ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Request to Divide the Fairbanks Nonattainment Area

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INTRODUCTION

This document is in support of a request from the State of Alaska to the Environmental Protection Agency (EPA) Region 10 to divide the Fairbanks North Star Borough (FNSB) fine particulate matter ($PM_{2.5}$) Nonattainment Area.

The nonattainment boundary for the FNSB $PM_{2.5}$ nonattainment area was based on information available in 2009. Since that time, significant resources from the EPA, Alaska Department of Environmental Conservation (ADEC), and FNSB have been devoted to improving our understanding of the factors that produce concentrations exceeding the 24-hour $PM_{2.5}$ National Ambient Air Quality Standard. New insight has been gained through expanded air quality and meteorological monitoring, speciation measurements, improved meteorological modeling, temporally and spatially resolved emission inventory development, improved photochemical modeling, and control strategy analysis. Considerable resources have also been spent on control programs designed to change out older higher emitting wood stoves and outdoor hydronic heaters. New control programs have also been implemented at the state, borough, and local levels. New highly resolved terrain measurements provide more insight into hydrologic drainage flows. New forecasts of population and travel are now available with greater temporal and spatial resolution.

The expansion of the air quality monitoring network now provides more information on trends and concentrations recorded within the nonattainment area. Insight into differences in source contributions to concentrations recorded is also now available. These measurements show a great disparity in the magnitude and trends in concentrations recorded in North Pole and those recorded in downtown Fairbanks. Collectively, this information indicates that Fairbanks is on a short-term path towards attainment of the 24-hour $PM_{2.5}$ standard, while North Pole has a challenging, difficult path to attainment. Because of the differences in air quality trends and factors affecting those trends, Alaska requests a change in the existing nonattainment boundary. This change would divide the existing $PM_{2.5}$ nonattainment area into two new nonattainment areas: Fairbanks and North Pole.

New information on each of the 9-factors addressed in the original boundary decision are presented in subsequent sections that highlight differences between the two proposed nonattainment areas. Information on an additional factor, speciation, is also included to provide information on differences in source mixes impacting monitors in Fairbanks and North Pole. ADEC requests that EPA consider these data in responding to this request to divide the nonattainment area.

FACTOR 1. POLLUTANT EMISSIONS

The first factor for which comparisons were developed between the proposed Fairbanks and North Pole nonattainment areas was pollutant emissions. Except where noted, all the comparisons in this section are based on the emission inventory (EI) data contained in the Moderate Area State Implementation Plan (SIP) that have been spatially divided into separate estimates for each nonattainment area, from the gridded attainment modeling inventories. In addition to sector-by-sector comparisons, a breakdown of actual and permitted point source emissions is provided. Emission density comparisons are also presented for each nonattainment area. In addition, spatial maps of known locations of outdoor hydronic heaters based on visual reconnaissance by FNSB staff are provided.

1.1 Episodic Emissions by Sector and Area

Average daily emissions (tons/day) during the November and January/February modeling episodes established under the Moderate Area SIP by source sector within the Fairbanks and North Pole nonattainment area are presented in Table 1-1 through Table 1-3. Within each table, episodic average emissions are broken down into five major sectors: (1) space heating area sources; (2) stationary point sources; (3) on-road mobile sources; (4) non-road mobile sources; and (5) other sources (all other area sources plus aircraft and airport emissions). Emissions are compared for both directly emitted $PM_{2.5}$ along with sulfur oxides (SOx) and nitrogen oxides (NOx) precursors. Table 1-1 and Table 1-2 present 2008 Baseline and 2015 Control inventory emission summaries based on 2008 actual emission levels for point sources. Table 1-3 then shows 2015 Control emissions based on permitted point source emission levels.

As shown in Table 1-1 through Table 1-3, $PM_{2.5}$ and key precursor emissions are higher within the Fairbanks nonattainment area because it is larger than the North Pole nonattainment area. In both areas, $PM_{2.5}$ emissions are dominated by the space heating and point source sectors (the latter being further elevated on the basis of permitted instead of actual emissions).

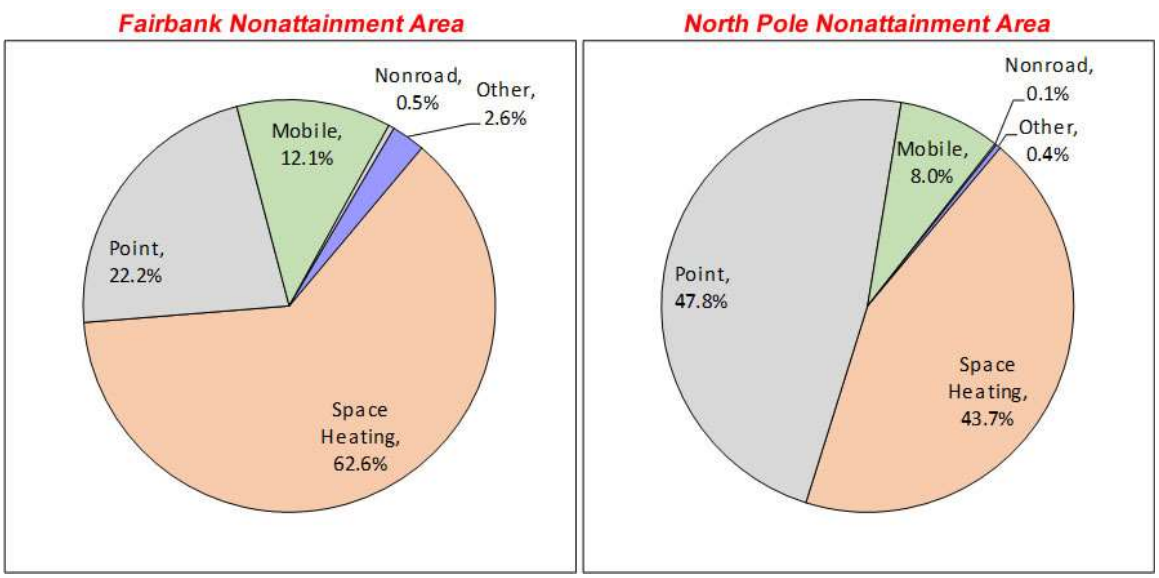
Table 1-1 Comparison of Episode Average Emissions by Area and Pollutant 2008 Baseline Inventory, Point Source Actual Emissions (tons/day)						
	$PM_{2.5}$		SOx		NOx	
Source Sector	Fairbanks	North Pole	Fairbanks	North Pole	Fairbanks	North Pole
Space Heating	1.877	0.833	2.930	0.681	1.657	0.402
Point (Actual)	0.582	0.830	6.116	2.051	6.727	6.557
On-Road Mobile	0.467	0.203	0.031	0.014	3.194	1.374
Non-Road Mobile	0.013	0.003	0.001	0.000	0.263	0.061
Other (incl. Airports)	0.066	0.006	0.075	0.000	0.764	0.001
TOTALS	**3.004**	**1.875**	**9.154**	**2.746**	**12.605**	**8.394**

Table 1-2 Comparison of Episode Average Emissions by Area and Pollutant 2015 Control Inventory, Point Source Actual Emissions (tons/day)						
	$PM_{2.5}$		SOx		NOx	
Source Sector	Fairbanks	North Pole	Fairbanks	North Pole	Fairbanks	North Pole
Space Heating	1.641	0.760	3.199	0.788	1.788	0.451
Point (Actual)	0.582	0.830	6.116	2.051	6.727	6.557
On-Road Mobile	0.318	0.139	0.012	0.005	1.743	0.729
Non-Road Mobile	0.012	0.002	0.006	0.001	0.245	0.054
Other (incl. Airports)	0.069	0.006	0.075	0.000	0.764	0.001
TOTALS	**2.622**	**1.737**	**9.408**	**2.845**	**11.267**	**7.792**

Table 1-3 Comparison of Episode Average Emissions by Area and Pollutant 2015 Control Inventory, Point Source Permitted Emissions (tons/day)						
	$PM_{2.5}$		SOx		NOx	
Source Sector	Fairbanks	North Pole	Fairbanks	North Pole	Fairbanks	North Pole
Space Heating	1.641	0.760	3.199	0.788	1.788	0.451
Point (Permitted)	1.523	1.318	13.182	12.584	16.467	15.630
On-Road Mobile	0.318	0.139	0.012	0.005	1.743	0.729
Non-Road Mobile	0.012	0.002	0.006	0.001	0.245	0.054
Other (incl. Airports)	0.069	0.006	0.075	0.000	0.764	0.001
TOTALS	**3.563**	**2.225**	**16.473**	**13.378**	**21.006**	**16.866**

To provide a clearer breakdown of the contribution from each sector within each area, Figure 1-1 presents pie charts showing relative $PM_{2.5}$ emissions (% of total) by sector within each nonattainment area based on 2008 actual point source emissions for the 2015 Control inventory. As shown in Figure 1-1, the relative contribution of space heating emissions is significantly higher in Fairbanks (62.6%) than in North Pole (43.7). But these share contributions are affected by the large differences in 2008 actual point source emissions in each nonattainment area: the North Pole 2008 actual point source share (47.8%) is much higher than that in Fairbanks (22.2%), thus diluting its space heating share.

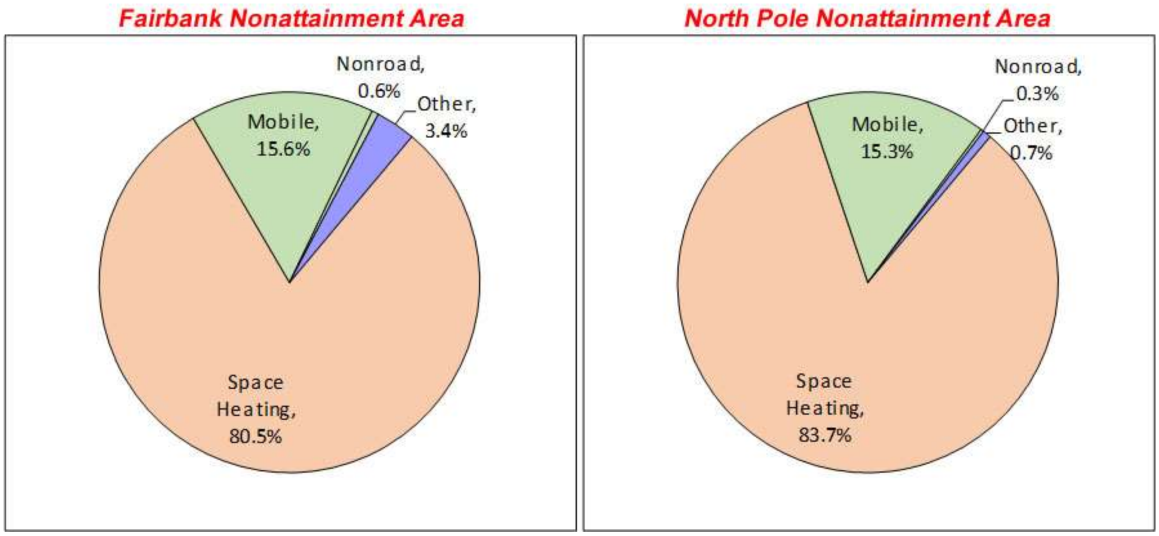
Figure 1-1
2015 Control Inventory Episode Average Direct $PM_{2.5}$ Emissions Share (%) by Area and Sector, 2008 Actual Point Sources



In the Moderate Area SIP attainment modeling, it was generally found that the contribution of point sources to the highest modeled concentrations throughout the FNSB nonattainment area was relatively modest due to their locations and stack-driven release heights. Thus, it is also instructive to examine 2015 Control emission contributions without including point sources; these are shown below in Figure 1-2.

As seen in Figure 1-2, when point sources are excluded the $PM_{2.5}$ emission shares by remaining source sector are very similar for both proposed nonattainment areas, with space heating slightly higher in North Pole (83.7%) than in Fairbanks (80.5%).

Figure 1-2
2015 Control Inventory Episode Average Direct $PM_{2.5}$ Emissions Share (%) by Area and Sector, Excluding Point Sources



1.2 Point Source Breakdown

A facility-by-facility breakdown of 2008 Baseline actual and permitted emissions is provided in Table 1-4. To make the comparisons more relevant under conditions during which ambient $PM_{2.5}$ violations have occurred, the emissions in Table 1-4 are presented as daily averages across the November and January/February modeling episodes and compared to annual permit limits (in tons per year) that have been converted to daily averages. (As explained in a table footnote, actual values in excess of permitted emissions compared on an episodic average daily basis do not indicate permitted annual limits were exceeded, due to seasonal variation in facility throughput.) Comparisons are presented for both directly emitted $PM_{2.5}$ and SOx and NOx precursors.

As noted in the "Nonattainment Area" column in Table 1-4, there are two facilities operating in North Pole and four in Fairbanks.[1] Almost all of the actual emissions in the North Pole nonattainment area emanate from the Golden Valley Electric Association (GVEA) Power Plant, and this facility was the largest source of direct $PM_{2.5}$ in the entire FNSB nonattainment area in 2008 by a wide margin. In contrast, actual emissions from point sources within the Fairbanks nonattainment area are less dominated by a single facility.

[1] An asphalt plant operated by Paving Products, Inc. is also located within the Fairbanks nonattainment area but was not listed in Table 1-4 because it is not operated during winter.

Table 1-4 2008 Baseline Episodic Actual and Permitted Point Source Emissions (tons/day) by Facility							
Facility	Nonattainment Area	$PM_{2.5}$		SOx		NOx	
		Actual	Permitted	Actual	Permitted	Actual	Permitted
Flint Hills North Pole Refinery	North Pole	0.031	0.063	0.022	0.797	0.636	1.008
Golden Valley Electric Association Zehnder Facility	Fairbanks	0.119	0.123	0.318	1.589	0.405	7.816
Golden Valley Electric Association North Pole Power Plant	North Pole	0.799	1.255	2.028	11.786	5.921	14.622
Aurora Energy Chena Power Plant	Fairbanks	0.011	0.047	2.002	2.351	1.521	1.745
University of Alaska Fairbanks Power Plant	Fairbanks	0.078	0.107	0.911	6.450	0.882	2.201
Fort Wainwright Army Base (Doyon Utilities)	Fairbanks	0.373	1.247	2.886[a]	2.792[a]	3.920	4.704
All Facilities	**Fairbanks**	**0.582**	**1.523**	**6.116**	**13.182**	**6.727**	**16.467**
All Facilities	**North Pole**	**0.830**	**1.318**	**2.051**	**12.584**	**6.557**	**15.630**
All Facilities	**FNSB**	**1.423**	**4.019**	**8.380**	**29.404**	**13.395**	**34.313**

[a] Although actual SOx emissions are nominally higher than permitted emissions as compared here, this does not constitute a violation of the facility permit because the permit reflects allowable annual emission limits (in tons per year). The comparisons in Table 1-4 are presented on an episodic average daily basis to provide more relevance during winter conditions when ambient $PM_{2.5}$ violations have occurred. For example, actual annual 2008 SOx emissions from the Fort Wainwright/Doyon Utilities facility were 14.37 tons/year, or an average of 2.007 tons/day (14.37/365), which is well within permitted limits (2.792 tons/day average).

In addition, a facility closure and decommissioning that was completed in 2014 will affect these comparisons in 2015 and beyond. Flint Hills Refinery in North Pole ceased production of gasoline and all other refined products in mid-2014. Although the facility is still being operated as a terminal (transporting product via rail to on-site storage tanks), refinery operations have ended. Beyond elimination of the refinery emissions at the facility, actual episodic emissions at the GVEA North Pole and Zehnder facilities are expected to be lower because both facilities burned HAGO (Heavy Atmospheric Gas Oil) during winter, a heavy by-product from the earlier Flint Hills refining operations that is no longer available. Although data from the GVEA facilities reflecting a shift to a lighter and cleaner distillate are not yet available, it is expected their actual emissions in 2015 and later years will be significantly below their 2008 levels reported in Table 1-4.

1.3 Emission Density Comparisons

Although the summaries of absolute and relative emissions (and point source breakdowns) presented in the preceding sub-sections are useful, they do not reflect the emission “strength” or density within each area that more directly relates to ambient $PM_{2.5}$ concentrations (all other factors being equal). Thus, a simple set of emission density (tons per day per square mile) comparisons were prepared by nonattainment area and source sector. These are presented below in Table 1-5.

Table 1-5 Comparison of Emission Density (tons/day-sq mi) by Nonattainment Area and Source Sector 2015 Control Inventory, Point Source Actual Emissions						
	$PM_{2.5}$		SOx		NOx	
Source Sector	Fairbanks	North Pole	Fairbanks	North Pole	Fairbanks	North Pole
Space Heating	**18.21**	**25.28**	35.49	26.22	19.83	15.02
Point (Actual)	**6.45**	**27.62**	67.84	68.25	74.62	218.20
On-Road Mobile	3.53	4.62	0.13	0.18	19.33	24.27
Non-Road Mobile	0.13	0.08	0.06	0.04	2.72	1.79
Other (incl. Airports)	0.76	0.21	0.83	0.00	8.47	0.02
TOTALS	**29.08**	**57.81**	104.35	94.68	124.97	259.31
TOTALS, less Pt Srcs	**22.63**	**30.19**	36.51	26.44	50.35	41.11

The emission densities shown in Table 1-5 were calculated as area composites (i.e., averages over each entire nonattainment area) by dividing emissions presented earlier in Table 1-2 by the size of each nonattainment area (Fairbanks = 180.3 sq mi, North Pole = 60.1 sq mi). As highlighted in Table 1-5, the $PM_{2.5}$ emission density for space heating and point source (the two largest sectors) is significantly higher across the North Pole area than Fairbanks. And ignoring the contribution from point sources (since they are emitted from selected "point" locations within each nonattainment area, rather than more broadly), the row at the bottom of Table 1-5 provides emission density comparisons when point sources are excluded. Even ignoring point sources, the North Pole $PM_{2.5}$ emission density is 33% higher (30.19 vs. 22.63 tons/day-sq mi) than that across Fairbanks.

Although emission densities for SOx are fairly similar across the proposed nonattainment areas, they are significantly higher for NOx (albeit largely due to point sources).

1.4 Borough OHH Location Data

A final element examined within this factor (pollutant emissions) was known[2] locations of outdoor hydronic heaters (OHHs) compiled by Borough staff[3] based on regular visual reconnaissance. As described in detail in the EI documentation for the Moderate Area SIP, OHHs tend to have the highest "per source" emissions of $PM_{2.5}$ and key precursors

[2] Based on estimates of OHH devices in the FNSB nonattainment area developed from multiple Home Heating surveys conducted in the area and discussions with Borough staff, the Borough-compiled OHH location data may under-represent the actual number of devices in use due to visual identification issues such as large lots/setbacks and view obstructions from trees and structures. Nevertheless, they likely provide a reasonable representation of the spatial distribution of OHHs throughout the FNSB nonattainment area.

[3] "Known_OHH_Extracted_06_26_15.xlsx," email from Todd Thompson, Fairbanks North Star Borough to Bob Dulla, Sierra Research, June 29, 2015.

based on the combination of their emission factors (per unit fuel energy) and usage rates. Thus, the Borough OHH data were plotted to identify where these high-emitting sources were located.

Figure 1-3 shows a zoomed-in map of the Fairbanks nonattainment area and identifies known OHH locations within that area. The Borough's OHH reconnaissance database also identified the type of fuel likely burned (wood vs. coal). The legend in Figure 1-3 indicates how OHHs of each type are identified on the map. As Figure 1-3 shows, there is a cluster of these high-emitting devices just south of downtown Fairbanks (including a number of coal-burning units). Other OHHs are more scattered to the west around Fairbanks International Airport and north and northeast along Farmer's Loop Road and the Steese Highway, respectively.

Figure 1-4 presents a similar map of known OHH locations within the North Pole nonattainment area. As Figure 1-4 shows, OHHs in North Pole tend to be a bit more uniformly distributed within the North Pole nonattainment area than they are in Fairbanks.

Figure 1-3
Known OHH Locations in the Fairbanks Nonattainment Area

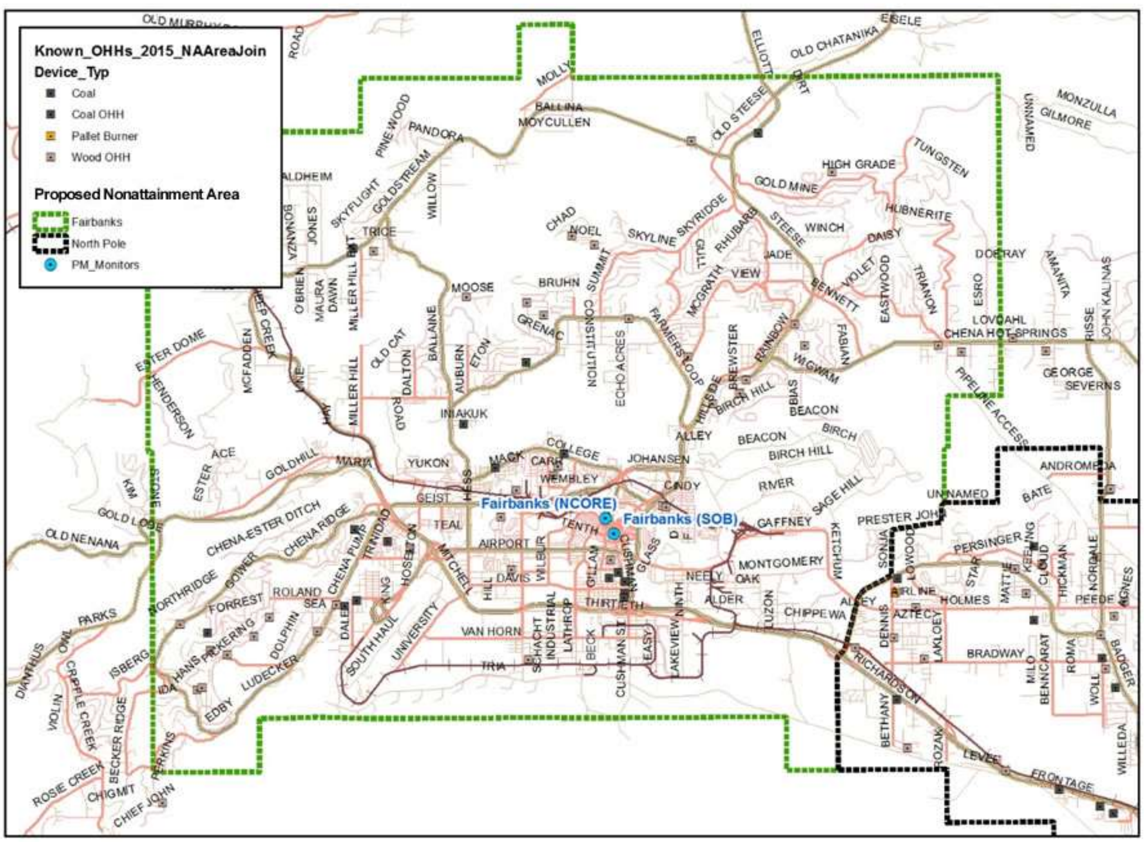
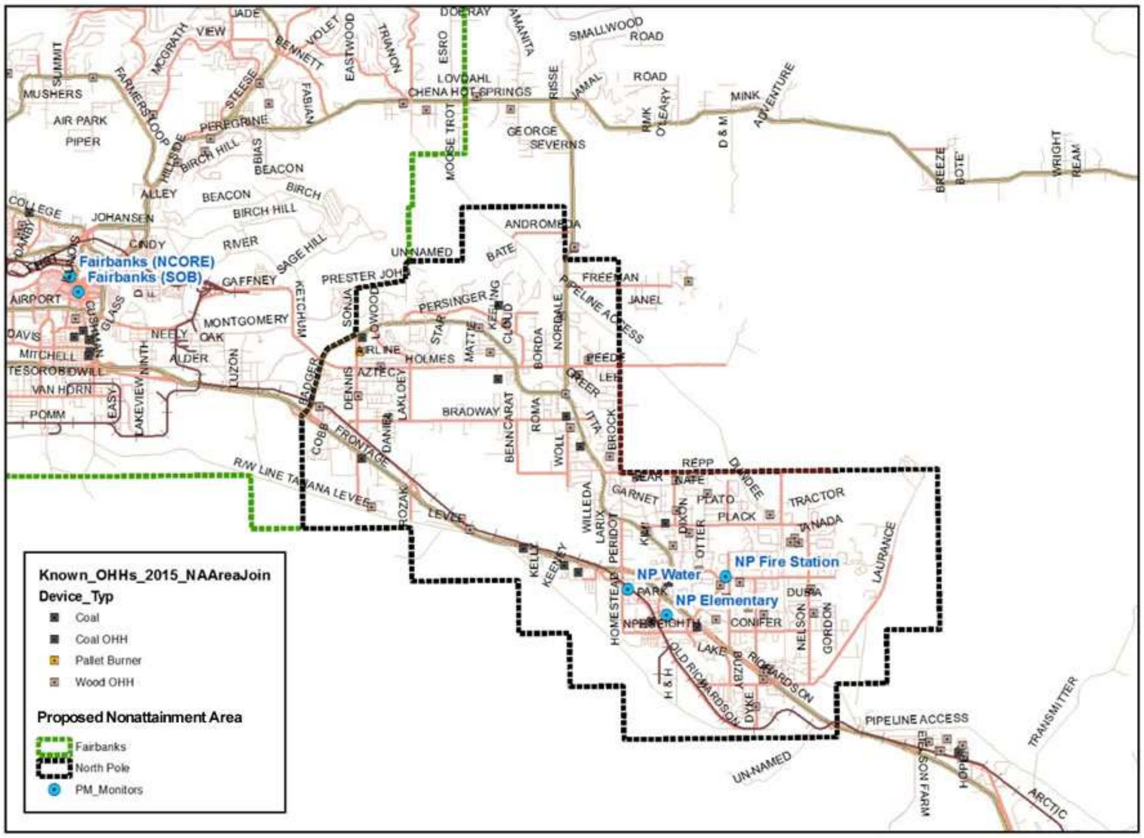


Figure 1-4
Known OHH Locations in the North Pole Nonattainment Area



To better understand potential differences in known OHHs between the two proposed nonattainment areas beyond these location maps, the data were tabulated into device counts and OHH density (number of devices per square mile) across each area. The results are presented in Table 1-6.

As seen in the top portion of Table 1-6, there are more known OHHs located in North Pole (59) than in Fairbanks (54). Although not a large difference on a device-count basis, OHH densities (devices/square mile) are dramatically different between the two nonattainment areas, as shown in the bottom portion of Table 1-6. The density of high-emitting OHHs across North Pole (0.965/square mile) is over three times higher than in Fairbanks (0.307/square mile).

Table 1-6 Comparison of OHH Device Counts and Density Across Fairbanks and North Pole Nonattainment Areas			
Device Type	Fairbanks	North Pole	FNSB
OHH Device Counts (Borough, June 2015)			
Coal OHH	16	16	32
Pallet Burner	0	1	1
Wood OHH	38	42	80
All	**54**	**59**	**113**
OHH Density (devices/sq mi)			
Coal OHH	0.0911	0.2618	0.1352
Pallet Burner	0.0000	0.0164	0.0042
Wood OHH	0.2164	0.6871	0.3379
All	**0.3075**	**0.9653**	**0.4773**

The higher "concentrations" of OHHs and other wood burning devices within the proposed North Pole nonattainment area relative to the entire FNSB nonattainment area have been repeatedly corroborated from multiple Home Heating surveys.[4] Since space heating is the largest source sector within the FNSB nonattainment area and is dominated by wood-burning emissions, higher densities of these types of devices in North Pole relative to Fairbanks has potential implications for applying area-specific control strategies and targeting of resources.

1.5 Summary

The emissions and high-emitting OHH device comparisons presented in the preceding sub-sections indicate that there are several differences in the mix of source emissions between Fairbanks and North Pole. First, although emission contributions by source sector (excluding point sources) are similar within each area, the emission densities or source strengths are distinctly different. As shown earlier in Table 1-5, $PM_{2.5}$ emissions across the North Pole area are 33% higher than those in Fairbanks when point sources are not considered; when point sources are included, the differences are larger.

In addition, the recent closure of the Flint Hills Refinery in North Pole will lead to significant changes in emissions in 2015 and potentially later years at the adjoining GVEA North Pole Power Plant triggered by its switch to a different grade of distillate caused by the refinery closure.

[4] ADEC and the Borough have conducted a number of annual telephone-based Home Heating surveys (sampling several hundred households per survey) of space heating devices and usage within the nonattainment area. Device usage data tabulated by ZIP code from these surveys have been used to represent spatial differences in space heating within the FNSB nonattainment area based on the device/fuel usage mix.

Finally, an examination of known locations of OHHs within the FNSB nonattainment area based on a Borough-compiled database indicates that these higher-emitting devices are much more concentrated in the proposed North Pole nonattainment area than in the proposed Fairbanks area. As shown in Table 1-6, North Pole has over three times the number of OHHs per square mile than Fairbanks. This is consistent with data collected from recurrent Home Heating surveys that more broadly show greater concentrations of wood-burning devices in North Pole than the rest of the FNSB nonattainment area, and these tend to have much higher emission rates per unit of energy than other space heating device such as those burning heating oil or natural gas.

FACTOR 2. AMBIENT AIR QUALITY TRENDS

This section of the analysis presents comparisons of 24-hour 98th percentile annual concentrations and moving three-year average design values recorded at the State Office Building and the NCORE site located in downtown Fairbanks and the North Pole Fire Station. Also presented is a comparison of average hourly $PM_{2.5}$ concentrations recorded at the NCORE and North Pole Fire Station monitors during the past winter (2014-2015).

2.1 Annual Concentrations, Design Values and Diurnal Profiles

The 24-hour $PM_{2.5}$ standard of 35μg/m^3 is designed to protect human health against short-term exposure to fine particles, particularly in areas with high peak $PM_{2.5}$ concentrations. A community attains the 24-hour standard when the 98th percentile of 24-hour $PM_{2.5}$ concentrations for each year, averaged over three years, is less than or equal to 35 μg/m^3. The μg/m^3 design value, computed as a three-year running average of the 98th percentile yearly concentrations, determines whether an area has reached attainment of the standard. Table 2-1 presents recent annual concentrations and design values for three monitor locations in the Borough.

The trend in ambient air quality for the State Office Building (SOB), the longest operating monitor, is shown in

Figure 2-1. The three-year average design values are in yellow triangles. This location peaked in 2010 and has shown decreasing values since then, with a 2014 design value of 40μg/m^3. The 98th percentile for 2014 is below the standard of 35 μg/m^3 and 2014 is considered a "clean data year," although the site will not reach attainment until the three-year design value is below the standard. A comparable trend is seen in the table for the NCORE monitor, which peaked in 2012 and has declined since. The 98th percentile for 2014 is also below the standard and 2014 is considered a "clean data year," although NCORE has not reached attainment.

Figure 2-2 adds the 98th percentiles for the North Pole Fire Station monitor to the data presented in

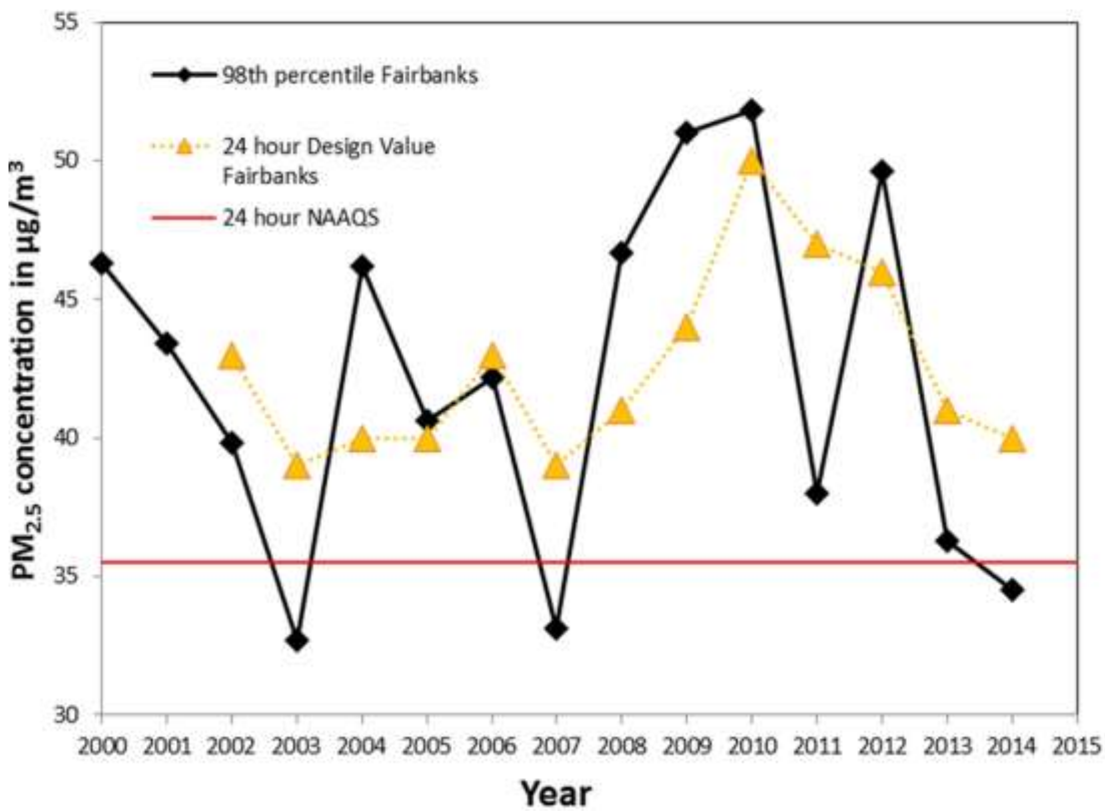
Figure 2-1. The North Pole area only has one three-year design value at 139μg/m^3, an average of the last three years. The difference in design values between North Pole and Fairbanks is 100μg/m^3. The Fire Station monitor design value is triple that of downtown

Fairbanks and triple the $PM_{2.5}$ standard of 35 $\mu g/m^3$. Although North Pole is very close to Fairbanks, it experiences vastly higher concentrations.

Table 2-1
$PM_{2.5}$ 24-hr 98% Percentile and Design Value Concentrations ($\mu g/m^3$) for the State Office Building (SOB), NCORE (downtown Fairbanks), and North Pole Fire Station (North Pole) Monitors

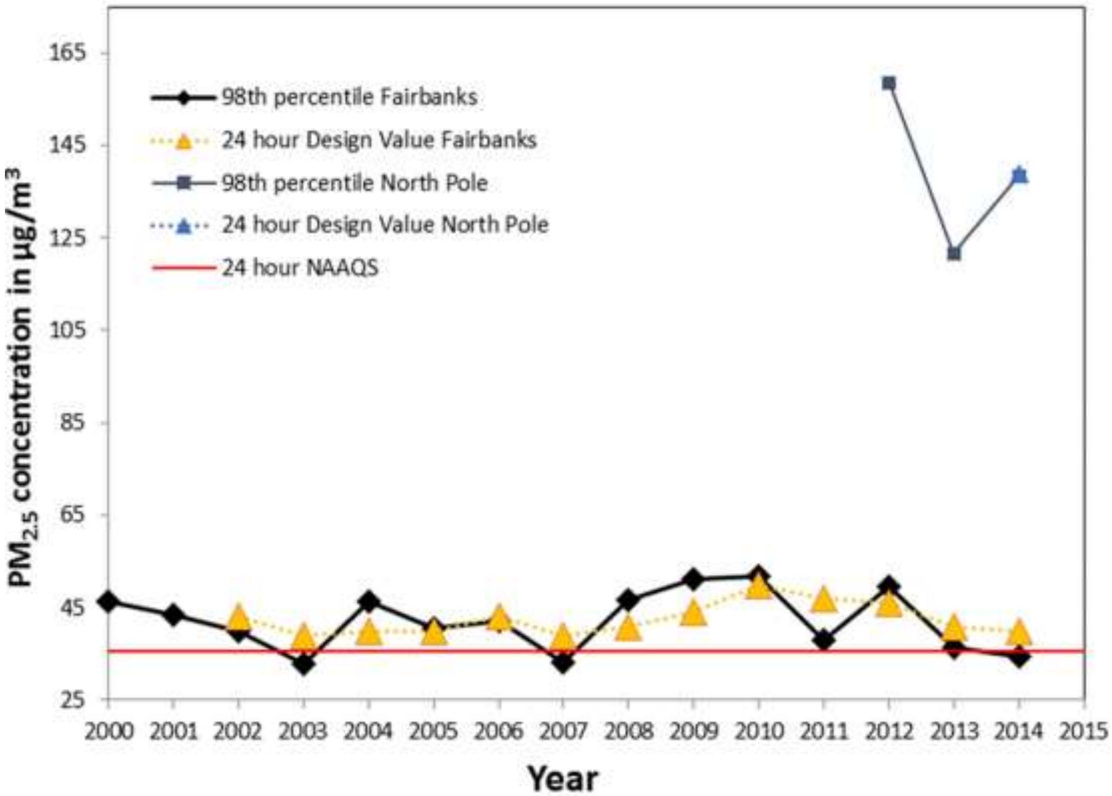
Site	98th percentiles				3-yr DV	
	2011	2012	2013	2014	2013	2014
SOB	38.0	49.6	36.3	34.5	41	40
NCORE	33.1	50.0	36.2	31.6	40	39
North Pole Fire Station	NA	158.4	121.6	138.3	NA	139

Figure 2-1
Fairbanks Monitor Located at the State Office Building



Note: $PM_{2.5}$ 98th percentile and 24-hour design values since the year 2000.

Figure 2-2
Fairbanks Monitor Located at the State Office Building and the North Pole Monitor Located at the Fire Station

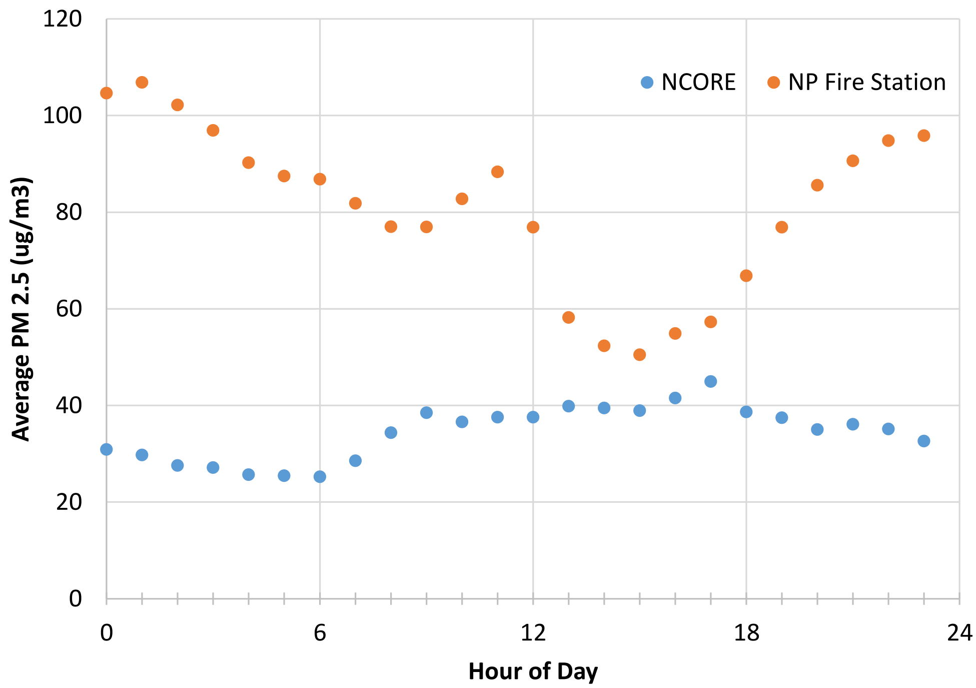


Note: $PM_{2.5}$ 98th percentile and 24-hour Design Values since the year 2000.

Even though 2015 is not complete, early concentrations indicate that the annual 98th percentile for Fairbanks may likely come in under the 24-hour standard. However, the annual 98th percentile for North Pole will greatly exceed the standard in 2015 as it has for the past three years.

The two areas also differ in terms of the mix of residential and commercial sources; this leads to differences in the diurnal profiles of $PM_{2.5}$ concentrations during the day, as shown in Figure 2-3. To create this graph, the days of the past winter (2014-2015) were ranked based on $PM_{2.5}$ concentrations at the Fire Station. The top 25 percent of days were selected, and the hourly $PM_{2.5}$ concentrations recorded at the BAM monitors were then averaged by hour at both monitors. For the North Pole Fire Station, all days in the top 25 percent exceeded the 24-hour standard, while only 18 of the days exceeded the standard at NCORE. However, the shape of the diurnal profile for the 18 exceedance days is not appreciably different than the profile for the top 25 percent of days that is shown in the figure.

Figure 2-3
Diurnal Profiles of $PM_{2.5}$ Concentrations at the NCORE and North Pole Fire Station Monitors



Note: Based on the days in the winter of 2014-2015 ranked in the top 25 percent for $PM_{2.5}$ concentrations.

The NCORE monitor is located in downtown Fairbanks, which is a center of commercial activity in the Borough. The downtown area is comprised of office, retail, and governmental buildings, including the Post Office, surrounded by residential structures such as apartment buildings and single-family homes. There is also a significant level of traffic flow throughout the day into and out of downtown. As seen in Figure 2-3, $PM_{2.5}$ concentrations begin to rise at 7 am and quickly reach the level of the daytime plateau by 9 am. There is an uptick in concentrations at 5 pm, followed by a slow decline through the evening and overnight hours.

The mix of residential and commercial activity is generally reversed in North Pole. The Fire Station monitor is located in a predominantly residential area of North Pole with mostly single-family homes intermixed with smaller commercial buildings. Many residents commute outside of North Pole to jobs at Eielson AFB or the Fairbanks area. Many homes are un-occupied during the day. As shown in Figure 2-3, $PM_{2.5}$ concentrations begin a morning rise after the 8 am hour. After a peak at 11 am, concentrations fall throughout the afternoon as wood-fired space heating devices burn down. Concentrations rise again starting at 4 pm and continue to rise throughout the evening to a peak at 1 am, before declining slowly through the overnight hours.

2.2 Summary

The Fairbanks and North Pole nonattainment areas are very different in terms of the level and diurnal pattern of $PM_{2.5}$ concentrations. The Fairbanks area has seen a downward trend in concentrations since 2010 (State Office Building monitor) and 2012 (NCORE monitor). The NCORE monitor has experienced one “clean data year” and appears headed toward a second such year in 2015. In contrast, North Pole experiences much higher $PM_{2.5}$ concentrations, with the Fire Station monitor having a 2014 design value that is more than triple the $PM_{2.5}$ standard of 35 $\mu g/m^3$. These large differences have led the State to undertake investigations into meteorological differences in temperature and/or wind speed between the areas and to re-examine the data on contributing sources.

The two areas also differ in terms of the daily patterns of activity. The NCORE monitor is located in downtown Fairbanks, which has a clustering of commercial activity along with residential structures. $PM_{2.5}$ concentrations tend to be highest during the workday hours (9 am to 5 pm) and to decline overnight. The Fire Station monitor is located in a predominantly residential area from which many residents commute to jobs in other parts of the Borough. $PM_{2.5}$ concentrations rise during the morning hours, but fall through the afternoon. Concentrations are highest in the evening hours when residences are re-occupied after the workday and space heating needs increase.

FACTOR 3. POPULATION DENSITY AND DEGREE OF URBANIZATION

This section of the analysis presents comparisons of population and household counts within the two proposed nonattainment areas compiled from block-level[5] data in the 2010 Census. In addition to static snapshots based on the 2010 Census, long-term population and household growth forecasts[6] developed by the Borough's Department of Community Planning at the block group level were used to examine any differences in forecasted growth rates between the Fairbanks and North Pole areas.

3.1 2010 Population and Household Density Distributions

Population and household counts compiled at the Census block level across the FNSB $PM_{2.5}$ Nonattainment Area (PM NAA) were examined within GIS-based maps that included base layers identifying (1) the boundaries of the FNSB PM NAA (and the proposed Fairbanks and North Pole nonattainment areas); (2) major roadways within the area; and (3) locations of the ambient $PM_{2.5}$ monitors either currently or historically operated within the area. And because the size of the census blocks varies significantly across the FNSB PM NAA, the Census data were plotted on a density basis (i.e., population or households per square mile).

Figure 3-1 and Figure 3-2 present spatial comparisons of 2010 population and household density (per sq. mi), respectively. Within each figure, the Fairbanks and North Pole nonattainment areas (referred to as "subareas" in the figure legends) are shown with dashed lines; blue dots mark the ambient monitor locations. Population density (in Figure 3-1) and household density (in Figure 3-2) are plotted using successively dark color shading from yellow to brown, as denoted in the map legends. (Although census block-based estimates were developed for the entire Borough, only those blocks that are largely contained within the PM NAA boundaries are plotted for clarity.)

[5] The Census utilizes three successively finer resolutions or entities over which collected data are spatially aggregated and reported: (1) tract; (2) block group; and (3) block. The FNSB $PM_{2.5}$ Nonattainment Area encompasses 18 Census tracts, 58 block groups and 2,777 individual blocks.
[6] Email from Janet Davison, Fairbanks North Star Borough Dept. of Community Planning, July 11, 2012.

Figure 3-1
2010 Census-Based Population Densities in FNSB $PM_{2.5}$ Nonattainment Area

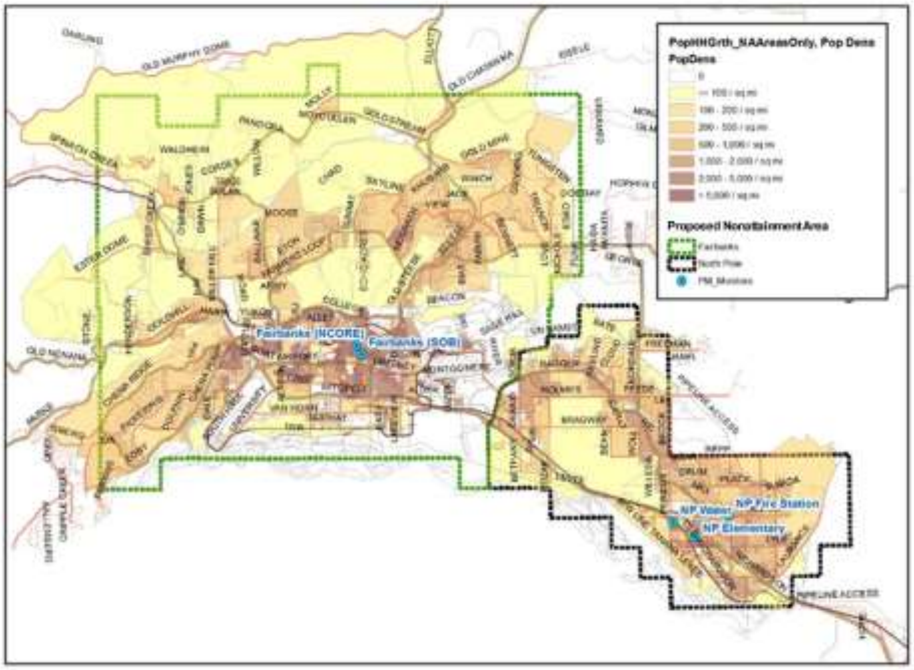
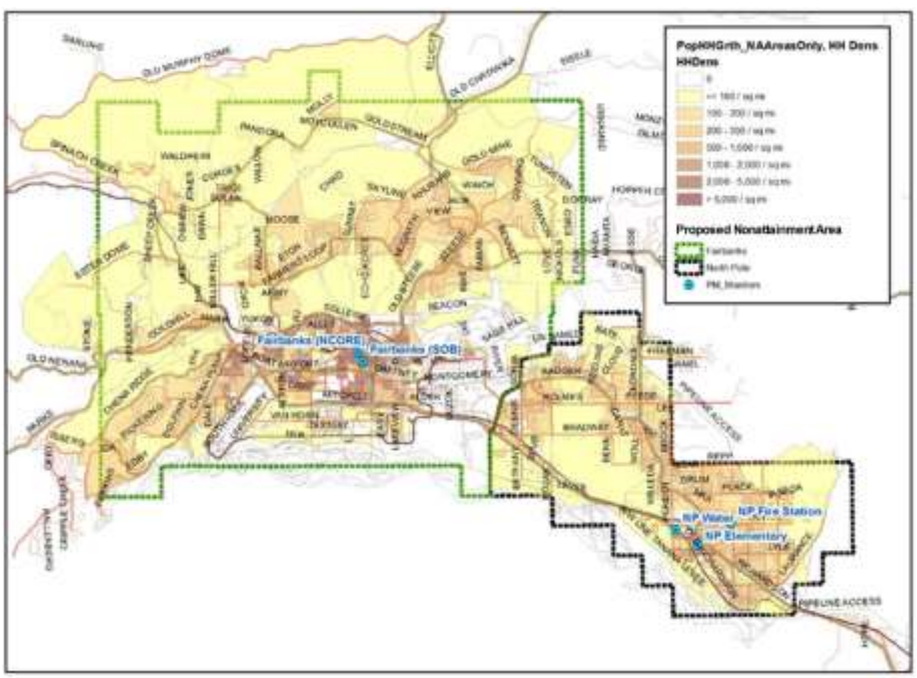


Figure 3-2
2010 Census-Based Household Densities in FNSB $PM_{2.5}$ Nonattainment Area



As seen in both figures, the downtown and immediately adjacent areas of Fairbanks (surrounding the two Fairbanks monitors) exhibit higher population densities than the rest of the Fairbanks nonattainment area, although moderate densities also occur to the northeast near the Steese Highway and Chena Hot Springs Road junction. Within the North Pole nonattainment area, census blocks with elevated population and household densities are more widespread across the subarea although they are not quite as high as those in downtown Fairbanks.

(In downtown Fairbanks, population densities are generally in the 5,000/sq. mi range as seen in Figure 3-1. In North Pole, population densities hover around 2,000/sq. mi, with only a few Census blocks exhibiting densities above 5,000/sq mi.) Each of the three North Pole monitors falls within the elevated areas of population and household density.

3.2 Borough Growth Rate Forecast Distributions

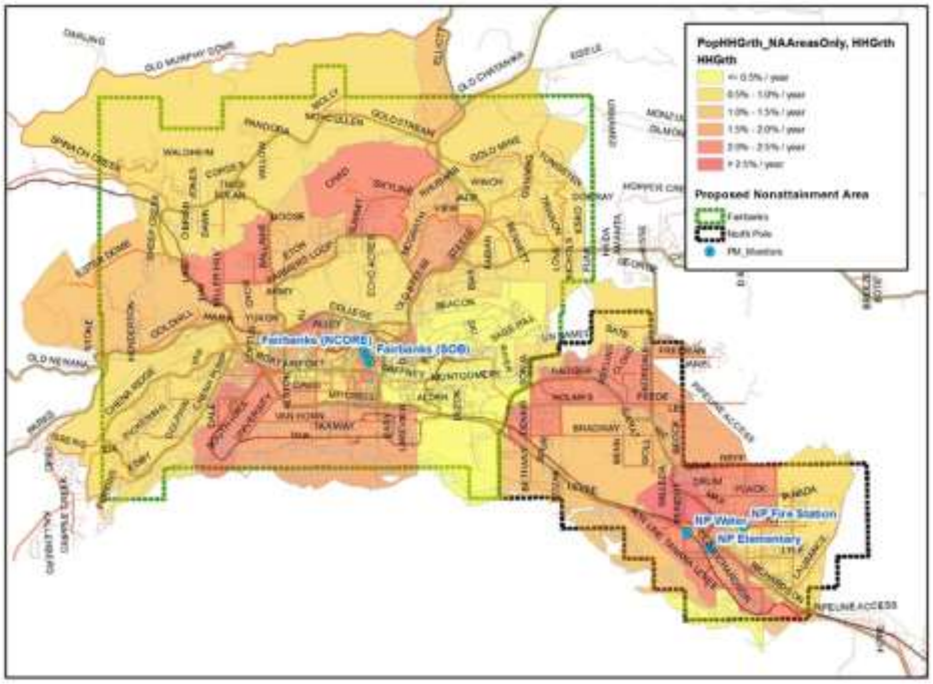
A similar set of the spatial distributions of long-term (2010 to 2030) population and household growth rates across the Fairbanks and North Pole nonattainment areas was also assembled, based on forecasts from the Borough's Community Planning department. Unlike the block-level 2010 Census data, the Borough growth rate forecasts were developed more coarsely by block group. Nevertheless, the resolution of these block groups is sufficient to identify higher-growth pockets within each nonattainment area, and compare growth rates across each nonattainment area.

Figure 1-3 presents the household growth rate comparisons across the FNSB nonattainment area. (A yellow to red color ramp is used to distinguish the growth rate plots from the 2010 Census "snapshot" plots of population and household density presented earlier. And again, only census blocks largely within the FNSB PM NAA are plotted for clarity.)

Several distinguishing differences can be seen between forecasted growth in the proposed Fairbanks and North Pole nonattainment areas. First, annualized household growth rates in the immediate vicinity of the Fairbanks monitors are generally below 1.5%, while the rates are in the 2.5% range in the areas surrounding the North Pole monitors. Second, a broader areal comparison of the growth rates across each nonattainment area shows somewhat higher forecasted growth in North Pole relative to Fairbanks. (This is seen more clearly in tabular comparisons that follow.) Finally, the area at the eastern boundary of the Fairbanks nonattainment area that includes, but is not limited to, the Ft. Wainwright Army Base reflects very mild forecasted growth (below 0.5% per year) and may represent a growth "buffer" between the two proposed nonattainment areas.

(The population growth rates are in very close agreement with the household growth rates. Thus, only the spatial household growth rate patterns were plotted.)

Figure 3-3
2010-2030 Household Growth Rate Forecasts (%, Annualized) by Block Group



Composite Subarea Growth Rates – A clearer illustration of the difference in forecasted long-term growth rates for each of the two nonattainment areas can be seen from the tabulated "composite" comparisons across each area. Table 3-1 first presents comparisons of 2010 Census counts and calculated population and household densities for each proposed nonattainment area in its entirety. In addition, the rightmost columns of Table 3-1 show the differences in composite (i.e., weighted average) growth rates for each proposed nonattainment area. As highlighted in Table 3-1, the average household growth rate for the entire North Pole area (1.81% per year) is some 76% higher than that for the Fairbanks area (1.03% per year).

Table 3-1
Composite Census Counts, Densities, and Growth Rates by Nonattainment Area

	2010 Census Counts			2010 Density (per sq. mi)		Average Annual Growth	
NAA	Population	Households	Size (sq. mi)	Population	Households	Population	**Households**
Fairbanks	64,856	27,456	205.32	315.9	133.7	1.03%	**1.03%**
North Pole	21,181	8,272	66.08	320.6	125.2	1.68%	**1.81%**
FNSB	86,037	35,728	271.40	317.0	131.6	1.20%	**1.23%**

Although forecasts are always revised over time, and growth in the region is heavily affected by employment and operational projections at the nearby Wainwright and Eielson military bases, these estimates reflect distinctly different long-term growth rates for Fairbanks and North Pole.

3.3 Summary

Spatial comparisons of 2010 Census-based population and densities within both the Fairbanks and North Pole portions of the existing FNSB nonattainment area (Figure 3-1 and Figure 3-2) show that Fairbanks has pockets with slightly higher densities than North Pole. However, on average across each proposed nonattainment area, composite population and household densities are very similar (Table 3-1). Densities across North Pole tend to be a bit more homogeneous than throughout the Fairbanks area.

Going forward from 2010, household and population growth rates within and across each area are significantly different. As highlighted earlier in Table 3-1, long-term (to 2030) annualized growth rates forecasted by the Borough's Community Planning department are significantly higher, on average, for North Pole than Fairbanks: overall household and population growth in North Pole is projected to be 76% and 63% higher respectively, than in Fairbanks. And growth rates in the immediate vicinity of the two currently operating ambient monitors in North Pole (Fire Station and Water) tend to be higher than those surrounding the downtown Fairbanks monitors (Figure 1-3). In addition, the eastern portion of Fairbanks that adjoins the proposed boundary split between the two nonattainment areas (from Ft. Wainwright eastward to Badger Road) exhibits very low (less than 0.5% per year) growth and thus may represent a spatial buffer between the projected growth patterns in each area.

FACTOR 4. TRAFFIC AND COMMUTING PATTERNS

On-road vehicle activity patterns for the Fairbanks North Star Borough (FNSB) $PM_{2.5}$ nonattainment area and the proposed Fairbanks and North Pole nonattainment areas are presented to highlight the current and projected differences in the local traffic flows.

4.1 2013 Regional Traffic Analysis

Travel demand model outputs produced for the Fairbanks Metropolitan Area Transportation System (FMATS) were used to summarize the vehicle flow (vehicle counts) and vehicle miles traveled (VMT) within the proposed nonattainment areas. Table 4-1 shows the total vehicle flow and VMT for both the proposed Fairbanks and North Pole nonattainment areas along with the totals across the FNSB nonattainment area.

Table 4-1
Modeled Vehicle Activity by Nonattainment Area (NAA)

	2013 Travel Model Activity			Density (per sq mi)		Annual Growth	
NAA	Vehicle Flow	VMT	Size (sq mi)	Vehicle Flow	VMT	Vehicle Flow	VMT
Fairbanks	6,490,723	1,315,422	175.60	36,962	7,491	1.17%	1.49%
North Pole	865,520	317,733	61.12	14,160	5,198	1.91%	2.00%
FNSB	7,356,243	1,633,155	236.73	31,075	6,899	1.26%	1.59%

Fairbanks shows a much higher amount of vehicle flow and VMT compared to North Pole: 7.5:1 and 4.1:1, respectively. Given that Fairbanks is 2.9 times larger than North Pole, the actual density of vehicle activity is not as drastically different. On a density basis, flow in Fairbanks is a factor of 2.6 larger than North Pole and VMT is a factor of 1.4 larger. Based on travel model projections through 2040, vehicle flow and VMT are estimated to grow at a faster annual rate than Fairbanks: 1.91% versus 1.17% for vehicle flow and 2.00% to 1.49% for VMT.

The location of the daily flow patterns is distinctly different for the Fairbanks and North Pole areas. As seen in Figure 4-1 and Figure 4-2, Fairbanks travel activity is concentrated in the downtown region specifically along arterials throughout the urbanized portions, with freeway travel concentrated along the Johansen Expressway, Steese Highway, and Richardson Highway in both the urban and rural areas. The vehicle flow on these links is on the order of 7,000 to 30,000 vehicles per day. Much less dense travel activity patterns are present on western, northern, and eastern periphery of the Fairbanks area. While the vehicle counts on freeways in these areas are in the range of 3,000 to 7,000 vehicles per day, the arterial traffic is typically below 1,000 vehicles per day, with the exception of major arterials such as Chena Hot Springs Road. The majority of the North Pole vehicle flow totals, shown in Figure 4-3, are spread over fewer links than in Fairbanks. The majority of the flow is carried along the Richardson Highway with daily vehicle flow on the order of 15,000 to 20,000; Badger Road shows the highest arterial daily vehicle flow, at just under 5,000.

Figure 4-1
2013 Travel Model Link-level Daily Flow for FNSB $PM_{2.5}$ Nonattainment Area

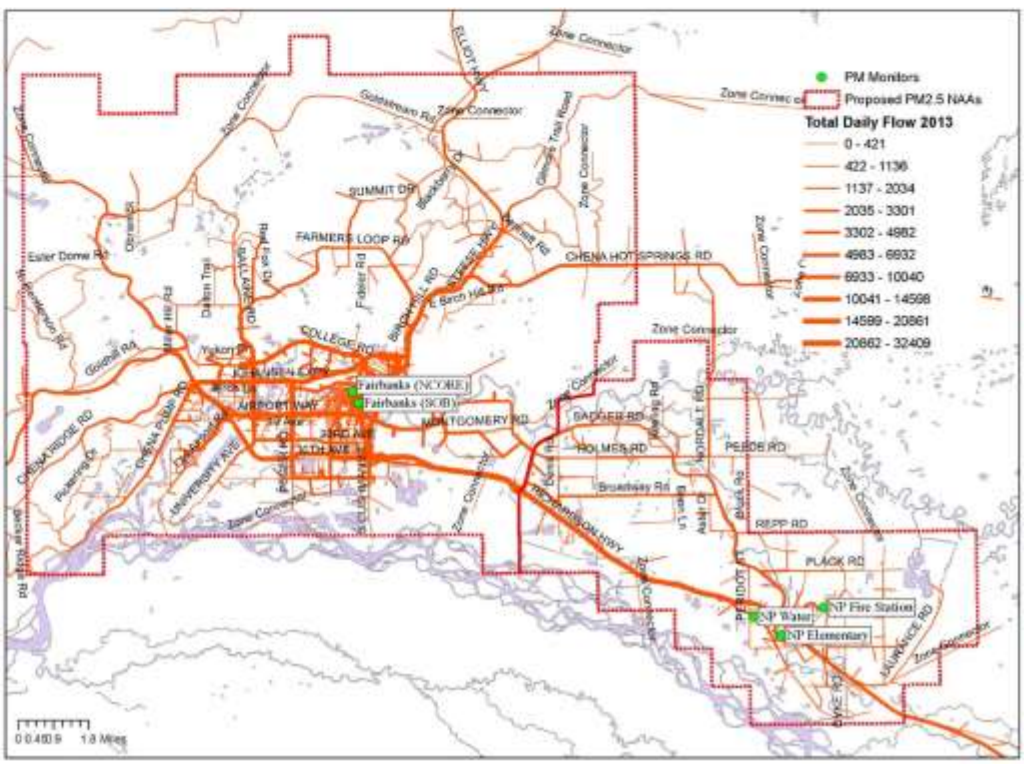


Figure 4-2
2013 Travel Model Link-level Daily Flow for the Fairbanks Nonattainment Area

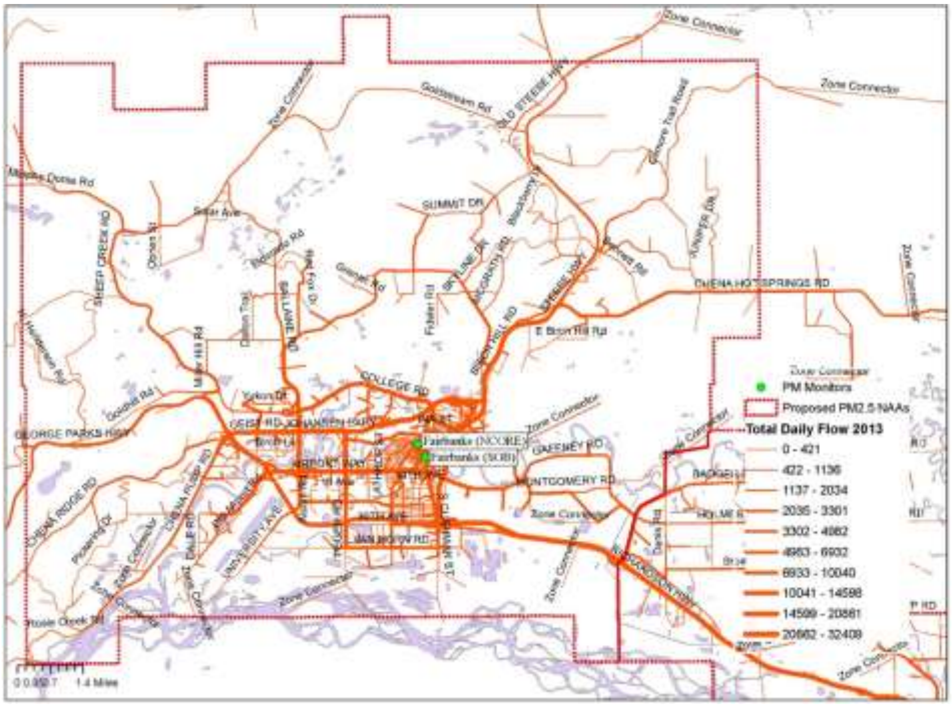
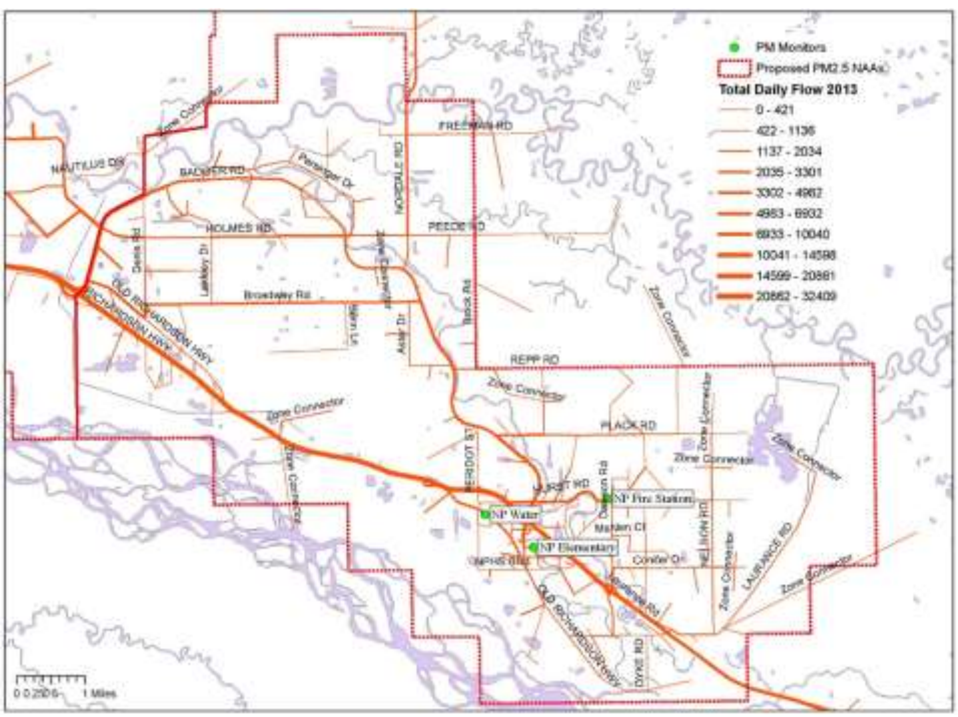
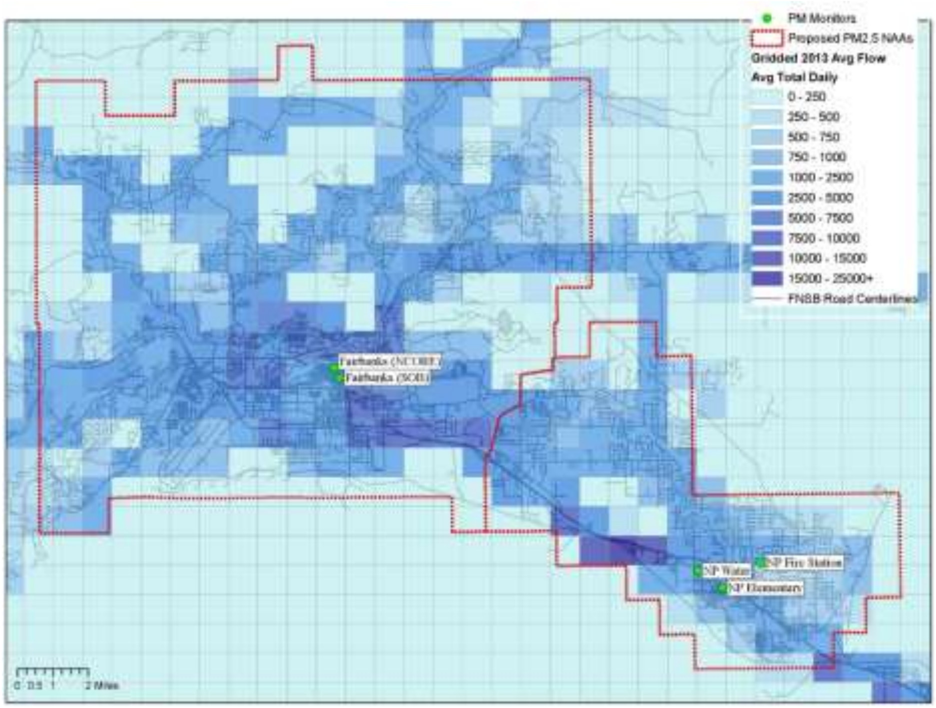


Figure 4-3
2013 Travel Model Link-level Daily Flow for North Pole Nonattainment Area



Overall, North Pole shows a much less dense network of roads with lower daily vehicle flow counts compared to Fairbanks. The differences in vehicle activity density are more readily visible when the vehicle flow counts are gridded, as seen in Figure 4-4. Daily vehicle activity counts for roads are averaged within 1.33 x 1.33 km cells. It should be noted that these cells contain the average of the activity across all links contained within the cells so the vehicle counts do not reach the peaks seen on any individual link depicted in Figure 4-1 to Figure 4-3. The cells in the downtown Fairbanks area show daily traffic flow counts of 2,000 to 10,000 vehicles. Away from the downtown area, the Fairbanks area's traffic counts drop below 1,000 vehicles per day with many areas in the range of 0 to 500 vehicles per day. The Fairbanks nonattainment area represents a broad range of vehicle counts. North Pole reflects overall lower vehicle flow density than seen in downtown Fairbanks with the exception of portions of the Richardson Highway. The highest daily vehicle counts are under 20,000 vehicles per day for cells along the Richardson Highway, where these cells are closer to representing the flow of the highway link in that grid cell rather than values averaged across several links. The bulk of the North Pole nonattainment area is in the range of 750 to 2,500 vehicle counts per day, with a small number of cells falling below 750 vehicle counts per day.

Figure 4-4
2013 Gridded Daily Flow Density for the FNSB $PM_{2.5}$ Nonattainment Area



4.2 Projected Changes Through 2040

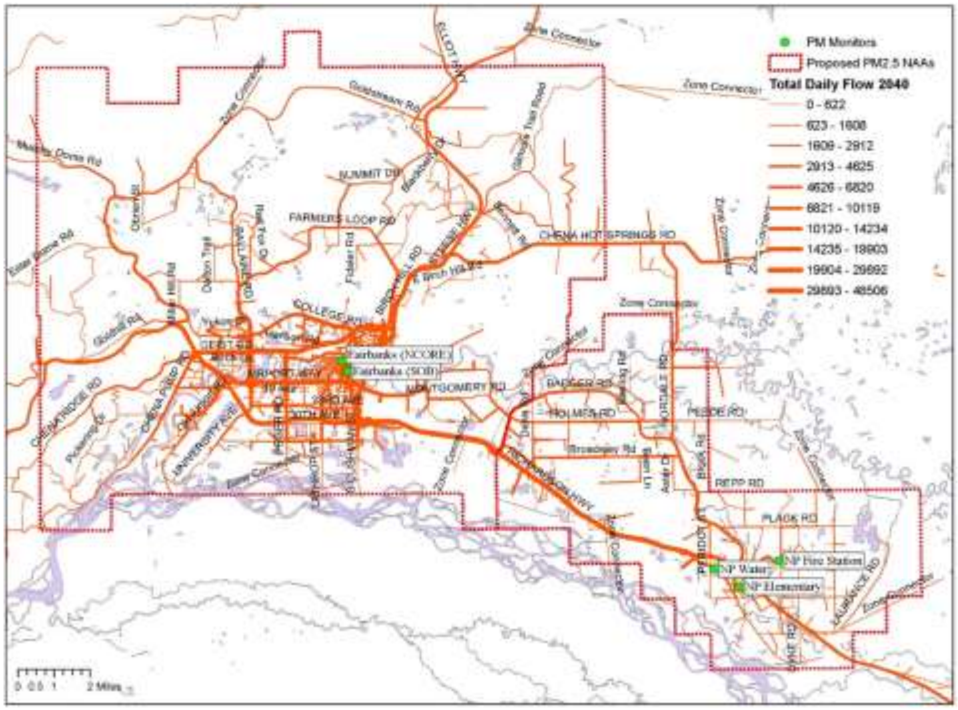
The Fairbanks and North Pole nonattainment areas are projected to experience different amounts of vehicle activity change through 2040, as shown in Table 4-2. The ratios of vehicle flow and activity between Fairbanks and North Pole are estimated to be 6.5:1 and 3.8:1 by 2040. These ratios are lower than those seen in the 2013 travel activity due to the higher rate of growth in North Pole, with vehicle flow changing by 51.47% and VMT changing by 53.03% over their 2013 values. Fairbanks will experience less strong total growth between 2013 and 2040 of 31.61% and 40.26% for vehicle flow and VMT, respectively. The ratio of vehicle flow density between Fairbanks and North Pole is 2.3:1, and the ratio of VMT density is 1.3:1 in 2040. The change in activity density from 2013 to 2040 between the two areas is small, but still reflects that overall activity in North Pole has grown at a faster rate than Fairbanks.

Table 4-2
Projected Modeled Vehicle Activity by Nonattainment Area (NAA)

	2040 Travel Model Activity			Density (per sq mi)		Change from 2013	
NAA	Vehicle Flow	VMT	Size (sq mi)	Vehicle Flow	VMT	Vehicle Flow	VMT
Fairbanks	8,542,566	1,845,071	175.60	48,647	10,507	31.61%	40.26%
North Pole	1,311,013	489,072	61.12	21,448	8,001	51.47%	53.93%
FNSB	9,853,579	2,334,143	236.73	41,624	9,860	33.95%	42.92%

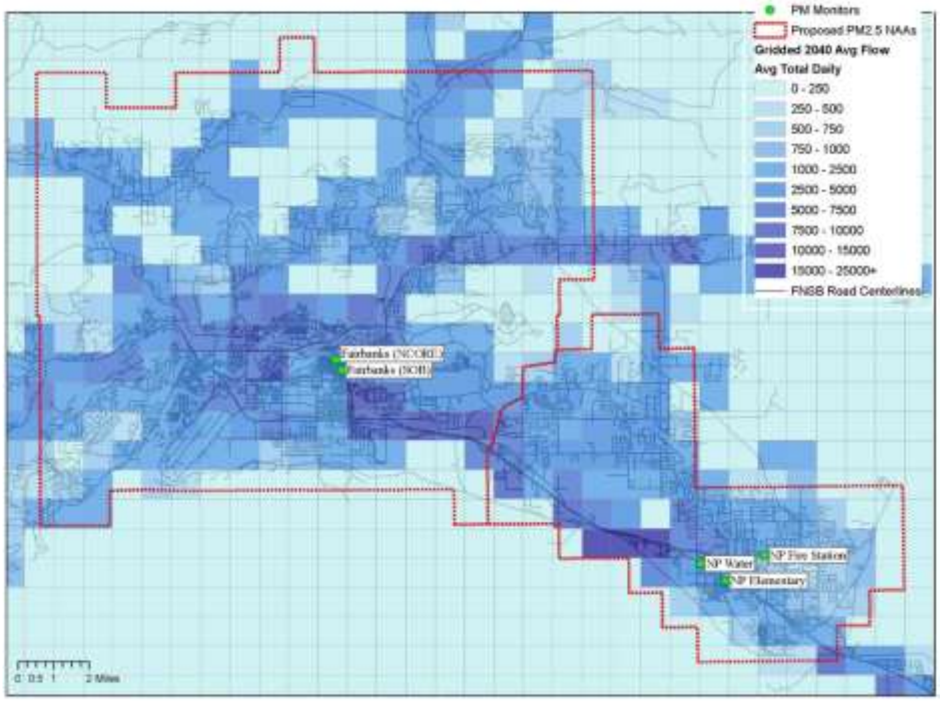
While the overall pattern of vehicle flow does not change drastically between 2013 and 2040, the absolute vehicle counts have broadly increased when individual links are examined, as shown in Figure 4-5. The major freeway daily vehicle flows seen on the Johansen Expressway, Steese Highway, and Richardson Highway have increased to 10,000 to 48,506 vehicles. The higher vehicle counts are closer to the downtown area, and the lower vehicle counts are towards the more rural areas. The arterial traffic has also increased throughout the region with the flow counts away from town typically below 1,000 vehicles per day. Exceptions such as Chena Hot Springs Road now see typical daily flows in the 3,000 to 10,000 range. In North Pole, the Richardson Highway shows daily vehicle flows in the 20,000 to 30,000 range and Badger Road in the 7,000 to 15,000 range.

Figure 4-5
2040 Travel Model Link-level Daily Flow for FNSB $PM_{2.5}$ Nonattainment Area



The pattern of the density in the areas has not changed drastically either for the 2040 projections, as shown in Figure 4-6. The vehicle flow density in the downtown Fairbanks area remains among the highest in the FNSB nonattainment area as a whole, with counts typically between 2,500 and 12,000 vehicles per day per cell. Fairbanks continues to show a sharp drop-off in traffic density away from the core downtown area with values in the 0 to 750 vehicles per day range except for those cells along the major highways and arterials. The peak cells in the domain remain those along the Richardson Highway in North Pole, where the cell values reflect values close to the actual link activity. These high cells are an artifact of the averaging process and the sparseness of the network in North Pole. Typical North Pole vehicle flow densities are in the range of 2,500 to 5,000 vehicles, with few cells dropping below 750 vehicles.

Figure 4-6
2040 Gridded Daily Flow Density for the FNSB $PM_{2.5}$ Nonattainment Area



4.3 Summary

The proposed Fairbanks and North Pole nonattainment areas demonstrate different overall traffic densities, road network densities, and projected growth rates. The proposed Fairbanks nonattainment area is a mix of high-density urban road networks and extremely sparse rural road networks away from the downtown core. The road activity that is most relevant to the monitored air quality values is that of the dense urban core. On an individual and density-averaged basis, these links show higher activity than the cells in the proximity of the North Pole monitors. While North Pole is expected to see enhanced growth in activity through 2040 compared to Fairbanks, the density and overall activity levels of Fairbanks are projected to remain substantially higher than North Pole.

FACTOR 5. GROWTH

This section presents a summary of growth forecasts for the requested Fairbanks and North Pole nonattainment areas. Forecasts of population/households presented in Factor 3 and vehicle counts and vehicle miles traveled (VMT) presented in Factor 4 are summarized.

5.1 Forecasts

Factor 3 presented long-term annualized forecasts of population growth between 2010 and 2030 prepared by the Borough's Community Planning Department. Population is projected to grow at an annualized rate of 1.03% in the Fairbanks nonattainment area and 1.68% in the North Pole nonattainment area. Similarly, household formation is projected to grow 1.03% per year in Fairbanks and 1.81% per year in North Pole over the same period.

Factor 4 presented long-term annualized FMATS forecasts of vehicle flow of 1.17% on roads in the Fairbanks nonattainment area and 1.91% on North Pole area roads between 2013 and 2040. Similarly, VMT growth is forecasted to be 1.49% per year in the Fairbanks area and 2.00% per year in the North Pole area over the same period.

5.2 Summary

The population forecasts show that household and population growth in the proposed North Pole nonattainment area is projected to be 76% and 63% higher, respectively, than in the Fairbanks nonattainment area. The travel forecasts show that vehicle flow and VMT in the North Pole area is projected to be 63% and 34% higher, respectively, than in the Fairbanks area. The consistency between these forecasts is not surprising since population growth and household formation are key drivers in travel demand modeling. More importantly, these forecasts show that the proposed North Pole nonattainment area is forecast to grow at a substantially higher rate than the Fairbanks area.

FACTOR 6. METEOROLOGY IN FAIRBANKS AND NORTH POLE

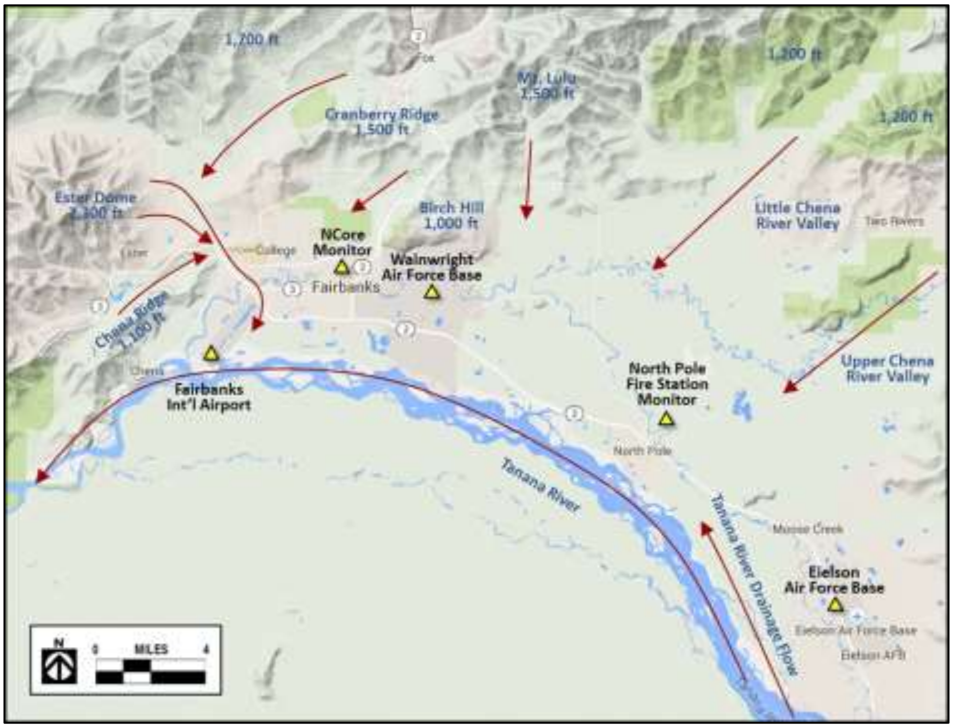
This section presents comparisons of wind speed and direction recorded at the NCore, North Pole Fire Station, and Ft. Wainwright monitors during recent winters. The data are organized to contrast patterns during overall average winter conditions and very low temperature conditions to provide insight into drainage flows and circulation patterns.

6.1 Overview of Winter Meteorology and Available Monitoring Data

$PM_{2.5}$ concentrations become elevated throughout the Fairbanks and North Star Borough (FNSB) during winter periods when strong surface inversions set up under conditions of cold air temperatures and bone dry, clear Arctic skies. Winds are usually calm during inversion periods and air flows aloft do not reach the surface to aid in dispersing pollutants. The most common meteorological condition in which concentrations become elevated is the presence of a cold surface high pressure zone in northwestern Canada or eastern Alaska and a warmer surface low along the western Alaska coast or in the Gulf.

With very low surface winds typical in the Borough during winter, regional drainage from the adjacent mountains and river valleys creates the primary source of air flow to disperse pollutants. These regional flows are katabatic, meaning driven by gravity as cold, dense air flows from higher to lower elevations. Such flows normally occur at the ground surface and extend above, but can, under some conditions, decouple from the stable surface layer and flow over it without mixing. The overland flows of cold dense air within the Tanana Valley commonly create winds of 0.5 to 1.0 m/s (1 to 2 mph) within the Borough. The chief regional drainage flows affecting the Borough are illustrated in Figure 6-1 and are discussed below as they affect the Fairbanks, Ft. Wainwright / Badger Road, and North Pole areas.

Figure 6-1
Regional Drainage Flows Affecting Fairbanks and North Pole



In addition to these regional flows, the Tanana Valley Jet[7] may flow along and south of the Tanana River during the winter. The jet occurs when a surface high pressure cell in the Yukon induces winds along the Tanana Valley toward a surface low west or southwest of Fairbanks. Winds can exceed 25 m/s (55-60 mph) at Delta Junction where the valley narrows, but the jet slows in speed as the valley widens. At Salcha, the jet enters the Tanana plain south and east of the nonattainment area and generally follows a westward path along the northern face of the Alaska Range toward Nenana (this path is to the south of the area shown in Figure 6-1). While the jet sometimes reaches north to Eielson AFB and Nenana, it does not flow north of the Tanana River to the Fairbanks area. When present, the jet is likely to influence air currents along the Tanana River, but these lower speed flows have not been studied.[8] While the jet may influence air flows in the Tanana Valley, it is not routinely present during the winter.

Sonic anemometers mounted 10 m (33 feet) above ground level at the two FNSB monitor sites (NCore and North Pole Fire Station) are sensitive to wind speeds as low as 0.1 m/s and provide the highest quality wind measurements available in the Fairbanks area. The

[7] J. Murray Mitchell Jr., 1956. Strong Surface Winds at Big Delta, Alaska. Mon. Wea. Rev., 84, 15–24.
[8] Personal communication from Mr. James Brader, National Weather Service Forecast Office, Fairbanks, AK. June 2015.

readings are accumulated during each hour to compute an hourly-average wind speed and direction. This section uses the hourly values reported by the monitors after they have been further averaged to 8-hour periods to attenuate some of the hourly fluctuation. The periods are consecutive (non-overlapping) 8-hour intervals that span the overnight, daytime, and evening hours. In contrast, the wind speed and direction measurements made at the airports in the area use cup anemometers, which do not have comparable resolution of low winds and will often report calm conditions during inversion periods.

6.2 Fairbanks Area

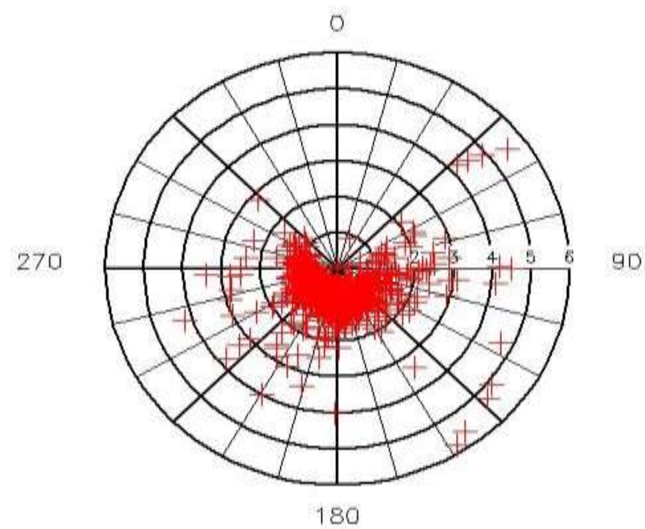
The Fairbanks portion of the Borough is affected by several drainage flows. Cold air flows out of the Goldstream, Ester, and other valleys behind Cranberry and Chena Ridges into the University of Alaska, Fairbanks area before emptying into the Tanana River. Relatively clean air comes from these directions, which helps to limit $PM_{2.5}$ concentrations in the western portion of Fairbanks during inversion periods. Cold air also drains off Birch Hill and Mt. Lulu into the eastern Fairbanks area.

Figure 6-2 shows the overall distribution of wind speed and direction for the past two winters at the NCore monitor located in downtown Fairbanks. Elevated winds (above 2 m/s or 4.5 mph) come from a variety of directions, including northeast, east, southeast, and southwest. However, wind speeds are below 2 m/s most of the time as the downtown area is sheltered by its location at the base of nearby mountain ridges. Fairbanks International Airport, located near the Tanana River plain, is more exposed and experiences higher wind speeds. With one exception, northerly winds are not recorded at the monitor, which implies that the flow off the ridge to the north, whether driven synoptically or by drainage, remains aloft. Borough air quality staff[9] believe that northerly air flows tend to *decouple* from the surface layer as they slide over the bowl of colder, denser air that has settled over downtown during inversion periods and strengthen the vertical trapping of pollutants.

When it is very cold, the NCore monitor registers a wind of about 1.0 m/s (2.2 mph) that can come from the southeast, south, or southwest (see Figure 6-3). The consistency of the wind speed suggests the flow is driven by drainage along the Chena River, which meanders through the downtown area. The monitor sits above the northern bank of the river, along a southeast-to-northwest stretch of the river between two prominent bends. Air flow along the river will be registered as a southeasterly wind at the monitor, while eddy currents off the river may induce the southerly and southwesterly flows. The wind directions recorded by the monitor are also consistent with observations by Borough air quality staff, who believe that pollutants circulate into the downtown area during inversion periods from nearby neighborhoods to the south and west before draining into the Chena River.

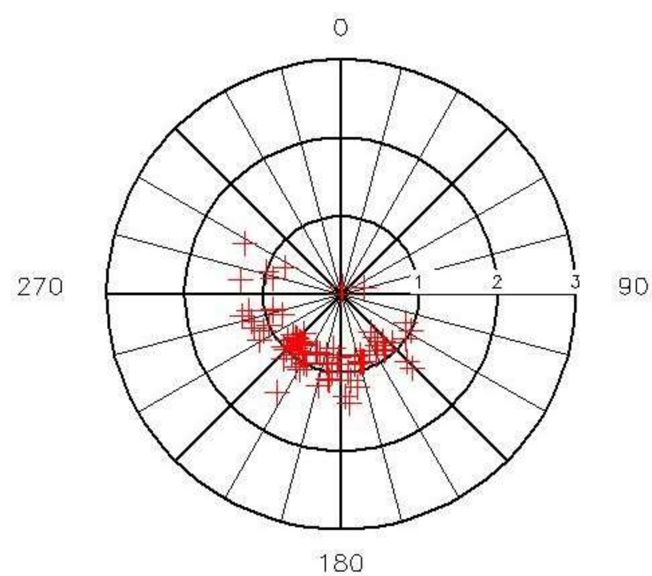
[9] Personal communication from Mr. Jim McCormick, Borough air quality staff.

Figure 6-2
All 8-hour Average Wind Speed (m/s) vs. Direction at the FNSB NCore Sonic Anemometer Winters 2013 - 2015



Note: The data are 8-hour averages for the winters of 2013-2014 and 2014-2015.

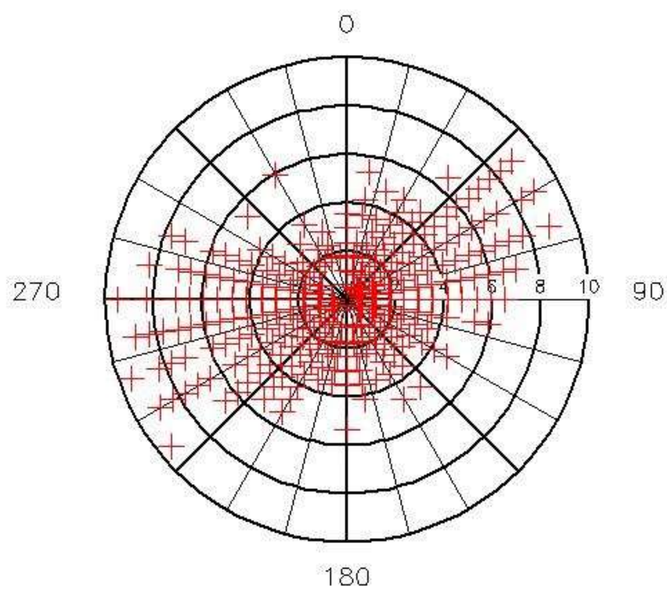
Figure 6-3
8-hour Wind Speed (m/s) vs. Direction at the FNSB NCore Sonic Anemometer under Cold Temperatures Winters 2013 - 2015



Note: The data are 8-hour averages for periods in the winters of 2013-2014 and 2014-2015 when the air temperature was below -27°C (17°F).

Figure 6-4 shows the overall hourly wind speeds and directions during the past winter. Ft. Wainwright is in a relatively windy location with speeds reaching 9-10 m/s. Winds above 5 m/s come primarily from the northeast (the direction of the Mt. Lulu and Little Chena River Valley flows) and the southwest and west (across the Tanana River plain). Winds between 2 and 5 m/s come from these directions and also from the southeast (the direction of North Pole and Eielson).

Figure 6-4
All Hourly Wind Speed (m/s) vs. Direction at the Ft. Wainwright ASOS Monitor
Winters 2014 - 2015



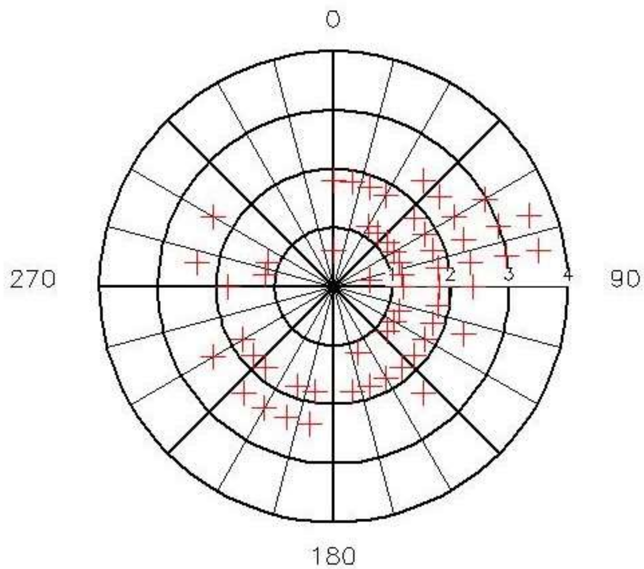
Note: The data are hourly values for the winter of 2014-2015.

Winds are much lighter at Ft. Wainwright when it is cold. When the air temperature is below -27°C (-17°F), the monitor records calm conditions more than 80 percent of the time. When winds are present, speeds of 2 m/s or higher come only from the northeast and southwest, with the exception of two hours when northwesterly winds were recorded and two additional hours when southeasterly winds were recorded (see Figure 6-5). Lighter winds, below 2 m/s in speed, are recorded from a range of directions, including the north, northeast, east, southeast, southwest, and west. Given the limitations[10] of the

[10] The wind speed threshold of cup monitors will vary by installation. The ASOS anemometer used at Fairbanks International Airport reports calm when wind speeds fall below 3 mph. ASOS anemometers at other locations may have lower thresholds.

wind instrument at low speeds, these results indicate more that the wind direction is poorly determined and less the actual direction of air movement.

Figure 6-5
Hourly Wind Speed (m/s) vs. Direction at the Ft. Wainwright ASOS Monitor under Cold Temperatures Winters 2014 -2015



Note: The data are hourly values for periods in the winter of 2014-2015 when the air temperature was below -27°C (-17°F).

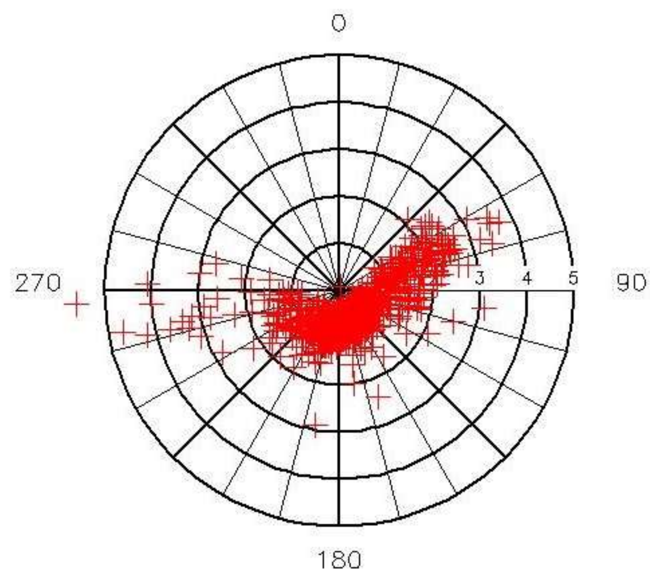
Overall, these data indicate there is little or no air flow from the Ft. Wainwright area toward either downtown Fairbanks or North Pole during inversion periods when $PM_{2.5}$ concentrations are elevated. Winds are most often reported calm when the temperature is very cold. When winds are present, they tend to move pollutants toward the Tanana River (when from the northeast) or toward the nearby mountain valley (when from the southwest).

6.3 North Pole Area

The North Pole area is affected by two main regional drainage flows as illustrated earlier in Figure 6-1: those along the Upper Chena River and the Tanana River. The Upper Chena River drainage causes accelerated airflow down Angel Creek into the Two Rivers community and the flow can reach into the southeastern portion of North Pole where the Fire Station monitor is located. Air also flows into North Pole from the southeast along the Tanana River, fed by drainage flows from the many mountain valleys to the east of Eielson and possibly from as far as the Alaska Range 100 miles to the south.

The impact of these regional air flows can be seen in data recorded at the Fire Station Monitor located in the southeastern portion of the North Pole area during the past two winters (see Figure 6-6). When high winds are present during the winter months, they come predominantly from the northeast due to the airflow from the Upper Chena River valley. $PM_{2.5}$ concentrations are low in North Pole when these winds are present as pollutants are swept into the Tanana River to the southwest. Elevated winds are occasionally experienced from the west. At all other times, wind speeds are low (≤ 2 m/s or 4.4 mph).

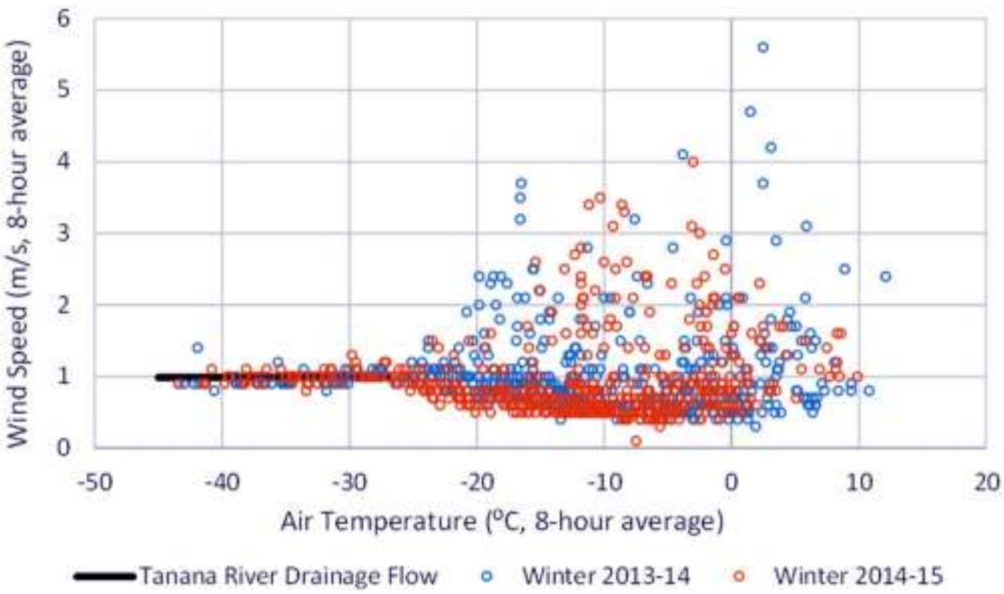
Figure 6-6
All 8-hour Average Wind Speed (m/s) vs. Direction at the FNSB NP Fire Station Sonic Anemometer Winters 2013 - 2015



Note: The data are 8-hour averages for the winters of 2013-2014 and 2014-2015.

As Figure 6-7 shows, the wind speeds observed at the Fire Station change markedly as it gets colder. While stronger winds can be experienced, the speed is generally below 2 m/s when it is cold. Some air flow is always present, and the lightest winds are never below ~0.3 m/s. As the temperature falls below 0°C (32°F), the strongest winds are progressively quelled and the lightest winds gradually increase in speed, reaching 0.5 m/s at -20°C (-4°F) and 1.0 m/s at −27°C (-17°F). In this temperature interval, the winds recorded are a combination of northeasterly, southerly, and westerly flows induced by the prevailing winds aloft and surface flows induced by regional drainage. As the air temperature falls to -27^{0}C (-17^{0}F), the synoptic wind component will weaken as the surface inversion strengthens and the drainage flow will become a larger part of the total air flow that is present.

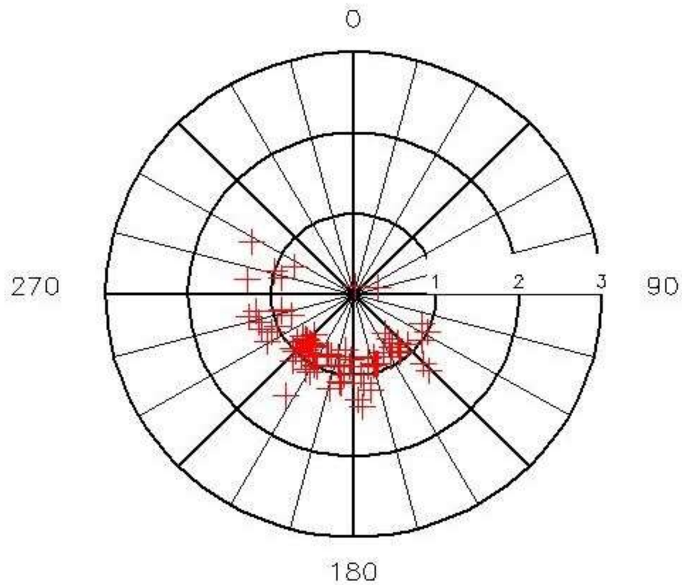
Figure 6-7
All 8-hour Average Wind Speed (m/s) vs. Air Temperature at FNSB NP Fire Station Sonic Anemometer Winters 2013 -2015



Note: The data are averages for 8-hour averages for the winters of 2013-2014 and 2014-2015.

A different pattern emerges when the air temperature falls below -27°C (-17°F). In this regime, the wind speed stabilizes at ~1 m/s and the direction narrows to southeast to southwest with few exceptions (see Figure 6-8). The consistency of the 1 m/s wind speed indicates that it is a katabatic flow driven by gravity from higher to lower elevations and the southerly direction points to a drainage flow along the Tanana River that develops under very cold temperatures. The variation in wind direction at the Fire Station suggests either that the drainage flow enters North Pole from a range of bearings due to variation in the flow itself (such as eddy currents that may exist at its Edges) or that the flow is diverted within North Pole by the stands of tall forest. The flow originates from the southeast because the characteristic 1 m/s wind speed can also be seen in ASOS data from Eielson at cold temperatures.

Figure 6-8
Wind Speed (m/s) vs. Direction at the FNSB NP Fire Station Monitor under Cold Temperatures

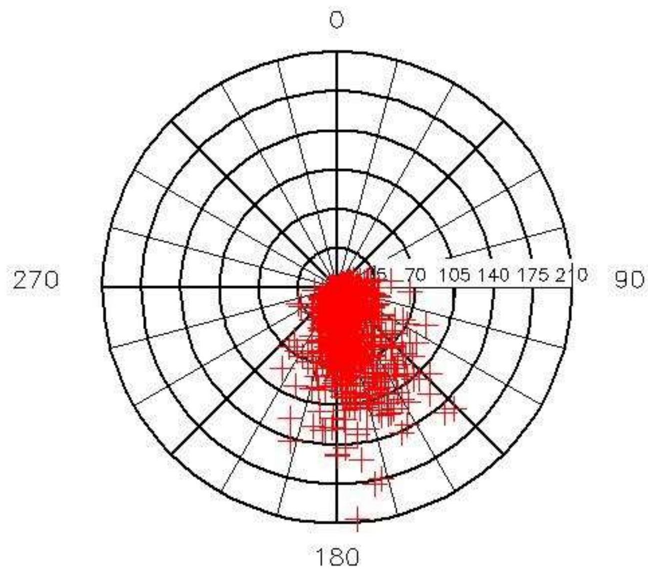


Note: The data are 8-hour averages for periods in the winters of 2013-2014 and 2014-2015 when the air temperature was below -27°C (-17°F).

$PM_{2.5}$ concentrations at the Fire Station monitor are highly elevated whenever the wind is from the south or the southeast (see Figure 6-9). Hourly concentrations frequently rise to the level of four times the 24-hour standard of 35 ug/m^3 and sometimes as high as six times the standard. And they do so in circumstances (cold temperatures) when a steady 1 m/s wind is recorded at the monitor. To understand this result better, a statistical analysis[11] was conducted that asked whether there was a wind direction in which $PM_{2.5}$ concentrations were higher (or lower) than would otherwise be expected after accounting for all other variables *including temperature and wind speed*. When this analysis was performed for the NCore monitor, no such favored wind direction was found. Increased winds were found to sharply reduce $PM_{2.5}$ concentrations and this was true regardless of the direction of wind. For the Fire Station monitor, the analysis estimated a preferred direction of 151° ± 4° (one-sigma), which closely parallels the Tanana River (see Figure 6-10). A 1 m/s wind along this axis does not strongly reduce $PM_{2.5}$ concentrations, while a 1 m/s wind perpendicular to the axis will.

[11] The statistical analysis was conducted in December 2014 and is now being updated as part of ongoing work to prepare the Air Quality Alert Model for use by Borough and ADEC staff this coming winter. Documentation on the updated statistical analysis will be available by October 1, 2015.

Figure 6-9
$PM_{2.5}$ Concentrations (ug/m^3) vs. Wind Direction at FNSB NP Fire Station Monitor



Note: The data are 8-hour averages for the winters of 2013-2014 and 2014-2015.

Figure 6-10
Preferred Wind Directions for $PM_{2.5}$ Concentrations at FNSB NP Fire Station Monitor at a Bearing of 151°

Note: Preferred Wind Directions for PM2.5 Concentrations at North Pole Fire Station at a bearing of 151^0. The 95% confidence interval is shown. This is the same direction as the south/southeasterly winds recorded at the monitor under low-temperature, inverted conditions.

We do not fully understand why the preferred direction exists. Based on other statistical tests, it does not appear to be simply the bearing to a few large sources that increase $PM_{2.5}$ concentrations at the monitor when they are upwind. Southerly to southeasterly winds from directions outside the 95 percent confidence intervals shown in Figure 6-10 are no more effective in reducing $PM_{2.5}$ concentrations than those that cross within the intervals. Thus, the preferred direction should be interpreted as indicating a southerly to southeasterly direction and not a narrow course.

The presence of this preferred direction is easily observed in the behavior of hourly $PM_{2.5}$ concentrations at the Fire Station. Concentrations quickly become elevated when it is cold and the wind is low and from the south or southeast; however, concentrations collapse abruptly when any wind arises from a direction perpendicular to the axis shown in Figures 6-9 and 6-10. North Pole is bordered by relatively undeveloped areas in the perpendicular directions to the northeast and southwest. Winds from these directions (usually northeast) are associated with low $PM_{2.5}$ concentrations and disperse pollutants away from the monitor, while winds along the axis appear to leave concentrations largely unchanged.

The Fire Station monitor experiences a sustained 1 m/s wind from the Tanana River flow whenever the temperature falls below -27°C (-17°F). That this flow appears to be ineffective in dispersing pollutants is one reason why $PM_{2.5}$ concentrations in North Pole can rise so high. Nothing like this is seen at the NCore monitor, making the Fire Station area something of a special case.

6.4 Summary

Regional drainage flows are the predominant source of air flow to disperse pollutants in Fairbanks and North Pole during wintertime inversion periods, but the origins and directions of the air flows are very different across the Borough.

In Fairbanks, cold and relatively clean air flows out of the Goldstream and other valleys into the western portion of Fairbanks, where it then flows toward the Tanana River. Drainage off Birch Hill to the north flows into the eastern portion of Fairbanks, but it appears to decouple and remain aloft as it flows over downtown. The Chena River carries a drainage flow into the downtown area from the east. During inversion periods, surface drainage across the terrain moves pollutants into the Chena River, which then carries them toward its junction with the Tanana River west of Fairbanks.

These regional and local drainage flows provide the primary means of horizontal dispersion during inversion periods when surface winds are otherwise quelled. The flows move pollutants to the west and out of the Fairbanks area along the Tanana River and cannot transport pollutants to North Pole in the southeast.

The Ft. Wainwright and Badger Road area is located on a broad, nearly flat plain between the southeastern portion of North Pole, where the Fire Station monitor is located, and the downtown Fairbanks area, where the NCore monitor is located. The area can experience high winds from the northeast and southwest. During inversion periods when surface winds are quelled, the drainage flow out of the Little Chena River Valley to the northeast tends to disperse pollutants toward the Tanana River. In these periods, there is little or no air flow in the direction of downtown Fairbanks or North Pole.

In North Pole, regional drainage flows come from the Upper Chena River valley (to the northeast) and along the Tanana River (to the southeast). The northeast Chena River flow can bring high winds to North Pole and disperse pollutants into the Tanana River to the southwest. When it is very cold, the southeast Tanana River flow induces a sustained 1 m/s wind at the Fire Station monitor, but this air flow appears to be ineffective in dispersing pollutants. This empirical result is not fully understood, but it is one reason why $PM_{2.5}$ concentrations at the Fire Station can rise so high.

Under strong inversion conditions, there will be little or no surface wind at the height at which PM 2.5 is measured and only the hydrologic drainage flow along the slough will help to disperse pollutants away from North Pole. The slough meanders along a broad, nearly flat plain toward Ft. Wainwright. While the slough may carry pollutants to the northwest, the flow rate will be slow under strong inversion conditions and there is a large geographic area between North Pole and Fairbanks (see Figure 6-1) over which to disperse them. As demonstrated by its wind rose under cold temperatures, there is little or no continued flow at Ft. Wainwright toward downtown, so that pollutants emitted near the Fire Station should not make a significant contribution to the downtown area. Overall, this analysis shows that airflow during winter inversions is very different in the proposed nonattainment subareas. It shows that Fairbanks air flow drains towards the west and southwest (away from North Pole). In contrast, airflow at the North Pole Fire Station flows towards the northwest, where there are wide fields for dispersion. Thus, Fairbanks airflows have little or no influence on North Pole and North Pole airflows have little influence on Fairbanks.

FACTOR 7. TOPOGRAPHY

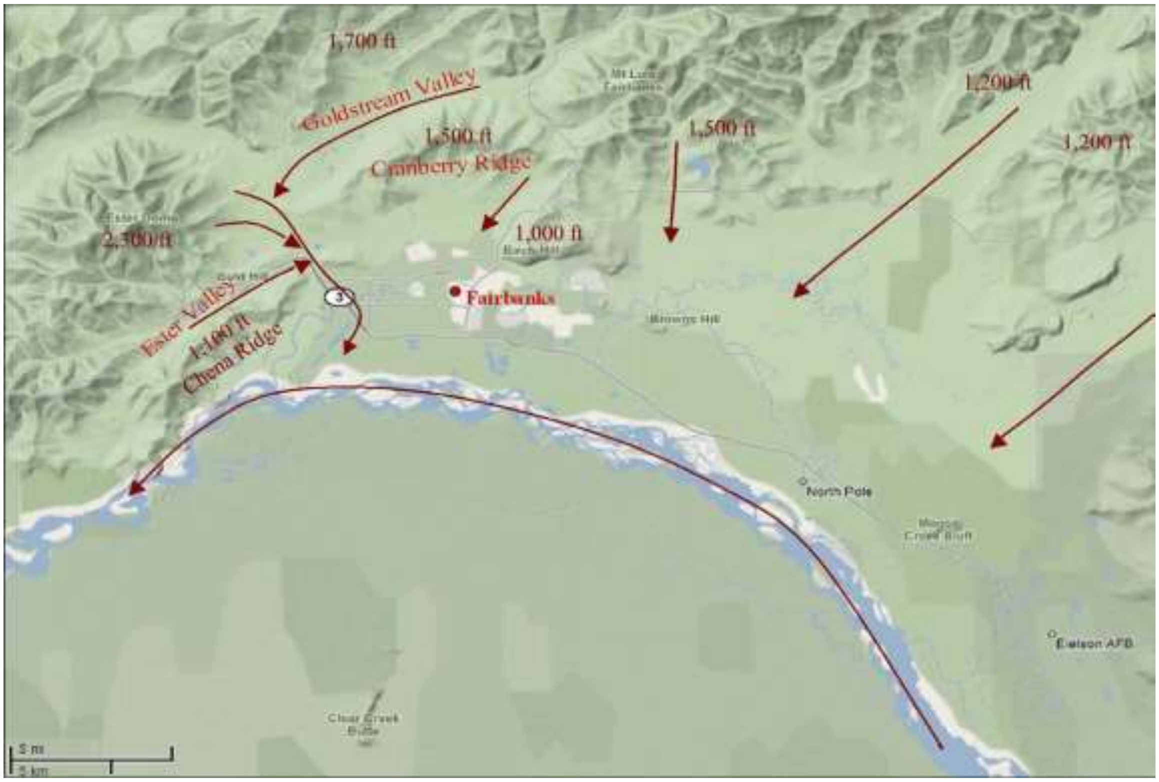
An analysis of topography and meteorology was included in the original Fairbanks North Star Borough $PM_{2.5}$ Nonattainment Boundary proposal. This analysis examined the large-scale terrain features and their influence on the trapping of emitted particulates and particulate precursors. Refined analyses of the latest topographic and meteorological data provide clear evidence for reevaluating the barriers that exist to the transport of particulates and their precursors in the region.

7.1 Overview of Geography

The larger-scale flow patterns and topographic features are shown in Figure 7-1, which was originally submitted by ADEC and FNSB in order to establish the current FNSB $PM_{2.5}$ Nonattainment Boundary.[12] Mountains and ridges form a semicircular barrier to the east, north, and west of the Fairbanks and North Pole areas ranging in size from 1,000 ft to 2,500 ft. Under cold, calm conditions, drainage flows off of the ridges and, following the path of the Goldstream and Ester Valleys, may form as shown in Figure 7-1. The Tanana River forms a barrier to the south of the areas with an east to west drainage flow following the flow of the river. In broad strokes, these features explain why Fairbanks and North Pole were likely to have minimal influence on areas outside of the FNSB nonattainment area and conversely why their air quality problems were driven by local emissions.

[12] ADEC $PM_{2.5}$ SIP Appendix III.D.5.03-1 Submitted December 2014.

Figure 7-1
Coarse Topography and Regional Drainage Flows in the Fairbanks Area



7.2 Highly Resolved Topographic Data

Since the submission of the original FNSB PM nonattainment area boundary data, a more highly resolved topographic map of the proposed Fairbanks and North Pole nonattainment areas has become available. This map was generated at 2 ft contour intervals by the Army Corps of Engineers as part of an inundation study of Moose Creek Dam.[13] The highly resolved contours show the surface gradients that exist throughout much of the Fairbanks and North Pole portions of the FNSB nonattainment area. Due to the extreme nature of the inversions that persist during high particulate concentration episodes, even these small elevation changes will influence the direction and nature of bulk transport between the sub-areas of Fairbanks and North Pole.

The downtown Fairbanks sub-area sits at around 441 ft, as indicated in Figure 7-2 and the marker for the NCORE monitor site. The lowest features in the Fairbanks nonattainment area are the Chena River and Tanana River, which flow to the southwest corner of the FNSB PM nonattainment area at 402 ft. Most of the Fairbanks region follows a gradient of 460 ft in the east to 402 ft in the southwestern corner of the FNSB nonattainment area, with Chena ridge in the west rising to over 1,000 ft. Cranberry ridge similarly rises to

[13] ftp://co.fairbanks.ak.us/GIS/Metadata_DVD/Metadata_DVD.doc

1,000 ft just north of the Chena River. Many of these features can be observed in greater detail in Figure 7-3. The meteorological analysis of the NCORE site showed signs of a drainage flow varying in direction from southeast, south, and southwest. Given that the Chena River lies in these directions at a low elevation relative to the monitor, this drainage flow makes sense.

Figure 7-2
FNSB $PM_{2.5}$ Nonattainment Area 2-ft Contour Topographic Map

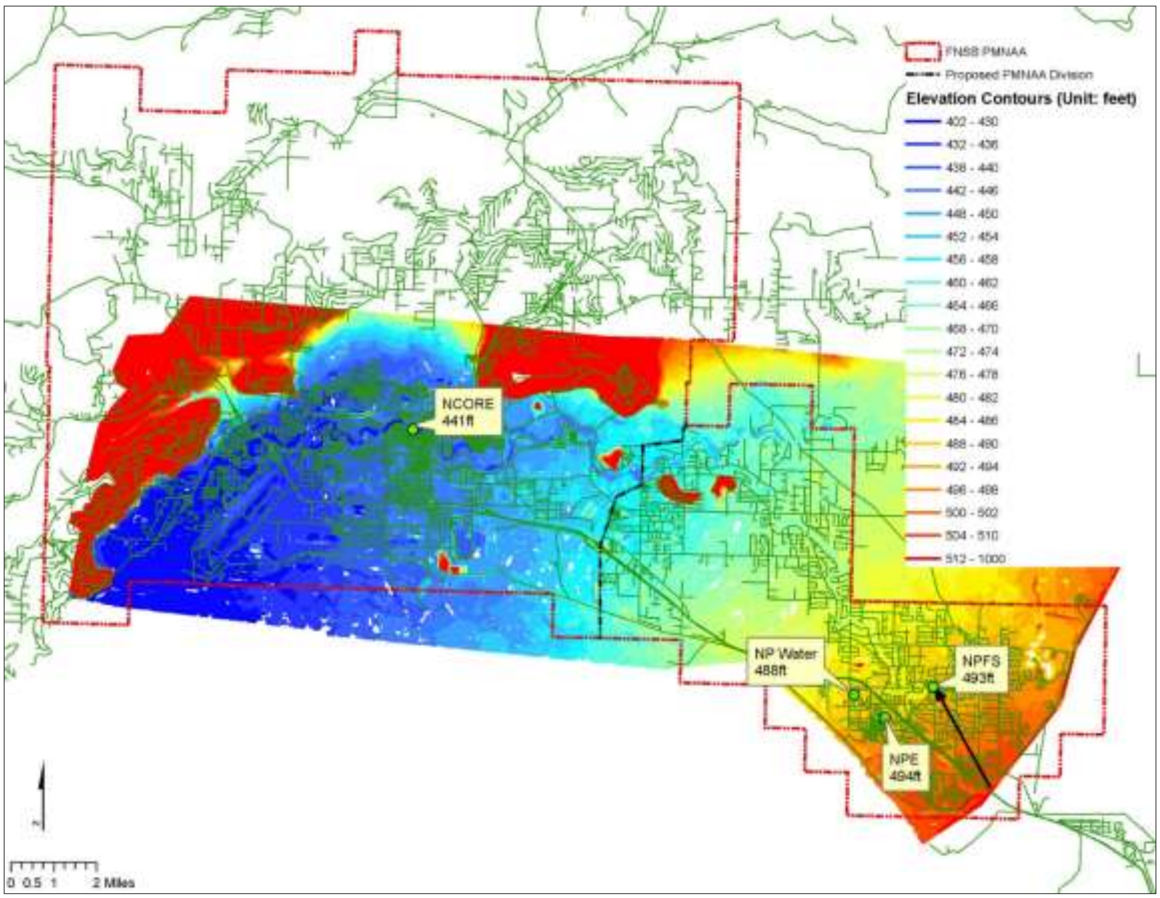
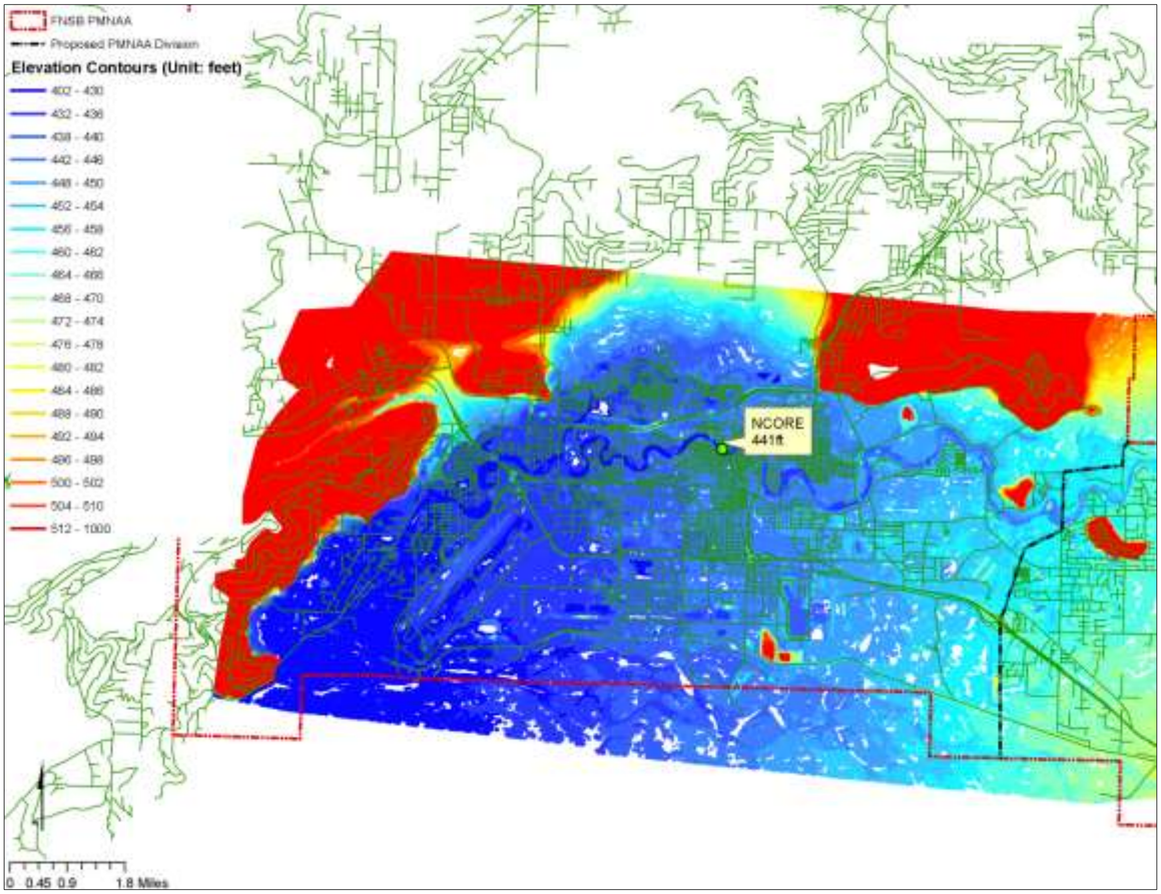
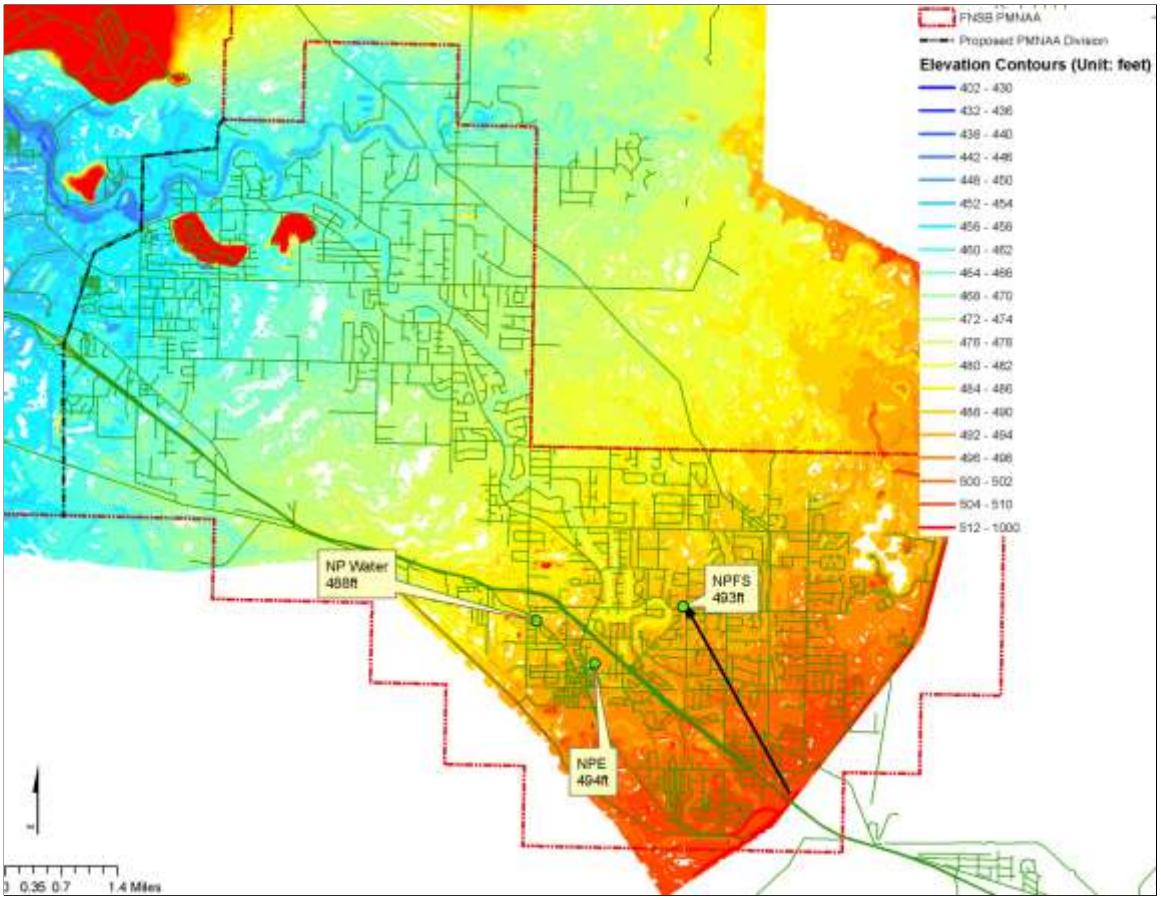


Figure 7-3
Fairbanks Nonattainment Area Southern Portion 2-ft Contour Topographic Map



The North Pole nonattainment area is elevated 50 ft above the Fairbanks nonattainment area to the southeast, as seen in Figure 7-2 and Figure 7-4 at the North Pole Fire Station (NPFS) monitor tag. The North Pole nonattainment area slopes upwards from the 460 ft mark at the border with the Fairbanks area to a high of 510 ft along the southeast border along the Moose Creek Dam. Drainage flow patterns at low temperatures are from the southwest and southeast. The preferred wind direction for inducing higher $PM_{2.5}$ concentrations as indicated by the meteorological analysis presented in Factor 6 of 151º is indicated by the arrow at the NPFS site on Figure 7-3 and Figure 7-4. The direction of the preferred flow aligns well with the gradient of the topography in North Pole.

Figure 7-4
North Pole Nonattainment Area Portion 2-ft Contour Topographic Map



7.3 Summary

Seemingly small-scale topographic features combined with extremely severe winter-time inversions serve to isolate the North Pole and Fairbanks nonattainment areas during air quality episodes. Drainage flows that may form during these extremely cold events suggest that Fairbanks would drain away from North Pole. Given the distance and direction of the North Pole drainage flow, the emissions from sources in the town of North Pole are likely to disperse and settle out on their path to the northeast.

FACTOR 8. JURISDICTIONAL BOUNDARIES

This section presents displays of boundaries for entities located within the Fairbanks North Star Borough $PM_{2.5}$ nonattainment area. Also presented is the requested boundary that would divide the FNSB nonattainment area into two separate nonattainment areas: Fairbanks and North Pole.

8.1 Presentation of Boundaries

Political entities located within the FNSB nonattainment area include the City of Fairbanks, the City of North Pole, the Fairbanks Metropolitan Area Transportation System (FMATS), and Fort Wainwright. Figure 8-1 depicts the boundaries for each, which are described in more detail below.

- The *City of Fairbanks* is located in the central Tanana Valley, straddling the Chena River near its confluence with the Tanana River. Immediately north of the city is a chain of hills that rises gradually until it reaches the White Mountains and the Yukon River. The southern border of the city is the Tanana River. To the east and west are low valleys separated by ridges of hills up to 3,000 feet (910 m) above sea level.[14] According to the U.S. Census Bureau, the city has a total area of 32.7 square miles (85 km^2), 31.9 square miles (83 km^2) of which is land and 0.8 square miles (2.1 km^2) of which (2.48%) is water.

- The *City of North Pole* is situated 13 miles (21 km) to the southeast of Fairbanks on the Richardson Highway. The city is about 1,700 mi (2,700 km) south of Earth's geographic North Pole. According to the U.S. Census Bureau, the city has a total area of 4.2 square miles (11 km^2), of which 4.2 square miles (11 km^2) is land and 0.04 square miles (0.10 km^2) (0.47%) is water. The city is located to the north and east of the Tanana River, although access to the river is not easily made due to the extensive system of levees. Beaver Springs Slough meanders through the heart of the city, emptying into Chena Slough.

- *FMATS* is the local Metropolitan Planning Organization (MPO). FMATS is a consensus-based transportation policy-making body that was formed in April 2003 when the Fairbanks Area was listed in the Federal Register of Qualifying Urban Areas for Census 2000. The FMATS Metropolitan Planning

[14] *https://en.wikipedia.org/wiki/Fairbanks,_Alaska#cite_note-USGS110-15*

Organization Boundary Map was determined by an agreement between the MPO and the Governor. At a minimum, the MPO boundaries encompass the entire existing urbanized area (as defined by the Bureau of the Census) plus the contiguous area expected to become urbanized within a 20-year forecast period for the metropolitan transportation plan—an area that covers 113 square miles.

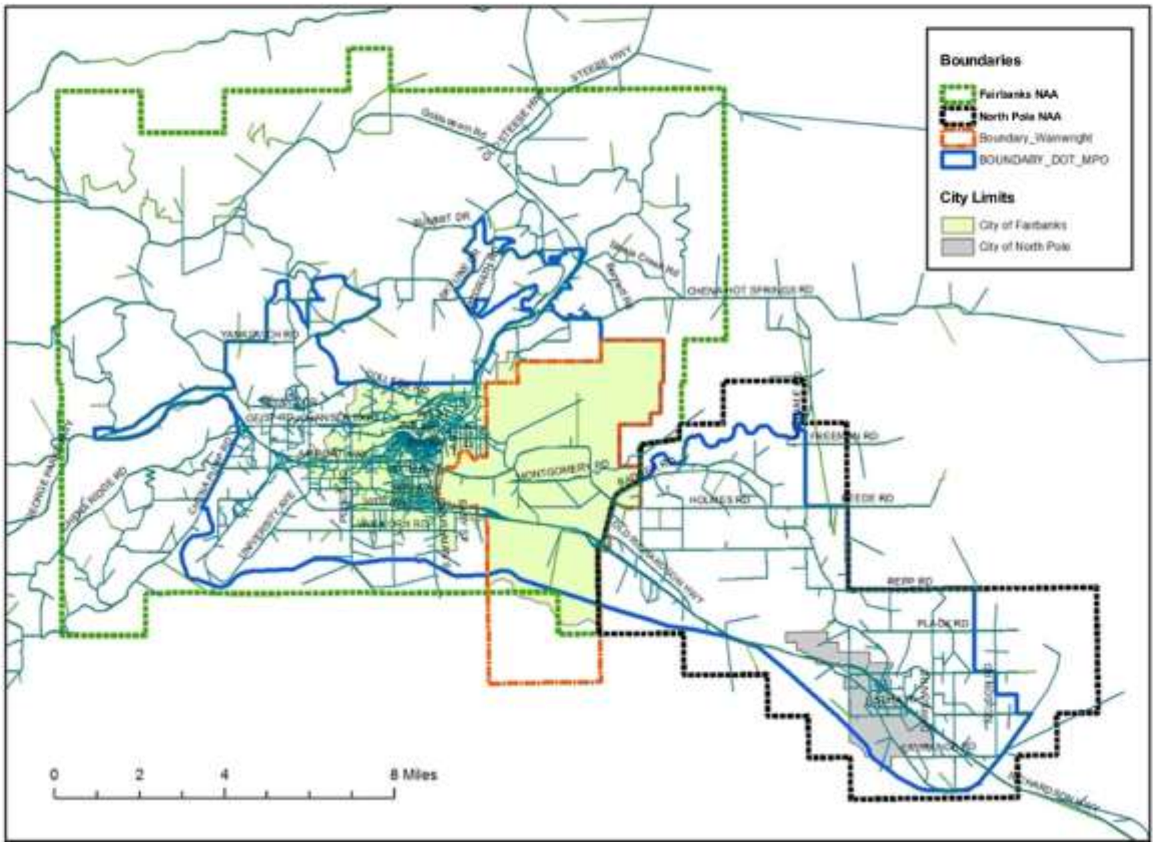
- *Fort Wainwright* is a U.S. Army Post that encompasses over one million acres and includes three separate areas: the Main Post is co-located with the City of Fairbanks and consists of 13,700 acres; the Tanana Flats Training Area is located south of the Main Post and covers over 655,000 acres; and the Yukon Training area is located 16 miles east-southeast of the City of Fairbanks and covers 247,952 acres. Figure 8-1 displays the boundaries of only the Main Post.

Also displayed in Figure 8-1 is the requested boundary that would divide the FNSB nonattainment area. Boundaries for the resulting nonattainment areas—titled Fairbanks and North Pole—are displayed in green and black, respectively. As can be seen, the eastern boundary for Fairbanks largely follows the eastern boundary of Fort Wainwright and the City of Fairbanks (although two small areas of the City of Fairbanks extend into the requested North Pole nonattainment area). It should also be noted that while the City of Fairbanks accounts for a substantial portion of the requested Fairbanks $PM_{2.5}$ nonattainment area, it does not encompass western (e.g., Chena Ridge, etc.) and northern (Goldstream Valley, etc.) areas. Similarly, the City of North Pole encompasses a small portion of the requested North Pole $PM_{2.5}$ nonattainment area.

The Borough established the requested boundary under authority provided by Ordinance No. 2015 – 29. It empowered the Borough to

> *…issue a daily PM2.5 forecast by 4:30 p.m. When the PM2.5 concentration reaches the onset level for an episode and is expected to remain at that level for 12 hours or more, an alert or advisory will be declared. An alert or advisory may apply to the air quality control zone as a whole, or to one or more sub-areas designated by the division*

Figure 8-1
Boundaries of Political Entities Located within the FNSB $PM_{2.5}$ Nonattainment Area



A detailed view of the boundary used to divide the Air Quality Control Zone specified in Ordinance No.2015-01 (i.e., the requested boundary that would divide the FNSB $PM_{2.5}$ nonattainment area) is presented in Figure 8-2. It begins at the northeast corner of F001S001E Section 10 southwest to Hobgoblin Lane, south to Prester John Drive, west to the northwest corner of T001S001E Section 9 SE ¼, south to the southeast corner and east to Sonja Street, south along Sonja Street and an extension to the intersection with Badger Road, southwest along Badger Road to its intersection with the northern border of T001S001E Section 21, west to the northwest corner of 001S001E Section 21 NE ¼ NW ¼, south to Badger Road, south on Badger Road to its intersection with the western border of T001S001E Section 21, and south along the section line to the intersection with the southern nonattainment area border at the southwest corner of T001S001E Section 33.

Figure 8-2
Proposed Boundary between Proposed Fairbanks and North Pole $PM_{2.5}$ Nonattainment Areas

8.2 Summary

The boundary requested to divide the Fairbanks North Star Borough $PM_{2.5}$ nonattainment area was specified by Borough staff to separate the Air Quality Control Zone into nonattainment areas expected to have different air quality levels during winter months. The requested boundary will produce two $PM_{2.5}$ nonattainment areas that together cover the same domain as the existing $PM_{2.5}$ nonattainment area—the area of $PM_{2.5}$ control will not be reduced.

FACTOR 9. LEVEL OF EMISSION SOURCE CONTROL

This section discusses the level of emission control within the FNSB nonattainment area and, where possible, examines differences in control levels achieved within the separate Fairbanks and North Pole nonattainment areas based on estimates contained in the Moderate Area State Implementation Plan (SIP) Emissions Inventory. In addition to summarizing the control measures that have been enacted for the FSNB nonattainment area, this section also presents estimates of control program participation rates.

9.1 Summary of Controls

Enacted control programs described in the Moderate Area SIP that reduce $PM_{2.5}$ or precursor emissions or reduce use of devices that emit these pollutants at the state and local levels are summarized below.

State Regulations

- *Wood-fired heating device emission standards (18 AAC 50.075)* – Prohibits operation of a wood-fired heating device in a manner that causes (1) black smoke; or (2) visible emissions above 50% opacity for which an air quality advisory is in effect. It also allows the operation of a wood-fired device in an area where ADEC has declared a $PM_{2.5}$ air quality episode only if (1) visible emissions or opacity are below limits identified in the episode announcement; or (2) the device operator obtains a written temporary waiver from ADEC.

- *Solid fuel heating device fuel requirements; commercial wood-seller registration (18 AAC 50.076)* – Limits operation of a solid-fuel heating device in the FNSB $PM_{2.5}$ nonattainment area to specific fuels approved by the device manufacturer. In addition, beginning in October 2015, further restricts solid-fuel heating device operation to dry wood, specific wood products (e.g., pellets or manufacturer compressed wood logs), or other device-manufacturer-approved fuels. Further requires commercial wood sellers in the nonattainment area to register with ADEC if the area is designated as a serious area by EPA or if ADEC issues a finding that wood smoke is a significant component of $PM_{2.5}$ formation in the area. Requires registered wood sellers to use a wood moisture content meter to measure wood moisture at the time of sale and report the measurement to the consumer and ADEC.

- *Standards for wood-fired heating devices (18 AAC 50.077)* – Beginning March 1, 2015, requires wood stoves and hydronic heaters (HHs) sold or installed on new homes in the FNSB $PM_{2.5}$ nonattainment area to be EPA certified (or Phase 2 qualified for HHs) and meet a 2.5 gram/hour $PM_{2.5}$ emission rate standard.

<u>Borough Programs</u>

- *Wood Stove Change Out (WSCO) Program* – Since June 2010, the Borough has operated a program within the FNSB nonattainment area designed to provide incentives for the replacement of older, higher-polluting residential wood-burning devices with new cleaner devices, or removal of the old devices. The design of the WSCO program has evolved over time, but these changes have generally consisted of both increasing the financial incentives as well as expanding the types of solid fuel burning appliances (SFBAs) or devices that are eligible to participate in the program. Through 2014, nearly 1,700 wood stoves/inserts, HHs, fireplaces, and coal devices were either replaced or removed under the WSCO program. The Borough added funds for the program at the end of 2014 and again in the fall of 2015.

- *Ordinance 2015-01* – The Fairbanks North Star Borough Assembly passed an ordinance in March 2015 that increases local involvement in air quality compliance. The Borough now has control zones, a three stage Advisory and Alert system, wood and coal installation requirements and setbacks, and the requirement that illegally installed devices be removed. The Borough now has their own year-round 20% moisture content requirement on wood, which will be enforced through opacity readings. The Borough also has a fine structure and the ability to call burn bans associated with State 2 and State 3 levels with exceptions for wood only households and if the temperature drops below -15 degrees Fahrenheit.

- *Vehicle Plug-In Program* – Fairbanks has an extensive network of electrical plug-ins powered at temperature of 20° F and below that allow citizens to use engine block heaters to keep their motor vehicle engines warm during cold temperatures. This program significantly reduces CO emissions from cold-starting vehicles and cold temperature vehicle testing performed by ADEC and the Borough indicates that plugging-in also has benefit for $PM_{2.5}$. As described in the SIP, the Borough is continuing to expand availability of plug-ins in parking lots throughout the nonattainment area.

- *Mass Transit Program* – The Borough Transportation Department operates a transit program called the Metropolitan Area Commuter System (MACS). The Borough began operating the MACS fixed-route transit service in 1977. The MACS system is comprised of nine fixed routes in the cities of Fairbanks and North Pole, as well as other nearby communities, and has shown a ridership increase of roughly 70% since 2008. The MACS provides some benefits through reduced VMT from mobile sources.

City Ordinances

- *Hydronic Heaters* – No hydronic heater may be installed inside the City of Fairbanks after June 8, 2009, without a permit issued by the City of Fairbanks Building Department. No permit shall be issued until standards are adopted by the Fairbanks City Council. However, permits for the upgrade or replacement of existing hydronic heaters may be issued if the upgraded or replacement heater is qualified by the U.S.EPA as meeting the federal emissions limit standard appropriate for that type of appliance or, in the event EPA regulations do not address a particular appliance, if the replacement appliance's emissions are improved and demonstrated as such by a certified U.S. EPA laboratory or official federal opacity assessment method.

Beyond the state regulations and local control programs contained or referenced in the Moderate Area SIP, there are other existing controls that help to control fine particulates. These are briefly summarized below.

- Major stationary sources are controlled through ADEC's permitting program. With regard to particulate matter, it should be noted that the coal-fired power plants in Fairbanks are controlled with bag houses.

- Mobile sources are controlled by federal fuel and emission rules that limit particulate matter and precursor pollutants. It is not known how effective these controls are at the extreme cold temperatures found in Fairbanks, but improvements should continue to be made as the vehicle fleet turns over.

- The Alaska Housing Finance Corporation (AHFC) has operated two state-level incentive programs—the Home Energy Rebate and Weatherization programs—that encourage replacement of heating devices or improve home energy efficiency.

- Open burning is prohibited within the nonattainment area from November 1 through the end of February, with camp fires being an exception.

- Prescribed fire for burns over 40 acres is managed by ADEC through a permitting process and a smoke management plan.

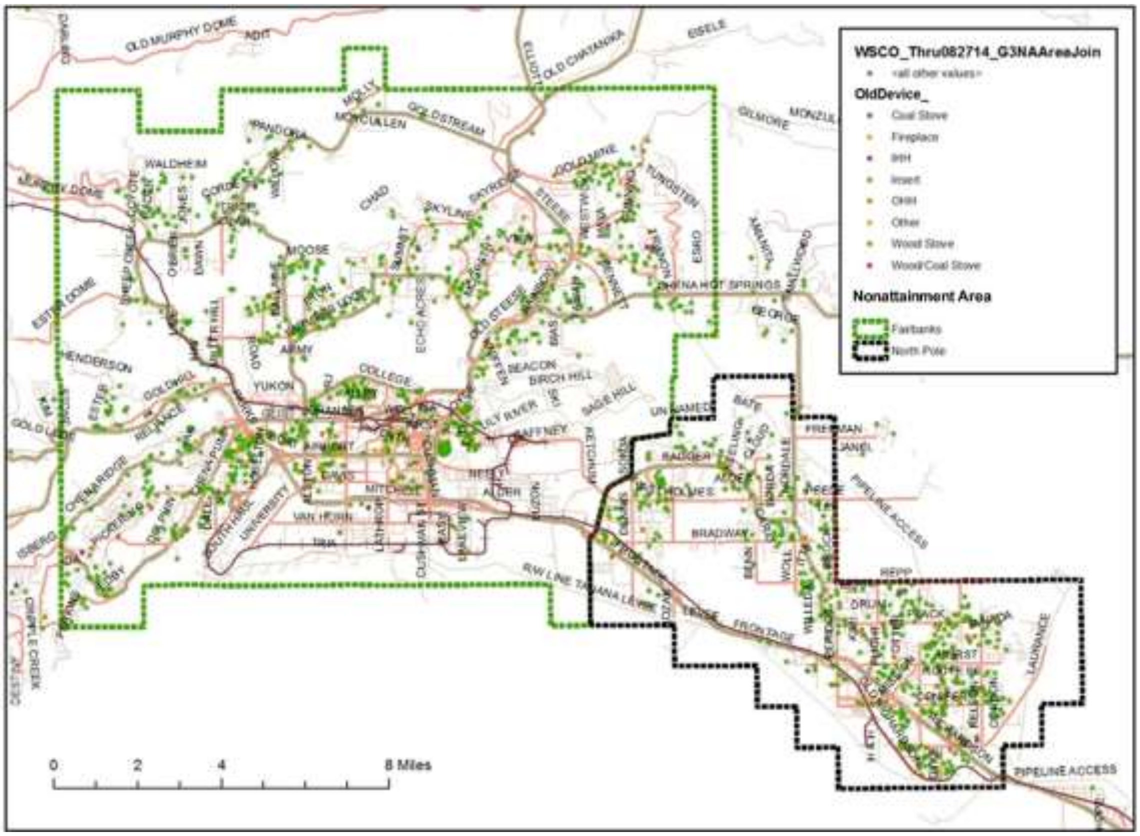
- The Alaska Railroad switched to ultra-low sulfur Diesel fuel in 2007, five years in advance of EPA's 2012 mandate.

9.2 Control Program Participation Rates

The only control program for which participation rates have been compiled to date is the Borough WSCO program. Figure 1-1 maps the locations of all (nearly 1,700) device change-outs (removals or replacements with cleaner units) since the program began in

June 2010. The device types are denoted by different symbol coloring as identified in the legend. As seen, an overwhelming majority of the change-outs have been for wood stoves or fireplace inserts.

Figure 9-1
Heating Device Change-Outs from Borough WSCO Program
(through August 2014)



The WSCO program data were also tabulated into breakdowns of change-outs by subarea as provided in Table 1-1. The upper rows in Table 1-1 contain counts of the cumulative number of change-outs by device type from the program's inception in 2010 through August 2014. As reported in the "Totals" row, 1,104 and 566 change-outs have occurred in the Fairbanks and North Pole nonattainment areas, respectively. Participation rates in the WSCO program by nonattainment area were then estimated by dividing these total change-outs by the number of households in each nonattainment area based on the 2010 Census (and reported earlier in Table 3-1). As shown in the bottom row of Table 1-1, the WSCO program participation rate in North Pole (6.8%) is some 70% higher than in Fairbanks (4.0%).

Table 9-1 **WSCO Program Change Outs and Participation Rates by Proposed Nonattainment Area**		
	Nonattainment Area	
Old Device Type	Fairbanks	North Pole
Wood Stove	962	477
Insert	12	2
OHH	46	67
IHH	14	6
Fireplace	67	9
Coal Stove	1	5
Wood/Coal Stove	1	0
Other	1	0
TOTALS	**1,104**	**566**
Households (2010 Census)	**27,456**	**8,272**
Participation Rate (%)	**4.0%**	**6.8%**

9.3 Summary

Control program efforts have been applied throughout the FNSB $PM_{2.5}$ nonattainment area. The wood stove change-out participation rate confirms the attractiveness of the program in both proposed nonattainment areas. However, based on the information presented, it is expected that beginning in the fall of 2015 control efforts will be applied more frequently to the North Pole nonattainment area because it records more frequent exceedances of the 35 µg 24-hour $PM_{2.5}$ standard.

FACTOR 10. PRELIMINARY SPECIATION MEASUREMENTS

This section of the analysis presents comparisons of speciation data collected at the four monitors in the FNSB nonattainment area: two located in downtown Fairbanks, at the State Office Building and at the NCORE monitoring site; and two located in North Pole, at the North Pole Elementary School (which is no longer in operation) and at the North Pole Fire Station. Data from these four monitors were used to compare the $PM_{2.5}$ speciated components for the top 25% of winter-time high concentration days for the years 2011-2014.

10.1 Speciation Comparisons

The average $PM_{2.5}$ level for 2011 to 2014 for speciation $PM_{2.5}$ days is 30 $\mu g/m^3$ in Fairbanks and 50 $\mu g/m^3$ in North Pole. These are the average top 25% of winter days and not the 98%-tile upon which the $PM_{2.5}$ standard is based. In order to have a representative amount of speciation data, the top 25% of winter days collected from both monitors in each nonattainment area are used.

The monitoring station at the State Office Building site uses a Met One SASS (Spiral Aerosol Speciation Sampler) and URG sampler, the other monitoring sites use Met One SASS samplers (without URG). The sites also differ in how the particulate is measured, based on different carbon method protocols for the organic carbon (OC) and elemental carbon (EC) species. The URG sampler at the State Office Building uses the IMPROVE Total Carbon by Reflectance (TOR) method, whereas the SASS samplers use either IMPROVE or the NIOSH Total Optical Transmittance (TOT) method. Thus, there were three possible sampler and analysis combinations in the regional monitoring data set: SASS/NIOSH, SASS/IMPROVE, and URG/IMPROVE. This is important to note because the ratio of OC/EC dependent on the sampler and method.[15]

Speciation data for 2011-2014[16] for Fairbanks and North Pole were averaged across the four years using a weighting factor based on the number of filters for a given winter that were in the top 25%. This method gives individual weight to the actual number of filters in the top 25% contributing to the highest concentration days of any year and monitor sites for both nonattainment areas. To account for the different samplers and analysis

[15] The SANDWICH method was not implemented for this analysis, but will be used in subsequent Serious Area SIP modeling.
[16] The current speciation data set does not include 2015. This data set will be updated once the 2015 air quality data have been validated through EPA's Air Quality System (AQS).

methods, the data were corrected to represent the SASS sampler/ NIOSH method, which is the most prevalent combination used in North Pole, the official violating monitor for the FNSB nonattainment area.

10.2 Results

The $PM_{2.5}$ speciation results are presented in Figure 10-1 and Figure 10-2 for Fairbanks and North Pole, respectively. As shown in the figures, the largest component of $PM_{2.5}$ in both areas is organic carbon, with the OC fraction being highest in North Pole: 80% versus 65% in Fairbanks. The other speciation components are elemental carbon, nitrate, sulfate, ammonium (NH_4), and other particulates (OPP). Fairbanks has approximately double the levels of sulfate, nitrate, and NH_4 compared to North Pole, which makes up for its lower fraction of OC.

The largest contributor to OC is home heating, and SIP-based emission inventories estimate that wood burning contributes approximately 96% of that source sector's $PM_{2.5}$ emissions. The main sulfate sources are home heating and stationary sources, and the primary contributors to nitrate are mobile vehicles and home heating.

10.3 Summary

The large differences between Fairbanks and North Pole speciation components suggest a different source mix contributing to the monitors and little comingling between the two areas.

Figure 10-1
Fairbanks $PM_{2.5}$ Speciation Data, Winter 2011 to 2014

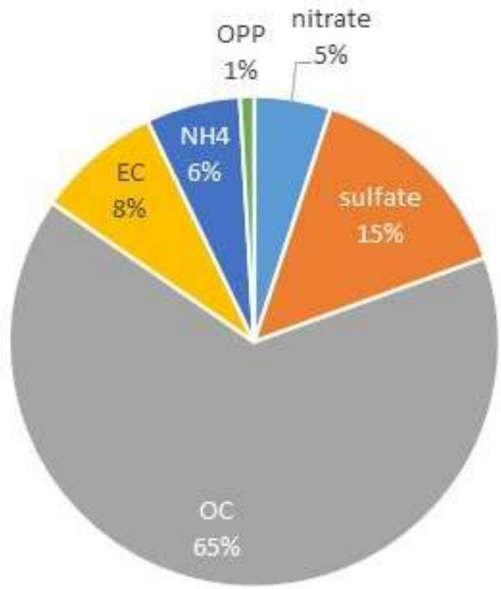
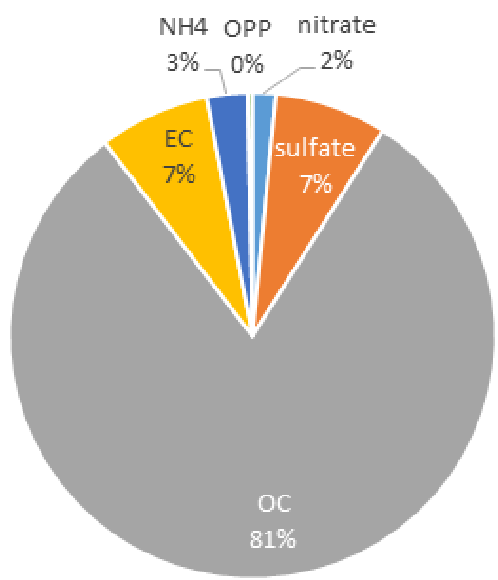


Figure 10-2
North Pole $PM_{2.5}$ Speciation Data, Winter 2011-2014



SUMMARY

Alaska's 2009 boundary request contained the following statement:

> *Many of the proposed areas are low density and located a considerable distance from downtown Fairbanks. These areas will be perceived as having no air quality problems since there is no monitoring data documenting violations of the 24-hour PM2.5 standard. Communities that will have this perspective include Chena Ridge, Ester, Ester Valley, Fox, Goldstream Valley, and **North Pole**.* (emphasis added)

The above statement confirms the paucity of insight into the distribution of concentrations occurring within the nonattainment area available in 2009. Since that time, temporary and fixed monitoring measurements have confirmed the accuracy of the above statement in all of the listed areas except one: North Pole. Multiple monitors sited in North Pole have since demonstrated consistent elevated concentrations exceeding the 24-hour ambient $PM_{2.5}$ standard. Presented below is a review of factor differences between the proposed Fairbanks and North Pole nonattainment areas.

- *Factor 1, Pollutant Emissions* – Ignoring point sources, whose contribution to monitored concentrations in both proposed nonattainment areas has been shown through modeling to be an order of magnitude lower than that of space heating, emissions in North Pole are 33% higher than Fairbanks; those differences are greater if point sources are included. More importantly, survey data indicate that North Pole has three times the number of OHHs per square mile than Fairbanks.

- *Factor 2, Ambient Air Quality Trends* – Fairbanks monitors demonstrate a consistent downward trend in concentrations since 2010, with one "clean data year" in 2014. North Pole monitors record more frequent exceedances of the 24-hour $PM_{2.5}$ standard with design values that are consistently more than three times the ambient standard, with no discernable trend towards attainment.

- *Factor 3, Population Density and Degree of Urbanization* – Household and population growth in the proposed North Pole nonattainment area is forecast to be 76% and 63% higher than in Fairbanks.

- *Factor 4, Traffic and Commuting Patterns* – While traffic density in Fairbanks is more than double the level recorded in North Pole, North Pole travel is projected to grow at an annualized rate that is more than 33% higher than Fairbanks.

- *Factor 5, Growth* – North Pole is projected to experience population, household, and travel growth rates that far exceed those projected for Fairbanks.

  - *Factor 6, Meteorology in Fairbanks and North Pole* – Wind speed and direction recorded at monitors in Fairbanks and North Pole show very different drainage flows under the low-temperature inverted conditions that produce high PM2.5 concentrations. Fairbanks consistently drains towards the west and southwest away from North Pole. Measurements at the North Pole Fire Station under low-temperature, inverted conditions show consistent air flows from the south or southeast towards the northwest where there are wide fields for dispersion.

- *Factor 7, Topography* – Analysis of two-foot contours now available from the Army Corps of Engineers confirms that hydrologic drainage flows are consistent with the wind speed and direction measurements recorded under cold-temperature inverted conditions at monitors located in downtown Fairbanks and the North Pole Fire Station.

- *Factor 8, Jurisdictional Boundaries* – A boundary is recommended to separate the existing nonattainment area into two new nonattainment areas; the overall size of the existing nonattainment area will not be reduced.

- *Factor 9, Level of Emission Source Control* – Control efforts, based on air quality alert forecasts, will be applied more frequently in North Pole starting in the fall of 2015, because it records more frequent exceedances of the 35µg 24-hour $PM_{2.5}$ standard.

- *Factor 10, Preliminary Speciation Measurements* – The largest component of $PM_{2.5}$ in both proposed nonattainment areas is organic carbon, with the OC fraction being highest in North Pole: 80% versus 65% in Fairbanks. Fairbanks has approximately double the levels of sulfate, nitrate, and NH_4 compared to North Pole, which makes up for its lower fraction of OC. These differences suggest a different source mix is located within the nonattainment areas.

These findings demonstrate that differences in conditions within the proposed nonattainment areas were not discernable when the boundary for the Fairbanks North Star Borough was established in 2009. With the exception of Jurisdictional Boundaries, the above findings show significant differences in the conditions producing elevated concentrations within the proposed nonattainment areas. Concentrations in North Pole are dramatically higher than found Fairbanks and exceedances are significantly more frequent. Emission density is significantly higher in North Pole than in Fairbanks. Control requirements will need to be more stringent to produce the 70% emission reductions needed to reach attainment and to offset the higher growth rates in household formation, population and travel activity forecast for North Pole. Topographic measurements support the differences in drainage flows observed under low-temperature inverted conditions. Collectively, this information supports the need to divide the Fairbanks North Star Borough $PM_{2.5}$ nonattainment area between Fairbanks and North Pole as proposed in this request.