SUMMARY OF AMBIENT AIR QUALITY MONITORING

CHEAKAMUS CROSSING NEIGHBORHOOD

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1. INTRODUCTION

Levelton Consultants Ltd. (Levelton) was retained by the Resort Municipality of Whistler (RMOW) to install an ambient air monitoring station in their new Cheakamus Crossing Neighbourhood (formerly the Whistler Athletes Village) to measure $PM_{2.5}$ (particulate matter with an aerodynamic diameter of 2.5 micrometers or less). Levelton was contracted to install and maintain an ambient particulate matter air quality monitoring station, provide public access to the monitoring data, and report a summary of the data to the RMOW. 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. This report summerizes the data from the monitoring station for the calendar year of 2011 (January 1st 2011, to December, 31st 2011).Ambient Particulate Matter ($PM_{2.5}$) Air Quality Monitoring Station

1.1 PRE-INSTALLATION

Prior to installing the monitoring station, Levelton attended the site along with a representative from the RMOW to choose a suitable location. The representative from the RMOW expressed interest in siting the monitoring station in a location to provide ambient particulate matter (PM) measurements representative of those experienced in the Cheakamus Crossing neighbourhood.

Selecting an appropriate site for the monitoring station was critical in order to obtain accurate meteorological and particulate matter data. To accurately record wind parameters, the site should be representative of the area of interest, and away from the influence of obstructions such as buildings and trees. In order to provide the most accurate readings of particulate matter, the manufacturer of the air monitor strongly recommends that the equipment be installed in an indoor location that is temperature and pressure stable (with the inlet for the monitor located outside).

The High Performance Centre (HPC) building (Figure 1) was selected for the monitoring site as it met the requirements outlined above. In addition, the air monitoring station was selected to be installed on the HPC rooftop 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 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 1 High Performance Centre (HPC) in Cheakamus Crossing Neighbourhood

1.2 INSTALLATION

On September 3rd, 2010 Levelton began the installation of the monitoring station at the HPC building (Figure 2). The TEOM Series 1400a Ambient Particulate Monitor (TEOM) with associated sensor unit, control unit and pump were installed inside the building's mechanical room. The TEOM air intake inlet was placed on the roof of the HPC building to provide measurements of the ambient particulate matter ($PM_{2.5}$) concentrations. The TEOM began sampling on September 3rd, 2010 at 18:00.

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

On September 15th, 2010 Levelton returned to the site to complete the installation of the remaining monitoring equipment equipment. This included installing a tripod on the roof to mount an anemometer. A datalogger was connected to the anemometer and the TEOM to process and record the measured data. A digital communication system was then installed to transfer the data back to Levelton's office. A detailed description of the equipment commissioned at the monitoring station is provided below.

1.2.1 TEOM

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).

The monitor installed at the HPC building was provided to the RMOW by the British Columbia Ministry of Environment (BC MOE). The BC MOE currently operates the same monitor at many of their air quality stations across the province. This unit is outfitted with a Sharp Cup 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/m³).

$PM_{2.5}$, 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.

A TEOM is made of two main sections; the sensor unit and the control unit (Figure 3).

- **The Sensor Unit –** The sensor unit contains the mass measurement hardware that continuously monitors the accumulated mass on the system's exchangeable filter cartridge. By maintaining a flow rate of 3 liters per minute (L/min) through the instrument and measuring the total mass accumulated on the filter cartridge, the device can calculate the particulate mass concentration of the sample air stream in real time.

- **The Control Unit -** The control unit houses an industrially hardened microprocessor system, flow control hardware, a gauge to determine filter lifetime, transformers and power supplies.

Completing the system are the inlet and the pump. The inlet is installed outside the building on the roof and is positioned directly above the sensor unit. The inlet includes a PM_{10} (particulate matter with an aerodynamic diameter of 10 micrometers or less) inlet followed by a SCC $PM_{2.5}$ inlet (Figure 3). Combined, these inlets prevent any larger airborne particulate from entering the sample tube. Mounted on the side of the inlet is a temperature and pressure sensor. This sensor allows the unit to accurately control the sample flow rate. The pump is located inside the building and provides a continuous 16.7 litres per minute (L/min) suction on the system that is then managed by the control unit so that a steady 3.0 L/min is drawn through the TEOM filter and sampled.

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

1.2.2 Anemometer

An 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 model chosen was the 05305, Air Quality Wind monitor. It has a wind speed range of 0-180 km/hr, an accuracy of +/-0.72 km/hr and a starting threshold of 1.44 km/hr. The wind direction accuracy is +/-3° a nd has a starting threshold of 1.8 km/hr.

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 4). The tripod contains a lightning rod and is grounded to the building's structure.

The anemometer is connected to the datalogger which calculates hourly average wind direction and wind speed that is displayed on the monitoring station's website.

Figure 4 **The Tripod Mounted Anemometer and TEOM Inlet located on the Roof of the HPC building**

1.2.3 Datalogger and Communication System

The datalogger is from Campbell Scientific Inc. (Model CR510). It is a fully programmable datalogger/controller which combines reliability, versatility, and telecommunications making it an ideal choice for single logger applications (Campbell Scientific, 2000). The datalogger outputs 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/whistler) where it is displayed in 'real-time'. A link to this site is provided on the RMOW website (www.whistler.ca)

1.3 POST-INSTALLATION

Levelton will be collecting and presenting the data obtained from the monitoring station for the extent of the monitoring program. Levelton has consulted with the BC MOE and is following the same standards by which the BC MOE operates their provincial system of ambient air monitoring stations. Levelton and the RMOW coordinated with the BC MOE to have the Cheakamus Crossing Ambient Air Monitoring Station audited by the BC MOE's provincial auditing team. This team conducts semi annual audits on all of the BC MOE stations to validate the condition of the equipment, therefore validating the data. The maintenance/calibration and verification schedules for the monitoring station are more stringent than the manufacturer's recommended schedule and are shown in Table 1 and Table 2 below.

Table 1 Maintenance and Calibration Schedule for the Cheakamus Crossing Monitoring Station

Equipment	Maintenance Procedures	Description	Interval
Data logger and data transfer system	Communication audit	Data audit to ensure communications between the systems components.	Monthly
TEOM	Visual inspection	Visually inspect the entire system for proper operation. This includes but is not limited to; The inlet, the sampling tubes, the Sensor unit, the Controller unit, and the pump.	Monthly
TEOM	TEOM Filter	Replace the TEOM filter before it reaches 75% load, or every 2 months (which ever comes sooner)	2 months
TEOM	Sample Inlet	Clean the sample inlet monthly	Monthly
TEOM	Large in-line filters	Replace the large in-line filters every 6 months, or as necessary	Bi-annually
TEOM	Air inlet system	Clean the air inlet system	Annually
TEOM	Sample Pump	Rebuild the sample pump.	18 months
Anemometer and Tri-pod	Calibration	Calibrate the anemometer bearings and potentiometer. Replace if necessary.	2 years

Table 2 Verification Schedule for the Cheakamus Crossing Monitoring Station

Equipment	Verification Procedures	Description	Interval
Data logger and data transfer system	Communication audit	Confirm connection between data transfer system and data display website.	Daily
Anemometer and Tri-pod	Visual inspection	Visually inspect the legs and stand of the tripod for wear or damage. Visually inspect the Anemometer for proper movement and function. Inspect the cables for damage and the grounding connection.	Monthly
TEOM	Data Display	Compate real time data from the TEOM with the datalogger data being trasnfered to the website.	Monthly
TEOM	Batteries	Test the batteries, and exchange them as necessary.	Bi-annually
TEOM	Pump	Test the pump for adequate flow rate.	Bi-annually
TEOM	Mass flow controller Software	Calibrate the mass flow controller's software.	Annually
TEOM	Mass flow controller Hardware	Calibrate the mass flow controller's hardware.	Annually
TEOM	Leak check	Perform a leak check on the system.	Annually
TEOM	Mass transducer	Verify the calibration of the mass transducer.	Annually
TEOM	Ambient air temperature	Verify the calibration of the ambient air temperature measurement.	Annually
TEOM	Ambient pressure	Verify the calibration of the Ambient pressure measurement.	Annually
TEOM	Flow Audit	Perform a flow audit	Annually
TEOM	Ambient temperature sensor	Calibrate the ambient temperature sensor.	Annually
TEOM	Ambient pressure sensor	Calibrate the ambient pressure sensor.	Annually

To supplement Levelton's monthly site visits a staff member of the RMOW was trained to assist with site maintenance. Specifically the TEOM filters can become loaded with particulate matter and need to replaced with a new filter within a short time interval. A station log is kept for all site visits. It includes the date, staff members onsite and the activities conducted while onsite. This abides by the BC MOE's standards for site maintenance and record keeping.

During site visits there are small gaps in the recorded data because the units are being calibrated and are not able to provide reliable readings. These periods of time are marked as 'maintenance' on the website instead of displaying data. This is the standard for required maintenance time for continuous monitoring equipment.

2. DATA DISPLAY

The data collected by the station is transferred electronically to Levelton's Air Quality Website, www.airquality.ca/whistler. On the site the data is presented in a table as well as graphically in a rolling 24-hour display (Figure 5). On the graph an hourly average (yellow) as well as a rolling 24-hour average (blue) is shown. This data is provided to show 'real-time' air quality measurments. The BC Ambient Air Quality Objective (BC AAQO) for $PM_{2.5}$ is 25 ug/m^{3*} for a 24 hour period (midnight to midnight). This objective is displayed on the graph as a solid green line as a general reference. Although there is no BC AAQO for the hourly average of $PM_{2.5}$, hourly concentration levels are also displayed on the website.

The wind direction and speed is presented as an hourly average on the website. Historical data can also be accessed through the site. As the data is presented in a 'real-time' manner it is considered unverified as stated in the disclaimer on the website. The historical data is therefore subject to change during a verification and quality assurance check completed by Levelton.

Along with the data displayed on the website, there is an overview page that describes the project in basic detail. There is also a link to the BC MOE Air Quality webpage that displays all of the data from the BC MOE's network of monitoring stations across BC.

* Based on annual 98th percentile value

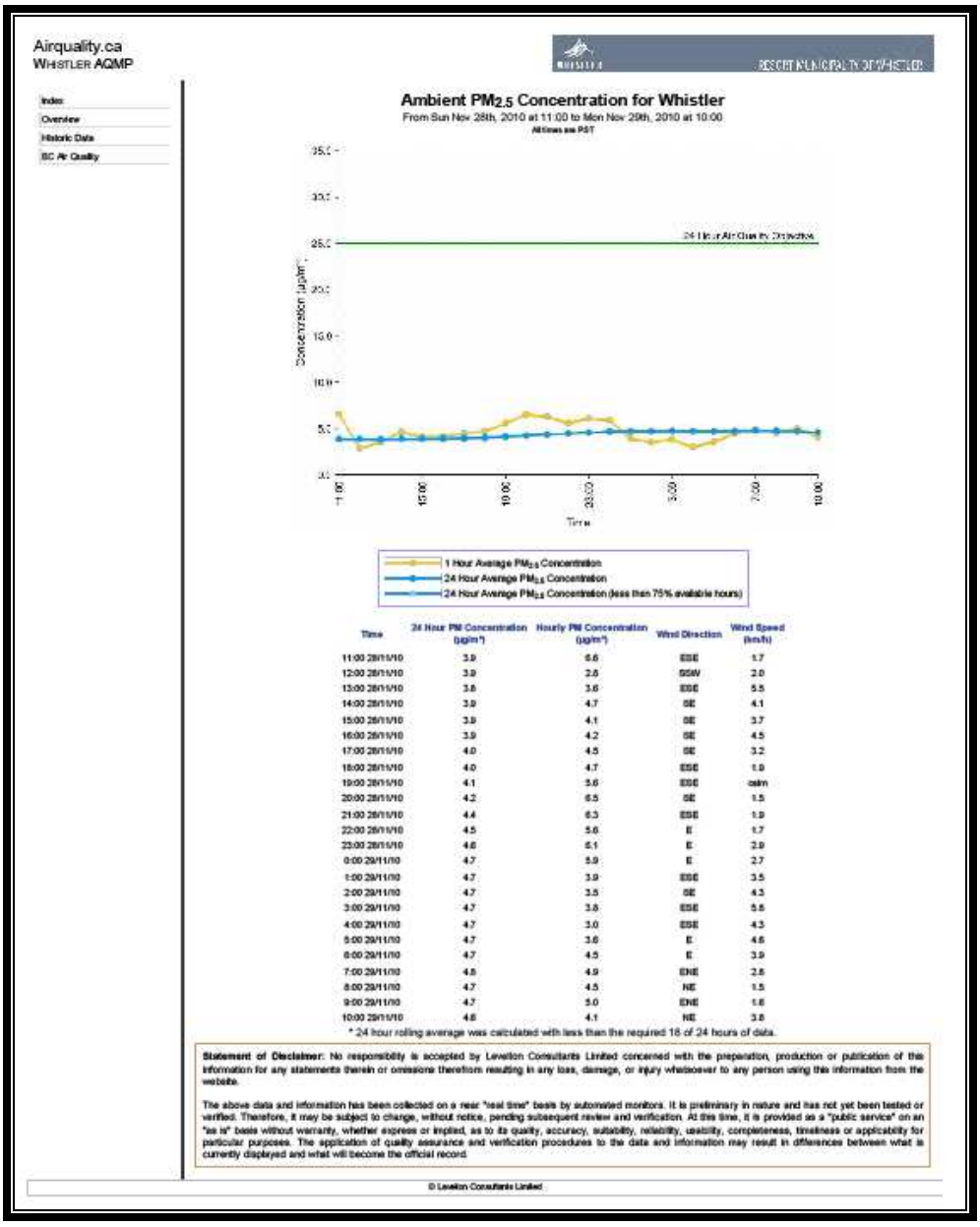

Figure 5 Sample Display from www.airquality.ca/whistler

3. DATA SUMMARY

Data collection began on September 3rd, 2010 for $PM_{2.5}$ data and on September 15th, 2010 for the wind data. The TEOM and anemometer continuously collect data. Required monthly maintenance results in the system being offline for short periods of time. A report was presented in December 2010 summerizing the first 3 months of monitoring data (September 15th, 2010 to November 30th, 2010). This report summerizes the data from the monitoring station for the calendar year of 2011 (January 1st 2011, to December, 31st 2011).

3.1 WIND DIRECTION AND WIND SPEED

A wind rose was created using the 2011 wind data (Figure 6). Wind roses are used to display the frequency of wind speed at wind direction. They typically show a dominant wind path dictated by the topography of the site. The dominant direction of wind at the station was from the west. This was also the direction that recorded the highest wind speeds. Winds from the southwest and south-southwest have the greatest potential to transport emissions directly from the asphalt plant towards the monitoring station. These winds occurred approximately 6% of the time over the 2011 monitoring period.

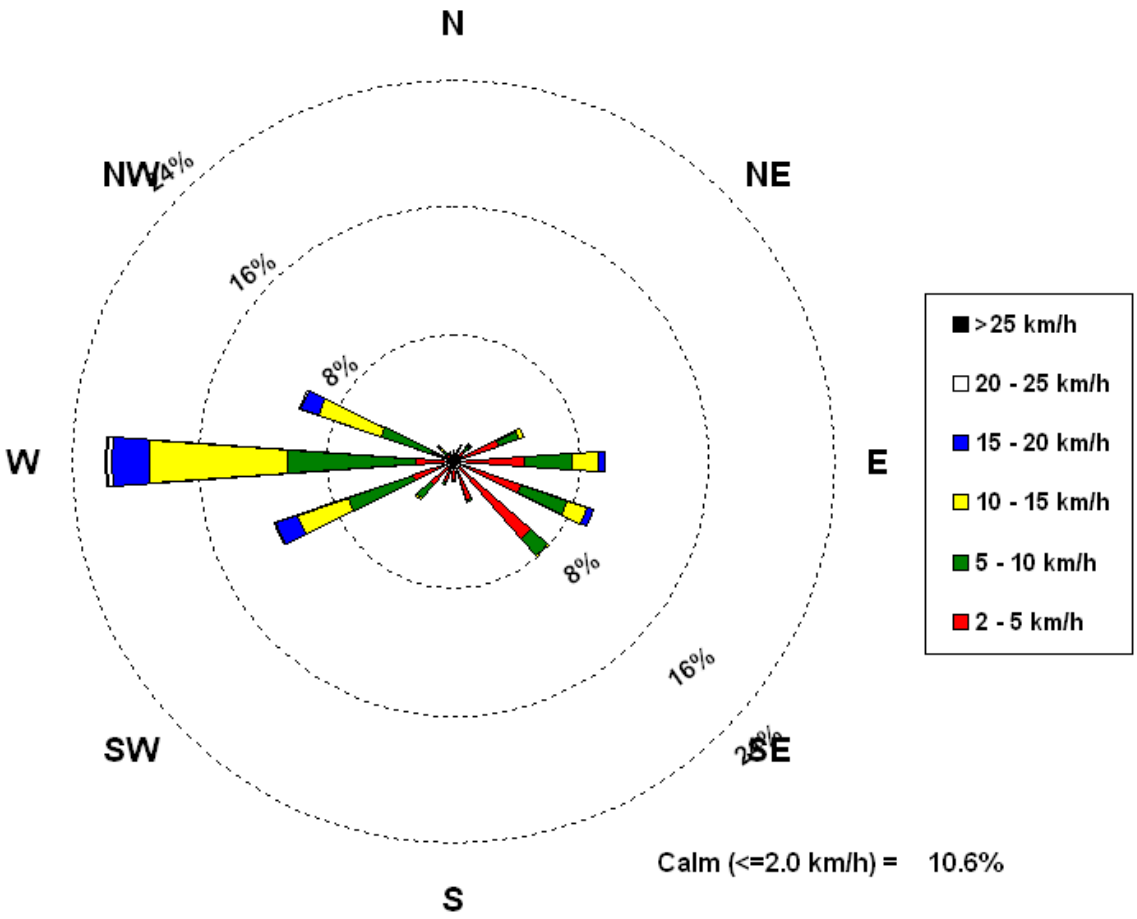

Figure 6 Windrose of the Cheakamus Crossing Anemometer Data, January 1st, 2011 to December 31st, 2011

3.2 $PM_{2.5}$ CONCENTRATIONS

The continuous monitoring data from the TEOM unit was used to calculate 1-hour $PM_{2.5}$ concentration averages. 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 website provides a 'real-time' representation of current conditions but is not to compare to the provincial objectives. When comparing the results to the BC AAQO, a daily 24-hour average (midnight to midnight), also reffered to as block average is used. Figure 7 displays a monthly breakdown of the 24-hour block averages and maximums along with the hourly maximums.

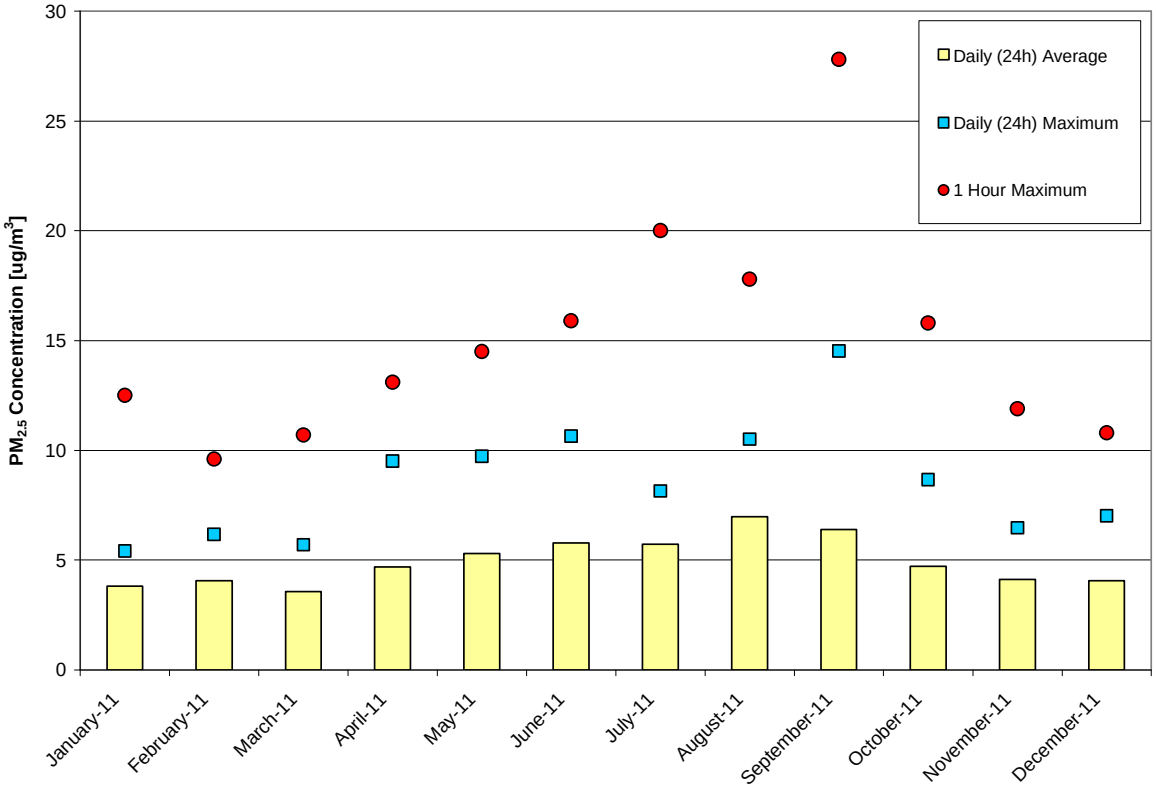

Figure 7 The Graph Displays the $PM_{2.5}$ Monthly 24-hour Averages, 24-hour Maximums, and 1-hour Maximums

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. In 2011 the 98th percentile value was 10 µg/m³, which is below the provincial objective. The maximum 24-hour value recorded during 2011 was 14.5 µg/m³. Although this value is not directly comparable to the BC AAQO, it is still below the objective.

The same data set is averaged to determine the annual value. This is compared to the Annual BC AAQO for $PM_{2.5}$ concentration which is 8 µg/m³. In 2011 the annual average was 4.9 µg/m³, which is below the provincial objective. The 2011 data is listed in Table 3 and displayed in Figure 8.

Table 3 $PM_{2.5}$ TEOM Data 2011 (January 1st, 2011 – December 31st, 2011)

Year	$PM_{2.5}$ (µg/m^3)				
	Maximum (24-hour)	98th Percentile (24-hour)	BC AAQO (24-hour)*	Annual Average	BC AAQO (Annual)
2011	14.5	10	25	4.9	8.0

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

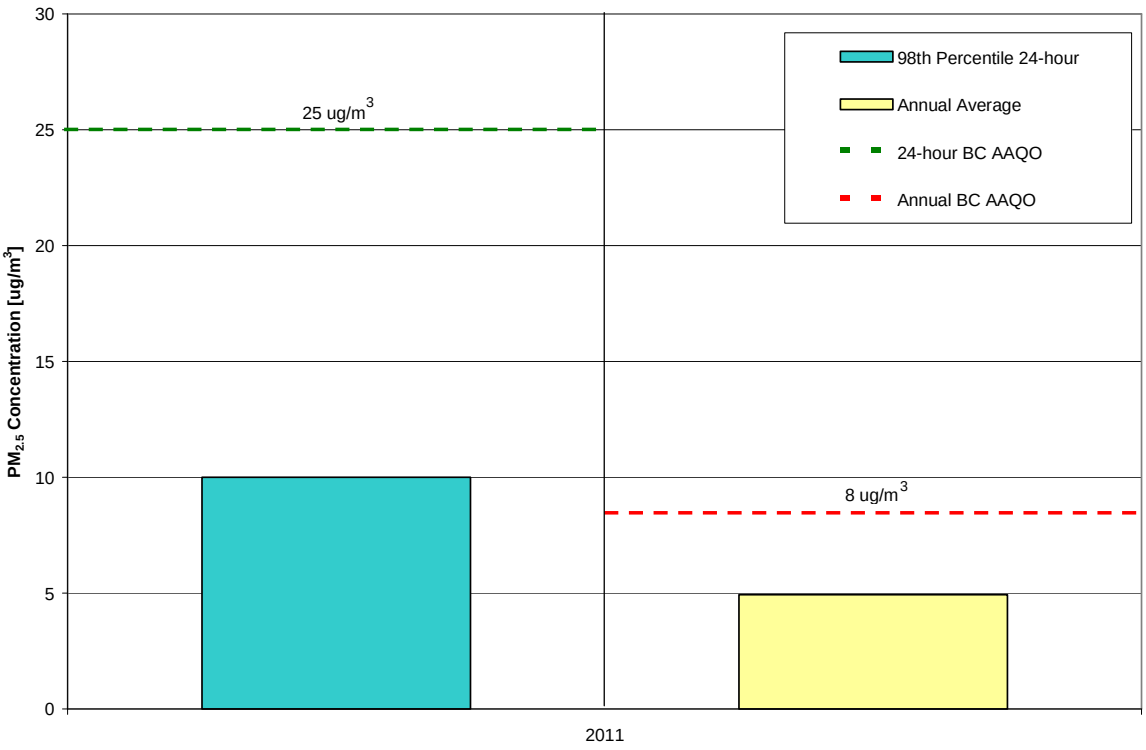

Figure 8 The Graph Displays the 24-hour and Annual Average Data Compared to Their Relavent BC AAQO

4. ODOUR

RMOW has been made aware of several odour complaints from certain parts of the Cheakamus Crossing neighbourhood. These odour issues have been associated with the operation of the asphalt plant in combination with wind speeds and directions that transport the emissions towards the residential neighbourhood. While it has not been part of Levelton's scope of work to monitor odour, we are aware of the concern. Odour observations do not necessarily indicate an air quality concern.

5. CONCLUSION

Levelton was retained by the RMOW to install an ambient air monitoring station in the Cheakamus Crossing Neighbourhood. The station is equipped with a Series 1400a TEOM unit to measure $PM_{2.5}$ with a R.M. Young anemometer to measure wind speed and direction. The station was installed in 2010 to address the concerns of potential ambient air quality issues associated with an asphalt plant located near the neighbourhood. Levelton continues to maintain the monitoring station and collect data. The data from the monitoring station for the calendar year of 2011 was summarized in this report.

The dominant wind direction recorded at the monitoring station was from the west. Winds from the southwest and south-southwest have the greatest potential to transport emissions from the asphalt plant towards the monitoring station. In 2011, the 24-hour average (based on the annual 98^{th} percentile value) $PM_{2.5}$ concentration was 10 µg/m³ and the annual average $PM_{2.5}$ concentration was 4.9 µg/m³, for both averaging periods these concentrations are below the BC AAQO of 25 µg/m³ and 8 µg/m³, respectively.

Given the proximity of the monitoring station to the Cheakamus Crossing neighbourhood, it is likely that these values are representative of the $PM_{2.5}$ concentrations in the neighbourhood.

6. 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