

**Description of Study for Identifying the most  
Significant Contributions to Ambient Fine  
Particulate (PM<sub>2.5</sub>) In Prince George, B.C.**

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# Background

## Ambient Monitoring Results

PM<sub>10</sub> has been monitored at various locations in Prince George since 1990, and the fine (PM<sub>2.5</sub>) fraction has been monitored at one central site since 1994 (MWLAP, 2004) (Figure 1). Continuous monitoring has been done since 1992 and 1997 for these two particulate components, respectively, at the central (Plaza) site. Monitoring of continuous sulphur dioxide, ozone, nitrogen oxides, carbon monoxide and total reduced sulphur is also done at the same site.

Annual average levels of ambient PM<sub>2.5</sub> are the highest in the province, and average 98<sup>th</sup> percentile values exceeded the Canada Wide Standard over the most recent three-year period. Trends in various PM<sub>2.5</sub> statistics, based on non-continuous monitoring, are shown in Table 1 below.

**Table 1** Annual Trend Summary of Non-Continuous PM<sub>2.5</sub> Data at Plaza

Year	Annual Average ( $\mu\text{g}/\text{m}^3$ )	No. (%) of Daily Values $> 15 \mu\text{g}/\text{m}^3$	No. (%) of Daily Values $> 30 \mu\text{g}/\text{m}^3$	Maximum Daily Value ( $\mu\text{g}/\text{m}^3$ )	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

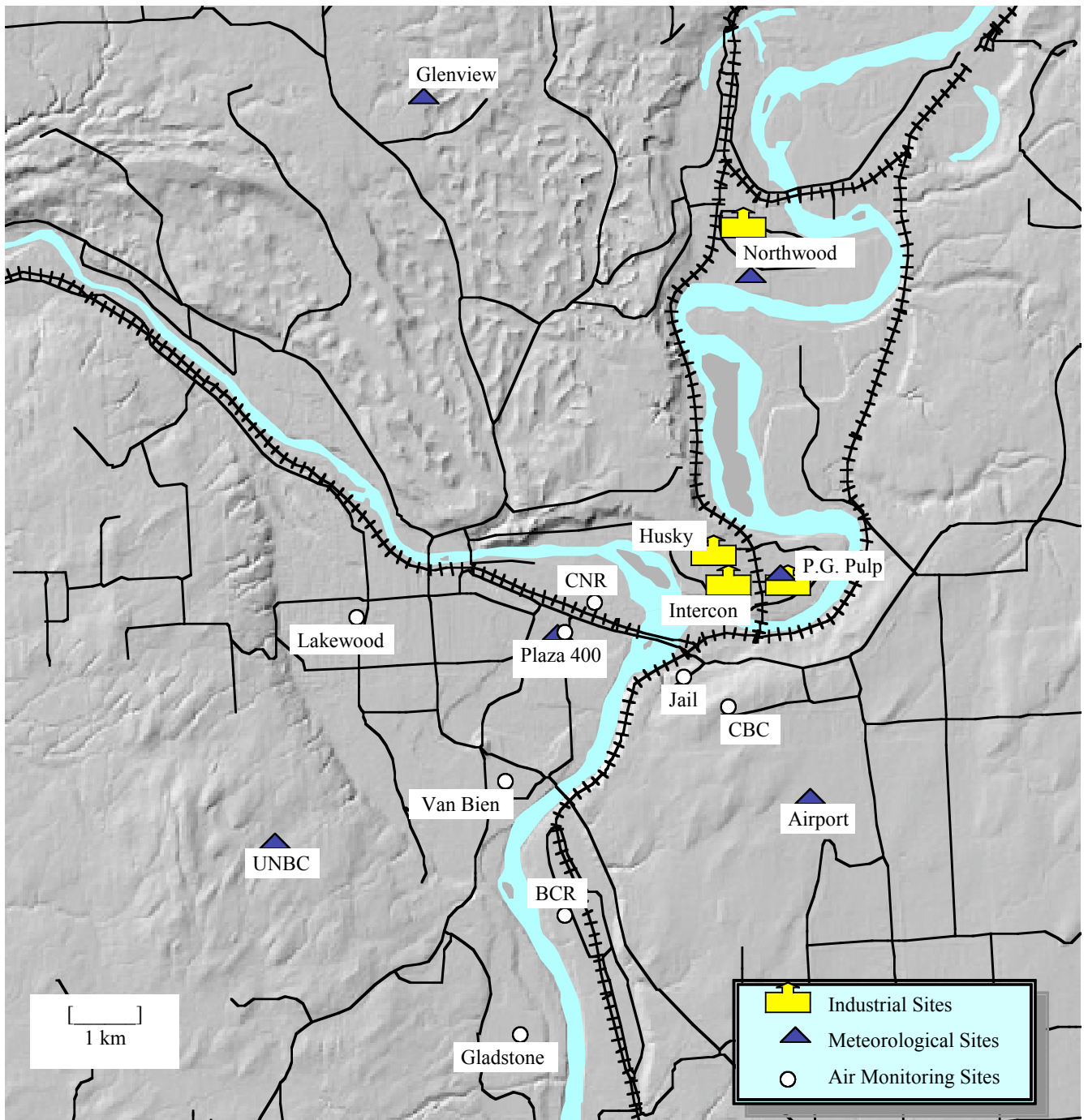
\* Instrument installed August 1994

## Source Identification under the Airshed Management Plan

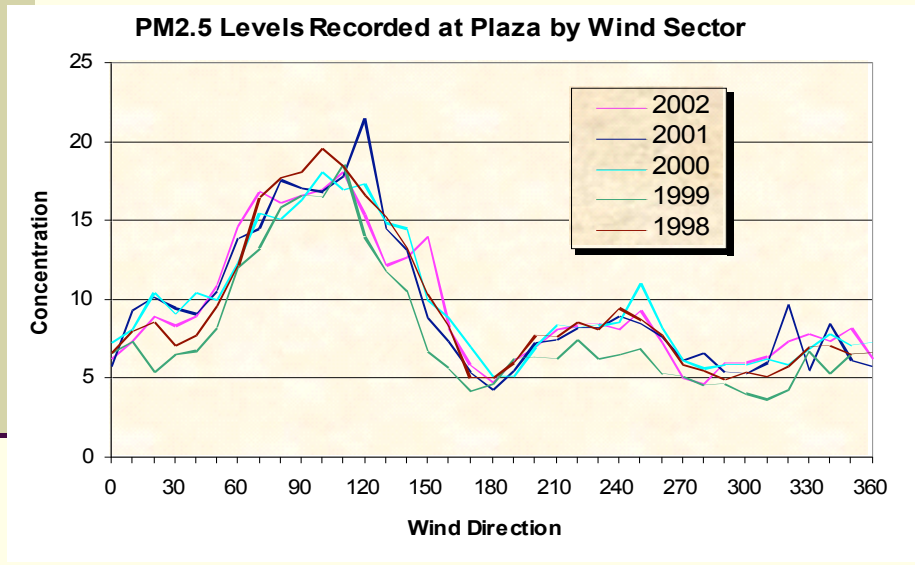
The air quality management plan that went into effect in 1999 achieved reductions in the largest primary particulate emission sources, including sawmills, pulpmills, road dust, domestic woodburning and open burning (Prince George Airshed Technical Management Committee, 1998). Despite these actions, ambient PM<sub>2.5</sub> levels remain high in the downtown area, indicating the need for more precise identification of sources.

The first step in improving source identification was taken by doing a wind sector analysis of the continuous PM<sub>2.5</sub> data, using annually averaged levels at the Plaza site. The distribution of PM<sub>2.5</sub> concentrations by wind direction, from 1998 through 2002, shows the highest concentrations consistently concentrated in the northeast to southeast sector (Figure 2). The product of the annual average concentration, and the duration of winds, in hours per year, from each sector was calculated to assess the effect of wind

direction on overall PM<sub>2.5</sub> contributions. The resulting distribution of cumulative contributions shows a pattern similar to that for PM<sub>2.5</sub> concentration alone. (Figure 3).

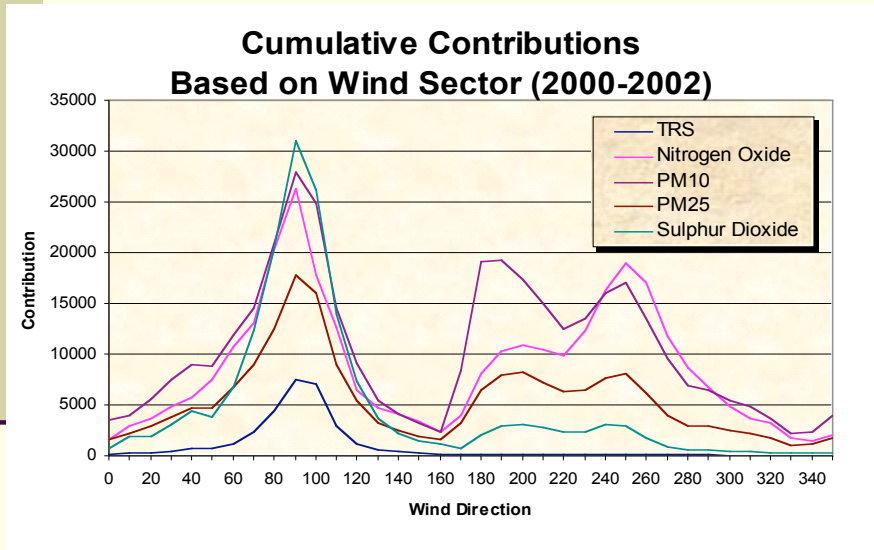


**Figure 1.** Location of meteorological and air monitoring sites in Prince George, BC.



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Figure 2: Prince George Plaza PM<sub>2.5</sub> Levels by Wind Sector (1998-2002)



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Figure 3: Prince George Plaza Cumulative PM<sub>2.5</sub> Contributions (2000-2002)

The most significant sources lie in the northeast-southeast, and south-southwest sectors relative to the central Plaza monitor. Contributions are particularly significant from the northeast-southeast sector, partly because of the prevalence of low-speed winds up-valley from the City. The strong co-varying relationship between the sulphur gases, which originate almost exclusively from sources in that sector, and PM<sub>2.5</sub>, corroborates the results of this analysis.

The worst fine particulate episodes in the airshed also have significant contributions from up-valley sources (Sutherland and Fudge, 2002). Over the past 10 years, episodes for which public advisories were issued average about 10 days per year, with individual episodes ranging from 1 day to 7 days in length. Maximum twenty-four PM<sub>10</sub> levels during these episodes ranged from 53 µg/m<sup>3</sup> to 155 µg/m<sup>3</sup>, and PM<sub>2.5</sub> levels from about 50% to 90<sup>+</sup>% of the PM<sub>10</sub> levels. Cold season episodes are mainly dominated by PM<sub>2.5</sub> and spring episodes are more evenly split between PM<sub>2.5</sub> and the coarser (PM<sub>10</sub> – PM<sub>2.5</sub>) fraction.

The wind sector analysis provides basic information about the most significant potential PM<sub>2.5</sub> source types. While individual sources are not identified by this analysis, comparison of contributions from the two dominant sectors indicates the following:

1. The distribution of PM<sub>2.5</sub> contributions in the northeast-southeast sector mirrored that of SO<sub>2</sub>, NO<sub>2</sub> and TRS, all of which originate from the industrial operations in that sector.
2. The combination of commercial and residential sources to the west-southwest of the Plaza site contributed significantly less PM<sub>2.5</sub> than all combined sources to the northeast-southeast, which indicates that commercial and residential sources are not the main contributors in this latter sector.

The overall conclusion from this analysis is that any future source identification studies must be able to distinguish between the northeast industrial sources and the commercial and residential sources that surround the Plaza monitoring site.

An attempt was made in 1997 to use the CALPUFF dispersion model to apportion PM<sub>10</sub> sources for selected episodes. Substantial over-prediction of the emissions from road dust, and uncertainty in sawmill beehive burner emissions limited the usefulness of this source modelling study for identifying sources. A second attempt at dispersion modelling has been initiated by the Prince George Air Quality Research Working Group, a multi-stakeholder management group. A strategy for preparing the emission inventory for this project has recommended that road dust emissions be measured locally by receptor speciation, rather than estimated using generic emission factors.

# Proposed Speciation Study

The purpose of this study is to identify and rank the highest priority contributors to ambient PM<sub>2.5</sub> levels in Prince George using receptor speciation methods.

## Speciation Methods

### Objectives

- 1) To understand the chemical constituents of PM<sub>2.5</sub> in the Prince George area via the mass reconstruction method outlined in Brook and Dann (1997).
- 2) To use the speciation data to get a preliminary understanding of PM<sub>2.5</sub> sources in Prince George on a yearly (and possibly seasonal) basis via receptor modeling tools such as CMB, PCA and PMF.
- 3) To complement the dispersion modeling and wind sector analysis tools used to identify sources and fill possible knowledge gaps regarding sources.

### Site Selection

Plaza 400 has been the central air quality monitoring station in Prince George for the past 30 years. Currently, there are several air quality monitoring instruments operating from the roof-top location, including continuous PM<sub>2.5</sub>, PM<sub>10</sub>, CO, NO<sub>x</sub>, SO<sub>2</sub>, O<sub>3</sub> and TRS. There are also two non-continuous Partisol samplers sampling PM<sub>2.5</sub> on a 1-in-3 day schedule. There is also a 7 metre meteorological tower sampling wind direction, wind speed, RH, temperature and solar radiation. Table 2 outlines the parameters monitored at Plaza 400 and the year measurement commenced.

**Table 2:** Ambient and Meteorological Parameters Measured at Plaza 400

<i>Parameter</i>	<i>Year Installed</i>	<i>Sampling Frequency</i>
PM <sub>2.5</sub> TEOM	1997	Hourly
PM <sub>10</sub> TEOM	1992	Hourly
PM <sub>10</sub> Hi-vol	1990	24hr 1-in-6 day (1-in-3-day in 2004)
PM <sub>2.5</sub> Partisol	1994	24hr 1-in-6 day (1-in-3-day in 2004)
TRS	1979	Hourly
CO	2002	Hourly
NO <sub>x</sub> /NO	1992	Hourly
SO <sub>2</sub>	1995	Hourly
O <sub>3</sub>	1995	Hourly
Wind Direction	1984	Hourly
Wind Speed	1984	Hourly
RH	2000	Hourly
Temperature	1984	Hourly
Solar Radiation	2000	Hourly

Starting January 1, 2005, Partisol PM<sub>2.5</sub> monitors will be added to three other airshed locations: a second valley site, the College Heights plateau site and a background site, all operated on a 1-in-3-day schedule. A TEOM PM<sub>2.5</sub> monitor and meteorological tower will also be added to the College Heights site.

The Plaza monitors are located in a commercially-zoned area atop a 22 meter building that sits next to a significant traffic route that accommodates heavy trucks (see Figure 4). Commercial and residential development lie to the south and west. To the north lies the CNR industrial area that includes a rail yard and two sawmills, about one kilometer away. Commercial operations lie immediately to the northeast, and two pulpmills are situated across the Fraser River about 3 kilometers in the same direction.

The location of the monitors at the building roof height reduces the effect of local sources such as vehicle traffic and woodstoves, and increases the representation of the broader urban area (Goswami *et al*, 2002). The location and elevation of the monitors makes it reasonably representative of the valley-based, downtown area of the community, which contains most of the City's population. A short-term study comparing ambient PM<sub>2.5</sub> levels at five B.C. valley and plateau sites showed a strong correlation between the sites, during winter, inversion-dominated conditions, with the highest levels at the Plaza site (Noullett, 2004).

The Plaza 400 site is also not close to any large point sources (such as sawmills and pulp mills) that would skew concentration data city-wide. In addition, siting the speciation monitor at an alternate nearby site is not feasible without other interfering factors such as building shadow and wind channelling occurring. Finally, the site is secure and easy to access.

While Plaza 400 may not be representative of the “worst case” ground level exposures to road dust and gases such as TRS it is likely the best available site to assess average PM<sub>2.5</sub> levels in the valley section of the City, which has the highest fine particulate levels and most episodes.



**Figure 4.** Plaza 400 with air monitoring equipment (left inset) and RM Young Wind Vane (right inset).

### **Instrument Selection**

The Prince George project will use the R&P 2300 4-channel speciation monitor for 24hr monitoring of PM<sub>2.5</sub> species. This is the same instrument model used by Environment Canada for their speciation program. A PM<sub>2.5</sub> Partisol already in use at the Plaza 400 site will be collocated with the speciation monitor to perform mass quality assurance on samples. This is similar to the Dichot/speciation monitor setup that Environment Canada uses for QA/QC in their speciation program.

A VOC canister sampler will be collocated with the speciation sampler for the analysis of organic gas species. Specific organic species may be helpful in distinguishing primary sources of high VOC emissions such as the oil refinery, the plywood plants and oil and gas exploration in the area. They may also be helpful in further fingerprinting of combustion sources such as woodstoves and diesel/gasoline vehicles.

### **Speciation Components**

The NAPS ETC lab will not be used for analysis of the speciation monitor sampling, however, wherever possible this study will follow the same analysis method protocols as Environment Canada. The parameters and their associated analysis methods are outlined in Table 3.

**Table 3.** Speciation Analysis. Instrument Setup, Methods and Parameters.

<b>Sampler/Module</b>	<b>Filter</b>	<b>Lab Analysis</b>	<b>Compounds</b>
PM <sub>2.5</sub> Partisol	Teflon	Gravimetry	Mass
Speciation Channel 1	Teflon	IC <sup>1</sup> , AA <sup>2</sup>	SO <sub>4</sub> , NO <sub>3</sub> , Cl, Na, K, Mg, NH <sub>4</sub> ...
	Nylon (back-up)	IC	NO <sub>3</sub>
Speciation Channel 2	Teflon	Gravimetry, XRF <sup>3</sup>	Mass, Al, Fe, Zn, Mn, Si, Ca, Ti, Cu, Ni, V, Se, As, Cr, Cd....
	Quartz (back-up)	TOR <sup>4</sup>	OC (1-4), EC

<sup>1</sup> Ion Chromatography

<sup>2</sup> Atomic Absorption for Na and K

<sup>3</sup> X-ray Fluorescence

<sup>4</sup> Thermal-Optical Reflectance – specifically, the Improve method developed by DRI

Speciation Channel 3	Quartz	TOR	OC (1-4), EC (1-3)
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VOCs will be analysed by the NAPS ETC lab in Ontario. VOC parameters sampled using the VOC canister will include primary species emitted from plywood veneer dryers (camphene, d-limonene, alpha-pinene and beta-pinene), oil refineries (propane, butane, pentane, ethane), wood combustion (naphthalene). No PAHs will be sampled. Appendix 1 – Table 1 shows the complete list of VOCs analysed by Environment Canada.

### ***Sampling Frequency and Duration***

The speciation monitor and VOC canister will run on a 24hr 1-in-3 day schedule for 1 year. This will allow for a reasonable number of samples for PMF analysis on a yearly and (possibly) seasonal average and will increase the probability that episodes will be sampled. The PM<sub>2.5</sub> partisol will run on a 1-in-6 day schedule to compare with the PM<sub>2.5</sub> mass measured by the speciation monitor for every other sample. All other samplers will measure hourly.

A 1-in-3 day sampling schedule was chosen over episodic sampling for several reasons. Firstly, a yearly average is important because it represents a more realistic scenario of personal exposure. Low concentration periods are valuable in determining persistent sources of PM and comparing them with high concentration periods. Secondly, a yearly approach to source apportionment allows analysts to separate sources by season. For example, seasonal variation of wood-smoke may be invaluable in differentiating between industry smoke sources (e.g. the pulp mill boilers all year) and residential woodstoves (winter).

### ***Data Quality Assurance***

There are a number of quality assurance features to this program. These include:

- Collocation of the PM<sub>2.5</sub> partisol with the speciation monitor for PM<sub>2.5</sub> mass comparison.
- Collocation of the PM<sub>2.5</sub> TEOM with the non-continuous PM<sub>2.5</sub> monitors for a second PM<sub>2.5</sub> mass comparison.
- Collocation of the VOC canister sampler with OC sampling from the speciation monitor.
- Proximity of five other meteorological sites within the Prince George area (PG Pulp, Glenview, Northwood, Airport and UNBC) to provide data for comparison of the zone of influence for meteorology and PM mass.
- Field filter blanks for lab analysis
- Duplicate analysis for 5 XRF samples and 5 OC/EC samples on the collocated PM<sub>2.5</sub> Partisol. (Ions cannot not be duplicated without a denuder).

Standard operating procedures (SOPs), data validation procedures and data quality objectives will be developed for the Prince George project. Procedures for data validation are being developed under the Golden QA/QC plan and will be used for the Prince George study as well. Data quality objectives will be developed for each continuous parameter and will include:

- Data completeness and capture
- Accuracy
- Precision
- Lower Quantifiable Limit (LQL)

A data quality summary report will be developed for each parameter at the end of the study and will outline the sampling frequency and location of each parameter measured and how well the results matched the objectives.

A number of quality assurance methods will be included for QA analysis of the laboratory results. These include: lab reference and field blanks and inter-laboratory comparison for metals, mass and VOCs.

All of these procedures will be documented as part of the Prince George QA/QC plan.

### ***Quality Control***

Quality control features of the study include:

- Routine flow and calibration checks
- Instrument maintenance procedures
- Filter/Cartridge/Canister handling, preparation and shipping protocols
- External site audits (WAMR)
- Laboratory Quality Control procedures

All of these protocols will be documented as part of the Prince George QA/QC plan.

### ***Data Analysis***

The speciation monitor and the VOC canister sampler will produce approximately 120 daily samples. This allows for an estimation using receptor models to apportion sources on a yearly average. An attempt will be made to calculate seasonal averages (e.g. Oct - March) as well to compare with yearly averages. This could be aided by running receptor models on the continuous data as well as to compare with the 24hr based data on a seasonal basis. The VOC data and the speciation data can be analysed separately or together in a receptor model.

Analysis of the data will involve a number of different statistical tools. If representative source profiles for industry (i.e. kraft pulp mills and refineries) and area sources can be found then the chemical mass balance model (CMB) may be useful, particularly to determine sources on episodic days.

Principal Component Analysis (PCA), Positive Matrix Factorization (PMF) and UNMIX are three of the multivariate receptor models that may be used to apportion sources of  $PM_{2.5}$ . Factor analysis (e.g. PCA) can be run with relative ease on the dataset as an initial tool to determine the best set of data (i.e. parameters and number of samples/seasons) for later source apportionment using PMF/UNMIX. PMF can be run on both the filter based speciation data and the continuous data. Factors from each of these two datasets can be compared.

Wind sector analysis will be performed on factors derived from both the continuous and non-continuous data and will be compared with previous wind sector analysis for continuous  $PM_{2.5}$  and  $SO_2$  data.

## References

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- Ministry of Water, Land and Air Protection. April 2004. *2002 Annual Air Quality Report for Prince George*. Environmental Protection Division, Prince George, B.C. Unpublished.
- Nouillett, M. (2004) Ambient and Personal Exposure Levels of Fine Particulate Matter (PM<sub>2.5</sub>) throughout the Prince George Airshed.
- Prince George Airshed Technical Management Committee, *Prince George Air Quality Management Plan - Phase One - Final Draft*. December, 1998.
- Sutherland, D. and D. Fudge. December 2002. *Review of Evidence for Significant Contributions to PM<sub>10</sub> Episodes in Prince George*. Ministry of Water, Land and Air Protection, Prince George, B.C.

## Appendix 1- Table 1: VOC species analysed by Environment Canada.

Compounds	CAS No.	UG/M3-PPB	CARBON ATOMS
Ethylbenzene	100-41-4	0.231	8
Styrene	100-42-5	0.235	8
Benzylchloride	100-44-7	0.192	
Benzaldehyde	100-52-7	0.231	7
cis-1,3-Dichloropropene	10061-01-5	0.220	3
trans-1,3-Dichloropropene	10061-02-6	0.220	3
n-Propylbenzene	103-65-1	0.204	9
n-Butylbenzene	104-51-8	0.182	10
p-Tolualdehyde	104-87-0	0.204	8
1,4-Diethylbenzene	105-05-5	0.182	10
1,4-Dichlorobenzene	106-46-7	0.166	6
EDB	106-93-4	0.130	2
Butane	106-97-8	0.421	4
1-Butene	106-98-9	0.436	4
1,3-Butadiene	106-99-0	0.453	4
1-Butyne	107-00-6	0.453	4
Acrolein	107-02-8	0.436	3
1,2-Dichloroethane	107-06-2	0.247	2
Hexylbenzene	1077-16-3	0.151	12
2-Methylpentane	107-83-5	0.284	6
2,4-Dimethylpentane	108-08-7	0.244	7
MIBK	108-10-1	0.244	6
m and p-Xylene	108-38-3	0.231	8
1,3,5-Trimethylbenzene	108-67-8	0.204	9
Methylcyclohexane	108-87-2	0.249	7
Toluene	108-88-3	0.266	7
Chlorobenzene	108-90-7	0.218	6
Pentane	109-66-0	0.339	5
1-Pentene	109-67-1	0.349	5
Hexane	110-54-3	0.284	6
1,4-Dichlorobutane	110-56-5	0.192	4
2-Pentanal	110-62-3	0.278	5
Valeraldehyde	110-62-3	0.278	5
Cyclohexane	110-82-7	0.291	6
Cyclohexene	110-83-8	0.298	6
Octane	111-65-9	0.214	8
1-Octene	111-66-0	0.218	8
Nonane	111-84-2	0.191	9
Undecane	1120-21-4	0.157	11
Dodecane	112-40-3	0.144	12
Propylene	115-07-1	0.582	3
1-Butene/Isobutene	115-11-7	0.436	4
1,2,4-Trichlorobenzene	120-82-1	0.135	6
Propionaldehyde	123-38-6	0.421	3

1-Nonene	124-11-8	0.192	9
Decane	124-18-5	0.172	10
Dibromochloromethane	124-48-1	0.101	1
Tetrachloroethylene	127-18-4	0.147	2
b-Pinene	127-91-3	0.180	
trans-2-Octene	13389-42-9	0.218	8
1,2-Diethylbenzene	135-01-3	0.182	10
sec-Butylbenzene	135-98-8	0.182	10
1,3-Diethylbenzene	141-93-5	0.182	10
Cyclopentene	142-29-0	0.359	5
Heptane	142-82-5	0.244	7
trans-2-Heptene	14686-13-6	0.249	7
trans-3-Heptene	14686-14-7	0.249	7
cis-1,2-Dichloroethylene	156-59-2	0.252	2
trans-1,2-Dichloroethylene	156-60-5	0.252	2
3,6-Dimethyloctane	15869-94-0	0.172	10
MTBE	1634-04-4	0.278	
cis-1,2-Dimethylcyclohexane	2207-01-4	0.218	8
cis-1,4/t-1,3-Dimethylcyclohexane	2207-03-6	0.218	8
trans-1,3-Dimethylcyclohexane	2207-03-6	0.218	8
trans-1,4-Dimethylcyclohexane	2207-04-7	0.218	8
2,5-Dimethylheptane	2216-30-0	0.191	9
3-Methyloctane	2216-33-3	0.191	9
4-Methyloctane	2216-34-4	0.191	9
Cyclopentane	287-92-3	0.349	5
2,2,5-Trimethylhexane	3522-94-9	0.191	9
trans-2-Hexene	4050-45-7	0.291	6
Crotonaldehyde	4170-30-3	0.349	4
cis-4-Methyl-2-pentene	4461-48-7	0.291	6
2,2-Dimethylpropane	463-82-1	0.339	5
2,2,3-Trimethylbutane	464-06-2	0.244	7
Indane	496-11-7	0.207	9
Formaldehyde	50-00-0	0.828	1
2-Methyl-2-butene	513-35-9	0.349	5
1,2,3-Trimethylbenzene	526-73-8	0.182	10
o-Tolualdehyde	529-20-4	0.204	8
iso-Butylbenzene	538-93-2	0.182	10
2,2,4-Trimethylpentane	540-84-1	0.214	8
1,3-Dichlorobenzene	541-73-1	0.166	6
Carbontetrachloride	56-23-5	0.159	1
3-methyl-1-Butene	563-45-1	0.349	4
2-Methyl-1-butene	563-46-2	0.349	4
2,3-Dimethylpentane	565-59-3	0.244	7
2,3,4-Trimethylpentane	565-75-3	0.214	8
2,5-Dimethylbenzaldehyde	5779-94-2	0.204	9
3-Methylhexane	589-34-4	0.244	7
2,4-Dimethylhexane	589-43-5	0.214	8
4-Methylheptane	589-53-7	0.244	8
3-Methylheptane	589-81-1	0.244	8
cis-2-Butene	590-18-1	0.436	5

2,2-Dimethylpentane	590-35-2	0.244	7
2,2-Dimethylhexane	590-73-8	0.214	8
2-Pentanone/Isovaleraldehyde	590-86-3	0.284	5
1-Methylcyclohexene	591-49-1	0.255	7
2-Methylhexane	591-76-4	0.244	7
2,5-Dimethylhexane	592-13-2	0.214	8
2-Methylheptane	592-27-8	0.244	8
1-Hexene	592-41-6	0.291	6
1-Heptene	592-76-7	0.249	7
Limonene	5989-27-5	0.180	
2-Ethyltoluene	611-14-3	0.204	9
trans-3-Methyl-2-pentene	616-12-6	0.291	6
3-Ethyltoluene	620-14-4	0.204	9
m-Tolualdehyde	620-23-5	0.204	8
4-Ethyltoluene	622-96-8	0.204	9
trans-2-Butene	624-64-6	0.436	4
2-Methyl-2-pentene	625-27-4	0.291	6
cis-2-Pentene	627-20-3	0.349	5
cis-1,3-Dimethylcyclohexane	638-04-0	0.218	8
cis-2-Heptene	6443-92-1	0.249	7
trans-2-Pentene	646-04-8	0.349	5
Hexanal	66-25-1	0.244	6
trans-4-Methyl-2-pentene	674-76-0	0.291	6
Acetone	67-64-1	0.461	3
Chloroform	67-66-3	0.205	1
trans-1,2-Dimethylcyclohexane	6876-23-9	0.218	8
4-Methyl-1-pentene	691-37-2	0.291	6
1-methylcyclopentene	693-89-0	0.298	6
Benzene	71-43-2	0.313	6
1,1,1-Trichloroethane	71-55-6	0.184	2
Bromomethane	74-83-9	0.257	1
Ethane	74-84-0	0.815	2
Ethylene	74-85-1	0.873	2
Acetylene	74-86-2	0.940	2
Chloromethane	74-87-3	0.484	1
Dibromomethane	74-95-3	0.140	1
Ethylbromide	74-96-4	0.224	2
Bromochloromethane	74-97-5	0.188	1
Propane	74-98-6	0.555	3
1-Propyne	74-99-7	0.611	3
Chloroethane	75-00-3	0.385	2
Vinylchloride	75-01-4	0.388	2
Acetaldehyde	75-07-0	0.549	2
Dichloromethane	75-09-2	0.287	1
Bromoform	75-25-2	0.097	1
Bromodichloromethane	75-27-4	0.148	1
Isobutane	75-28-5	0.421	4
1,1-Dichloroethane	75-34-3	0.247	2
1,1-Dichloroethylene	75-35-4	0.252	2
Freon22	75-45-6	0.281	1

Bromotrichloromethane	75-62-7	0.123	1
Freon11	75-69-4	0.178	1
Freon12	75-71-8	0.202	1
2,2-Dimethylbutane	75-83-2	0.284	6
3-Methyl-1-pentene	760-20-3	0.291	6
2-Ethyl-1-Butene	760-21-4	0.291	6
Freon113	76-13-1	0.131	
Freon114	76-14-2	0.143	2
2-Methyl-1-pentene	763-29-1	0.298	6
cis-2-Octene	7642-04-8	0.218	8
cis-3-Heptene	7642-10-6	0.249	7
cis-2-Hexene	7688-21-3	0.291	6
Isopentane	78-78-4	0.339	5
Isoprene	78-79-5	0.359	5
1,2-Dichloropropane	78-87-5	0.216	3
MEK	78-93-3	0.339	4
1,1,2-Trichloroethane	79-00-5	0.184	2
Trichloroethylene	79-01-6	0.187	2
2,3-Dimethylbutane	79-29-8	0.284	6
1,1,2,2-Tetrachloroethane	79-34-5	0.145	2
Camphene	79-92-5	0.180	
a-pinene	80-56-8	0.180	
1-Undecene	821-95-4	0.159	
1-Decene	872-05-9	0.175	10
Hexachlorobutadiene	87-68-3	0.094	
Naphthalene	91-20-3	0.191	
cis-3-Methyl-2-pentene	922-61-2	0.291	6
o-Xylene	95-47-6	0.231	8
1,2-Dichlorobenzene	95-50-1	0.166	6
1,2,4-Trimethylbenzene	95-63-6	0.204	9
3-Methylpentane	96-14-0	0.284	6
Methylcyclopentane	96-37-7	0.291	6
tert-Butylbenzene	98-06-6	0.182	10
iso-Propylbenzene	98-82-8	0.204	9
p-Cymene	99-87-6	0.182	10