Air Quality in the Capital Regional District 2003

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EXECUTIVE SUMMARY

Air quality monitoring data is collected in the Capital Regional District (CRD) under the long-term air quality monitoring program which is the result of a partnership between the CRD and the British Columbia Ministry of Water, Land and Air Protection (MWLAP). This report presents an analysis of the air quality data collected in the CRD during 2003.

In June 2004, the CRD established air quality guidelines for the region. In this report, these guidelines are used for the first time to assess the regional monitoring data. Monitoring data were also compared to provincial and federal air quality objectives and standards, although these tend to be higher in value than the CRD-specific guidelines. The CRD air quality guidelines are used to help clarify the reporting of air quality to the general public and to assist the CRD in interpreting trends in air pollutant concentrations.

For the same purposes, the CRD identified the need to construct baseline concentrations for each common air contaminant to evaluate trends in future ambient air quality. This latter initiative is a requirement of the 'Keeping Clean Areas Clean' provision of the Canada Wide Standards (CWS), which calls for interim reporting beginning in 2005. The baseline concentrations were constructed using data from 2001-2003, which is a period with continuous data capture for all of the air contaminants measured in the CRD.

The 2003 monitoring data was collected from continuous and sequential (non-continuous) monitoring stations throughout the district. Concentrations of carbon monoxide (CO), nitrogen dioxide (NO_2), ground-level ozone (O_3), sulphur dioxide (SO_2), inhalable particulate matter (PM_{10}) and respirable particulate matter ($PM_{2.5}$) were measured. Analysis included looking at spatial and temporal trends to determine source-receptor relationships, especially in the case of an exceedence of an applicable guideline. Meteorological data were also analyzed to determine the influence of wind, temperature and precipitation patterns on ambient air concentrations.

Data capture at the monitoring stations was generally very good. Royal Roads station in particular had a much higher percentage of valid NO_x and ground-level ozone data available for analysis, compared to 2002. A noteworthy exception was the Langford Dogwood School station, which monitors $PM_{2.5}$. At this location, 12.2% of the hourly concentrations were missing. Since there is greater concern of late regarding the health impacts of fine particulate matter, SENES recommends that effort be applied to achieving a higher data capture rate in future years.

Monitoring data from 2003 shows that air quality in the CRD remains relatively good. With the exception of ground-level ozone, concentrations of gaseous pollutants are low compared to both CRD guidelines and provincial/federal objectives and standards. Infrequent exceedences of

PM_{10} or $PM_{2.5}$ CRD guidelines or provincial objectives can occur in the CRD. Particulate matter concentrations during 2003 were lower on average when compared to 2002, although three exceedences of the CRD $PM_{2.5}$ air quality guideline occurred during the year at Victoria Topaz and Royal Roads monitoring stations.

Ground-level ozone is measured at the Saturna Island, Victoria Topaz and Royal Roads monitoring stations. Ozone data were also collected for a short period of time in late 2003 at the Stellys site. The data set was too short to be included in detailed analysis. The CRD 8-hour guideline of 120 µg/m³ was exceeded at the Saturna Island station on two separate days (136 µg/m³ on June 17th and 139 µg/m³ on July 10th), representing an exceedence rate of less than 0.2% for the total number of hours in the year. This station consistently records the highest ozone concentrations in the CRD. The relatively infrequent exceedence of the CRD guideline and the low population density on and around Saturna Island is unlikely to result in any measurable short-term adverse health outcomes. The potential for long-term health effects from exposure to ozone during the two exceedence days is minimal.

The Saturna ozone data were also compared to the 8-hour CWS for ground-level ozone (127.6 µg/m³ for a three-year average of the 4th highest daily maximum). Although ozone concentrations have increased by a small increment at all three station locations over the past three years, the current CRD comparison value of 114.6 µg/m³ is below the standard.

There were no exceedences of the CRD 24-hour PM_{10} guideline of 50 µg/m³ at any of the six PM_{10} Hi-Vol monitoring locations. However, there were three exceedences of the CRD 24-hour $PM_{2.5}$ air quality guideline of 25 µg/m³. It was determined that the one exceedence of 39.8 µg/m³ at the Royal Roads station, which occurred on June 6th, was caused either by a localized source, or by instrument error (there were no high $PM_{2.5}$ concentrations indicated elsewhere at this time). It was noted that there was construction activity near the station in June. The two exceedences at Victoria Topaz occurred on adjoining days (October 31st and November 1st), and were likely influenced by Halloween fireworks and fires in the vicinity of the monitoring station. At this time, elevated $PM_{2.5}$ concentrations were also experienced at Stellys, although the CRD guideline was not exceeded (the Langford dataset was missing data during this interval). The spatial extent of elevated $PM_{2.5}$ concentrations above the CRD guideline value in the vicinity of the Victoria Topaz station is unknown, but may have been restricted to the immediate vicinity of the station in Topaz Park. The extent of exposure for the general public to elevated concentrations of $PM_{2.5}$ may have been relatively small (i.e., limited in extent and duration). As such, the significance of any such exposure to human health impacts is uncertain.

The CWS for $PM_{2.5}$ is based on the 98th percentile, spatially-averaged 24-hour concentration (averaged over three years). For 2003, the CRD comparison value is 12.7 µg/m³, which is well below the 30 µg/m³ standard.

Data from the Victoria Topaz station were used to determine each CRD baseline air quality concentration, with the exception of ground-level ozone. Topaz was used because it has a valid dataset for all common air contaminants during the period, and experiences the highest concentrations due to its location within the urban core of Victoria. Saturna Island data were used for the ozone baseline, as this location is somewhat removed from the urban core and therefore tends to experience higher ozone concentrations. During the last three years, the Saturna Island station recorded the highest ambient ground-level ozone concentrations of the three ozone stations in the CRD.

Consistent with the previous work done for the CRD to establish a protocol for determination of baseline concentrations, the baselines were derived using the 2001-2003 data, 98th percentile concentrations. An exception was made for the PM_{10} baseline, which is defined from the 95th percentile. This distinction was made due to the fact that all PM_{10} measurements in the CRD are produced by sequential measurements (one day in six), which produces a much smaller data set in comparison to the other air contaminants monitored in the CRD. Because of this, there is greater fluctuation in higher percentile values from year to year. These established baselines can be used in future years to track trends in the common air contaminants within the region.

1.0 INTRODUCTION

1.1 AIR QUALITY MONITORING

The air quality monitoring program conducted in the Capital Regional District (CRD) is a result of the Long Term Monitoring Program (LTMP), a partnership between the CRD and the British Columbia Ministry of Water, Land and Air Protection (MWLAP).

Air Quality data are collected and analysed for several reasons, including the following:

- to provide information on air quality to the public;
- to conduct long-term trend analysis;
- to fulfill Federal reporting requirements (re: Canada Wide Standards); and,
- to compare ambient concentrations to air quality objectives.

Air quality monitoring locations are chosen to capture air concentrations that are representative of either larger geographic areas, or ‘hot spots’ where higher contaminant air concentrations are suspected. Local topography and the location(s) of pollutant sources can indicate how well a monitoring location represents an area. With the advent of the Canada Wide Standards (CWS) for ozone and particulate matter, to be implemented by 2010, ‘community-oriented’ monitoring sites are to be used. These sites are described as locations where people live, work and play[1]. The CRD monitoring network is designed to adequately characterize the air quality in the region, and to support the initiatives described above.

Within the Capital Regional District (CRD), the following common air contaminants are monitored: carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ground-level ozone (O_3) and particulate matter (PM). In addition, nitric oxide (NO) concentrations are recorded, since these measurements are automatically made with the NO_2 sampling instrument. There is interest in ambient NO levels due to the role this gas plays as a precursor to the formation of NO_2 and O_3.

Air quality and meteorological data were collected at 4 long term monitoring stations in the CRD during 2003. The Stellys station was added later in the year and will continue to be used in the LTMP in the future. In addition, data from Saturna Island and three additional PM monitoring sites were collected. A description of the parameters measured at each monitoring station is given in Table 1.1. For particulate matter, the type of measuring instrument is also indicated.

[1] Canadian Council of Ministers for the Environment, 2000. Guidance Document on Achievement Determination: Canada Wide Standards for Particulate Matter and Ozone. www.ccme.ca.

Table 1.1 Air Quality Monitoring Stations in the Capital Regional District

Monitoring Location	Type of Site	Parameters Monitored		
		Gaseous	**Particulate Matter**	**Meteorology**
Victoria, Topaz Avenue	NAPS[1] Long Term Monitoring Site	CO, NO, NO_2 SO_2 & O_3	PM_{10} (S-Hi-Vol) PM_{10} & $PM_{2.5}$ (S-Dicot) $PM_{2.5}$ (C-TEOM)	WS, WD, T, RH
Royal Roads University	Long Term Monitoring Site	NO, NO_2, O_3	$PM_{2.5}$ (C-TEOM)	WS, WD, T, RH
Langford Dogwood School[2]	Long Term Monitoring Site		$PM_{2.5}$ (C-TEOM) PM_{10} (S-Hi-Vol)	WS, WD
Stellys, Saanich Peninsula[3]	Long Term Monitoring Site	O_3	PM_{10} (Partisol) $PM_{2.5}$ (C-TEOM)	WS, WD
Saturna Island	CAPMoN[4] Site	NO, NO_2, O_3		WS, WD
Oak Bay Recreational Centre[5]	Site of special interest (Hi-Vol)		PM_{10} (S-Hi-Vol)	
Braefoot Elementary School[6]	Site of special interest (Hi-Vol)		PM_{10} (S-Hi-Vol)	
Keating Elementary School	Site of special interest (Hi-Vol)		PM_{10} (S-Hi-Vol)	

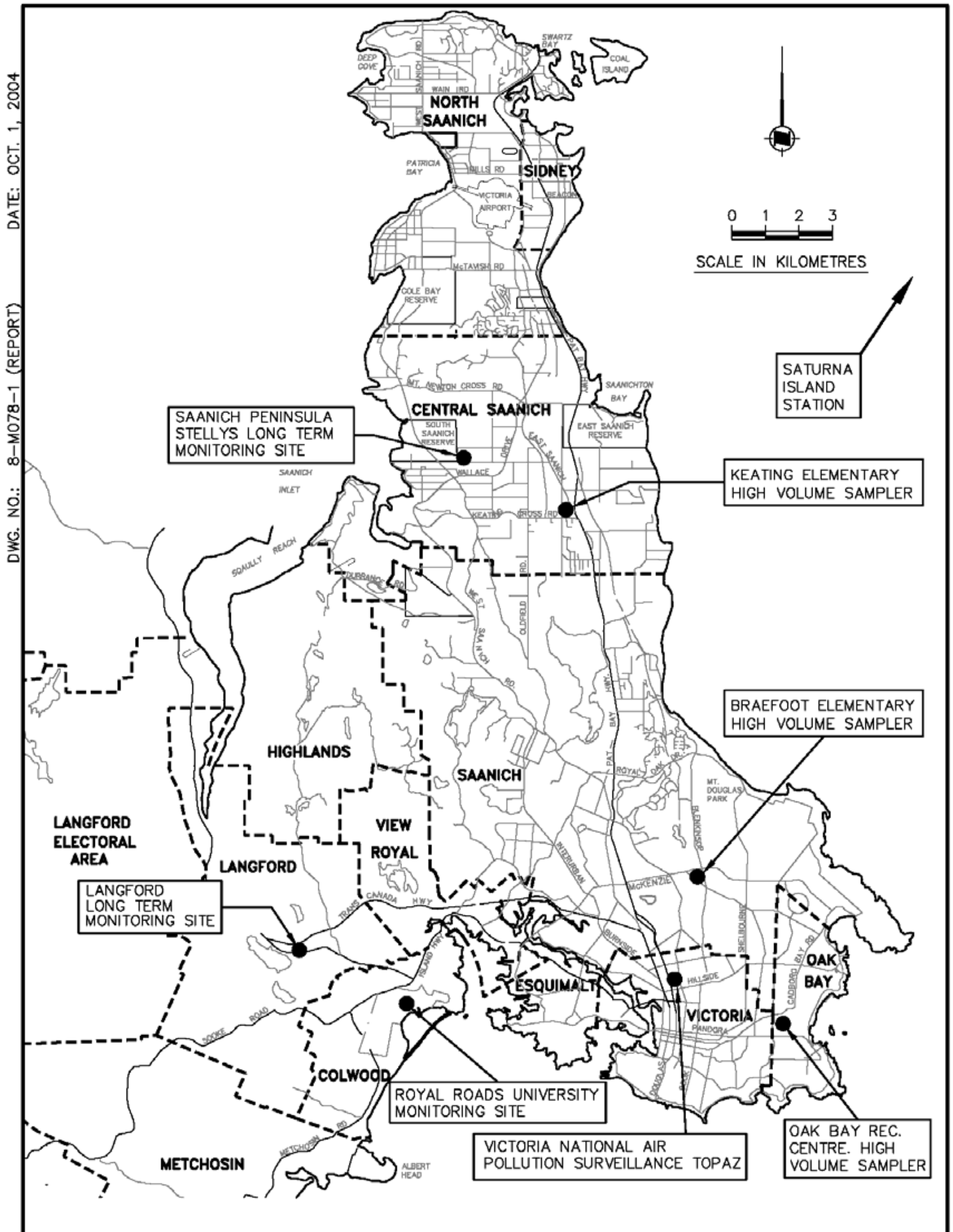
Notes:

WS – wind speed; WD – wind direction; T – temperature; RH – relative humidity
S-Hi-Vol - sequential sampling using a High Volume sampler
S-Dicot - sequential sampling using a dichotomous sampler
Partisol – sequential sampling using constant air flow Partisol sampler
C-TEOM – continuous sampling using Tapered Element Oscillating Microbalance samplers
1- National Air Pollution Surveillance
2- Station began operating in November, 2002
3- Station began operating in August, 2003
4- Canadian Air and Precipitation Monitoring Network
5- Special area of interest since October 1996
6- Special area of interest since November 1995

Gaseous air pollutants are monitored at four station locations. The National Air Pollution Surveillance (NAPS) station at Victoria Topaz measures CO, NO, NO_2, SO_2, and O_3. NAPS is a joint federal, provincial territorial and municipal network of (primarily) urban monitoring sites throughout Canada, and was established in 1969. The Royal Roads site collects NO, NO_2 and O_3. Stellys (Saanich Peninsula) collects O_3, since August of 2003. These data were made available by the Province. Ground-level ozone is also monitored at the Canadian Air and Precipitation Monitoring (CAPMoN) station on nearby Saturna Island. CAPMoN is similar in scope to NAPS, but is a rural network with fewer stations. Ozone data from this station were provided by Environment Canada.

Particulate matter is measured at each of the 4 CRD long term monitoring stations, the CAPMoN site and the three other sites of interest. Four different sampling instruments were used to determine inhalable particulate matter (PM_{10}) concentrations and respirable particulate matter ($PM_{2.5}$) concentrations. The differences between the three types of sampling instruments are described in chapter 4. All PM monitoring data were supplied by the Province. Figure 1.1 shows the location of each monitoring station.

Air quality concentrations can have considerable spatial variation in an airshed. It is for this reason that air contaminants of greater concern are measured at more than one location within the CRD. In the past, the ability to conduct long-term trend analysis has been limited, due to lack of monitoring data from stations that remain fixed spatially for extended periods of time. Victoria Topaz has now been located at the same spot since 1998. The CAPMoN site at Saturna has also remained fixed for the same period (and likely much longer). Data from these stations can be used to establish air quality baselines that enable trend analysis to be conducted for each common air contaminant measured in the CRD. The creation and discussion of CRD air quality baselines is presented in Appendix B.



2003 LOCATIONS OF SAMPLING SITES FOR THE CRD LONG TERM MONITORING PROGRAM

FIGURE 1-1

1.2 CRD AIR QUALITY GUIDELINES

Jurisdictions within British Columbia have the flexibility to define ambient air quality guidelines that are below the national criteria. There is a growing awareness of the need to update existing national and provincial air quality objectives and guidelines in Canada. Although the Canada-Wide Standards setting process has addressed the need to update ambient air quality criteria for ground-level ozone and fine particles ($PM_{2.5}$), the current objective level for PM_{10} was established in 1995, and the objectives for CO, SO_2 and NO_2 have not been reviewed since the mid-1970's. The existing provincial and national objectives may not reflect the current knowledge and understanding of the health effects of these air pollutants.

Furthermore, apart from the numerical standards for particulate matter and ozone, the CWS setting process has a requirement for continuous improvement and keeping clean areas clean for those areas where existing ambient concentrations of $PM_{2.5}$ and ozone fall below the numerical standards. According to a recent discussion paper[2], the concept of keeping clean areas clean can be described as a framework on managing ambient concentrations of particulate matter and ozone below the CWS to minimize any increase in ambient concentrations and, ideally, maintain or reduce ambient concentrations.

During 2003, the CRD initiated a process of defining ambient air quality guidelines for use in both trend analysis and reporting. This process resulted in CRD-specific air quality guidelines and established a methodology for determining baseline concentrations of all common air contaminants monitored in the CRD[3]. The air quality guidelines and provisional baseline levels are listed in Table 1.2. The CRD air quality guidelines are equal to, or lower than all existing federal and provincial objectives or standards. Appendix C contains a discussion and listing of all relevant provincial and federal air quality objectives.

The Canada Wide Standards are currently set at 127.6 $\mu g/m^3$ (fourth highest eight-hour daily maximum concentration), and 30 $\mu g/m^3$ (98^{th} percentile), averaged over three consecutive years, for ozone and $PM_{2.5}$ respectively[4].

[2] Schutte, A, and I. Liepa 2003. *Continuous Improvement and Keeping Clean Areas Clean: An Issues Paper*. Prepared for the Air pollution Prevention Directorate, Transboundary Air Issues Branch, Environmental Protection Service, Environment Canada and the Canadian Council of Ministers of the Environment by Levelton Engineering Limited, Richmond, BC.

[3] SENES Consultants Ltd., 2004. *Development of Air Quality Guidelines for the Capital Regional District*. Final Report, May 2004.

[4] Canadian Council of Ministers for the Environment, 2000. Guidance Document on Achievement Determination: Canada Wide Standards for Particulate Matter and Ozone. www.ccme.ca.

Table 1.2[5]
Air Quality Guidelines for the Capital Regional District

Category/Averaging Time	Pollutant Concentration (in µg/m³)					
	CO	NO_2	SO_2	O_3	PM_{10}	$PM_{2.5}$
Upper-bound Guideline						
1-hour		200				
8-hour	5,500			120		
24-hour			125		50	25
Provisional Baseline						
1-hour		55				
8-hour	1,850			90		
24-hour			20		40	20

(cyan)	WHO Guideline
(green)	BC Ambient Air Quality Objective
(yellow)	Recommended – CARB & Puget Sound; adopted in Newfoundland & New Zealand
(blue)	Approximate 98th percentile value in 2002 at Topaz (CO, NO_2, SO_2 &$PM_{2.5}$), Colwood (PM_{10}) and Saturna (O_3)

[5] Taken from *Development of Air Quality Guidelines for the Capital Regional District*. SENES Consultants Ltd., May 2004.

1.3 METEOROLOGICAL MONITORING

Local meteorological conditions dictate the transport, chemical reaction and dispersion of air contaminants released into the CRD airshed. In addition, climatic conditions influence anthropogenic activity such as burning fuel for home heating or transportation. Data from the Victoria Topaz, Royal Roads University and Saturna Island meteorological stations were acquired and used to characterize the wind patterns experienced during 2003 in the CRD. As well, climate data from the Victoria International Airport were used to depict monthly mean temperatures and precipitation amounts. Meteorological monitoring now occurs at the Langford and Stellys locations as well, although a full annual dataset for 2003 is not available for these stations.

Climate data for Victoria in 2003 is shown in Table A.1, Appendix A, and Table A.2 shows the climate norm between 1971 – 2000. Generally, 2003 experienced greater total precipitation, with a drier summer and a wetter winter than the climate norm. In particular, the month of October had much more rainfall than is normal, and February was far drier.

For each of the three meteorological monitoring sites, a high percentage of the hourly-mean wind speed and direction was available. The Royal Roads station had the lowest data capture, at 96.3% retrieval, followed by Victoria Topaz and Saturna Island, each with 99.7% of the hourly values for the year. Wind rose diagrams, which show the frequency of wind direction and wind speed experienced at a location, were created for each station and are shown in Appendix A. In each case, these diagrams are very similar to the corresponding wind rose diagrams constructed from 2002 meteorological data[6].

1.3.1 Victoria Topaz

The Victoria Topaz station is located at 923 Topaz Avenue, close to Blanshard St., which is a major traffic artery. The site is jointly run by the provincial and federal governments as part of the National Air Pollutant Surveillance (NAPS) program. This station is located several kilometres from the coast and characterizes the urban environment in Victoria.

Wind speed, wind direction, temperature and relative humidity were monitored for the duration of 2003. The wind rose diagram for Victoria Topaz is presented in Figure A.1 (Appendix A).

Wind speeds experienced at this location were generally light, with an average of 2.8 m/s, and calm conditions (wind speeds less than 0.5 m/s) reported 1.6% of the time. Winds from the southwest occurred most frequently, followed by northerly and southeasterly flow. High wind

[6] SENES Consultants Ltd., 2003. *Air Quality in the Capital Regional District, 2002*.

speeds tended to occur with a southwesterly or southeasterly direction. Winds from the northwest tended to be very light.

1.3.2 Royal Roads University

The Royal Roads University station is located on the Cobourg Peninsula, near Esquimalt Lagoon. The site is operated by the University, which collected wind speed, wind direction and temperature data for the duration of 2003. Figure A.2 (Appendix A) presents the wind rose diagram for the station.

The prevalent wind direction at Royal Roads is quite different than for the Topaz station, even though the two stations are separated by just 8 km. The windrose diagram has a high percentage of light winds from the north-northwest. Westerly winds tended to be higher in speed than from other directions. The average wind speed for the year was 2.5 m/s.

The lack of southwesterly flow experienced at this site, yet clearly indicated at the other two meteorological sites, suggests that this monitoring location may not have proper exposure to the regional flow, and instead is indicative of localized circulations. A study to determine whether the wind sensor is performing properly is advised.

1.3.3 Saturna Island

The meteorological station on Saturna Island is a Canadian Air and Precipitation Monitoring site (CAPMoN) operated by Environment Canada. This location is northeast of Victoria, out in the Strait of Georgia. The wind rose diagram for the station is presented in Figure A.3 (Appendix A).

The annual average wind speed at the Saturna station (4.5 m/s) is significantly higher than those at the other two stations, which is normal for this location. Winds were most frequent from a south/southwesterly direction, similar to the Victoria Topaz location. In addition, wind from the northwest occurred almost 20% of the time.

2.0 GASEOUS POLLUTANTS

Gas samplers take a measurement of the ambient air concentrations every several seconds. These values are then used to produce 1-hour averages, which can be re-averaged to produce 8-hour or 24-hour average concentrations. The samplers are designed to automatically re-calibrate themselves at relatively frequent intervals, which causes them to periodically 'miss' an hourly measurement.

2.1 CARBON MONOXIDE (CO)

Carbon monoxide is a colourless, odourless and tasteless gas that is produced both naturally from events such as volcanic eruptions and forest fires, and from the incomplete combustion of fuels containing carbon. In urban areas, motor vehicles are the largest source of carbon monoxide. CO has a strong affinity for haemoglobin in blood, and is able to impair the ability of blood to transport oxygen. Because of this ability, CO is considered a major atmospheric pollutant.

Hourly CO concentrations were measured at the Victoria Topaz monitoring station with a total of 8385 hours of valid data (4.3% missing) in 2003. The hourly concentrations are described in Table 2.1.1.

Table 2.1.1 Hourly CO Concentrations at Victoria Topaz

Percentile Values						Max $\mu g/m^3$	Min $\mu g/m^3$	Mean $\mu g/m^3$	Std. Dev. $\mu g/m^3$	Missing Values
5	25	50	75	98	99					% of Total Hours
0	100	200	500	2000	2700	9000	0	371	512	4.3

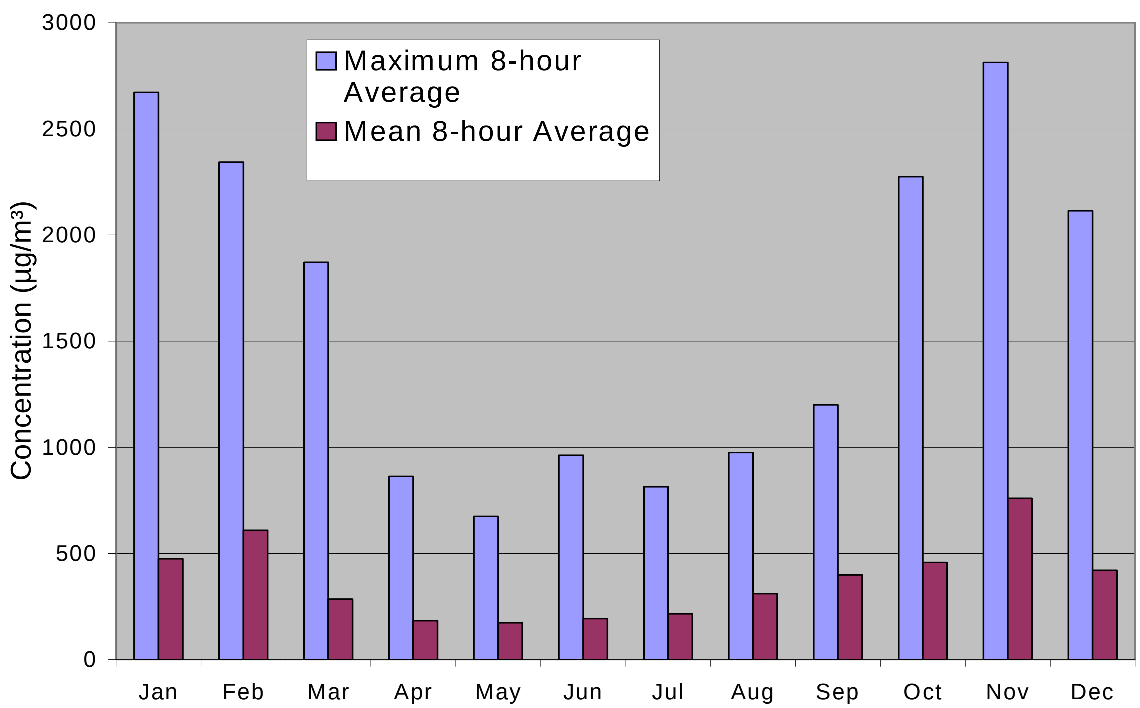
The 8-hour sequential average concentrations for this site are summarized in Table 2.1.2. No exceedences of the 8-hour CRD objective of 5,500 $\mu g/m^3$ were determined.

Table 2.1.2 8-Hour Sequential Mean of CO at Victoria Topaz

Percentile Values						Max µg/m³	Min µg/m³	Mean µg/m³	Std. Dev. µg/m³	Percent of 8-h Averages > CRD Guideline (5500 µg/m³)	Missing Values[a]
5	25	50	75	98	99						% of Total 8-h Averages
36	125	250	483	1662	1931	2813	0	371	382	0.0	0.1

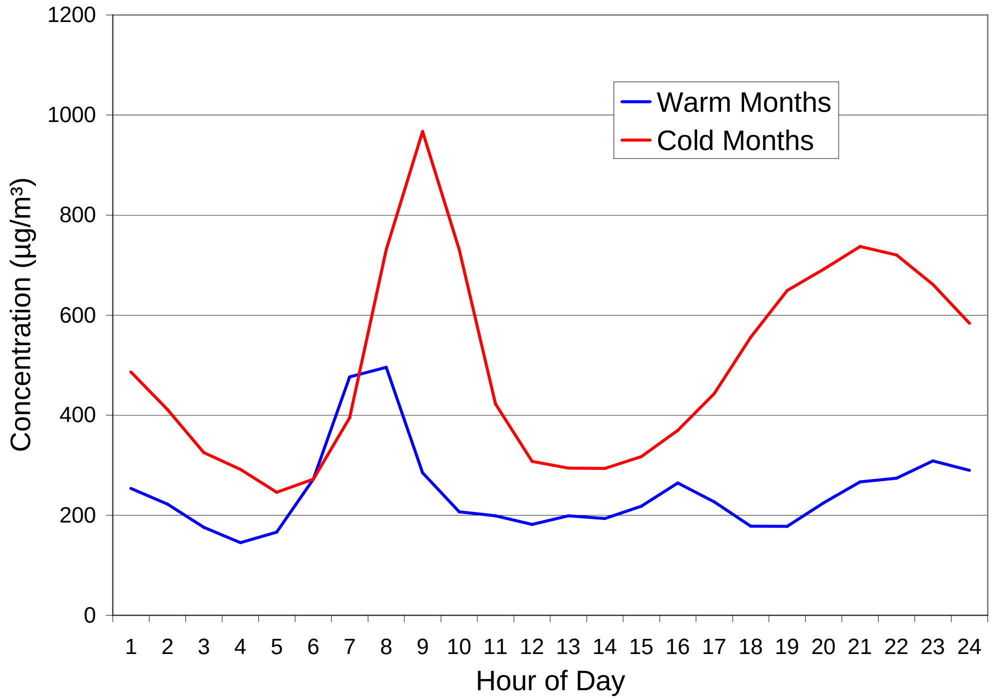
Figure 2.1.1 shows the maximum and mean sequential 8-hour concentrations for each month of 2003. A clear pattern of higher CO concentrations during the cooler months is evident. Increased use of fuel for heating of homes is a likely contributor to the higher winter concentrations. Figure 2.1.2 shows the average diurnal pattern of CO levels during both warm and cold months at Victoria Topaz. Each profile shows an early morning increase in concentrations, but only the winter profile shows a secondary peak in the evening. The first peak is due to morning vehicular traffic, and for the cold months the second peak is caused by traffic and additional emissions from the use of fuels for residential space heating.

Figure 2.1.1 Maximum and mean 8-Hour CO Concentrations by Month at Victoria Topaz



[a] An 8-hour average concentration was determined for every interval having 6 or more valid hours of data.

Figure 2.1.2 Average Diurnal CO Pattern for Victoria Topaz During Cold Months (November - March) and Warm Months (April – October)



Comparison of CRD CO concentrations to provincial and federal objectives is shown in Appendix C.

2.2 NITROGEN OXIDES (NO AND NO_2)

Of the five major nitrogen gases in the atmosphere, nitric oxide (NO) and nitrogen dioxide (NO_2) have been identified as pollutants in the lower atmosphere. Due to the fact that NO and NO_2 easily convert from one form to the other in photochemical reactions, they are commonly referred to collectively as 'NO_x'. Nitric oxide is colourless, odourless and tasteless, and not considered toxic at the concentrations found in the lower atmosphere. There are no CRD or provincial/federal air quality guidelines or objectives for NO. At high enough concentrations, nitrogen dioxide has an orange/red colour and an irritating odour. It is also considered toxic at higher concentrations. NO_2 can cause both health-related effects and the reduction of light transmittance in air (causing reduction in visibility).

In urban settings, NO is formed by high temperature combustion processes, such as automobile exhaust, fossil-fuel electricity generating stations, industrial incinerators and residential space heating. NO concentrations commonly follow daily transportation cycles, with peaks in the early morning and late afternoon. NO_2 is produced by the direct oxidation of NO and by a complex balance of reactions involving other atmospheric constituents including ozone. Peak NO_2 levels tend to follow NO maximums by several hours, due to chemical and photochemical oxidation of NO.

During 2003, NO and NO_2 hourly concentrations were taken at the Victoria Topaz and Royal Roads monitoring stations. Table 2.2.1 shows an analysis of the hourly data. For both stations, there were no exceedences of the CRD 1-hour guideline of 200 µg/m³. The mean and maximum concentrations experienced at the Topaz site were considerably higher than those at the Royal Roads site, due to the Topaz station being situated within the urban centre of Victoria.

Table 2.2.1 Hourly NO_2 Concentrations in the CRD

Percentile Values						Max µg/m³	Min µg/m³	Mean µg/m³	Std. Dev. µg/m³	Percent of 1-h Averages > CRD Guideline (200 µg/m³)	Missing Values
5	25	50	75	98	99						% of Total Hours
Victoria Topaz											
3.8	9.6	19.1	30.6	61.2	68.8	124.3	0.0	21.7	15.0	0.0	5.6
Royal Roads University											
0.0	1.9	7.6	15.3	36.3	40.2	61.2	0	10.3	10.1	0.0	4.5

Table 2.2.2 presents a summary of the sequential 24-hour average concentrations for NO_2 in 2003.

Table 2.2.2 24-Hour Sequential Mean NO_2 Concentrations in the CRD

Percentile Values						Max µg/m³	Min µg/m³	Mean µg/m³	Std. Dev. µg/m³	Missing Values[b]
5	25	50	75	98	99					% of Total 24-h Averages
Victoria Topaz										
9.1	15.7	20.2	25.6	45.4	50.6	59.1	3.0	21.7	8.8	1.9
Royal Roads University										
0.7	4.2	9.4	15.5	26.3	28.2	34.0	0.0	10.3	7.4	0.3

[b] A 24-hour average concentration was determined for any day having 18 or more valid hours of data.

The monthly average NO and NO_2 concentrations are shown in Figure 2.2.1. NO concentrations are higher in the winter months. The NO_2 monthly concentrations do not follow this pattern, likely due to differences in conversion rates of NO to NO_2 by month. Greater solar insolation and higher temperatures during the spring and summer months allow a greater percentage of NO conversion to NO_2. In addition, mixing heights are typically higher during the warmer months, allowing emitted NO to disperse through greater volumes of air, thereby reducing ground level concentrations.

Figure 2.2.2 shows a similar comparison for the Royal Roads monitoring location. At this site, NO and NO_2 concentrations are very low during the spring and summer months. An analysis of wind direction from the adjoining meteorological station during these months (not shown here) indicates that the prevalent directions are southerly and westerly, bringing in relatively clean air from offshore locations. Much of the NO released in the urban core of Victoria does not mix with the air surrounding the Royal Roads site during these months.

Figure 2.2.1 Average 24-Hour NO and NO_2 Concentrations by Month at Victoria Topaz

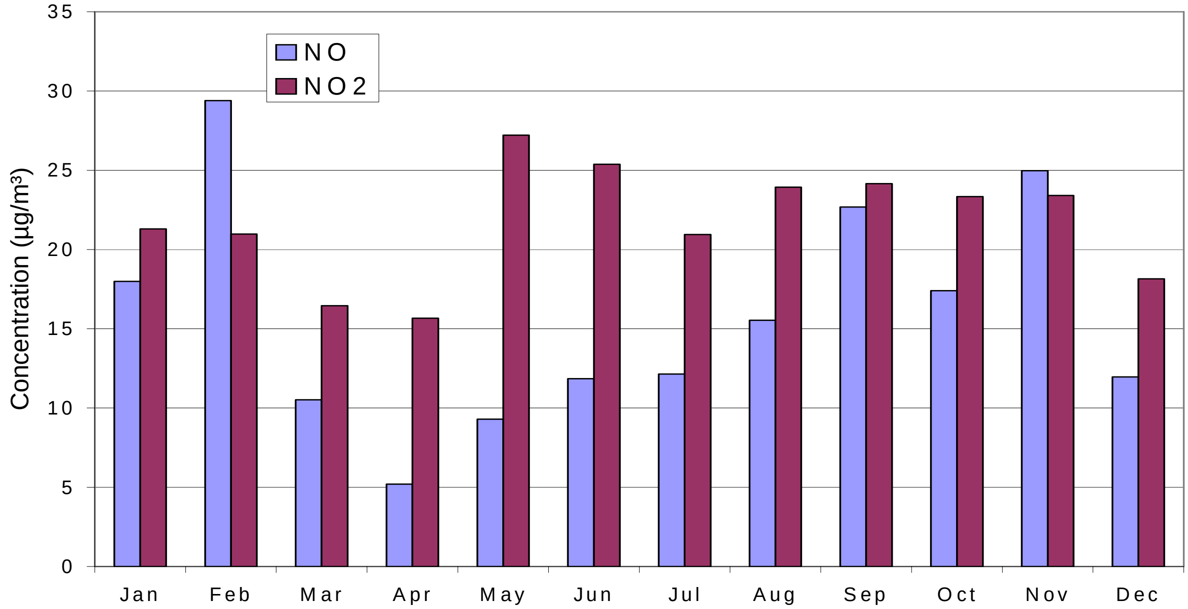
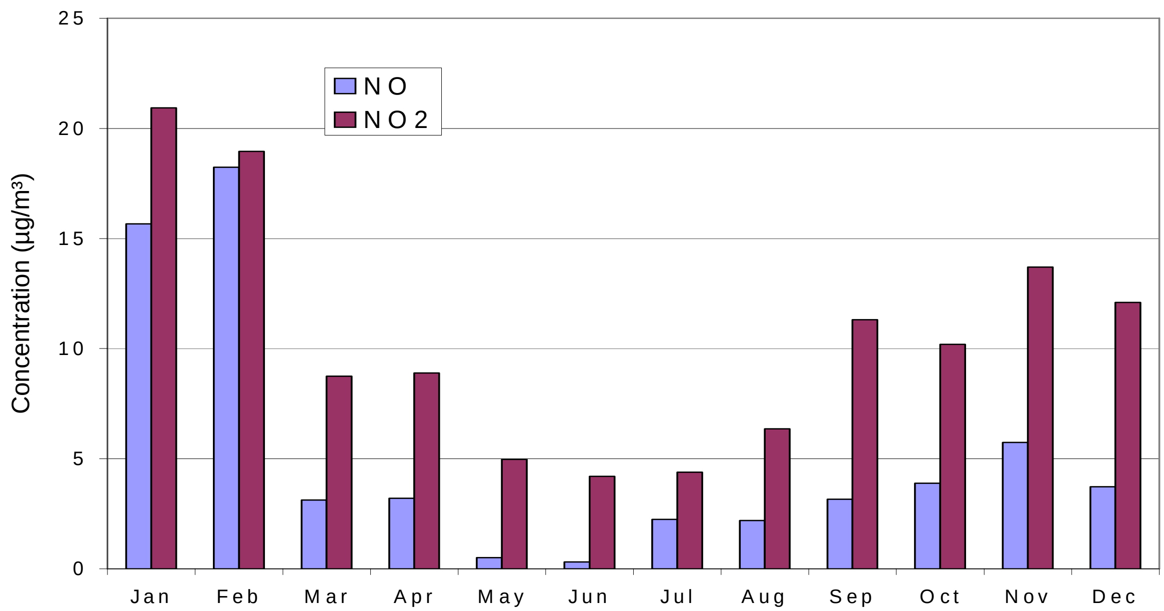


Figure 2.2.2 Average 24-Hour NO and NO_2 Concentrations by Month at Royal Roads University



Figures 2.2.3 and 2.2.4 show the average diurnal pattern of NO and NO_2 at Victoria Topaz and Royal Roads University. Each figure shows peaks in both NO and NO_2 coinciding with increased traffic volumes in the morning and late afternoon. The afternoon NO peaks are lower than during the morning, due to generally higher afternoon mixing heights, and increased oxidation of NO to NO_2. NO_2 concentrations tend to vary by a lesser degree throughout the day.

Figure 2.2.3 Average NO and NO_2 Diurnal Pattern for Victoria Topaz in 2003

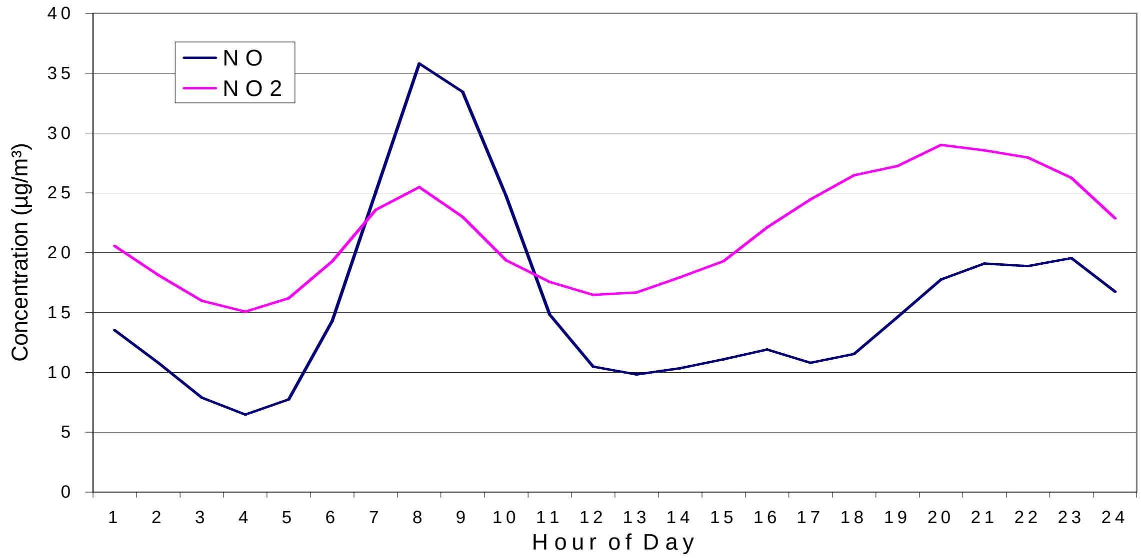
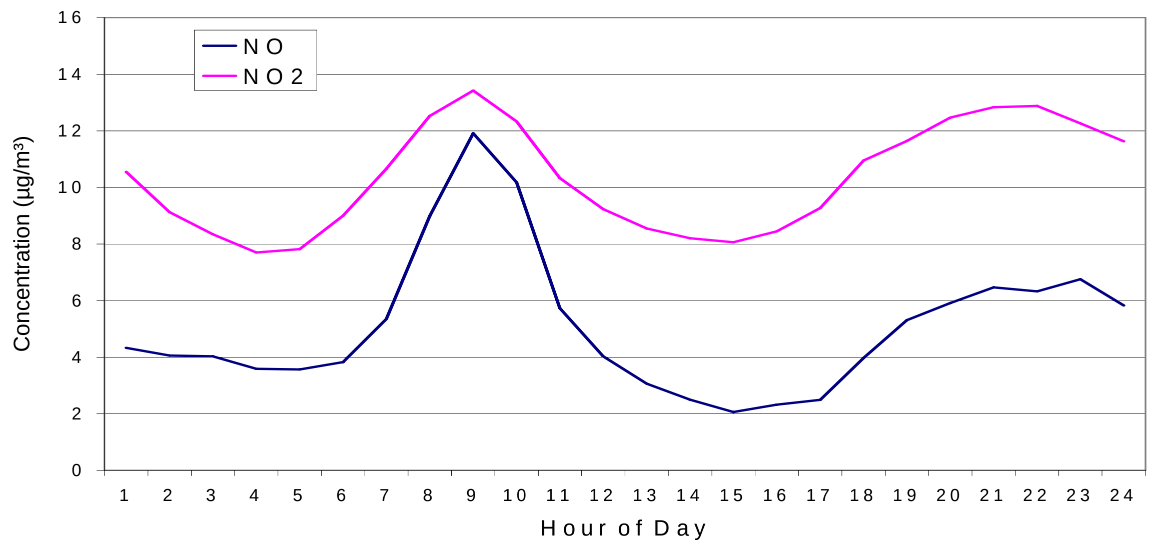


Figure 2.2.4 Average NO and NO_2 Diurnal Pattern for Royal Roads University in 2003



Comparison of CRD NO_2 concentrations to provincial and federal objectives is shown in Appendix C.

2.3 SULPHUR DIOXIDE (SO_2)

SO_2 is considered a hazardous gas due to both its direct affect on human respiration, and its ease of conversion in the atmosphere to sulphuric acid, potentially leading to acid rain. SO_2 can also be converted to sulphates, which are a component of suspended particulate matter. Background concentrations of sulphur dioxide tend to be relatively low, but elevated levels are possible near industrial areas.

Anthropogenic emissions are the greatest contributor to concentrations experienced in the lower troposphere[7]. SO_2 is produced by the combustion of fossil fuels. Burning fuel with greater levels of sulphur and sulphides results in higher SO_2 emissions. SO_2 was monitored at the Victoria Topaz monitoring station in 2003. Table 2.4.1 shows the 1-hour and annual average concentrations. Table 2.4.2 summarizes the 24-hour concentrations, which are well below the CRD guideline of 125 µg/m³.

Table 2.3.1 Hourly SO_2 Concentrations at Victoria Topaz

Percentile Values						Max µg/m³	Min µg/m³	Mean µg/m³	Std. Dev. µg/m³	Missing Values
5	25	50	75	98	99					% of Total Hours
0	0	0	3	19	24	178	0	3.0	5.9	4.2

Table 2.3.2 24-Hour Sequential Mean SO_2 Concentrations at Victoria Topaz

Percentile Values						Max µg/m³	Min µg/m³	Mean µg/m³	Std. Dev. µg/m³	Percent of 24-h Averages > CRD Guideline (125 µg/m³)	Missing Values[b]
5	25	50	75	98	99						% of Total 24-h Averages
0.1	0.9	2.0	3.9	12.0	14.2	25.0	0.0	3.0	3.2	0.0	0.0

[7] Godish, 1991. *Air Quality*. 2nd Edition. Lewis Publishers Inc, Michigan, U.S.A.
[b] A 24-hour Concentration was determined for every day having 18 or more valid hours of data.

The monthly average and monthly maximum 24-hour average SO_2 concentrations at Victoria Topaz are illustrated in Figure 2.4.1, and the average diurnal pattern for both cooler and warmer months are shown in Figure 2.4.2.

Maximum 24-hour concentrations were relatively high during the summer and early fall, although average concentrations remained similar to other months. A bimodal distribution is evident for the average daily SO_2 concentrations during the cooler months, which is not indicated during warmer months. A contributing cause of the peak during early evening for the cooler months is the combustion of sulphur-containing fuel for home heating. Increased traffic volumes contribute to the morning peak that is present in both profiles.

Figure 2.3.1 Average and Maximum SO_2 Concentrations by Month at Victoria Topaz

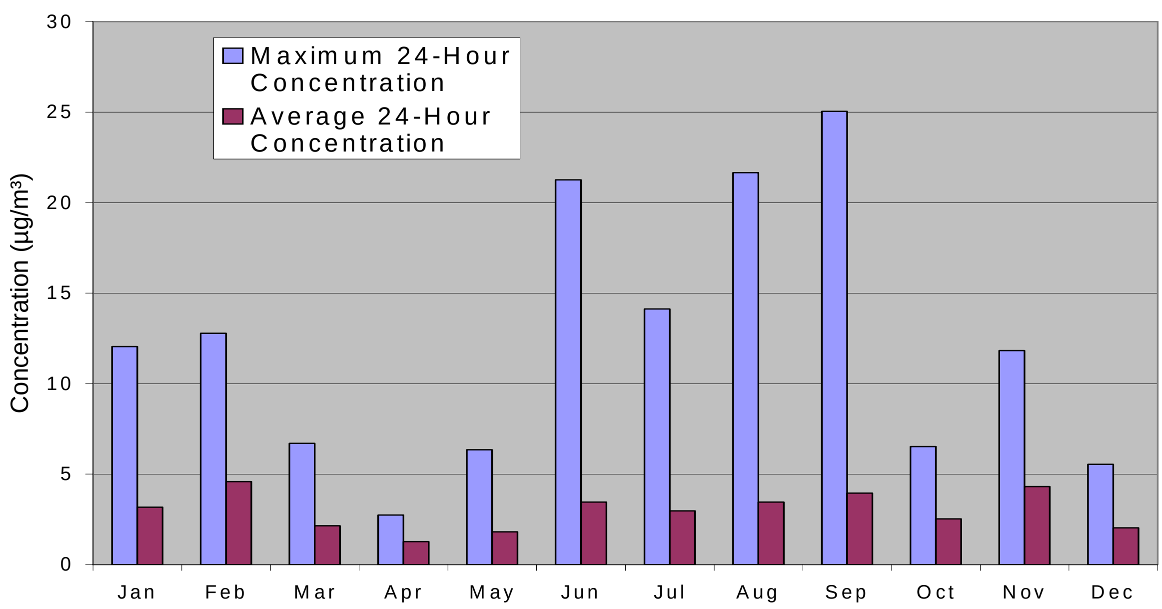
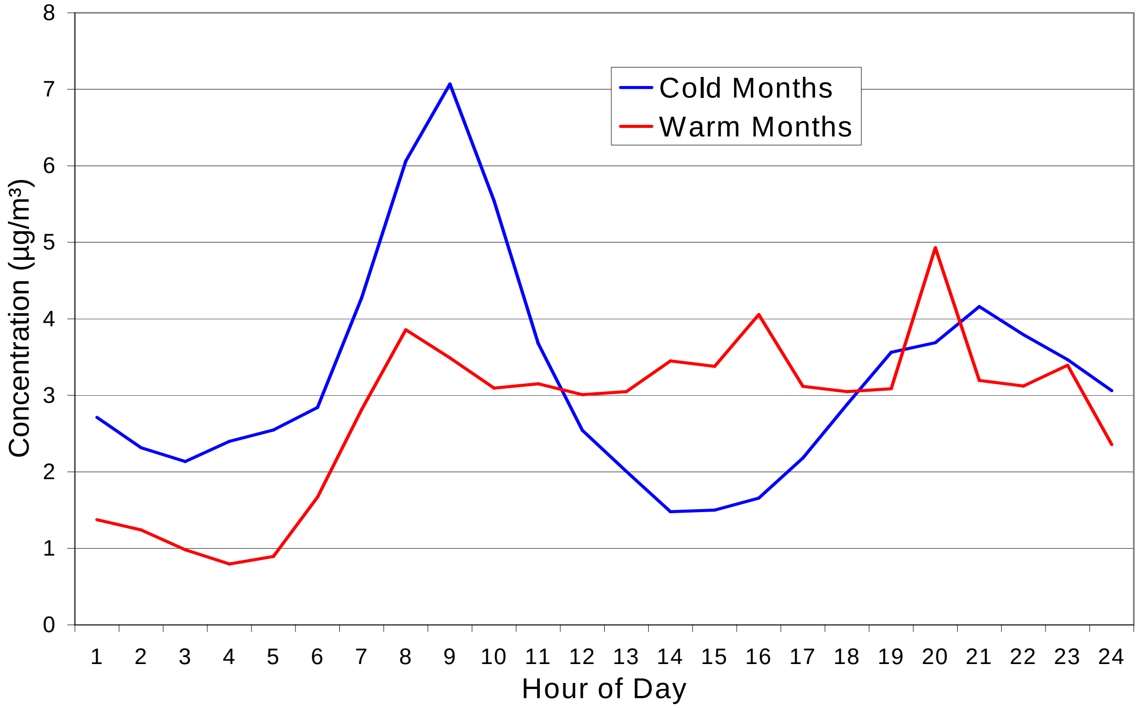


Figure 2.3.2 Average SO_2 Concentrations at Victoria Topaz by Hour of Day



Comparison of CRD SO_2 concentrations to provincial and federal objectives is shown in Appendix C.

2.4 GROUND-LEVEL OZONE (O_3)

Ozone is a gas that naturally exists and is created in the stratosphere, where it is essential for absorbing harmful ultraviolet radiation from the sun. Ozone can also occur in the lower troposphere, where it is called ground-level ozone. Ground-level ozone is a secondary pollutant, meaning that it is formed by the chemical reactions of primary pollutants. Ozone is a strong irritant to the eyes and upper respiratory system, and can also damage crops and man-made materials.

Anthropogenic production of ozone occurs from the photochemical reaction of nitrogen oxides and volatile organic compounds (VOCs). VOCs are emitted by motor vehicles, chemical plants, refineries and natural sources. VOCs include compounds such as benzene, naphthalene, toluene and many others. Sunny (high pressure), warm conditions favour ozone production. Urban ozone levels commonly have a diurnal pattern that follows that of vehicular activity and solar insolation. Ozone is considered a regional pollutant, since it can be produced at considerable distances downstream from the areas where the primary pollutants are released; in Canada, rural areas commonly experience higher ozone concentrations than at nearby urban locations. Changing weather patterns contribute to yearly differences in monitored ozone concentrations.

Background levels of ground-level ozone are naturally produced by the reaction of compounds in the lower troposphere and by intrusion of stratospheric ozone. It is known that in some areas the background ozone concentration can exceed existing Federal air quality objectives. During 2003, a full year of hourly ground-level ozone data was recorded at Victoria Topaz, Royal Roads University and at the CAPMoN station on Saturna Island. An additional two years of ozone data (for 2001 and 2002) were used for the Saturna Island site to facilitate comparison to the Canada Wide Standard.

Table 2.3.1 presents a summary of the hourly ozone measurements for 2003. The monitoring station at Stellys was not operating during the spring and early summer, when ground-level ozone concentrations tend to be highest in the CRD. Measured concentrations at this site during the fall and early winter of 2003 are similar in magnitude to those from the other two sites that are more urban in setting than Saturna. Concentrations at Saturna Island are shown to be considerably higher than those experienced at Topaz and Royal Roads, due to its location downwind of the urban core.

Table 2.4.1 Hourly Ozone Concentrations in the CRD

Percentile Values						Max $\mu g/m^3$	Min $\mu g/m^3$	Mean $\mu g/m^3$	Std. Dev. $\mu g/m^3$	Missing Values
5	25	50	75	98	99					% of Total Hours
Victoria Topaz										
0.0	16.0	37.9	57.9	85.8	89.8	117.7	0.0	37.8	25.1	6.4
Royal Roads University										
2.0	14.0	38.9	67.8	95.8	99.8	119.7	0.0	42.1	29.4	9.7
Stellys										
2.0	16.0	37.9	57.9	79.8	83.8	97.8	0.0	36.7	23.4	72.0
Saturna Island										
19.6	41.2	58.8	74.5	107.8	113.7	158.8	2.0	58.4	24.0	0.8

Table 2.3.2 shows the 8-hour rolling average concentrations at the 4 monitoring sites. Rolling average concentrations are used to be consistent with that required for CWS achievement. There were no exceedences of the CRD 8-hour guideline of 120 µg/m³ at Topaz, Royal Roads and Stellys. The guideline was exceeded on 13 occasions (0.2% of the year) at the Saturna station. These exceedences occurred over the course of two separated days (during six hours on June 16 and seven on July 9th).

Table 2.4.2 8-Hour Rolling Average Ozone Concentrations in the CRD

Percentile Values						**Max µg/m³**	**Min µg/m³**	**Mean µg/m³**	**Std. Dev. µg/m³**	**Number of 8-h Averages > CRD Guideline (120 µg/m³)**	**Missing Values[a]**
5	**25**	**50**	**75**	**98**	**99**						**% of Total Hours**
Victoria Topaz											
4.0	20.2	37.0	55.0	80.1	84.0	103.3	0.0	37.9	21.7	0	2.6
Royal Roads University											
5.0	18.9	39.1	64.6	92.1	94.8	107.8	0.0	42.1	26.4	0	6.4
Stellys											
4.3	20.5	37.2	53.4	75.3	80.7	84.8	0.0	36.8	20.3	0	70.9
Saturna Island											
21.6	42.4	58.6	73.5	103.6	108.1	139.4	2.0	58.4	22.3	13	0.8

The relatively infrequent exceedence of the CRD guideline and the low population density on and around Saturna Island is unlikely to result in any measurable short-term health outcomes. The potential for health effects from exposure to ozone during the two exceedence days is minimal.

The Canada Wide Standard for ozone, to be implemented in 2010, is based on 8-hour rolling averages. The annual 4th highest, daily maximum concentration, averaged over three consecutive years, at a monitoring station location representative of the highest metropolitan (urban) ozone concentrations is used. Typically, the lowest ozone concentrations within a Census Metropolitan Area (CMA) occur within the urban centre and the highest concentrations occur in the suburban fringes[8]. The Topaz, Royal Roads University and Stellys monitoring locations are not representative of locations where maximum ozone concentrations would be expected to occur, due to nearby production of ozone precursors. Instead, locations somewhat downstream of

[a] An 8-hour average concentration was calculated for each interval having 6 or more hours of valid data.
[8] Canadian Council of Ministers for the Environment, 2000. Guidance Document on Achievement Determination: Canada Wide Standards for Particulate Matter and Ozone. www.ccme.ca.

higher NO_x and VOC concentrations experience higher ozone levels. The Saturna Island monitoring location, although not representative of a location where a sizeable portion of people in the CRD live and work, clearly experiences higher ozone concentrations than the two urban sites. Therefore, the Saturna Island monitoring data provides a more conservative indication of CWS compliance for ozone in the CRD. Computer modelling can be used to predict the magnitudes and locations where maximum ground-level ozone concentrations occur in the CRD. This effort could be helpful to support the assumption that Saturna Island ozone concentrations are representative of the highest values experienced in the CRD. However, due to the complexity of ozone chemistry, long range transport issues, and the temporal and spatial variability in emissions of precursor gases, such a modelling exercise is a non-trivial task.

Table 2.4.3 8-Hour Rolling Mean Ozone Concentrations at Saturna Island, 2001-2003

Year	% 8-Hour Concentrations Missing	Mean 8-Hour Concentration (μg/m^3)	Maximum 8-Hour Concentration (μg/m^3)	4th Highest Daily Maximum 8-Hour Concentration (μg/m^3)
2001	2.2	53.4	120.8	112.9
2002	1.9	55.9	116.9	115.4
2003	1.2	58.4	139.4	115.4

Table 2.3.3 summarizes the rolling 8-hour average ozone concentrations at Saturna Island for 2001 – 2003. The annual mean concentration has increased over the past three years. The average 4th highest annual daily maximum 8-hour ozone concentration for the three years is 114.6 μg/m^3. This is below the CWS of 65 ppb, which is equivalent to 127.6 μg/m^3. It should be noted that a similar comparison in the 2002 air quality report for the CRD improperly used sequential 8-hour averages instead of the required rolling averages[9]. The appropriate 8-hour averages for 2000 – 2002 are noted in Table 2.3.4. During this period, the CWS comparison value is 110.2 μg/m^3.

Table 2.4.4 8-Hour Rolling Mean Ozone Concentrations at Saturna Island, 2000-2002 (Correction from 2002 AQ Report)

Year	% 8-Hour Concentrations Missing	Mean 8-Hour Concentration (μg/m^3)	Maximum 8-Hour Concentration (μg/m^3)	4th Highest Daily Maximum 8-Hour Concentration (μg/m^3)
2000	1.2	49.7	111.5	102.2
2001	2.2	53.4	120.8	112.9
2002	1.9	55.9	116.9	115.4

[9] SENES Consultants Ltd., 2003. *Air Quality in the Capital Regional District, 2002*.

The sequential 24-hour average ozone concentrations are presented in Table 2.3.5.

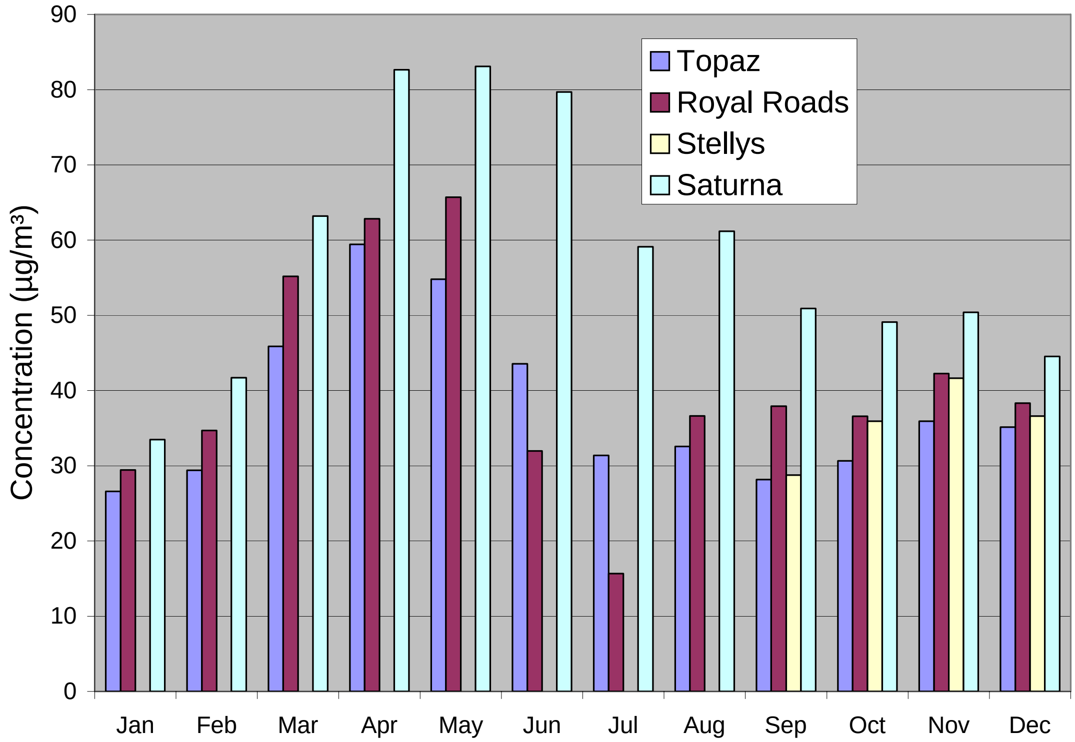
Table 2.4.5 24-Hour Sequential Mean Ozone Concentrations in the CRD

Percentile Values						Max µg/m³	Min µg/m³	Mean µg/m³	Std. Dev. µg/m³	Missing Values[b] % of Total 24-h Averages
5	**25**	**50**	**75**	**98**	**99**					
Victoria Topaz										
12.5	24.2	36.3	50.7	71.7	75.4	82.2	3.0	37.9	17.2	2.5
Royal Roads University										
10.0	24.9	40.7	57.8	85.9	89.3	94.8	2.5	42.2	21.8	6.0
Stellys										
13.1	26.1	36.0	48.6	65.7	66.1	70.0	1.5	36.8	15.4	71.0
Saturna Island										
24.4	44.2	57.8	72.6	95.4	97.9	101.8	7.2	58.4	20.1	0.5

Figure 2.3.1 shows the monthly average 8-hour ozone concentrations for the four sites. The ozone levels at each station follow the same general pattern, with concentrations on Saturna Island consistently the highest. For each station, concentrations are highest during the spring when hours of sunlight and magnitudes of temperature are not at a maximum. This indicates that natural production of ozone may be significant in the spring, potentially due to tropospheric folding or other natural events. Transport of ozone from other areas is also a possibility. During the spring and summer months, concentrations are much higher at Saturna Island than at the other monitoring locations.

[b] A 24-hour average concentration was determined for every day having 18 or more valid hours of data.

Figure 2.4.1 Monthly Average 8-Hour Ozone Concentrations at Victoria Topaz, Royal Roads University, Stellys and Saturna Island



* Most of the data for July was missing in the Royal Roads dataset, and half of the data for September was missing in the Stellys dataset.

Figures 2.3.2a and 2.3.2b show the average diurnal pattern of ozone concentrations during cooler and warmer months respectively (Stellys data are not used here, due to an incomplete dataset for the year). Greater variation is evident in the profiles for the two urban monitoring locations. For all sites, ozone concentrations are at a maximum during the afternoon, when temperatures and sunshine are generally at maximum. The effect of ozone scavenging is evident for the two urban sites for both cooler and warmer months. Increased levels of $NO_{x,}$ due to morning traffic volumes, result in a net destruction of ozone for several hours of the day.

Figure 2.4.2a Average Diurnal Ozone Pattern During Cooler Months (November-March)

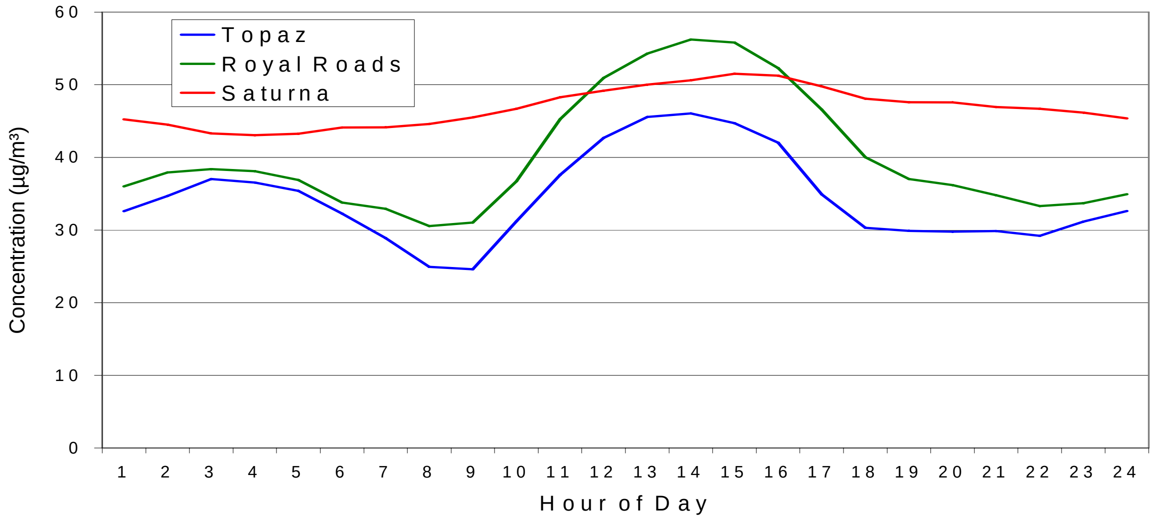
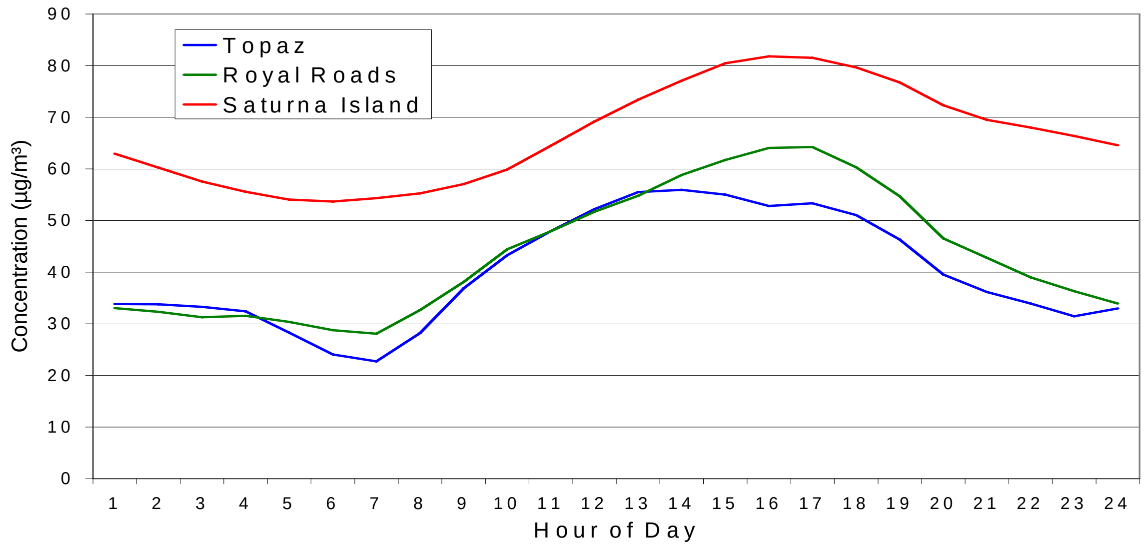


Figure 2.4.2b Average Diurnal Ozone Pattern During Warmer Months (April-October)



Comparison of CRD ground-level ozone concentrations to provincial and federal objectives is shown in Appendix C.

3.0 PARTICULATE MATTER

Particulate matter (PM) denotes suspended materials in air that are both solid and liquid in form. These materials can remain suspended for periods ranging from several seconds up to several months. The individual particles vary considerably in size, shape and chemical composition. As with gases, suspended particulate matter can be caused by natural events, such as soil erosion by wind, or anthropogenic activity, such as the burning of fossil fuels. Primary PM describes matter emitted directly to the atmosphere, whereas secondary PM describes solid or liquid particles that are formed in the atmosphere from the chemical reaction of other compounds. Particulate matter is considered an atmospheric contaminant due to its respiratory effects on humans and animals, and its ability to impair visibility.

Suspended particulate matter is measured as three different distribution ranges. Total Suspended Particulate (TSP) includes all suspended particulate less than 30 microns (µm). PM_{10} and $PM_{2.5}$ refer to particulate fractions less than 10 microns and 2.5 microns respectively. In the CRD, both PM_{10} and $PM_{2.5}$ are measured. Recent research into the effects of particulate matter on human health indicates that the smaller particles are of more concern. Nationally, greater emphasis on urban concentrations of small suspended particles is reflected in both the recent Canada Wide Standards and the Health Reference Levels, which specifically target fine particulate. Currently, PM_{10} is considered the *inhalable* fraction and $PM_{2.5}$ the *respirable* fraction of TSP.

Four different particulate sampling devices are currently used in the CRD. Tapered Element Oscillating Microbalance (TEOM) samplers are used to collect frequent air concentrations of $PM_{2.5}$ that are recorded as hourly averaged concentrations. These samplers run continuously, with periodic maintenance depending on how quickly the sampling filter reaches capacity. Sequential high volume (Hi-Vol) samplers are used to determine 24-hour concentrations of PM_{10} on a cycle of one in every six days. One Partisol sampler was installed in 2003 for PM_{10} measurement. A Partisol sampler is a sequential sampler like the Hi-Vols, but instead utilizes a low-volume of airflow while collecting particulate. Finally, one dichotomous (Dicot) sampler is used to produce 24-hour concentrations of both PM_{10} and $PM_{2.5}$ on the same rotation cycle. The latter three sampler types collect particulate matter on a filter, from midnight of one day to midnight of the next. Once a collection period has ended, the filter is analyzed in a lab to determine the 24-hour concentration.

Hi-Vol samplers were used at six different locations during 2003. The Partisol sampler and a TEOM sampler became operational at Stellys late in 2003. At three of the Hi-Vol locations, a TEOM was also present. Victoria Topaz had a Hi-Vol, a Dicot and a TEOM operating during 2003. The sampling data are presented separately for each type of monitoring instrument, to facilitate comparison between the samplers. Measured PM concentrations from the same air sample can differ depending on the type of instrument used. This is due to different instrument biases[10].

3.1 INHALABLE PARTICULATE MATTER (PM_{10})

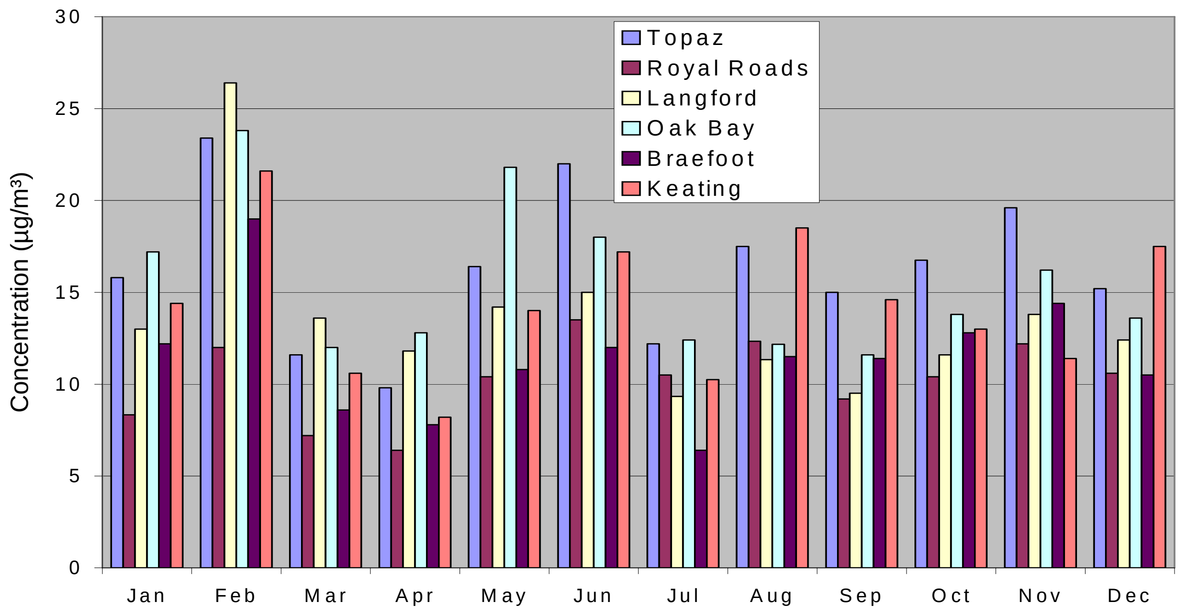
Table 3.1 shows the 24-hour Hi-Vol PM_{10} data for 2003. Victoria Topaz recorded the highest annual mean concentration, due to its location within the core area of Victoria. There were no exceedences of the CRD 24-hour guideline of 50 µg/m³ at any station location. Figure 4.1 shows the average PM_{10} concentration by month for each station. Concentrations at Royal Roads are typically lower than at other stations, due to its location near the coast.

Table 3.1 Hi-Vol Sequential 24-Hour Mean PM_{10} Concentrations

Statistic	Topaz	Royal Roads	Langford	Oak Bay	Braefoot	Keating
Mean (µg/m^3)	16.3	10.3	13.7	15.5	11.5	14.4
Std. Dev. (µg/m^3)	7.1	4.1	7.1	6.9	4.8	5.9
Maximum (µg/m^3)	38	24	40	42	30	36
98th percentile (µg/m^3)	30.8	17.9	38.3	31.3	22.0	24.8
# > CRD Guideline (50 µg/m³)	0	0	0	0	0	0
# of Samples	60	55	54	60	60	59
Percent Missing (%)	1.6	9.8	11.5	1.6	1.6	3.3

[10] For example, the TEOM is known to measure lower 24-hour average PM concentrations, especially during colder months, than a co-located sequential instrument like the Partisol. This is due to particulate loss by evaporation as the TEOM heats the incoming sample to remove excess moisture.

Figure 3.1 Monthly Average 24-Hour PM_{10} Concentrations for Hi-Vol Samplers



Partisol 24-hour concentrations are shown in Table 3.2. This sampler was operational from late August, 2003; therefore the statistics are not representative of a full annual dataset.

Table 3.2 Partisol Sequential 24-Hour Mean PM_{10} Concentrations (Stellys)

Statistic	PM_{10}
Mean (µg/m^3)	11.6
Std. Dev. (µg/m^3)	5.6
Maximum (µg/m^3)	22
98th percentile (µg/m^3)	21.6
# > CRD Guideline (50 µg/m^3)	0
# of Samples	20
Percent Missing (%)	67.2

Table 3.3 provides a summary of the PM_{10} Dicot data for the year at Victoria Topaz. The Dicot sampler tends to measure lower particulate concentrations than the Hi-Vol at the same location. Both the mean and the maximum concentration for the year are lower than the Topaz Hi-Vol values. However, the Dicot sampler had a slightly smaller data capture than the Hi-Vol at this location (56/61 compared to 60/61).

Table 3.3 Dicot Sequential 24-Hour Mean PM_{10} Concentrations (Victoria Topaz)

Statistic	PM_{10}
Mean (μg/m^3)	14.3
Std. Dev. (μg/m^3)	7.0
Maximum (μg/m^3)	32.7
98th percentile (μg/m^3)	29.1
# > CRD Guideline (50 μg/m^3)	0
# of Samples	56
Percent Missing (%)	8.2

3.2 RESPIRABLE PARTICULATE MATTER ($PM_{2.5}$)

3.2.1 Dicot Sampling Results

Table 3.4 provides a summary of $PM_{2.5}$ sampling data from the Dicot sampler at Victoria Topaz during 2003. All 24-hour concentrations are below the CRD guideline of 25 μg/m^3.

Table 3.4 Dicot Sequential 24-Hour Mean $PM_{2.5}$ Concentrations (Victoria Topaz)

Statistic	$PM_{2.5}$
Mean (μg/m^3)	7.6
Std. Dev. (μg/m^3)	4.5
Maximum (μg/m^3)	21.0
98th percentile (μg/m^3)	20.0
# > CRD Guideline (25 μg/m^3)	0
# of Samples	56
Percent Missing (%)	8.2

3.2.2 TEOM Sampling Results

Hourly TEOM sampling results from Victoria Topaz, Royal Roads University, Langford Dogwood School and Stellys are presented in Table 3.5. Victoria Topaz experienced the highest hourly maximum and annual mean concentration of the four monitoring sites during 2003.

Table 3.5 Hourly $PM_{2.5}$ Concentrations at Victoria Topaz

Percentile Values						Max µg/m³	Min µg/m³	Mean µg/m³	Std. Dev. µg/m³	Missing Values	
5	**25**	**50**	**75**	**98**	**99**					**# of Hours**	**% of Total Hours**
Victoria Topaz											
0	2	4	8	24	31	182	0	5.9	7.3	16	0.2
Royal Roads University											
0	2	4	6	15	19	102	0	4.5	4.7	124	1.4
Langford Dogwood School											
0	2	4	7	20	24	97	0	5.0	5.2	1068	12.2
Stellys											
1	4	6	10	26	30	65	0	7.8	6.4	6207	70.9

Table 3.6 summarizes the sequential 24-hour averaged concentrations determined at the TEOM sites for 2003. The CRD 24-Hour guideline of 25 µg/m³ was exceeded on two occasions at Victoria Topaz, and on one occasion at Royal Roads. The yearly maximum of 39.8 µg/m³ at Royal Roads occurred on June 6. The TEOM log file at Royal Roads shows that there were problems with the air pump within an interval including June 6, which was indicated by excess noise from the pump unit. However, the Royal Roads Hi-Vol PM_{10} sampling data shows that the maximum concentration for the year (24 µg/m³) occurred on June 8, two days following the high $PM_{2.5}$ value. The PM_{10} data supports that there were relatively high particulate concentrations in the area around the June 6 date. The Royal Roads meteorological data indicates that June 6 was a warm, sunny day with very light winds from the northeast. Since $PM_{2.5}$ concentrations were not similarly high at Topaz and Langford, it is likely that a localized source of particulate was responsible for this exceedence. Construction activity occurred in this area in June[11]. The second-highest $PM_{2.5}$ 24-hour concentration at Royal Roads for the year was 15.7 µg/m³ (on November 14), which is considerably lower than the June 6 value.

[11] Personal Communication with Chris Robins, CRD.

Table 3.6 24-Hour Sequential Mean $PM_{2.5}$ Concentrations at Victoria Topaz

Percentile Values						Max µg/m³	Min µg/m³	Mean µg/m³	Std. Dev. µg/m³	Percent of 24-h Averages > CRD Guideline (25µg/m³)	Missing Values[b]
5	25	50	75	98	99						% of Total 24-h Averages
Victoria Topaz											
1.9	3.3	5.0	7.3	14.8	17.3	29.7	0.5	5.9	3.7	0.5	0.0
Royal Roads University											
1.4	2.7	3.8	5.6	10.7	11.9	39.8	0.6	4.5	3.1	0.3	0.0
Langford Dogwood School											
1.4	2.9	4.2	6.3	13.9	15.3	19.9	0.1	5.0	3.2	0.0	12.6
Stellys											
3.6	5.1	6.5	10.1	16.8	19.3	19.6	3.3	7.8	3.8	0.0	71.0

At Victoria Topaz, the exceedences of the 24-hour CRD objective occurred on October 31 and November 1. An interval of elevated hourly $PM_{2.5}$ concentrations began during the early evening of the first day and extended through the morning of the next. The highest hourly concentration occurred at midnight. Meteorological data from the Topaz station shows that this evening was very calm with cool temperatures; this led to strong overnight stability, which tends to suppress atmospheric mixing. As this was Halloween evening, the exceedence may have been caused by small fires and the use of fireworks in the vicinity of the Topaz station. High concentrations have been noted on this date from previous years[12]. Yearly maximum $PM_{2.5}$ levels were also recorded at the Stellys monitoring station, for the reduced period of sampling during 2003. In this case however, an exceedence of the CRD objective did not occur. Royal Roads did not experience higher than normal concentrations, and the Langford site is missing sampling data on these two days. Due to the meteorological conditions during the evening, residential emissions would also have been a contributing factor.

The spatial extent of the region experiencing elevated $PM_{2.5}$ concentrations above the CRD guideline value is unknown, but may have been restricted to the immediate vicinity of the monitoring station in Topaz Park. The degree of exposure for the general public to exceedence-level concentrations of $PM_{2.5}$ may have been relatively small in both temporal and spatial terms. As such, the effect of the exposure to human health impacts is uncertain.

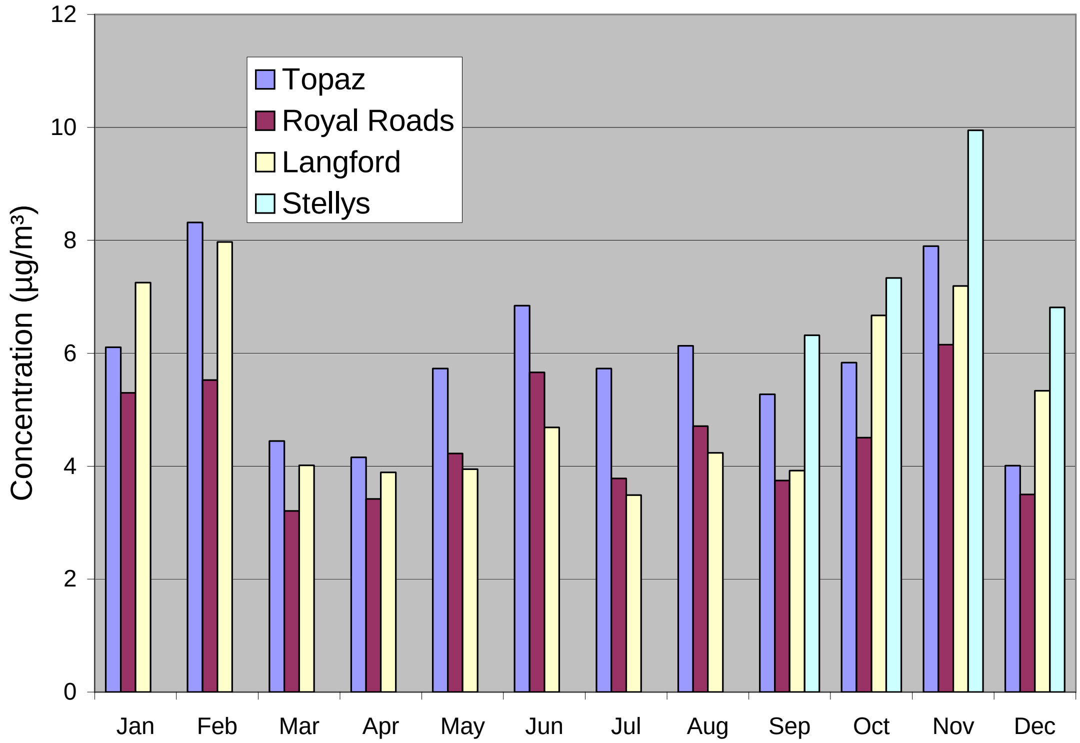
[b] A 24-hour average was determined for every day having 18 or more valid hours of data.
[12] Personal communication with Chris Robins, CRD. September 14, 2004.

Continuous monitoring data are required to determine achievement of the CWS for $PM_{2.5}$. Each of the four TEOM $PM_{2.5}$ monitoring sites meets the criteria of the "neighbourhood" or "urban" classification that are necessary to determine achievement of the CWS comparison value[13]. In such cases, the arithmetic average of each station's midnight-to-midnight 24-hour concentration is to be determined, for stations collecting a minimum of 18 hours of data during the period. The annual 98th percentile of these concentrations, averaged over three consecutive years is then used to determine achievement of the standard. Currently, Langford does not have data available for a three-year period. For the year 2003, the 98th percentile $PM_{2.5}$ concentration for the CRD is 12.7 µg/m^3. This value is well below the CWS of 30 µg/m^3. Stellys data were not used in this determination, due to its limited data capture in 2003.

Figure 3.2 presents monthly average 24-hour $PM_{2.5}$ concentrations from the four TEOM sites. Langford clearly experiences higher concentrations during winter months, but this trend is not as evident for Topaz and Royal Roads. This differs from previous years, where greater ambient concentrations, due to increased particulate emissions from home heating, typically occur in colder months. Increased precipitation during October and January likely caused particulate counts to remain lower than during the same months of previous years. The monthly average concentrations for Stellys indicate that this station may experience higher $PM_{2.5}$ concentrations than at Victoria Topaz, where historically the highest measured concentrations in the CRD have been occurred. This will have to be confirmed with monitoring data from 2004.

[13] Canadian Council of Ministers for the Environment, 2000. Guidance Document on Achievement Determination: Canada Wide Standards for Particulate Matter and Ozone. www.ccme.ca.

Figure 3.2 Average 24-Hour $PM_{2.5}$ Concentrations by Month from TEOM Samplers



Figures 3.3a and 3.3b show the average diurnal patterns of $PM_{2.5}$ concentrations at the three stations during cold and warm months. The similarity of the patterns indicates that small particulate is relatively well mixed in the CRD. Hourly particulate concentrations increase with the morning traffic during all months of the year. A second, larger peak occurs during cooler months, which can be attributed to additional particulate emissions from the burning of fuel for home heating. Concentrations at the Topaz station are consistently higher than at the other two stations during the warmer months.

Figure 3.3a Average Diurnal $PM_{2.5}$ Pattern During Cooler Months at TEOM Sites (November – March)

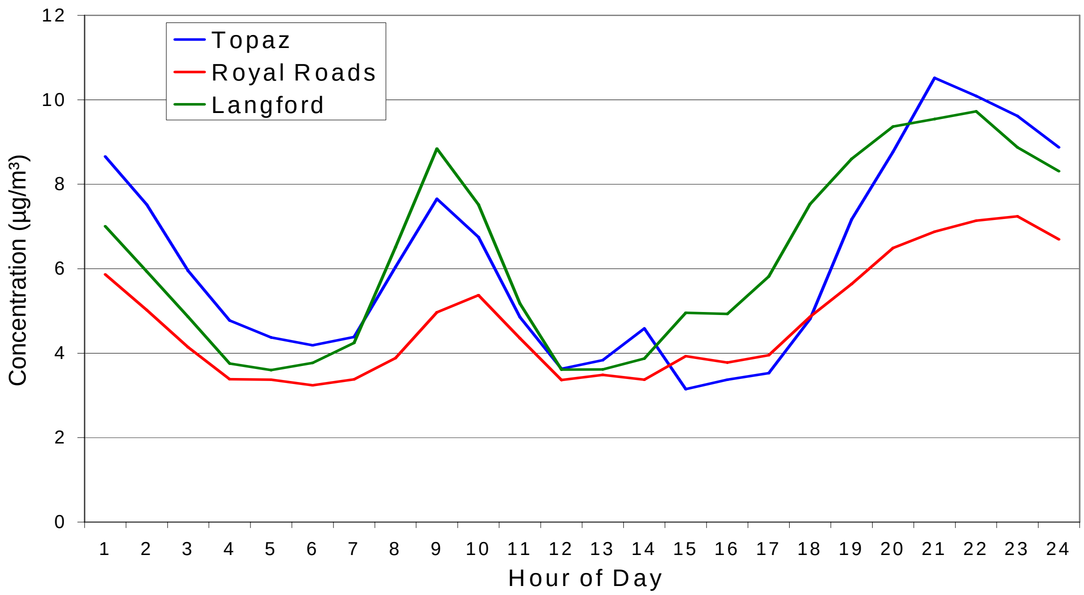
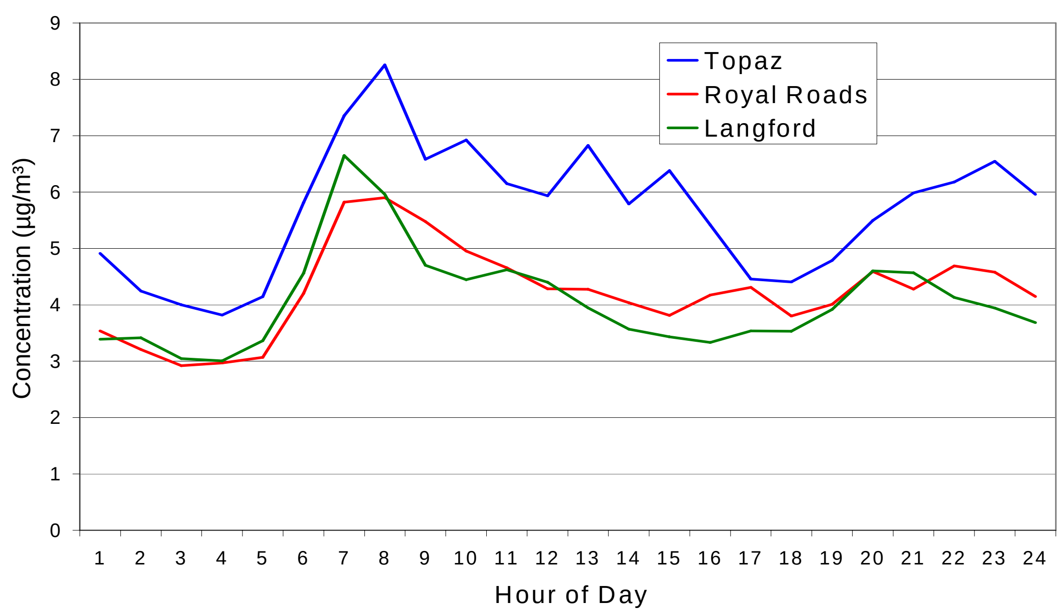


Figure 3.3b Average Diurnal $PM_{2.5}$ Pattern During Warmer Months at TEOM Sites (April - October)



4.0 CONCLUSION

Ambient concentrations of common air contaminants in the CRD remain relatively low. Air concentrations measured in 2003 were compared to a set of community-based air quality guidelines that were established for the CRD earlier in 2004. As well, assessments against the Canada Wide Standards and provincial/federal objectives were made (comparisons to the federal/provincial objectives can be found in Appendix C). Table 4.1 provides a summary of the air quality data collected from the Capital Regional District's ambient monitoring program during 2003.

Sampling instruments were operating at four long term monitoring station locations, in addition to three sites of interest and one CAPMoN station during 2003. Additions to the CRD monitoring program from 2002 include a new (long term) station on the Saanich Peninsula (Stellys). The Stellys station was established later in the year with a sequential PM_{10} Partisol monitor, a $PM_{2.5}$ TEOM and a continuous ozone sampler. Particulate matter is now sampled in the CRD using four different instruments: TEOMs (for PM_{10} and $PM_{2.5}$), a Dicot (for PM_{10} and $PM_{2.5}$), Hi-Vols (for PM_{10}) and a Partisol (for PM_{10}). 2003 is the first year for which a full dataset of $PM_{2.5}$ is available from the Langford station. Monitoring at the Royal Roads station, which has been in the monitoring program for several years, was expanded to include PM_{10} (Hi-Vol), for which a full annual dataset was available. In addition, data capture for NO and NO_2 at this station was much higher than during 2002.

Annual datasets were available from three meteorological stations within the CRD during 2003. In each case, the wind rose diagram (which shows the frequency of wind speed and direction for a location) for 2003 is virtually identical to that determined with 2002 data[14]. Monthly climate data for the Victoria International Airport indicates that 2003 experienced greater rainfall during fall and early winter, but very little precipitation during the summer months, compared to the climate norm. The summer was also relatively warm.

Air concentrations of the gaseous pollutants (CO, NO_2, SO_2 and O_3) were well below CRD guidelines, with the exception of ground-level ozone. The CRD 8-hour ozone guideline of 120 $\mu g/m^3$ was exceeded 0.2% of the time at Saturna Island, but was not exceeded at Victoria Topaz, Royal Roads, or Stellys. The exceedences occurred over two days only, one during late spring and the other during early summer. The relatively infrequent exceedence of the CRD guideline and the low population density on and around Saturna Island is unlikely to result in any measurable short-term adverse health outcomes. The potential for long-term health effects from exposure to ozone during the two exceedence days is minimal.

[14] SENES Consultants Ltd., 2003. *Air Quality in the Capital Regional District, 2002*.

For Saturna Island, the three-year average of the 4th highest annual maximum daily 8-hour ozone concentrations was determined to be 114.6 µg/m³. This value, representative of 2001-2003, is below the CWS of 127.6 µg/m³. The mean 8-hour ozone concentration at Saturna for 2003 was higher than that determined for 2002, which in turn was higher than 2001. This suggests a minor trend towards increasing ground-level ozone concentrations over the past several years. Concentrations at Topaz and Royal Roads also follow this trend. This is not likely due to local production, as ambient levels of NO_2 in the CRD have not followed the same pattern.

Particulate matter concentrations are typically low in the CRD. During 2003, PM_{10} levels at 6 Hi-Vol stations in the CRD were similar to 2002, although the annual mean 24-hour concentration at Topaz (16.3 µg/m³) was notably lower than that experienced the previous year (19.6 µg/m³)[15]. There were no exceedences of the CRD 24-hour guideline of 50 µg/m³. $PM_{2.5}$ concentrations were generally lower at both Topaz and Royal Roads over last year. However, the maximum concentrations experienced at these two stations were considerably higher (in particular at Royal Roads), which led to one exceedence of the CRD 24-hour guideline of 25 µg/m³ at Royal Roads and two exceedences at Victoria Topaz. Royal Roads data shows that the exceedence level of 39.8 µg/m³, recorded on June 6, is not typical of this location, which recorded 24-hour concentrations less than 16 µg/m³ at all other times during the year. Further analysis of data from the Royal Roads meteorological station and other particulate monitors suggests that either a localized source was responsible for the exceedence, or an instrument error occurred. There was construction activity in the area during June, which may have contributed to the higher ambient concentrations on June 6. The two Victoria Topaz exceedences occurred on adjoining days and were likely due to additional sources of smoke from Halloween fireworks and small fires. During this interval, elevated fine particulate counts persisted through the evening of October 31 until late morning of November 1. Higher fine particulate levels were experienced at Stellys during the same hours and this may have been the case at Langford as well (but this can't be assessed due to missing data). The spatial extent of elevated $PM_{2.5}$ concentrations above the CRD guideline value in the vicinity of the Victoria Topaz station is unknown, but may have been restricted to the immediate vicinity of the station in Topaz Park. The extent of exposure for the general public to elevated concentrations of $PM_{2.5}$ may have been relatively small (i.e., limited in extent and duration). As such, the significance of any such exposure to human health impacts is uncertain.

Achievement of the Canada Wide Standard for particulate matter was assessed. The 98th percentile 24-hour $PM_{2.5}$ concentration for 2003 was 12.7 µg/m³. This value, representative of the CRD $PM_{2.5}$ monitoring sites, is well below the CWS of 30 µg/m³. Relatively high monthly average $PM_{2.5}$ concentrations were experienced during the 4 months the Stellys station was

[15] SENES Consultants Ltd., 2003. *Air Quality in the Capital Regional District, 2002*.

operating, indicating that this location may experience the highest $PM_{2.5}$ concentrations of the 4 long term monitoring stations operating in the CRD.

The 2003 monitoring data show that diurnal patterns of CO, NO, SO_2 and $PM_{2.5}$ are well correlated in the CRD, indicating similar sources for each. These patterns suggest that fuel combustion is the dominant emission source, with ambient concentrations closely following peak traffic activity. Residential home heating was determined to be a large contributor to emissions of these air contaminants during the fall and winter months, particularly for $PM_{2.5}$.

Long term monitoring provides the data needed to establish baseline air concentrations for a region. With the addition of 2003 monitoring data, there now exists a three-year, continuous dataset for all common air contaminants monitored in the CRD. A set of baseline air concentrations was constructed using 2001-2003 data, which is presented in Appendix B. Such a baseline is crucial for future airshed trend analysis, and for determining CWS compliance. It is therefore recommended that air quality monitoring in the CRD continue at the present level.

Table 4.1
Summary of Maximum Pollutant Concentrations (μg/m³) in the CRD for 2003

		Air Quality Criteria		Monitoring Station							
Contaminant	Averaging Period	CWS	CRD Guideline	Victoria Topaz	Royal Roads	Langford	Stellys	Oak Bay	Braefoot	Keating	Saturna Island
Carbon Monoxide	8-hour*		5500	2813							
Nitrogen Dioxide	1-hour*		200	124.3	61.2						
Sulphur Dioxide	24-hour*		125	25.0							
Ground-level Ozone	8-hour**		120	103.3	107.8		84.8[1]				139.4
PM_{10}	24-hour*		50	38 (HiVol) 32.7 (Dicot)	24 (HiVol)	40 (HiVol)	22[2] (Partisol)	42 (HiVol)	30 (HiVol)	36 (HiVol)	
$PM_{2.5}$	24-hour*		25	21 (Dicot) 29.7 (TEOM)	39.8 (TEOM)	19.9 (TEOM)	19.6[1] (TEOM)				
Canada-Wide Standards											
Ozone	8-hour**	127.6[3]									114.6
$PM_{2.5}$	24-hour*	30[4]		12.7[5]							

Notes:
* Sequential averaging periods used.
** Rolling average periods used.
[1] Partial record: September 17 – December 31, 2003.
[2] Partial record: August 31 – December 23, 2003
[3] Achievement by 2010, based on the annual 4th highest daily measurement, averaged over 3 consecutive years.
[4] Achievement by 2010, based on the 98th percentile ambient measurement annually, averaged over 3 consecutive years.
[5] Value determined for 2003 only; data does not exist to determine a three year average.

Appendix A: Meteorological Data

Table A.1 2003 Monthly Climate Data for Victoria[d]

	Mean Max Temp	Mean Temp	Mean Min Temp	Extr Max Temp	Extr Min Temp	Total Rain	Total Snow	Total Precip
	°C	°C	°C	°C	°C	mm	cm	mm
Jan	10.1	6.8	3.5	14.9	-2.3	177.5	0	177.5
Feb	9.3	5.5	1.8	12.7	-3.3	24	0.4	24.4
Mar	11.2	7.7	4.2	15	-2	109.8	15.6	125.4
Apr	13	9	5	19.5	0.4	52.8	0	52.8
May	16.6	11.8	7	22.7	1.6	22.1	0	22.1
Jun	22.4	16.5	10.5	33.5	6	4.3	0	4.3
Jul	23.9	18.1	12.2	29.3	9.6	14.4	0	14.4
Aug	23.6	17.4	11.1	28.4	7.9	0.8	0	0.8
Sep	20.9	15	9.2	30.1	6.2	21.2	0	21.2
Oct	15	11.4	7.8	22.6	-1.4	318.8	0	318.8
Nov	9	4.8	0.6	14.4	-4.1	160.7	3	163.7
Dec	7.8	4.7	1.5	11.2	-3.9	96.4	T	96.4
Sum						**1002.8**	**19**	**1021.8**

Notes: T = trace amount

Table A.2 Climate Norm (1971 – 2000) for Victoria[d]

	Mean Max Temp	Mean Temp	Mean Min Temp	Extr Max Temp	Extr Min Temp	Total Rain	Total Snow	Total Precip
	°C	°C	°C	°C	°C	mm	cm	mm
Jan	6.9	3.8	0.7			121.8	15.2	136.6
Feb	8.4	4.9	1.4			98.8	9.0	107.8
Mar	10.5	6.4	2.3			75.8	2.4	78.0
Apr	13.4	8.8	4.1			44.5	0.0	44.5
May	16.6	11.8	6.9			36.5	0.0	36.5
Jun	19.3	14.4	9.3			32.0	0.0	32.0
Jul	21.9	16.4	10.8			19.5	0.0	19.5
Aug	22.0	16.4	10.8			23.9	0.0	23.9
Sep	19.4	14.0	8.4			30.4	0.0	30.4
Oct	14.2	9.8	5.3			75.6	0.2	75.7
Nov	9.5	6.1	2.7			144.4	3.3	147.2
Dec	6.9	4.0	1.0			138.3	13.8	151.2
Sum						**841.50**	**43.7**	**883.3**

[d] Sourced from Environment Canada, http://www.climate.weatheroffice.ec.gc.ca/climateData/

Figure A.1
2003 Wind Rose Diagram for Victoria Topaz

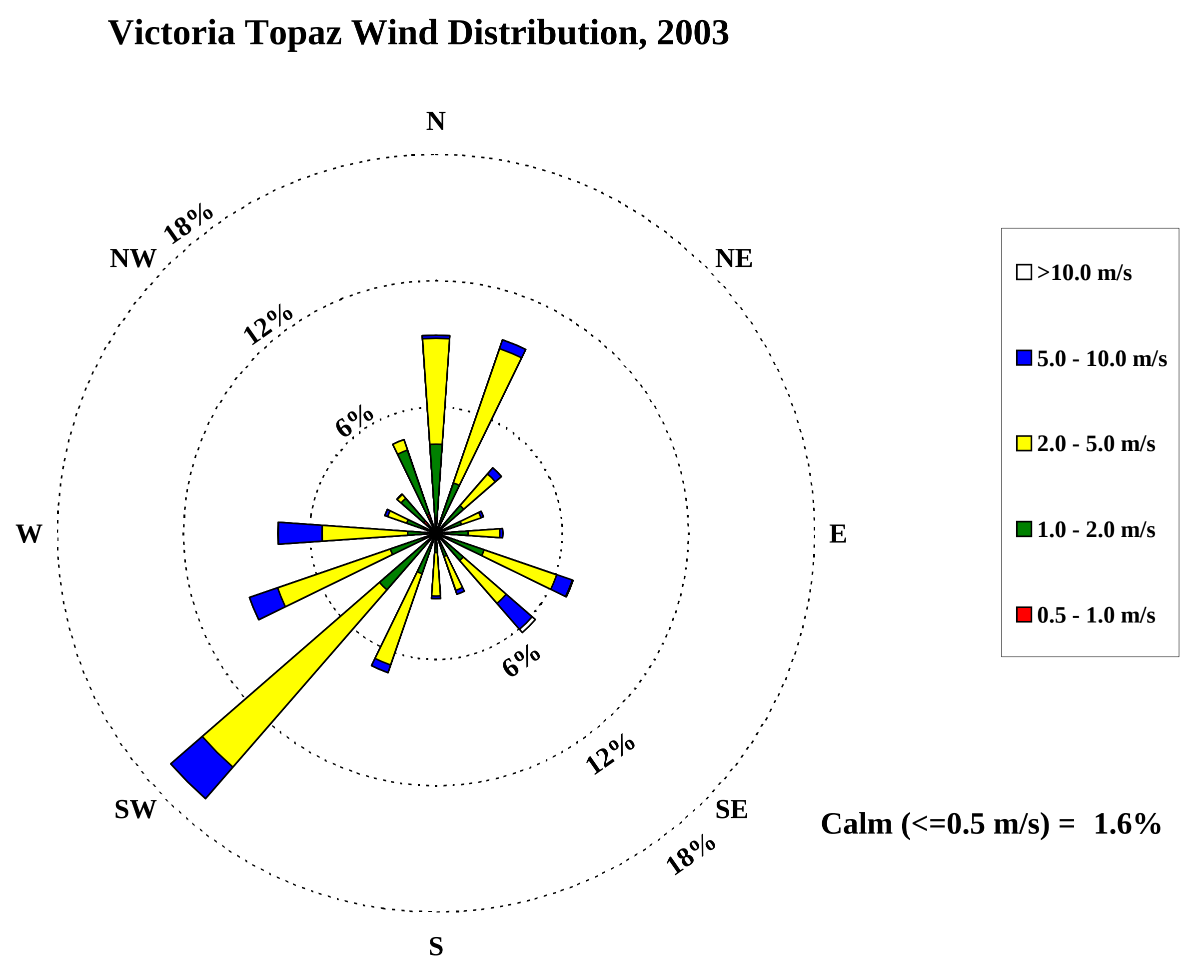


Figure A.2
2003 Wind Rose Diagram for Royal Roads University

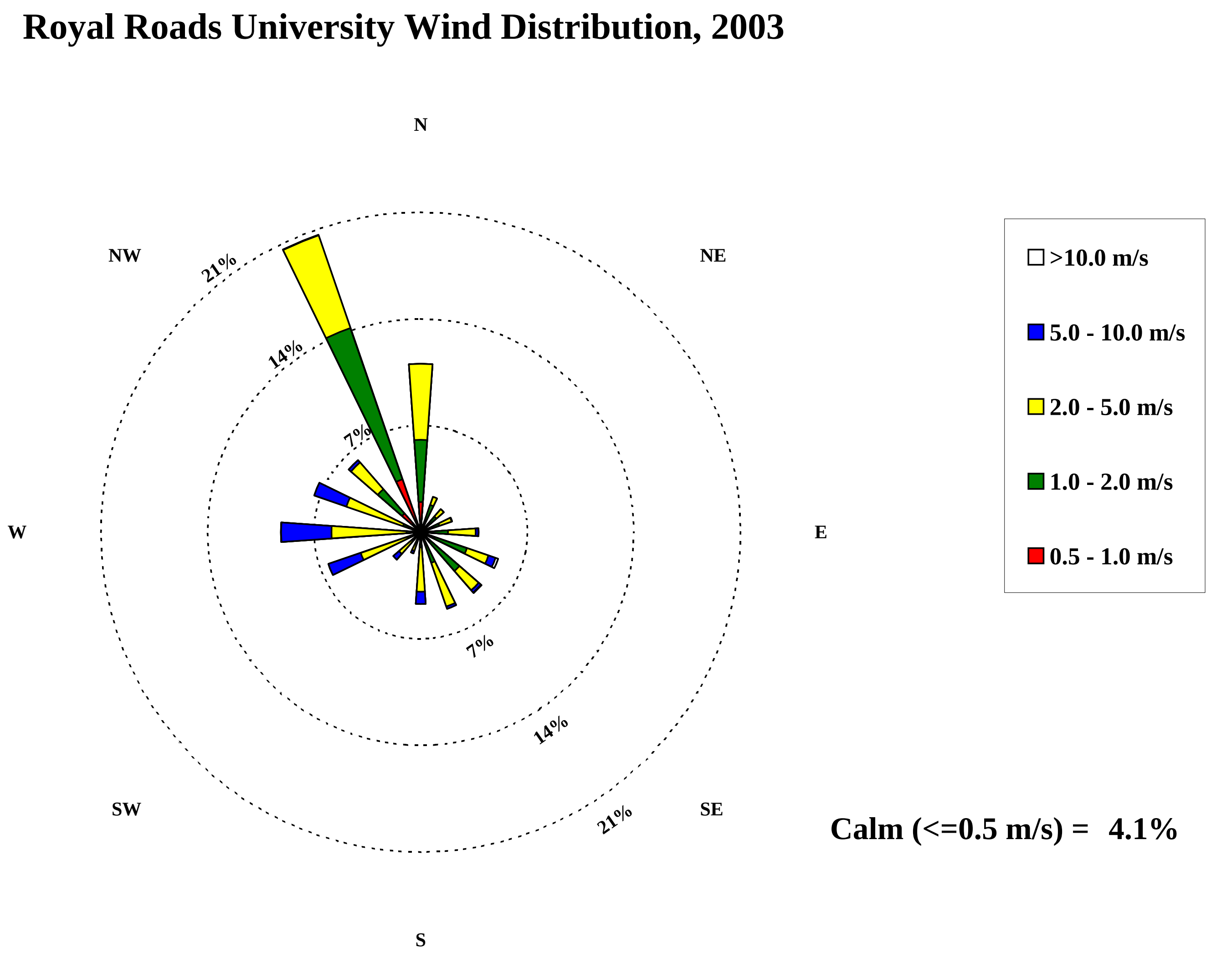
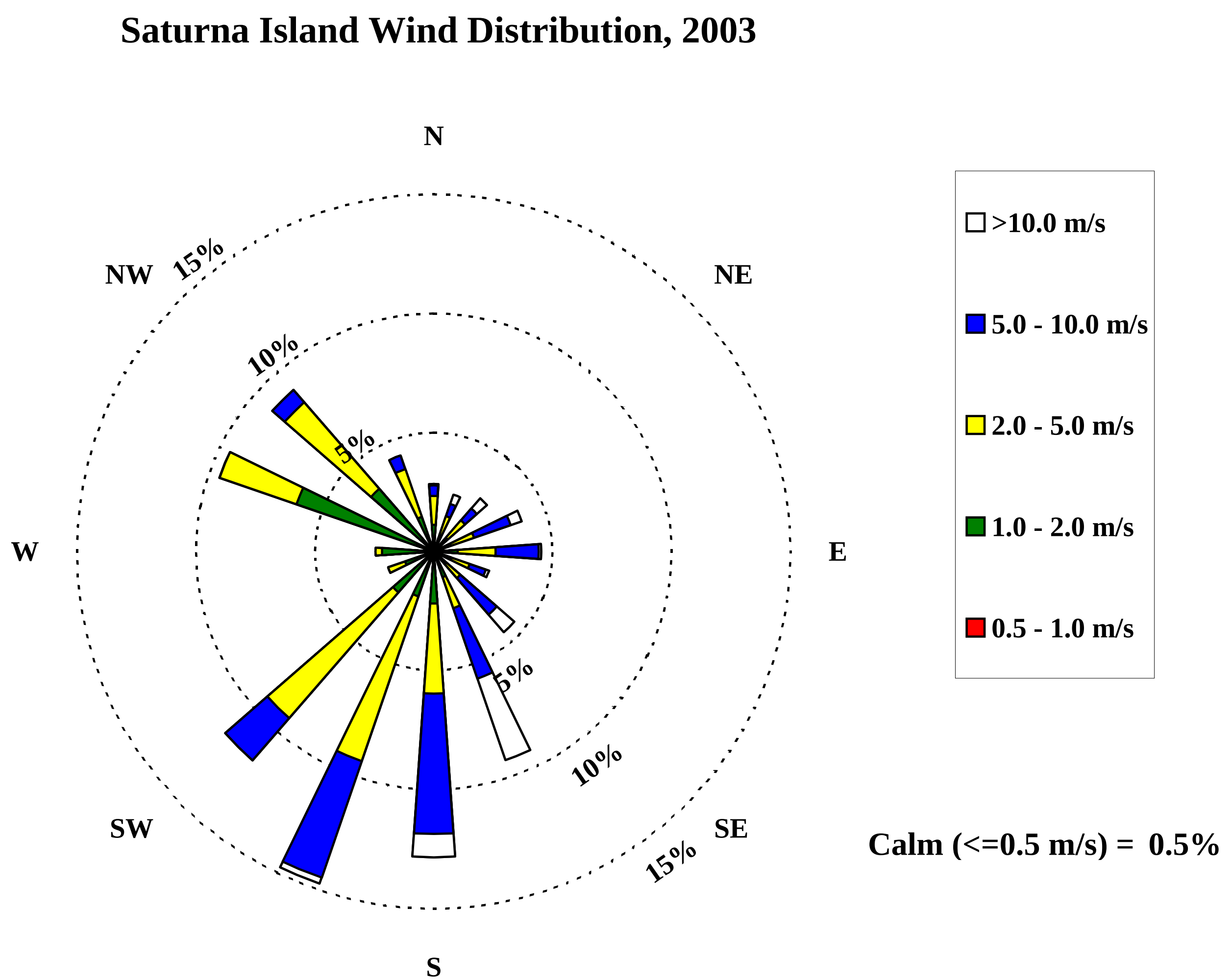


Figure A.3 2003
Wind Rose Diagram for Saturna Island



APPENDIX B: CRD AIR QUALITY BASELINE LEVELS

B.1 INTRODUCTION

Early in 2004, a set of provisional baseline air quality concentrations was determined for the CRD, for the common air contaminants (CACs)[16]. With the addition of monitoring data for 2003, revised baseline concentrations can be constructed, using monitoring data from three consecutive years (2001 to 2003). The provisional baselines, which were set primarily for the purpose of presenting the concept, were based on 98th percentile concentrations from 2002 monitoring data. These baselines are listed in Table 1.2.

The provisional baselines for NO_2, SO_2, CO and $PM_{2.5}$ were determined with monitoring data from the Victoria Topaz NAPS site. The Colwood monitoring station was used for PM_{10}, as this was the only station during 2002 that collected continuous PM_{10} data. For ground-level ozone, the Saturna Island CAPMoN data were used.

The establishment of a new set of three-year baselines for the CACs follows the same approach used with the 2002 data, with one exception: sequential gravimetric PM_{10} data from the Topaz station were used instead of that from Colwood (which is no longer in operation). As such, the baseline levels for NO_2, SO_2, CO, $PM_{2.5}$, and ozone are determined from continuous sampling data, whereas the baseline for PM_{10} derives from sequential Hi-Vol data. This is appropriate, since all of the other PM_{10} monitoring sites use Hi-Vols. The Topaz site is used for all contaminants except ozone, since this station is most representative of the maximum community-oriented air contaminant concentrations experienced in the CRD. Saturna Island data are used for ground-level ozone, since maximum concentrations in the CRD are consistently experienced at this monitoring location.

In the following sections, trends are shown for longer periods than the three years that are used to determine the revised baselines. This is for discussion purposes only, and to illustrate the potential variability in percentile concentrations over the period in which complete or near-complete annual datasets are available for a particular air contaminant. A three-year mean percentile concentration is determined for each compound; the three-year interval (2001-2003) represents a common, continuous period with a high percentage of data capture for all six air contaminants. The percentile concentrations are determined for each one-year period, and then averaged over the three years. In most cases, the 98th percentile is used for the baseline, since this statistic is representative of the highest concentrations experienced during a year, but does not have the significant year-to-year variability found in the maximum or near-maximum air concentrations. An exception is made for PM_{10}, since only sequential data are available. For PM_{10}, the 95th percentile is used for the baseline, due to a greater year-to-year fluctuation in higher percentile values. This issue is discussed in more detail in Section B.6.

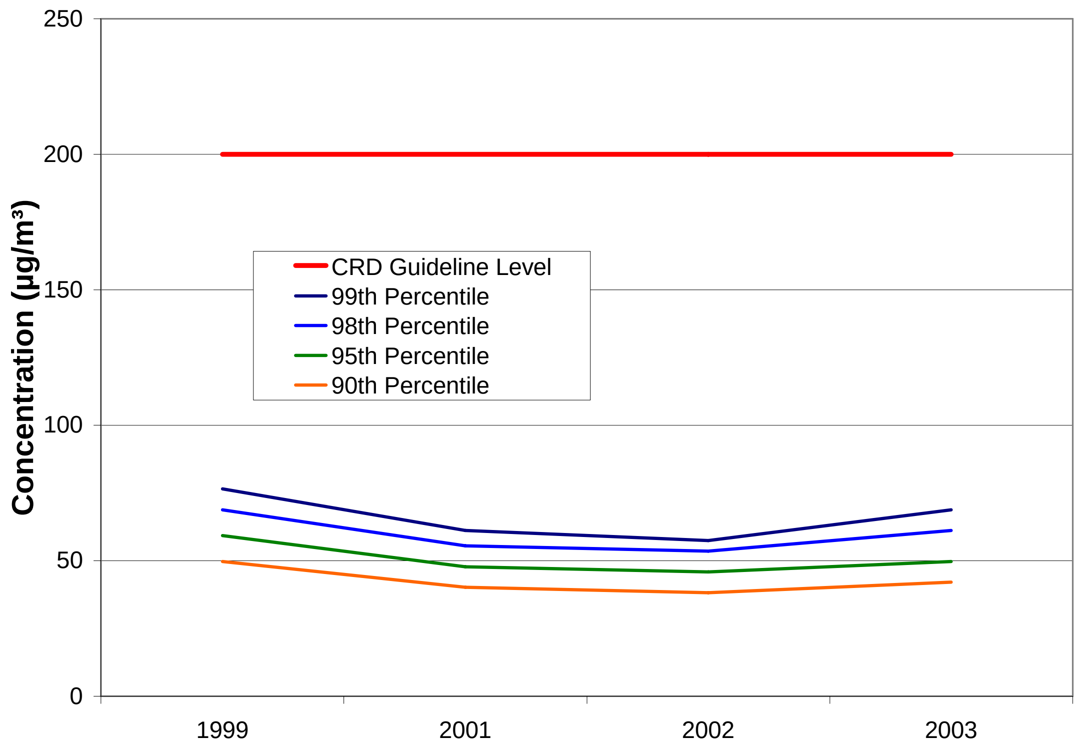
[16] SENES Consultants Ltd., 2004. *Development of Air Quality Guidelines for the Capital Regional District*. Final Report, May 2004.

Finally, it should be noted that sequential averaging was used for all air contaminants except ground-level ozone, which is based on rolling 8-hour concentrations.

B.2 NITROGEN DIOXIDE

NO_2 1-hour percentile concentrations during 1999 to 2003 are shown in Figure B.1. The three-year baseline 98th percentile hourly NO_2 concentration is 56.7 µg/m³, currently well below the CRD guideline of 200 µg/m³.

Figure B.1: 1-Hour NO_2 Percentile Concentrations at Victoria Topaz, 1999-2003*

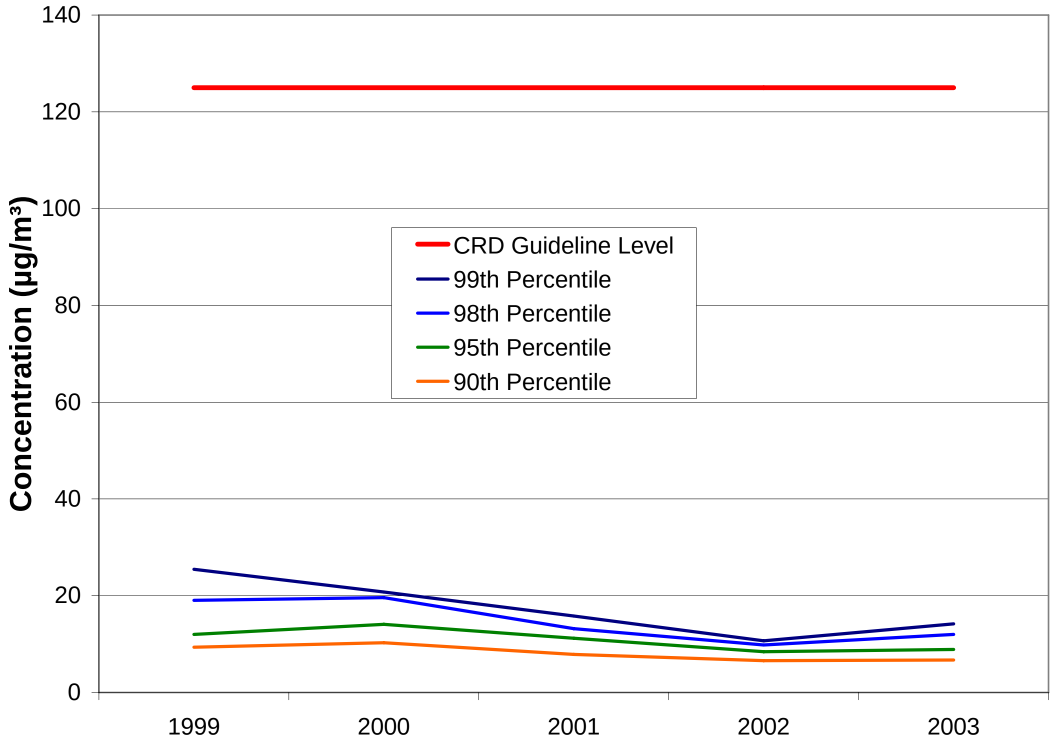


*data from 2000 is omitted, since data capture was approximately 50%.

B.3 Sulphur Dioxide

Figure B.2 shows the trend of sequential 24-hour averaged percentile SO_2 concentrations during 1999 to 2003. A prominent decline is evident during the first four years, which may be partly due to the setting of a low-sulphur diesel standard for fuel sold in B.C., which came into effect in south-western B.C. in 1999. The three-year baseline 24-hour SO_2 concentration is 11.7 µg/m³, which is currently well below the CRD guideline of 125 µg/m³.

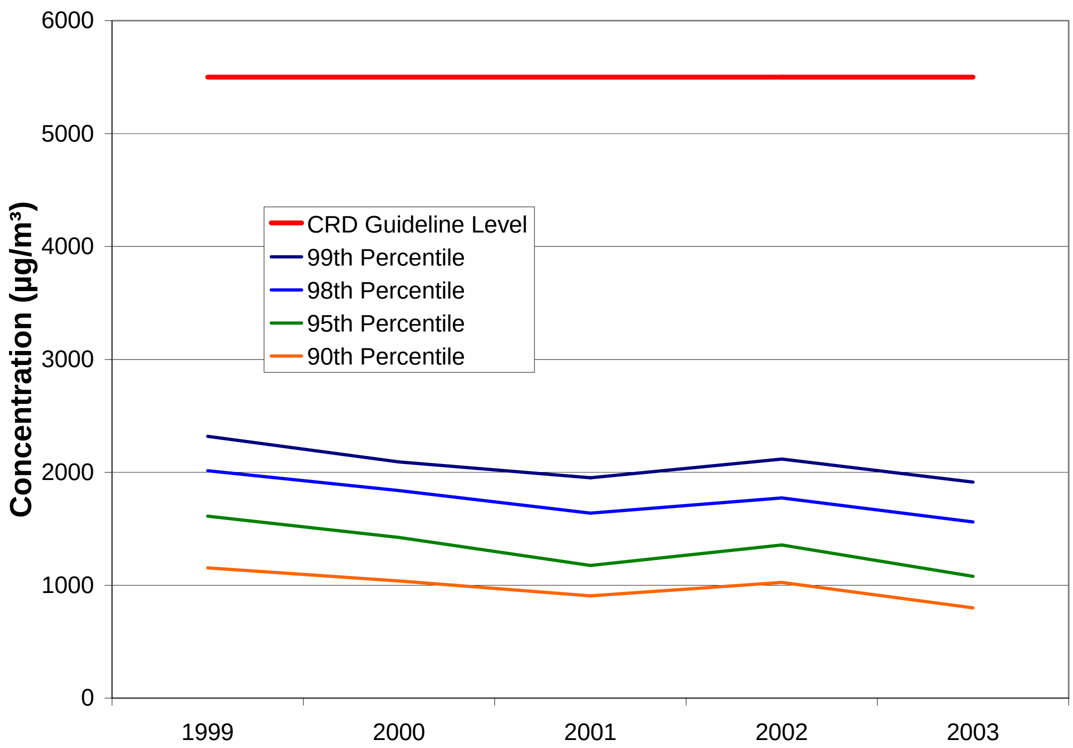
Figure B.2: Sequential 24-Hour SO_2 Percentile Concentrations at Victoria Topaz, 1999-2003



B.4 CARBON MONOXIDE

Percentile concentrations of sequential 8-hour averaged CO concentrations are shown in Figure B.3 for Victoria Topaz during 1999 to 2003. A downward trend is evident during the five years, although concentrations appear more uniform during 2001-2003. The three-year baseline for 98^{th} percentile 8-hour CO concentrations is 1658 µg/m³, currently well below the CRD guideline level of 5500 µg/m³.

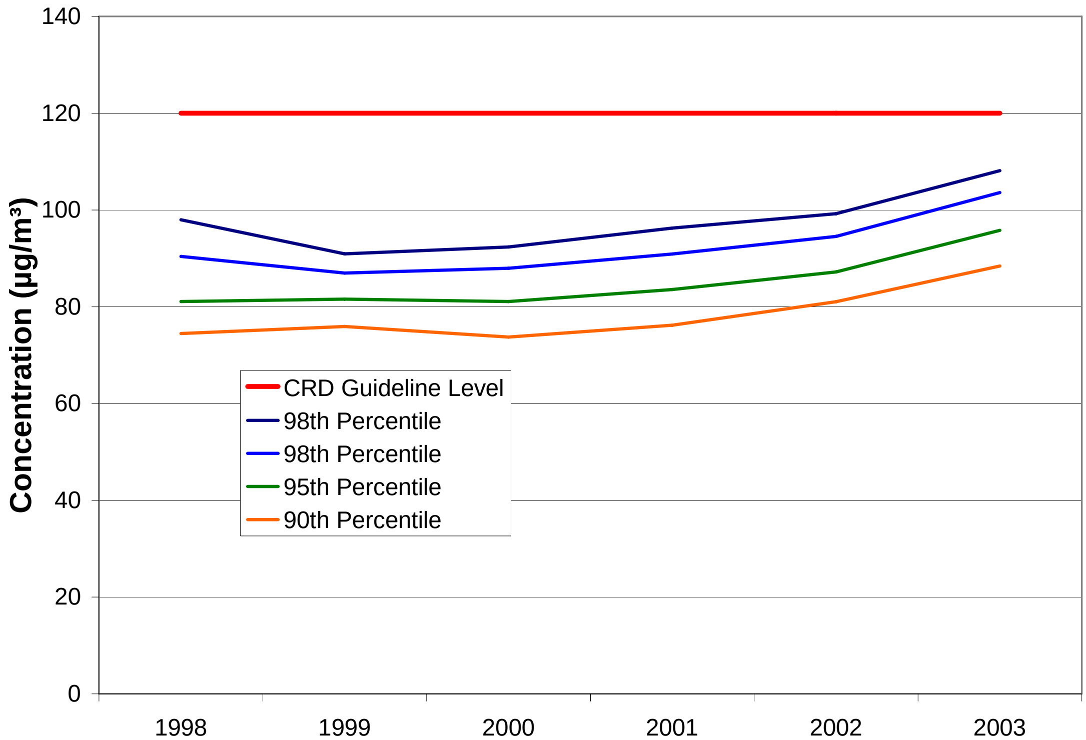
Figure B.3: Sequential 8-Hour CO Percentile Concentrations at Victoria Topaz, 1999-2003



B.5 GROUND-LEVEL OZONE

Ground-level ozone percentile concentrations (8-hour rolling averages) are shown in Figure B.4 for the period of 1998 to 2003 at Saturna Island. The three-year baseline 98th percentile 8-hour ozone concentration is 96.4 µg/m³, which is well below the CRD 8-hour guideline level of 120 µg/m³.

Figure B.4: Rolling 8-Hour Ground-Level Ozone Percentile Concentrations for Saturna Island, 1998 - 2003

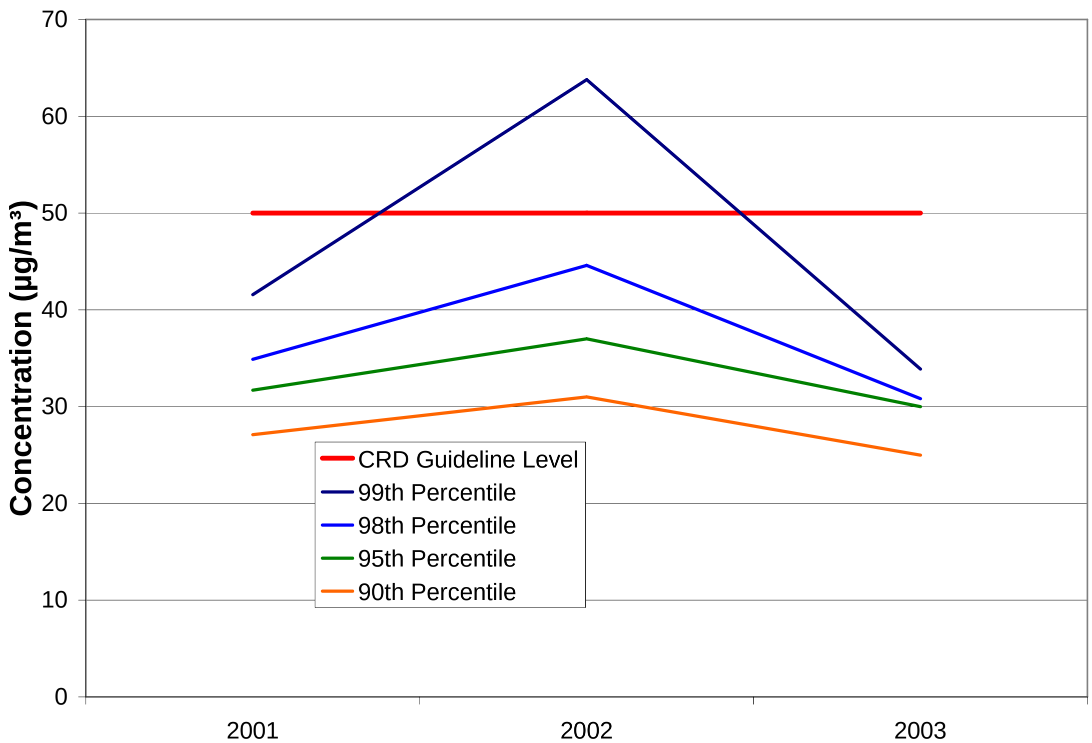


B.6 PARTICULATE MATTER

B.6.1 PM_{10}

Figure B.6 shows the 24-hour PM_{10} percentile concentrations at Victoria Topaz for the years 2001 to 2003. The dataset used to determine the percentiles is considerably smaller than those for other air contaminants, due to the fact that the PM_{10} Hi-Vol data are derived from a sampling frequency of one in six days. With a smaller distribution, the 98th percentile value can fluctuate significantly from year to year. For this reason, the 95th percentile concentration is chosen as a basis for the baseline concentration. It should be noted that a 95th percentile concentration will tend to be several points lower than a 98th percentile concentration. The three-year baseline 95th percentile 24-hour concentration for PM_{10} is 32.9 µg/m³, which is well below the CRD 24-hour guideline level of 50 µg/m³.

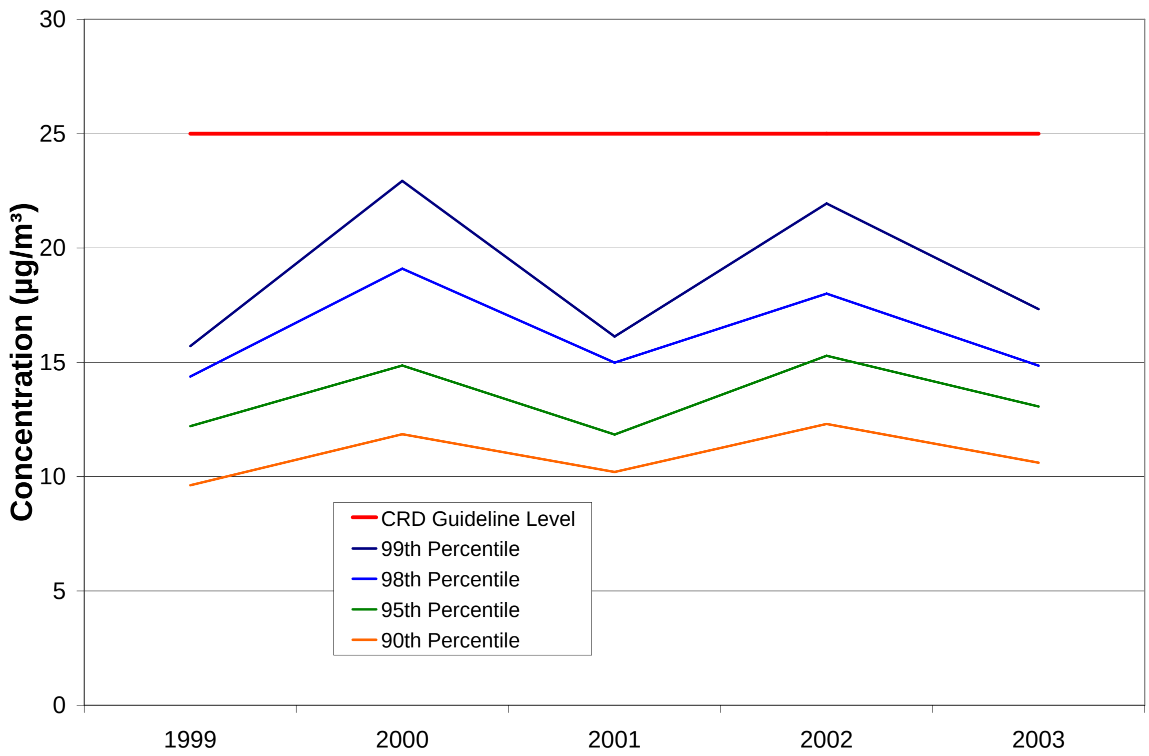
Figure B.5: 24-Hour Hi-Vol PM_{10} Percentile Concentrations at Victoria Topaz, 2001-2003



B.6.2 $PM_{2.5}$

Sequential 24-hour average $PM_{2.5}$ percentile concentrations from 1999 to 2003 for Victoria Topaz are shown in Figure B.7. The three-year baseline 98th percentile, 24-hour concentration is 15.9 µg/m³, which is currently well below the CRD guideline level of 25 µg/m³, but is slightly higher than the Health Reference Level of 15 µg/m³.

Figure B.6: Sequential 24-Hour TEOM $PM_{2.5}$ Percentile Concentrations at Victoria Topaz, 1999-2003



B.7 SUMMARY

The three-year (2001-2003) baseline concentrations for NO_2, SO_2, CO, ground-level ozone, PM_{10} and $PM_{2.5}$ are listed in Table B.1, along with the set of CRD air quality guidelines established earlier in 2003.

Table B.1 Summary of CRD Air Quality Guidelines and Baseline Concentrations

Category/Averaging Time	Pollutant Concentration (in µg/m³)					
	NO_2	SO_2	CO	O_3	PM_{10}	$PM_{2.5}$
Upper-bound Guideline						
1-hour	200					
8-hour			5500	120		
24-hour		125			50	25
Baseline						
1-hour	57					
8-hour			1660	96		
24-hour		12			33	16

(green) Based on Topaz data, 98th percentile of sequential averages
(blue) Based on Saturna Island, 98th percentile of rolling averages
(orange) Based on Victoria Topaz, 95th percentile of sequential averages

Appendix C: Federal/Provincial Air Quality Objectives

C.1 FEDERAL AND PROVINCIAL OBJECTIVES AND STANDARDS

The Canadian National Ambient Air Quality Objectives (NAAQO) is a three-tiered system. Each level has a specific concentration for an individual air contaminant, with one or more averaging periods used. The three levels are:

- The **Maximum Tolerable Level**, representing a time-averaged concentration, above which immediate action is necessary to protect the health of the general population.

- The **Maximum Acceptable Level**, representing a time-averaged concentration suitable to protect human health, animals, soils, water, vegetation, materials and visibility against the effects of air pollution.

- The **Maximum Desirable Level**, representing a time-averaged concentration that is a long term goal for air quality and also provides a benchmark for preserving air quality in the least polluted parts of the country.

Some of the effects of air contaminants above or below the three Federal objective levels are summarized in Table C.1.

British Columbia also has air quality criteria for ambient air concentrations defined at three levels. However, there are no consistent or official definitions for these objectives. In the case of the Bulkley Valley, the levels are interpreted in the same manner as the Federal objectives, but use simplified descriptions[17]. These levels are:

- **Level A;** below this level, air quality is ‘good’. It represents the maximum desirable concentration.

- **Level B;** below this level (but above Level A), air quality is ‘fair’. It represents the maximum acceptable concentration.

- **Level C;** below this level (but above Level B), air quality is ‘poor’. Above this level, air quality is ‘very poor’. It represents the maximum tolerable concentration.

All federal and provincial air quality criteria are presented in Table C.2.

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[17] Johnson, D., *Bulkley Valley Air Quality Management Plan*. February 1999. http://wlapwww.gov.bc.ca/ske/skeair/reports/BVAQMP1999.pdf

Table C.1:
National Ambient Air Quality Objectives
and Their Relationship to Some Health and Environmental Effects
(Source: Environment Canada 1991)[18]

POLLUTANT	**GOOD RANGE** (0-MAX. DESIRABLE)	**FAIR RANGE** (MAX. DESIRABLE-MAX. ACCEPTABLE)	**POOR RANGE** (MAX. ACCEPTABLE - MAX. TOLERABLE)	**VERY POOR RANGE*** (OVER THE MAX. TOLERABLE)
Sulphur Dioxide (SO_2)	no effects	increasing injury to species of vegetation	odorous; increasing vegetation damage and sensitivity	increasing sensitivity of patients with asthma and bronchitis
Total Suspended Particulate (TSP)	no effects	decreasing visibility	decreased visibility; evident soiling	increasing sensitivity of patients with asthma and bronchitis
Ground-Level Ozone (O_3)	no effects	increasing injury to some species of vegetation	decreasing performance by some athletes exercising heavily	light exercise produces effect in some patients with chronic pulmonary disease
Carbon Monoxide (CO)	no effects	no detectable impairment but blood chemistry changing	increasing cardiovascular symptoms in smokers with heart disease	increasing cardiovascular symptoms in non-smokers with heart disease; some visual impairment
Nitrogen Dioxide (NO_2)	no effects	odorous	odour and atmospheric discoloration; increasing bronchial reactivity in asthmatics	increasing sensitivity of patients with asthma and bronchitis

***The upper limit of the very poor range is not defined. At extremely high levels of any of these pollutants, symptoms would be worse than those listed.**

[18] Environment Canada 1991. *The State of Canada's Environment.* Government of Canada, Ministry of Supply and Services, Ottawa.

Table C.2 Federal and Provincial Air Quality Objectives

For Contaminants[1] Monitored in the CRD

Contaminant	Averaging Period	Canada Maximum Desirable	Canada Maximum Acceptable	BC Level A	BC Level B	BC Level C
Carbon Monoxide	1-hour	15000	35000	14300	28000	35000
	8-hour	6000	15000	5500	11000	14300
Nitrogen Dioxide	1-hour		400			
	24-hour		200			
	Annual Arithmetic Mean	60	100			
Ozone	1-hour	100	160			
	24-hour	30	50			
	Annual Arithmetic Mean		30			
Sulphur Dioxide	1-hour	450	900	450	900	900 -1300
	24-hour	150	300	160	260	360
	Annual Arithmetic Mean	30	60	25	50	80
Ambient Air Quality Objectives Established in 1995						
PM_{10}	24- hour			50		

Notes:
[1] All units in µg/m^3

C.2 COMPARISON OF CRD LEVELS TO FEDERAL AND PROVINCIAL OBJECTIVES

Table C.3 provides a summary of CRD air quality concentrations at averaging times corresponding to provincial and/or federal ambient objectives. Comparisons to CRD objectives, and the Canada Wide Standards can be found in the main body of this report. There were no exceedences of provincial objectives, and no exceedences of federal objectives, with the exception of 24-hour and annual average ground-level ozone. However, these federal objectives were set in the mid 1970's and are known to be outdated. The federal ozone objectives are commonly exceeded at several rural monitoring sites in Canada. The more current Canada Wide Standard for ozone (8-hour average) is not exceeded at any ozone monitoring station in the CRD (see Section 2.3).

Table C.3
Comparison of Maximum Pollutant Concentrations (μg/m³) in the CRD for 2003 to Provincial and Federal Objectives

		Air Quality Criteria	Monitoring Station							
Contaminant	Averaging Period*	B.C. or Federal Maximum Acceptable Level	Victoria Topaz	Royal Roads	Langford	Stellys	Oak Bay	Braefoot	Keating	Saturna Island
Carbon Monoxide	1-hour	28000	9000							
	8-hour	11000	2813							
Nitrogen Dioxide	1-hour	400	124.3	61.2						
	24-hour	200	59.1	34.0						
	Annual	100	21.7	10.3						
Ozone	1-hour	160	117.7	119.7		97.8[1]				158.8
	24-hour	50	82.2	94.8		70.0[1]				101.8
	Annual	50	37.8	42.1		NA				58.4
Sulphur Dioxide	1-hour	900	178							
	24-hour	300	25.0							
	Annual	60	3.0							
PM_{10}	24-hour	50	38 (HiVol) 32.7 (Dicot)	24 (HiVol)	40 (HiVol)	22[2] (Partisol)	42 (HiVol)	30 (HiVol)	36 (HiVol)	

Notes:
* Type of averaging period (i.e., rolling or sequential) is not specified. SENES has assumed sequential averaging for each.
[1] Partial record: Sept 17 – December 31, 2003.
[2] Partial record: August 31 – December 23, 2003.