Portable Air Monitoring Lab Project

Air Quality Monitoring Report

Elk Run, Canmore

October 2019 to March 2020 | April 2021 to September 2021

Special thanks to the Town of Canmore, Alberta Environment and Parks (AEP) for providing funding for the deployment of PAML, Pieridae Energy for being a community sponsor and AEP for the donation of monitoring equipment.

About Calgary Region Airshed Zone

Calgary Region Airshed Zone (CRAZ) is a non-profit organization whose mission is to monitor, analyze, and provide information on air quality and develop strategies to manage air quality within the airshed zone. To support its regional air quality monitoring strategy and goals for education and outreach programs, CRAZ developed a portable air monitoring laboratory (PAML). This large and prominently signed portable promotion and education 'platform' is equipped with several state-of-the-art air quality monitors that demonstrate the commitment of CRAZ to its mission and goals.

PAML Description

CRAZ operates a PAML that can be sited throughout the region to monitor ambient air quality. The PAML is equipped to monitor: oxides of nitrogen (NO_x); nitric oxide (NO); nitrogen dioxide (NO_2); ozone (O_3); fine particulate matter ($PM_{2.5}$); ambient temperature; wind speed and direction. Three parameters required to calculate the Air Quality Health Index (AQHI) include NO_2, O_3, and $PM_{2.5}$.

PAML Monitoring Program Purpose and Objectives

CRAZ identified the PAML's principal role to produce real-time data on air quality and provide information on potential health risks using the AQHI indicator. In addition, the PAML deployments will support education and demonstration programs to build public, stakeholder and member support for CRAZ's long-term strategy for ambient air quality monitoring and reporting in its region. CRAZ also recognizes the need to deploy the PAML to support ongoing research programs, including CRAZ's air quality management planning initiative (CRAZ Air Quality Management Plan, 2019).

Implementation of the CRAZ portable air monitoring program will achieve the following objectives through the PAML deployments in the CRAZ region:

- Provide real-time information about air quality impacts on health based on the AQHI.
- Support CRAZ's long-term strategy for ambient air quality monitoring in its region.
- Help CRAZ stakeholders and members better understand air quality in CRAZ and what they can do to improve it.
- Provide transparent, open data for public use and scientific studies.
- Measure air quality in the areas that have little or no previous monitoring to address technical or geographical data gaps.
- Address some of the monitoring gaps identified by the regional network analysis that identified smaller urban centers should have continuous monitoring to assess emissions in relation to Alberta's Ambient Air Quality Objectives (AAAQOs) and to that in Calgary.

PAML Location

The PAML was deployed twice at the Elk Run, Canmore for the October 2019 to March 2020 and April 2021 to September 2021 monitoring periods. Figure below shows the monitoring location.

PAML - Elk Run

Project Monitoring Results

Results compared to Alberta Ambient Air Quality Objectives

Alberta Ambient Air Quality Objectives (AAAQOs) are regulatory tools established by the Government of Alberta, under the Alberta Environmental Protection and Enhancement Act. Alberta Environment and Parks (AEP) works with a variety of stakeholders, including other government departments, the scientific community, environmental organizations, industry, and the public to develop and review objectives.

The AAAQOs provide environmental and human health protection to an extent technically and economically feasible, as well as consider what is socially and politically acceptable. The AAAQOs are set well below what are considered emergency levels.

Table 1 provides details of the AAAQO exceedances measured and reported at the Canmore Elk Run site including the dates, the number of exceedances of each type and the attribution assigned by CRAZ and submitted to AEP.

Table 1: Detail of Exceedances Measured at Canmore Elk Run for the October 2019 to March 2020 and April 2021 to September 2021 Monitoring Periods

Date	Substance	1 Hour	24 Hour	Attribution
July 14, 2021	$PM_{2.5}$	0	1	Wildfire Smoke
July 15, 2021	$PM_{2.5}$	0	1	Wildfire Smoke
July 16, 2021	$PM_{2.5}$	0	1	Wildfire Smoke
July 18, 2021	$PM_{2.5}$	5	1	Wildfire Smoke
July 19, 2021	$PM_{2.5}$	7	1	Wildfire Smoke
July 22, 2021	$PM_{2.5}$	9	1	Wildfire Smoke
July 23, 2021	$PM_{2.5}$	9	1	Wildfire Smoke
July 24, 2021	$PM_{2.5}$	0	1	Wildfire Smoke
July 25, 2021	$PM_{2.5}$	0	1	Wildfire Smoke
July 27, 2021	$PM_{2.5}$	1	1	Wildfire Smoke
July 28, 2021	$PM_{2.5}$	1	1	Wildfire Smoke
July 29, 2021	$PM_{2.5}$	18	1	Wildfire Smoke
July 30, 2021	$PM_{2.5}$	1	1	Wildfire Smoke
July 31, 2021	$PM_{2.5}$	1	1	Wildfire Smoke
July 15, 2021	O_3	2	-	Wildfire Smoke

Results compared against the Project Objectives

Fine Particulate Matter Results

Fine particulate matter ($PM_{2.5}$) consists of tiny particles that are smaller than 2.5 microns. In comparison, a strand of human hair is about 100 microns in width, meaning that a $PM_{2.5}$ particle is approximately 1/40 the diameter of a human hair. Sources of $PM_{2.5}$ include soil, roads, agricultural dust, vehicles, industrial emissions, wildfire smoke, cigarettes, household heating, fireplaces and barbecues. Secondary particulate matter may also be produced in the atmosphere through several complex chemical processes involving other substances. Particulates can come from both solid matter and liquid aerosols.

In high concentrations, suspended particulates may lead to human health problems. Inhaling particulate matter can make breathing more difficult or may aggravate existing lung and heart problems. Smaller particles have the ability to travel deep into the lungs where they may cause permanent lung damage.

Higher levels of $PM_{2.5}$ typically occur during winter temperature inversions when air movement is limited or in the summer months during periods of very warm weather with little or no wind. This is particularly problematic when coupled with smoke from wildfires. $PM_{2.5}$ is measured and reported in micrograms per cubic meter ($\mu g/m^3$) throughout this report.

- Alberta has established a 24-hour AAAQO for $PM_{2.5}$ at 29 $\mu g/m^3$.
- Alberta also has a one-hour average guideline in place for fine particulate at 80 $\mu g/m^3$.

Figure 1 and Figure 2 show the hourly average concentrations of $PM_{2.5}$ at Canmore Elk Run. Figure 3 and Figure 4 show the monthly average concentrations of $PM_{2.5}$ at Canmore Elk Run. The maximum 1-hour average $PM_{2.5}$ concentrations recorded for the October 2019 to March 2020 and April 2021 to September 2021 monitoring periods were 37.6 $\mu g/m^3$ and 459.4 $\mu g/m^3$, respectively. There were 49 exceedances of the 1-hour air criteria and 14 exceedances of the 24-hour air criteria recorded during the April 2021 to September 2021 monitoring period.

Figure 5 and Figure 6 show the monthly average concentrations of $PM_{2.5}$ at Canmore Elk Run, Calgary Inglewood, Calgary Southeast, and Calgary Varsity air monitoring stations for the two monitoring periods. For majority of the time, the $PM_{2.5}$ levels at Elk Run, Canmore do not differ substantially from other locations in Calgary where $PM_{2.5}$ is monitored; however, during the months of July 2021 and August 2021, $PM_{2.5}$ levels were significantly higher than other locations in Calgary.

Figure 1: $PM_{2.5}$ Hourly Averages from October 2019 to March 2020

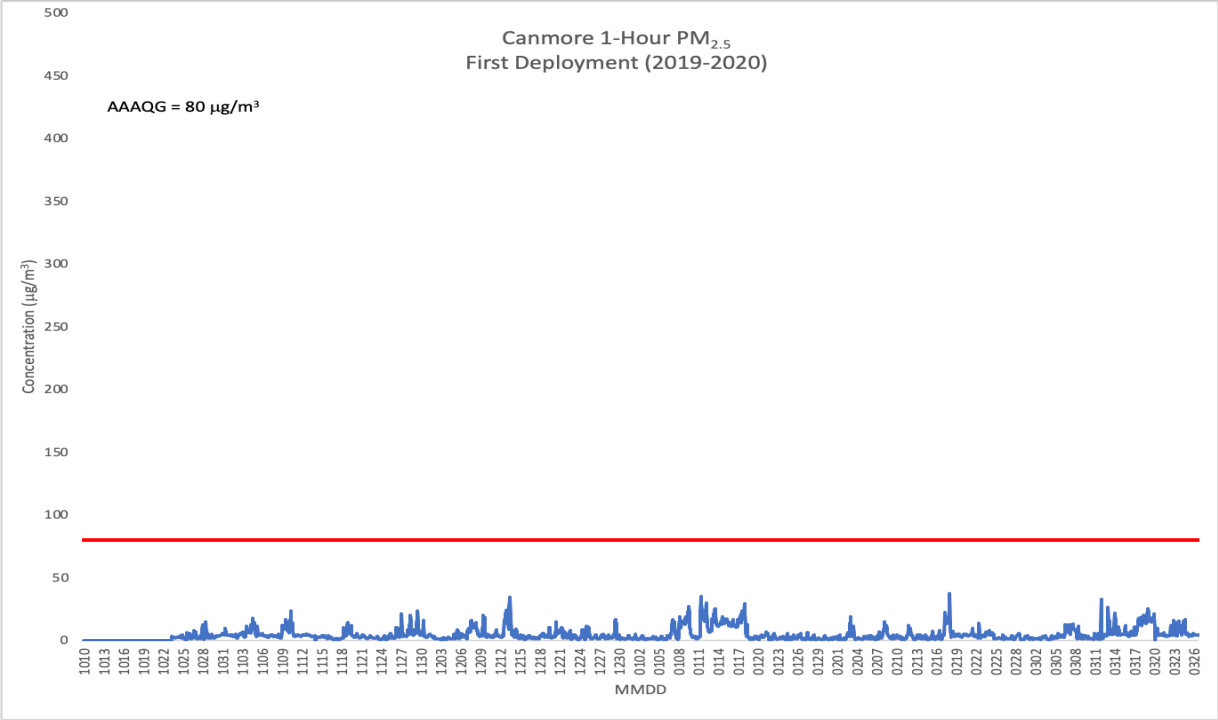


Figure 2: $PM_{2.5}$ Hourly Averages from April 2021 to September 2021

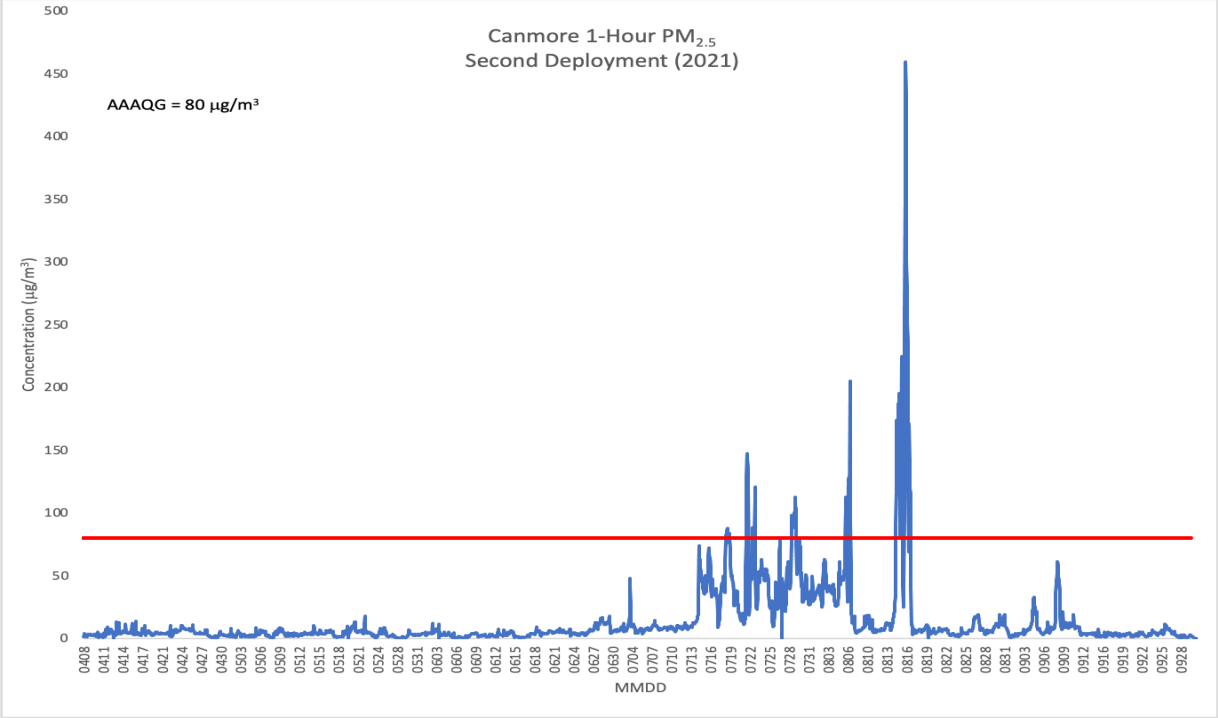


Figure 3: $PM_{2.5}$ Daily (24-hour) Averages from October 2019 to March 2020

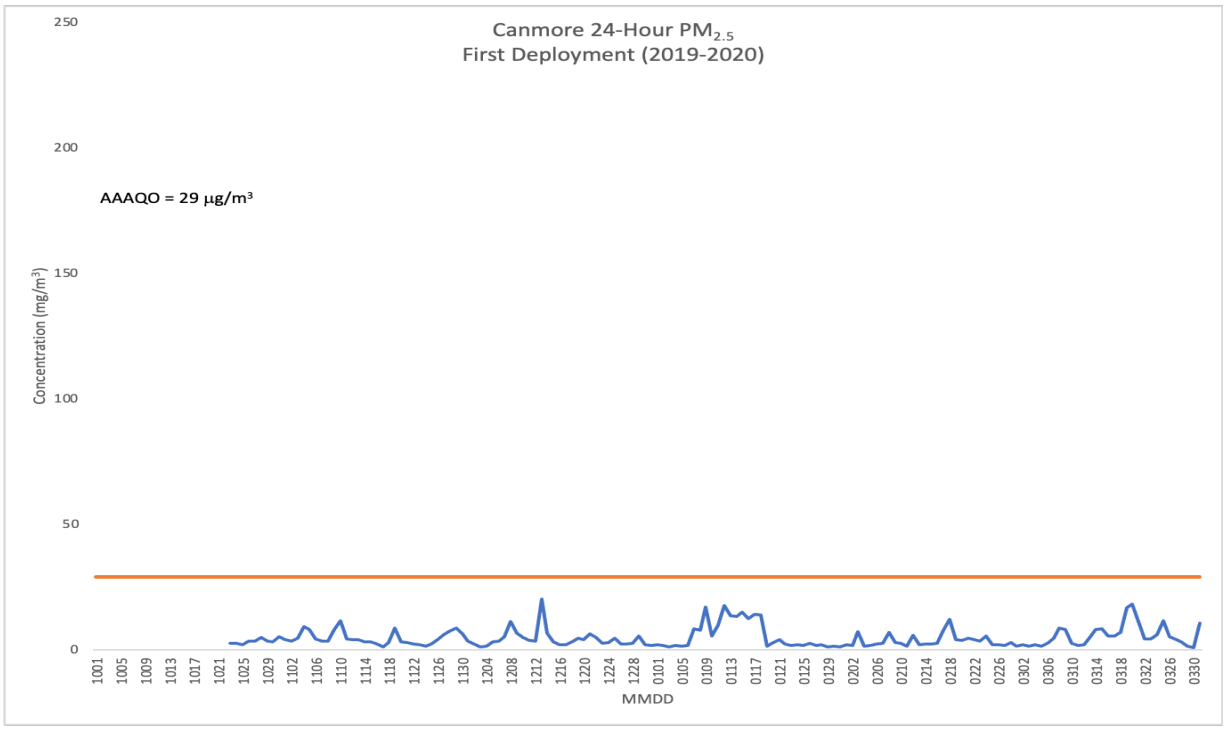


Figure 4: $PM_{2.5}$ Daily (24-hour) Averages from April 2021 to September 2021

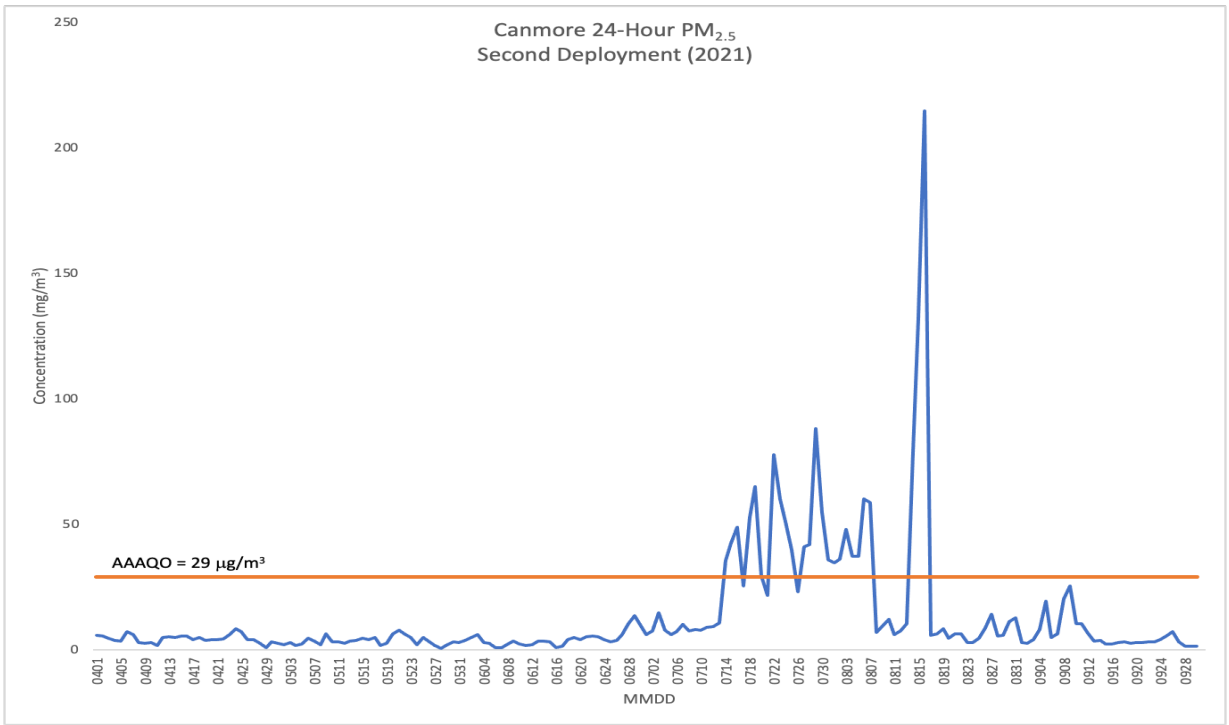


Figure 5: $PM_{2.5}$ Monthly Averages from October 2019 to March 2020

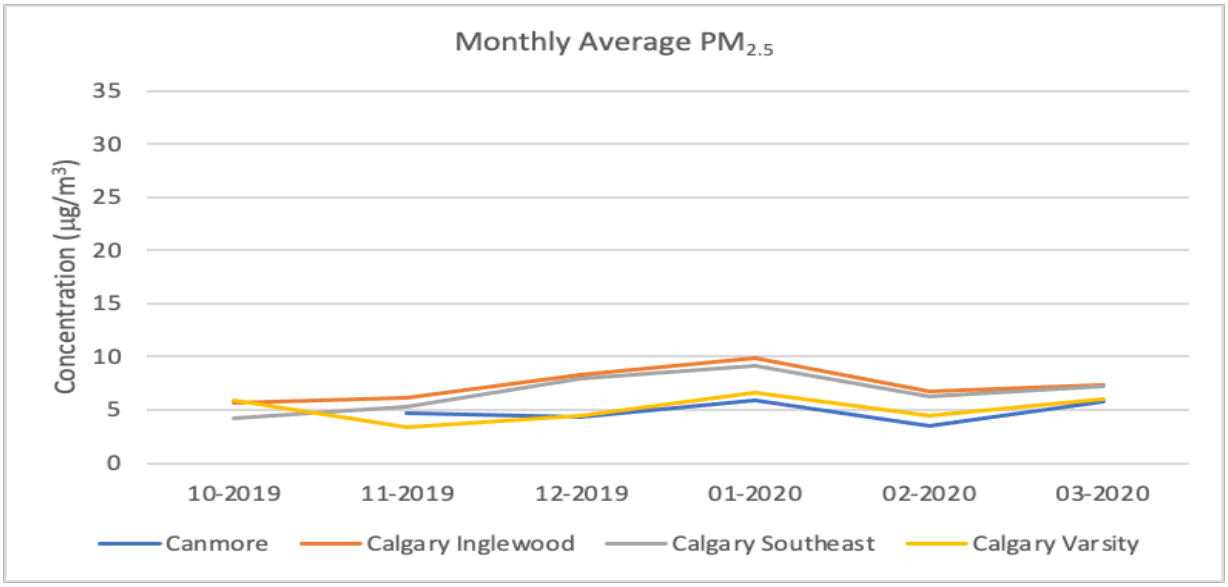
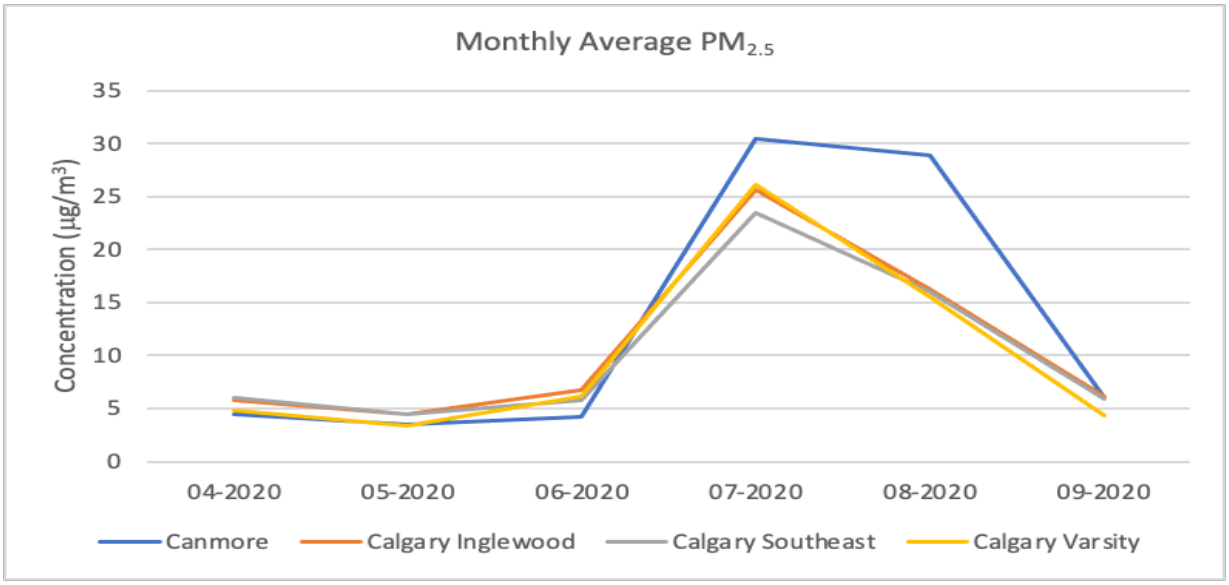


Figure 6: $PM_{2.5}$ Monthly Averages from April 2021 to September 2021



Nitrogen Dioxide Results

Nitrogen Dioxide (NO_2) is a component of nitrogen oxides (NOx), along with nitric oxide (NO), dinitrogen monoxide (N_2O) and nitrogen pentoxide (NO_5). Most NO in the ambient air will react readily with ozone to form nitrogen dioxide. NO_2 is a reddish-brown gas with a pungent odour and is partially responsible for the brown haze often observed near large cities. Sources of NOx in Alberta include transportation, oil and gas industry, natural gas combustion, heating fuel combustion (including home heating) and forest fires.

NO_2 is reported as parts per billion (ppb). Alberta has established the following AAAQOs for NO_2:

- One-hour average concentration at 159 ppb.
- Annual average concentration at 24 ppb.

Figure 7 and Figure 8 show the hourly average concentrations of NO_2 at Canmore Elk Run. The maximum 1-hour average NO_2 concentrations recorded for the October 2019 to March 2020 and April 2021 to September 2021 monitoring periods were 36.4 ppb and 30.5 ppb, respectively, which were below the 1-hour air criteria.

Figure 7: NO_2 Hourly Averages from October 2019 to March 2020

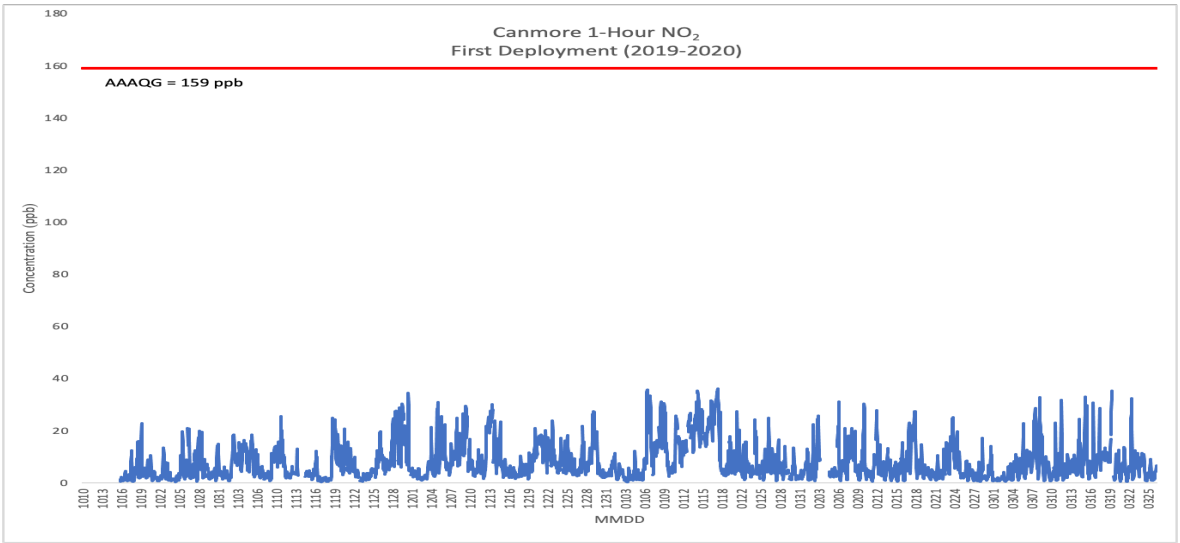


Figure 8: NO_2 Hourly Averages from April 2021 to September 2021

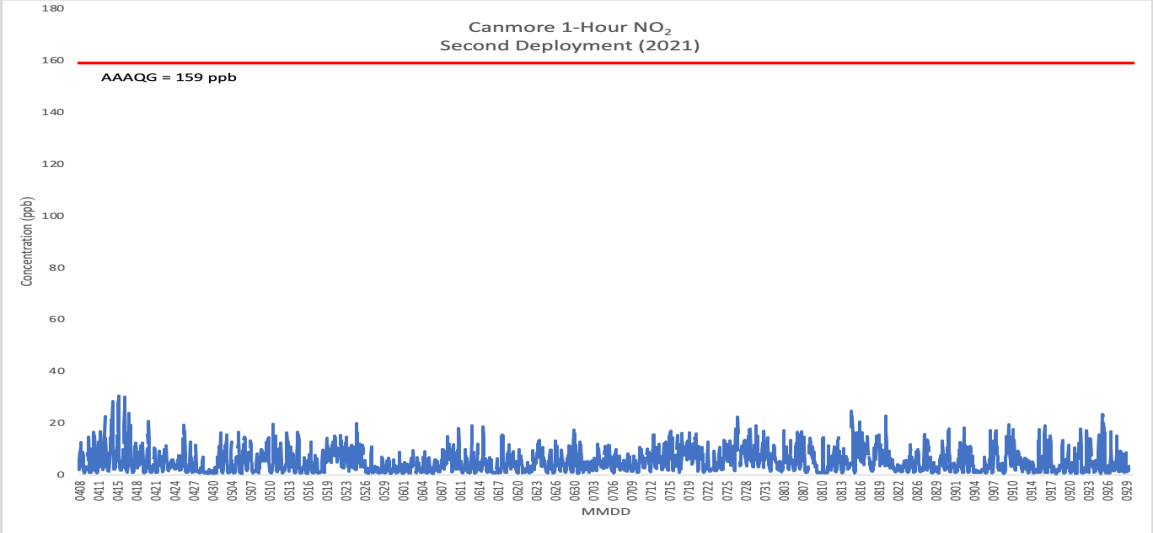


Figure 9 and Figure 10 show the monthly average concentrations of NO_2 at Canmore Elk Run, Calgary Inglewood, Calgary Southeast, and Calgary Varsity air monitoring stations. Elk Run, Canmore had the lowest monthly NO_2 averages for majority of the project term.

Figure 9: NO_2 Monthly Averages from October 2019 to March 2020

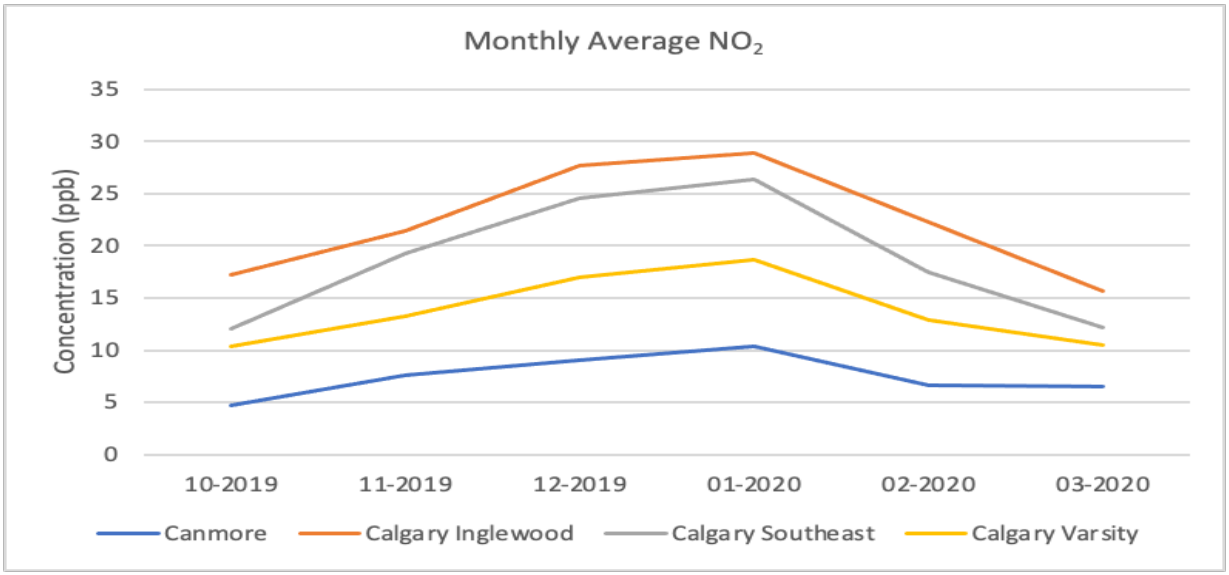
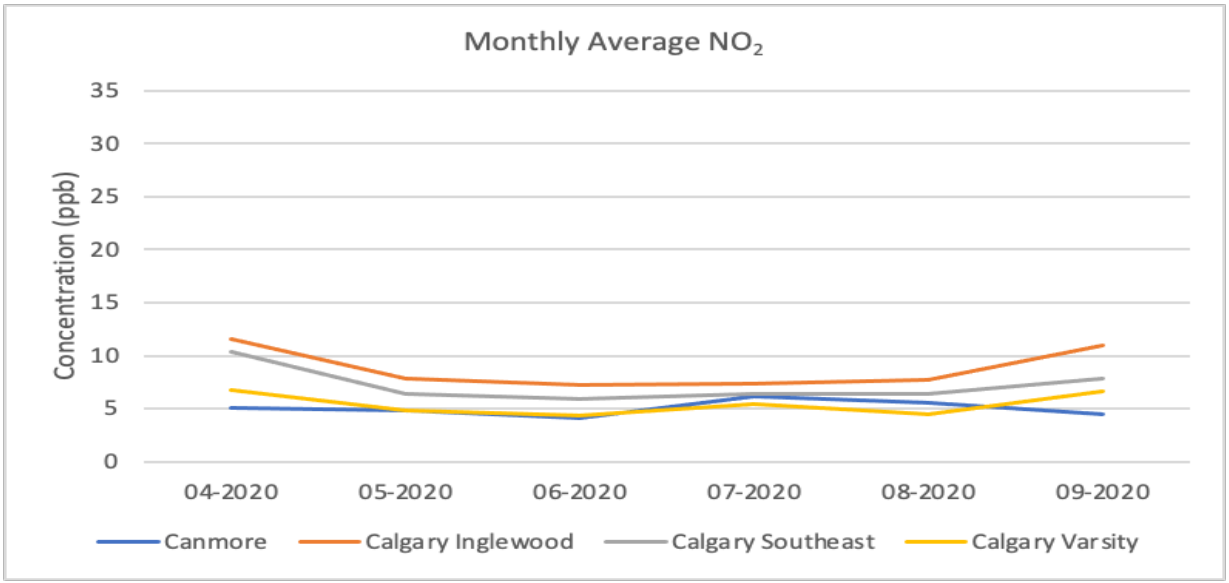


Figure 10: NO_2 Monthly Averages from April 2021 to September 2021



Ozone Results

Unlike other pollutants ozone (O_3) is not emitted directly by anthropogenic (human made) activities. O_3 in the lower atmosphere is produced by a complicated set of chemical reactions involving oxides of nitrogen (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. Significant natural sources of VOCs in remote and rural areas of Alberta are emissions from trees and vegetation. O_3 is also transported to the ground from the ozone rich upper atmosphere by natural weather processes. O_3 and substances that form O_3, such as NOx and VOCs (referred to as ozone precursors), may also be carried from upwind sources such as urban centers and industrial complexes. This phenomenon can be observed in Alberta particularly in summer when warm temperatures (upwards of 30°C or more), coupled with light winds and abundant sunshine, result in an air quality condition referred to as summertime smog. O_3 concentrations are generally lower at urban locations than at rural locations due to the destruction of O_3 by nitric oxide (NO) generated by the combustion of fossil fuels. This is known as ozone scavenging. O_3 levels are generally higher during the spring and summer months because of increased concentrations coming from the upper atmosphere and more sunlight, which leads to more rapid chemical reactions that form O_3.

Clear skies provide ample sunlight, which combined with warm temperatures and a stable air mass, result in summertime smog. These weather conditions are conducive to the formation of secondary pollutants from ozone precursors emitted by multiple sources both small and large in the CRAZ region. This smog takes some time to form and is often experienced dozens of kilometres downwind of the urban core.

At normal outdoor concentrations, O_3 is a colourless, odourless gas. However, O_3 does have a characteristically sharp ‘very fresh air’ odour at extremely high concentrations, such as that experienced immediately after lightning storms. O_3 is reported as parts per billion (ppb). Alberta has established the one hour average concentration AAAQO for ozone at 76 ppb.

Figure 11 and Figure 12 show the hourly average concentrations of O_3 at Canmore Elk Run. The maximum 1-hour average O_3 concentrations recorded for the October 2019 to March 2020 and April 2021 to September 2021 monitoring periods were 54.8 ppb and 89.9 ppb, respectively. There were two exceedances of the 1-hour air criteria recorded during the April 2021 to September 2021 monitoring period. The highest one-hour average O_3 recorded on July 15, 2021 was associated with atmospheric reactions of wildfire smoke products creating O_3.

Figure 11: O_3 Hourly Averages from October 2019 to March 2020

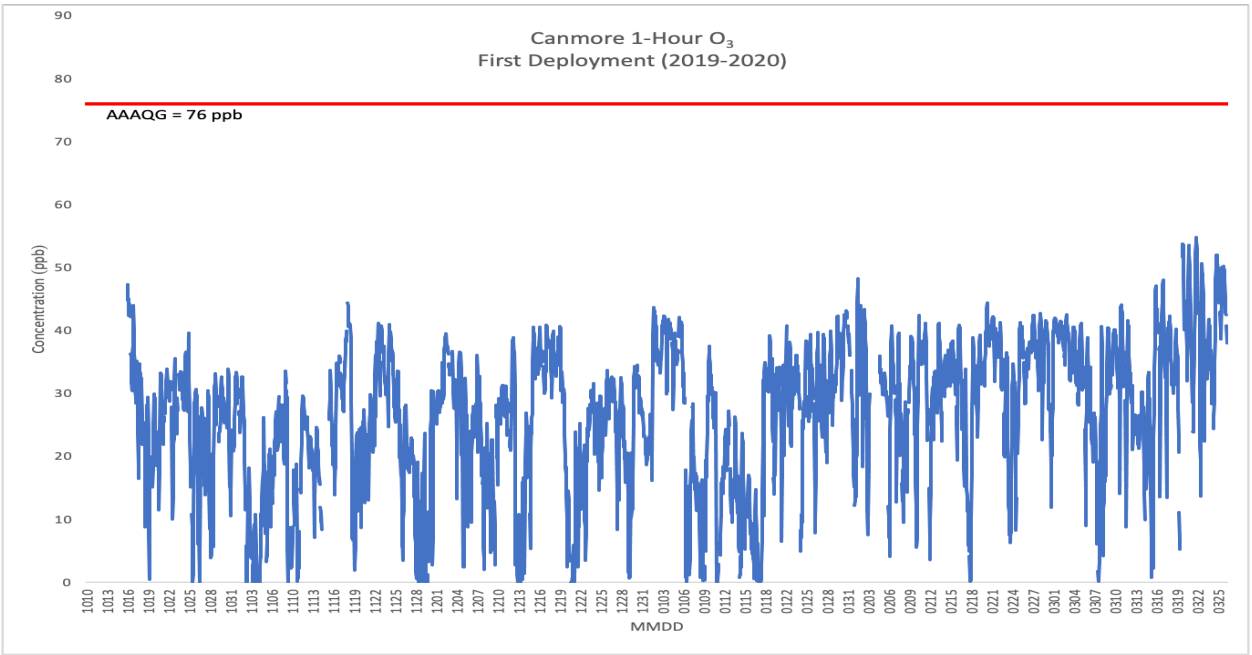


Figure 12: O_3 Hourly Averages from April 2021 to September 2021

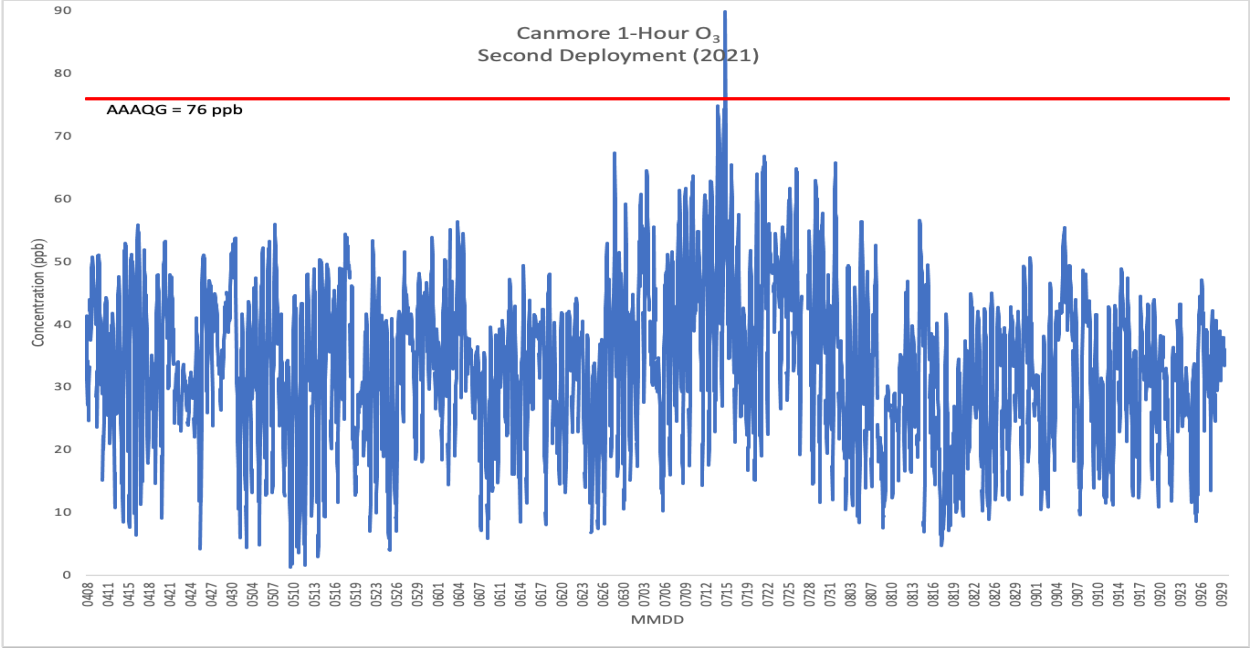


Figure 13 and Figure 14 show the monthly average concentrations of O_3 at Canmore Elk Run, Calgary Inglewood, Calgary Southeast, and Calgary Varsity air monitoring stations. The O_3 levels at Elk Run, Canmore do not differ substantially from other locations in Calgary where O_3 is monitored.

Figure 13: O_3 Monthly Averages from October 2019 to March 2020

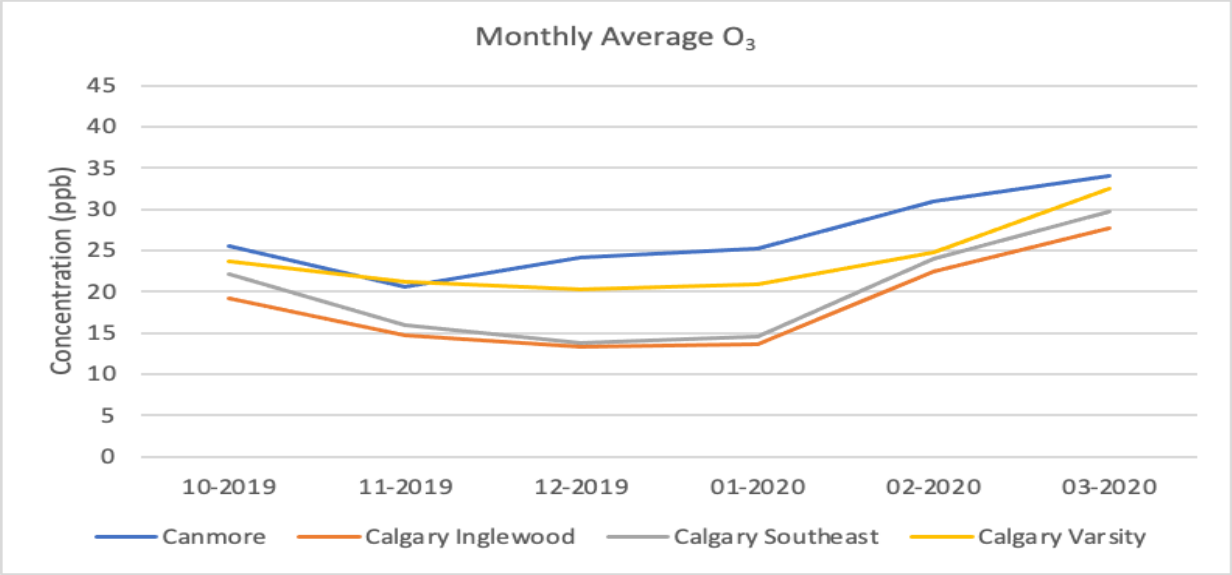
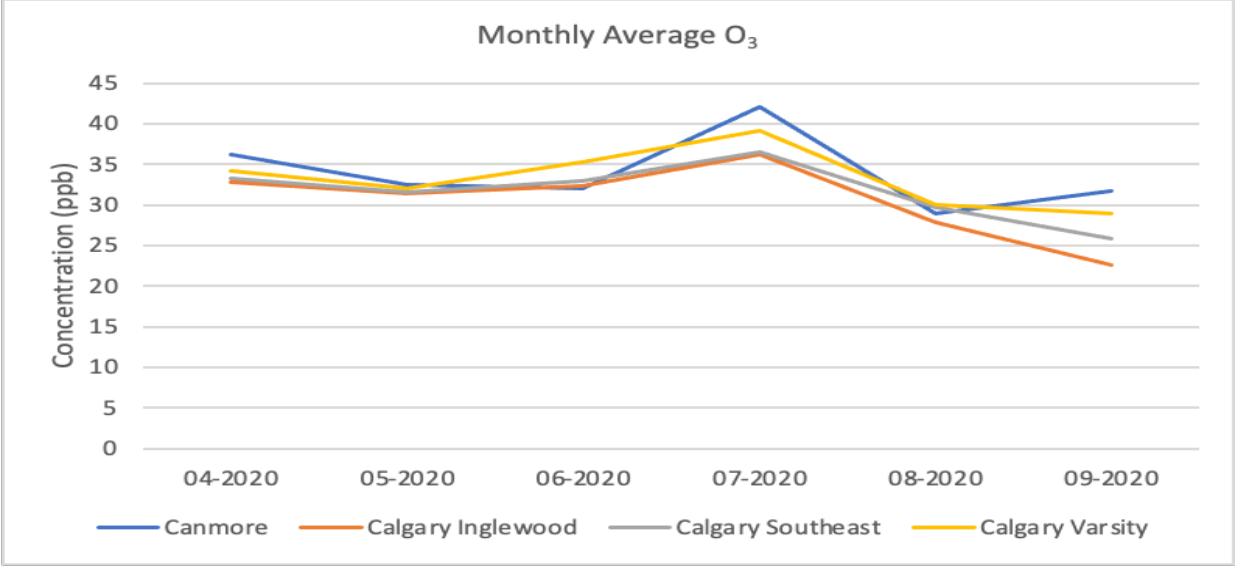


Figure 14: O_3 Monthly Averages from April 2021 to September 2021



Meteorology – Wind Direction and Speed

Figure 15 and Figure 16 show the wind roses for Canmore Elk Run station for the October 2019 to March 2020 and April 2021 to September 2021 monitoring periods. The wind roses show that winds at the Elk Run station were predominantly from the west of northwest and northwest directions.

Figure 15: Wind Rose for Elk Run, Canmore (October 2019 to March 2020)

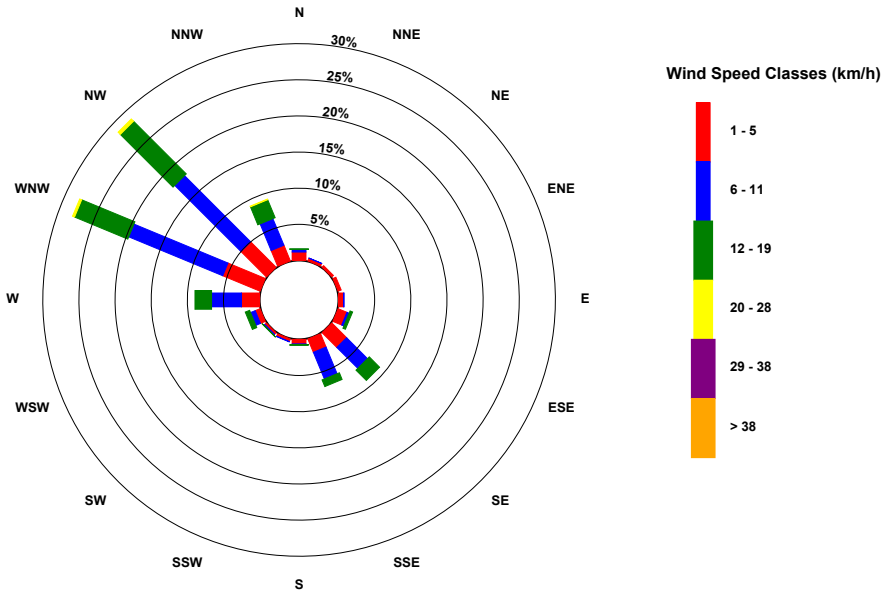
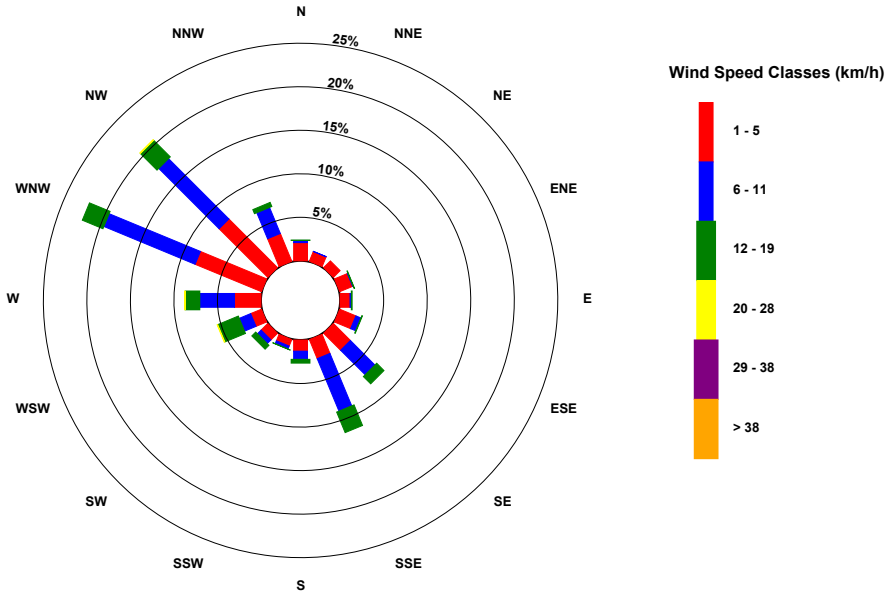


Figure 16: Wind Rose for Elk Run, Canmore (April 2021 to September 2021)



Air Quality Health Index Results

The Air Quality Health Index (AQHI) is a scale designed to help you understand how the air quality around you relates to your health. It is a tool developed by health and environmental professionals to communicate the health risk posed by air pollution.

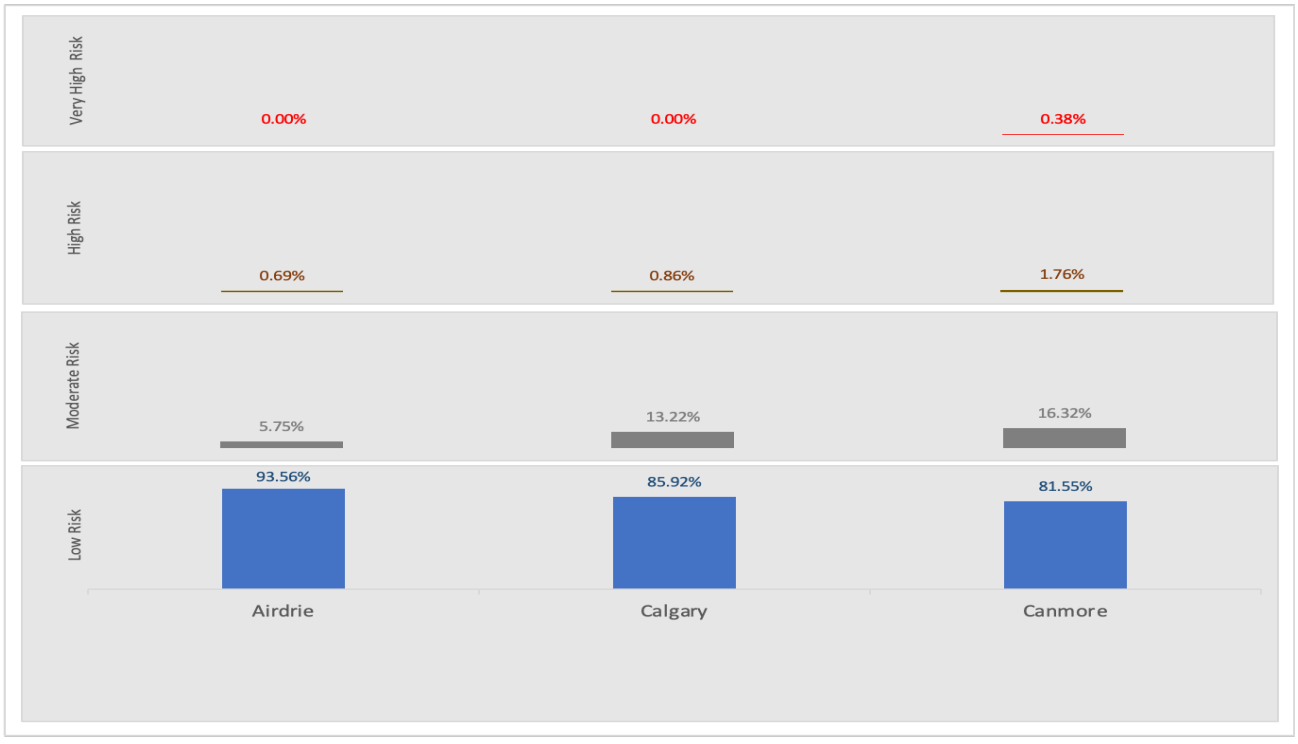
It is designed to help you make decisions to protect your health and the environment by:

- Reducing your exposure to air pollution;
- Adjusting your activity during episodes of increased air pollution and encouraging physical activity on days when the index is lower; and
- Reducing your personal contribution to air pollution.

Each individual reacts differently to air pollution. The AQHI provides specific advice for people who are especially vulnerable to the effects of air pollution, as well as the general public.

Figure 17 shows the AQHI summary for the Airdrie, Calgary, and Canmore communities for the October 2019 to March 2020 and April 2021 to September 2021 monitoring periods. Majority of the time, the air quality in Canmore is at low health risk (81.6%).

Figure 17: AQHI Summary for the CRAZ Region



Conclusions

The CRAZ PAML was deployed twice at the Elk Run, Canmore for the October 2019 to March 2020 and April 2021 to September 2021 monitoring periods.

Measured air concentrations for NO_2 did not exceed the air criteria set by AEP and the Government of Alberta. While the region was under wildfire smoke, O_3 emissions exceeded the 1-hour air criteria twice and $PM_{2.5}$ exceeded the 1-hour and 24-hour air criteria 49 and 14 times, respectively. The O_3 monthly average levels at Elk Run, Canmore were relatively similar to the levels observed at the three locations in Calgary where these pollutants are continuously monitored.

Monthly average NO_2 levels at Elk Run, Canmore exhibited the same seasonal patterns during the first deployment and were lower than the levels observed at the three locations in Calgary. During the second deployment, slightly different seasonal patterns for NO_2 were observed when compared to the emissions at Calgary locations.

For majority of the time, the $PM_{2.5}$ levels at Elk Run, Canmore do not differ substantially from other locations in Calgary where $PM_{2.5}$ is monitored; however, during the months of July 2021 and August 2021, $PM_{2.5}$ levels were significantly higher than other locations in Calgary.

Overall, the air quality in Canmore was at low health risk (81.6%) the majority of the time. Forest fire smoke affected the air quality in Canmore more than Calgary and Airdrie during the second deployment resulting in significant time in moderate health risk (16.3%).

Data collected during the sampling period is available for download at Alberta Air Data Warehouse.