2004 ANNUAL AIR QUALITY REPORT FOR PRINCE GEORGE

Environmental Protection Division
Ministry of Environment
Omineca and Peace Regions

Prince George, British Columbia

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PREFACE

This report presents a summary and assessment of the 2004 air pollutant emission sources, the ambient air quality, and the meteorological information from the Prince George airshed. This report is prepared for the use of the Prince George Air Quality Implementation Committee, and for the joint government/industry monitoring group, the Prince George Air Quality Monitoring Working Group.

The Prince George Air Quality Implementation Committee comprises representatives from:

B.C. MINISTRY OF ENVIRONMENT - OMINECA-PEACE REGION
REGIONAL DISTRICT - FRASER-FORT GEORGE
CITY OF PRINCE GEORGE
MINISTRY OF TRANSPORTATION
NORTHERN HEALTH AUTHORITY
UNIVERSITY OF NORTHERN B.C.
PRINCE GEORGE CHAMBER OF COMMERCE
PRINCE GEORGE AND DISTRICT MEDICAL SOCIETY
CANFOR
HUSKY
CENTRAL INTERIOR WOOR PROCESSORS' ASSOCIATION
CARRIER LUMBER

All operational and maintenance costs are funded by the Prince George Air Quality Monitoring Working Group.

The report was prepared by the Environment Protection Division of the Ministry of Environment, Omineca-Peace Region. The contributors are:

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The Ministry provides an air quality index that is updated twice daily during the work week, and which is accessible to the public via a telephone answering machine (565-6457). Air quality index values for selected pollutants are also provided to the local newspaper, radio and T.V. station on a daily basis, as well as to the Weather Network, and is available on the internet at http://wlapwww.gov.bc.ca:8000/pls/aqiis/air.summary. The Ministry also installed a 24-hour complaint line (565-4487) in June 1996 where the public can record reports of poor air quality in their area (with the option of remaining anonymous).

Archived data from previous monitoring programs in Prince George are available at the Ministry's Regional office in Prince George.

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OBJECTIVES

The purpose of the airshed monitoring program is to conduct an ambient air quality and meteorological monitoring program in Prince George, which is used to establish the relationship between air quality, source emissions and meteorological conditions, and to determine the acceptability of air quality based on B.C.'s air quality objectives. This program is also being used to determine trends in air pollution and to assess the effectiveness of pollution reduction.

This report summarizes the data collected in 2004 and includes a summary of ambient air quality and meteorological data, and a trend analysis of these data. The appendices contain operating hours of monitoring equipment at the air quality stations, ambient air quality objectives, additional data summary tables, photographs of monitoring sites and a glossary of terms.

EXECUTIVE SUMMARY

This report summarises the data collected in the Prince George airshed for 2004 and describes the air quality and meteorological data.

In 2004, eight air quality monitoring stations were in operation to measure seven criteria pollutants. The parameters measured were PM_{10} (Particulate Matter less than 10 microns (µm) in size), $PM_{2.5}$ (Particulate Matter less than 2.5 microns in size), NO_x (Nitrogen Oxides), O_3 (Ozone), CO (Carbon Monoxide), TRS (Total Reduced Sulphur), and SO_2 (Sulphur Dioxide).

There still was a concern in 2004 with PM_{10} levels meeting the provincial Level B objective. Further reductions in particulate emissions would further reduce the risk of various health effects. Annual average continuous PM_{10} levels at Plaza and BCR monitoring sites were the highest since 1998. Exceedances of the Level B daily PM_{10} objective ranged from 0% (Lakewood) to 14.0% (BCR). The frequency of exceedances of the level B objective (24-hour average of 50 $\mu g/m^3$) decreased at Gladstone and Plaza, but increased by 73% at the BCR site, and was the greatest number of exceedances on record due to an increase in dust at this location

Ambient $PM_{2.5}$ levels gradually decreased at the Plaza site from 1994 to 1999. Since then concentrations have increased. The annual average at the Plaza continuous monitor was similar to that recorded in 2003. Presently B.C. does not have an objective for $PM_{2.5}$. However, $PM_{2.5}$ at Plaza continues to exceed the Federal Canada-Wide Standard (to be implemented in 2010), which is based on a three year average 98th percentile.

The annual average TRS concentrations recorded at the Jail and Plaza monitoring sites were the highest and second highest, respectively, recorded at those sites since 1998. The annual average at Lakewood in 2004 was the highest recorded at that site since 1995. The Jail site recorded the highest frequencies of exceedances of the Level A one-hour and 24-hour objectives since 1998, and the highest frequency of exceedances of the Level B one-hour objective since 1995. The number of exceedances of the Level A 1-hour objective and the Level B 24-hour objective at the Lakewood site were the highest since 1995. The number of exceedances of the Level B 1-hour objective at the Lakewood site was the highest since 1989.

The annual average SO_2 level at all three monitoring sites were lower in 2004 than in 2003. The annual average SO_2 level at Plaza was the lowest ever recorded at that site. During this monitoring period, there were six exceedances of the ambient SO_2 Level A objective recorded at CBC, with the maximum one-hour average (703 $\mu g/m^3$) occurring in January. The Plaza and Jail did not record any exceedances of the Level A one-hour objective.

The annual average ozone level at Plaza in 2004 was the lowest recorded since 2000. The number of exceedances of the Level A 1-hour objective at that site was the second lowest since 1997. In 2004, most of the hourly ozone exceedances of the Level A objective occurred in spring. One exceedance of the provincial one-hour Level B objective (160 µg/m^3) occurred in 2004. This hourly value of 172 µg/m3 (recorded in August) was the highest ever recorded at this site.

There were five air quality advisories issued in 2004. These advisories are listed in Table 5.1 (page 73) along with the duration of the episode and the maximum 24-hour rolling average during each period.

1. PRINCE GEORGE MONITORING NETWORK

In 2004, eight air quality monitoring stations and six meteorological stations were in operation (Figure 1.1). The parameters monitored at each site are listed in Table 1.1. Photographs of most of these locations are including in Appendix D. Archived data from discontinued stations and monitors are available at the Ministry's Regional office in Prince George.

Table 1.1 Prince George air quality monitoring program for 2004

Site No.	Location	Parameters
0450322	Jail	TRS, SO_2
0450307	Plaza	$\mathrm{PM}_{2.5}$, PM_{10}, $\mathit{PM}_{2.5}$, PM_{10}, TRS, NO_x, SO_2, O_3, CO
0450232	Van Bien School	PM_{10}
0450324	Lakewood Jr. School	PM_{10}, TRS
0450270	Gladstone School	PM_{10}, SO_2
E218771	CNR Site	PM_{10}
E224013	BCR Warehouse	PM_{10}
E209179	CBC Transmitter Site	SO_2
M109912	Plaza	WD, T, RH, SR
M109911	P.G. Pulp	WD, T
M109913	Northwood	WD, T
E224014	Hart	WD, T
71908	Airport	WD, T, RH, SR, VIS, CC,PRC, PRS
-	UNBC	WD, T, RH, SR

TRS = Total Reduced Sulphur Compounds (as $\mathrm{H}_2\mathrm{S}$)
SO_2 = Sulphur Dioxide
NO_x = Nitrogen Oxides (includes nitric oxide (NO) and nitrogen dioxide (NO_2))
PM_{10} = Particulate Matter less than 10 microns in size (continuous)
PM_{10} = Particulate Matter less than 10 microns in size (non-continuous)
$\mathrm{PM}_{2.5}$ = Particulate Matter less than 2.5 microns in size (continuous)
$\mathit{PM}_{2.5}$ = Particulate Matter less than 2.5 microns in size (non-continuous)
O_3 = Ozone
CO = Carbon Monoxide
T = Temperature
WD = Wind Direction and Wind Speed
SR = Solar Radiation
RH = Relative Humidity
VIS = Visibility
CC = Cloud cover as well as cloud type and ceiling heights
PRC = Precipitation amount and type, including snow on ground
PRS = Barometric Pressure

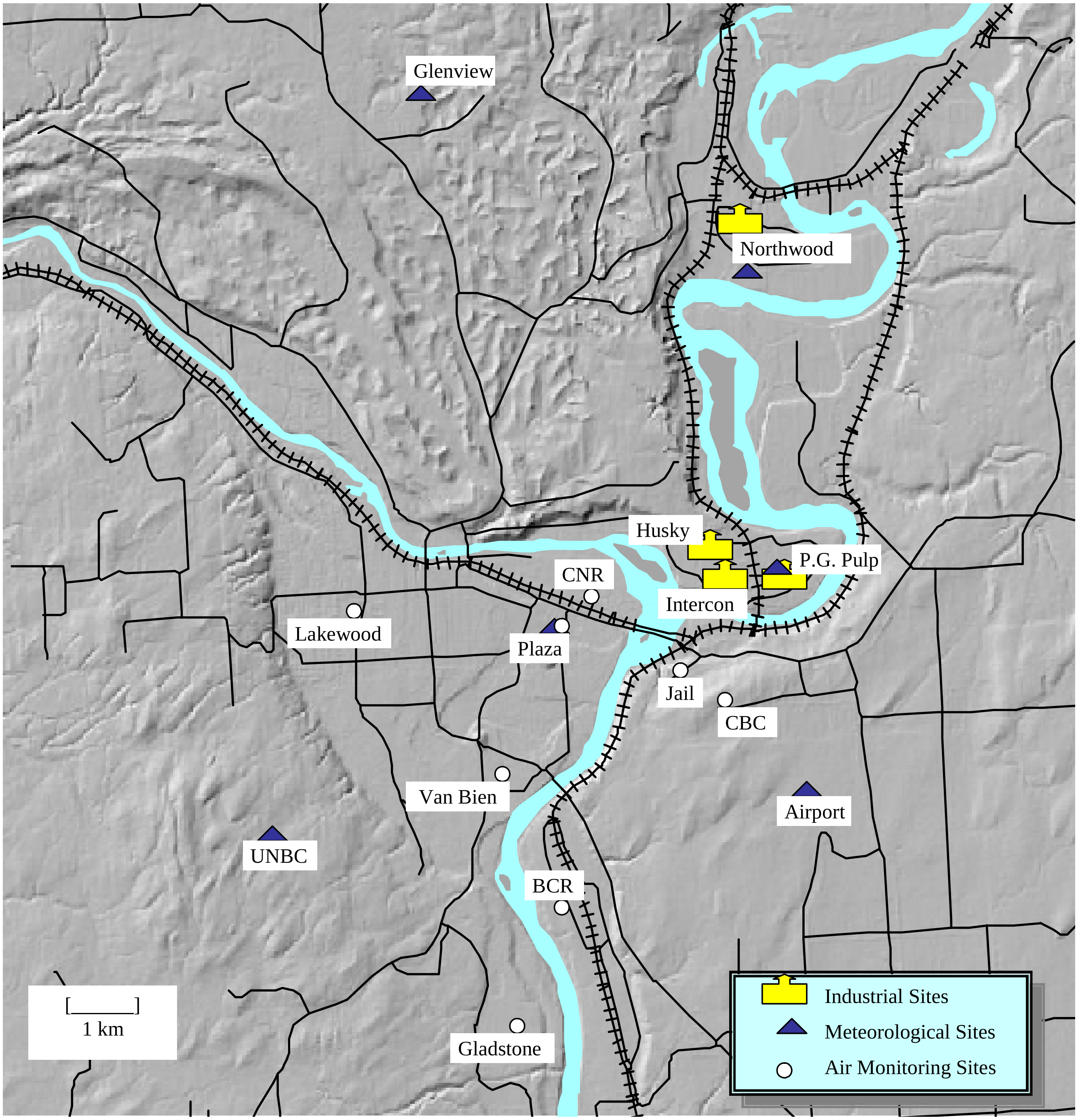


Figure 1.1 *Prince George monitoring sites*

2. METEOROLOGICAL INFORMATION FOR 2004

During 2004, four Meteorological Information Stations (MIS) were operated by the Ministry of Water, Land and Air Protection (now Ministry of Environment), in addition to the federal meteorological station located at the airport, and a monitor operated at the University of Northern B.C. (UNBC). These stations are listed in Table 2.1 along with their locations, elevations and the percent of valid data reovered the past year. Data recovery ranged from 96.9% (Plaza) to 99.9% (Airport).

Table 2.1 2004 meteorological stations with percent valid data

Station Name	**Latitude (deg/min/sec)**	**Longitude (deg/min/sec)**	**Elevation (metres)**	**Percent of Valid Data**
Plaza	53 54 48	122 44 28	595	96.9
Northwood	53 58 03	122 41 27	577	99.0
P.G. Pulp	53 55 28	122 41 10	600	98.2
Hart	53 59 44	122 46 32	750	98.9
Airport	53 53 20	122 40 30	691	99.9
UNBC	53 53 43	122 48 52	814	99.6

Hourly averages for wind direction, wind speed and temperature are measured at the meteorological stations listed, except for the Airport station where the archived data consist only of the values recorded about five minutes before each hour. Solar radiation is also monitored at the Plaza and UNBC sites. Relative humidity is recorded at the Plaza, Hart, and Airport sites. At the Airport site, Environment Canada also monitors cloud type and cover, precipitation amounts, snow on the ground, visibility, and barometric pressure.

Since September 2001, all anemometers used in the Prince George airshed are RM Young wind monitors (Fig. 2.1). The RM Young is a more sensitive instrument and has a much lower starting threshold than the older Gill Microvane/3-Cup that were originally located at the Ministry's meteorological stations. In order to compensate, an adjustment of 0.45 m/s was added to all scalar wind speeds at all sites that used the Gill instrument that produced a lower frequency of calm winds at those sites that used the Gill instrument. No adjustment is needed for the RM Young instruments. This change in instruments has made it difficult to assess the long term trend in wind speeds. At the Plaza and the P.G. Pulp sites, the Gill anemometers were replaced by RM Young monitors in May 2000, at Northwood in August 2001 and at Hart in September 2001.

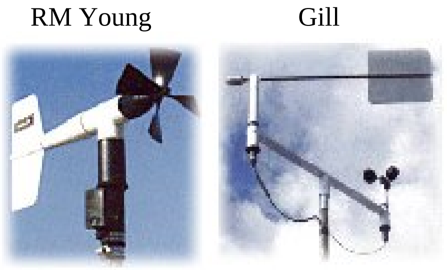


Fig. 2.1 Anemometers used in Prince George monitoring program

2.1 Analysis of Winds

Figure 2.2 shows the wind direction frequencies at each of the 16 major compass points, and the average wind speed in each direction at the six meteorological stations (wind direction refers to the direction from which the wind is blowing) on a map of the Prince George area. For example, at Northwood, winds from the south occurred about 17% of the time. All sites showed a high frequency of winds (at least 14%) from the south and, with the exception of the Plaza site, all sites showed a low frequency (<3%) of winds from the east. The frequency of calms from the Plaza and Northwood sites (located in the valley) was approximately 23.7%, but at the P.G. Pulp site the frequency of calms was only 18.4%. Calm winds recorded at the three sites located at higher elevations ranged from 13.8% - 18.4%.

The frequency distributions of wind directions at Northwood and P.G. Pulp show a classic valley-type flow with the directions being predominately southerly or northerly, in line with the valley. The effect of the expansion of the valley into the larger bowl area is noted on the wind patterns at P.G. Pulp, with stronger and more frequent southwest to west winds. Light winds from the north occurred more frequently than those from the south at Northwood and P.G. Pulp in 2004. This is typical, and due to down valley winds that occur at night or during winter and are normally less than 2 m/s. The increased frequency of northerly winds is due to the drainage effect. At night, wind speeds are known to diminish as the air cools. The cooler air (which is heavier) sinks and moves down the valley, resulting in the higher frequency of light northerly winds. Valley monitoring sites show this northerly flow, but sites on top of the plateau may report calm winds or light winds from another direction.

At Plaza, the north/south valley effect is not as predominant. Although south is still the dominant direction, there are more east than north winds. This occurs because north winds are deflected eastward by the hills located south of the pulp mills, before reaching the Plaza monitoring site. In fact, most of the east winds are light; < 4 m/s. The stronger winds tend to occur in all sectors except from the east sector. The low frequency of strong winds from the southwest is probably due to the air flow from that direction being blocked by Connaught Hill which is located about 200 metres directly southwest of the monitor.

The Hart, Airport and UNBC sites also show the terrain influence on air flow. The lower frequency of northerly winds at the Hart and UNBC sites compared to Northwood and P.G. Pulp sites show that because of their elevations, there is less of an influence from the terrain features, compared to the valley sites. When valley sites are showing a northerly flow, sites on top of the plateau may report calm winds or light winds from another direction. The reason for the much higher frequency of north and south winds at the Airport could be due to the instrument used at the airport using a less sensitive, 3-cup anemometer similar to the Gill instrument (Figure 2.1) previously used at Prince George sites.

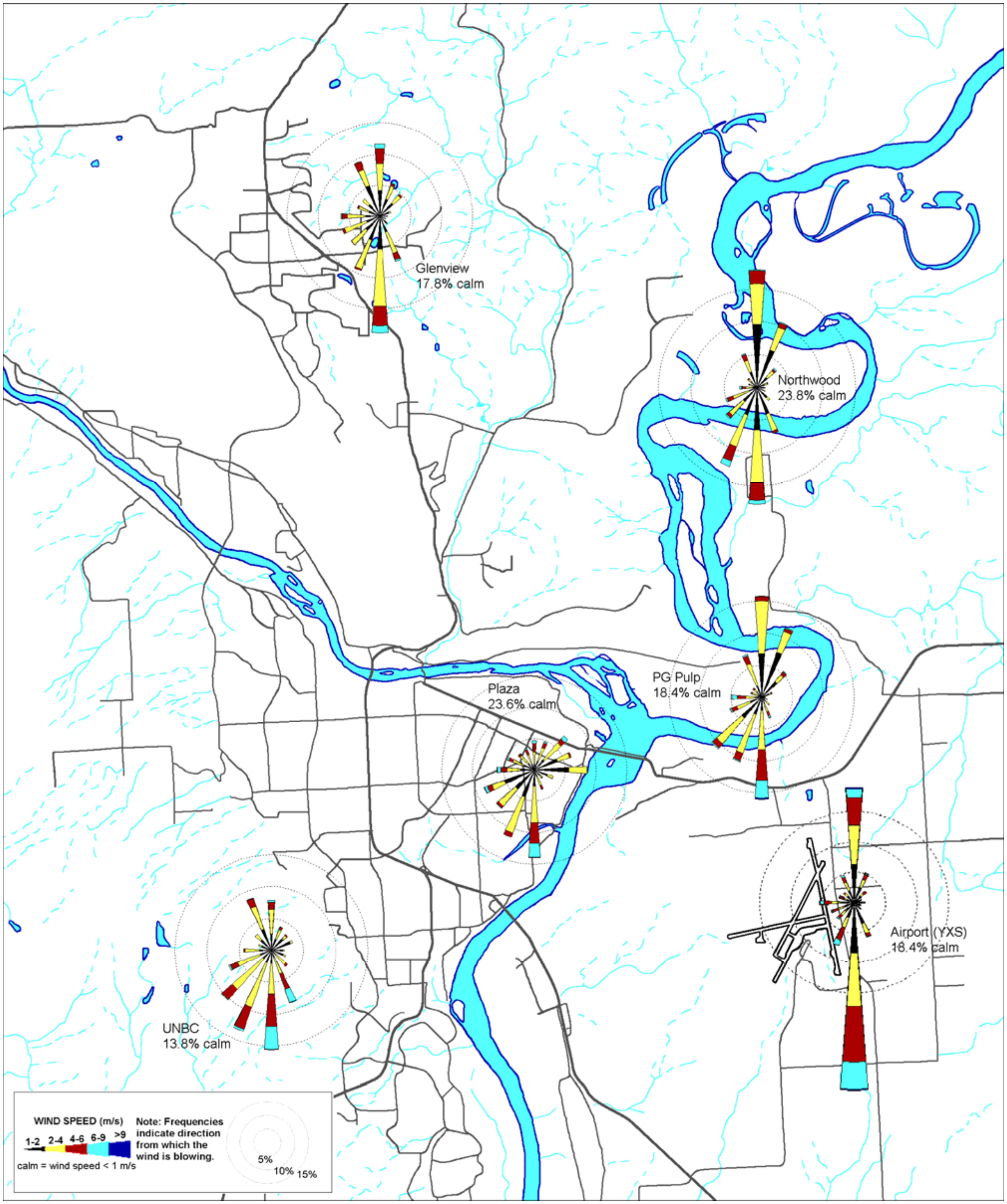


Figure 2.2: Map of Prince George showing the six wind roses for 2004

Figure 2.3 shows the monthly average 2004 wind speeds from the Prince George airport compared with the 10 year average (1994-2003). Higher elevation sites tend to have higher wind speeds, so those sites within the bowl of the P.G. airshed would experience lower monthly average wind speeds. February, April, July and August recorded wind speeds lower than the 10-year mean at the airport although the average annual wind speed in 2004 was higher than the 10-year mean.

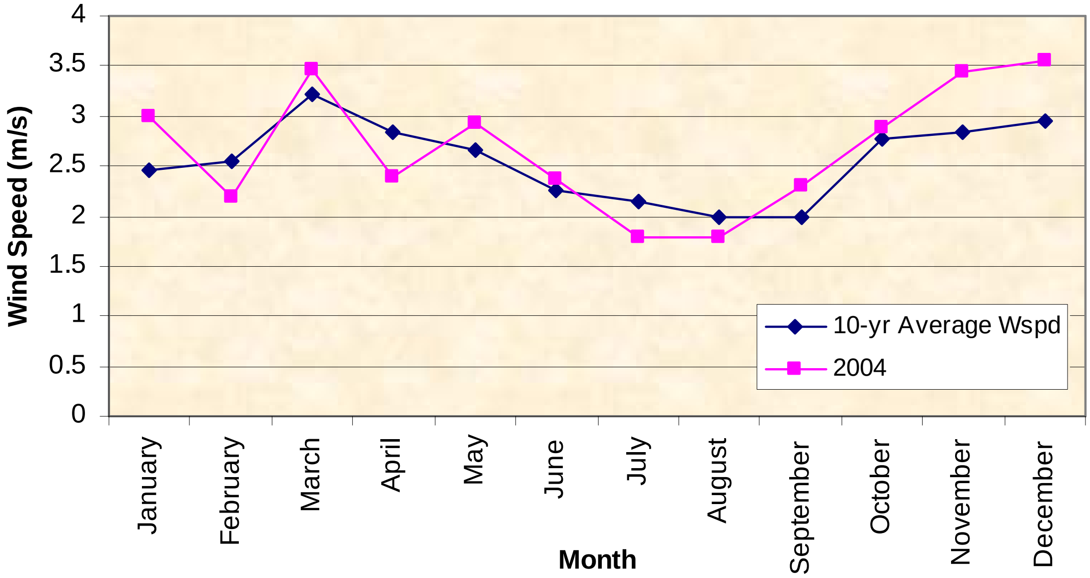


Figure 2.3 Average monthly wind speed in m/s (2004 and 10 Year Mean) at the Prince George Airport

Meteorological factors such as synoptic scale phenomena (frontal passage, movements of high and low-pressure regimes), and cloud cover affect wind flow. Higher wind speeds generally produce better air quality, depending on wind direction. A clear sunny day normally would produce more daytime mixing and stronger winds than clear skies at night with temperature inversions and calmer winds. Also, on clear nights, radiation cooling causes air to sink and move down the valley resulting in a higher frequency of light northerly winds in Prince George.

2.2 Analysis of Precipitation

Precipitation plays an important role in air quality. Not only does rain wash pollutants out of the air, but also prevents surface dust from being emitted into the airshed. Water droplets can also contribute to faster chemical reactions of pollutants. For example, SO_2 can be readily converted to sulphuric acid in the presence of water droplets.

Figure 2.4 shows the monthly total precipitation recorded at the airport compared to the 10-year average (1994-2003). Precipitation was above the ten-year average for the last five months and in February and May. Considerably lower relative precipitation amounts were recorded in April and July.

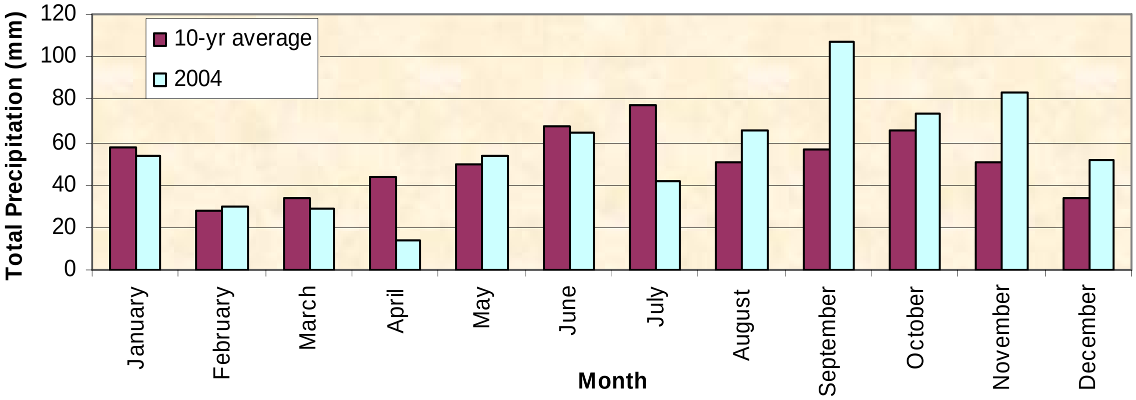


Figure 2.4 Comparison of total monthly precipitation (mm) at the airport between 2004 and the 10-year average

Figure 2.5 shows the trend in the total annual precipitation recorded at the Prince George Airport. The annual average precipitation in 2004 was substantially higher than in 2002 and 2003, and the highest recorded since 1999. In addition to precipitation, air quality is also affected by wind speed and direction, and emission trends.

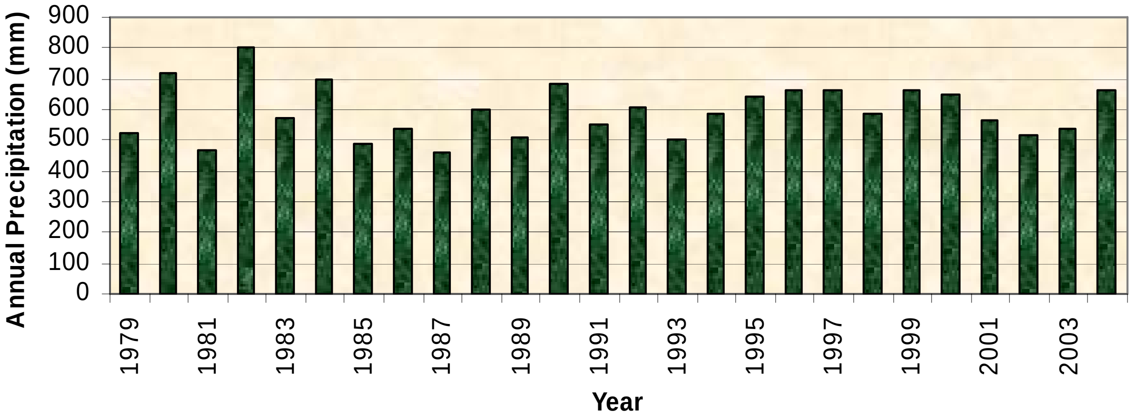


Figure 2.5 Total annual precipitation (mm) at the Prince George Airport

2.3 Analysis of Temperature

Temperature can also have an influence on air pollution levels, both directly and indirectly. Indirectly, cold temperatures in Prince George can result in the production of more emissions in the airshed from industrial and residential use of wood and other fuels. Also, vehicle emissions are known to increase during colder weather as a result of engines becoming less efficient and requiring more fuel to warm up the engines. A direct effect is that chemical reactions are known to be dependant on temperature. Most reactions have a direct relationship to temperature. Pollutants like ozone can be produced faster at higher temperatures, and the destruction of ozone also occurs at a greater rate in warmer conditions. It is uncertain whether the net ozone increases or decreases with temperature, although some consider the former the more viable option.

Figure 2.6 shows the daily maximum and minimum temperature in 2004 recorded at Plaza compared to the historical maximum and minimum daily temperatures since monitoring started at that site. Record minimum temperatures were recorded on three days in October, and one day for each of January, April, May and July. Record maximum temperatures were recorded on nine days in June, six days in April, five days in January, three days in March and August, twice in July and December, and once in February.

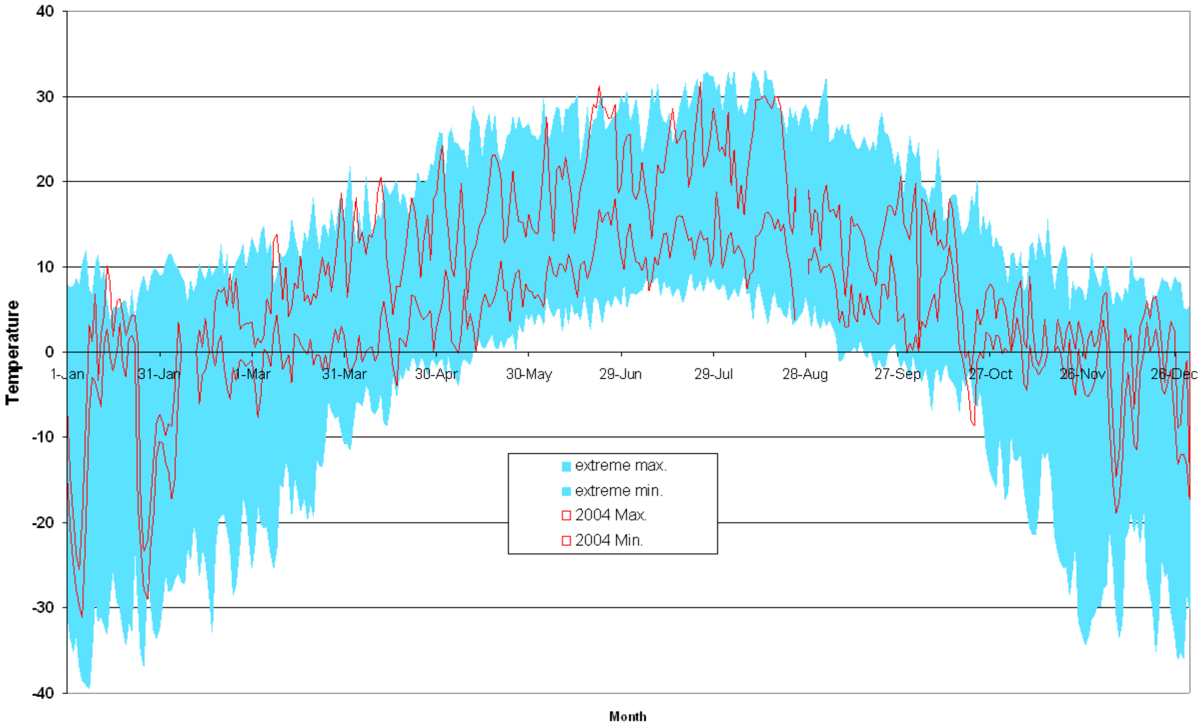


Figure 2.6 2004 maximum and minimum temperatures (^{o}C) in Prince George (Plaza station) compared to the 1985-2003 values

Average temperatures at the downtown (Plaza) location tend to be somewhat higher than all other sites. This could be due to the heat island effect in which temperatures in urban areas are typically higher than rural areas. Temperatures at higher elevations are normally lower than those at lower elevations because temperatures normally decrease as one ascends in altitude. However, temperatures at night are normally lower at low elevations than those at higher elevations because at night cold air sinks causing areas in valleys to be colder than hill tops.

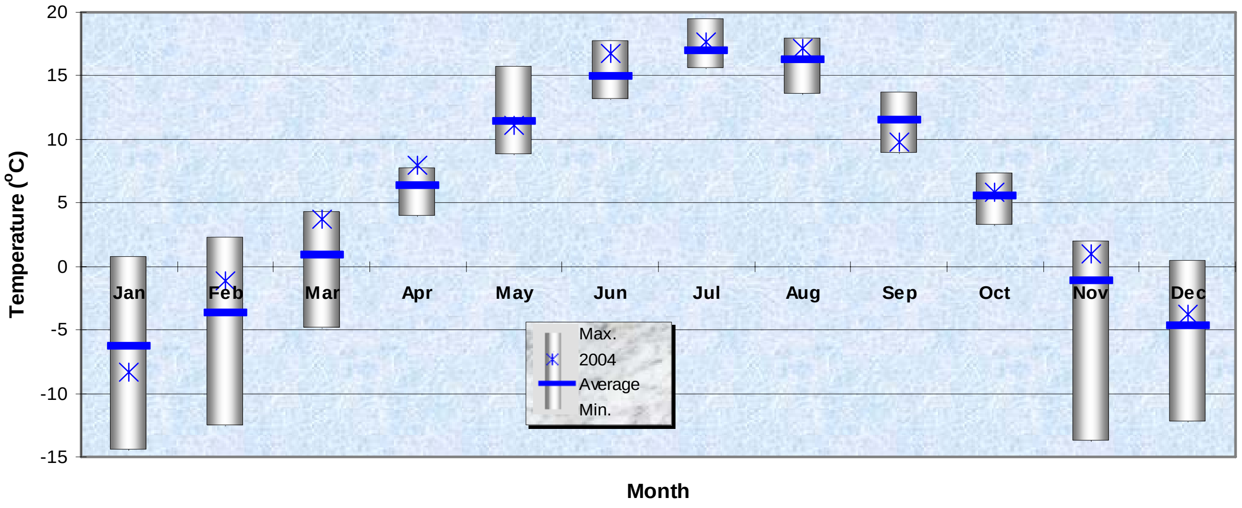


Figure 2.7 *Comparison of 2004 with long-term average monthly temperatures (°C) at Plaza since 1985*

Figure 2.7 shows the range in monthly mean temperatures at Plaza since monitoring began at that site in 1985. Monthly mean temperatures in 2004 ranged from a low of -8.3°C (January) to a high of 17.7°C (July). Temperatures were below normal only for January and September. April showed the highest monthly average on record for that month. The range in the average monthly temperature (max – min) is the greatest during the winter (about 15°C) and the least during the summer (about 4°C).

3. AMBIENT AIR QUALITY RESULTS AND TRENDS

3.1 Particulate Matter (PM_{10}) Results

Particulate matter refers to small particles ranging in size from 0.001 μm to 100 μm (1 million μm = 1 m). Particles range in chemical composition, size, shape, and physical properties. Particles less than 10 μm (PM_{10}) tend to stay suspended longer in the atmosphere than larger particles. The inability of the atmosphere to disperse small particulates is often evident during hazy days in the autumn when mixing is weak.

Larger particles may cause a nuisance or irritation, but smaller particles (less than 10 μm), either alone or in combination with other pollutants in the air, cause the greatest health effects because some can be inhaled deep into the lung cavities (Vedal, 1995). These health effects include premature death, increased hospital admissions, increased respiratory symptoms and disease, and decreased lung function. The main effects on vegetation are reduced growth and productivity due to interference with photosynthesis and phototoxic impacts as a result of particulate composition.

In Prince George, the major PM_{10} emission sources are pulp mills, sawmills and road dust (Prince George Airshed Technical Management Committee, 1996). Particles can be classified as primary or secondary based on their origins. Secondary particles may be generated from natural sources (volcanoes, decomposition of biological matter, trees) or man-made sources (industrial, motor vehicles). Gases can be transformed in the atmosphere as chemical reactions take place to form particles, such as sulphates, nitrates and various hydrocarbon species. The generation of these particles can result in acidic precipitation and reduction of visibility, components typical of smog conditions. The chemical and physical compositions of PM_{10} vary depending on location, time of year, and meteorology.

PM_{10} is measured by drawing air through a size selective inlet prior to collection on a Teflon coated glass fibre filter at a rate of about 1.14 cubic metres per minute (Figure 3.1.1). These non-continuous samplers are run for 24 consecutive hours, from midnight to midnight, on a National Air Pollution Surveillance (NAPS) schedule (i.e., once every sixth day). The results from these samplers are not available for several months due to the processing and analysis of the filters. The minimum detection limit using this method is 2 μg/m^3.

Figure 3.1.1: PM_{10} non-continuous monitor

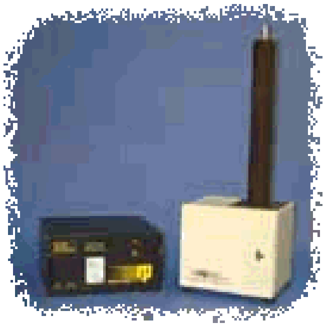


Figure 3.1.2 PM_{10} TEOM monitor

Particulate is also measured continuously using the Tapered Element Oscillating Microbalance (TEOM) technology (Figure 3.1.2). This technique involves the measurement of mass collected on a filter seated on the tapered element and monitoring the changes in oscillating frequency of the tapered element as loading of the filter occurs. This method not only gives instantaneous 24-hour average concentrations but also provides measurements on a continuous basis. The minimum detection limit of the TEOM monitor is 5 µg/m^3.

The quality of the non-continuous PM_{10} data is assessed by regular measurement of laboratory filter weighing error and by calibration of the air flow controllers on the samplers. The quality of continuous data is evaluated by bi-weekly field checks and quarterly mass calibrations, as well as twice annual independent audits. The audit results in Appendix B, Table B-1 indicate that all three monitors had excellence performance in April, and at the BCR and Gladstone sites in November, and was satisfactory at the Plaza in November. Data completeness was satisfactory with valid data ranging from 97.8% to 99.2% at the Plaza, BCR, and Gladstone continuous monitors.

Table 3.1.1 2004 airshed PM_{10} summary

Station	Annual Average (µg/m^3)	No. (%) of Daily Values		Maximum Daily (µg/m^3)	Minimum Daily (µg/m^3)	No. of Values
		>50µg/m^3	>100µg/m^3			
Non-continuous						
Lakewood	15.0	0	0	46	4	60
Van Bien	19.2	1 (1.6%)	0	51	4	61
CNR	22.8	4 (6.7%)	0	79	6	60
Plaza	18.5	3 (4.9%)	0	63	6	61
Continuous						
Plaza	20.3	12 (3.3%)	0	69	3	362
BCR- Warehouse	25.9	50 (14.0%)	0	100	3	358
Gladstone	14.6	1 (0.3%)	0	57	3	357

Table 3.1.1 summarizes the continuous and non-continuous PM_{10} data from 2004 for all the monitoring sites in Prince George. All sites except for Lakewood exceeded the level B 24-hour objective (50 µg/m^3) at least once in 2004. The BCR site recorded the highest percent of exceedances of the Level B 24-hour objective. The relatively high annual average and objective exceedance rate at the BCR site suggests the effect of local PM_{10} sources, which include unpaved railway and log storage yards and two sawmills in particular. Monitoring of finer particles ($PM_{2.5}$) at the same location could indicate whether dust or combustion particles are the predominant component.

3.1.1 PM_{10} Continuous Monitoring Results

In 2004, PM_{10} was continuously sampled at the Plaza, Gladstone, and BCR stations. Figure 3.1.3 and Tables C - 1.1 to C - 1.3 provide the monthly summaries of data from these sites. These figures show monthly average levels and number of days when the PM_{10} objective was exceeded each month. Maximum monthly PM_{10} levels have historically occurred in March due to an increase in dust from accumulated winter road traction material that is crushed and dispersed by motor vehicles. This was not the case in 2004 at any of the sites. The highest averages occurred in April (Plaza and BCR) and August (Gladstone). The elevated values in April can most likely be attributed to dust in the airshed, since the lowest amount of precipitation recorded in 2004 was in April. There were at least 3 months (January, November and December) where there were no daily values ≥ 50 µg/m^3 at any site in 2004.

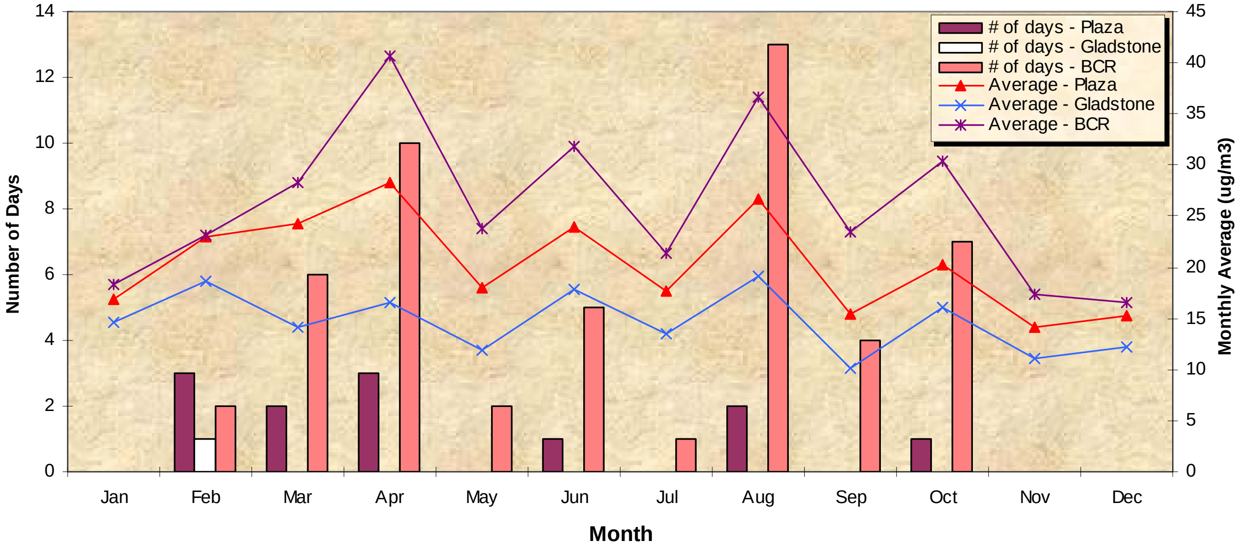


Figure 3.1.3 Monthly average PM_{10} levels (µg/m^3) and the number of days exceeding the Level A 24-hour objective at sites in Prince George

It should be noted that these monitoring sites are elevated and ground-level values are likely higher near roadways. A short term monitoring program was conducted from March to May 1996 to determine the effect of road dust on PM_{10} levels at street level. A site located on a one story building at the same intersection as the Plaza site measured 24-hour levels that were on average 7 µg/m^3 (30%) higher than what was recorded at Plaza. During one occasion, levels at this site were 69% higher than at Plaza (16 µg/m^3 at Plaza and 27 µg/m^3 at the one story building). Since then, with the reduction in road dust, it is expected that differences in concentrations at the different elevations are now less than what was shown in 1996.

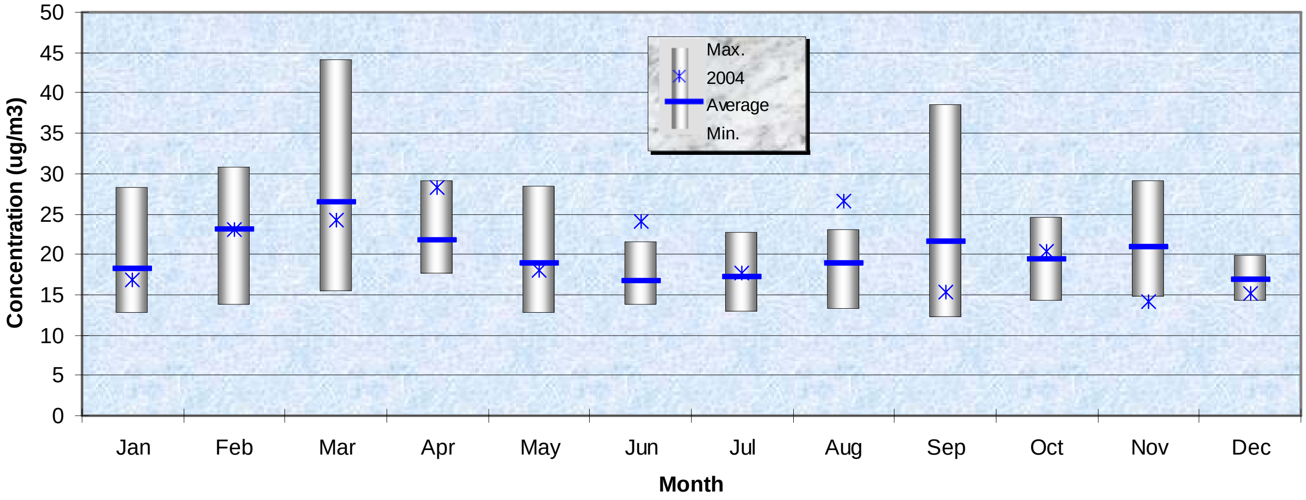


Figure 3.1.4 Comparison of 2004 with long term average monthly PM_{10} levels ($\mu g/m^3$) at Plaza since 1995

Figures 3.1.4 to 3.1.6 show the range in monthly averages of PM_{10} recorded at Plaza, Gladstone and BCR. Monthly averages ranged from a high of 44.2 $\mu g/m^3$ (March 1995) to a low of 12.1 $\mu g/m^3$ (September 2002) at Plaza, a high of 24.2 $\mu g/m^3$ (Feb. 1996) to a low of 9.0 $\mu g/m^3$ (May 1999) at Gladstone, and a high of 49.1 $\mu g/m^3$ (April 1998) to a low of 11.9 $\mu g/m^3$ (February 2002) at BCR. Monthly averages at Plaza and Gladstone have historically tended to be the highest in February-March due primarily to road dust from winter sand and the lowest during June. Unlike the other two continuous sites, monthly averages at BCR tend to be highest during April. The lowest April long term average at BCR was higher than the monthly normals recorded during all other months except for May, August and September. There is another smaller peak in levels at BCR during late summer, likely due to dust. The monthly averages in 2004 at Plaza and Gladstone were the lowest on record for the month of November, and the highest on recorded for the months of June and August. These high monthly averages were due to episodes in those months resulting in Air Quality Advisories being issued. As with Plaza and Gladstone, the monthly averages at BCR for June and August 2004 were the highest ever recorded for those months, but the October average was also the highest on record for that month.

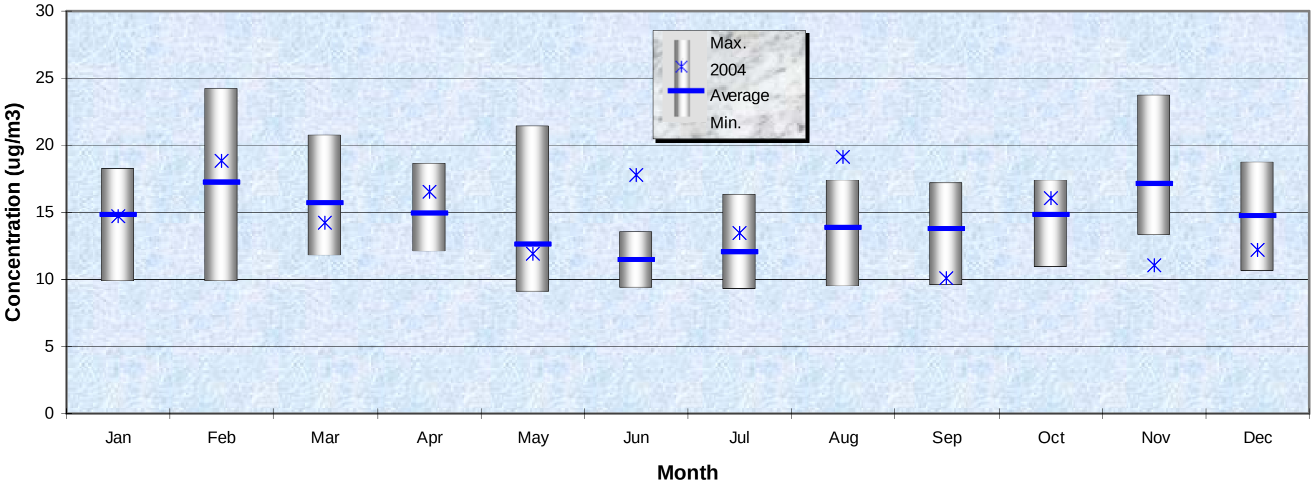


Figure 3.1.5 *Comparison of 2004 with long term average monthly* PM_{10} *levels (*$\mu g/m^3$*) at Gladstone since 1996*

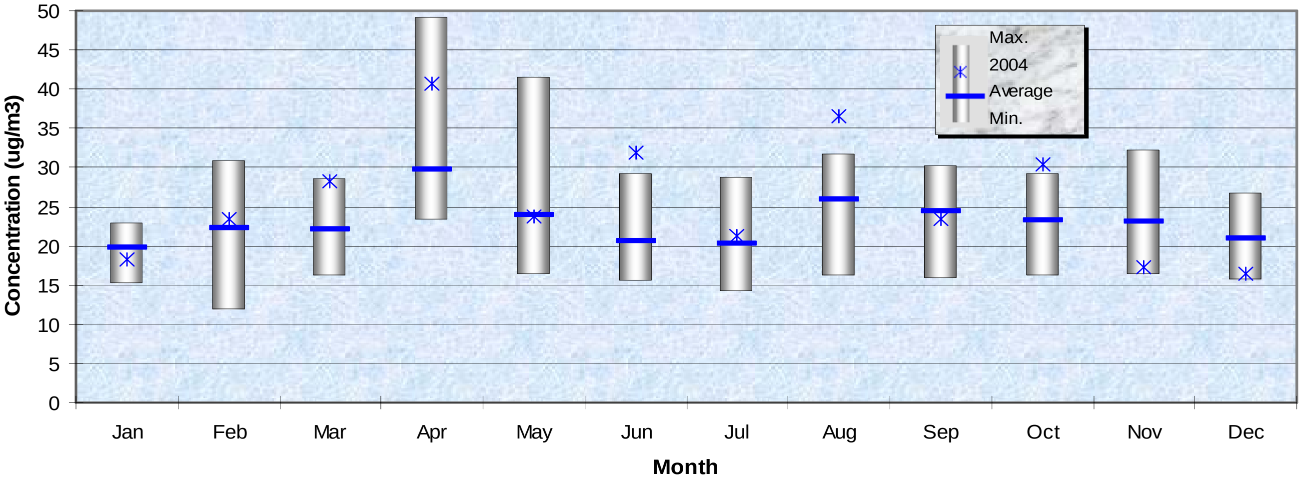


Figure 3.1.6 *Comparison of 2004 with long term average monthly* PM_{10} *levels (*$\mu g/m^3$*) at BCR since 1996*

Figure 3.1.7 shows the 2004 PM_{10} pollution rose for the Plaza site based on the meteorological data, using only data for wind speeds $\geq$ 1 m/s. Winds below 1 m/s are less able to flush the pollutants out of the airshed, therefore confusing the location of the predominant source. The mean concentration for wind speeds < 1 m/s was 35.4 $\mu g/m^3$ (the 24-hour Level B objective is 50 $\mu g/m^3$) which was around 1.5 times the annual average. This figure indicates the importance of low wind speed and calm conditions on downtown PM_{10} levels. Concentrations greater than 50 $\mu g/m^3$ occurred mainly when winds were blowing from the east-northeast to southeast sector. One-hour average particulate levels below 10 $\mu g/m^3$ seldom occurred when winds were blowing from those directions, but occurred about 30-40% of the time whenever winds were from the west and north direction.

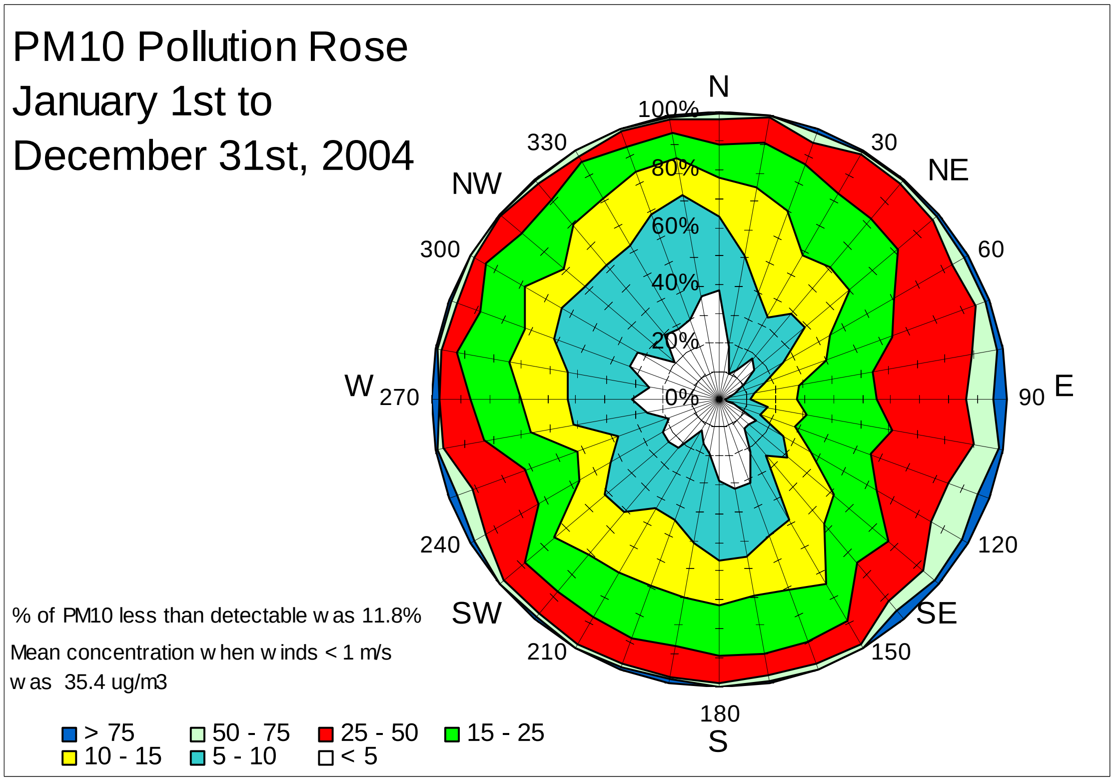


Figure 3.1.7 *PM$_{10}$ Pollution Rose at Plaza for 2004*

3.1.2 PM$_{10}$ Annual Trends

Tables 3.1.2 to 3.1.8 show the trends in PM$_{10}$ levels at all of the monitoring sites. Average 2004 levels increased compared to those in 2003 at all four non-continuous monitoring sites, ranging from a 3.8% increase at Van Bien to a 16.9% increase at CNR. Levels were the highest recorded in the past six years at the continuous monitoring sites (with the exception of Gladstone where the annual average decreased slightly from 2003), but still considerably lower than those in 1998. A comparison between the non-continuous monitor and the TEOM (continuous) showed that from 1994-2001 average non-continuous PM$_{10}$ levels were consistently higher than the TEOM levels. However, in 2001-2004 levels recorded by the non-continuous monitor were generally lower than those from the TEOM. Because continuous PM$_{10}$ monitoring was not started at Plaza until 1992, and because the TEOM monitor generally underestimates levels (except for 2001-2003) (Hauck et. al., 1997; Allen et. al., 2000), non-continuous monitoring continues as a long term trend indicator at that site.

In 2004, the maximum daily average decreased at all 3 continuous monitoring sites (Tables 3.1.7 to 3.1.9). The frequency of exceedances of the level B objective (50 µg/m^3) decreased at Gladstone and Plaza, but increased by 73% at the BCR site, and was the greatest number of exceedances on record due to an increase in dust at this location. There were no daily exceedances recorded in 2004 above 100 µg/m^3. Due to an instrument upgrade, annual averages of PM$_{10}$ from the Plaza TEOM were underestimated in 1992 and 1993. In January 1998 the internal temperature for the TEOM monitors was changed from

50°C to 40°C. This temperature was reduced to minimize PM_{10} loss due to the volatilization of sulphate, nitrate and VOC compounds from the small particles. It is assumed that this adjustment would increase concentrations, but the amount of increase is unknown, so no adjustment to the database could be done.

Table 3.1.2 Annual trend summary of non-continuous PM_{10} data at Van Bien

Year	**Annual Average (µg/m³)**	**No. (%) of Daily Values > 50 µg/m³**	**No. (%) of Daily Values > 100 µg/m³**	**Maximum Daily Value (µg/m³)**	**Number of Samples**
1990	-	7 (26.9%)	0	62	26*
1991	27.6	8 (13.6%)	0	84	59
1992	27.0	7 (12.5%)	0	89	56
1993	27.9	6 (10.2%)	0	99	59
1994	21.8	3 (6.3%)	0	69	48
1995	25.2	6 (10.2%)	1 (1.7%)	106	59
1996	23.9	4 (7.3%)	0	67	55
1997	20.8	3 (5.3%)	0	74	57
1998	28.4	6 (10.9%)	0	91	55
1999	22.7	3 (5.2%)	0	56	58
2000	17.4	2 (3.5%)	0	84	57
2001	17.4	1 (1.7%)	0	61	60
2002	20.4	3 (4.9%)	0	62	61
2003	18.5	2 (3.7%)	0	76	54
2004	19.2	1 (1.6%)	0	51	61

* Note: TSP (total suspended particulates) sampler converted to PM_{10} monitor on August 1, 1990.

Table 3.1.3 Annual trend summary of non-continuous PM_{10} data at Lakewood

Year	**Annual Average (µg/m³)**	**No. (%) of Daily Values > 50 µg/m³**	**No. (%) of Daily Values > 100 µg/m³**	**Maximum Daily Value (µg/m³)**	**Number of Samples**
1990	17.4	0	0	40	24*
1991	21.8	5 (8.5%)	0	89	59
1992	24.8	7 (11.9%)	0	74	59
1993	27.3	4 (7.6%)	1 (1.9%)	129	53
1994	18.9	1 (1.7%)	0	56	58
1995	18.7	4 (7.4%)	0	63	54
1996	16.3	0	0	50	59
1997	15.9	1 (1.7%)	0	51	59
1998	19.8	1 (1.9%)	0	61	54
1999	17.4	1 (1.8%)	0	74	56
2000	14.1	0	0	50	60
2001	13.9	1 (1.7%)	0	52	58
2002	13.2	0	0	45	61
2003	14.4	1 (1.7%)	0	64	59
2004	15.0	0	0	46	60

* Note: TSP (total suspended particulates) sampler converted to PM_{10} monitor on August 1, 1990.

Table 3.1.4 Annual trend summary of non-continuous PM_{10} data at the CNR site

Year	Annual Average (µg/m^3)	No. (%) of Daily Values > 50 µg/m^3	No. (%) of Daily Values > 100 µg/m^3	Maximum Daily Value (µg/m^3)	Number of Samples
1991	30.9	5 (13.2%)	2 (5.3%)	124	38*
1992	28.3	6 (10.3%)	1 (1.7%)	103	58
1993	33.3	14 (23.0%)	1 (1.6%)	104	61
1994	25.2	8 (13.6%)	0	75	59
1995	27.5	8 (13.3%)	1 (1.7%)	110	60
1996	28.1	5 (8.3%)	1 (1.7%)	110	60
1997	22.8	2 (3.6%)	0	65	55
1998	34.0	8 (13.8%)	2 (3.4%)	124	58
1999	28.0	8 (13.6%)	1 (1.7%)	106	59
2000	21.3	3 (5.1%)	0	61	59
2001	18.0	3 (4.9%)	0	56	61
2002	20.9	3 (5.1%)	0	73	59
2003	19.5	2 (3.4%)	0	100	59
2004	22.8	4 (6.7%)	0	79	60

* Note: Monitoring started May 6, 1991.

Table 3.1.5 Annual trend summary of non-continuous PM_{10} data at Plaza

Year	Annual Average (µg/m^3)	No. (%) of Daily Values > 50 µg/m^3	No. (%) of Daily Values > 100 µg/m^3	Maximum Daily Value (µg/m^3)	Number of Samples
1990	-	2 (7.7%)	0	90	26*
1991	29.4	7 (11.7%)	1 (1.7%)	217	60
1992	28.6	6 (10.2%)	0	92	59
1993	30.2	10 (16.7%)	0	92	60
1994	24.1	6 (10.0%)	0	85	61
1995	23.6	4 (6.6%)	0	85	61
1996	21.7	2 (3.5%)	0	61	61
1997	20.8	1 (1.7%)	0	56	61
1998	26.9	5 (8.2%)	1 (1.6%)	111	61
1999	21.3	2 (3.3%)	0	73	61
2000	19.0	1 (1.7%)	0	65	61
2001	15.7	2 (3.3%)	0	52	61
2002	18.2	2 (3.3%)	0	62	61
2003	17.0	2 (3.3%)	0	67	61
2004	18.5	3 (4.9%)	0	63	61

* Note: TSP (total suspended particulates) sampler converted to PM_{10} monitor on August 1, 1990.

Table 3.1.6 Annual trend summary of continuous PM$_{10}$ data at Plaza

Year	Annual Average (µg/m^3)	Maximum Hourly Average (µg/m^3)	No. (%) of Days > 50 µg/m^3		No. (%) of Days > 100 µg/m^3		Maximum Daily Average (µg/m^3)	Hours Instrument Operated
1992	21.6	488	18	(6.1%)	0	(0%)	80	7083
1993	22.3	171	11	(4.5%)	0	(0%)	75	5828
1994*	22.3	284	19	(5.6%)	4	(1.2%)	117	8162
1995	24.2	291	33	(9.1%)	2	(0.6%)	108	8686
1996	20.5	373	10	(2.8%)	3	(0.8%)	152	8567
1997	20.2	208	13	(3.6%)	0	(0%)	76	8719
1998	22.7	319	20	(5.5%)	2	(0.5%)	114	8719
1999	17.8	211	10	(2.7%)	0	(0%)	98	8609
2000	18.0	175	9	(2.5%)	0	(0%)	71	8695
2001	18.1	170	9	(2.6%)	1	(0.3%)	110	8442
2002	18.2	154	12	(3.4%)	0	(0%)	75	8495
2003	19.5	199	15	(4.1%)	0	(0%)	100	8669
2004	20.3	170	12	(3.3%)	0	(0%)	69	8713

* Monitor returned in January after upgrades.

Table 3.1.7 Annual trend summary of continuous PM$_{10}$ data at the BCR-Warehouse

Year	Annual Average (µg/m^3)	Maximum Hourly Average (µg/m^3)	No. (%) of Days > 50 µg/m^3		No. (%) of Days > 100 µg/m^3		Maximum Daily Average (µg/m^3)	Hours Instrument Operated
1996*	-	125	5	(5.3%)	0	(0%)	68	2263*
1997	24.2	401	32	(8.8%)	2	(0.5%)	111	8705
1998	29.1	582	49	(13.5%)	4	(1.1%)	127	8702
1999	21.3	380	19	(5.5%)	0	(0%)	79	8718
2000	20.0	288	13	(3.6%)	0	(0%)	86	8739
2001	20.1	387	17	(4.7%)	0	(0%)	98	8634
2002	22.1	430	27	(7.4%)	0	(0%)	84	8696
2003	24.4	262	29	(8.1%)	1	(0.3%)	106	8534
2004	25.9	332	50	(14.0%)	0	(0%)	100	8604

* Note: Monitoring started September 28, 1996.

Table 3.1.8 Annual trend summary of continuous PM_{10} data at Gladstone

Year	Annual Average (µg/m^3)	Maximum Hourly Average (µg/m^3)	No. (%) of Days > 50 µg/m^3		No. (%) of Days > 100 µg/m^3		Maximum Daily Average (µg/m^3)	Hours Instrument Operated
1996	15.0	253	7	(1.9%)	1	(0.3%)	102	8688
1997	14.8	155	7	(1.9%)	0	(0%)	61	8673
1998	17.2	207	7	(1.9%)	0	(0%)	74	8642
1999	12.7	127	0	(0%)	0	(0%)	47	8663
2000	13.6	148	4	(1.1%)	0	(0%)	55	8686
2001	13.5	164	2	(0.6%)	0	(0%)	78	8610
2002	13.6	109	4	(1.1%)	0	(0%)	68	8707
2003	14.8	237	5	(1.4%)	0	(0%)	74	8623
2004	14.6	175	1	(0.3%)	0	(0%)	57	8594

Figure 3.1.8 shows the trend in annual mean PM_{10} levels at continuous sites in Prince George. These means are calculated based upon a one year rolling average (i.e., the average annual concentration at Plaza on July 8, 1995 is about 25 µg/m^3, which covers the period from July 9, 1994 to July 8, 1995). This was done in order to reduce seasonal variations in the concentrations to make any trends clearer. Levels at all three sites remained the consistent until November 1997, increased considerably from July to October 1998 and decreased until February 2002. Levels have shown a gradual increase since late 2002.

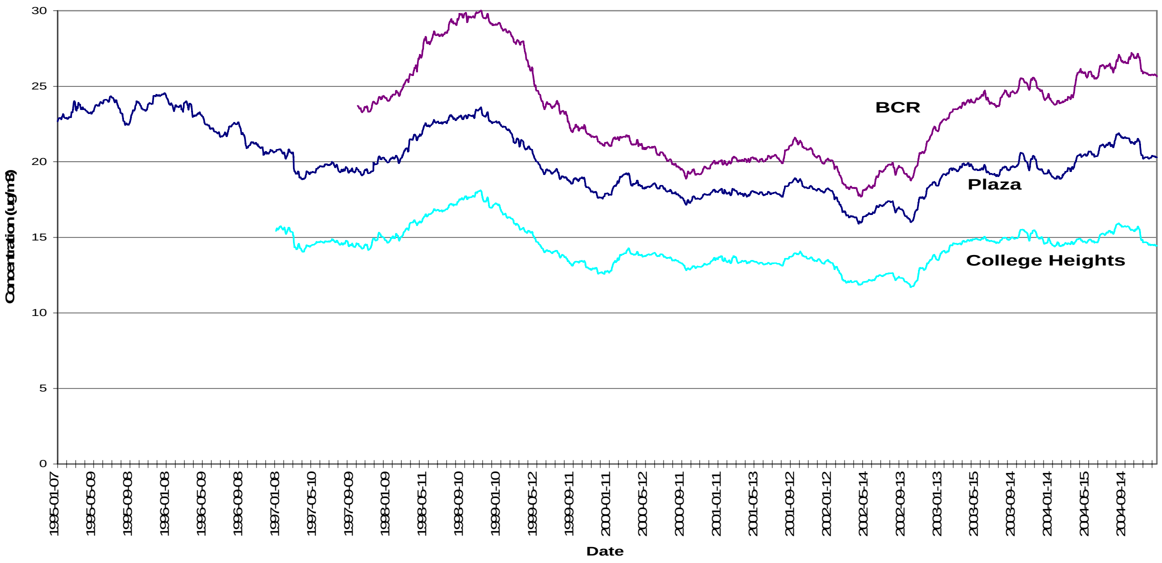


Figure 3.1.8 Rolling average annual PM_{10} levels ($\mu g/m^3$) recorded at continuous sites in Prince George

Overall, PM_{10} annual levels have declined significantly since monitoring began at Plaza in 1990. Various source management actions have likely contributed to this trend. These actions include shutdown of all beehive burners in the airshed, increased fine particulate removal in some of the pulp mill sources, use of coarser winter street traction material and improved street cleaning. Other source reduction actions are identified in the Air Quality Management Plan (Prince George Airshed Technical Management Committee, 1998).

Non-source emission factors, such as meteorology and an increase in forest fires, could have contributed to the overall increase in PM_{10} levels since late 2002. Both total precipitation and the number of forest fires have increased since 2002. In the Prince George forest area, there were about 62 significant forest fires (burning 74,535 hectares of forest) reported in 2004 compared to 57 fires (burning 36,131 hectares of forest) in 2003 and 38 fires (burning 3623 hectares of forest) in 2002. The area burned in 2004 was twenty times greater than that of 2002.

Figure 3.1.9 shows annual average PM_{10} levels at the Plaza site in relation to the calculated risk factor from ambient PM_{10} exposure. This information is presented to illustrate the effect of overall (not just average) levels on a PM_{10} health risk indicator. This risk factor is normalized, based on the 2000 average risk calculated for all B.C. communities that have continuous PM_{10} monitors. The risk factors in this figure can be used to determine the potential health effects, including the number of disability days for people with chronic obstructed lung diseases or asthma, the number of hospital visits due to respiratory problems, reduction in physical activity, and even death. A risk factor of 2 means you are twice as likely to develop health effects from PM_{10} compared to that in 2000. This estimate is based on the PM_{10} concentrations for days with levels greater than 25 $\mu g/m^3$ (Health Canada, 1997). For example, a day in which the 24 hour average PM_{10} concentration was 40 $\mu g/m^3$ yields 15 increments (40 – 25 = 15) and is equivalent to five days when the 24-hour concentration was 28 $\mu g/m^3$ (5*(28 – 25) = 15). The annual sum of these increments is then normalized to the 2000 B.C. average to determine the annual risk factor.

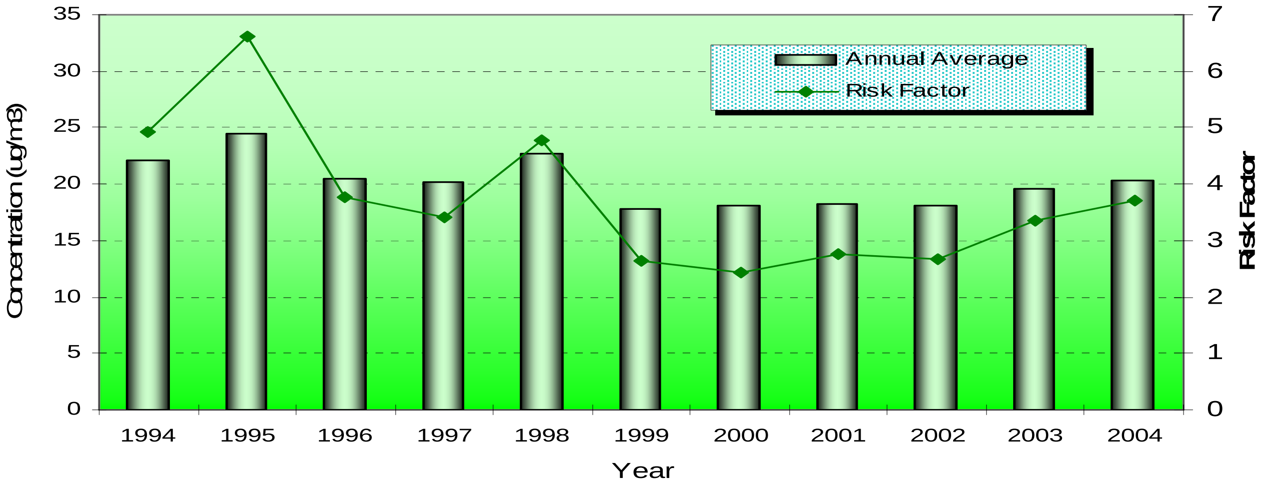


Figure 3.1.9 Annual PM_{10} concentration ($\mu g/m^3$) compared to risk factor

As shown in Figure 3.1.9, the risk of illnesses due to PM_{10} in 1995 was about 6.6 compared with 3.8 in 2004. This is a decrease of about 43% in the risk of health effects due to PM_{10}, whereas annual averages for PM_{10} decreased by about 17% from 1995 to 2004.

Tables C -2.1 and C – 2.2 in Appendix C show the annual percentiles of the 1-hour and 24-hour PM_{10} averages, respectively, since 1996 for the three continuous monitoring sites. The percentiles give a more complete indication of trends than just annual averages, maximum values, or objective exceedances, and they can provide better insight into the reasons for any trends. From 1999-2002 all three sites showed a decreasing trend in hourly values above the 50th percentile, indicating the effect of decreasing levels on the frequency of the higher values (Table C – 2.1). At the BCR site, the 2004 one-hour higher percentiles (> 90th percentile) increased from the previous year and were similar to 1997 values. At Plaza and Gladstone, there was little change in the hourly percentile values from 2003 to 2004 and they remain among the highest at those sites since 1999. The 24-hour higher percentiles exhibit an entirely different trend. At the Plaza and Gladstone sites, the 98th and 99th percentiles decreased from 2003-2004 (Table C – 2.2). At the BCR site, all percentiles above the 75th increased. Hourly values at BCR exceeded 97 $\mu g/m^3$ only 1% of the time in 2001, compared to 2004 when levels were over 143 $\mu g/m^3$ for 1% of the time (Table C – 2.1). Also, the 24-hour averages at BCR were below 55 $\mu g/m^3$ for 98% of the time in 2000, but only about 90% of the time in 2004. An increase in the higher percentiles may not affect the annual average but may explain the increase in risk.

3.1.3 Comparison of Prince George PM_{10} Levels with Other B.C. Locations

Figure 3.1.10 compares the 2004 PM_{10} annual averages at the Prince George continuous monitoring sites with annual averages from other sites in B.C. (only sites with greater than 90% of data captured). The twenty highest averages were recorded at sites in the interior of B.C. The BCR (an industrial site) and Plaza (a commercial site) had the second and eighth highest of all the sites, respectively. Gladstone had the 10th highest annual average out of the 29 residential sites.

When comparing with the same sites that monitored in 2003, twenty-five of the forty-nine monitoring sites recorded an increase in 2004. Williams Lake – Skyline School showed the greatest incremental increase. Fort Nelson recorded the greatest incremental decrease due to the paving of a road near the monitor in September 2003. The Prince George-BCR site showed the third greatest increase in annual average since 2003.

Figures 3.1.10 and 3.1.11 compare the calculated risks from ambient PM_{10} exposure between B.C. communities, with continuous and non-continuous PM_{10} monitoring, respectively. This information is presented to illustrate the effect of overall (not just average) levels on a PM_{10} health risk indicator. This figure shows that, even though the annual average may be lower in one community than another, the health risk may be higher in that community.

Figure 3.1.10 shows that at Plaza the risk of hospital visits due to respiratory problems, or decrease in physical activity, or even death due to PM_{10} is almost four times higher than the 2000 provincial average. For the non-continuous sites, the Plaza risk was over 2.5 times the provincial average. Both figures show that a slight increase in annual averages can dramatically increase the risk of deaths due to PM_{10}.

Figure 3.1.11 compares the 2004 PM_{10} annual averages recorded at the Prince George non-continuous monitoring sites with those from other B.C. non-continuous monitoring sites with greater than 80% data capture. Prince George-CNR recorded the second highest annual average out of the 35 non-continuous sites, Van Bien the sixth highest of the 26 residential sites, and Plaza the third highest of the commercial sites. Only sites that were operating on the NAPS schedule (monitoring once every six days, for a 24-hour, midnight-to-midnight period) were included.

When comparing the same monitoring sites in 2003, 16 of the 28 monitoring sites recorded an increase in 2004. Radium showed the greatest decrease in average PM_{10} and Taylor showed the greatest increase. It should be noted that the non-continuous PM_{10} database includes those airsheds with the highest PM_{10} levels, including Valemount and Cranbrook, but not those with the lowest levels, such as the Lower Mainland sites.

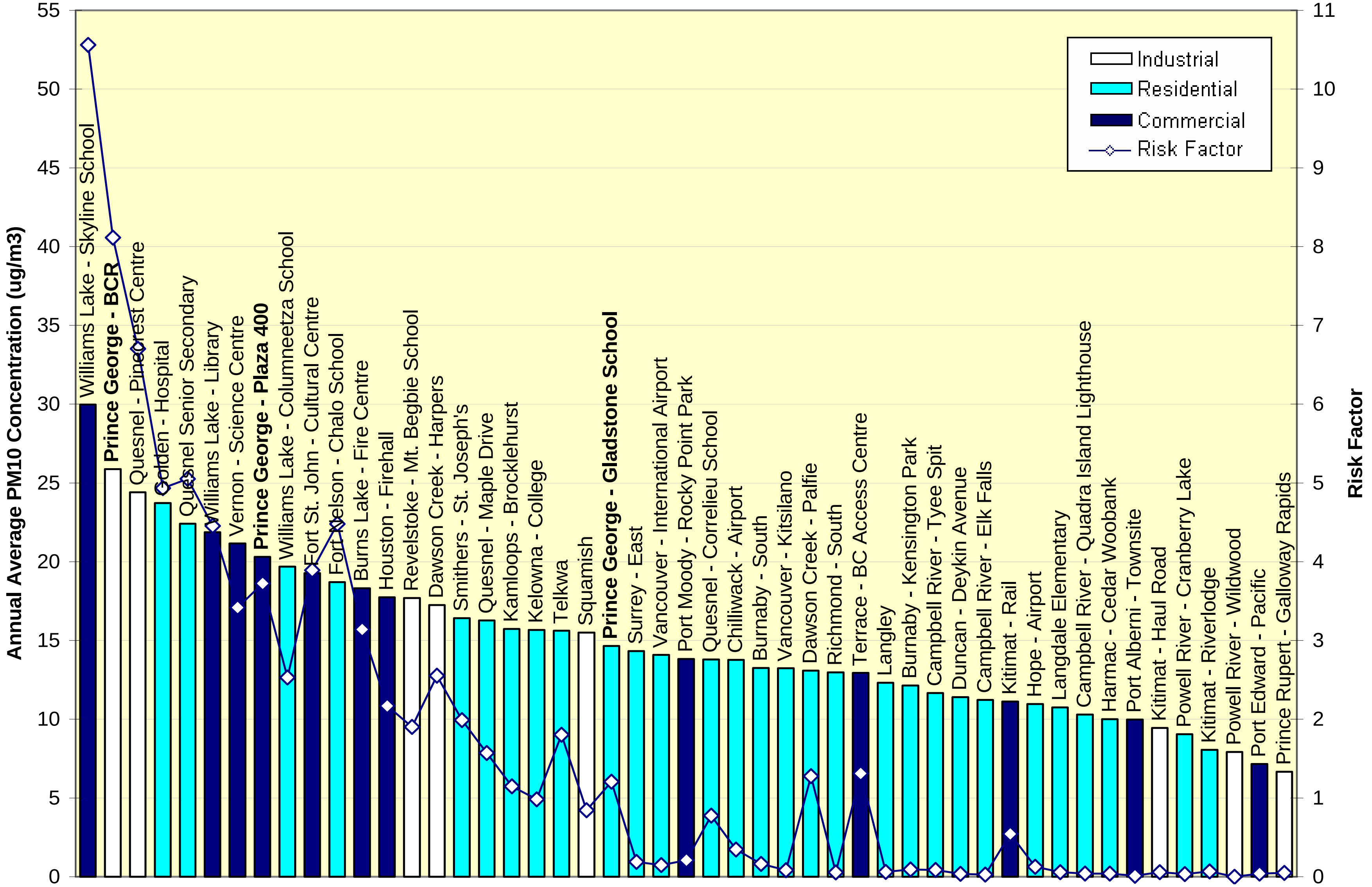


Figure 3.1.10 *Comparison of 2004 annual average PM10 levels (μg/m^3) in Prince George with other B.C. locations (continuous monitors)*

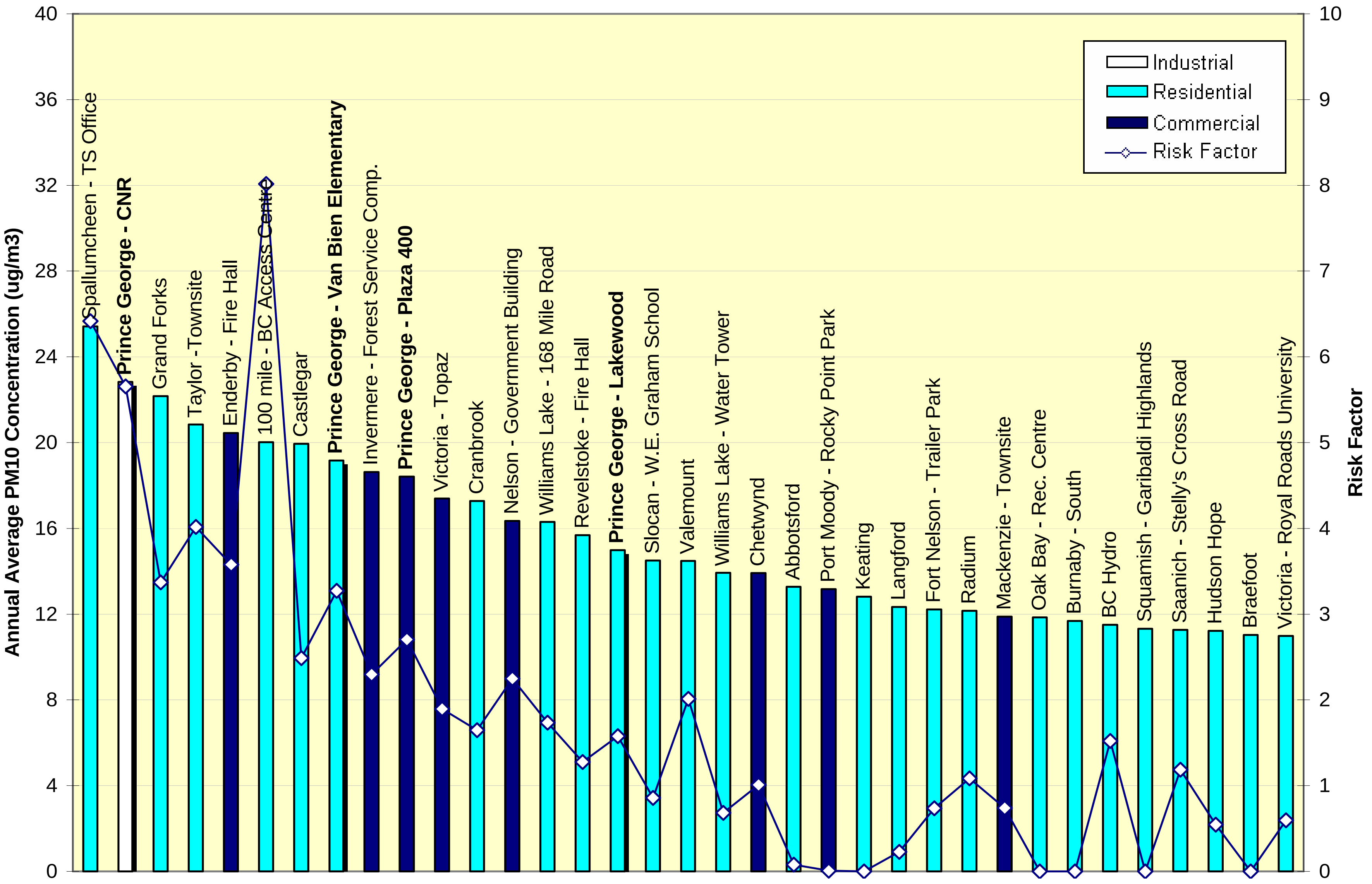


Figure 3.1.11 *Comparison of 2004 annual average PM10 levels ($\mu g/m^3$) in Prince George to other B.C. locations (non-continuous monitors)*

3.1.4 Particulate Matter ($PM_{2.5}$) Results

Recent health and medical studies have shown that very fine particles may have more serious health impacts than coarser particles (Vedal, 1995; CEPA/FPAC Working Group, 1998; Pope et. al., 2002). These smaller particles are able to reach deeper into lungs than coarser particles. Also, they remain longer in the atmosphere (sometimes for weeks) and are more complex chemically than the coarser particles.

Most $PM_{2.5}$ comes from the exhaust from fuel combustion in motor vehicles, space heaters and industrial facilities. The primary natural source of $PM_{2.5}$ is forest fires, due to the high temperatures. These fine particles can also be formed (as secondary pollutants) by the transformation of gaseous emissions such as SO_2, NO_x and various hydrocarbon species. Secondary particulates occur predominantly as $PM_{2.5}$. Major natural secondary $PM_{2.5}$ sources are VOCs released from trees and nitrogen oxides released from soil.

In 2004, Prince George had only one continuous monitor and one non-continuous $PM_{2.5}$ monitor, both at the Plaza site. $PM_{2.5}$ is measured non-continuously by drawing air through a size selective inlet prior to collection on a Teflon fibre filter at a rate of about 0.017 cubic metres per minute (Fig. 3.1.12). The sampler is run for 24 hours at a time on a 6-day cycle (i.e., once every sixth day). The continuous monitor (a TEOM 1400a sampler) operates in the same manner as the PM_{10} continuous monitor (Fig 3.1.2), but with a $PM_{2.5}$ selective inlet like the one shown in Fig 3.1.12.

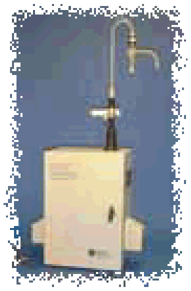


Fig. 3.1.12
$PM_{2.5}$ Partisol

The quality of the non-continuous $PM_{2.5}$ data is assessed by regular measurement of laboratory filter weighing error and by calibration of the air flow meters on the samplers. Continuous data quality is evaluated by bi-weekly field checks and quarterly mass calibrations. Based on the annual independent auditing, the quality of the 2004 $PM_{2.5}$ data at Plaza was excellent in April and satisfactory in November (Appendix B). Data completeness was satisfactory, with 99.2% valid data from the Plaza continuous monitor, and 98.4% for the non-continuous monitor.

3.1.5 $PM_{2.5}$ Continuous Monitoring Results

The continuous $PM_{2.5}$ monitor was installed at Plaza in September 1997. Simultaneous continuous monitoring of PM_{10} and $PM_{2.5}$ can provide an indication of the contribution of different sources, such as combustion and road dust, to ambient levels. Table C – 1.4 shows the monthly summary of 2004 $PM_{2.5}$ data recorded at this site. Similar to the PM_{10} results at Plaza, some of the highest monthly averages occurred in April, February, and August. This, as well as the $PM_{2.5}/PM_{10}$ ratio, is an indication that these high levels were mainly due to combustion sources rather than dust during these months, as normally a small portion of the road dust is $PM_{2.5}$. Because the $PM_{2.5}$ level and ratio were lower in March than February, the higher March PM_{10} level was likely due to a greater road dust contribution than was the case in February. February was the only month in which a 24-hour average $PM_{2.5}$ level exceeded 50 $\mu g/m^3$.

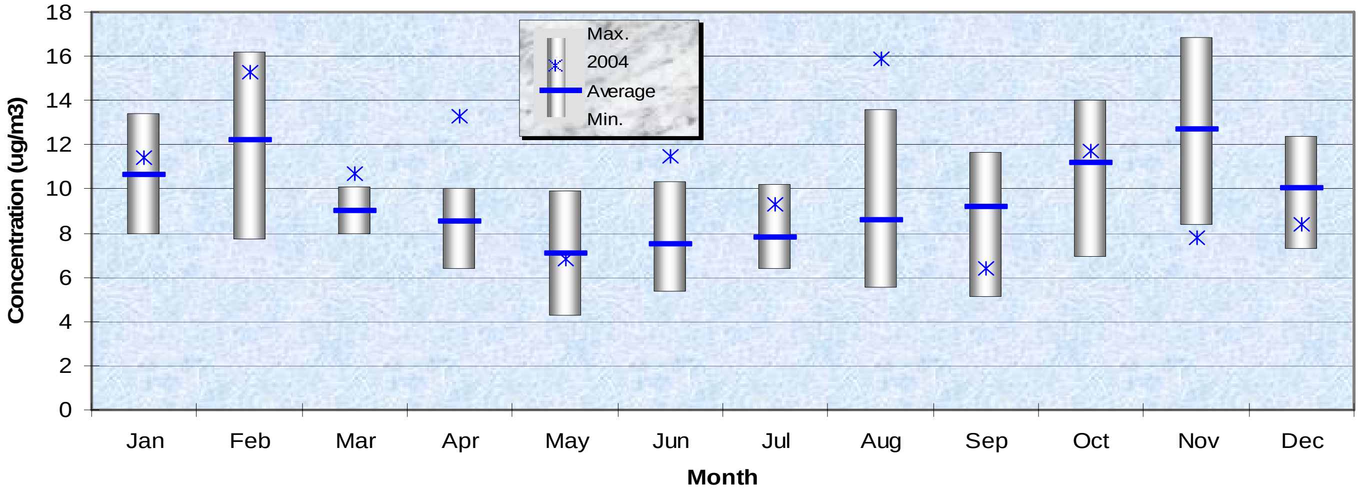


Figure 3.1.13 Comparison of 2004 with long-term average monthly PM2.5 levels (μg/m^3) at Plaza since 1997

Figure 3.1.13 shows the monthly $PM_{2.5}$ averages for the seven full years of continuous Plaza data. Normally, the lowest monthly averages occur in May through July, but in 2004, above-normal averages occurred from January through August (except for May), and the monthly averages were below-normal during September, November and December. Five months in 2004 posted record monthly averages: March, April, June and August posted record high monthly averages for those months, and November posted the only record low average.

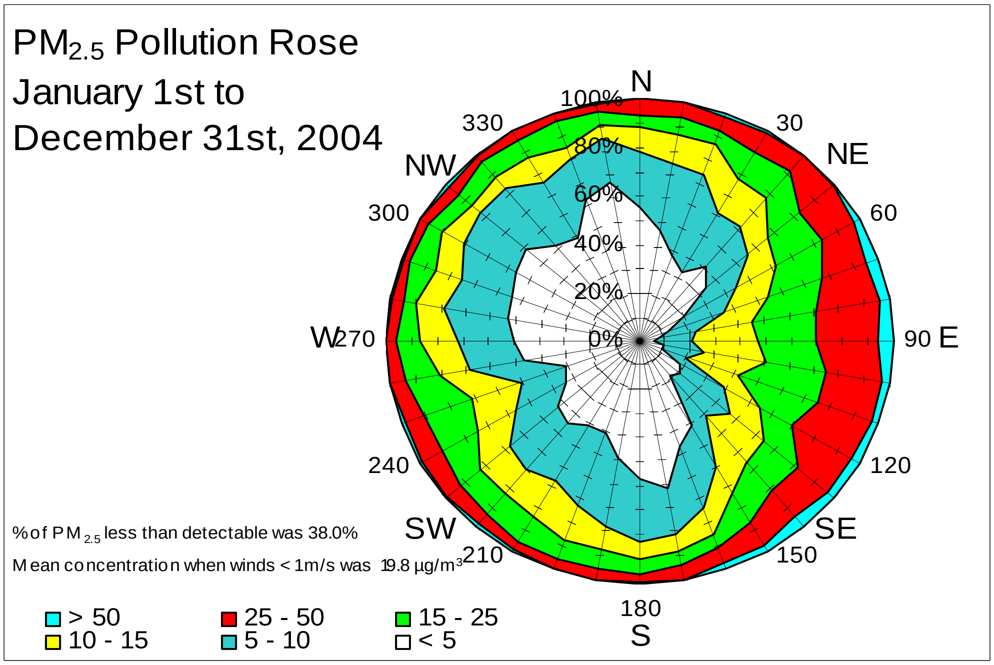


Figure 3.1.14 $PM_{2.5}$ pollution rose at Plaza for 2004

Figure 3.1.14 shows the 2004 $PM_{2.5}$ pollution rose for the Plaza site based on the meteorological data at that site. Wind directions were only considered whenever wind speeds were $\geq$ 1 m/s. Similar to the PM_{10} pollution rose, one-hour average particulate levels were seldom below 5 µg/m^3 when winds were blowing from the east-northeast to east-southeast sector. With winds from the north, south and west directions, particulate levels were below 5 µg/m^3 60-70% of the time. Also, similar to the PM_{10} distribution, there was a distinctive wind direction from which the highest concentrations occurred. The $PM_{2.5}$ concentration exceeded 15 µg/m^3 most often when winds were from the east-northeast to southeast sector.

The most likely explanations for this pattern are that winds from this sector are generally lighter, providing less dilution, and that this sector contains major combustion sources. The average concentration when winds were less than 1 m/s was 18.0 µg/m^3 (approximately 54% of the PM_{10} level for light winds), demonstrating the significance of both calms and light winds. Unlike those for SO_2 and H_2S, the $PM_{2.5}$ pollution rose shows that, although there is a dominant wind sector, significant contributions originate from other sectors as well. Elevated $PM_{2.5}$ levels can build up in an area under calm conditions and remain high for some time after wind speeds increase. These higher $PM_{2.5}$ levels occur with winds that indicate the direction of flushing rather than direction of the sources.

Figure 3.1.15 shows the distribution, by wind direction, of $PM_{2.5}$ levels averaged over the period 1998 to 2004 at the Plaza site. (A circular graph of seven-year $PM_{2.5}$ averages, centred on the Plaza site, is superimposed on a City map, so the levels can be shown relative to the compass points from which the wind was blowing. Each concentric circle in the graph is 6 µg/m^3.) This multi-year $PM_{2.5}$ pollution rose shows that a pattern of contributions from the east-southeast has persisted over the seven-year period of continuous monitoring at the Plaza site. Lower, but still significant contributions are shown for the southwest wind sector (approximately 9µg/m^3 versus about 18µg/m^3 for the east-southeast sector). Different wind sector distributions may be found at other locations in the airshed, under the influence of different emission sources and meteorology. Monitoring of continuous $PM_{2.5}$ and wind direction started at Gladstone School in February 2005 will enable pollution roses to be constructed for that area starting in 2006.

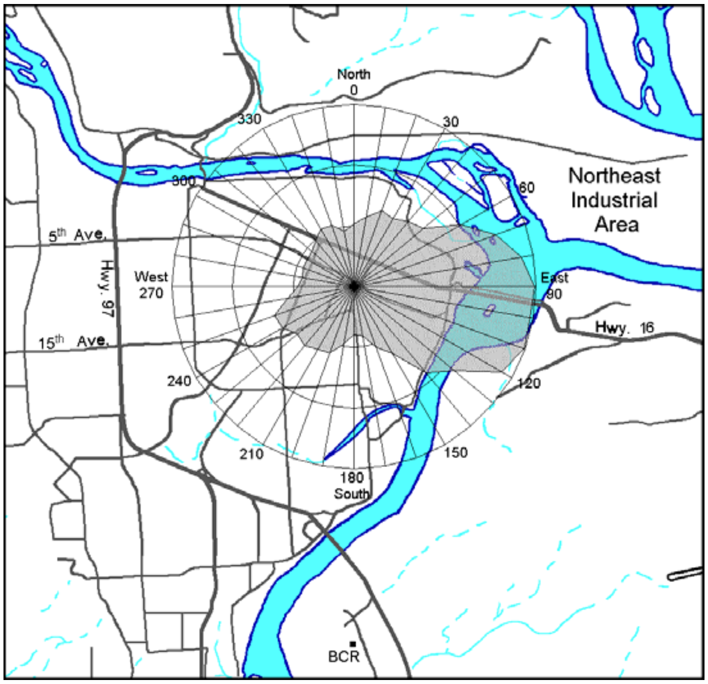


Figure 3.1.15: Distribution of average (1998 - 2004) Prince George Plaza 400 $PM_{2.5}$ concentrations ($\mu g/m^3$) by wind direction (degrees). Each circle = 6 $\mu g/m^3$ $PM_{2.5}$.

Figure 3.1.16 shows the hourly average $PM_{2.5}$ from the continuous monitor at Plaza with several months plotted to show the seasonal differences in the timing of $PM_{2.5}$ peaks. Although vehicular traffic is an important source of $PM_{2.5}$, the different times of the morning peak in $PM_{2.5}$ levels shows that these peaks cannot be driven by traffic. These timing differences are instead due to fumigation conditions in the morning when the nocturnal inversion in downtown Prince George is breaking up. This timing is seasonal due to the sunrise being earliest in the summer (early morning $PM_{2.5}$ peak in June) and latest in the winter. The levels are low for September due to the high levels of precipitation for that month (nearly twice the 10-year average) (Figure 2.4) washing out the particulates.

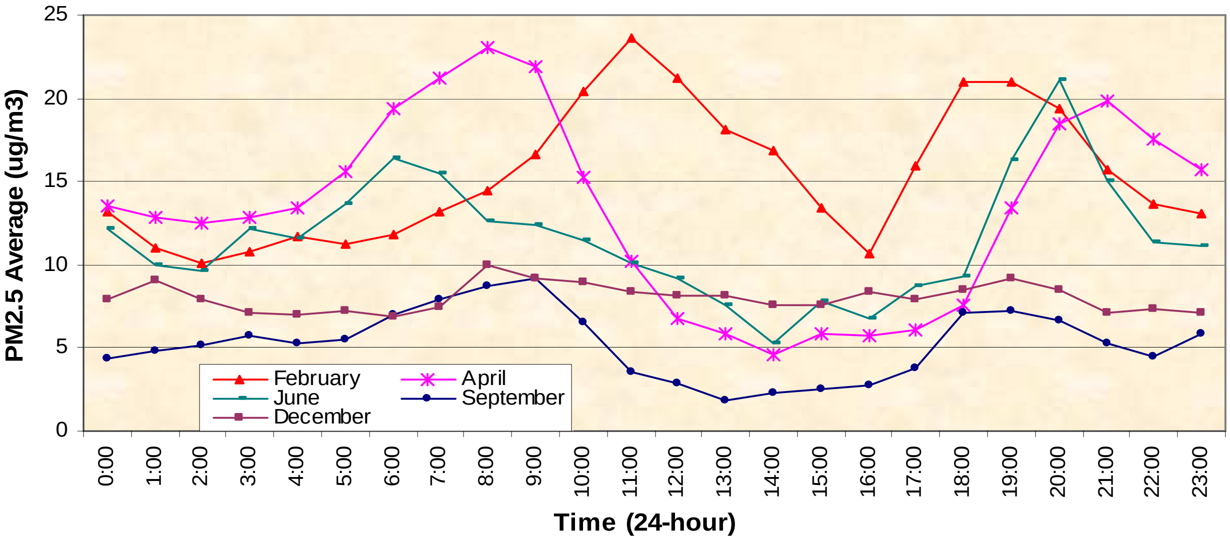


Figure 3.1.16 Daily average $PM_{2.5}$ pattern ($\mu g/m^3$) in Prince George in 2004

3.1.6 $PM_{2.5}$ Annual Trend

Tables 3.1.10 and 3.1.11 show the annual trend summaries of $PM_{2.5}$ data at Plaza's non-continuous and continuous monitors, respectively. Table 3.1.10 shows a gradual and steady decrease until 2000. From 1995 through 1999 annual averages decreased about 28%. This trend was reversed from 2000 through 2003. Levels in 2004 decreased from the previous year (22% decrease for non-continuous and 2% decrease for continuous). The ambient average in 2004 for the continuous monitor and the frequency of exceedance of 30 $\mu g/m^3$ were the second highest ever recorded and the frequency of exceedance of 15 $\mu g/m^3$ was the highest ever recorded at this site.

Table 3.1.10 Annual trend summary of non-continuous $PM_{2.5}$ data at Plaza

Year	Annual Average ($\mu g/m^3$)	No. (%) of Daily Values > 15 $\mu g/m^3$	No. (%) of Daily Values > 30 $\mu g/m^3$	Maximum Daily Value ($\mu g/m^3$)	Number of Samples
1994*	-	4 (18.2%)	1 (4.5%)	52	22
1995	13.3	19 (31.1%)	3 (4.9%)	54	61
1996	12.7	17 (28.3%)	2 (3.3%)	40	60
1997	12.3	16 (26.2%)	5 (8.2%)	43	61
1998	11.3	18 (29.5%)	3 (4.9%)	52	61
1999	9.6	11 (18.3%)	2 (3.3%)	38	60
2000	11.5	12 (19.7%)	5 (8.2%)	52	61
2001	9.9	16 (26.2%)	4 (6.6%)	35	61
2002	11.2	14 (23.0%)	5 (8.2%)	34	61
2003	12.1	15 (24.6%)	3 (4.9%)	38	61
2004	9.5	15 (25.0%)	2 (3.3%)	33	60

* Instrument installed August 1994

Table 3.1.11 Annual trend summary of the continuous $PM_{2.5}$ data at Plaza

Year	Annual Average ($\mu g/m^3$)	Maximum Hourly Average ($\mu g/m^3$)	No. (%) of Days > 15 $\mu g/m^3$		No. (%) of Days > 30 $\mu g/m^3$		Maximum Daily Average ($\mu g/m^3$)	Hours Instrument Operated
1997	-	87	15	(30.1%)	6	(12.2%)	55.4	1167*
1998	9.6	119	69	(18.9%)	7	(1.9%)	52.1	8722
1999	7.9	117	42	(11.5%)	4	(1.1%)	34.1	8657
2000	9.5	92	61	(16.8%)	11	(3.0%)	47.0	8610
2001	9.5	137	60	(16.4%)	11	(3.1%)	57.9	8373
2002	9.2	84	56	(15.5%)	7	(1.9%)	58.6	8685
2003	10.8	158	75	(20.7%)	15	(4.1%)	62.9	8614
2004	10.7	127	86	(23.5%)	14	(3.8%)	60.8	8742

*Note: Monitoring started Sept. 1997

In July 1999, the federal government released the "National Ambient Air Quality Objectives for Particulate Matter ($PM_{2.5}$)". This established a Canada Wide Standard for $PM_{2.5}$ which takes effect in 2010. The $PM_{2.5}$ standard is a 24-hour averaged value of 30 $\mu g/m^3$, with achievement to be based on averaging of the annual 98th percentile over three consecutive years. For 2000-2002, 2001-2003, and 2002-2004, the Canada Wide Standard for $PM_{2.5}$ was exceeded in Prince George, with average 98th percentiles of 32.2 $\mu g/m^3$, 35.7 $\mu g/m^3$, and 36.3 $\mu g/m^3$, respectively. Prince George was the only site in B.C. to exceed the $PM_{2.5}$ Canada Wide Standard.

Table C – 2.3 shows the annual percentiles of both the 1-hour and 24-hour $PM_{2.5}$ values using the continuous monitoring data at Plaza for the past seven years. In 2003 and 2004, the 75th percentile of one-hour averages and the 90th percentile for 24-hour averages were the highest recorded.

Figure 3.1.17 shows annual average $PM_{2.5}$ levels at the Plaza site in relation to the calculated health risk factor from ambient $PM_{2.5}$ exposure. This information is presented to illustrate the effect of overall (not just average) levels on a $PM_{2.5}$ health risk indicator. The risk factor is normalized, based on the 2001 average risk calculated for all communities in B.C. which monitor $PM_{2.5}$ continuously. This estimate is based on days with $PM_{2.5}$ levels were greater than 15 $\mu g/m^3$ (Health Canada, 1997), and calculate similar to that described in Section 3.1.2 for PM_{10}.

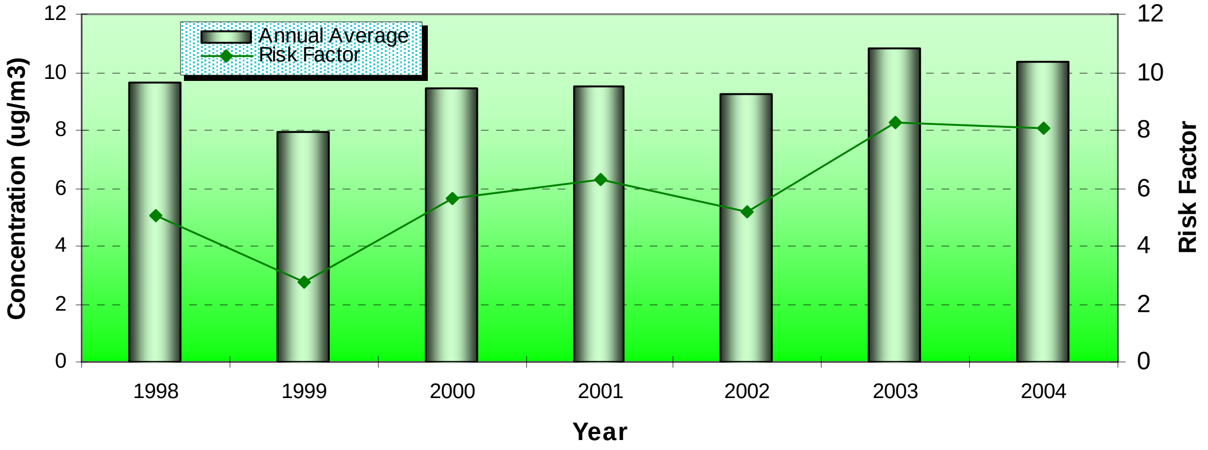


Figure 3.1.17 Annual $PM_{2.5}$ concentration ($\mu g/m^3$) compared to the risk factor

As shown in Figure 3.1.17, ambient levels in 1998 were similar to those in 2000 and 2001, but the risk of illnesses due to $PM_{2.5}$ was about 15% lower in 1998. In 1999, ambient levels were about 27% lower than those recorded in 2003, but the risk of illnesses was about 66% lower. The 2004 health risk decreased along with the annual average, and the 98th plus percentiles. This indicates the importance of reducing the frequency of the highest $PM_{2.5}$ concentrations in the airshed.

3.1.7 Comparison of Prince George $PM_{2.5}$ Levels with Other B.C. Locations

Figure 3.1.18 compares the 2004 $PM_{2.5}$ annual averages at the Prince George (Plaza) site with annual averages from other monitoring sites in B.C. (only sites with greater than 90% of data captured were included). Because of the small number of $PM_{2.5}$ monitoring sites in B.C., both the continuous and non-continuous data are compared on the same figure. The Bear Lake non-continuous site recorded the highest $PM_{2.5}$ annual average. The continuous (solid) monitoring site in Prince George recorded the second highest annual average in the province, followed by the Prince George non-continuous site (checkered). It should be noted that the monitors at Plaza and Bear Lake sites used a different sampling head (URG) than those at other sites (Sharp Cut). The head on the instrument separates the fine particles from the coarse particles. The Sharp Cut head has been shown to provide more accurate data, and that TEOMs using these heads record levels lower that those using the conventional heads. This is due to a lower percent of the coarser particles (2.5 – 5 µm) reaching the filter with the Sharp Cut head.

When comparing the last two years for 25 continuous sites that monitored $PM_{2.5}$, only six out of the 25 sites recorded higher $PM_{2.5}$ levels in 2004. Kelowna recorded the greatest decrease from 2003 to 2004, and Williams Lake-Skyline School recorded the greatest incremental increase in 2004.

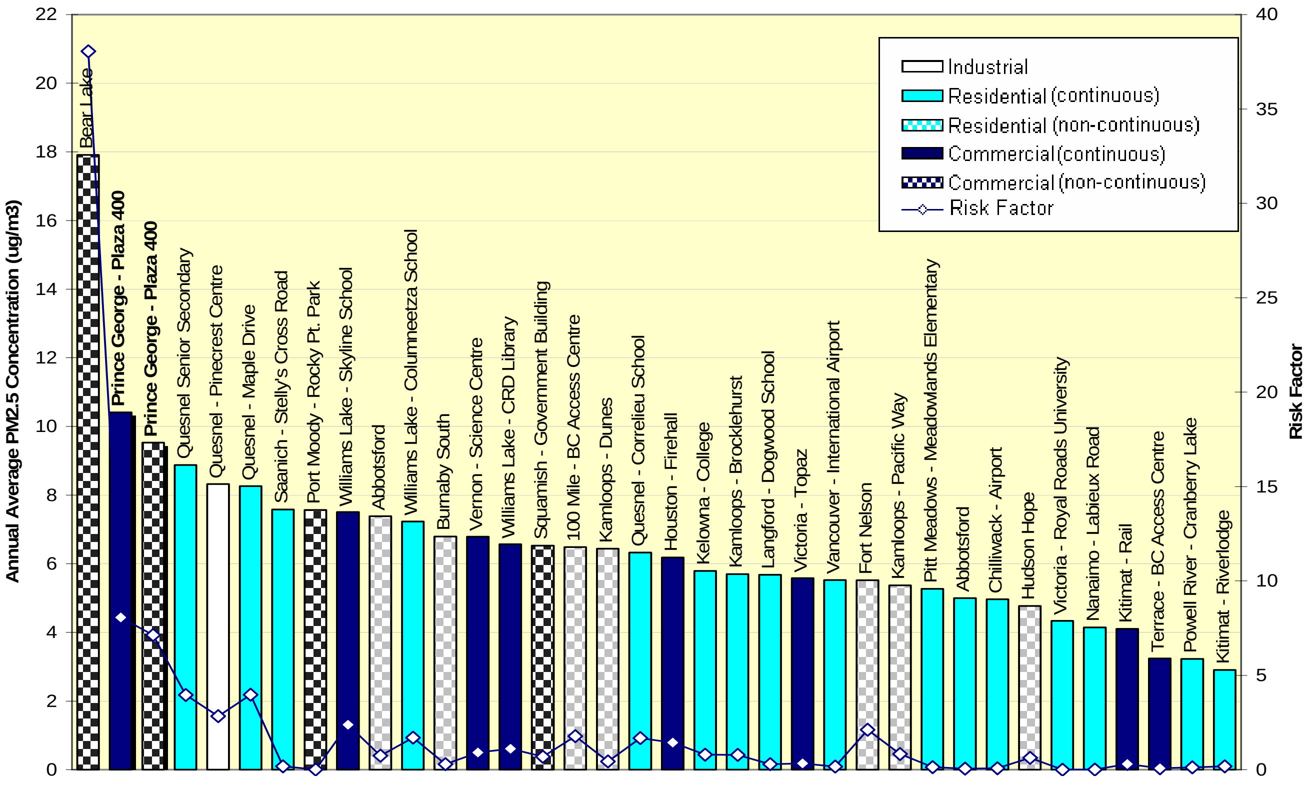


Figure 3.1.18 Comparison of 2004 annual average $PM_{2.5}$ levels ($\mu g/m^3$) in Prince George with other B.C. locations

Figure 3.1.18 also shows the health risk expected each year in each community due to ambient $PM_{2.5}$. This estimate is based on the $PM_{2.5}$ concentrations for days that levels were greater than 15 µg/m^3 (see Health Canada, 1997). The comparison of risks indicates a substantially higher risk for Northern Interior communities. A slight difference in $PM_{2.5}$ can make a big difference in the risk of respiratory deaths. The Prince George site recorded an annual $PM_{2.5}$ average about twice as high as Nanaimo, yet the risk of respiratory deaths was over 700 times greater than in Nanaimo. Again, it should be pointed out that Prince George and Bear Lake are the only two $PM_{2.5}$ monitoring sites that used the conventional heads, which is expected to increase levels somewhat relative to sites using the Sharp Cut heads. The head was replaced at the Prince George site on September 10th which should remove any discrepancy.

Prince George was the only continuous site to record a 98th percentile for the 24-hour average $PM_{2.5}$ that was greater than the 30 µg/m^3 Canada Wide Standard for $PM_{2.5}$ in 2004. Prince George is the only community in B.C. that has ever exceeded the Canada Wide Standard. The 2002-2004 24-hour average 98th percentile was 36.3 µg/m^3. The 24-hour average 98th percentile recorded in Prince George in 2004 was 36 µg/m^3.

3.2 Total Reduced Sulphur (TRS) Results

Total Reduced Sulphur (TRS) is a colourless gas with a characteristic offensive odour similar to rotten eggs or rotten cabbage. TRS describes a group of sulphur compounds containing gases made up primarily of one or more of the following four compounds; dimethyl disulphide (DMDS), dimethyl sulphide (DMS), methyl mercaptan (MESH), and hydrogen sulphide (H_2S). Methyl mercaptan is the most odorous of the four main sulphur compounds that make up TRS and can be detected by a sensitive person in concentrations as low as 0.2 $\mu g/m^3$ (or about 0.1 parts per billion, ppb). The concentration is expressed in $\mu g/m^3$ of pollutant in air as H_2S equivalent.

These compounds are largely by-products of the pulping process; that is, these compounds are not added directly but form because of the use of sulphides in the pulping process. Pulp mills using the kraft process emit the largest amounts of TRS followed by oil and gas processing plants (refining) and to a small extent the sewage treatment plant and automobiles (catalytic converters). Natural sources include swamps, bogs, and marshes.

At low levels, TRS is considered to be a nuisance pollutant, causing no adverse health effects, but producing odour problems. However, at levels > 1000 $\mu g/m^3$, sensitive individuals may suffer headaches and nausea due to extreme odour. It should be noted that levels as high as this have never been recorded at the monitoring sites in Prince George.

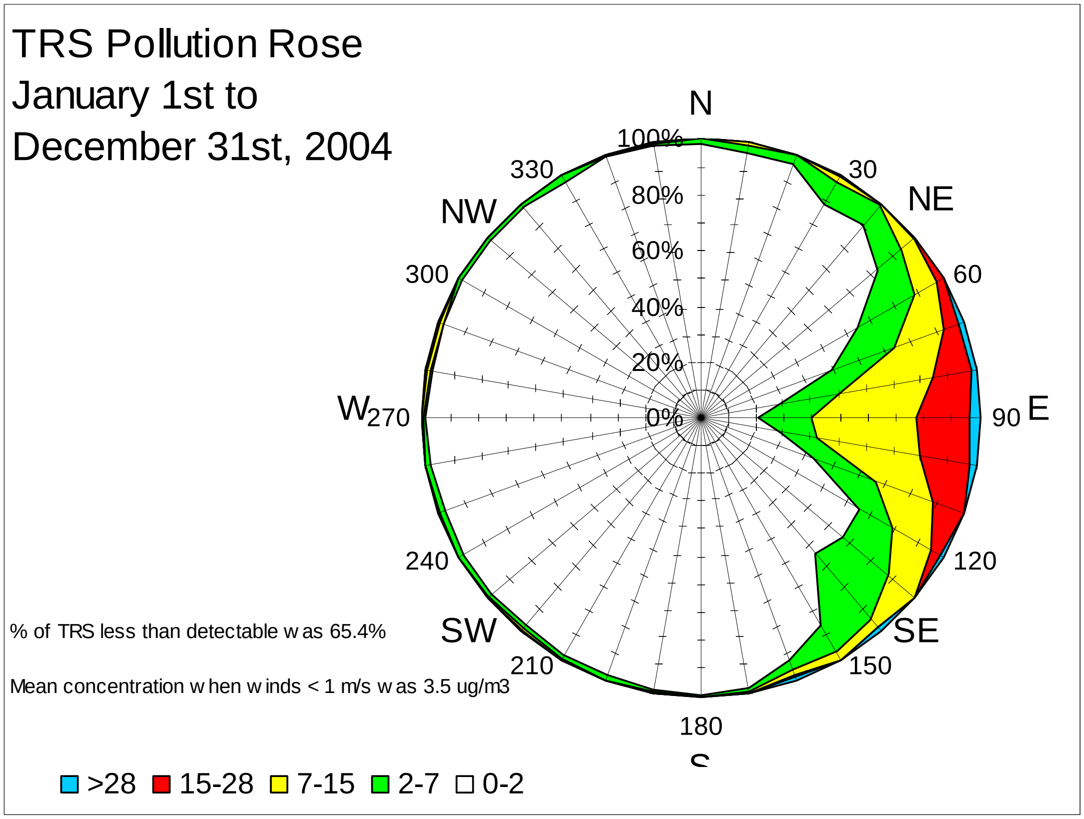
The ultimate end product of any gaseous sulphur compound (TRS or SO_2) is that it is oxidized to form sulphate (a secondary pollutant) which may become sulphuric acid, a component of acid rain. Unlike TRS or SO_2, sulphates are very small particles, about 0.1 micrometre in size. The rate at which sulphates are formed is highly variable and can take anywhere from 2 to 48 hours. It is this end product that has the detrimental effects on health and vegetation in the long term. Human health effects are lung and breathing problems which are amplified during times when weather systems produce humid conditions. High humidity causes more sulphate to be formed and to be retained in the lung tissue.

The current analyzers have a detection limit of about 1.5 $\mu g/m^3$ or 1 ppb (Fig 3.2.1). The analyzer measures the total amount of TRS gases by oxidizing these gases in an oven (900°C) to form SO_2. The SO_2 concentration is then measured using fluorescent excitation by ultra-violet radiation.

Fig. 3.2.1 TRS monitor located at Plaza

The quality of the TRS data was evaluated through monthly calibrations and independent auditing in April and November. The auditing results in Appendix B, Table B-1 indicate that the TRS monitor at the Plaza had excellent performance in both audits, whereas both the Lakewood and Jail monitors performed satisfactorily in April audit and excellently in November. Data quality is considered unsatisfactory if the monitor deviates by 15% or more from the auditing results. Data recovery ranged from 86.8% at Lakewood to 95.4% at Plaza.

Figure 3.2.2 shows the TRS pollution rose for the Plaza site based on the 2004 meteorological data at that site. Wind directions were only considered whenever wind speeds were ≥ 1 m/s. The highest concentrations occurred with winds from the east even though the main sources are located northeast of this monitoring site. This is expected since the winds blowing from the northeast are deflected eastward by the hills south of the pulp mills and refinery before reaching the monitoring site (Section 2.2). When winds were blowing from the east, TRS levels exceeded 7 µg/m^3 (one-hour Level A Objective) 60.7% of the time and exceeded 28 µg/m^3 (one-hour Level B Objective) 4.2% of the time. Detectable TRS levels were recorded at almost all the 16 wind sectors. This is not an indication of sources in all sectors, but a result of TRS levels building up in the area under calm conditions, and not having sufficient time to be flushed out of the airshed once wind speeds increase (regardless of direction).



% of TRS less than detectable was 65.4%

Mean concentration when winds < 1 m/s was 3.5 ug/m3

Figure 3.2.2: TRS pollution rose at Plaza for 2004

Figure 3.2.3 shows average monthly TRS concentrations for each of the three Prince George ambient air monitoring stations and the number of hours of exceedance of the hourly Level A air quality objective in 2004. Actual values and additional information can be found in Tables C - 1.5 to C - 1.7 in Appendix "C". Monthly averages ranged from a high of 5.8 µg/m^3 at the Jail site (in February) to 0.1 µg/m^3 at Lakewood (during July). The Jail had the highest annual average and the highest frequency of exceedances of the Level A and B 1-hour and daily objectives. All sites recorded exceedances of both the Level A and B objectives which were more frequent during the months of January or February.

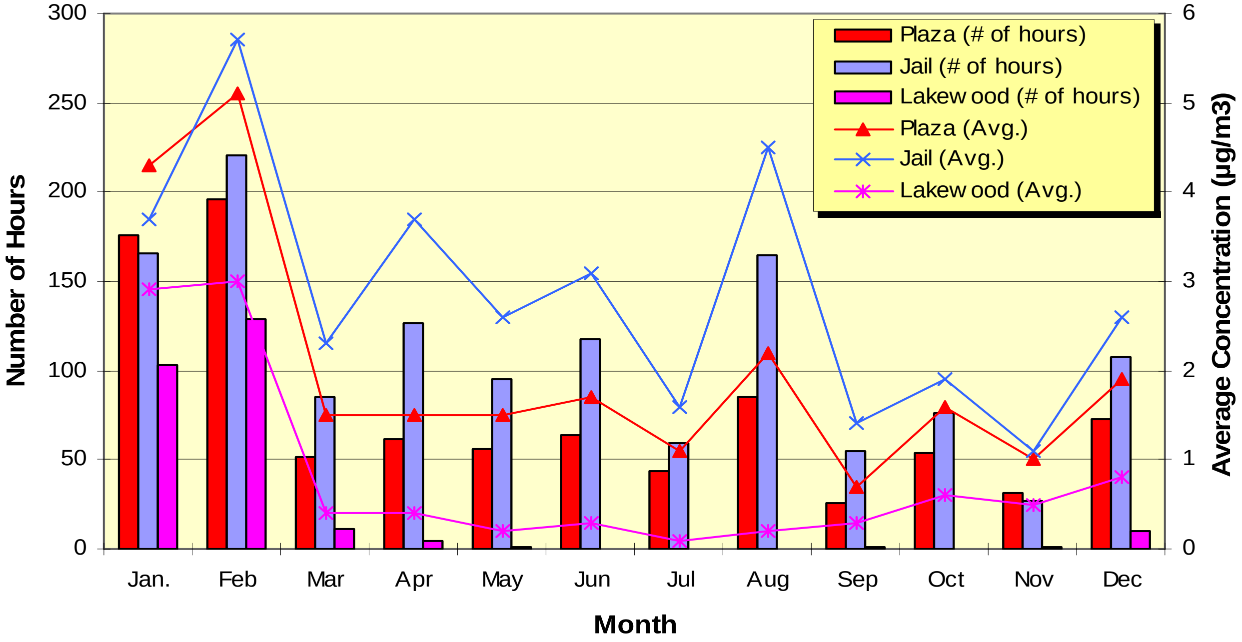


Figure 3.2.3: 2004 monthly average TRS levels (µg/m^3) and the number of hours exceeding the one-hour Level A objective at sites in Prince George

Figures 3.2.4 to 3.2.6 show the range in monthly average TRS levels at the Plaza, Jail and Lakewood sites, respectively, since 1995. Data collected prior to 1995 was not used because the method used to archive that data could produce a lower monthly average. Monthly averages at Plaza and Lakewood tend to be the highest during winter and lowest during early summer, whereas, monthly averages at Jail tend to be highest during late winter and again during early autumn, and lowest in late spring. Monthly averages at Plaza and Lakewood have not exceeded 1.8 µg/m^3 and 0.5 µg/m^3, respectively, from April through July since 1995. In 2004, February's monthly average was the highest recorded at all three sites for that month since 1995. May's average was also the highest recorded at Plaza for that month since 1995. September and December recorded the lowest monthly averages for these months at both Plaza and Lakewood.

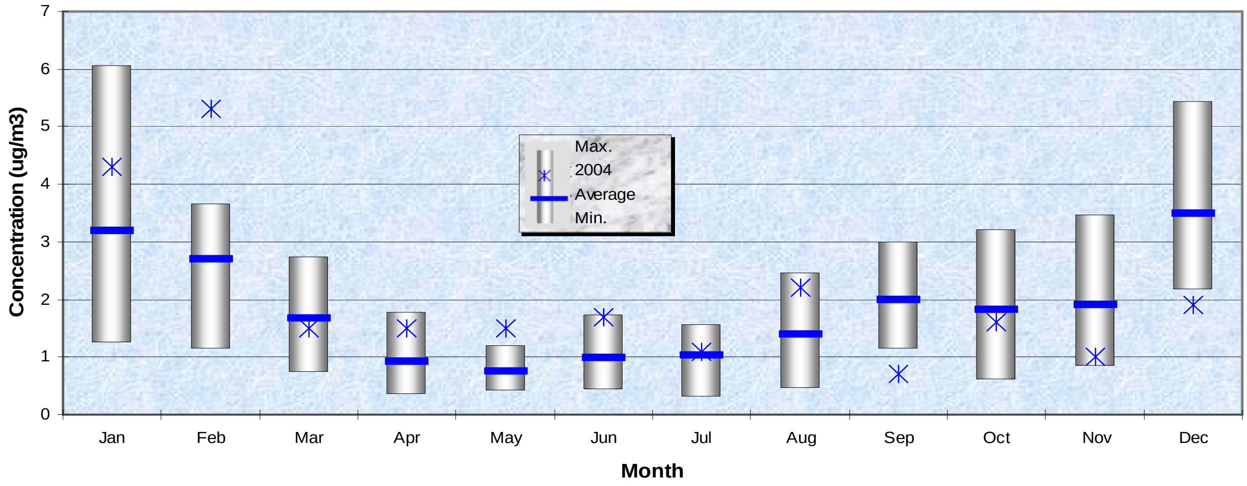


Figure 3.2.4 Comparison of 2004 with long-term average monthly TRS levels (µg/m^3) at Plaza since 1995

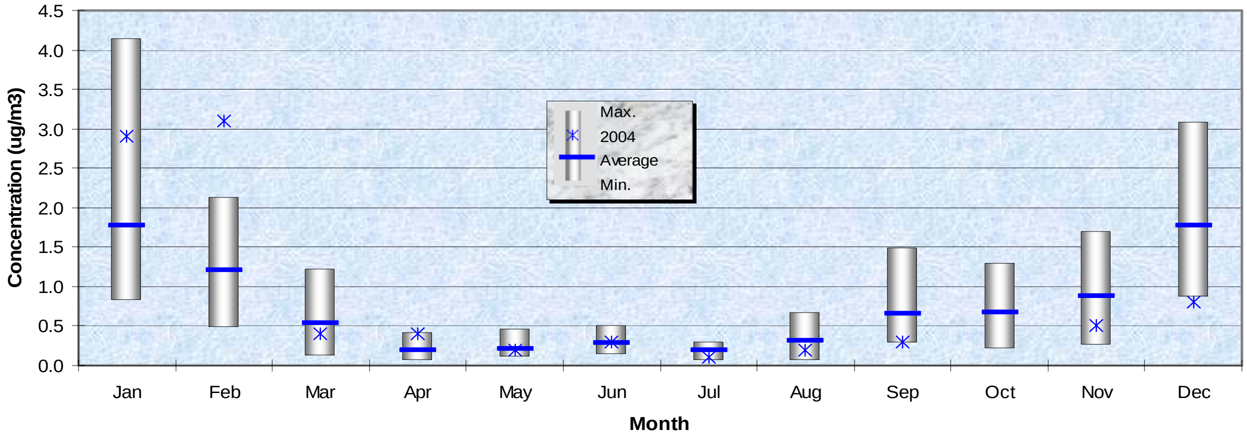


Figure 3.2.5 Comparison of 2004 with long-term average monthly TRS levels (µg/m^3) at Lakewood since 1995

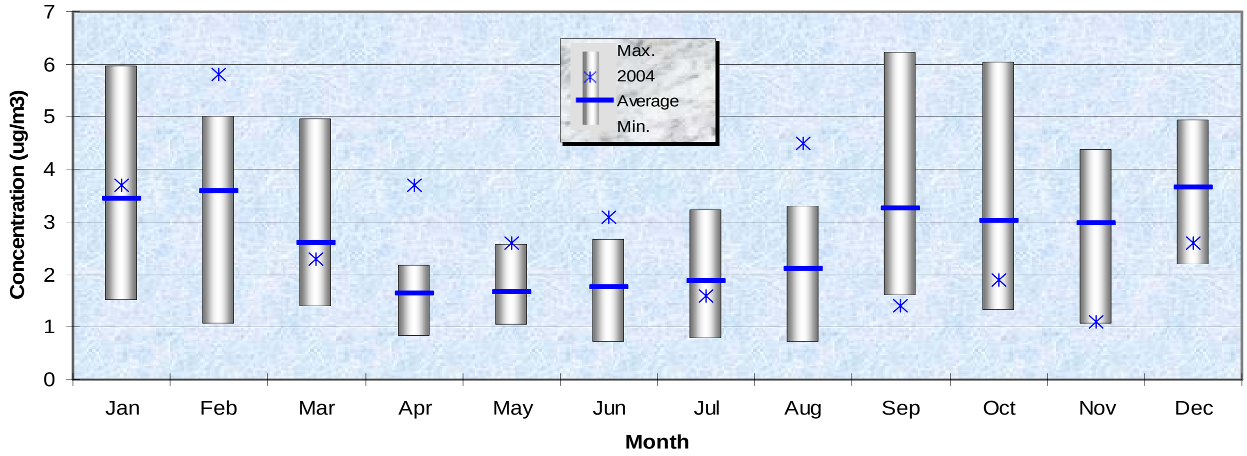


Figure 3.2.6 Comparison of 2004 with long-term average monthly TRS levels (µg/m^3) at Jail since 1995

Figure 3.2.7 shows the 2004 average TRS concentration for each hour of the day for sites in Prince George, giving a general pattern of TRS levels. Levels at both Plaza and Jail start increasing in the evening, which is an indication of a nocturnal ground level inversion developing. Emissions get trapped in this inversion and gradually build up overnight. Once the inversion breaks in the morning, TRS levels start decreasing. Levels are the lowest in the afternoon when mixing is greatest. At the Lakewood site, levels do not start increasing until just before midnight, but the increase is slight compared to the other two sites.

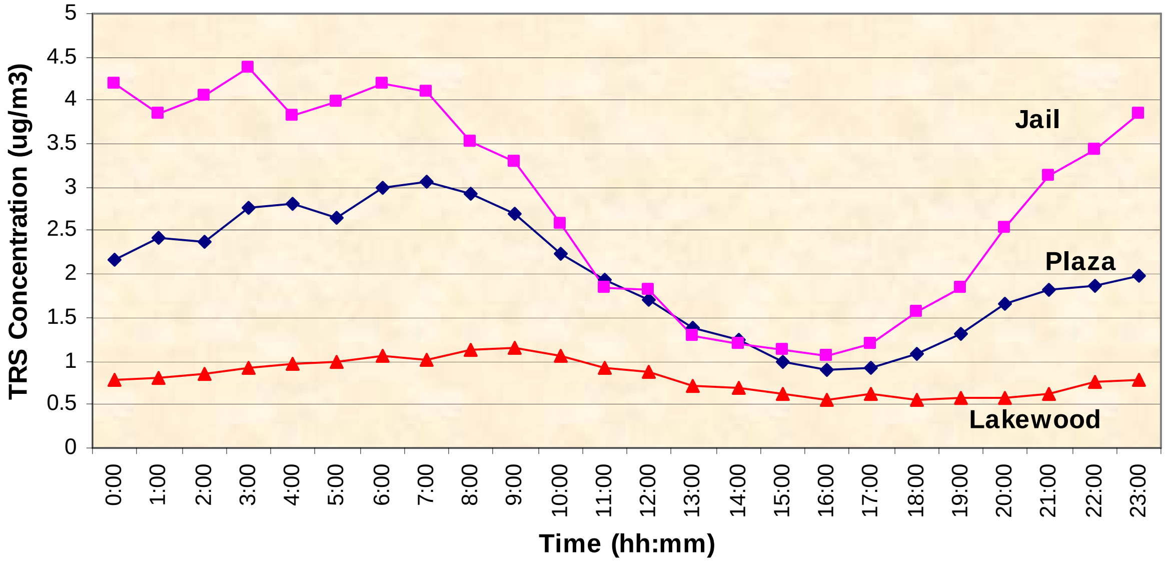


Figure 3.2.7 Average daily pattern of TRS levels (μg/m3) in Prince George in 2004

3.2.1 TRS Annual Trends

The data from the Plaza station, the Jail, Lakewood stations were examined to reveal trends in Prince George. The following tables (Table 3.2.1 - Table 3.2.3) and Figure 3.2.8 summarize the TRS data from the three existing stations over the full monitoring period.

At Plaza, the 2004 annual average and Level A and B Objective exceedances have decreased from the previous year (Table 3.2.1), whereas at the Jail site, these values have all increased from 2003 (Table 3.2.2) The frequency of Level B one-hour exceedances at Plaza were the second highest since 1993. The annual average at the Jail as well as the frequency of exceedances of both the Level A one-hour and daily exceedances were the highest since 1998. However, levels at Plaza and Jail are only about 26% of what was recorded before 1989 (Fig. 3.2.8). Lakewood had the highest annual average for 2004 since 1995 and the highest maximum daily average since 1987. The number of hours exceeding the Level B one-hour objective was the highest recorded since 1989, equivalent to the total number of exceedances in the preceding 10 years. The reduction of odorous emissions from the pulp mill effluent treatment ponds in 1990 produced a significant improvement in air quality at all stations. Since these source reductions, TRS levels at the Plaza and Jail sites gradually decreased until 2002, the increase in the previous 2 years may have been due to increased production levels at industrial sources.

Table 3.2.1 Annual trend summary of TRS data at Plaza

	Annual Average	**No. (%) of 1-Hour Values**		**Maximum Hourly Average**	**No. (%) of Daily Values**		**Maximum Daily Average**	**No. of hours Instrument Operated**
Year	**(µg/m^3)**	**>7µg/m^3**	**>28µg/m^3**	**(µg/m^3)**	**>3µg/m^3**	**>6µg/m^3**	**(µg/m^3)**	
1980	5.9	1085 (16.0%)	449 (6.6%)	163	127 (45.0%)	85 (30.1%)	62.4	6772
1981	6.0	1276 (16.9%)	566 (7.5%)	241	136 (43.2%)	101 (32.1%)	53.8	7558
1982	5.3	1241 (15.1%)	445 (5.4%)	198	156 (45.5%)	111 (32.4%)	41.3	8235
1983	8.6	1670 (20.7%)	817 (10.1%)	177	180 (53.4%)	150 (44.5%)	90.5	8082
1984	4.7	978 (11.9%)	372 (4.5%)	227	121 (35.2%)	84 (24.4%)	51.7	8246
1985	4.8	875 (12.3%)	406 (5.7%)	297	106 (35.8%)	78 (26.4%)	81.6	7115
1986	7.9	1295 (20.1%)	677 (10.5%)	289	126 (46.8%)	102 (37.9%)	61.4	6456
1987	9.0	1806 (21.8%)	972 (11.7%)	218	174 (48.2%)	143 (39.6%)	69.0	8280
1988	7.3	1633 (19.7%)	792 (9.5%)	194	159 (44.0%)	121 (33.5%)	69.4	8297
1989	5.9	1376 (16.9%)	594 (7.3%)	184	140 (40.8%)	111 (32.4%)	41.8	8166
1990	2.7	905 (11.0%)	187 (2.3%)	122	100 (28.0%)	57 (16.0%)	47.0	8234
1991	2.2	925 (11.2%)	43 (0.5%)	58	84 (23.3%)	46 (12.8%)	19.4	8256
1992	2.1	882 (10.6%)	34 (0.4%)	69	89 (24.5%)	49 (13.5%)	18.4	8300
1993	2.4	956 (11.4%)	92 (1.1%)	72	89 (24.6%)	54 (14.9%)	29.8	8360
1994	1.9	790 (9.5%)	22 (0.3%)	67	84 (23.3%)	34 (9.4%)	19.1	8295
1995	1.9	757 (9.2%)	20 (0.2%)	44	93 (26.1%)	32 (9.0%)	20.5	8205
1996	1.7	622 (7.5%)	28 (0.3%)	103	71 (19.8%)	25 (7.0%)	27.2	8262
1997	1.6	654 (7.8%)	13 (0.2%)	40	65 (17.9%)	22 (6.0%)	12.9	8371
1998	2.2	958 (11.6%)	9 (0.1%)	50	88 (24.6%)	32 (8.9%)	19.5	8245
1999	1.7	784 (9.5%)	13 (0.2%)	44	71 (19.8%)	24 (6.7%)	18.5	8247
2000	1.5	675 (8.1%)	16 (0.2%)	45	58 (15.9%)	23 (5.5%)	21.8	8314
2001	1.7	882 (10.7%)	5 (0.1%)	35	68 (18.7%)	25 (6.9%)	21.0	8257
2002	1.7	726 (8.9%)	25 (0.3%)	57	61 (17.3%)	25 (7.1%)	16.4	8167
2003	2.1	963 (11.7%)	41 (0.5%)	61	95 (26.6%)	31 (8.7%)	16.5	8220
2004	2.0	918 (10.9%)	36 (0.4%)	41	83 (22.7%)	26 (7.1%)	22.3	8384

Table 3.2.2 Annual trend summary of TRS data at Jail

Year	Annual Average (µg/m^3)	No. (%) of 1-Hour Values		Maximum Hourly Average (µg/m^3)	No. (%) of Daily Values		Maximum Daily Average (µg/m^3)	No. of Hours Instrument Operated
		>7µg/m^3	>28µg/m^3		>3µg/m^3	>6µg/m^3		
1981	7.2	1673 (21.7%)	638 (8.3%)	177	151 (47.0%)	121 (37.7%)	59.6	7701
1982	-	1169 (23.8%)	519 (10.6%)	149	125 (61.0%)	99 (48.3%)	53.5	4915
1983	11.0	2051 (27.3%)	1066 (14.2%)	156	184 (58.8%)	151 (48.2%)	70.2	7511
1984	6.5	1341 (17.6%)	593 (7.8%)	170	136 (42.8%)	109 (34.3%)	54.8	7638
1985	6.4	1483 (19.1%)	546 (7.0%)	149	145 (44.8%)	117 (36.1%)	44.9	7773
1986	9.8	2404 (29.1%)	1028 (12.4%)	347	197 (57.1%)	169 (49.0%)	68.0	8268
1987	11.6	2268 (29.0%)	1306 (16.7%)	382	200 (59.0%)	175 (51.6%)	86.0	7817
1988	11.6	2307 (27.9%)	1343 (16.2%)	312	197 (54.6%)	166 (46.0%)	94.6	8267
1989	9.2	1852 (25.8%)	793 (11.0%)	212	174 (54.5%)	134 (42.0%)	68.3	7183
1990	5.4	927 (14.3%)	215 (3.3%)	177	91 (32.6%)	66 (23.7%)	46.7	6494
1991	3.1	1195 (14.4%)	138 (1.7%)	126	117 (32.3%)	61 (16.9%)	39.2	8316
1992	3.7	1103 (14.9%)	71 (1.0%)	78	109 (34.0%)	66 (20.6%)	17.7	7387
1993	3.8	1343 (16.7%)	201 (2.5%)	69	123 (35.4%)	86 (24.8%)	37.7	8061
1994	3.1	1214 (15.1%)	108 (1.3%)	57	119 (35.0%)	67 (19.7%)	19.7	8017
1995	3.3	1274 (15.2%)	73 (0.9%)	64	157 (43.1%)	64 (17.6%)	23.0	8359
1996	2.6	1043 (12.5%)	42 (0.5%)	62	112 (30.8%)	53 (14.6%)	18.8	8359
1997	2.5	1157 (13.9%)	42 (0.5%)	55	119 (32.7%)	37 (10.2%)	21.3	8347
1998	3.1	1488 (17.9%)	57 (0.7%)	51	138 (38.2%)	62 (17.2%)	26.1	8314
1999	2.4	1085 (13.4%)	44 (0.5%)	123	107 (30.2%)	43 (12.1%)	26.5	8117
2000	2.4	1079 (13.1%)	37 (0.5%)	62	105 (28.8%)	43 (11.8%)	18.4	8214
2001	2.2	1106 (13.2%)	13 (0.2%)	37	93 (25.7%)	42 (11.6%)	20.2	8352
2002	2.1	894 (10.7%)	35 (0.4%)	44	85 (23.2%)	31 (8.5%)	18.5	8375
2003	2.7	1267 (15.1%)	55 (0.7%)	61	120 (32.9%)	56 (15.3%)	21.7	8374
2004	2.8	1300 (15.7%)	64 (0.7%)	84	119 (32.5%)	61 (16.7%)	18.2	8300

The Level B Objective is still being exceeded at all sites within the city (most frequently at Jail), indicating the need for the additional TRS reductions called for in the Prince George Air Quality Plan (see Prince George Airshed Technical Management Committee, 1998). The Level B hourly exceedances at Lakewood were the most frequent since 1989 (Table 3.2.3). In order to improve air quality in the Prince George downtown core, the annual average at Plaza (2.0 µg/m^3) will likely have to be similar to the Lakewood average (< 1.0 µg/m^3) to diminish these exceedances.

Table 3.2.3 Annual trend summary of TRS data at Lakewood

	Annual Average	**No. (%) of 1-Hour Values**		**Maximum Hourly Average**	**No. (%) of Daily Values**		**Maximum Daily Average**	**No. of hours Instrument Operated**
Year	**($\mu g/m^3$)**	**>7$\mu g/m^3$**	**>28$\mu g/m^3$**	**($\mu g/m^3$)**	**>3$\mu g/m^3$**	**>6$\mu g/m^3$**	**($\mu g/m^3$)**	
1982	-	176 (3.0%)	22 (0.4%)	85	22 (9.1%)	13 (5.4%)	19.7	5785
1983	2.6	615 (7.9%)	147 (1.9%)	99	79 (24.5%)	43 (13.4%)	40.7	7737
1984	0.9	199 (2.4%)	15 (0.2%)	64	34 (9.9%)	10 (2.9%)	15.4	8269
1985	1.0	216 (2.9%)	28 (0.4%)	50	29 (9.3%)	12 (3.9%)	21.6	7456
1986	1.7	439 (5.6%)	110 (1.4%)	71	51 (15.7%)	32 (9.9%)	27.1	7807
1987	1.6	461 (6.0%)	106 (1.4%)	92	51 (15.6%)	34 (10.4%)	35.7	7680
1988	1.1	270 (3.6%)	38 (0.5%)	64	38 (11.8%)	23 (7.1%)	17.5	7462
1989	0.7	170 (2.8%)	33 (0.5%)	92	22 (8.1%)	8 (2.9%)	28.0	6057
1990	-	66 (1.2%)	3 (< 0.1%)	79	8 (3.4%)	1 (0.4%)	10.5	5484
1991	0.6	173 (2.3%)	3 (< 0.1%)	37	19 (5.7%)	4 (1.2%)	18.7	7667
1992	0.6	214 (2.6%)	0 (0.0%)	27	22 (6.0%)	9 (2.5%)	11.7	8351
1993	0.9	307 (4.4%)	5 (< 0.1%)	50	31 (9.7%)	13 (4.4%)	19.4	6952
1994	0.6	147 (1.8%)	2 (< 0.1%)	74	21 (5.9%)	4 (1.1%)	11.5	8196
1995	0.9	270 (3.2%)	2 (< 0.1%)	37	37 (10.2%)	11 (3.0%)	15.0	8358
1996	0.7	227 (2.7%)	8 (0.1%)	44	27 (7.5%)	7 (1.9%)	15.0	8281
1997	0.7	174 (2.1%)	0 (0.0%)	27	17 (4.8%)	4 (1.1%)	9.8	8211
1998	0.7	215 (2.6%)	0 (0.0%)	18	21 (6.0%)	5 (1.4%)	10.7	8204
1999	0.6	172 (2.1%)	1 (< 0.1%)	28	14 (4.0%)	5 (1.4%)	9.5	8191
2000	0.5	157 (1.9%)	0 (0.0%)	23	15 (4.1%)	3 (0.8%)	12.8	8348
2001	0.7	249 (3.0%)	0 (0.0%)	23	21 (5.8%)	9 (2.5%)	13.0	8345
2002	0.6	191 (2.3%)	0 (0.0%)	23	18 (5.2%)	6 (1.7%)	10.5	8254
2003	0.6	178 (2.1%)	0 (0.0%)	23	12 (3.3%)	2 (0.5%)	8.8	8370
2004	0.8	261 (3.4%)	13 (0.2%)	44	22 (6.0%)	10 (2.7%)	28.2	7621

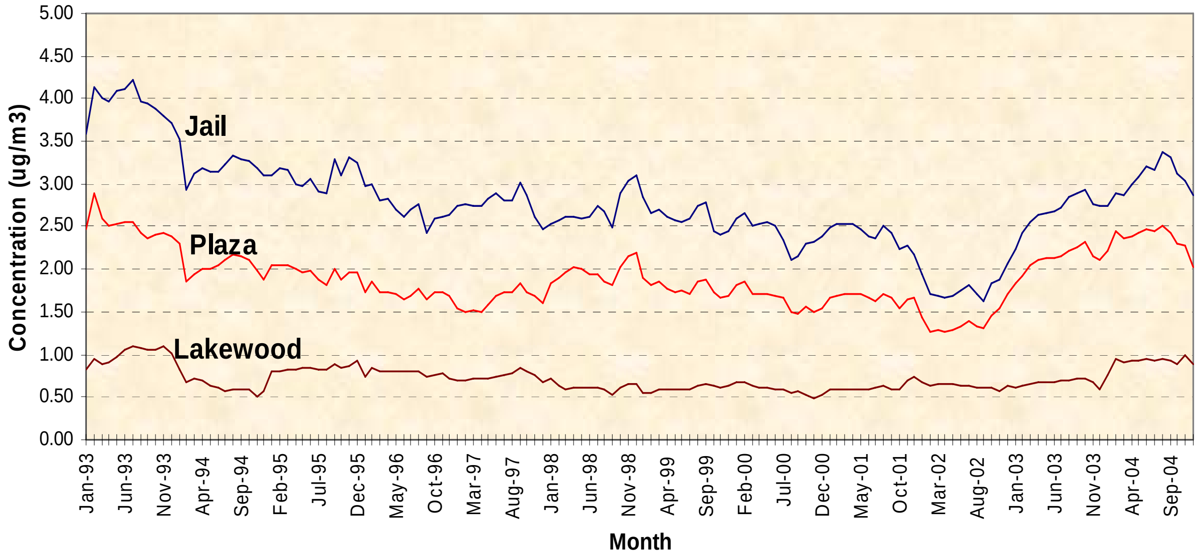


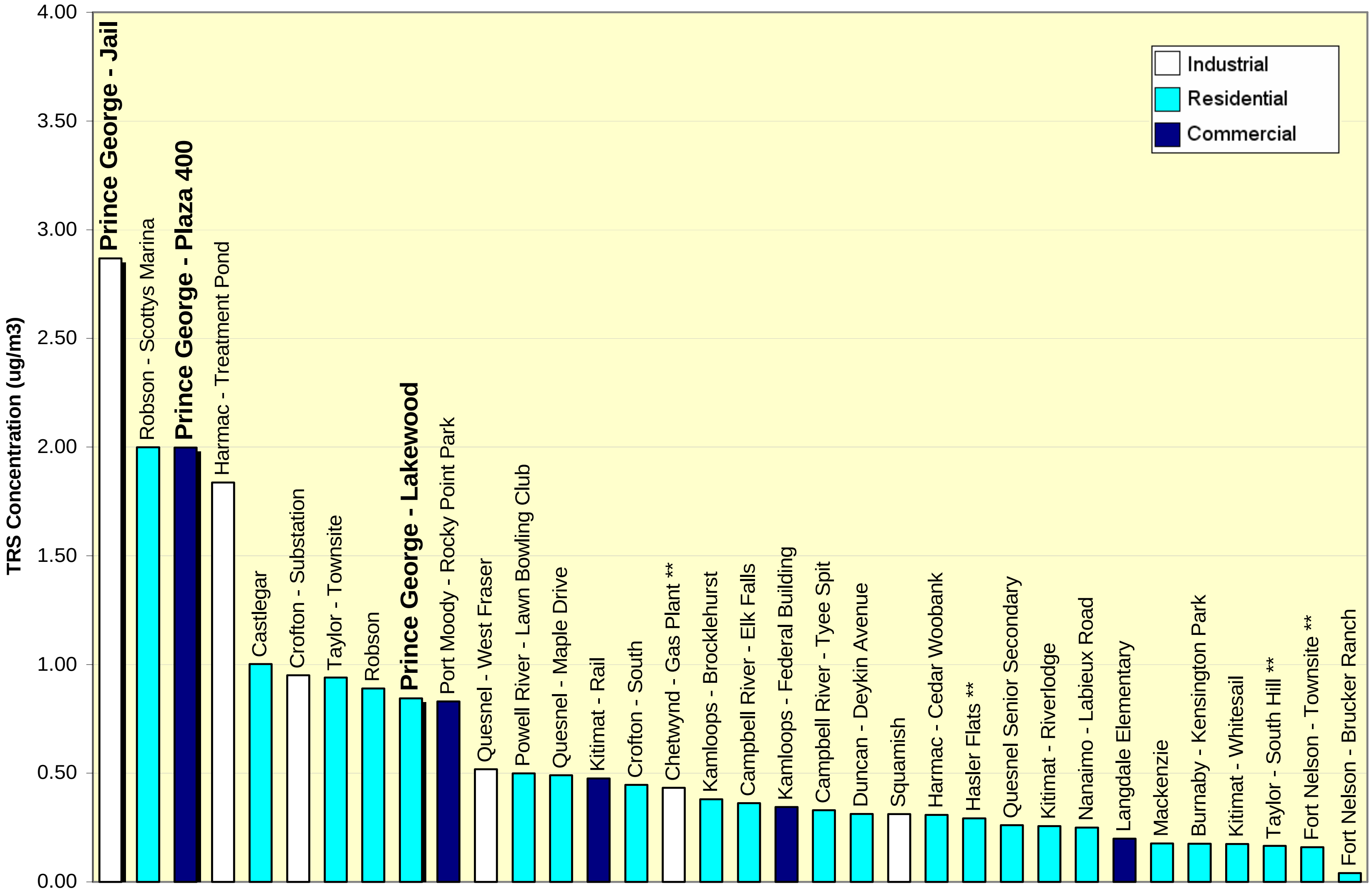
Fig. 3.2.8 Rolling annual average TRS levels ($\mu g/m^3$) recorded at sites in Prince George

Figure 3.2.8 shows rolling annual average TRS levels recorded at the three monitoring sites in Prince George using one-month intervals. The rolling annual average was used to reduce seasonal influences on the trends. A rolling annual average is the average for a 365 consecutive day period (i.e., the average on July 22, 1998 is for the period from July 23, 1997 to July 22, 1998). Annual averages at the Lakewood site showed a slight decrease of only about 0.2 µg/m^3 since 1993, while the Jail site averages decreased about 0.9 µg/m^3 since 1993. The rolling annual averages for the Jail and Plaza sites in August 2004 were the greatest since January 1994 (Figure 3.2.8).

The annual breakdown of percentiles of TRS levels for the past ten years are shown in Table C – 2.4 in Appendix “C”. All three sites showed a slight decrease in the higher percentiles for TRS from 1995 to 2002. However, the higher percentiles at Plaza in 2003 and 2004 were the highest in the ten years.

3.2.2 Comparison of Prince George TRS Levels with Other B.C. Locations

Figure 3.2.9 compares the TRS annual averages recorded in Prince George with those at other monitoring sites in B.C. (all sites with greater than 80% of data captured). The Jail site continues to record the highest annual average of all the monitored sites in B.C. The Plaza’s commercial site recorded the second highest annual average (same annual average as the Robson – Scotty’s Marina site), which was over twice as high as most other sites that monitor TRS in B.C. Lakewood recorded the fourth highest annual TRS average of the twenty-two B.C. residential sites, compared with sixth position in 2003.



** Only monitors H_2S

Figure 3.2.9 Comparison of 2004 annual average TRS levels ($\mu g/m^3$) in Prince George with other B.C. locations

3.3 Sulphur Dioxide (SO_2) Results

SO_2 is a colourless gas that has a pungent odour at concentrations above 900 µg/m^3 (Level B one-hour objective). SO_2 can adversely affect both human health and vegetation. Very high levels of SO_2 can cause breathing discomfort, respiratory illness, alterations in the lung's defences, and aggravation of existing respiratory and cardiovascular diseases. Effects of SO_2 on vegetation depend on the plant species and range from acute to chronic injury.

SO_2 is formed primarily by the combustion of material containing sulphur. At present, the major sources of SO_2 in the Prince George area are the Husky refinery and the three pulp mills. Minor sources include the Marsulex sulphuric acid plant and the railways (Prince George Airshed Technical Management Committee, 1996). Other anthropogenic sources (i.e., residential and commercial space heating) and natural sources (i.e., long range transport of SO_2 from volcanoes and swamps) are very small compared to the emissions produced by the industries.

SO_2 can be oxidized (either photochemically or in the presence of a catalyst) to sulphur trioxide, which in the presence of water vapour, is readily converted to sulphuric acid mist. Sulphuric acid and other sulphates can account for about 5%-20% of the total suspended particulates in some urban airsheds. Many health problems attributed to SO_2 may be the result of the oxidation of SO_2 to other compounds. Only small amounts of SO_2 gas reach the lower respiratory tract, whereas acid aerosols such as sulphates can be carried into the deeper lung airways. Asthmatics have shown demonstrable health effects when exercising at SO_2 levels as low as 1000 µg/m^3 but are also sensitive to acid aerosol concentrations as low as 100 µg/m^3 (Brimblecombe, 1996).

The current analyzers have a detection limit of 2.5 µg/m^3 (Fig 3.3.1). The analyzers measure the total amount of SO_2 gases by fluorescent excitation of SO_2 by ultra-violet radiation.

Fig 3.3.1 TECO SO2 monitor

The quality of the SO_2 data was evaluated through monthly calibrations and independent auditing in April and November. The auditing results in Appendix B, Table B-1 indicate that the SO_2 monitors at Plaza and CBC had excellent performance in April and satisfactory performance in November, and the Jail monitor was excellent in both April and November. Data quality is considered unsatisfactory if the monitor deviates by 15% or more from the auditing results. Data recovery was over 95% at all three sites.

The SO_2 data from the Jail, Plaza and CBC Transmitter sites are summarized in Figure 3.3.2. Actual values and additional information can be found in Tables C – 1.8 to C – 1.10 in Appendix "C". Ambient SO_2 levels exceeded the Level A one-hour provincial objective only at the CBC site, which recorded 6 Level A hourly exceedances in 2004. There were no exceedances of the Level B hourly objective, nor the 24-hour objectives. The highest monthly concentrations were recorded in August (Jail and CBC) or December (Plaza). The highest hourly concentrations occurred August, October, and January at the Jail, Plaza, and CBC sites, respectively.

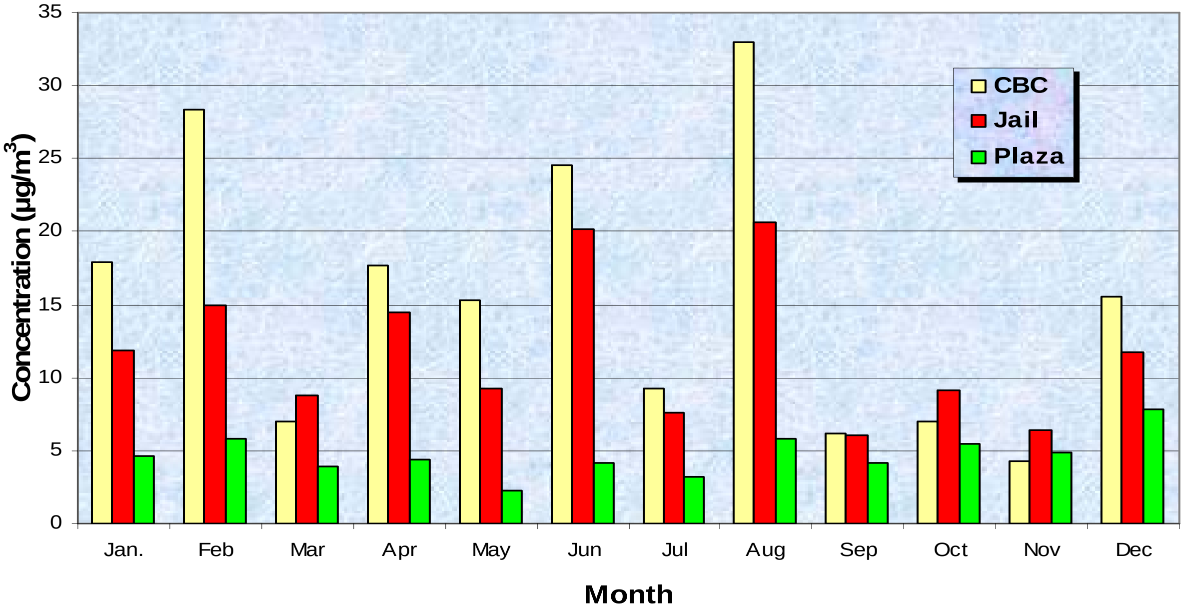


Figure 3.3.2 *2004 monthly average SO_2 levels (µg/m^3) in Prince George*

Figures 3.3.3 – 3.3.5 show the trends in monthly SO_2 values at the Plaza, Jail and CBC sites, respectively, since 1995. Monthly averages in 2004 were below normal for all months at Plaza, and for at least seven months at Jail and CBC. These lower levels can be mainly attributed to the installation of the Sulphur Recovery Unit at Husky in 1997. Monthly averages ranged from a high of 35.8 µg/m^3 (Feb. 1996) to a low of 2.3 µg/m^3 (May 2004) at Plaza, from a high of 53.9 µg/m^3 (March 1996) to a low of 3.0 µg/m^3 (August 2000) at Jail, and from a high of 42.1 µg/m^3 (Dec. 1996) to a low of 2.9 µg/m^3 (Dec. 1999) at CBC. Monthly averages at Plaza tend to be highest from December to February, and lowest during April through July. Since 1995, monthly averages have not exceeded 12 µg/m^3 in April through July at this site.

At the Jail site, monthly averages tend to be highest during March and lowest during July and October, and at CBC they tend to be highest during February and lowest during October. In 2004, the average SO_2 levels in January, May, and September were the lowest average levels ever recorded at Plaza for those months (since 1995). The monthly average for November 2004 was the lowest recorded at the Jail site for that month since 1995. At CBC, March, September, and November 2004 saw the lowest monthly averages recorded for those months since 1995. June and August experienced the highest monthly averages in 2004 at this site since 1995.

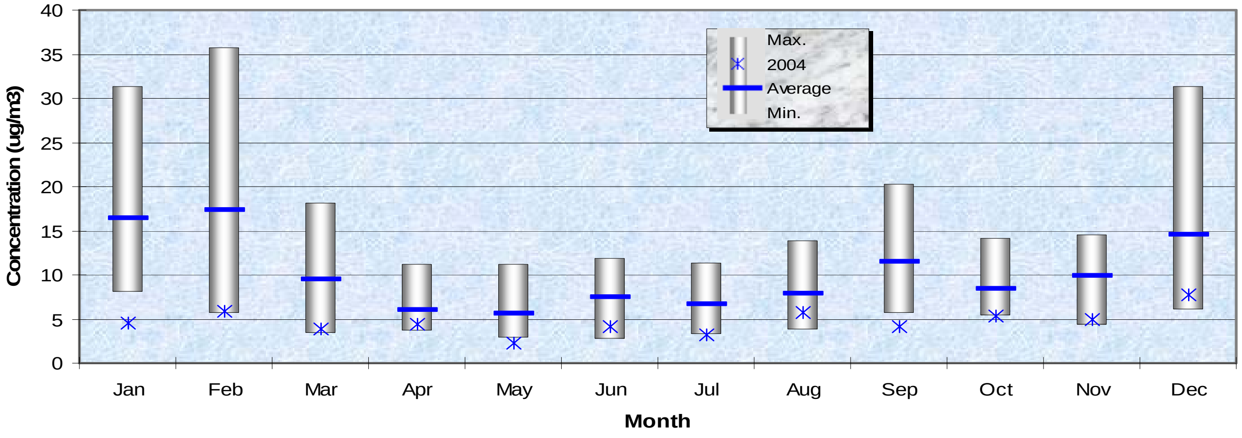


Figure 3.3.3 *Comparison of 2004 with long-term average monthly* SO_2 *levels* ($\mu g/m^3$) *at Plaza since 1995*

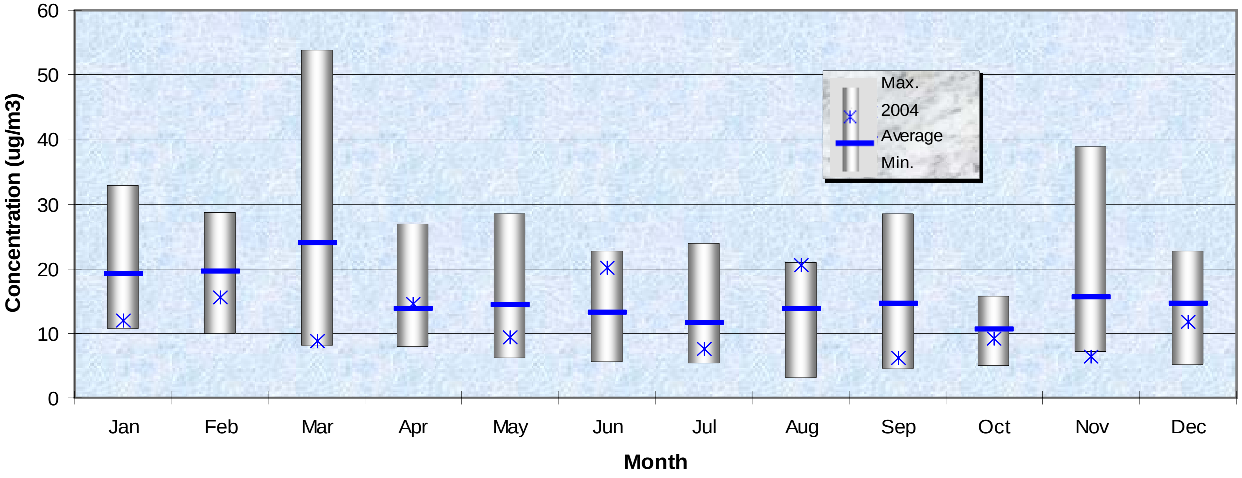


Figure 3.3.4 *Comparison of 2004 with long-term average monthly* SO_2 *levels* ($\mu g/m^3$) *at Jail since 1995*

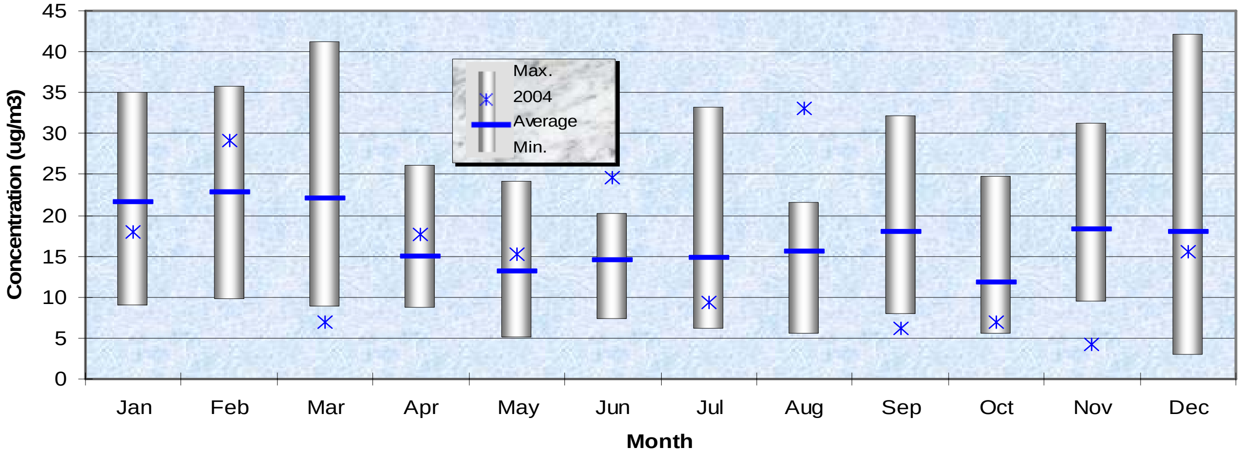


Figure 3.3.5 *Comparison of 2004 with long-term average monthly* SO_2 *levels* ($\mu g/m^3$) *at CBC since 1995*

Figure 3.3.6 shows the SO_2 pollution rose for the Plaza site based on the 2004 meteorological data at that site. Wind directions were only considered when wind speeds were $\geq$ 1 m/s. Similar to the TRS pollution rose, the highest concentrations occurred with winds from the east. SO_2 levels were less than 4 µg/m^3 for about 28% of the time when the winds were blowing from the east, whereas with winds from the west, levels were less than 4 µg/m^3 95% of the time. Detectable SO_2 levels were recorded at almost all the 16 wind sectors. This may not be an indication of sources, but a result of SO_2 levels building up in the area under calm conditions, and indicating the direction of flushing winds rather than source winds. A sulphuric acid plant located in the BCR Industrial Park may be the source for the higher frequency of SO_2 levels above 4 µg/m^3 from the west-southwest sector.

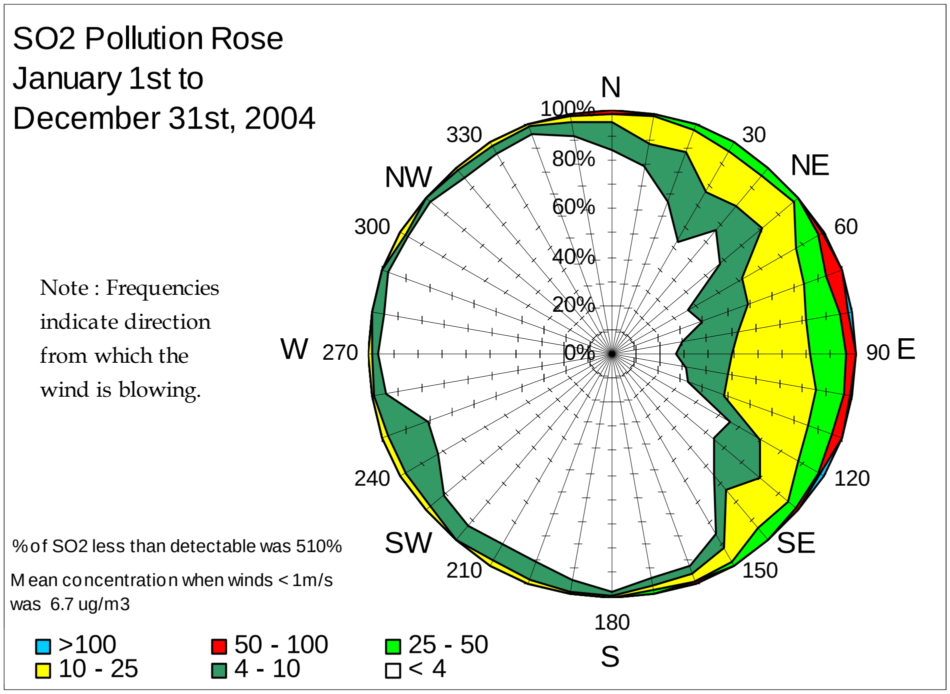


Figure 3.3.6 *SO_2 Pollution Rose at Plaza for 2004*

Figure 3.3.7 shows the average SO_2 concentrations in 2004 for each hour of the day at each monitoring site, giving the average diurnal pattern. Unlike TRS, levels of SO_2 at Plaza generally do not increase in the evening, but start increasing in the morning. These high morning concentrations are due to a process known as fumigation. Levels build up overnight above the inversion layer, and once the inversion breaks due to daytime heating, this pollution is brought down to the valley surface. This pattern results from the fact that SO_2 is emitted from high stacks, whereas most TRS is emitted closer to the ground

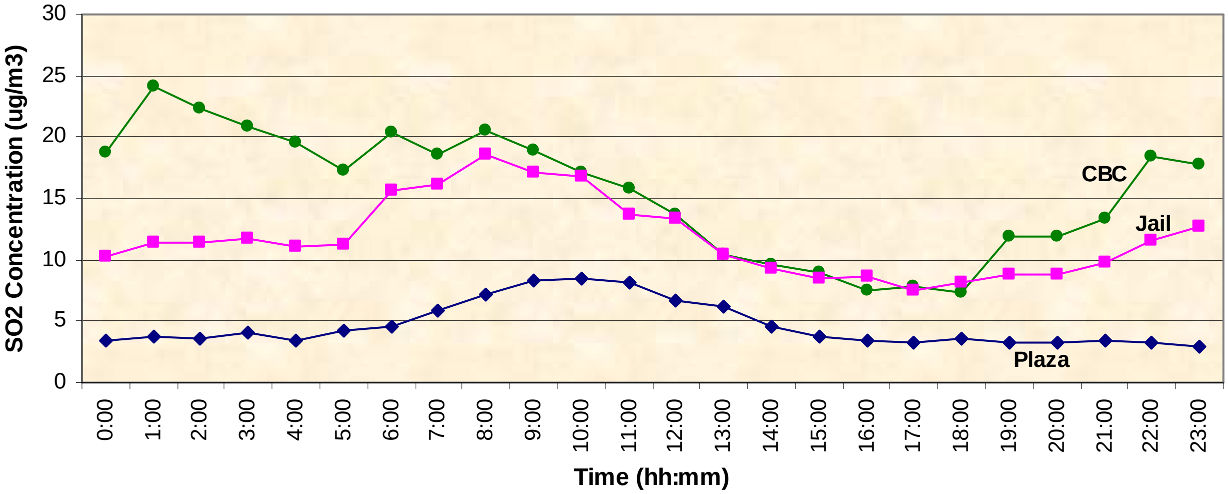


Figure 3.3.7 Average daily pattern in SO_2 levels ($\mu g/m^3$) in Prince George for 2004

The CBC site does not show this fumigation pattern, but levels start increasing late in the evening until just after midnight and remain high throughout the night (Fig. 3.3.7). The SO_2 emitted from the high elevation stacks gets trapped in the inversion that develops over the plateau. This inversion prevents the plume from spreading vertically and only allows horizontally spread. Thus, the plume is forced to stay well above the Plaza and Jail monitoring sites, but is able to impact the CBC site, which is located at a higher elevation. The Jail site is located at a lower elevation (intermediate between CBC site and the Plaza site) and also experiences fumigation and, on occasion the trapping process.

3.3.1 SO_2 Annual Trends

Table 3.3.1 summarizes the SO_2 data collected at the Jail station from 1986 to 2004. Since 1990, the annual SO_2 average recorded at the Jail in has been gradually increasing with the highest annual average, and the frequency of exceedances of the hourly Level A objective, recorded in 1996. The contribution of SO_2 from the industrial emission sources increased significantly each year until 1997. These increases were caused predominantly by higher sulphur levels in the crude oil processed at the Husky refinery, as well as by increased TRS incineration at the pulp mills. After the new sulphur recovery unit was installed at Husky in 1997, ambient SO_2 levels have decreased significantly in the airshed. The full impact of this reduction on air quality is noticeable from 1998 to 2004 (Figure 3.3.8). Levels have again increased since then at Jail and CBC, but continue to decrease at Plaza. This may be due to variability in emissions from different sources as well as meteorological factors.

Table 3.3.1 Annual trend summary of SO_2 data at Jail

Year	Annual Average (µg/m³)	No. of 1-Hour Values >450µg/m³	Maximum Hourly Average (µg/m³)	No. of Daily Values >160µg/m³	Maximum Daily Average (µg/m³)	No. of Hours Instrument Operated
1986	16.9	4	538	0	152.5	8278
1987	12.8	2	666	0	123.0	8348
1988	13.8	8	586	1	173.8	8412
1989	12.0	1	659	0	99.6	8165
1990	5.5	0	283	0	56.7	6719
1991	8.7	1	492	0	118.1	8236
1992	12.1	1	450	0	104.0	8363
1993	10.9	0	363	0	81.8	8225
1994	12.5	1	469	0	123.0	8162
1995	20.5	1	530	0	118.8	8354
1996	23.7	10	735	2	189.8	8368
1997	20.5	4	759	0	143.2	8350
1998	18.6	1	469	0	129.0	7580
1999	10.0	0	306	0	103.9	8358
2000	9.0	0	415	0	96.3	8362
2001	12.1	1	458	1	164.7	8348
2002	11.6	1	519	0	82.3	8367
2003	13.2	0	336	0	91.7	8373
2004	11.7	0	341	0	74.7	8396

Table 3.3.2 Annual trend summary of SO_2 data at Plaza

Year	Annual Average (µg/m³)	No. of 1-Hour Values >450µg/m³	Maximum Hourly Average (µg/m³)	No. of Daily Values >160µg/m³	Maximum Daily Average (µg/m³)	No. of Hours Instrument Operated
1995	-	2	474	0	156.3	5323*
1996	15.8	13	913	1	167.9	8229
1997	14.6	8	663	0	118.3	8363
1998	11.9	0	399	0	93.5	8220
1999	7.2	1	490	0	105.3	8703
2000	7.4	0	341	0	58.7	8071
2001	9.5	1	455	1	173.0	8340
2002	7.2	1	527	0	68.0	8362
2003	5.7	0	333	0	53.5	8365
2004	4.7	0	349	0	48.2	8348

* Instrument installed May 1995

Table 3.3.3 Annual trend summary of SO_2 data at CBC

Year	Annual Average (µg/m^3)	No. of 1-Hour Values >450µg/m^3	Maximum Hourly Average (µg/m^3)	No. of Daily Values >160µg/m^3	Maximum Daily Average (µg/m^3)	No. of Hours Instrument Operated
1995	-	4	597	0	101.1	5096*
1996	23.9	10	794	4	189.3	8370
1997	20.1	9	778	2	197.7	8312
1998	22.6	10	597	1	224.0	8361
1999	13.0	11	751	1	227.1	8560
2000	-	2	519	0	142.4	6958
2001	16.2	10	969	4	193.7	8347
2002	12.5	4	623	0	104.4	8348
2003	15.9	11	623	1	163.3	8348
2004	15.5	6	703	0	126.8	8371

* Instrument installed May 1995

It is believed that the Jail and Plaza sites are affected more by Husky's emissions than the CBC site. Prior to the implementation of the Sulphur Recovery unit at Husky, ambient levels at both the CBC and Jail sites were fairly similar. After the unit was installed, levels at the Jail site have been about 30% lower than those at the CBC site due most likely to reduction in the frequency of flaring. From 1998-2004 emissions decreased at Husky, but no consistent trend in pulp mill SO_2 has been shown.

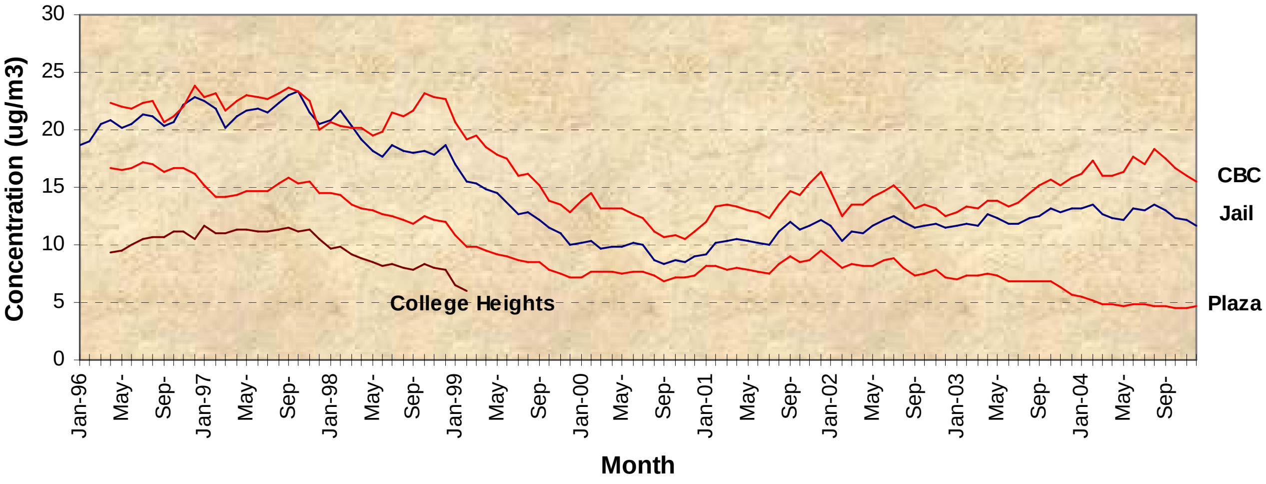


Figure 3.3.8 Rolling average SO_2 level (µg/m^3) at sites in Prince George

Table C – 2.5 in Appendix "C" shows the annual distribution of SO_2 percentiles for the past nine years. The Plaza and Jail sites showed a decrease in the higher percentile values (> 90th percentile) in 2004. At the CBC site, the 98th percentile increased from the previous year. At Plaza, the 90th-99th percentiles were the lowest recorded for the nine-year period. In 1997, the Plaza site had levels over 37µg/m^3 at least 10% of the time but in 2004, levels over 37µg/m^3 occurred only 2% of the time. There was no noticeable decrease in the lower percentiles mainly because levels were near detectable for over half the time.

The annual trends in SO_2 demonstrate the effect of emissions from higher elevation stack sources at the surface of the valley. Even though the refinery emissions are discharged well above the valley floor with substantial plume rise, a reduction in ambient levels consistent with reduction of that source demonstrates the effectiveness of thermal inversions and subsequent fumigation at transferring these emissions to the valley floor.

3.3.2 Comparison of Prince George SO_2 Levels with Other B.C. Locations

Figure 3.3.9 compares the SO_2 annual averages recorded in Prince George with those at other monitoring sites in B.C. (only sites with greater than 75% of data captured are included). The highest annual average was measured at Trail-Butler Park, which was one-third higher than the next highest monitoring site. The CBC and Jail sites recorded the second and eighth highest SO_2 annual averages, respectively out of the 32 sites. The Plaza site rated second among the commercial sites, behind Vancouver Robson Square site. Port Alice, Trail, and Prince George are the only communities that recorded exceedances of the Level A one-hour objective for SO_2.

When comparing the same sites that monitored SO_2 in 2003, 17 out of the 32 sites recorded an increase in 2004. The Port Alice-Rumble Beach Hospital site recorded the biggest incremental increase in annual averages out of all sites and Trail-Warfield showed the biggest incremental decrease in 2004. All Prince George sites also showed decreased annual averages from 2003 to 2004, with the Jail site showing the second biggest incremental decrease.

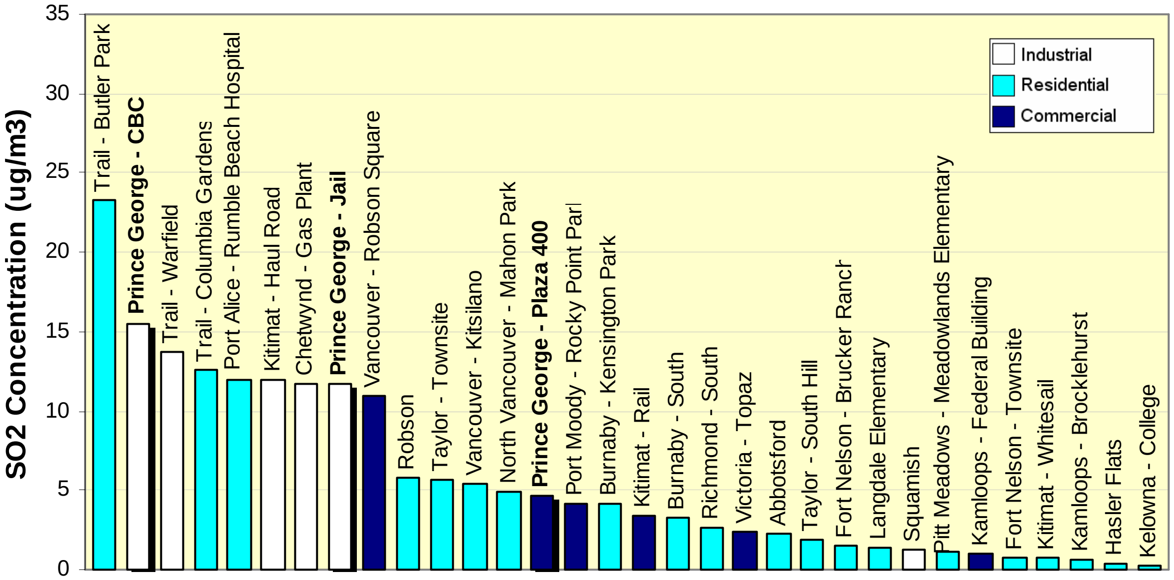


Figure 3.3.9 Comparison of 2004 annual average SO_2 levels ($\mu g/m^3$) in Prince George with other B.C. locations

3.4 Ozone (O_3) Results

Ground level ozone is termed a secondary pollutant because it is not directly emitted into the atmosphere in significant amounts. It is produced through a complex series of chemical reactions involving oxides of nitrogen and volatile hydrocarbons in the presence of sunlight. Because of this, ozone tends to form downwind of industrial sources and can be produced by local, as well as long-range precursor sources. Other pollutants generated by these chemical reactions may include oxygen, nitrogen dioxide, nitric oxide, ketoses, aldehydes, and peroxyacetyl nitrates (PAN).

Ozone is an irritant that affects respiratory function. Exposure to ozone can result in symptoms such as chest tightness, coughing and wheezing (Ontario Ministry of Environment and Energy, 1995). It causes eye and throat irritation, and is known to increase mucous production. Long term exposures to ozone present the possibility of irreversible changes in the lungs, which could lead to premature aging of the lungs and/or chronic respiratory illnesses. It also accelerates the aging of many materials, resulting in cracking of rubber or fading of dyes and paints (Ibid.). Short-term exposures to relatively high concentrations (> 300 µg/m^3) generally result in acute visible foliar injury (Krupa, et. al., 1998). Visible signs of vegetation injuries are flecking and discolouration of the leaves. Long term chronic exposures to lower concentrations (100 – 160 µg/m^3) can cause physiological alterations that may result in chlorosis, premature senescence, and in growth and yield reductions (Ibid.).

There is only one ozone monitor in Prince George. An API Model 400 Ozone monitor (Fig. 3.4.1) was installed at Plaza in late April 1995. This analyzer has a detection limit of 1.2 µg/m^3. Monitoring of ozone is based on the absorption of (UV) ultra-violet light (wavelength at 254 nanometres) due to an internal electronic resonance of the ozone molecule. Ozone is a very efficient absorber of UV light, which is demonstrated by the fact that the stratospheric ozone protects life on earth from harmful UV radiation from the sun.

Fig 3.4.1 API ozone monitor

The quality of the O_3 data was evaluated through monthly calibrations and independent auditing in April and November. The auditing results in Appendix B, Table B-1 indicate that the O_3 monitor at Plaza had satisfactory performance for both audits. After quality assurance and quality control was applied to the data, 97.9% of O_3 data were valid in 2004.

Figures 3.4.2 and 3.4.3 summarize the ozone data from Plaza in 2004. Actual values and additional information can be found in Table C – 1.11 in Appendix "C". The maximum one-hour level (172 µg/m^3) was recorded on August 13th (the only one-hour level B objective exceedance of 2004), while the 24-hour maximum (96.8 µg/m^3) occurred on April 23rd. Maximum hourly levels are normally expected from May to August, since these months have the longest hours of daylight, and solar radiation is normally at its maximum. Any exceedances of the one-hour Level A objective would be expected to occur from March through to September, which is shown in the 2004 monthly summary data. Exceedances of the 24-hour Level A objective can occur during any month, as there is some evidence that this objective is below the background level for ozone (Altshuller, et. al., and Browell, et. al.). In 2004, exceedances of the Level B daily objective were recorded during each month. Monthly averages in March, April, and May were higher than the Level B daily objective.

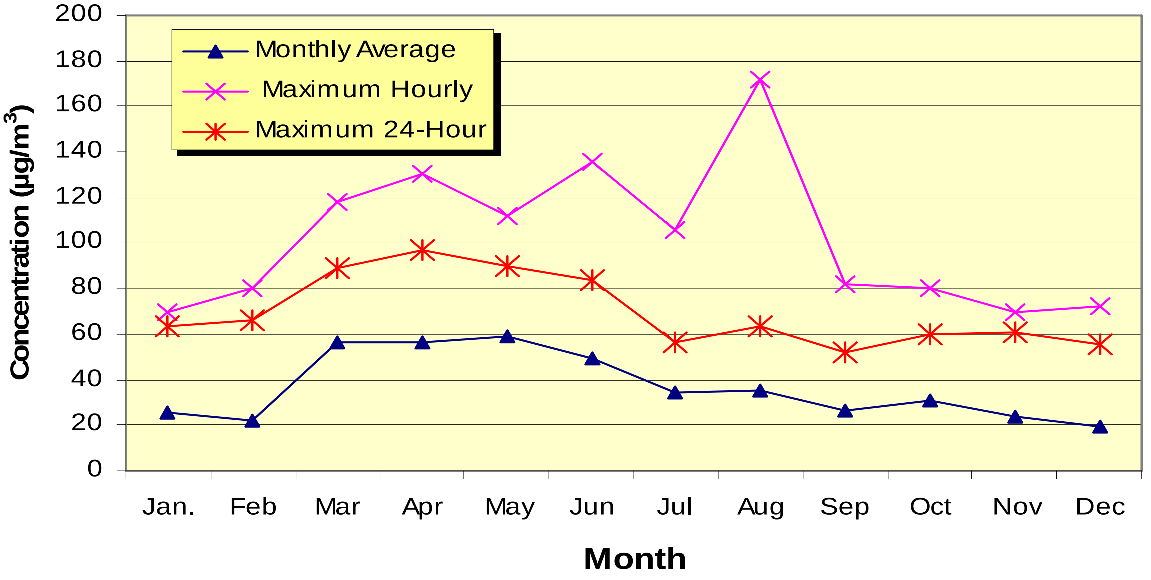


Figure 3.4.2 Monthly ozone levels (µg/m^3) at Plaza in 2004

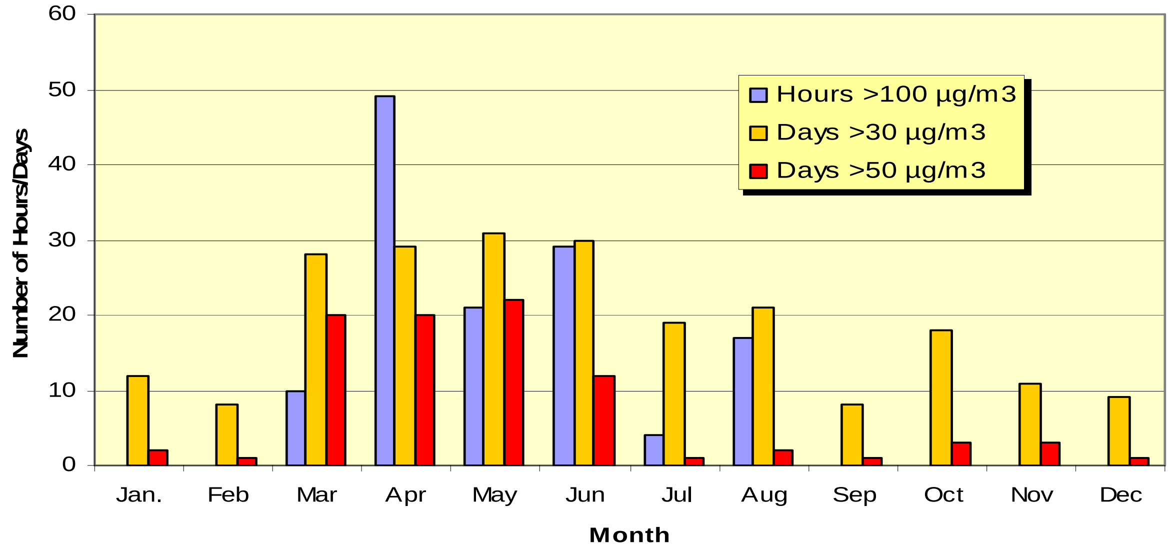


Figure 3.4.3 Number of hours or days ozone levels exceeded the Level A or B objective at Plaza in 2004

Figure 3.4.4 shows the range in monthly average ozone levels at the downtown location since monitoring began in 1995. Monthly averages ranged from a high of 71.6 µg/m^3 (Apr. 2000) to a low of 15.2 µg/m^3 (Nov. 1997). Monthly 2004 average ozone levels were below normal for six months. The monthly average for December 2004 was the lowest ever recorded for that month.

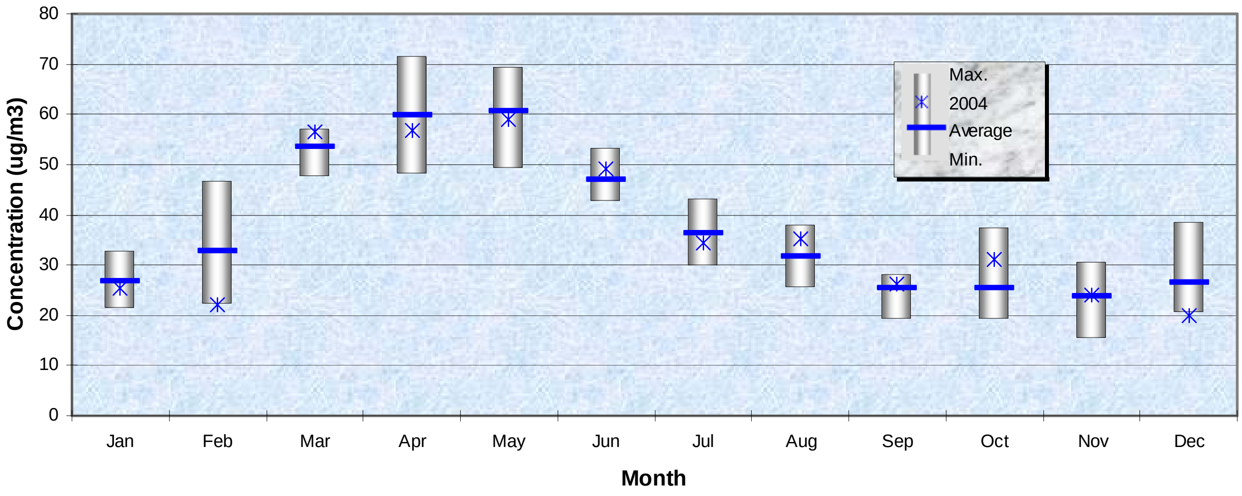


Figure 3.4.4 Comparison of 2004 with long-term average monthly ozone levels (µg/m^3) at Plaza since 1995

Figure 3.4.5 shows the O_3 pollution rose for the Plaza site based on the 2004 meteorological data, using only data for wind speeds $\geq$ 1 m/s. Unlike the TRS and SO_2 pollution roses, low levels occurred quite often (25% of the time) when winds were blowing from the east. This was probably due to ozone being scavenged out of the atmosphere by NO and other pollutants from the industrial sources east-northeast of the monitoring site. Unlike other pollutants, the average concentration during light winds tends to be low (8.9 µg/m^3 in 2004). This is due to a combination of other pollutants in the airshed (light winds tend to be associated with a build-up of certain pollutants) causing reduced ozone in the absence of sunlight, and to ozone being removed by dry deposition.

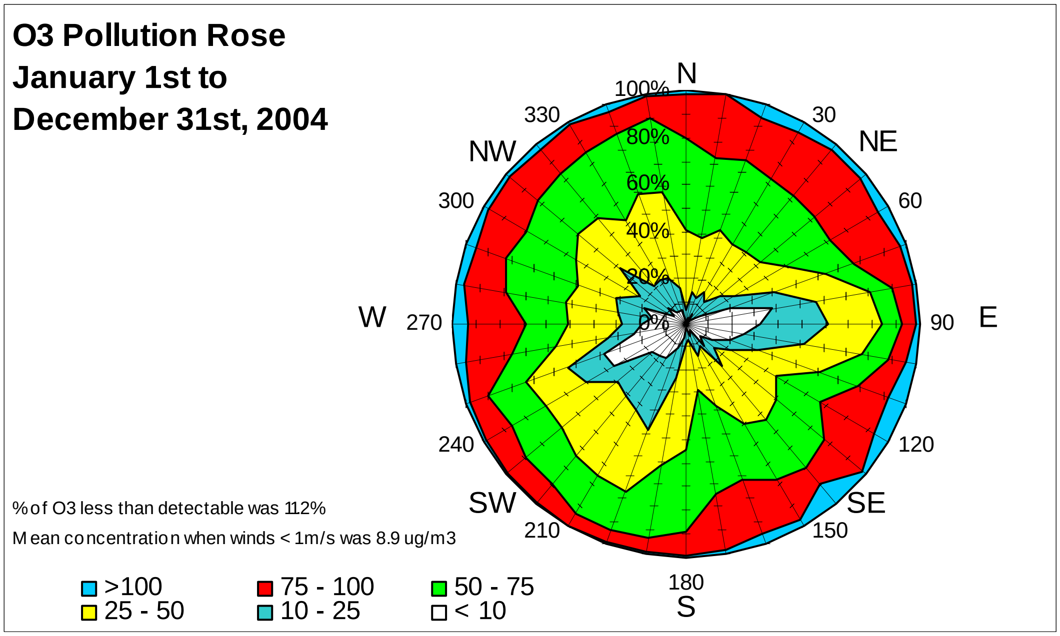


Figure 3.4.5 O_3 pollution rose at Plaza for 2004

Although pollutants such as NO_2 and volatile organics contribute to ozone production in the presence of sunlight, NO can destroy it. Close to the NO sources the reaction tends to be dominated by destruction, whereas further downwind from the sources, ozone can form. It is noticeable that low ozone levels (< 25 µg/m^3) only occurred approximately 10% of the time when winds were from the south (165-185 degrees) (Fig. 3.4.5). This was likely due to the low frequency of light winds from that sector. The average wind speed from this sector was the highest of all sixteen wind sectors.

Figure 3.4.6 shows the diurnal ozone pattern for selected months of 2004. It is uncertain as to why the daytime levels are much higher in spring (April-June) than any other season. Possible reasons could be an increase in ozone precursors in the atmosphere; more snow cover at higher elevations, increasing the amount of solar radiation reflected back into the atmosphere; an increase in stratospheric intrusion; or even a combination of all these factors. Lower levels during the night were likely due to a net scavenging in the absence of sunlight. The diurnal trend in the winter (January) shows only a slight increase in day-time levels, due to the short sunshine period and weak solar radiation.

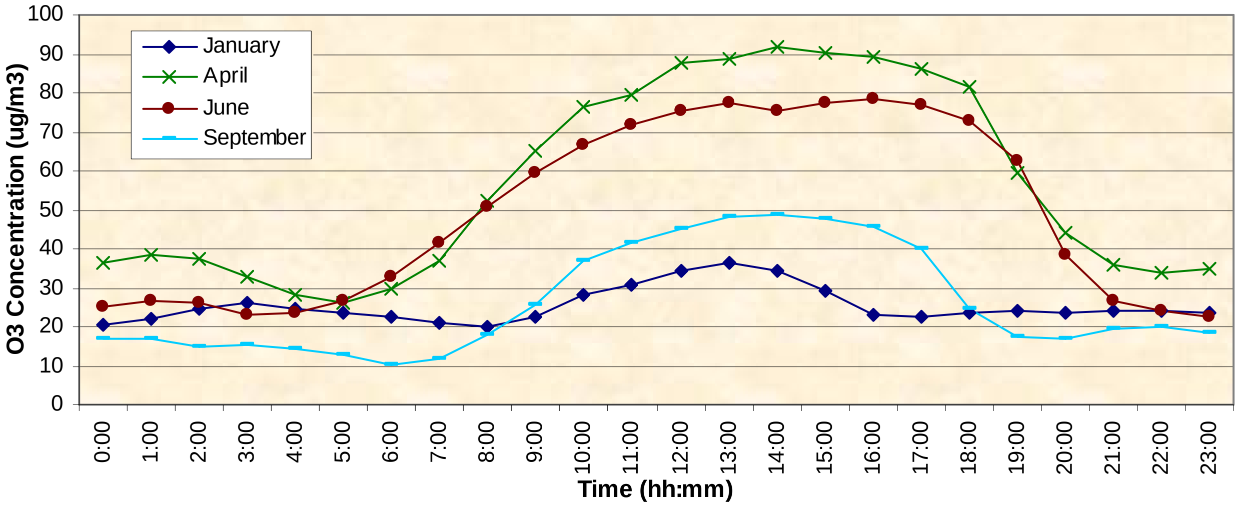


Figure 3.4.6 Daily average ozone pattern (µg/m^3) in Prince George in 2004

3.4.1 O_3 Annual Trend

Table 3.4.1 and Figure 3.4.7 summarize the annual O_3 data collected at Plaza. The maximum one-hour and eight-hour averages, 172 µg/m^3 (exceedance of the one-hour level B objective and the highest value recorded at this site) and 122 µg/m^3, respectively, were recorded in August. The number of exceedances of the one-hour Level A objective has increased since 2003 and is comparable to 2002 measures, but the annual average is much lower than in 2002. The number of exceedances of the Level A and B 24-hour objectives was the lowest at Plaza since 2000 and 1998, respectively. Rolling annual average levels increased from March 1996 to July 2002 (about 31% of the initial value), but have decreased by about 15% since the maximum value was recorded.

Table 3.4.1 Annual trend summary of O_3 data at Plaza

	Annual Avg.	**No. (%) of 1-Hour Values**		**Max. Hourly Avg.**	**No. of 8-Hr. Values**	**Max. 8-Hr. Avg.**	**No. (%) of Daily Values**		**Max. 24-Hr. Avg.**	**No. of Hours Instr. Operated**
Year	**(µg/m^3)**	**>100µg/m^3**	**>160µg/m^3**	**(µg/m^3)**	**>130µg/m^3**	**(µg/m^3)**	**>30µg/m^3**	**>50µg/m^3**	**(µg/m^3)**	
1995	-	30 (0.5%)	0	112	0	104	109 (45.2%)	32 (13.3%)	76.7	5548*
1996	35.2	21 (0.3%)	0	120	0	109	209 (58.2%)	87 (24.2%)	91.1	8290
1997	35.3	57 (0.7%)	0	120	0	107	217 (59.6%)	87 (23.9%)	84.1	8358
1998	37.3	166 (2.0%)	0	156	2	132	217 (60.3%)	93 (25.8%)	99.9	8284
1999	38.2	153 (1.9%)	0	140	0	117	223 (61.9%)	94 (26.1%)	105.4	8265
2000	36.4	182 (2.2%)	0	132	0	115	200 (55.1%)	89 (24.5%)	107.2	8309
2001	40.7	172 (2.0%)	2	170	3	137	238 (65.2%)	117 (32.1%)	99.5	8319
2002	40.3	130 (1.5%)	0	128	0	115	240 (66.1%)	118 (32.5%)	102.2	8591
2003	39.1	121 (1.4%)	0	134	0	119	238 (65.2%)	110 (30.1%)	97.8	8565
2004	36.7	130 (1.5%)	1	172	0	122	224 (61.5%)	88 (24.2%)	96.8	8597

* Note: API Analyzer installed in late April 1995

In July 1999, the federal government released the "National Ambient Air Quality Objectives for Ground-Level Ozone", which established a Canada Wide Standard for ozone that takes effect in 2010. The Canada Wide Standard for ozone is 130 µg/m^3, which is the annual 4th highest 8-hour value, averaged over three consecutive years. So far in Prince George, the Canada Wide Standard has been achieved, in the past 3 years no exceedances have occurred. Only three times in the last four years have single 8-hour averages exceeded 130 µg/m^3, and those exceedances occurred on two days in August, 2001.

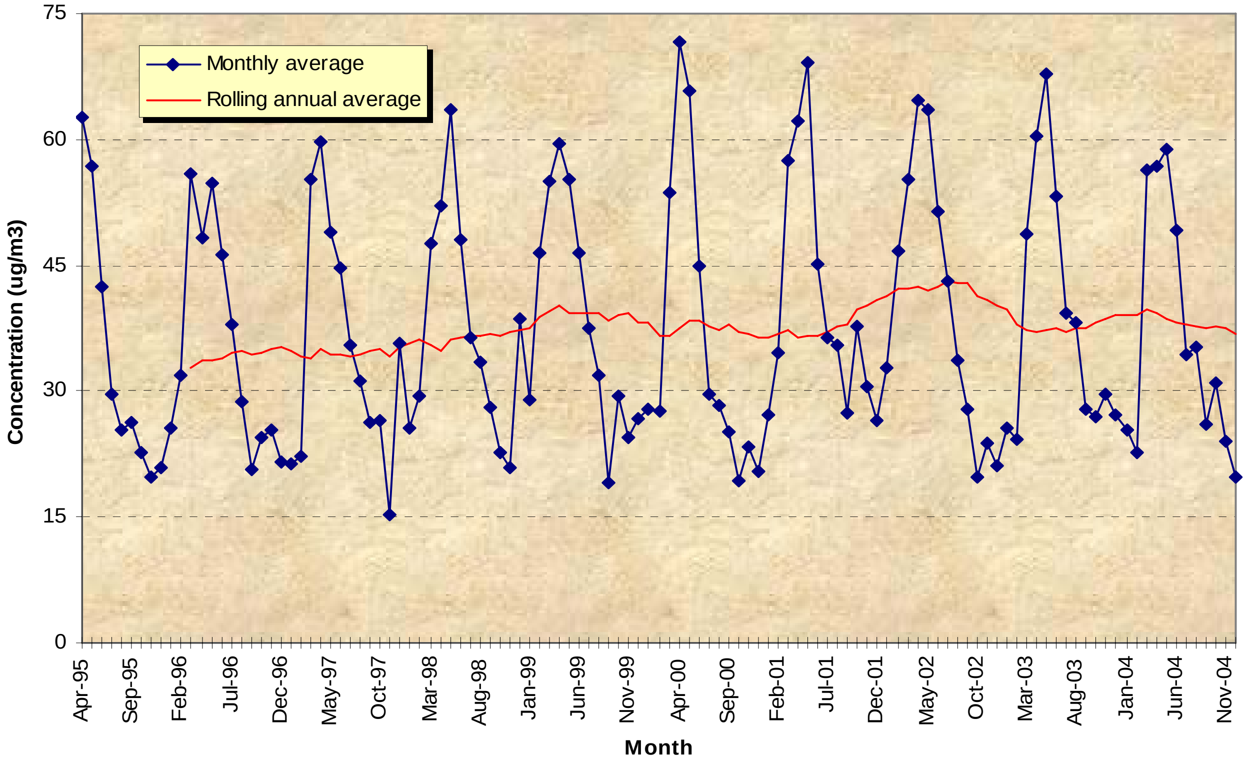


Figure 3.4.7 Rolling average annual and monthly ozone trends ($\mu g/m^3$) at Prince George

Figure 3.4.7 also shows that monthly averages tend to be the lowest during autumn and early winter, and the highest during spring (similar trend to Figure 3.4.4). Monthly averages during the spring of 2000-2003 were the four highest recorded at this site. Rolling annual averages gradually increased from 1995 to 2002 and have been decreasing since that time.

Table C – 2.6 shows the annual percentiles of the 1-hour, 8-hour and 24-hour ozone averages since 1996. The percentiles give a more complete indication of trends than just annual averages, maximum values, or the number of objective exceedances. They also give a better understanding of the causes for any trends. Levels of the higher percentiles (> 90th percentile) for the 1-hour, 8-hour and 24-hour values increased from 1996 to 1998, were stable until 2002, but decreased since.

3.4.2 Comparison of Prince George O_3 Levels with Other B.C. Locations

Figure 3.4.8 compares the 2004 ozone annual average at the Plaza site with other monitoring sites in B.C. (only sites with greater than 80% of data captured).

In 2004, there were 31 ozone monitoring sites in B.C. but only eleven outside the Greater Vancouver Regional District. The lowest annual averages came from sites that had the highest NO_2 annual averages, which is likely due to ozone scavenging. Prince George had the ninth highest annual average for 2004.

Out of the 27 sites that monitored ozone in both 2003 and 2004, only one site (Smithers-St. Joseph's) recorded an increase in 2004. Kamloops-Brocklehurst recorded the greatest incremental decrease. Prince George was one of five sites that recorded exceedances of the Level B one-hour objective in 2004. The highest one-hour level recorded in B.C. was 184 µg/m^3 which was recorded in Hope on August 11th.

Because of the complexity in the production of ozone, annual average concentrations for ozone may not be an indication of whether a site has ozone concerns. As shown in Figure 3.4.8, the sites with the highest annual averages did not record the highest maximum hourly concentrations. Chilliwack, which recorded the 18th highest annual average, had the third highest maximum hourly concentration. Victoria-Royal Roads University, which had the second highest annual average, placed 26th for the maximum one-hour average.

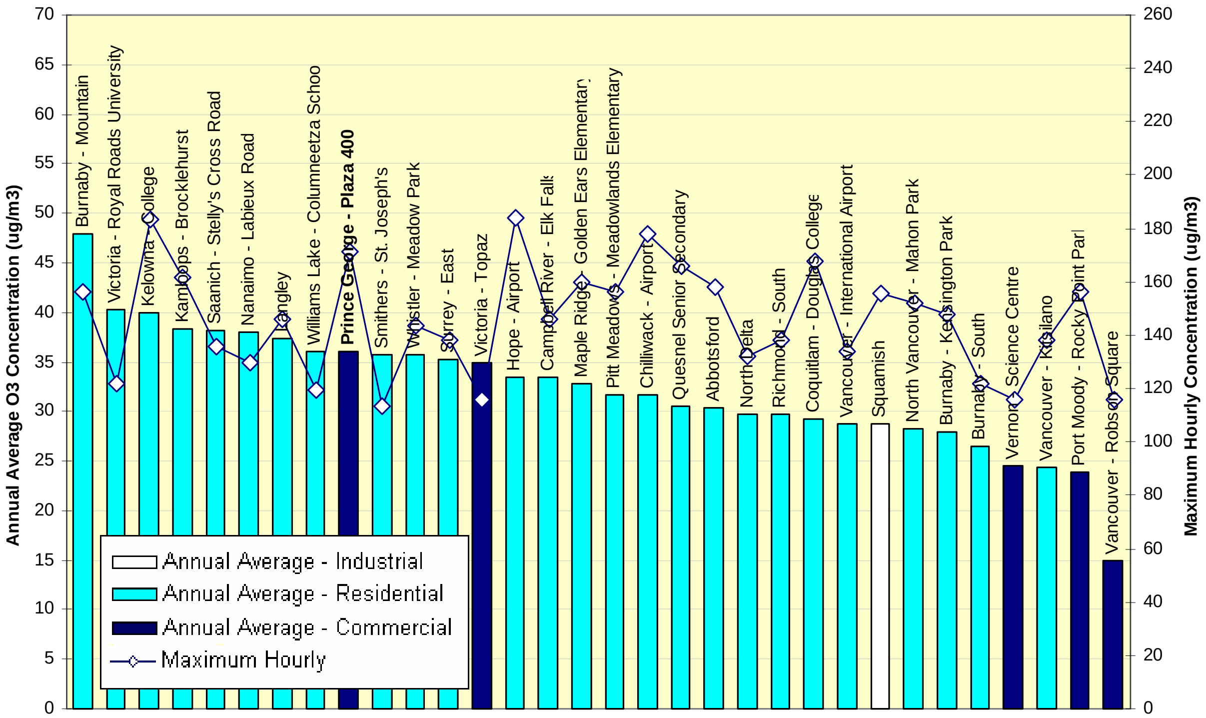


Figure 3.4.8 Comparison of 2004 maximum hourly and average ozone levels (µg/m^3) in Prince George with other B.C. locations

3.5 Nitrogen Oxides (NO_x) Results

The atmosphere contains approximately 78% nitrogen and 21% oxygen by volume. Of the five major forms of gaseous nitrogen in the atmosphere: nitrogen (N_2), ammonia (NH_3), nitrous oxide (N_2O), nitrogen dioxide (NO_2), and nitric oxide (NO), only the latter two are monitored in Prince George.

Nitric oxide (NO) is formed during high temperature combustion of nitrogen and oxygen gases, primarily from motor vehicle exhaust and stationary combustion (such as industrial processes, waste incineration, and fuel combustion for heating homes and buildings). Emissions of NO are greater during winter months when use of heating fuels increases. Natural sources of NO include lightning and soil bacteria.

Nitric oxide is easily oxidized to NO_2 (a reddish-brown gas with a pungent and irritating odour at concentrations over 250 µg/m^3) by combining with ozone or certain hydrocarbons. NO_2 in the presence of sunlight then produces ozone. The NO_2 absorbs short wave blue light, leaving longer wavelengths that cause it to appear reddish-brown, thereby contributing to the degradation in visibility. Higher incidents of eye irritation and respiratory health problems occur during smog-like conditions. The effects of short-term exposure of NO_2 are unclear, but frequent exposure to concentrations higher than those normally found in the ambient air may increase acute respiratory diseases in children (Brimblecombe, 1996). Extremely high concentrations of NO_2 (> 2000 µg/m^3) can cause both reversible and irreversible effects arisen from structural changes in cells in the respiratory system (Ibid). Unlike SO_2, NO_2 can penetrate directly to the pulmonary region of the lungs (Stern et. al., 1984). NO_2 also degrades materials such as metals, fabrics, and rubber and has an adverse effect on vegetation. Only rarely at extremely high concentrations of NO is there visible foliar injury. However, NO_2 can cause vegetation injury at concentrations as low as 160 ppb (300 µg/m^3) or even lower concentrations when combined with SO_2 or O_3 (Bytnerowicz et. al., 1998). The presence of SO_2 can inhibit potential means of detoxification of NO_2 products.

Generally, NO_2 reacts with water to form nitric acid, a component of acid rain. The transformation of NO_2 to nitric acid is much more rapid than that of SO_2 to sulphuric acid. Acidification also produces acid aerosols (nitrates) which have been measured in this airshed and is available at the Ministry's Regional office in Prince George.

The current analyzer (Fig. 3.5.1) has a detection limit of 1.2 µg/m^3. Monitoring of nitric oxides is based on the principle of chemiluminescence involving a gas phase reaction of NO and ozone. For NO_2, the gas is passed through a catalytic converter where NO_2 is reduced to NO. The total concentration of NO is then treated as oxides of nitrogen (NO_x). The difference between the two measurements is considered to be NO_2.

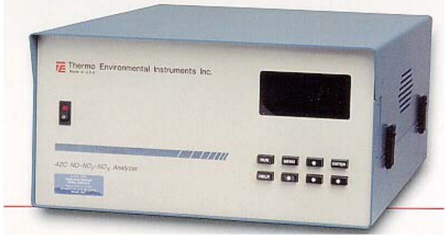


Fig 3.5.1 Chemiluminescence NOx monitor

The quality of the NO_x data was evaluated through monthly calibrations and independent auditing in April and November. The auditing results in Appendix B, Table B-1 indicate that the NO_x monitor at Plaza performed excellently during the April audit and satisfactorily in November. The percent valid data for the year was 82.5%, which is acceptable by Ministry standards for compliance with air quality objectives but could not be used in assessing annual trends.

The nitrogen dioxide data from the Plaza site are summarized in Figure 3.5.2. Actual values and additional information can be found in Table C – 1.12 in Appendix "C". Ambient NO_2 levels were well within the provincial objectives with no Level A hourly or daily exceedances. The highest monthly averages, maximum hourly average, and maximum daily average at Plaza occurred in February. Data from November 15th to the end of 2004 were not considered due to instrument malfunction.

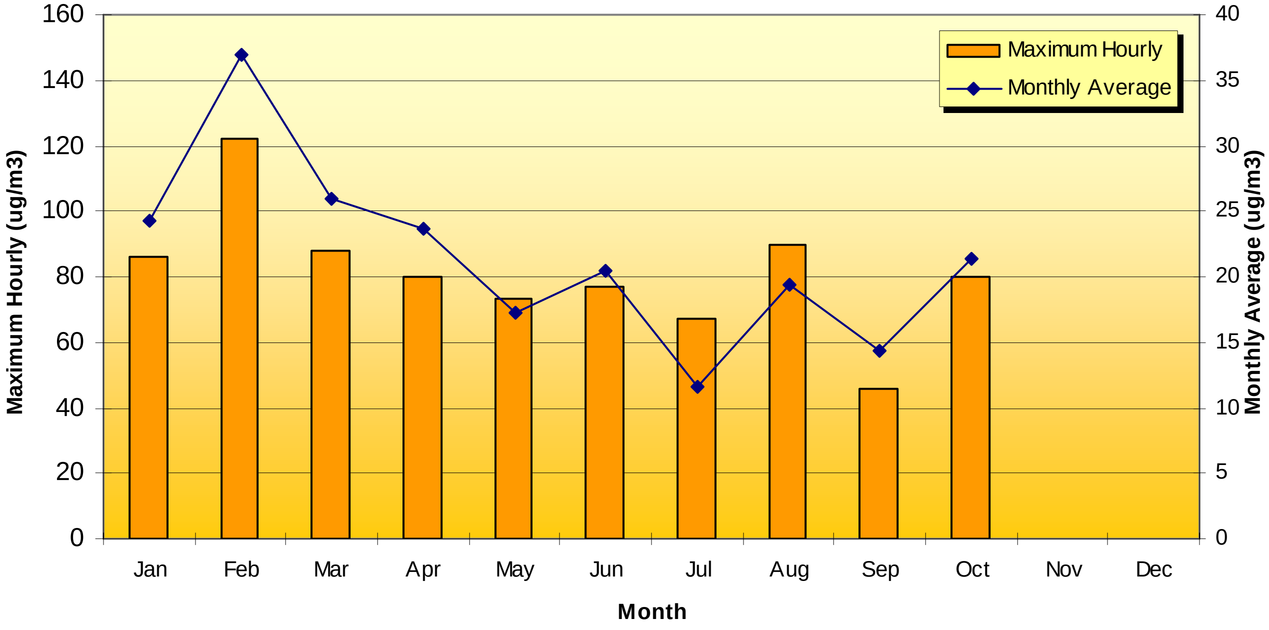


Figure 3.5.2 2004 average and maximum hourly NO_2 levels (µg/m3) by month at sites in Prince George

Figure 3.5.3 shows the range in the average monthly NO_2 levels at the downtown location since 1995. In the long term record, the highest levels have occurred in January and February and the lowest in July. The high winter levels occur because inversions tend to be stronger during winter, there are additional sources (i.e., increased use of heating fuels) in winter, and there is less solar radiation to promote the breakdown of NO_2 to NO, which causes NO_2 levels to build up in the troposphere. All months in 2004 recorded NO_2 levels lower than the average, except for June and August. The highest June average and the lowest January average since 1995 were recorded in 2004.

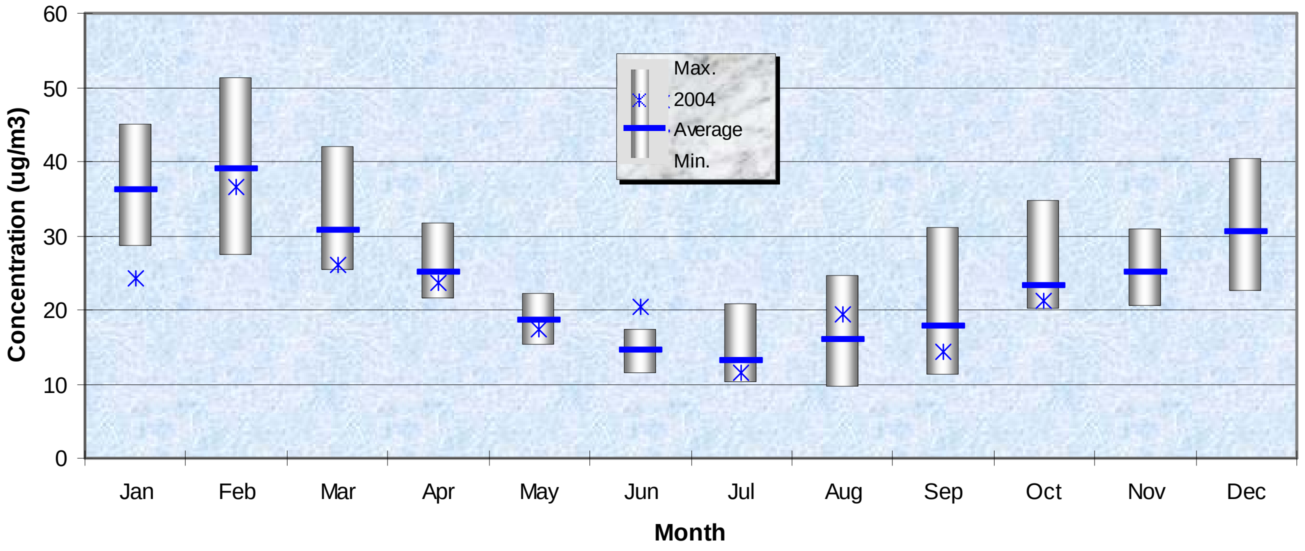


Figure 3.5.3 Comparison of 2004 with long-term average monthly NO_2 levels (µg/m3) at Plaza since 1995

Figures 3.5.4 and 3.5.5 show the NO_2 and NO pollution roses, respectively, for the Plaza site based on the meteorological data for 2004, using only data for wind speeds $\geq$ 1 m/s. NO values were below detectable far more frequently; 24.4% of the NO values compared to 6.9% of the NO_2 values below detectable. This is probably due to NO reacting with other pollutants such as ozone and quickly being converted to NO_2. Most NO_2 in the Prince George airshed is likely a secondary pollutant (i.e., derived from NO from local sources), since it is estimated that about 10% of the NO_x from stacks is emitted as NO_2 and the remaining 90% as NO. Also, under wind conditions < 1 m/s, the average NO_2 concentration was 37.7 µg/m^3, which was approximately 40% of the total NO_x concentration under the same conditions.

These pollution roses show that the higher concentrations of both NO_2 and NO originated from a number of wind directions, not from one sector predominantly as shown for TRS and SO_2. The major sources of NO_x are dispersed throughout the airshed. Similar to the SO_2 pollution rose, low concentrations occurred less frequently (approximately 10% for NO_2 and 20% for NO) with east winds, than occurred (at least 50%) from the south to south-southeast sector. This points to contributions from the industrial sources in that area, and potentially also to rail locomotive traffic. The highest concentrations originated from the east sector, but also from the southwest to west direction, which likely indicates contributions from the BCR industrial site and rail locomotives, as well as motor vehicles and space heaters.

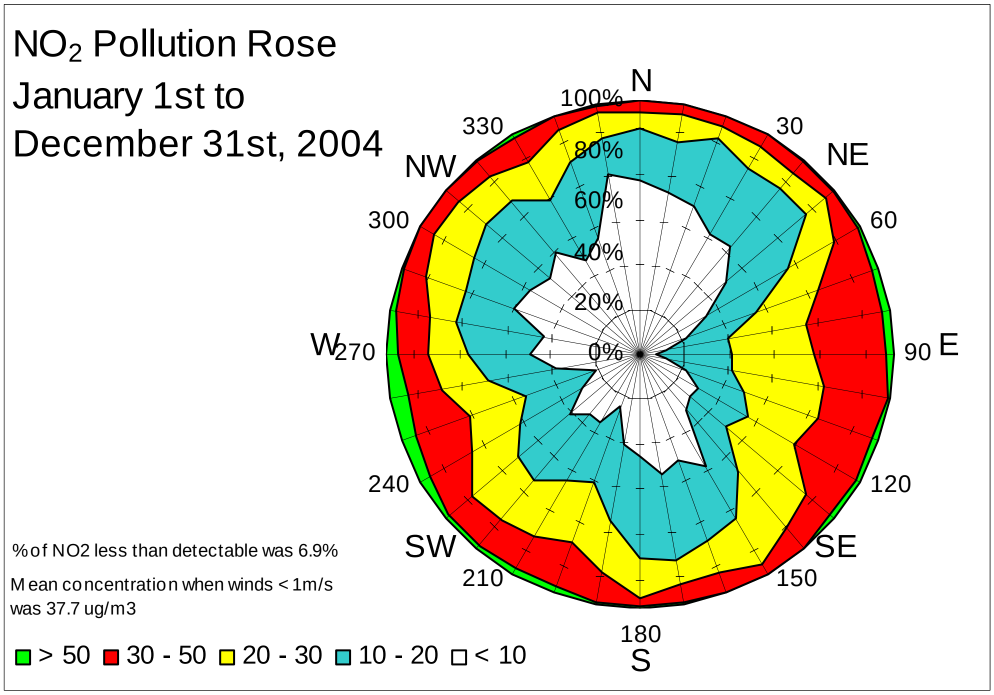


Figure 3.5.4 *NO_2 pollution rose at Plaza for 2004*

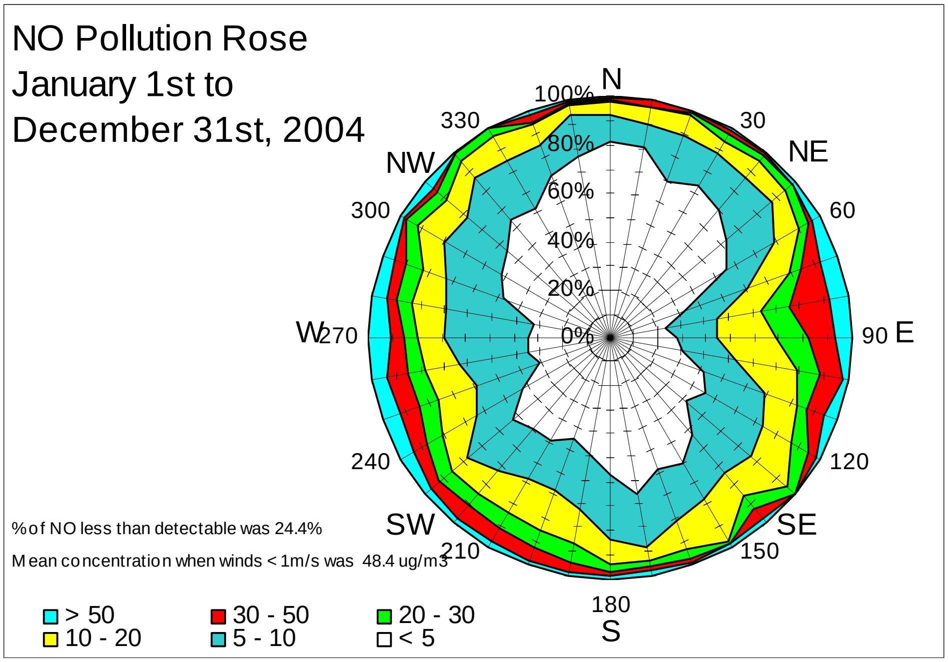


Figure 3.5.5 *NO pollution rose at Plaza for 2004*

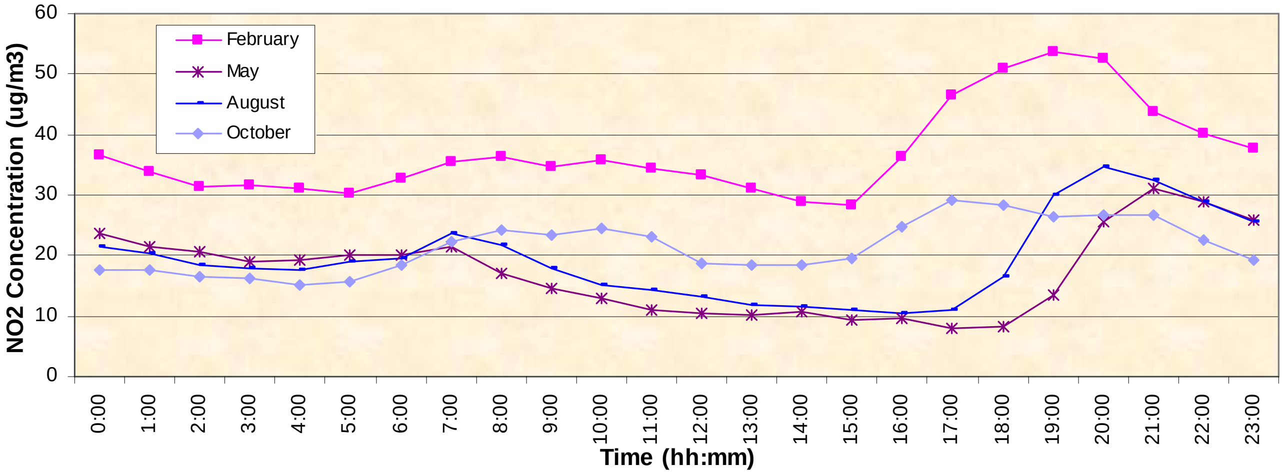


Figure 3.5.6 Daily average NO_2 pattern ($\mu g/m^3$) in Prince George in 2004

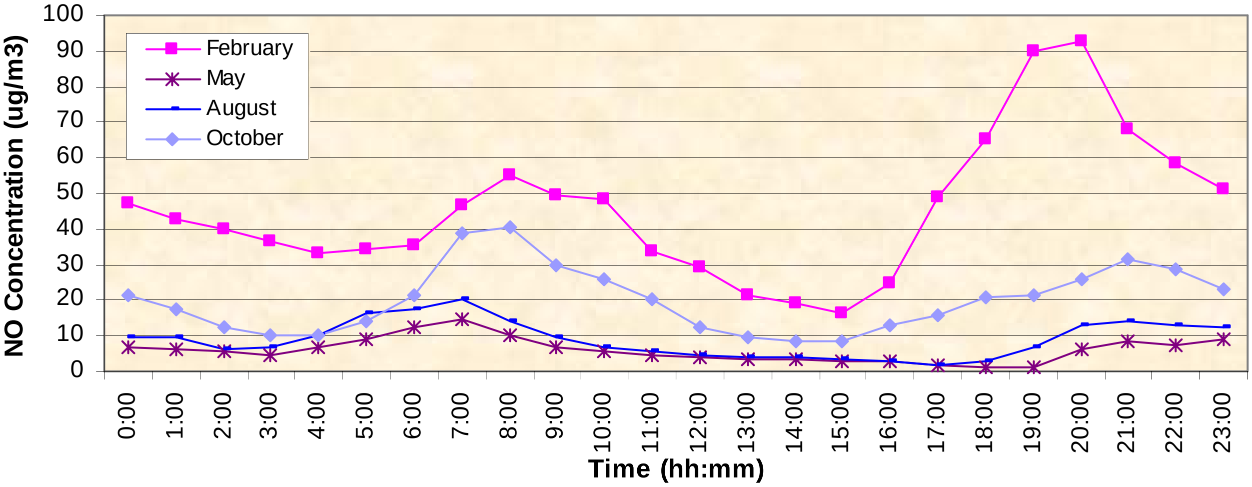


Figure 3.5.7 Daily average NO pattern ($\mu g/m^3$) in Prince George in 2004

Figures 3.5.6 and 3.5.7 show the typical diurnal patterns of NO_2 and NO, respectively, for specified months of the year in 2004. Both figures show higher levels in the evening and morning and lower levels in the late afternoon. However, the typical pattern for the morning peak is more noticeable for NO during the winter months. These peaks are likely due not to rush hour traffic as typically seen in major cities, but due to fumigation from industrial sources similar to that shown for SO_2. These peaks occur later during winter than summer days, indicating a later inversion break up in winter. NO_2 levels in August peak at around 8:00 pm and then decrease until morning. This is likely due to NO reacting with ozone at night to produce NO_2. This NO_2 then slowly reacts with other compounds causing the NO_2 levels to decrease. The highest daytime and night-time levels occurred in February for both NO_2 and NO and the lowest levels occurred in May.

3.5.1 NO_X Annual Trend

Table 3.5.1 and Figure 3.5.8 summarize the annual NO_2 trend at Plaza. Since late 1998 there appears to be a decreasing trend in annual NO_2 levels in the airshed. The average levels in 2001 to 2003 were the lowest ever recorded at this site. The highest annual average occurred in 1998. The maximum daily average was recorded in December 1999. So far there have been no exceedances of the provincial NO_2 objectives at Plaza. The maximum hourly value, 186 μg/m^3, occurred on Jan. 2, 1997.

Table 3.5.1 Annual trend summary of NO_2 data at Plaza

Year	Annual Average (μg/m^3)	No. of 1-Hour Values >400μg/m^3	Maximum Hourly Average (μg/m^3)	No. of Daily Values >200μg/m^3	Maximum Daily Average (μg/m^3)	No. of Hours Instrument Operated
1992	-	0	61	0	97.0	4825*
1993	25.4	0	149	0	83.3	8072
1994	23.7	0	130	0	70.7	7852
1995	-	0	101	0	61.5	4957**
1996	25.9	0	151	0	84.6	7787
1997	24.3	0	186	0	91.5	8242
1998	28.7	0	143	0	67.1	8051
1999	25.6	0	143	0	99.1	8218
2000 (a)	-	0	149	0	81.9	5070**
2001	23.0	0	111	0	81.5	8295
2002	20.2	0	138	0	75.1	8176
2003	20.8	0	105	0	63.4	8297
2004 (b)	-	0	122	0	69.1	7244**

* Note: NO_2 Analyzer Installed in June 1992
** Note: NO_2 Operational Problems
(a) Note: NO_2 Analyzer replaced on November 22, 2000
(b) Note: NO_2 Analyzer replaced on April 13, 2004

Figure 3.5.8 shows that the rolling annual average has ranged from about 20 μg/m^3 to 29 μg/m^3 since 1996. Levels seem to have gradually decreased since 1999. Monthly averages show that the highest levels occur during the winter, and the lowest in summer. As previously explained, this difference is likely due to increased emissions in winter, as well as unfavourable meteorological conditions and reduced solar radiation.

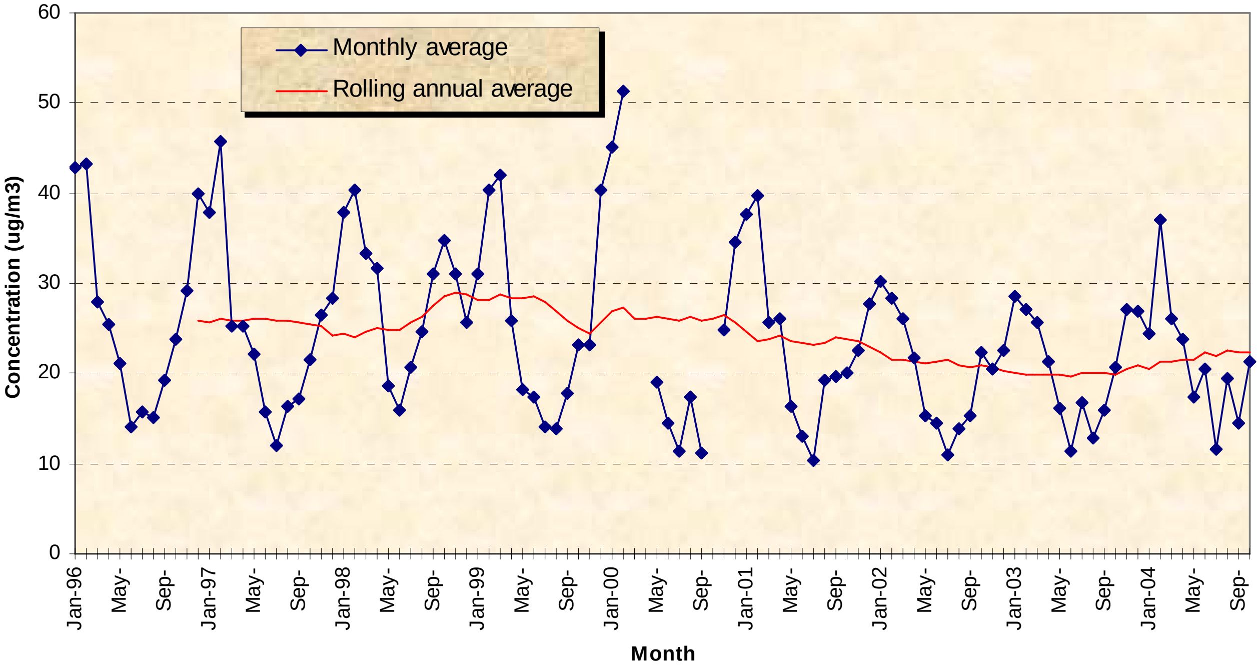


Figure 3.5.8 Rolling annual and monthly NO_2 ($\mu g/m^3$) trends in Prince George

Table C – 2.7 in Appendix "C" shows the annual percentiles of both the NO_2 and NO values for the past ten years. Because NO_2 is seasonally influenced, and due to instrument malfunction in December 2004, NO_2 percentile data for that year could not be compared to other years. For the six years of complete data there is a slight decrease in most of the percentiles for NO_2. NO levels in 2004 were higher than those from 2003, but still one of the lowest years recorded in all percentiles. NO levels in 1998 were higher at all percentiles compared to all other years except for the 99th percentile. Peak NO_2 levels occurred marginally less frequently in 1998 compared to any other years from 1996-2000 (i.e., 98th percentile in 1998 was 77 $\mu g/m^3$ compared to 78-88 $\mu g/m^3$ in 1996 to 2000).

3.3.2 Comparison of Prince George NO_2 Levels with Other B.C. Locations

Figures 3.5.9 and 3.5.10 compare the NO_2 and NO annual averages at Plaza with those at other selected monitoring sites in B.C. (all sites with greater than 80% of data captured). NO_2 data were summarized from January 1 to November 15 so all sites had the same study period as the Prince George site; NO data include the entire year.

In 2004, there were 29 NO_2 monitoring sites in B.C., but only nine outside the Greater Vancouver Regional District. The 11 highest NO_2 levels were all in the Greater Vancouver Regional District, which was the case in previous years. For NO, there were 5 sites in the Greater Vancouver Regional District with higher annual averages than those at Plaza. Prince George recorded the highest annual average of all the sites outside the Greater Vancouver Regional District for NO_2 and the second highest for NO.

When comparing the same sites that monitored NO_2 in 2003, 22 of the 25 sites recorded a decrease in 2004. Kitimat-Rail showed the greatest incremental increase. The other two sites to post an increase in 2004 were Chilliwack-Airport and the Prince George site. The greatest decrease was shown at Vancouver-Robson Square. For NO, 12 of the sites showed an increase in 2004 compared to 2003. The greatest incremental increase occurred at Prince George, and the greatest decrease occurred at Vancouver-International Airport.

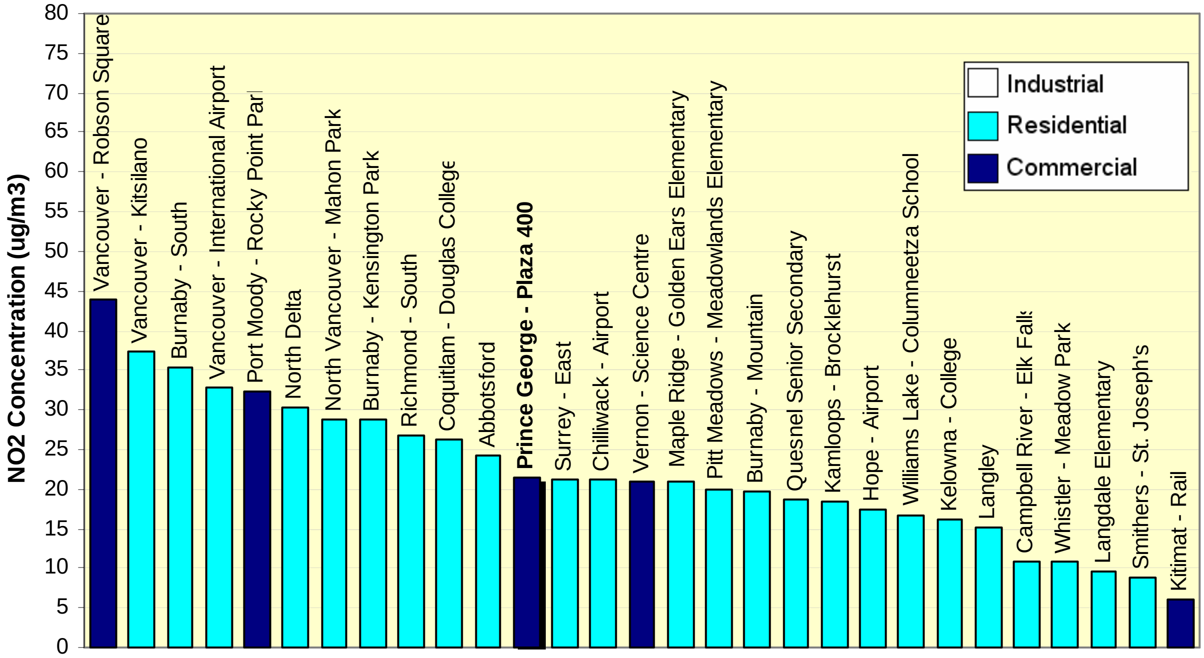


Figure 3.5.9 *Comparison of average NO_2 levels (μg/m3) in Prince George with other B.C. locations (January through November 15th, 2004)*

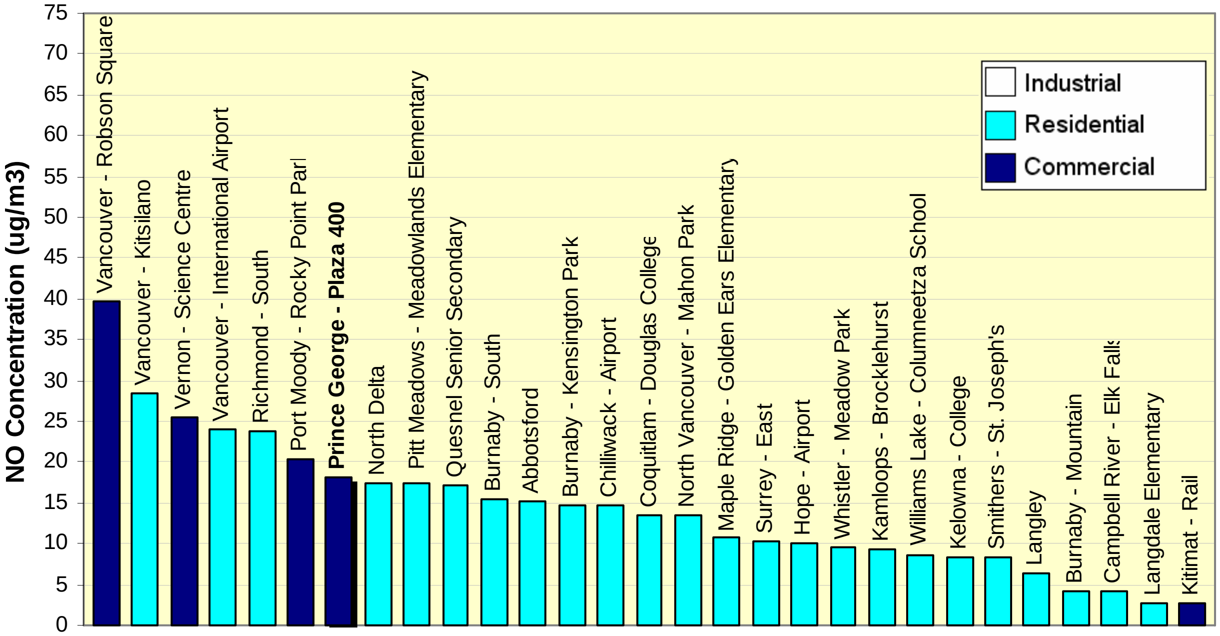


Figure 3.5.10 *Comparison of 2004 annual average NO levels (μg/m3) in Prince George with other B.C. locations*

3.6 Carbon Monoxide (CO) Results

Carbon monoxide is a colourless, odourless and tasteless gas. It is toxic at sufficiently high concentrations and death can result from asphyxiation. Hemoglobin in the blood has an affinity for CO that is about 200 times greater than for oxygen, so presence of CO reduces the blood's ability to carry oxygen.

In an urban setting, CO levels are typically one hundred percent anthropogenic as a result of incomplete combustion of fossil fuels, mainly in motor vehicles. CO is produced when the oxygen supply is reduced (fuel to oxygen ratio is too high), and when the temperature of combustion is lowered, slowing the oxidation process.

There is only one carbon monoxide monitor in Prince George. An API Model 300A CO monitor (Fig. 3.6.1) was installed at Plaza in late December 2003. This analyzer has a detection limit of 100 µg/m^3 (86 ppb). Monitoring of CO is based on non-dispersive infra-red radiation.

Fig 3.6.1 API CO monitor

The quality of 2004 CO data at Plaza was excellent based on the monthly calibrations as well as annual independent auditing in April and November (Appendix B). After quality assurance and quality control were applied to the data, 97.9% of data were valid in 2004.

Short term monitoring of CO was done at Hart Highlands in 1997 and 1998 and at Lakewood in 1997. Data for those two sites are available at the Ministry's Regional office in Prince George.

Figure 3.6.2 shows the summary of monthly CO levels recorded at the Plaza site. Raw data are contained in Table C – 1.13 of Appendix "C". The highest monthly average occurred in September, and the highest hourly value and 8-hour averages occurred in February. No exceedances of the one-hour or 8-hour Level A objectives were recorded in 2004.

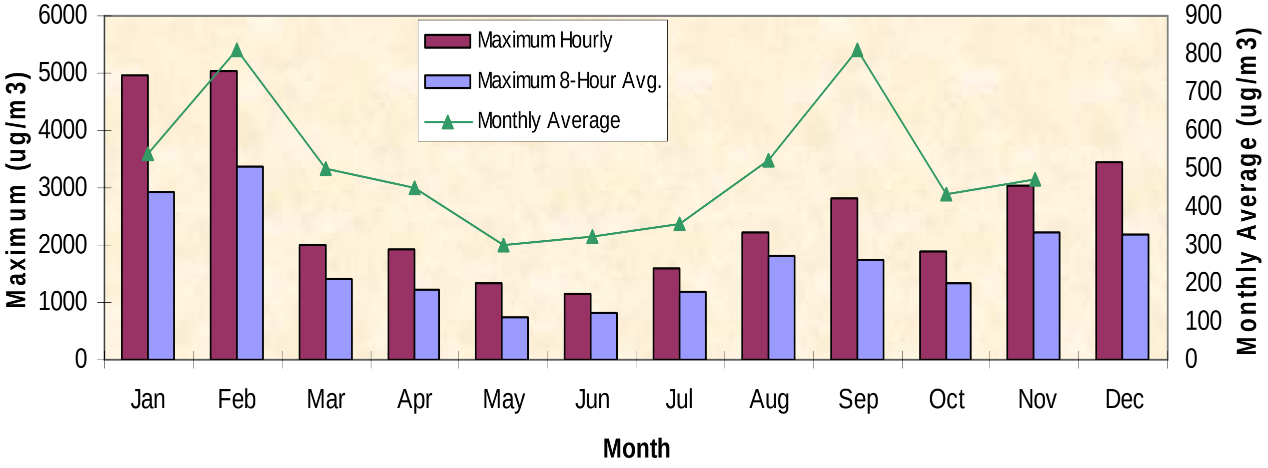


Figure 3.6.2 *2004 average and maximum hourly and 8-hour average CO levels (µg/m3) by month at sites in Prince George*

Figure 3.6.3 shows the CO pollution rose for the Plaza site based on the 2004 meteorological data. Wind directions were only considered whenever wind speeds were ≥ 1 m/s (winds below 1 m/s may not be strong enough to flush the pollutants out of the airshed, therefore confusing the location of the predominant source). Low levels (<100 µg/m^3) occurred more often (approximately 30% of the time) when winds were blowing from the north and south, but only about 7% of the time when winds were blowing from the east-southeast. The highest CO levels (>1000 µg/m^3) occurred with winds blowing from almost every sector but was more frequent from the west. The average concentration during light winds was about 795 µg/m^3 in 2004 compared to 429 µg/m^3 when winds were greater than 1 m/s.

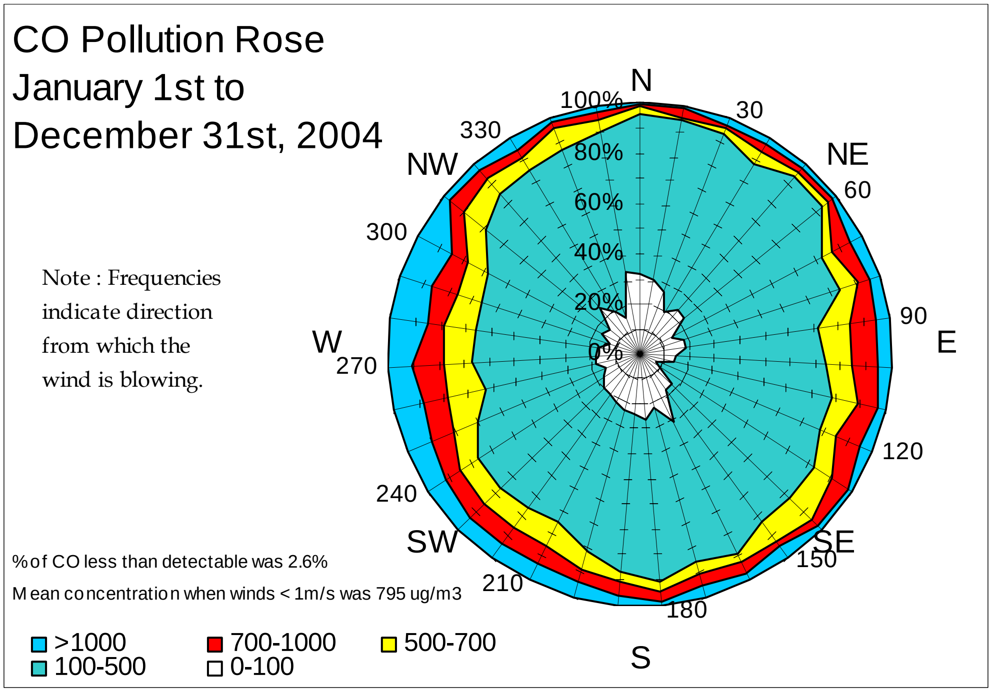


Figure 3.6.3 CO pollution rose at Plaza for 2004

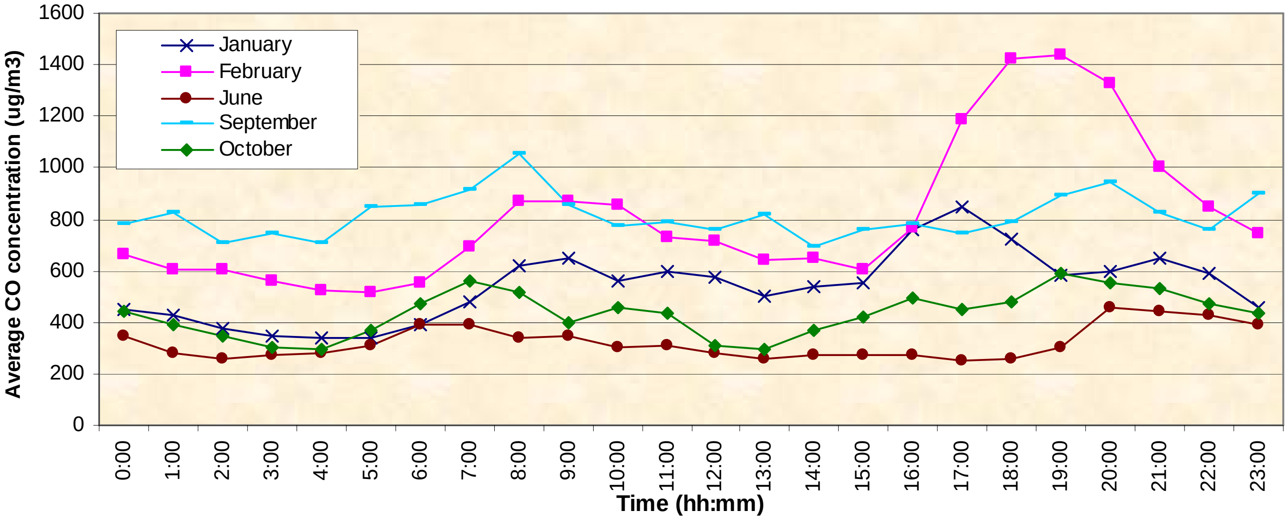


Figure 3.6.4 Daily average CO pattern (µg/m3) in Prince George in 2004

Figure 3.6.4 shows the typical diurnal patterns of CO during the specified times of the year in 2004. All months (except for November and December due to missing data) were analysed but only selected months are shown. This figure shows higher levels in the evening and morning and lower levels either in the afternoon or just before sunrise. Evening peaks occur earlier in January and February, with February having the highest diurnal average at 20:00. These peaks may not be due to rush hour traffic as typically seen in major cities, but due to fumigation of elevated plumes from industrial sources or perhaps a chemical or photochemical reaction. CO peaks occur later in the morning in winter than in the remainder of the year, indicating a later inversion break-up in winter. During the second peak, CO levels in June peak just before midnight but much earlier on winter evenings which seems to coincide with sunset and the nocturnal inversion starting to develop.

Table C – 2.8 shows the annual percentiles of both the one-hour and 8-hour CO values at the plaza site for the two-year data record. For the one-hour averages, the percentiles have increased starting at the 25th percentile. For the 8-hour averages, the percentiles have increased right from the 5th percentile. With additional years of data, it will be possible to determine whether this is a longer-term trend, or simply year-to-year fluctuation.

3.6.1 Comparison of Prince George CO Levels with Other B.C. Locations

Figure 3.6.5 compares the 2004 CO annual averages (from January through November 15th) at the Prince George site with averages from other monitoring sites in B.C. (only sites with greater than 75% of data capture were included). Vancouver-Robson Square recorded the highest average. Prince George recorded the eighth highest annual average out of the 20 sites in the province and the second highest maximum hourly value. With Victoria-Topaz having the second highest annual average, 12 of the 15 sites in the Greater Vancouver Regional District rounded out the highest 14 annual averages.

When comparing the same twenty sites that monitored CO in 2003, only five sites recorded higher CO annual averages in 2004. Victoria-Topaz recorded the greatest increase in the annual CO average and Richmond-South recorded the greatest decrease.

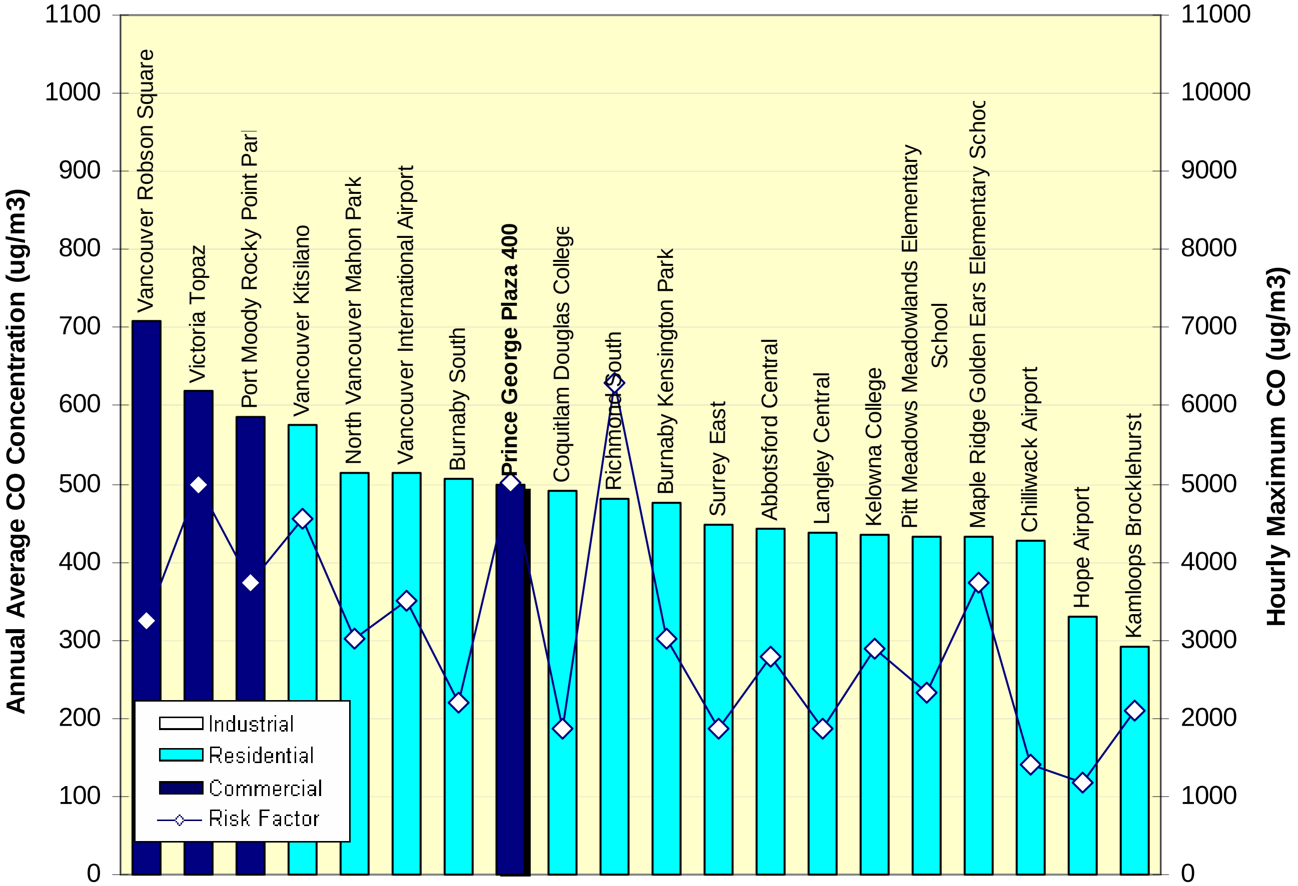


Figure 3.6.5 *Comparison of 2004 annual average (from January 1st to November 15th, 2004) CO levels (μg/m³) in Prince George with other B.C. locations*

4. Air Quality Advisories

The Ministry provides an air quality index that is updated twice daily during the work week, and that is accessible to the public via a telephone answering machine (565-6457). Air quality index values for selected pollutants are also provided to the local newspaper, radio and T.V. station on a daily basis, as well as to the Weather Network, and are available on the internet at http://wlapwww.gov.bc.ca:8000/pls/aqiis/air.summary.

When air quality deteriorates to "poor" or "very poor" the Ministry issues air quality advisories to the public through the local news media, unless circumstances make it unnecessary or infeasible. Advisories have been mainly limited to PM_{10} levels to date, and are issued when the rolling average 24-hour PM_{10} level exceeds the 50 µg/m^3 objective, and the meteorological forecast shows continuing limited dispersion in the airshed. We recognize that health effects from fine particulates do not show a threshold and therefore effects can occur at levels significantly lower than 50 µg/m^3. Ozone advisories are normally issued whenever ozone levels are expected to exceed the one-hour objective of 160 µg/m^3. There were no ozone advisories issued in 2004.

There were eighteen occurrences in 2004 of the 24-hour rolling average PM_{10} levels exceeding 50 µg/m^3 at the Plaza station (compared to 10 occurrences in 2003). The duration of these occurrences ranged from 1 to 53 hours. Five of these occurrences lasted 24-hours or longer. Out of these eighteen exceedances, five air quality advisories were issued. This is fewer than the 6 issued in 2003 and the combined duration of these advisories was approximately 2/3 of the number of advisory hours in 2003. These advisories are listed in Table 4.1 along with the duration of the episode and the maximum 24-hour rolling average recorded during each period. Advisories were not issued for other exceedances, either because the elevated levels occurred at night or on weekends when staff were not on duty, or because improvement in meteorological conditions was expected within 6 hours.

Table 4.1 Advisories issued in 2004

Start Date (PST)	End Date (PST)	Duration (hours)	Max. 24-hour Level (µg/m^3)
Mar. 23 14:30	Mar. 24 12:00	20	76.6
Apr. 2 09:30	Apr. 3 16:30	31	71.3
Jun. 23 10:00	Jun. 26 11:00	73	73.1
Aug. 13 09:00	Aug 15 11:00	50	67.2
Aug. 17 09:00	Aug. 19 10:00	49	51.9

5. CONCLUSIONS

5.1 Air Quality Acceptability and Trends

Typically the winter and fall have poorer air quality because meteorological conditions are less favourable for dispersion of pollutants. The following trends and results were measured in 2004.

i) Annual average PM_{10} levels in 2004 were higher than those in 2003 at all four non-continuous monitoring sites. Annual averages in 2004 at CNR and Lakewood were the highest recorded at those sites since 1999. Lakewood was the only non-continuous site to not record an exceedance of the daily objective.

Annual average continuous PM_{10} levels at Plaza and BCR monitoring sites were the highest since 1998. The frequency of exceedances of the Level B objective (50 $\mu g/m^3$) decreased at Gladstone and Plaza, but increased by 73% at the BCR site. The frequency of exceedances of the level B objective at the BCR site was the highest ever recorded at that site. There were two months in 2004 in which monthly averages at all three sites were the highest ever recorded for those months. The discrepancy in the trend between the continuous and non-continuous monitors was mainly due to the sample frequency of the non-continuous monitors.

ii) The annual average $PM_{2.5}$ level in 2004 at the Plaza continuous monitor was similar to that recorded in 2003, and was one of the highest ever recorded at that site since 1998. The continuous monitor, installed in late 1997, has not produced a noticeable trend, but increased about 17% from 2002 to 2004.

iii) The annual average TRS concentrations recorded at the Jail and Plaza monitoring sites were the highest and second highest, respectively, recorded at those sites since 1998. The annual average at Lakewood in 2004 was the highest recorded at that site since 1995. The Jail site recorded the highest frequencies of exceedances of the Level A one-hour and 24-hour objectives since 1998, and the highest frequency of exceedances of the Level B one-hour objective since 1995. The number of exceedances of the Level A 1-hour objective and the Level B 24-hour objective at the Lakewood site were the highest since 1995. The number of exceedances of the Level B 1-hour objective at the Lakewood site was the highest since 1989. The rate of exceedance of the Level B 1-hour objective at the Plaza site was the second highest since 1993. These exceedances of the Level B Objective at Plaza indicate the need for the additional TRS reductions called for in the Prince George Air Quality Management Plan. 2004 February and May monthly averages were the highest recorded at Plaza for those months.

Even though levels and the frequency of exceedances increased in 2003 and 2004, the trend in annual averages and the frequency of exceedance of TRS objectives has decreased considerably since emission source changes were implemented in late 1990. The operation of foul condensate steam stripping, collection and incineration, which has reduced odorous emissions from the pulp mill effluent treatment ponds, is responsible for most of the reduction in exceedances since to 1990. The Air Quality Management Plan calls for the identification of other reduction sources to further improve compliance with the air quality objectives, particularly in the downtown.

iv) Since the installation of a sulphur recovery unit at Husky in November 1997, average ambient SO_2 levels have decreased at all three monitoring sites. The annual average SO_2 level at all three monitoring sites were lower in 2004 than in 2003. The annual average SO_2 level at Plaza was the lowest ever recorded at that site. In 2004, ambient SO_2 levels exceeded the provincial one-hour objective six times at the CBC site and not once at the Plaza and Jail sites. No monitoring site in Prince George exceeded the daily Level A objective in 2004. Monthly averages in 2004 were below normal for all months at Plaza.

v) Annual average ozone levels recorded at Plaza in 2004 was the lowest recorded since 2000. The number of exceedances of the Level A 1-hour objective at that site was the second lowest since 1997. The number of daily exceedances of the Level A objective in 2004 was the lowest recorded since 2000. One exceedance of the provincial one-hour Level B objective (160 $\mu g/m^3$) occurred in 2004. This hourly value of 172 µg/m3 (recorded in August) was the highest ever recorded at this site.

vi) Due to missing data during winter it was not possible to calculate the annual average NO_2 level at Plaza. Monthly averages were below normal for eight of the ten available months in 2004. Since the replacement NO_2 monitor was installed there seems to be a decreasing trend in NO_2 levels. No NO_2 exceedances have ever been recorded at that site.

5.2 Recommendations and Actions to the End of 2004

i) Add non-continuous $PM_{2.5}$ to Van Bien and Lakewood PM_{10} monitoring sites,

ii) Add a background monitoring site for both non-continuous $PM_{2.5}$ and PM_{10}.

iii) Increase the frequency of PM_{10} non-continuous monitoring at Van Bien, Lakewood, CNR and Plaza to once every three days,

iv) Add continuous $PM_{2.5}$ monitoring at Gladstone, along with meteorological data and continuous SO_2 to enable the sources of episodic and average PM levels to be identified.

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APPENDIX "A"

B.C. Ambient Air Quality Objectives

Air quality objectives of B.C. are generally based on objectives set by the Federal Government in the Clean Air Act. The objectives are based on protecting human health and protecting the environment. Objectives are often set at three levels.

Level A	Maximum Desirable for the long-term goal for air quality and forms the basis for anti-degradation policy for the pristine parts of the country and for continuing development of control technology.
Level B	Maximum Acceptable is intended to provide adequate protection against the effects of pollution on soil, water, vegetation, materials animals, visibility, personal comfort and well being.
Level C	Maximum Tolerable denotes time based concentrations of air contaminants beyond which, due to diminishing margins of safety, appropriate action is required without delay to protect the health of the general population.

Table A -1 Provincial air quality objectives (µg/m^3)

Contaminant	Averaging Period	Level A	Level B	Level C
Total Reduced Sulphur	1 hour	7.5	28	42
	24 hour	4	6	7.5
Sulphur Dioxide	1 hour	450	900	1300
	24 hour	160	260	360
	Annual	25	50	80
Nitrogen Dioxide	1 hour		400	1000
	24 hour		200	300
	Annual	60	100	
Total Suspended Particulate (TSP)	24 hour	150	200	260
	Annual	60	70	75
Particulate Matter (PM_{10})	24 hour		50	
Formaldehyde (HCHO)	1 hour	60		
Lead in TSP	24 hour	4	4	6
	Annual	2	2	3
Ozone	1 hour	100	160	300
	24 hour	30	50	
	Annual		30	
Carbon Monoxide	1 hour	14,300	28,000	35,000
	8 hour	5500	11,000	14,300

Appendix “B”

Monitoring Program Notes

i) Continuous Monitor Audit Results

Multi-point (five point) calibrations are performed monthly in addition to audit checks. The continuous monitor audit (the five-point average) results are listed below (instrument calibration drifts are listed in percentages). In 2004, according to the two audits performed during the year (April and November), all continuous monitors performed within the allowable instrument deviation of plus or minus 15% as determined by an auditor from the Ministry of Water, Land and Air Protection (now Ministry of Environment).

Table B – 1 2004 continuous monitor audit results

Pollutant	Station	April	Nov.
TRS (ML 8850)	Plaza	+4.7%	+4.5%
	Lakewood School	-10.8%	+3.9%
	Jail	-13.1%	+3.7%
SO_2 (ML 8850)	Plaza	+4.0%	+7.9%
	CBC	+4.5%	-6.3%
SO_2 (TECO 43A)	Jail	+3.8%	+2.4%
O_3 (API 400)	Plaza	+7.3%	+8.3%
CO	Plaza	+0.7%	-2.7%
NO_2 (TECO 42)	Plaza	+2.1%	+6.1%
PM_{10} (TEOM)	Plaza	-2.8%	-5.1%
	BCR	-2.3%	-1.2%
	Gladstone	+1.5%	-3.3%
$PM_{2.5}$	Plaza	-0.1%	-6.0%

ML 8850 - Monitor Lab 8850 Analyzer and STI Thermal Oxidizer

Excellent	≤ ±5%
Satisfactory	±5% to ±15%
Unsatisfactory	≥ ±15%

ii) Instrument Operating Hours

Table B-2 shows the percent of valid monitoring time at each station. Within the 8784 monitoring hours in a year, ambient air analyzers require both scheduled and unscheduled maintenance to maintain the instrument's calibration and sensitivity to the appropriate standard. Hours of monitoring are reduced by automated daily calibrations, manual weekly calibrations and monthly five point calibrations, annual audits, as well as power failures, instrument malfunction and occasional operator error.

Due to scheduled daily and monthly calibrations, the highest percent valid time available would be 96% for all monitors except the TEOMs . A monitor with a low percent valid time may bias the monitoring results, especially if the pollutant monitored is seasonally dependent. 75% of 8784 hours (6588 hours) is considered acceptable as actual instrument operating hours.

Table B – 2 Instrument percent valid data for 2004

Pollutant	Station	% of Valid Data
TRS	Plaza	95.4%
	Lakewood	86.8%
	Jail	94.8%
SO_2	Plaza	95.0%
	Jail	95.6%
	CBC	95.3%
O_3	Plaza	97.9%
PM_{10}	Plaza	99.2%
	Gladstone	97.8%
	BCR	98.0%
CO	Plaza	88.7%
NO_2	Plaza	82.5%
$PM_{2.5}$	Plaza	99.2%

Appendix "C"

Additional Data Summary

i) Monthly Data Summary Tables:

Tables C – 1.1 through C – 1.13 summarize 2004 ambient air quality data on a monthly basis for all pollutants and monitoring locations included in this report. The summaries include (among other values) monthly averages, maximum hourly averages, exceedances, maximum 24-hour averages and the number of hours the instrument was in operation.

Table C – 1.1 2004 monthly summary of continuous PM_{10} data at Plaza

	Monthly Average ($\mu g/m^3$)	**Maximum Hourly Average ($\mu g/m^3$)**	**No. of Daily Values**		**Maximum Daily Average ($\mu g/m^3$)**	**Maximum 24 Hour Average ($\mu g/m^3$)**	**Minimum 24 Hour Average ($\mu g/m^3$)**	**No. of Hours Instrument Operated**
			>50 $\mu g/m^3$	**>100 $\mu g/m^3$**				
January	16.8	94	0	0	44.58	49.0	4.0	743
February	23.0	139	3	0	68.83	79.8	4.0	690
March	24.2	170	2	0	67.88	76.6	3.8	744
April	28.3	151	3	0	54.71	71.6	7.5	713
May	18.0	164	0	0	41.25	52.8	4.0	735
June	24.0	162	1	0	66.25	73.1	2.8	718
July	17.7	121	0	0	38.52	43.9	4.0	722
August	26.6	136	2	0	66.08	67.2	5.1	744
September	15.4	103	0	0	36.92	38.6	4.5	720
October	20.3	118	1	0	54.67	58.3	2.0	736
November	14.1	55	0	0	23.75	25.3	5.8	712
December	15.2	77	0	0	37.46	51.9	2.1	736
Annual	**20.3**	**170**	**12**	**0**	**68.83**	**79.8**	**2.0**	**8713**

Table C – 1.2 2004 monthly summary of continuous PM$_{10}$ data at Gladstone

	Monthly Average (µg/m^3)	Maximum Hourly Average (µg/m^3)	No. of Daily Values		Maximum Daily Average (µg/m^3)	Maximum 24 Hour Average (µg/m^3)	Minimum 24 Hour Average (µg/m^3)	No. of Hours Instrument Operated
			>50 µg/m^3	>100 µg/m^3				
January	14.7	92	0	0	49.42	52.5	3.3	619
February	18.7	109	1	0	57.13	70.9	1.9	691
March	14.2	175	0	0	35.50	42.6	2.6	742
April	16.5	99	0	0	38.39	41.6	5.0	715
May	11.9	50	0	0	22.17	29.7	4.1	740
June	17.8	90	0	0	49.39	51.0	2.7	715
July	13.5	85	0	0	29.25	35.6	3.7	730
August	19.1	143	0	0	46.96	47.8	4.3	726
September	10.1	59	0	0	18.38	19.8	3.9	718
October	16.1	86	0	0	46.54	50.0	3.1	742
November	11.1	64	0	0	27.88	28.6	3.0	718
December	12.2	72	0	0	37.42	44.7	1.3	738
Annual	**14.6**	**175**	**1**	**0**	**57.13**	**70.9**	**1.3**	**8594**

Table C – 1.3 2004 monthly summary of continuous PM$_{10}$ data at BCR

	Monthly Average (µg/m^3)	Maximum Hourly Average (µg/m^3)	No. of Daily Values		Maximum Daily Average (µg/m^3)	Maximum 24 Hour Average (µg/m^3)	Minimum 24 Hour Average (µg/m^3)	No. of Hours Instrument Operated
			>50 µg/m^3	>100 µg/m^3				
January	18.3	78	0	0	46.92	49.5	2.9	740
February	23.2	112	2	0	60.50	86.6	5.1	692
March	28.3	170	6	0	79.92	79.9	6.3	740
April	40.7	332	10	0	99.58	105.5	6.5	714
May	23.8	191	2	0	55.29	67.3	5.3	705
June	31.9	226	5	0	80.87	93.1	2.7	711
July	21.3	187	1	0	55.09	58.3	4.9	719
August	36.6	319	13	0	81.47	83.3	3.4	664
September	23.4	247	4	0	75.08	91.8	3.3	720
October	30.4	313	7	0	95.71	102.2	2.1	741
November	17.3	81	0	0	37.65	40.1	5.0	716
December	16.5	89	0	0	39.83	50.6	3.8	742
Annual	**25.9**	**332**	**50**	**0**	**99.58**	**105.5**	**2.1**	**8604**

Table C – 1.4 2004 monthly summary of continuous PM$_{2.5}$ data at Plaza

	Monthly Average (µg/m^3)	**PM$_{2.5}$/PM$_{10}$ Ratio**	**Maximum Hourly Average (µg/m^3)**	**No. of Daily Values**		**Maximum 24 Hour Average (µg/m^3)**	**Minimum 24 Hour Average (µg/m^3)**	**No. of Hours Instrument Operated**
				>15 µg/m^3	**>30 µg/m^3**			
January	11.1	0.66	101	7	2	33.8	1.7	740
February	15.3	0.67	127	14	2	66.0	1.4	694
March	10.7	0.44	115	7	1	37.3	1.5	744
April	13.3	0.47	103	12	1	36.5	1.8	705
May	6.8	0.38	59	2	0	24.5	0.5	744
June	11.5	0.48	74	8	1	41.9	0.2	718
July	9.3	0.53	72	7	0	30.0	1.5	738
August	15.9	0.60	88	14	6	54.7	0.9	741
September*	6.4	0.42	65	0	0	15.0	0.5	720
October*	11.7	0.58	85	11	1	47.2	0.5	744
November*	7.8	0.55	36	0	0	15.5	2.0	720
December*	8.4	0.55	59	4	0	40.3	0.0	744
Annual	**10.7**	**0.51**	**127**	**86**	**14**	**66.0**	**0.0**	**8752**

* Values estimated

Table C – 1.5 2004 monthly summary of TRS data at Plaza

	Monthly Average (µg/m^3)	**No. of 1-Hour Values**		**Maximum Hourly Average (µg/m^3)**	**No. of Daily Values**		**Maximum Daily Average (µg/m^3)**	**Maximum 24 Hour Average (µg/m^3)**	**No. of Hours Instrument Operated**
		>7µg/m^3	**>28µg/m^3**		**>3µg/m^3**	**>6µg/m^3**			
January	4.3	176	16	38	13	7	22.3	22.6	711
February	5.1	196	11	41	13	11	17.0	18.4	665
March	1.5	51	4	33	5	1	11.2	12.6	711
April	1.5	62	2	31	6	1	7.0	9.1	686
May	1.5	56	1	38	7	1	8.2	9.0	711
June	1.7	64	0	26	8	0	5.6	5.6	687
July	1.1	44	0	24	4	0	4.3	5.1	713
August	2.2	85	0	20	11	1	7.1	9.1	712
September	0.7	26	0	14	2	0	4.1	4.4	689
October	1.6	54	2	34	4	2	8.8	11.5	709
November	1.0	31	0	20	2	0	5.6	8.5	679
December	1.9	73	0	26	8	2	8.8	10.8	711
Annual	**2.0**	**918**	**36**	**41.1**	**83**	**26**	**22.3**	**22.6**	**8384**

Table C – 1.6 2004 monthly summary of TRS data at Jail

	Monthly Average (µg/m^3)	**No. of 1-Hour Values**		**Maximum Hourly Average (µg/m^3)**	**No. of Daily Values**		**Maximum Daily Average (µg/m^3)**	**Maximum 24 Hour Average (µg/m^3)**	**No. of Hours Instrument Operated**
		>7µg/m^3	>28µg/m^3		>3µg/m^3	>6µg/m^3			
January	3.7	166	4	44	13	8	18.2	18.7	710
February	5.7	221	15	61	16	12	17.4	19.9	664
March	2.3	85	6	33	7	4	11.8	13.5	711
April	3.7	126	12	64	11	7	13.9	16.6	683
May	2.6	95	5	84	12	4	12.3	16.2	712
June	3.1	117	6	30	14	5	9.6	10.3	689
July	1.6	59	3	30	6	1	7.2	9.1	712
August	4.5	165	10	44	15	12	13.0	15.9	713
September	1.4	55	0	23	7	0	5.2	6.9	684
October	1.9	76	2	35	6	3	13.6	15.4	710
November	1.1	27	0	16	3	0	6.0	6.7	686
December	2.6	108	1	31	9	5	9.3	10.5	626
Annual	**2.8**	**1300**	**64**	**83.6**	**119**	**61**	**18.2**	**19.9**	**8300**

Table C – 1.7 2004 monthly summary of TRS data at Lakewood

	Monthly Average (µg/m^3)	**No. of 1-Hour Values**		**Maximum Hourly Average (µg/m^3)**	**No. of Daily Values**		**Maximum Daily Average (µg/m^3)**	**Maximum 24 Hour Average (µg/m^3)**	**No. of Hours Instrument Operated**
		>7µg/m^3	>28µg/m^3		>3µg/m^3	>6µg/m^3			
January	2.9	103	13	44	9	4	28.2	28.4	713
February	3.0	129	0	27	11	6	16.6	16.8	665
March	0.4	11	0	20	1	0	3.7	3.7	703
April	0.4	5	0	11	0	0	1.9	2.6	685
May	0.2	1	0	7	0	0	1.0	1.2	712
June	0.3	0	0	4	0	0	1.0	1.3	595
July	0.1	0	0	6	0	0	0.6	0.7	711
August	0.2	0	0	4	0	0	0.9	1.1	710
September	0.3	1	0	7	0	0	1.1	1.3	689
October	-	-	-	-	-	-	-	-	123
November	0.5	1	0	7	0	0	1.8	2.3	606
December	0.8	10	0	13	1	0	6.0	6.1	709
Annual	**0.8**	**261**	**13**	**43.9**	**22**	**10**	**28.2**	**28.4**	**7621**

Table C – 1.8 *2004 Monthly Summary of SO_2 Data at Jail*

	Monthly Average ($\mu g/m^3$)	**No. of 1-Hour Values >450 $\mu g/m^3$**	**Maximum Hourly Average ($\mu g/m^3$)**	**No. of Daily Values >160 $\mu g/m^3$**	**Maximum Daily Average ($\mu g/m^3$)**	**Maximum 24 Hour Average ($\mu g/m^3$)**	**No. of Hours Instrument Operated**
January	11.9	0	141	0	56.7	61.6	712
February	15.0	0	178	0	58.5	67.9	665
March	8.8	0	123	0	50.0	50.9	712
April	14.5	0	216	0	54.1	69.0	685
May	9.3	0	112	0	34.8	54.4	711
June	20.2	0	168	0	65.7	83.2	689
July	7.6	0	197	0	42.7	44.6	711
August	20.6	0	341	0	74.7	95.7	712
September	6.1	0	189	0	35.4	36.7	688
October	9.1	0	205	0	57.0	71.0	712
November	6.4	0	138	0	50.0	54.1	687
December	11.8	0	181	0	61.0	69.6	712
Annual	**11.7**	**0**	**341**	**0**	**74.7**	**95.7**	**8396**

Table C – 1.9 *2004 Monthly Summary of SO_2 Data at Plaza*

	Monthly Average ($\mu g/m^3$)	**No. of 1-Hour Values >450 $\mu g/m^3$**	**Maximum Hourly Average ($\mu g/m^3$)**	**No. of Daily Values >160 $\mu g/m^3$**	**Maximum Daily Average ($\mu g/m^3$)**	**Maximum 24 Hour Average ($\mu g/m^3$)**	**No. of Hours Instrument Operated**
January	4.6	0	51	0	15.9	20.6	698
February	5.8	0	112	0	32.0	32.1	636
March	3.9	0	154	0	21.8	22.8	713
April	4.4	0	109	0	22.0	23.7	686
May	2.3	0	29	0	6.6	10.6	711
June	4.2	0	51	0	15.0	17.5	688
July	3.2	0	67	0	14.1	15.6	713
August	5.8	0	123	0	22.0	22.5	712
September	4.2	0	101	0	19.5	27.0	689
October	5.4	0	349	0	48.2	48.2	711
November	4.9	0	75	0	24.2	29.3	680
December	7.8	0	146	0	38.7	47.7	711
Annual	**4.7**	**0**	**349**	**0**	**48.2**	**48.2**	**8348**

Table C – 1.10 2004 Monthly Summary of SO$_2$ Data at CBC Transmitter

	Monthly Average (µg/m^3)	No. of 1-Hour Values >450 µg/m^3	Maximum Hourly Average (µg/m^3)	No. of Daily Values >160 µg/m^3	Maximum Daily Average (µg/m^3)	Maximum 24 Hour Average (µg/m^3)	No. of Hours Instrument Operated
January	17.9	1	703	0	116.9	138.9	712
February	28.3	1	562	0	115.9	132.3	664
March	7.0	0	194	0	36.6	40.5	703
April	17.7	0	314	0	75.0	93.5	683
May	15.3	1	466	0	92.9	100.7	711
June	24.6	0	445	0	93.0	100.1	684
July	9.3	0	325	0	75.8	81.8	710
August	33.0	2	687	0	117.8	163.6	712
September	6.2	0	146	0	36.4	41.4	688
October	7.0	0	415	0	36.0	40.3	712
November	4.3	0	376	0	35.3	41.3	685
December	15.5	1	581	0	126.8	147.9	707
Annual	**15.5**	**6**	**703**	**0**	**126.8**	**163.6**	**8371**

Table C – 1.11 2004 monthly summary of O$_3$ data at Plaza

	Monthly Average (µg/m^3)	No. of 1-Hour Values		Maximum Hourly Average (µg/m^3)	No. of Daily Values		Maximum 24 Hour Average (µg/m^3)	Minimum 24 Hour Average (µg/m^3)	No. of Hours Instrument Operated
		>100 µg/m^3	>160 µg/m^3		>30 µg/m^3	>50 µg/m^3			
January	25.3	0	0	70	12	2	63.2	0.4	731
February	22.2	0	0	80	8	1	66.1	3.2	684
March	56.4	10	0	118	28	20	89.0	9.2	733
April	56.7	49	0	130	29	20	96.8	21.2	701
May	58.9	21	0	112	31	22	89.6	31.8	732
June	49.2	29	0	136	30	12	83.8	28.5	709
July	34.4	4	0	106	19	1	56.4	16.0	728
August	35.3	17	1	172	21	2	63.6	15.0	732
September	26.1	0	0	82	8	1	52.2	5.4	708
October	31.1	0	0	80	18	3	59.5	5.3	735
November	24.1 *	0	0	70	11	3	61.0	0.2	697
December	19.8 *	0	0	72	9	1	55.9	0.2	707
Annual	**36.7**	**130**	**1**	**171.6**	**224**	**88**	**96.8**	**0.2**	**8597**

* Note: Due to a problem with the API Model 400 Ozone monitor, periods of data were estimated from November 15 – December 31

Table C – 1.12 2004 monthly summary of NO_2 data at Plaza

	Monthly Average	No. of 1-Hour Values	Maximum Hourly Average	No. of Daily Values	Maximum Daily Average	Maximum 24 Hour Average	Minimum 24 Hour Average	No. of Hours Instrument Operated
	(µg/m^3)	>400 µg/m^3	(µg/m^3)	>200 µg/m^3	(µg/m^3)	(µg/m^3)	(µg/m^3)	
January	24.3	0	86	0	53.20	55.7	2.7	704
February	37.0	0	122	0	69.09	71.9	9.7	660
March	26.0	0	88	0	48.38	49.2	4.8	709
April	23.7	0	80	0	37.20	41.7	3.3	652
May	17.3	0	73	0	32.67	34.5	1.0	709
June	20.4	0	77	0	32.43	35.5	3.5	686
July	11.6	0	67	0	21.85	25.3	2.3	703
August	19.4	0	90	0	34.83	38.7	2.6	708
September	14.4	0	46	0	23.36	25.3	3.0	687
October	21.3	0	80	0	36.16	36.2	4.4	709
November	-	0	48	0	31.92	32.2	6.6	317
December	-	-	-	-	-	-	-	0
Annual	**-**	**0**	**122.4**	**0**	**69.09**	**71.9**	**1.0**	**7244***

* Missing data from Nov. 15 (05:00) through Dec. 31 (23:00) due to instrument malfunction

Table C – 1.13 2004 monthly summary of CO data at Plaza

	Monthly Average	No. of 1-Hour Values	Maximum Hourly Average	No. of Daily Values	Maximum 8 Hour Average	No. of Hours Instrument Operated
	(µg/m^3)	>14300µg/m^3	(µg/m^3)	>5500µg/m^3	(µg/m^3)	
January	539.2	0	4980	0	2935	710
February	809.9	0	5020	0	3387	663
March	501.6	0	2000	0	1409	712
April	450.0	0	1920	0	1206	659
May	300.5	0	1350	0	743	710
June	320.9	0	1150	0	804	687
July	354.4	0	1600	0	1195	711
August	522.6	0	2240	0	1818	711
September	813.8	0	2820	0	1757	682
October	433.0	0	1900	0	1319	710
November	469.6	0	3050	0	2206	548
December	-	0	3460	0	2171	292*
Annual	**504.6**	**0**	**5020**	**0**	**3387**	**7795**

*Note: Instrument Operational Problems

ii) Annual Percentile Tables:

Tables C – 2.1 through C – 2.8 summarize annual percentile values for all pollutants and monitoring locations included in this report. The summaries include percentiles, maximum and average values for the averaging period and the number of samples collected for the year. Percentiles are used to describe the distribution of data for each year as the percentage of the data set that lies below the stated value. For example, the 95th percentile indicates that 95% of the data are below that value, or alternatively, that value is exceeded only 5% of the time.

Table C – 2.1 Percentiles of the 1-hour PM_{10} levels ($\mu g/m^3$) at the continuous PM_{10} monitoring sites

Site	Year	Hourly Percentile ($\mu g/m^3$)									Max.	Average	No. of
		5	10	25	50	75	90	95	98	99	($\mu g/m^3$)	($\mu g/m^3$)	Samples
Plaza	1995	4	5	10	17	29	52	73	103	130	388	24.6	8662
	1996	3	4	8	15	25	41	56	81	111	373	20.5	8577
	1997	3	5	8	14	26	43	56	76	92	208	20.2	8721
	1998	4	6	9	16	27	46	65	90	110	319	22.7	8719
	1999	2	4	7	13	22	37	51	72	87	211	17.8	8609
	2000	3	4	8	13	22	39	51	67	78	175	18.0	8692
	2001	2	4	7	13	23	39	51	69	85	170	18.2	8683
	2002	2	4	7	13	23	39	52	71	82	154	18.2	8683
	2003	2	4	7	14	25	43	58	78	91	199	19.5	8669
	2004	2	4	8	14	26	45	59	78	95	170	20.3	8713
BCR	1997	3	5	9	17	30	51	70	97	121	401	24.2	8706
	1998	4	6	11	20	36	58	83	126	161	582	29.1	8703
	1999	2	4	8	15	27	46	61	83	100	380	21.3	8719
	2000	2	4	8	15	26	42	55	75	93	288	20.0	8739
	2001	2	4	7	14	26	44	57	81	97	387	20.1	8634
	2002	2	4	8	15	28	48	66	91	112	430	22.1	8707
	2003	3	5	9	17	30	53	72	99	121	262	24.4	8534
	2004	2	4	9	17	32	58	79	113	143	332	25.9	8604
Gladstone	1996	1	3	5	10	19	33	45	65	80	253	15.4	8716
	1997	1	3	5	10	19	34	44	61	73	155	14.8	8644
	1998	2	4	7	12	22	36	48	66	82	207	17.2	8643
	1999	1	2	5	9	16	28	37	50	58	140	12.7	8671
	2000	1	3	5	10	17	29	38	52	61	148	13.6	8686
	2001	1	3	5	9	18	30	40	52	63	164	13.5	8693
	2002	2	3	6	10	17	30	38	52	64	109	13.6	8696
	2003	1	3	6	10	19	32	43	57	68	237	14.8	8623
	2004	1	2	5	10	20	32	42	56	67	175	14.6	8594

Table C – 2.2 *Percentiles of the 24-hour PM_{10} levels ($\mu g/m^3$) at the continuous PM_{10} monitoring sites*

Site	Year	24-hour Percentile ($\mu g/m^3$)									Max.	Average	No. of
		5	10	25	50	75	90	95	98	99	($\mu g/m^3$)	($\mu g/m^3$)	Samples
Plaza	1995	7	9	13	19	30	48	62	83	93	120.8	24.6	8677
	1996	6	8	11	17	25	35	44	61	89	155.4	20.5	8514
	1997	7	8	11	17	26	37	47	57	65	79.1	20.2	8700
	1998	7	9	13	19	29	40	52	66	79	113.7	22.7	8728
	1999	6	7	10	14	22	34	44	53	61	97.6	17.9	8570
	2000	6	7	10	15	23	34	42	52	55	70.5	18.1	8711
	2001	6	7	10	15	23	35	43	52	58	109.6	18.2	8661
	2002	6	7	10	15	23	34	44	55	61	81.1	18.2	8459
	2003	6	8	11	15	24	35	47	62	71	100.3	19.5	8737
	2004	6	7	11	17	26	39	47	55	63	79.8	20.3	8761
BCR	1997	8	10	13	19	30	47	60	73	80	115.1	24.3	8708
	1998	9	11	15	23	36	57	71	92	101	127.1	29.2	8709
	1999	7	8	11	18	28	41	51	58	64	81.8	21.3	8702
	2000	6	7	11	17	26	37	46	55	62	86.3	19.9	8740
	2001	6	7	10	16	27	40	49	60	70	97.8	20.2	8699
	2002	6	8	11	17	29	45	53	61	72	88.5	22.1	8737
	2003	8	10	13	19	30	47	57	69	77	110.0	24.2	8572
	2004	7	9	12	19	35	55	67	78	84	142.0	26.2	8749
Gladstone	1996	5	5	8	12	19	29	38	50	57	107.4	15.4	8720
	1997	4	5	7	12	19	29	39	48	54	71.3	14.9	8611
	1998	5	6	9	15	22	32	39	48	53	74.2	17.3	8636
	1999	4	5	7	11	16	24	30	36	39	46.6	12.7	8702
	2000	4	5	7	11	17	26	31	41	48	55.3	13.5	8715
	2001	4	5	7	10	18	27	33	39	46	78.0	13.5	8737
	2002	4	5	8	11	17	24	32	44	53	74.2	13.6	8737
	2003	6	6	8	12	18	27	34	45	60	78.8	14.8	8685
	2004	5	6	7	12	19	28	34	40	47	70.9	14.7	8671

Table C – 2.3 *Percentiles of 1-hour and 24-hour continuous $PM_{2.5}$ levels ($\mu g/m^3$) at the Plaza site*

Averaging Time	Year	Percentile ($\mu g/m^3$)									Max.	Average	No. of
		5	10	25	50	75	90	95	98	99	($\mu g/m^3$)	($\mu g/m^3$)	Samples
1-hr	1998	0	1	3	7	13	21	29	40	51	119	9.6	8722
	1999	0	0	2	5	12	18	24	35	44	117	7.9	8657
	2000	0	0	3	6	13	22	31	42	50	92	9.5	8610
	2001	0	0	2	6	13	22	30	42	50	139	9.5	8575
	2002	0	0	2	6	13	22	29	40	49	84	9.2	8685
	2003	0	0	3	7	14	25	34	48	58	158	10.8	8614
	2004	0	0	3	7	14	26	34	47	54	127	10.7	8752
24-hr.	1998	2	3	5	8	13	19	22	28	38	52.1	9.6	8724
	1999	1	2	4	7	11	16	20	24	29	34.1	7.9	8658
	2000	2	2	4	7	13	19	25	32	36	47.0	9.5	8637
	2001	2	3	4	7	12	20	26	33	37	57.9	9.5	8537
	2002	2	2	4	7	12	18	22	32	38	65.3	9.2	8643
	2003	2	3	5	8	13	21	27	42	49	62.9	10.8	8682
	2004	2	3	5	8	14	22	28	35	40	66.0	10.7	8761

Table C – 2.4 Percentiles of 1-hour TRS levels (µg/m^3) at the three TRS monitoring sites

Site	Year	Percentile (µg/m^3)									Max.	Average	No. of
		50	60	70	75	80	90	95	98	99	(µg/m^3)	(µg/m^3)	Samples
Plaza	1995	0	1	1	3	3	7	11	17	21	44	2.1	8205
	1996	0	0	1	1	3	6	10	16	20	103	1.8	8229
	1997	0	0	1	1	1	6	9	13	17	40	1.6	8372
	1998	0	1	1	1	3	7	11	16	18	50	2.2	8245
	1999	0	0	1	1	1	6	10	16	17	44	1.7	8247
	2000	0	0	0	0	1	1	6	9	14	45	1.5	8314
	2001	0	0	1	1	3	7	10	13	16	35	1.7	8257
	2002	0	0	1	1	1	6	10	17	20	57	1.7	8167
	2003	0	0	1	1	3	9	13	18	23	61	2.1	8220
	2004	0	0	1	1	1	7	13	18	23	41	2.0	8384
Jail	1995	0	1	3	4	6	11	17	24	28	64	3.4	8359
	1996	0	1	3	3	4	10	14	20	24	62	2.8	8359
	1997	0	1	1	3	4	9	13	18	23	55	2.5	8347
	1998	0	1	3	4	6	11	16	21	26	51	3.1	8314
	1999	0	1	1	1	4	9	13	18	24	123	2.4	8117
	2000	0	1	1	3	4	9	11	17	23	62	2.4	8214
	2001	0	0	1	1	3	9	13	17	20	37	2.2	8352
	2002	0	0	1	1	3	7	11	18	23	44	2.1	8375
	2003	0	1	1	3	4	10	14	20	26	61	2.7	8374
	2004	0	0	1	3	4	10	16	21	26	84	2.8	8300
Lakewood	1995	0	1	1	1	1	4	6	10	13	37	1.2	8358
	1996	0	0	0	1	1	3	4	8	13	44	0.9	8283
	1997	0	0	0	0	1	1	4	7	9	27	0.7	8211
	1998	0	0	0	0	1	1	4	9	10	18	0.7	8204
	1999	0	0	0	0	1	1	3	7	10	28	0.6	8191
	2000	0	0	0	0	0	1	3	6	10	23	0.5	8348
	2001	0	0	0	0	1	1	4	7	10	23	0.7	8345
	2002	0	0	0	0	1	1	3	7	10	23	0.6	8254
	2003	0	0	0	0	1	1	3	7	9	23	0.6	8370
	2004	0	0	0	0	1	1	4	10	15	44	0.8	7621

Table C – 2.5 *Percentiles of 1-hour SO_2 levels ($\mu g/m^3$) at the three SO_2 monitoring sites*

Site	Year	Percentile (µg/m^3)									Max.	Average	No. of
		20	25	40	50	75	90	95	98	99	(µg/m^3)	(µg/m^3)	Samples
Plaza	1996	0	0	0	3	8	43	81	151	217	912	16.0	8232
	1997	0	0	3	3	11	37	72	125	182	663	14.6	8364
	1998	0	0	3	3	8	35	61	99	135	399	11.9	8220
	1999	0	0	0	3	5	19	35	61	83	490	7.2	8304
	2000	0	0	0	3	8	21	35	59	77	341	7.4	8071
	2001	0	0	0	3	8	27	45	77	111	455	9.5	8340
	2002	0	0	0	3	5	19	37	59	77	527	7.2	8362
	2003	0	0	0	0	5	16	27	48	64	333	5.7	8365
	2004	0	0	0	0	5	13	21	37	51	349	4.7	8348
Jail	1996	0	0	0	3	16	78	138	210	269	734	24.1	8378
	1997	0	0	3	3	16	61	112	184	224	759	20.5	8350
	1998	0	0	3	3	19	59	93	144	181	469	18.6	7580
	1999	0	0	0	3	5	29	56	91	123	306	10.0	8358
	2000	0	0	0	0	8	27	48	80	104	415	9.0	8362
	2001	0	0	0	3	8	37	64	104	128	458	12.1	8348
	2002	0	0	0	0	8	40	64	99	123	519	11.6	8367
	2003	0	0	0	3	11	42	72	111	137	336	13.2	8373
	2004	0	0	0	0	11	40	67	96	120	341	11.7	8396
CBC	1996	0	0	0	3	19	77	136	218	255	793	23.9	8372
	1997	0	0	3	3	13	56	101	178	242	778	20.1	8320
	1998	0	3	3	5	19	59	109	202	275	597	22.6	8361
	1999	0	0	0	3	5	35	69	123	192	751	13.0	8204
	2000	0	0	0	0	8	35	61	109	160	519	11.6	6958
	2001	0	0	0	0	11	45	88	162	237	969	16.2	8347
	2002	0	0	0	0	8	37	64	109	157	623	12.5	8348
	2003	0	0	0	0	13	45	77	141	210	623	15.9	8348
	2004	0	0	0	0	11	45	77	151	208	703	15.5	8371

Table C – 2.6 Percentiles of 1-hour, 8-hour and 24-hour ozone levels (μg/m³) at Plaza

Year	**Percentile (μg/m³)**									**Max.**	**No. of**
	5	**10**	**25**	**50**	**75**	**90**	**95**	**98**	**99**	**(μg/m³)**	**Samples**
1-hour											
1996	0	2	10	34	56	74	82	88	94	120	8635
1997	1	2	8	34	58	74	82	90	96	120	8660
1998	2	4	12	32	60	78	88	100	110	156	8584
1999	2	2	10	36	58	82	91	100	104	140	8617
2000	2	2	10	32	56	82	92	102	106	132	8650
2001	2	2	12	40	64	82	92	101	106	170	8566
2002	0	2	12	38	64	82	90	100	104	128	8591
2003	0	2	12	38	62	80	90	98	104	134	8565
2004	0	0	9	34	60	80	90	98	104	172	8597
8-hour											
1996	2	5	15	34	54	69	77	85	89	109	8644
1997	2	4	14	34	53	69	77	85	90	107	8646
1998	4	6	16	34	55	72	82	93	102	132	8598
1999	3	5	17	36	56	76	86	95	101	117	8569
2000	3	6	14	32	54	76	88	97	101	115	8620
2001	3	6	18	39	60	77	86	95	100	137	8602
2002	2	4	18	38	60	79	87	95	100	115	8644
2003	2	5	17	37	58	75	85	92	97	119	8694
2004	1	4	15	35	55	74	84	91	96	122	8745
24-hour											
1996	8	11	20	34	49	61	69	79	83	91	8607
1997	5	9	21	34	49	61	68	76	78	84	8719
1998	9	13	23	35	50	64	72	79	85	100	8615
1999	8	14	22	36	50	67	77	87	91	105	8619
2000	7	10	19	32	51	69	80	88	91	107	8676
2001	9	14	25	39	55	71	78	86	88	100	8660
2002	5	11	24	39	56	70	79	87	93	102	8698
2003	7	13	23	38	53	67	75	82	88	98	8737
2004	7	11	21	35	50	63	74	83	86	97	8734

Table C – 2.7 Percentiles of 1-hour NO_2 and NO levels ($\mu g/m^3$) at Plaza

Year	**Percentile (µg/m³)**									**Max. (µg/m³)**	**No. of Samples**
	5	**10**	**25**	**50**	**75**	**90**	**95**	**98**	**99**		
NO2											
1995	4	6	11	23	38	54	61	75	80	101	5182
1996	4	6	10	19	36	55	69	82	92	151	7800
1997	2	4	10	19	34	52	63	78	88	186	8243
1998	4	6	13	25	40	57	67	77	83	143	8051
1999	4	6	10	19	34	56	71	84	94	143	8218
2000	2	4	10	19	36	56	71	88	99	149	5070
2001	2	4	10	17	33	50	61	75	82	111	8295
2002	2	4	8	15	29	42	54	65	75	138	8176
2003	2	4	8	17	29	44	54	63	71	105	8297
2004	2	4	10	17	29	44	54	65	75	122	7244
NO											
1995	-	-	<22	<22	22	55	87	144	187	344	5188
1996	0	1	3	7	24	61	100	162	206	440	7778
1997	0	0	3	8	24	59	97	168	243	544	8181
1998	1	1	4	10	30	74	119	182	241	566	8074
1999	0	1	4	9	24	57	87	126	170	479	8226
2000	0	1	4	9	26	66	110	182	236	447	5070
2001	0	1	3	6	19	51	87	145	189	497	8294
2002	0	1	3	6	18	42	72	120	166	530	8175
2003	0	0	1	5	16	41	69	116	156	358	8297
2004	0	0	3	6	20	47	79	124	166	379	8286

Table C – 2.8 Percentiles of the 1-hour and 8-hour CO levels at the Plaza site

Averaging Time	**Year**	**Percentile (µg/m³)**									**Max. (µg/m³)**	**Average (µg/m³)**	**No. of Samples**
		5	**10**	**25**	**50**	**75**	**90**	**95**	**98**	**99**			
1-hr	2003	145	170	230	340	560	910	1230	1770	2190	4960	472.1	8348
	2004	130	160	230	360	640	1040	1330	1690	2050	5020	504.6	7795
8-hr.	2003	162	191	256	322	554	910	1156	1500	1727	3513	472.2	8698
	2004	155	189	166	402	642	987	1190	1445	1666	3387	505.1	8048

Appendix "D"

Photographs of the Monitoring Sites in Prince George

Lakewood Jr. Secondary looking towards the east

CNR site (Lakeland Mills) looking towards the south

CBC Transmitter site looking towards the west

Gladstone School looking towards the north

Jail looking towards the north

BCR site looking towards the east

Plaza’s ambient and meteorological site looking towards the southwest

Glenview ambient and meteorological site looking towards the west

P.G. Pulp meteorological site looking towards the southeast

Northwood meteorological site looking towards the east.

Appendix “E”

Glossary

Airshed:

The mass of air contained within a certain boundary (usually topographical boundary).

Aldehydes:

An organic compound that contains an oxygen atom doubly bonded to a carbon atom and possesses at least one hydrogen atom.

Ambient Air:

The portion of the atmosphere, external to buildings, to which the general public has access; open air.

Anthropogenic:

Referring to environmental alterations resulting from the presence or activities of humans.

Carcinogen:

An agent that incites development of cancer.

CO:

Carbon monoxide. A colourless, odourless and poisonous gas which is produced as a result of incomplete combustion of fossil fuels.

Detection Limit:

The minimum concentration of a compound contaminant that can be determined by a specific analytical method.

H_2S:

Hydrogen Sulphide. A colourless gas having a characteristic odour of rotten eggs.

HCHO:

Formaldehyde. The simplest member of the aldehyde group.

Inversion:

A meteorological condition in which a layer of warm air resides over a layer of cold air (usually occurring during nights when the sky is clear). Pollution is trapped below this warm air resulting in poor air quality over an area.

Level A Criteria:

A Criteria established to provide the basis for an anti-degradation policy for undeveloped areas with an adequate safety margin.

Level B Criteria:

A criterion established to provide adequate protection against adverse effects on personal health and comfort, animals, vegetation, soil, water, materials and visibility.

Level C Criteria:
A criterion established to provide protection against health effects that are specific to each contaminant.

Micron:
Micrometre (µm). 1 µm = 0.001 millimetres.

MIS:
Meteorological Information Station. Usually measuring continuous wind speed and direction.

NAPS:
National Air Pollution Surveillance. A federal schedule in which pollutants are monitored for a 24 hour period (from midnight to midnight) once every six days.

NO_2:
Nitrogen Dioxide. A reddish brown gas with a pungent and irritating odour at high concentrations.

NO:
Nitric Oxide. A colourless odourless gas emitted from combustion sources.

NO_x:
Oxides of nitrogen. Emitted from combustion sources. Assumed to be the sum of nitrogen dioxide and nitric oxide concentrations in the atmosphere.

O_3:
Ozone. The main constituent of smog found in the lower atmosphere and, when found in the upper atmosphere (stratosphere), a filter for ultra violet radiation.

PAH:
Polycyclic Aromatic Hydrocarbons are probable human carcinogens emitted during such processes as the incomplete combustion of biomass.

Percentile:
The percentage of the data set that lies below the stated value. For example, if the 70 percentile value is 10 $\mu g/m^3$, then 70% of the data are equal to or below 10 $\mu g/m^3$.

PGAATC:
Prince George Ambient Air Technical Committee. A committee that consists of the Ministry of Environment, Ministry of Health, Northwood, Canfor pulp and paper mills, and Husky.

PM_{10}:
Particulate matter that are less than 10 micrometres (0.00001 metre) in diameter.

$PM_{2.5}$:

Particulate matter that are less than 2.5 micrometres (0.0000025 metre) in diameter.

PPB:
Parts (of contaminant) per billion (parts of air)

Primary Pollutant:
A contaminant which is directly emitted to the atmosphere.

Secondary Pollutant:
A contaminant which is formed from other pollutants present in the atmosphere.

SO_2:
Sulphur dioxide. A corrosive gas produced mainly from the combustion of fossil fuels that contain sulphur.

TRS:
Total reduced sulphur. Main components include hydrogen sulphide, methylmercaptan, dimethyldisulphide and dimethylsulphide.

TSP:
Total Suspended Particulate matter that range in diameter from 0.001 micrometre to 100 micrometre.

VOC:
Volatile organic compounds. Emitted from sources such as oil-based paints, automobiles and dry cleaning fluids. A catalyst in the generation of tropospheric ozone.

$\mu g/m^3$:
Micrograms (0.000,001 grams) of contaminant per cubic metre.

µm:
Micrometre (0.001 millimetres).