

FAIRBANKS AIR QUALITY SYMPOSIUM SUMMARY

Overview

The Fairbanks North Star Borough held a three-day Symposium in July (July 15–17) on the status of efforts to investigate and understand the causes of elevated fine particulate matter (2.5 microns and smaller, commonly referred to as PM_{2.5}) concentrations recorded during winter months in Fairbanks. The goal was to bring together members of the community and people with experience in PM_{2.5} measurement, analysis, and modeling from within Fairbanks, the state, and the lower-48 states to engage in thoughtful discussions about the science governing PM_{2.5} formation during winter months in Fairbanks. In addition to opening remarks from the Mayor and the Commissioner of the Alaska Department of Environmental Conservation (DEC), 35 presentations were made on a range of topics, including health effects, monitoring trends, chemical speciation, modeling, and education programs. Presenters included representatives from DEC; the U.S. Environmental Protection Agency (EPA); the Borough; the University of Alaska at Fairbanks (UAF); the Alaska Department of Transportation & Public Facilities (DOT&PF); the National Weather Service (NWS); consultants; several universities outside of Alaska, including Washington University in St. Louis and the University of Montana; and the Hearth Patio & Barbecue Association (HPBA). Sign-up sheets indicated that over 100 people attended each day of the Symposium, key themes from which are discussed below.

Nonattainment Designation

Responding to new information on the adverse health effects of exposure to elevated PM_{2.5} concentrations, EPA strengthened the National Ambient Air Quality Standard for PM_{2.5} in December 2006 by lowering the nonattainment threshold for a 24-hour period from 65 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) to 35 $\mu\text{g}/\text{m}^3$. States were required to examine monitoring data collected within their communities and make designation recommendations based on this new standard by December 2007. DEC examined data collected for Anchorage, the Mat-Su Valley, Fairbanks, and Juneau and determined that the values recorded between 2004 and 2007 consistently exceeded the new standard in Fairbanks (and to a lesser extent in Juneau). The State subsequently recommended that EPA designate Fairbanks as a PM_{2.5} nonattainment area.

Based on this recommendation, EPA initiated a process to define the size of the PM_{2.5} nonattainment area within Fairbanks. Since monitoring data were collected at only one location between 1999–2006, this process did not have much insight into how concentrations varied throughout the Borough. This produced some posturing, with EPA initially suggesting the bulk of the Borough should be designated nonattainment (to be conservative) and the State and Borough suggesting a radically smaller area in response. Ultimately a compromise was reached, but not before an extensive set of data was assembled describing population density; terrain; meteorology; available air quality data, including limited measurements from Fort Wainwright and Eielson Air Force bases; available emission inventory estimates, etc. Figure 1 compares the proposed and final nonattainment boundary, with more detail for the final boundary shown in Figure 2. As shown, the area is bounded to the south by the Tanana River, North Pole to the south east, Ester to the west, and Goldstream Valley to the north.

Figure 1
EPA Recommended and Final Negotiated PM_{2.5} Nonattainment Boundary

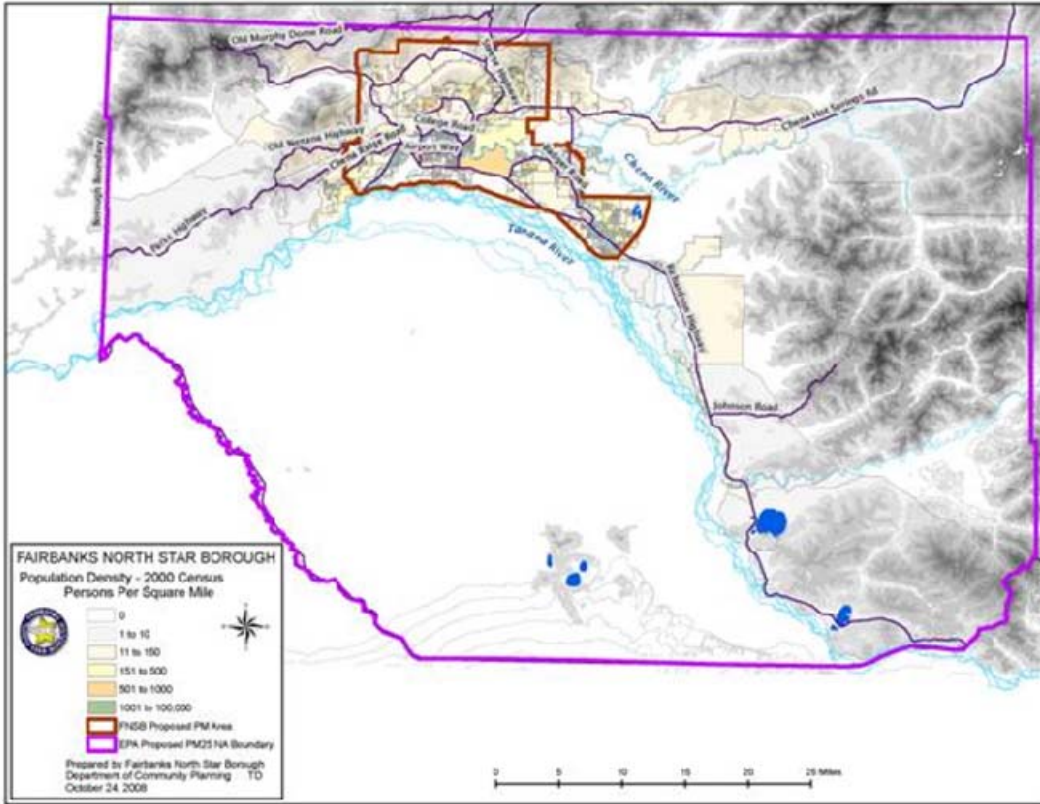
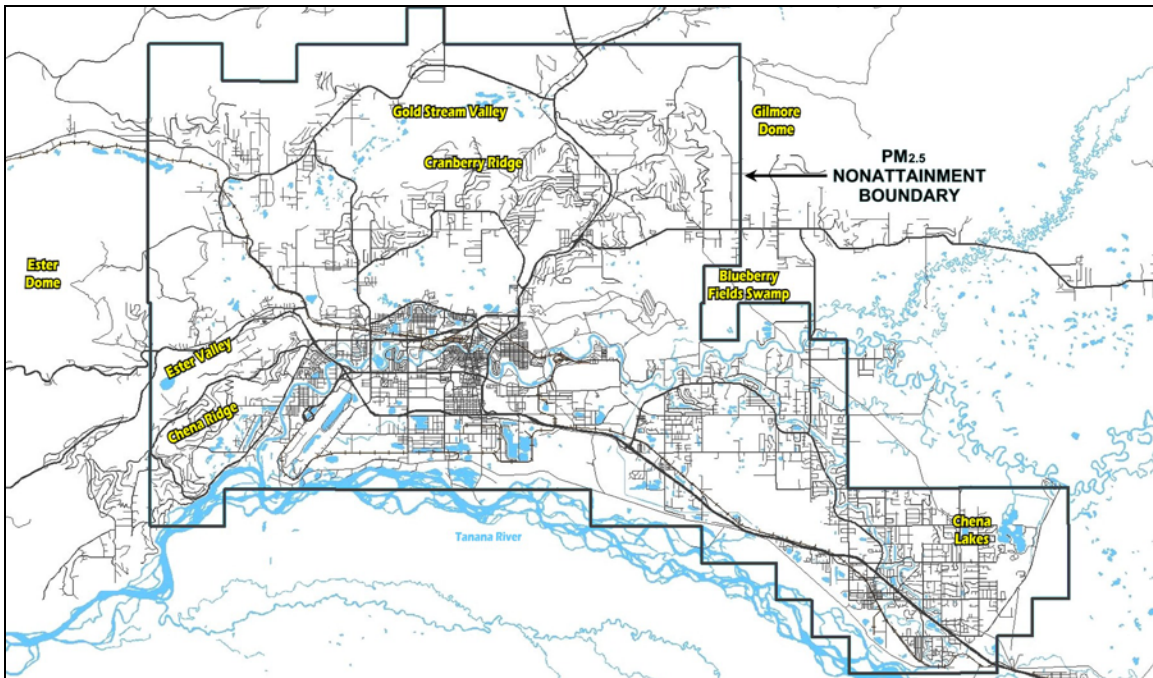


Figure 2
Detailed View of Fairbanks PM_{2.5} Nonattainment Boundary



Eielson was excluded from the nonattainment area because monitoring data from the base showed that PM_{2.5} concentrations were dramatically lower than those collected in downtown Fairbanks and meteorological data showed that upper air wind flows, which move the plume from the Central Heat and Power Plant, were rarely in the direction of the nonattainment area when concentrations were above the standard. Conversely, no measurements were available to document concentrations within the Ester and Goldstream Valleys. Since these areas are growing and have similar meteorology to the downtown area, where elevated concentrations have been recorded, they were included within the nonattainment boundary. Because preliminary measurements collected by the Borough at the Transportation Center on Peger Rd. and in North Pole indicated that these areas experienced elevated PM_{2.5} concentrations, they were also included within the nonattainment boundary.

The timeline for implementing the 24-hour PM_{2.5} standard is presented in Table 1. The change in administration delayed the release of the Federal Register Notice announcing the nonattainment designations, which formally starts the clock for when the State Implementation Plan (SIP) must be submitted to EPA. The timeline is important because it specifies dates when the Borough must reach decisions about which emission sources it will control to reach attainment. Recently, EPA notified the states that it will issue the Federal Register Notice for PM_{2.5} designations in November. Once issued, it will become effective in 30 days and a SIP will be required by the end of 2012. The SIP will need to document the controls that will be adopted and their effectiveness, and demonstrate through modeling how the Borough will attain the PM_{2.5} standard by the end of 2014. If the Borough cannot reach the standard by 2014, it is possible for the Borough to request and for EPA to grant one-year extensions to the attainment date, up to the end of 2019.

Table 1 Timeline for Implementing 24-hour PM_{2.5} Standard		
Milestone	Deadline	Note
1. Final Rule for PM _{2.5} Designations	December 22, 2008	EPA decision date
2. FRN publication of Final Rule	Expected in November	EPA recently announced it will be issued in November
3. Effective Date of Designation	December 2009	30 days after FR publication
4. SIPs Due	December 2012	Three years after effective date of designation
5. Attainment Date	December 2014	Five years after effective date of designation
6. Attainment Date with Extension	December 2019	No later than ten years after effective date of designation

Several agencies gave presentations outlining the support they are providing to the Borough as it works to understand the relative contributions of individual source categories (e.g., cars and trucks, non-road equipment, power plants, space heating, industrial sources, etc.) to the concentrations recorded at different monitoring sites.

- EPA – Both Region 10 (located in Seattle) and the Office of Research and Development (at Research Triangle Park, North Carolina) are developing a model that accounts for the effects of different emission sources located throughout the Borough on concentrations at specific locations. This type of modeling divides the Borough into a set of grid cells that integrates information about the meteorology, emissions, and chemistry that governs particle formation in the atmosphere. Separate studies are being prepared (1) to estimate emissions within each grid cell within the Borough and (2) to create a stratified profile of the meteorology both horizontally and vertically within the Borough on periods when the PM_{2.5} standard was exceeded in the winter of 2007–2008. EPA plans to use this model to help the Borough assess the benefits of alternate control strategies on Fairbanks’ ability to attain the 24-hour PM_{2.5} standard.
- DEC – DEC provided extensive support to the Borough in assembling data that provided the basis for reducing the size of the nonattainment area originally proposed by EPA. In addition, DEC has been supporting the Borough’s efforts over the past two winters to significantly increase the number of monitoring sites so that insight can be gained on temporal and spatial variations in recorded concentrations. This support has included supplying equipment, conducting quality control reviews, contracting with out-of-state laboratories to measure the contributions of individual chemical species to concentrations recorded on the filters at monitoring sites located within the Borough, and interpreting the collected data. DEC also prepared detailed comments to EPA on concerns about how well the forthcoming motor vehicle emissions model “MOVES” represents PM_{2.5} emissions from vehicles operating in Fairbanks during the winter.
- UAF – The University has been funded by the Borough to configure a different grid model and conduct an independent but parallel effort to EPA’s model development and analysis. Preliminary results from that model were presented. The University has also been funded by the Borough to evaluate motor vehicle contributions to PM_{2.5} concentrations recorded at roadside monitors, and preliminary results were also presented. UAF researchers also gave presentations on related on-going research efforts, including analysis of meteorological data collected during periods when high concentrations occur and speciation measurements collected in Fairbanks and other areas of Alaska. University researchers also were active participants in the Symposium, providing comments on subjects ranging from chemistry to meteorology, to atmospheric modeling, to source apportionment.
- NWS – The Fairbanks office has provided support to the Borough by making meteorological data collected in Fairbanks available as well as making staff available to interpret conditions of interest. NWS staff gave a presentation that reviewed winter conditions in Fairbanks as well as conditions that occur when high concentrations are recorded.

- DOT&PF – The agency has provided substantial financial support to FMATS to evaluate the significance of mobile source emissions to elevated PM_{2.5} concentrations recorded in Fairbanks during the winter. It has also expressed concerns to EPA about how well MOVES represents Alaska communities during winter operating conditions. DOT&PF is currently working with FMATS to oversee the development of a new model to predict travel activity within the FMATS area. It is also working with FMATS to expand the domain of the model to account for travel throughout the PM_{2.5} nonattainment area, which is larger than the FMATS area.

A historical perspective was presented by Richard Joy, who managed the Borough's air quality program from 1974–1989. He said that it took 15 years for the Borough to figure out that I/M was needed for carbon monoxide (CO) control and 35 years to solve the problem. He also said the Borough should take its time in figuring out how to solve the PM_{2.5} problem since it is more complicated and the sources are less understood.

Health Effects

Two presentations were given on the health effects of PM_{2.5}. The first, by Dr. Lori Verbrugge of the Alaska Division of Public Health, explained that fine and ultra fine particles (i.e., PM_{2.5}) behave like a gas—they penetrate indoors from outside air, they adsorb toxic compounds, and they penetrate deep into the lung. Groups who are at most risk from exposure to elevated concentrations include children, the elderly, people with heart and lung disease, people with weakened immune systems, and people who work outdoors. Children are more susceptible because they breathe more air per body weight than adults, they tend to be active, they mouth-breathe when active (i.e., crying), and their lungs are still developing. An additional concern is that their immune and brain defenses are not fully formed. Older adults lose immune and respiratory defenses with aging; they may also have lung injuries, circulatory illness, diabetes, etc., which increases their vulnerability to PM_{2.5}.

Health effects from short-term exposure can include eye, nose, throat and lung irritation, headache, nausea, aggravated asthma, acute respiratory symptoms, and increased risk of heart attack. Health effects of chronic exposure to elevated PM_{2.5} can include inflammation of respiratory membranes, bronchoconstriction, impaired respiratory defense, decreased heart rate variability, and accumulation of particles in the lung. The consequences of chronic exposure are increased hospital admissions and ER visits, chronic bronchitis, reduced lung capacity, increased cardiopulmonary mortality, reduction in life expectancy, and increased risk of lung cancer.

Dr. Verbrugge said the literature was very clear and consistent about the health effects of PM_{2.5} and cited over 20 separate studies that consistently showed an increase in mortality associated with long-term particulate exposure. Collectively, the studies showed a 6–17% increase in relative mortality with each 10 µg/m³ of PM_{2.5} exposure. She said the available data showed there is increased mortality with short-term exposure to PM_{2.5} concentrations that are less than 20 µg/m³, which is considerably below the new “health-based” 24-hour standard of 35 µg/m³.

Overall, she said it is estimated that elevated PM_{2.5} levels are responsible for 60,000 deaths per year in the U.S.

The second presentation, by Rachel Kossover, also from the Alaska Division of Public Health, outlined a study she is conducting to evaluate whether there is a relationship between daily PM_{2.5} concentrations and local hospitalization rates in Fairbanks. That study, however, has just been started and results are not expected until next summer. When completed, it should provide the first insight into how relative risk varies within Fairbanks in relation to age, sex, rurality, and ethnicity.

On-Going Monitoring Activity

Six presentations addressed different categories of monitoring data that have been collected in Fairbanks. Since a variety of instruments were used to collect the measurements reported in these presentations, it is useful to first review where they were located and differences in measurement techniques before discussing the presentations. Since there has been some confusion about the number of monitoring sites, a description of each location and its principal purpose is provided below.

- State Office Building – This is the long-term PM_{2.5} monitoring site (filter measurements started in 1999). The monitors are located on the roof of the building at the corner of 7th Ave and Barnett St.
- Sadlers – This is a temporary site established to determine if there are any differences between ground-level measurements and those collected on the roof of the State Office Building. A trailer equipped with multiple monitors was located in the parking lot mid-block on 7th Ave between Barnett and Cushman.
- Nordale School – This is a temporary site located in a high-density residential area east of downtown. A trailer equipped with multiple monitors was located on the south side of the school’s parking lot.
- North Pole – This is a temporary site located at North Pole Elementary School. A trailer equipped with multiple monitors was located on the north side of the parking lot.
- Peger Rd. – This is a temporary site located at the Borough’s Transportation Building just south of the Mitchell Expressway. A cluster of individual instruments is located in the northwest corner of the parking lot adjacent to Peger Rd.
- Instrumented Vehicle – A Borough vehicle was instrumented to collect continuous measurements of concentrations, GPS position, temperature, etc., while traveling over a defined set of road routes.

- Cranberry Ridge – This is a temporary site located south of Farmers Loop Rd. A set of cameras was positioned with views of downtown Fairbanks and Fort Wainwright to take pictures every five minutes during winter months.
- Downtown Tower – This is a retractable meteorological tower located behind the Max Lyon Transportation Center. When extended, the tower records information on meteorological variables at heights of 3, 10, and 20 meters.
- Post Office – This is the long-term CO monitoring site located at the Old Post Office building on Cushman in downtown Fairbanks.
- Hunter School – This is a long-term CO monitoring site located on the west of the school.
- Moveable Trailer – This trailer is equipped with multiple instruments and designed so that it can be moved from site to site during winter months to provide measurements at different locations throughout the Borough.

Table 2 summarizes the location of each of the 49 separate instruments deployed by Borough and DEC staff last winter. It shows most of the instruments were focused on collecting measurements of particulates and meteorology, with limited measurements of CO and particulate precursor emissions from NO_x and SO₂ (which lead, respectively, to the formation of nitrate and sulfate particles).

Site	Particulate	CO	NO _x	SO ₂	Meteorology	Other
State Office Bldg.	4	-	-	-	-	-
Sadlers	3	-	1	1	-	-
Nordale	4	-	-	-	1	-
North Pole	3	-	-	-	1	-
Peger Rd.	4	-	-	-	1	-
Instrumented Vehicle	1	-	-	-	1	1 GPS 1 Car Chip
Cranberry Ridge	-	-	-	-	-	2 Cameras
Downtown Tower	-	-	-	-	9	-
Post Office	-	1	-	-	-	-
Hunter School	-	1	-	-	-	-
Moveable Trailer	2	1	-	-	5	-
Total	21	3	1	1	18	5

Table 2 shows that most of the monitoring sites employed more than one instrument to measure particulate concentrations. That is because a variety of measurement techniques are available and each provides a different insight. Some instruments use filters to collect particles below a selected size threshold (e.g., less than 2.5 microns in diameter), others measure variations in light scattering to estimate particulate concentrations (with no filters), others measure changes in microbalance oscillations (again with no filters), some measure radiation attenuation, and still others collect measurements of black carbon. The time scale employed by these instruments also varies: some collect filter measurements for a 24-hour period; others collect continuous second-by-second measurements, compute hourly average values, and then discard the second-by-second data; and still others provide a combination of second-by-second and hourly data. Because of the cost of collecting and weighing filter measurements, they are typically collected on a 1-in-3 day or 1-in-6 day schedule. This provides time for staff to travel to each site, collect exposed filters, and replace them with fresh filters.

The problem with filter measurements is they miss two-thirds of the days (based on a 1-in-3 day schedule) and they collect no information on hourly variations. This is the reason instruments are frequently collocated so that measurements of the hourly values, which are collected continuously, can be used to provide insight into concentrations on days when filter measurements are not collected (since they can be averaged to provide 24-hour values) and insight into the diurnal profile on days when they are collected. The collocation of measurements also provides the basis to assess how well they replicate each other (i.e., quantify the difference between 24-hour averages of hourly values using a light scattering measurement technique versus a 24-hour filter measurement).

Another issue is how particulate measurements are used for regulatory purposes. While most of the collected measurements are reported to EPA, only the 24-hour filter measurements from a particular class of instruments (referred to as FRMs or Federal Reference Method instruments) are used to determine whether the Borough is in or out of attainment with the ambient PM_{2.5} standard. Thus, it can be confusing when measurements from different instruments are reported because the continuous instruments collect measurements for every day of the winter, while the filter measurements capture data for only one-third of those days. This can result in EPA announcing that Fairbanks exceeded the standard X days in a winter (using FRM-based filter measurements collected on a 1-in-3 day schedule) and the Borough can provide data showing the standard was exceeded X+Y days in a winter (using continuous instruments that capture Y days exceeding the standard when no filter measurements were taken).

Aside from the difficulty of keeping all of the instruments operating under subarctic conditions, many collect data on a variety of parameters (e.g., ambient temperature, relative humidity, settings, error flags) on the same time scale the particulate measurement is being collected. Thus, some instruments can produce relatively small data files and others can produce unusually large data files. Since the Borough does not have telemetry access to all of the instruments, it means that staff must collect measurements from each instrument on a schedule that ensures that the storage capacity of the instrument is not exceeded and data are not lost. The result is that many different files with different measurement parameters covering different time periods are collected from different sites over the winter. All of these files need to be checked for quality, and screened for outliers and possible errors before the analysis can begin.

In the case of the filter measurements, they are placed in cold storage and are periodically sent in batches to DEC to be weighed and to a laboratory in North Carolina for chemical analysis (i.e., speciation). This means the results of these measurements can lag those of the continuous monitors by a period of months before the results are received and analyzed.

Presented below is a review of the presentations that addressed particulate concentrations. The results of chemical analysis of filter measurements and related modeling efforts are presented in subsequent sections.

The first presentation on particulate concentrations, by Jim Conner of the Borough, outlined long-term trends in PM_{2.5} concentrations recorded at the downtown monitoring site and efforts to expand the monitoring network last winter. Figure 3 charts daily values recorded between 2004 and 2008: it shows a clear seasonal pattern of elevated concentrations, with higher values being recorded both during the winter and during the summer (when forest fires occur). As also shown in the figure, the number of winter days exceeding the 24-hour standard increased significantly after the stringency of the standard was increased by lowering it from 65 µg/m³ to 35 µg/m³. It should be noted that the chart stops displaying concentrations at 100 µg/m³; higher values were recorded during both summer and winter months (with the highest values reported during forest fires).

Figure 3
PM_{2.5} Measurements in Downtown Fairbanks
24-hour Moving Average of Hourly Values, October 2004 – March 2008

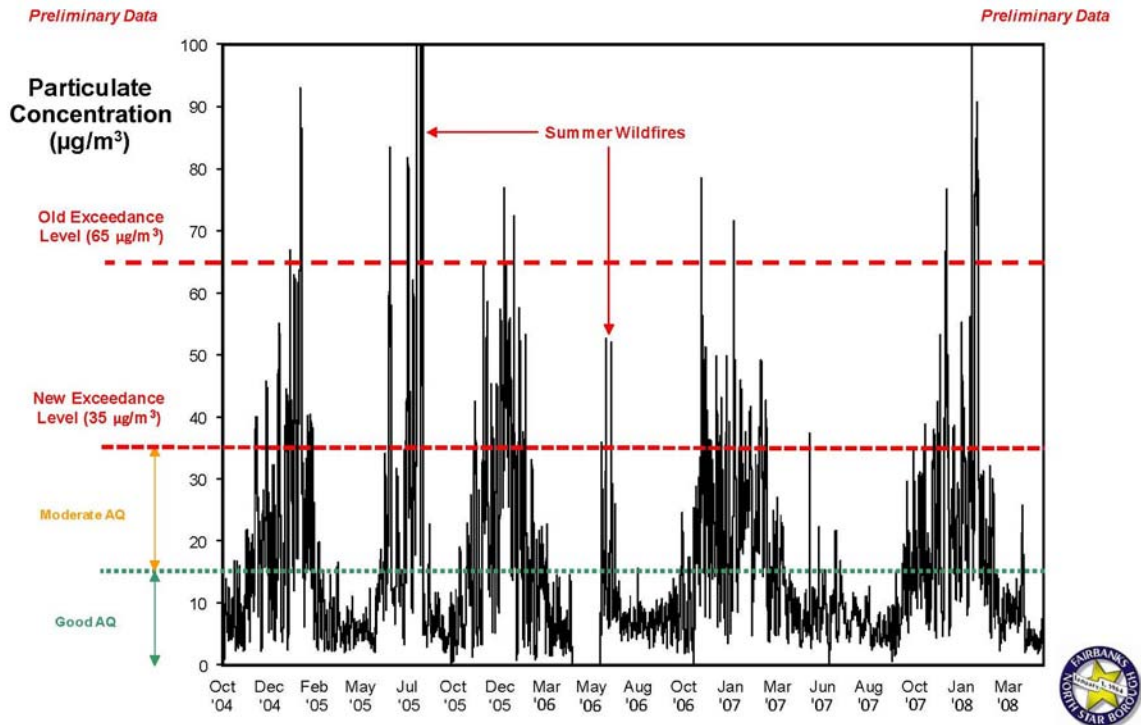


Figure 3 displays only concentrations recorded at the downtown monitor and provides no insight into what concentrations look like throughout the rest of the Borough. To address this issue, the Borough, with support from DEC, installed monitors for extended periods of time at four additional sites: an additional site downtown on the ground at Sadlers, approximately 75 meters from the State Office Building site, to provide a comparison with the long-term monitors located on the roof of the State Office Building; Nordale School; the Transportation Building on Peger Road; and North Pole Elementary. The location of these monitors and the time periods they were operated are presented in Figure 4.

Figure 4
Location of Fixed Site PM_{2.5} Monitors in Fairbanks

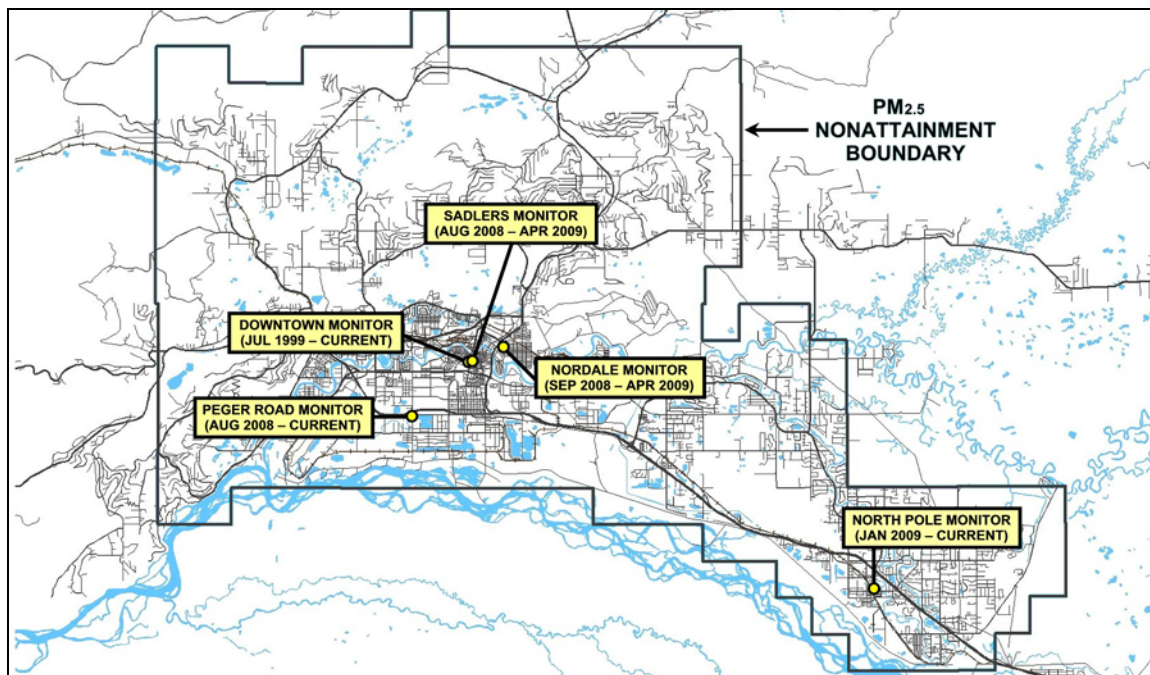
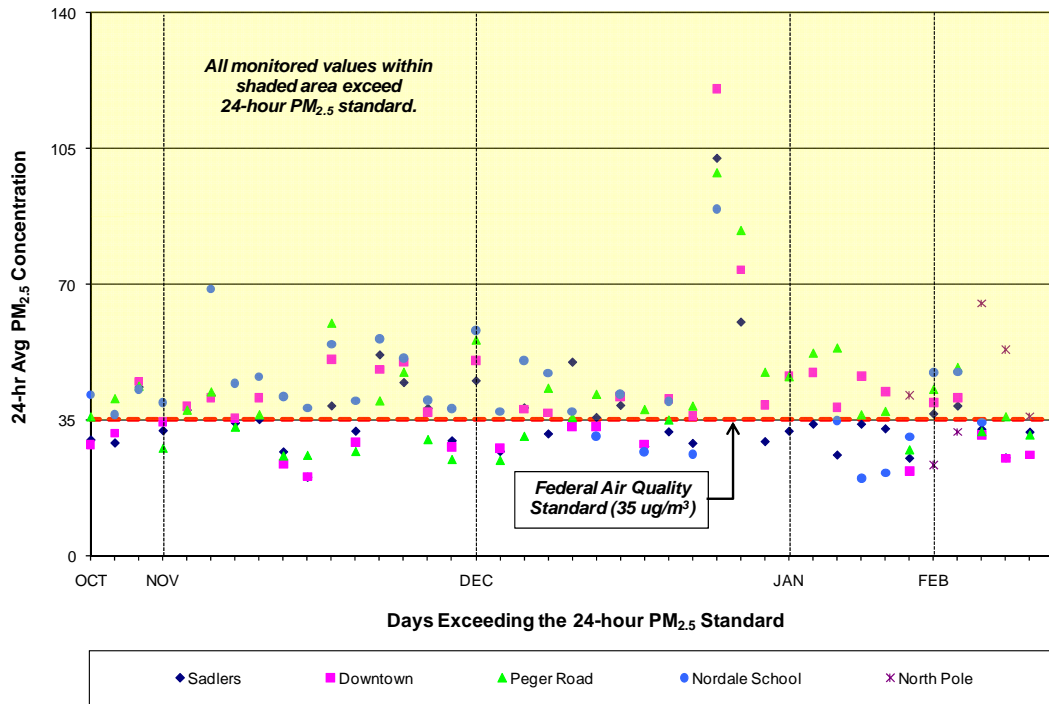


Figure 5 summarizes the concentrations recorded at each of these sites last winter and shows that between late October 2008 and late February 2009, the Borough frequently exceeded the 24-hour PM_{2.5} standard. It also shows that exceedances were not limited to the downtown monitoring site—they were recorded frequently at all of the other locations. It should be noted that the North Pole site did not begin operating until mid-January 2009; however, it recorded several exceedances for the brief period that it was in service last winter. Overall, the chart shows that the Borough exceeded the 24-hour standard 41 out of 123 days in the period presented (i.e., exceedances were recorded on fully one-third of the days at multiple locations). What is not shown on the chart is that exceedances were not randomly distributed but frequently occurred in clusters of sequential days (e.g., 3, 5, etc.) associated with strong inversions and severe meteorology. These episodes are problematic because concentrations tend to build over time as inversions limit the dispersion of accumulated pollutants.

Figure 5
Last Winter the Borough Exceeded the 24-hour PM_{2.5} Standard at One or More Monitoring Sites on 41 Days (10/29/08 – 2/16/09)



Not presented at the Symposium but of interest is that the Borough prepared a relocatable trailer equipped with multiple monitors, which was sited for limited periods of time (typically two to four weeks) at multiple locations. The goal was to use this equipment to fill in gaps about concentrations occurring in areas not captured by the fixed sites. Figure 6 depicts the locations of these sites and the time periods in which they were operated. Not all of the data collected from the first year of operation were usable; however, insight from these measurements provided the basis for establishing a fixed site in North Pole, because high values were recorded the previous winter. Measurements collected this past winter showed that elevated concentrations were not recorded at the Landfill site, the Ester site, or in air draining out of the Ester and Goldstream Valleys past the Reindeer site (on farm land below the University).

Another type of monitoring system was also deployed in an instrumented vehicle to collect instantaneous (second-by-second) concentrations while operated on roads throughout the nonattainment area. A summary of the roads over which it was operated is presented in Figure 7. It shows that coverage in the urban portions of Fairbanks and North Pole is extensive, while the roads driven in the Ester and Goldstream Valleys were more limited.

Figure 6
Location of Temporary Monitoring Sites in Fairbanks
Using Borough's Relocatable Air Monitoring System (RAMS) Trailer

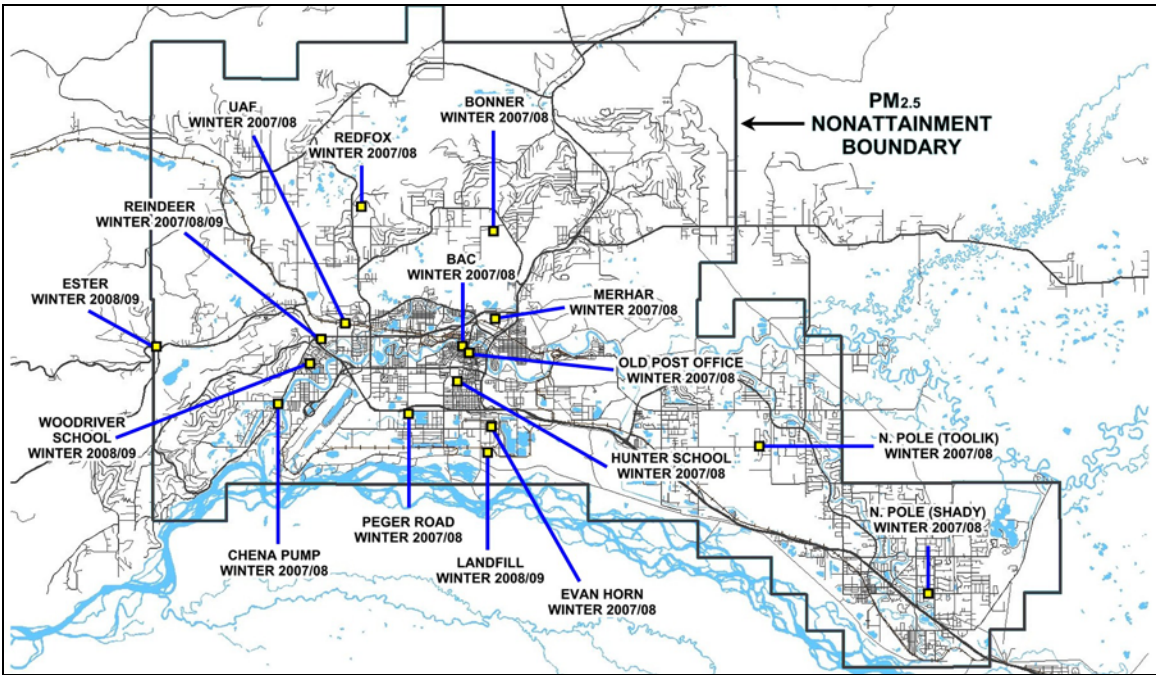
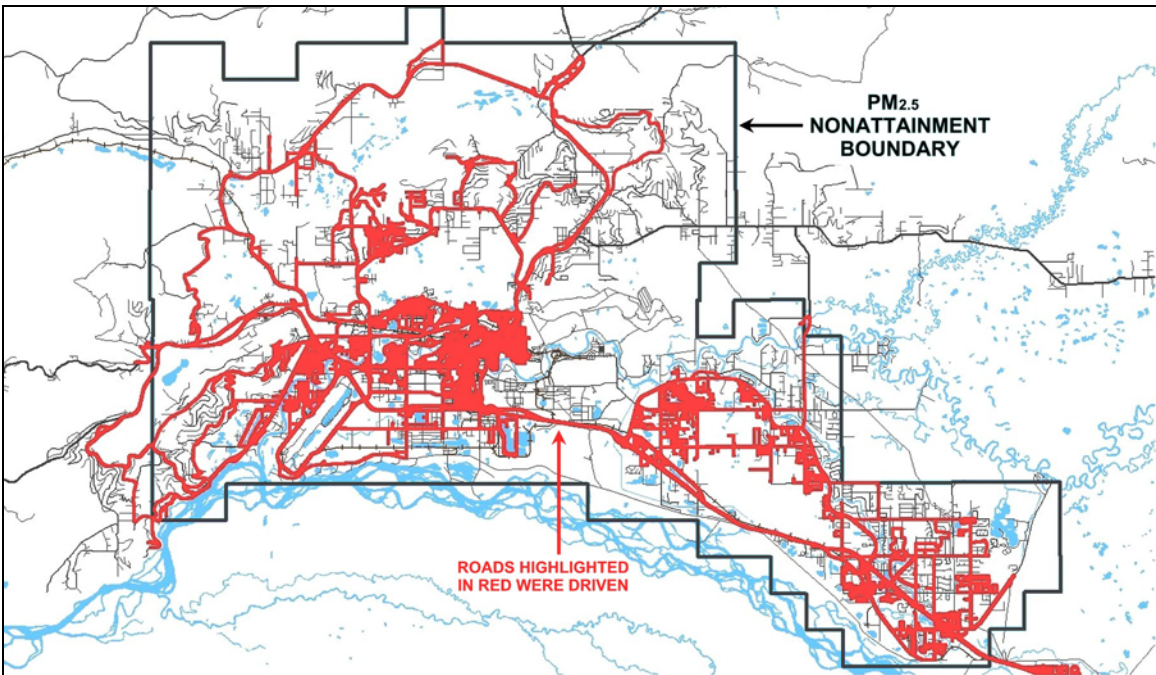


Figure 7
Roads Driven Last Winter to Collect PM_{2.5} Measurements
Within Nonattainment Area (11/08 – 2/09)



While the instantaneous measurements are not directly comparable to the fixed site measurements (one is collected by a moving vehicle with two-second average values and the others are hourly and 24-hour average values at fixed locations), they provide insight into concentrations throughout the nonattainment area. Generally, the instantaneous measurements indicated that the highest concentrations were recorded in the most densely populated areas and following some vehicles. They also showed that certain areas within the nonattainment area (e.g., Goldstream Valley) routinely had substantially lower concentrations. Consistent with the fixed site findings, the highest concentrations were recorded between 4–6 pm. Pockets of high concentrations were also identified in neighborhoods that were older, had high levels of wood-burning, or were located in “low (elevation) spots” (e.g., west of the Airport).

Source Attribution

Gaining an understanding of which sources are the principal sources of emissions impacting the monitors is a critical challenge. Carbon monoxide was easy: 80+% of the CO emitted came from cars and trucks; therefore, control strategies focused on how to reduce the CO levels emitted by vehicles. PM_{2.5} is more complex, for three reasons:

1. Many sources emit PM_{2.5} and current estimates of their emissions are not well developed, so it is difficult to know which sources are the most important to control.
2. Some sources (e.g., cars, trucks, snow machines, home heating, etc.) emit below the inversion layer. Point sources with tall stacks (e.g., central heat, power plants, refineries, etc.) can emit above the inversion layer. Since high concentrations typically occur on days with low inversions, it is not clear whether emissions from the point sources with tall stacks are impacting the concentrations being recorded at the monitors.
3. Concentrations recorded at the monitors include both directly emitted and secondary PM_{2.5}. Secondary PM_{2.5} occurs when pollutants emitted as gases combine to form particles in the atmosphere (e.g., ammonia and nitrogen oxide form ammonium nitrate). The chemistry governing particle formation in cold dry climates with little or no sunlight is not well understood.

Despite these limitations, several presentations provided some insight into source contributions. One study looked at the percent share of chemical compounds found on filters at different monitoring sites. Another looked at correlations between traffic activity and concentrations found on nearby monitors. Another looked at concentrations reported at Denali and assessed the significance of transport (from other countries). Another used EPA statistical models to look at common patterns of variance in chemical species to determine possible source contributions. Experts from UAF, lower-48 universities, and related agencies shared their experience and raised questions about some of the results, which was the goal of the Symposium. Overall, these discussions reached a consensus on the points summarized below.

- Information about source contributions to average winter PM_{2.5} concentrations is inconsistent. One study showed wood burning to contribute roughly 30% of the

average winter PM_{2.5} levels; another suggested the wood-burning contribution could be considerably higher, on the order of 40–50%. One study showed motor vehicles to be responsible for less than 10%, another showed motor vehicles contributing up to 35% of the winter concentrations. Differences in estimates from the available methodologies need to be resolved.

- The role of sulfur and ammonia in contributing to secondary particle formation is poorly understood. The chemical analysis showed that ammonium sulfate accounted for 26% of the mass recorded on the filters, which makes it a significant contributor. Given the lack of photochemistry during Fairbanks winters, the process governing sulfate formation is not clear. Suggestions ranged from a rapid conversion mechanism, to direct emission as primary sulfate, to artifact formation on sampling filters. More work is required to determine how sulfate particles are formed during the winter in Fairbanks.
- The EPA statistical models identified an unusual metals-related source as being responsible for roughly 20% of wintertime PM_{2.5}. An ad hoc analysis found that waste oil burning could be the source. This suggestion, however, has not been confirmed and more analysis is required to determine if waste oil burning is a significant contributor to wintertime PM_{2.5} levels.
- Transport is not a significant contributor to the Fairbanks PM_{2.5} problem. This means local emissions are the cause of Fairbanks' elevated PM_{2.5} concentrations.

Modeling

The goal of modeling is to determine the contribution from area sources and to test the benefits of control strategies in reducing PM_{2.5} concentrations. Several steps are required to make this process work, including those described below.

- Preparing an estimate of the pollutants emitted from Fairbanks emission sources. This involves collecting information on activity levels (e.g., miles traveled, landings and takeoffs, hours of operation, etc.) and appropriate emission factors (e.g., grams/mile, grams per landing/takeoff, grams/hour of operation, etc.) that are adjusted to represent Fairbanks' winter conditions. The emission estimates are needed for activity levels within a gridded area (e.g., 1 kilometer by 1 kilometer cells) that covers the Borough. This requires tracking the activity for each of the homes, businesses, point sources, roads, airports, etc., located in each grid cell and estimating the emissions for each pollutant (e.g., CO, PM_{2.5}, etc.) by hour of the day. It also requires an estimate of the height at which the pollutants are emitted.
- Preparing an estimate of the meteorology that occurs within each grid cell within the Borough on days when elevated concentrations occur. This involves tracking meteorology not only horizontally across the individual grid cells but also vertically above the grid cells so that the effects of inversions on pollutant movement through the atmosphere can be tracked.

- Selecting and using atmospheric chemistry models that govern particle formation in the atmosphere.
- Selecting and using air quality models that integrate information from emissions, meteorology, and chemistry on particle formation and concentrations that occur at selected locations (referred to as receptor sites) throughout the PM_{2.5} nonattainment area.

Although many types of air quality models are available, EPA recognizes only certain models for use in regulatory analyses. At this point, fine particulate modeling is recognized as an evolving science that is at least a decade behind ozone modeling in terms of accuracy and the ability to account for atmospheric interactions. For this reason, many communities that have prepared SIPs for PM_{2.5} have used a variety of models and statistical techniques to provide insight into processes governing particle formation and the potential benefits that can be expected from alternate control measures. Several presenters outlined on-going efforts, summarized below, to develop models that can be used to address the steps outlined above.

- EPA's Office of Research and Development (ORD) located in North Carolina has been working on a project for more than a year to configure one of its regulatory models—the Community Multiscale Air Quality (CMAQ) Modeling System—to represent Fairbanks PM_{2.5} winter episodes. This involves the development (by Sierra Research) of the first gridded emissions inventory for Fairbanks, the development (by Penn State) of a meteorological model representing Fairbanks atmospheric conditions during episodes in the winter of 2007–2008, the selection of an available chemistry model, and the operation and evaluation of CMAQ performance in representing concentrations recorded during episodes in the winter 2007–2008. This work is still in progress and EPA's Region 10 staff are involved in the project. The goal is to create a workable model that can be used to determine which sources are responsible for the high winter concentrations and to evaluate the benefits of alternate control strategies.
- UAF staff have been using the Weather Research and Forecasting (WRF) chemistry model known as WRF/Chem to simulate Fairbanks PM_{2.5} winter episodes. At this point, WRF/Chem is not an accepted EPA regulatory model. Nevertheless, it uses many of the same inputs that are being created for CMAQ and it provides alternate insights into particle formation in Fairbanks. Preliminary analysis of Fairbanks runs using EPA-derived inventory estimates (not those currently under development) found reasonable agreement between predicted and actual concentrations. That analysis also found no significant contribution from secondary particle formation, which is inconsistent with the available monitoring data and shows the need for further model development.
- A statistical analysis of the influence of meteorology on PM_{2.5} concentrations was prepared to determine which factors had the greatest impacts on concentrations recorded in the 2008–2009 winter. The results showed that meteorological variables can be used to predict PM_{2.5} concentrations. Their accuracy can be improved by

evaluating meteorology over a longer period of time and, if coupled with emission inventory estimates, it is possible to predict the probability of exceeding the PM_{2.5} standard in future years. A similar methodology was used to predict the probability of attaining the ambient CO standard in the soon to be EPA approved Maintenance Plan, which drops the I/M program.

From these presentations, it became clear that more work is needed before the models can be used to assess the source contributions and control measure benefits in Fairbanks.

Next Steps

The Symposium achieved its goal of bringing together members of the community and people with experience in PM_{2.5} measurement, analysis, and modeling to discuss the science governing PM_{2.5} formation during winter months in Fairbanks. On the last day of the conference, participants divided into four groups to identify areas of high-priority data collection and analysis needed to address issues that became apparent from the presentations. A brief summary of each follows.

- Chemistry – Led by researchers at UAF and the University of Washington, St. Louis and DEC, this group recommended a careful examination of monitor operation at cold temperatures to ensure that secondary particle formation is not an artifact of the sampling process. They also recommended additional data collection and analysis efforts to determine the cause of high concentrations observed along selected roadways.
- Meteorology – Led by forecasters from the National Weather Service, Fairbanks, UAF, and the Borough, the group discussed the possibility that some form of recirculation caused by drainage flows of cold air along the ground from upper elevations during periods of low wind, strong inversions, and limited dispersion may be responsible for diurnal profiles observed on days with high concentrations (i.e., a build-up during the day followed by a drop off in concentrations after 6 pm). Recommendations were made for siting instruments needed to collect meteorological measurements to quantify this behavior.
- Modeling – Led by a combination of Borough, EPA Region 10, and UAF staff, this group identified the collection of upper air meteorological observations as a high priority so that meteorological model predictions can be validated. They also noted that the phenomena identified by the meteorological group as a possible cause of patterns of observed concentrations cannot be addressed within the limits of available air quality models.
- Data Collection – Led by a combination of Borough and DEC staff, this group was determined that several efforts are needed to improve the accuracy of available emission inventories. These include data on residential and commercial space heating fuel use (wood, fuel oil, etc.), traffic patterns, non-road equipment use, etc. on days in which high concentrations occur.

Finally, and possibly most importantly, several members of the Assembly and the public asked for increased public education about PM_{2.5} monitoring results, causes of elevated concentrations, voluntary practices that can reduce wood-burning emissions, and more outreach about what the Borough is doing to understand and address this problem. This Symposium summary is the first step in addressing those requests.

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