Resort Municipality of Whistler

2011 - 2014 Summary of Ambient Air Quality Monitoring

Cheakamus Crossing Ambient Air Quality Monitoring Station

Submitted by:

Levelton Consultants Ltd.

150 - 12791 Clarke Place

Richmond, BC V6V 2H9

T: 604.278.1411

F: 604.278.1042

info@levelton.com

Date: April 11, 2015

Levelton File # EE10-1383-00

LEVELTON

April 11, 2015

Andrew Tucker
Resort Municipality of Whistler
4325 Blackcomb Way
Whistler, BC
V0N 1B4

Dear Mr. Tucker:

Regarding: Summary of the Ambient Air Quality Monitoring Program, Cheakamus Crossing Neighborhood

Levelton is pleased to provide a Summary of the Ambient Air Monitoring Program for the Resort Municipality of Whistler for 2011 to 2014. The report compares the monitored levels of $PM_{2.5}$ at the Cheakamus Crossing Air Monitoring Station with BC Ambient Air Quality Objectives, data collected at the BC Ministry of Environment's Meadow Park Station and with activity data from the nearby asphalt plant. Levelton has also provides its recommendations on continuing monitoring in the Neighbourhood.

Sincerely,
Levelton Consultants Ltd.

Braden Bartnik, B.Sc., BC-CESCL

Table of Contents

List of Figures

List of Tables

1. Introduction

Levelton Consultants Ltd. (Levelton) has operated and maintained the Cheakamus Crossing Ambient Air Monitoring Station on behalf of the Resort Municipality of Whistler (RMOW) since September, 2010. The station was installed to assist in addressing local citizen's concerns of potential ambient air quality issues associated with an asphalt plant located near the neighbourhood. The station continuously monitors ambient particulate matter ($PM_{2.5}$) and wind direction/speed. Levelton provides public access to the monitoring data via a dedicated website. Annual reports on the data collected from 2010 – 2014 have been provided to RMOW following each year of monitoring.

This report summarizes and compares the data from the monitoring station for 2011 through the end of 2014. The objectives of the report are to:

- Provide comparison of the $PM_{2.5}$ concentrations monitored at Cheakamus Crossing with the British Columbia Ministry of Environment's (BC MOE) monitoring site at Meadow Park;
- Analyze the monitored $PM_{2.5}$ concentrations during the asphalt plant operations;
- Provide conclusions on the current monitoring program;
- Provide recommendations for future monitoring.

2. Ambient Air Monitoring Station Details

The Cheakamus Crossing Ambient Air Monitoring Station is located on the High Performance Centre (HPC) building (Figure 1). The High Performance Centre (HPC) building (Figure 2-1) was selected for the monitoring site because:

- the HPC building is one of the closest structures to the property currently occupied by the asphalt plant;
- the HPC building is located in the Cheakamus Crossing neighbourhood (Figure 2) and provides a suitable location to record representative measurements of particulate matter concentrations in the neighbourhood;
- the location minimizes interference from surrounding buildings or vegetation;
- the monitoring station's indoor sensors/controllers as well as the rooftop equipment are safely accessible for routine maintenance and cleaning; and,
- the HPC building is a secure location to house the monitoring station, as it contains sensitive/expensive scientific equipment.

Figure 2-1 High Performance Centre (HPC) in Cheakamus Crossing Neighbourhood

Figure 2-2 Location of the Monitoring Station in the Cheakamus Crossing Neighbourhood (shown as a red star)

The monitoring equipment at the station includes:

- TEOM Series 1400a Ambient Particulate Monitor (TEOM) (Figure 3)
- R.M. Young 05305 Air Quality Wind Anemometer

The TEOM Series 1400a Ambient Particulate Monitor incorporates the patented Tapered Element Oscillating Microbalance (TEOM) technology to measure particulate matter mass concentrations continuously. The TEOM has been recognized by the US EPA as an acceptable continuous monitor of

particulate matter concentrations (Rupprecht, 2002). This unit is outfitted with a Sharp Cut Cyclone (SCC) $PM_{2.5}$ inlet. Ambient air is pumped through the SCC inlet, which only allows airborne particulate matter with an aerodynamic diameter of 2.5 micrometers (2.5 µm = 0.0000025 meters) or less into the TEOM's sensor unit. The TEOM then measures the mass of particulate matter per volume of air sampled and displays it in micrograms per cubic meter (µg/m^3).

$PM_{2.5}$, also known as fine particulate, is so small it can only be detected with an electron microscope. Sources of fine particles include all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes.

The R.M. Young anemometer was installed to determine hourly wind direction and speed, which is useful in interpreting the particulate matter concentrations recorded at the monitoring station. The anemometer is mounted on a 10 foot tripod installed on the roof of the HPC building in the Cheakamus Crossing Neighbourhood adjacent to the TEOM inlet (Figure 2-4).

The datalogger records 1-hour averages for both the TEOM and anemometer data to an onsite computer system. Along with storing the data on the onsite computer system, data is also transferred to Levelton's Air Quality website (www.airquality.ca/clients/Whistler) where it is displayed in 'real-time'. A link to this site is provided on the RMOW website (www.whistler.ca)

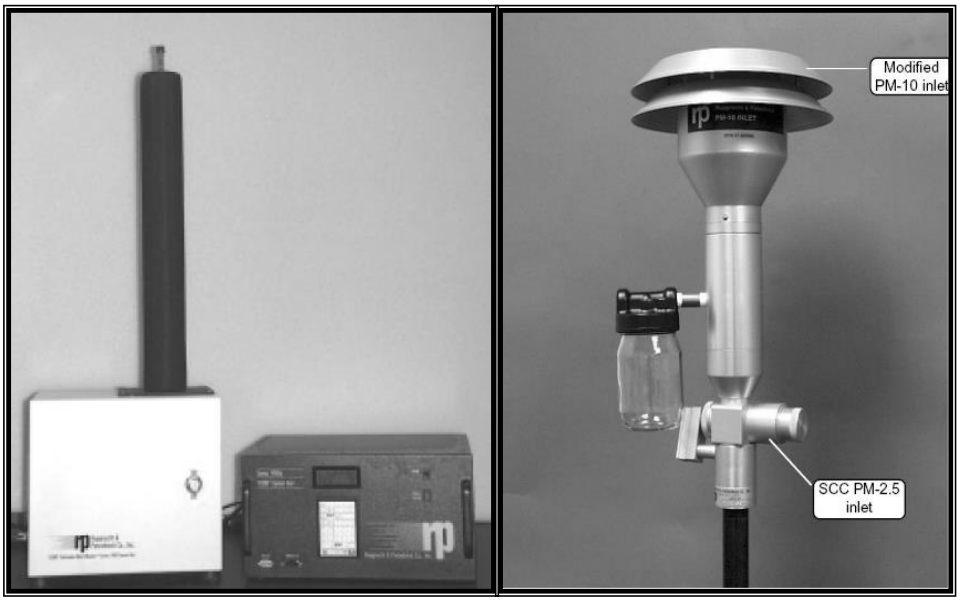

Figure 2-3 TEOM Sensor Unit (left), Control Unit (middle) and Inlet System (right)

Figure 2-4 Tripod Mounted Anemometer and TEOM Inlet located on the Roof of the HPC building

3. Applicable Regulatory Guidelines

In Canada, the Federal and Provincial Governments have implemented ambient air quality objectives (AAQO) that must be met to ensure long-term protection of public health and the environment. The BC AAQO are non-statutory limits (ie. not legally binding). The AAQOs are used to:

- Gauge current and historical air quality,
- Guide decisions on environmental impact assessments and authorizations,
- Guide airshed planning efforts,
- Inform regulatory development, and
- Develop and apply episode management strategies such as air quality advisories.

The British Columbia AAQO for $PM_{2.5}$ were considered in this assessment as the primary regulatory guideline (Table 2-4).

Table 3-1 BC Ambient Air Quality Objectives (AAQOs) Considered in Assessment

Air Contaminant	Averaging Time	Ambient Air Quality Objectives ($\mu g/m^3$)
Fine Particulate Matter ($PM_{2.5}$)	24-hour	25*
	Annual	8

* The 24-hour $PM_{2.5}$ BC AAQO is compared to the annual 98th Percentile 24-hour block average concentration

4. Monitoring Program Data Summary

Monitoring of particulate matter less than 2.5 microns ($PM_{2.5}$) began on September 3rd, 2010 at the Cheakamus Crossing Ambient Air Monitoring Station. Annual reports have been presented following each year of data collection from 2010 - 2014. This section summarizes the PM data collected for over the duration of the monitoring program.

4.1 Cheakamus Crossing Ambient Air Monitoring Station $PM_{2.5}$ Concentrations

The continuous monitoring data from the TEOM unit was used to calculate 1-hour average $PM_{2.5}$ concentrations. From these hourly averages a rolling 24-hour average is calculated using the last 24 hourly averages at each hour of the data set. The rolling 24-hour average displayed on the Levelton and RMOW website provides a 'real-time' representation of current conditions but is not to compared to the provincial objectives. When comparing the results to the BC AAQO, a daily 24-hour average (midnight to midnight), also referred to as block average is used.

Using the full annual data set, the 98th percentile value for a 24-hour block is determined and compared to the BC AAQO of 25 µg/m³. The same data set is averaged to determine the annual average $PM_{2.5}$ concentration. This is compared to the Annual BC AAQO for $PM_{2.5}$ (8 µg/m³). Since the implementation of the monitoring program, the 24-hour and annual metrics have remained below the BC AAQOs.

Table 4-1 Annual $PM_{2.5}$ TEOM Data (2011 – 2014)

Year	$PM_{2.5}$ (µg/m³)				
	Maximum (24-hour)	98th Percentile (24-hour)	BC AAQO (24-hour)*	Annual Average	BC AAQO (Annual)
2011	14.5	10.0	25	4.9	8.0
2012	22.5	12.9		5.3	
2013	14.0	10.3		5.0	
2014	22.1	13.3		5.3	

* The 24-hour $PM_{2.5}$ BC AAQO is compared to the annual 98th Percentile 24-hour block average concentration

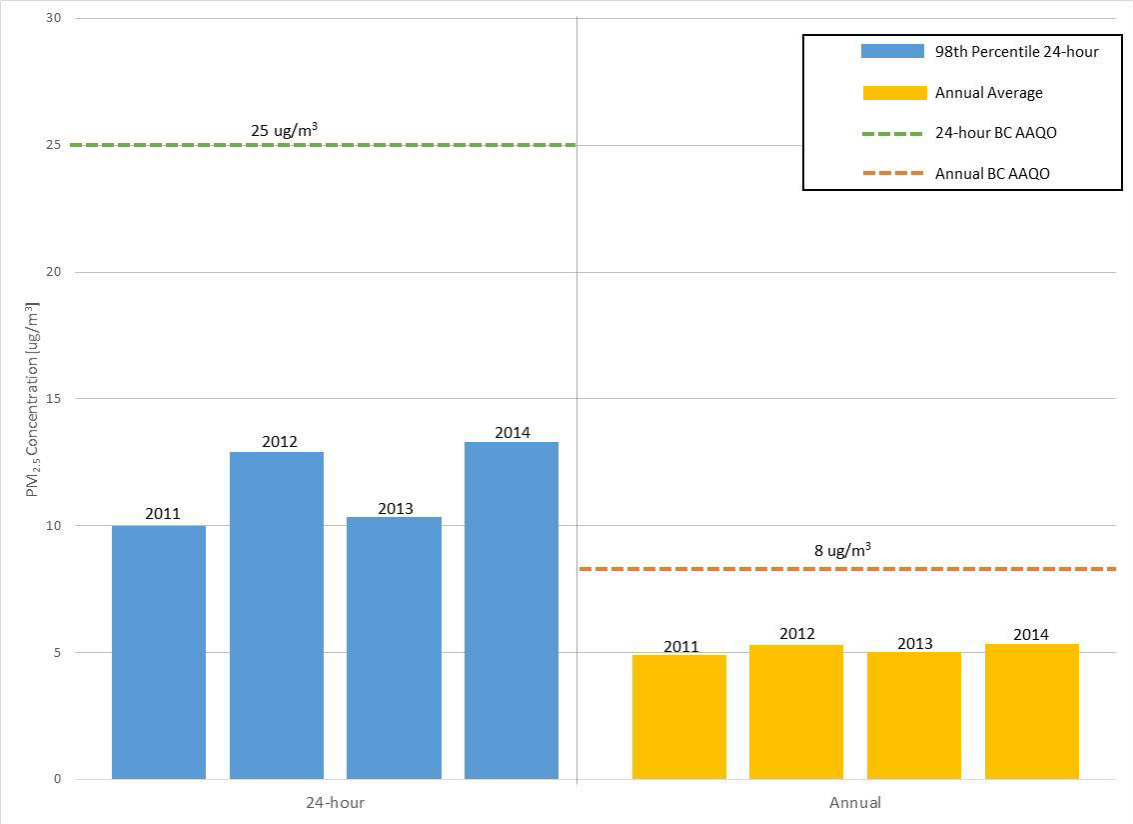

Figure 4-1 **$PM_{2.5}$ 24-hour 98th Percentile and Annual Average Data for 2011 - 2014 Compared to BC AAQOs for $PM_{2.5}$**

4.2 Comparison to British Columbia Ministry of Environment Air Quality Station at Meadow Park

The BC MOE operates air quality monitoring stations throughout BC, including the primary air quality monitoring station located at Meadow Park in Whistler. The following table and figure provide a comparative summary of the $PM_{2.5}$ data collected at the Meadow Park Station with data collected at Cheakamus Crossing.

Table 4-2 **Comparison of $PM_{2.5}$ TEOM Data (2011 - 2014) Monitored at Cheakamus Crossing and Meadow Park Air Monitoring Stations**

Station	Cheakamus Crossing $PM_{2.5}$ TEOM			Whistler Meadow Park $PM_{2.5}$ TEOM			BC 24-hour AAQO	BC Annual AAQO
Year	24-hour Maximum	24-hour 98th Percentile	Annual Average	24-hour Maximum	24-hour 98th Percentile	Annual Average		
2011	14.5	10.0	4.9	14.1	9.0	3.3	25	8
2012	22.5	12.9	5.3	16.3	11.5	3.3		
2013	14.0	10.3	5.0	13.5	9.9	3.5		
2014	22.1	13.3	5.3	18.4	11.5	3.5		

The concentrations of $PM_{2.5}$ monitored at both stations are below the BC AAQOs that are set to ensure long-term protection of public health and the environment. The ambient concentrations at Cheakamus Crossing are, on average, higher than those recorded at Meadow Park. Despite this, variations in short-term and annual average concentrations appear similar at both sites, suggesting that both stations are subject to similar regional effects based on the overall release of PM into the airshed and meteorological and atmospheric conditions.

It should be noted that although the Cheakamus Crossing Air Monitoring Station is intended to monitor potential contributions of PM from the asphalt plant operations, the ambient concentrations of $PM_{2.5}$ recorded at the station include emissions from all sources in the area, including emissions from traffic, home heating, and natural sources. The difference in ambient $PM_{2.5}$ concentrations at the two monitoring locations in Whistler are likely attributable to differences in emissions and dispersion from these types of local sources immediately surrounding each of the monitoring stations, as more regional-type influences on emissions (i.e. wildfires) or meteorology (i.e. high-pressure stagnant atmospheric conditions or inversions) would be likely to impact both monitors. The following section looks closer at the potential contributions of $PM_{2.5}$ from the asphalt plant specifically on monitored concentrations at Cheakamus Crossing.

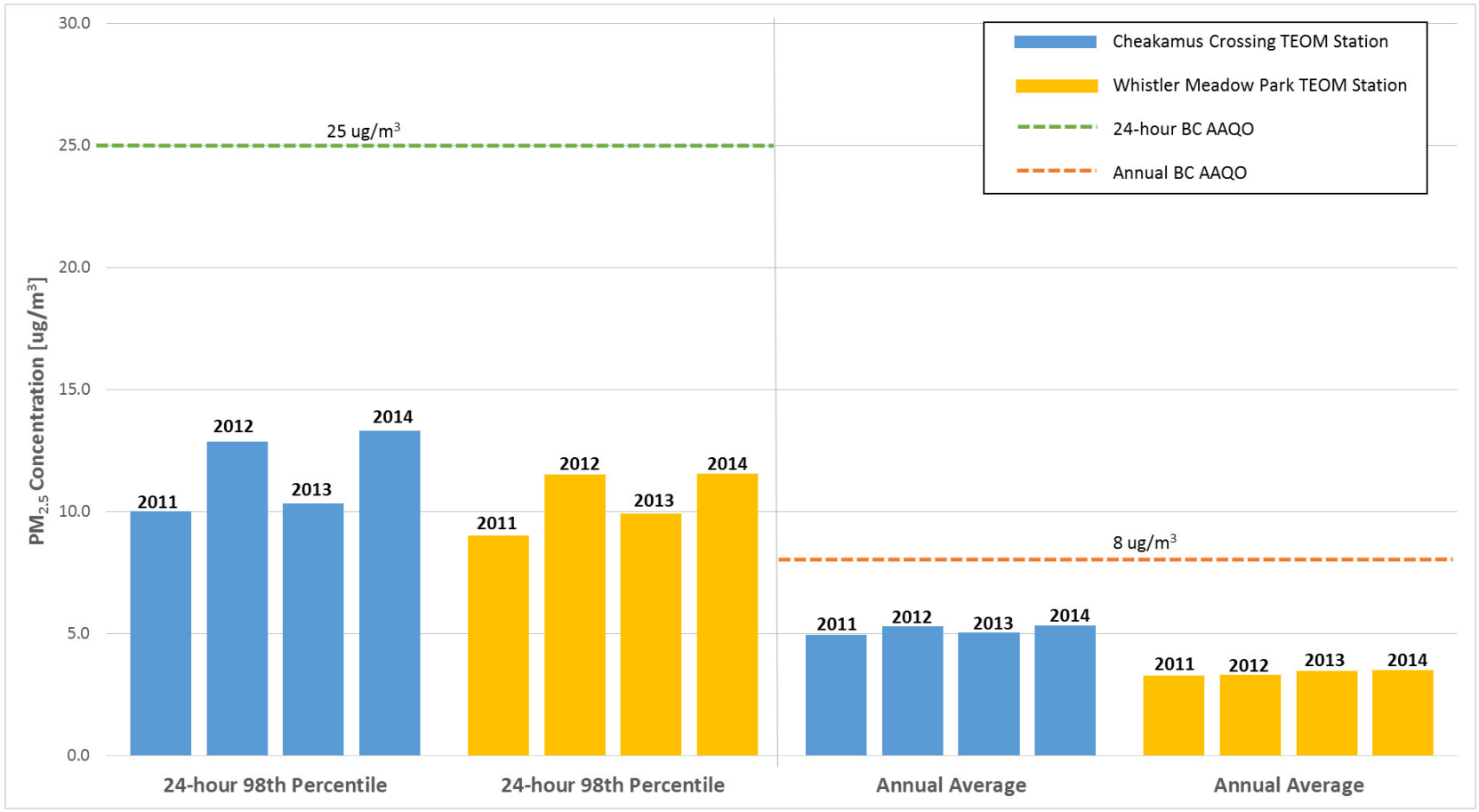

Figure 4-2 Comparison of $PM_{2.5}$ TEOM Data (2011 – 2014) Monitored at Cheakamus Crossing and Meadow Park Air Monitoring Stations

5. Asphalt Plant Operations

The asphalt plant to the southwest of the monitoring station operates in a batch process. The primary source of $PM_{2.5}$ emissions from an asphalt plant are the combustion emissions used to heat the dryer/drum mixer operations.

Data on operations of the plant was provided for 2012 – 2014 by RMOW for comparison with the monitored $PM_{2.5}$ concentrations at Cheakamus Crossing. Plant operations have been limited to primarily spring, summer and fall days with a maximum of five consecutive days of operations. Based on the information provided, the impact analysis for asphalt plant operations focused on the comparison of short-term daily averages on days with and without plant operations.

The figures below (Figures 5-1 to 5-3) show the daily (24-hour average) $PM_{2.5}$ concentrations measured at Cheakamus Crossing for each year. Days with plant operations are marked as orange bars. The predominant wind direction and average wind speed for the days of operation are also indicated on the figures.

The time series of daily averages shows that it is difficult to distinguish the plant operation days from typical variability in $PM_{2.5}$ concentrations over the entire data record. On plant operation days the concentrations of $PM_{2.5}$, which include potential contributions from the asphalt plant and all other sources in the area, were below the BC AAQOs.

The maximum 24-hour average $PM_{2.5}$ concentration recorded on a plant operations day occurred on August 12, 2014. The $PM_{2.5}$ concentrations recorded for the previous (August 11) and following (August 13) days and the predominant wind direction on August 12 suggests that other sources of particulate matter in the airshed contributed to the maximum recorded. On other plant operation days, when wind conditions suggest the potential for plant emissions to impact the Cheakamus Crossing monitor (winds with a westerly component), it is likely that $PM_{2.5}$ concentrations are influenced by the plant, but concentrations remain well below BC AAQOs.

A two-sample t-test was performed to test the significance of the difference in the average daily (24-hour) $PM_{2.5}$ concentrations on days when the asphalt plant compared with days when the asphalt plant was not operational. The test was restricted to the spring – fall period when the asphalt plant was operational. There was not a significant difference in the mean daily (24-hour) $PM_{2.5}$ concentrations for non-asphalt days ($M=5.39$, $SD=2.54$) and asphalt days ($M=5.82$, $SD=3.30$), conditions $t(94)=1.03$, $p=0.15$. These results suggest that there is no statistically significant effect on daily average $PM_{2.5}$ concentrations from the operation of the asphalt plant.

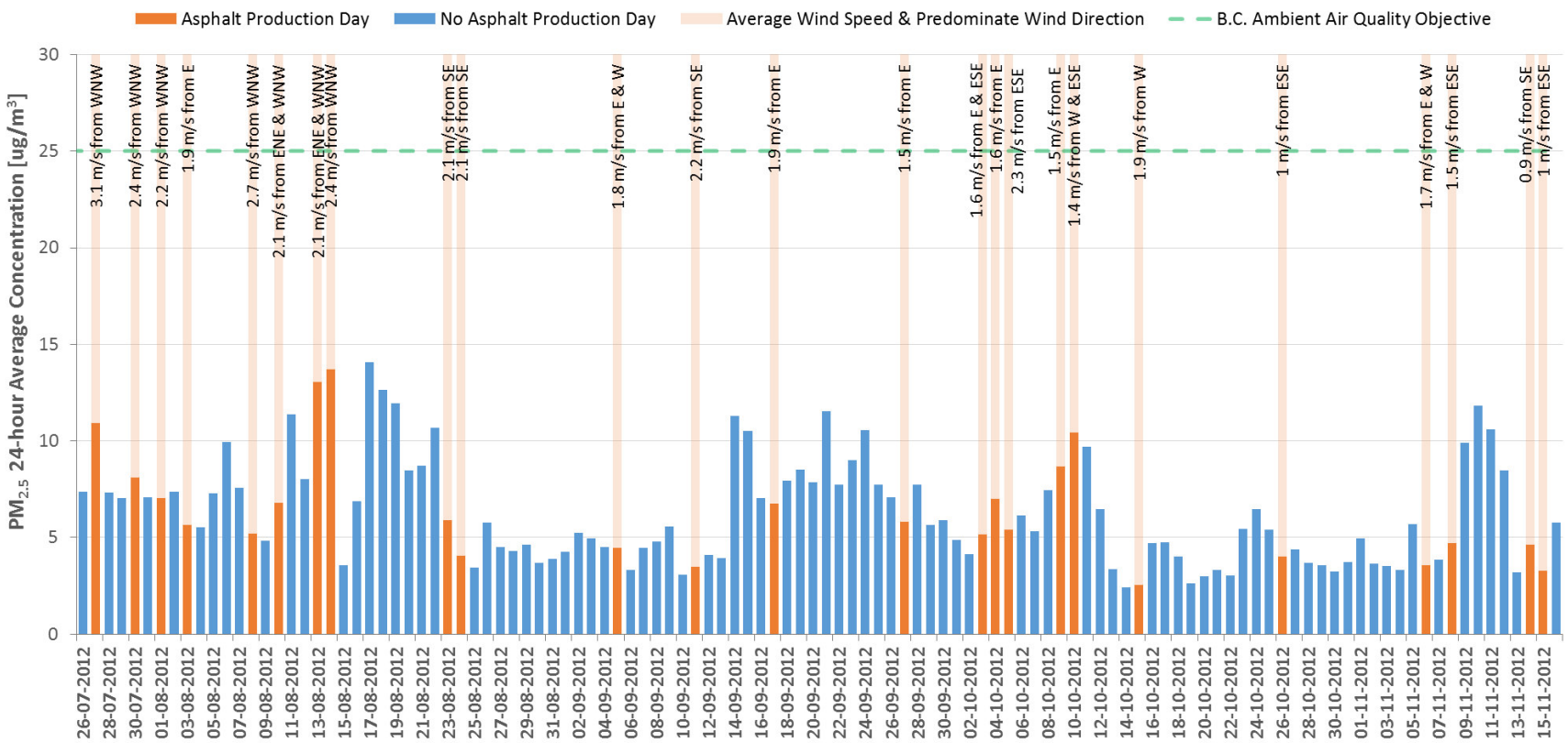

Figure 5-1 Timeseries of Daily Average $PM_{2.5}$ Concentrations Monitored at Cheakamus Crossing, 2012

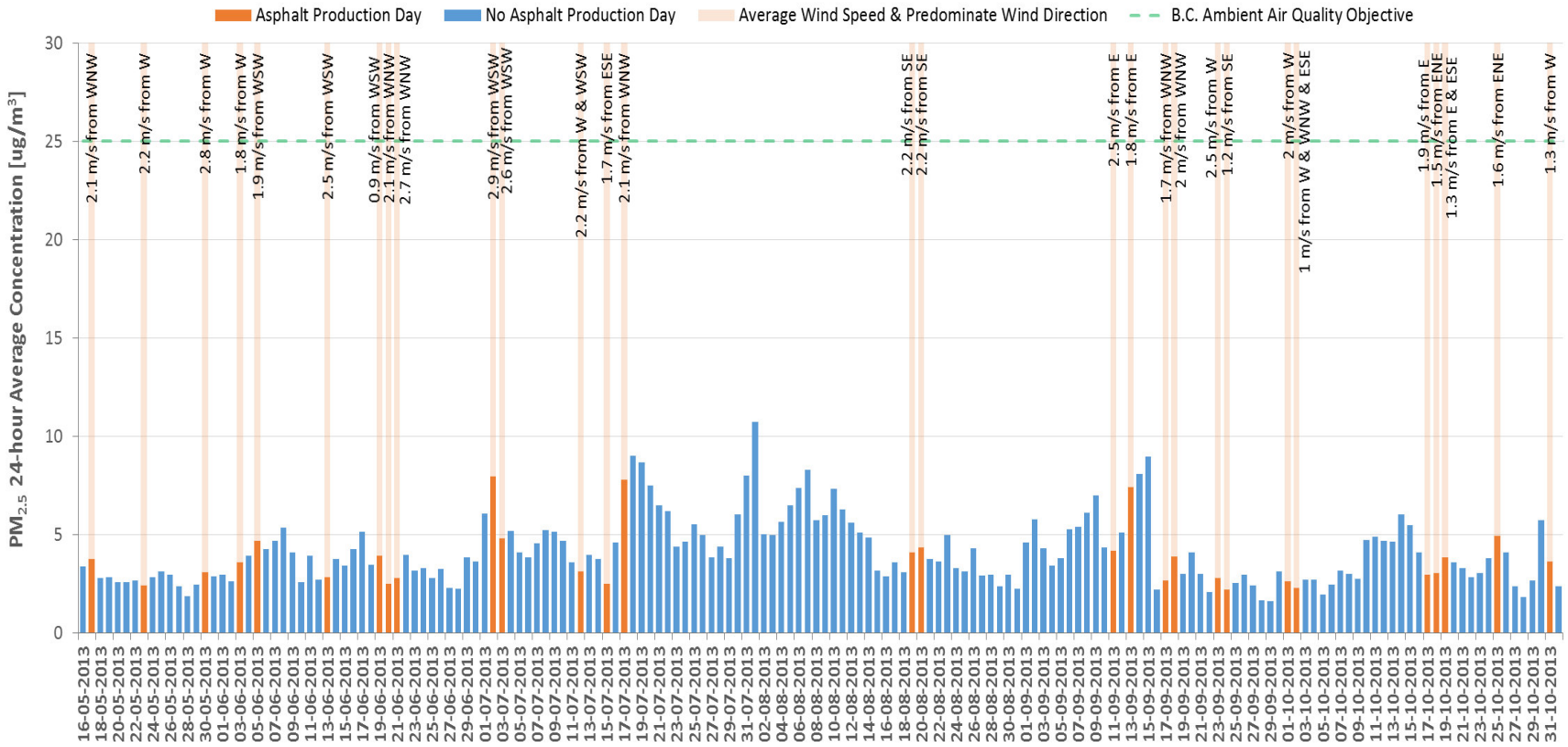

Figure 5-2 Timeseries of Daily Average $PM_{2.5}$ Concentrations Monitored at Cheakamus Crossing, 2013

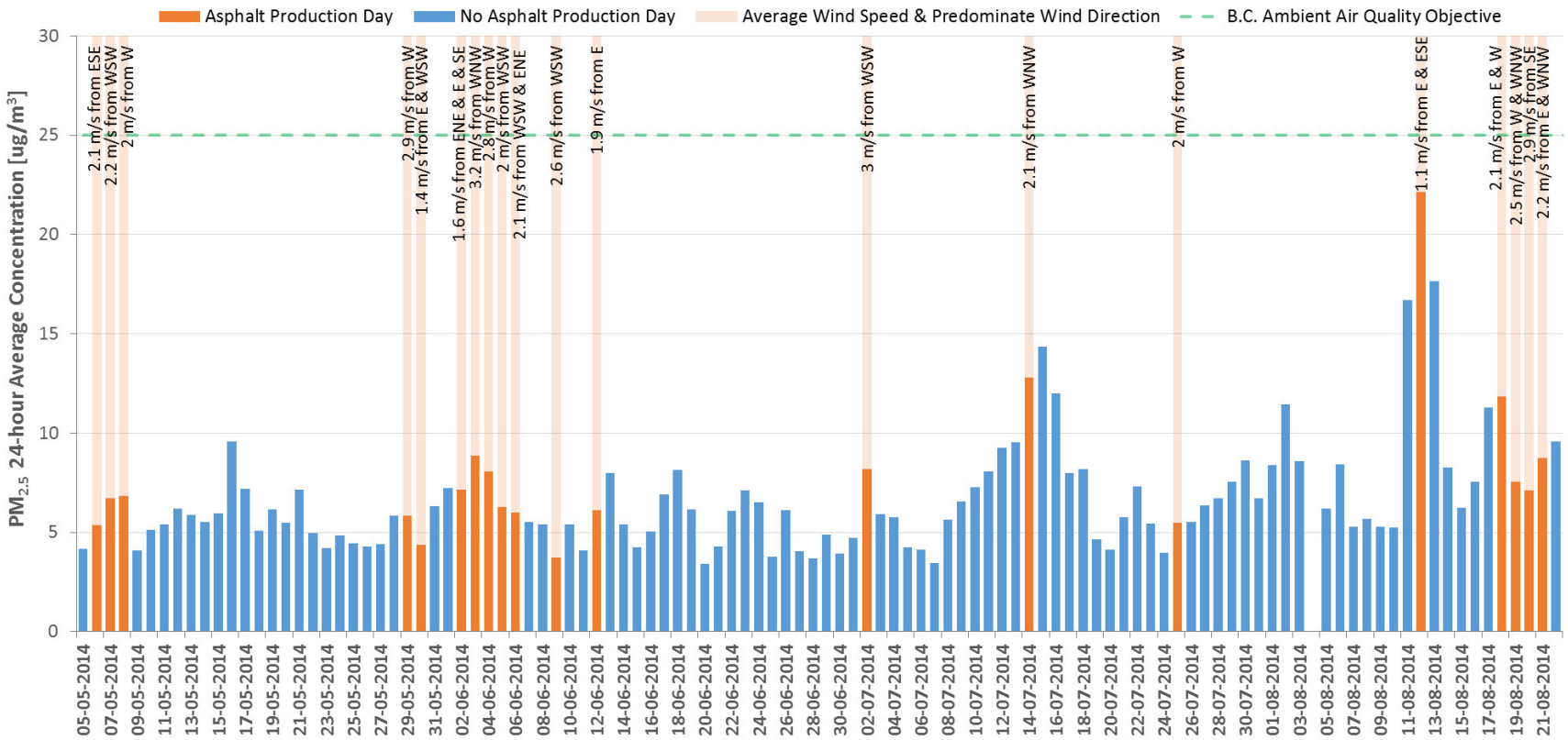

Figure 5-3 Timeseries of Daily Average $PM_{2.5}$ Concentrations Monitored at Cheakamus Crossing, 2014

Further analysis investigated concentrations on days (7:00 – 16:00) and evenings (17:00 – 0:00) before, during and after asphalt plant operation days (Figures 5-4 to 5-9). During consecutive days of plant operation, the day or evening before and after the consecutive operation period was used for comparison. The comparison of day and evening periods is intended to allow for comparison of similar levels of emissions from other potential sources in the area, but changes in the factors affecting emissions or atmospheric conditions cannot be accounted for in the analysis.

Paired t-tests were used to investigate potential differences between the average concentrations during the periods before, during and after asphalt plant operation days. The table below outlines the results of the t-tests.

Table 5-1 Paired t-tests of Statistical Significance for Periods of Asphalt Production

Comparison	p-value (significant <0.05)	Result and Interpretation
Day-time before, Day-time during	0.013	Difference is statistically significant; 95% confidence that increase ranges between 0.08 – 1.29 ug/m^3
Day-time before, Day-time after	0.072	Not significant
Day-time during, Day-time after	0.26	Not significant
Evening before, Evening during	0.49	Not significant
Evening before, Evening after	0.31	Not significant
Evening during, Evening after	0.28	Not significant

This analysis suggests a minor potential impact of the asphalt plant on $PM_{2.5}$ concentrations at Cheakamus Crossing, although it is not a consistent pattern on each day of operation and increases in concentrations cannot be attributed to emissions solely from the plant. Although the difference is statistically significant, by analyzing the confidence intervals, we can be 95% sure that the increase realized during the day-time period with asphalt operations as compared with the day-time period prior to asphalt operations will range from 0.08 – 1.29 ug/m^3. This is a small, temporary potential increase in $PM_{2.5}$ concentration, as no other significant change in $PM_{2.5}$ concentrations is recorded. The test of significance also assumes that other sources of emissions or atmospheric conditions are not affecting the $PM_{2.5}$ concentrations on asphalt plant operation days, as the analysis did not account for the variance attributable to these other conditions.

Despite the small potential for impact from the plant during the day-time period, all days, with or without operations, remained below the AAQOs and tests of statistical significance suggested the change over the 24-hour period used to compare against the AAQO was not significant.

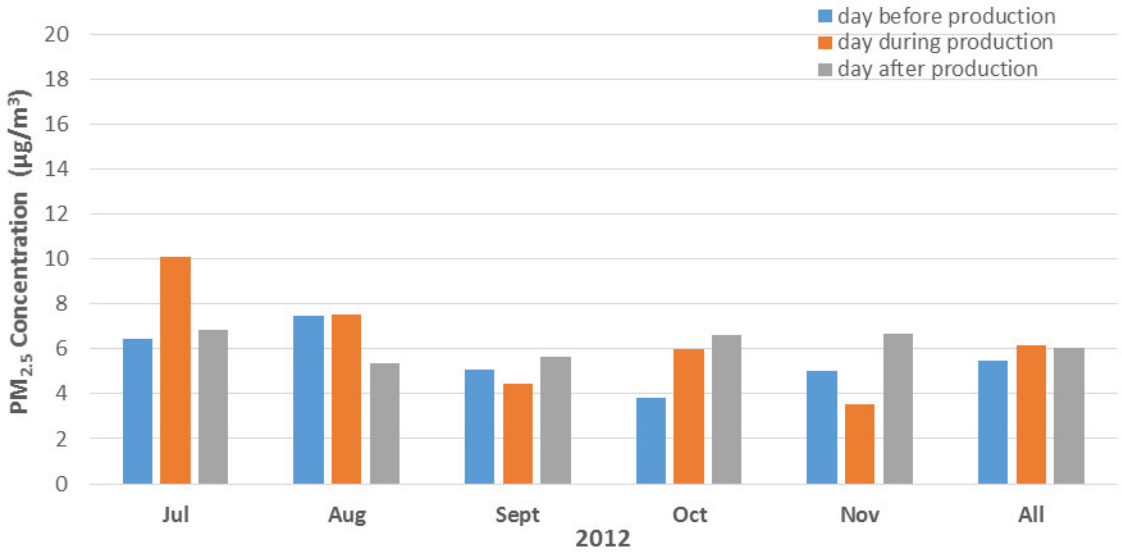

Figure 5-4 **Comparison of $PM_{2.5}$ Concentrations the Day (7:00 – 16:00) Before, Day During and Day After Asphalt Production, 2012**

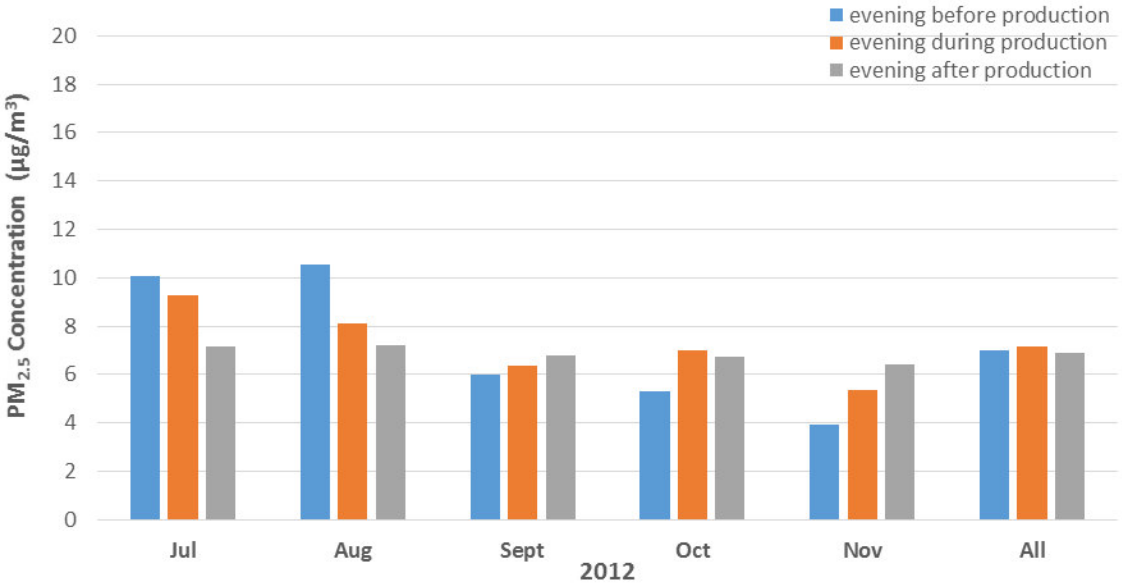

Figure 5-5 **Comparison of $PM_{2.5}$ Concentrations the Evening (17:00 – 0:00) Before, Evening During and Evening After Asphalt Production, 2012**

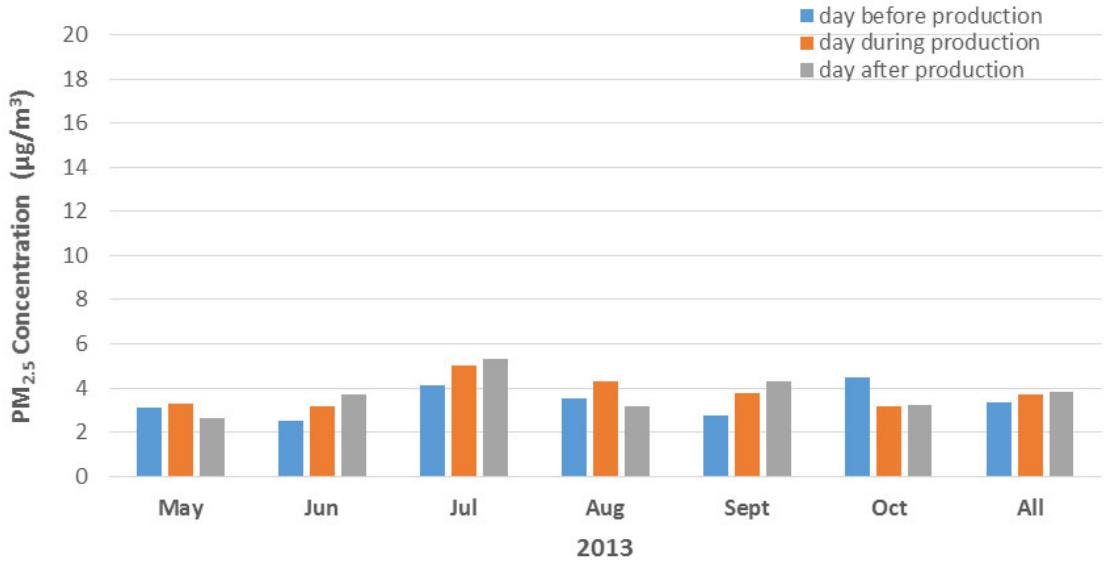

Figure 5-6 **Comparison of $PM_{2.5}$ Concentrations the Day (7:00 - 16:00) Before, Day During and Day After Asphalt Production, 2013**

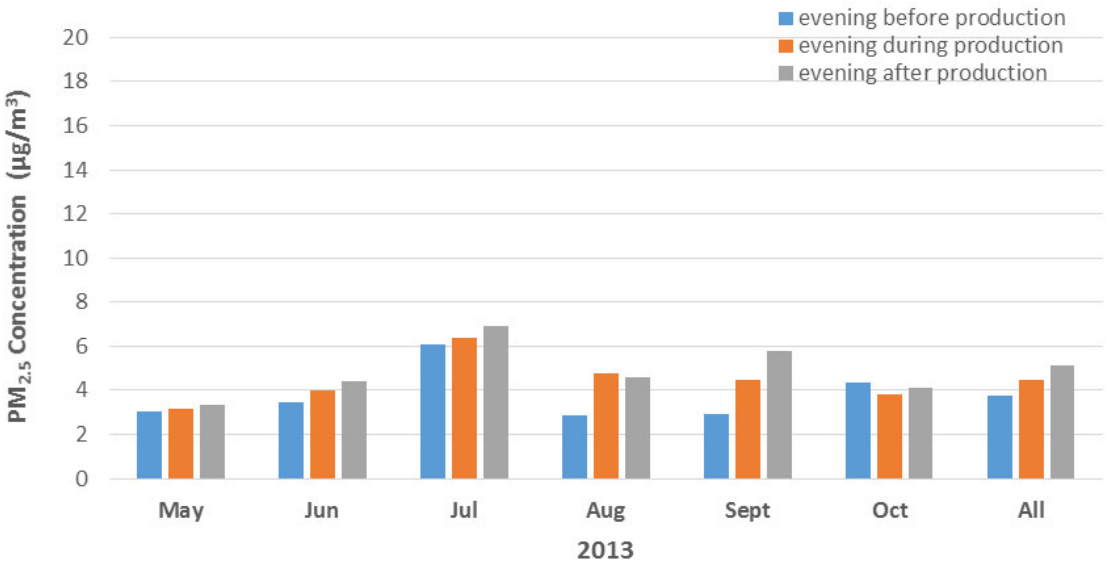

Figure 5-7 **Comparison of $PM_{2.5}$ Concentrations the Evening (17:00 - 0:00) Before, Evening During and Evening After Asphalt Production, 2013**

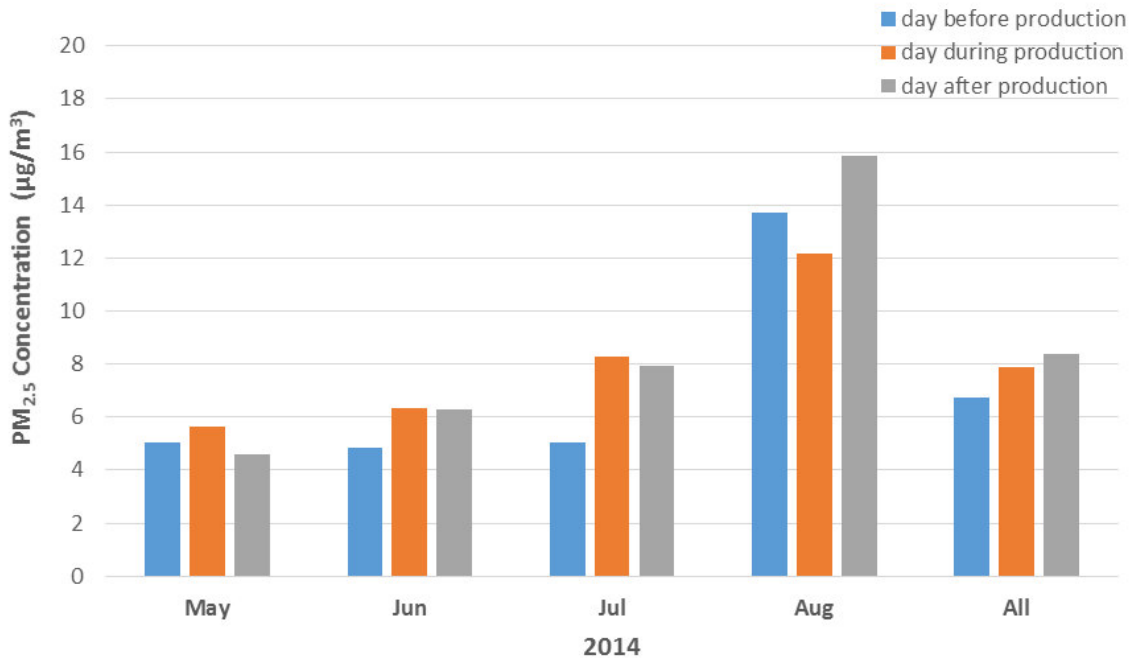

Figure 5-8 **Comparison of $PM_{2.5}$ Concentrations the Day (7:00 - 16:00) Before, Day During and Day After Asphalt Production, 2014**

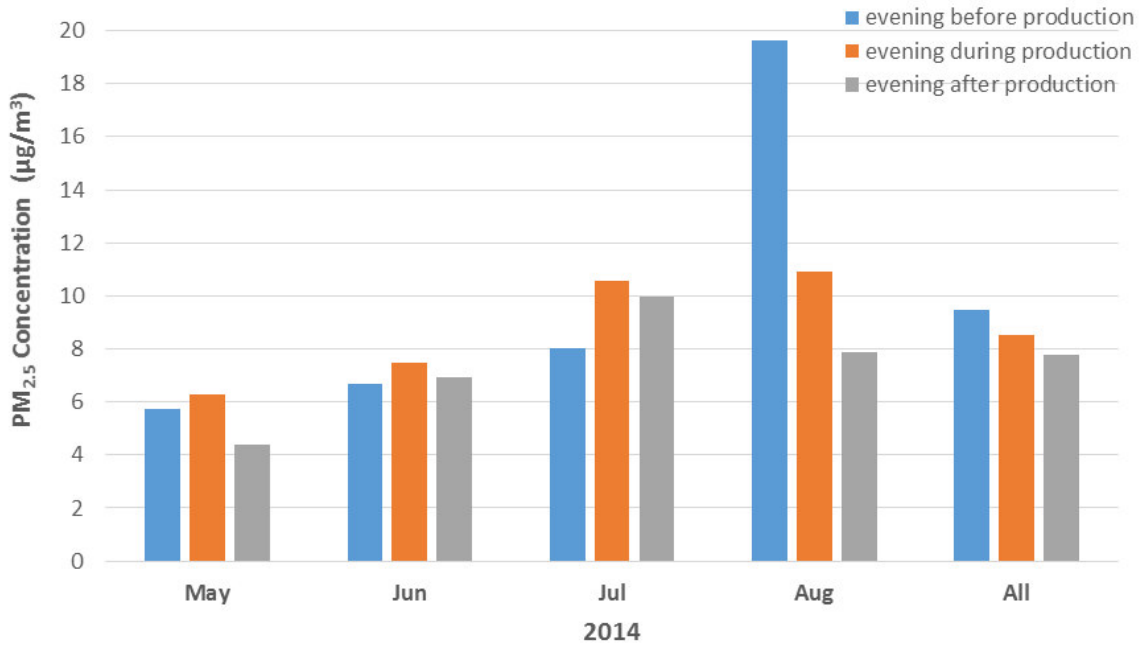

Figure 5-9 **Comparison of $PM_{2.5}$ Concentrations the Evening (17:00 - 0:00) Before, Evening During and Evening After Asphalt Production, 2013**

5.1 Case Study: New Brunswick

The New Brunswick Department of Environment (NB ENV) conducted a relevant air quality monitoring program[1] in Moncton, New Brunswick in 2009 that may provide RMOW with supplemental information on the potential for air quality impacts from an asphalt plant. The NB ENV monitoring program was setup in response to residents concern about nuisance and possible health effects relating to air emissions from various facilities operating within a light industrial park, including an asphalt plant, dust from exposed stockpiles and diesel truck emissions. Furthermore, the light industrial park was situated immediately adjacent to a primary school.

The air quality monitoring program measured the concentrations of a number of air pollutants including sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ground level ozone (O3), total reduced sulphur (TRS) particulate matter (TSP, PM_{10} and $PM_{2.5}$), volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs). The primary focus of the monitoring was the activities associated with the asphalt plant. The air quality monitoring was conducted at a distance of 160 metres from the asphalt plant.

No exceedance of the health related air quality objectives examined in the study were measured for any of the pollutants. Only the daily average value for total suspended particulate (TSP) exceeded the air quality objective on three days during the study due to wind-blow dust issues. Overall, the levels of all pollutants were comparable with levels recorded at another air quality monitoring site in Moncton.

6. Conclusions and Recommendations

Levelton Consultants Ltd. has operated and maintained the Cheakamus Crossing Ambient Air Monitoring Station on behalf of the Resort Municipality of Whistler (RMOW) since September, 2010. The station monitors ambient $PM_{2.5}$ air concentrations, along with wind speed and direction and was installed to address the concerns of potential ambient air quality issues associated with an asphalt plant located near the neighbourhood.

Since commissioning, the station has not recorded an exceedance of the BC AAQOs for $PM_{2.5}$. The $PM_{2.5}$ concentrations measured at the Cheakamus Crossing Air Monitoring Station are slightly higher than those measured at the Meadow Park Air Monitoring Station operated by the BC MOE. Both stations show similar trends in short-term (daily) maximums and average conditions on annual basis, suggesting that both stations are subject to similar regional effects based on the overall release of particulate matter into the airshed and meteorological and atmospheric conditions.

Comparison of the $PM_{2.5}$ concentrations with operations at the asphalt plant shows a minor potential impact of emissions to temporarily affect the monitored concentrations during operations. Evaluation of days with the asphalt plant active versus days without asphalt plant activity, shows that the mean difference between daily (24-hour) average $PM_{2.5}$ concentrations is not statistically significant.

[1] *New Brunswick Department of Environment, 2010. MacAleese Lane Air Quality Report, 2009 Monitoring Program. Accessed on April 10, 2015: http://www1.gnb.ca/0009/airQuality/0001-e.pdf*

Regardless of the potential impacts from the asphalt plant emissions, all days monitored at the Cheakamus Crossing Station show compliance with the BC AAQO.

Given the length of data record, that monitored levels of $PM_{2.5}$ concentrations at the Cheakamus Crossing Air Monitoring Station remain consistently below BC AAQOs even on days when the asphalt plant is in operation, and that daily average $PM_{2.5}$ concentrations on days with the asphalt plant in operation are not statistically distinguishable from days without operations, continued monitoring of $PM_{2.5}$ at the station for the sole purpose of evaluating the impact of emissions from the asphalt plant is not recommended.

Furthermore, an air quality monitoring case study conducted by NB ENV showed no exceedances of health related air quality objectives for sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ground level ozone (O3), total reduced sulphur (TRS) particulate matter (TSP, PM_{10} and $PM_{2.5}$), volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs).

Levelton would suggest that the results of the $PM_{2.5}$ monitoring program summarized in this report be communicated to the residents in the Cheakamus Crossing Neighbourhood. The forum for communicating the results should allow for RMOW to receive feedback from the community to determine ongoing air quality concerns in the neighbourhood. If air quality concerns still exist, it is recommended to determine the cause for concern. Of particular interest to the potential for future monitoring at the site is whether concerns are related to fine particulate matter (typically from combustion emissions), fugitive dust particulate matter (typically windblown or from traffic disturbance) or odours (associated with VOC releases from the asphalt process).

The responses from the residents, along with the results and recommendations presented in this report, would inform the need for / next steps for monitoring in the neighbourhood, which could include:

1. Investigation of other size fractions of particulate matter

Larger size fractions of particulate matter, total particulate matter (TPM) or particulate matter less than 10 microns (PM_{10}) are typically associated with fugitive dust issues. If neighbourhood concerns remain regarding fugitive dust, monitoring of these larger size fractions could be used to ensure that these pollutants are also in compliance with BC AAQOs. However, it may be more cost-effective to address fugitive dust concerns by working directly with the asphalt plant to address and mitigate potential fugitive dust sources that are identified by the residents.

2. Investigation of volatile organic compounds (VOCs)

If neighbourhood concerns remain regarding VOCs which have the potential to cause odour issues, an option for continued monitoring would be to confirm the VOC results presented in the NB ENV study to ensure that VOC levels are below relevant health objectives. Odours are often detected at a nuisance-level concentration that is much below concentrations that would cause health concerns.

Costs of the potential monitoring options presented above are outlined for RMOW under separate proposals.

7. References

Campbell Scientific, Inc., 2000, Operator's Manual: CR510 Basic Datalogger.

Rupprecht & Patashnick Co., Inc., 2002, Operating Manual: TEOM® Series 1400a Ambient Particulate (PM-10) Monitor (AB Serial Numbers), Revision B, March.