

The Case for Using PM_{2.5} Objectives In the Prince George Airshed

PM_{2.5} and Particulate Health Risk

PM_{2.5} Levels in the Airshed

- Exceedance frequencies
- Annual trends
- Trends in PM_{2.5}:PM₁₀ ratios
- Episode levels

Significance of PM_{2.5} for Airshed Management

- **Most critical component of ambient PM₁₀**
 - Most directly tied to health risk reduction
 - Major sources are continuous, (vs. intermittent, short-term)
- **Focus on PM_{2.5} now most cost-effective**
 - Switch emphasis from predominantly coarse sources, e.g. dust (but maintain current management of concentrated dust sources)
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Benefit of Using PM_{2.5} Objectives

- Provide goals for airshed plan
- Provide more certainty for source owners
- Two objectives provide short and long-term management goals

Suggested Options

- Alberta CASA Framework (multi-tier, applied to all airsheds)
- Episode and annual objectives?

What is the PM_{2.5} Issue?

The main focus of the Phase I Prince George Air Quality Plan has been fine particulate, or more specifically PM₁₀. PM₁₀ is defined in the Plan as “fine particulate matter with a maximum particle diameter of 10 microns”, which includes the ultra-fine particle component known as PM_{2.5}. These two particle size categories are measured with separate instruments, that segregate the particles based on their aerodynamic properties. Finer particles stay in suspension in an air stream longer than coarser particles. Because “acceptable air quality” is defined in the Plan as “the level of an air quality objective that meets an ambient air quality objective”, meeting the provincial PM₁₀ objective was effectively the goal of Phase One.

The Air Quality Plan focuses on PM₁₀ because the only provincial fine particulate air quality objective is the 24-hour PM₁₀ objective (50 µg/m³). This objective was adopted in B.C. in 1995, using health risk information that was based on the available monitoring data, which at that time was mostly PM₁₀ data. Monitoring of ambient PM_{2.5} levels began in 1994 in Prince George, and by 2000 there were fourteen B.C. communities reporting that pollutant. Sufficient monitoring was available across Canada to enable Health Canada to assess the health risk of PM_{2.5} in 1998, and for a PM_{2.5} Canada Wide Standard to be adopted in 2000 (in effect nationally in 2010).

The recommendations in the current Plan address both the coarse (that is PM₁₀ minus PM_{2.5}) and fine fractions (PM_{2.5}). Monitoring in Prince George and other airsheds has shown that road and other dust emissions are predominantly coarse particle sources. Conversely, wood and fossil fuel combustion emissions are predominantly fine particle sources. The ratio of PM_{2.5} to PM₁₀ is a measure of the relative importance of the coarse and fine fractions in the airshed. The significance of the PM_{2.5} component for health effects and for effective fine particulate management in this airshed is the focus of this review.

PM_{2.5} Levels in the Airshed

Annual Trends

PM_{2.5} is measured at one site, on the roof of the Plaza 400 building on Queensway Road, with continuous and non-continuous instruments. Non-continuous monitoring, on a six-day frequency, started in August 1994 and continuous monitoring in November of 1997.

The trends in non-continuous PM_{2.5} levels from 1994 to 2002 are shown in the Table 1. The annual average dropped from the mid-1990's to 1999, although the level increased in 2000 and 2002. Average continuous levels have been relatively constant since monitoring started in 1997 (Table 2). Non-continuous annual average levels were about 18% higher than the continuous averages (10.7 µg/m³ versus 9.1 µg/m³), due to the greater loss of some volatile components in the continuous monitor. Average annual levels in Prince George have been the overall highest in B.C. since 1998.

The percent exceedance of 15 µg/m³ and 30 µg/m³ are variable from year-to-year, averaging about 25% and 6%, respectively, over the 8 complete years of non-continuous monitoring data. The frequency of exceedance of these two levels are lower for the five years of continuous data, averaging about 2%, respectively, consistent with the overall difference between these two monitoring methods.

Table 1.

Annual Trend Summary of Non-Continuous PM_{2.5} Data at Plaza

Year	Annual Average (µg/m ³)	PM _{2.5} :PM ₁₀ Ratio	No. (%) of Daily Values > 15 µg/m ³	No. (%) of Daily Values > 30 µg/m ³	Maximum Daily Value (µg/m ³)	Number of Samples
1994	-	-	-	-	52	22*
1995	13.3	0.56	19(31.1%)	3 (4.9%)	54	61
1996	12.7	0.58	17(28.3%)	2 (3.3%)	40	60
1997	12.3	0.59	16(26.2%)	5 (8.2%)	43	61
1998	11.3	0.42	18(29.5%)	3 (4.9%)	52	61
1999	9.6	0.45	11(18.3%)	2 (3.3%)	38	60
2000	11.5	0.63	12 (19.7%)	5 (8.2%)	52	61
2001	9.9	0.63	16(26.2%)	4 (6.6%)	35	61
2002	11.2	0.62	14(23.0%)	5 (8.2%)	34	61
2003	12.0	0.72	12(26.7%)	2 (4.4%)	36	45

* Instrument installed August 1994

Table 2.

Annual Trend Summary of the Continuous PM_{2.5} Data at Plaza

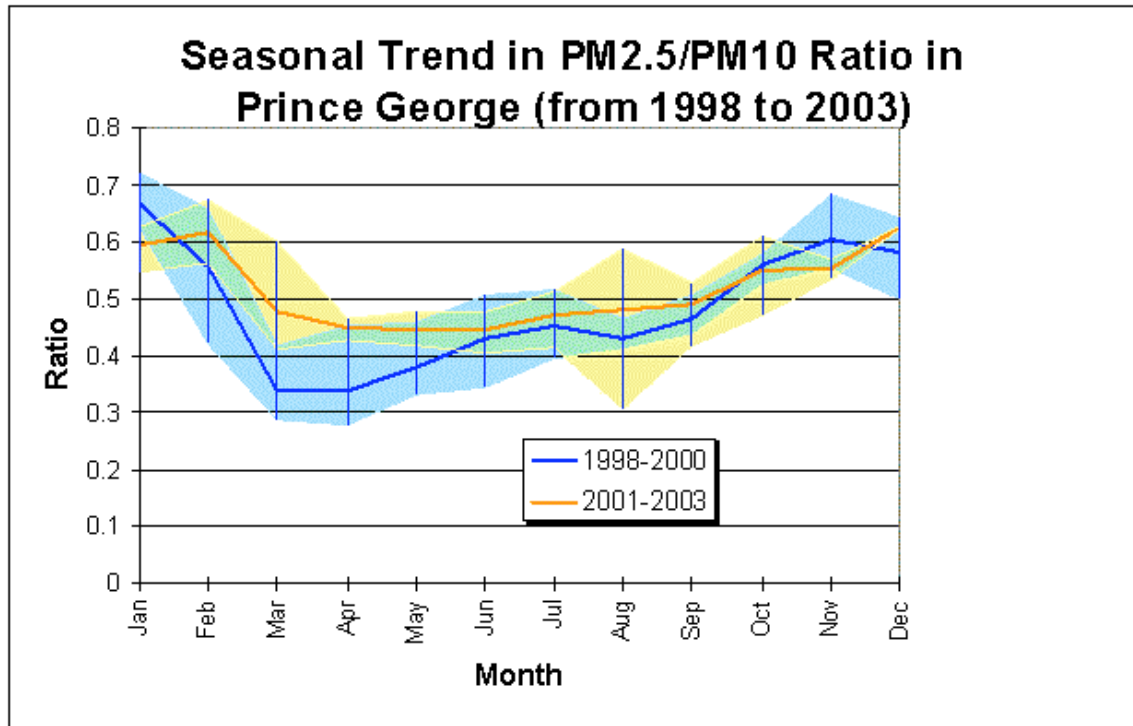
Year	Annual Average (µg/m ³)	Maximum Hourly Average (µg/m ³)	PM _{2.5} :PM ₁₀ Ratio	No. (%) of Days >15 µg/m ³	No. (%) of Days > 30 µg/m ³	Maximum 24-Hour Average (µg/m ³)	Hours Instrument Operated
1997	-	-	-	-	-	55.4	1167*
1998	9.6	119	0.42	69(18.9%)	7 (1.9%)	52.1	8722
1999	7.9	117	0.44	42(11.5%)	4 (1.1%)	34.1	8657
2000	9.5	92	0.53	61(16.8%)	11 (3.0%)	47.0	8610
2001	9.5	139	0.52	60(16.4%)	11 (3.1%)	57.9	8575
2002	9.2	84	0.51	56(15.5%)	7 (1.9%)	65.3	8685
2003	10.8	158	0.54	70(22.0%)	15(4.7%)	62.3	7630

* Monitoring started November 1997.

The ratio of PM_{2.5} to PM₁₀ levels is an indicator of the composition of particles, and provides an inference about the relative contributions of source types. The average ratio since monitoring of both particle sizes began in 1994 is about ??, meaning that % of the PM₁₀ is PM_{2.5}. However, this ratio is not constant throughout the year, varying with the mixture of emission sources and with meteorological conditions. Monthly ratios since 1998, when continuous monitoring of both size fractions started, vary from about 0.3 to 0.7 (Figure 1). Ratios have varied seasonally, with the highest ratios occurring in late fall and winter, and the lowest in spring. The seasonal trend has changed since 2000, with a substantial increase in the March, April and May average ratios, indicating the effect of reductions in road dust, which are composed predominantly of coarse particles.

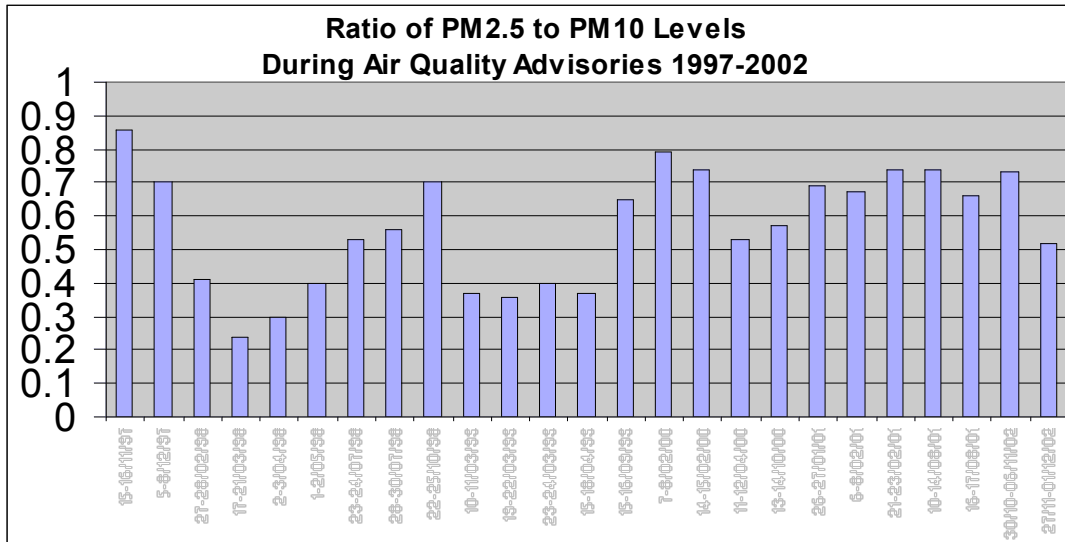
As well as spring $PM_{2.5}$ ratios, overall annual ratios have increased since 1999, as shown in Tables 1 and 2. While the ratios are somewhat lower for the continuous data compared with the non-continuous data, the trend is similar, and

Figure 1.



likely due to the decrease in coarse particulates during the spring months.

$PM_{2.5}$ ratios during air quality advisory episodes show an increasing trend since 1999, compared with the previous three years (Figure 2). This trend is due mainly to the occurrence of fewer episodes in March and April since 1999, and to higher ratios during the most recent February episodes, rather than to higher ratios in the late fall and winter months. The best explanation for the trend of increasing $PM_{2.5}$ ratios during advisory episodes is the reduction of spring road dust emissions, which is supported by the trend in monthly ratios in the last three years.



The Significance of PM_{2.5} for Airshed Management

Combustion of wood and fossil fuels is a concentrated source of PM_{2.5}. Sources such as pulpmill power and recovery boilers, on and off-road gasoline and diesel vehicles and locomotives, residential wood and natural gas heating and commercial and industrial heating are the main combustion sources. More intermittent sources include open burning of landclearing and silvicultural debris, and yard wastes. These sources produce solid particles, also known as primary particulates.

Dust from paved and unpaved roads and other surfaces, and from wood processing plants contains a lower portion of PM_{2.5} than the combustion sources. Dust emissions are also more intermittent than the largest combustion emitters, with emissions more prevalent following spring snowmelt, and during dry periods. Continuous emissions are more likely to affect ambient PM_{2.5} levels because they are more available, than intermittent ones, to encounter poor mixing meteorology. For example, wind speeds are lowest during winter and mid to late-summer, and PM_{2.5} levels are also highest during those periods. Sources running continuously would therefore tend to make greater contributions to annual PM_{2.5} levels than sources restricted to none, or only one of those periods. The continuous emission sources in this airshed are mainly combustion sources, pulpmills, on and off-road vehicles, sawmills and other industrial sources that use combustion for purposes other than space heating. The seasonal sources include combustion sources such as residential and commercial woodburning, but also non-combustion sources such as dust. Although crustal dust emissions occur predominantly during warm periods, they also depend on precipitation levels, making them even more intermittent than other seasonal sources.

Secondary particulates are particles formed in the atmosphere from emission gases. The main sources of secondary particulate in the airshed are the emitters of nitrogen oxides from combustion, including the pulpmills, the refinery, other industrial operations, and commercial and residential heating. Secondary particulate is also produced from sulphur dioxide emissions, from sources such as the pulpmill recovery boilers and reduced sulphur incinerators, the refinery, a sulphuric acid plant and combustion of gasoline and diesel fuel. Secondary particles are mainly part of the PM_{2.5} component.

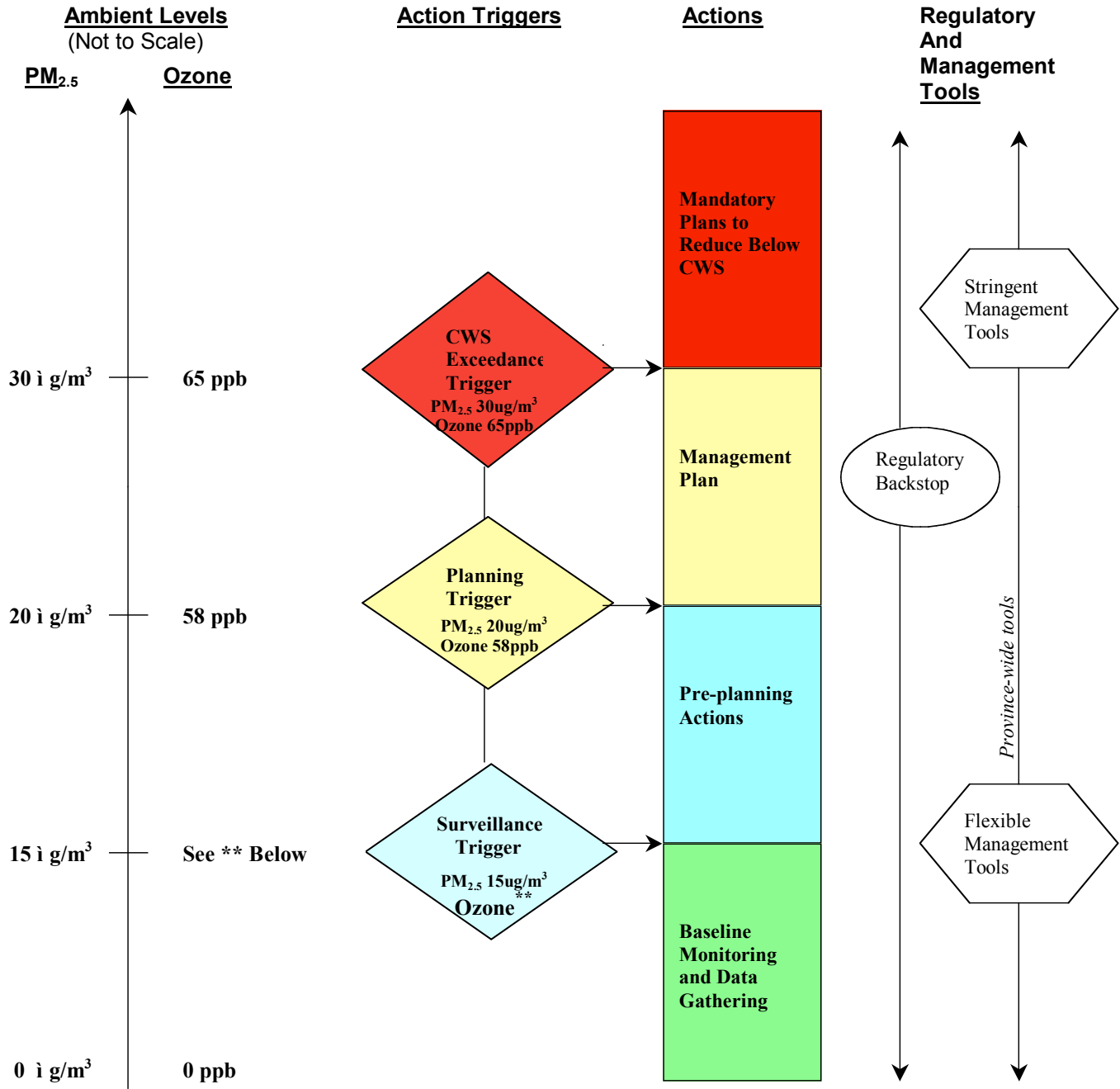
Benefits of Using PM_{2.5} Objectives

Air quality objectives provide the goalposts for airshed management. The literature indicates that there is no threshold for health risk from fine particulate. Therefore, it is not possible to select objectives for this pollutant that provide full protection from health effects. Objectives must be chosen that provide interim goals for reducing ambient fine particulate levels. The current PM₁₀ objective provided the goal for the first phase of the Airshed Plan. However, the most recent studies indicate that the PM_{2.5} component of PM₁₀ is the top management priority. The ambient data show that PM_{2.5} is the largest component of PM_{2.5} in the valley, where PM₁₀ levels are highest in the airshed.

Adopting a PM_{2.5} objective would provide a performance-based goal for achieving the next management steps for this airshed, and help focus source reduction actions where the greatest health risk reduction could be achieved. A PM_{2.5} objective would also provide greater certainty to source owners and management agencies as to where reduction efforts should be focused.

Options for PM_{2.5} Objectives

FIGURE 1: FINE PARTICULATE MATTER AND OZONE MANAGEMENT FRAMEWORK



** For Ozone, Alberta Environment will determine on an annual basis which areas of the province are in baseline and which are in surveillance.

Trigger levels for PM_{2.5} are based on a 24 hr average, and achievement is based on the 98th percentile ambient measurement annually, averaged over 3 consecutive years. Trigger levels for ozone are based on an 8 hr average, and achievement is based on the 4th highest measurement annually, averaged over 3 consecutive years

The Framework must be applied in the context of its key elements, including guiding principles, existing initiatives and mechanisms that support management of PM & O₃, and the goals and objectives for each level of management.