 * (\frac{6.34}{7} + .82 + 1.392) * \frac{1}{1000} * \frac{1}{365} = 2.563\ \frac{kilograms}{day}$$

$$Capital\ Recovery\ Factor\ (\boldsymbol{CRF}) = \frac{(1+0.05)^5 * (0.05)}{(1+0.05)^5 - 1} = 0.231$$

$$Cost-Effectiveness\ of\ CMAQ\ Funding = \frac{(0.231)*(920{,}000)*1000}{(2.563)*365} = 227{,}174\ \frac{dollars}{metric\ ton}$$

$$Cost-Effectiveness\ of\ Total\ Cost = \frac{(0.231)*(920{,}000)*1000}{(2.563)*365} = 227{,}174\ \frac{dollars}{metric\ ton}$$

<u>HIGH OCCUPANCY VEHICLE FACILITIES</u>

"Promotion of High Occupancy Vehicle Lanes and By-Pass Ramps" is a committed control measure in the MAG 1999 Serious Area CO and PM-10 Plans. High occupancy vehicle (HOV) facilities reduce emissions by increasing vehicle operating speeds and encouraging higher auto occupancies, especially during peak traffic periods.

The MOBILE5a and PART5 models will be run for 2015 to estimate the onroad emissions of CO, TOG, and PM-10 ($\boldsymbol{BEF_{CO}}$, $\boldsymbol{BEF_{TOG}}$, and $\boldsymbol{BEF_{PM}}$) in grams per mile for average 24-hour speeds, with and without the HOV improvement. The VMT and daily speeds will be obtained from 2015 MAG traffic assignments with and without the improvement. The emission factors for the speeds with and without the improvement will be multiplied by the corresponding vehicle miles of travel to quantify the emissions benefit of the HOV project.

Inputs Required from Entity Requesting CMAQ Funds:

•***CMAQ Funding***.
•***Total Cost***.
•Length and location of HOV improvement in sufficient detail for highway network coding.

Formulas:

$$Emissions\ with\ HOV\ Improvements\ (EH) = \boldsymbol{VMT_{HOV}} * \left(\frac{EF_{CO-HOV}}{7} + EF_{TOG-HOV-} + EF_{PM10-HOV}\right)$$

$$\boldsymbol{where: EF_{PM10-HOV} = EE_{HOV} + (PVR_{Fwy} * FF) + ((1.0 - PVR_{Fwy}) * NF))}$$

where: $\boldsymbol{VMT_{HOV}}$ = regional daily VMT with HOV improvement

$\boldsymbol{EF_{CO\text{-}HOV}}$ = CO emission factor for daily speed with HOV improvement

$\boldsymbol{EF_{TOG\text{-}HOV}}$ = TOG emission factor for daily speed with HOV improvement

$\boldsymbol{EF_{PM10\text{-}HOV}}$ = total PM-10 emission factor with HOV improvement

$\boldsymbol{EE_{HOV}}$ = PM-10 exhaust emission factor with HOV improvement

FF = freeway fugitive dust emission factor

NF = non-freeway fugitive dust emission factor

$\boldsymbol{PVR_{Fwy}}$ = percent of total VMT reduction occurring on freeways

$$\textit{Emissions with No HOV Improvements } (\textit{ENH}) = \boldsymbol{VMT_{NonHOV}} * \left(\frac{EF_{CO-NonHOV}}{7} + EF_{TOG-NonHOV-} + EF_{PM10-NonHOV}\right)$$

$$\textbf{\textit{where}}: \boldsymbol{EF_{PM10-NonHOV}} = \boldsymbol{EE_{NonHOV}} + (\boldsymbol{PVR_{Fwy}} * \boldsymbol{FF}) + ((1.0 - \boldsymbol{PVR_{Fwy}}) * \boldsymbol{NF}))$$

where: $\boldsymbol{VMT_{NonHOV}}$ = regional daily VMT without HOV improvement

$\boldsymbol{EF_{CO\text{-}NonHOV}}$ = CO emission factor for daily speed without HOV improvement

$\boldsymbol{EF_{TOG\text{-}NonHOV}}$ = TOG emission factor for daily speed without HOV improvement

$\boldsymbol{EF_{PM10\text{-}NonHOV}}$ = total PM-10 emission factor without HOV improvement

$\boldsymbol{EE_{\text{-}NonHOV}}$ = PM-10 exhaust emission factor without HOV improvement

FF = freeway fugitive dust emission factor

NF = non-freeway fugitive dust emission factor

$\boldsymbol{PVR_{Fwy}}$ = percent of total VMT reduction occurring on freeways

$$\textit{Daily Emissions Reduction} = (\boldsymbol{ENH} - \boldsymbol{EH}) * \frac{1}{1000} * \frac{250}{365} = \frac{\textit{kilograms}}{\textit{day}}$$

where: 250/365 = factor to convert from an average weekday to average annual day

$$\textit{Capital Recovery Factor } (\boldsymbol{CRF}) = \frac{(1+i)^{life}\,(i)}{(1+i)^{life} - 1}$$

where: *i* = discount rate of 5 percent

life = effectiveness period of 20 years

$$Cost\text{-}Effectiveness\ of\ CMAQ\ Funding = \frac{(\mathbf{CRF}) * (\mathbf{CMAQ}\ Funding) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

$$Cost\text{-}Effectiveness\ of\ Total\ Cost = \frac{(\mathbf{CRF}) * (\mathbf{Total}\ Cost) * 1000}{(Daily\ Emissions\ Reduction) * 365} = \frac{dollars}{metric\ ton}$$

where: ***CMAQ Funding*** = the CMAQ funding requested for the project
Total Cost = the total cost of the project

High Occupancy Vehicle Lanes **EXAMPLE**

ADOT requests $2,829,000 in CMAQ funds to construct an additional HOV lane in each direction on a three mile segment of I-10. ADOT proposes to provide $171,000 in matching funds. Using the EMME/2 travel demand models, MAG simulates 24-hour vehicle traffic for 2010 with and without the proposed HOV lanes. The traffic assignments indicate that regional VMT with the HOV lanes is 89,232,238 million per day and the average daily speed is 30.1 mph. Without the HOV lanes, the daily regional VMT is 89,389,549 million and the average regional speed, 30.0 mph. The models also determine that 75 percent of the VMT reduction due to the HOV lanes occurs on the freeway.

Inputs Required from Entity Requesting CMAQ Funds:

- ***CMAQ Funding*** = $2,829,000.
- ***Total Cost*** = $3,000,000.

Calculations:

$$Emissions\ with\ HOV\ (EH) = 89{,}232{,}238 * \left(\frac{5.91}{7} + .93 + (.32 + (.75 * .132) + (.25 * 1.062)\right)) = 219{,}402{,}952$$

$$Emissions\ with\ No\ HOV\ (ENH) = 89{,}389{,}549 * \left(\frac{5.93}{7} + .93 + (.32 + (.75 * .132) + (.25 * 1.062)\right)) = 220{,}045{,}145$$

$$\textit{Daily Emissions Reduction} = (220{,}045{,}145 - 219{,}402{,}952) * \frac{1}{1000} * \frac{250}{365} = 440\ \frac{\textit{kilograms}}{\textit{day}}$$

$$\textit{Capital Recovery Factor}\ (\boldsymbol{CRF}) = \frac{(1+0.05)^{20} * (0.05)}{(1+0.05)^{20} - 1} = 0.0802$$

$$\textit{Cost-Effectiveness of CMAQ Funding} = \frac{(.0802) * (2{,}826{,}000) * 1000}{440 * 365} = 1{,}411\ \frac{\textit{dollars}}{\textit{metric ton}}$$

$$\textit{Cost-Effectiveness of Total Cost} = \frac{(.0802) * (3{,}000{,}000) * 1000}{440 * 365} = 1{,}498\ \frac{\textit{dollars}}{\textit{metric ton}}$$

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APPENDIX

Response to Comments
on the
Draft Revised Methodology for Evaluating
Congestion Mitigation and Air Quality Improvement Projects

RESPONSE TO COMMENTS
ON THE
DRAFT REVISED METHODOLOGY FOR EVALUATING
CONGESTION MITIGATION AND AIR QUALITY IMPROVEMENT PROJECTS

AUGUST 10, 2001

The Maricopa Association of Governments distributed a draft revised methodology for evaluating Congestion Mitigation and Air Quality Improvement (CMAQ) projects for interagency review and comment as well as to MAG modal and technical committees for review and comment in July, 2001. A summary of the comments and responses by project category are below.

GENERAL COMMENTS

Comment: A comment was made regarding what effect the cost-effectiveness of total project cost will have on the ranking of CMAQ projects.

Response: Total project cost-effectiveness was added as a ranking measure in the Revised 2001 CMAQ Methodology to respond to a recommendation by the Federal Highway Administration. For most project types, CMAQ funding constitutes 94.3 percent of the total project cost and the addition of the 5.7 percent local match to the cost-effectiveness measure does not alter the relative ranking of these projects. Compared with projects having a match requirement, projects for which the CMAQ funding and total cost are identical have a slight advantage when ranked by total cost-effectiveness. Projects not requiring a dollar match include vanpool vehicles, regional rideshare program, ozone education program, telework program, and teleconferencing. The only project with a total cost significantly higher than the CMAQ contribution is the Trip Reduction Program (TRP), with less than half of the total cost being provided by CMAQ funds. However, using either CMAQ funding or total cost, this program has a higher cost-effectiveness than many other project types. So the use of total cost-effectiveness does not have a significant effect on the ranking of the TRP.

Comment: Is the Agricultural PM-10 Best Management Practices program mentioned in this report. Would this be an opportunity to plug for expanding the program to soil conservation for the entire state. Also missing from that program's publication are rain water retention and water erosion control. These should include all vacant parcels of land over ten acres rather than just agricultural land.

Response: The primary purpose of the Congestion Mitigation and Air Quality Improvement Program is to fund projects or programs in air quality nonattainment and maintenance areas that reduce transportation-related emissions. Soil conservation or soil stabilization on vacant parcels are not eligible activities under the CMAQ Program.

Comment: It would be helpful to have a one page summary of the examples showing the basic funding criteria chosen for each and how they fared when run through the revised formula (ranked from the least to most expensive per metric ton of emissions reduction).

Response: A comparative ranking of example projects would not be appropriate, because costs and other project-specific variables have been assigned hypothetical values in order to demonstrate how the formulas will be applied. The actual CMAQ projects submitted by MAG member agencies may differ significantly from these examples.

Comment: It would be helpful if the Introduction included a sentence or two explaining that evaluation of proposed projects follow federal guidelines and are based solely on air quality benefits, not e.g., on improvements in safety or land use. It would also be helpful to include the reference for the federal CMAQ guidelines as well.

Response: A paragraph has been added to the end of the Introduction to clarify the purpose of the air quality evaluation for proposed CMAQ projects. A reference to the Federal guidance has also been provided.

Comment: Priority should be placed on projects based on other factors (i.e., time savings) since the CMAQ methodology only considers air quality benefits.

Response: The methodologies in the MAG document were developed in response to federal guidance requiring the quantification of emission reductions for proposed CMAQ projects. The quantified air quality benefits (i.e. emission reductions, cost-effectiveness) represent only one set of factors used in prioritizing projects for CMAQ funding. The Congestion Management System (CMS) score, which takes into consideration travel time savings, is also considered in the CMAQ project evaluation process.

Comment: The draft MAG CMAQ assessment approach utilizes spreadsheet software programs to evaluate CMAQ proposals. Recently, the California Air Resources Board (CARB) has developed a Microsoft Access database program tool for these evaluations. The CARB Access analysis tool should be evaluated and revised by MAG staff with assistance and concurrence by the MAG Air Quality Technical Advisory Committee.

Response: Methodologies and default assumptions from the CARB document, Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, 1999 Edition, are being used extensively in the MAG CMAQ methodologies, as indicated in the MAG document. The CARB methods are automated in a Microsoft Access database, while the MAG methods are automated in an EXCEL spreadsheet. Use of a different automated tool would not add value to the current CMAQ project evaluation process. As in the past, MAG will continue to seek ways to simplify data collection for member agencies, update the methodologies, and expedite the evaluation of CMAQ projects. Each year, the MAG Air Quality Technical Advisory Committee, as well as the MAG modal committees, review and provide comments on the CMAQ methodologies before they are applied to evaluate the emission benefits of proposed CMAQ projects.

Comment: The 1999 federal CMAQ guidance document requires that evaluation of the emissions reductions for CMAQ-eligible projects must include ozone precursor emissions. MAG's draft methodology addresses only total organic gas (TOG) emissions, and does not include the other air pollution precursor of ozone air pollution, nitrogen oxides.

Response: Final CMAQ guidance, issued in the Federal Register on February 23, 2000, states that "projects funded under the CMAQ program must be expected to result in tangible reductions in CO, ozone precursor emissions, or PM-10 pollution." In the MAG CMAQ methodology, reductions in the ozone precursor emissions of total organic gases have been quantified for proposed CMAQ projects, where appropriate. (Note that some types of eligible projects reduce only PM-10.) Emissions from the ozone precursor, nitrogen oxides (NO_x), have not been included in the evaluation of air quality benefits for CMAQ projects, because the U. S. Environmental Protection Agency (EPA) approved a NO_x exemption petition for the ozone nonattainment area, effective April 11, 1995. This waiver acknowledges that reductions in NO_x emissions do not contribute to attainment of the ozone standard in the Maricopa County nonattainment area.

Comment: The 1999 federal CMAQ guidance document identifies eligible activities and programs. The list of projects in the MAG methodology does not identify how the list of projects for consideration is generated, and why the MAG project list does not include methodologies for all activities and programs eligible under the CMAQ guidance. We ask that MAG solicit project ideas from MAG member organizations that address all eligible activities and programs listed in the guidance document, and include examples of evaluation methodologies for these additional projects.

Response: Section IX of the Draft FY 2003-2007 MAG TIP Guidance Report, June 2001, provides guidance to MAG member agencies on the types of projects that are eligible for CMAQ funding, based on the 1999 federal guidance. The MAG CMAQ methodology document includes methodologies for only those types of projects submitted for CMAQ funding in the past. As stated in the Introduction, "if a different type of project is proposed, a new methodology to evaluate the project may be developed, if possible." Each year the CMAQ methodology document has been updated to include additional project types. For example, in 2001 six new methodologies have been added: Rideshare Programs, Trip Reduction Program, Ozone Education Program, Telework Program, Teleconferencing, and HOV Facilities. In addition, roundabouts have been added to the Intersection Improvements methodology.

BUS PROJECTS

Comment: Under "Bus Projects", there should be a consideration of free bus rides. The MAG Conformity Analysis says there are about 37,000,000 boardings. From the fares the report lists, it is reasonable to assume there is an average of about one dollar per boarding. This would say there is about $37,000,000 per year in fares. That represents only 2.6 percent of the Public Transit/Rapid Transit budget or 1.6 percent of the total Transportation Control Funding budget. The question worthy of study is how much would number of boardings go up if the rides were all free. It is quite possible that free rides would give a high dollar return on air quality. Other benefits would be less idling time while fares are collected, elimination of ticket costs, and elimination of administrative costs for handling money.

Response: In FY 1999-2000, the total number of boardings for fixed route bus transit that includes local and express services was 37,496,804. Farebox revenues comprised less than 31 percent of the operating costs. The Transportation Control Measure pie chart includes primarily capital funding or $1,414.3 million for "Public Transit/Rapid Transit". To increase ridership, operators of fixed route service occasionally promote free transit use, but, thus far, only on a periodic basis. Federal CMAQ guidance states that "CMAQ funds can be used to subsidize transit fares only if the reduced fare is offered as a component of a comprehensive, targeted program to reduce SOV use during episodes of high pollutant concentrations." For example, CMAQ funds could be used to subsidize bus fares during "ozone alert" days each summer, but could not be used to permanently eliminate bus fares.

Comment: In the methodology for "Operation of New Bus Service", the cold start emissions factor was used for all 1.2 miles of the home-to-transit trip. For the home-to-destination trip (that bus use would replace) it is unclear whether any miles were presumed to be in the cold start mode. Not presuming any cold start miles in these home-destination trips would have the effect of underestimating the benefits of a new bus program. You may want to consider any possible inconsistent use of cold start emission factors in the methodologies.

Response: In the modeling of automobile emission factors with MOBILE5, the first 505 seconds or 3.59 miles of a trip where the vehicle has been shut off for an extended period of time is considered to be a "cold start". Such "cold start" emissions are included in the emission factors for automobile commute trips that have been replaced by transit.

Comment: On page 5, paragraph 2, "New Bus Service", how is the $\boldsymbol{VMT_{REP}}$ (automobile VMT replaced) factor listed in sentence 1 determined? How was the average trip length factor listed in sentence 2 determined to be representative of the VMT "saved" by new bus service? If you use average trip length as a factor, what geographic area is used to generate that number? Given regional differences in bus service and patronage, we recommend that city-based numbers be used to evaluate CMAQ project proposals instead of the regional averages. It would be better to calculate the VMT value for each bus rider; the 0.50 value is not representative. For many transit riders, no automobile trip would be generated and therefore those should get the full VMT reduction credit.

Response: The $\boldsymbol{VMT_{REP}}$ (automobile VMT replaced) factor listed in the first sentence is calculated as described in the first formula listed for the New Bus Service. This equation uses as inputs an estimated ridership per bus, fraction of riders who previously drove, and trip length replaced for each rider who previously drove. The aforementioned trip length replaced for each rider uses a default value of nine miles and is based upon the CARB document, as described in the MAG methodology. As indicated in the MAG methodology, the value of nine miles is a default value used in the absence of locally-derived data. Similar to the trip length value, the fraction of riders who previously drove to their destination has a default value of 0.5 that is used in the absence of locally-derived data. If locally-derived data and supporting documentation are provided with the project request, these data may be substituted for the default values.

<u>Comment:</u> On page 6, paragraph 1, "New Bus Service," the $\boldsymbol{VMT_{BUS}}$ ("assumed" distance a bus travels each day) factor of 150 miles might not be representative of a bus fleet like Tempe's. Tempe buses operate 350+ days out of 365, but may not drive as far the calculated average of 36,000 miles per year. Other MAG cities also have bus service operating more than 240 days per year. In view of the significant differences between city numbers and regional averages, we recommend that individual cities always provide the data used for evaluating the projects. Tempe can generate the numbers required for the model and is willing to provide annual changes as may be required to reflect changing operational conditions.

<u>Response:</u> As indicated in the revised Introduction, locally-derived values may be used in the evaluation of air quality benefits, when supplied with supporting documentation as part of the CMAQ project request. For example, if the annual mileage traveled by a typical Tempe bus and the number of bus service operating days were available from local service provider, Tempe could forward this information to MAG with the CMAQ request for new bus service. MAG would use this data to estimate the number of miles the new bus would travel each working day as a replacement for the default value of 150 in the equation for bus emissions (***BUS***). Similarly, other default assumptions may be replaced if local data and supporting documentation are provided with the CMAQ project request.

<u>Comment:</u> On page 6, paragraph 2, "New Bus Service," how is the $\boldsymbol{VMT_{ADD}}$ (automobile VMT added due to new bus service) factor determined? How is the fraction of riders on the bus who drive to transit determined? Has the average trip length to reach transit been surveyed in the Maricopa urban region? If so, is it geographically variable?

<u>Response:</u> The $\boldsymbol{VMT_{ADD}}$ (automobile VMT added due to new bus service) factor is calculated as described in the fourth formula listed for the New Bus Service. This equation uses as inputs an estimated ridership per bus, fraction of riders who drive to transit, and average trip length driven to transit. As indicated in the MAG methodology document, a default value for the fraction of riders on the bus who drive to transit is based on a 1995 On-Board Origin and Destination Study for the MAG region. Similarly, a default value for average trip length driven to transit is provided, based upon Valley Metro data. As indicated in the revised Introduction, locally-derived values may be used in the evaluation of air quality benefits, when supplied with supporting documentation as part of the CMAQ project request.

<u>Comment:</u> On page 6, "New Bus Service", the inputs $\boldsymbol{F_2}$ (fraction of riders who drive to reach the bus) and $\boldsymbol{trip\ length_2}$ (average length of trip from home to transit) factors are not uniform for all types of bus service. Based on Tempe's bus operations experience, the values used for the $\boldsymbol{F_2}$ and $\boldsymbol{trip\ length_2}$ factors could be much less. For example, our transit system is accessible within ½ mile from any point in the City of Tempe. Since Tempe bus service can be accessed with ½ mile, the penalty drive of 1.2 miles to access transit is not consistent with our experience. The only possible

application for such driving to access transit is for express service. The express bus service is a minor part of Tempe's system.

Response: As indicated in the MAG methodology document, the value provided for $\boldsymbol{F_2}$ (fraction of riders who drive to reach the bus) is a default value based upon a 1995 On-Board Origin and Destination Study for the MAG region, for use in the absence of locally-derived data. Similarly, the value provided for ***trip length₂*** (average length of trip from home to transit) is a default value based upon Valley Metro data. As indicated in the revised Introduction, locally-derived values may be used in the evaluation of air quality benefits, when supplied with supporting documentation as part of the CMAQ project request.

Comment: On page 8, for the example on the operation of new bus service, it seems unlikely that the "fraction of riders who previously drove to their destination" is only 0.5. If the destination is greater than the distance "typically" walked by a pedestrian, then this factor is much higher, maybe above 0.9. How was the "fraction of riders who drive to reach transit" determined? That factor would be better addressed on a project-specific basis, since access, proximity, and population density are important factors in deciding where to place new bus service. How was the "average length of trip from home to transit" of 1.2 miles determined to be representative? This factor needs to account for both automobile exhaust and PM reentrainment emissions in calculating the benefits of adding new bus service.

Response: The default value of 0.5 for $\boldsymbol{F_1}$ (the fraction of riders who previously drove to their destination) is based on a CARB estimate of the share of bus riders who are not transit dependent. "Not transit dependent" means a bus rider had access to a vehicle as a driver or passenger on the day he or she rode the bus. The On-Board Origin and Destination Survey conducted by RPTA in 1995 indicates that 21 percent of *local* bus riders in the Valley were not transit dependent, while 81 percent of *express* bus riders were not transit dependent. The MAG CMAQ methodology uses the CARB default value of .50 for $\boldsymbol{F_{1,}}$ to represent the average share of riders using new bus service (either local or express) who are not transit dependent. This value is likely to overestimate the actual auto VMT replaced ($\boldsymbol{VMT_{REP}}$), since some of these bus riders may have previously used an alternate mode (i.e., different transit route/service, bicycle, carpool, vanpool, or telecommuting), rather than driving, even though a vehicle was available. The value provided for ***trip length*** $_2$ (average length of trip from home to transit) is a default value based upon Valley Metro data. As indicated in the revised Introduction, locally-derived values may be used in the evaluation of air quality benefits, when supplied with supporting documentation as part of the CMAQ project request.

BICYCLE AND PEDESTRIAN FACILITIES

Comment: The methodology assumes that bicycle/pedestrian trips replace vehicle trips that are four miles or less. However the Maricopa County Trip Reduction surveys indicate that the average one-way bicycle commute in Maricopa County is 5.5 miles. Using a number that is lower automatically devalues the CMAQ score for bicycle projects compared to other modes.

Based on data in Bicycle Demand and Benefit Model (Alta Transportation Consulting) the methodology assumes that an average bicycle trip length is four miles. However, according to Mia Birk with Alta Transportation Consulting, the average bicycle trip length of four miles was based on the average one-way bicycle commute of communities in the Los Angeles area. Since the residential density of Los Angeles is higher than Phoenix, the assumption that bicycle trips in Phoenix and Los Angeles are the same length is incorrect. Actual data from Maricopa County Trip Reduction surveys indicate that on average, Phoenix cyclists bicycle further that their counterparts in California.

Response: The assumption that an average one-way bicycle commute trip is four miles long was derived from Bicycle Demand and Benefit Model Documentation by Alta Transportation Consulting, April 2000. This average trip distance is based on surveys conducted in thirty metropolitan areas by Alta Transportation Consulting, as well as data from the National Bicycling and Walking Study: Case Study Number 1 and the City of Portland Bicycle User Survey. The Trip Reduction Program (TRP) conducts surveys of employees who work for the largest organizations (i.e., 50 or more employees at one site) in Maricopa County. Due to the larger size of the TRP organizations and the fact that these employers are involved in concerted efforts to increase alternate mode use, including bicycle travel, the statistics reported by this program may not be representative of region-wide commute trip lengths by bicycle.

In addition, it should also be noted that the methodology for quantifying the emission benefits of bicycle facilities in the MAG CMAQ document is based on the 1999 CARB methodology. The default bicycle trip length used in the CARB methodology is 1.8 miles, as derived from the National Personal Transportation Survey. By substituting four miles as a default, MAG is giving more than twice the emissions reduction credit for bicycle facilities than is awarded by the CARB methodology.

Comment: The methodology assumes that the life effectiveness period is 20 years for bicycle and pedestrian paths, 50 years for an overpass or underpass, ten years for bicycle lanes on a road without curb and gutter, and 20 years for bicycle lanes on a road with curb and gutter. However, the Maricopa County Department of Transportation designs and builds all roadways based on a 20-year life expectancy. The bicycle lane is designed and constructed using the same materials as the rest of the roadway. Adding a curb and gutter does not affect its expected life. A bicycle lane on a road with or without curb and gutter should have a 20-year life.

Response: The practical life span of a roadway is a function of the construction of the edge of the roadway, among other factors. A roadway segment which does not have curb and gutter would be expected to deteriorate in less than twenty years, in the absence of additional re-construction efforts. However, roadways designed and constructed with a "Maricopa edge" tend to last longer than those without curb and gutter. In recognition of this fact, the 2001 CMAQ methodology has been revised to include a 15-year life expectancy for bicycle lane projects built with a "Maricopa edge" and if the pavement on the bicycle lane portion of the roadway is at least as thick as the pavement on the remaining portion.

Comment: The methodology quantifies activity centers only on the existence of a building and its proximity to the project - not on the actual activity level of the center as measured by how many people use it. (i.e., less than 100 week, 100-1,000 per week, 1,000-20,000 per week, 20,000 plus per week - something like that.)

Response: The annual average daily traffic on the nearest parallel arterial is the measure used to approximate the number of people attracted to the activity center. It would require an extensive data collection effort throughout the Valley to substitute local adjustment factors for those provided in the 1999 CARB report.

Comment: On page 8, "Bicycle and Pedestrian Facilities", the example should either be expanded to include, or a separate section developed for, light rail transit project activities actively under development in MAG member cities. The 1999 federal CMAQ guidance document clearly specifies transit projects as eligible. In addition, improvements made to accommodate multi-modal transfers are not incorporated in the evaluation process. Planning, construction and improvements of transit stations/transit centers are eligible for funding under CMAQ.

Response: As stated in the Introduction, "if a different type of project is proposed, a new methodology to evaluate the project may be developed, if possible." If a MAG member agency proposes a new type of CMAQ-eligible project, then a new methodology may be developed to quantify the emissions benefits. If a methodology can not be developed, due to lack of time or other considerations, the proposed project would receive a qualitative assessment, as permitted in the federal CMAQ guidance.

Comment: On page 11, the factors described in the table are not weighted for the size or type of the activity center. These characteristics are interactive, so perhaps a matrix of activity center credit values needs to be developed for application to project-specific lists of affected activity centers. Calculating projected users for pedestrian and bicycle facilities should be based on each City's demonstrated use. Additional points should be awarded based on activity centers, congestion, and other factors that promote the use of the facility.

Response: In the MAG methodology, the annual average daily traffic on the nearest parallel arterial is the proxy measure used to "weight" the intensity of the activity center. The activity center data and methodology used for Bicycle and Pedestrian Activities were derived from the 1999 CARB report, Methods to Find Cost Effectiveness of Funding Air Quality Projects. The CARB data was utilized in the absence of comparable data for the MAG region. It would require an extensive data collection effort throughout the Valley to substitute local adjustment factors for those provided in the 1999 CARB report.

PAVING PROJECTS

Comment: On page 14, paragraph 2, "Paving Projects," many other factors enter into the air quality benefits of effectiveness of paving unpaved roads, paving unpaved shoulders, and/or adding curbs and gutters. The calculations need to be reorganized to accommodate the revisions and additions suggested below.

On page 14, the formula for "Paving Unpaved Shoulders/Curbs and Gutters" must be broken into 2 separate formulas, Paving Unpaved Shoulders and Adding Curbs and Gutters. The air quality effect of paving an unpaved shoulder is likely to be different than adding a curb and gutter, for a given length of roadway. The physics of dust moving onto the road surface are quite different in the two cases, and sweeping effectiveness is likely to be higher for roadways with curbs and gutters. Paving projects should support cleaner air by encouraging and allowing effective sweeping activities that remove dust before it can reach or remain on the roadway travel surface.

Response: The 50 percent reduction factor for paving unpaved shoulders/adding curbs and gutters was derived from the MAG, Particulate Control Measure Feasibility Study, prepared by Sierra Research in 1997. MAG is not aware of more recent information showing that curbs and gutters provide intrinsically lower particulate emission rates than the paving of shoulders. The current methodology attempts to quantify the emission reduction impact of the CMAQ paving project, independent of the characteristics of any street sweeping activities which may or may not occur after project completion.

Comment: On page 14, for the formula "Paving Unpaved Roads", the multiplicative factor difference between ***BEF*** (the unpaved road PM-10 emissions rate of 573.91 grams/mile) and ***AEF*** (the paved road PM-10 emissions rate of 1.573 grams/mile) is more than 364. Is it appropriate to simply subtract ***AEF*** from ***BEF*** to calculate the emission rate difference? Is the relative precision and accuracy of these factors sufficiently comparable to allow the subtraction? More importantly, how will the air quality effects resulting from the induced demand for additional VMT caused by paving an unpaved road be quantified?

Response: One goal of the CMAQ analysis is to estimate the emissions reduction from the proposed project in terms of kilograms reduced per day, rather than the fractional reduction in emissions. Using the difference between AEF and BEF is appropriate to estimate emissions reduction in absolute terms (i.e. grams, pounds, kilograms), while the ratio of AEF to BEF is appropriate to estimate an emissions reduction in relative terms (i.e. an X percent reduction in emissions). AEF and BEF represent the best-available emission rates, based on EPA's PART5 emissions model. The air quality effects from induced travel demand (after paving the roads) is not currently incorporated in the methodology, because any estimates would be highly speculative and the impact of the VMT increase would be relatively small. For example, a tenfold increase in VMT after the paving of an unpaved roadway would diminish the particulate emissions reduction by less than five percent.

Comment: On page 16, the equation for paving unpaved roads (no curb/gutter) must be modified to discount the air quality benefit of paving unpaved roads without adding curbs and gutters at the same time, versus the paving unpaved roads while adding curbs and gutters simultaneously. The reservoir of dust available to the newly paved surface is much larger when there is no curb and gutter.

Response: The paving of unpaved roads with curb and gutter and the paving of unpaved roads without curb and gutter result in different cost effectiveness estimates due to the different life span assumptions for projects with and without curb and gutter.

PM-10 CERTIFIED STREET SWEEPERS

Comment: As the number of street sweepers in a fleet increases, it appears the emissions reduced by each sweeper declines.

Response: This scenario would only occur when no new lane miles of streets have been added or when the sweeping cycle (frequency) in which streets are swept remains constant.

Comment: On page 19, what is the source of the data in the emission factor table used for PM-10 certified street sweepers?

Response: As indicated in the MAG CMAQ methodology document, the source of the emission factors described in the table is the MAG, Most Stringent PM-10 Control Measures Analysis, prepared by Sierra Research in 1998.

Comment: On page 21, relating to the PM-10 certified street sweeper example, leaving in the current inputs, additional inputs and the subsequent calculations necessary to estimate the air quality benefits of replacing existing street sweepers with PM-10 emissions efficient, certified street sweepers must be changed to include: (a) the manufacturer-reported difference between old and new engine emissions (for PM-10, NO_x, CO, and VOC; (b) the calculated difference in the "pigpen effect", i.e., the fugitive PM-10 emissions rate of the old sweeper versus the new sweeper; and, (c) the manufacturer-reported difference between the old and the new street sweeper PM-10 removal efficiencies. Including all of this information in the calculation will allow a more accurate air quality benefit to be better estimated.

Response: The additional emissions benefit from the reduction in reentrainment from the certified sweeper itself, as described in the 2001 CARB methodology, will be added to the CMAQ methodology for PM-10 efficient sweepers. It is important to note that the reduction in dust entrainment during the sweeping activity itself is expected to be minor in comparison with the reduction in entrainment from subsequent vehicular traffic on the roadway. Additionally, the methodology will be amended to give additional credit for alternatively-fueled street sweepers, consistent with the methodology for alternatively-fueled buses.

Comment: We agree with using paved road emission factors for estimating air quality benefits of PM-10 Certified Street Sweepers. However, we suggest that you expand the formula to include reductions the dust entrainment during the sweeping activity itself. CARB has estimated this incremental benefit of clean sweepers to be 0.05 pounds per mile swept. For more information, see http://www.arb.ca.gov/planning/tsaq/eval/SweeperFINAL.doc

Response: As previously stated, the additional reduction in emissions as described in the 2001 CARB methodology will be appended to the CMAQ methodology for PM-10 efficient sweepers. It is important to note that the reduction in dust entrainment during the sweeping activity itself is expected to be minor in comparison with the reduction in entrainment from subsequent vehicular traffic on the roadway.

Comment: In addition, because dust from adjacent property and track-out affects curb lanes and because traffic tends to blow road dust toward the curb lanes the formula should give greater weight to sweeping curb lanes.

Response: MAG is not aware of any data which quantifies the silt loading levels in different lanes of traffic. Additionally, track-out may affect any or all travel lanes, depending upon the nature of the project or roadway. For example, a project requiring vehicles to repeatedly pass from one side of a roadway to the other may result in track-out and higher silt loadings across the entire roadway.

TRAFFIC FLOW IMPROVEMENTS

Comment: Under Traffic Flow Improvements, there should be a heading for Roundabouts as an equal to traffic signals etc. There should be data provided to illustrate the different designs that accommodate different traffic loads and how they reduce travel time, eliminating idling time, eliminate traffic light maintenance and operation costs, and eliminate road rage.

Response: The decision to submit a roundabout project for CMAQ funding and the attendant design considerations are the responsibility of the requesting agency. For more detailed information on Roundabouts, please refer to Roundabouts: An Informational Guide (FHWA-RD-00-67). The document is available electronically from the Turner-Fairbank Highway Research Center library at www.tfhrc.gov/safety/00068.htm.

It is important to note that the CMAQ methodologies were developed in response to federal guidance requiring the quantification of emission reductions for proposed CMAQ projects. The air quality evaluation does not address other potential project benefits such as improvements in safety and reductions in maintenance and operating costs. However, in addition to the air quality evaluation, CMAQ projects are evaluated on the basis of a Congestion Management System (CMS) score which does take into consideration reductions in travel time and idling.

Comment: On Page 29, "Freeway Management System," it is unclear exactly how adding three miles of freeway to the freeway management system results in improved air quality. The potential air quality benefit may be counteracted by the effect of the sign on drivers slowing or diverting attention to read the sign. How does the freeway management system know which alternate routes (usually someone would switch to arterial streets) to direct drivers to use? In order for the sign to cause an air quality benefit the system would have to simultaneously evaluate emission conditions or a surrogate on possible alternative routes. The primary purpose of a highway sign is for traffic management; air quality improvement is perhaps a limited ancillary benefit.

Response: As indicated in the MAG CMAQ methodology document, additional freeway management system mileage improves air quality by informing motorists of potential problems ahead. This provides motorists with an option to choose an alternative route. The resultant reduction in congestion improves traffic flow and vehicle speeds, leading to lower vehicle emissions.

INTERSECTION IMPROVEMENTS

Comment: The term "existing queue lengths" needs to be clarified.

Response: "Existing queue length" means the most recent traffic engineering data on the average number of vehicles stopping at a stoplight or stop sign in the turning movement direction during the morning (7-9 am) and evening (4-6 pm) peak periods at the intersection, before it is improved. The turning movement direction is based on the improvement to be made. If a second left turn lane were being added, the average morning and evening peak period number of vehicles queuing in the existing left turn lane would be provided. If a new dedicated right turn lane were being added, where there currently was a lane serving both right turns and through traffic, then the average number of vehicles stopped at the traffic light in the existing through/right turn lane would be averaged over the four peak hours. Queue length data is usually collected in 15-minute intervals, in which case it would be averaged for each peak hour (i.e., sum the 15-minute average vehicle queue lengths and divide by four) and over the four peak hours (i.e., sum the 7-8 am, 8-9 am, 4-5 pm and 5-6 pm averages and divide by four). If not provided by the requestor, existing queue lengths will be derived from data collected for major Valley intersections in the 1998 MAG Regional Congestion Study.

Comment: May a jurisdiction provide queue length data in lieu of providing the estimated delay reduction based on simulation of the intersection, and if so, what queue length data is needed.

Response: If a jurisdiction provides existing queue length for the am and pm peak periods based upon recent data collected for the intersection, then this will be substituted for $\boldsymbol{Q_{am}}$ and $\boldsymbol{Q_{pm}}$ in the daily emissions reduction formula. See the previous response for the definition of "existing queue length."

Comment: Table 4 (page 32) shows unrealistic queue lengths. For example, how could there be a 24 vehicle queue in a left turn lane when almost all left turn lanes are less than 250 feet long (i.e., capacity of 10 vehicles). After that, the left turners would queue into the adjacent through lane of the approach, and how could an observer distinguish between vehicles queued up to turn left versus those queued up to go through.

Response: As suggested, the queue lengths in Table 4 have been reduced and the calculations for the example have been revised to reflect more realistic turning lane capacities.

Comment: How is the weighted average turning movement percent calculated?

Response: To be clearer, the term "weighted" has been removed from the description of the methodology. The average turning movement percent (***TM***) must only be specified when a new dedicated turn lane is being constructed next to a lane which currently accommodates both through and turning traffic. ***TM*** represents the average percent of vehicles turning (i.e. right, for a new right turn lane, and left, for a new left turn lane) from the existing through/turn lane during the morning (7-9 am) and evening (4-6 pm) peak hours. This is calculated by dividing the number of vehicles turning by the total volume traveling through and turning from the lane that will be adjacent to the improvement. For example, if a dedicated right turn lane were proposed, the right turn and total approach volumes in the lane adjacent to the proposed lane would be counted for the peak periods (7-9 am and 4-6 pm) on a typical weekday and the right turn volumes would be divided by the total approach volumes to determine ***TM***. If vehicle delay reductions based on traffic operations modeling are not provided by the requestor, the average turning movement percent is derived from data collected for major Valley intersections by the 1998 MAG Regional Congestion Study.

VANPOOL VEHICLES

Comment: Vanpool vehicles are in operation at least 255 days per year, rather than 250.

Response: The methodology has been updated to reflect this change.

Comment: A comment was made to consult with the RPTA Vanpool Program to obtain updated information on the average vehicle occupancy and other statistics for the vanpool program.

Response: The methodology has been revised to include the updated information provided by RPTA.

Comment: In the example, RPTA should be requesting CMAQ funds for vanpool vehicles. No matching funds are required.

Response: The example text and CMAQ funding levels have been changed accordingly.

TRIP REDUCTION PROGRAM

Comment: The percent of employees (i.e. 61 percent) working for organizations with 50 or more employees derived from the RPTA 2001 TDM survey information overestimates the number of employees working for Trip Reduction Program (TRP) organizations. The TRP estimates that 35 percent of employees work for employers with at least 50 employees at one site. (The TDM survey percent is higher, because it includes organizations for which employees are distributed at a number of sites.)

Response: The text and formula have been reduced to 35 percent.

Comment: A comment was made to check with Maricopa County Trip Reduction Office to determine if there is more accurate information from the Trip Reduction Program concerning the percent of work trips in TRP organizations using alternate modes and other program statistics.

Response: The Maricopa County Trip Reduction Office provided updated information and the assumptions have been revised accordingly.

Comment: Since there is considerable variation from year to year in the statistics reported by the Regional Public Transportation Authority Transportation Demand Management surveys, use a three year average trip length, i.e. 1999-2001.

Response: The 1999-2001 average trip length of 12.6 miles has been substituted for the 2001 value of 11.8 miles in the formulas for the rideshare programs and ozone education program.

Comment: The travel occurring during a telecommuting or compressed work day would take place (i.e. after work or during lunch) even if the employee were commuting to work. This travel should not be used to offset the reduction in commute trip VMT.

Response: There is no survey data quantifying how much of the travel occurring during a telecommute or compressed work day is discretionary. In addition, most of this substitute travel occurs during off-peak traffic periods. Consequently, the VMT increase formulas have been dropped from the methodologies for the ozone education program and the telework program, as well as the trip reduction program.

OZONE EDUCATION PROGRAM

Comment: On page 45 for the example Summer Ozone Education Program, there is likely great public education benefit to sponsoring a summer ozone education program. How is "...the share of alternative mode use attributable to the Summer Ozone Education Program is ten percent."determined? We see that a significant percentage of employees employed outside the home use alternate modes, but the exact effect of the Summer Ozone Education Program will need to be better justified.

Response: The share of alternative mode use attributable to the Summer Ozone Education Program (***P***) would be provided by the sponsoring agency, in this case, RPTA. This factor would be derived from survey data, such as the annual TDM survey. If appropriate survey data are not available, the factor would be based on the best professional judgment of staff from the sponsoring agency.

TELEWORK PROGRAM

Comment: Check the RPTA 2000 Telecommuting Study to determine if there are more accurate data on telecommuting than provided by the 2001 TDM Survey. The sample size of telecommuters is higher in the Telecommuting Study.

Response: The average one-way trip length of telecommuters, as reported by the 2000 Telecommuting Study, is 19 miles. This trip length has been substituted in the TELEWORK formula.

Comment: In the example, the percent (***P***) of telecommuting attributable to the Telework Program appears to be too low.

Response: In the telework example, ***P*** has been raised from 10 percent to 20 percent. However, the example value is purely hypothetical; the actual values of ***P*** used in calculating emission reductions and cost-effectiveness of the telework program, as well as the rideshare program, trip reduction program, and ozone education program, is to be provided annually by the agencies requesting the CMAQ funds.

TELECONFERENCING

Comment: The depreciation time of three years for telecommunications equipment, in general, and videoconferencing and audioconferencing equipment, specifically, should be longer than three years. Norstan has concurred with this and say their equipment is in place far longer than this, once it is purchased. It is suggested that the life of the equipment be at least five years.

Response: The CMAQ methodology already assumes a life expectancy of five years for teleconferencing projects.

Comment: Some of the member agencies have purchased additional equipment to add to their telecommunications needs. Similarly, other agencies have equipment that will become part of our "network". It is, therefore, suggested that the savings in time, VMT, etc., for this additional equipment be added to the score for a project.

Response: The benefits of additional equipment in the "network" may be reflected in the CMAQ methodology by estimating the impact of these resources on the number of vehicle trips reduced by teleconferencing each year (***ATR***). The value of ***ATR*** is provided by the MAG teleconferencing program manager as part of the CMAQ project funding request.

Comment: This equipment is sometimes used to facilitate discussion with areas outside of Maricopa County, thus ensuring less travel by car and by plane, to and from the area. It is therefore suggested that the savings in time, VMT, etc., for this additional travel be added to the score for a project.

Response: The benefits of using the equipment to facilitate discussion outside Maricopa County may be reflected in the CMAQ methodology by estimating the impact of these discussions on the number of vehicle trips reduced (***ATR***) and the average trip length of vehicle trips reduced (***TL***) by teleconferencing each year. The values of ***ATR*** and ***TL*** are supplied by the MAG teleconferencing program manager as part of the CMAQ project funding request.

Comment: It was also felt that projects of a regional nature should be given additional credit because of the scope of the project.

Response: The regional nature of the project's impact will be captured in the large number of vehicle trips reduced (***ATR***) and the long average trip length of vehicle trips reduced (***TL***) by teleconferencing each year. This information is provided by the project sponsor as part of the CMAQ funding request.