

PAVING PROJECTS

“Pave or Stabilize Unpaved Shoulders” and “Pave or Stabilize Existing Public Dirt Roads and Alleys” are committed measures in the MAG Five Percent Plan for PM-10 (MAG 2007b). 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 reduce PM-10, but not CO, TOG, or NOx emissions.

The Five Percent Plan for PM-10 assumes an unpaved road emission rate of 666.62 grams per vehicle mile of travel (g/vmt) (**BEF**) and an average paved road emission rate of 3.51 g/vmt (**AEF**) on low volume roads (i.e., those carrying less than 10,000 vehicles per day) with unpaved shoulders. The difference between these paved and unpaved emission rates, 663.11 g/vmt, represents the reduction in PM-10 emissions due to paving of dirt roads outside the Salt River Area. In the Salt River Area, the average emission rate is 6.88 g/vmt for paved roads without shoulders and the emission reduction due to paving a dirt road in the Salt River Area is 659.74 g/vmt.

The benefits of paving unpaved shoulders and/or installing curbs and gutters (C&G) are derived from the MAG Five Percent Plan for PM-10. Outside the Salt River Area, the emission reduction factor (**RF**) for paving shoulders with C&G on both sides of the road would be 1.81 g/vmt for roads carrying less than 10,000 vehicles per day and 1.49 g/vmt for roads carrying 10,000 or more vehicles per day. In the Salt River Area, the **RF** for paving shoulders with C&G on both sides of a road is 3.44g/vmt.¹ As shown in the formulas below, the **RFs** vary based on the extent of shoulder and/or C&G paving.

To be consistent with the Five Percent Plan, paving unpaved access points will be assumed to reduce emissions by 343 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 Cost.**
- Project length (*centerline miles*).
- Average weekday traffic (*ADT*) for paving unpaved roads or shoulders.
- The number of access points to be paved (*access points*) - if paving unpaved access points.
- Whether the project includes paving the shoulder and/or providing curb and gutter on one or both sides of the road.

¹According to Sierra Research, paving unpaved shoulders with curb and gutter in the Salt River Area reduces paved road emissions by 50 percent; therefore, **RF** due to paving shoulders with curb and gutter in the Salt River Area is 6.88 g/vmt x 0.5 = 3.44 g/vmt. (MAG, 2008).

Formulas:

For Paving Unpaved Shoulders and/or Providing Curb and Gutter (C&G):

$$\text{Daily Emissions Reduction} = w4 * RF * \text{miles} * ADT * 0.91 * \frac{1}{1000} = \frac{\text{kilograms}}{\text{day}}$$

where: *miles* = the length of the project (in centerline miles)

ADT = the average weekday traffic on the road adjacent to the unpaved shoulders

0.91 = the factor to convert from weekday to annual average daily traffic

w4 = the PM-10 weighting factor

RF = Emission reduction factor in grams per vehicle mile of travel (vmt) for:

Low volume arterials (<10,000 ADT) outside the Salt River Area =

1.81 g/vmt, if paving shoulders and providing C&G on both sides of the road;

1.36 g/vmt, if paving shoulders on both sides of the road without C&G;

0.91 g/vmt, if paving shoulder and providing C&G on one side of the road;

0.68 g/vmt, if paving shoulder on one side of the road without C&G;

0.45 g/vmt, if providing C&G on both sides of a road with paved shoulders; or

0.23 g/vmt, if providing C&G on one side of a road with a paved shoulder.

High volume arterials (\geq 10,000 ADT) outside the Salt River Area =

1.49 g/vmt, if paving shoulders and providing C&G on both sides of the road;

1.12 g/vmt, if paving shoulders on both sides of the road without C&G;

0.75 g/vmt, if paving shoulder and providing C&G on one side of the road;

0.56 g/vmt, if paving shoulder on one side of the road without C&G;

0.37 g/vmt, if providing C&G on both sides of a road with paved shoulders; or

0.19 g/vmt, if providing C&G on one side of a road with a paved shoulder.

All arterials inside the Salt River Area =

3.44 g/vmt, if paving shoulders and providing C&G on both sides of the road;

2.58 g/vmt, if paving shoulders on both sides of the road without C&G;

1.72 g/vmt, if paving shoulder and providing C&G on one side of the road;

1.29 g/vmt, if paving shoulder on one side of the road without C&G;

0.86 g/vmt, if providing C&G on both sides of a road with paved shoulders; or

0.43 g/vmt, if providing C&G on one side of a road with a paved shoulder.

For Paving Unpaved Roads:

$$\text{Daily Emissions Reduction} = w4 * (BEF - AEF) * \text{miles} * ADT * 0.91 * \frac{1}{1000} = \frac{\text{kilograms}}{\text{day}}$$

where: **BEF** = the PM-10 emission factor for vehicles traveling on unpaved roads = 666.62 g/vmt
AEF = the PM-10 emission factor for vehicles traveling on paved roads outside the Salt River Area = 3.51 g/vmt or inside the Salt River Area = 6.88 g/vmt
miles = the length of the project (in centerline miles)
ADT = the average weekday traffic on the road adjacent to the unpaved shoulders
0.91 = the factor to convert from weekday to annual average daily traffic
w4 = the PM-10 weighting factor

For Paving Unpaved Access Points:

$$\text{Daily Emissions Reduction} = w4 * \frac{343 \text{ grams}}{\text{access point-day}} * \text{access points} * \frac{1}{1000} = \frac{\text{kilograms}}{\text{day}}$$

where: **access points** = the number of access points to be paved
w4 = the PM-10 weighting factor

For All Paving Projects:

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

where: **i** = discount rate of 3 percent
life = effectiveness period of 20 years

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

where: **CMAQ Cost** = the CMAQ funding requested for the project.

Paving Unpaved Roads without Paved Shoulders or Curb and Gutter

EXAMPLE

A city proposes to pave a 1.5 mile section of unpaved road in FY 2009 which has an average weekday traffic volume of 150 vehicles per day. No paved shoulders or curb and gutter will be provided. The project is located outside of the Salt River Area. The city proposes to pay \$15,111 and requests \$250,000 in CMAQ funds.

Inputs Required from Entity Requesting CMAQ Funds:

- *CMAQ Cost* = \$250,000.
- Project length (*miles*) = 1.5 miles.
- Average weekday traffic (*ADT*) on unpaved road = 150.

Calculations:

$$\text{Daily Emissions Reduction} = 1.0 * (666.62 - 3.51) * 1.5 * 150 * 0.91 * \frac{1}{1000} = 135.77 \frac{\text{kilograms}}{\text{day}}$$

$$\text{Capital Recovery Factor (CRF)} = \frac{(1+0.03)^{20} * (0.03)}{(1+0.03)^{20} - 1} = 0.0672$$

$$\text{Cost-Effectiveness} = \frac{0.0672 * 250,000 * 1000}{135.77 * 365} = 339 \frac{\text{dollars}}{\text{metric ton}}$$

Paving Unpaved Roads With Paved Shoulders and Curb and Gutter

EXAMPLE

A city proposes to pave a one-mile unpaved road in FY 2009 which has a traffic volume of 150 vehicles per average weekday. The project will pave the shoulders and provide curb and gutter on both sides of the road. The paving project is located outside of the Salt River Area. The city proposes to pay \$15,111 and requests \$250,000 of CMAQ funding.

Inputs Required from Entity Requesting CMAQ Funds:

- *CMAQ Cost* = \$250,000.
- Project length (*miles*) = 1 mile.
- Average weekday traffic (*ADT*) on unpaved road = 150.

Calculations:

Calculate the daily emission reduction from paving the unpaved road:

$$\text{Daily Emissions Reduction} = 1.0 * (666.62 - 3.51) * 1.0 * 150 * 0.91 * \frac{1}{1000} = 90.51 \frac{\text{kilograms}}{\text{day}}$$

Calculate the daily emission reduction from paving the shoulder and providing curb and gutter on both sides of the road:

$$\text{Daily Emissions Reduction} = 1.0 * 1.81 * 1.0 * 150 * 0.91 * \frac{1}{1000} = 0.25 \frac{\text{kilograms}}{\text{day}}$$

$$\text{Capital Recovery Factor (CRF)} = \frac{(1+0.03)^{20} * (0.03)}{(1+0.03)^{20} - 1} = 0.0672$$

$$\text{Cost-Effectiveness} = \frac{0.0672 * 250,000 * 1000}{90.76 * 365} = 507 \frac{\text{dollars}}{\text{metric ton}}$$

Paving Unpaved Access Points

EXAMPLE

A city proposes to pave unpaved access points on two miles of road in FY 2009. The city proposes to pay \$15,111 and requests \$250,000 of CMAQ funding.

Inputs Required from Entity Requesting CMAQ Funds:

- **CMAQ Cost** = \$250,000.
- Project length (**miles**) = 2 miles.
- Access points to be paved (**access points**): assume default of 8 per mile.

Calculations:

$$\text{Daily Emissions Reduction} = 1.0 * \left(\frac{343 \text{ grams}}{\text{access point-day}} \right) * 16 * \frac{1}{1000} = 5.49 \frac{\text{kilograms}}{\text{day}}$$

$$\text{Capital Recovery Factor (CRF)} = \frac{(1+0.03)^{20} * (0.03)}{(1+0.03)^{20} - 1} = 0.0672$$

$$\text{Cost-Effectiveness} = \frac{0.0672 * 250,000 * 1000}{5.49 * 365} = 8,384 \frac{\text{dollars}}{\text{metric ton}}$$