Alaska Department of Environmental Conservation

Amendments to State Air Quality Control Plan

Vol. III: Appendix III.D.2.2

Anchorage Assembly Resolution No. AR 2020-61Adopting the Draft Eagle River Second 10-Year PM_{10} Limited Maintenance Plan

Adopted

July 22, 2020

Mike Dunleavy
Governor

Jason W. Brune
Commissioner

Municipal Clerk's Office
Approved
Date: February 25, 2020

Submitted by: Chair of the Assembly at the Request of the Mayor
Prepared by: Anchorage Health Dept.
For Reading: February 25, 2020

ANCHORAGE, ALASKA
AR No. 2020 – 61

A RESOLUTION OF THE MUNICIPALITY OF ANCHORAGE ADOPTING THE DRAFT EAGLE RIVER SECOND 10-YEAR PM_{10} LIMITED MAINTENANCE PLAN AND REQUESTING THE ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION INCLUDE THE PLAN IN ALASKA'S STATE IMPLEMENTATION PLAN.

WHEREAS, in 1991, the Anchorage Assembly approved the Eagle River PM_{10} Control Plan and subsequently controlled road dust emissions eliminating violations of the PM_{10} air quality standard; and

WHEREAS, in 2010, the Anchorage Assembly approved the Eagle River PM_{10} Limited Maintenance Plan (LPM), the first of two 10-year plans, which acknowledged attainment of the air quality standard and provided for continued control of emissions into the future; and

WHEREAS, in March 2013, the Environmental Protection Agency (EPA) approved the first Eagle River PM_{10} LPM which initiated a 20-year maintenance period for the area; and

WHEREAS, the Clean Air Act requires an update to the PM_{10} maintenance plan for Eagle River to address the second half of the 20-year planning period that began in March 2013; and

WHEREAS, the Alaska Department of Environmental Conservation (ADEC) has prepared a draft second 10-year Limited Maintenance Plan which will fulfill that requirement upon approval by the U.S. EPA; and

WHEREAS, the AMATS Policy Committee, during their meeting on November 21, 2019; recommended that the Anchorage Assembly give its approval to ADEC to release that plan for public review and inclusion in the State Implementation Plan (SIP); now therefore,

THE ANCHORAGE ASSEMBLY RESOLVES:

Section 1. To adopt the draft Eagle River Second 10-Year PM_{10} LPM request that the Alaska Department of EPA, upon finalization, submit it to the Environmental Protection Agency for approval and inclusion in the Alaska SIP for air quality.

Section 2. This resolution shall become effective immediately upon passage and approval by the Anchorage Municipal Assembly.

PASSED AND APPROVED by the Anchorage Assembly this 25th day of February, 2020.

Chair

ATTEST:

Jennifer Veneklasen

Municip l Clerk

Alaska Department of Environmental Conservation

Amendments to State Air Quality Control Plan

Vol. III: Appendix III.D.2.5

PM_{10} Design Values for Eagle River 2nd 10-year PM-10 Limited Maintenance Plan

Adopted

July 22, 2020

Mike Dunleavy
Governor

Jason W. Brune
Commissioner

Appendix to Volume II., Section III.D.2.5

PM10 Design Values for Eagle River and Qualification for Second 10-year limited Maintenance Plan

<u>Computation of 24-hr Design Value</u>

Computational methods for determining the 24-hour design value (DV) are outlined in the *PM_{10} SIP Development Guideline (EPA-450/2-86-001, June 1987)*. The empirical frequency distribution approach (see Section 6.3.3. of the guidance) was used to determine the site-specific PM10 concentration that would be expected to be exceeded at a frequency of once every 365 days.

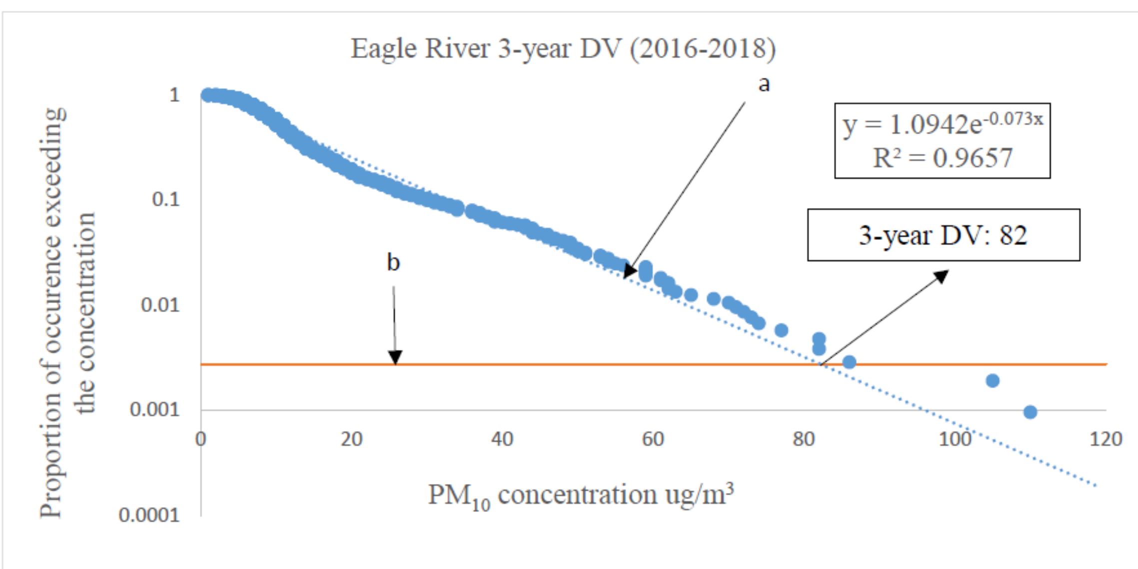
All observations by PM_{10} concentration were ranked for each 3-year block during the 2009 – 2018 period in descending order. Since PM_{10} concentrations were monitored generally on a one-in-six-days basis, each 3-year block had approximately 180 observations. Thus, the lowest concentration measured in each 3-year block had a rank order approximately 180.

Next, for a concentration ranked (*i*), the proportion of PM_{10} observations that exceed that concentration is calculated as:

i / total number of observations

The empirical frequency distribution for each 3-year block was then graphed by plotting the proportion of occurrence against PM10 concentrations. Figure 1 below shows an example of 2016-2018 period.

Figure 1
Example – Determination of 24-hr DV for 2016-2018



Since the DV is a concentration that corresponds to an exceedance frequency of 1/365 (line b), the DV was graphically determined as the intersecting point of Lines ***a*** and **b** in the Figure 1.

Line ***a*** = the empirical frequency distribution for all the observations during the 2016-2018 period. Line ***b*** = DV frequency by definition (1/365). Total number of observations = 1043. For this particulate period, DV was determined to be 82 μg/m^3.

Table 1 below shows the calculated DVs for the last decade, all eight 3-year blocks, to demonstrate that there is no increasing trend in DVs over the period. The average DV during the last 5-year period (2014-2018) was 96 μg/m^3, which is below the LMP criteria of 98 μg/m^3.

Table 1
Computation of Average DV for Parkgate Site in Eagle River

3-yr Period	**Equation of Line Describing Empirical Frequency Distribution**	**R^2**	**DV(computed from previous 3 years data using empirical frequency distribution** (μg/m^3))
2009-2011	$y = 1.0959e^{-0.062x}$	0.9103	96
2010-2012	$y = 1.1021e^{-0.067x}$	0.9306	90
2011-2013	$y = 1.1116e^{-0.068x}$	0.9640	88
2012-2014	$y = 1.0152e^{-0.055x}$	0.9770	106
2013-2015	$y = 1.0367e^{-0.056x}$	0.9789	106
2014-2016	$y = 1.0698e^{-0.055x}$	0.9840	109
2015-2017	$y = 1.1496e^{-0.070x}$	0.9795	86
2016-2018	$y = 1.0942e^{-0.073x}$	0.9657	82
	Average DV 2014-2018	=	**96** μg/m^3
	LMP Qualification Criteria		**< 98** μg/m^3

*In this equation y is the proportions of concentrations exceeding a particular PM10 concentrations and x is the concentration of interest. If y is set = 1/365 = 0.0027, the equation can be used to solve for x, the concentration that would be expected to be exceeded once per year.

Computation of a Site-Specific Design Value

Attachment B of the Limited Maintenance Plan guidance (Wegman memo, EPA, August 9, 2001) outline a procedure for computing a site-specific value (called a critical design value or CDV) that may serve as alternative to the 98 μg/m^3 value used to determine whether an area qualifies for LMP option or meets the Motor Vehicle Regional Emissions Analysis Test. The computation is described below:

CDV = NAAQS/(1+tcCV)

Where:

CDV = the critical design value

CV = the coefficient of variation of the annual design values (the ratio of standard deviation divided by the mean design value in the past)

t_c = the critical one-tail t-value corresponding to a given probability of exceeding the NAAQS in the future and the degree of freedom in the estimate for the CV.

The Tables below illustrate the guidance received from EPA Region 10 staff. CDV was calculated based on 3-yr DVs from tabular ADV (see attached Appendix A for details), the ADV for all empirical data, ADV for empirical greater than 40 µg /m^3, and ADV for upper 10% Tail Dist, using 10% to determine the appropriate critical one-tail t value (t_c) in the computation

Table 2
3-Year Average Design Values (ADVs) Data

Years	**3-Yr OBS**	**Tabular ADV**		**Empirical – ADV**	**Empirical – ADV**	**Upper 10% Tail Dist - ADV**
		upper	lower	all data	>= 40 µg /m^3	
2011-2013	1041	111	109	108	114	108
2012-2014	1037	111	109	106	114	105
2013-2015	1038	110	109	108	109	107
2015-2017	1045	90	86	86	93	96
2016-2018	1043	105	86	82	91	95

Table 3
Critical Design Value Calculation

CDV = NAAQS/(1+tcCV)	**Tabular**	**Empirical (all)**	**Empirical (>39)**	**U10% Tail Dist**
SD	12.6	12.9	11.3	6.2
Mean	99.8	98.0	104.2	102.2
CV	0.126	0.131	0.109	0.061
NAAQS	150.0	150.0	150.0	150.0
n	5	5	5	5
df	4	4	4	4
t_c (10%, one-tail)	1.533	1.533	1.533	1.533
Critical Design Value (CDV)	125.7	124.8	128.5	137.2

With the 5-year ADV (96 µg/m^3) for this monitoring station, less than the CDV (124.8 µg/m^3), these CDVs provide additional evidence that the Eagle River Maintenance Area continues to remain eligible for a Limited Maintenance Plan. Hence, there is less than 10% probability of violating the PM_{10} 24-hr standard in the future at the Parkgate site in Eagle River.

All the site-specific values are considerably greater than the “default” value of 98 μg /m^3. The site-specific value (124.8 μg/m^3) was used as a margin of safety (MOS) value in the Motor Vehicle Regional Emissions Analysis Test.

Alaska Department of Environmental Conservation

Amendments to State Air Quality Control Plan

Vol. III: Appendix III.D.2.6

2017 PM_{10} Emission Inventory for Eagle River 2nd 10-year PM-10 Limited Maintenance Plan

Adopted

July 22, 2020

Mike Dunleavy
Governor

Jason W. Brune
Commissioner

Overview

With the exception of the on-road vehicle emissions and the non-road emissions sections which are new, all other sections of this appendix document for the second 10-year Limited Maintenance Plan (LMP) are updates of the appendix to the first 10-year LMP.

A maintenance plan typically contains an emission or modeling demonstration that shows how the area will stay in compliance through the 10-year maintenance period. This demonstration requires a projected emissions inventory usually. However, an area meeting the LMP qualification criteria is at little risk of violating the standard because emissions are not expected to grow sufficiently to threaten the maintenance of the standard. As stated in Section V.b. *Maintenance Demonstration of the Wegman memo*, "if the tests described in Section IV are met, we will treat that as a demonstration that the area will maintain the NAAQS. Consequently, there is no need to project emission over the maintenance period."

This document describes the assumptions and methods used to develop the 2017 base year PM_{10} emission inventory. The 2007 inventory is also shown for illustrative purposes. As shown in the inventory, the most significant sources of the crustal material (dust), in the maintenance area, are dust stirred up by vehicle traffic traveling on paved roadways and wind-lofted dust from roads, parking lots and un-vegetated areas within the area. This finding is consistent with past source apportionment studies that have consistently shown that the vast majority of PM_{10} in Eagle River and Anchorage consists of crustal material.[1]

In 1991, when the attainment plan for Eagle River was prepared, the most important source of PM_{10} was unpaved roads. Since that time, however, all of the roads in the area have been paved, so unpaved road emissions are no longer included in the inventory. Unlike the first 10-year LMP, six PM_{10} source categories were inventoried for the second 10-year LMP. These include (1) dust from paved roads; (2) wind-generated dust from roads, parking lots and un-vegetated areas; (3) fireplaces and woodstoves; (4) natural gas combustion; (5) exhaust, tire and brake wear emissions from motor vehicles; and (6) non-road emissions

AP-42, "Compilation of Air Pollution Emissions Factors," is an EPA publication that provides guidance on the estimation of emissions on a large variety of air pollution emission sources. Similar to the first 10-year LMP, emissions from significant sources within the 9 km^2 area were estimated using same standard methodologies outlined in AP-42 for fugitive PM_{10} sources. However, MOVES2014b, instead of MOBILES6.2, as shown in the attached spreadsheet, was used to estimate the contribution of motor vehicle exhaust, tire and brake wear emissions, and non-road equipment emissions to PM_{10}. The methods and assumptions used to estimate emissions from each of these sources are described in the next five sections.

[1] Four studies have been performed to characterize the sources of particulate and Anchorage and Eagle River. These include two chemical mass balance/source apportionment studies (Pritchett & Cooper, 1985, Cooper & Vodovinos, 1988) and two studies that used microscopy (Crutcher, 1994, R.J. Lee, Inc., 1995) to identify and quantify the types (and probable sources) of particulate.

(1) Dust from Paved Roads

Dust from paved roads is a major source of PM_{10} in Eagle River and Anchorage. Roads are often laden with large amounts of "sediment" and other fine-grained minerals left over from winter sanding operations, material abraded from the road surface itself by traffic (especially from vehicles equipped with studded tires), and spillage from hauling activities. Roads tend to be dirtiest during the spring break-up period which generally occurs between mid-March and the end of April. Although the grain size of most of the sediment on the roads is too large to be PM_{10}, some of this material has been pulverized to a grain size less than 10 microns. When these very fine grained particles are re-entrained into the air by turbulence from traffic traveling on the road, they become PM_{10}.

Section 13.2.1 of AP-42 outlines procedures for estimating PM_{10} emissions from paved roads. According to AP-42, emissions from a paved road are a function of how much fine-grained sediment or silt is on the road and the weight of vehicles using the road.[2] Paved road emissions increase in direct proportion to the amount of traffic or vehicle miles travelled (VMT) on the roads. Higher traffic volumes result in greater emissions.

The air quality conformity analysis for the 2007 Chugiak-Eagle River Long Range Transportation Plan (CE/LRTP) included VMT estimates for analysis years 2007, 2017, and 2027. These VMT estimates served as the basis for the 2017 inventory presented here. Since 2017 was of the five most recent years used for the calculation of ADV, it was selected as the base year. The VMT estimate for 2033, used for computation of the motor vehicle regional emissions analysis test, was obtained from the TDM consultant for Anchorage Transportation Planning Department of the Municipality of Anchorage. The projected VMT estimate for 2033 was calculated from the travel demand model of the road networks within the maintenance area (see attached Appendix B for details).

In the conformity analysis for the CE/LRTP, the FHWA-approved Anchorage Transportation Model was used to estimate VMT on arterials and freeways in the Eagle River Maintenance area; the model did not provide VMT estimates for local roads. In the first 10-year LMP, VMT on local roads was estimated by assuming that each household within the maintenance area makes seven home-based trips per day, each involving 0.62 miles of travel on local roads.[3] Each household was assumed to generate 4.34 miles *(7 trips x 0.62 m)* of local road VMT each day.

[2] Silt is defined as the finer-grained soil particles that pass a #200 mesh sieve; these are particles nominally 75 microns and smaller.
[3] For example, a trip from home to the local grocery store and back would count as two home-based trips.

Table 1
Estimated VMT in Eagle River PM10 Maintenance Area for Year 2017

Local Road VMT (based on housing Stock) **Arterial and Freeway VMT**

Year	Housing Stock	Local Unpaved VMT	Paved (RAP)* VMT	Paved (SP/CG)** VMT	Arterials	Glenn Highway
2007	4,548	0	7,659	12,079	68,664	77,532
2017	4,908	0	8,264	13,034	83,370	107,640

* RAP = recycled asphalt pavement
** SP/CG = strip paved or curb and gutter
Data was extracted from the Air Quality Conformity Analysis for the 2007 Chugiak-Eagle River Long Range Transportation Plan (CE/LRTP)

Paved Road Emission Factor

Section 13.2.1 of AP-42 (updated November 2006) outlines recommended procedures for estimating PM_{10} emissions from paved roads. The paved road emission factor, the amount of PM_{10} generated in pounds per vehicle mile traveled (VMT), is a function of the "silt loading" on the road and the average weight of the vehicles traveling on the road.

The AP-42 paved road emission factor equation is:

$$E = k(sL/2)^{0.65} \times (W/3)^{1.5} - C$$

where

E = PM_{10} emissions in Ibs/VMT

k = 0.016 (AP-42 specified particle size multiplier for PM_{10})

sL = road surface silt loading (varies by roadway type)

W = mean vehicle weight in tons (assumed to be 2 tons)

C = vehicle exhaust, tire and brake wear emissions (AP-42 recommendation = 0.00047 Ibs/VMT)

Data collected in Anchorage in 1996 (Montgomery-Watson, 1996) showed that silt loading varied by roadway type (for this inventory, Eagle River was assumed to have silt loadings identical to Anchorage).

The Municipality of Anchorage maintains a detailed inventory of the surface treatment of roads in the Chugiak – Eagle River area. While the majority of the roads in the area are paved with "traditional" hot asphalt paving (HAP) about one-third of the local roads in the maintenance area are constructed with recycled asphalt paving or RAP. Although air quality monitoring data suggest RAP treatment has proven to be an effective means in reducing PM_{10} from gravel roads in Eagle River, the surface of these roads is less durable and more erodible than those constructed using HAP. Because roadway abrasion is a significant source of silt on roads, it seems reasonable to assume that the silt loadings on RAP roads are higher than those surfaced with HAP.[4] For the purpose of this inventory, RAP-constructed roads were assumed to have silt loadings twice those constructed with HAP.

Table 2 shows average silt loading measurements and the computed AP-42 PM_{10} emission factor for roadway type for the spring and fall PM_{10} seasons.

Table 2
Typical Silt Loadings and PM_{10} Emission Factors by Season for Paved Roads in Eagle River

Roadway Type	Silt Loading (g/m^2)	Spring PM_{10} Emission Factor (Ibs/VMT)	Silt Loading (g/m^2)	Fall PM_{10} Emission Factor (Ibs/VMT)
Arterial Paved Roads	6.7	0.0207	1.1	0.0061
Freeways (Glenn Hwy)	20.4	0.0433	2.6	0.0110
Local Paved Roads (hot asphalt paving)	18.4	0.0404	4.7	0.0164
Local Paved Roads (recycled asphalt)	36.8#	0.0637	9.4#	0.0260

Silt loading estimated to be double those of local roads constructed with hot asphalt paving
Data was extracted from the appendix to the first 10-year LMP

Using AP-42 Emission Factors and VMT Estimates to Compute Paved Road PM10

Paved road PM_{10} emissions can be readily computed from the emission factor and VMT on each roadway type. Table 3 shows estimated emissions for the spring and fall periods for base year 2017.

[4] The Municipality of Anchorage recently completed a study that suggests that roadway abrasion is the source of about 25% of the "dirt" on the road surface during spring break-up.

Table 3
Estimated PM_{10} 2017 Emissions from Paved Roads in the Eagle River Maintenance Area

Road Type	VMT	2017 Spring Emissions (tons/day)	2017 Fall Emissions (tons/day
Arterial Paved Roads	83,370	0.86	0.25
Freeways (Glenn Hwy)	107,640	2.33	0.59
Local Paved Roads (hot asphalt paving)	13,034	0.26	0.11
Local Paved Roads (recycled asphalt)	8,264	0.26	0.11
Total	**212,308**	**3.71**	**1.06**

(2) Wind Generated Dust from Roads, Parking Lots and Un-vegetated Areas

Although EPA guidance allows the flagging of PM_{10} exceedances that occur as a result of extreme wind events such as those that occurred on October 30, 2009, in Eagle River, PM_{10} observations resulting from commonly occurring, less energetic wind-related events are considered valid data and are not excluded when determining the design value for an area or determining whether the area is in compliance with the NAAQS. Monitoring data suggest that wind-generated dust frequently contributes to elevated PM_{10} concentrations in Eagle River.

Estimating the Amount of Area Covered by Roads, Parking Lots and Un-vegetated Areas

Wind-generated dust generally originates from paved surfaces laden with dirt and silt. These paved surfaces include roadways and parking lots in the maintenance area. There are also some cleared, un-vegetated areas that are unpaved.

Estimates of the amount of area available for the generation of windblown dust are shown in Table 4. The area amount of roadway was estimated by the length of each type of roadway and the average width of that type of roadway. For example, there are 6.2 miles of arterial roadway in the maintenance area and arterial roadways have an average paved width of approximately 60 feet.

The surface area of the arterial roadways in the maintenance area is therefore:

$$(6.2 \text{ miles length})(5{,}280 \text{ ft/mi})(60 \text{ ft width}) = 1{,}964{,}160 \text{ ft}^2$$

$$1{,}964{,}160 \text{ ft}^2 / 43{,}560 \text{ ft}^2 \text{/acre} = 45.1 \text{ acres}$$

In 2010 when the first 10-year LMP was developed, the amount of acreage covered by parking lots, paved school playgrounds, and similar areas was estimated by inspecting Google satellite photos of the maintenance area. The acreage of unvegetated, cleared areas was estimated in like manner. The Google map utility includes a distance key that allows the dimensions and acreage of a particular surface feature to be estimated. For example, a parking lot with dimensions of 250 feet by 500 feet is approximately 3 acres in size. Because parking areas, particularly those serving retail establishments serve the local population, it was assumed that the total area covered by parking lots and the likes would increase in direct proportion with housing stock. Housing stock was projected to increase by 7.9% between 2007 and 2017; paved parking areas were assumed to increase by same proportion.

The total amount of paved or cleared area in the maintenance area in base year 2017 was estimated to be 292 acres. This constitutes about 12.6% of the land surface in the maintenance area.

Table 4
Estimated Surface Area Coverage of Roads, Parking Lots and Un-vegetated Areas in Eagle River PM10 Maintenance Area

	2007 Roadway Length (miles)	2007 Estimated Area (acres)	2017 Roadway Length (miles)	2017 Estimated Area (acres)
Glenn Highway	1.1	13	1.1	13
Arterials	6.2	45	6.2	45
Local Roads	45.6	165	45.6	165
Parking Lots	----	55	----	59
Un-vegetated Areas	----	10	----	10
Total		**288**		**292**

Note: To compute the total paved area of roadways, a paved width of 100 feet was assumed for the Glenn Highway, 60 feet for arterials, and 30 feet for local roads

Wind Blown Dust Emission Factor Estimation

AP-42 does not provide an emission factor methodology specific to estimating PM_{10} emission from roads, parking lots and un-vegetated areas. However, it does outline a methodology (see AP-42 Section 13.2.5.1) for estimating emissions from aggregate storage piles and open areas within an industrial facility. After examining other alternatives, the methodology recommended for estimating wind-generated PM_{10} emissions from open areas in industrial facilities seemed to offer the best fit available for estimating wind-generated PM_{10} in Eagle River.

The AP-42 Section 13.2.5.1 outlines a step-by-step procedure for estimating wind generated PM_{10} emission factor for open areas in industrial facilities. This methodology was applied to the estimation of emissions from open areas in Eagle River.

AP-42 provides the following equation for estimating PM_{10} emissions from wind-blown dust:

Equation 1

$$EF_{wind} = 0.5(58(u^* - u_t^*)^2 + 25\ (u^* - u_t^*))$$

where:

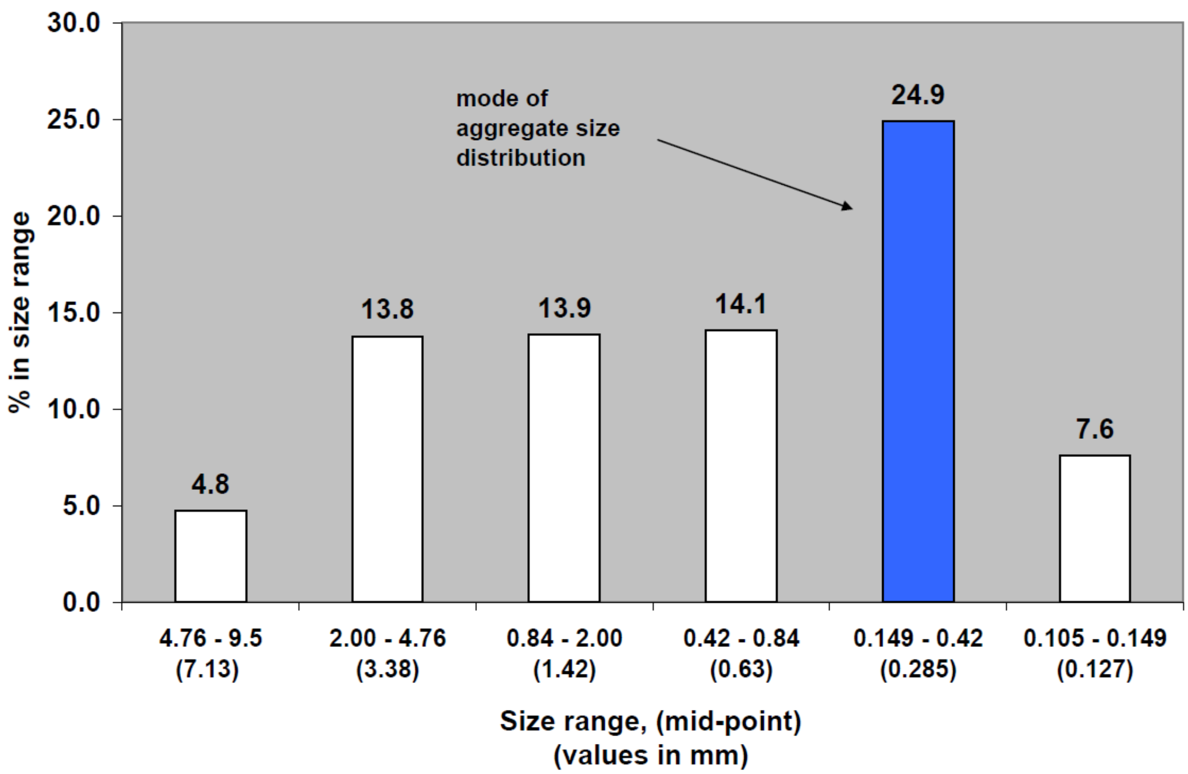
u^* = friction velocity (m/s)
u_t^* = threshold friction velocity (m/s)

The next two sub-sections will describe how the variables u^* and u_t^* were determined.

Determining u_t^*

AP-42 outlines a field procedure and lab test (sieve analysis) for estimating the threshold friction velocity (u_t^*). The mode of the aggregate size distribution is determined and can be related empirically (see AP-42 Table 13.2.5-1) to u_t^*. In order to estimate u_t^* for the aggregate material in the Eagle River maintenance area, existing sieve analysis data from street sediment collected in Anchorage was used.[5] Over 300 street sediment samples were collected and sieved. Although the sieves used in this analysis did not correspond exactly to those prescribed in Table 13.2.5-1, they were similar enough so that a reasonable estimate of u_t^* could be made.[6] The mode size was determined from the average of all 300+ sieve analysis results. On average, 24.9% of the total street sediment was "captured" between sieves #40 (0.42 mm) and #100 (0.149 mm). The midpoint size between these two sieves is 0.285 mm (See Figure 1).

Figure 1
Sieve Analysis Results for Anchorage Street Sediment Data



Note: The figure was extracted from the appendix document to the 1st 10-year LMP

Table 13.2.5-1 recommends a value for $u_t^* = 0.43$ m/s for a midpoint size range of 0.375 mm. Again, because different sieves were used to characterize the size distribution of Anchorage

[5] These data were collected in spring of 1996 by Montgomery-Watson, Inc. for the MOA Watershed Management Section as part of an analysis of street sediment impacts on streams and lakes in Anchorage.
[6] The sieves used in the Anchorage Street Sediment Testing were #4, #9, #20, and #100. The method recommends using sieves #5, #9, #16, #32, and #60.

Road Sediment than prescribed by AP-42, our midpoint value is slightly different. Nevertheless the data suggest that 0.43 m/s is a reasonable assumption of u_t^* for Eagle River road sediment.

Determining u^*

The friction wind velocity (u^*) is the estimated wind velocity at the ground surface where street sediment and other fine materials lay available for re-entrainment by the wind. Wind speed measurements are taken at 10 meters above the ground (u_{10}^+), however, the actual wind speed at the ground surface is significantly lower. AP-42 recommends the following equation to estimate u^*:

$u^* = 0.053\, u_{10}^+$ (expressed in m/sec)

For the first 10-year year LMP, to estimate the contribution of wind-blown dust to PM_{10}, the five highest PM_{10} days during spring break-up (March, April) and fall freeze-up (October, November) were identified over the 10-year period 1998-2007, as illustrated in Table 5.

Note: The same conservative approach was made for the second 10-year LMP.

Table 5
Equivalent Friction Wind Velocities on High PM_{10} Days
During Spring Break-up and Fall Freeze-up (2009-2018)

Date	PM_{10} ($\mu g/m^3$)	Max 2-min Wind Speed u_{10}^+ (mph)	Equivalent Friction Wind Velocity u^* (m/s)	Date	PM_{10} ($\mu g/m^3$)	Max 2-min Wind Speed u_{10}^+ (mph)	Equivalent Friction Wind Velocity u^* (m/s)
3/10/2003	**92**	**23**	**0.55**	11/13/2006	65	16	0.38
3/17/2005	90	15	0.36	11/7/1998	55	7	0.17
3/4/2003	82	23	0.55	**10/21/2000**	**52**	**20**	**0.47**
4/15/2004	70	8	0.19	10/31/2005	51	14	0.33
3/14/2001	69	13	0.31	11/7/2006	48	20	0.22
u^* =			**0.55**				**0.47**

Computing the Wind Blown Dust Emission Factor from Equation (1)

With the determination of the threshold friction velocity u_t^* and equivalent wind friction velocity u^* for the spring and fall PM_{10} seasons, the Equation 1 can be used to compute the PM_{10} emission factor for wind-blown dust.

(Equation 1) $EF_{wind} = 0.5(58(u^* - u_t^*)^2 + 25\,(u^* - u_t^*))$

Substituting the values for $u_t^* = 0.43$ m/sec and $u^* = 0.55$ m/s (spring) and 0.47 m/s (fall), the resultant spring and fall windblown dust PM_{10} emission factor are:

Spring Windblown Dust PM_{10} Emission Factor = 1.9 $g/m^2/day$ = 17 Ibs/acre/day
Fall Windblown Dust PM_{10} Emission Factor = 0.5 $g/m^2/day$ = 5 Ibs/acre/day

Table 6
Estimated Windblown Dust PM10 Emissions from Roads, Parking Lots and Un-Vegetated Areas

		Spring Break-up	Spring Break-up	Fall Freeze-up	Fall Freeze-up
Year	**Total Estimated Area of Roads, Parking Lots, and Un-vegetated Areas (acres)**	**Wind Blown Dust PM10 Emission Factor (Ibs/acre)**	**Total PM10 Emission Factor (tons/day)**	**Wind Blown Dust PM10 Emission Factor (Ibs/acre)**	**Total PM10 Emission Factor (tons/day)**
2007	288	17	2.45	5	0.72
2017	292	17	2.48	5	0.73

(3) Fireplace and Woodstoves

Basic assumptions regarding fireplace and wood stove were obtained from a telephone survey conducted by ASK Marketing and Research in 1990. This survey asked Anchorage residents how many hours per week they burned wood in their fireplace or wood stove. Because the AP-42 emission factors for fireplaces and wood stoves (See AP-42, Sections 1.9 and 1.10) are based on the amount of wood (dry weight) burned, hourly usage rates from the survey had to be converted into consumption rates. Based on discussions between MOA and several reliable sources (OMNI Environmental Services, Virginia Polytechnic Institute, Colorado Department of Health), average burning rates (in wet weight) of 11 pounds per hour for fireplaces and 3.5 pounds per hour for wood stoves were assumed.

Residential wood burning assumptions are detailed in Table 7.[7]

[7] Assumptions regarding wood burning activity levels (i.e. the number of households engaging in wood burning on a winter season design day) were corroborated by a more recent telephone survey conducted by In 2003 Ivan Moore Research (IMR) asked approximately 600 Anchorage residents whether they had used their fireplace or woodstove during the preceding day. The survey was conducted when the preceding day had a minimum temperature between 5 and 15 ºF. Although the IMR survey did not provide as detailed information as the ASK survey, its results were roughly consistent with the assumptions used in this inventory.

Table 7
Estimation of Residential Wood Burning PM_{10} Emission Factors for Eagle River

Device	Average use per weekday (hours/household/ day)	Average dry weight of wood consumed (lbs/hour)*	Average amount of wood burned per household (dry lbs /day)	AP-42 Emission Factor for PM10 (g/dry lb wood burned)	Estimated PM10 emissions per household (g/day)
Fireplaces	1.04	7.15	7.44	7.9	58.8
Wood Stoves	0.85	2.275	1.94	5.4**	10.5
Total	**1.89**	**------**	**9.38**	**------**	**69.3**

Note: Data was extracted from the appendix document to the 1st 10-year LMP
* The moisture content of wood burned was assumed to be 35%. Thus, dry burning rates were 65% of wet rates.
** The wood stove emission factor was determined by assuming that the wood stove population in Eagle River is comprised of equal proportions of conventional, catalyst, and non-catalyst stoves. The emission factor above was calculated as the weighted average of the AP-42 emission factors for each stove type. AP-42, 5th Edition (Oct 1996)

PM_{10} emissions from residential wood burning can be estimated from the emission factor computed above and the estimated number of households. Table 8 shows estimated PM_{10} emissions from residential wood burning for illustrative year 2007 and base year 2017.

Table 8
Estimated PM_{10} Emissions from Residential Wood Burning in Eagle River Maintenance Area 2007 and 2017

Year	Housing Stock in Inventory Area	AP-42 PM10 Wood Burning Emission Factor for Eagle River (g/household/day)	Estimated PM10 Emissions from Fireplaces and Woodstoves (tons/day)
2007	4,548	64.5	0.32
2017	4,908	64.5	0.35

Note: Wood burning rates per household were assumed to be the same in 2007 and 2017.

(4) Natural Gas Combustion

Natural gas is the main fuel source for space heating in the Municipality of Anchorage, including Eagle River. Survey information suggests that the vast majority of households use natural gas as their primary source of heat. Average household natural gas consumption during a peak heating day in the winter in the Anchorage area has been estimated to be 658 ft3/day. We, however, were interested in estimating natural gas consumption (and consequent PM_{10} emissions) during spring break-up and fall freeze-up when temperatures are warmer. Estimates of peak household natural gas consumption were estimated for a day when the average ambient temperature was approximately -10 ºF while the typical average daily temperature during the spring and fall PM_{10} seasons is approximately +30 ºF. Natural gas consumption for a +30 ºF day can be estimated from consumption on a -10 ºF day by assuming that consumption is proportional to heating degrees. The computation is as follows:

Peak-day natural gas consumption per household = 658 ft^3/day
Ambient temperature on day of peak natural gas consumption = -10 ºF, heating degrees = 75
Ambient temperature on typical fall or spring day in PM10 season = +30 ºF, heating degrees = 35
Assume natural gas consumption is proportional to heating degree days, then
Natural gas consumption during fall or spring PM10 day = 658 ft^3/day x (35/75) = ***307 ft^3/day***

The Eagle River maintenance area is predominantly residential. While there are some commercial natural gas users, there is little if any industrial or utility usage. Because "nonresidential use" is relatively small within the maintenance area, it seemed reasonable to assume that combined commercial and industrial use would be no more than 50% of residential. Thus, for the purpose of this inventory, total natural gas use was assumed to be 150% of estimated residential use.

The emission factor for "total" particulate matter (see AP-42 Section 1.4, July 1998) is estimated to be 7.6 lbs per 10^6 ft^3 of natural gas consumed. PM_{10} emissions from natural gas combustion in the Eagle River maintenance area can be readily computed from the amount of gas consumed and this emission factor. Table 9 shows the results of this computation.

Table 9
Estimation of PM_{10} Emissions from Natural Gas Combustion in Eagle River Maintenance Area

	Natural Gas Consumption per Household (ft^3)	Housing Stock	Total Residential Natural Gas Consumption (ft^3)	Estimated Commercial and Industrial Natural Gas Consumption (ft^3)	Combined Residential, Commercial and Industrial Natural Gas Consumption (ft^3)	AP-42 PM10 Emission Factor (lbs per 10^6 (ft^3)	Estimated PM10 Emissions (tons/day)
2007	307	4,548	1.40×10^6	0.70×10^6	2.10×10^6	7.6	0.008
2017	307	4,908	1.51×10^6	0.75×10^6	2.26×10^6	7.6	0.009

(5) Exhaust, Tire and Brake Wear Emissions from Motor Vehicles

In addition to the PM_{10} that vehicles stir-up as they travel along dirty roadways, motor vehicles are also responsible for more “direct” PM emissions. These include tail pipe exhaust emissions, and emissions that result from tire and break wear. These emissions were estimated by using the latest EPA's mobile source emission factor model, MOVES2014b. For the first 10-year LMP, MOBILE6.2 was used. The county-level on-road vehicle emissions (Table 10) were developed from the local fleet data submitted to EPA for the 2017 NEI and the 2010 U.S. Census block level populations, using ArcGIS and the planning area map. As shown in Table 11, the on-road emissions for the Eagle River Maintenance area were calculated by scaling the data in Table 10 by a factor of 0.0339 (see attached Appendix C for details).

Table 10
County-Level MOVES2014b On-road Vehicle 2017 PM_{10} Emissions (tons/day)

	Break-up	Freeze-up
Vehicle Regulatory Type	Mar-Apr	Oct-Nov
Motorcycles	0.001	0.001
Light Duty Vehicles	0.116	0.123
Light Duty Trucks	0.353	0.373
Class 2b Trucks with 2 Axles and 4 Tires (8,500 lbs < GVWR <= 10,000 lbs)	0.049	0.051
Class 2b Trucks with 2 Axles and at least 6 Tires or Class 3 Trucks (8,500 lbs < GVWR <= 14,000 lbs)	0.034	0.035
Class 4 and 5 Trucks (14,000 lbs < GVWR <= 19,500 lbs)	0.040	0.041
Class 6 and 7 Trucks (19,500 lbs < GVWR <= 33,000 lbs)	0.046	0.047
Class 8a and 8b Trucks (GVWR > 33,000 lbs)	0.133	0.135
Urban Bus (see CFR Sec 86.091_2)	0.003	0.003
On-Road Fleet Totals	**0.775**	**0.809**

Table 11
Estimation of Eagle River On-road Vehicle 2017 PM_{10} Emissions (tons/day)

	Break-up	Freeze-up
Vehicle Regulatory Type	Mar-Apr	Oct-Nov
Motorcycles	0.000	0.000
Light Duty Vehicles	0.004	0.004
Light Duty Trucks	0.012	0.013
Class 2b Trucks with 2 Axles and 4 Tires (8,500 lbs < GVWR <= 10,000 lbs)	0.002	0.002
Class 2b Trucks with 2 Axles and at least 6 Tires or Class 3 Trucks (8,500 lbs < GVWR <= 14,000 lbs)	0.001	0.001
Class 4 and 5 Trucks (14,000 lbs < GVWR <= 19,500 lbs)	0.001	0.001

Class 6 and 7 Trucks (19,500 lbs < GVWR <= 33,000 lbs)	0.002	0.002
Class 8a and 8b Trucks (GVWR > 33,000 lbs)	0.005	0.005
Urban Bus (see CFR Sec 86.091_2)	0.000	0.000
On-Road Fleet Totals	**0.026**	**0.027**

(6) Non-road Emissions

In the first 10-year LMP, the emissions from non-road sector in Eagle River were assumed to be zero. However, to ensure that all the PM_{10} emissions are accounted for in this second 10-year LMP, DEC made MOVES2014b runs to see if there are any emissions from the sector in the Maintenance area for 2017. Unlike the on-road emissions which were developed from the county-level NEI data, the non-road estimates are based on MOVES defaults. However, similar to the on-road estimates, the non-road emissions for the maintenance area (Table 12) were calculated from the county-level data by using a scaling factor of 0.0339 or zeroing out where applicable (see attached Appendix D for details).

Table 12
Estimation of Eagle River Non-road Vehicle 2017 PM_{10} Emissions (tons/day)

	Break-up	Freeze-up
Non-Road Equipment Sector	Mar-Apr	Oct-Nov
Recreational	0.0011	0.0011
Construction	0.0080	0.0078
Industrial	0.0003	0.0003
Lawn/Garden	0.0030	0.0030
Agriculture	0.0000	0.0000
Commercial	0.0011	0.0011
Airport Support	0.0000	0.0000
Oil Field	0.0000	0.0000
Pleasure Craft	0.0000	0.0000
Railroad	0.0000	0.0000
Non-Road Totals	**0.0135**	**0.0132**

Eagle River PM_{10} Emissions Inventory Summary

The Eagle River PM_{10} emissions inventory for the base year 2017 is summarized in Table 13. The inventory consists of the two peak PM_{10} periods, fall freeze-up and the spring break-up. As shown in the Table, the most significant sources of PM_{10} in the Eagle River maintenance area for the second 10-year LMP, similar to the first 10-year LMP, are paved roads, wind-blown dust, and fireplaces and wood stoves.

Table 13
Eagle River 2nd 10-year Limited Maintenance Area PM_{10} 2017 Emissions Inventory
(All Emissions in tons/day with % of Total)

Source Category	Spring Break-up (March, April) (tons/day)	Fall Freeze-up (October, November) (tons/day)
Paved Roads	3.71 (56.3%)	1.06 (48.4%)
Wind-blown Dust from Paved Roads, Parking Lots and Un-Vegetated Areas	2.48 (37.6%)	0.73 (33.3%)
Fireplaces and Wood Stoves	0.35 (5.31%)	0.35 (16.0%)
Natural Gas Combustion	0.009 (0.14%)	0.009 (0.41%)
Exhaust, Tire and Brake Wear Emissions from Motor Vehicles	0.026 (0.39%)	0.027 (1.23%)
Non-Road Equipment Emissions	0.0135 (0.20%)	0.0132 (0.60%)
Total	6.589 (100%)	2.1892 (100%)