FORT AIR PARTNERSHIP

We Monitor the Air You Breathe

Fort Air Partnership Fine Particulate Matter Speciation Study

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Introduction to Fine Particulate Matter ($PM_{2.5}$)

Fine particulate matter ($PM_{2.5}$) consists of tiny particles, 2.5 micrometers in size and smaller. In comparison, a strand of human hair is about seventy micrometers in width. Sources of $PM_{2.5}$ include soil, road and agricultural dust, vehicles, industrial emissions, smoke from wildfires, household heating, fireplaces, barbecues, gas-powered lawn maintenance equipment and even cigarettes. $PM_{2.5}$ directly emitted into the air is known as *primary particulate matter*. $PM_{2.5}$ may also be produced in the atmosphere through complex chemical processes involving other substances and is referred to as *secondary particulate matter*. $PM_{2.5}$ may lead to human health problems. Small particles have the ability to travel deep into the lungs which can make breathing more difficult or may aggravate existing lung and heart problems.

Higher levels of $PM_{2.5}$ typically occur during the summer months due to smoke from wildfires, or during periods of very warm weather with little or no wind. Elevated levels can also occur during temperature inversions that occur in the winter when air movement is limited. $PM_{2.5}$ is included in the determination of the Air Quality Health Index (AQHI), a tool used to relate ambient air quality (including fine particulate matter) to health in Canada.

$PM_{2.5}$ is measured and reported in micrograms per cubic meter ($\mu g/m^3$). There are both provincial and federal standards in place for $PM_{2.5}$, this includes Alberta Ambient Air Quality Objectives and Canadian Ambient Air Quality Standards.

FAP Activities related to $PM_{2.5}$

Fort Air Partnership participates in many collaborative regional efforts related to $PM_{2.5}$, including:

- Continuous monitoring of $PM_{2.5}$ at seven air quality monitoring stations.
- Installation of PurpleAir® $PM_{2.5}$ microsensors in the FAP network to monitor for $PM_{2.5}$ in communities that do not currently have continuous $PM_{2.5}$ monitoring.
- Capital Region Oversight Advisory Committee and the ongoing implementation of a Fine Particulate Matter Response Plan.
- Industrial Heartland Designated Industrial Zone Pilot Project Air Working Group

Fine Particulate Matter Speciation Study Objective

A 2011 assessment of the FAP air monitoring network recommended the addition of a speciated measurement program of $PM_{2.5}$ to provide valuable information about the sources of fine particulate

matter both within and outside of FAP affecting $PM_{2.5}$ levels in the FAP region. The objectives of this study were to improve the understanding of $PM_{2.5}$ composition as well as identify the major primary and secondary sources of $PM_{2.5}$ measured in the city of Fort Saskatchewan. The full study report can be found here.

Study and Comparison Sites

The $PM_{2.5}$ speciation study was conducted at FAPs Ross Creek station, which is situated in the southwest corner of the Industrial Heartland, on the outer edge of the residential area of the city of Fort Saskatchewan, with the bulk of the city of Edmonton located to the southwest. There is also a separate heavy industrial area to the southwest referred to as the Strathcona Industrial Area. Fort Saskatchewan is a city of approximately 27,000 residents and is part of the greater Edmonton Metropolitan Area (population ~1.3 million). The Industrial Heartland has multiple petrochemical facilities along the North Saskatchewan River. The land use surrounding the Ross Creek monitoring site also includes agricultural activities. The primary FAP monitoring objective for the Ross Creek station is to measure the influence of local industrial emissions on air quality in the city of Fort Saskatchewan.

Images of the Ross Creek monitoring station and its speciated $PM_{2.5}$ sampling equipment are shown in **Figure 1** and **Figure 2**, respectively.

Figure 1. Picture of the Ross Creek station

Figure 2. Ross Creek Station Speciation Equipment

Ross Creek is a unique location for speciated $PM_{2.5}$ monitoring, as the combination of being adjacent to a suburban area and a heavy industrial zone is not similarly duplicated at any other monitoring sites in Canada or the United States.

Six speciated $PM_{2.5}$ monitoring sites were selected from Canada and the United States for comparison to the Ross Creek site. The three Canadian sites selected, including Edmonton-McIntyre, Ottawa Downtown, and Burnaby South in greater Vancouver, were intended to provide a cross-section of Canada. The Edmonton-McIntyre site is located in south Edmonton just north of Whitemud Drive, a major city roadway. The Burnaby South site is in a residential area and is far from any industrial or roadway sources. The Ottawa Downtown site is also in a residential area near the Rideau River.

The three United States sites that were included for comparison are Granite City, Illinois; Deer Park, Texas; and Teddy Roosevelt National Park, North Dakota. The Granite City site is in East St. Louis, Illinois, near a petrochemical upgrader and heavy industry including a major steel facility. The Deer Park site is located near the Houston ship channel in Texas, another major North American petrochemical refinery area. Finally, the Teddy Roosevelt National Park site is located near upstream shale oil production in rural North Dakota; this site is similar in terms of geography and climate to Fort Saskatchewan although it does not have major industrial facilities or population centers within 10 km.

It is important to note that data sets for the entire study period were not available for all of the comparison sites at the time this report was finalized.

Study Results

$PM_{2.5}$ concentrations at the Fort Saskatchewan Ross Creek site were slightly higher than those at the Edmonton-McIntyre site and much higher than comparison sites in Downtown Ottawa, Burnaby South, and Teddy Roosevelt NP in North Dakota. Ross Creek mean and median $PM_{2.5}$ concentrations were

significantly lower than the industrially influenced sites of Deer Park, Texas and Granite City, Illinois. Monthly comparisons of mean $PM_{2.5}$ concentrations indicated that Ross Creek had higher relative concentrations in the winter months, and lower relative concentrations in the summer months. The Ross Creek site is more suburban/rural than the Edmonton-McIntyre site but is downwind of the major Edmonton Metropolitan Area about 40% of the time and can be reasonably expected to be influenced by transport of regional urban emissions from metropolitan Edmonton towards the Fort Saskatchewan area. Thus, the study site is expected to measure concentrations from a broad range of sources including emissions from industrial and urban activities, including transportation.

Days with elevated levels of $PM_{2.5}$ at the study site were driven by two main types of events:

- **Wildfire smoke** – these were the most influential, driving concentrations well above the 24-hour AAAQO. Wildfire smoke events are more likely to occur during Alberta's wildfire season, March through October. .
- **Wintertime temperature inversions** – these events can result in elevated regional $PM_{2.5}$ concentrations during stagnant meteorological conditions with elevated organic matter, nitrate and sulphur concentrations as the most notable contributing components.

Two different methods were used to determine the components (factors) contributing to total $PM_{2.5}$ at Ross Creek: Reconstructed Fine Mass (RCFM) and Positive Matrix Factorization (PMF). A detailed results analysis for both are presented in the full report. The results from the PMF method indicate that the most significant contributing components of the total $PM_{2.5}$ mass at Ross Creek were as follows:

Ammonium Nitrate

Ammonium nitrate made up 20% of total $PM_{2.5}$ mass at Ross Creek. Similarly to organic matter, wind direction and wind speed during the study time period did not point to a specific contributing source of the ammonium nitrate factor contributing to $PM_{2.5}$. This factor has notable contribution from secondary particulate formation, formed in the atmosphere by gases emitted through the combustion of fossil fuels such as coal, oil, gas and gasoline. As such, this factor likely arose from a variety of sources both within and outside of the FAP region.

Smoke

Smoke from wildland fires, prescribed burns, and local residential fireplaces, made up 19% of total $PM_{2.5}$ mass at Ross Creek. During the study time period, wind direction and wind speed did not point to a specific contributing source of the smoke factor contributing to $PM_{2.5}$. Smoke from wildfires, which also contributes to organic matter, is most often transported from outside the region and is unlikely to be due to local fires within the Fort Air Partnership boundaries during the summer months. Local and regional residential wood burning may contribute to elevated smoke concentrations in the winter.

Organic Carbon and Metals

A factor identified as organic carbon and metals contributed 16% of total $PM_{2.5}$ mass at Ross Creek. Key chemical species in this factor included organic compounds, elemental carbon, and metals including chromium. Organic matter pertains to any of the carbon-based compounds that abound in nature. Particulate organic matter is produced indirectly from the combustion of fossil fuels such as coal, oil, natural gas and gasoline, with motor vehicle emissions being a significant contributor in some areas. Motor vehicle emission contributions to $PM_{2.5}$ were associated both

within the FAP region, as well as with the broader Edmonton Metropolitan Region. It should be noted than organic carbons also contribute to the Smoke component.

Ammonium Sulphate
Ammonium sulphate results from the burning of sulphur-containing fossil fuels, primarily from industrial sources. Study results show a noticeably clear ammonium sulphate signal originating from the Alberta Industrial Heartland sector to the northeast. Overall, those concentrations were responsible for 16% of the total $PM_{2.5}$ mass at the study site. Winds were less frequent from the northeast and therefore the influence of this contributing source was somewhat muted.

Other components that made up the remaining total $PM_{2.5}$ mass at Ross Creek included:

Salt and Metals
Salt and metals concentrations were higher in the winter, this is likely associated with winter road resuspended dust. Higher winter concentrations may be associated with local de-icing activities.

Crustal matter
Crustal matter refers to particulates originating from soil, sand and gravel. Concentrations were highest in the spring months and may be associated with local agricultural operations generating dust.

Conclusions

$PM_{2.5}$ mass concentrations at the Ross Creek station located in Fort Saskatchewan had the largest contributions from secondary particulate matter components consisting of organic carbon and metals, ammonium nitrate, and ammonium sulphate. The substances that react to form the observed secondary particulate matter are emitted by urban and industrial activities both within and outside of Fort Air Partnership's boundaries and the broader Edmonton Metropolitan Area.

High daily concentrations of $PM_{2.5}$ were furthered by meteorological conditions conducive to pollution buildup, especially in the case of wintertime temperature inversions in the winter months, and wildfire smoke episodes during the summer months.

$PM_{2.5}$ is often considered a regional-scale issue given the secondary formation of components like nitrate, sulphate, and organic matter, but the much lower residential density and transportation density in the Ross Creek area does not appear to yield lower concentrations than a central urban site like Edmonton-McIntyre.

Although a major contributing factor to elevated $PM_{2.5}$ levels in the FAP region is wildfire smoke that cannot be directly managed by entities in FAP or the Edmonton Metropolitan Area, there is still a significant contribution from other sources generating secondary particulate matter, including both urban and industrial. This contribution from other sources highlights the need for collective regional air quality stewardship.