Fine Particulate Matter ($PM_{2.5}$) in Lavington, BC

Preliminary summary of data collected at the Lavington air quality monitoring station from November 9th, 2015 to January 14th, 2016

February 2nd, 2016

Environmental Protection Division
Monitoring, Assessment and Stewardship

1 Introduction

In early November the Ministry of Environment began monitoring fine particulate matter ($PM_{2.5}$) in the community of Lavington. The purpose of this document is to describe the monitoring program, the objectives of the monitoring, and to supply a brief summary of the data collected in the first weeks of monitoring. This document will be updated as more measurements become available.

2 Background

The pollutants of primary concern in the interior of BC are fine particulate matter, or $PM_{2.5}$ and PM_{10}. These small particles can remain suspended in the atmosphere and be transported long distances. PM_{10} and $PM_{2.5}$ are those particles that are less than 10 or 2.5 µm (millionths of a metre) in diameter respectively. Of these two size classes of particulate matter, $PM_{2.5}$ is of most concern for human health.

In the community of Lavington, sources of $PM_{2.5}$ include: wildfires, open-burning, wood-heating, vehicles, and industrial sources. The industrial sources include the dryers at the Pinnacle pellet plant, bag-houses and cyclones at the pellet plant and Tolko sawmill, and other fugitive dust sources.

More detailed information about real-time air quality readings for communities and potential health impacts of $PM_{2.5}$ can be found on the ministry's air quality website.[1] The BC Lung Association's site [2] is also an excellent source of information on air quality and health.

With the commissioning of the new Pinnacle pellet plant and changes at the Tolko sawmill, concerns were raised by Lavington community members regarding current air quality in the area. Of particular concern was air quality at the Lavington Elementary School, due to its proximity to the pellet plant.

Prior to the installation of the Lavington monitor, the closest ministry-operated air quality station was in Vernon, a larger community located to the west of Lavington. $PM_{2.5}$ measurements were also made in 2005-2007 at Lumby, a small community located approximately 15 km to the east of Lavington.

To address public concerns, the ministry installed a $PM_{2.5}$ and weather monitoring station at the Lavington Baptist Church in November, 2015. This report summarizes measurements from full operation of the site beginning on Nov. 9th, 2015 to January 14th, 2016.

3 Monitoring Objectives and Instrumentation

3.1 Objectives

The objective of the monitoring is to collect data which can be used to assess the current air quality in the community, determine the relationship between air quality and weather conditions, investigate the differences in air quality over time, and to supply information that will allow the ministry to determine if additional monitoring is required in the airshed. While the monitoring

[1] Ministry of Environment BCAirQuality site: www.bcairquality.ca

[2] BC Lung Association Air Quality Resources
https://bc.lung.ca/lung-health/patient-educations-support/order-info-resources

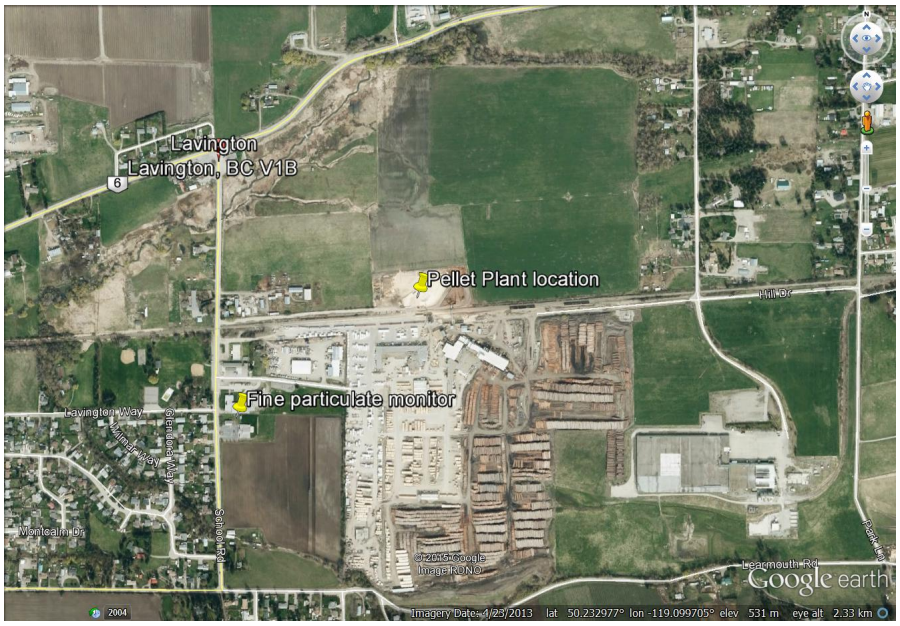

Figure 1: Google earth image showing location of station and site of Pinnacle pellet plant. North is toward the top of the image.

cannot be used to determine the specific impacts of the Pinnacle Pellet plant and Tolko sawmill on air quality, it will supply information that will determine if additional monitoring is required, and may be used to design a more complex monitoring program, if required.

3.2 Site selection and instrumentation

Although four potential air monitoring sites were identified by ministry staff, ultimately, the Lavington Baptist Church was selected due to technical and logistical considerations. The station was installed on November 6th 2015; after an initial calibration period, measurements began on November 9th. Figures 1, 2, and 3 show the location of the station and a photo of the station.

Consistent with the equipment used in Kamloops, Vanderhoof and at other ministry air monitoring stations, a BAM 1020 instrument for monitoring $PM_{2.5}$ was installed in Lavington. The BAM is housed in an enclosure that includes a heater and an air conditioner to control the temperature of the instrument, and telemetry equipment. Air temperature, wind direction and speed are also measured at the site.

The data collected by the instruments are retrieved by telemetry. The data are available to ministry technicians and meteorologists in real time. The data from the Lavington station was made available on January 27th, 2016 to the public at the ministry air quality website .[3]

[3] Ministry of Environment Air Quality Data: http://www.bcairquality.ca/readings/index.html

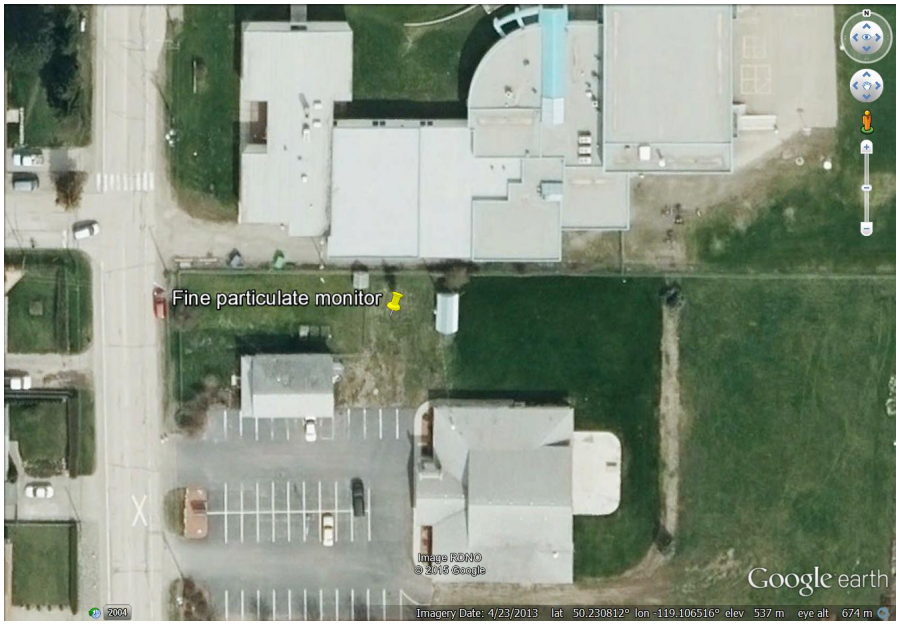

Figure 2: Google earth image showing location of the monitor in the Lavington Baptist Church yard. North is toward the top of the image. The coordinates of the monitor are 50.230818° N, 119.106654° W. School Road is on the left of the image and the building to the North is the Lavington Elementary School.

Figure 3: Fine particulate and weather instruments as installed at the church. The view is to the NE, toward the Pinnacle pellet plant. The shed behind the monitor is on church property, the building north of the fence is the Lavington Elementary School.

	Lavington	Vernon
mean (μgm^{-3})	11.4	10.1
hourly maximum (μgm^{-3})	43.5	50.9
daily maximum (μgm^{-3})	23.9	22.2
days above 25 μgm^{-3}	0	0
hours running mean above 25 μgm^{-3}	0	5

Table 1: Statistics for Lavington and Vernon $PM_{2.5}$ monitors for the period 9th November 2015 to 14th January 2016. Daily statistics are based on midnight to midnight values. Daily statistics are calculated only for days with greater than 75% data capture. The running mean is the mean value for previous 24 hours calculated for each hour of the day. This statistic is included as it is used in the issuing of air quality advisories.

3.3 Quality Assurance and Quality Control

Particulate monitors of this type are routinely shut down for short periods of maintenance; in addition, calibrations taking up to 72 hours are conducted each year. The Lavington instrument was calibrated before the measurements began on the 9 th November. All maintenance on the Lavington monitoring site will be conducted by ministry staff. The ministry also uses a team of technicians who independently audit all instruments used in the Provincial Air Monitoring Network.

3.4 Data capture

In order for data to be used to calculate air quality statistics, a data capture rate of 75% is required for each calendar day, each quarter, and each year. Data capture statistics reported in this summary are based on complete days from November 10th, 2015 to January 13th, 2016. There were no days in this period where data capture was less than 75%.

The instruments were installed on November 6th 2015, after an initial calibration period, measurements began on November 9th. This summary includes data collected up until the morning of January 14th 2016. During this period 1555 out of 1560 possible hours of particulate data were collected. Only 5 hours were missed. This is over 99.7% capture. The missing hours were all due to routine maintenance shut-downs.

4 Summary of particulate measurements

Summary statistics for $PM_{2.5}$ are shown in Table 1. Data from the Vernon Science Centre air quality station was analysed for the same period and is shown in the table for comparison. The instrument at the Vernon air-station is a Sharp model 5030 monitor and the values from the Lavington and Vernon instruments are directly comparable.

The mean values measured in Lavington are similar to those measured in Vernon; 11.4 and 10.1 μgm^{-3}, respectively. There is not yet sufficient data to compare the mean with the annual Provincial Ambient Air Quality Objective (AAQO)of 8 μgm^{-3}. It is usual for levels to be higher in

the November to March period than the rest of the year. Note that the annual average for Vernon in 2015 was 9.3[4] μgm^{-3}, lower than the mean for the November to January period reported here.

The hourly maximums during the period of measurement were 43.5 and 50.9 μgm^{-3} at the Lavington and Vernon stations, respectively. The hourly maximum at Lavington occurred on the evening of Friday November 20th during a period of light winds (3 ms^{-1}) from the ENE. The hourly maximum at Vernon occurred on the evening of the 21st November during a period of calm winds. There is great variability in the maximum hourly values and there is insufficient data from Lavington to reach any conclusions of how the hourly maxima measured compare with other stations.

The maximum daily mean value during this time period, of 23.9 μgm^{-3} occurred in Lavington on January 6th 2016. Similarly, the maximum daily mean value during this time period of 22.2 μgm^{-3} occurred in Vernon on January 9th. During the measurement period, there were no days that exceeded the value of the Provincial 24 hour average AAQO[5] of 25μgm^{-3}at either Lavington or Vernon. In addition there were no periods that met the criteria for an air quality advisory.[6]

5 Additional analysis

The $PM_{2.5}$statistics presented above summarize all of the hours of data collected. The mean, the hourly maximum, the daily maximum etc., supply information about the entire population of data. As the monitoring station at the Lavington Baptist Church reports hourly averages of $PM_{2.5}$, wind-speed, wind-direction and air temperature, the data can be analysed in other ways to look for patterns and relationships in addition to the statistics presented above.

Two important relationships are those between $PM_{2.5}$ and wind-direction, and the variation of $PM_{2.5}$ with time (such as time-of-day, season, month, and day-of-the-week). These can supply information that can be used to investigate the sources causing any elevated levels of $PM_{2.5}$, information that can be used in airshed planning, and information used in decisions regarding the monitoring methods used in an airshed.

Monitoring has now been underway for just over two months; it is still too early to reach any conclusions regarding these relationships. However, some preliminary work on the relationship between $PM_{2.5}$ and wind-direction, and the temporal variation in $PM_{2.5}$ is shown below. As more data are collected over the coming months and seasons, these analyses will be repeated, and more complex statistical tools will be employed to investigate $PM_{2.5}$in the Lavington airshed.

[4]This is based on preliminary 2015 data. The effect of forest fires has not been removed. This is the value that will be reported in the BC Lung State of the Air Report.

[5]The Provincial 24 hour AAQO is based on the 98th percentile of the daily averages for an entire year, in practice this approximately corresponds to the 6th highest daily average in a year. There are not yet enough days of data available to calculate this statistic. However, to this point there have been no days when the value (25 μgm^{-3}) was exceeded.

[6]The criteria for issuing an air quality advisory due to $PM_{2.5}$ is that the 24 hour running mean $PM_{2.5}$ value must exceed 25 μgm^{-3} and be expected to stay above that value for an additional period of a half to many days. The running mean is the average value of the previous 24 hours and is calculated for each hour of the day. It is not the same as the daily average which is calculated form from midnight to midnight and there is a single value for each day.

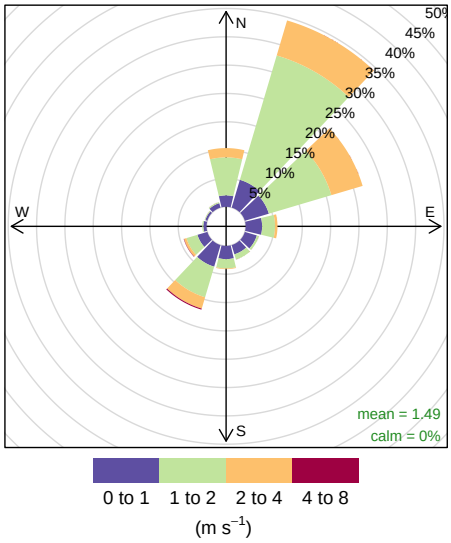

Figure 4: Wind-rose for Lavington for the period November 9th, 2015 to January 14th, 2016.

5.1 Relationship between $PM_{2.5}$ and wind-direction

In most valley communities, winds at the valley floor flow along the valley in response to the movement of large weather systems and the pressure gradients associated with them. Winds in Lavington are generally aligned with the valley, however, when pressure gradients due to weather systems are weak, light winds driven by temperature differences along the valley and up and down the valley walls, can be produced. Occasionally, events such as winter storms produce strong winds that blow across the valley rather than along it.

The wind-directions and speeds that have been observed at Lavington since November 9th, 2015 are summarised in Figure 4. This figure is a wind-rose[7], a graphical tool for summarising large quantities of wind-speed and wind-direction data. Each pie-shaped sector shows the percentage of time that the wind blows from each 30° sector. For instance, figure 4 shows that in Lavington, during the period of measurement, wind has blown from the sector spanning 15 to 45° just under 35% of the time. The different colours within each sector show the percentage of time that winds of different speeds blew from that direction. For instance, figure 4 shows that the majority of winds from 15 to 45° are light winds from 1 to 2 ms^{-1}. It also shows that the strongest winds tend to come from the SW quadrant. The wind-rose also shows the mean windspeed and the percentage of calm winds. Calms are defined as hours when the mean windspeed is zero.

The relationship between wind-direction and air quality is of interest because it can supply information about the direction, relative to the wind-sensor, of sources that affect the air quality. These techniques cannot determine the specific source, but only the direction in which the sources lie. In addition, the fact that in valleys, winds tend to blow along rather than across the valley, means that the proportion of winds from each direction must be taken into account. In order to perform these types of statistical analysis it is important that the wind data used

[7] A more detailed description of wind-roses may be found at the US National Water and Climate Center web-site at http://www.wcc.nrcs.usda.gov/climate/windrose.html

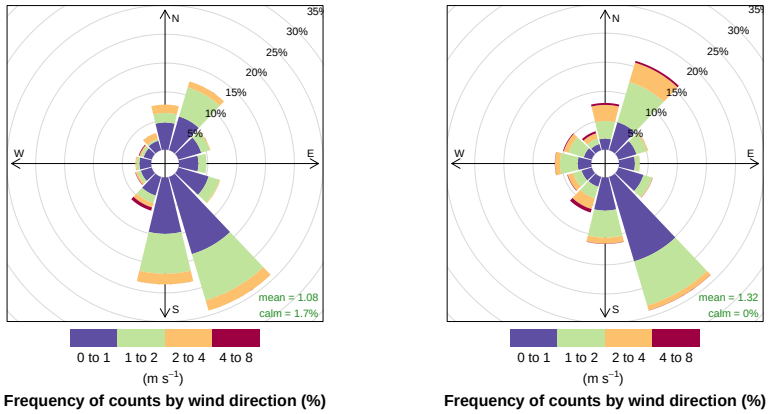

Figure 5: Wind-roses for Vernon. The wind-rose on the left includes the values for the time since the Lavington station started operating in November 2015 until present. The rose on the right shows the values for all the hours in 2014.

are representative of the winds over a full annual cycle in order to reflect the changes in wind patterns and air quality sources that occur over the seasons.

The orientation of the wind-rose in figure 4 is similar to that expected, but the uneven distribution of winds is not. To check this, the wind-roses for the Vernon air station were produced as a comparison. These are shown in figure 5. The wind-rose on the left includes the values for the time since the Lavington station started operating in November 2015 until present. The rose on the right shows the values for all the hours in 2014. The wind-rose for all of 2014 has a lower proportion of winds from the South to South-East than the wind-rose for the period that the Lavington station has been operating.

Given that the wind-rose for Vernon during the period that measurements are available in Lavington is not representative of the winds over a full year, it is probable that the wind-rose for Lavington may also not be representative of the winds that would be expected over a full year and all seasons. Further analysis cannot be completed until more wind data has been collected.

5.2 Temporal patterns in $PM_{2.5}$

The variation of air quality over time can supply information about which sources are affecting air quality. The most important patterns are those that occur over the seasons, the days of the week, and the time of day. For instance, wood-heating often results in a daily pattern of $PM_{2.5}$ concentration with peaks in the evening and overnight. In communities where traffic is an important source of $PM_{2.5}$, there is often a decrease in concentrations on the weekend.

With only two months of data available, it is not possible to look at the relationship between months of the year, or seasons, and $PM_{2.5}$. The relationships between time of the day and day of the week and $PM_{2.5}$ for the period of measurement are shown below in figure 6 and 7. These are box-plots or box and whisker plots.[8] Like wind-roses, these are a tool for graphically presenting large amounts of data.

[8] A more detailed description of box-plots may be found on Wikipedia at https://en.wikipedia.org/wiki/Box_plot

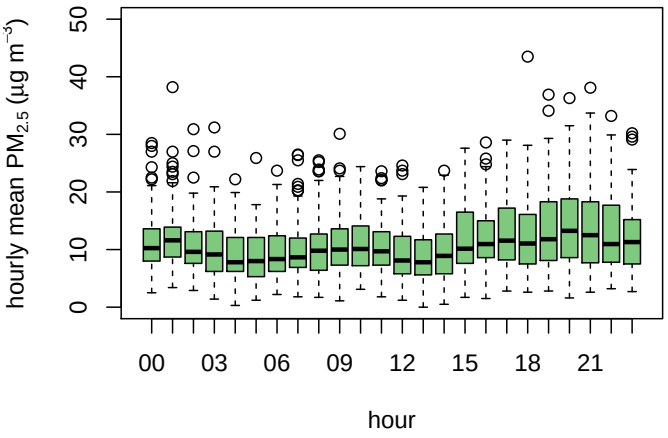

Figure 6: Distribution of hourly $PM_{2.5}$ values through the day at Lavington.

In a box-plot all the hourly average $PM_{2.5}$ data are separated into groups, in figures 6 and 7 the hours of the day or days of the week. All the measurements for a particular hour of the day or day of the week are then plotted as a box with whiskers. The line in the centre of each box is the median (half the values are larger and half smaller than this value). This is not the same as the average or mean value of the group; in air quality statistics the median is usually slightly larger than the mean. The top of the box is the 75th percentile (three-quarters of the values are lower than this value and one quarter are larger). Similarly the bottom of the box is the 25th percentile (one-quarter of the points are lower and three-quarter larger). The top of the upper the whiskers are placed at the highest value that is less than the value of the top of the box plus 1.5 times the difference in values of the top and bottom of the box. Similarly the end of the lower whisker is the largest value greater that the value of the bottom of the box minus 1.5 times the difference between the top and bottom of the box. All the data values that are larger or smaller than the ends of the whiskers are shown as individual points. In simple terms, half of the values fall within the box, all the values beyond the ends of whiskers can be considered the extreme values or outliers. In air quality statistics is often these outlying values that are responsible for degraded air quality, and supply information that may be useful to identify possible sources and develop airshed plans.

Figure 6 shows a summary of all 1550 hours of $PM_{2.5}$ measurements. The distribution of the outliers and medians show that the highest values occur in the evening and overnight. Figure 7 shows a similar summary for the days of the week. The figure shows that the highest values occur on Friday and Saturday. Closer examination of the data shows that most of the higher values that occur on Friday and Saturday occurred in the evening and overnight on the nights of 13th-14th and 20th-21st November. The higher values on other days of the week occurred during the extended period of poor dispersion and higher $PM_{2.5}$ levels that occurred in early January.

As with the analysis of the relationship between wind-direction and $PM_{2.5}$ levels, there is not

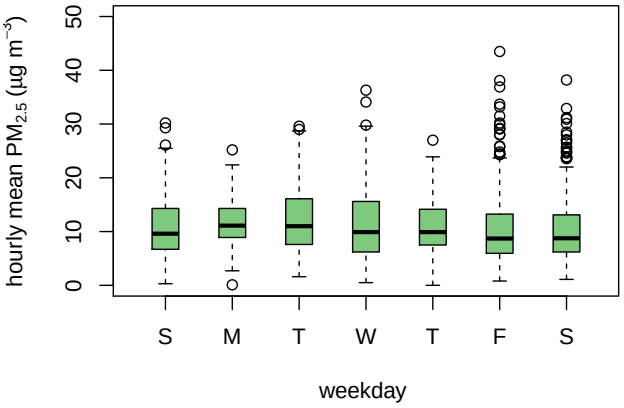

Figure 7: Distribution of hourly $PM_{2.5}$ values through the week at Lavington. The week begins with Sunday.

yet enough information to reach any conclusions, but the wind-roses and box-plots above show examples of the kinds of analyses that will be possible when more data are collected.

6 Conclusion

A station to monitor $PM_{2.5}$ and weather was installed at the Lavington Baptist Church on November 6th, 2015. Measurements began on 9th November. This report summarises the data collected from November 9th to January 14th, 2016. This report will be updated at intervals as more data are collected.

In general, the patterns of changes in $PM_{2.5}$ levels in Lavington and Vernon were similar and driven by weather patterns. During the period of measurement, $PM_{2.5}$ values never deteriorated to levels where the criteria for issuing an air quality advisory due to elevated $PM_{2.5}$ were met and no air quality advisories were issued. The mean value of $PM_{2.5}$during the period was 11.4 μgm^{-3} at Lavington, and 10.1 μgm^{-3} in Vernon. The maximum daily averages in Lavington and Vernon during the period were 23.9 and 22.2 μgm^{-3}, respectively. Both communities experienced a period of higher $PM_{2.5}$ levels and poor dispersion during early January. In Lavington the highest $PM_{2.5}$ levels occurred overnight on the 13th-14th and 20th-21st of November (Friday-Saturday night).

Up until January 14th, there are insufficient data available to reach conclusions about the relationship of $PM_{2.5}$ levels to wind-direction, or about variations in $PM_{2.5}$ levels with time (hour of day, day of week, month and season).