RE-EVALUATION OF MONTANA'S AIR QUALITY PROGRAM

FHWA/MT-13-006/8220

Final Report

prepared for
THE STATE OF MONTANA
DEPARTMENT OF TRANSPORTATION

in cooperation with
THE U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

August 2013

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RESEARCH PROGRAMS

MDT

RE-EVALUATION OF MONTANA'S AIR QUALITY PROGRAM

Prepared for the
MONTANA DEPARTMENT OF TRANSPORTATION
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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
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16. Abstract

This project examined the Montana DOT's current methods for determining projects for the Montana Air and Congestion Initiative (MACI) program, and made recommendations to improve and implement this program. A major project objective was to keep the program oriented towards high-value investments for Montana communities. Key project tasks included:

(1) Determine the best use of Congestion Mitigation and Air Quality (CMAQ) funds for each of Montana's transportation-related pollutants
(2) Determine project recommendations that use highest cost to air quality benefit for long-term attainment
(3) Determine needed funding and program policy changes
(4) Identify areas prone to future transportation-related issues
(5) Determine need for education in Montana communities on best practices to prevent nonattainment of transportation related pollutants

One of the primary products of this research is a set of methods descriptions and MS Excel-based tools that are designed for MDT staff and other Montana agencies to use to estimate the air pollution emission reduction benefit and the cost effectiveness of the new measures and projects that are being considered in the state.

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CONTENTS

TABLES

Page

FIGURES

ACRONYMS AND ABBREVIATIONS

ADT	average daily traffic
BLS	Bureau of Labor Statistics
CAAA	Clean Air Act Amendments
CMAQ	Congestion Mitigation and Air Quality
CMB	chemical mass balance
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CPI	Consumer Price Index
CRFs	Capital Recovery Factors
EPA	U.S. Environmental Protection Agency
FHCEHD	Flathead City-County Environmental Health Department
FHWA	Federal Highway Administration
FMVECP	Federal Motor Vehicle Emission Control Program
FTA	Federal Transit Authority
g/m^2	grams per meter squared
GHG	greenhouse gas
GWP	global warming potential
I/M	inspection and maintenance
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITS	Intelligent Transportation Systems
kg	kilogram
lbs	pounds
MAAQS	Montana Ambient Air Quality Standards
MACI	Montana Air and Congestion Initiative
MAP-21	Moving Ahead for Progress in the 21st Century
MDT	Montana Department of Transportation
MEHD	Missoula Environmental Health Division
mg/m^3	milligrams per cubic meter
mm	millimeters
MOVES	Motor Vehicle Emissions Simulator
mph	miles per hour
MPO	metropolitan planning organization
MRTMA	Missoula Ravalli Transportation Management Association
MSLA	Missoula
MTDEQ	Montana Department of Environmental Quality
NAAQS	National Ambient Air Quality Standard
NEI	National Emissions Inventory
NEPA	National Environmental Policy Act
NH_3	ammonia
NH_4NO_3	secondary ammonium nitrate
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
O_3	ozone
OMB	Office of Management and Budget
Pb	lead
Ped	pedestrian
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less

$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less
ppb	parts per billion
ppm	parts per million
PSI	Pollutant Standards Index
RWC	residential wood combustion
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SC&A	S. Cohen and Associates
SIP	State Implementation Plan
SO_2	sulfur dioxide
SO_4	secondary sulfate
SOV	single-occupancy vehicle
STIP	Statewide Transportation Improvement Plan
STP	Surface Transportation Program
TCMs	Transportation Control Measures
TEA-21	Transportation Equity Act for the 21st Century
TIP	Transportation Improvement Plan
VMT	vehicle miles traveled
VOC	volatile organic compound
VSP	Vehicle Specific Power
Wtd.	weighted
$\mu g/m^3$	micrograms per cubic meter

CHAPTER I. INTRODUCTION

The State of Montana Department of Transportation (MDT) hired SC&A, Inc. (SC&A) to develop practical refinements to MDT's current method for determining projects for the Montana Air and Congestion Initiative (MACI) program, recommendations to improve and implement the MACI program, and to keep the program oriented to high-value investments for Montana communities. This research effort includes a synthesis of relevant studies and what current practices are appropriate for Montana. Review of past MDT projects and processes were performed.

The objectives for this research project are to:

- Determine the best use of Congestion Mitigation and Air Quality (CMAQ) funds for each of Montana's transportation-related pollutants.
- Determine project recommendations that use highest cost to air quality benefit for long-term attainment.
- Determine needed funding and program policy changes.
- Identify areas prone to future transportation-related pollutant issues.
- Determine need for education in Montana communities on best practices to prevent nonattainment of transportation related pollutants.

One of the primary products of this research is a set of methods descriptions and MS Excel-based tools that are designed for MDT staff and other Montana agencies to use to estimate the air pollution emission reduction benefit and the cost effectiveness of the new measures and projects that are being considered in the state.

As with any project, there are a few key resources or regulatory uncertainties that remain unresolved at contract completion. In this case, these key uncertainties include nonattainment designations under the December 2012 EPA revisions to the annual average particulate matter with an aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$) National Ambient Air Quality Standard (NAAQS), the U.S. Environmental Protection Agency's (EPA's) forthcoming revisions to the ozone (O_3) NAAQS, and the Federal Highway Administration's (FHWA's) CMAQ guidance under Moving Ahead for Progress in the 21st Century (MAP-21). With Montana's most recent air quality readings (2009–2011), there are unlikely to be significant issues associated with $PM_{2.5}$ or O_3 nonattainment, so the FHWA CMAQ guidance is likely to be the most important to Montana's programs in the next few years.

CHAPTER II. LITERATURE REVIEW

A. INTRODUCTION

This chapter provides a literature review of policies, regulations, and studies on air quality issues applicable to Montana. This literature review is the first major task in a contract that is re-assessing Montana's use of CMAQ Improvement Program and MACI funds to finance transportation projects and programs to help meet the requirements of the Clean Air Act (CAA) (EPA 1990).

This chapter is organized in three major sections. The first section uses the ambient air quality monitoring data by pollutant to assess where the ongoing NAAQS nonattainment issues are likely to be in Montana. Ambient air quality monitoring data from the three most recent complete calendar years of data are used for this analysis. This part of the assessment is important because it may present a different picture of where the potential air quality problem areas are in Montana than by using nonattainment area designations – which for some pollutants are based on older measurements.

The second section in this chapter provides information from the most recent EPA designations and State Implementation Plan (SIP) documents that contain information about the current nonattainment status for each county in Montana by pollutant, the relative importance of motor vehicles by source category in contributing to the nonattainment problem (or maintenance area) for each past/current nonattainment area, and the set of transportation source control strategies in each SIP.

Section three of this chapter uses chemical mass balance (CMB) studies from the Montana nonattainment areas with potential $PM_{2.5}$ [or particulate matter with an aerodynamic diameter of 10 microns or less (PM_{10})] nonattainment problems to identify the sources that have historically contributed the most to wintertime 24-hour average $PM_{2.5}$ concentrations. The results from these CMB analyses provide the best possible picture of which sources contribute the most $PM_{2.5}$ mass to ambient $PM_{2.5}$ concentrations when the NAAQS levels are likely to be exceeded. The key transportation-related sources that are consistently tracked in these CMB studies include street sand, automobiles (which really means gasoline-powered light-duty vehicles and trucks), and diesels. While diesel engines may be used in stationary source applications, they are probably mostly on-road and non-road engines/vehicles.

The final section of the literature review is a short summary of the key findings from the ambient air quality data, SIP, and CMB analysis reviews. These findings are summarized in a way to help guide the analyses to be performed under this contract.

B AMBIENT AIR QUALITY MONITORING DATA BY POLLUTANT

Three years of ambient air quality monitoring data for Montana monitoring sites were reviewed to evaluate whether any new areas in Montana might be designated nonattainment in the event that EPA elects to lower the levels of any of the pollutant NAAQS during upcoming standard reviews. At the time when this part of the project was initiated, EPA was considering revisions to the $PM_{2.5}$ and O_3 NAAQS. In December 2012, EPA lowered the level of the annual average $PM_{2.5}$ NAAQS to 12 micrograms per cubic meter ($\mu g/m^3$). Monitoring data for years 2009, 2010, and 2011 were obtained from EPA's Air Data *Air Quality Statistics Report*. The *Air Quality Statistics Report* contains air pollution values which were then compared to the national standards (EPA 2012a). Below are the results of the analysis, by pollutant.

Montana has adopted additional state air quality standards. The Montana Ambient Air Quality Standards (MAAQS) establish statewide targets for acceptable amounts of ambient air pollutants to protect human health (MTDEQ 2012). The MAAQS, by pollutant, are included in the discussion below.

1. Carbon Monoxide (CO)

Carbon monoxide (CO) is a colorless, odorless gas emitted from combustion processes. Nationally and, particularly in urban areas, the majority of CO emissions are from mobile sources (EPA 2012b). The current primary NAAQS for CO are 9 parts per million (ppm) (8-hour average) and 35 ppm (1-hour average), not to be exceeded more than once per year. There is no discussion of EPA making any revisions to the CO NAAQS (EPA 2012c). The primary MAAQS for CO are 9 ppm (8-hour average) and 23 ppm (1-hour average), not to be exceeded more than once per year (MTDEQ 2012).

Table II-1 shows the CO design values for years 2009, 2010, and 2011 obtained from EPA's *Air Quality Statistics Report* for Montana counties. Some county data have been left blank due to incomplete reporting.

Table II-1. Montana Area CO 1-hour and 8-hour 2nd Max Design Values for Years 2009, 2010, and 2011 (ppm)

	2009		2010		2011	
County	CO ppm (1-hr 2nd Max)	CO ppm (8-hr 2nd Max)	CO ppm (1-hr 2nd Max)	CO ppm (8-hr 2nd Max)	CO ppm (1-hr 2nd Max)	CO ppm (8-hr 2nd Max)
Cascade	2.9	1.6	3.5	1.9	1.6	0.9
Flathead	12.8	2.6	2.1	1.4	-	-
Gallatin	6.2	2.3	6.6	1.6	3.7	1.3
Lewis and Clark	-	-	-	-	0.5	0.3
Missoula	3.1	2.5	2.6	2.2	2.7	1.8
Yellowstone	4.3	1.8	6.3	1.9	2.5	1.3

Note: The CO 8-hour 2nd Max values represent the 2nd highest non-overlapping 8-hour average in the year. The CO 1-hour 2nd Max values represent the 2nd highest 1-hour measurement in the year.
Source: EPA 2012a.

As the table indicates, all Montana counties reporting CO measurements during these three years are well below the 1-hour and 8-hour NAAQS and MAAQS for CO.

2. Nitrogen Dioxide (NO_2)

Nitrogen dioxide (NO_2) is one of a group of gasses known as *oxides of nitrogen* or *nitrogen oxides (NO_x)*. While the NAAQS covers this entire group of NO_x, NO_2 is the component of greatest interest and the indicator for the larger group of nitrogen oxides. NO_2 forms quickly from emissions from cars, trucks and buses, power plants, and off-road equipment (EPA 2012d).

The current primary NAAQS for NO_2 is 100 parts per billion (ppb) (1-hour average). The form of the standard is the 98th percentile, averaged over three years. This standard was revised by EPA in 2010. "The annual NAAQS for NO_2 is 53 ppb. The form of this standard is the annual arithmetic average. This standard has not been revised since 1971" (EPA 2012c).

The primary MAAQS for NO_2 is 0.30 ppm (1-hour average) and 0.05 ppm (annual average) (MTDEQ 2012). The 1-hour average MAAQS is not to be exceeded more than once per year and the annual average MAAQS is not to be exceeded.

Table II-2 shows the NO_2 1-hour average design values for years 2009, 2010, and 2011 obtained from EPA's *Air Quality Statistics Report* for Montana counties. Some county data have been left blank due to incomplete reporting. The NO_2 98th percentile values represent the 98th percentile of the daily maximum 1-hour average measurements in the year.

Table II-2. Montana Area NO_2 1-hour Average Design Values for Years 2009, 2010, and 2011 (ppb)

	NO_2 (98th Percentile)			2009–2011
County	2009	2010	2011	1-hour Average Design Value
Gallatin	-	22	22	22
Powder River	-	24	15	20
Richland	10	9	9	9
Rosebud	59	31	65	52

Source: EPA 2012a.

As the table indicates, all Montana counties reporting NO_2 measurements during these three years are well below the 1-hour NAAQS and MAAQS for NO_2.

3. Ozone (O_3)

Ozone (O_3) is found in two regions of the Earth's atmosphere – at ground level and in the upper regions of the atmosphere. Both types of O_3 have the same chemical composition (O_3). Ozone is formed in the presence of sunlight (ultraviolet or UV). Tropospheric, or ground level ozone, is not emitted directly into the air, but is created by chemical reactions between NO_x and volatile organic compounds (VOC). Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NO_x and VOC (EPA 2012e).

The current primary NAAQS for O_3 is 0.075 ppm (8-hour average). The form of the standard is the annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years (EPA 2012c). The 1-hour standard, 0.12 ppm, was revoked by EPA in 1997. The O_3 NAAQS are currently being reviewed by EPA. The 8-hour standard may be reduced from the current 0.075 ppm to a value in the range of 0.060 to 0.070 ppm (EPA 2010a). The primary 1-hour MAAQS for O_3 is 0.10 ppm (1-hour average), not to be exceeded more than once per year (MTDEQ 2012).

Table II-3 shows the O_3 design values for years 2009, 2010, and 2011 obtained from EPA's *Air Quality Statistics Report* for Montana counties. Some county data has been left blank due to incomplete reporting. The O_3 8-hour 4th Max values represent the 4th highest daily max 8-hour average in the year.

Table II-3. Montana Area Ozone 8-hour 4th Max Design Values for Years 2009, 2010, and 2011 (ppm)

	2009	2010	2011	2009-2011
County	O_3 (8-hour 4th Max)	O_3 (8-hour 4th Max)	O_3 (8-hour 4th Max)	8-hour Average Design Value
Flathead	0.055	0.055	0.055	0.055
Glacier	0.058	0.058	-	0.058
Lewis and Clark	-	-	0.057	0.057
Missoula	-	0.054	0.053	0.054
Powder River	-	0.056	0.054	0.055
Richland	0.058	0.057	0.052	0.056
Rosebud	-	0.059	0.052	0.056

Source: EPA 2012a

Under the current NAAQS, all Montana counties reporting O_3 are below the 8-hour average standard. 2009–2011 design values are averaging between 0.054 to 0.058 ppm. Even if EPA lowers the 8-hour standard to a level within a range of 0.060 ppm to 0.070 ppm, all counties should continue to be in attainment for O_3.

4. Sulfur Dioxide (SO_2)

Sulfur dioxide (SO_2) is one of a group of gasses known as *oxides of sulfur*. The largest sources of SO_2 emissions are from fossil fuel combustion at power plants and other industrial facilities (EPA 2012f).

The current primary NAAQS for SO_2 is 75 ppb (1-hour average). The form of the standard is the 99^{th} percentile of 1-hour daily maximum concentrations, averaged over three years. This standard was revised by EPA in 2010. The 1971 annual and 24-hour SO_2 standards that were revoked do remain in effect until one year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards will remain in effect until implementation plans to attain or maintain the 2010 standard are approved (EPA 2012c). The annual standard was 0.03 ppm (annual arithmetic average) and the 24-hour standard was 0.14 ppm The 24-hour standard could not be exceeded more than once per year and the annual standard could not be exceeded at all (EPA 2012g). This provision pertains to the two areas in Montana currently classified as nonattainment for SO_2, the East Helena Area (Lewis and Clark Co.) and Laurel Area (Yellowstone Co.) (EPA 2012h).

The primary MAAQS for SO_2 is 0.50 ppm (1-hour average), 0.10 ppm (24-hour average), and 0.02 ppm (annual average). It is a state violation if the 1-hour average is exceeded more than 18 times in any 12 consecutive months. The 24-hour average MAAQS is not to be exceeded more than once per year and the annual average MAAQS is not to be exceeded (MTDEQ 2012).

Table II-4 shows the SO_2 design values for years 2009, 2010, and 2011 obtained from EPA's *Air Quality Statistics Report* for Montana counties. Some county data has been left blank due to incomplete reporting. The SO_2 99^{th} percentile values represent the 99^{th} percentile of the daily max 1-hour measurements in the year.

Table II-4. Montana Area SO_2 Design Values for Years 2009, 2010, and 2011 (ppb)

	2009	2010	2011	2009-2011
County	SO_2 (99^{th} Percentile)	SO_2 (99^{th} Percentile)	SO_2 (99^{th} Percentile)	1-hour Average Design Value
Lewis and Clark	-	-	1	1
Richland	-	6	6	6
Rosebud	12	16	12	13
Yellowstone	72	91	74	79

Source: EPA 2012a

As indicated by Table II-4, all counties, except for Yellowstone, are well below the primary Federal standard of 75 ppb and MAAQS standard of 0.50 ppm. As for Yellowstone County, the Montana Department of Environmental Quality (MTDEQ) stated in a report to EPA in 2011 regarding Montana SO_2 designations that "the most significant change in Yellowstone County (Billings/Laurel area) SO_2 emissions during the 2008–2010 timeframe was a near 1,700-ton increase at ExxonMobil during the latter part of calendar year 2010. This emissions increase was a "direct result of ExxonMobil performance under an SO_2 additive testing schedule pursuant to an EPA consent decree" (MTDEQ 2011). This explains the 26 percent increase from 2009 to 2010 and then a 19 percent decrease from 2010 to 2011. When comparing the average over the three years, the 2009–2011 design value for Yellowstone County is 79 ppb, which is above the national standard. Until 2012 and 2013 monitoring data are available and new annual design values are calculated, Yellowstone County will continue to be in nonattainment for SO_2.

5. Particulate Matter (PM)

Particulate matter (PM) is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles.

EPA groups particle pollution into two categories:

- Inhalable coarse particles, such as those found near roadways and dusty industries, are less than or equal to 10 micrometers in diameter.
- Fine particles, such as those found in smoke and haze, are 2.5 micrometers in diameter and smaller. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air (EPA 2012i).

a. $PM_{2.5}$

The current primary and secondary NAAQS for $PM_{2.5}$ are 12 µg/m^3 (annual average) and 35 µg/m^3 (24-hour average). The level of the annual average $PM_{2.5}$ NAAQS was revised to 12 from 15 µg/m^3 in December 2012. The form of the annual standard is the annual mean, averaged over three years. The form of the 24-hour standard is the 98th percentile, averaged over three years (EPA 2012c). Lincoln County is currently the only county in Montana designated nonattainment for violating the 1997 $PM_{2.5}$ NAAQS annual average standard (15.0 µg/m^3) (EPA 2012h). There are currently no MAAQS for $PM_{2.5}$.

Table II-5 shows the $PM_{2.5}$ design values for years 2009, 2010, and 2011 obtained from EPA's *Air Quality Statistics Report* for Montana counties. Some county data has been left blank due to incomplete reporting. The $PM_{2.5}$ (98th percentile) design values represent the 98th percentile of the daily average measurements in the year (24-hour). The $PM_{2.5}$ (Wtd Mean) design values represent the weighted annual mean (mean weighted by calendar quarter) for the year (annual).

Table II-5. Montana Area $PM_{2.5}$ Design Values for Years 2009, 2010, and 2011 (µg/m^3)

	2009		2010		2011		24-Hour Average Design Values	Annual Average Design Values
County	$PM_{2.5}$ (98th Percentile)	$PM_{2.5}$ (Wtd Mean)	$PM_{2.5}$ (98th Percentile)	$PM_{2.5}$ (Wtd Mean)	$PM_{2.5}$ (98th Percentile)	$PM_{2.5}$ (Wtd Mean)	2009-2011	2009-2011
Cascade	14	5.1	-	-	-	-	14	5
Flathead	28	9.6	29	8.9	27	9.2	28	9
Gallatin	26	7.7	35	9.2	31	7.9	31	8
Lewis and Clark	39	10.4	54	10.6	41	7.7	45	10
Lincoln	32	10.8	31	11	32	13.5	32	12
Missoula	30	11.8	38	9.5	35	10	34	10
Powder River	-	-	14	5.2	17	5.8	16	6
Ravalli	20	7	35	11.5	28	6.5	28	8
Richland	12	5.8	15	4.9	14	7.2	14	6
Rosebud	-	-	11	4.1	11	4.1	11	4
Sanders	18	6.2	13	5.7	14	5.2	15	6
Silver Bow	39	9.7	43	17.8	34	9.3	39	12
Yellowstone	13	6	-	-	-	-	13	6

Source: EPA 2012a

According to the table, there are two counties that could be designated nonattainment of the 24-hour NAAQS standard. Lewis and Clark County had high 98th percentile values for all three years which led to a 2009–2011 average 24-hour design value of 45 µg/m^3. In Silver Bow County, the 98th percentile values were high for 2009 and 2010 which led to a 2009–2011 average 24-hour design value of 39 µg/m^3.

As indicated by Table II-5, all counties are attaining the annual standard, even Lincoln County, which is currently designated nonattainment. With the December 2012 lowering of the annual standard to 12 µg/m^3, the two counties that are borderline nonattainment are Lincoln and Silver Bow.

b. PM_{10}

The current primary and secondary NAAQS for PM_{10} is 150 µg/m^3 (24-hour average), which is not to be exceeded more than once per year on average over 3 years. EPA revoked the annual PM_{10} NAAQS in 2006 (EPA 2012c). In June 2012, EPA proposed to retain the current 24-hour PM_{10} NAAQS to continue to provide protection against effects associated with short-term exposure to thoracic coarse particles. There are currently six counties in Montana designated nonattainment for PM_{10}: Flathead, Lake, Lincoln, Missoula, Rosebud, and Silver Bow (EPA 2012h). The nonattainment area in Lake and Rosebud Counties are under U.S. EPA jurisdiction since they are tribal lands.

The primary MAAQS for PM_{10} are 150 µg/m^3 (24-hour average) and 50 µg/m^3 (annual average). A state violation of the 24-hour MAAQS occurs when the expected number of days per calendar year with a 24-hour average above the standard is more than one (MTDEQ 2012).

Table II-6 shows the PM_{10} design values for years 2009, 2010, and 2011 obtained from EPA's *Air Quality Statistics Report* for Montana counties. Some county data has been left blank due to incomplete reporting. The PM_{10} 24-hr 2nd Max value represents the 2nd highest 24-hour average measurement in the year.

Table II-6. Montana Area PM_{10} Design Values for Years 2009, 2010, and 2011 (µg/m^3)

	PM_{10} (24-hr 2nd Max)			24-Hour Design Value
County	2009	2010	2011	2009-2011
Flathead	55	94	52	67
Lake	-	76	43	60
Lincoln	47	87	61	65
Missoula	63	50	54	56
Powder River	-	78	120	99
Richland	100	85	102	96
Rosebud	112	86	130	109
Sanders	19	20	28	22
Silver Bow	110	75	67	84

Source: EPA 2012a.

As the table indicates, all Montana counties reporting PM_{10} measurements, including those counties currently designated nonattainment, are well below the 150 µg/m^3 24-hour average current Federal and state standards.

6. Lead (Pb)

Lead (Pb) is a metal found naturally in the environment as well as in manufactured products. The major sources of Pb emissions have historically been from fuels in on-road motor vehicles (such as cars and trucks) and industrial sources. Today, the highest levels of Pb in air are usually found near Pb smelters. The major sources of Pb emissions to the air today are ore and metals processing and piston-engine aircraft operating on leaded aviation gasoline (EPA 2012j).

The current primary and secondary NAAQS for Pb is 0.15 µg/m^3 (a rolling three month average), which is not to be exceeded (EPA 2012c). The three month average statistics for Pb are currently not available in EPA's Air Quality Statistics report. The MAAQS for Pb is 0.15 µg/m^3, which is a rolling three month average that is never to be exceeded (Montana 1996).

7. Summary

Based on the 2009–2011 ambient monitoring data, CO, PM_{10}, O_3, and NO_2 NAAQS are being met by all Montana counties. For SO_2, Yellowstone County continues to have issues with nonattainment of the standard, based on the 2010 monitoring data. As for $PM_{2.5}$, Lewis and Clark and Silver Bow Counties could be designated nonattainment for the 24-hour standard based on their 2009–2011 design values.

C. STATUS OF CO AND PM NONATTAINMENT AREAS

Montana has 13 official nonattainment areas, and 2 additional maintenance areas. The Missoula area is both a nonattainment area (PM_{10}) and a maintenance area (CO). The East Helena area is in nonattainment for both lead and SO_2; however, the boundaries of the nonattainment area differ for the two pollutants. Three areas are on Native American reservations with tribal/EPA jurisdiction; the remaining areas are under state jurisdiction. Table II-7 shows nonattainment and maintenance areas with the pollutants and jurisdiction for each.

Table II-7. Montana Nonattainment Area Status Summary

Area	Pollutant	Status	Jurisdiction
Billings Area	CO	Maintenance	State
Great Falls Area	CO	Maintenance	State
Missoula Area	CO, PM_{10}	Maintenance (CO), Nonattainment (PM_{10})	State
Lewis & Clark County (part); City of East Helena and vicinity	Pb	Nonattainment	State
East Helena Area	SO_2	Nonattainment	State
Flathead County; Columbia Falls and vicinity	PM_{10}	Nonattainment	State
Flathead County; Kalispell and vicinity	PM_{10}	Nonattainment	State
Flathead County; Whitefish and vicinity	PM_{10}	Nonattainment	State
Lake County; Polson	PM_{10}	Nonattainment	Tribal/EPA
Lake County; Ronan	PM_{10}	Nonattainment	Tribal/EPA
Lincoln County; Libby and vicinity	PM_{10}, $PM_{2.5}$	Nonattainment	State
Rosebud County; Lame Deer	PM_{10}	Nonattainment	Tribal/EPA
Sanders County (part); Thompson Falls and vicinity	PM_{10}	Nonattainment	State
Silver Bow County; Butte	PM_{10}	Nonattainment	State
Laurel	SO_2	Nonattainment	State

Source: EPA 2012h.

Pb and SO_2 nonattainment issues in Montana are mostly due to industrial sources in the East Helena and Billings/Laurel areas. The most important sources contributing to the CO nonattainment are vehicle emissions, wood burning sources, and industrial emissions. The most important sources contributing to PM nonattainment are road dust, wood burning sources, and industrial emissions. Each of the CO and PM nonattainment areas are discussed below.

1. Billings CO

Billings was designated a CO nonattainment area in 1978 as a result of the 1977 Clean Air Act Amendments. The CO violation was attributed primarily to motor vehicle emissions. The initial CO control plan focused on traffic flow improvements (intersection reconstruction at Exposition and First Avenue) and projected emission reductions from the Federal Motor Vehicle Emission Control Program (FMVECP). Based on the 1990 Clean Air Act Amendments and the lack of exceedances in the CO monitoring data for 1988 and 1989, Billings was reevaluated and listed as a *not classified* nonattainment area for CO in 1991 (MTDEQ 2000a). In 2001, Montana submitted a request to redesignate the Billings area as attainment for CO. In 2002, the request and maintenance plan was approved (*Federal Register* 2002). The maintenance plan attributes the improvement in air quality to the FMVECP and the improved traffic flow at Exposition and First Avenue. The only other control program included in the maintenance plan is an open burning regulation requiring permits.

2. Great Falls CO

Great Falls was designated a CO nonattainment area in 1980, after 16 violations of the 8-hour CO standard at the original 10th Avenue South monitor. The primary contributors to CO emissions were determined to be motor vehicles, wood smoke, and industrial processes. Control plans were developed after the nonattainment designation, but none were approved by EPA. Based on the 1990 Clean Air Act Amendments and the lack of exceedances in the CO monitoring data for 1988 and 1989, Great Falls was reevaluated and listed as a *not classified* nonattainment area for CO. The maintenance plan attributes the improvement in air quality to the FMVECP. No other control programs are to be implemented, except in the case of another violation which would trigger contingency controls, including use of oxygenated fuel in winter months, episodic wood burning curtailment, and other measures to be determined (MTDEQ 2000b).

3. Missoula CO and PM_{10}

Missoula was designated a nonattainment area for CO in 1978 after 55 exceedances of the 8-hour CO standard by as much as 50 percent at monitoring stations downtown and at the intersection of Brooks Street (U.S. Highway 12), Russell Street, and South Avenue (MTDEQ 2012). The 1990 base year emission inventory submitted to EPA, indicated that transportation sources were estimated to be responsible for 64 percent of winter CO emissions, residential wood burning contributed 26 percent, and industrial sources contributed 10 percent (MEHD 2012). To reduce CO levels, Missoula decided to focus on decreasing emissions from motor vehicles and wood stoves. In addition to improvements in air quality due to the FMVECP, strategies to reduce emissions from vehicles included improving traffic flow, especially at the intersection of Brooks Street, Russell Street, and South Avenue, and the use of oxygenated fuels in winter months. Missoula has been in compliance with CO air quality standards since 1993, and was redesignated as a maintenance area in 2007 (*Federal Register* 2007).

Missoula was designated as a nonattainment area for PM_{10} in 1990 and is currently classified as moderate (EPA 2012k). In the winter of 1986-87, a CMB study at Rose Park found that residential wood smoke was 47 percent of the PM_{10} during the study, followed by road dust at 22.6 percent, motor vehicle exhaust at 10.2 percent, and industry at 7.6 percent. The county adopted regulations on residential wood stoves, outdoor burning, industry, fugitive emissions, street sanding, and street maintenance. New roads and parking lots in the air stagnation zone must be paved. Missoula has not violated a Federal particulate standard since 1989. In the winter of 1995–1996, Missoula performed another CMB study to see if the apportionment of particulate had changed and found that total PM_{10} levels had decreased by 45 percent. However, road dust emissions had increased by 24 percent, despite the use of de-icer in place of street sand on most city streets during the study period (MEHD 2012).

4. Flathead County (Columbia Falls, Kalispell, and Whitefish Areas) PM_{10}

The Columbia Falls and Kalispell Areas in Flathead County were designated as nonattainment areas for PM_{10} in 1990. The Whitefish and Vicinity Area was designated as a nonattainment area for PM_{10} in 1993 (EPA 2012k). Results from a mass balance study in Kalispell indicated that material from road dust, gravel roads, parking lots, and construction activities were the main sources of the area's particulate matter. Source apportionment studies conducted in Columbia Falls (1989–1990) and Whitefish (1993–1994) indicated that fugitive dust, especially reentrained road dust as the largest source of particulate (MTDEQ 2003). Transportation-related control strategies adopted by Flathead County include:

- New specifications for sand and gravel applied to local roads for snow and ice traction;
- Prioritized street sweeping and flushing;
- Paving of existing roads averaging more than 200 vehicles per day;

- Paving of new roads with projected traffic volume >50 vehicles per day; and
- Paving of large unpaved parking lots.

Flathead County also adopted the following contingency plan: use of liquid deicer for snow and ice traction (except in extraordinary circumstances) (FHCEHD 2012). Since implementation of PM_{10} controls, emissions and measured 24-hour ambient air concentrations of PM_{10} have continued to decline. These areas have not yet requested redesignation (MTDEQ 2012).

5. Polson, Ronan, and Lame Deer Area PM_{10}

The Polson and Ronan Areas in Lake County and the Lame Deer Area in Rosebud County are Tribal areas. These areas were designated as nonattainment areas for PM_{10} in 1990. At this time, none of the SIP requirements have been met for these areas (EPA 2012k).

6. Libby Area PM_{10} and $PM_{2.5}$

Libby was designated a nonattainment area for PM_{10} in 1990 (EPA 2012k). Reentrained road dust and residential wood combustion were determined to be the principal sources of particulate. There have been no exceedances of the PM_{10} standards in Libby since 1992; therefore, the area was determined to be in attainment in a *Federal Register* notice in 2011 (*Federal Register* 2011a).

Libby is also a nonattainment area for $PM_{2.5}$ (designated in 2005). A 2003–2004 CMB study, found that residential wood combustion (wood stoves) was the largest source of $PM_{2.5}$ in the Libby Valley (81 percent), followed by automobiles (7 percent), ammonium nitrate (5 percent), diesel exhaust (4 percent), and secondary sulfate (2 percent). Because residential wood is the largest contributor to $PM_{2.5}$ emissions by far, control programs have focused on that source. EPA recently lowered the fine particulate annual average standard to 12 $\mu g/m^3$. Monitoring data shows that Libby has a 2009–2011 annual $PM_{2.5}$ design value of 12 $\mu g/m^3$ as shown in Table II-5 (EPA 2012a). However, in a 2010 *Federal Register* notice, EPA proposed finding on-road directly emitted $PM_{2.5}$ in the Libby area insignificant for regional transportation conformity purposes (*Federal Register* 2010).

7. Thompson Falls and Vicinity PM_{10}

The Thompson Falls Area was designated as a nonattainment area for PM_{10} in 1994 (EPA 2012k). The Thompson Falls control plan, approved in 2004, regulates street sweeping activities on selected routes within the Thompson Falls nonattainment area; sets the type of sanding material to be used on paved roads; and determines what unpaved roads, alleys, and parking lots are to be paved (EPA 2012l).

8. Butte PM_{10}

The Butte Area was designated as a nonattainment area for PM_{10} in 1990 and is currently classified as moderate (EPA 2012k). A source apportionment study determined that the largest source of PM_{10} was the Montana Resources facility. Therefore, one of the main control strategies was the installation of diesel exhaust control devices on haul trucks at this industrial source (MTDEQ 2003). Other strategies in the control plan include: standards for sanding and chip sealing, street sweeping and flushing policies, and regulations for residential wood burning and idling diesel vehicles and locomotives (EPA 2012l). The Butte/Silver Bow Health Department also adopted a contingency plan that implements the mandatory use of liquid de-icer on all roads, with the exception of priority routes with extraordinary circumstances.

D. MONTANA CHEMICAL MASS BALANCE STUDIES

With the variety of contributors, or potential contributors to ambient $PM_{2.5}$ concentrations, including direct $PM_{2.5}$, SO_2, NO_x, VOC, and ammonia, CMB analyses provide important insights about source contributions to high $PM_{2.5}$ levels. The CMB model expresses ambient chemical concentrations as the sum of products of species abundances and source contributions. These equations are solved for the source contributions when ambient concentrations and source profiles are supplied as model input. Source profiles consist of the mass fractions of selected particle properties in source emissions.

For the Montana Department of Transportation's purposes, CMB studies are important because they provide information about the relative importance of various source categories to measured $PM_{2.5}$ mass concentrations in $\mu g/m^3$. The CMB studies that have been performed for the MTDEQ have focused on $PM_{2.5}$ concentrations in PM_{10}, or potential $PM_{2.5}$, nonattainment areas in the western half of the state. The emphasis of these studies is on measuring the importance of residential wood combustion on ambient $PM_{2.5}$ concentrations in each area and on measuring the effectiveness of residential wood combustion emission control. However, each study also provides estimates of street sand, automobiles, and diesel emissions percent contributions to overall $PM_{2.5}$ mass. These are the three source categories that indicate potential transportation source influences.

The CMB studies are discussed individually, and then in summary in the sub-sections below.

1. Libby

Table II-8 presents the $PM_{2.5}$ sources ($\mu g/m^3$) identified by the CMB models for the 2003–2004 and 2007–2008 winter sampling programs, respectively (Ward, Palmer and Noonan 2010). Also presented in Table II-8 are the source percent contribution to overall $PM_{2.5}$ mass and the corresponding standard errors. The standard error is a single standard deviation, and when multiplied 2 or 3 times, the result can be taken as an upper or lower limit of an individual source's contribution. There is approximately a 66 percent probability that the true source contribution is within 1 standard error, and approximately a 95 percent probability that the true contribution is within 2 standard errors of the source contribution estimate.

Table II-8. Libby, Montana CMB Results and Associated Standard Errors and Percent Contributions to Overall $PM_{2.5}$ Mass per Source ($PM_{2.5}$ Mass in $\mu g/m^3$)

Source	2003–2004 Libby		2007–2008 Libby CMB		Percent Difference
	$PM_{2.5}$ Mass	Percent Contribution to Overall $PM_{2.5}$ Mass	$PM_{2.5}$ Mass	Percent Contribution to Overall $PM_{2.5}$ Mass	
Street Sand	0.02 $\pm$ 0.01	0.1	0.04 $\pm$ 0.01	0.2	145
SO_4	0.6 $\pm$ 0.1	2.1	0.5 $\pm$ 0.07	2.2	-23
NH_4NO_3	1.5 $\pm$ 0.2	5.2	1.3 $\pm$ 0.1	6.3	-13
Automobiles	2.1 $\pm$ 0.8	7.4	0.9 $\pm$ 0.3	4.5	-56
Diesel	1.0 $\pm$ 0.3	3.6	1.1 $\pm$ 0.3	5.3	5
Residential Wood Combustion (RWC)	22.8 $\pm$ 3.0	81.0	16.4 $\pm$ 2.3	81.3	-28
Unexplained	0.19	0.7	0.03	0.2	-83
$PM_{2.5}$ Mass	28.2	-	20.1	-	-25.6

Source: Ward, Palmer and Noonan 2010.

In total, six source profile types were identified as contributing to the Libby $PM_{2.5}$ in the 2003–2004 and 2007–2008 CMBs. These include street sand, secondary sulfate (SO_4), secondary ammonium nitrate (NH_4NO_3), automobiles, diesel exhaust, and residential wood combustion. Residential wood combustion (woodstoves) was identified as the largest source of $PM_{2.5}$ in the Libby Valley for both studies. For the 2003–2004 study, automobiles were detected by the model on 6 of the 17 days, while they were detected on only 3 of the 19 sample days in the 2007–2008 program. Diesel exhaust was detected on 6 of the 17 days in the 2003–2004 study and on 7 of the 19 days in the 2007–2008 sample days.

There were two secondary aerosols (NH_4NO_3 and SO_4) identified by the CMB model as being pure secondary sources. Both of these secondary sources were detected in nearly all of the model runs for both years. Street sand was only detected in one model run during 2003–2004, and two times during the 2007–2008 program. It was an insignificant contributor to the Libby $PM_{2.5}$ during the winter months. There could be additional area sources and background contributions to airshed $PM_{2.5}$ levels throughout each of the two winters; however, individually they are small.

Table II-8 shows that there was a reduction in $PM_{2.5}$ mass when comparing the pre-changeout winter of 2003–2004 with the post-changeout winter of 2007–2008. Pre- and post-changeout refers to a woodstove changeout program to replace older uncontrolled woodstoves with new lower emitting woodstoves. The wood smoke component of the ambient $PM_{2.5}$ was reduced by 28 percent over this time period.

The three $PM_{2.5}$ sources in Libby of most interest to the transportation planner are street sand, automobiles, and diesel. In the most recent CMB assessment (2007–2008), their percentage contributions to the overall $PM_{2.5}$ mass were as follows:

Table II-9. Transportation-Related Source contribution to PM2.5 Mass in Libby, Montana

Transportation-Related Sources	Percent Contribution to Overall $PM_{2.5}$ Mass in Libby
Street Sand	0.2%
Automobiles	4.5%
Diesel	5.3%
Total	10.0%

This suggests that if the long-term interest in reducing air pollution levels in the Libby, Montana area is for fine particles ($PM_{2.5}$), transportation source measures are not likely to reduce $PM_{2.5}$ concentrations by more than 10 percent. While street sweeping may have proven to be effective in reducing PM_{10} concentrations, the Libby CMB analyses indicate that street sweeping is not likely to be effective in reducing 24-hour average wintertime $PM_{2.5}$ concentrations. Similarly, diesel-powered vehicles (which should be primarily heavy-duty diesel powered trucks) are a more important $PM_{2.5}$ contributor than automobiles – and are increasing in importance with time – while auto contributions are declining.

Table II-10 summarizes the CMB analysis averages for other Montana areas where CMB studies have been performed. Most of these studies were performed with 2007–2008 measurements. In areas where multiple CMB studies have been performed, the most recent study has been summarized. The same statistics are provided in Table II-10 as are provided in Table II-8 for the Libby area. Comments on the individual area CMB analysis results are provided below.

Table II-10. Montana CMB Study Summary by Area ($PM_{2.5}$ Mass in µg/m³)

	Belgrade			Butte		
Source	$PM_{2.5}$ Mass	Std. Error	Percent Contribution to Overall $PM_{2.5}$ Mass	$PM_{2.5}$ Mass	Std. Error	Percent Contribution to Overall $PM_{2.5}$ Mass
Street Sand	0.4	0.1	4.0%	0.4	0.1	3.0%
Sulfate	0.3	0.0	3.0%	0.4	0.1	3.0%
Ammonium Nitrate	2.0	0.1	20.2%	1.4	0.1	10.4%
Autos	0.2	0.1	2.0%	0.5	0.2	3.7%
Diesel	0.04	0.01	0.4%	0.03	0.01	0.2%
RWC	7.0	1.2	70.7%	10.9	1.4	80.7%
Unexplained	-	-	-	-	-	-
$PM_{2.5}$ Mass	9.9			13.5		
	Hamilton			**Helena**		
Source	$PM_{2.5}$ Mass	Std. Error	Percent Contribution to Overall $PM_{2.5}$ Mass	$PM_{2.5}$ Mass	Std. Error	Percent Contribution to Overall $PM_{2.5}$ Mass
Street Sand	0.1	0.04	0.9%	0.3	0.1	3.3%
Sulfate	0.5	0.1	4.5%	0.5	0.1	5.6%
Ammonium Nitrate	2.0	0.2	18.2%	1.8	0.1	20.0%
Autos	-	-	-	0.2	0.1	2.2%
Diesel	-	-	-	0.03	0.01	0.3%
Cement Kilns	-	-	-	0.05	0.02	0.6%
RWC	8.6	1.2	78.2%	6.3	1.3	70.0%
Unexplained	-	-	-	-	-	-
$PM_{2.5}$ Mass	11.0			9.0		
	Kalispell			**Missoula**		
Source	$PM_{2.5}$ Mass	Std. Error	Percent Contribution to Overall $PM_{2.5}$ Mass	$PM_{2.5}$ Mass	Std. Error	Percent Contribution to Overall $PM_{2.5}$ Mass
Street Sand	0.21	0.08	1.9%	0.12	0.02	0.9%
Sulfate	0.43	0.05	3.9%	0.00	0.00	0.0%
Ammonium Nitrate	1.77	0.16	16.2%	2.90	0.27	21.2%
Autos	0.09	0.03	0.8%	0.00	0.00	0.0%
Diesel	0.79	0.21	7.2%	0.71	0.27	5.2%
Hog Fuel Boilers	-	-	-	1.81	0.39	13.2%
Kraft Recovery Boilers	-	-	-	1.08	0.32	7.9%
RWC	7.84	0.99	71.7%	8.60	1.29	62.8%
Unexplained	-	-	-	-	-	-
$PM_{2.5}$ Mass	10.94			13.70		

- = not detected.

Sources: Ward 2007; 2008a; 2008b; 2008c; 2008d; 2009.

2. Belgrade

Almost 71 percent of the observed $PM_{2.5}$ wintertime mass was contributed by residential wood combustion. The other major $PM_{2.5}$ contributor was ammonium nitrate (20 percent). Street sand was a more important contributor to $PM_{2.5}$ mass in Belgrade than observed in other Montana areas, but still accounts for just 4 percent of $PM_{2.5}$ mass. The automobile contribution is just 2 percent, while the diesel contribution is less than ½ percent (Ward 2008a).

3. Butte

Residential wood combustion contributes 81 percent of the $PM_{2.5}$ mass. The diesel contribution is insignificant. Street sand and automobiles are about equally important (Ward 2008b).

4. Hamilton

The Hamilton CMB analysis was during the 2007–2008 winter. Residential wood combustion contributes 78 percent of the CMB mass. The other major contributor was ammonium nitrate (18 percent), and sulfate contributes most of the remaining $PM_{2.5}$ mass (5 percent). The only transportation-related $PM_{2.5}$ source in Hamilton is street sand, but that is less than one percent of $PM_{2.5}$ (Ward 2008c).

5. Helena

The Helena CMB analysis results are very similar to those for Belgrade, with 70 percent of the CMB mass from residential wood combustion and 20 percent ammonium nitrate. Sulfate is slightly more than 5 percent of the observed $PM_{2.5}$ mass in Helena, with lesser contributions of street sand, autos, and diesel in Helena—in that order. A trace contribution from a cement kiln was observed in Helena (Ward 2008d).

6. Kalispell

Residential wood combustion contributes 72 percent of the $PM_{2.5}$ mass. Ammonium nitrate is 16 percent of the observed mass. Kalispell has the largest diesel share (7.2 percent) of any of the Montana areas where CMB analyses were performed. The automobiles contribution, however, is less than one percent (Ward 2009).

7. Missoula

Residential wood combustion contributes 63 percent of the $PM_{2.5}$ mass in Missoula. Ammonium nitrate is 21 percent of the $PM_{2.5}$ mass. Other notable contributors in Missoula include hog fuel boilers (13 percent), kraft recovery boilers (8 percent), and diesels (5 percent). Other sources combined contribute less than one percent (Ward 2007).

Automobiles were only detected by the CMB model on two days. These were December 16, 2006 (1.95 $\mu g/m^3$) and February 26, 2007 (1.02 $\mu g/m^3$). The autos' contribution is listed as zero in Table II-10 because it is not included in the Missoula source contribution table.

E. 2009–2011 AMBIENT AIR QUALITY MONITORING SUMMARY

Based on 2009–2011 calendar years of ambient air quality monitoring data, there are relatively few continuing nonattainment problems in Montana and the priority list of areas and pollutants includes:

Table II-11. Montana Areas with Current (2009–2011) Monitored Concentrations Above the Federal NAAQS Level by Pollutant

County	Concentrations Above NAAQS Level
Yellowstone	SO_2
Lewis and Clark	$PM_{2.5}$ (24-hour average)
Silver Bow	$PM_{2.5}$ (24-hour average)

EPA has recently (December 2012) lowered the level of the $PM_{2.5}$ annual average standard to 12 $\mu g/m^3$ (*Federal Register* 2013). Recent (2009–2011) annual average design values indicate that the Lincoln County $PM_{2.5}$ design value is now 12 $\mu g/m^3$. Therefore, with the annual average $PM_{2.5}$ level lowered to 12 $\mu g/m^3$, Lincoln County is borderline nonattainment. The more recent design values also suggest that Silver Bow County may be nonattainment for the annual average standard, but this is based on a 2010 weighted mean $PM_{2.5}$ value that is double what was observed during 2009 and 2011. Further analysis of the 2010 $PM_{2.5}$ data for Silver Bow County would be needed to determine if the 2010 annual average is valid.

Street sweeping has proved to be an effective control for reducing PM_{10} concentrations in Montana's PM_{10} nonattainment areas. CMB studies indicate that additional street sweeping would have limited effectiveness in reducing ambient $PM_{2.5}$ levels in the areas where Montana may need emission reductions. However, given the effectiveness of street sweeping to date, the Montana Department of Transportation needs to have a strategy for replacing that equipment as it reaches the end of its useful life.

Transportation sources contribute very little to the SO_2 concentrations in the Billings nonattainment area. Transportation source SO_2 contributions will be declining even further as diesel fuel sulfur limits are implemented.

Montana needs to take the necessary steps to get its remaining PM_{10} nonattainment areas redesignated to attainment by EPA, as they all now achieve the 24-hour average NAAQS.

For any Montana areas that exceed the $PM_{2.5}$ NAAQS, controls on wintertime residential wood combustion emissions are likely to be the most effective in reducing fine particle concentrations. In the Montana areas where CMB studies have been performed, transportation-related sources typically contribute between 5 and 10 percent of the $PM_{2.5}$ mass. The percentage contributions to $PM_{2.5}$ mass for street sand, automobiles, and diesels can be used in each area to target the transportation sources likely to produce the biggest $PM_{2.5}$ concentration changes if control programs are initiated.

In summary, Montana does not have significant remaining nonattainment problems, and the areas that might have continuing nonattainment problems have limited transportation source contributions. *Therefore, the focus of CMAQ funding should be on measures that help maintain attainment status in the areas/pollutants where transportation sources are important.* While air pollution emission reductions are an important attribute of CMAQ funding decisions for Montana, the lack of any strong transportation source influence on existing or expected future Montana nonattainment problems means that the Montana Department of Transportation will want to also consider variables other than air quality impact when selecting projects for CMAQ funding.

CHAPTER III. REVIEW OF CMAQ PROGRAM PAST PRACTICES IN MONTANA

A. INTRODUCTION

This chapter provides a review of the past practices undertaken by Montana with Federal funds available through the CMAQ Program. This chapter seeks to provide context to Montana decision makers on the types of programs which have received CMAQ funding in the past, and how that funding has been allocated. This will help provide context to the discussion in later chapters of how to make adjustments to meet FHWA guidance and address Montana's transportation air quality challenges.

The CMAQ program was established under the Intermodal Surface Transportation Efficiency Act of 1991(ISTEA), expanded under the Transportation Equity Act for the 21st Century (TEA-21), and continued in Federal law through subsequent surface transportation reauthorization acts. The purpose of the CMAQ program is to fund transportation projects that improve air quality by reducing transportation-related emissions. Funding is available to reduce congestion and improve air quality for areas that do not meet the NAAQS for O_3, CO, or PM (nonattainment areas) as well as former nonattainment areas that are now in compliance (maintenance areas). States with no nonattainment or maintenance areas may use their CMAQ funds for any CMAQ-eligible project. CMAQ programs support projects that result in measurable reductions in emissions for criteria pollutants and each state must provide an annual report specifying how CMAQ funds have been spent and the expected air quality benefits. The FHWA's CMAQ Program Guidance (FHWA 2008) states that, consistent with the Clean Air Act Amendments (CAAA), transportation projects that reduce emissions are given funding priority and transportation control measures listed in CAAA section 108(f) are the "kinds of projects intended by the TEA-21 for CMAQ funding".

States with designated CO, PM, or O_3 nonattainment or maintenance areas are required to spend CMAQ funds in those areas, with national guidance identifying transportation control measures contained in the SIPs as the highest funding priority. The 2008 Final Program Guidance for CMAQ Program under SAFETEA-LU (FHWA 2008) indicates that all projects funded under CMAQ must also come from a conforming Transportation Improvement Plan (TIP).

The types of projects eligible for CMAQ funding include new facilities, equipment, and services designed to reduce emissions. CMAQ funds can be used for inspection and maintenance (I/M) programs, alternative fuel vehicle programs, public education, experimental projects, and projects that focus on PM_{10} reduction (e.g., paving dirt roads, replacing diesel vehicles, and purchasing street sweeping equipment).

The MACI was established to take advantage of the flexibility in funding provided by TEA-21. Prior to TEA-21, almost all CMAQ funds had to be used in Missoula, Montana's only classified moderate CO nonattainment area. "Pure" CMAQ funds that come to Montana based on the former Federal formula are directed to Missoula. Projects are prioritized through the Missoula metropolitan planning organization (MPO) process. At the direction of the Montana Transportation Commission, MDT uses the remainder of the CMAQ apportionment to provide funding to areas in nonattainment status that were previously ineligible for CMAQ funds and to proactively address statewide air quality and automobile congestion problems through the MACI Program. Although Missoula continues to receive the CMAQ funds that come to Montana by virtue of the former Federal formula, MDT has directed approximately 90 percent of Montana's CMAQ apportionment to several other state established programs.

MACI funding is divided into two parts: discretionary funds and guaranteed funds. MACI discretionary funds are distributed to nonattainment areas and areas identified by the Department of Environmental Quality as high risk for becoming nonattainment. Project selection is through an application process that is administered by the Transportation Planning Division of MDT. MACI guaranteed funds are distributed to Billings and Great Falls at a level equivalent to what Missoula receives each year in CMAQ funds. Projects are prioritized through the respective MPO planning processes. Most of the funds in these areas have been spent on signalization, flow improvements, and bike/pedestrian improvements. MPOs can accumulate funds from year to year.

Under the MAP-21 legislation (GPO 2012), CMAQ provisions have been altered and a state with $PM_{2.5}$ (fine particulate matter) areas must use a portion of its funds to address $PM_{2.5}$ emissions in such areas; eligible projects to mitigate $PM_{2.5}$ include diesel retrofits. Highlighted CMAQ eligibilities include transit operating assistance and facilities serving electric or natural gas-fueled vehicles (except where this conflicts with prohibition on rest area commercialization). MAP-21 will be discussed in greater detail in Chapter IV.

This chapter is organized into four sections. The first is a summary of the 2004 MDT report on the cost effectiveness of various MACI programs and putting this report into the larger context of Montana's current air quality challenges. The second section discusses what investments MDT has made since the 2004 report. The third section discusses project lifetimes, discount rates and how to evaluate the cost effectiveness of the MACI spending. The final section discusses the changing context of the air quality challenges in Montana, and how available funding can be most effectively spent in the future.

B. MDT TRANSPORTATION INVESTMENTS IN AIR QUALITY IMPROVEMENT (1993–2003)

The 2004 report, "Air Quality Analysis of MDT Transportation Improvements: Cost-Effectiveness Analysis of the MACI Program" analyzed the costs and emissions reductions achieved from the CMAQ and MACI programs from 1993-2003. The report was commissioned by MDT but written by researchers at UC-Davis (Niemeier and Shafizadeh 2004).

PM_{10} and CO were the pollutants given priority in this analysis, and were analyzed separately, although many projects achieved both CO and PM_{10} reductions. There were ongoing issues with nonattainment in Montana for both pollutants. Great Falls, Missoula, and Billings are CO maintenance areas and several areas such as Columbia Falls, Polson, and Libby are in moderate nonattainment for PM_{10}.

Emissions reduction policies were grouped by UC-Davis into four project types: Transit, bike/ped, traffic flow and miscellaneous PM_{10} reduction, such as paving and purchasing air quality equipment (street sweepers). The most cost effective PM_{10} reduction projects were purchasing air quality equipment and paving projects. Bike/Ped (pedestrian) projects were less cost effective and transit projects were often the least cost effective for PM_{10}. Compare this with CO projects, which found that traffic flow improvements were typically the most cost-effective, whereas transit and bike/ped projects were least cost effective. Table III-1 shows the projects undertaken within the CMAQ and MACI programs between 1993 and 2003. These are organized by project type, and then sorted by year. The majority of the 59 MACI projects from the 1993–2003 period were either Bike/Ped (20 projects) or Traffic Flow (22 projects).

Table III-1. CMAQ and MACI Projects in Montana, 1993–2003

Year	Project Location/Description	Project Type	City	Total Cost	CO kg/year	PM_{10} kg/year
1994	Bike/Ped Coordinator	Bike/Ped	Missoula	$190,050	N/A	N/A
1995	Reserve Street Landscaping	Bike/Ped	Missoula	$53,492		
1995	South Avenue Bike/Ped Path	Bike/Ped	Missoula	$171,107		
1995	Bicycle Land Network	Bike/Ped	Missoula	$286,110		
1995	Bicycle Commuter Network	Bike/Ped	Missoula	$622,500		
1995	California Street Bridge	Bike/Ped	Missoula	$1,380,399		
1995	Northside Access	Bike/Ped	Missoula	$1,857,693		
1995	Primary Sidewalk Network	Bike/Ped	Missoula	$3,595,700		
1997	North Reserve Street	Bike/Ped	Missoula	$5,350,750	78,531	149,165
1998	Missoula TDM	Bike/Ped	Missoula	$630,194	14,484	497
1998	Clark Fork-Orange Street Bridge	Bike/Ped	Missoula	$9,362,648	7,432	133
2000	Annual Bike/Ped Facil. Improvements	Bike/Ped	Great Falls	$200,000	1,707	N/A
2001	West Bank Trail Connection	Bike/Ped	Great Falls	$554,399	500	N/A

Year	Project Location/Description	Project Type	City	Total Cost	CO kg/year	PM_{10} kg/year
2001	Sidewalks - Kalispell	Bike/Ped	Kalispell	$607,681	472	5
2002	Bike/Ped Path - Whitefish	Bike/Ped	Whitefish	$725,000	N/A	20
2002	Swords Park Path - Billings	Bike/Ped	Billings	$770,000	1,557	N/A
2002	Sidewalks - Great Falls	Bike/Ped	Great Falls	$1,100,000	2,479	N/A
2002	Annual Sidewalk Prog.	Bike/Ped	Great Falls	$2,311,320	13,761	N/A
2003	13th St S/13th Ave S Sidewalk	Bike/Ped	Great Falls	$115,000	1,154	18
2003	Kelley Island Walkway	Bike/Ped	Missoula	$200,000	2,217	1,269
1993	Street Sweepers	PM-10 Reduction	Missoula	$1,194,585	N/A	33,216
1994	Missoula County Paving	PM-10 Reduction	Missoula	$1,089,461	N/A	104,160
1994	Missoula City Paving	PM-10 Reduction	Missoula	$2,150,611	N/A	70,560
1998	Air Quality Equipment	PM-10 Reduction	Statewide	$4,424,107	N/A	482,483
2000	Air Quality Equipment	PM-10 Reduction	Statewide	$568,087	N/A	569,758
2001	Foxfield Ave - Hamilton	PM-10 Reduction	Hamilton	$126,500	N/A	765
2001	Division/5th St Polson	PM-10 Reduction	Polson	$239,514	N/A	9,435
2001	Brady St/Joslyn St - Helena	PM-10 Reduction	Helena	$383,486	N/A	94,436
2001	Paving - Thompson Falls	PM-10 Reduction	Thompson Falls	$418,766	N/A	14,983
2001	Off System Paving - Butte	PM-10 Reduction	Butte	$506,959	N/A	177,617
2001	Paving - Wolf Point	PM-10 Reduction	Wolf Point	$627,882	N/A	15,980
2002	Off System Paving - Lame Deer	PM-10 Reduction	Lame Deer	$600,000	N/A	8,953
2002	Air Quality Equipment	PM-10 Reduction	Statewide	$2,855,156	N/A	672,821
1993	Brooks/South/Russell	Traffic Flow	Missoula	$1,880,556	21,314	N/A
1993	Areawide Signal	Traffic Flow	Missoula	$4,920,000	7,277	N/A
1999	North 93 Signals - Kalispell	Traffic Flow	Kalispell	$190,116		N/A
1999	Idaho-LaSalle Signals - Kalispell	Traffic Flow	Kalispell	$481,179	10,608	N/A
1999	Custer Ave - Signal Synch - Helena	Traffic Flow	Helena	$72,061		N/A
2000	Custer & McHugh - Helena	Traffic Flow	Helena	$470,178	1,853	N/A
2000	19th & Main Bozeman	Traffic Flow	Bozeman	$894,770	8,299	N/A
2000	Kalispell-Main St Kalispell Traffic Flow	Traffic Flow	Kalispell	$1,574,263	4,713	N/A
2000	1999 Signal Upgrade - Butte	Traffic Flow	Butte	$2,274,493	8,944	N/A
2001	South Arterial Study	Traffic Flow	Great Falls	$200,000	N/A	N/A
2001	Traffic Signals-Telemetry-Great Falls	Traffic Flow	Great Falls	$210,000	24,580	N/A
2001	2nd Ave N - Signals-Great Falls	Traffic Flow	Great Falls	$244,335	216	N/A
2001	Main St - Billings Heights	Traffic Flow	Billings	$551,780	9,567	N/A
2001	Arthur Ave - Missoula	Traffic Flow	Missoula	$600,000	1	N/A
2001	Citywide Signals - Bozeman	Traffic Flow	Bozeman	$1,275,000	7,986	N/A
2001	6th Ave N to Bench Blvd	Traffic Flow	Billings	$6,915,000	6,077	N/A
2002	I-90 Interchange Study - Billings	Traffic Flow	Billings	$330,000	N/A	N/A
2002	South 19th & College - Bozeman	Traffic Flow	Bozeman	792,000	6,745	N/A
2002	Signal Upgrade - Helena	Traffic Flow	Helena	$1,094,561	14,185	N/A
2002	Dewey Blvd Extension - Butte	Traffic Flow	Butte	$1,388,695	489	N/A
2003	VIS/Entrance - W Yellowstone	Traffic Flow	W. Yellowstone	$323,000	4,198	N/A
2003	North Meridian Rd - Kalispell	Traffic Flow	Kalispell	$1,118,086	7,279	N/A
1993	$ Transfers - Transit (1993–2003)	Transit	Missoula	$5,756,799	N/A	569
2000	Federal Transit Authority (FTA) Fund Transfer	Transit	Great Falls	$500,000	N/A	168
2001	Missoula/Ravalli TMA	Transit	Missoula	$320,000	N/A	3,746
2001	FTA Transfer - Butte	Transit	Butte	$346,500	N/A	5

1. Bike/Pedestrian Infrastructure

There were 20 Bike/Ped projects between 1993 and 2003, and the majority were built in either Missoula (12 projects) or Great Falls (5). Bike/Ped infrastructure investment had a total cost of just over $30 million dollars and is estimated to reduce CO emissions by 124 tons/year and PM_{10} emissions by 151 tons/year.

2. PM_{10} Reduction (Street Sweepers/Paving)

There were two primary types of PM_{10} reduction projects in the 1993–2003 period: street sweepers and road paving. The projects described as "Air Quality Equipment" are investments in street sweepers, whereas the paving projects reduce PM_{10} by paving previously unpaved roads to reduce fugitive dust emissions. There were 13 PM_{10} Reduction projects in this time period, with a total cost of over $15 million dollars. Three of these projects were considered statewide, which includes all municipalities except the three MPOs (Great Falls, Missoula, and Billings). Three PM_{10} Reduction projects were in Missoula and the rest were in localities across the state. Statewide PM_{10} emissions are estimated to decline by 2,255 tons/year as a result of these projects (there were no CO benefits estimated).

3. Traffic Flow Improvements

There were 22 traffic flow improvement projects in the 1993–2003 period with a total price tag of nearly $28 million. The majority of projects focused on improving traffic flow at individual intersections and projects were spread across the state (Kalispell had the most traffic flow projects with four). Traffic flow improvements were estimated to reduce CO emissions by 144 tons/year. There were no PM_{10} benefits estimated, although it would be possible for future projects to investigate PM_{10} benefits from traffic flow improvements on a case by case basis, as tailpipe PM_{10} emissions vary based on a number of factors, including vehicle speed and vehicle type.

4. Transit Investments

There were four transit projects under the CMAQ and MACI program in the 1993-2003 period—two in Missoula (Missoula in Motion and a carpool/vanpool investment), transit investment in Great Falls, and a new transit center in Butte. These projects had a total cost of nearly $7 million and were estimated to reduce PM_{10} emissions by 4.5 tons/year (there were no CO benefits estimated). From a funding standpoint, 94 percent of the transit project spending occurred in Missoula.

$PM_{2.5}$ was not considered in this section, and later analyses will need to fill in this data gap.

C. MDT TRANSPORTATION INVESTMENTS IN AIR QUALITY IMPROVEMENT (2004–2012)

Information about the projects undertaken in the CMAQ & MACI programs in Montana from 2004–2012 was provided by MDT, and is displayed in Table III-2 below. Like the projects discussed in Chapter II, these are organized into four project types for Bike/Ped Infrastructure, Transit Investments, Traffic Flow Improvements, and PM_{10} Reduction. The total CMAQ & MACI investment of these projects is just over $30 million dollars between 2004 and 2012, and this is estimated to reduce CO emissions by over 100 metric tons per year and PM_{10} emissions by over 370 tons. It is likely that these emissions reductions are an underestimate, because only 9 of the 22 projects have any reductions attributed to them at this time.

Table III-2. CMAQ & MACI Projects in Montana, 2004–2012

Year	Project Location/Description	Project Type	City	Total Cost	CO kg/year	PM_{10} kg/year
2005	10th Ave S - 26th to 38th	Bike/Ped	Great Falls	$334,847	288	N/A
2005	West Broadway Project	Bike/Ped	Missoula	$374,314	N/A	N/A
2006	Madison Street Bridge trail	Bike/Ped	Missoula	$50,035	1,056	N/A
2006	Black Eagle Trail	Bike/Ped	Great Falls	$87,008	N/A	N/A
2006	Bike/Ped Improvement	Bike/Ped	Great Falls	$728,590	12,768	N/A
2010	Missoula (MSLA) Bike Ped Striping*	Bike/Ped	Missoula	$123,283	66,387	1,071
2011	ADA Curbs 1st Ave to 25th-38th	Bike/Ped	Great Falls	$144,206	NA	NA
2011	ADA Curbs 2nd Ave to 37th-15th	Bike/Ped	Great Falls	$286,539	NA	NA
2005-2012	Missoula Bike/Ped Program	Bike/Ped	Missoula	$319,697	3,552	336
2007	Air Quality Equipment	PM_{10} Reduction	Great Falls	$512,977	NA	NA
2004, 2009, 2011	Statewide Equipment Purchase	PM_{10} Reduction	Great Falls, Missoula, Butte-SB, Libby, Kalispell, Whitefish, Helena, Lewis & Clark Co, Ravalli Co, Lincoln Co, Sanders Co, Cascade Co, Flathead Co	$15,787,302	NA	374,640
2005, 2007, 2008, 2010	Equipment Purchase - Missoula City	PM_{10} Reduction	Missoula	$1,325,254	NA	NA
N/A	Equipment Purchase - Missoula County	PM_{10} Reduction	Missoula	$160,173	NA	NA
2006	South Hills Interchange	Traffic Flow	Helena	$119,160	NA	NA
2010	Signal Upgrade - Smelter Ave-3rd ST-DIV RD	Traffic Flow	Great Falls	$385,762	NA	NA
2010	MSLA Signal Optimization	Traffic Flow	Missoula	$412,632	NA	NA
2010	MSLA LED Upgrades	Traffic Flow	Missoula	$422,227	NA	NA
2005-2012	MSLA Transportation Demand Management Planning	Traffic Flow	Missoula	$1,757,783	3,552	NA
2005	Dornblaser Park & Ride Marketing	Transit	Missoula	$20,817	312	NA
2010	2010 Bus Purchase	Transit	Missoula	$265,650	NA	NA
2005-2011	Vanpool operations	Transit	Missoula, Ravalli Co	$4,155,863	15,960	2,472
2006-2010	Great Falls Transit	Transit	Great Falls	$2,250,000	NA	NA

*For further information, see Table III-4.

There were several projects that received CMAQ funding for initiatives in Montana's urban areas. These were divided into two main categories. The Urban Pavement Preservation Program, which was a one-time program initiated in 2004 to extend the pavement lifetime and reduce PM_{10} emissions. The second is the Urban Highway Pilot Improvement Program, which began in 2004–2005 and covered a variety of urban improvements, including signal work, intersection improvements, paving, etc. Further information on these programs is included in Table III-3 below.

Table III-3. Other CMAQ Projects in Montana, 2004–2012

Project Category	Project Location	City	Project Type	Total Cost
Urban Pavement Preservation	Sycamore Street - Anaconda	Anaconda	Overlay	$78,333
Urban Pavement Preservation	Rimrock Road - Shiloh-54th	Billings	Reconstruction	$4,291,777**
Urban Pavement Preservation	Signal- N. 7th & Griffin	Bozeman	Signal	$86,826
Urban Pavement Preservation	Signal-N. 19th & Baxter	Bozeman	Signal	$412,818
Urban Pavement Preservation	Montana & Rowe Rd.	Butte	Intersec. Reconfigure	$971,847
Urban Pavement Preservation	13 St S-10th to 21st-GTF	Great Falls	Overlay	$1,631,822
Urban Pavement Preservation	Downtown Sidewalk Ramps	Havre	Sidewalk/Ramps	$155,803
Urban Pavement Preservation	Whitefish Stage Rd- Kalispell	Kalispell	Overlay	$439,547
Urban Pavement Preservation	Mainstreet Improvement-Laurel	Laurel	Curbs & Sidewalks	$313,603
Urban Pavement Preservation	Brassey/Casino Cr - Lewistown	Lewistown	Seal & Cover	$71,234
Urban Pavement Preservation	5th & Park Livingston	Livingston	Signals & lights	$229,814
Urban Pavement Preservation	Bridge Street-Miles City	Miles City	Surfacing	$459,438
Urban Pavement Preservation	Higgins/Hill/Beckwith	Missoula	Signals & lights	$503,724
Urban Pavement Preservation	39th & Reserve-Missoula	Missoula	Signal	$99,630
Urban Pavement Preservation	Broadway Ped Xing Study - MSLA	Missoula	Ped crossing study	$739,868**
Urban Pavement Preservation	Arthur Ave - (5th/6th/Arthur)	Missoula	Reconstruction & Curbs	$334,107
Urban Pavement Preservation	Country Road 350-Sidney	Sidney	Resurface	$92,248
Urban Highway Pilot Improvement Program	2nd Meridian-3rd Ave E	Kalispell	Overlay	$222,729
Urban Highway Pilot Improvement Program	Center ST-Kalispell	Kalispell	Overlay	$168,336
Urban Highway Pilot Improvement Program	Arthur Ave-South to S 6th	Missoula	Overlay	$189,511
Urban Highway Pilot Improvement Program	Mount Ave-Russell to Hill	Missoula	Overlay, Chip Seal	$165,163
Urban Highway Pilot Improvement Program	7th-Karrow to Baker	Whitefish	Overlay	$106,788
Urban Highway Pilot Improvement Program	Karrow-2nd to 7th	Whitefish	Overlay	$141,066
Urban Highway Pilot Improvement Program	4th-Hickory to RR-Xing	Anaconda	Overlay	$299,288
Urban Highway Pilot Improvement Program	Highland-Kagy to Main	Bozeman	Mill/Fill, Seal & Cover	$386,995
Urban Highway Pilot Improvement Program	Peach-N 7 to Rouse	Bozeman	Seal and Cover	$42,582
Urban Highway Pilot Improvement Program	Continental Dr-Butte	Butte	Mill, Overlay	$412,954
Urban Highway Pilot Improvement Program	Geyser-Park to "F" St	Livingston	Overlay, Seal & cover	$442,892
Urban Highway Pilot Improvement Program	5th St Park to 10th Ave-S	Great Falls	Mill/Fill, Seal & Cover	$548,312
Urban Highway Pilot Improvement Program	Park Garden-Fox Farm to 14th	Great Falls	Seal and Cover	$50,333
Urban Highway Pilot Improvement Program	4th Ave SW-6th to 3rd St	Great Falls	Seal and Cover	$54,984
Urban Highway Pilot Improvement Program	10th ST-1st to 5th Ave	Havre	Overlay, Seal & Cover, ADA Ramps	$222,662
Urban Highway Pilot Improvement Program	13th ST-Monroe to 1st	Havre	Overlay, Seal & Cover, ADA Ramps	$170,963
Urban Highway Pilot Improvement Program	Benton-Custer to Wilder	Helena	Mill, Overlay,Seal & Cover, Gutters	$227,000
Urban Highway Pilot Improvement Program	Cruse-Park to 11th	Helena	Overlay, Seal & Cover	$199,000
Urban Highway Pilot Improvement Program	Wicks-Governor to Main	Billings	Mill, Overlay	$461,360
Urban Highway Pilot Improvement Program	6th Ave N 7th N 27th	Billings	Mill, Overlay	$377,500
Urban Highway Pilot Improvement Program	1st Ave-Main to 12th	Laurel	Mill, Fill, Seal & Cover	$388,362

**These programs included some MACI funding.

1. Bike/Pedestrian Infrastructure

The 2004 analysis found that bike/pedestrian infrastructure was often amongst the least cost effective projects for improving air quality. However, demand for bike/pedestrian projects goes beyond air quality benefits, and investments in this infrastructure have continued since 2003. Bike/pedestrian investments have been made both within the CMAQ and MACI guaranteed program for Billings, Great Falls, and Missoula, as well as within the MACI discretionary program. The overall costs and estimates of the air quality benefits of bike/ped infrastructure for 2004–2012 are displayed in Table III-2 above. Like the 2004 analysis, this calculation makes the conservative assumption of 240 typical transportation days per year. Not all bike/pedestrian projects have an associated emissions reduction estimate. As can be seen in Table III-2 above, of the nine bike/pedestrian projects listed, five have a calculated CO benefit and only one has any estimated PM_{10} benefit. These projects are estimated to reduce CO emissions by over 84,000 kg/year and PM_{10} emissions by 1,071 kg/year.

A study from the Missoula County Health Department (Schmidt 2009) estimated the potential savings of repainting bike lanes with epoxy. These will make the demarcations between road and bike lanes more distinct, which are expected to increase bike ridership. These bike lanes are estimated to reduce annual vehicle miles traveled (VMT) in Missoula by 1.45 million miles, or 3,970 miles per day. Based on an estimate of a 1.25 million miles per weekday in Missoula (from the Missoula 2008 Long Range Transportation Plan), this is equivalent to a 0.3 percent reduction in total VMT (MDT 2008). The pollutant benefits from this VMT reduction are displayed in Table III-4. This is the only MACI project that includes an estimate of $PM_{2.5}$ emission reductions, although this will need to become more common as the importance of $PM_{2.5}$ emissions increases.

Table III-4. Estimated Reduction in Pollutants from Repainting Epoxy Bike Lanes in Missoula

	Annual Kilograms Avoided
CO	66,387
PM_{10}	1,071
$PM_{2.5}$	236

The emission reductions displayed in Table III-4 are based on calculations in Schmidt 2009. These calculations are based on emission factors from AP-42, but these AP-42 emission factors have since been updated. Based on the most recent information from AP-42, the proper emission factors for road dust are 0.004238 lb PM_{10}/VMT (as opposed to the 0.00047lb PM_{10}/VMT used) and 0.00104 lb $PM_{2.5}$/VMT, (as opposed to the 0.0000 figure used). Based on this new information, it is likely that the PM_{10} and $PM_{2.5}$ emissions benefits were underestimated in the 2009 study.

2. Traffic Flow Improvements

There were five traffic flow improvement projects funded under the CMAQ and MACI program in Montana between 2004 and 2012—three in Missoula, one in Helena and one in Great Falls. Of these projects, only the Missoula Transportation Demand Management program had any emissions reductions calculated, and this project is estimated to reduce CO emissions by 3,552 kg per year. The five projects have a total cost of just over $3 million.

3. Transit Investments

As seen in Table III-2 above, there were four Montana transit projects funded under the CMAQ and MACI program between 2004 and 2012. These projects include three Missoula Projects: marketing for a new park and ride lot, purchasing a new bus for the Mountain Line, and investment in overall vanpool operations, operated by the Missoula Ravalli Transportation Management Association (MRTMA). There was also a project to expand transit service in Great Falls. These projects had a total cost of nearly $6.7 million and are estimated to reduce annual CO emissions by over 16,000 kg and annual PM_{10} emissions by 2,400 kg.

4. PM_{10} Reduction (Street Sweepers)

There were four projects listed in Table III-2 as PM_{10} reduction projects, and these are estimated to reduce PM_{10} emissions by 374 metric tons annually (there were no estimated CO benefits). The most common type of PM reduction equipment in Montana are street sweepers, which have been used to improve local air quality for decades and have the potential to reduce both PM_{10} and $PM_{2.5}$. In 2009, nearly 3 million dollars in CMAQ funding was used for street sweeping equipment across Montana, and in 2011 the state made an additional 8 million dollar investment. These CMAQ investments in street sweepers are estimated to reduce PM_{10} emissions by 1,561 kg/day, or 374,640 kg/year (no estimate is available at this time of $PM_{2.5}$ reductions). Recent initiatives in Lewis and Clark County have also included recycling sand and other materials picked up in street sweeping for use in winter road treatments. This served to reduce costs for winter treatment and prevent unnecessary waste in landfills. In many cases, these street sweepers are being purchased for smaller, non-MPO cities that have PM_{10} problems. Many of the CMAQ funded projects aimed at PM_{10} reduction in the 1993–2003 time period were focusing on paving previously unpaved roads, but no such projects have been included under the CMAQ funded program since 2002.

5. Winter Road Treatment Processes

A variety of different substances are used for winter road treatment in Montana, including salt, sand and liquid de-icers. Sand can be crushed by traffic and produce airborne dust, which contributes to pollution. Because sand is easily blown off the road by traffic, it requires repeated applications, which can in aggregate contribute to air quality concerns. In many cases liquid chloride de-icers work better by preventing or removing snow-pack and the need for sand. In cases where temperatures are above 15 degrees (F), liquid de-icers can keep snow from firmly sticking to the pavement and ensure a faster return to bare pavement. Sand is still recommended for treating roadways in cases of very low temperatures, because the traction provided by sand is not temperature dependent. For more information on winter road treatment, see http://www.mdt.mt.gov/mdt/travinfo_faq.shtml.

6. Construction

Emissions from fugitive dust at roadway construction sites are always higher during periods of intense wind. Therefore, shutting down construction sites during high wind periods may be a good practice to maintain air quality. This practice, along with other construction mitigation measures to reduce dust, is written into contract documents for projects in PM nonattainment areas. There are no CMAQ projects aimed at reducing construction emissions listed in Table III-2.

7. Bus Idling

In 2009, Montana began the Clean Air Zone program (MTDEQ 2009) to improve air quality in and around school buildings and local communities. This program provides guidelines to reduce bus idling emissions while buses are waiting to pick students up from school. This emissions reduction can be achieved both by providing education to bus drivers to limit idling as well as regular maintenance/replacement of vehicles. Bus idling and bus queuing can increase the concentration of particulates both inside school buses and inside nearby buildings. Although breathing diesel exhaust may not measurably impair lung function in adults, recent studies demonstrate that particulate pollution can impair the development of lungs in children. Reduced bus idling should improve local air quality for PM_{10}, $PM_{2.5}$ and CO around schools. The contribution of bus idling to ambient air quality levels will differ by location. For more information on the Clean Air Zone program see: http://deq.mt.gov/Recycle/CleanAirZone.mcpx.

D. PROJECT EVALUATION AND COST EFFECTIVENESS CONSIDERATIONS

This section outlines the different factors which must be considered when contrasting attributes of different projects, including their cost effectiveness in order to make the comparison as accurate as possible. For example, selecting different project lifetimes and discount rates can have a significant impact on the estimates of the overall cost effectiveness of a project.

The UC-Davis report from 2004 (Niemeier and Shafizadeh 2004) established a framework for evaluating emission benefits and costs of projects, and then used information provided by MDT about its projects to estimate a cost effectiveness value (cost per ton) for each project where there was sufficient data. This analysis shows the need for consistency in estimating (1) the annual expected air pollution emission reductions associated with a project, (2) project costs, and (3) the annualized project cost per ton of pollutant (or pollutants) reduced for the expected project lifetime.

At the time the UC-Davis analysis was performed, MOBILE6 was the EPA mobile source emission factor model of choice, so any emission benefits associated with individual projects would have used that model's emission factors. EPA released the Motor Vehicle Emissions Simulator (MOVES) 2010 (EPA 2010b) model in December 2009, so any new evaluations of the emission reductions associated with projects need to use the emission rates from that model.

However, depending on the application, the general logic of the methods laid out by UC-Davis in their report for estimating emission benefits still apply even though MOVES now needs to be used to generate the emission factors.

The exception to the above is in estimating the particulate matter emission reductions associated with projects that reduce fugitive dust emissions. In those cases, emission factor equations from EPA's AP-42 Compilation of Emission Factors need to be used (EPA 2012m). AP-42 equations are for estimating emissions from reducing fugitive dust emissions on paved roads, paving or applying treatments to unpaved roads, or estimating fugitive dust emissions from the various activities at construction sites, whether they be roadway or building construction. AP-42 fugitive dust emission factor equations are for PM_{10} and $PM_{2.5}$.

UC-Davis also developed general descriptions of appropriate methods for estimating the emission reductions associated with CMAQ projects for the following project types: (1) Improvements to Bicycle-Pedestrian Facilities, (2) Roadway Facilities Traffic Flow Improvements, and (3) Transit System Improvements. Within the overall category of Transit System Improvements, UC-Davis examined four specific projects (Niemeier and Shafizadeh 2004), and each of these four specific project types can be considered as an example of how emission benefits might be estimated for other similar projects of that type. The first specific Transit System Improvement project was a new transit center in Butte. The second was a carpool/vanpool program in the Missoula area. The third Transit System Improvement project was Missoula in Motion. Missoula in Motion encourages use of a wide variety of transportation options including walking, biking, transit, carpooling, vanpooling, and flexible work schedules. The emission benefit estimates for Missoula in Motion were based on trip elimination and expected VMT reductions. The fourth project, which was listed as two projects that involve street sweeping and/or de-icing, was really a method for estimating the PM emission benefits of using de-icers instead of sand or salt to keep roadways clear during winter storms. In general, the UC Davis methodology will not necessarily be used to determine the emission reductions of CMAQ projects. A project objective is to improve upon these previous methods.

1. Project Lifetimes

The cost effectiveness of different projects needs to be calculated in a comparable way, in spite of different project years and lifetimes. Table III-5 below shows the assumed different lifespans for different project types.

Table III-5. Assumed Project Lifespans for Different Project Types

Project Lifespan	Types of Projects
1–2 Years	Existing Transit Service Improvement Travel Demand Management Programs Ridesharing Programs Vanpool Programs Pricing/Fare Strategies
4–5 Years	Telework Programs Paratransit Vehicles
10–12 years	Roadway Signal Systems Freeway Management Systems New Buses Alternative Fueled Buses Sidewalk or Bike Facilities Street Sweepers
20 years	Roadway Improvements Rail Signalization
30–35 years	Rail Transit Systems Parking Structures Locomotive Rail Cars Pavement Improvements Bridge Improvements

Project lifespans come from the 2004 MDT-sponsored report (Niemeier and Shafizadeh 2004), which were based on the California Air Resources Board methods for evaluating project cost effectiveness. While the Air Resources Board estimates seem reasonable, because the CMAQ program is administered by the Federal Government, it would be preferable to have project lifetime estimates that are consistent with Federal guidance. Our review did not find any single reference that had such guidance.

2. Discount Rates

A discount rate of 5 percent was used in the 2004 analysis, although this can be reconsidered and modified as needed. The discount rate is meant as a proxy for the interest rate on a loan, and a lower rate may be appropriate in the case of government loans. Costs need to be evaluated in the same year, and any costs need to be discounted accordingly to be expressed in a comparable way. The Consumer Price Index—or an index more closely tied to the transportation sector—can be used to convert all costs to equivalent dollars. These assumptions, such as discount rate and project lifespan, can have a big impact on the overall cost effectiveness of each policy. Evaluation methods also need to consider whether investments that are being made for reasons other than air quality need to have different or additional performance metrics.

Both an interest rate and a discount rate reflect a time value of money. While an interest rate is a charge for the use of money, the discount rate represents a different concept—an opportunity cost. When dollars in the public sector are invested in Project A, that money is not available for Project B or for any other public or private purpose. The discount rate thus ensures that the return on Project A in terms of benefits to the public is at least as great as the minimum return that could be gained by investing in alternative investment opportunities (Project B or other options, whether public or private) (Markow 2012).

According to the U.S. Office of Management and Budget (OMB) Circular A-94 (OMB 2003), the current discount rate for benefit-cost analyses is 7 percent. Additional data are provided in Appendix C of the Circular and are updated annually; these values are intended for cost effectiveness analysis. For projects with an analysis period of 20 to 30 years or longer, the Appendix C rates are 4.4 to 4.5 percent—considerably lower than the 7 percent recommended for benefit-cost work. For the purposes of MDT evaluations, the selected discount rate can affect the results of a discounted cash flow or cost effectiveness analysis.

Higher discount rates reduce the present value of future costs and benefits more rapidly, while lower discount rates reduce the present value of future costs and benefits less rapidly. Table III-6 below shows the capital recovery factors (CRFs) for three project lifetimes and three alternative discount rates. These capital recovery factors are important in placing projects on an equal footing for evaluation (i.e., computing an annualized cost estimate). The annualized project cost is estimated by multiplying the CRF by the estimated one-time or initial project cost. So, using a 5 percent discount rate, if a 10-year project and a 30-year project are being compared, and the initial cost of the 30- year project was twice that of the 10-year project, they would have equal annualized costs.

Table III-6. Capital Recovery Factors for Various Project Lifetimes

Project Lifetimes	Discount Rates		
	3%	5%	7%
10 years	0.1172	0.1295	0.1423
20 years	0.0672	0.0802	0.0943
30 years	0.0510	0.0650	0.0805

Because there may also be a need to compare CMAQ project investments with other potential air pollution control strategies, it is useful to examine the discount rates being used in other air pollution assessments. As one example, the EPA PM Regulatory Impact Analysis (EPA 2012n) estimated compliance costs using both 3 and 7 percent discount rates.

3. Combined Cost Effectiveness in Montana

PM_{10} and CO were analyzed separately in the 2004 report, although many projects achieved both CO and PM_{10} reductions. $PM_{2.5}$ was not included in the report, although it is an increasing problem in some areas of Montana, particularly Libby, Montana, which is currently in nonattainment for the 24-hour average $PM_{2.5}$ Standard. It is likely that many of the measures aimed at PM_{10} reductions will also provide $PM_{2.5}$ benefits. If a project has benefits for PM_{10}, $PM_{2.5}$, and CO, it is likely that the overall cost effectiveness may be underestimated unless the benefits of all three are considered in a single figure. In order to better capture the true benefits of a project, reductions in all relevant pollutants could be considered in a single metric of all relevant pollutants. If we assume that PM_{10}, $PM_{2.5}$, and CO are the three pollutants of concern for this analysis, there are two possible approaches. One would be to continue the method used in the 2004 report, which examines the costs per kilogram of emissions reductions separately. The 2004 report considered only PM_{10} and CO and it might be appropriate to reevaluate the pollutants of greatest concern to see if additional pollutants, such as $PM_{2.5}$, should also be considered in cost-effectiveness calculations. The second approach would be to utilize some form of combined $/kg reduced figure. This would combine the emission reductions of all pollutants of interest (possibly adjusted to account for the differing importance of each pollutant) in order to more accurately convey the "total" cost effectiveness of a given project. This would better capture the benefits of a project across different pollutants, but would no longer represent a true cost per ton figure.

E. MAP-21 AND THE CHANGING AIR QUALITY CHALLENGES IN MONTANA

The 2004 UC-Davis report (Niemeier and Shafizadeh 2004) focused on CO and PM_{10}, which both have well established health risks to citizens. Montana air quality monitoring data shows that all Montana areas have CO and PM_{10} concentrations that are below the Federal NAAQS. There is one area (Libby, Montana) in $PM_{2.5}$ nonattainment and it is uncertain how Libby will be designated with respect to the lowered level of the annual average NAAQS of 12.0 $\mu g/m^3$.

The new CMAQ provisions in MAP-21 require a portion of CMAQ funding be allocated towards $PM_{2.5}$ projects. Future analyses will need to consider $PM_{2.5}$ as well as CO and PM_{10}, as $PM_{2.5}$ may be the pollutant of greatest concern with respect to nonattainment going forward. Here is the relevant $PM_{2.5}$ passage from MAP-21 (GPO 2012):

> *PRIORITY OF USE OF FUNDS IN PM2.5 AREAS*
> *(1) IN GENERAL - For any state that has a nonattainment or maintenance area for fine particulate matter, an amount equal to 25 percent of the funds apportioned to each State under section 104(b)(40) for a nonattainment or maintenance area that are based on all or in part on the weighted population of such area in fine particulate matter nonattainment shall be obligated to projects that reduce such fine particulate matter emissions in such area, including diesel retrofits.*
> *(2) CONSTRUCTION EQUIPMENT AND VEHICLES - In order to meet the requirements of paragraph (1), a State or metropolitan planning organization may elect to obligate funds to install diesel emission control technology on nonroad diesel equipment or on-road diesel equipment that is operated on a highway construction project within a PM2.5 nonattainment or maintenance area.*

Allocating a portion of CMAQ funding towards $PM_{2.5}$ projects would require significant changes in Montana's transportation expenditures. The FHWA will release a technical guidance document in the future to provide more details on how the CMAQ program will change under MAP-21, but until guidance is released, there is some uncertainty as to what impacts this legislation will have on Montana. It is recommended that MDT consider providing information about the situation in Libby, so that FHWA procedures will take Montana's circumstances into account.

The CMB studies for the Libby area show that transportation-related sources contribute about 10 percent of the overall $PM_{2.5}$ mass during the winter time when 24-hour average NAAQS exceedances are most likely. As a result, investing CMAQ funds to reduce fine PM emissions in Libby is not likely to provide much payoff in reducing ambient $PM_{2.5}$ concentrations. One potential option that FHWA has in implementing the MAP-21 prioritization for using funds in $PM_{2.5}$ areas is to allow $PM_{2.5}$ precursors to be considered as “fine particulate matter emissions.” However, such an interpretation is not likely to help MDT unless motor vehicle emissions are shown to be an important contributor to the ammonium nitrate concentrations in Libby.

Chapter IV examines MAP-21 in greater detail, as well as examining how CMAQ changes will impact Montana. Chapters V through VII will then consider funding priorities to improve transportation air quality and how best to estimate the efficacy of transportation projects in years to come.

CHAPTER IV. CMAQ PROGRAM FEDERAL FUNDING PRACTICES

A. INTRODUCTION TO CMAQ FUNDING IN THE U.S.

This chapter discusses FHWA's CMAQ guidance, and how these guidelines impact Montana. An example from the year 2011 is used to show Montana's CMAQ funds in the context of the nation as a whole, as well as other Federal funding for Montana's transportation infrastructure. This chapter summarizes the CMAQ guidance and outlines changes that may be on the horizon under MAP-21, where that information is available.

The SAFETEA-LU program was first established in 2005 and included transportation funding for years 2005–2009. SAFETEA-LU was later extended for years 2010 and 2011. The funding for 2011 is displayed in Figure IV-1 below. Several of the categories are different types of highway funding, including highway expansion and maintenance, bridge infrastructure, and CMAQ funding. SAFETEA-LU was replaced by the *MAP-21* program in 2012. The majority of the guidelines discussed in this chapter come from the FHWA 2008 CMAQ Guidance Document (FHWA 2008). Direct quotes from the guidance document are included with italics and indented.

> *The purpose of the CMAQ program is to fund transportation projects or programs that will contribute to attainment or maintenance of NAAQS for O_3, CO, and PM. The CMAQ program supports two important goals of the [Federal] Department of Transportation: improving air quality and relieving congestion. SAFETEA-LU established priority consideration for cost-effective emission reduction and congestion mitigation activities when using CMAQ funding.*

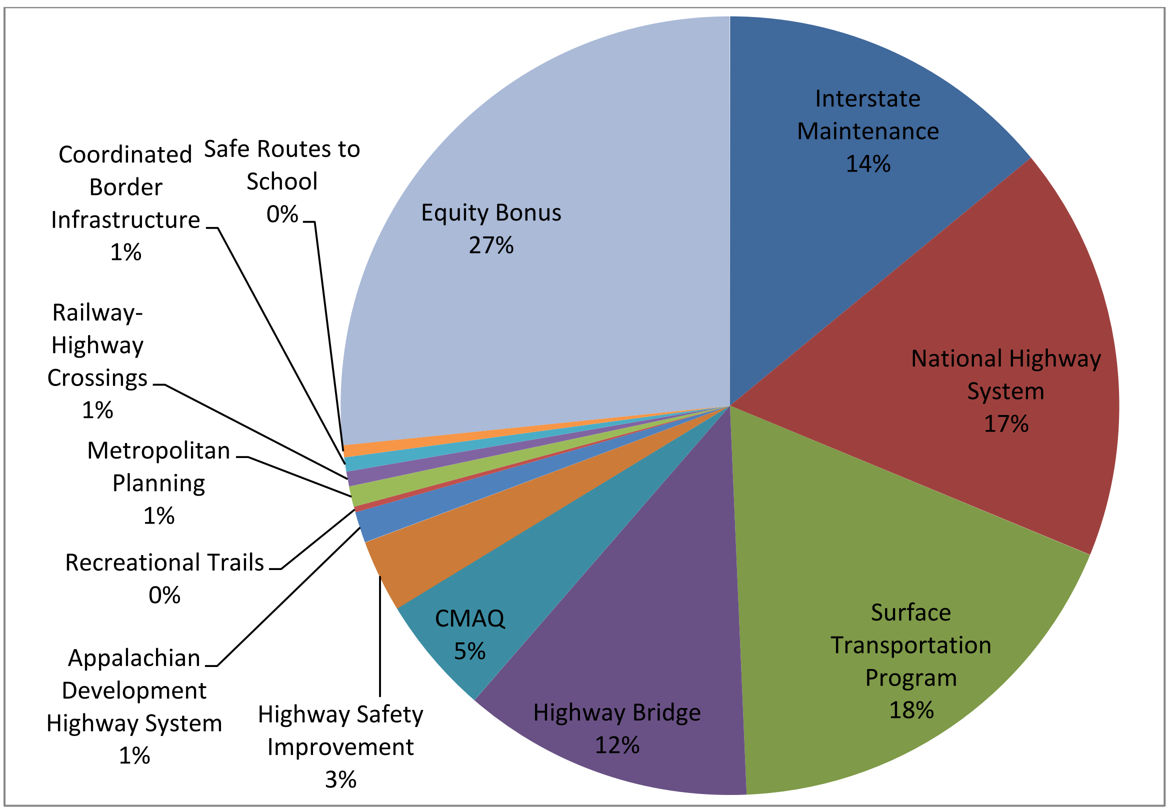

Figure IV-1. Federal Transportation Appropriations for all States in 2011

CMAQ funding in the U.S. was $1,977 million in 2011 under the SAFETEA-LU program. Federal CMAQ funds are apportioned annually to each state according to the severity of its O_3 and CO problems.

> *The population of each county (based upon Census Bureau data) that is in a nonattainment or maintenance area for O_3 and/or CO is weighted by multiplying by the appropriate factor...PM nonattainment and maintenance areas and former 1-hour [O_3] areas, except those few 1-hour maintenance areas participating in Early Action Compacts, are not included in the apportionments.*

Table IV-1 shows the weighting of SAFETEA-LU apportionment factors used to distribute CMAQ funds.

Table IV-1. SAFETEA-LU CMAQ Apportionment Factors

Pollutant	Classification at the Time of Annual Apportionment	Weighting Factor	Involved in Montana Apportionment?
O_3 or CO	Maintenance (these areas had to be previously eligible as nonattainment areas - See Section VI.)	1.0	Yes
O_3	Subpart 1 (“Basic”)	1.0	No
O_3	Marginal	1.0	No
O_3	Moderate	1.1	No
O_3	Serious	1.2	No
O_3	Severe	1.3	No
O_3	Extreme	1.4	No
CO	Nonattainment	1.0	No
O_3 and CO	O_3 nonattainment or maintenance and CO nonattainment or maintenance	1.2 x O_3 factor (between 1.0 and 1.4)	No
All states – minimum apportionment	1/2 of 1 percent total annual apportionment of CMAQ funds	N/A	Yes

It is important to note that while CMAQ funds can be spent on transportation projects to reduce O_3 precursor, CO, and PM emissions, funds are only allocated based on the populations within O_3 and CO areas. PM nonattainment areas are not factored into CMAQ apportionments. Unlike SAFETEA-LU, there is no longer a statutory distribution formula for CMAQ apportionment under MAP-21. Starting October 1, 2012, state’s CMAQ apportionments will be determined by their share of the total CMAQ apportionment in 2009 (FHWA 2012b).

The information provided above is based on the 2008 CMAQ final guidance under SAFETEA-LU (FHWA 2008). MAP-21 went into effect in 2012, and it changed CMAQ funding priorities. This includes having CMAQ funds be allocated based on PM nonattainment and maintenance areas, as well as the two pollutants of concern in SAFETEA-LU (O_3, CO). One of the key provisions of MAP-21 is setting priorities for use of funds in $PM_{2.5}$ nonattainment areas.

> *For any State that has a nonattainment or maintenance area for fine particulate matter, an amount equal to 25 percent of the funds apportioned to each State under section 104(b)(4) for a nonattainment or maintenance area that are based all or in part on the weighted population of such area in fine particulate matter nonattainment shall be obligated to projects that reduce such fine particulate matter emissions in such area, including diesel retrofits.*

MAP-21 also says that in order to meet the above requirements, a state or MPO may elect to obligate funds to install diesel emission control technology on non-road diesel equipment or on-road diesel equipment that is operated on a highway construction project within a $PM_{2.5}$ nonattainment or maintenance area (FHWA 2012c).

Since Montana does have a $PM_{2.5}$ nonattainment area in Libby, this requirement may have an impact on Montana funding. Montana is still in discussion with FHWA about whether CMAQ funds will need to be spent in the Libby area, because Libby’s $PM_{2.5}$ ambient air quality nonattainment problems are not from transportation sources. This is confirmed by EPA in its 2011 approval of the attainment plan for the Libby, Montana $PM_{2.5}$ nonattainment area (*Federal Register* 2011b):

> *Finally, EPA is finding on-road directly emitted $PM_{2.5}$ and NO_X in the Libby, Montana nonattainment area insignificant for regional transportation conformity purposes. As a result of this finding the Libby, Montana nonattainment area will not have to perform a regional emissions analysis for either direct $PM_{2.5}$ or NO_X as part of future conformity determinations for the 1997 annual $PM_{2.5}$ NAAQS.*

B. CMAQ FUNDING IN MONTANA

There are no O_3 nonattainment/maintenance areas in Montana, and only a few CO maintenance areas. Because only a small portion of Montana's population is located in nonattainment and maintenance areas, CMAQ funding allocated to Montana on this basis would be very small (approximately 0.05 percent of the total funding). However, the minimum allocation of CMAQ funds for each state is 0.5 percent of the national total, which significantly increases Montana's CMAQ apportionment.

> *Each state is guaranteed a minimum apportionment of one-half percent of the year's total program funding, regardless of whether the state has any nonattainment or maintenance areas.*

Montana does have one maintenance area for CO in Missoula, and 10.0 percent ($1.08 million) of Montana's 2011 CMAQ appropriations were based on the Montana population located in nonattainment/maintenance areas. These funds are considered *mandatory*. There are two types of CMAQ funding: mandatory and flexible. Mandatory CMAQ funds must be used on projects located within or in proximity to areas that are designated nonattainment or maintenance areas. Because the population-based allocation was not sufficient to meet the 0.5 percent threshold of total CMAQ spending, there was additional flexible funding allocated to Montana. The remaining funding, $9.71 million in 2011, is considered *flexible*, and can be spent on any eligible air quality/congestion projects within the state. While PM nonattainment and maintenance areas are not included in the allocation of CMAQ funds (as shown in Table IV-1 above), CMAQ funds may be used for eligible projects to reduce PM.

There is additional funding for the CMAQ program coming from the *Equity Bonus*. The Equity Bonus is designed to ensure that states receive an equitable share of fuel taxes collected within the state. These funds are allocated to a variety of different transportation programs, including CMAQ. Once funds from the equity bonus are included, mandatory CMAQ apportionments for Montana in 2011 were $1.6 million, whereas flexible funds were $14.7 million. Total CMAQ funding in Montana for 2011 was $16.3 million (FHWA 2012d).

CMAQ is just one part of Montana's overall Federal transportation apportionments, and these apportionments are significantly different from the total Federal transportation budget. Figure IV-2 shows the breakdown of all Federal transportation appropriations to Montana in 2011. Equity bonus funding is included in its own category, although a portion of this funding does go towards CMAQ. Comparing the information in Figure IV-2 with the Federal allocations in Figure IV-1 shows that CMAQ funding made up 4.3 percent of nationwide transportation allocations, but only 2.5 percent of Montana allocations in 2011. This figure provides context to the overall discussion of Montana's transportation funding, as well as the various programs receiving Federal funds in the state.

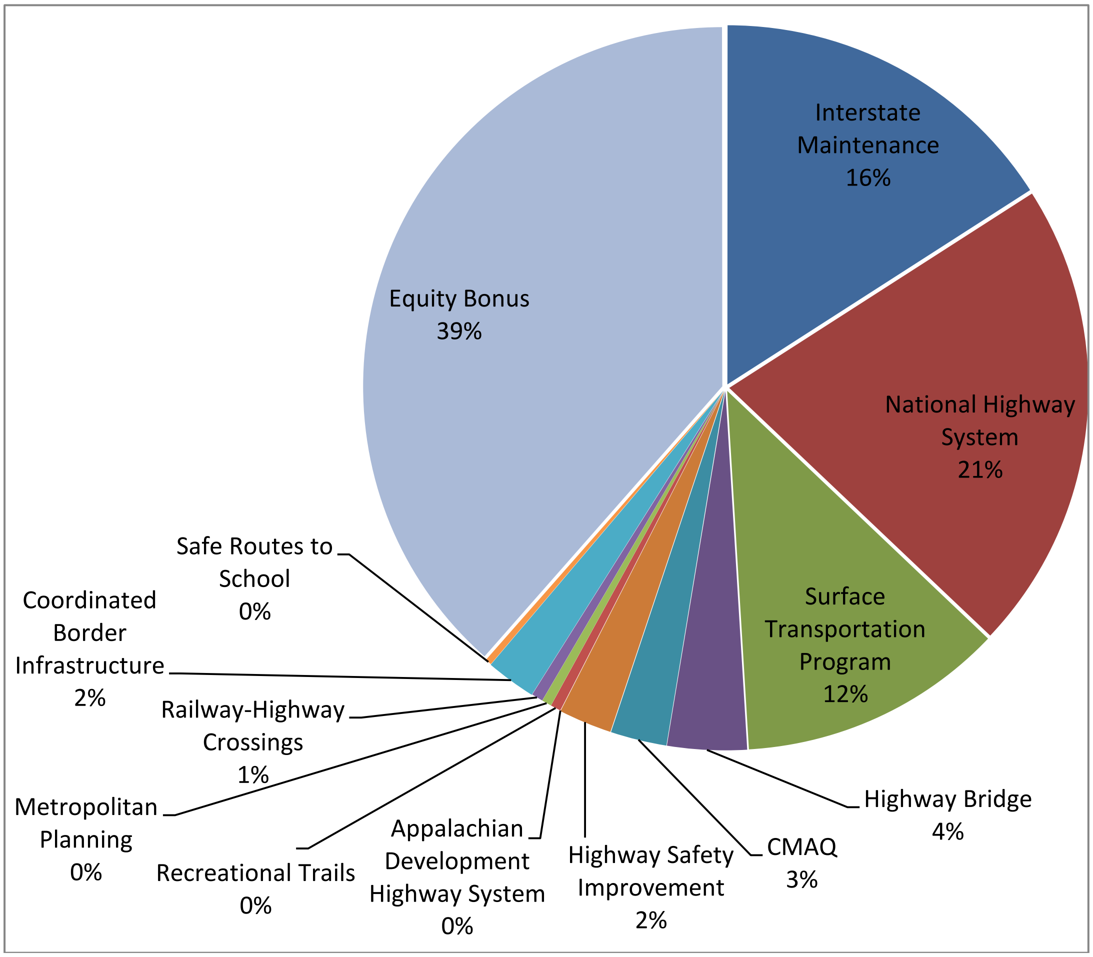

Figure IV-2. Federal Transportation Appropriations to Montana in 2011

C. TRANSFERABILITY OF FUNDS

States may choose to transfer a limited portion of their CMAQ apportionment to some of the other Federal-aid highway programs shown in Figure IV-2, such as the Surface Transportation Program, National Highway System, Highway Bridge Program, Interstate Maintenance, Recreational Trails Program, and the Highway Safety Improvement Program. Montana may transfer CMAQ funds up to 50 percent of the amount of the state's annual apportionment, minus the amount Montana would have received if total CMAQ funding were $1.35 billion dollars. If total CMAQ funding were $1.35 billion dollars, then Montana's share of funds would be $6.65 million. Therefore, the portion of the funds which are considered transferable is calculated as follows:

Transferable Funding = ((Total Montana CMAQ Funding in 2011) – (Montana Funding if Total Funds were $1.35 billion)) * (50%)

Transferable Funding = ($16.35 million – $6.65 million) * 50%

Transferable Funding = ($ 9.69 million) * (50%)

Transferable Funding = $4.85 million

Any transfer of such funds must still be obligated in nonattainment and maintenance areas. Each year, FHWA informs states how much CMAQ funding is transferable and tracks this movement of CMAQ funds.

> *SAFETEA-LU provided additional flexibility to complete such transfers when the receiving Federal agency had entered into an agreement with the State to undertake an eligible Federal-aid project. These opportunities applied to projects that met all CMAQ eligibility requirements prior to the transfer.*

Montana is under no statutory obligation to allocate CMAQ funds in the same way they are apportioned. States are encouraged to consult affected MPOs to determine regional and local CMAQ priorities and work with them to allocate funds accordingly. Montana may use its CMAQ funds in any O_3, CO, or PM nonattainment or maintenance area. Montana does not have any ozone nonattainment or maintenance areas, and does not expect to in the future even if the level of the standard is lowered.

Under MAP-21, a state may transfer up to 50 percent of any apportionment to another formula program, except no transfers are permitted of Metropolitan Planning funds, or funds suballocated to areas based on population.

The Federal share for most CMAQ projects, generally, has been 80 percent. However, under Title 23, this 80 percent figure is subject to a sliding scale based on the percentage of Federal lands within the state. Due to the high portion of Federal lands in the state, the Federal share has been set at 86.58 percent for Montana, with only a 13.42 percent state/local match. Under the Energy Independence and Security Act of 2007 (GPO 2007), the Federal share for eligible CMAQ projects carried out with funds obligated in fiscal year 2008 or 2009, or both, may be, at Montana's discretion, up to 100 percent of the cost of the project or program. Preliminary guidance on MAP-21 (FHWA 2012a) indicates that starting on October 1, 2012, the CMAQ Federal share will generally be 80 percent of the total project cost, although the exceptions for certain eligible project types (such as some carpool/vanpool projects), along with the sliding scale for states with a large percentage of Federal lands will remain. More information will be available when the MAP-21 technical guidance document is released.

D. GEOGRAPHIC RESTRICTIONS ON CMAQ FUNDING

CMAQ funds may be invested in any O_3, CO, and PM nonattainment and maintenance areas. Funds also may be used for projects in proximity to nonattainment and maintenance areas if the benefits will be realized primarily within the nonattainment or maintenance area. The delineation of an area considered "in proximity" should be discussed with the FHWA and FTA field offices and elevated to headquarters if necessary. CMAQ funds may be invested in maintenance areas that have approved maintenance plans under the CAAA section 175A. Montana has PM_{10} and CO maintenance areas, as well as one ($PM_{2.5}$) nonattainment area.

> *While States may use flexible CMAQ funding anywhere and for any CMAQ- or STP [Surface Transportation Program] -eligible project, the FHWA encourages States and MPOs to evaluate the cost-effectiveness and benefits to public health of targeting flexible CMAQ funding to projects that reduce PM. Examples of such projects include implementing a diesel retrofit or idle reduction program, constructing freight/intermodal transfer facilities, traffic signalization, or ITS projects that reduce congestion; paving dirt roads, and purchasing street sweeping equipment.*

E. PROJECT ELIGIBILITY

To be eligible for CMAQ funds, a project must be included in an MPO's current transportation plan and TIP, or the current Statewide Transportation Improvement Plan (STIP) in areas without an MPO. In nonattainment and maintenance areas, the project also must meet the conformity provisions contained in section 176(c) of the CAAA and the transportation conformity regulations. In addition, all CMAQ-funded projects need to complete National Environmental Policy Act (NEPA) requirements and meet basic eligibility requirements for funding under Titles 23 and 49 of the United States Code. The following projects and programs are eligible for CMAQ funding. Not all possible requests for CMAQ funding are covered – this section provides examples of activities eligible for CMAQ funds. Below is the list of eligible projects included in the 2008 Guidance Document:

1. Transportation Control Measures (TCMs)
2. Extreme Low-Temperature Cold Start Programs
3. Alternative Fuels and Vehicles
4. Congestion Reduction & Traffic Flow Improvements
5. Transit Improvements
6. Bicycle and Pedestrian Facilities and Programs
7. Travel Demand Management
8. Public Education and Outreach Activities
9. Transportation Management Associations
10. Carpooling and Vanpooling
11. Freight/Intermodal
12. Diesel Engine Retrofits & Other Advanced Truck Technologies
13. Idle Reduction
14. Training
15. I/M Programs
16. Experimental Pilot Projects

More information on these project types and how project eligibility is determined is in the 2008 CMAQ Guidance Document. MAP-21 will allow funding for all project types eligible under SAFETEA-LU. MAP-21 also makes special mention of additional project types which will be included, such as high-occupancy vehicle lanes, purchase of interoperable emergency communications equipment, and facilities serving electric or natural gas-fueled vehicles.

F. PROJECT SELECTION AND ADMINISTRATION

Proposals for CMAQ funding should include a precise description of the project, providing information on its size, scope, location, and timetable. Also, an assessment of the project's expected emission reduction benefits should be completed prior to project selection to better inform the selection of CMAQ projects. Quantified emissions benefits (reductions) and disbenefits (increases) should be included in all project proposals, except where it is not possible to quantify emissions benefits. If emissions changes cannot be accurately estimated, qualitative assessments based on reasoned and logical determinations that the projects or programs will decrease emissions and contribute to attainment or maintenance of a NAAQS are acceptable. Public education, marketing, and other outreach efforts, which can include advertising alternatives to single-occupancy vehicle (SOV) travel, employer outreach, and public education campaigns, may fall into this category. In some situations, such as bus route expansion and a simultaneous demand management campaign, it may be more appropriate to examine the impacts of comprehensive strategies to improve air quality by grouping projects.

CMAQ projects are selected by the MDT or the MPO. MPOs, MDT, and transit agencies develop CMAQ project selection processes in accordance with the metropolitan and/or statewide planning process. The selection process should involve state and/or local transportation and air quality agencies. This selection process provides an opportunity for states and/or local agencies to present a case for the selection of eligible projects that will best use CMAQ funding to meet the requirements and advance the goals of the Clean Air Act.

The CMAQ project selection process should be transparent, in writing, and publicly available. The process should identify the agencies involved in rating proposed projects, clarify how projects are rated, and name the committee or group responsible for making the final recommendation to the MPO board or other approving body. The selection process should also clearly identify the basis for rating projects, including emissions benefits, cost effectiveness, and any other ancillary selection factors such as congestion relief, greenhouse gas (GHG) reductions, safety, system preservation, sustainable development and freight, reduced SOV reliance, multi-modal benefits, and others. At a minimum, projects should be identified by year and proposed funding source.

Information on the cost-effectiveness of CMAQ-eligible projects can be used as a guidepost in evaluating the different types of projects under consideration by an MPO or state. However, cost-effectiveness ultimately will depend on local conditions and project specific factors that affect emission reductions and costs.

Regarding the Federal Government's role in project administration, the FTA determines the eligibility of transit projects, and the FHWA determines the eligibility of all other projects. The FHWA Division offices and the FTA Regional offices are responsible for administering the CMAQ program. In general, the FHWA transfers funds to the FTA to administer CMAQ-funded transit projects, and all other projects are administered by the FHWA. The FHWA Division office is responsible for tracking obligation of mandatory and flexible CMAQ funds in appropriate areas. Montana prepares an annual report detailing how CMAQ funds have been invested, as maintenance of a cumulative database of all CMAQ projects is required by SAFETEA-LU. CMAQ annual reports are submitted through the web-based CMAQ Tracking System. More information on the CMAQ system is available at: http://www.fhwa.dot.gov/environment/cmaqpgs/usersguidemail.htm.

The report is entered into the CMAQ Tracking System and includes:

1. A list of CMAQ projects, in one of seven categories (Transit, Shared Ride, Traffic Flow Improvements, Demand Management, Bike/Pedestrian, Other TCMs, and STP/CMAQ, which use flexible funds).
2. The amount of CMAQ funds obligated or deobligated for each project during the Federal fiscal year.
3. Emissions benefits (and disbenefits) for each project developed from project-level analyses.
4. Public-private partnerships and experimental pilot projects should be identified.
5. Other required information: MPO, nonattainment/maintenance area, project description.
6. Optional information such as TIP, state, and/or Fiscal Management Information System project numbers are highly recommended. Other optional information includes: GHG emission reductions, cost effectiveness, safety, congestion relief, and other ancillary benefits.

G. CONCLUSIONS

Montana has significant flexibility in how to distribute the flexible CMAQ funding, and the state should continue to explore how best to distribute these funds to improve Montana's transportation network and improve overall air quality. Prior to the TEA-21, almost all CMAQ funds had to be used in Missoula - Montana's only classified moderate CO nonattainment area. However, flexibility in spending flexible funding, and potentially transferring funding to other programs, means that Montana increasingly has discretion with respect to where and how to spend CMAQ funds.

Montana will need to reassess its practices when the MAP-21 technical guidance document is released, as this will replace the recommendations from the 2008 SAFETEA-LU Guidance Document. Montana will need to periodically reevaluate their transportation spending and best practices as Federal guidance is constantly undergoing adjustments.

$PM_{2.5}$ is likely to be the pollutant of greatest concern in Montana going forward, with the Libby nonattainment area (Lincoln County) and other areas, such as Butte in Silver Bow County and Lewis and Clark Counties, at risk to potentially move into nonattainment. On December 14, 2012, EPA revised (lowered) the level of the annual average $PM_{2.5}$ NAAQS from 15 to 12 $\mu g/m^3$. However, the process of making final designations of $PM_{2.5}$ nonattainment areas for the revised annual average $PM_{2.5}$ NAAQS takes about two years, so the designations will likely become effective in 2015. $PM_{2.5}$ will be included in Federal CMAQ allocations when MAP-21 goes into effect, although the interpretations of the new $PM_{2.5}$ requirements and funding allocations are still under review. If other areas in Montana move into nonattainment, it is possible that a higher percentage of CMAQ funding will be mandatory, rather than flexible, as this percentage is calculated based on the populations living in nonattainment/maintenance areas.

CHAPTER V. MONTANA COMMUNITIES AT RISK ANALYSIS

A. IDENTIFY AND EVALUATE COMMUNITIES AT RISK

This chapter provides an analysis that seeks to identify which communities have the greatest risk of health effects associated with current criteria air pollutant exposure and to identify Montana areas prone to future transportation-related issues. The following criteria were used to identify the communities at the greatest risk of air pollution problems:

1. 2010 County Population;
2. Monitoring Data and Current Pollution Levels;
3. Current Nonattainment Areas;
4. Transportation Network/Vehicle Miles Traveled (VMT) Factors;
5. Cost/Benefit Analysis;
6. Adjacent Community Benefits from Eligible Areas; and
7. Individual Characteristics of the Community.

Of the criteria on this list, the first two are considered the most important in determining where transportation dollars need to be spent to improve air quality. The other five items are discussed in a qualitative way, but are difficult to compare quantitatively. Therefore, these criteria are not included in the overall ranking of community risk, although this information can still be used to inform future decision-making.

This analysis focuses on the communities at risk from transportation-related pollutants, namely O_3, CO, and PM. There were nine Montana cities/counties that have had NAAQS issues in or near nonattainment with two of these three pollutants (CO and PM) in the past: Great Falls, Billings, Missoula, Flathead County, Libby, Polson, Ronan, Thompson Falls, Lame Deer, and Butte. This analysis will be done at the county level, as that is where the majority of transportation data is available. In addition, Gallatin and Lewis and Clark counties have been added due to their relatively high populations (both have over 50,000 residents) and the availability of air pollution monitoring measurements in these areas. Therefore, the counties included in this evaluation are Missoula, Flathead, Gallatin, Lincoln, Cascade, Yellowstone, Lake, Silver Bow, Lewis and Clark, Ravalli, Sanders, and Rosebud. These 12 counties contain more than two thirds of Montana's population. The population and population growth of each county is displayed in Table V-1. Population figures are US Census Bureau population estimates.

Table V-1. Population and Population Growth of Montana Counties Included in Analysis

County	Major Cities	2000 County Population	2010 County Population	2000–2010 Population Growth
Yellowstone	Billings	129,347	147,972	14.4%
Missoula	Missoula	93,805	109,299	16.5%
Flathead	Columbia Falls, Kalispell, Whitefish	74,507	90,928	22.0%
Gallatin	Belgrade, Bozeman	67,837	89,513	32.0%
Cascade	Great Falls	80,356	81,327	1.2%
Lewis and Clark	Helena	55,716	63,395	13.8%
Ravalli	Hamilton	36,070	40,212	11.5%
Silver Bow	Butte	34,625	34,200	-1.2%
Lake	Polson, Ronan	26,482	28,746	8.5%
Lincoln	Libby	18,820	19,687	4.6%
Sanders	Thompson Falls	10,238	11,413	11.5%
Rosebud	Lame Deer	9,389	9,233	-1.7%

Source: MCEC 2010

Table V-1 has both 2000 and 2010 population estimates to show where transportation source influences may be increasing with time.

The population growth shows that a few of these areas, notably Rosebud, Silver Bow, Cascade, and Lincoln counties, have very limited population growth (less than 5 percent) which indicates that air pollution problems may be relatively flat or declining, at least in cases where pollution is tied to VMT and vehicle standards. By comparison, the fastest growing counties like Gallatin and Flathead may have increasing air quality issues as the population and associated VMT expands.

Montana's 2008 statewide VMT was 11.0 billion miles, and 59 percent of this VMT occurred in the 11 counties considered in this analysis. County level VMT estimates for 2008 come from the NEI, and are displayed in Table V-2.

Table V-2. 2008 VMT in Selected Montana Counties

County	Major Cities	2008 VMT (million Miles)	2008 VMT (percentage of state total)
Yellowstone	Billings	1,223	11.1%
Missoula	Missoula	992	9.0%
Flathead	Columbia Falls, Kalispell, Whitefish	870	7.9%
Gallatin	Belgrade, Bozeman	919	8.3%
Cascade	Great Falls	699	6.3%
Lewis and Clark	Helena	608	5.5%
Ravalli	Hamilton	489	4.4%
Silver Bow	Butte	295	2.7%
Lake	Polson, Ronan	349	3.2%
Lincoln	Libby	212	1.9%
Sanders	Thompson Falls	92	0.8%
Rosebud	Lame Deer	223	2.0%

Source: EPA, 2012o

Comparing Table V-2 and Table V-1, the counties with the highest VMT are typically those with the highest population as well, with a few minor exceptions. Counties with higher than average VMT per capita are those like Rosebud County with a major interstate highway (I-94) contributing a significant fraction of its VMT. The two largest MPOs in Montana, Billings and Missoula, also have the highest VMT in 2008. The other Montana MPO – Great Falls – is in the county with the 5th highest VMT (and the 5th highest population). While Flathead and Gallatin counties do not have any cities large enough to be MPOs, they each have more than one population center, so their 2008 VMT estimates are the 3rd and 4th highest ranked in the state – consistent with the population rankings. Because the Montana VMT rankings and population rankings are consistent, transportation network/VMT factors were not included quantitatively in the communities at risk assessment, because population is an accurate surrogate for VMT in the state.

A number of options were considered for estimating the risk of being exposed to criteria air pollutants in Montana. We reviewed the methods that EPA uses for its NAAQS regulatory analyses, but these rely on regional air quality modeling and pollutant-specific relationships between air pollution exposures and expected health effects at each ambient air quality level. Because the EPA regulatory impact analysis methods were too resource intensive for this project, we focused on using methods based on the Pollutant Standards Index (PSI) that is used daily by EPA and communities to communicate with citizens about the air pollution risks that they are likely to face the following day (similar to a weather forecast). Through the EPA PSI, an area can issue an alert (code orange) if pollutant levels will be near the level of the ambient air quality standard or (code red) if pollutant levels are expected to be above the NAAQS. The PSI is therefore an indicator of the relative risk of exposure to certain pollutant concentrations, and can be used to differentiate more than just whether concentrations are above or below the NAAQS. However, the PSI only has a few concentration ranges for each pollutant that it uses to differentiate hazard levels, so we sought to find a pollutant indexing scheme that provides more differentiation of the risks of being just below or just above the NAAQS.

A 2007 study by Cairncross and John indicates that the overall risk from air pollution can be estimated based on the increased health risks and mortality of higher pollution levels (Cairncross and John 2007). Because the approach in this study provided more pollutant ranges than the PSI, it was decided to perform this Montana community risk analysis using the indexes and relative risk factors recommended by Cairncross and John. The 11 counties under consideration will be evaluated for the largest risk to cause health effects in the population. The metric used in this analysis is displayed in Table V-3. The Index Value provides an approximation of the health risks posed by air pollution at each level, and the Index Value can be summed for all pollutants to provide an estimate of the overall health risks a given community faces.

Table V-3. Relative Risk of CO, O_3, PM_{10} and $PM_{2.5}$ Exposure

Index Value	Relative Risk	CO [milligrams per cubic meter (mg/m^3)]	O_3 (µg/m^3)	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)
0	1	0	0	0	0
1	1.015	3.9	30	21	10
2	1.031	7.9	60	41	20
3	1.046	11.8	90	62	30
4	1.061	15.7	120	83	40
5	1.077	19.7	150	104	50
6	1.092	23.6	180	124	60
7	1.107	27.5	210	145	70
8	1.123	31.5	241	166	80
9	1.138	35.4	271	186	90
10	1.153	39.3	301	207	100

Source: Cairncross and John 2007

Because PSIs are based on daily expected air pollution levels, use of a PSI in this risk analysis means that one has to accept that daily air pollution levels are an accurate indicator of air pollution exposure in each Montana area. The pollutant where this might be a concern is PM, where both daily and annual average exposures are important. Therefore, we are using 24-hour $PM_{2.5}$ and PM_{10} exposures as a surrogate for annual average exposures.

CO, O_3, PM_{10}, and $PM_{2.5}$ concentrations measured at various Montana locations were discussed in Chapter II, and this information is summarized in Table V-4 below. In the case of CO and O_3 values, Chapter II presents these in parts per million, and this information was converted to grams per cubic meters (using conversion factors provided by EPA) (Mintz 2012), in order to match the units seen in Table V-2. CO concentrations represent the average of the 8-hour 2nd max design values for 2009–2011. O_3 concentrations are based on the average of the 8-hour 4th max design values for 2009–2011. PM_{10} and $PM_{2.5}$ are the 24-hour average design values for 2009–2011. Many counties do not have monitoring data for all four pollutants. EPA risk and exposure assessments were used to fill in an estimate of background concentrations of CO, O_3, and $PM_{2.5}$ in counties where there is no monitoring data available. The background concentrations used are 0.17 mg/m^3 for CO (EPA 2010c), 0.1 µg/m^3 for O_3 (EPA 2012p), and 1.42 µg/m^3 for $PM_{2.5}$ (EPA 2010d), and are shown in italics in Table V-4. There was no background air pollution concentration data for PM_{10} and those counties instead use the $PM_{2.5}$ values as a conservative estimate. All 11 counties have 24-hour average design values for 2009–2011 for either PM_{10} or $PM_{2.5}$.

Table V-4. Air Pollution Levels in Selected Montana Counties (2009–2011)

County	CO (8-hour Average Design Value mg/m³)	O_3 (8-hour Average Design Value µg/m³)	PM_{10} (24-Hour Design Value µg/m³)	$PM_{2.5}$ (24-Hour Design Value µg/m³)	Past/Present Nonattainment Pollutants
Yellowstone	1.92	*78*	*13*	13	CO Maintenance Area
Missoula	2.49	106	56	34	CO Maintenance Area
Flathead	2.30	108	67	28	PM_{10} Nonattainment Area
Gallatin	1.99	*78*	*31*	31	None
Cascade	1.69	*78*	*12*	14	CO Maintenance Area
Lewis and Clark	0.35	112	*45*	45	Pb Nonattainment
Ravalli	*0.17*	*78*	28	28	None
Silver Bow	*0.17*	*78*	84	39	PM_{10} Nonattainment Area
Lake	*0.17*	*78*	60	*1.42*	PM_{10} Nonattainment Area
Lincoln	*0.17*	*78*	65	32	$PM_{2.5}$ Nonattainment Area
Sanders	*0.17*	*78*	22	15	PM_{10} Nonattainment Area
Rosebud	*0.17*	110	109	11	PM_{10} Nonattainment Area
NAAQS Threshold for Nonattainment	*10.35*	147	150	35	

The 2007 Cairncross and John study indicates that total health impacts can be measured based on the combined impact of these pollutants. For example, in Missoula, the CO value is at index level 0, O_3 is level 3, PM_{10} is level 2, and $PM_{2.5}$ is level 3. The Cairncross and John study recommends only using one of PM_{10} and $PM_{2.5}$, because these values are often closely linked. Therefore, the higher of these index values is always used, and the total overall air pollution index is a rating between 0 and 30. Missoula's rating is 6, based on the sum of the $PM_{2.5}$ and O_3 values. The community with the highest rating is actually Rosebud County, due to its relatively high PM_{10} figure. The Index Levels for each pollutant and in total is displayed in Table V-5 below.

Table V-5. Air Pollution Index Levels for Various Pollutants

County	CO	O_3	PM_{10}	$PM_{2.5}$	Total Air Pollution Index
Yellowstone	0	2	0	1	3
Missoula	0	3	2	3	6
Flathead	0	3	3	2	6
Gallatin	0	2	1	3	5
Cascade	0	2	0	1	3
Lewis and Clark	0	3	2	4	7
Ravalli	0	2	1	2	4
Silver Bow	0	2	4	3	6
Lake	0	2	2	0	4
Lincoln	0	2	3	3	5
Sanders	0	2	1	1	3
Rosebud	0	3	5	1	8

The Total Air Pollution Index rating was calculated for all 12 counties, and then multiplied by the county population to show the relative population risk within each area. This was then normalized based on the highest value (the Relative Population Risk in Missoula), to show the relative risk for each county in a single number. The normalization shows the fraction of population risk each county has, compared to the county with the highest risk (Missoula). Counties with relatively low populations and Air Pollution Index Values, such as Sanders County, have a very low normalized population risk. This will be applied in the decision-making regarding which policies to pursue in each area.

This normalized population risk is useful because it expresses the community risk as a single number, which can be valuable for comparison purposes. However, it also leaves out several factors which may need to be considered in overall decision-making. For example, population growth is not factored into this calculation at all. Likewise, VMT was not included in this estimate, although VMT is directory related to transportation emissions.

The normalized community risk values in Table V-6 can be used by MDT to determine which areas of the state are likely to benefit the most by investments that reduce transportation source emissions that contribute to observed air quality concentrations in the state. While this community risk analysis continues to suggest that Missoula is the first priority for CMAQ investments, the rank ordering of the counties (and associated cities) just below Missoula County in community risk appears to be considerably different from any previous rankings.

Table V-6. Air Pollution Index Values and Adjusted Community Risk

County	Total Air Pollution Index	Pollutant of Greatest Concern	Relative Population Risk (Population * Risk Index)	Normalized Community Risk
Yellowstone	3	O_3	443,916	0.68
Missoula	6	$O_3/PM_{2.5}$	655,794	1.00
Flathead	6	O_3/PM_{10}	545,568	0.83
Gallatin	5	$PM_{2.5}$	447,565	0.68
Cascade	3	O_3	243,981	0.37
Lewis and Clark	7	$PM_{2.5}$	443,765	0.68
Ravalli	4	$O_3/PM_{2.5}$	160,484	0.25
Silver Bow	6	PM_{10}	205,200	0.31
Lake	4	O_3/PM_{10}	114,984	0.18
Lincoln	5	PM	98,435	0.15
Sanders	3	O_3	34,239	0.05
Rosebud	8	PM_{10}	73,864	0.11

The Chapter VI analysis that follows uses the community risk analysis presented here, along with estimated transportation source emissions by area and the ranges of emission reduction benefits expected to be available for candidate CMAQ measures, to estimate the potential emission reduction benefits that might be achieved in the Montana areas of need.

B. MISSOULA EXAMPLE

This section uses Missoula County as an example to show how the community risk analysis was performed. Table V-4 in this chapter provides the following measured air pollution levels for Missoula County during 2009–2011.

Table V-7. Missoula County Air Quality Design Values and Index Values (2009–2011)

Pollutant	Design Values (2009–2011)	Associated Index Value
CO	2.49 $\mu g/m^3$ 8-hour average	0
O_3	106 $\mu g/m^3$ 8-hour average	3
PM_{10}	56 $\mu g/m^3$ 24-hour average	2
$PM_{2.5}$	34 $\mu g/m^3$ 24-hour average	3

The design values listed above in Table V-7 for each pollutant are based on the measured ambient air quality monitoring values in Missoula County during calendar years 2009, 2010, and 2011. At the time of this analysis, 2011 was the most recent complete year of monitoring data. A design value is computed in such a way that it can be compared with the applicable ambient air quality standard. In this case, the design value is being used as an indicator of the maximum daily level of the pollutant during 2009–2011. (Attainment/nonattainment decisions are typically based on three consecutive years of data.)

The associated index values listed above were determined using the pollutant-specific design values and the index values in Table V-3 of this chapter. For example, the CO design value is lower than 3.9 mg/m^3, so the index value for CO is 0. The ozone design value is 106 $\mu g/m^3$, which is between 90 and 120 $\mu g/m^3$, so the index value for this range of ozone concentrations in Table V-3 is 3.

The PM_{10} index is 2 because the 24-hour average PM_{10} design value is in the range between 41 and 62 $\mu g/m^3$. Similarly, the $PM_{2.5}$ index is 3 because the design value is 34, which is in the range between 30 and 40 $\mu g/m^3$.

The convention for computing a total air pollution index value is to select the higher of the PM_{10} or $PM_{2.5}$ index value (to represent PM exposure) and to then add that index to the sum of the CO and O_3 indexes. The $PM_{2.5}$ index is 3, which is higher than the PM_{10} index, so the Missoula total air pollution index is computed as follows:

Missoula Total Air Pollution Index = CO index + O_3 index + PM index

Missoula Total Air Pollution Index = 0 + 3 + 3
Missoula Total Air Pollution Index = 6

This total air pollution index for Missoula County is shown in the right-most column in Table V-5. The only counties with higher air pollution indexes than Missoula County are Lewis and Clark County (with an index of 7) and Rosebud County (with an index of 8).

The total air pollution index and the county population for Missoula County are then used to calculate a population risk value, which is the total air pollution index (6) multiplied by the Missoula County 2010 population (109,299). This population risk value is 655,794, which is shown in Table V-6. This population risk value is a measure of the population exposure to air pollution in Missoula County. Note that the relative population risk number is designed to be used to establish a ranking for priority setting (across areas). Because Missoula County has the highest relative population risk in Table V-6, it has a normalized community risk of 1.00. The normalized community risk for other Montana counties is computed by dividing their relative population risk values by Missoula County's.

CHAPTER VI. CMAQ MEASURE EMISSION REDUCTION POTENTIAL

A. INTRODUCTION

This chapter first discusses the emissions reductions achievable by CMAQ measures. Then, the contributions of transportation sources to total emissions in Montana are analyzed. Finally, those two elements are combined to calculate the total county-specific emission reduction potentials of CMAQ measures.

B. CMAQ MEASURE EMISSION REDUCTION POTENTIAL

The primary data source used to determine the achievable emissions reductions from each policy is the EPA publication, "Potential Changes in Emissions Due to Improvements in Travel Efficiency" (EPA 2011a). As can be seen in Table VI-1, this was used for six of the ten policy categories under consideration for Montana. This table shows the potential VMT reductions that have been seen by implementing these policies in various areas across the country. VMT reductions are assumed to have a relatively linear relationship with emissions. In all cases, the low estimate is used as an approximation for the reductions achievable in Montana, in order to produce a conservative estimate. The highest emission reduction rating seen is for transit improvements, and this is specifically focusing on bus transit (rail mass transit can achieve higher VMT reductions, but are not practical in Montana).

Table VI-1. Emission Reduction Rating, Policies that Reduce VMT

	Percentage VMT Reduction		Emission Reduction Rating
	Low Estimate	High Estimate	
Transit Improvements	0.6	1	0.6%
Bicycle & Pedestrian	0.1	0.1	0.1%
Travel Demand Management	0.1	0.3	0.1%
Public Education and Outreach Activities	Typically Implemented in conjunction with other policies		0.0%
Carpooling and Vanpooling	0.2	3.3	0.2%
Freight/Intermodal	0.3	0.7	0.3%

Source: EPA 2011a

The EPA report did not quantify the emissions reductions achievable for projects that do not affect VMT. Therefore, alternative data sources needed to be found for the four remaining policy categories. Table VI-2 shows the Emission Reduction Rating for each remaining policy, and the data source for these figures. Emission Reduction Ratings are calculated based on the potential to reduce $PM_{2.5}$ emissions. The Penetration Rate is meant to show the degree to which a policy might be able to be implemented. In the case of Alternative Fuels and Congestion Relief/Traffic Flow Improvement, the rate chosen was 5 percent, because dramatically expanding biofuel use through state policy is very difficult, and there are a limited number of opportunities where traffic flow could potentially be improved through signal synchronization or other congestion relief investments.

The penetration rate selected for Diesel Engine Retrofits and Idle Reduction was 50 percent, to show what the potential of these policies might be with a strong push. Although this penetration rate is high, these measures focus on school and transit buses, which only make up a small portion of heavy duty emissions in Montana as described later. In the case of all four estimates, the Penetration Rate is an engineering judgment, as there are no data sources available on the degree to which these policies could be implemented in Montana. If more accurate estimates could be provided, then they will be used in the Emissions Reduction Rating Estimate. Nonetheless, some penetration rate must be used in this calculation.

The Alternative Fuels $PM_{2.5}$ Emission Reduction is based on the difference in emissions rate between B20 biodiesel and traditional diesel fuel, based on information from EPA's Regulatory Impact Analysis of the 2010 Renewable Fuel

Standard (EPA 2010e). The Congestion Relief and Traffic Flow Improvement emission reduction is based on the emission reduction from improving average speeds from 30 to 40 miles per hour on a given road. This information comes from FHWA MOVES Sensitivity Testing (Houk 2009), and is likely a very high estimate of the achievable $PM_{2.5}$ reductions from traffic flow improvement (the majority of VMT in Montana is not in a congested area, and therefore would not be affected). This is why the relatively low penetration rate of 5 percent was chosen. The Diesel Engine Retrofit estimate (EPA 2012q) is focusing on school and transit buses, which make up 4.3 percent of heavy duty emissions in Montana (based on NEI data). Therefore the Emission Reduction Rating is 4.3 percent * 25 percent * 50 percent. The Idle Reduction Policy is based on installing Auxiliary Power Units in heavy-duty trucks to reduce emissions. Idling emissions make up 3.4 percent of total heavy duty emissions, and therefore the Emission Reduction Rating for Idling Reduction is 3.4 percent * 10 percent * 50 percent. The Equipment Purchase option relates to the use of street sweepers to remove PM emissions from paved roads. The low and high estimates of $PM_{2.5}$ emissions reduction come from EPA's AP-42 documentation and refer to different technologies: "Water Flushing" (69 percent efficiency), and "Flushing & Broom Sweep" (73 percent efficiency) (EPA 2011b). Note that AP-42 also includes control efficiencies for PM_{10}, which are generally higher than those of $PM_{2.5}$. It is unlikely that all the roads within a county will be swept by newly acquired street sweepers. We estimated that half of the roads would be swept, and a penetration rate of 50 percent was thus chosen. This penetration rate tries to capture both the percentage of streets in an area that are swept after sand/salt application and the timeliness of this action.

Table VI-2. Emission Reduction Rating, Policies that Reduce $PM_{2.5}$ Emissions

	Estimated $PM_{2.5}$ Emissions Reduction		Penetration Rate	Emission Reduction Rating	Data Source
	Low Estimate	High Estimate			
Alternative Fuels	16%		5%	0.8%	EPA. Renewable Fuel Standard Regulatory Impact Analysis. Feb. 2010. Table 3.1-5.
Congestion Relief and Traffic Flow Improvement	20%		5%	1.0%	Houk, Jeff. FHWA MOVES Sensitivity Testing. October 2009.
Diesel Engine Retrofit	25%	90%	50%	0.5%	National Clean Diesel Campaign. Verified Retrofit Technologies. http://epa.gov/cleandiesel/verification/verif-list.htm, EPA 2012q.
Idle Reduction	10%	25%	50%	0.2%	Massachusetts Department of Environmental Protection. Technology Guide. Pollutant Reduction by Technology. MDEP 2011.
Equipment Purchase (Street Sweepers)	69%	73%	50%	34.5%*	EPA 2011b. Emission Factor Documentation for AP-42, Section 13.2.1, Paved Roads.

*Rating includes the control efficiencies for PM10

C. TRANSPORTATION SOURCE EMISSIONS BY AREA

SC&A developed estimates of transportation source emissions by county (as a proxy for the nonattainment area) from the EPA 2008 NEI (EPA 2012p). These estimates are shown in Table VI-3. Table VI-4 shows the transportation source emissions contributions to total county emissions in Montana on a percentage basis. While the county-level estimates of mobile source emissions developed for the NEI include the use of MOVES model defaults that may not be Montana or area-specific, the 2008 NEI emission estimates were used because they provide a consistent and recent set of emission estimates for the areas of interest. We considered using SIP emission inventories for this analysis, but they are not current, and are not readily available in publicly accessible documents. In addition, SIP emission inventories are often limited to one or two pollutants. Further, $PM_{2.5}$ is likely to be the pollutant of most interest/importance going forward, and emission estimation methods and emission factors have improved significantly in the past 10 years.

Of the NEI source categories, the ones that are most likely to be directly affected by CMAQ measures include the on-road gasoline and diesel-powered vehicles plus fugitive dust sources from paved roads (street sweeping). Fugitive dust emissions from unpaved road travel are viewed as a less likely control candidate because these emissions are likely to be lower during wintertime fine PM events (peak concentrations). Additionally, unpaved roads are so widespread in Montana that paving them is impractical. Note that the last rows of each table (county total) refer to emissions from all sectors, while the individual rows only include transportation related emissions. PM_{10}-PRI and $PM_{2.5}$ PRI refer to primary PM, which is the sum of filterable and condensable PM (directly emitted from a source, as opposed to secondary PM, which form through chemical reactions in the ambient air).

Table VI-3. Transportation Source 2008 NEI Emission Estimates for Montana Counties

Emissions in Tons Per Year

Missoula County Annual Emissions (Tons)

Sector	CO (tons)	NO_x (tons)	PM_{10}-PRI (tons)	$PM_{2.5}$-PRI (tons)	SO_2 (tons)	VOC (tons)
Dust - Paved Road Dust	0	0	497	124	0	0
Dust - Unpaved Road Dust	0	0	6,845	682	0	0
Mobile - Aircraft	137	20	3	1	3	10
Mobile - Locomotives	87	620	20	18	6	29
Mobile - Non-Road Equipment - Diesel	193	315	27	26	7	34
Mobile - Non-Road Equipment - Gasoline	3,818	51	13	12	0	398
Mobile - Non-Road Equipment - Other	218	41	0	0	0	10
Mobile - On-Road Diesel Heavy Duty Vehicles	342	1,249	73	66	27	93
Mobile - On-Road Diesel Light Duty Vehicles	15	25	2	2	1	4
Mobile - On-Road Gasoline Heavy Duty Vehicles	1,512	157	3	2	3	62
Mobile - On-Road Gasoline Light Duty Vehicles	12,364	1,326	52	33	35	900
Total Missoula	**36,355**	**5,466**	**10,471**	**2,286**	**273**	**31,805**

Flathead County Annual Emissions (Tons)

Sector	CO (tons)	NO_x (tons)	PM_{10}-PRI (tons)	$PM_{2.5}$-PRI (tons)	SO_2 (tons)	VOC (tons)
Dust - Paved Road Dust	0	0	704	176	0	0
Dust - Unpaved Road Dust	0	0	12,914	1,287	0	0
Mobile - Aircraft	261	15	6	1	3	13
Mobile - Locomotives	242	1,659	54	50	17	81
Mobile - Non-Road Equipment - Diesel	212	381	32	31	9	39
Mobile - Non-Road Equipment - Gasoline	5,150	59	22	21	1	766
Mobile - Non-Road Equipment - Other	249	46	0	0	0	12
Mobile - On-Road Diesel Heavy Duty Vehicles	300	1,073	64	59	23	78
Mobile - On-Road Diesel Light Duty Vehicles	13	21	2	2	1	3
Mobile - On-Road Gasoline Heavy Duty Vehicles	1,691	176	2	1	3	63
Mobile - On-Road Gasoline Light Duty Vehicles	10,775	1,152	44	30	30	778
Total Flathead	**60,035**	**5,510**	**17,021**	**3,382**	**210**	**49,842**

Emissions in Tons Per Year

Rosebud County Annual Emissions (Tons)

Sector	CO (tons)	NO_x (tons)	PM_{10}-PRI (tons)	$PM_{2.5}$-PRI (tons)	SO_2 (tons)	VOC (tons)
Dust - Paved Road Dust	0	0	144	36	0	0
Dust - Unpaved Road Dust	0	0	2,646	264	0	0
Mobile - Aircraft	37	1	1	0	0	1
Mobile - Locomotives	119	809	27	25	8	40
Mobile - Non-Road Equipment - Diesel	89	174	16	16	4	17
Mobile - Non-Road Equipment - Gasoline	394	5	1	1	0	53
Mobile - Non-Road Equipment - Other	2	0	0	0	0	0
Mobile - On-Road Diesel Heavy Duty Vehicles	112	480	25	23	10	27
Mobile - On-Road Diesel Light Duty Vehicles	3	4	0	0	0	1
Mobile - On-Road Gasoline Heavy Duty Vehicles	507	53	1	0	1	16
Mobile - On-Road Gasoline Light Duty Vehicles	2,710	285	9	7	7	179
Total Rosebud	**18,426**	**28,845**	**9,548**	**1,785**	**15,525**	**33,164**

Lake County Annual Emissions (Tons)

Sector	CO (tons)	NO_x (tons)	PM_{10}-PRI (tons)	$PM_{2.5}$-PRI (tons)	SO_2 (tons)	VOC (tons)
Dust - Paved Road Dust	0	0	347	87	0	0
Dust - Unpaved Road Dust	0	0	6,430	641	0	0
Mobile - Aircraft	46	1	1	0	0	1
Mobile - Locomotives	4	39	1	1	0	1
Mobile - Non-Road Equipment - Diesel	85	176	15	15	4	17
Mobile - Non-Road Equipment - Gasoline	1,929	29	10	9	0	421
Mobile - Non-Road Equipment - Other	57	10	0	0	0	3
Mobile - On-Road Diesel Heavy Duty Vehicles	130	482	28	26	10	32
Mobile - On-Road Diesel Light Duty Vehicles	5	8	1	1	0	1
Mobile - On-Road Gasoline Heavy Duty Vehicles	798	83	1	1	1	27
Mobile - On-Road Gasoline Light Duty Vehicles	4,223	452	15	11	11	294
Total Lake	**15,348**	**1,682**	**7,837**	**1,274**	**84**	**15,926**

Sanders County Annual Emissions (Tons)

Sector	CO (tons)	NO_x (tons)	PM_{10}-PRI (tons)	$PM_{2.5}$-PRI (tons)	SO_2 (tons)	VOC (tons)
Dust - Paved Road Dust	0	0	108	27	0	0
Dust - Unpaved Road Dust	0	0	3,133	312	0	0
Mobile - Aircraft	34	0	1	0	0	1
Mobile - Locomotives	143	1,008	32	30	10	48
Mobile - Non-Road Equipment - Diesel	45	88	8	8	2	9
Mobile - Non-Road Equipment - Gasoline	731	9	3	3	0	112
Mobile - Non-Road Equipment - Other	17	3	0	0	0	1
Mobile - On-Road Diesel Heavy Duty Vehicles	33	120	7	6	2	8
Mobile - On-Road Diesel Light Duty Vehicles	1	2	0	0	0	0
Mobile - On-Road Gasoline Heavy Duty Vehicles	219	23	0	0	0	7
Mobile - On-Road Gasoline Light Duty Vehicles	1,091	119	4	3	3	80
Total Sanders	**18,630**	**1,778**	**4,451**	**1,222**	**94**	**30,068**

Emissions in Tons Per Year

Silver Bow County Annual Emissions (Tons)

Sector	CO (tons)	NO_x (tons)	PM_{10}-PRI (tons)	$PM_{2.5}$-PRI (tons)	SO_2 (tons)	VOC (tons)
Dust - Paved Road Dust	0	0	69	17	0	0
Dust - Unpaved Road Dust	0	0	913	91	0	0
Mobile - Aircraft	104	13	3	1	2	7
Mobile - Locomotives	7	56	2	1	0	3
Mobile - Non-Road Equipment - Diesel	25	36	3	3	1	4
Mobile - Non-Road Equipment - Gasoline	1,147	10	3	3	0	124
Mobile - Non-Road Equipment - Other	36	7	0	0	0	2
Mobile - On-Road Diesel Heavy Duty Vehicles	121	501	26	24	11	33
Mobile - On-Road Diesel Light Duty Vehicles	4	7	1	1	0	1
Mobile - On-Road Gasoline Heavy Duty Vehicles	417	43	1	1	1	17
Mobile - On-Road Gasoline Light Duty Vehicles	3,844	398	17	11	10	282
Total Silver Bow	**10,136**	**1,927**	**2,818**	**615**	**105**	**7,752**

Lincoln County Annual Emissions (Tons)

Sector	CO (tons)	NO_x (tons)	PM_{10}-PRI (tons)	$PM_{2.5}$-PRI (tons)	SO_2 (tons)	VOC (tons)
Dust - Paved Road Dust	0	0	212	53	0	0
Dust - Unpaved Road Dust	0	0	5,362	535	0	0
Mobile - Aircraft	25	0	1	0	0	1
Mobile - Locomotives	269	1,831	60	55	19	90
Mobile - Non-Road Equipment - Diesel	31	68	5	5	2	6
Mobile - Non-Road Equipment - Gasoline	1,045	14	6	5	0	193
Mobile - Non-Road Equipment - Other	49	9	0	0	0	2
Mobile - On-Road Diesel Heavy Duty Vehicles	80	296	17	16	6	20
Mobile - On-Road Diesel Light Duty Vehicles	3	5	0	0	0	1
Mobile - On-Road Gasoline Heavy Duty Vehicles	489	51	1	0	1	17
Mobile - On-Road Gasoline Light Duty Vehicles	2,638	279	10	7	7	184
Total Lincoln	**26,628**	**3,018**	**7,313**	**1,825**	**150**	**39,311**

Cascade County Annual Emissions (Tons)

Sector	CO (tons)	NO_x (tons)	PM_{10}-PRI (tons)	$PM_{2.5}$-PRI (tons)	SO_2 (tons)	VOC (tons)
Dust - Paved Road Dust	0	0	335	84	0	0
Dust - Unpaved Road Dust	0	0	5,157	514	0	0
Mobile - Aircraft	178	38	4	2	5	18
Mobile - Locomotives	21	159	5	4	1	8
Mobile - Non-Road Equipment - Diesel	314	555	51	49	12	57
Mobile - Non-Road Equipment - Gasoline	4,240	40	11	10	0	342
Mobile - Non-Road Equipment - Other	84	17	0	0	0	4
Mobile - On-Road Diesel Heavy Duty Vehicles	253	955	54	49	21	69
Mobile - On-Road Diesel Light Duty Vehicles	10	18	1	1	1	3
Mobile - On-Road Gasoline Heavy Duty Vehicles	1,036	107	2	1	2	43
Mobile - On-Road Gasoline Light Duty Vehicles	8,805	941	38	24	25	649
Total Cascade	**22,707**	**4,101**	**9,850**	**1,761**	**118**	**19,675**

Yellowstone County Annual Emissions (Tons)						
Sector	CO (tons)	NO_x (tons)	PM_{10}-PRI (tons)	$PM_{2.5}$-PRI (tons)	SO_2 (tons)	VOC (tons)
Dust - Paved Road Dust	0	0	510	128	0	0
Dust - Unpaved Road Dust	0	0	7,112	709	0	0
Mobile - Aircraft	403	63	11	3	8	26
Mobile - Locomotives	221	1,557	50	46	16	78
Mobile - Non-Road Equipment - Diesel	388	618	55	53	14	68
Mobile - Non-Road Equipment - Gasoline	7,892	72	21	19	1	703
Mobile - Non-Road Equipment - Other	283	56	1	1	0	13
Mobile - On-Road Diesel Heavy Duty Vehicles	445	1,652	106	97	41	110
Mobile - On-Road Diesel Light Duty Vehicles	19	31	2	2	1	5
Mobile - On-Road Gasoline Heavy Duty Vehicles	1,122	106	3	2	2	66
Mobile - On-Road Gasoline Light Duty Vehicles	15,434	1,625	63	38	49	1,171
Total Yellowstone	**45,145**	**11,198**	**14,781**	**3,550**	**7,782**	**26,150**

Gallatin County Annual Emissions (Tons)						
Sector	CO (tons)	NO_x (tons)	PM_{10}-PRI (tons)	$PM_{2.5}$-PRI (tons)	SO_2 (tons)	VOC (tons)
Dust - Paved Road Dust	0	0	548	137	0	0
Dust - Unpaved Road Dust	0	0	7,605	758	0	0
Mobile - Aircraft	281	33	7	1	4	15
Mobile - Locomotives	80	569	18	17	6	27
Mobile - Non-Road Equipment - Diesel	311	513	46	45	11	54
Mobile - Non-Road Equipment - Gasoline	5,154	48	26	24	1	816
Mobile - Non-Road Equipment - Other	199	38	1	1	0	9
Mobile - On-Road Diesel Heavy Duty Vehicles	333	1,238	71	65	26	87
Mobile - On-Road Diesel Light Duty Vehicles	13	22	2	2	1	4
Mobile - On-Road Gasoline Heavy Duty Vehicles	1,660	172	3	2	3	64
Mobile - On-Road Gasoline Light Duty Vehicles	11,535	1,221	49	33	32	844
Total Gallatin	**29,400**	**4,490**	**11,482**	**1,926**	**107**	**23,222**

Lewis and Clark County Annual Emissions (Tons)						
Sector	CO (tons)	NO_x (tons)	PM_{10}-PRI (tons)	$PM_{2.5}$-PRI (tons)	SO_2 (tons)	VOC (tons)
Dust - Paved Road Dust	0	0	172	43	0	0
Dust - Unpaved Road Dust	0	0	2,233	223	0	0
Mobile - Aircraft	237	7	5	1	1	11
Mobile - Locomotives	42	295	9	9	3	14
Mobile - Non-Road Equipment - Diesel	119	199	18	17	4	21
Mobile - Non-Road Equipment - Gasoline	2,601	26	11	10	0	382
Mobile - Non-Road Equipment - Other	48	10	0	0	0	2
Mobile - On-Road Diesel Heavy Duty Vehicles	227	867	49	45	19	60
Mobile - On-Road Diesel Light Duty Vehicles	9	15	1	1	0	2
Mobile - On-Road Gasoline Heavy Duty Vehicles	1,004	104	2	1	2	39
Mobile - On-Road Gasoline Light Duty Vehicles	7,549	803	31	20	21	546
Total Lewis and Clark	**20,757**	**3,052**	**4,198**	**823**	**64**	**30,257**

Table VI-4 shows the transportation source emissions contributions to total county emissions in Montana. These are the same data as Table VI-3, but on a percentage basis.

Table VI-4. Transportation Source Percentage Contributions to Total 2008 NEI-Estimated County Emissions in Montana

Emissions in % (of Total County Emissions)						
% Missoula Co. emissions due to transportation	**CO**	**NO_x**	**PM_{10}-PRI**	**$PM_{2.5}$-PRI**	**SO_2**	**VOC**
Dust - Paved Road Dust	0.0%	0.0%	4.8%	5.4%	0.0%	0.0%
Dust - Unpaved Road Dust	0.0%	0.0%	65.4%	29.8%	0.0%	0.0%
Mobile - Aircraft	0.4%	0.4%	0.0%	0.0%	1.1%	0.0%
Mobile - Locomotives	0.2%	11.3%	0.2%	0.8%	2.3%	0.1%
Mobile - Non-Road Equipment - Diesel	0.5%	5.8%	0.3%	1.1%	2.7%	0.1%
Mobile - Non-Road Equipment - Gasoline	10.5%	0.9%	0.1%	0.5%	0.2%	1.3%
Mobile - Non-Road Equipment - Other	0.6%	0.8%	0.0%	0.0%	0.1%	0.0%
Mobile - On-Road Diesel Heavy Duty Vehicles	0.9%	22.8%	0.7%	2.9%	9.9%	0.3%
Mobile - On-Road Diesel Light Duty Vehicles	0.0%	0.5%	0.0%	0.1%	0.3%	0.0%
Mobile - On-Road Gasoline Heavy Duty Vehicles	4.2%	2.9%	0.0%	0.1%	1.1%	0.2%
Mobile - On-Road Gasoline Light Duty Vehicles	34.0%	24.3%	0.5%	1.4%	12.8%	2.8%
All emissions due to transportation %	***51.4%***	***69.6%***	***71.9%***	***42.2%***	***30.4%***	***4.8%***
Non-transportation related emissions %	***48.6%***	***30.4%***	***28.1%***	***57.8%***	***69.6%***	***95.2%***
% Flathead Co. emissions due to transportation	**CO**	**NO_x**	**PM_{10}-PRI**	**$PM_{2.5}$-PRI**	**SO_2**	**VOC**
Dust - Paved Road Dust	0.0%	0.0%	4.1%	5.2%	0.0%	0.0%
Dust - Unpaved Road Dust	0.0%	0.0%	75.9%	38.1%	0.0%	0.0%
Mobile - Aircraft	0.4%	0.3%	0.0%	0.0%	1.2%	0.0%
Mobile - Locomotives	0.4%	30.1%	0.3%	1.5%	8.1%	0.2%
Mobile - Non-Road Equipment - Diesel	0.4%	6.9%	0.2%	0.9%	4.1%	0.1%
Mobile - Non-Road Equipment - Gasoline	8.6%	1.1%	0.1%	0.6%	0.3%	1.5%
Mobile - Non-Road Equipment - Other	0.4%	0.8%	0.0%	0.0%	0.1%	0.0%
Mobile - On-Road Diesel Heavy Duty Vehicles	0.5%	19.5%	0.4%	1.7%	10.8%	0.2%
Mobile - On-Road Diesel Light Duty Vehicles	0.0%	0.4%	0.0%	0.0%	0.3%	0.0%
Mobile - On-Road Gasoline Heavy Duty Vehicles	2.8%	3.2%	0.0%	0.0%	1.5%	0.1%
Mobile - On-Road Gasoline Light Duty Vehicles	17.9%	20.9%	0.3%	0.9%	14.2%	1.6%
All emissions due to transportation %	***31.5%***	***83.1%***	***81.3%***	***49.0%***	***40.6%***	***3.7%***
Non-transportation related emissions %	***68.5%***	***16.9%***	***18.7%***	***51.0%***	***59.4%***	***96.3%***
% Rosebud Co. emissions due to transportation	**CO**	**NO_x**	**PM_{10}-PRI**	**$PM_{2.5}$-PRI**	**SO_2**	**VOC**
Dust - Paved Road Dust	0.0%	0.0%	1.5%	2.0%	0.0%	0.0%
Dust - Unpaved Road Dust	0.0%	0.0%	27.7%	14.8%	0.0%	0.0%
Mobile - Aircraft	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%
Mobile - Locomotives	0.6%	2.8%	0.3%	1.4%	0.1%	0.1%
Mobile - Non-Road Equipment - Diesel	0.5%	0.6%	0.2%	0.9%	0.0%	0.1%
Mobile - Non-Road Equipment - Gasoline	2.1%	0.0%	0.0%	0.1%	0.0%	0.2%
Mobile - Non-Road Equipment - Other	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mobile - On-Road Diesel Heavy Duty Vehicles	0.6%	1.7%	0.3%	1.3%	0.1%	0.1%
Mobile - On-Road Diesel Light Duty Vehicles	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mobile - On-Road Gasoline Heavy Duty Vehicles	2.8%	0.2%	0.0%	0.0%	0.0%	0.0%
Mobile - On-Road Gasoline Light Duty Vehicles	14.7%	1.0%	0.1%	0.4%	0.0%	0.5%
All emissions due to transportation %	***21.6%***	***6.3%***	***30.1%***	***20.9%***	***0.2%***	***1.0%***
Non-transportation related emissions %	***78.4%***	***93.7%***	***69.9%***	***79.1%***	***99.8%***	***99.0%***

% Lake Co. emissions due to transportation	CO	NO_x	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	VOC
Dust - Paved Road Dust	0.0%	0.0%	4.4%	6.8%	0.0%	0.0%
Dust - Unpaved Road Dust	0.0%	0.0%	82.0%	50.3%	0.0%	0.0%
Mobile - Aircraft	0.3%	0.0%	0.0%	0.0%	0.1%	0.0%
Mobile - Locomotives	0.0%	2.3%	0.0%	0.1%	0.3%	0.0%
Mobile - Non-Road Equipment - Diesel	0.6%	10.4%	0.2%	1.2%	4.5%	0.1%
Mobile - Non-Road Equipment - Gasoline	12.6%	1.7%	0.1%	0.7%	0.3%	2.6%
Mobile - Non-Road Equipment - Other	0.4%	0.6%	0.0%	0.0%	0.0%	0.0%
Mobile - On-Road Diesel Heavy Duty Vehicles	0.8%	28.6%	0.4%	2.0%	12.1%	0.2%
Mobile - On-Road Diesel Light Duty Vehicles	0.0%	0.5%	0.0%	0.0%	0.3%	0.0%
Mobile - On-Road Gasoline Heavy Duty Vehicles	5.2%	4.9%	0.0%	0.0%	1.7%	0.2%
Mobile - On-Road Gasoline Light Duty Vehicles	27.5%	26.9%	0.2%	0.9%	13.6%	1.8%
All emissions due to transportation %	***47.4%***	***76.0%***	***87.4%***	***62.1%***	***32.9%***	***5.0%***
Non-transportation related emissions %	***52.6%***	***24.0%***	***12.6%***	***37.9%***	***67.1%***	***95.0%***
% Sanders Co. emissions due to transportation	**CO**	**NO_x**	**PM_{10}-PRI**	**$PM_{2.5}$-PRI**	**SO_2**	**VOC**
Dust - Paved Road Dust	0.0%	0.0%	2.4%	2.2%	0.0%	0.0%
Dust - Unpaved Road Dust	0.0%	0.0%	70.4%	25.6%	0.0%	0.0%
Mobile - Aircraft	0.2%	0.0%	0.0%	0.0%	0.1%	0.0%
Mobile - Locomotives	0.8%	56.7%	0.7%	2.4%	10.8%	0.2%
Mobile - Non-Road Equipment - Diesel	0.2%	4.9%	0.2%	0.6%	2.0%	0.0%
Mobile - Non-Road Equipment - Gasoline	3.9%	0.5%	0.1%	0.2%	0.1%	0.4%
Mobile - Non-Road Equipment - Other	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%
Mobile - On-Road Diesel Heavy Duty Vehicles	0.2%	6.7%	0.2%	0.5%	2.7%	0.0%
Mobile - On-Road Diesel Light Duty Vehicles	0.0%	0.1%	0.0%	0.0%	0.1%	0.0%
Mobile - On-Road Gasoline Heavy Duty Vehicles	1.2%	1.3%	0.0%	0.0%	0.4%	0.0%
Mobile - On-Road Gasoline Light Duty Vehicles	5.9%	6.7%	0.1%	0.2%	3.2%	0.3%
All emissions due to transportation %	***12.4%***	***77.2%***	***74.1%***	***31.9%***	***19.3%***	***0.9%***
Non-transportation related emissions %	***87.6%***	***22.8%***	***25.9%***	***68.1%***	***80.7%***	***99.1%***
% Silver Bow Co. emissions due to transportation	**CO**	**NO_x**	**PM_{10}-PRI**	**$PM_{2.5}$-PRI**	**SO_2**	**VOC**
Dust - Paved Road Dust	0.0%	0.0%	2.5%	2.8%	0.0%	0.0%
Dust - Unpaved Road Dust	0.0%	0.0%	32.4%	14.8%	0.0%	0.0%
Mobile - Aircraft	1.0%	0.7%	0.1%	0.1%	1.5%	0.1%
Mobile - Locomotives	0.1%	2.9%	0.1%	0.2%	0.4%	0.0%
Mobile - Non-Road Equipment - Diesel	0.2%	1.9%	0.1%	0.5%	0.8%	0.1%
Mobile - Non-Road Equipment - Gasoline	11.3%	0.5%	0.1%	0.5%	0.1%	1.6%
Mobile - Non-Road Equipment - Other	0.4%	0.4%	0.0%	0.0%	0.0%	0.0%
Mobile - On-Road Diesel Heavy Duty Vehicles	1.2%	26.0%	0.9%	3.9%	10.3%	0.4%
Mobile - On-Road Diesel Light Duty Vehicles	0.0%	0.4%	0.0%	0.1%	0.2%	0.0%
Mobile - On-Road Gasoline Heavy Duty Vehicles	4.1%	2.2%	0.0%	0.1%	0.8%	0.2%
Mobile - On-Road Gasoline Light Duty Vehicles	37.9%	20.6%	0.6%	1.8%	9.8%	3.6%
All emissions due to transportation %	***56.3%***	***55.6%***	***36.8%***	***25.0%***	***24.0%***	***6.1%***
Non-transportation related emissions %	***43.7%***	***44.4%***	***63.2%***	***75.0%***	***76.0%***	***93.9%***
% Lincoln Co. emissions due to transportation	**CO**	**NO_x**	**PM_{10}-PRI**	**$PM_{2.5}$-PRI**	**SO_2**	**VOC**
Dust - Paved Road Dust	0.0%	0.0%	2.9%	2.9%	0.0%	0.0%
Dust - Unpaved Road Dust	0.0%	0.0%	73.3%	29.3%	0.0%	0.0%
Mobile - Aircraft	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%
Mobile - Locomotives	1.0%	60.7%	0.8%	3.0%	12.6%	0.2%
Mobile - Non-Road Equipment - Diesel	0.1%	2.3%	0.1%	0.3%	1.1%	0.0%
Mobile - Non-Road Equipment - Gasoline	3.9%	0.5%	0.1%	0.3%	0.1%	0.5%
Mobile - Non-Road Equipment - Other	0.2%	0.3%	0.0%	0.0%	0.0%	0.0%
Mobile - On-Road Diesel Heavy Duty Vehicles	0.3%	9.8%	0.2%	0.9%	4.1%	0.1%
Mobile - On-Road Diesel Light Duty Vehicles	0.0%	0.2%	0.0%	0.0%	0.1%	0.0%
Mobile - On-Road Gasoline Heavy Duty Vehicles	1.8%	1.7%	0.0%	0.0%	0.6%	0.0%
Mobile - On-Road Gasoline Light Duty Vehicles	9.9%	9.2%	0.1%	0.4%	4.7%	0.5%
All emissions due to transportation %	***17.4%***	***84.6%***	***77.6%***	***37.1%***	***23.4%***	***1.3%***
Non-transportation related emissions %	***82.6%***	***15.4%***	***22.4%***	***62.9%***	***76.6%***	***98.7%***

% Cascade Co. emissions due to transportation	CO	NO_x	PM_{10}-PRI	$PM_{2.5}$-PRI	SO_2	VOC
Dust - Paved Road Dust	0.0%	0.0%	3.4%	4.8%	0.0%	0.0%
Dust - Unpaved Road Dust	0.0%	0.0%	52.4%	29.2%	0.0%	0.0%
Mobile - Aircraft	0.8%	0.9%	0.0%	0.1%	4.1%	0.1%
Mobile - Locomotives	0.1%	3.9%	0.0%	0.3%	1.2%	0.0%
Mobile - Non-Road Equipment - Diesel	1.4%	13.5%	0.5%	2.8%	9.9%	0.3%
Mobile - Non-Road Equipment - Gasoline	18.7%	1.0%	0.1%	0.6%	0.3%	1.7%
Mobile - Non-Road Equipment - Other	0.4%	0.4%	0.0%	0.0%	0.1%	0.0%
Mobile - On-Road Diesel Heavy Duty Vehicles	1.1%	23.3%	0.5%	2.8%	17.7%	0.3%
Mobile - On-Road Diesel Light Duty Vehicles	0.0%	0.4%	0.0%	0.1%	0.5%	0.0%
Mobile - On-Road Gasoline Heavy Duty Vehicles	4.6%	2.6%	0.0%	0.1%	1.7%	0.2%
Mobile - On-Road Gasoline Light Duty Vehicles	38.8%	22.9%	0.4%	1.4%	21.1%	3.3%
All emissions due to transportation %	***65.8%***	***69.0%***	***57.4%***	***42.0%***	***56.7%***	***6.1%***
Non-transportation related emissions %	***34.2%***	***31.0%***	***42.6%***	***58.0%***	***43.3%***	***93.9%***
% Yellowstone Co. emissions due to transportation	**CO**	**NO_x**	**PM_{10}-PRI**	**$PM_{2.5}$-PRI**	**SO_2**	**VOC**
Dust - Paved Road Dust	0.0%	0.0%	3.5%	3.6%	0.0%	0.0%
Dust - Unpaved Road Dust	0.0%	0.0%	48.1%	20.0%	0.0%	0.0%
Mobile - Aircraft	0.9%	0.6%	0.1%	0.1%	0.1%	0.1%
Mobile - Locomotives	0.5%	13.9%	0.3%	1.3%	0.2%	0.3%
Mobile - Non-Road Equipment - Diesel	0.9%	5.5%	0.4%	1.5%	0.2%	0.3%
Mobile - Non-Road Equipment - Gasoline	17.5%	0.6%	0.1%	0.5%	0.0%	2.7%
Mobile - Non-Road Equipment - Other	0.6%	0.5%	0.0%	0.0%	0.0%	0.0%
Mobile - On-Road Diesel Heavy Duty Vehicles	1.0%	14.7%	0.7%	2.7%	0.5%	0.4%
Mobile - On-Road Diesel Light Duty Vehicles	0.0%	0.3%	0.0%	0.1%	0.0%	0.0%
Mobile - On-Road Gasoline Heavy Duty Vehicles	2.5%	0.9%	0.0%	0.1%	0.0%	0.3%
Mobile - On-Road Gasoline Light Duty Vehicles	34.2%	14.5%	0.4%	1.1%	0.6%	4.5%
All emissions due to transportation %	***58.1%***	***51.6%***	***53.7%***	***30.9%***	***1.7%***	***8.6%***
Non-transportation related emissions %	***41.9%***	***48.4%***	***46.3%***	***69.1%***	***98.3%***	***91.4%***
% Gallatin Co. emissions due to transportation	**CO**	**NO_x**	**PM_{10}-PRI**	**$PM_{2.5}$-PRI**	**SO_2**	**VOC**
Dust - Paved Road Dust	0.0%	0.0%	4.8%	7.1%	0.0%	0.0%
Dust - Unpaved Road Dust	0.0%	0.0%	66.2%	39.4%	0.0%	0.0%
Mobile - Aircraft	1.0%	0.7%	0.1%	0.1%	4.1%	0.1%
Mobile - Locomotives	0.3%	12.7%	0.2%	0.9%	5.3%	0.1%
Mobile - Non-Road Equipment - Diesel	1.1%	11.4%	0.4%	2.3%	10.4%	0.2%
Mobile - Non-Road Equipment - Gasoline	17.5%	1.1%	0.2%	1.2%	0.5%	3.5%
Mobile - Non-Road Equipment - Other	0.7%	0.8%	0.0%	0.0%	0.3%	0.0%
Mobile - On-Road Diesel Heavy Duty Vehicles	1.1%	27.6%	0.6%	3.4%	24.6%	0.4%
Mobile - On-Road Diesel Light Duty Vehicles	0.0%	0.5%	0.0%	0.1%	0.7%	0.0%
Mobile - On-Road Gasoline Heavy Duty Vehicles	5.6%	3.8%	0.0%	0.1%	2.9%	0.3%
Mobile - On-Road Gasoline Light Duty Vehicles	39.2%	27.2%	0.4%	1.7%	29.4%	3.6%
All emissions due to transportation %	***66.6%***	***85.8%***	***72.9%***	***56.2%***	***78.0%***	***8.3%***
Non-transportation related emissions %	***33.4%***	***14.2%***	***27.1%***	***43.8%***	***22.0%***	***91.7%***
% Lewis and Clark Co. emissions due to transportation	**CO**	**NO_x**	**PM_{10}-PRI**	**$PM_{2.5}$-PRI**	**SO_2**	**VOC**
Dust - Paved Road Dust	0.0%	0.0%	4.1%	5.2%	0.0%	0.0%
Dust - Unpaved Road Dust	0.0%	0.0%	53.2%	27.0%	0.0%	0.0%
Mobile - Aircraft	1.1%	0.2%	0.1%	0.1%	2.3%	0.0%
Mobile - Locomotives	0.2%	9.7%	0.2%	1.1%	4.6%	0.0%
Mobile - Non-Road Equipment - Diesel	0.6%	6.5%	0.4%	2.1%	6.8%	0.1%
Mobile - Non-Road Equipment - Gasoline	12.5%	0.8%	0.3%	1.3%	0.4%	1.3%
Mobile - Non-Road Equipment - Other	0.2%	0.3%	0.0%	0.0%	0.2%	0.0%
Mobile - On-Road Diesel Heavy Duty Vehicles	1.1%	28.4%	1.2%	5.4%	29.1%	0.2%
Mobile - On-Road Diesel Light Duty Vehicles	0.0%	0.5%	0.0%	0.1%	0.8%	0.0%
Mobile - On-Road Gasoline Heavy Duty Vehicles	4.8%	3.4%	0.0%	0.1%	3.0%	0.1%
Mobile - On-Road Gasoline Light Duty Vehicles	36.4%	26.3%	0.7%	2.5%	32.4%	1.8%
All emissions due to transportation %	***57.0%***	***76.2%***	***60.3%***	***44.9%***	***79.4%***	***3.6%***
Non-transportation related emissions %	***43.0%***	***23.8%***	***39.7%***	***55.1%***	***20.6%***	***96.4%***

D. EMISSIONS CONTRIBUTIONS COMPARED WITH CHEMICAL MASS BALANCE MODELING

One of the validity comparisons that was made for the NEI emission estimates was to compare the on-road gasoline- and diesel-powered vehicles (and paved road dust) $PM_{2.5}$ emission contributions from the 2008 NEI with those from the recent Montana CMB studies that were summarized in Chapter II. In the comparisons, the street sand contribution from the CMB studies is compared with paved road dust $PM_{2.5}$ emission estimates for the county. Because the direct $PM_{2.5}$ emission estimates in the NEI are thought to over-estimate fugitive dust contributions to ambient air quality concentrations, transport factors were applied to the fugitive dust emissions before the contribution percentages were computed. Transport factors account for the percentage of fugitive dust emissions that are expected to contribute to ambient $PM_{2.5}$ concentrations in the area. These transport factors take into account the primary land cover in the area. The transport factors that are used in the analysis are the county-level transport factors that were used by EPA in its recent Regulatory Impact Analysis for the $PM_{2.5}$ NAAQS (EPA 2012p).

There are three source types in the CMB analyses that potentially represent transportation source contributions:

- Street sand;
- Automobiles; and
- Diesel.

Table VI-5 below shows how the NEI source categories were aligned with the CMB source types for these comparisons.

Table VI-5. Emission Source Applicability

CMB Emission Source	NEI Emission Source
Street Sand	Dust - Paved Road Dust
	Dust - Unpaved Road Dust
	Mobile - Aircraft
Diesel	Mobile - Locomotives
Diesel	Mobile - Non-Road Equipment - Diesel
	Mobile - Non-Road Equipment - Gasoline
	Mobile - Non-Road Equipment - Other
Diesel	Mobile - On-Road Diesel Heavy Duty Vehicles
Diesel	Mobile - On-Road Diesel Light Duty Vehicles
Autos	Mobile - On-Road Gasoline Heavy Duty Vehicles
Autos	Mobile - On-Road Gasoline Light Duty Vehicles

While the CMB source type labeled “Automobiles” is based on source profiles for light-duty vehicles and light-duty trucks, it really captures a gasoline engine/vehicle signature, so it may also reflect emission contributions from non-road gasoline engine/vehicles. However, the correspondence table above excludes non-road gasoline emissions from the comparisons that follow. If non-road gasoline engine/vehicle $PM_{2.5}$ emissions were included, the Automobiles percentage for the NEI could be as much as a percentage point higher in some counties.

The other key issue with processing the 2008 NEI emissions for the CMB comparisons was determining which of the fugitive dust sources (paved and unpaved roads) to include. It was decided that the Street Sand contribution from the $PM_{2.5}$ CMB analyses would be most directly comparable to paved road dust emissions. And the paved road dust emissions for each county have a transport factor applied to account for their expected contribution to ambient $PM_{2.5}$ levels. Unpaved road dust emissions were excluded from the comparison because they are less likely to be a $PM_{2.5}$ source during the Montana wintertime when the CMB studies are performed (and when the highest $PM_{2.5}$ levels are observed). Unpaved road emissions are negligible when there has been recent precipitation (or snow cover).

Table VI-6 shows the transportation source emissions versus CMB study comparison for four Montana areas.

Table VI-6. Transportation Source Emissions Comparison CMB Studies versus 2008 NEI Estimates

Comparison	CMB	NEI	*NEI - CMB*
Libby	$PM_{2.5}$-PRI	$PM_{2.5}$-PRI	*$PM_{2.5}$-PRI*
Street Sand	0.2%	2.9%	*2.7%*
Automobiles	4.5%	0.4%	*-4.1%*
Diesel	5.3%	4.2%	*-1.1%*

Comparison	CMB	NEI	*NEI - CMB*
Missoula	$PM_{2.5}$-PRI	$PM_{2.5}$-PRI	*$PM_{2.5}$-PRI*
Street Sand	0.9%	5.4%	*4.5%*
Automobiles	0.0%	1.5%	*1.5%*
Diesel	5.2%	4.9%	*-0.3%*

Comparison	CMB	NEI	*NEI - CMB*
Butte	$PM_{2.5}$-PRI	$PM_{2.5}$-PRI	*$PM_{2.5}$-PRI*
Street Sand	3.0%	2.8%	*-0.2%*
Automobiles	3.7%	1.9%	*-1.8%*
Diesel	0.2%	4.8%	*4.6%*

Comparison	CMB	NEI	*NEI - CMB*
Kalispell	$PM_{2.5}$-PRI	$PM_{2.5}$-PRI	*$PM_{2.5}$-PRI*
Street Sand	1.9%	5.2%	*3.3%*
Automobiles	0.8%	0.9%	*0.1%*
Diesel	7.2%	4.2%	*-3.0%*

Comparison	CMB	NEI	*NEI - CMB*
Average 4 NAAs	$PM_{2.5}$-PRI	$PM_{2.5}$-PRI	*$PM_{2.5}$-PRI*
Street Sand	1.5%	4.1%	*2.6%*
Automobiles	2.3%	1.2%	*-1.1%*
Diesel	4.5%	4.5%	*0.0%*

For the 4-county sample where 2008 NEI $PM_{2.5}$ emissions versus CMB comparisons were made, the results show that the emission-based percentage contribution to $PM_{2.5}$ levels are a reasonable estimator of the effect on transportation sources on $PM_{2.5}$ concentrations. In general, the NEI emission-based percentage contribution to $PM_{2.5}$ from street sand is slightly higher than what the CMB analysis suggests based on $PM_{2.5}$ concentrations (4.1 percent on average for the emission-based percentage contribution to $PM_{2.5}$ levels, compared to a 1.5 percent contribution from the $PM_{2.5}$ CMB analyses). For emissions related to automobiles, the difference is smaller, with 1.2 percent on average for the emission-based percentage contribution to $PM_{2.5}$ levels, compared to a 2.3 percent contribution from the $PM_{2.5}$ CMB analyses). Contributions from diesel are the same for the CMB studies and the 2008 NEI estimates. This is also the category with the highest contribution to $PM_{2.5}$ emissions. Therefore, the analyses that follow use the 2008 NEI emissions to estimate the potential benefit of applying available CMAQ measures in Montana areas.

E. MONTANA-SPECIFIC CMAQ MEASURE EMISSION REDUCTION POTENTIAL

Given the estimates of CMAQ emission reduction potential from the literature – which were presented in Table VI-1 and Table VI-2 – the county-specific emission reduction potentials were estimated by applying the measure-specific emission reductions to the 2008 NEI $PM_{2.5}$ emission estimates by source category – which were presented in Table VI-3 and Table VI-4. The 2008 NEI $PM_{2.5}$ emissions included in this calculation were only those from sources affected by the CMAQ strategy considered.

For instance, if we consider Traffic Flow Improvements in Missoula: the approach used to estimate the county-specific emission reduction potential is as follows:

1. Calculate the 2008 NEI $PM_{2.5}$ emission estimates from sources affected by Traffic Flow Improvements (i.e., on-road gasoline and diesel vehicles). Table VI-4 shows that $PM_{2.5}$ emissions for these 4 source categories account for 4.5 percent of total emissions in Missoula (2.9 percent for diesel heavy-duty vehicles + 0.1 percent for diesel light-duty vehicles + 0.1 percent for gasoline heavy-duty vehicles + 1.4 percent for gasoline light-duty vehicles).

2. Estimate the emission reduction potential for Traffic Flow Improvement strategies. Table VI-2 indicates that Congestion Relief and Traffic Flow Improvement can reduce $PM_{2.5}$ emissions by 1.0 percent.

3. Apply the measure-specific emission reductions of 1.0 percent to the 2008 NEI $PM_{2.5}$ emission estimates of 4.5 percent. The total CMAQ emission reduction potential for Traffic Flow Improvements in Missoula is thus 0.045 percent.

Summaries of these results by area are shown on the following page in Table VI-7.

The CMAQ measure emission reduction potential analyses show that the transportation sources that CMAQ projects seek to produce emission reduction benefits from offer limited air pollution emission reduction potential. Therefore, CMAQ strategy decisions should be based on more than just air quality considerations. A key consideration might be whether a proposed CMAQ project is consistent with the TIP for an area—with an emphasis on initiatives that reduce single occupant vehicle travel, or that improve traffic flow (which reduces emission rates) or reduce congestion (less vehicle idling).

Table VI-8 lists the CMAQ strategies in priority order for inclusion in Chapter VII analyses. By this, we mean that the top CMAQ strategies in Table VI-8 be the ones where we develop tools for the MDT and MPOs (and other local governments) to use to estimate the emission benefits and costs of CMAQ measures. It is important to note that the priorities below are based on an analysis for $PM_{2.5}$. However, some CMAQ measures can reduce all pollutants (typically, the strategies which reduce VMT), while others only reduce certain pollutants (for instance diesel particulate filters strongly reduce PM but have limited efficiency in reducing VOCs and CO). Therefore, the priorities shown in Table VI-8 could be revised if the capacity to reduce all pollutants is deemed essential.

The first priority would be to provide tools that can be used to evaluate congestion relief and traffic flow improvement options like traffic signal synchronization, which would reduce all pollutants. This is the type of measure where a combination of micro-simulation models (or their output) and MOVES 2010 can be used to greatly improve the emission benefits estimates from what was possible with previous models.

Efficient equipment purchase programs are the second priority on this list. This priority is due to the high PM emission reductions that can be achieved by street sweepers throughout Montana counties. Unlike traffic flow improvements though, street sweepers only reduce PM emissions.

Table VI-7. Estimated CMAQ Strategy $PM_{2.5}$ Emission Reduction Potentials by Montana County

	CMAQ Strategy	Missoula	Flathead	Rosebud	Lake	Sanders	Silver Bow	Lincoln	Cascade	Yellowstone	Gallatin	Lewis and Clark
1	Alternative Fuels	0.036%	0.022%	0.014%	0.024%	0.006%	0.048%	0.010%	0.034%	0.031%	0.042%	0.065%
2	Congestion Relief and Traffic Flow Improvement	0.045%	0.027%	0.017%	0.030%	0.008%	0.059%	0.013%	0.043%	0.039%	0.053%	0.082%
3	Transit Improvements	0.027%	0.016%	0.010%	0.018%	0.005%	0.036%	0.008%	0.026%	0.024%	0.032%	0.049%
4	Bicycle & Pedestrian	0.002%	0.001%	0.000%	0.001%	0.000%	0.002%	0.000%	0.001%	0.001%	0.002%	0.003%
5	Travel Demand Management	0.002%	0.001%	0.000%	0.001%	0.000%	0.002%	0.000%	0.001%	0.001%	0.002%	0.003%
6	Public Education and Outreach Activities	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%	0.000%
7	Carpooling and Vanpooling	0.003%	0.002%	0.001%	0.002%	0.000%	0.004%	0.001%	0.003%	0.002%	0.004%	0.005%
8	Freight/Intermodal	0.009%	0.005%	0.004%	0.006%	0.002%	0.012%	0.003%	0.009%	0.008%	0.010%	0.017%
9	Diesel Engine Retrofit	0.024%	0.021%	0.018%	0.016%	0.018%	0.023%	0.021%	0.029%	0.028%	0.033%	0.043%
10	Idle Reduction	0.010%	0.008%	0.007%	0.007%	0.007%	0.009%	0.008%	0.012%	0.011%	0.013%	0.017%
11	Equipment Purchase (Street Sweepers)	1.542%	0.929%	0.599%	1.031%	0.263%	2.051%	0.450%	1.485%	1.356%	1.818%	2.817%

Table VI-8. CMAQ Strategies Priority Ranking for Montana

Rank	Strategy
1	Congestion Relief and Traffic Flow Improvement
2	Equipment Purchase (Street Sweepers)
3	Diesel Engine Retrofit
4	Bicycle & Pedestrian
4	Carpooling and Vanpooling
4	Public Education and Outreach Activities
7	Idle Reduction
8	Alternative Fuels
8	Transit Improvements
8	Travel Demand Management
8	Freight/Intermodal

Diesel engine retrofits is third priority on the list mainly because some diesel retrofit technologies can also achieve significant $PM_{2.5}$ emission reductions when installed on engines that operate solely or primarily within the nonattainment area. There are many different types of diesel engines and applications that are retrofit candidates. The key is to identify ones that are most likely to produce emission reductions in the Montana areas where there is emission reduction potential. This is likely to result in small number of attractive diesel retrofit options for Montana—making this a lower priority in the overall ranking than indicated in Table VI-8.

Bicycle and pedestrian improvement projects, carpooling and vanpooling, and public education and outreach activities are fourth priority. These were given fourth priority because they are activities that have been pursued as Montana CMAQ projects historically and are likely to continue to be of interest to Montana areas in the future. However, significant emission benefits are not expected from these options for any single CMAQ project (public education and outreach activities are expected to yield emissions benefit only when in combination with another CMAQ strategy).

Idle reduction measures are seventh priority, with the caveat that only those idle reduction options that are likely to be effective in Montana areas be addressed. Truck stop electrification does not appear to be of interest because large truck stops are not located in or near Montana nonattainment or maintenance areas. Idle reduction options that are more likely to be successful in Montana communities include restricted idling times for diesel-buses or trucks, or providing funding for retrofitting trucks that operate primarily within a nonattainment area, or installing auxiliary power units on trucks that would otherwise idle at local distribution centers.

The lowest priority CMAQ strategies in Table VI-8 are ones estimated to have low emission reduction potential in the Montana areas of interest and are unlikely to be key parts of Montana area TIPs. These lowest priority CMAQ strategies are the ones that were excluded from further analysis or tool development.

Given that the EPA MOVES model can generate emission estimates and emission rates for all of the potential pollutants of interest, it is recommended that the pollutants that the FHWA CMAQ project database asks about be included in the emission reduction estimation. These pollutants are:

- VOC;
- CO;
- NO_x;
- PM_{10};
- $PM_{2.5}$; and
- Carbon dioxide (CO_2).

As described in the Chapter III, the tools described in Chapter VII will need to be designed to provide cost and cost effectiveness estimates for a range of CMAQ projects and pollutants. SC&A recommends that the following key parameters be used to develop cost and cost effectiveness estimates for CMAQ projects:

Discount Rate:	5 percent
Project Lifetime:	Use either Air Resources Board report values or estimates from consistent FHWA or Federal guidance documents.
Annualized Costs:	Formulas/templates will be provided to allow users to compute annualized costs given overall project costs (capital versus operating and maintenance where available) using the assigned discount rate and estimated project lifetime.
Cost per Ton:	Provide estimates by individual pollutant and for ozone precursor dollars per ton.

Any direct cost savings from the project, such as fuel savings, will be captured in the annualized cost estimate.

CHAPTER VII. MONTANA-SPECIFIC CRITERIA AND METHODS AND TOOLS

A. INTRODUCTION

Previous tasks performed on this project produced a prioritization of CMAQ measures that might be most worthwhile for Montana areas to consider. Based on this prioritization, SC&A developed a set of emission quantification spreadsheet tools that can be used by the MDT and local agencies within the state to estimate the emission reductions associated with these various CMAQ projects. An additional spreadsheet tool was developed by SC&A to estimate the cost effectiveness of these projects based on the emission reductions quantified in the emission tools. This chapter documents these emission spreadsheet tools as well as the cost template tool.

This chapter is organized in the five following sections. The name of the associated tool (Excel file) is also indicated:

- Traffic Flow Improvement Projects – Tool file: "Traffic Flow Improvement Emissions Benefit Quantification.xlsx";
- Street Sweeping Programs – Tool file: "Street Sweeper Emissions Benefit Quantification.xlsx";
- Road Paving Programs – Tool file: "Road Paving Emissions Benefit Quantification.xlsx";
- Vehicle-Miles-Traveled and Trip-Reduction Projects – Tool file: "Emissions Benefit Quantification from VMT and Trip Reduction Measures.xlsx"; and
- Cost-Effectiveness Estimates for Projects – Tool file: "Montana Cost Template Spreadsheet.xlsx".

Within each one of the first four sections of this chapter—which discuss the four different emissions benefit calculation tools—a consistent structure was used to organize the information. Each section starts with some background information regarding the type of projects that can be evaluated with the tool, along with a brief description of the general approach used to estimate emissions benefit. Detailed instructions on how to use the tool are then provided to help users understand which inputs are required. Finally, for a deeper understanding of how the tool was developed and to see which assumptions were used, readers can refer to the end of each section.

The only pollutant affected by street sweeping and road paving projects is PM, so the tools associated with those projects estimate emission benefits of PM_{10} and $PM_{2.5}$. For traffic flow improvement projects and projects reducing VMT or trips, all pollutants are affected, so the associated tools estimate emission benefits of the following pollutants: O_3 precursors (VOCs, NO_x, and CO), $PM_{2.5}$ (organic carbon, elemental carbon, sulfate particulate, brakewear, and tirewear), PM_{10} (all components), potential PM precursors [SO_2 and ammonia (NH_3)], as well as CO_2e. CO_2e is the metric measure used to compare emissions from GHGs based upon their global warming potential (GWP). The CO_2e for a gas is derived by multiplying the tons of the gas by the associated GWP. The MOVES model uses the following equivalents to calculate CO_2e emissions: CO_2 = 1 CO_2e, methane = 21 CO_2e and nitrous oxide = 320 CO_2e.

B. TRAFFIC FLOW IMPROVEMENT PROJECTS

1. Introduction

This section presents an approach for estimating the emissions benefits of traffic flow improvement projects. After describing briefly the general methodology used to develop the tool, this section outlines the tool's structure and discusses the user inputs in detail. Instructions on how to use the tool are also provided. Then, the types of projects that this tool was designed to evaluate are described. For a deeper understanding of how the tool was developed, readers can refer to section "4. TOOL DEVELOPMENT METHODOLOGY," which discusses issues related to pollutants, processes, and key parameters of the MOVES runs performed to develop emission rates.

Traffic flow improvement projects are projects that can be implemented to enhance the travel capability of a roadway system, without actually adding new roads or significantly widening existing roads. These projects typically fall under two categories: (1) projects primarily oriented to urban freeways or expressways and (2) projects oriented to arterial and local streets. Examples of such projects are provided in section "3. TYPICAL TRAFFIC FLOW IMPROVEMENT PROJECTS." Most traffic flow improvements are implemented with a focus on a peak period work trip. However, the applicability of many of these actions, such as the improvement of arterial signal systems, can easily be expanded to include traffic conditions throughout the day.

2. Emissions Benefit Quantification Tool

a. General Approach

A wide range of methods can be used to estimate the emission benefits of traffic flow improvement projects, ranging from simple methods to complex ones such as traffic micro-simulation. The methodology described below estimates the change in emissions that results from the average increase in travel speed after the traffic flow improvement has been completed. This tool has built-in calculations used for estimating the benefits of a traffic flow improvement project. The basic concept is to utilize a number of user-provided parameters to automatically estimate the emissions benefits. Users of the tool will not need to develop inputs to run the MOVES model or set up complex run specification files, since Montana-specific emission rates are provided in the tool. Based on simple user inputs, such as analysis year, road type, road grade, and average speed, the tool selects the appropriate emission rates, which are vehicle-specific, and can be used to calculate emissions before and after the traffic flow improvement project.

b. Overall Spreadsheet Structure

The structure of the emissions benefit quantification tool can be broken-down into the following sections:

- "Instructions" worksheet.
- "Tool" worksheet.
- Calculation Worksheets (hidden).
    - Emission Rates.
    - Default VMT Mix.

The "Instructions" worksheet serves two purposes: first, it provides a general description of the tool along with some important notes regarding its use. Then, it provides detailed steps that the user needs to take ("How to Use This Tool" guide) and describes the inputs that the user needs to supply.

The "Tool" worksheet allows users to define the project parameters and provides the resulting emissions benefits. This page is described in greater detail in the next section.

The calculation worksheets are designed to utilize the user-provided parameters and automatically generate the emissions benefit estimate. These pages are hidden and should not be revised by the user. To access emission rates, these worksheets can be revealed by right-clicking on any tab and selecting "Unhide."

c. Instructions to Use the Emissions Benefit Quantification Tool

The "Tool" worksheet allows users to define project parameters and provides estimates of resulting emissions benefits. These parameters are listed and described below.

Figures VII-1 through VII-3 illustrate the main tool worksheet. Figure VII-1 shows the user inputs section. Red cells in the worksheet indicate required inputs. To facilitate usability and improve user experience, a description and explanation of each specific cell is provided next to the input. For some required inputs, the user needs to click on a drop-down menu and select one of the options (for instance, the range of road grades is limited). When that is the case, a description and explanation of that specific cell pops up when the user clicks that cell. This is illustrated in Figure VII-2. By clicking on the arrow of the drop down menu, the list of options appears. This is illustrated in Figure VII-3.

When possible, cells that require inputs from the user have validation criteria. For instance, for the “Fraction of Annual Operating Days in each Season” input, users should enter fractions (i.e., values between 0 and 1). If they enter a different value, an error message will pop up. This will avoid erroneous inputs or format differences which could lead the formulas in the spreadsheet not to work. This is illustrated in Figure VII-4.

Key information that needs to be assembled before this tool can be used includes:

- Analysis Year;
- Road Type;
- Road Grade;
- Link Average Peak Hour Traffic;
- Number of Daily Peak Hours;
- Length of Link;
- Number of Days of Use per Year (of traffic controller or improvement);
- Average Speed [miles per hour (mph)] Before/After Signal Synchronization; and
- Fraction of Annual Operating Days in winter/summer.

General Project Information		
Analysis Year	2013	
Road Type	Urban Unrestricted	
Road Grade	0.0	
Link Average Peak Hour Traffic (all vehicle categories combined)	1500	
Daily Peaks Hours	6	
Are Link Peak Hour VMT Fractions available by MOVES Vehicle Category?	No	
Length of Link (estimate emissions benefits on each link separately)	2	
Number of Days of Use per Year (of traffic controller or improvement)	300	
Link Description (estimate emissions benefits on each link separately)	**Summer**	**Winter**
Average Speed (mph) ***Before*** Signal Synchronization	15.0	15.0
Average Speed (mph) ***After*** Signal Synchronization	20.0	20.0
Fraction of Annual Operating Days in each Season (must sum to 1).	0.65	0.35
Peak Hour VMT Fractions By Vehicle (select "No" in row 10, if unknown)	**Summer**	**Winter**
Passenger Car	0.537	0.537
Passenger Truck	0.284	0.284
Light Commercial Truck	0.095	0.095
Intercity Bus	0.001	0.001
Transit Bus	0.000	0.000
School Bus	0.001	0.001
Single Unit Short-haul Truck	0.028	0.028
Single Unit Long-haul Truck	0.004	0.004
Combination Short-haul Truck	0.020	0.020
Combination Long-haul Truck	0.029	0.029
Total Peak Hour Traffic By Vehicle Category - Default VMT Fraction	**Summer**	**Winter**
Passenger Car	4,833	4,833
Passenger Truck	2,560	2,560
Light Commercial Truck	855	855
Intercity Bus	10	10
Transit Bus	3	3
School Bus	12	12
Single Unit Short-haul Truck	253	253
Single Unit Long-haul Truck	36	36
Combination Short-haul Truck	179	179
Combination Long-haul Truck	259	259

Figure VII-1. User Inputs

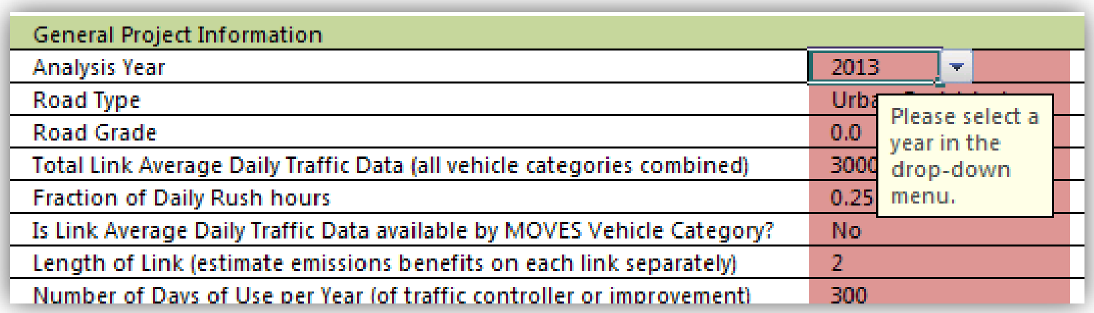

Figure VII-2. Drop-down Menu Options, Analysis Year Example (click on cell)

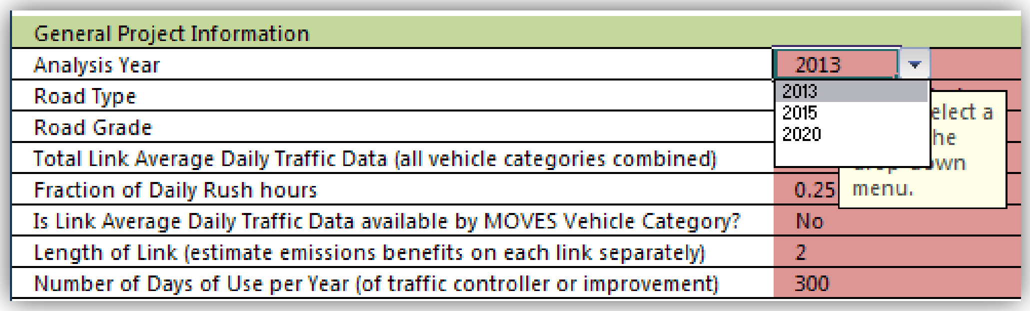

Figure VII-3. Drop-down Menu Options, Analysis Year Example (click on menu arrow)

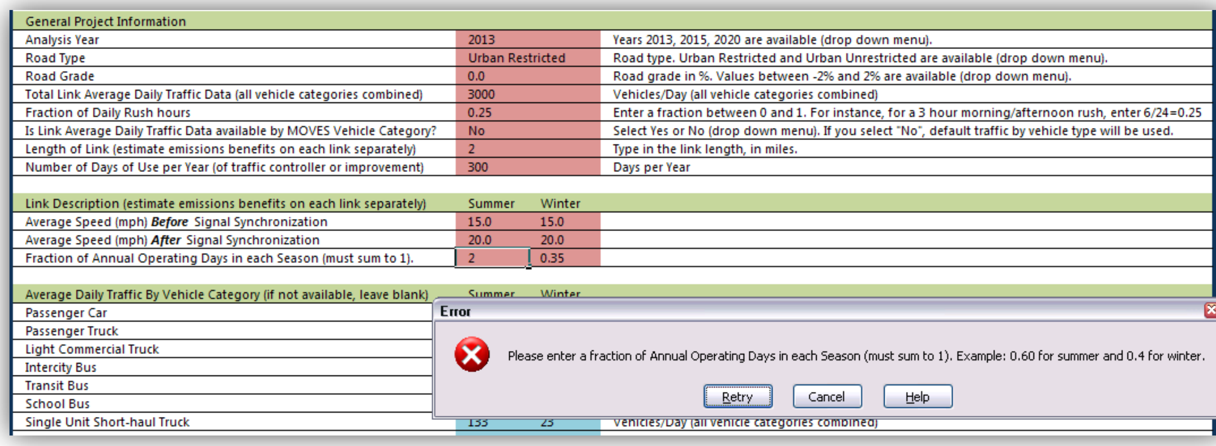

Figure VII-4. Example Error Message if Users Provide Incorrect Inputs

d. Step-by-Step How to Use Guide

The following 14 steps need to be followed to generate the emissions benefits. Please note that users may experience some waiting time during MS Excel calculations.

- Step 1. Enter "Analysis Year" (required input): years 2013, 2015, and 2020 are available. Emission rates and default average daily traffic (ADT) by vehicle category change depending on the year selected.
- Step 2. Enter "Road Type" (required input): urban restricted and urban unrestricted road types are available. Emission rates vary for a single speed (because the default MOVES driving cycles change based on road type).
- Step 3. Enter "Road Grade" (required input): road grade, in percentage. Values between -2 percent and 2 percent are available. Emission rates are very sensitive to road grade. If evaluating a road segment going in two directions with opposite grades, we recommend estimating emissions benefit for each direction separately.
- Step 4. Enter "Average Peak Hour Traffic" (required input): total number of vehicles driving on the link during each peak hour. As mentioned earlier, the tool assumes that the traffic flow improvement project will only impact emissions during peak hours. Therefore, traffic activity inputs should only include vehicles traveling during peak hours.

- Step 5. Enter "Daily Peak Hours" (required input): total number of peak hours in a day (number between 0 and 24). For instance, for a 3-hour morning and afternoon rush, enter the number 6.
- Step 6. Select "Yes" or "No" to indicate whether or not Link Peak Hour VMT Fractions are available by vehicle type (required input): indicate whether link traffic data are available by MOVES vehicle category or not. If not, default data are available.
- Step 7. Enter "Length of Link" (required input): link length, in miles.
- Step 8. Enter "Days of Use per Year" (required input): number of days of use per year (of traffic controller for instance). Enter 365 if the improvement is permanent.
- Step 9. Enter "Average Speed (mph) Before" (required input): average speed (mph) before signal synchronization (or other traffic flow improvement project). Average speeds between 5 mph and 45 mph (1 mph increments) can be selected.
- Step 10. Enter "Average Speed (mph) After" (required input): average speed (mph) after signal synchronization (or other traffic flow improvement project). Average speeds between 5 mph and 45 mph (1 mph increments) are available.
- Step 11. Enter "ADT by Vehicle Category" (optional input): ADT on link by MOVES vehicle category (if this is not available, leave cells empty, as defaults are available).
- Step 12. Enter "Fraction of Annual Days in each Season" (required input): fraction of annual operating days in each season (total of winter days and summer days fractions must sum to 1).
- Step 13. Emissions Benefits are automatically calculated: daily & annual emissions benefits are available in rows 45-63.
- Step 14. Additional information is available, if necessary: rows 65-106 provide daily & annual emissions before/after the project. Rows 107-302 provide emission rates before/after the project. Those rows are hidden by default, but can easily be revealed by clicking on the "+" sign to the left of the row number.

To estimate emissions benefits from a multiple-link traffic flow improvement project, the tool must be used multiple times (one link at a time). If local or more recent data become available, the accuracy of the tool can be improved by updating emission rates. Users would need to run the MOVES model with the appropriate inputs, and update the Montana-specific emission rates in the tab "Emission Rates" (currently hidden).

3. Typical Traffic Flow Improvement Projects

a. Arterial and Local Street Projects

An example of a traffic flow improvement project oriented to arterial and local streets is traffic signalization. Signal synchronization projects usually re-time traffic signals in various transportation corridors in order to improve traffic flow during peak traffic periods. A typical project involves upgrading all the traffic signals along a route to keep the signals synchronized, placing vehicle detectors in the pavement to detect the presence of vehicles, coordinating the timing of the signals between successive intersections, and automatically adjusting the traffic signals to facilitate the movement of vehicles through the intersections.

Traffic engineers can optimize traffic signal performance by varying cycle time, green splits, offsets and phase type, as well as sequencing. Cycle time is the total signal time to serve all of the signal phases including the green time plus any change interval. Longer cycles will accommodate more vehicles per hour but that will also produce higher average delays. Green splits indicate how long each phase will have the right of way (green indication). The term offset defines the time relationship (in seconds or as a percent of the cycle length), between coordinated phases at subsequent traffic signals. These variables may be controlled in pre-timed, actuated or adaptive traffic signal control systems. A brief description of each is provided below.

- In pre-timed signal controls, the cycle lengths, phases and intervals are preset. Each cycle of the pre-timed signal is exactly like any other, and all intervals, as well as phase times, are the same. The signal timing plans are developed off-line and the controller assigns the right-of-way to drivers at an intersection according to a pre-determined schedule. The sequence of the right of way assignments and length of the time interval of each signal indication in the cycle are fixed and based on historic patterns and experience. Signals thus operate according to preset timing plans.
- In actuated traffic signals, the right-of-way is assigned based on the actual traffic demand at the stop line, as registered by the actuation of vehicles and pedestrians. The signal indications are not of fixed length but are bounded by pre-set minima and maxima, which are invariant through the cycle. Actuated signals can be either semi- or fully actuated. Semi-actuated control provides for traffic actuation of all phases except the main phase, whereas the fully actuated control provides for traffic actuation for all phases. In times of congestion, when the intersection is over saturated, actuated control behaves identically to pre-timed signal control by defaulting to maximum cycle and phase lengths.
- In adaptive signal controls, no preset plans are specified in advance. Only the upper and lower bounds of cycle time, green splits and offsets are provided. The online algorithms are used along with real time data obtained from upstream loop detectors. The new signal timing plans are then computed dynamically based on prevailing traffic patterns so as to maximize the intersection's efficiency. These timing plans continually adjust cycle lengths, splits, offsets and phases to provide better progression. Thus, the adaptive traffic control system tracks any fluctuations in traffic demand online and then adapts signal timing plans dynamically.

b. Urban Freeway Projects

Examples of traffic flow improvement projects oriented to urban freeways or expressways include freeway on-ramp metering or freeway-to-freeway interchange ramp metering. Figure VII-5 shows an example of a test network for a simple ramp metering condition project. Ramp metering is the use of traffic signals at freeway on-ramps to manage the rate of vehicles entering the freeway. It allows one automobile at a time to drive through the green light creating a delay between cars, so that traffic merges at a steady pace. In estimating the emissions benefit of ramp metering for instance, the following links should be isolated: upstream (before ramp), ramp, merge area (right after ramp), and downstream (further away after ramp).

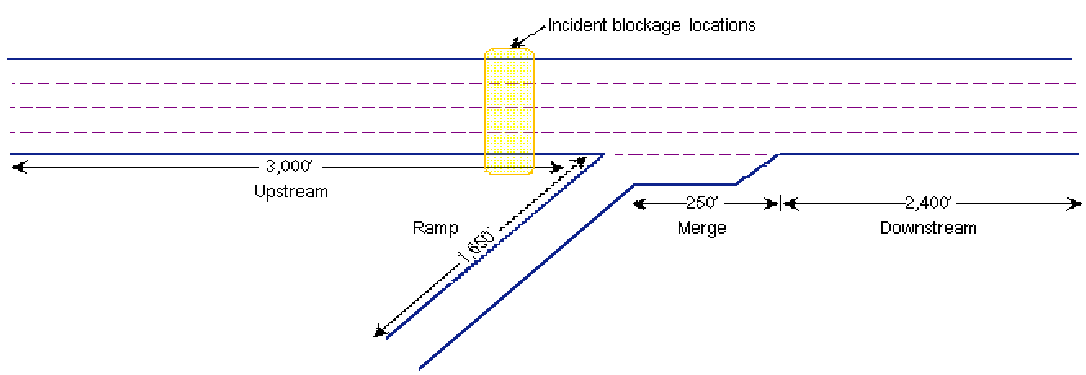

Figure VII-5. Example of Network Configuration for Ramp Metering

4. Tool Development Methodology

a. General Approach

The methodology described below estimates the change in emissions that results from the average increase in travel speed after the traffic flow improvement has been completed. Note that this tool is designed primarily for arterial and local street projects, since it only allows speeds up to 45 mph.

This tool has built-in calculations used for estimating the benefits of a traffic flow improvement project. The basic concept is to utilize a number of user-provided parameters to automatically estimate the emissions benefits. Users of the tool will not need to develop inputs to run the MOVES model or set up complex run specification files, since Montana-specific emission rates were already generated, and are included in the tool. Based on simple user inputs, such as analysis year, road type, road grade, and average speed, the tool selects the appropriate emission rates. These emission rates are vehicle-specific, and can be used to calculate total emissions before and after the project, based on VMT by vehicle type.

The tool was designed based on the underlying assumption that the traffic flow improvement project will only have an impact on emissions during peak hours (i.e., during off-peak hours, traffic is assumed to experience free-flow conditions, both before and after the project). Therefore, when estimating emissions benefits, the tool only considers traffic activity (number of vehicles, VMT fraction by vehicle type) during peak hours.

b. MOVES Runs Performed to Generate Montana Emission Rates

SC&A developed a database of Montana-specific emission rates by running the MOVES model at the project-level for a number of average speed and road grade combinations. The version of the model used for this project was MOVES2010b (version 2012/04/10) (EPA 2012r), and the corresponding default MOVES database was movesdb20120410. The sections below outline the selections for setting up the run specification files.

Modeling Scale Calculation Type – For project analyses such as signal synchronization, the modeling scale is the project scale (as opposed to county or national scale). While the project scale requires more detailed information at the link level, the resulting MOVES emission rates are much more accurate. Use of the inputs at the project level scale allows the user to fully define how travel is occurring on a specific roadway link.

Calculation Type – Within the project scale, MOVES can calculate emission inventories (total quantity of emissions for a given time) or emission rates (emissions divided by distance or population). Since this tool will be used to estimate emission benefits for a variety of projects, the emission rate calculation was selected to generate emission rate look-up tables. Users of the tool can just multiply those rates by the VMT to estimate total emissions benefits.

Time Spans – The MOVES time spans panel includes five sections: one to select the time aggregation level, and four to select specific years, months, days, and hours. The time aggregation level determines the amount of pre-aggregation of input data. At the project-level, the MOVES model can only calculate emissions for a single hour, day type, month, and year. Therefore, if multiple time periods need to be modeled for project analyses, then multiple MOVES runs need to be performed. After discussion with the MDT, it was agreed to perform MOVES runs for calendar years 2013 (base year), 2015, and 2020. In addition, since Montana experiences significant seasonal fluctuations and since mobile source emissions are temperature dependent, it was essential to capture the variations in emission rates throughout the year. The selected approach was to develop emission rates for the winter and the summer seasons. Winter is the time of the year that will most likely see the higher CO emission rates, while summer will most likely be the worst-case scenario for O_3. Annual emission rates can then be calculated based on the winter and summer rates. Table VII-1 summarizes the MOVES simulations performed.

Table VII-1. Montana MOVES Runs

Analysis Year	Summer Design Day (O_3)	Winter Design Day (CO)
2013	Summer p.m. peak (July, 4:00 p.m.–7:00 p.m.)	Winter a.m. peak (January, 6:00 a.m.–9:00 a.m.)
2015	Summer p.m. peak (July, 4:00 p.m.–7:00 p.m.)	Winter a.m. peak (January, 6:00 a.m.–9:00 a.m.)
2020	Summer p.m. peak (July, 4:00 p.m.–7:00 p.m.)	Winter a.m. peak (January, 6:00 a.m.–9:00 a.m.)

Geographic Bounds – Missoula County was selected to perform the Montana MOVES runs. This allowed a more direct access to some of the MOVES database default inputs which had to be used when local data was not provided by MDT.

Vehicle / Equipment – The vehicles/equipment panel of MOVES allows users to specify the vehicle types that need to be included in the MOVES run. A total of 13 source use types (i.e., vehicle types) are included in the model. For traffic flow improvement projects which typically reduce rush hour congestion, we estimated that motor homes, refuse trucks, and motorcycles would likely not comprise a significant portion of travel. We thus only included the other 10 MOVES vehicle categories including: Passenger Car, Passenger Truck, Light Commercial Truck, Intercity Bus, Transit Bus, School Bus, Single Unit Short-haul Truck, Single Unit Long-haul Truck, Combination Short-haul Truck, and Combination Long-haul Truck.

Road Types – The road type panel is used to define the types of roads that are included in the MOVES run. The five different Road Types included in the model are (1) Off-Network: locations where activity includes vehicle starts, vehicle parking, and idling; (2) Rural Restricted Access (rural highways that can only be accessed by an on-ramp); (3) Rural Unrestricted Access (all other rural roads); (4) Urban Restricted Access (urban highways that can only be accessed by an on-ramp); and (5) Urban Unrestricted Access (all other urban roads including arterials, connectors, and local streets). For traffic flow improvement projects, only road types 4 and 5 (Urban Restricted and Unrestricted Access) were included. Most projects modeled with this tool are expected to fall in the Urban Unrestricted Access road type category.

Pollutants and Processes – For these MOVES runs, the following pollutants were included: O_3 precursors (VOC, NO_x, and CO), $PM_{2.5}$ (organic carbon, elemental carbon, sulfate particulate, brakewear, and tirewear), PM_{10} (all components), and the potential PM precursors (SO_2 and NH_3), as well as, CO_2e. As mentioned earlier, since only driving links will be modeled, start and extended idling emission processes were not included. The MOVES model cannot model evaporative VOC emissions at the project-scale. Therefore, only running exhaust and crankcase running exhaust processes were modeled.

c. Project Inputs – MOVES Project Domain Manager

At the project level scale, the inputs are specified to the MOVES model via the Project Domain Manager. The inputs that need to be provided for use in a project level run are listed below.

Links – This input allows the user to define individual roadway links; average speeds by link in combination with link lengths, volumes, road types, and average grades. For our MOVES runs, the length and volumes were not important since emission rates were generated. However, we defined different links with different road types, average speed, and road grade combinations. That allowed us to limit the number of required MOVES runs. Average speeds between 5 mph and 45 mph are available (1 mph increments), and road grades between -2 percent and 2 percent are available (1 percent increments). A total of 410 links were thus defined (205 speed/grade combinations for 2 road types).

Link Source Type – This input allows the user to enter the fraction of the link traffic volume which is driven by each source type in a given hour. Again, since emission rates were generated, this input was not important.

Off Network – This input provides information about vehicles which are not driving on the project links, but still contribute to the project emissions while idling or starting. As mentioned earlier, since only driving links will be modeled, start and extended idling emission processes were not included. This input was thus not required.

Link Drive Schedule – This input allows the user to define the precise speed and grade for each second on a particular roadway link. Drive schedules were not provided so average speeds were used.

Operating Mode Distribution – This input allows the user to define project-specific distributions of vehicle activity by operating mode (e.g., cruise, acceleration, braking), speed group, and Vehicle Specific Power (VSP) group for each link. These were not provided for this project, so average speeds were used.

Meteorology – This input allows the user to import temperature and humidity data. Default MOVES data for Missoula County during the hours shown in Table VII-1 were averaged to obtain the temperature and humidity data that were used to model the peak hours.

Age Distribution – This input allows the user to enter data that provides the distribution of vehicle counts by age for each calendar year and vehicle type. Default data for Missoula County were used.

Fuel Formulation / Fuel Supply – This input allows the user to select an existing fuel in the MOVES database and change its properties as well as assign existing fuels to counties, months, and years. The MOVES default fuel supply and formulations data were used.

The MOVES inputs are summarized in Table VII-2.

Table VII-2. Summary of MOVES Run Specifications

Traffic Flow Improvement Project – MOVES Run Specifications		
Scale	Domain	Project
	Calculation Type	Emissions Rates
Time Spans	Aggregation	Hour
	Years	Base year = 2013 Projection years = 2015, 2020
	Months	January (winter season), July (summer season)
	Days	Week day
	Hours	1 hour only (HourID 8 for a.m. peak, HourID17 for p.m. peak)
Geographic Bounds		Missoula County (temperature and humidity are based on Missoula County default data)
Vehicle/Equipment		10 vehicle types (no motor home, refuse trucks, motorcycles)
Road Types		Road Types 4 and 5 (Urban Restricted and Unrestricted Access)
Pollutants		VOC, CO, PM_{10}, $PM_{2.5}$, NO_x, SO_2, NH_3, CO_2e
Emissions Processes		Running exhaust and crankcase running exhaust
Links Inputs		410 links: - 2 road types (Urban Restricted and Urban Unrestricted Access) - average speeds between 5 mph - 45 mph (1 mph increments) - road grades between -2% and 2% (1% increments)

C. STREET SWEEPING PROGRAMS

1. Introduction

This section presents the approach that SC&A used to develop the emissions benefit quantification tool for street sweeping programs. After describing briefly the general methodology used to develop the tool, this section outlines the tool's structure and discusses the user inputs in detail. Instructions on how to use the tool are also provided. Then, some of the typical street sweeping methods are described. For a deeper understanding of how the tool was developed, readers can refer to section "4. TOOL DEVELOPMENT METHODOLOGY," which discusses EPA's AP-42 equation, as well as the PM control efficiency assumptions used in this tool. However, users do not need to read section 4 in order to use this tool.

Street sweeping, either manual or mechanical, has been a common operation for municipalities for a long time. Street sweeping materials consisted of trash, dirt and vegetation. Aesthetics and sanitation were the two driving forces for municipalities to keep streets clean. In recent years, there has been a renewed focus on street cleaning activities, with some municipalities seeing it as a means to reduce road dust emissions and PM_{10} and improve air quality. Street sweepers generally fall into three categories: mechanical broom, regenerative-air, and vacuum high-efficiency units. Vacuum-assisted and regenerative-air sweepers are generally better than mechanical sweepers at removing finer sediments, while mechanical sweepers are better at removing larger debris (FHWA 2007). Montana typically buys mechanical broom sweepers, usually via the MACI Equipment purchase program.

2. Emissions Benefit Quantification Tool

a. General Approach

The methodology used to estimate emission benefits of street sweeping programs is described below. The tool estimates the change in particulate emissions from paved roads that results from the implementation of such programs. Emissions are calculated with EPA's AP-42 equation with and without street sweeping (EPA 2011c). The tool only requires five user inputs. For increased accuracy, users can provide another 10 optional inputs, but should these be unavailable, default values are included. Details regarding the emission factor calculations and inputs are offered below.

b. Overall Spreadsheet Structure

The structure of the emissions benefit quantification tool is broken-down into the following sections:

- "Instructions" worksheet;
- "Tool" worksheet; and
- "Calculations" Worksheet (hidden).

The "Instructions" worksheet serves two purposes. First, it provides a general description of the tool along with some important notes regarding its use. Then, it provides detailed steps that the user needs to take ("How to Use This Tool" guide) and describes the inputs that the user is required to supply.

The "Tool" worksheet allows users to define the project parameters and provides the resulting emissions benefits. This page is described in greater detail in the next section.

The "Calculations" worksheet is designed to utilize the user-provided parameters and automatically generate the emissions benefit estimate. This page is hidden and should not be updated by the user. To access the equations, assumptions, and default parameters, this worksheet can be revealed by right-clicking on any tab and selecting "Unhide."

c. Instructions to Use the Emissions Benefit Quantification Tool

The “Tool” worksheet allows users to define the project parameters and provides the resulting emissions benefits. These parameters are listed and described below.

Figures VII-6 through VII-8 illustrate the tool worksheet. Figure VII-6 shows the user inputs section, along with an example calculation. Blue cells in the worksheet indicate required inputs. To facilitate usability and improve user experience, a description and explanation of each specific cell is provided next to the input (not shown here). For some required inputs, the user needs to click on a drop-down menu and select one of the options (for instance, the average delay between applications of antiskid abrasive). When that is the case, a description and explanation of that specific cell pops up when the user clicks that cell. This is illustrated in Figure VII-7. By clicking on the arrow of the drop down menu, the list of options appears. This is illustrated in Figure VII-8.

When possible, cells that require inputs from the user have validation criteria. For instance, for the “Annual days with application of antiskid abrasive” input, users should enter a value that is lower than the total number of days in the winter months. If they enter a different value, an error message will appear. This will avoid erroneous inputs or format differences which could lead the formulas in the spreadsheet not to work. This is illustrated in Figure VII-9.

Required input. *Must be provided by users.*	
Optional input. *More accurate with user input but default value is provided.*	
Please do not change. *Output calculated by the tool.*	
Road Length (miles)	50
Road average daily traffic (ADT)	3000
Annual days with application of antiskid abrasive	20
Average delay between application of antiskid abrasive (days)	5
Is the road to be swept a limited access road?	No
Winter Months (with frozen precipitation)	4
Number of "wet" days during non winter months	62
Number of "wet" days during winter months	62
Vehicle Weight (tons):	2.0
PM10 Equipment Control Efficiency (%) - Silt Removal Only	80%
PM2.5 Equipment Control Efficiency (%) - Silt Removal Only	0%
Penetration Factor	100%
sL = road surface silt loading (g/m2) - baseline during non winter months	
sL = road surface silt loading (g/m2) - baseline during winter months	
sL = road surface silt loading (g/m2) - with antiskid abrasive	
sL = road surface silt loading (g/m2) - baseline during non winter months	0.200
sL = road surface silt loading (g/m2) - baseline during winter months	0.600
sL = road surface silt loading (g/m2) - with antiskid abrasive	2.600
Annual PM10 Emissions (Tons/yr) - no sweeping	60.8
Annual PM10 Emissions (Tons/yr) - with sweeping	24.8
Annual PM10 Reduction (Tons/yr)	36.0
Annual PM2.5 Emissions (Tons/yr) - no sweeping	14.9
Annual PM2.5 Emissions (Tons/yr) - with sweeping	14.9
Annual PM2.5 Reduction (Tons/yr)	0.0

Figure VII-6. User Inputs

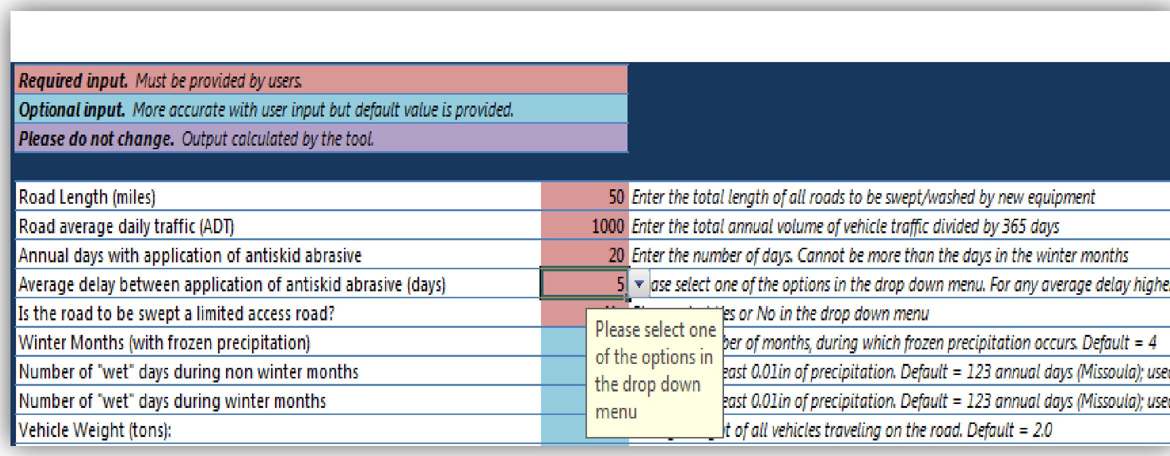

Figure VII-7. Drop-down Menu Options, Delay between Application of Antiskid Abrasive (click on cell)

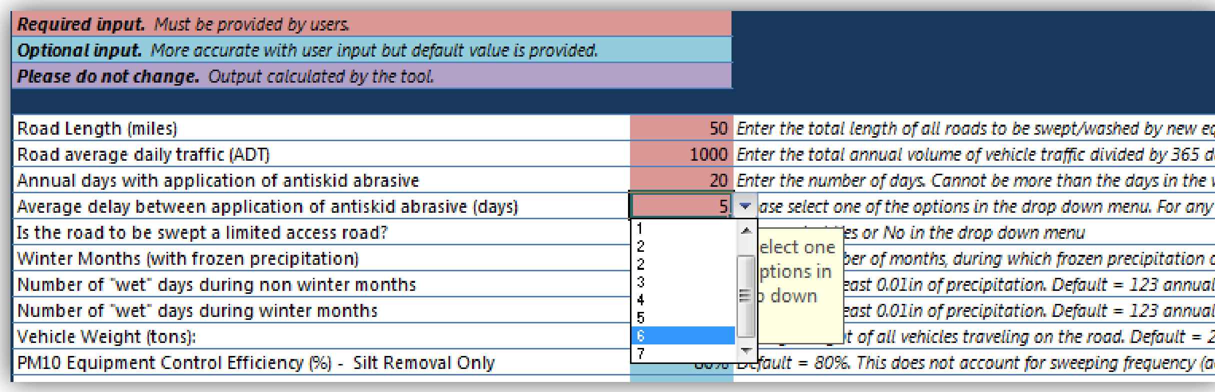

Figure VII-8. Drop-down menu options, Delay Between Application of Antiskid (click on menu)

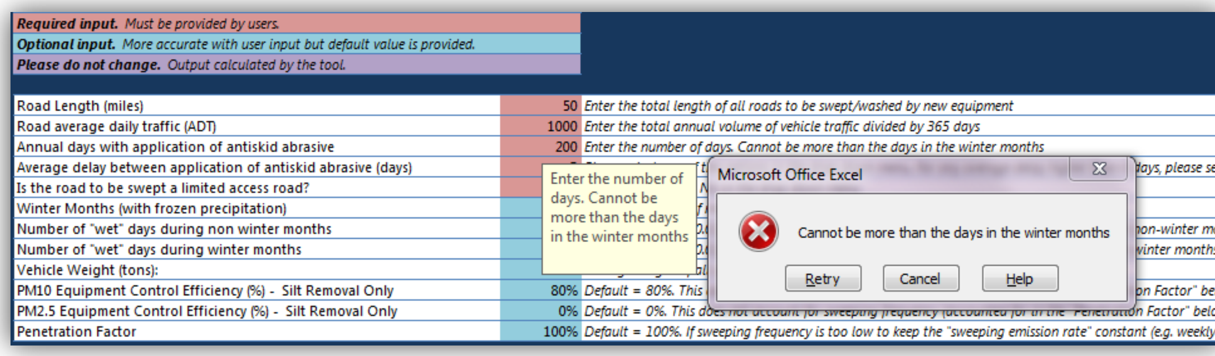

Figure VII-9. Example Error Message if Users Provide Incorrect Inputs

d. Step-by-Step How to Use Guide

The following 14 steps need to be followed to generate the emissions benefits.

- Step 1. Enter "Road Length" (Required): Enter the total length of all roads to be swept/washed by new equipment. This input should be entered in miles.
  Note: if estimating emissions benefits for a city, then we recommend breaking down the total length of the street sweeper route into sections with significantly different travel activity or vehicle fleet. Then, use the tool for each section individually (and sum up emissions benefits for all the sections). This is because average vehicle weight and ADT have an impact on emissions.
- Step 2. Enter "ADT" (Required): Enter the road ADT. This should be the total annual volume of vehicle traffic divided by 365 days.
- Step 3. Enter "Days with antiskid abrasive" (Required): Enter the number of annual days on which antiskid abrasive is applied to the road. This number cannot be more than the total number of days in the winter months.
- Step 4. Enter "Antiskid Abrasive Delay" (Required): Enter the delay between applications of antiskid abrasive (in days). Please select one of the options in the drop down menu.
- Step 5. Enter "Limited Access Road" (Required): Indicate whether the road to be swept is a limited access road. Please select Yes or No in the drop down menu.
- Step 6. Enter "Winter Months" (Optional): Enter the number of months during which frozen precipitation occurs. The default value for this input is 4 months.
- Step 7. Enter "Wet Days – non-winter months" (Optional): Enter the number of days during non-winter months with at least 0.01 inch of precipitation. The default value for this input was calculated based on a total of 123 annual days (for Missoula). Half of these 123 days were assigned to non-winter months (i.e., 62 days with precipitation in the spring, summer, and fall).
- Step 8. Enter "Wet Days - winter months" (Optional): Enter the number of days during winter months with at least 0.01 inch of precipitation. The default value for this input was calculated based on a total of 123 annual days (for Missoula). Half of these 123 days were assigned to winter months.
- Step 9. Enter "Vehicle Weight" (Optional): Enter the average weight of all vehicles traveling on the road. The default value for this input is 2.0 tons.
- Step 10. Enter "PM_{10} Control Efficiency" (Optional): Enter the PM_{10} Equipment Control Efficiency (percent) for silt removal. The default value for this input is 80 percent, as explained earlier. This does not account for sweeping frequency (accounted for in the "Penetration Factor" below).
- Step 11. Enter "$PM_{2.5}$ Control Efficiency" (Optional): Enter the $PM_{2.5}$ Equipment Control Efficiency (percent) for silt removal. The default value for this input is 0 percent, as explained earlier. This does not account for sweeping frequency (accounted for in the "Penetration Factor" below).
- Step 12. Enter "Penetration Factor" (Optional): Enter a penetration factor to account for the street sweeping frequency. The default value for this input is 100 percent, which indicates that the sweeping occurs frequently enough to maintain the emissions level “with sweeping” (as calculated by the AP-42 equation). If the frequency is too low to keep the emission rate “with sweeping”, then users need to reduce penetration factor (0 percent would indicate no sweeping). The minimum frequency would vary by area, road type, and traffic conditions but a typical sweeping frequency would be every 1 to 2 weeks. For less frequent sweeping, users should decrease the penetration factor.

- Step 13. Enter "Road Surface Silt Loading" (Optional): If available, enter local values for silt loading [grams per meter squared (g/m^2)]. Three values are needed: (1) non-winter baseline silt loading, (2) winter baseline silt loading, and (3) silt loading with antiskid abrasive. If these values are not available, users should leave these cells blank as the defaults are calculated based on traffic inputs.
- Step 14. Emissions Benefits are automatically calculated: Annual Emissions Benefits are automatically calculated, and available in rows 26-32.

3. Typical Street Sweeping Methods

a. Mechanical Broom Sweepers

Mechanical broom sweepers remove debris by sweeping material with gutter brooms back into the path of a pick-up broom. The pick-up broom then sweeps the material by moving it upward with a conveyor system into a hopper. These broom sweepers are generally used for coarse pollutant pick-up, not smaller particles. Also, the performance of these units decreases substantially on pavement with cracks and uneven sections. This is the type of street sweeping equipment that Montana typically buys, usually via the MACI Equipment purchase program.

b. Regenerative-Air Sweepers

Regenerative-air sweepers were designed to increase the removal of both large (not resuspendable) and small (resuspendable) materials on typical pavement with cracks or uneven sections where sediment would become lodged. To capture sediments, these sweepers are equipped with gutter brooms and a pick-up head. The gutter brooms direct materials towards the pick-up head. The regenerative-air process blows air into one end of the horizontal pick-up head and onto the pavement, dislodging materials entrained within cracks and uneven pavement. The other end of the pick-up head has a suction hose that immediately vacuums out the materials within the pick-up head into a hopper. While these units have significantly greater pick-up of soluble pollutants and fine road surface materials than mechanical sweepers, they are less efficient in picking up wet vegetation and large road debris.

c. Vacuum Sweepers

Vacuum sweepers were developed in the last two decades in an attempt to remove both the coarse and fine materials within typical pavement structure. These units have gutter brooms and strong vacuum heads for picking-up both large and small materials. While some models use water as a dust suppressor, others can operate in a dry mode. These units are believed to be more effective than regenerative-air and mechanical sweepers for pollutant removal, but like regenerative-air sweepers, they are less efficient in picking up wet vegetation and large road debris.

4. Tool Development Methodology

a. Emission Factor Equation

Particulate emissions occur when vehicles travel over a paved surface. Depending on the road surface characteristics and vehicle mix, the most significant emissions may arise from the surface material loading or a combination of engine exhaust, brake and tire wear emissions. In estimating paved road emissions, SC&A used the latest version of EPA’s AP-42 equation. This version of the paved road emission factor equation only estimates particulate emissions from re-suspended road surface material since the particulate emissions from vehicle exhaust, brake and tire wear, are now estimated separately using EPA's MOVES model. This approach eliminates the possibility of double counting emissions. The street sweeping efficiency is calculated as the ratio of paved road emissions eliminated by street sweeping to paved road emissions before sweeping.

The quantity of particulate emissions from re-suspension of material on the road surface due to vehicle travel on a paved road is estimated using the following equation (on a daily basis):

$$E_{ext} = [\ k\ (sL)^{0.91} \times (W)^{1.02}\ ]\ (1 - P/4N) \qquad \text{Eq. 1}$$

where:

E_{ext} = particulate emission factor (having units matching the units of k);
sL = road surface silt loading (g/m^2);
k = particle size multiplier for particle size range and units of interest;
W = average weight (tons) of the vehicles traveling the road;
P = number of "wet" days with at least 0.254 millimeters (mm) (0.01 inch) of precipitation during the averaging period; and
N = number of days in the averaging period (e.g., 365 for annual, 91 for seasonal, 30 for monthly).

According to EPA, the particle size multiplier k is 0.0022 pounds (lbs)/VMT for PM_{10} and 0.00054 lbs/VMT for $PM_{2.5}$. Table VII-3 presents default silt loadings for normal and winter baseline conditions (EPA 2011c). In addition to the ubiquitous baseline silt loading, EPA suggests that an additional (temporary) silt loading contribution of 2 g/m^2 occurs with each application of antiskid abrasive for snow and ice control. The tool accounts for this temporary peak, and assumes a linear decay to come back to baseline conditions, per EPA's guidance.

When calculating the impact of street sweeping on emissions, the tool assumes that no sweeping is performed on the days during which antiskid abrasive is applied for snow and ice control. However, the tool does assume that street sweeping may occur on the days after application of antiskid abrasive (during which additional silt loading may be present during the decay days). In addition, users should note that if the average delay (days) between applications of antiskid abrasive is less than the number of days required to return to a baseline condition (see Table VII-3), then annual emissions may be lower when antiskid abrasive is applied sooner (considering a fixed number of annual applications of antiskid abrasive). For instance, if the road traffic is 400 vehicles per day, then the number of days required to return to a baseline condition would be 7, per Table VII-3. In this situation, for a total number of 20 applications of antiskid abrasive during the year, total annual emissions would be lower for a delay of 2 days between applications, than for a delay of 4 days between applications. The underlying assumption is that if some of the additional silt loading from the temporary peak is still on the road at the time of a new application of antiskid abrasive, then the loading after the new application is the same as it would have been if the application had occurred after the road had returned to baseline conditions. As a result, there are fewer days with the additive contribution, causing overall emissions to be lower for a shorter period between applications if the number of applications has not changed. In other words, the number of days with the additional loading of antiskid abrasive is reduced.

Table VII-3. Silt Loading Default Values with Hot Spot Contributions from Anti-Skid Abrasives (g/m^2)

Silt Loading Default Values				
Road average daily traffic (ADT) Category	< 500	500-5,000	5,000-10,000	>10000
Ubiquitous Baseline g/m2	0.6	0.2	0.06	0.03
Ubiquitous Winter Baseline Multiplier during months with frozen precipitation	4	3	2	1
Initial peak additive contribution from application of antiskid abrasive (g/m2)	2	2	2	2
Days to return to baseline conditions (assume linear decay)	7	3	1	0.5

**For limited access roads, Ubiquitous Baseline = 0.015 g/m^2*

b. PM Control Efficiency

As discussed earlier, street sweeping is a management practice used to reduce the amount of fugitive dust re-entrained by traffic. However, when discussing sweeping efficiency, an important distinction must be made between efficiencies in dust removal and in air quality improvement (i.e., the capability to reduce ambient PM levels in the vicinity of the road). The "PM control efficiency" discussed below represents sedimented dust removal efficiency.

Efficiency for dust removal is expressed as a percentage of the removed street sediment mass with respect to the initial load. A testing protocol to certify sweepers for PM_{10} emissions was developed and some local governments require street sweepers to be PM_{10} efficient models. Obtaining PM_{10} certification indicated that a sweeper has achieved 80 percent pick-up efficiency on the test track and entrained PM_{10} particles are filtered adequately to not exceed the 200 milligram requirement based upon the ambient particulate air monitors (SCAQMD 1999). Generally, all brands of street sweepers in use today in the United States have achieved PM_{10} certification (Schilling 2005). Based on these findings, the default PM_{10} control efficiency for street sweepers was set to 80 percent in the tool. If more accurate data are available for a specific piece of equipment, this efficiency can be changed by users.

Unlike for PM_{10}, it is unclear if street sweepers are actually an efficient method for reducing $PM_{2.5}$. Limited literature exists regarding this specific subject (most research on PM control efficiency of street sweepers focuses on PM_{10}). In developing this tool, SC&A reviewed the literature, and also contacted street sweeping equipment manufacturers to assess $PM_{2.5}$ removal efficiency. In a recent paper, a team of researchers examined the $PM_{2.5}$ mass concentration and analyzed the effects of the meteorological variability, traffic flow and street washing activities. The results revealed that traffic flow is the most important factor that controls $PM_{2.5}$ hourly concentrations while street washing activities did not influence fine particle mass levels (Karanasiou 2012). In addition, in our multiple conversations with street sweeper original equipment manufacturers [including Brian Giles (Matos 2012a) from Elgin and Marjorie Strandlund from Python Manufacturing Inc. (Matos 2012b)], it became clear that sweepers are not, at this time, a proven method to reduce $PM_{2.5}$ emissions. Based on these findings, the default $PM_{2.5}$ control efficiency for street sweepers was set at 0 percent in the tool. Like PM_{10} control efficiency, this $PM_{2.5}$ efficiency can easily be changed by users.

D. ROAD PAVING PROGRAMS

1. Introduction

This section presents the approach that SC&A used to develop the emissions benefit quantification tool for road paving programs. After describing the overall methodology used to develop the tool, this section outlines the tool's structure and provides details regarding the user inputs required, as well as, instructions on how to use the tool. For a deeper understanding of how the tool was developed, readers can refer to section "3. TOOL DEVELOPMENT METHODOLOGY," which discusses the EPA's AP-42 equation for both unpaved roads, and paved roads.

Unpaved roads are a major source of dust. Particulate emissions occur when vehicles travel on unpaved roads due to pulverization of surface material caused by the force of the wheels on the road surface. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong air currents. The turbulence behind the vehicle continues to act on the road surface after the vehicle has passed (EPA 2006).

The quantity of dust generated on unpaved roads depends on several factors including the nature of the road's surface (such as gravel or dirt) and the traffic volume. Other important parameters include the vehicle characteristics, such as vehicle weight, the properties of the road surface material, such as moisture content, and the meteorological conditions, such as frequency of precipitation. Road paving is one of the most efficient methods of controlling dust from unpaved surfaces.

2. Emissions Benefit Quantification Tool

a. General Approach

The tool estimates the change in particulate emissions that results from a road paving project. The control efficiency of road paving is estimated by comparing emission factors for unpaved and paved road conditions. Emissions are calculated with EPA's AP-42 equation: chapter 13.2.2 for unpaved roads (EPA 2006), and chapter 13.2.1 for paved roads (EPA 2011c). The tool was designed to require only seven user inputs. For increased accuracy, users have the option of providing as many as nine other inputs to the emission equations, but should these not be available, default values are included.

b. Overall Spreadsheet Structure

The structure of the emissions benefit quantification tool is broken-down into the following sections:

- "Instructions" worksheet;
- "Tool" worksheet; and
- "Calculations" Worksheet (hidden).

The "Instructions" worksheet serves two purposes: first, it provides a general description of the tool along with some important notes regarding its use. Then, it provides detailed steps that the user needs to take ("How to Use This Tool" guide) and describes the inputs that the user is required to supply.

The "Tool" worksheet allows users to define the project parameters and provides the resulting emissions benefits estimates. This page is described in greater detail in the next section.

The "Calculations" worksheet is designed to utilize the user-provided parameters and automatically generate the emissions benefit estimate. This page is hidden and should not be updated by the user. To access the equations, assumptions, and default parameters, this worksheet can be revealed by right-clicking on any tab and selecting "Unhide."

c. Instructions to Use the Emissions Benefit Quantification Tool

The "Tool" worksheet allows users to define the project parameters and provides the resulting emissions benefits. These parameters are listed and described below.

Figures VII-10 through VII-12 illustrate the tool worksheet. Figure VII-10 shows the user inputs section, along with an example calculation. Blue cells in the worksheet indicate required inputs. To facilitate usability and improve user experience, a description and explanation of each specific cell is provided next to the input (not shown here). For some required inputs, the user needs to click on a drop-down menu and select one of the options (for instance, to indicate if the road to be swept is a limited access road). When that is the case, a description and explanation of that specific cell pops up when the user clicks that cell. This is illustrated in Figure VII-11. By clicking on the arrow of the drop down menu, the list of options appears. This is illustrated in Figure VII-12.

When possible, cells that require inputs from the user have validation criteria. For instance, for the "Winter Months" input, users should enter a value between 0 and 12. If a different value is entered, an error message will appear. This will avoid erroneous inputs or format differences which could lead the formulas in the spreadsheet not to work. This is illustrated in Figure VII-13.

Required input. *Must be provided by users.*	
Optional input. *More accurate with user input but default value is provided.*	
Please do not change. *Output calculated by the tool.*	
Road Length (miles)	3
Traffic Volume (vehicles/day)	80
Annual days with application of antiskid abrasive	20
Average delay between application of antiskid abrasive (days)	5
Is the road to be swept a limited access road?	No
Traffic Speed (mph)	25
Annual days with frozen precipitation	30
Winter Months (with frozen precipitation)	4
Number of "wet" days during non winter months	62
Number of "wet" days during winter months	62
Vehicle Weight (tons):	2.0
Unpaved Road Surface Silt Content (%)	6.4
Unpaved Road Surface Moisture Content (%)	0.5
Paved road surface silt loading (g/m2) - baseline during non winter months	
Paved road surface silt loading (g/m2) - baseline during winter months	
Paved road surface silt loading (g/m2) - with antiskid abrasive	
sL = road surface silt loading (g/m2) - baseline during non winter months	0.600
sL = road surface silt loading (g/m2) - baseline during winter months	2.400
sL = road surface silt loading (g/m2) - with antiskid abrasive	4.400
Annual PM10 Emissions (Tons/yr) - Unpaved Road	25.3
Annual PM10 Emissions (Tons/yr) - Paved Road	0.3
Annual PM10 Reduction (Tons/yr)	25.1
Annual PM2.5 Emissions (Tons/yr) - Unpaved Road	2.5
Annual PM2.5 Emissions (Tons/yr) - Paved Road	0.1
Annual PM2.5 Reduction (Tons/yr)	2.5

Figure VII-10. User Inputs

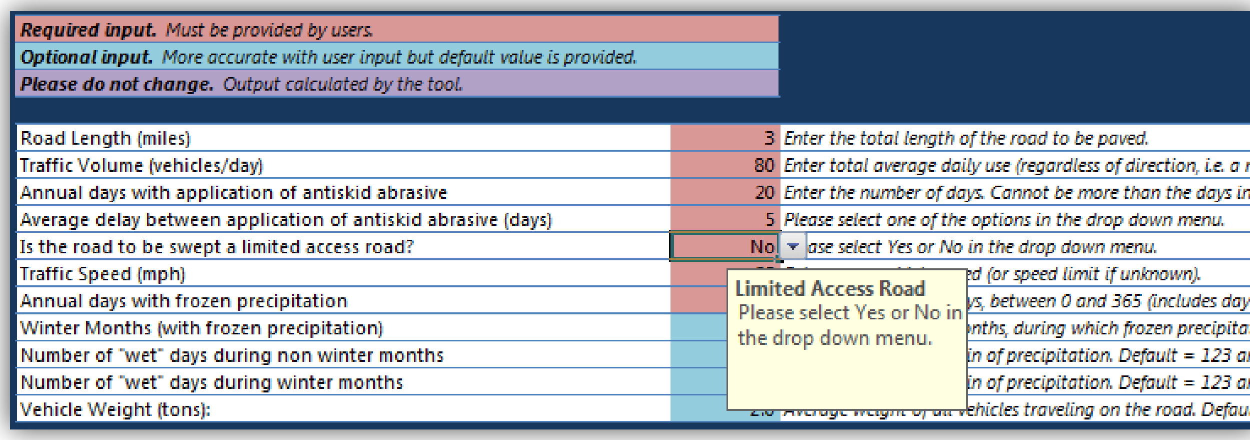

Figure VII-11. Drop-down Menu Options, "Is road a limited access road?" (click on cell)

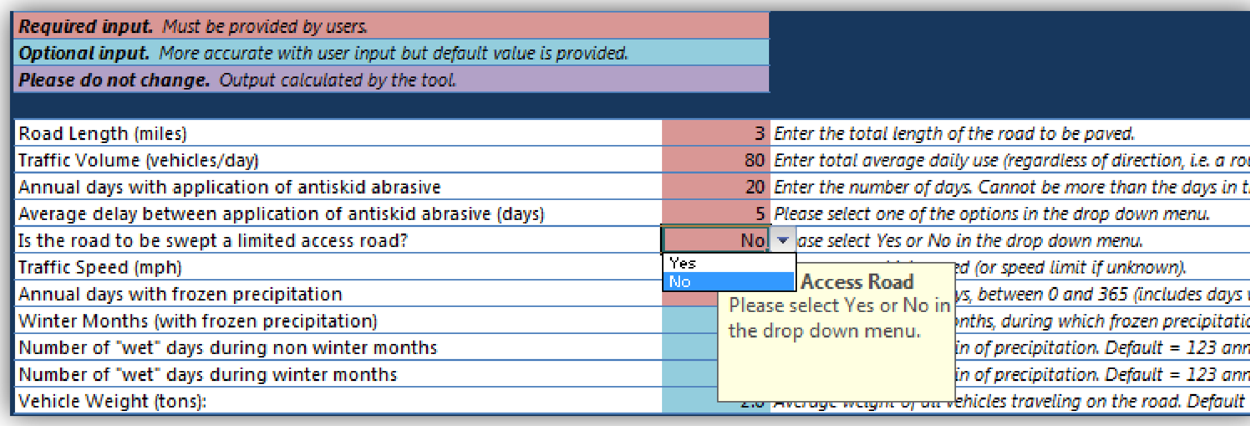

Figure VII-12. Drop-down Menu Options, "Is road a limited access road?" (click on menu)

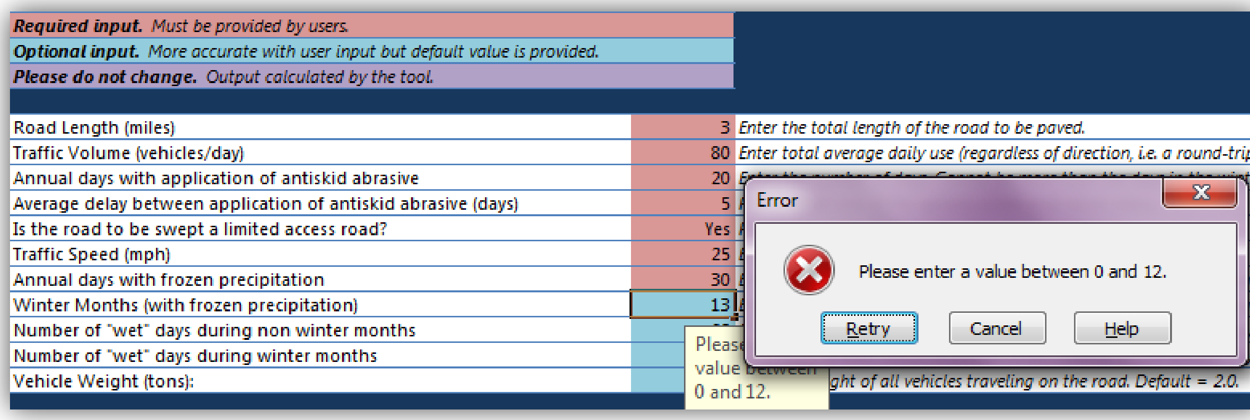

Figure VII-13. Example Error Message if Users Provide Incorrect Inputs

d. Step-by-Step How to Use Guide

The following 14 steps need to be followed to generate the emissions benefits.

- Step 1. Enter "Road Length" (Required): Enter the total length of the road to be paved. This input should be entered in miles.
- Step 2. Enter "Traffic Volume" (Required): Enter the total average daily use (regardless of direction, i.e., a round-trip is equivalent to 2 vehicles). This should be a number of vehicles/day.
- Step 3. Enter "Days with antiskid abrasive" (Required): Enter the number of annual days on which antiskid abrasive is applied to the road. This number cannot be more than the total number of days in the winter months.
- Step 4. Enter "Antiskid Abrasive Delay" (Required): Enter the time interval between applications of antiskid abrasive (in days). Please select one of the options in the drop down menu.
- Step 5. Enter "Limited Access Road" (Required): Indicate whether the road to be swept is a limited access road or a regular road. Please select Yes (for limited access) or No in the drop down menu.
- Step 6. Enter "Traffic Speed" (Required): Enter the mean vehicle speed, in mph (or speed limit if actual speeds are unknown).
- Step 7. Enter "Days with frozen precipitation" (Required): Enter the number of days with frozen precipitation, between 0 and 365 (includes days with antiskid abrasive). This number cannot be higher than the number of days in the winter months.
- Step 8. Enter "Winter Months" (Optional): Enter the number of months during which frozen precipitation occurs. The default value for this input is 4 months.
- Step 9. Enter "Wet Days – non-winter months" (Optional): Enter the number of days during non-winter months with at least 0.01 inch of precipitation. The default value for this input was calculated based on a total of 123 annual days (for Missoula). Half of these 123 days were assigned to non-winter months (i.e., 62 days with precipitation in the spring, summer, and fall).
- Step 10. Enter "Wet Days - winter months" (Optional): Enter the number of days during winter months with at least 0.01 inch of precipitation. The default value for this input was calculated based on a total of 123 annual days (for Missoula). Half of these 123 days were assigned to winter months.
- Step 11. Enter "Vehicle Weight" (Optional): Enter the average weight of all vehicles traveling on the road. The default value for this input is 2.0 tons.
- Step 12. Enter “Unpaved Road Surface Silt Content” (Optional): If available, enter the local value. A range is provided for this input (1.8 percent–35 percent). A default value is also provided, based on EPA guidance: 6.4 percent for gravel roads and 11 percent for dirt roads (EPA 2006). These values are not Montana-specific.
- Step 13. Enter “Unpaved Road Moisture Content” (Optional): If available, enter the local value. A range is provided for this input (0.03–13 percent). A default value is also provided, based on EPA guidance: 0.5 percent (EPA 2006). These values are not Montana-specific.
- Step 14. Enter "Road Surface Silt Loading" (Optional): If available, enter local values for silt loading (g/m^2). Three values are needed: non-winter baseline silt loading, winter baseline silt loading, and silt loading with antiskid abrasive. If these values are not available, users should leave these cells blank as the defaults are calculated based on traffic inputs.

- Step 15. Emissions Benefits are automatically calculated: Annual Emissions Benefits are available in rows 27–33.

3. Tool Development Methodology

a. Emission Factor Equation – Unpaved Roads

In estimating unpaved road emissions, SC&A used the latest version of EPA's AP-42 equation. This version of the unpaved public road emission factor equation only estimates particulate emissions from re-suspended road surface material. The particulate emissions from vehicle exhaust, brake wear, and tire wear are now estimated separately using EPA's MOVES model. Emissions from unpaved roads have been found to vary directly with the fraction of silt (particles smaller than 75 micrometers in diameter) in the road surface materials. Since the silt content of a rural dirt road will vary with geographic location, it should be measured for use in estimating emissions. However, if measurements are impossible, the silt content range and default values for gravel roads and dirt roads are provided in the tool, based on EPA documentation (these defaults are not specific to Montana).

The quantity of particulate emissions can be calculated by the following equation (for vehicles traveling on publicly accessible roads, dominated by light duty vehicles):

$$E = \frac{k\ (s/12)^a (S/30)^d}{(M/0.5)^c} - C \qquad \text{Eq. 2}$$

where:

E = size-specific emission factor (lbs/VMT);
k, a, b, c, d are empirical constants;
s = surface material silt content (percent);
M = surface material moisture content (percent);
S = mean vehicle speed (mph); and
C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear.

Table VII-4 below provides the values of the empirical constants (EPA 2006) and the PM_{10} and $PM_{2.5}$ emission factors for exhaust, brake wear and tire wear of a 1980's fleet (parameter C of the equation). Local and project-specific values should be used for s (surface material silt content), and M (surface material moisture content) to improve the accuracy of the emissions estimate. However, should these values not be available, default values are included in the tool.

Table VII-4. Unpaved Roads Emission Factor Equation – Empirical Constant Values

Equation Parameter	Value
k (lbs/VMT) - PM_{10}	1.8
k (lbs/VMT) - $PM_{2.5}$	0.18
a =	1.0
c =	0.2
d =	0.5
C (lbs/VMT) - PM_{10}	0.000470
C (lbs/VMT) - $PM_{2.5}$	0.000360

It is important to note that natural precipitation has an impact of emissions from unpaved roads. Since all roads are subject to this natural mitigation, the tool extrapolates the emissions estimated by equation (2) to annual emissions.

This is illustrated by the equation below (EPA 2006). The underlying assumption is that annual average emissions are inversely proportional to the number of days with measurable (more than 0.254 mm or 0.01 inch) of precipitation.

$$E_{ext} = E\ [(365 - P)/365] \qquad \text{Eq. 3}$$

where:

E_{ext} = annual size-specific emission factor extrapolated for natural mitigation (lbs/VMT);
E = emission factor from Equation 2; and
P = number of "wet" days with at least 0.254 mm (0.01 in) of precipitation during the averaging period.

b. Emission Factor Equation – Paved Roads

Particulate emissions occur when vehicles travel over a paved surface. Depending on the road surface characteristics and vehicle mix, the most significant emissions may arise from the surface material loading or a combination of engine exhaust, brake and tire wear emissions. In estimating paved road emissions, SC&A used the latest version of EPA's AP-42 equation. This version of the paved road emission factor equation only estimates particulate emissions from re-suspended road surface material since the particulate emissions from vehicle exhaust, brake wear, and tire wear are now estimated separately using EPA's MOVES model. This approach eliminates the possibility of double counting emissions.

The quantity of particulate emissions from re-suspension of material on the road surface due to vehicle travel on a paved road is estimated using the following equation (on a daily basis):

$$E_{ext} = [\ k\ (sL)^{0.91} \times (W)^{1.02}\ ]\ (1 - P/4N) \qquad \text{Eq. 4}$$

where:

E_{ext} = particulate emission factor (having units matching the units of k);
sL = road surface silt loading (grams per square meter) (g/m^2);
k = particle size multiplier for particle size range and units of interest;
W = average weight (tons) of the vehicles traveling the road;
P = number of "wet" days with at least 0.254 mm (0.01 in) of precipitation during the averaging period; and
N = number of days in the averaging period (e.g., 365 for annual, 91 for seasonal, 30 for monthly).

According to EPA, the particle size multiplier k is 0.0022 lbs/VMT for PM_{10} and 0.00054 lbs/VMT for $PM_{2.5}$. Table VII-5 presents default silt loadings for normal and winter baseline conditions (EPA 2011c). In addition to the ubiquitous baseline silt loading, EPA suggests that an additional (temporary) silt loading contribution of 2 g/m^2 occurs with each application of antiskid abrasive for snow and ice control. The tool accounts for this temporary peak, and assumes a linear decay to come back to baseline conditions, per EPA's guidance.

When calculating the impact of street sweeping on emissions, the tool assumes that no sweeping is performed in the days during which antiskid abrasive is applied for snow and ice control. However, the tool does assume that street sweeping may occur in the days after application of antiskid abrasive (during which additional silt loading may be present during the decay days). In addition, users should note that if the average delay (days) between applications of antiskid abrasive is less than the number of days required to return to a baseline condition (see Table VII-5), then annual emissions may be lower when antiskid abrasive is applied sooner (considering a fixed number of annual applications of antiskid abrasive). For instance, if the road traffic is 400 vehicles per day, then the number of days required to return to a baseline condition would be 7, per Table VII-5. In this situation, for a total number of 20 applications of antiskid abrasive during the year, annual emissions would be lower for a delay of 2 days between applications, than for a delay of 4 days between applications. The underlying assumption is that if some of the additional silt loading from the temporary peak is still on the road at the time of a new application of antiskid abrasive, then the loading after the new application is the same as it would have been if the application had occurred after the road had returned to baseline conditions. As a result, there are fewer days with the additive contribution, causing overall emissions to be lower for a shorter period between applications if the number of applications has not changed. In other words, the number of days with the additional loading of antiskid abrasive is reduced.

To estimate emissions benefits during one season only, users should adjust the number of winter months accordingly. For instance, to estimate winter emissions benefits only, users should enter "12" as the number of winter months. The tool will then perform calculations with the winter equations only. To compute the actual winter emissions benefits, use the tool's output, and multiply by the real ratio of winter to year months (e.g., if there are actually only 4 winter months, multiply the tool's output by 4 and divide by 12).

Table VII-5. Paved Road Silt Loading Default Values with Hot Spot Contributions from Anti-Skid Abrasives (g/m^2)

Silt Loading Default Values				
Road average daily traffic (ADT) Category	< 500	500-5,000	5,000-10,000	>10000
Ubiquitous Baseline g/ m2	0.6	0.2	0.06	0.03
Ubiquitous Winter Baseline Multiplier during months with frozen precipitation	4	3	2	1
Initial peak additive contribution from application of antiskid abrasive (g/ m2)	2	2	2	2
Days to return to baseline conditions (assume linear decay)	7	3	1	0.5

*For limited access roads, Ubiquitous Baseline = 0.015 g/m^2

E. VMT AND TRIP REDUCTION PROJECTS

1. Introduction

This section presents an approach for estimating the emissions benefits of projects designed to reduce VMT or trips. After a brief general methods description, the tool's structure is outlined and then user inputs are covered. Instructions on how to use the tool are also provided. Then, the types of projects that this tool was designed to evaluate are described. For a deeper understanding of how the tool was developed, readers can refer to section "4. TOOL DEVELOPMENT METHODOLOGY," which discusses issues related to pollutants, processes, and key parameters of the MOVES runs performed to develop emission rates.

VMT and trip reduction projects can include a number of different project types. Bicycle and pedestrian projects fall under this umbrella if the project results in trip mode shifts replace or reduce motorized vehicle trips with either bicycle or pedestrian trips. In addition, car and van pool programs are included if they result in removing or reducing vehicle trips. This also includes employer-based programs that promote car and vanpooling as well as employee trip reduction programs. Projects that entice drivers to switch to transit, such as park-and-ride facilities, bus station and bus stop improvements, transit service expansion, transit fare incentives, and transit priority systems for signalized intersections can all be modeled as VMT or trip reduction programs. Additional projects that can be modeled in this manner include regional car sharing, telecommuting, park-and-ride lots, and parking tax/pricing strategies. A generic template was built to evaluate the emission benefits of a variety of project types. This document discusses how the emission benefits of all of these types of programs can be estimated using the VMT and Trip Reduction Tool.

2. VMT and Trip Reduction Emissions Benefit Quantification Tool

a. General Approach

The emission benefits of the types of projects described above can all be evaluated by estimating the emissions associated with the base trip mode and subtracting the emissions from the new trip mode. In some cases, entire vehicle trips are replaced with trips from another mode. In these cases, the startup and running emissions from the base mode are eliminated. In other cases, the vehicle trip length is reduced, such as when replacing a single-occupant vehicle trip to work with a shorter trip to a bus stop followed by a bus trip, running emissions are reduced in proportion to the reduction in trip length, but the vehicle start-up emissions are not eliminated since the vehicle is driven to the bus stop. The replacement trip may either be a 0 emissions trip, such as for a pedestrian or bike trip, or a trip whose emissions must be accounted for, such as a car/vanpool trip or a bus trip.

To capture these variations, the user must supply information about the trips from the base mode that are being reduced—including the number of days that any of these mode shifts occur, number of trips reduced or eliminated per day, and the average distance of the trip reduced or eliminated. In addition, if the trips are being replaced by another type of motorized vehicle, then the same type of information must be supplied for the replacement trips, keeping in mind that only additional trips should be accounted for (e.g., buses would likely have some capacity for increased ridership that would not increase the number of bus trips; however, if a project significantly increases ridership or adds routes, then these additional bus trips must be accounted for). The tool also requires the user to specify the types of vehicles for which trips are being reduced or eliminated (e.g., passenger cars) as well as the type of replacement vehicles.

The tool will then estimate emissions of the base mode, using pre-generated MOVES startup and running emission rates, and subtract the emissions of the replacement modes, where applicable.

b. Overall Spreadsheet Structure

The structure of the emissions benefit quantification tool can be broken-down into the following sections:

- "Instructions" worksheet
- "Tool Inputs & Results" worksheet
- Calculation Worksheets (hidden)
  - Emission Rates
  - Calculations

The "Instructions" worksheet serves two main purposes: first, it provides a general description of the tool along with some important notes regarding its use. Then, it provides detailed steps that the user needs to take ("How to Use This Tool" guide) and describes the inputs that the user is required to supply.

The "Tool Inputs & Results" worksheet allows users to define the project parameters and provides the resulting emissions benefits. This page is described in greater detail in the next section.

The calculation worksheets are designed to utilize the user-provided parameters and automatically generate the emissions benefit estimate. These pages are hidden and should not be updated by the user. To access emission rates, these worksheets can be revealed by right-clicking on any tab and selecting "Unhide."

c. Instructions to Use the Emissions Benefit Quantification Tool

The "Tool Inputs & Results" worksheet allows users to define the project parameters and provides the resulting emissions benefits. These parameters are listed and described below.

Figure VII-14 illustrates the user inputs section of the worksheet. Red cells in the worksheet indicate required inputs. For some required inputs, the user needs to click on a drop-down menu and select one of the options (for instance, the range of available analysis years is limited). When that is the case, a description and explanation of that specific cell pops up when the user clicks that cell. By clicking on the arrow of the drop down menu, the list of options appears.

When possible, cells that require inputs from the user have validation criteria. For instance, for the "Fraction of Annual Operating Days in each Season" input, users should enter fractions (i.e., values between 0 and 1). If they enter a different value, an error message will pop up. This will avoid erroneous inputs or format differences which could cause the formulas in the spreadsheet not to work.

Key information that needs to be assembled before this tool can be used includes:

- Analysis Year and
- Affected Number of Operating Days per Year and the fractional number of operating days by season.

The following information is needed on the vehicles with VMT or trip reductions, by vehicle type (for vehicle types not affected by the project, these values should be populated with 0):

- Total number of trips starts eliminated per day and average length of the eliminated trips and
- Total number of trips per day with reduced VMT and the average decrease in mileage of such trips.

The following information is needed on the replacement vehicles or trips, by vehicle type:

- Total number of new trips starts added per day and the average length of these trips and
- Total number of replacement trips per day with increased VMT and average increase in VMT.

The following inputs are optional:

- The fractional road type mix of the affected VMT.

Activity Information - Required & Optional Inputs

General Project Information		
Control Strategy Name		
Control Strategy Description		
Analysis Year	2013	Years 2013, 2015, 2020 are available
Affected Number of Operating Days per Year	366	Days per Year
Fraction of Annual Operating Days in each Season (must sum to 1)		
Summer Fraction:	0.50	
Winter Fraction:	0.50	

	Eliminated Trips		Shortened Trips	
Affected Vehicle Types for VMT or Trip Reductions	Number of Trips Eliminated per Day	Average Length of Eliminated Trips (miles)	Number of Shortened Trips	Average Decrease in Mileage per Trip (miles)
Motorcycle	15	10.0	0	0.0
Passenger Car	25	15.0	500	15.0
Passenger Truck	0	0.0	0	0.0
Light Commercial Truck	0	0.0	0	0.0
Intercity Bus	0	0.0	0	0.0
Transit Bus	0	0.0	0	0.0
School Bus	0	0.0	0	0.0
Single Unit Short-haul Truck	0	0.0	0	0.0
Single Unit Long-haul Truck	0	0.0	0	0.0
Combination Short-haul Truck	0	0.0	0	0.0
Combination Long-haul Truck	0	0.0	0	0.0

	New Trips		Lengthened Trips	
Affected Vehicle Types for Replacement Trips	Number of New Trips Added per Day	Average New Trip Length (miles)	Number of Lengthened Trips	Average Increase in Mileage per Trip (miles)
Motorcycle	0	10.0	0	0.0
Passenger Car	15	50.0	0	0.0
Passenger Truck	0	0.0	0	0.0
Light Commercial Truck	0	0.0	0	0.0
Intercity Bus	0	0.0	20	30.0
Transit Bus	0	0.0	0	0.0
School Bus	0	0.0	0	0.0
Single Unit Short-haul Truck	0	0.0	0	0.0
Single Unit Long-haul Truck	0	0.0	0	0.0
Combination Short-haul Truck	0	0.0	0	0.0
Combination Long-haul Truck	0	0.0	0	0.0

Optional Road Type VMT Fractions	
Rural Restricted Access	0.000
Rural Unrestricted Access	0.000
Urban Restricted Access	0.500
Urban Unrestricted Access	0.500

Figure VII-14. User Inputs

d. Step-by-Step Instructions for Using the Tool

The following steps need to be followed to generate the emissions benefits.

- Step 1. Enter “Control Strategy Name” and “Control Strategy Description” (optional inputs). These inputs are useful for tracking the documenting and tracking the projects analyzed.
- Step 2. Enter "Analysis Year" (required input): years 2013, 2015, and 2020 are available. Emission rates change depending on the year selected.
- Step 3. Enter “Affected Number of Operating Days per Year” (required input): This represents the total number of days in a calendar year that the strategy will be implemented. For example, a weekday-only program might operate 260 days per year, whereas a seasonal weekday program (e.g., one adding bike or pedestrian modes) might only achieve vehicle trip start or VMT reductions 50 days per year.
- Step 4. Enter “Summer Fraction” and “Winter Fraction” (required input): These two inputs must sum to 1. Use the summer fraction to quantify the fraction of operating days whose meteorology is best represented by summer conditions and winter fraction to quantify the fraction of operating days whose meteorology is best represented by winter conditions. For example, if a project operates in the summer only, then the summer fraction should be filled in with 1 and the winter fraction with 0.

The inputs that are required for quantifying the change in base trips that are eliminated or shortened are listed below. All inputs are on a daily basis for a day in which the control measure will be operating. Count each trip separately (e.g., the trip from home to work and then from work to home should be considered as two separate trips).

- Enter "Number of Trips Eliminated per Day" (required input): This input represents the number of base case trips (on an operating day) that are completely eliminated due to the control measure. As an example, a daily vehicle trip from home to work and then from work to home that is eliminated and replaced by walking to a bus stop followed by a bus trip, eliminates two trip starts. However, if the commute trip is replaced by driving to the bus stop, then no trip starts are eliminated. Enter "Average Length of Eliminated Trips (miles)" (required input): The average length of base case trips (on an operating day) that are completely eliminated due to the control measure in miles.
- Enter “Average Length of Eliminated Trips (miles)” (required input): This input represents the average trip length associated with each trip eliminated.
- Enter "Number of Shortened Trips" (required input): The number of base case trips (on an operating day) that are not eliminated, but are shortened due to the control measure (e.g., a trip to a bus stop replacing a trip to work).
- Enter "Average Decrease in Mileage per Trip (miles)" (required input): The average decrease in the length of base case trips (on an operating day) that are not eliminated, but are shortened due to the control measure (e.g., for a trip to a bus stop replacing a trip to work, enter the difference in miles between the distance for the trip to work and the trip to the bus stop).

The following inputs are used to quantify the new trips that are added or base trips that are lengthened as a result of the control strategy. All inputs are on a daily basis for a day in which the control measure will be operating. Count each trip separately (e.g., the trip from home to work and then from work to home should be considered as two separate trips). A new trip might be a new vanpool trip while a lengthened trip might be a carpool trip where a driver is now driving an extra 4 miles per trip to pick up a passenger who previously drove to work separately.

- Enter "Number of New Trips Added per Day" (required input): The number of trips (on an operating day) that are added due to the control measure.
- Enter "Average New Trip Length (miles)" (required input): The average length of the new trips (on an operating day) that are added due to the control measure in miles.

- Enter "Number of Lengthened Trips" (required input): The number of trips (on an operating day) that are not new, but are lengthened due to the control measure (e.g., picking up a passenger on a trip to work).
- Enter “Average Increase in Mileage per Trip (miles)" (required input): The average increase in the length of trips in miles (on an operating day) that are not new, but are lengthened due to the control measure (e.g., for picking up a new passenger on the trip to work, enter the difference in miles between the distance for the base case trip to work and the new trip with the additional passenger pickup).

Optionally, the user may enter “Optional Road Type VMT Fractions” for each of four road types. The four available road types are: Rural Restricted Access, Rural Unrestricted Access, Urban Restricted Access, and Urban Unrestricted Access. It is expected that in most cases, the VMT fraction assigned to the rural road types will be 0. This input affects the speeds and operating modes at which the emission factors are calculated.

Daily and annual emissions benefits are automatically calculated and are available in rows 47-67.

3. Typical VMT and Trip Reduction Projects

A large variety of projects can ultimately be considered VMT and trip reduction projects. The ultimate goal of such projects is to reduce the number of light-duty vehicle trips, their length, or both. In some cases, these involve a mode shift, such as to bike, pedestrian, or transit mode. In other cases, trips are completely eliminated (e.g., telecommuting), or combined to increase the occupancy of vehicle trips (e.g., car and vanpooling). Thus, projects labeled as bicycle and pedestrian projects, carpooling and vanpooling projects, transit improvement projects, or travel demand management projects all fall in the category of projects that reduce VMT or trips. These projects are categorized below into three groups to better explain how to analyze these types of projects using the VMT and Trip Reduction Emissions Benefit Quantification Tool. In all cases, keep in mind that a trip is defined here as a single trip with a vehicle start and the accompanying VMT (e.g., a trip from home to work). Thus, a trip from home to work followed by the trip from work to home counts as two separate trips.

a. Projects that Eliminate Emission-based Trips

A number of projects are available that completely eliminate emissions from a given trip. This is accomplished by a mode shift to a zero-emissions mode, such a walking or bike riding, or by completely eliminating a trip, such as with telecommuting. Such projects eliminate both VMT and trip starts. Specific examples include: Bicycle and Pedestrian Striping, Bicycle Parking (e.g., next to government buildings), and Telecommuting.

To quantify the emission benefits from these projects, the number of daily light-duty vehicle trips that are completely eliminated and the average length of these trips must be estimated. The number of daily eliminated trips by vehicle type is entered into cells D15–D18 of the tool, and the corresponding average length of these eliminated trips in cells E15–E18. There may be cases where these projects just shorten trips rather than eliminate them. This would be the case when an auto trip is still taken to get to the start of a bike trip. In this instance, the number of these trips should be entered in cells F15–F18, and the difference in length between this trip and the original, auto-only trip should be entered in cells G15–G18.

For these projects, there are no replacement trips, so cells D29-G39 should all be filled with 0.

b. Projects with Transit Replacement Trips

Transit-based projects sometimes completely eliminate auto-based trips, while in other cases they shorten the auto-based trips. However, since the transit trips (assumed here to be buses) are not emission-free, the emissions from these replacement trips must be accounted for, if the project leads to additional bus VMT or additional bus trips. Examples of projects that fall in this group include park-and-ride facilities, bus station and bus stop improvements, transit service expansion, transit priority system for signalized intersections, and transit fare incentives program.

Additionally, projects to increase school bus ridership, thereby reducing student drop-offs/pick-ups and teens driving to school, would also be included in this group.

These strategies should lead to some trips being completely eliminated (in cases where the transit improvements enable a new passenger to ride transit with a zero-emission mode by arriving at the transit stop by walking or biking) and other trips with reduced VMT (in cases where auto trips are converted to an auto trip to a transit station followed by the transit ride). In some cases, if transit demand increases sufficiently such that additional bus trips are added, or if the route of an existing bus trip is increased, then the additional bus emissions must be accounted for.

To quantify the emission benefits from these projects, the number of daily light-duty vehicle trips that are completely eliminated and the average length of these trips by vehicle type are entered into cells D15–D18 of the tool, and the corresponding average length of these eliminated trips in cells E15–E18. In cases where an auto trip is used to get to a transit stop, the number of these trips should be entered in cells F15–F18, and the difference in length between this trip and the original, auto-only trip should be entered in cells G15–G18.

In cases where these projects lead to increases in bus VMT or bus trips, the additional bus emissions are modeled by appropriately filling in cells D33–E35 to account for new bus trips, and in cells F33–G35 to account for an increase in the length of a bus trip.

c. Projects that Increase Vehicle Occupancy

This third group of projects includes projects that increase vehicle occupancy, while reducing the number or length of auto-based trips. In some cases, a new trip may replace six separate auto-based trips as in the case of vanpooling. In other cases, there may be no new trips, when an existing auto trip takes on additional passengers. Examples of projects in this group include carpooling programs, vanpooling programs, regional car sharing, trip matching programs, and other employee trip reduction programs.

To quantify the emission benefits from these projects, the number of daily light-duty vehicle trips that are completely eliminated and the average length of these trips by vehicle type are entered into cells D15–D18 of the tool, and the corresponding average length of these eliminated trips in cells E15–E18. In cases where one or more vehicles meet in a central location and then continue on in a single vehicle, the number of shortened trips and the difference in trip length between the full trip and the trip to the meeting location is entered in cells F15–G18.

In cases where a replacement vehicle is used (e.g., a vanpool vehicle), the number of these replacement vehicles and the average length of these replacement vehicle trips should be entered in cells D29–E32. If a vehicle that was previously making a trip continues to make this trip, but now has a longer trip due to picking up passengers, the appropriate information would be entered in cells F29–G32.

4. Tool Development Methodology

a. General Approach

A wide range of methods can be used to estimate the emission benefits of traffic flow improvement projects, ranging from simple methods to complex traffic demand modeling. The methodology described below estimates the change in emissions that results from the average increase in travel speed after the traffic flow improvement has been completed. Note that this tool is designed primarily for arterial and local street projects, since it only allows speeds up to 45 mph.

This tool has built-in calculations used for estimating the benefits of a traffic flow improvement project. The basic concept is to utilize a number of user-provided parameters to automatically estimate the emissions benefits. Users of the tool will not need to develop inputs to run the MOVES model or set up complex run specification files, since

Montana-specific emission rates were already generated, and are included in the tool. Based on simple user inputs, such as analysis year, road type, road grade, and average speed, the tool selects the appropriate emission rates. These emission rates are vehicle-specific, and can be used to calculate total emissions before and after the project, based on VMT by vehicle type.

The tool was designed to estimate the changes in daily emissions due to changes in the number of trip starts and the changes in the number of vehicle miles traveled. Each trip start has associated start-up and some evaporative emissions, while exhaust, brakewear, tirewear, and some evaporative emissions are associated with the number of miles traveled.

These emission rates will differ by analysis year, season, vehicle type, and road type. When the spreadsheet is populated with analysis year, seasonal splits, road type mix, and activity by vehicle type, the vehicle start and miles traveled data are associated with the corresponding emission rate in grams per mile (for VMT) or grams per start (for trip starts). The tool then calculates the amount of emissions that are reduced from the specified project.

b. MOVES Runs Performed to Generate Montana Emission Rates

SC&A developed a database of Montana-specific emission rates by running the MOVES model at the national level for Missoula County. The version of the model used for this project was MOVES2010b (version 2012/04/10), and the corresponding default MOVES database was movesdb20120410. The sections below outline the selections for setting up the run specification files. These are summarized in Table VII-6.

Modeling Scale Calculation Type – For analyses of VMT and trip reduction strategies, such as carpooling or bike lane improvements, the modeling scale selected was the national scale (as opposed to county or project scale). While the county scale would be preferred, the necessary local inputs are not available; thus, the national scale uses EPA's default data for a single county.

Calculation Type – Within the national scale, MOVES can calculate emission inventories (total quantity of emissions for a given time) or emission rates (emissions divided by distance or population). In order to capture emission variations over the period of a day, and to separate start emissions from running emissions, the inventory mode was selected. However, using the resulting daily emissions and activity data, emission rates per vehicle start and per VMT were calculated for use in the tool.

Time Spans – The MOVES time spans panel includes five sections: one to select the time aggregation level, and four to select specific years, months, days, and hours. The time aggregation level determines the amount of pre-aggregation of input data. The hourly level of pre-aggregation was selected in order to obtain evaporative emissions, which can only be calculated at the hourly level, and to account for temperature variations over the period of a day, which can have a significant impact on particulate and VOC pollutants, as well as a smaller impact on the other pollutants. Separate runs were developed for each of three calendar years—2013 (base year), 2015, and 2020. In addition, since Montana experiences significant seasonal fluctuations and since mobile source emissions are temperature dependent, it was essential to capture the variations in emission rates throughout the year. The selected approach was to develop emission rates for the winter and the summer seasons. Winter is the time of the year that will most likely see the higher CO emission rates, while summer will most likely be the worst-case scenario for O_3. Annual emission rates can then be calculated based on the winter and summer rates. Emissions were calculated based on weekday activity patterns. Table VII-6 summarizes the MOVES simulations performed.

Geographic Bounds – Missoula County was selected to represent the urban areas in Montana for these MOVES runs.

Vehicle / Equipment – The vehicles/equipment panel of MOVES allows users to specify the vehicle types that need to be included in the MOVES run. A total of 13 source use types (i.e., vehicle types) are included in the model. All feasible combinations of these source use types using gasoline or diesel fuel were modeled.

Road Types – The road type panel is used to define the types of roads that are included in the MOVES run. The five different Road Types included in the model are (1) Off-Network: locations where activity is vehicle starts, parking, and idling; (2) Rural Restricted Access (rural highways that can only be accessed by an on-ramp); (3) Rural Unrestricted Access (all other rural roads); (4) Urban Restricted Access (urban highways that can only be accessed by an on-ramp); and (5) Urban Unrestricted Access (all other urban roads including arterials, connectors, and local streets). All road types were selected for the modeling. Start and some evaporative emissions are allocated in MOVES to the off-network road type.

Pollutants and Processes – For these MOVES runs, the following pollutants were included: O_3 precursors (VOC, NO_x, and CO), $PM_{2.5}$ (organic carbon, elemental carbon, sulfate particulate, brakewear, and tirewear), PM_{10} (all components as well), and the potential PM precursors (SO_2 and NH_3), as well as, CO_2e. As mentioned earlier, since only driving links will be modeled, start and extended idling emission processes were not included. The MOVES model cannot model evaporative VOC emissions at the project-scale. All types of start, running, and evaporative processes were selected for these pollutants, with the exception of extended idling exhaust emission processes.

Output Selections – In order to be able to calculate start and running emission rates, the activity data selected to be included in the MOVES output file were distance traveled and starts. Additionally, the resulting emissions were aggregated to a 24-hour day, with emissions separated by emission process, road type, and source use type. This will allow emission rates to be calculated for start and running emissions, and with separate emission rates for each road type and source use type combination.

Table VII-6. Summary of MOVES Run Specifications

Traffic Flow Improvement Project – MOVES Run Specifications		
Scale	Domain	National
	Calculation Type	Inventory
Time Spans	Aggregation	Hour
	Years	Base year = 2013 Projection years = 2015, 2020
	Months	January (winter season), July (summer season)
	Days	Week day
	Hours	All 24 hours of the day
Geographic Bounds		Missoula County (temperature and humidity are based on Missoula County default data)
Vehicle/Equipment		All possible combinations of source use type with gasoline and diesel fuel
Road Types		All road types
Pollutants		VOC, CO, PM_{10}, $PM_{2.5}$, NO_x, SO_2, NH_3, CO_2e
Emissions Processes		Running exhaust, start exhaust, brakewear, tirewear, evap permeation, evap fuel vapor venting, evap fuel leaks, crankcase running exhaust, and crankcase start exhaust
Output	Activity	Distance traveled, starts
	Emissions	24-hour day, emission process, road type, source use type

F. USING THE MONTANA COST TEMPLATE SPREADSHEET

The information in this section and the associated spreadsheet allow the user to estimate the overall cost effectiveness (on a cost/ton basis) of various emissions reduction projects. This allows projects to be compared on an equivalent basis. This spreadsheet includes four tabs: Project Costs, Capital Recovery Factors, Cost Indexing, and Pollutants.

The **Project Costs** tab has several cells highlighted in blue for user inputs. In order to perform a cost/ton calculation, the user will need to provide inputs for Project Lifetime, Project Cost Year, Capital Cost, Annual Operations and Maintenance costs, other costs, cost savings, and a discount rate. For more detail on what information is needed for each of these inputs, see the Glossary of Terms below. A default discount rate is set at 5 percent, but this can be adjusted up or down by the user. The output of the Project Cost tab is the Annualized Project Cost figure. This is calculated based on the CRF. This annualized cost figure is then converted from the dollars of the project cost year to 2012 dollars using the Bureau of Labor Statistics (BLS) Consumer Price Index (CPI), which adjusts for the impact inflation has on the value of a dollar. The CPI was selected because it provides a projection through the year 2030, whereas most other price indexes only show historical values. The final output of the Project Cost tab is the Annualized Project Cost expressed in 2012 dollars.

The **Capital Recovery Factors** and **Cost Indexing** tabs both contain lookup tables for expressing the time value of money. There are no user inputs or outputs on these pages, and in general the user should not make any changes to these spreadsheets. If a different discount rate is desired, then that change should be made on the Project Costs tab.

The **Pollutants** tab allows the user to input emission reductions in order to calculate the cost effectiveness (on a cost/ton basis) of a given project or program. Column C shows the annualized project cost value which was calculated in the earlier Project Costs tab. This information is pulled automatically from that tab and should not be input by the user. In Column D, the user needs to add the annual emissions benefit of each pollutant, as estimated in the appropriate tool. In Column E, the values from Column C and D are used to calculate the Annualized Cost/Ton for each pollutant. These are all cost effectiveness values by pollutant, with the exception of the O_3 precursor cost per ton, which includes both VOC and NO_x emission reductions.

Glossary of Terms

Annual Cost Savings – Any annual savings that can be attributed to the project, such as fuel savings.

Annualized Cost – This is the annual cost averaged over the lifetime of the project.

Annualized Cost (2012 dollars) – If a year other than 2012 is entered for the Project Cost Year, then the Annualized Cost will be converted to reflect 2012 dollars.

CRF – A CRF converts a present value into a stream of equal annual payments over a specified time, at a specified interest/discount rate. This figure is calculated based on the following formula, where i=interest/discount rate and n= Project Lifetime.

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1} \qquad \text{Eq. 5}$$

CPI – Every month the BLS updates the CPI, to estimate changes in the prices paid by urban consumers for a representative basket of goods and services. The CPI is used to demonstrate the impact inflation has on the value of a dollar. Future inflation rates for 2013–2030 are estimated by the Seattle City Budget Office using The Puget Sound Economic Forecaster.

Interest Rate / Discount Rate – The annual rate of interest a borrower is charged when they borrow money. For example, with a 5 percent discount rate, a loan of $100 would require the borrower to pay back $105 one year from now.

O_3 Precursors – This is the sum of NO_x and VOC emissions, both of which contribute to the formation of ground level O_3.

Project Lifetime (Years) – This is the number of years for which a project will last and over which any emissions reductions should be expected. If this information is not available, then Table VII-7 may provide a default project lifespan for different project types.

Table VII-7. Assumed Project Lifespans for Different Project Types

Project Lifespan	Types of Projects
1–2 Years	Existing Transit Service Improvement Travel Demand Management Programs Ridesharing Programs Vanpool Programs Pricing/Fare Strategies
4–5 Years	Telework Programs Paratransit Vehicles
10–12 years	Roadway Signal Systems Freeway Management Systems New Buses Alternative Fueled Buses Sidewalk or Bike Facilities Street Sweepers
20 years	Roadway Improvements Rail Signalization
30–35 years	Rail Transit Systems Parking Structures Locomotive Rail Cars Pavement Improvements Bridge Improvements

Project Cost Year – This is the year in which all money was spent on this project. If a project was funded over multiple years, choose the year which best represents the average of when that money was spent.

CHAPTER VIII. RECOMMENDATIONS

Based on the findings of this research, the following recommendations are offered to MDT:

1. **Concentrate MACI discretionary funding in high-risk areas, based on DEQ requisites.** The normalized community risk values in the final project report can be used by MDT to determine which areas of the state are likely to benefit the most by investments that reduce transportation source emissions that contribute to observed air quality concentrations in the state.

2. **Continue efficient equipment purchase programs.** Continue to purchase street sweepers and other air quality equipment to replace current equipment in areas where this equipment has been effective in bringing PM_{10} concentrations below the NAAQS. Program expansion is not warranted given CMB study findings of sand/salt contributions to $PM_{2.5}$ measurements. In addition, street sweeping is not likely to be an effective $PM_{2.5}$ emission reduction option.

3. **Invest in congestion management options that achieve significant improvements in average speed (> 10 mph).** Traffic flow/intersection channelization improvements will likely achieve the highest emission reductions in Montana. Use of operational strategies provides a toolbox of alternatives that can be implemented to mitigate growing congestion. The benefits of successful operational strategies are multiple – faster, more reliable trips, improved safety, and reduced environmental impacts. Traditional arterial signal systems operate with fixed timings based upon expected volumes during certain portions of the day. Adaptive signal control technologies can adjust to handle varying traffic conditions that may differ from fixed-time operations to improve traffic flow.

4. **Consider more than just air quality benefits when evaluating CMAQ-eligible projects.** Based on Montana's nonattainment areas and what this study found about the culpable sources for nonattainment, on-road vehicle control strategies would be expected to provide limited air quality benefits in Montana areas. The focus of CMAQ funding should be on measures that help maintain attainment status in the areas/pollutants where transportation sources are most important. While air pollution emission reductions are an important attribute of CMAQ funding decisions for Montana, the lack of any strong transportation influence on existing or expected future Montana nonattainment problems means that the MDT will want to also consider variables other than air quality impact when selecting projects for CMAQ funding.

5. **Use the provided tools to estimate benefits of CMAQ-eligible projects.** The tools (in MS Excel) allow MDT to estimate the emission reductions and cost effectiveness of CMAQ/MACI measures and projects. These tools use EPA's latest guidance (AP-42) and the latest approved emission factor model (MOVES2010b) to calculate the potential emission reductions from proposed projects. As new MOVES model versions are released by EPA, consider updating emission rates in the tools.

   Montana emission rates by vehicle type were generated by running EPA's MOVES model. These are built into the tools delivered to MDT to estimate benefits of CMAQ-eligible projects. This was done so that users of the tools do not need to run the MOVES model prior to using them. However, EPA regularly releases updates to the MOVES model. When EPA releases a new version of the model, we recommend that Montana staff review those updates to determine whether emission rates were revised and whether it will be necessary to update the emission factors in the provided tools with revised MOVES emission rates. EPA guidance or documentation about the new version of the model will indicate if emission rates were updated.

6. **Take advantage of opportunities to use CMAQ funds in conjunction with other transportation spending programs.** States may choose to transfer a limited portion of their CMAQ apportionment to some of the other Federal-aid highway programs, such as the Surface Transportation Program, National Highway System, Highway Bridge Program, Interstate Maintenance, Recreational Trails Program, and the

Highway Safety Improvement Program. Montana may transfer CMAQ funds up to 50 percent of the amount of the state's annual apportionment, minus the amount Montana would have received if total CMAQ funding were $1.35 billion.

7. **Consider providing outreach/training to Montana staff and stakeholders in using the emission reduction and cost effectiveness tools developed for this research project.** While the methods descriptions and associated spreadsheets that have been developed for this project are designed to be user friendly, there may be value in providing some training to new users of these materials, along with user support in order to ensure that the tools are being used correctly by staff. It is expected that MDT will use the results of the project evaluations prepared using these tools to provide information about expected emission reductions and project cost effectiveness to the FHWA CMAQ database.

8. **Review MAP-21 guidance document when it becomes available to determine how FHWA wants to implement the CMAQ program under MAP-21 legislation.** MAP-21 calls for a state that has $PM_{2.5}$ nonattainment and maintenance areas to use a portion of its CMAQ funds for projects that reduce $PM_{2.5}$ in such areas. Diesel retrofits are highlighted in MAP-21 as eligible to effect such mitigation. Further information about this will be provided in the future. However, diesel retrofits are unlikely to produce much $PM_{2.5}$ air quality improvement in Montana's $PM_{2.5}$ nonattainment areas – as shown by CMB analyses.

   As written, it appears that MAP-21 may force Montana to spend significant amounts of its future CMAQ funds for diesel retrofits in the Libby $PM_{2.5}$ nonattainment area. The most recent (2007-2008) CMB modeling that was performed for Libby indicates that diesels contribute about 5 percent of the total wintertime $PM_{2.5}$ mass in the nonattainment area. This CMB estimate is consistent with recent emission summaries for the area. Therefore, it is recommended that MDT work with the FHWA to invest as little funding as possible for diesel retrofits in Libby. Another option is to work in cooperation with the MTDEQ to get $PM_{2.5}$ concentrations in Libby below the NAAQS and to have this nonattainment area redesignated to attainment.

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