PARTICULATE MATTER IN BRITISH COLUMBIA

A Report on PM10 and PM2.5 Mass Concentrations up to 2000

May 2003

British Columbia
Ministry of Water, Land and Air Protection

Environment Canada Environnement Canada

National Library of Canada Cataloguing in Publication Data
Suzuki, Natalie M.
Particulate matter in BC : a report on PM10 and PM2.5 mass concentrations up to 2000.

Cover title.
Running title: PM sampling in BC.
Co-produced by British Columbia Ministry of Water, Land and Air Protection, and the Pacific and Yukon Region of Environment Canada.
Also available on the Internet.
Includes bibliographical references: p.
ISBN 0-7726-4904-9

1. Air quality management - British Columbia. 2. Particles - Health aspects - British Columbia. 3. Particles - Environmental aspects - British Columbia.
4. Subject - British Columbia. I. Taylor, Bill.
II. British Columbia. Water, Air and Climate Change Branch. III. Canada. Environment Canada. Pacific and Yukon Branch. IV. Title. V. PM sampling in BC.

TD883.7.C32B74 2003 363.739'22'09711 C2003-960018-1

Addendum

Methods of reporting $PM_{2.5}$ data collected from TEOM monitors in Canada changed beginning in 2002. Prior to this date, hourly data were adjusted using an offset of 3.0 and a multiplier of 1.03, as was the practice by the U.S. Environmental Protection Agency. These adjustment factors were removed from the provincial data archive in April 2002, before the bulk of the data summarized in this report was analysed. As a result, $PM_{2.5}$ levels described in this report are about 3 $\mu g/m^3$ greater than what would be calculated based on numbers from the current database.

Preface

There is mounting evidence that particulate matter (PM) represents a significant environmental health concern. In order to assess ambient levels of PM in British Columbia (BC), Natalie Suzuki from the Ministry of Water, Land and Air Protection, and Bill Taylor from Pacific and Yukon Region of Environment Canada have compiled available PM data from monitoring sites throughout the province and summarized them in this report.

The data have been analysed to determine the concentrations of PM_{10} (<10 μm diameter) and $PM_{2.5}$ (<2.5 μm diameter) experienced in various BC communities. The authors have examined the data for trends to determine if ambient levels are increasing or decreasing over time at each site. They have also looked for temporal patterns in the data to identify seasonal influences on PM concentrations, and to determine whether concentrations change depending on the day of the week or the time of day. The frequency with which the provincial ambient PM_{10} objective and the Canada Wide Standard are exceeded in various communities has been calculated, and the authors present some preliminary conclusions about the conditions that lead to episodes of poor air quality in those communities. In short, the findings in this report help identify where our efforts to improve air quality in BC should be directed. The report also highlights the limitations of the data and the need for additional monitoring and analysis.

Air quality management planning is already underway in many communities, and measures taken to date to reduce emissions of fine particles and associated precursors are clearly evident. However, high concentrations of fine particles continue to occur, so more work needs to be done to reduce the risks to human health and the environment posed by these exposures.

This report is a joint undertaking of the provincial Ministry of Water, Land and Air Protection, and the Pacific and Yukon Region of Environment Canada. The report is intended as a vehicle to engage various agencies and interested parties in informed discussions on implementing strategies such as Canada-wide Standards and other airshed planning initiatives.

Hu Wallis
Director, Water, Air and Climate Change Branch
BC Ministry of Water, Land and Air Protection
Victoria BC

Kirk Johnstone
Manager, Aquatic and Atmospheric Sciences Division
Environment Canada
Pacific and Yukon Region
Vancouver BC

For more information on air quality and related activities in British Columbia, contact:

Water, Air and Climate Change Branch
Ministry of Water, Land and Air Protection
Government of British Columbia

Phone: (250) 387-9932 Fax: (250) 356-7197
E-mail: wacc@victoria1.gov.bc.ca
2975 Jutland Rd
PO Box 9341 Stn Prov Govt
Victoria BC V8W 9M1
website: http://wlapwww.gov.bc.ca/air

Pacific and Yukon Region
Environment Canada

Phone: (604) 664-9100 Fax: (604) 664-9195
E-mail: greenlane.pyr@ec.gc.ca
Environment Canada
Pacific & Yukon Region
#201, 401 Burrard
Vancouver, BC V6C 3S5
website: http://www.pyr.ec.gc.ca/EN/Air/index.shtml

Acknowledgements

This report was prepared by:

Natalie Suzuki
Air Quality Science Specialist
Water, Air and Climate Change Branch
BC Ministry of Water, Land and Air Protection

Bill Taylor
Senior Scientist, Atmospheric Issues
Pacific and Yukon Region
Environment Canada

This report would not have been possible without the significant contributions of time and expertise of a number of people. In particular, the authors would like to acknowledge the efforts of Robert Marsh and Ernie Tradewell from the ministry who provided the ambient air quality data and resolved several issues regarding data quality assurance, and Kathy Ostermann, who conducted the trends analysis.

We also appreciate and acknowledge the comments provided by the ministry's regional air quality meteorologists during the technical review of the report, particularly Dennis Fudge. Special thanks to Dr. Ian McKendry of the University of British Columbia, and Tom Dann and Marjorie Shepherd of Environment Canada for their insightful comments and suggestions. Additional thanks go to Ken Reid of the Greater Vancouver Regional District who contributed to the technical review. Finally, we wish to thank Alex Cannon of Environment Canada for technical assistance in the generation of the report graphics.

Contents

List of Figures

List of Tables

List of Units, Acronyms, and Abbreviations

ARB	Air Resources Branch, Ministry of Water, Land and Air Protection
CCME	Canadian Council of Ministers of the Environment
CEPA	*Canadian Environmental Protection Act*
CWS	Canada-wide Standard
EPA	United States Environmental Protection Agency
FVRD	Fraser Valley Regional District
GVRD	Greater Vancouver Regional District
MDL	Minimum Detection Limit
MELP	BC Ministry of Environment, Lands and Parks
$\mu g/m^3$	Micrograms per cubic metre (concentration)
μm	Micrometres (10^{-6} m) (diameter)
LFV	Lower Fraser Valley
NAAQOs	National Ambient Air Quality Objectives
NAPS	National Air Pollution Surveillance
NOx	Oxides of Nitrogen
PESC	Pacific Environmental Science Centre
PM	Particulate Matter
PM_{10}	Particulate matter with aerodynamic diameter less than or equal to 10 μm
$PM_{2.5}$	Particulate matter less aerodynamic diameter less than or equal to 2.5 μm
REVEAL	Regional Visibility Experimental Assessment in the Lower Fraser Valley
SSI	Selective Size Inlet (high-volume sampler)
TEOM	Tapered Element Oscillating Microbalance
TSP	Total Suspended Particulate
UBC	University of British Columbia
WGAQOG	Federal/Provincial Working Group on Air Quality Objectives and Guidelines
WLAP	BC Ministry of Water, Land and Air Protection (formerly MELP)

Executive Summary

In June 2000, the Canadian Council of Ministers of the Environment ratified a Canada-wide Standard for particulate matter (PM). The following year, federal Ministers of Environment and Health declared inhalable particulate matter (PM_{10}) a toxic substance because of its adverse effects on human health. This report was prepared to document ambient concentrations of inhalable particulate matter less than 10 μm and 2.5 μm in diameter (PM_{10} and $PM_{2.5}$, respectively) in various communities in British Columbia as a step toward developing strategies to reduce emissions of PM and its precursors.

A comprehensive evaluation of ambient levels of $PM_{2.5}$ is hampered by a lack of data. A much longer record exists for PM_{10} for which a provincial air quality objective exists. Thus our knowledge of particulate matter in BC is based largely on PM_{10} monitoring augmented by limited measurements of $PM_{2.5}$.

Concentrations of PM within the province vary considerably from one community to the next. Spatial variations in PM concentrations are likely due to regional patterns in land use and industrial development, proximity of monitoring sites to PM sources, and regional differences in geography and meteorological conditions. Since concentrations of PM can vary widely over a small area, data from individual sites may not be representative of the air quality in the surrounding geographic area.

Based on data collected to the end of 2000, PM_{10} and $PM_{2.5}$ levels are highest in the interior of the province and lowest in coastal communities. PM levels exhibit strong seasonality that varies across the province and between PM_{10} and $PM_{2.5}$. Analysis of monthly variations in PM_{10} data shows two predominant seasonal patterns. In the Lower Fraser Valley (LFV), highest concentrations are observed during the late summer and lowest concentrations are found in the late fall and winter. At interior sites, the highest concentrations are typically observed in the late winter/early spring, and the lowest concentrations occur in early winter as well as in early summer. Data from $PM_{2.5}$ sites consistently indicate that the highest $PM_{2.5}$

concentrations occur during the fall. The Lower Fraser Valley sites also experience higher $PM_{2.5}$ concentrations during the late summer months, while lowest concentrations typically occur during the winter.

PM_{10} concentrations are usually lowest on Sunday, and mean mid-week PM_{10} concentrations are typically 30% higher than those on Sundays. Weekday/ weekend differences in excess of 50% are observed at sites in Prince George, Williams Lake, and Quesnel, suggesting that industrial/commercial sources are particularly significant in these communities. Relatively little day-to-day variation ($\pm$ 3 $\mu g/m^3$) was observed for $PM_{2.5}$ data, with mid-week concentrations typically higher than Sunday concentrations. Morning and evening peaks are evident in the hourly data, which shows that the diurnal variation in $PM_{2.5}$ is much less pronounced than that seen in PM_{10}.

Occasionally, meteorological conditions persist that produce extended periods of high PM_{10} concentrations in which the provincial ambient air quality objective of 50 $\mu g/m^3$ is exceeded. Episodes typically last between two and six days. In the interior, PM_{10} episodes are most likely to occur during February and March, although episodes have been reported in every month of the year. PM_{10} episodes occur very rarely in the Lower Fraser Valley and coastal regions of BC. Based on the limited $PM_{2.5}$ data available in the province, 9 of 11 $PM_{2.5}$ episodes have occurred in Prince George. $PM_{2.5}$ episodes are most frequent between September to February, with none occurring during the month of March, when PM_{10} episodes are most frequent in the province. The relatively short monitoring history at most sites precludes a robust trend analysis of PM_{10} or $PM_{2.5}$ data. Whereas PM levels do appear to be decreasing at a number of sites in the province, they remain at levels that are associated with increased risks of potential health effects.

1 Introduction

1.1 Purpose

Particulate matter (PM) is a component of smog and a form of air pollution for which significant adverse environmental and health effects have been identified. PM encompasses many different substances originating from a myriad of different sources. PM is usually categorized according to particle size. The term PM_{10} refers to particles with a nominal aerodynamic diameter ≤ 10 micrometres (μm), while $PM_{2.5}$ refers to a subset of PM_{10} representing particles with diameters ≤ 2.5 μm. Particles up to 100 μm in diameter are called total suspended particulate or TSP.

PM_{10} and $PM_{2.5}$ have been associated with a range of adverse health effects including hospitalization for lung and heart problems, increases in emergency room visits for lung problems, increases in days of restricted activity in adults and school absenteeism in children, increases in respiratory symptoms, and small reductions in measures of lung function. Increases in particle concentrations are also associated with increased risk of premature death. A review of medical studies has shown that there is no apparent lower threshold for adverse health effects related to PM_{10} or $PM_{2.5}$, and has prompted governments to review and strengthen air quality criteria for PM in order to reduce the risks to Canadians (WGAQOG, 1999a).

$PM_{2.5}$ also contributes to a degradation in visibility. All particles scatter light. However, particles with diameters near the wavelength of natural light (~0.4 to 0.7 μm) are particularly efficient at scattering light, resulting in a reduction in visual range, and affecting the colour, clarity and contrast of scenes (Malm, 2000).

This report summarizes PM_{10} and $PM_{2.5}$ ambient concentrations in British Columbia in an effort to guide the implementation of the Canada-wide Standard (CWS) for particulate matter. These data are analysed for temporal variations on annual, seasonal, hebdomadal and diurnal time scales. The report also examines episodes of elevated particulate during the 1990s and compares ambient concentrations during these events to provisional episode criteria. The report concludes by identifying information needed to support the preparation and implementation of emission reduction strategies aimed at achieving the national standard.

1.2 Regulatory Framework

1.2.1 Federal

Canada-wide Standards were established under the 1998 Canada-wide Accord on Environmental Harmonization of the Canadian Council of Ministers of the Environment (CCME) and its Canada-wide Environmental Standards Sub-Agreement. The CCME ratified the CWS for $PM_{2.5}$ in June 2000 in Quebec City. The agreement requires jurisdictions to develop implementation plans for achievement of the CWS by establishing and maintaining monitoring networks, producing air quality management plans and tracking progress. The $PM_{2.5}$ standard is 30 μg/m^3, where achievement is based on the annual 98th percentile 24-hour ambient measurement, averaged over three consecutive years. The standard is to be achieved by 2010 with requirements for periodic reviews and interim reporting beginning in 2005 (CCME, 2000).

Areas with ambient concentrations below the CWS are required to implement programs of continuous improvement and pollution prevention, and to adopt management programs to "Keep Clean Areas Clean." Jurisdictions will be required to take remedial and preventive actions to reduce emissions from anthropogenic sources to the extent practicable.

The new standard balances the need to minimize risks of particulate matter to human health and the environment with the near term technical feasibility and economic costs of attaining the standard. At the time that the CWS was established, the CCME recognized that whereas the CWS will reduce the impacts of $PM_{2.5}$ on human health, it will not be fully protective.

Concern about PM and its precursors was reinforced when the federal government declared PM_{10} a toxic substance under CEPA in May 2001, and announced its intent to add PM precursor gases (sulphur dioxide, nitrogen oxides, ammonia and volatile organic compounds) to the List of Toxic Substances in July 2000. Under CEPA, once a substance has been added to the List of Toxic Substances, the government must identify and implement risk management instruments for the substance. CWS implementation contributes to that control strategy. A proposed order to add these PM precursors to the List of Toxic Substances was published in Schedule 1 of the Canada Gazette in July 2002.

Finally, the federal government has committed to pursuing negotiations of a PM Annex under the Canada/U.S. Air Quality Agreement, which is anticipated in 2005.

1.2.2 British Columbia

The Ministry of Water, Land and Air Protection (WLAP) has primary responsibility for air management in the province of British Columbia (BC). The *Waste Management Act* provides WLAP with the authority to regulate emissions of atmospheric pollutants in BC. Tools used by the province to manage air quality include regulations, permits, fees, emission guidelines, air quality monitoring, emission inventories, air quality modelling, development of air quality objectives and emission standards, and public education and information. These activities also contribute to British Columbia's obligations under federal legislation and several international agreements. The provincial government works closely with municipalities and regional districts to develop airshed management plans in parts of the province where serious air quality problems exist. Under its Threatened Airsheds Initiative, the province has further committed to improving air quality in BC communities. Stakeholder feedback on clean air issues raised as part of the *Waste Management Ac*t Review (wlapwww.gov.bc.ca/epd/waste_mgt_review) will be considered in the development of an airshed improvement plan. Stakeholder consultation on clear air issues took place in early 2003.

Air pollution control activities in the Greater Vancouver area are delegated to the Greater Vancouver Regional District (GVRD) under the provincial *Waste Management Act*. In the early 1990s, the GVRD developed a comprehensive Air

Quality Management Plan to address the complex air pollution issues facing this large urban airshed (GVRD, 1994). A new plan is under development as part of the GVRD's Sustainable Region Initiative. Similar activities are underway for the Fraser Valley Regional District (FVRD).

In the Lower Fraser Valley, air quality management activities are coordinated through the Lower Fraser Valley Air Quality Coordinating Committee whose member organizations include the GVRD, Fraser Valley Regional District (FVRD), BC Ministry of Water, Land and Air Protection (WLAP), Environment Canada, and Northwest Air Pollution Authority in Washington State.

In 1995, the province adopted an ambient air quality objective for PM_{10} of 50 μg/m^3 (micrograms per cubic metre), based on a 24-hour averaging period. This criterion is employed in the air quality index (AQI), which is updated hourly in various communities across the province where real-time PM_{10} data are available. No provincial objective currently exists for $PM_{2.5}$.

2 Properties and Adverse Effects of PM

2.1 Particle Size and Formation Processes

Particle size is an important characteristic of PM as it affects atmospheric residence times and removal processes. Particles are generally found in three naturally occurring size distributions or modes. The nucleation mode consists of very fine particles that are less than 0.1 μm in diameter. These particles are formed by gas-to-particle conversion and have very short lifetimes because they quickly coagulate to form larger particles. Accumulation mode particles (0.1 to 1.0 μm in diameter) form from this coagulation process as well as from condensation on nuclei. The largest particles, called coarse mode particles, are typically 2 to 10 μm in diameter and are often produced from mechanical processes such as grinding, crushing and erosion. A more complete discussion of the physical characteristics of PM and its atmospheric processes may be found in MSC (2001).

By convention, particles are classified into two size groups: PM_{10} ($\leq$ 10 μm) and $PM_{2.5}$ ($\leq$ 2.5 μm). As shown in Figure 1, particles in the 2.5 to 10 μm size range are called the coarse fraction of PM_{10}, while those smaller than 2.5 μm are referred to as the fine fraction.

Particles in the coarse fraction are efficiently removed by gravitational settling and are therefore short-lived in the atmosphere – on the order of hours to days. $PM_{2.5}$, on the other hand, often remains suspended in the atmosphere for days to weeks and is eventually removed by dry deposition onto the surface or by scavenging from the atmosphere by precipitation.

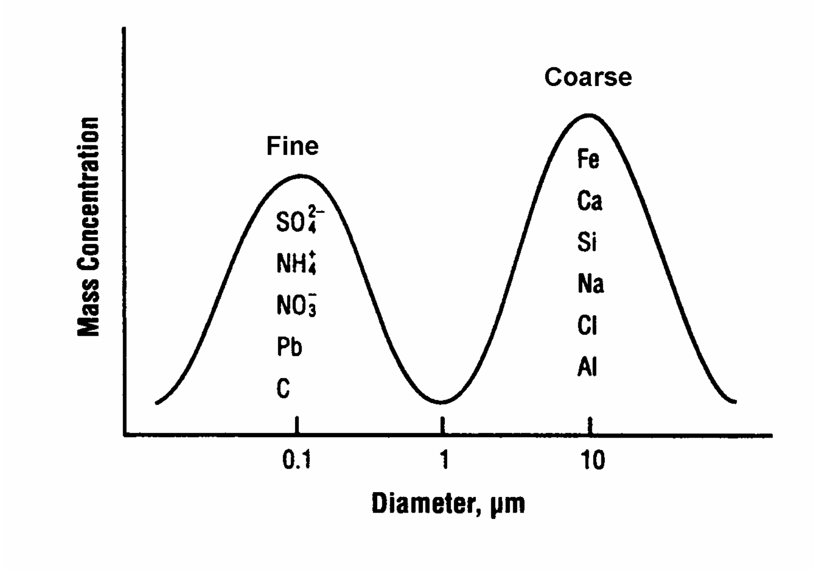


Figure 1 Size distribution of particulate matter. The fine fraction refers to PM less than 2.5 μm while the coarse fraction generally lies between 2.5 and 10 μm. Based on Seinfeld (1986).

2.2 Sources of PM and PM Precursors

The sources of PM are many and varied. PM is emitted by natural sources and anthropogenic (i.e. human-caused) activities. Natural sources include forest fires, windblown soil, volcanic dust, sea spray, pollen, spores and bacteria. Associated particles are typically found in the coarse fraction, although forest fires produce predominantly fine particles. Anthropogenic activities that emit PM include fossil fuel combustion (motor vehicles, electric power plants, space heating), industrial processes, prescribed burning, wood stoves, and fugitive dust from roads, construction sites and agriculture. PM derived from fossil fuel or biomass combustion is predominantly composed of fine particles, whereas fugitive dust is characterized by coarse particles.

Particles can further be distinguished between primary and secondary particles. Primary particles are emitted directly into the atmosphere. They may be fine or coarse, and from biogenic or anthropogenic sources. Secondary particles are formed from physical or chemical transformations that occur in the atmosphere, and are most often found in the fine fraction. Precursor gases involved in secondary formation include sulphur dioxide (SO_2), oxides of nitrogen (NO_x), ammonia (NH_3) and various hydrocarbons referred to as volatile organic compounds (VOCs). There are linkages between the formation of secondary sulphate, nitrate and organic compounds that must considered in the development of control measures for secondary PM. For a detailed description of the chemical pathways involved, see MSC (2001).

Primary PM - Annual 1995 emissions of primary PM_{10} and $PM_{2.5}$ (excluding road dust[1]) are summarized in Figure 2(a) for the LFV and Figure 2(b) for the rest of the province (MELP, 1999). A detailed breakdown of emissions is provided in Appendix I. Within the Lower Fraser Valley, PM_{10} emissions are split fairly evenly between point (40%), area (32%) and mobile sources (24%). Natural emissions account for a relatively small amount (4%). In contrast, mobile sources account for the greatest amount of $PM_{2.5}$ emissions (37%), followed by point (35%), area (26%) and natural sources (2%). Outside of the Lower Fraser Valley, relative contributions from natural sources increase significantly and those from mobile sources decrease compared to what is found in the Lower Fraser Valley. PM_{10} emissions are split between point (41%), natural (27%), area (20%), and mobile (12%). $PM_{2.5}$ emissions are distributed between point (39%), natural (25%), area (22%) and mobile sources (14%).

A more detailed breakdown of the anthropogenic sources of PM_{10} and $PM_{2.5}$ emissions (excluding road dust) is presented in Figure 3 (MELP, 1999).

---

[1] Road dust estimates were excluded due to the large uncertainties associated with these numbers. However, based on estimates for 1995, road dust accounted for 47% of total PM_{10} and 28% of $PM_{2.5}$ emissions in the Lower Fraser Valley, and 47% of total PM_{10} and 17% of total $PM_{2.5}$ in the rest of the province. Of the road dust contributions, emissions from unpaved roads accounted for 47% of the PM_{10} emissions and 17% of the $PM_{2.5}$ emissions outside of the Lower Fraser Valley. Road dust emissions within the Lower Fraser Valley were assumed to be from paved roads only.

a) The Lower Fraser Valley.

(b) BC excluding the Lower Fraser Valley.

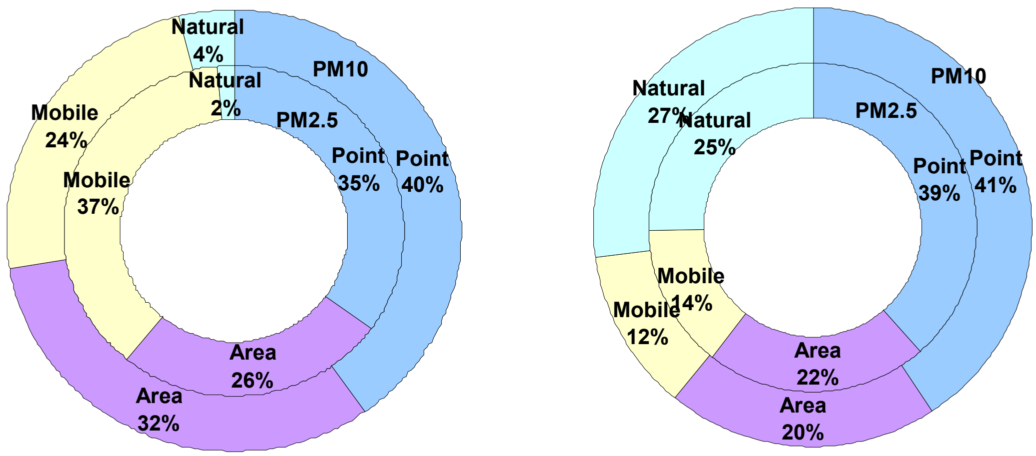


Figure 2 Sources of PM_{10} (outer ring) and $PM_{2.5}$ (inner ring) (a) within the Lower Fraser Valley, and (b) within BC but excluding the Lower Fraser Valley (MELP, 1999).

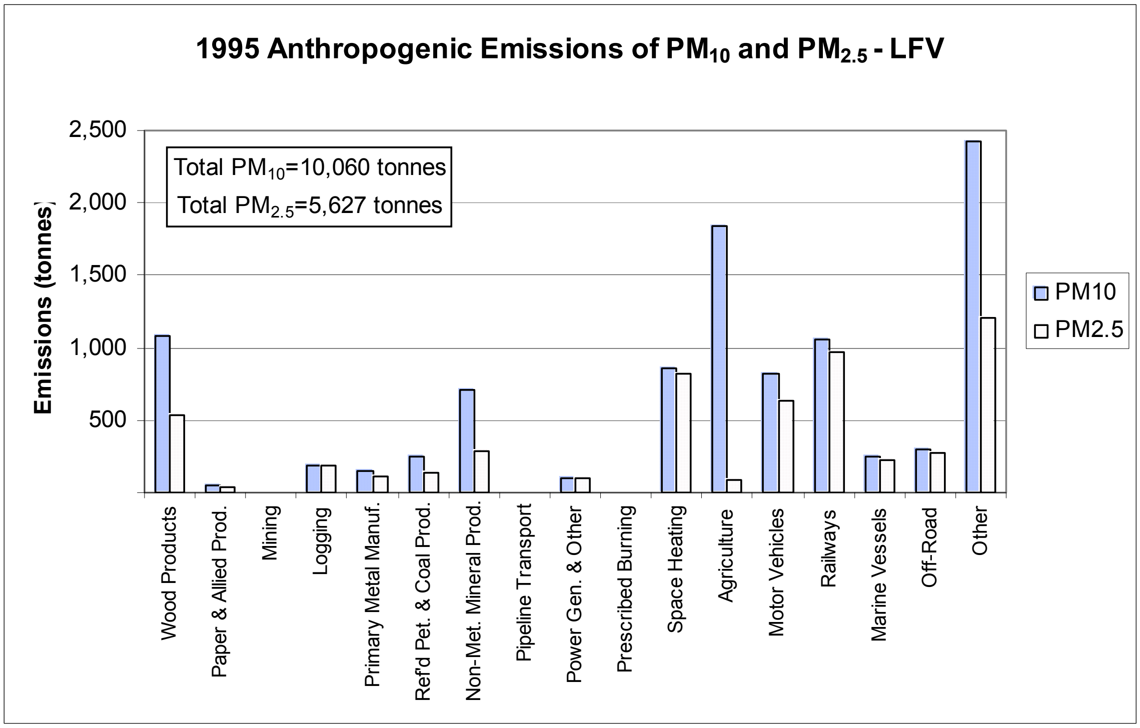
In the Lower Fraser Valley, agriculture is the largest source sector of PM_{10} emissions (18%), followed by the railways (10%), the wood products industry (10%),and space heating (8%). In contrast, agriculture is a minor contributor to $PM_{2.5}$ emissions (2%). Railways (17%) are the largest source, followed by space heating (14%), motor vehicles (11%), and the wood products industry (9%). This mix of sources reflects the complex nature of developing control programs in this and other regions of the province, as the management of the identified sources have traditionally fallen under the jurisdiction of three different levels of government: transportation – federal and provincial governments; point sources – provincial government (and the GVRD within its boundaries); commercial/residential space heating – regional or local government.

Outside the Lower Fraser Valley, anthropogenic PM_{10} and $PM_{2.5}$ emissions are predominantly from the forestry sector, with a combined 59% of PM_{10} emissions and 58% of $PM_{2.5}$ emissions resulting from the wood products industry, the paper and allied products sector, logging and prescribed burning. Railways and space heating account for a further 12 and 9% of PM_{10} emissions and 14 and 11% of $PM_{2.5}$ emissions, respectively. Motor vehicles account for less than 2% of both PM_{10} and $PM_{2.5}$ emissions.

Secondary PM - Although the provincial emissions inventory does not provide estimates of secondary PM formation, relative contributions from primary sources may be inferred from precursor emissions of SO_x, NO_x, VOCs, and NH_3. Emissions of SO_x, NO_x, and VOCs from specific source sectors in the Lower Fraser Valley and the rest of the province are presented in Figure 4 (MELP, 1999). Detailed estimates may be found in Appendix I. Anthropogenic precursor emissions within the Lower Fraser Valley are characterized by large contributions of NO_x (48%) and VOC (43%) emissions from the motor vehicle sector. Other NO_x sources include marine vessels (10%), the non-metallic mineral products sector (i.e. cement plants – 10%), marine vessels (9%), railways (8%) and space heating (7%). Solvent evaporation is the only other significant source of anthropogenic VOC emissions (26%). SO_x emissions are small in magnitude relative to NO_x and VOC. The refined petroleum and coal products sector is the largest source (39%), followed by marine vessels (21%). Contributions from natural sources such as wildfires and vegetation are not shown in Figure 4, but account for less than 1% of total NO_x and SO_x emissions, and 27% of total VOC emissions in the region.

Outside the Lower Fraser Valley, emissions of SO_x are more comparable with those of NO_x and VOCs, and there is a greater distribution of precursor emissions among various source sectors. However, transportation is clearly the largest source of anthropogenic NO_x emissions, as evidenced by contributions from marine vessels (27%), motor vehicles (22%), and railways (13%).[2]

[2] Clearly, there will be some degree of spatial variation in the distribution of emissions among emission sources, as highlighted by the large NO_x contributions from marine vessels. A detailed analysis of spatial emission patterns is beyond the scope of this report.



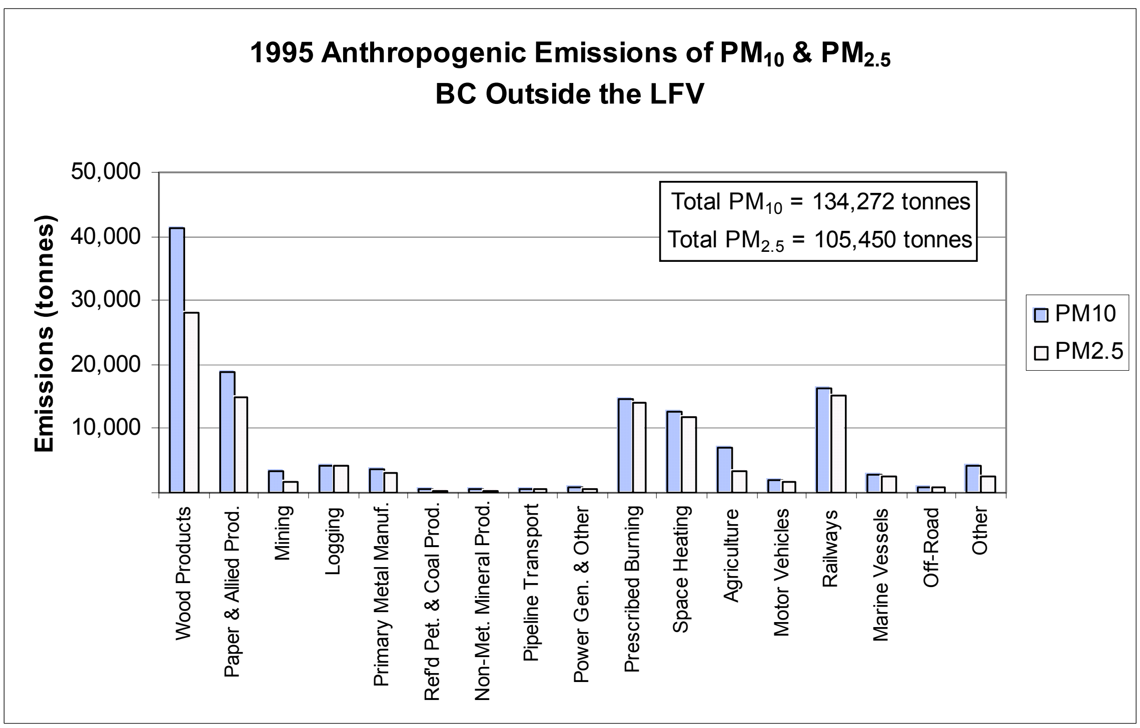
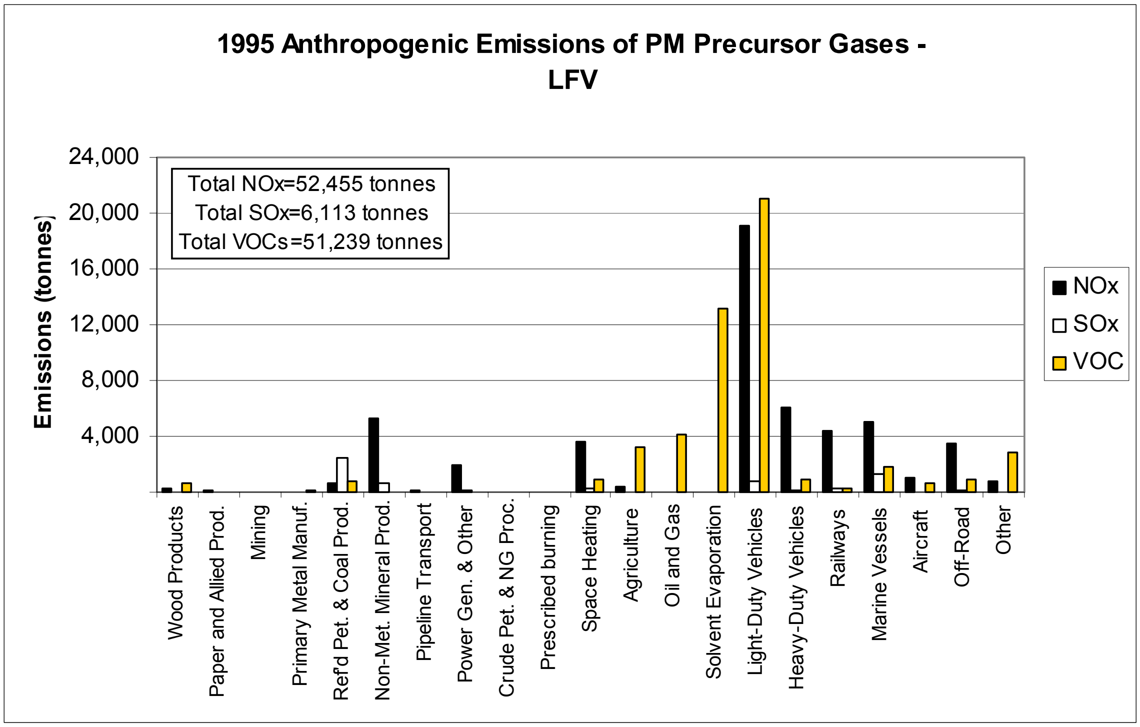


Figure 3 Annual 1995 emissions of primary PM_{10} and $PM_{2.5}$ for (top) the Lower Fraser Valley and (bottom) the rest of BC outside the Lower Fraser Valley (MELP, 1999). Road dust estimates are excluded.



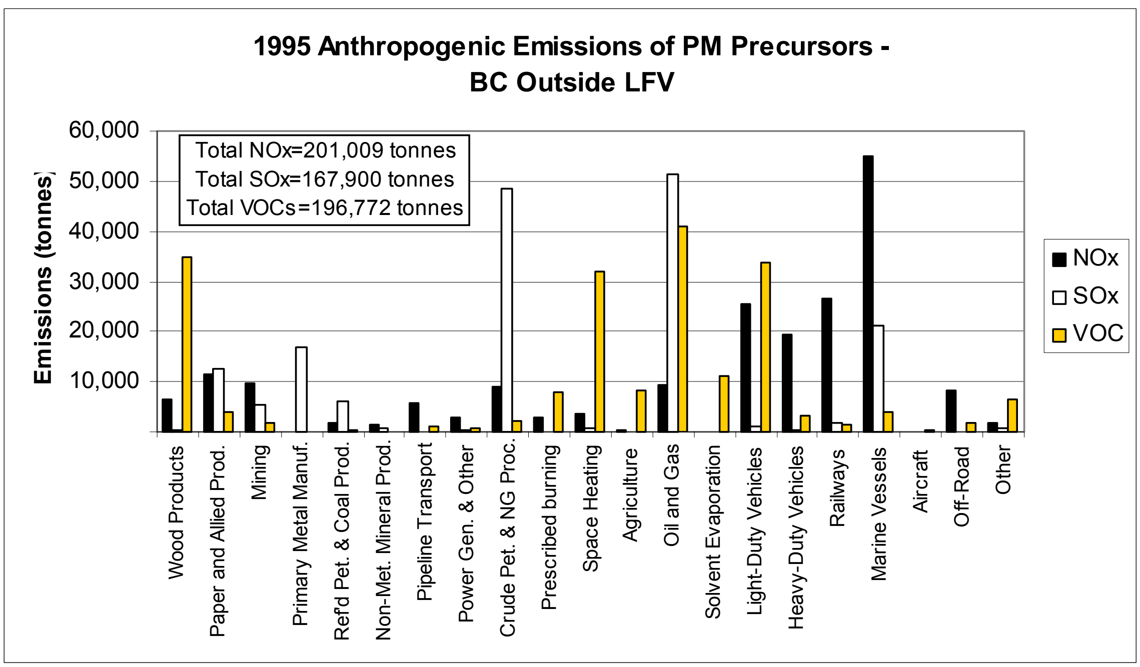


Figure 4 1995 emissions of PM precursors from anthropogenic sources (top) in the Lower Fraser Valley and (bottom) outside of the Lower Fraser Valley (MELP, 1999).

Anthropogenic VOC emissions are distributed among the oil and gas sector (21%), the paper and allied products sector (18%), motor vehicles (19%) and space heating (16%). SO_x emissions are predominantly from the oil and gas sector (30%) and the crude petroleum and natural gas processing sector (29%).

Additional sources include marine vessels (12%) and primary metal manufacturing (10%). Although not presented in Figure 4, it is important to note that natural sources are a significant source of VOC emissions, accounting for approximately 93% of total estimates. Emissions from natural NO_x sources are small by comparison, accounting for only 6% of total NO_x emissions. Ammonia is primarily associated with agriculture, although emissions from catalytic converters in motor vehicles are a growing concern (Buijsman et al., 1987; Sutton et al., 1995**)**. Detailed provincial emission estimates compiled by Environment Canada are found in Appendix II (Source: http://www.ec.gc.ca/pdb/ape/ape_tables/NH95_e.cfm).

Open sources, predominantly animal livestock, account for 68% of total provincial emissions. Miscellaneous sources such as pesticide and fertilizer application contribute a further 17%. Transportation sources (predominantly motor vehicles) account for 9% of provincial ammonia emission estimates.

Not reflected in the annual emission estimates is the fact that most emission sources are subject to seasonal cycles that affect emissions of pollutants. For example, the "burning season" in the interior of BC is a period from September to November when summer burning restrictions are lifted. During this period, homeowners, farmers and forestry workers burn residual material accumulated over the summer, subject to limits established by regulations and bylaws. Road dust is a major issue in the early spring in many interior communities, when roads are cleaned of traction material that has accumulated over the winter. In winter, lower temperatures drive up heating requirements resulting in higher fuel consumption and therefore higher emissions.

2.3 Chemical Composition

As a consequence of the different mechanisms by which they are formed, the chemical compositions of the fine and coarse fractions are markedly different. The coarse fraction is characterized by elements derived from the earth's crust, and is therefore rich in oxides of silicon, aluminum, iron and calcium. In contrast, the fine fraction is largely composed of organic and inorganic carbon compounds, sulphates, nitrates, ammonium, and various trace metals such as lead and cadmium.

The carbon compounds and trace metals are typically associated with high-temperature fuel combustion, such as motor vehicles, space heating, and industrial processes. Sulphates, nitrates, ammonium and some organic compounds reflect secondary PM formation, in which various precursor gases react in the atmosphere to form PM. Information on particle size and composition can be used to infer the sources of PM.

2.4 Background PM Concentrations

Little information exists on natural background levels of PM in Canada since most monitoring occurs in urban centres. A study of six remote rural locations in Alberta showed PM_{10} concentrations in the range of 2.9 to 12.0 $\mu g/m^3$ with a mean value of 8.8 $\mu g/m^3$, and $PM_{2.5}$ concentrations between 1.7 to 3.8 $\mu g/m^3$ with an average of 3.2 $\mu g/m^3$ (Cheng et al., 2000). $PM_{2.5}$ concentrations measured at rural sites in eastern Canada while under northerly transport conditions ranged from 4.1 $\mu g/m^3$ at Egbert, Ontario to 6.1 $\mu g/m^3$ at St. Anicet, Quebec (Brook et al., 2002a). In the western United States, natural background levels of 4 to 8 $\mu g/m^3$ have been reported for PM_{10}, and 1 to 4 $\mu g/m^3$ for $PM_{2.5}$ (US EPA, 1996).

Data from the National Air Pollution Surveillance (NAPS) network from 1984 to 1995 show that most Canadian cities experience mean 24-hour PM_{10} concentrations in the range of 20 to 30 $\mu g/m^3$, and concentrations of 8 to 20 $\mu g/m^3$ for $PM_{2.5}$ (WGAQOG, 1999a).

2.5 Human Health Effects

From the perspective of human health, it is the inhaled concentration that is important. Deposition of particles in the respiratory tract is largely influenced by particle size. Very coarse particles are filtered by the nose and upper airways, whereas $PM_{2.5}$ is small enough to penetrate deeply into the lungs (WGAQOG, 1999a). Once deposited in the lungs, it is not conclusive whether it is the size, mass, number or chemical composition of particles that results in its toxicity. However, there are suggestions that $PM_{2.5}$ and sulphate are more toxic than PM_{10} in inducing mortality and morbidity (WGAQOG, 1999a). The ultra-fine component appears to be important, due to the large number and slow clearance rates associated with these particles. Furthermore, recent studies (e.g. Godleski et al., 1998; Suwa et al., 2002; Pope et al., 1999; Gold et al., 2000; Brook et al., 2002b; Peters et al., 1999) have suggested a link between PM concentrations and increased risks of heart disease and stroke.

Based on evidence from epidemiological studies, the effects of exposure to PM_{10} and $PM_{2.5}$ concentrations are reflected in:

- increases in mortality due to cardio respiratory diseases,
- increases in hospitalization due to cardio respiratory diseases,
- decreases in lung function in children and asthmatic adults,
- increases in respiratory stresses that can lead to absenteeism from work or school and a restriction in activities, and
- chronic effects including reduced lung function and capacity in children, increases in development of chronic bronchitis and asthma in some adults, and reduced survival.

Those most susceptible to PM-related health impacts include children, the elderly, asthmatics, and people with pre-existing cardio respiratory disease.

Health impacts have been shown to begin at very low concentrations, and to increase with PM concentrations (the so-called *continuum of effects*). A safe threshold, below which there are no health impacts, has not been demonstrated. Recognizing that potential health risks are occurring at air quality levels below existing air management criteria, the Federal-Provincial Working Group on Air Quality Objectives and Guidelines identified reference levels of 25 $\mu g/m^3$ (24-h average) for PM_{10} and 15 $\mu g/m^3$ (24-h average) for $PM_{2.5}$ (WGAQOG, 1999b). These reference levels represent estimates of the lowest ambient PM levels at which statistically significant increases in health effects have been demonstrated, based on the current state of knowledge. They are not to be interpreted as effects thresholds, nor are they intended to be used as management targets.

PM-related health risks may be characterized by a “pyramid of effects”, as shown in Figure 5. Although mortality represents the most severe health endpoint, a greater number of people will suffer from less severe symptoms such as reduced lung function and increased coughing. As an example, Vedal (1995) estimated that increases in PM_{10} cause in the order of 80 premature deaths in BC every year, 150 hospitalizations due to asthma, lung and heart disorders and 350 extra emergency room visits for asthma, chronic bronchitis or emphysema. Increased risks of dying were associated with levels of PM_{10} presently found in many towns and cities in BC.

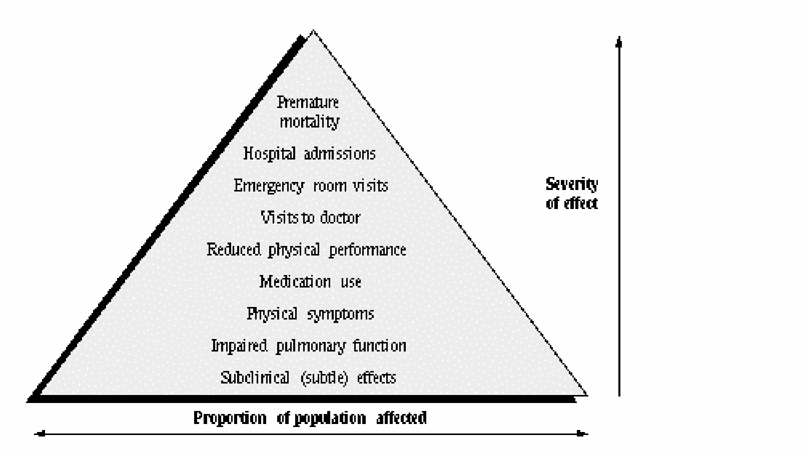


Figure 5 The health effects pyramid. The most adverse effects occur in a small portion of the population, however, large numbers of people suffer from less severe symptoms. Source: Health Canada. www.hc-sc.gc.ca/hecs-sesc/air_quality/definitions.htm

2.6 Visibility Impairment

To many in the general public, poor visibility is an indicator of poor air quality. It affects quality of life, poses transportation safety problems, and has direct economic costs associated with the potential loss of revenue from tourism (McNeill et al., 2001).

Visibility is actually a function of a number of diverse factors, including the presence of particles and gases that alter the passage of light through the atmosphere; psychophysical processes such as form, contrast detail and the colour of near and distant features; and concurrent value judgments. However, reduced visibility is generally a function of particles in the atmosphere. Light scattering efficiency is greatest when particle diameter is close to the wavelength of natural light (~0.4 to 0.7 μm). Consequently, the fine fraction of PM contributes disproportionately to visibility impairment (Malm, 1999). Sulphates and nitrates are of special relevance to reduced visibility, as these particles are *hygroscopic*, meaning that they absorb water from the atmosphere and therefore increase in particle size once a threshold level of relative humidity is exceeded. These larger hydrated particles then scatter light more efficiently.

Two intensive field studies known as REVEAL (Regional Visibility Experimental Assessment in the Lower Fraser Valley) and REVEAL II were carried out by the province and the FVRD between 1993 and 1995 (Sakiyama, 1994; Pryor et al., 1995, 1999, 2000). The goals of the REVEAL studies were to characterize aerosol and visibility conditions in the Lower Fraser Valley, and to provide information regarding the sources and effects of existing aerosol concentrations. Results were based largely on observations taken at sites in the Lower Fraser Valley, including Pitt Meadows (located approximately 30 km east of Vancouver), Clearbrook (near Abbotsford in the central part of the valley), and Chilliwack (located in the eastern part of the valley).

The REVEAL studies concluded that visibility in the Lower Fraser Valley is frequently degraded below publicly acceptable levels. While organic carbon compounds accounted for much of the $PM_{2.5}$ mass, nitrates and sulphates formed in the atmosphere were the largest contributors to reduced visibility.

In the interior of the province, a five-year study into visibility degradation was conducted in Kootenay National Park near Radium Hot Springs during the late 1990s. The frequency of days with impaired visibility determined from photographs and nephelometer[3] data was calculated to identify the nature and the likely cause of visibility impairment in the area. Preliminary analysis indicates visibility at this site is reduced by haze, which is regional in extent, and from local sources, the largest being a beehive burner. The regional haze is predominant in spring, summer and fall under stable atmospheric conditions and especially during forest fire season. Local smoke from the beehive burner as well as residential wood stoves lowers visibility mainly in winter under stable atmospheric conditions that produce temperature inversions (Evans et al., 1998).

---

[3] Nephelometers measure the scattering ability of particles and gases in the atmosphere. The scattering coefficient b_{scat}, which is derived from these data, can be used to determine estimates of visibility measures such as visual range.

3 PM Sampling in British Columbia

PM sampling in British Columbia is undertaken by WLAP, except in the Lower Fraser Valley where it is done by the GVRD. Ambient PM data from both networks are archived in the provincial database. The federal government also conducts limited PM_{10} and $PM_{2.5}$ monitoring in the Lower Fraser Valley and Victoria as part of their NAPS network.

3.1 Sampling Methodology

Particles are collected within appropriate size categories using samplers equipped with inlet heads that are specially designed to separate out larger particles. The inlet heads are defined by their 50% cutpoint (d_{50}), which is the particle size at which the sampler collects 50% of the sample and rejects 50% of the sample. For example, PM_{10} samplers have a d_{50} of 10 µm. Particles larger than 10 µm can be captured, but at progressively lower efficiencies. In light winds, an acceptable PM_{10} sampler must collect 45% to 55% of PM mass with aerodynamic equivalent diameters of 9.5 to 10.5 µm (40 CFR Part 50.6).

Different methods are available to fractionate the sample stream on the basis of particle size (Chow, 1995). They include direct impaction, virtual impaction and cyclonic flow. In direct impactors, the air stream is drawn through a series of nozzles and directed toward a flat impaction plate. Heavier particles stick to the impaction plate while smaller particles continue in the stream. In virtual impactors, the impaction plate is replaced with an opening that directs larger particles to one sampling substrate and the smaller particles to another. Cyclonic flow inlets use impellers to impart a circular motion to the inlet air stream. The air stream then enters a cylindrical tube, where centripetal force pushes more of the particles towards the walls of the tube. Particles either stick to the wall, or drop into a hopper at the bottom of the tube. Cyclonic flow inlets generally have a higher loading capacity than impactor surfaces, due to larger collection area and availability of the hopper.

3.2 Provincial Network

The provincial PM sampling network consists of a mix of manual (non-continuous) and continuous samplers. The manual sampler represents the traditional gravimetric filter approach. The continuous sampler, which uses an indirect estimation of PM mass, is finding widespread application due to its ease of operation and ability to provide real-time measurements. Both methods are described in the following.

3.2.1 Manual Samplers

The manual sampler draws air through a pre-weighed filter for a specified period (usually 24 hours) at a known flowrate. The filter is then removed and sent to a laboratory to determine the gain in filter mass due to particle collection. Ambient PM concentration is calculated on the basis of the gain in filter mass, divided by the product of sampling period and sampling flowrate. Additional analysis can also be performed on the filter to determine the chemical composition of the sample.

Two types of manual samplers are presently used in the WLAP and GVRD networks: the size-selective inlet (SSI) high-volume sampler and the Partisol sampler. The SSI sampler is manufactured by Andersen, and uses an impactor inlet. The sampler is operated at a flow rate of 1132 L/min. Samples are collected on a Teflon-coated glass fibre filter. The Partisol sampler is manufactured by Rupprecht and Patashnick (R&P). Partisols are used primarily for $PM_{2.5}$ sampling in the province. Most of the Partisol units in the province are equipped with URG cyclone inlets, with R&P Sharp Cut Cyclone (SCC) inlets introduced at a limited number of sites beginning in 2000.[4] Flow is controlled at 16.7 L/min.

Manual sampling in the province is carried out according to the NAPS protocol which typically specifies a sampling frequency of one day in six. Sampling is done on the same day consistently for all networks in North America. A maximum of 61 samples is obtained each year, and over a long period of time, each day of the week

[4] The SCC inlets have been found to provide better accuracy. Performance tests have also shown that the SCC inlets collect fewer particles greater than the 50% cutpoint of 2.5 µm. As a result, it is anticipated that measurements obtained using SCC inlets will be lower than equivalent measurements made using URG cyclone inlets.

is sampled equally. Post-2000, sampling frequency has been increased to one-in-three days at certain sites to improve temporal resolution.

3.2.2 Continuous Samplers

In recent years, a program of continuous sampling using automatic samplers has been introduced. An instrument widely adopted for this use is the Tapered Element Oscillating Microbalance (TEOM). The TEOM operates under the following principles. Ambient air is drawn in through a heated inlet. It is then drawn through a filtered cartridge on the end of a hollow, tapered tube. The tube is clamped at one end and oscillates freely like a tuning fork. As particulate matter gathers on the filter cartridge, the natural frequency of oscillation of the tube decreases. The mass accumulation of particulate matter is then determined from the corresponding change in frequency. The PM_{10} monitors are equipped with either R&P or Andersen impactor inlets. As of the end of 2000, most $PM_{2.5}$ monitors were equipped with URG cyclones, with limited deployment of the SCC heads (see footnote 4).

A recognized problem with the TEOM is that some particle mass is likely volatilized from the sample because the air stream and filter are heated to remove free water and to standardize sampling conditions (Meyer et al., 1992; Meyer et al., 1995). This feature can be problematic in areas impacted by wood smoke or ammonium nitrate, which are readily volatilized. To reduce the potential for volatilization, operating temperatures were reduced from 50°C to 40°C at all provincial TEOM sites as of January 1, 1998. Further consideration is being given to an operating temperature of 30°C for instruments equipped with a Nafion dryer and operating in nitrate-impacted areas (B. Bevan, pers. comm.)

Real-time PM_{10} measurements are incorporated into the Air Quality Index, which provides a measure of air quality to the general public. Hourly PM_{10} and $PM_{2.5}$ data are also used to investigate diurnal patterns of PM, and are used in conjunction with meteorological data to study the relationship between weather conditions and PM concentrations.

3.2.3 Monitoring Sites

Ambient PM levels are measured to establish ambient levels of pollutants, and to determine what concentrations the inhabitants in various communities in British Columbia are exposed to. Monitoring enables regulators and policy makers to identify the air quality impacts of current sources, and to determine the impacts of new sources or emission control measures. Monitoring over longer periods allows communities to assess trends in the data to determine whether air quality is getting better or worse.

The monitoring history of PM_{10} and $PM_{2.5}$ in the province is summarized in Appendix III. The PM_{10} sampling program is well established, with a period of record extending back to the 1980s. The combined WLAP and GVRD provincial monitoring network currently consists of nearly 100 PM_{10} sites of which roughly 50 are continuous and another 50 are manual. The $PM_{2.5}$ monitoring network is less well-developed, with 14 TEOM instruments operating as of the end of 2000. The longest $PM_{2.5}$ TEOM monitoring record is for Chilliwack, which dates back to June 1995. Four other sites have at least three complete years of $PM_{2.5}$ data as of the end of 2000. Maps of PM_{10} and $PM_{2.5}$ monitoring sites are shown in Figures 6 and 7 respectively.

PM measurements are strongly influenced by the proximity of the sampler to emission sources. Accordingly, the data from a given sampler may not be representative of the ambient air quality of the community as a whole. Further, regional scale events such as forest fires or even hemispheric scale phenomena like “Kosa” dust events originating in Asia can also have an impact on ambient concentrations of PM in a community (McKendry *et al.*, 2001).

3.3 NAPS Network

Environment Canada, in cooperation with the province and the GVRD, has been measuring PM with dichotomous samplers at sites in Vancouver and Port Moody since 1984 and in Victoria since 1985, with some interruptions due to changes in station location (Dann, 1994).

The dichotomous samplers are manufactured by Graseby-Andersen. They are equipped with an inlet characterized by a 10 µm cutpoint. Particles entering the sampler are divided into two size fractions by a virtual impactor: a fine fraction containing particles less than 2.5 µm in diameter (i.e. $PM_{2.5}$) and a coarse fraction containing particles greater than 2.5 µm in diameter. Samplers are operated at a flow rate of 16.7 L/min. Particles are collected on 37 mm polyolefin ring supported Teflon membrane filters manufactured by Gelman Sciences (2 µm pore size). The samplers are typically run for a 24-hour period once every six days. However, a three-day sampling schedule was used at the Vancouver site from January 1985 to January 1986, and at the Port Moody site from January 1985 to December 1988.

3.4 Speciation Sampling

Chemical speciation of PM samples is not typically done on a routine basis at provincial monitoring sites. However, sites in and around Trail have been monitored for a suite of metals since 1990, and PM samples collected in Prince George (Plaza 400) are routinely monitored for sulphate content. Analyses are based on filter samples taken from conventional manual samplers. Samples collected at NAPS stations in Kitsilano, Port Moody and Victoria are also subject to analysis for a number of elements, sulphate, nitrate, and various anions and cations (Dann, 1994). Short-term studies have been carried out in a limited number of communities, including Victoria, Duncan, Lumby and Creston (Bartlett, 1993); Quesnel (Plain and Carmichael, 1998); Prince George (Breed, 1998); Burnaby (Cui and Beech, 1997); and the Lower Fraser Valley during REVEAL and REVEAL II (Sakiyama, 1994; Pryor and Steyn, 1994; Pryor and Barthelmie, 1996). Detailed chemical speciation performed for the REVEAL and REVEAL II samples supported subsequent source apportionment studies (Lowenthal et al., 1994; Pryor and Steyn, 1994).

(a) PM_{10} TEOM sites

(b) PM_{10} SSI and Partisol sites

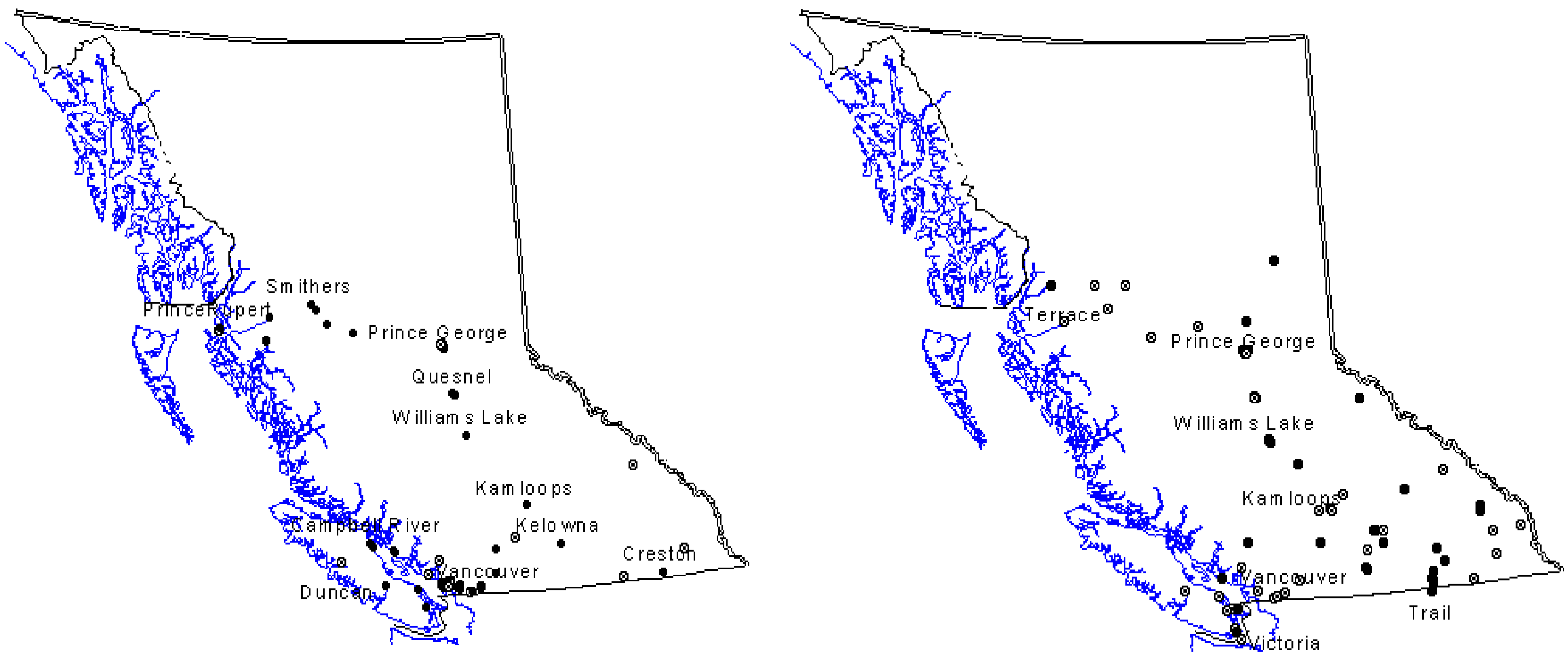


Figure 6 PM_{10} monitoring sites in BC including (a) TEOM and (b) SSI and Partisol sites. Dark and light circles represent active and closed sites, respectively.

(a) $PM_{2.5}$ TEOM sites (b) $PM_{2.5}$ Partisol sites

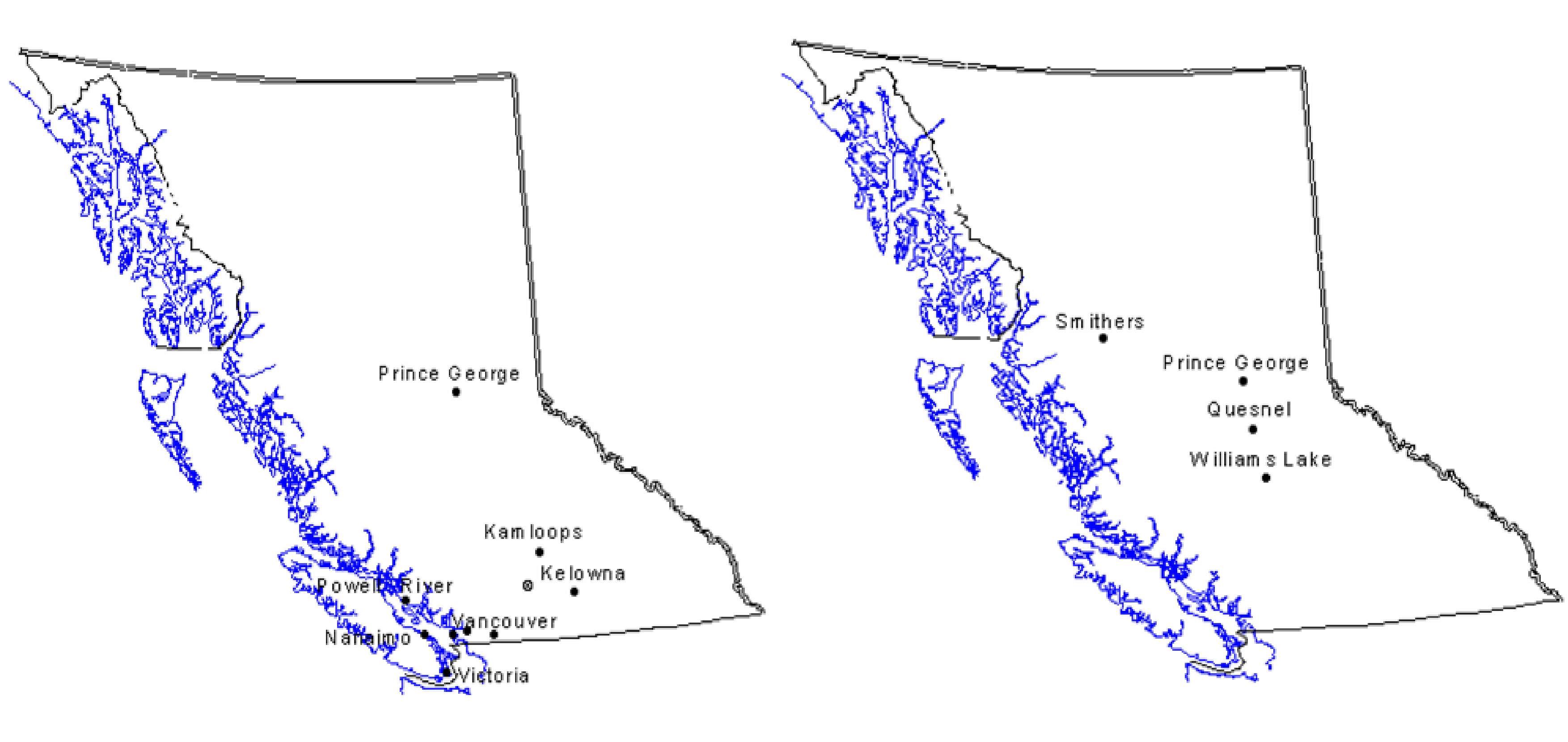


Figure 7 $PM_{2.5}$ monitoring sites in BC including (a) TEOM and (b) Partisol sites. Dark and light circles represent active and closed sites, respectively.

3.5 Data Quality Assurance and Analysis Techniques

Provincial monitoring guidelines have been developed for non-continuous samplers (MELP, 1996). They establish minimum requirements for instrument siting, installation, operation and calibration. Continuous monitors are operated according to U.S. EPA guidelines (U.S. EPA, 1998).

As part of the provincial air audit program, all continuous PM monitors are audited at least once per year by the provincial air audit team. In addition, non-continuous samplers are regularly calibrated, maintained and operated by regional ministry staff, contractors and permittees. The GVRD follows the same maintenance and inspection procedures as the Province.

Prior to May 2000, gravimetric (weight) analyses on filter samples, and where requested, analyses for sulphates, elements and ions, were conducted at Philip Analytical Services Inc. of Burnaby, BC. Between May and December 2000, analyses were then conducted at the Pacific Environmental Science Centre (PESC) in North Vancouver.[5] Analytical techniques at both facilities were based on guidelines developed by the ministry in conjunction with Philip Analytical Services Inc. (MELP, 1998a).

Techniques for $PM_{2.5}$ gravimetric analysis at the Philip and PESC laboratories do not meet U.S. EPA protocols. In particular, both facilities lack a clean room, which is required to achieve the detection limits that the U.S. EPA specifies. It is estimated that $PM_{2.5}$ filter measurements are accurate to only +/- 4 $\mu g/m^3$ (E. Tradewell, pers. comm.). The dichotomous samplers operating at NAPS sites are subject to period audits by Environment Canada staff using reference flow control devices (Dann, 1994). Filters are analyzed at Environment Canada's Environmental Technology Centre in Ottawa, Ontario. Mass measurements are made using a Mettler M3 or Mettler MT5 electronic microbalance. Elemental analysis is conducted using nondestructive X-ray fluorescence. A multidimensional

[5] The provincial contract for laboratory services with PESC expired December 31, 2000. the current laboratory contract is with Philip Analytical Services Inc.

ion chromatographic (IC) system (Dionex) is used to analyze the 14 anions and 11 inorganic cations in water extracts (isopropanol wetting agent). Four IC methods are used: anion isocratic, anion gradient with and without concentrator column and cation gradient (Brook et al., 1997).

Data from all manual and most continuous samplers are archived in a central database operated by the ministry. An exception is the data from dichotomous samplers, which are managed by Environment Canada. The archived ministry data represent all data that have met internal screening criteria. Problems are known to exist in the PM archive that may potentially affect the statistical distributions and trend analyses presented in this report. For example, before 1997, all data below the minimum detection limit (MDL) were archived as zero. This procedure was changed for subsequent years such that the actual values below MDL are now being recorded. This will affect the lowest percentiles of the data distributions for years before 1997, but this bias is small and not likely significant for health effects (Robert Marsh, pers. comm.). Some of the data also suffer from inconsistencies due to changes in instruments or operating procedures associated with the evolution of monitoring technology. More recently, the offset factor of 3.0 and the adjustment factor of 1.03 were removed from all archived $PM_{2.5}$ TEOM data.[6] The information presented in this report was based on analysis prior to this adjustment, so changes in the record not attributable to actual changes in PM concentrations can occur.

[6] Offset and adjustment factors were originally assigned the same values as used by PM_{10} TEOM instruments. As it was never determined whether this was an appropriate assumption, federal and provincial NAPS managers agreed to remove these factors from the archive.

4 Ambient Concentrations of PM in BC

PM_{10} and $PM_{2.5}$ data for all BC sites where routine measurements are made are summarized in the following tables and figures. Numerical summaries are based on all available data from more than 140 active and closed sites with records longer than one year. The mean, standard deviation, minimum and maximum concentrations along with percentile values are presented in tabular form. Exceedances of the provincial objective and other thresholds are presented for the full data set.

Box and whisker plots are presented for a number of selected sites. It is not possible to plot all data from all sites due to space limitations, so a subset of TEOM and SSI PM_{10} sites were selected from various locations within the province. An effort was made to select sites that were representative of a particular region and located in a populated area with a long period of record. Sites were also included if they had a history of high PM_{10} values. The subset of selected PM_{10} stations consists of 14 TEOM samplers and four SSI samplers. Given the many differences in technology and sampling schedules between the continuous TEOM monitors and the non-continuous manual SSI samplers, the results of the data analysis for these two sampling regimes are presented separately.

Owing to the dearth of $PM_{2.5}$ data, we have included data from all of the continuous TEOM sites even though the period of record is extremely short. Despite concerns over precision, we have also included Partisol data from four interior sites where the period of record exceeds three years. Finally, overall summaries of data from dichotomous samplers at NAPS stations are included, owing to the relatively long monitoring history at these sites.

Concentrations of PM can vary widely over a small area. This may often be attributed to instrument siting decisions. For example, locating an instrument near a major intersection will generally result in much higher ambient concentrations being recorded than if a different site in the same general area had been chosen.

An evaluation of the spatial homogeneity of PM measurements in specific communities is beyond the scope of this report. Caution should be exercised in extending conclusions about air quality from the sampling site to the surrounding geographic area.

4.1 Frequency Analysis (All Data)

Frequency distributions of 24-hour average PM_{10} concentrations based on all available data longer than one year from all TEOM sites in the province are presented alphabetically in Table 1. Table 2 shows 24-hour average PM_{10} concentrations ranked from highest to lowest for each TEOM site with at least one year of data.

Overall mean PM_{10} concentrations for the entire period of record up to 2000 ranged from 7 to 26 $\mu g/m^3$ at TEOM monitoring sites with at least one year of data. The highest concentrations were observed in the interior of the province, particularly at sites in Golden, Prince George, Quesnel and Boston Bar, which each recorded overall mean 24-hour concentrations in excess of 20 $\mu g/m^3$. However, the majority of sites in coastal areas recorded mean concentrations of less than 15 $\mu g/m^3$. Single-day measurements in excess of 150 $\mu g/m^3$ were recorded in Golden, Quesnel, Prince George, Burns Lake and Kamloops.

Data collected from manual samplers (including SSI and Partisol samples) are summarized in Table 3 and 4. Table 3 shows the frequency distribution while Table 4 shows mean 24-hour PM_{10} concentrations ranked from highest to lowest for each site with at least one year of data and still active as of December 2000. Much of the PM_{10} data from manual sampler sites was collected prior to 1996. Of the 32 sites still in operation at the end of 2000, overall mean PM_{10} concentrations ranged from 11 $\mu g/m^3$ at Sechelt to 34 $\mu g/m^3$ at Merritt. Two-thirds of these sites had mean concentrations in the range of 15-24 $\mu g/m^3$. Approximately 25% had mean concentrations of 25 $\mu g/m^3$ or higher, including Merritt, Vernon (City Hall and Coldstream), Williams Lake (Skyline School and Firehall), Grand Forks, and Prince George (CNRail and Plaza 400).

As shown in Table 5 mean 24-hour $PM_{2.5}$ concentrations from TEOM sites ranged from a low of 6 μg/m^3 at Powell River to a high of 13 μg/m^3 at Prince George. Overall mean 24-hour concentrations at other monitoring sites were clustered between 8 and 9 μg/m^3, suggesting remarkable similarity among $PM_{2.5}$ levels at these sites. All sites recorded exceedances of 30 μg/m^3 (the numerical value of the CWS), with the exception of Powell River, Pitt Meadows, Vancouver International Airport and the Merritt mobile monitor. Both Prince George and Kelowna recorded $PM_{2.5}$ concentrations in excess of 50 μg/m^{3}over the period of record.

Overall mean 24-hour $PM_{2.5}$ concentrations at Partisol and dichotomous sampler sites, as shown in Table 6, ranged from 8 μg/m^3 at Smithers to 12 μg/m^3 at Prince George, while maximum 24-hour concentrations ranged from 23 μg/m^3 to 75 μg/m^3.

4.2 Exceedance Frequency (All Data)

To assess current PM levels with respect to existing air quality criteria, PM_{10} concentrations were compared against the BC air quality objective of 50 μg/m^3 (24-hour average) and also the health Reference Level of 25 μg/m^3 (24-hour average), above which there is some certainty of increasing risks to human health. Exceedance frequencies are summarized in Table 7 for all TEOM sites and Table 8 for all SSI and Partisol sites still in operation at the end of 2000 and where at least one year of monitoring data exists.

The provincial air quality objective is exceeded relatively infrequently at the majority of PM_{10} TEOM monitoring sites in the province. Approximately two-thirds of these sites reported exceedance frequencies of 1% or less, and one-half of these have never recorded a single exceedance. These sites are primarily located on Vancouver Island, in the Lower Fraser Valley, and along the Sunshine and Central Coasts.

The remaining one-third of all sites experienced exceedance frequencies ranging from 2 to 7% of the time. The highest rates were observed at sites in Prince George (BCRail and Plaza 400), Golden, and Quesnel (Pinecrest and Quesnel Sr.

Secondary), where the provincial air quality objective was exceeded at least 5% of the time.

All active SSI and Partisol sites reported at least one exceedance of the provincial PM_{10} objective over the period of record. One-third of the sites reported exceedance frequencies of 1% of the time or less, and approximately 40% of the sites reported exceedances more than 5% of the time. The air quality objective was exceeded most frequently at the Merritt (17% of the time) and Vernon City Hall (15% of the time) monitoring stations.

A different view on acceptable PM concentrations is obtained when comparing ambient levels to the identified Health Reference Level. Exceedances of the PM_{10} Health Reference Level have occurred at least once at all TEOM sites except Port Edward, and at all active SSI and Partisol sites in the province. Exceedance frequencies of 25% or greater have been reported at six of the TEOM sites still operating at the end of 2000: Prince George BCRail and Plaza 400, Quesnel Pinecrest and Quesnel Sr. Secondary, Boston Bar, and Golden Hospital. A total of 21 SSI and Partisol sites also experienced exceedance frequencies of 25% or greater, and six sites experienced exceedance frequencies of 40% or greater, including Merritt, Prince George (CNRail), Williams Lake (Firehall and Skyline School), Grand Forks and Vernon (City Hall).

$PM_{2.5}$ concentrations were compared against a benchmark of 30 $\mu g/m^3$ (24-hour average) and the Health Reference Level of 15 $\mu g/m^3$ (24-hour average), as summarized in Table 9 for TEOM sites and Table 10 for Partisol and dichotomous sampler sites. Note that while numerically similar, the 30 $\mu g/m^3$ benchmark is not directly comparable to the CWS, which is based on an annual 98^{th} percentile concentration, averaged over 3 years. Based on the limited TEOM data monitoring to date, the level of 30 $\mu g/m^3$ has been exceeded less than 1% of the time at all sites except Prince George, where it has been exceeded 4% of the time. Exceedances of the Health Reference Level ranged from 2% of the time in Powell River to 26% of the time in Prince George.

Based on the non-continuous $PM_{2.5}$ data, as summarized in Table 10, there were few to no exceedences of the 30 μg/m^3 benchmark except at dichotomous sampler sites in Port Moody, Kitsilano, and Victoria (the now closed PAPS site) and the Partisol site in Prince George where it was exceeded 6% of the time over its five-year history. The Health Reference Level of 15 μg/m^3 was exceeded at all sites, with exceedance frequencies ranging from 5% at Victoria (Topaz) to 26% at Prince George (Plaza 400).

Table 1 Frequency distribution of 24-hour average PM_{10} concentrations (in $\mu g/m^3$) based on all available data from TEOM sites in British Columbia with at least one year of data.

Location		Period of Record		Percentiles													>25µg/m³		>50µg/m³	
ID	Station Name	Start Date	End Date	N	Mean	Std	Min	10	25	50	75	90	95	98	99	Max	No.	%	No.	%
E238212	Abbotsford Bevan Ave.	19-Sep-98	31-Dec-00	814	13	7	2	6	8	12	17	22	25	29	34	53	41	5	1	0
E217029	Abbotsford Library	20-Jul-94	14-Sep-98	1391	17	9	4	8	10	15	21	28	33	41	45	66	223	16	10	1
E238240	Boston Bar RCMP Station	09-Jul-99	31-Dec-00	533	22	14	3	8	12	18	30	41	47	56	67	95	179	34	19	4
0310177	Burnaby Kensington Park	14-May-94	31-Dec-00	2379	12	6	2	6	8	10	15	20	24	27	29	57	83	3	3	0
E207418	Burnaby South	30-Mar-94	31-Dec-00	2443	14	7	3	7	9	12	17	23	27	32	35	59	192	8	3	0
E225267	Burns Lake Fire Centre	08-Mar-97	31-Dec-00	1319	19	16	1	6	9	14	22	36	48	66	83	171	267	20	53	4
E229798	Campbell River Tyee Split	12-Dec-97	31-Dec-00	1103	12	6	2	7	8	11	15	21	24	29	31	65	46	4	2	0
E220891	Chilliwack Airport	01-Mar-95	31-Dec-00	2067	13	8	2	6	8	11	17	24	28	35	40	79	171	8	10	0
E206612	Chilliwack Work Yard	02-Nov-94	28-Feb-95	101	17	18	3	5	8	11	17	40	52	78	84	94	18	18	6	6
E220203	Cranbrook PR3	21-Apr-94	29-Nov-98	1615	17	13	0	5	9	14	21	30	41	55	64	111	261	16	47	3
E206243	Cranbrook Swimming Pool	01-May-92	15-Sep-93	432	21	12	0	8	12	19	26	35	46	59	63	71	129	30	14	3
E221199	Creston PC School	27-Oct-94	31-Dec-00	1730	18	12	1	7	10	15	22	32	41	56	69	99	334	19	48	3
E234670	Duncan Deykin Ave.	01-Nov-98	31-Dec-00	778	11	5	3	6	7	10	13	17	19	23	25	28	8	1	.	.
E222520	Elk Falls	09-Dec-95	31-Dec-00	1586	12	5	2	7	9	11	14	18	21	25	28	49	28	2	.	.
0110203	Gold River Pumphouse	06-Feb-97	08-Nov-98	626	8	6	0	2	4	7	11	16	18	21	25	46	7	1	.	.
E235070	Golden Hospital	11-Feb-99	24-Dec-00	625	26	20	4	11	14	21	31	43	67	99	113	152	230	37	44	7
E225377	Harmac Cedar Woobank	08-Jul-97	31-Dec-00	978	10	5	0	5	7	9	13	17	19	23	25	39	11	1	.	.
E223756	Hope Airport	04-Dec-96	31-Dec-00	1477	11	6	3	5	7	9	13	19	22	26	28	53	34	2	1	0
M107004	Houston Firehall	24-Sep-94	31-Dec-00	2213	20	14	2	8	11	16	24	36	45	61	72	113	489	22	79	4
E206898	Kamloops Brocklehurst	01-Jan-94	31-Dec-00	2521	15	12	1	7	9	13	18	25	31	47	54	357	253	10	35	1
0500886	Kelowna College	23-Jan-94	31-Dec-00	2511	16	10	0	7	10	14	20	27	34	45	51	76	331	13	32	1
E223616	Kitimat Haul Rd.	11-Aug-98	31-Dec-00	868	9	5	2	5	6	8	12	16	18	22	24	37	8	1	.	.
E223827	Kitimat Rail	18-Aug-98	31-Dec-00	857	10	7	1	4	5	8	12	18	23	29	37	62	32	4	3	0
E216670	Kitimat Riverlodge	11-Aug-98	31-Dec-00	870	7	4	2	4	5	6	9	12	15	19	20	26	3	0	.	.
0310175	Kitsilano	15-Dec-93	31-Dec-00	2527	14	6	2	8	10	13	17	22	25	30	34	50	126	5	1	0
E222778	Langdale Elem.	06-Jan-96	24-Dec-00	1465	10	4	1	5	7	9	12	15	17	20	23	41	10	1	.	.
E209178	Langley Central	01-Jan-94	31-Dec-00	2398	13	6	3	6	8	11	16	21	24	27	29	41	92	4	.	.
E232245	Maple Ridge Golden Ears Elem.	21-Feb-98	31-Dec-00	1020	12	6	3	6	8	11	15	20	22	26	29	67	31	3	2	0

Location		Period of Record		Percentiles													>25$\mu g/m^3$		>50$\mu g/m^3$	
ID	Station Name	Start Date	End Date	N	Mean	Std	Min	10	25	50	75	90	95	98	99	Max	No.	%	No.	%
E237431	Merritt Granite-Garcia Mobile	16-May-99	28-May-00	376	19	11	4	8	11	17	24	33	41	48	55	61	88	23	5	1
E207723	North Delta	17-Dec-93	31-Dec-99	2088	13	7	2	6	8	12	17	23	27	31	34	62	154	7	2	0
0450270	PG Gladstone	07-Dec-95	31-Dec-00	1828	15	10	0	5	7	12	19	28	35	45	50	103	246	13	19	1
0450307	PG Plaza 400	01-Mar-92	31-Dec-00	3042	21	15	0	8	11	17	26	39	48	63	74	155	824	27	141	5
E228065	Port Alberni Townsite	16-Sep-97	31-Dec-00	1183	10	5	1	5	6	8	12	16	18	23	26	44	13	1	.	.
E225184	Port Edward Pacific	30-Apr-98	04-Nov-00	879	7	4	1	3	4	6	9	12	15	17	19	23	.	.	.	.
0310162	Port Moody Rocky Pt. Park	01-Nov-93	31-Dec-00	2449	15	7	3	7	9	13	19	25	28	32	34	58	222	9	5	0
0220204	Powell River Cranberry Lake	12-Jan-96	31-Dec-00	1764	10	6	1	5	6	8	12	17	22	29	36	59	60	3	1	0
0220205	Powell River Wildwood	19-Jun-97	31-Dec-00	1276	9	4	3	5	6	8	10	14	17	20	25	37	14	1	.	.
E224013	Prince George BCRail	29-Sep-96	31-Dec-00	1548	24	16	2	9	12	19	30	45	55	70	80	115	516	33	115	7
E224014	Prince George Glenview School	11-Jun-98	31-Dec-00	927	10	5	3	5	6	8	12	17	21	26	30	43	20	2	.	.
E225868	Prince George Hart Highlands	05-Apr-97	21-Mar-98	351	16	14	3	7	9	12	19	28	35	52	82	130	50	14	8	2
E231838	PrinceRupert Galloway Rapids	24-Apr-98	31-Dec-00	890	7	4	1	3	4	6	9	13	16	19	21	26	1	0	.	.
E225378	Quadra Island Lighthouse	23-Feb-97	31-Dec-00	1361	11	5	1	6	8	10	13	17	19	23	25	39	13	1	.	.
E216667	Quesnel Maple Dr.	25-May-95	31-Dec-00	1997	16	11	1	6	9	14	20	29	36	47	56	106	301	15	29	1
E221885	Quesnel Pinecrest	10-Jun-95	31-Dec-00	1954	22	15	1	8	11	18	29	43	52	64	73	103	622	32	111	6
E208096	Quesnel Sr. Sec.	17-Apr-94	31-Dec-00	2419	22	16	2	9	12	18	27	39	49	70	89	178	719	30	117	5
E207417	Richmond South	28-Oct-93	31-Dec-00	2557	14	7	4	8	10	13	17	23	27	33	36	79	179	7	5	0
E206589	Smithers St. Josephs	15-May-92	31-Dec-00	2956	18	12	0	8	11	15	21	31	38	50	64	142	536	18	59	2
0310172	Squamish	12-Sep-94	14-Dec-00	2176	14	8	1	6	8	11	18	25	31	36	38	59	211	10	4	0
E206271	Surrey East	07-Jan-94	31-Dec-00	2487	13	6	3	7	9	12	16	20	23	27	30	73	81	3	3	0
E230557	Telkwa	05-Feb-98	31-Dec-00	1010	16	11	2	6	8	12	20	30	41	51	60	74	165	16	22	2
M107028	Terrace BC Access Centre	18-Dec-96	31-Dec-00	1459	14	10	2	5	7	11	17	26	32	40	45	93	159	11	11	1
0250009	Trail Butler Park	12-Apr-94	08-May-00	1751	17	9	2	7	10	15	21	29	33	42	48	95	280	16	12	1
E232246	Vancouver International Airport #2	01-Feb-98	31-Dec-00	1055	14	6	4	7	10	13	17	21	26	31	35	53	58	5	1	0
0550502	Williams Lake	17-Dec-92	31-Dec-00	2646	20	12	1	8	11	16	25	34	42	54	65	141	635	24	65	2

Table 2 Ranked mean 24-hour average PM_{10} concentrations (in $\mu g/m^3$) based on all data from TEOM sites in British Columbia with at least one year of data.

ID	Station Name	Start Date	End Date	N	Overall Mean
E235070	Golden Hospital	11-Feb-99	24-Dec-00	625	26
E224013	Prince George BCRail	29-Sep-96	31-Dec-00	1548	24
E221885	Quesnel Pinecrest	10-Jun-95	31-Dec-00	1954	22
E238240	Boston Bar RCMP Station	09-Jul-99	31-Dec-00	533	22
E208096	Quesnel Sr. Sec.	17-Apr-94	31-Dec-00	2419	22
0450307	PG Plaza 400	01-Mar-92	31-Dec-00	3042	21
E206243	Cranbrook Swimming Pool	01-May-92	15-Sep-93	432	21
0550502	Williams Lake	17-Dec-92	31-Dec-00	2646	20
M107004	Houston Firehall	20-Sep-94	31-Dec-00	2213	20
E237431	Merritt Granite-Garcia Mobile	16-May-99	28-May-00	376	19
E225267	Burns Lake Fire Centre	08-Mar-97	31-Dec-00	1319	19
E221199	Creston PC School	27-Oct-94	31-Dec-00	1730	18
E206589	Smithers St. Josephs	15-May-92	31-Dec-00	2956	18
E206612	Chilliwack Work Yard	02-Nov-94	28-Feb-95	101	17
0250009	Trail Butler Park	12-Apr-94	08-May-00	1751	17
E217029	Abbotsford Library	20-Jul-94	14-Sep-98	1391	17
E220203	Cranbrook PR3	21-Apr-94	29-Nov-98	1615	17
E216667	Quesnel Maple Dr.	25-May-95	31-Dec-00	1997	16
E225868	Prince George Hart Highlands	05-Apr-97	21-Mar-98	351	16
E230557	Telkwa	05-Feb-98	31-Dec-00	1010	16
0500886	Kelowna College	23-Jan-94	31-Dec-00	2511	16
E206898	Kamloops Brocklehurst	01-Jan-94	31-Dec-00	2521	15
0310162	Port Moody Rocky Pt. Park	01-Nov-93	31-Dec-00	2449	15
0450270	PG Gladstone	07-Dec-95	31-Dec-00	1828	15
E207417	Richmond South	28-Oct-93	31-Dec-00	2557	14
0310175	Kitsilano	15-Dec-93	31-Dec-00	2527	14
E232246	Vancouver International Airport #2	01-Feb-98	31-Dec-00	1055	14
E207418	Burnaby South	30-Mar-94	31-Dec-00	2443	14
M107028	Terrace BC Access Centre	18-Dec-96	31-Dec-00	1459	14
0310172	Squamish	12-Sep-94	14-Dec-00	2176	14
E220891	Chilliwack Airport	01-Mar-95	31-Dec-00	2067	13
E207723	North Delta	17-Dec-93	31-Dec-99	2088	13
E238212	Abbotsford Bevan Ave.	19-Sep-98	31-Dec-00	814	13
E206271	Surrey East	07-Jan-94	31-Dec-00	2487	13
E209178	Langley Central	01-Jan-94	31-Dec-00	2398	13
E229798	Campbell River Tyee Split	12-Dec-97	31-Dec-00	1103	12
0310177	Burnaby Kensington Park	14-May-94	31-Dec-00	2379	12
E232245	Maple Ridge Golden Ears Elem.	21-Feb-98	31-Dec-00	1020	12
E222520	Elk Falls	09-Dec-95	31-Dec-00	1586	12
E225378	Quadra Island Lighthouse	23-Feb-97	31-Dec-00	1361	11
E234670	Duncan Deykin Ave.	01-Nov-98	31-Dec-00	778	11
E223756	Hope Airport	04-Dec-96	31-Dec-00	1477	11
E225377	Harmac Cedar Woobank	08-Jul-97	31-Dec-00	978	10
E224014	Prince George Glenview School	11-Jun-98	31-Dec-00	927	10
E222778	Langdale Elem.	06-Jan-96	24-Dec-00	1465	10
0220204	Powell River Cranberry Lake	12-Jan-96	31-Dec-00	1764	10
E223827	Kitimat Rail	18-Aug-98	31-Dec-00	857	10

ID	Station Name	Start Date	End Date	N	Overall Mean
E228065	Port Alberni Townsite	16-Sep-97	31-Dec-00	1183	10
E223616	Kitimat Haul Rd.	11-Aug-98	31-Dec-00	868	9
0220205	Powell River Wildwood	19-Jun-97	31-Dec-00	1276	9
0110203	Gold River Pumphouse	06-Feb-97	08-Nov-98	626	8
E216670	Kitimat Riverlodge	11-Aug-98	31-Dec-00	870	7
E231838	PrinceRupert Galloway Rapids	24-Apr-98	31-Dec-00	890	7
E225184	Port Edward Pacific	30-Apr-98	04-Nov-00	879	7

Table 3 Frequency distribution of 24-hour average PM_{10} concentrations (in $\mu g/m^3$) based on all available data from SSI and Partisol sites in British Columbia with at least one year of data.

	Location	Period of Record						Percentiles									>25 $\mu g/m^3$		>50 $\mu g/m^3$	
ID	Station Name	Start Date	End Date	N	Mean	Std	Min	10	25	50	75	90	95	98	99	Max	No.	%	No.	%
E218444	100 Mile House	Mar-93	Dec-00	582	20	18	2	5	9	15	26	40	56	83	91	120	146	25	36.0	6
E217029	Abbotsford Library	May-92	Mar-95	160	20	11	4	8	11	18	26	37	43	50	51	56	42	26	3.0	2
E217319	Albion Elementary School	Jun-94	Jan-96	106	16	7	5	8	11	14	20	25	27	31	34	40	9	8	.	.
E222636	BC Hydro Bldg	Oct-95	Nov-00	229	15	13	2	4	6	10	19	34	42	53	63	65	36	16	6.0	3
E219592	Burns Lake	Oct-93	Oct-96	116	19	15	2	5	10	16	24	34	40	59	83	102	23	20	4.0	3
E224515	Camosun College	Aug-97	Dec-99	130	13	10	2	6	8	10	14	20	29	44	46	85	11	8	1.0	1
E206931	Castlegar	Apr-90	Dec-00	570	23	14	2	10	14	20	28	40	49	63	71	103	187	33	26.0	5
E222858	Chetwynd	Jan-95	Dec-00	313	19	16	0	6	10	15	23	32	44	69	90	115	63	20	15.0	5
E213114	Chilliwack Merlins	Nov-90	May-94	205	19	12	2	7	10	17	25	32	40	45	54	108	47	23	3.0	1
E222689	Cominco Northport	Aug-93	Dec-00	430	15	13	0	4	6	12	21	30	38	49	59	96	70	16	8.0	2
E206241	Cranbrook Amy Woodland School	Apr-85	Mar-91	163	43	34	5	10	17	34	62	89	106	126	172	196	99	61	54.0	33
E206243	Cranbrook Swimming Pool	Jul-89	Feb-99	555	26	20	3	7	13	21	34	50	60	84	101	150	213	38	54.0	10
E213056	Creston Hospital	Sep-90	Jun-98	376	28	30	2	9	14	22	32	49	75	109	120	419	140	37	35.0	9
E206379	Crofton Community Hall	Oct-92	Apr-94	85	16	8	5	7	11	14	19	26	29	39	49	49	9	11	.	.
E206378	Crofton Vernon@Shasta	Oct-92	Apr-94	83	18	9	4	8	11	16	22	31	34	38	38	38	16	19	.	.
0250182	Elkford	Feb-88	Mar-93	75	28	43	2	7	9	14	21	59	129	202	232	232	14	19	9.0	12
E231478	Esquimalt Guardhouse	Feb-98	Dec-99	115	17	11	3	7	10	15	21	29	37	45	54	81	19	17	2.0	2
E231477	Esquimalt Lookout	Feb-98	Nov-99	111	14	9	2	7	8	12	17	26	32	38	43	55	12	11	1.0	1
E222859	Ft. St. James	Oct-94	Feb-00	143	19	13	1	7	10	15	23	36	42	65	69	72	28	20	4.0	3
E222140	Genelle	Sep-95	Dec-00	290	16	9	1	7	11	14	19	25	29	37	54	92	29	10	3.0	1
E216700	Golden	Jan-92	Jul-00	461	34	24	2	12	19	28	41	59	77	104	114	212	262	57	78.0	17
E207520	Grand Forks	Jul-92	Dec-00	458	25	13	5	11	15	22	31	41	51	64	73	86	184	40	23.0	5
E216752	Harmac Canoxy	Jan-92	Dec-92	55	13	4	5	8	9	12	16	19	22	23	25	25	.	.	.	.
E216751	Harmac Nicholl's Farm	Jan-92	Dec-92	59	17	6	6	8	12	15	21	27	30	30	31	31	7	12	.	.
E214615	Hope Firehall	Mar-91	Nov-96	322	15	8	2	6	9	13	18	25	28	36	40	49	31	10	.	.
E218458	Houston Silverthorne	Feb-93	Jan-95	82	26	25	5	8	12	19	32	49	57	139	156	156	27	33	8.0	10
E220202	Invermere Forest	Mar-94	Dec-00	388	22	14	2	8	12	19	27	38	51	61	65	114	110	28	21.0	5
0605001	Kamloops Airport	Jan-90	Dec-93	222	20	13	3	8	12	17	26	36	42	59	64	86	57	26	10.0	5
E206898	Kamloops Brocklehurst	Jan-90	Dec-94	271	24	21	4	9	13	19	26	43	53	77	116	221	75	28	15.0	6

	Location	Period of Record						Percentiles									>25 µg/m³		>50 µg/m³	
ID	Station Name	Start Date	End Date	N	Mean	Std	Min	10	25	50	75	90	95	98	99	Max	No.	%	No.	%
E206725	Kamloops Federal Bldg.	Feb-90	Dec-00	625	23	13	2	10	14	20	28	39	46	66	72	95	201	32	27.0	4
E206304	Kelowna Okanagan College	Mar-89	Dec-95	386	24	16	2	9	13	21	30	45	52	66	98	130	132	34	22	6
E206302	Lumby	Apr-93	Mar-97	173	33	24	7	13	16	26	42	60	82	105	123	146	90	52	29	17
E208083	Merritt	Jan-90	Dec-00	532	34	25	2	11	18	29	44	66	86	108	126	167	297	56	90	17
E238019	Merritt Airport North Field	May-99	May-00	56	11	6	0	6	7	11	14	19	24	32	32	32	2	4	0	0
E217320	Mission Pioneer	Aug-92	Dec-00	495	18	11	3	8	11	16	23	32	38	48	57	74	100	20	7	1
E229537	Mission Secondary	Dec-97	Jun-00	149	13	11	3	5	7	10	15	24	31	69	69	80	13	9	3	2
E206375	Nelson	Apr-90	Dec-00	510	20	14	2	7	11	16	24	37	48	53	73	121	112	22	19	4
E225285	New Aiyansh	Jul-97	Dec-00	88	12	11	2	4	5	9	15	24	31	48	63	63	8	9	1	1
E218578	New Hazelton DFO	Mar-93	Sep-96	164	26	17	2	11	14	22	33	46	56	77	86	118	64	39	13	8
E224512	Oak Bay Rec. Centre	Feb-97	Dec-00	193	15	10	0	7	9	12	18	26	33	44	63	66	21	11	3	2
0500869	Penticton	Nov-92	Oct-98	289	15	13	2	6	9	13	19	25	31	43	71	159	27	9	3	1
E229217	Penticton MOE	Nov-97	Dec-00	178	16	13	2	6	9	13	19	28	33	66	75	117	26	15	4	2
E206169	Pitt Meadows Airport	Feb-91	Feb-96	264	15	9	2	5	8	13	21	30	34	38	41	47	37	14	0	0
E233567	Polar Bear Lake	Jul-98	Dec-00	283	15	27	0	3	4	8	16	33	47	73	147	296	45	16	11	4
E218772	Prince George BCRail	Apr-93	Aug-96	195	39	27	6	13	19	32	52	77	90	110	143	181	116	59	50	26
E223128	Prince George BCRail Warehouse	May-96	Jan-99	163	30	19	0	11	16	25	40	56	72	79	89	92	81	50	24	15
E218771	Prince George CNRail	Apr-93	Dec-00	443	27	19	2	10	14	21	35	54	61	85	106	124	180	41	51	12
0450325	Prince George Foreman Flats	Aug-90	May-92	101	17	11	2	7	9	14	22	31	42	45	46	57	18	18	1	1
0450270	Prince George Gladstone	Jun-92	Jan-99	380	18	13	2	6	9	15	23	35	43	53	57	122	79	21	11	3
0450324	Prince George Lakewood	Aug-90	Dec-00	582	19	15	2	6	9	15	24	38	49	61	74	129	139	24	24	4
0450307	Prince George Plaza 400	Aug-90	Dec-00	585	25	18	2	9	14	20	31	45	56	79	90	217	204	35	44	8
0450232	Prince George Van Bien	Aug-90	Dec-00	573	24	17	2	8	12	20	32	48	57	69	79	106	202	35	53	9
0110263	Pt. Alberni Auto Marine	Aug-88	Feb-95	127	23	13	4	9	14	20	29	41	46	59	64	73	38	30	4	3
0110264	Pt. Alberni Courthouse	Feb-85	May-97	527	22	16	2	7	10	17	29	42	54	69	79	100	163	31	31	6
0110254	Pt. Alberni Firehall	Oct-92	May-97	238	17	10	4	7	11	14	21	29	40	46	47	57	33	14	2	1
E228064	Quesnel Correlieu	Nov-97	Oct-00	160	21	16	2	6	9	16	27	44	57	62	80	97	48	30	12	8
E206113	Quesnel Firehall	Nov-90	Feb-95	221	38	40	3	12	19	29	41	66	95	166	181	391	124	56	39	18
E213032	Quesnel Pinecrest School	Oct-90	Mar-92	78	28	17	3	10	15	24	36	57	64	69	86	86	36	46	10	13
E232982	Radium	Jul-98	Dec-00	354	14	10	0	4	7	12	17	26	31	36	39	109	39	11.0	2	0.6
E217680	Revelstoke Firehall	Dec-92	Dec-00	458	21	13	0	8	12	18	26	37	48	55	63	103	124	27	20	4
E237978	Sechelt	Jun-99	Dec-00	87	11	8	4	5	7	9	12	17	22	33	69	69	3	3	1	1

	Location	Period of Record						Percentiles									>25 μg/m³		>50 μg/m³	
ID	Station Name	Start Date	End Date	N	Mean	Std	Min	10	25	50	75	90	95	98	99	Max	No.	%	No.	%
E207914	Skookumchuk	Apr-90	Oct-00	504	11	8	2	4	6	9	14	21	27	38	43	64	32	6	1	0
0260104	Slocan	Nov-91	Dec-00	494	17	10	2	7	10	15	21	31	38	46	55	82	74	15	6	1
E206589	Smithers St. Josephs	Jul-90	Apr-94	207	24	20	2	7	12	18	30	44	53	80	105	169	68	33	15	7
0310172	Squamish	Dec-90	Dec-94	172	20	10	3	9	13	18	25	32	38	49	51	78	41	24	3	2
0435079	Terrace	Oct-93	Mar-96	131	21	15	4	7	12	16	26	38	48	64	76	93	35	27	5	4
0250009	Trail Butler Park	Apr-90	Dec-00	516	22	12	2	9	13	19	27	37	46	54	66	92	152	29	13	3
0260022	Trail Oasis	Jan-93	Sep-00	453	18	16	1	6	9	14	21	34	46	61	78	164	84	19	19	4
E222141	Trail West	Jan-98	Dec-00	174	17	10	0	7	11	16	20	26	33	40	61	73	21	12	2	1
E234293	Valemont Partisol	Jan-00	Dec-00	21	19	23	2	4	6	13	20	39	72	92	92	92	3	14	2	10
E229817	Vernon Coldstream	Jan-98	Dec-00	152	25	16	4	11	15	21	33	44	50	65	115	115	62	41	7	5
0500827	Vernon City Hall	Oct-89	Dec-00	443	30	20	5	11	17	24	37	55	67	84	111	135	210	47	66	15
0110030	Victoria PAPS	Apr-88	Dec-97	276	16	8	2	8	10	14	19	26	31	36	40	52	29	11	1	0
E231866	Victoria Topaz	May-98	Dec-00	155	19	10	2	9	12	17	24	34	37	39	56	58	36	23	2	1
E208805	Westsyde	May-90	Dec-96	390	21	13	2	8	12	17	26	37	47	63	71	95	99	25	12	3
E227431	Whistler Meadow Park	Oct-97	Nov-00	109	13	10	0	4	6	10	16	27	33	39	44	54	11	10	1	1
E229457	Williams Lake 168 Mile	Dec-97	Dec-00	185	22	14	3	9	12	17	28	39	46	62	67	96	59	32	8	4
E206112	Williams Lake Firehall	May-87	Dec-00	597	27	19	0	10	14	22	33	49	60	81	102	146	247	41	56	9
0605020	Williams Lake Skyline School	Mar-92	Dec-00	517	28	22	2	7	13	22	36	56	76	91	111	162	215	42	59	11
E222242	Williams Lake Water Tower	Nov-95	Dec-00	296	15	10	2	6	8	12	19	26	33	43	47	74	31	10	1	0

Table 4 Ranked mean 24-hour PM_{10} concentrations (in $\mu g/m^3$) based on all data from SSI and Partisol sites in British Columbia with at least one year of data and still active at 31 December 2000.

ID	Station Name	Start Date	End Date	N	OverallMean
E208083	Merritt	Jan-90	Dec-00	532	34
0500827	Vernon City Hall	Oct-89	Dec-00	443	30
0605020	Williams Lake Skyline School	Mar-92	Dec-00	517	28
E218771	Prince George CNRail	Apr-93	Dec-00	443	27
E206112	Williams Lake Firehall	May-87	Dec-00	597	27
E229817	Vernon Coldstream	Jan-98	Dec-00	152	25
E207520	Grand Forks	Jul-92	Dec-00	458	25
0450307	Prince George Plaza 400	Aug-90	Dec-00	585	25
0450232	Prince George Van Bien	Aug-90	Dec-00	573	24
E206931	Castlegar	Apr-90	Dec-00	570	23
E206725	Kamloops Federal Bldg.	Feb-90	Dec-00	625	23
0250009	Trail Butler Park	Apr-90	Dec-00	516	22
E220202	Invermere Forest	Mar-94	Dec-00	388	22
E229457	Williams Lake 168 Mile	Dec-97	Dec-00	185	22
E217680	Revelstoke Firehall	Dec-92	Dec-00	458	21
E218444	100 Mile House	Mar-93	Dec-00	582	20
E206375	Nelson	Apr-90	Dec-00	510	20
0450324	Prince George Lakewood	Aug-90	Dec-00	582	19
E231866	Victoria Topaz	May-98	Dec-00	155	19
E222858	Chetwynd	Jan-95	Dec-00	313	19
E217320	Mission Pioneer	Aug-92	Dec-00	495	18
0260104	Slocan	Nov-91	Dec-00	494	17
E222141	Trail West	Jan-98	Dec-00	174	17
E222140	Genelle	Sep-95	Dec-00	290	16
E229217	Penticton MOE	Nov-97	Dec-00	178	16
E222689	Cominco Northport	Aug-93	Dec-00	430	15
E233567	Polar Bear Lake	Jul-98	Dec-00	283	15
E224512	Oak Bay Rec. Centre	Feb-97	Dec-00	193	15
E222242	Williams Lake Water Tower	Nov-95	Dec-00	296	15
E232982	Radium	Jul-98	Dec-00	354	14
E225285	New Aiyansh	Jul-97	Dec-00	88	12
E237978	Sechelt	Jun-99	Dec-00	87	11

Table 5 Frequency distribution of 24-hour average $PM_{2.5}$ concentrations (in $\mu g/m^3$) based on all available data from TEOM sites in British Columbia with at least one year of data.

Location		Period of Record						Percentiles									>15µg/m³		>30µg/m³	
ID	Station Name	Start Date	End Date	N	Mean	Std	Min	10	25	50	75	90	95	98	99	Max	No.	%	No.	%
E220891	Chilliwack Airport	01-Jun-95	31-Dec-00	1963	8	4	3	5	6	7	10	13	15	18	20	32	104	5	1	0
E206898	Kamloops Brocklehurst	03-Oct-97	31-Dec-00	1101	9	4	3	5	6	8	10	13	15	19	20	40	63	6	1	0
0500886	Kelowna Okanagan College	01-Nov-97	31-Dec-00	1121	9	4	3	5	6	8	11	14	16	19	21	55	79	7	3	0
E237431	Merritt Granite-Garcia Mobile	16-May-99	28-May-00	375	8	3	3	5	6	7	10	13	15	16	20	24	15	4	.	.
E229797	Nanaimo Labieux Rd.	12-Dec-97	31-Dec-00	1098	8	3	3	5	6	7	9	12	14	17	19	43	41	4	2	0
E232244	Pitt Meadows	15-Jan-99	31-Dec-00	707	9	4	3	4	5	8	11	15	17	18	19	23	66	9	.	.
0220204	Powell River Cranberry Lake	21-Sep-98	31-Dec-00	792	6	3	3	4	5	6	8	10	12	14	16	24	12	2	.	.
0450307	Prince George Plaza 400	13-Nov-97	31-Dec-00	1135	13	7	3	6	8	11	15	22	26	35	40	59	297	26	40	4
E232246	Vancouver Int. Airport #2	17-Mar-99	31-Dec-00	656	9	4	3	5	7	8	11	15	17	20	22	29	58	9	.	.
E231866	Victoria Topaz	02-May-98	31-Dec-00	907	9	4	3	5	6	8	11	14	17	21	27	34	73	8	2	0

Table 6 Frequency distribution of 24-hour average $PM_{2.5}$ concentrations (in $\mu g/m^3$) based on all available data from Partisol and dichotomous sampler sites in British Columbia with at least one year of data. “P” refers to Partisol sites and “D” refers to dichotomous sampler sites.

Location		Period of Record						Percentiles									>15µg/m³		>30µg/m³	
ID	Station Name	First Date	Last Date	N	Mean	Std	Min	10	25	50	75	90	95	98	99	Max	No.	%	No.	%
0450307	Prince George Plaza 400 (P)	Sep 94	Dec 00	353	12	10	0	4	6	10	16	22	34	40	52	75	93	26	21	6
E206589	Smithers St. Josephs (P)	Apr 96	Dec 00	150	8	6	0	3	4	7	11	17	22	25	28	29	19	13	.	.
E208096	Quesnel Sr. Secondary (P)	Nov 95	Dec 00	288	11	7	0	5	6	9	15	19	23	29	31	48	55	19	3	1
E221197	Williams Lake Columneetza (P)	Oct 94	Dec 00	342	9	6	0	4	5	8	11	16	19	25	27	44	39	11	3	1
100111	Port Moody Rocky Point Pk (D)	Aug 84	Dec 00	996	11	8	2	4	6	9	14	20	27	35	42	62	205	21	31	3
100118	Kitsilano Secondary School (D)	Dec 86	Dec 00	750	10	7	1	4	6	8	12	18	24	32	35	49	118	16	19	3
100303	Victoria PAPS (D)	Jan 85	Oct 97	581	10	8	0	4	5	8	13	21	27	33	39	60	115	20	15	3
100304	Victoria Topaz (D)	May 98	Dec 00	133	7	4	2	3	4	6	8	11	14	17	18	23	6	5	.	.

4.3 Canada-wide Standards Achievement

As previously discussed, the CWS for $PM_{2.5}$ is 30 μg/m^3 (24-hr average), based on the annual 98th percentile averaged over three consecutive years. Achievement of the CWS, based on the final draft of the CWS reporting protocol (CCME, 2002) is summarized in Tables 11 and 12 for all TEOM and Partisol sites meeting the minimum data requirements (including valid data for at least 75% of days in each quarter). Based on the limited $PM_{2.5}$ data available, Prince George Plaza 400 (TEOM and Partisol sites) and Williams Lake Columneetza (Partisol site, based on two consecutive years of data only) were the only two ministry stations to exceed the CWS in BC, with other sites well below the CWS.

Excluding the offset and adjustment factors used with the $PM_{2.5}$ data, the Prince George TEOM site was also below the CWS. While it is premature to suggest that instrument selection may affect CWS attainment, in the case of Prince George data, the choice of data from a TEOM or Partisol sampler did make a difference. Some exceedances of the standard were observed at dichotomous sampler sites in Vancouver, Port Moody and Victoria (not shown here) prior to 1991, but over the past 10 years, the CWS metric has ranged from 15-19 μg/m^3 in the Lower Mainland sites, and averaged 23 μg/m^3 in Victoria prior to the close of the PAPS site.

Table 7 Frequency of occurrence of PM_{10} exceeding 25 μg/m^3 and the provincial objective of 50 μg/m^3 at TEOM sites with at least one year of data (rounded to nearest 1%). Sites are ranked according to percent exceedence of the provincial objective.

					>25μg/m^3		>50μg/m^3	
ID	Station Name	Start Date	End Date	N	No.	%	No.	%
E224013	Prince George BCRail	29-Sep-96	31-Dec-00	1548	516	33	115	7
E235070	Golden Hospital	11-Feb-99	24-Dec-00	625	230	37	44	7
E221885	Quesnel Pinecrest	10-Jun-95	31-Dec-00	1954	622	32	111	6
E208096	Quesnel Sr. Sec.	17-Apr-94	31-Dec-00	2419	719	30	117	5
0450307	PG Plaza 400	01-Mar-92	31-Dec-00	3042	824	27	141	5
E225267	Burns Lake Fire Centre	08-Mar-97	31-Dec-00	1319	267	20	53	4
M107004	Houston Firehall	24-Sep-94	31-Dec-00	2213	489	22	70	4
E238240	Boston Bar RCMP Station	09-Jul-99	31-Dec-00	533	179	34	19	4
E206243	Cranbrook Swimming Pool	01-May-92	15-Sep-93	432	129	30	14	3
E220203	Cranbrook PR3	21-Apr-94	29-Nov-98	1615	261	16	47	3
E221199	Creston PC School	27-Oct-94	31-Dec-00	1730	334	19	48	3
0550502	Williams Lake	17-Dec-92	31-Dec-00	2646	635	24	65	2

					>25µg/m³		>50µg/m³	
ID	Station Name	Start Date	End Date	N	No.	%	No.	%
E225868	Prince George Hart Highlands	05-Apr-97	21-Mar-98	351	50	14	8	2
E230557	Telkwa	05-Feb-98	31-Dec-00	1010	165	16	22	2
E206589	Smithers St. Josephs	15-May-92	31-Dec-00	2956	536	18	59	2
E216667	Quesnel Maple Dr.	25-May-95	31-Dec-00	1997	301	15	29	1
E206898	Kamloops Brocklehurst	01-Jan-94	31-Dec-00	2521	253	10	35	1
E237431	Merritt Granite-Garcia Mobile	16-May-99	28-May-00	376	88	23	5	1
0500886	Kelowna College	23-Jan-94	31-Dec-00	2511	331	13	32	1
0450270	PG Gladstone	07-Dec-95	31-Dec-00	1828	246	13	19	1
M107028	Terrace BC Access Centre	18-Dec-96	31-Dec-00	1459	159	11	11	1
E217029	Abbotsford Library	20-Jul-94	14-Sep-98	1391	223	16	10	1
0250009	Trail Butler Park	12-Apr-94	08-May-00	1751	280	16	12	1
E220891	Chilliwack Airport	01-Mar-95	31-Dec-00	2067	171	8	10	0
E223827	Kitimat Rail	18-Aug-98	31-Dec-00	857	32	4	3	0
0310162	Port Moody Rocky Pt. Park	01-Nov-93	31-Dec-00	2449	222	9	5	0
E232245	Maple Ridge Golden Ears Elem.	21-Feb-98	31-Dec-00	1020	31	3	2	0
E207417	Richmond South	28-Oct-93	31-Dec-00	2557	179	7	5	0
0310172	Squamish	12-Sep-94	14-Dec-00	2176	211	10	4	0
E229798	Campbell River Tyee Split	12-Dec-97	31-Dec-00	1103	46	4	2	0
0310177	Burnaby Kensington Park	14-May-94	31-Dec-00	2379	83	3	3	0
E238212	Abbotsford Bevan Ave.	19-Sep-98	31-Dec-00	814	41	5	1	0
E207418	Burnaby South	30-Mar-94	31-Dec-00	2443	192	8	3	0
E206271	Surrey East	07-Jan-94	31-Dec-00	2487	81	3	3	0
E207723	North Delta	17-Dec-93	31-Dec-99	2088	154	7	2	0
E232246	Vancouver International Airport #2	01-Feb-98	31-Dec-00	1055	58	5	1	0
E223756	Hope Airport	04-Dec-96	31-Dec-00	1477	34	2	1	0
0220204	Powell River Cranberry Lake	12-Jan-96	31-Dec-00	1764	60	3	1	0
0310175	Kitsilano	15-Dec-93	31-Dec-00	2527	126	5	1	0
E234670	Duncan Deykin Ave.	01-Nov-98	31-Dec-00	778	8	1	.	.
E222520	Elk Falls	09-Dec-95	31-Dec-00	1586	28	2	.	.
0110203	Gold River Pumphouse	06-Feb-97	08-Nov-98	626	7	1	.	.
E225377	Harmac Cedar Woobank	08-Jul-97	31-Dec-00	978	11	1	.	.
E223616	Kitimat Haul Rd.	11-Aug-98	31-Dec-00	868	8	1	.	.
E216670	Kitimat Riverlodge	11-Aug-98	31-Dec-00	870	3	0	.	.
E222778	Langdale Elem.	06-Jan-96	24-Dec-00	1465	10	1	.	.
E209178	Langley Central	01-Jan-94	31-Dec-00	2398	92	4	.	.
E228065	Port Alberni Townsite	16-Sep-97	31-Dec-00	1183	13	1	.	.
E225184	Port Edward Pacific	30-Apr-98	04-Nov-00	879	.	.	.	.
0220205	Powell River Wildwood	19-Jun-97	31-Dec-00	1276	14	1	.	.
E224014	Prince George Glenview School	11-Jun-98	31-Dec-00	927	20	2	.	.
E231838	PrinceRupert Galloway Rapids	24-Apr-98	31-Dec-00	890	1	0	.	.
E225378	Quadra Island Lighthouse	23-Feb-97	31-Dec-00	1361	13	1	.	.

Table 8 Frequency of occurrence of PM_{10} exceeding 25 $\mu g/m^3$ and the provincial objective of 50 $\mu g/m^3$ at SSI and Partisol sites with at least one year of data (rounded to nearest 1%). Sites are ranked according to percent exceedence of the provincial objective.

					> 25$\mu g/m^3$		> 50 $\mu g/m^3$	
ID	Station Name	Start Date	End Date	N	No.	%	No.	%
E208083	Merritt	Jan-90	Dec-00	532	297	56	90	17
0500827	Vernon City Hall	Oct-89	Dec-00	443	210	47	66	15
E218771	Prince George CNRail	Apr-93	Dec-00	443	180	41	51	12
0605020	Williams Lake Skyline School	Mar-92	Dec-00	517	215	42	59	11
E206112	Williams Lake Firehall	May-87	Dec-00	597	247	41	56	9
0450232	Prince George Van Bien	Aug-90	Dec-00	573	202	35	53	9
0450307	Prince George Plaza 400	Aug-90	Dec-00	585	204	35	44	8
E218444	100 Mile House	Mar-93	Dec-00	582	146	25	36	6
E220202	Invermere Forest	Mar-94	Dec-00	388	110	28	21	5
E207520	Grand Forks	Jul-92	Dec-00	458	184	40	23	5
E222858	Chetwynd	Jan-95	Dec-00	313	63	20	15	5
E229817	Vernon Coldstream	Jan-98	Dec-00	152	62	41	7	5
E206931	Castlegar	Apr-90	Dec-00	570	187	33	26	5
E217680	Revelstoke Firehall	Dec-92	Dec-00	458	124	27	20	4
E229457	Williams Lake 168 Mile	Dec-97	Dec-00	185	59	32	8	4
E206725	Kamloops Federal Bldg.	Feb-90	Dec-00	625	201	32	27	4
0260022	Trail Oasis	Jan-93	Sep-00	453	84	19	19	4
0450324	Prince George Lakewood	Aug-90	Dec-00	582	139	24	24	4
E233567	Polar Bear Lake	Jul-98	Dec-00	283	45	16	11	4
E206375	Nelson	Apr-90	Dec-00	510	112	22	19	4
0250009	Trail Butler Park	Apr-90	Dec-00	516	152	29	13	3
E229217	Penticton MOE	Nov-97	Dec-00	178	26	15	4	2
E222689	Cominco Northport	Aug-93	Dec-00	430	70	16	8	2
E224512	Oak Bay Rec. Centre	Feb-97	Dec-00	193	21	11	3	2
E217320	Mission Pioneer	Aug-92	Dec-00	495	100	20	7	1
E231866	Victoria Topaz	May-98	Dec-00	155	36	23	2	1
0260104	Slocan	Nov-91	Dec-00	494	74	15	6	1
E237978	Sechelt	Jun-99	Dec-00	87	3	3	1	1
E222141	Trail West	Jan-98	Dec-00	174	21	12	2	1
E225285	New Aiyansh	Jul-97	Dec-00	88	8	9	1	1
E222140	Genelle	Sep-95	Dec-00	290	29	10	3	1
E232982	Radium	Jul-98	Dec-00	354	39	11	2	1
E222242	Williams Lake Water Tower	Nov-95	Dec-00	296	31	10	1	0

Table 9 Frequency of occurrence of $PM_{2.5}$ exceeding 15 $\mu g/m^3$ and 30 $\mu g/m^3$ at TEOM sites with at least one year of data (rounded to nearest 1%). Sites are ranked according to percent exceedence of the numerical CWS target of 30 $\mu g/m^3$.

Location		Period of Record			>15µg/m³		>30µg/m³	
ID	Station Name	Start Date	End Date	N	No.	%	No.	%
0450307	Prince George Plaza 400	13-Nov-97	31-Dec-00	1135	297	26	40	4
0500886	Kelowna Okanagan College	01-Nov-97	31-Dec-00	1121	79	7	3	0
E231866	Victoria Topaz	02-May-98	31-Dec-00	907	73	8	2	0
E229797	Nanaimo Labieux Rd.	12-Dec-97	31-Dec-00	1098	41	4	2	0
E206898	Kamloops Brocklehurst	03-Oct-97	31-Dec-00	1101	63	6	1	0
E220891	Chilliwack Airport	01-Jun-95	31-Dec-00	1963	104	5	1	0
E237431	Merritt Granite-Garcia Mobile	16-May-99	28-May-00	375	15	4	.	.
E232244	Pitt Meadows	15-Jan-99	31-Dec-00	707	66	9	.	.
0220204	Powell River Cranberry Lake	21-Sep-98	31-Dec-00	792	12	2	.	.
E232246	Vancouver Int. Airport #2	17-Mar-99	31-Dec-00	656	58	9	.	.

Table 10 Frequency of occurrence of $PM_{2.5}$ exceeding 15 $\mu g/m^3$ and 30 $\mu g/m^3$ at Partisol and dichotomous sampler sites with at least three years of data (rounded to nearest 1%). Sites are ranked according to percent exceedence of the numerical CWS target of 30 $\mu g/m^3$. "P" refers to Partisol sites and "D" refers to dichotomous sampler sites.

Location		Period of Record			>15µg/m³		>30µg/m³	
ID	Station Name	First Date	Last Date	N	No.	%	No.	%
0450307	Prince George Plaza 400 (P)	Sep 94	Dec 00	353	93	26	21	6
E208096	Quesnel Sr. Secondary (P)	Nov 95	Dec 00	288	55	19	3	1
E221197	Williams Lake Columneetza (P)	Oct 94	Dec 00	342	39	11	3	1
E206589	Smithers St. Josephs (P)	Apr 96	Dec 00	150	19	13	0	0
100111	Port Moody Rock Point Park (D)	Aug 84	Dec 00	996	205	21	31	3
100118	Kitsilano Secondary School (D)	Dec 86	Dec 00	750	118	16	19	3
100303	Victoria PAPS (D)	Jan 85	Oct 97	581	115	20	15	3
100304	Victoria Topaz (D)	May 98	Dec 00	133	6	5	0	0

Table 11 Achievement of $PM_{2.5}$ CWS of 30 $\mu g/m^3$ (24-hr average) at TEOM sites. Achievement based on annual 98th percentile value averaged over three consecutive years.

Site ID	Site Name	Year	CWS ($\mu g/m^3$)
0450307	Prince George Plaza 400	2000	32
0500886	Kelowna Okanagan College	2000	19
E206898	Kamloops Brocklehurst	2000	18
E220891	Chilliwack Airport	1998	18
E220891	Chilliwack Airport	1999	18
E220891	Chilliwack Airport	2000	18
E229797	Nanaimo Labieux Rd.	2000	17

Table 12 Achievement of $PM_{2.5}$ CWS of 30 $\mu g/m^3$ (24-hr average) at Partisol sites. Achievement based on annual 98th percentile value averaged over three consecutive years.

Site ID	Site Name	Year	CWS
0450307	PG Plaza 400	1997	39
0450307	PG Plaza 400	1998	36
0450307	PG Plaza 400	1999	36[a]
0450307	PG Plaza 400	2000	41
E208096	Quesnel Sr. Secondary	1998	32[a]
E208096	Quesnel Sr. Secondary	1999	25
E208096	Quesnel Sr. Secondary	2000	24
E221197	Williams Lake Columneetza	1997	29
E221197	Williams Lake Columneetza	1998	n/a
E221197	Williams Lake Columneetza	1999	n/a
E221197	Williams Lake Columneetza	2000	22

[a] Based on two valid consecutive years of data.

4.4 *Temporal variability in PM Concentrations (Select Sites)*

Box and whisker plots are presented for a number of selected sites to facilitate visual exploration of temporal patterns. PM concentrations vary according to season, day of the week, and time of day. Meteorological conditions in combination with variations in emissions on many different time scales contribute to these temporal patterns.

4.4.1 Annual Variations

Annual frequency distributions of PM_{10} concentrations from select TEOM sites between 1990-2000 are summarized in Figure 8. Those from SSI sites are presented in Figure 9. Although TEOM and SSI data are presented separately, SSI monitors actually preceded TEOM monitors at a number of sites in the province. Hence, a more complete data record could be constructed for these sites, but owing to differences regarding the sampling technology and frequency, we have chosen not to combine these data records in this report. Consequently, there is no data to report for Victoria Topaz prior to 1999, and for sites in Merritt, and Golden for the later years. Years with less than 75 percent completeness of record were also excluded from the analysis.

Apparent decreasing trends, based on mean, quartile and/or 98th percentile values, are observed at a number of sites in the province, with the most obvious improvements noted in extreme values. These sites include some of the areas with the highest PM_{10} concentrations. Of note, Williams Lake (Columneetza) has experienced decreases in both mean concentrations and upper extreme (98th percentile) concentrations since the early 1990s. The phase-out of local beehive burners is believed to be a contributing factor to improving PM concentrations in this community. Houston has also experienced improvements in mean and upper extreme concentrations.

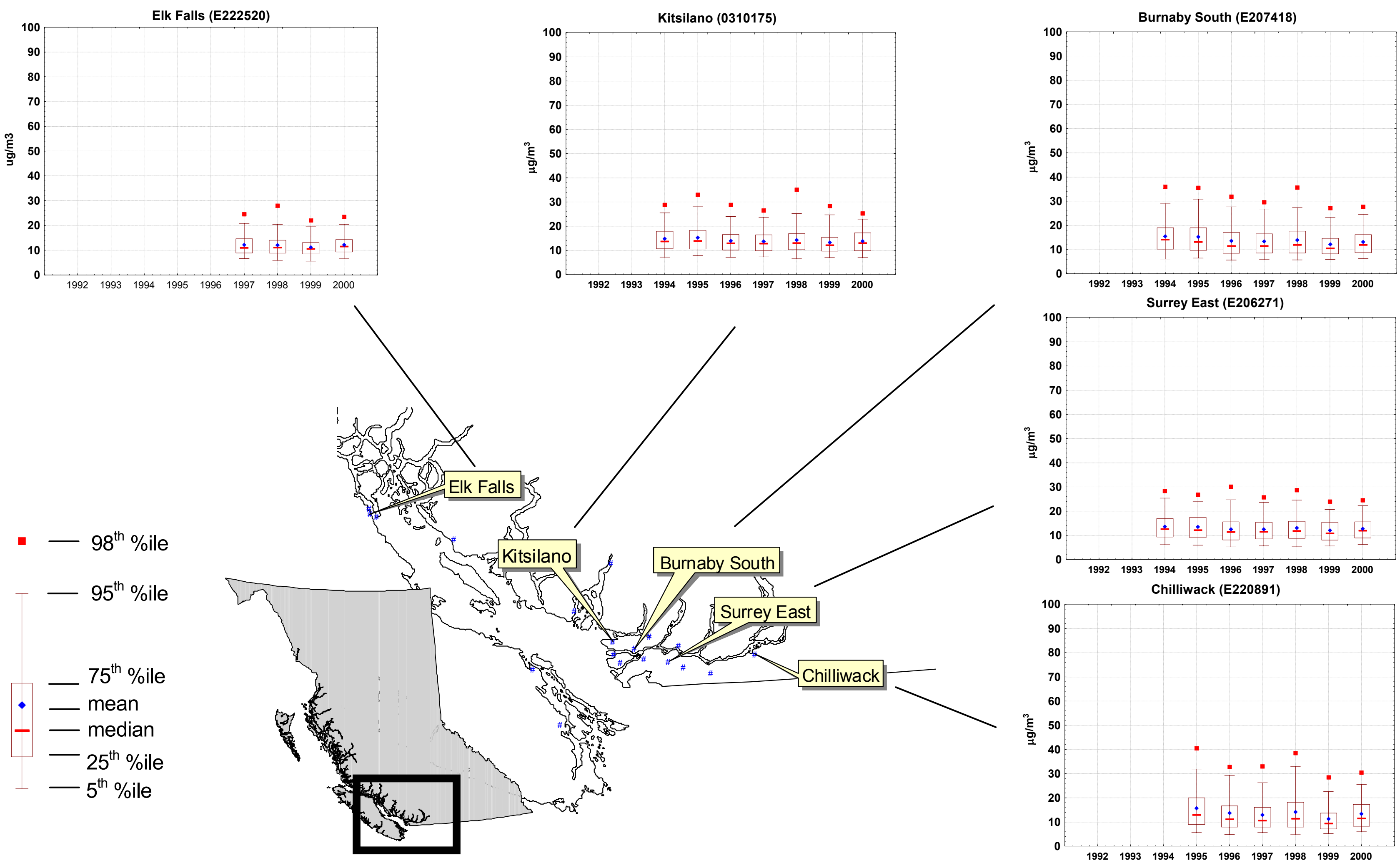


Figure 8 Annual variations in 24-hour average PM_{10} measurements from select TEOM sites.

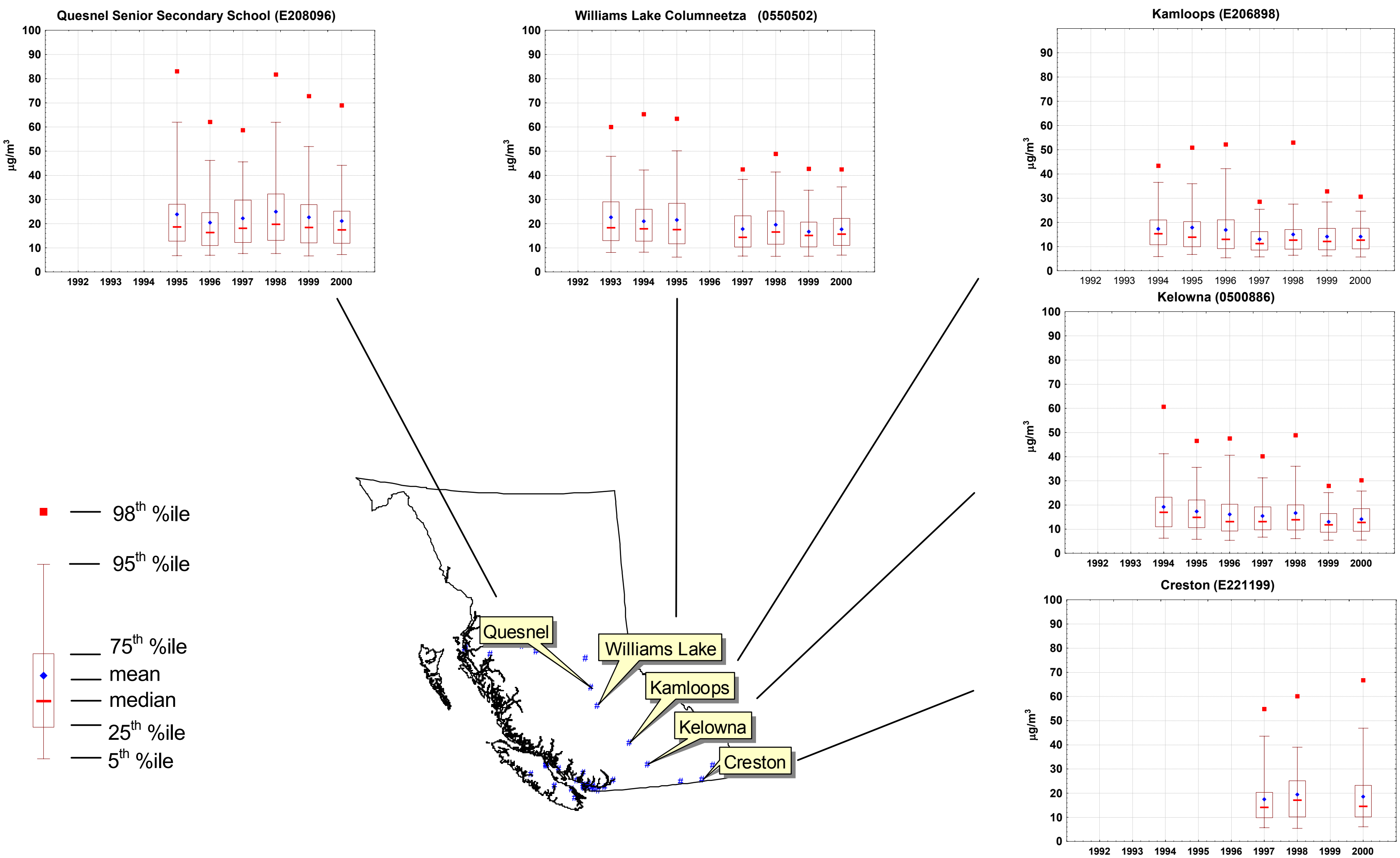


Figure 8 continued: Annual variations in 24-hour average PM_{10} measurements from select TEOM sites.

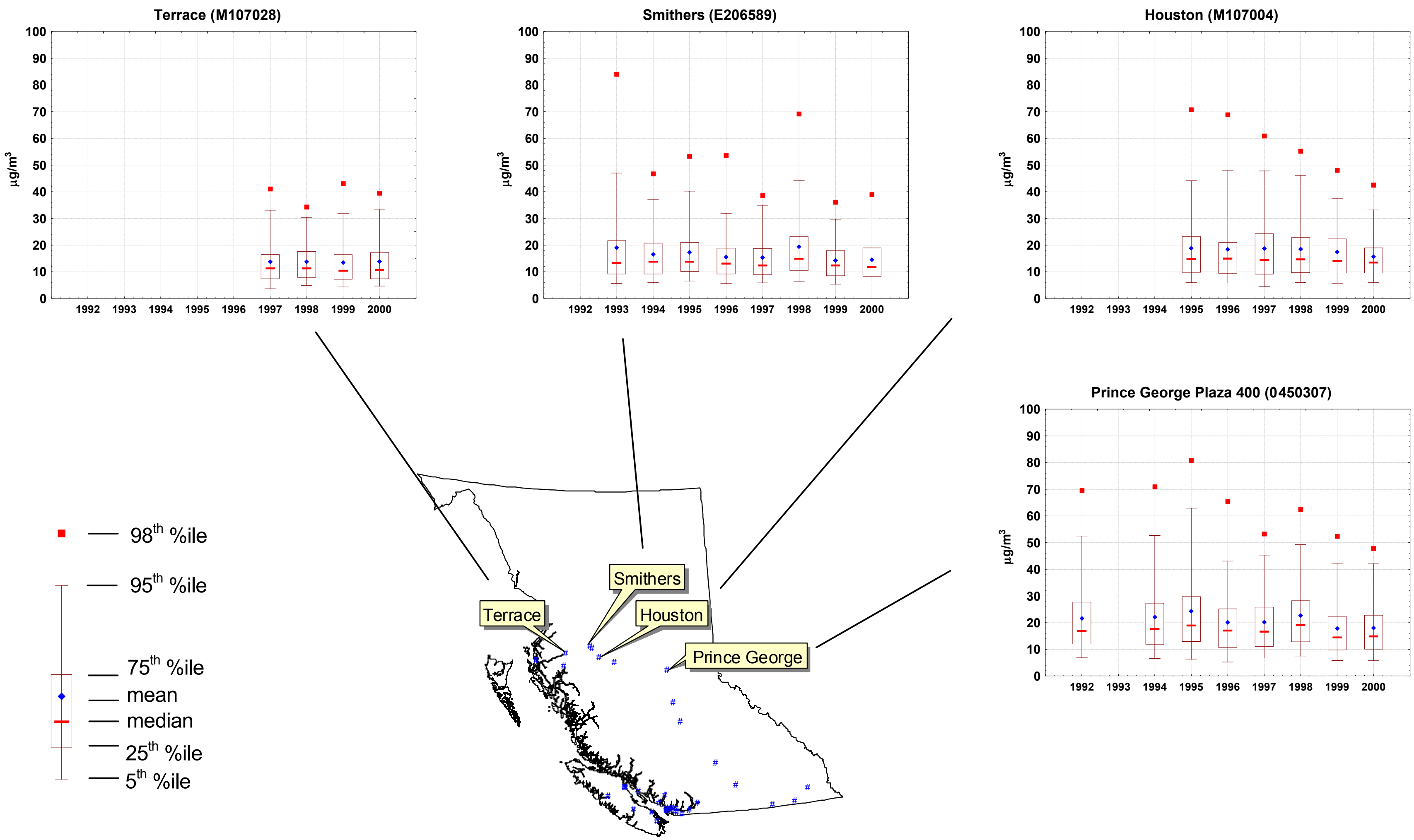


Figure 8 continued: Annual variations in 24-hour average PM_{10} measurements from select TEOM sites.

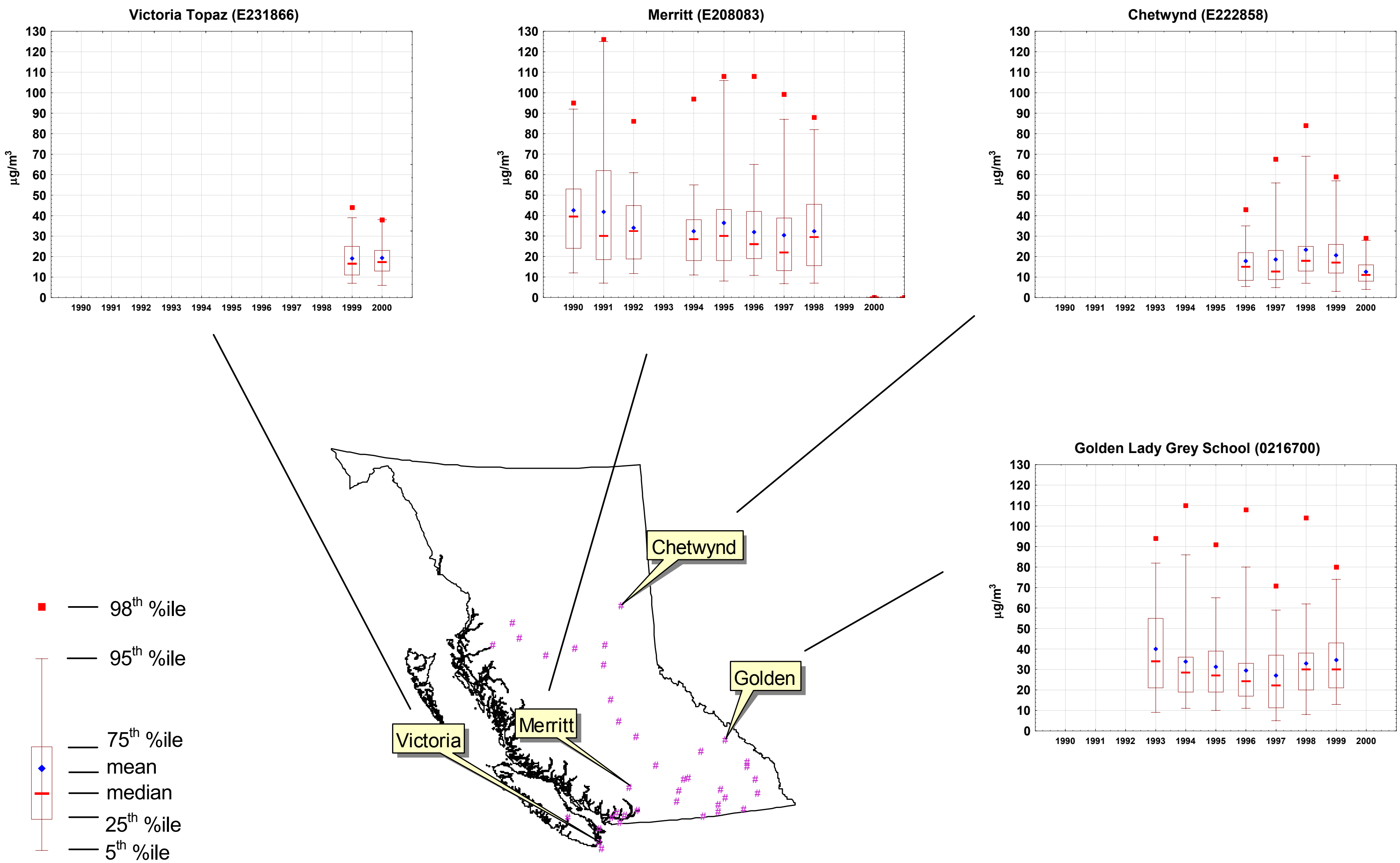


Figure 9 Annual variations in 24-hour average PM_{10} measurements from select SSI sites.

$PM_{2.5}$ TEOM data from select sites are summarized in Figure 10. Of the 14 TEOM sites operating at the end of 2000, Chilliwack had the longest record (five years), while four other sites had roughly three years of data and the remainder had two years or less. Based on an inter-site comparison of data collected in 2000, most of the stations are characterized by similar concentration distributions, with interquartile concentrations falling between 5 and 11 $\mu g/m^3$. The exception is Prince George, which exhibits significantly higher $PM_{2.5}$ concentrations than elsewhere in the province. This finding reflects in part the limited amount of $PM_{2.5}$ monitoring taking place in the province, as well as the type and density of industrial and other PM sources in the airshed, its complex topography, and prevailing meteorology.

Annual frequency distributions for $PM_{2.5}$ from three Partisol sites are presented in Figure 11. With the exception of NAPS sites prior to 1991, interquartile concentrations generally lay between 5 and 15 $\mu g/m^3$. Ambient concentrations at the Prince George (Plaza 400) site are generally higher than those at other sites. All three Partrisol sites show slight downward trends in mean 24-hour concentrations to 1998, and higher concentrations in 2000. Greater downward trends are observed in data from the NAPS sites that provide the longest $PM_{2.5}$ record in the province.

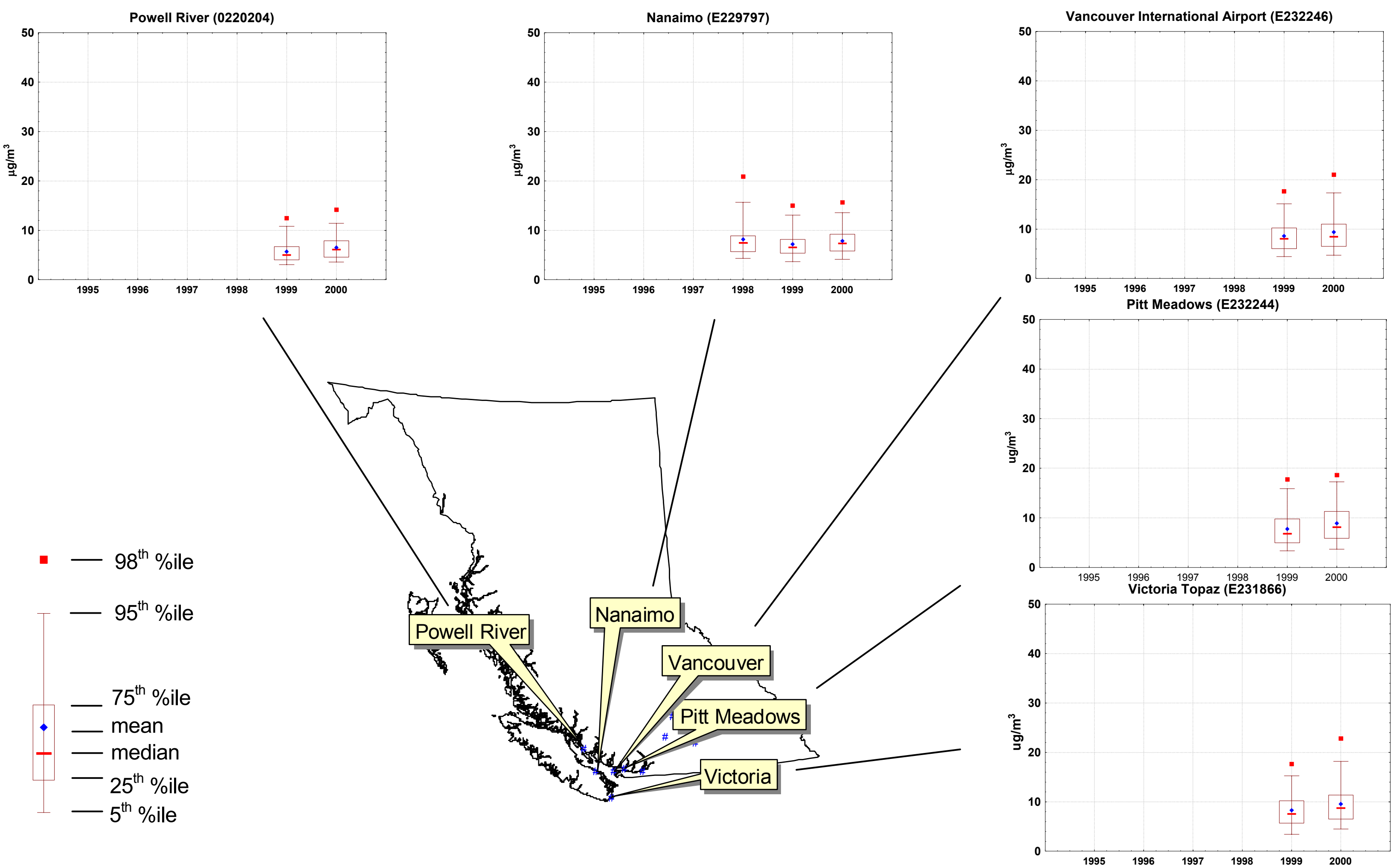


Figure 10 Annual variations in 24-hour average $PM_{2.5}$ measurements from select TEOM sites.

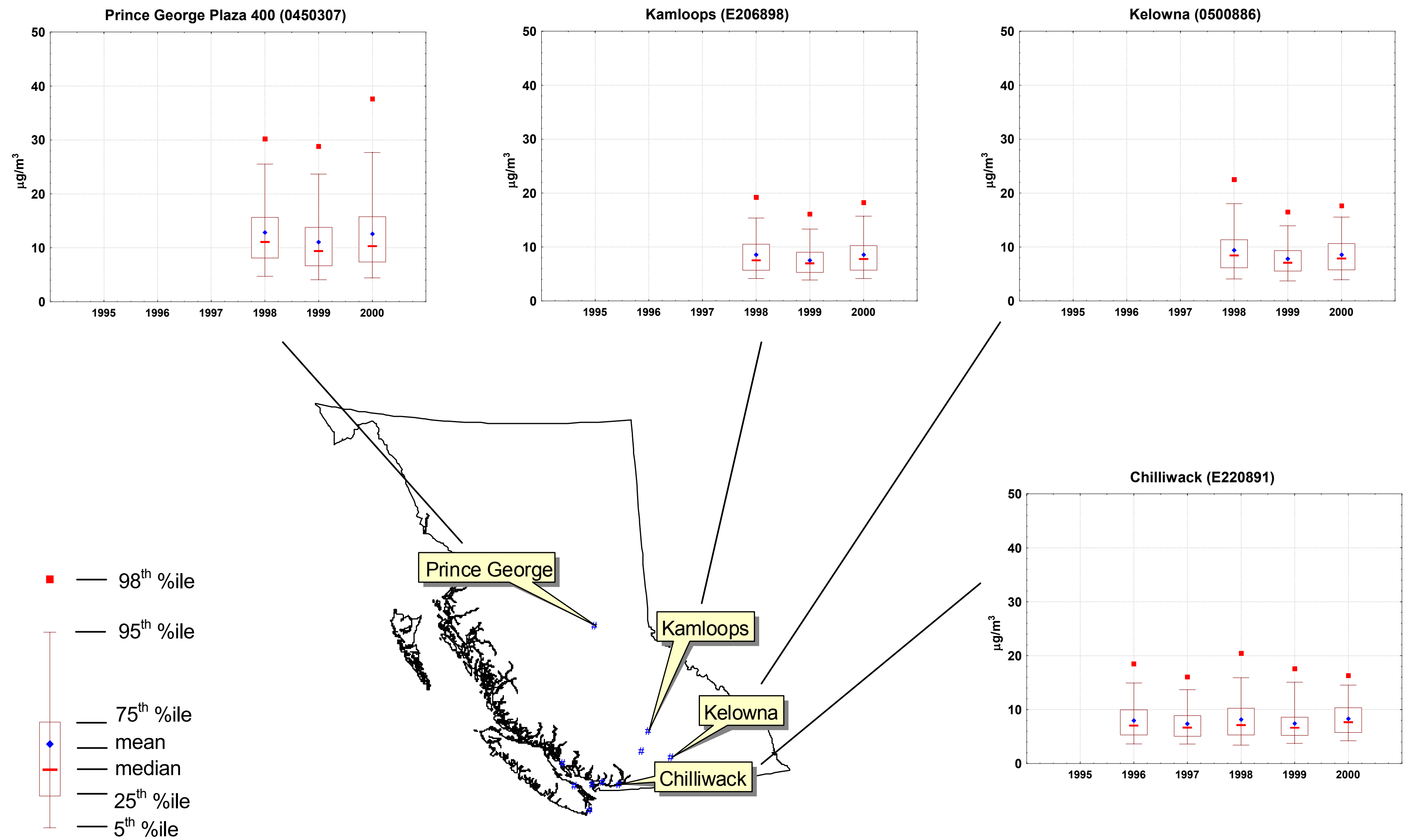


Figure 10 continued: Annual variations in 24-hour average $PM_{2.5}$ measurements from select TEOM sites.

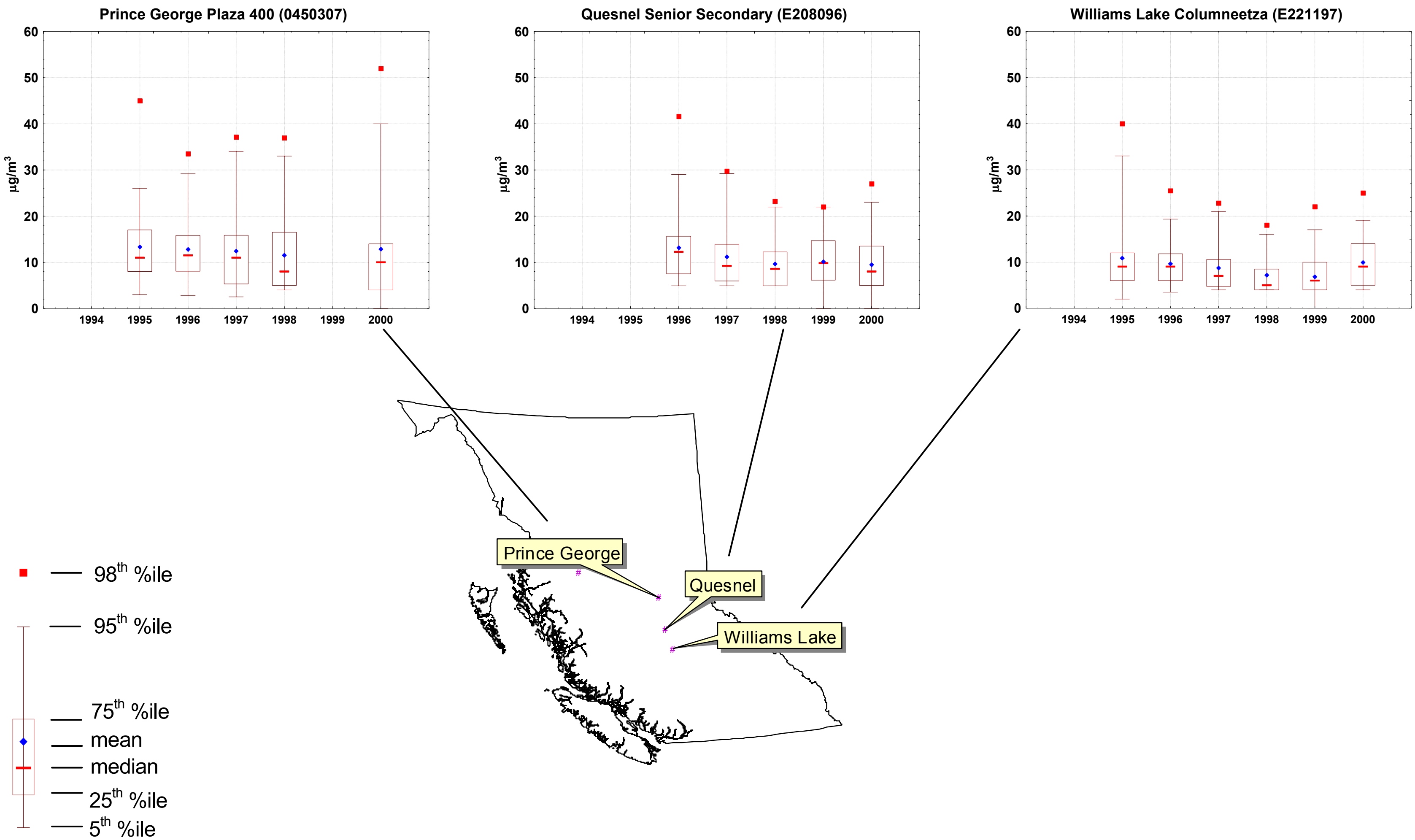


Figure 11 Annual variations in 24-hour average $PM_{2.5}$ measurements from select Partisol sites.

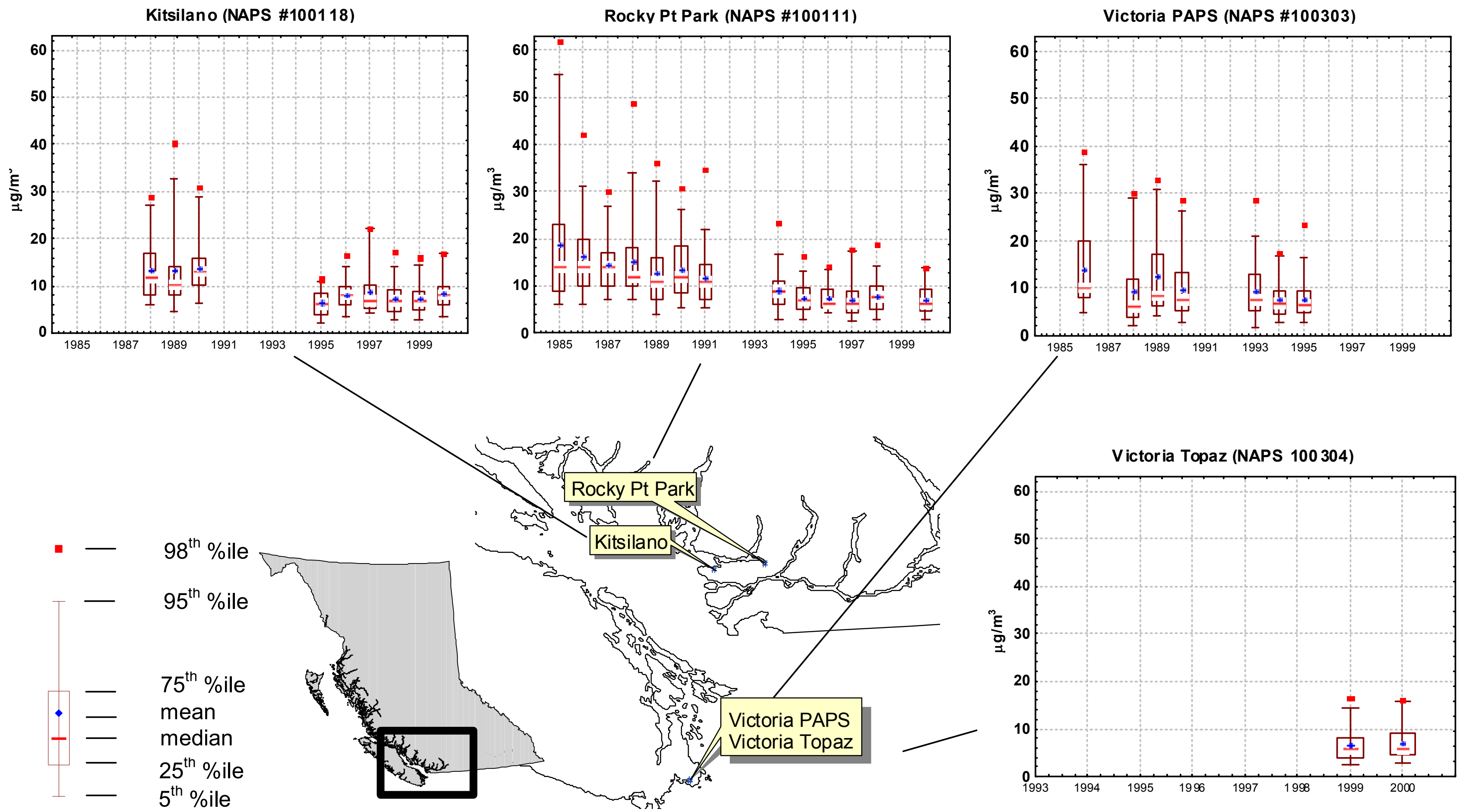


Figure 11 Continued - Annual variations in 24-hour average $PM_{2.5}$ measurements from select dichotomous (NAPS) sites**.**

It is important to note that part of the variation in year to year concentrations of PM is due to interannual climate variability, since meteorological conditions will favour dispersion in some years and not others. The time series presented here have not been de-climatized to adjust for this factor.

In summary, improvements in annual PM_{10} and $PM_{2.5}$ levels appear to be occurring at a number of sites in the province. However, analyses are limited by the short monitoring record in this province. In general, data and trends analyses presented here are not robust enough to make definitive comments about what the trends are or why they are occurring. [See Section 4.5 for more detailed treatment.] Future analyses based on a longer monitoring record should enable more definitive comments to be made.

4.4.2 Seasonal Variations

PM_{10} data from select TEOM sites are summarized on a monthly basis in Figure 12 and from SSI sites in Figure 13. Two different patterns are readily identified: a summer maximum and winter minimum; and a late winter/early spring maximum and a December-January and/or May-June minimum.

At TEOM sites in the Lower Fraser Valley, the lowest concentrations (mean, median and 75th percentile) generally occur between November and March, when precipitation rates in the Lower Fraser Valley are highest. In contrast, the highest concentrations typically occur during the late summer (August-September), when secondary PM is believed to contribute significantly to the $PM_{2.5}$ fraction (Pryor and Steyn, 1994; Lowenthal et al., 1994). A number of factors may contribute to this finding. Stagnant anticyclonic conditions that are conducive to ground level ozone production during the summertime are also conducive to the formation of secondary PM. In addition, contributions of coarse particles from road dust and agricultural activities are significant during this period. Elevated PM_{10} concentrations are also periodically observed during the winter, when strong Arctic outflow winds are believed to contribute to the suspension of fine riverbed silts (McKendry, 2000).

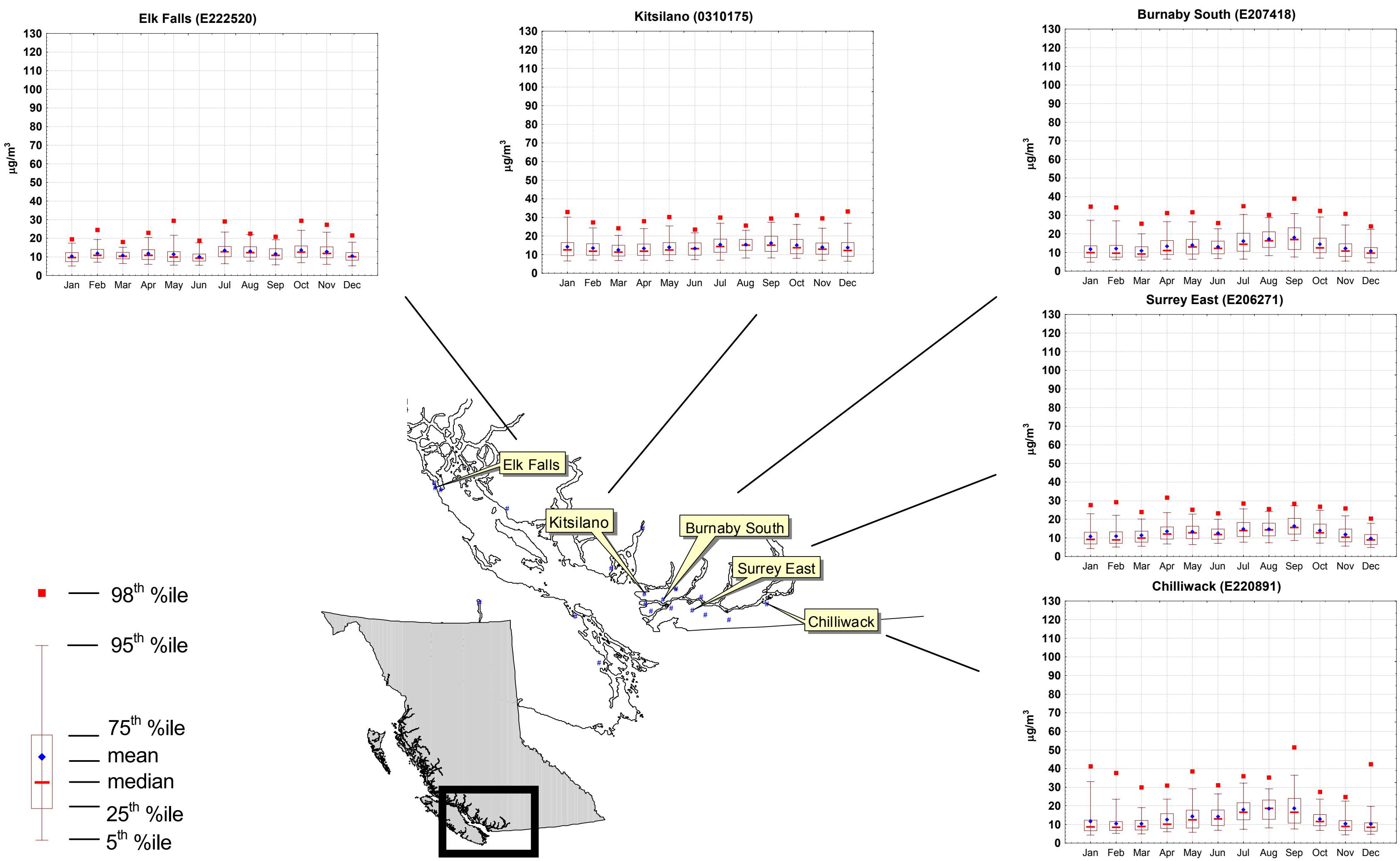


Figure 12 Seasonal variations in 24-hour PM_{10} measurements at select TEOM sites.

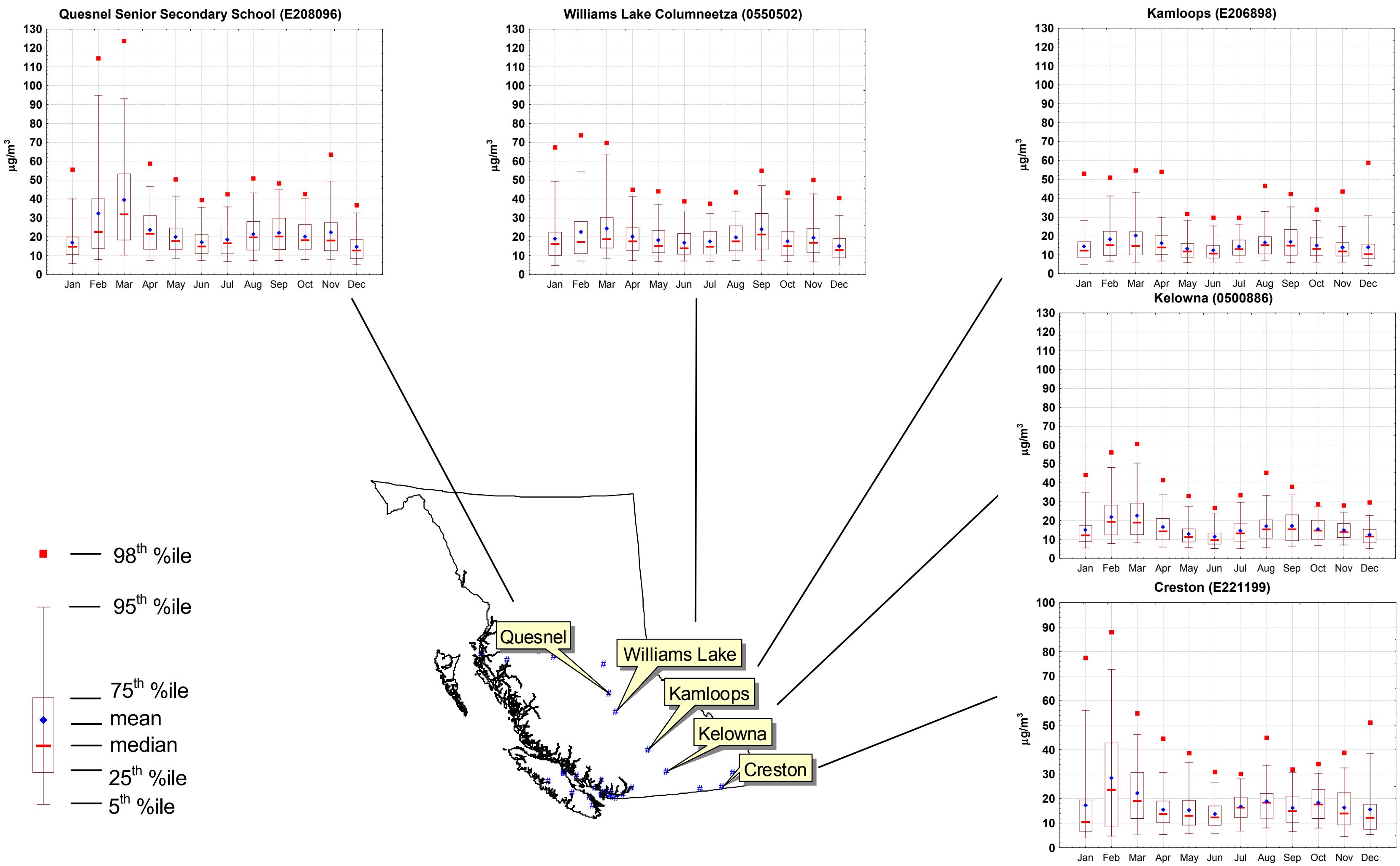


Figure 12 continued: Seasonal variations in 24-hour PM_{10} measurements at select TEOM sites.

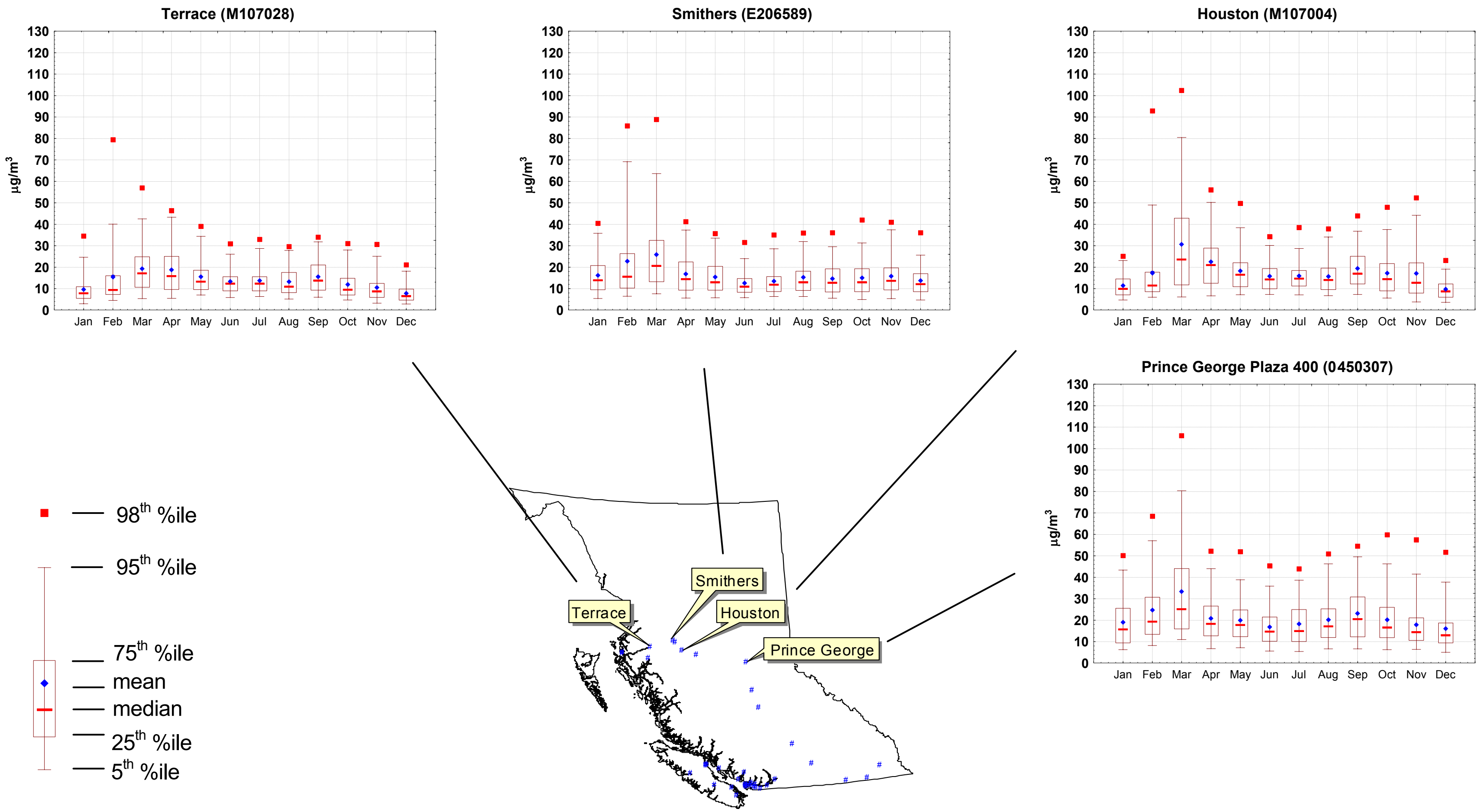


Figure 12 continued: Seasonal variations in 24-hour PM_{10} measurements at select TEOM sites.

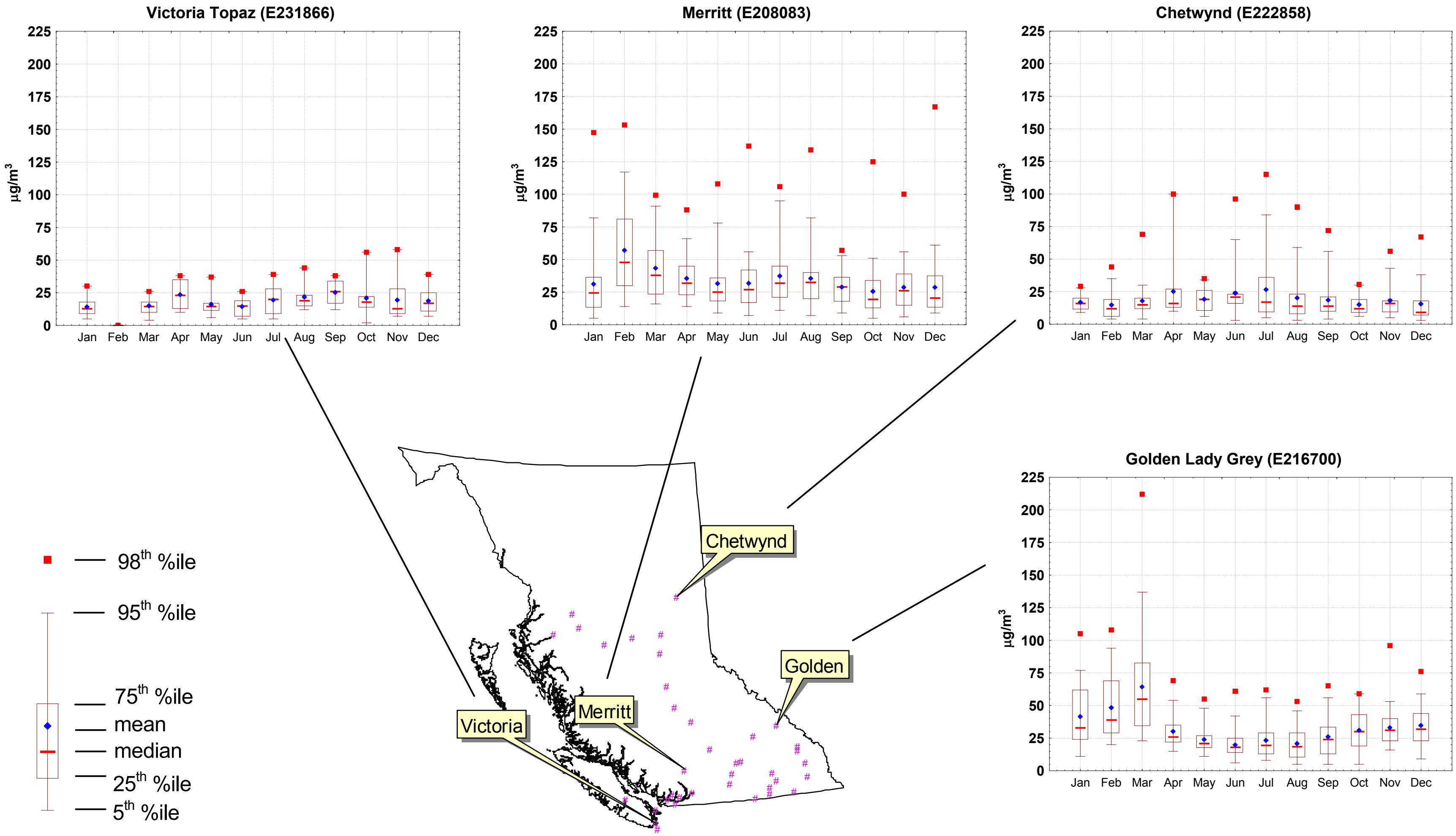


Figure 13 Seasonal variations in 24-hour average PM_{10} measurements from select SSI sites.

At most TEOM sites in the interior of the province, the highest concentrations are typically observed in the late winter/early spring. The lowest concentrations occur between November and January and also during May and June. Examples include Quesnel (Sr. Secondary), Williams Lake (Columneetza), Prince George (Plaza 400), Terrace, Smithers and Houston. Road dust is believed to be an important contributor to the elevated concentrations in the late winter/early spring at some of these sites (Plain and Carmichael, 1998; Breed, 1998). However, other as-yet unidentified factors may also be important. In Kelowna and Kamloops, a smaller, secondary peak is also found during the late summer. This may be attributed to a number of factors, including dry conditions, increased secondary PM formation, and/or emissions from seasonal sources such as wildfires. Low concentrations during the winter may be a function of precipitation and snow cover, which reduces fugitive dust emissions.

Large differences are observed among the four SSI sites that were selected. Concentrations in Merritt are the highest between February-March and lowest between October and January. Based on a limited dataset, PM_{10} levels in Victoria are relatively low year-round, with interquartile concentrations in the September are noticeably higher than at other times of the year. In Golden, the highest concentrations generally occur in February-March, and lowest in July-August. Residential wood combustion is believed to be a significant contributor to wintertime PM_{10} in this community (MELP, 1998b). In relation to other sites, PM_{10} concentrations in Chetwynd show little similarity. Interquartile concentrations are highest in July, and lowest during the winter.

Seasonal $PM_{2.5}$ data from TEOM and Partisol/dichotomous samplers are summarized in Figures 14 and 15 respectively. Analysis of seasonal trends is hampered by the lack of available monitoring data. However, it is clear that seasonal patterns for $PM_{2.5}$ data differ from those shown for PM_{10}. All sites experience elevated $PM_{2.5}$ concentrations during at least part of the autumn.

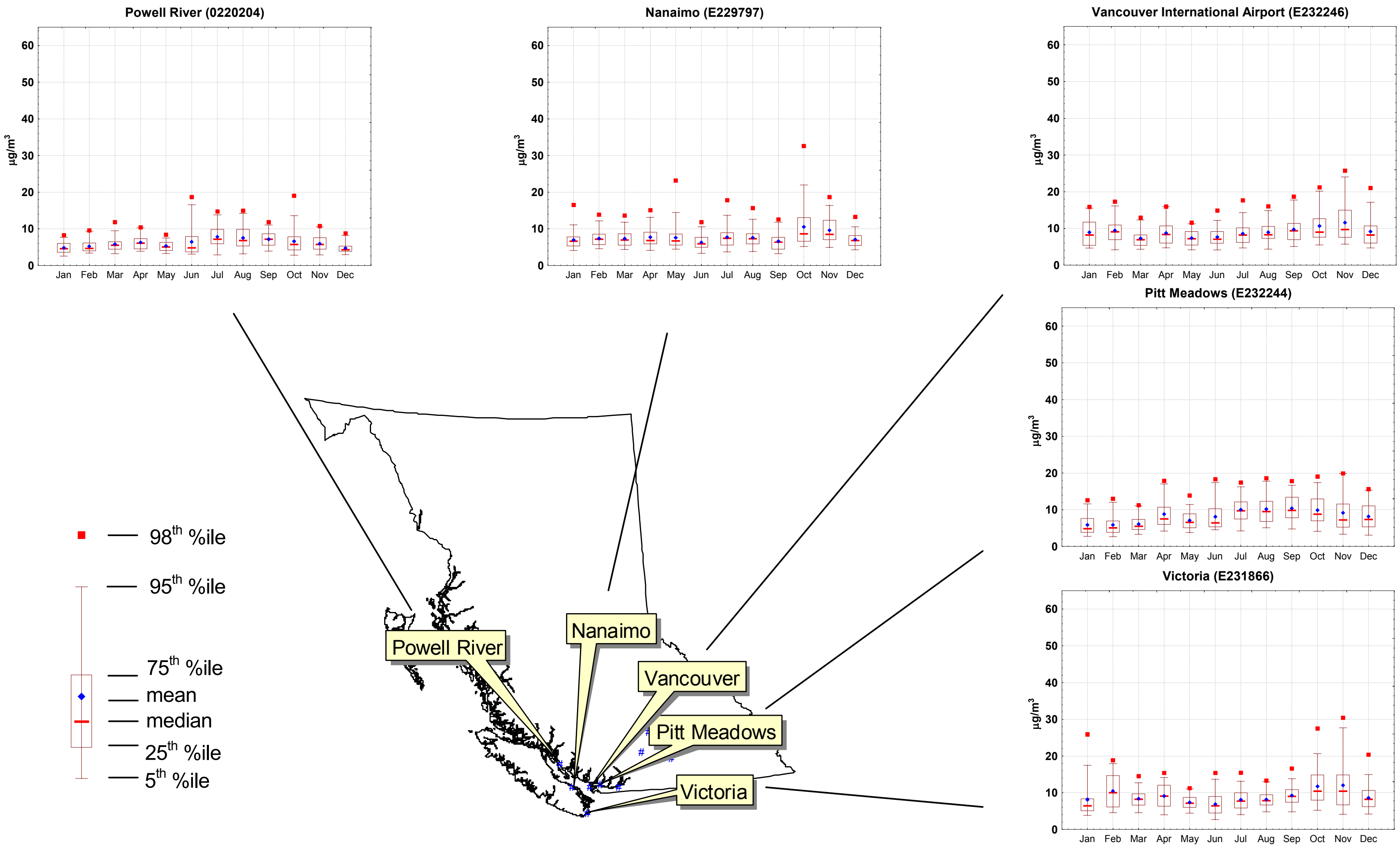


Figure 14 Seasonal variations in 24-hour average $PM_{2.5}$ measurements from TEOM sites.

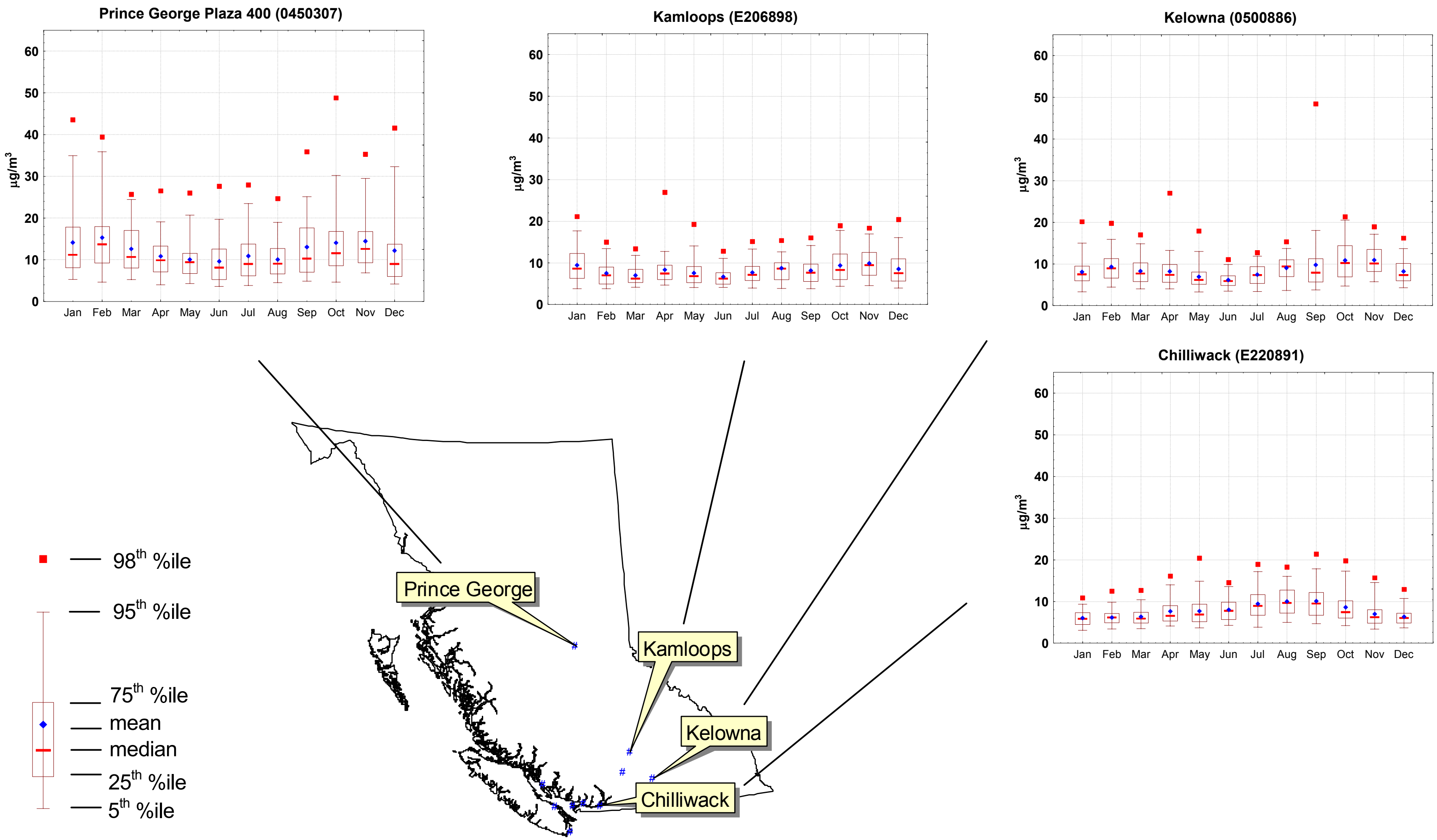


Figure 14 continued: Seasonal variations in 24-hour average $PM_{2.5}$ measurements from TEOM sites.

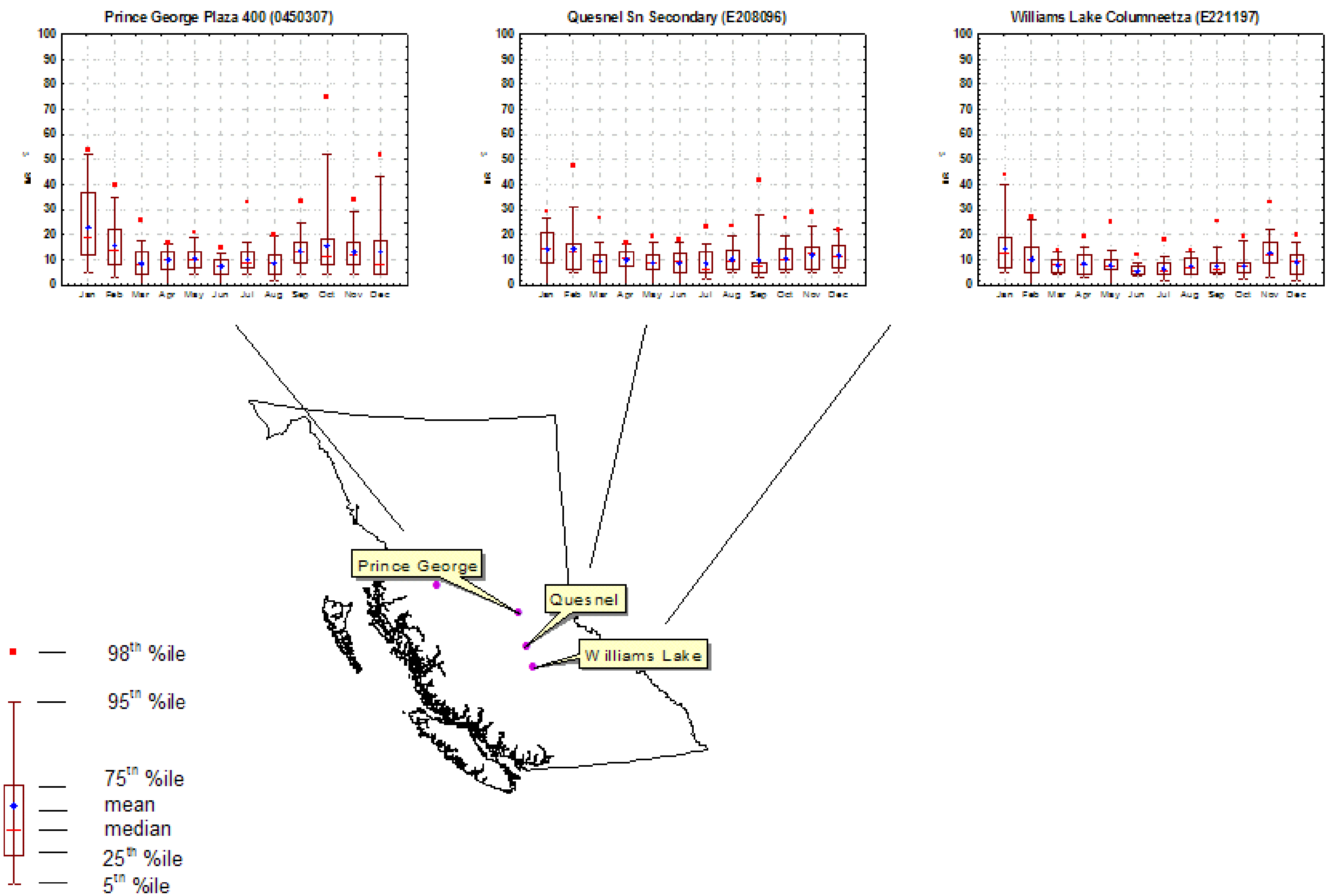


Figure 15 Seasonal variations in 24-hour $PM_{2.5}$ measurements from select Partisol sites.

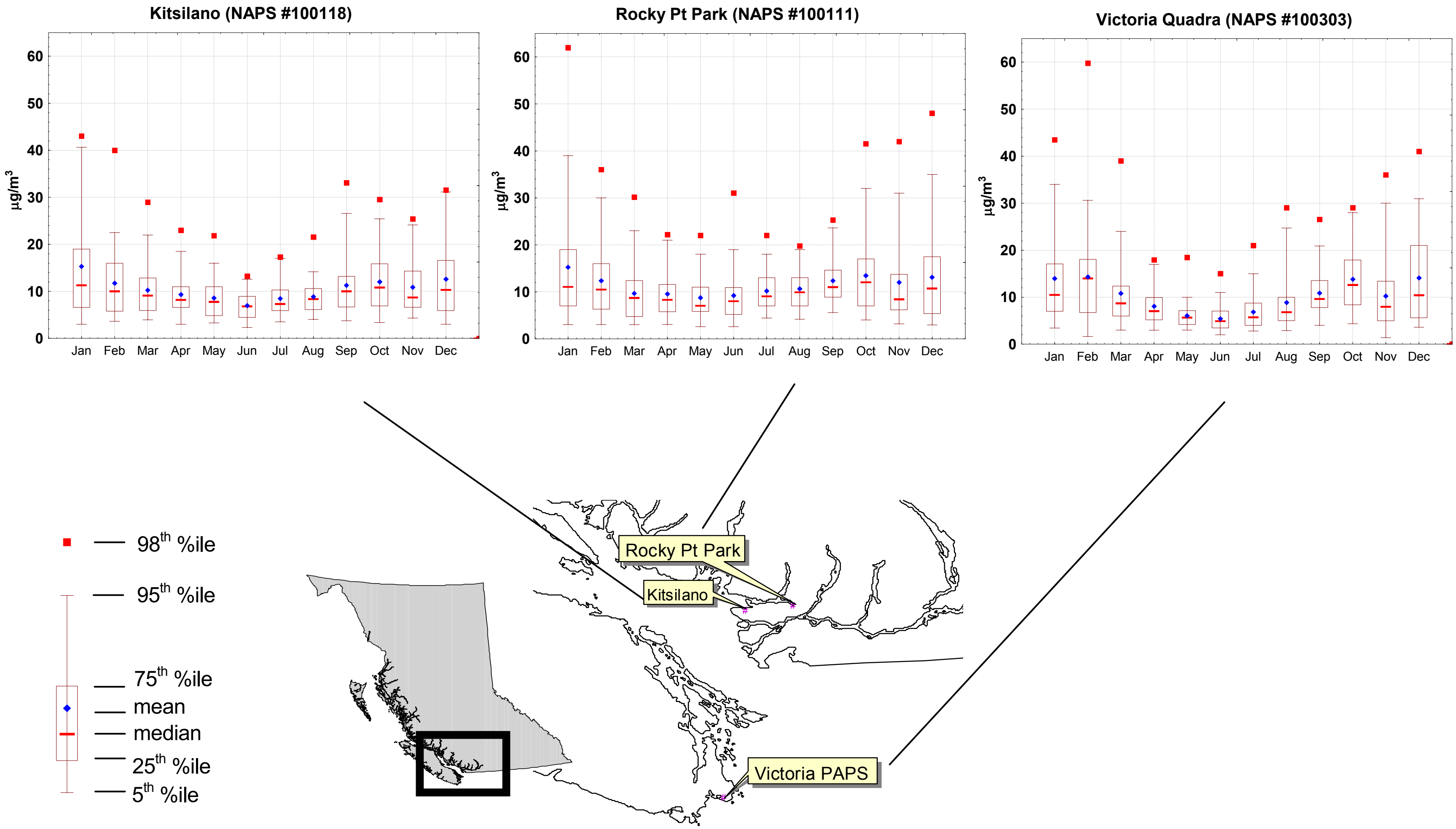


Figure 15 continued: Seasonal variations in 24-hour average $PM_{2.5}$ measurements from select dichotomous (NAPS) sites.

This may reflect a combination of reduced dispersion and/or increased vegetative burning (e.g. prescribed or backyard). Some regional differences are evident. Inland sites in the LFV (Chilliwack and Pitt Meadows) also experience elevated concentrations in the summer, suggesting contributions from secondary PM formation. Similar patterns are not evident at the Vancouver Airport site, which is located along the coast. In the interior (Prince George, Kamloops and Kelowna), and the long term NAPS sites in Vancouver, Port Moody and Victoria, elevated concentrations also occur during the early winter.

Reduced dispersion and/or increased residential wood combustion may be factors contributing to this finding. TEOM sites in the Lower Fraser Valley exhibit their lowest concentrations during at least one month of the winter, whereas all interior sites and all NAPS dichotomous sampler sites experience their lowest concentrations (mean and median) in June and/or July. Differences between seasonal trends at TEOM and NAPS sites in the Lower Fraser Valley may be a function of station location, differences in period of record or some other unidentified factors.

In summary, PM_{10} and $PM_{2.5}$ levels exhibit strong seasonality that varies across the province and between PM_{10} and $PM_{2.5}$. Higher PM_{10} concentrations are typically observed during the late winter and early spring at interior sites, and during the late summer at sites in the Lower Fraser Valley. In contrast, higher $PM_{2.5}$ concentrations are found during at least part of the fall at all BC sites, and during the summer at inland sites in the Lower Fraser Valley. In the interior, elevated concentrations are also observed during the early winter. These findings underlie the need for each region to identify when it is most susceptible to higher concentrations and to develop management plans accordingly, recognising that the same approach will not necessarily work for all areas of BC and for both PM_{10} and $PM_{2.5}$.

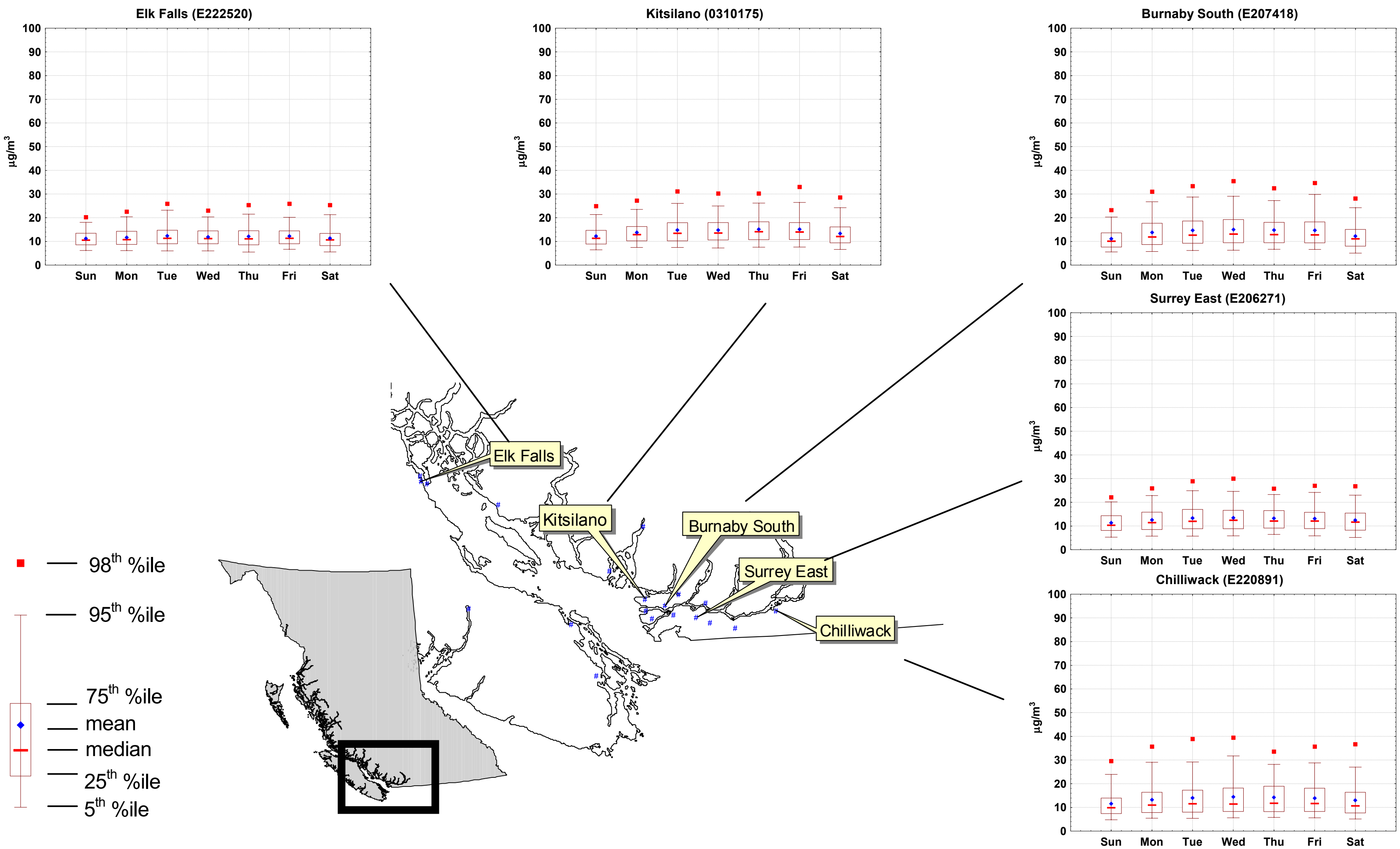


Figure 16 Hebdomadal variations in 24-hour PM_{10} measurements at select TEOM sites.

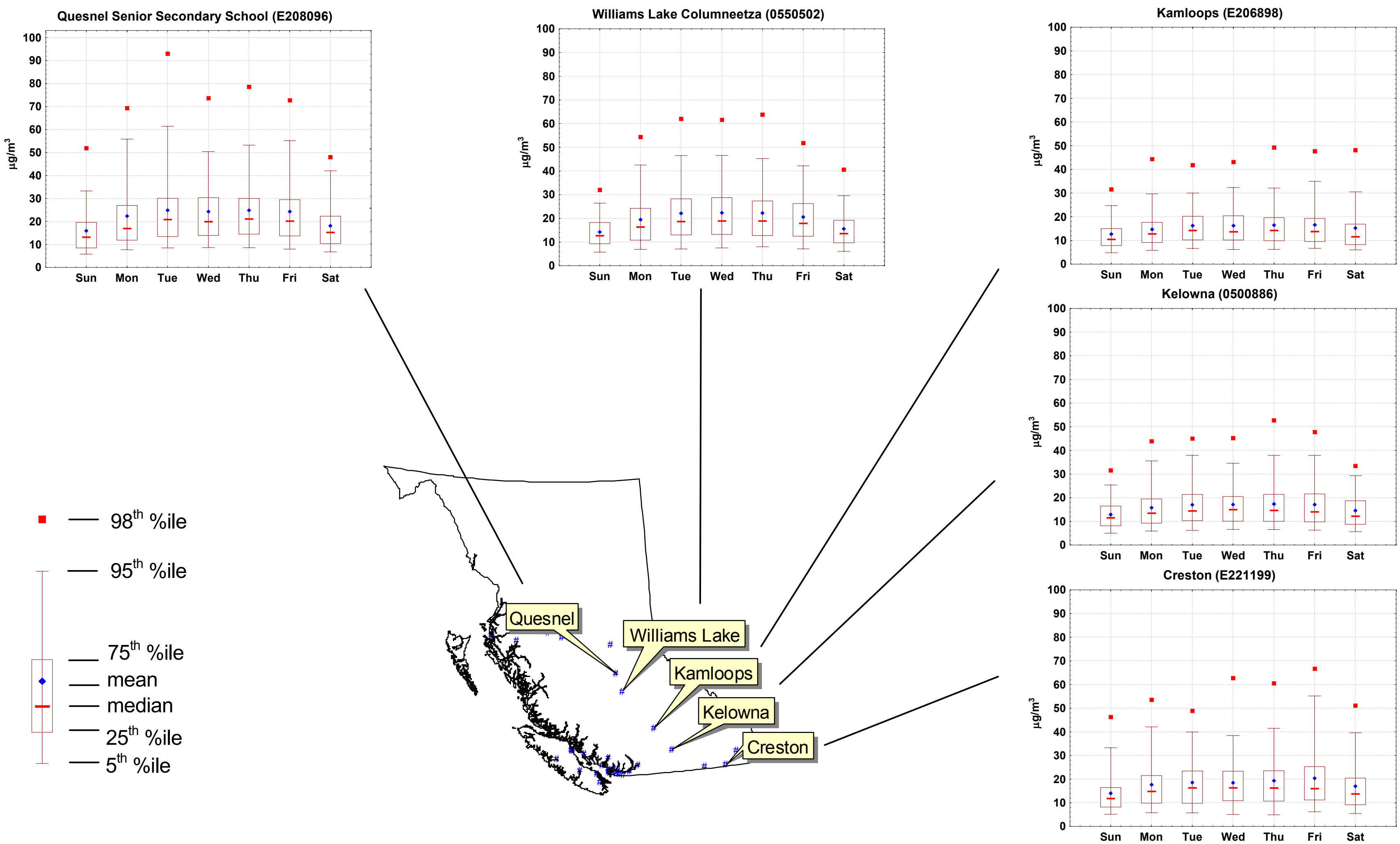


Figure 16 continued: Hebdomadal variations in 24-hour PM_{10} measurements at select TEOM sites.

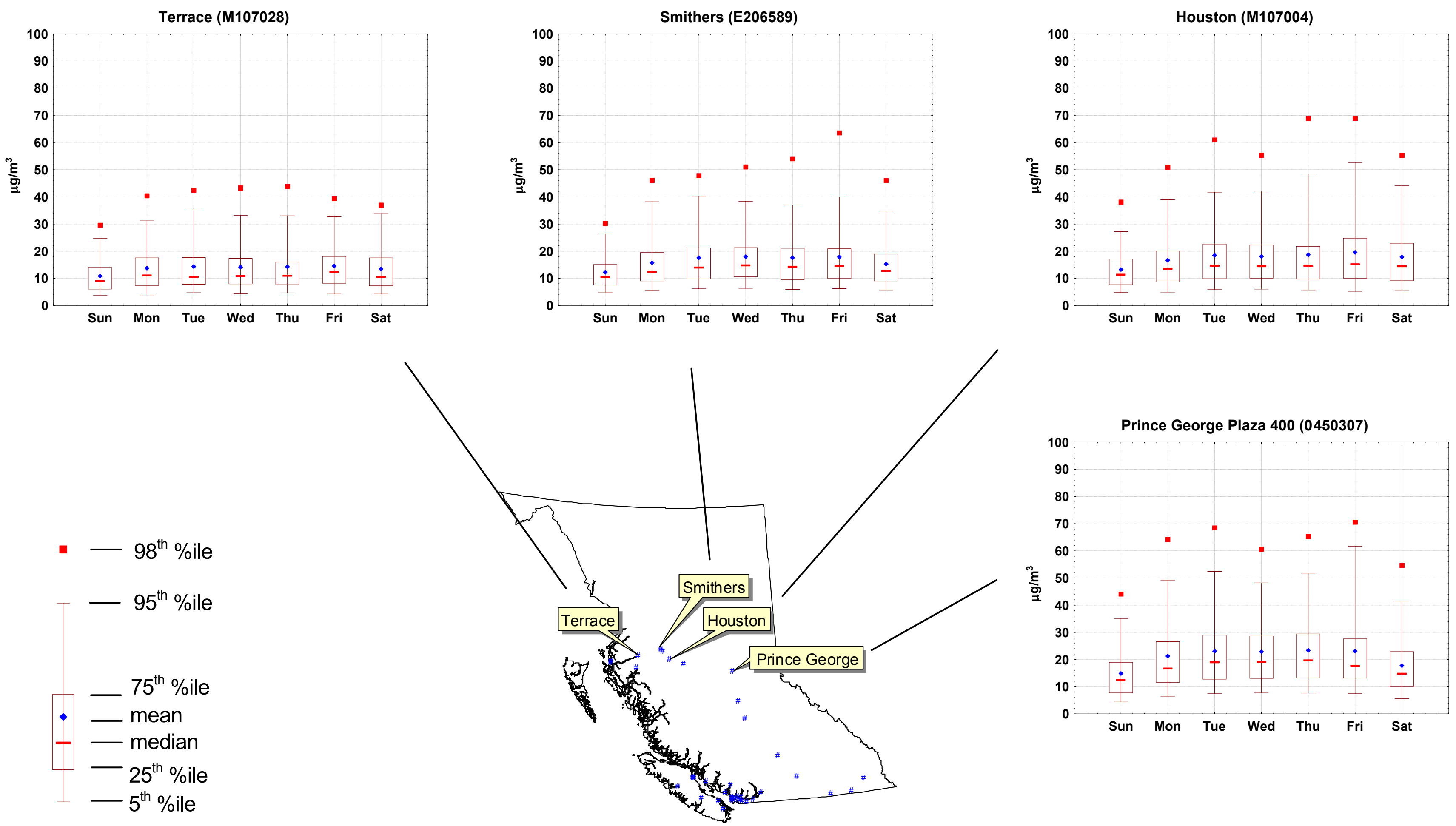


Figure 16 continued: Hebdomadal variations in 24-hour PM_{10} measurements at select TEOM sites.

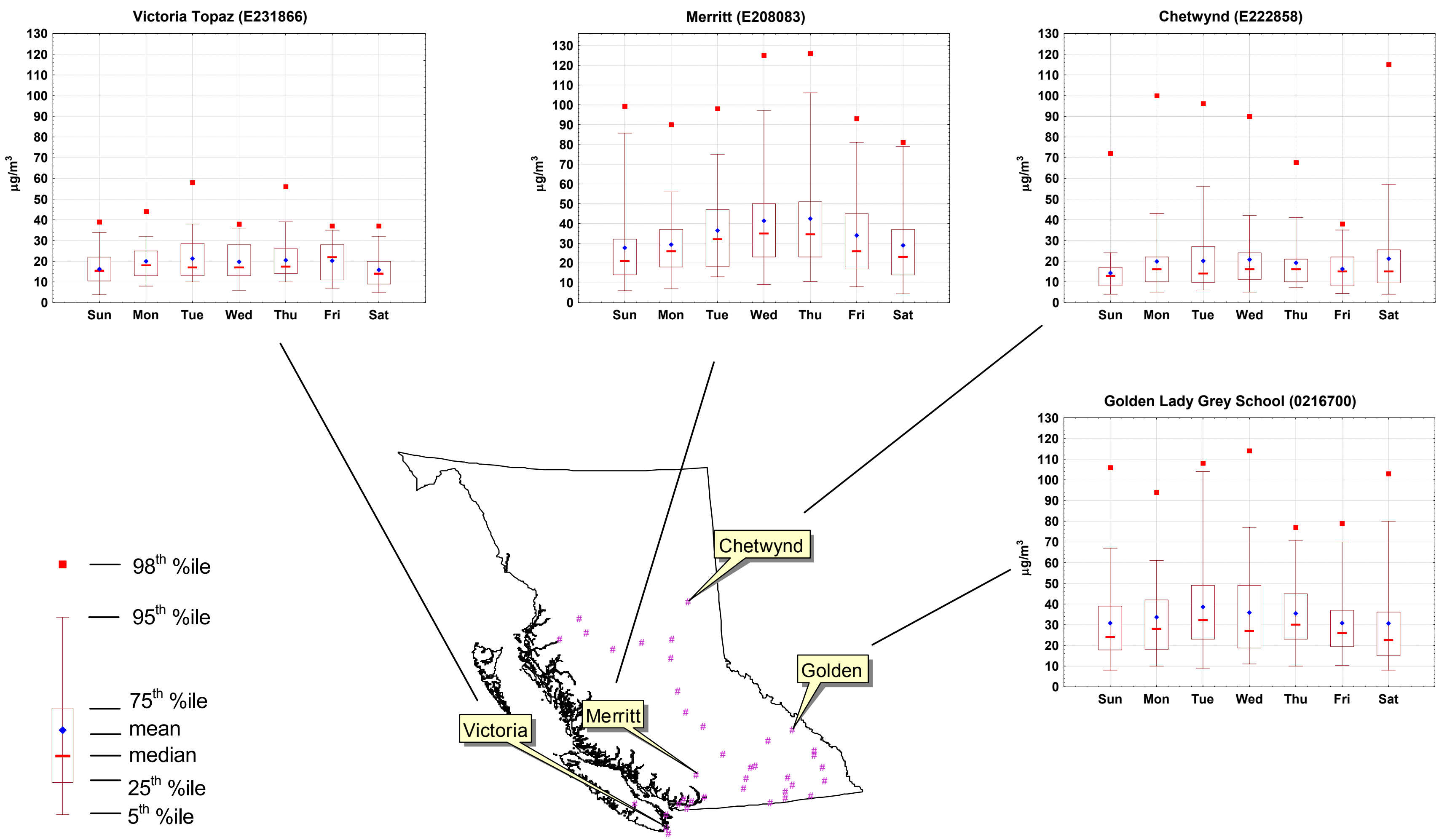


Figure 17 Hebdomadal variations in 24-hour PM_{10} measurements from select SSI sites.

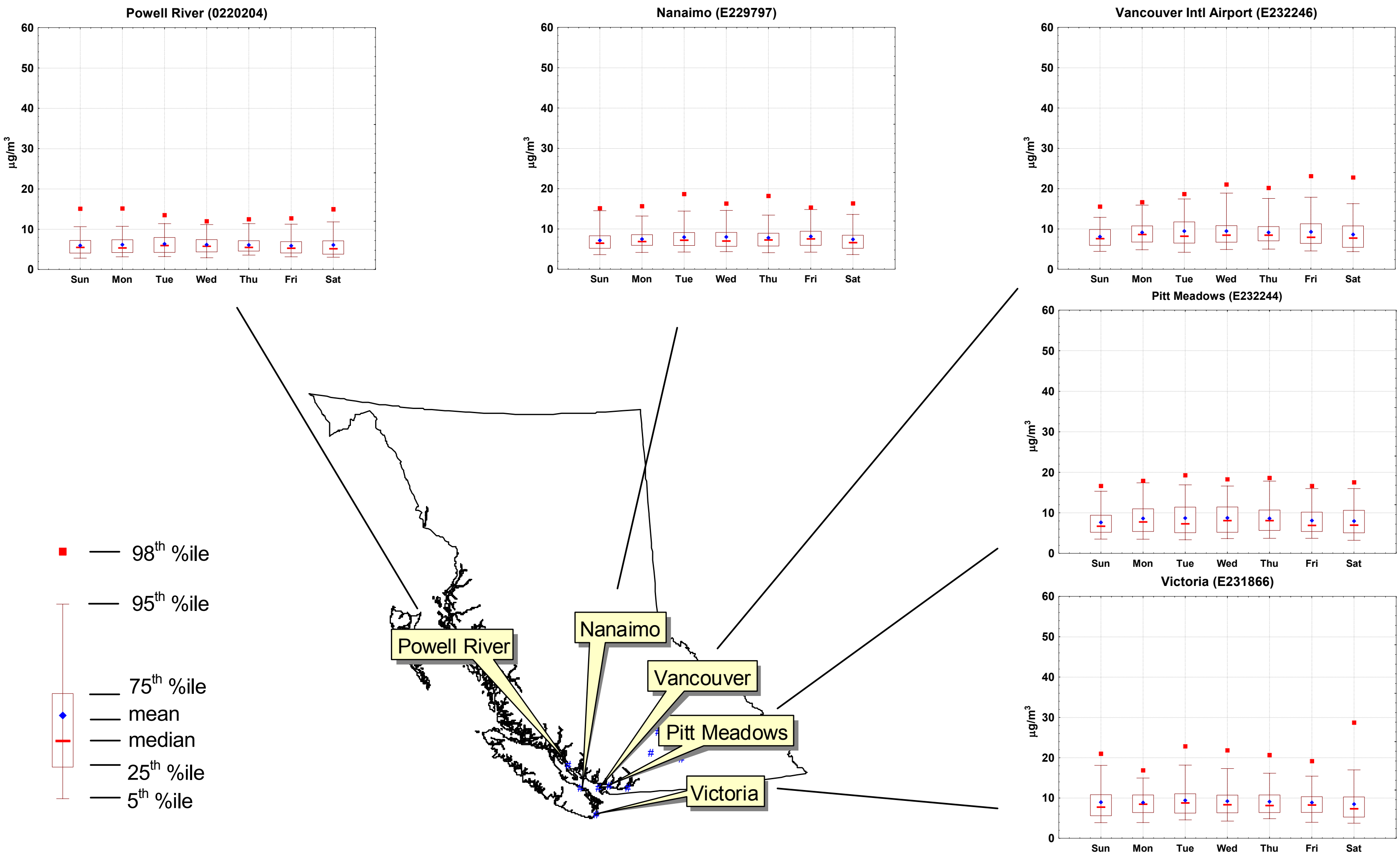


Figure 18 Hebdomadal variations in 24-hour average $PM_{2.5}$ measurements at select TEOM sites.

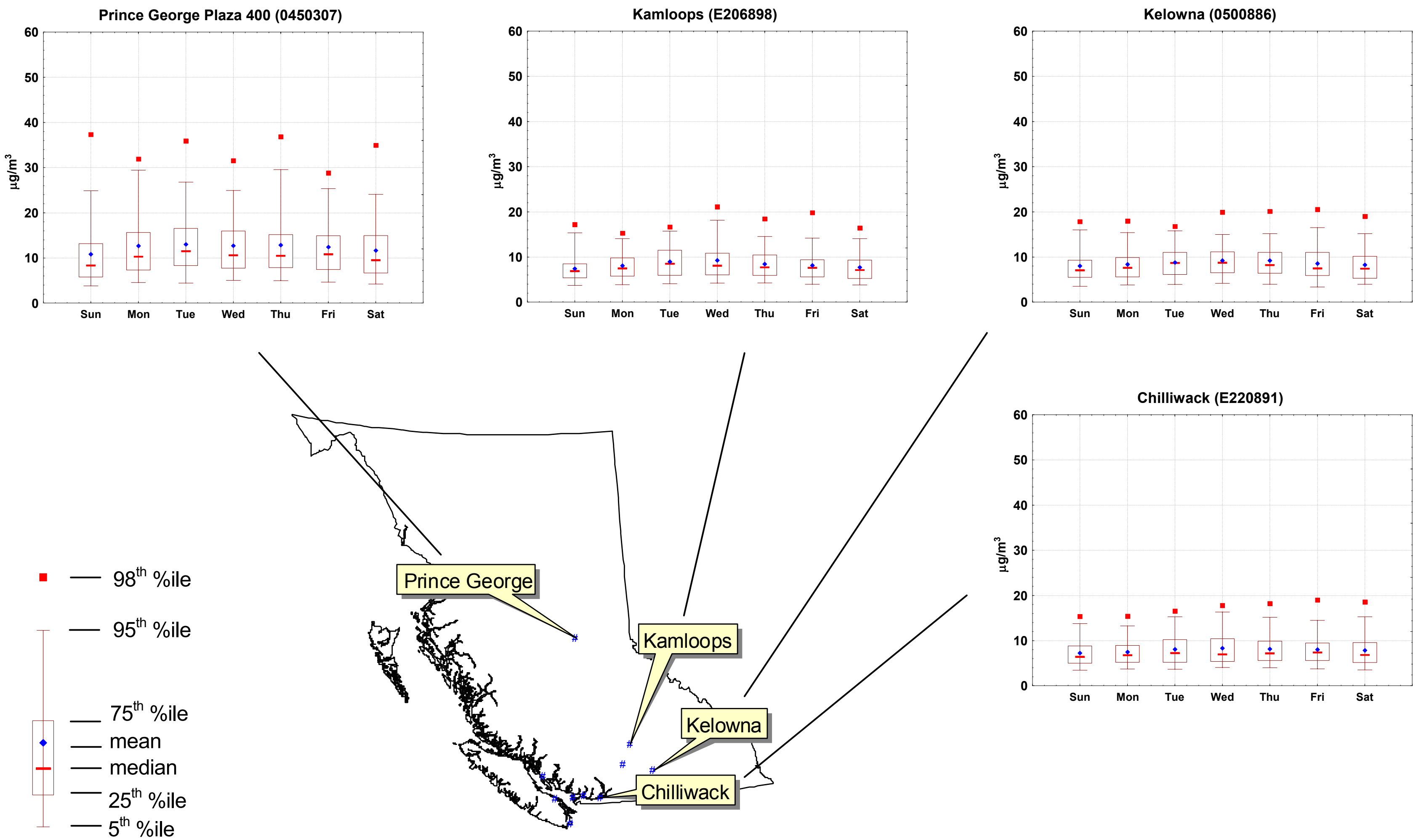


Figure 18 continued: Hebdomadal variations in 24-hour average $PM_{2.5}$ measurements at select TEOM sites.

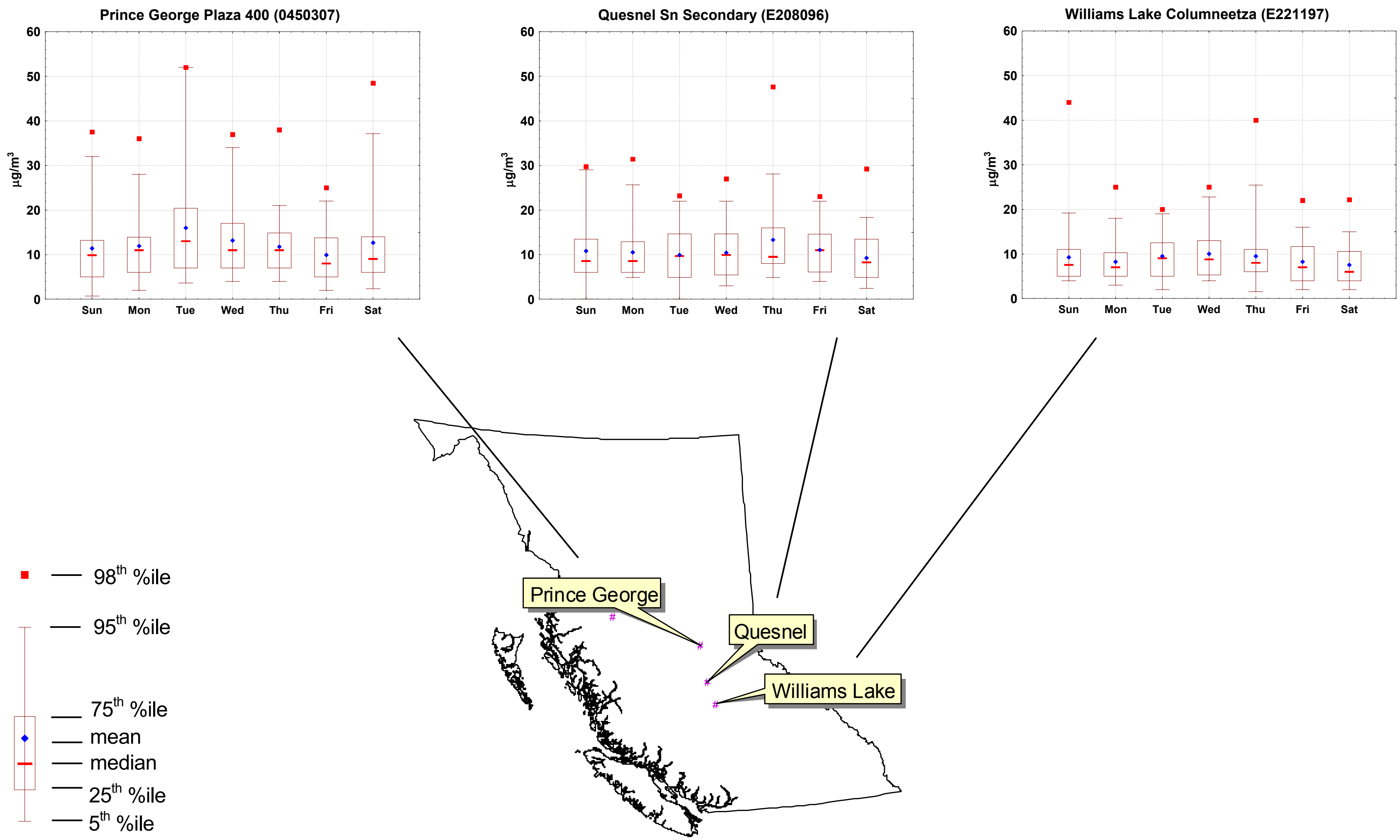


Figure 19 Hebdomadal variations in 24-hour average $PM_{2.5}$ measurements at select Partisol sites.

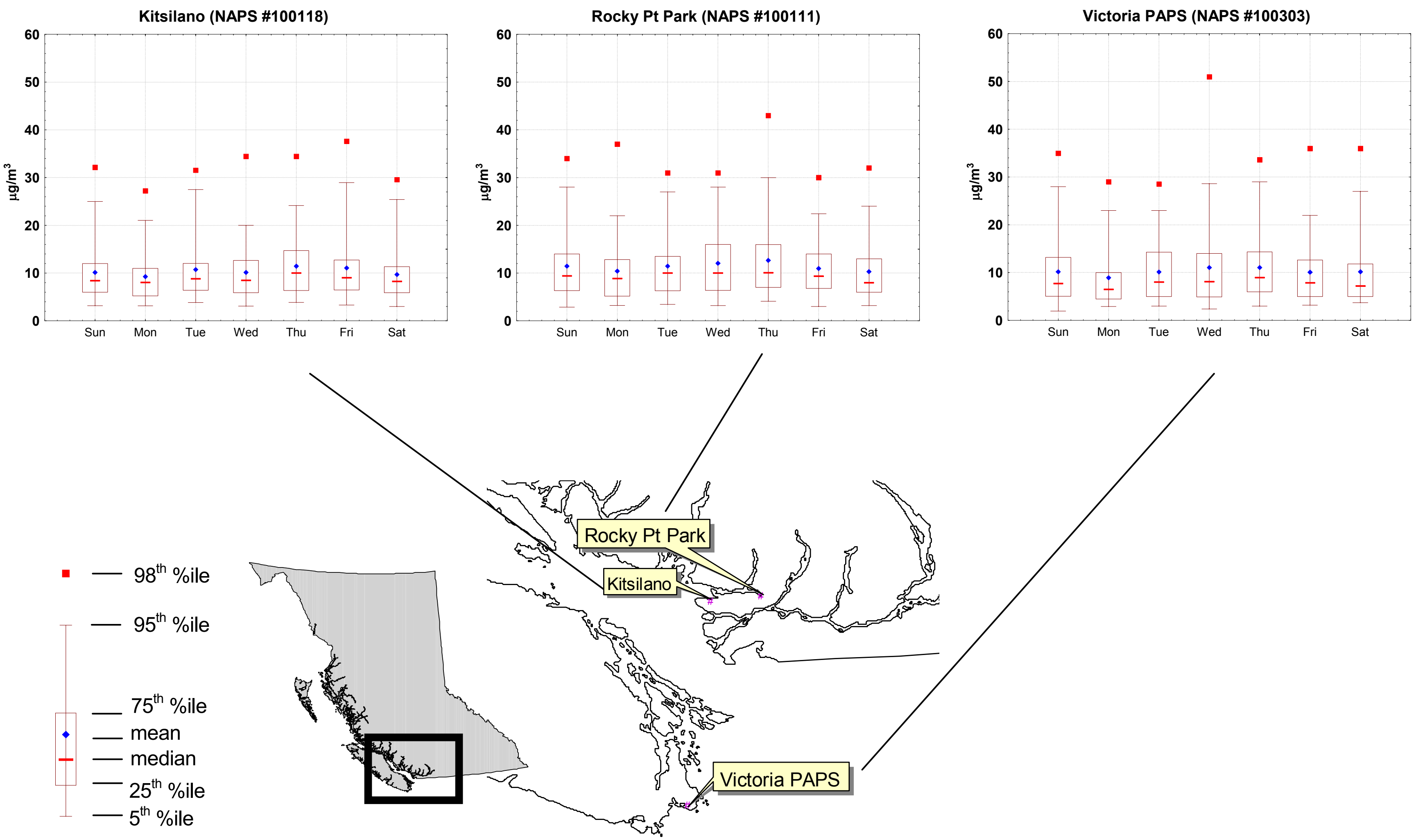


Figure 19 continued: Hebdomadal variations in 24-hour $PM_{2.5}$ measurements from select dichotomous (NAPS) sites

4.4.3 Hebdomadal Variations

PM_{10} data from select TEOM and SSI PM_{10} monitoring sites are presented on a hebdomadal basis in Figures 16 and 17, respectively. Most sites exhibit peaks in both the 50th and 75th percentile concentrations between Tuesday and Friday, and corresponding minima on Sundays, reflecting the influence of anthropogenic sources on local PM_{10} concentrations. Some exceptions to the typical pattern were noted. Lower concentrations are observed on Monday rather than Sunday in Victoria. Highest or second highest 75th percentile concentrations in Chetwynd (SSI), Houston and Terrace occurred on Saturdays. For the 14 PM_{10} TEOM sites examined, mean mid-week (Tuesday-Wednesday) concentrations were approximately 30% higher than mean Sunday concentrations, in agreement with findings across the NAPS network (WGAQOG, 1999). Differences between mid-week and Sunday concentrations in excess of 50% were observed at Prince George Plaza 400, Williams Lake, and Quesnel Sr. Secondary School, where industrial sources are believed to have a large influence on ambient PM concentrations. In contrast, differences of less than 20% occurred at residential areas such as Kitsilano, Surrey and Victoria, Chilliwack and Elk Falls.

Hebdomadal variations in $PM_{2.5}$ data are summarized in Figures 18 and 19 for select TEOM and Partisol/dichotomous sites, respectively. Relative to PM_{10}, little day-to-day variation in mean weekday concentrations (± 3 $\mu g/m^3$) is observed at most sites. This may be a result of several contributing factors, including the influence of residential sources such as home heating, the longer residence time of $PM_{2.5}$ in the atmosphere relative to PM_{10}, and the industrial "background" produced by sources operating 24 hours per day, 7 days per week. Mid-week concentrations are typically higher than weekend levels. An exception is Quesnel (Senior Secondary site), where mean Sunday concentrations are second highest to those observed on Thursdays.

4.4.4 Diurnal Variations

Hourly TEOM data were used to examine diurnal variability in PM concentrations. Figure 20 shows the diurnal pattern for selected PM_{10} sites. Some stations show very little diurnal variation, and patterns may be difficult to detect due to the generally low concentrations such as those found along the coast and in the Lower Mainland. Where a pattern is discernible, there are often two peaks in the median concentration: one in the morning between 7 and10 am, and another in the evening between 7 and 10 pm. Concentrations decrease during the day from mid-morning to early evening, however the most dramatic decrease occurs at night, following the evening peak, between midnight and roughly 5 am. The exact timing of the peak concentration varies from location to location. The amplitude of the diurnal variation at some sites, particularly those along the coast and in the Lower Fraser Valley, is much lower than at interior sites. Of the 14 TEOM sites analysed, maximum hourly concentrations in excess of 120 $\mu g/m^3$ occurred at Quesnel Senior Secondary, Houston Firehall, Creston Prince Charles School, Williams Lake Columneetza, and Prince George Plaza 400. At most sites, median concentrations vary up to 10 $\mu g/m^3$ around a central value over the course of a day, with the highest values reported for the evening hours. However, at the Prince George Plaza 400, Quesnel, Smithers, Kitsilano and Burnaby South sites, morning peaks in mean and 75th percentile concentrations were of equal or greater magnitude than those observed during the evening. As shown in Figure 21, morning and evening peaks are also evident in the hourly $PM_{2.5}$ data at most sites, however, the diurnal variation in $PM_{2.5}$ is much less pronounced than that seen in the PM_{10} data, with median concentrations typically varying not more than a few $\mu g/m^3$ throughout the day. An exception is for Prince George, where median hourly concentrations may vary by as much as 5 $\mu g/m^3$ over a day. In comparison to other sites, Victoria Topaz shows a particularly high evening peak, with 98^{th} percentile concentrations of the same order of magnitude as those observed in Prince George.

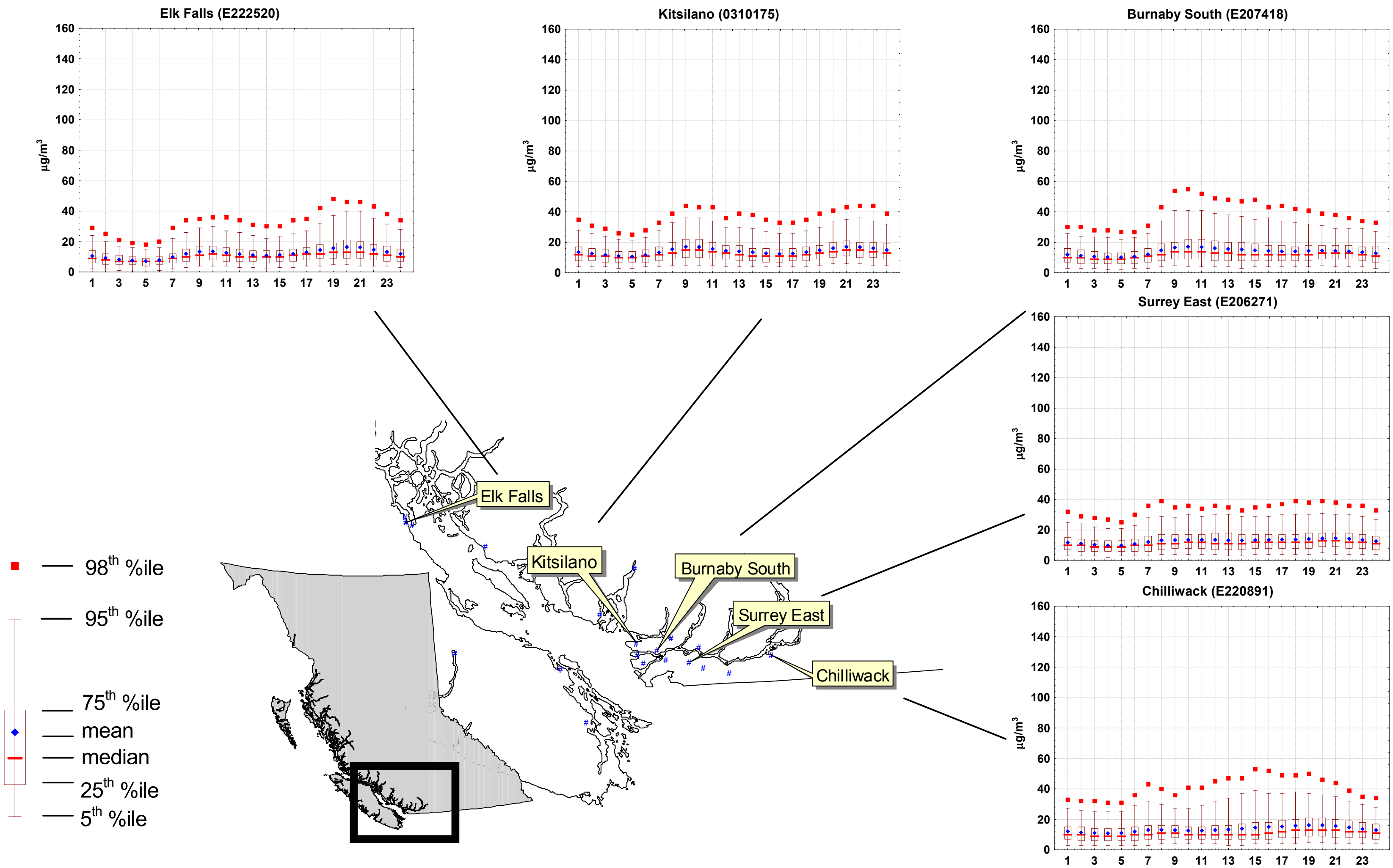


Figure 20 Diurnal variations in hourly PM_{10} measurements at select TEOM sites.

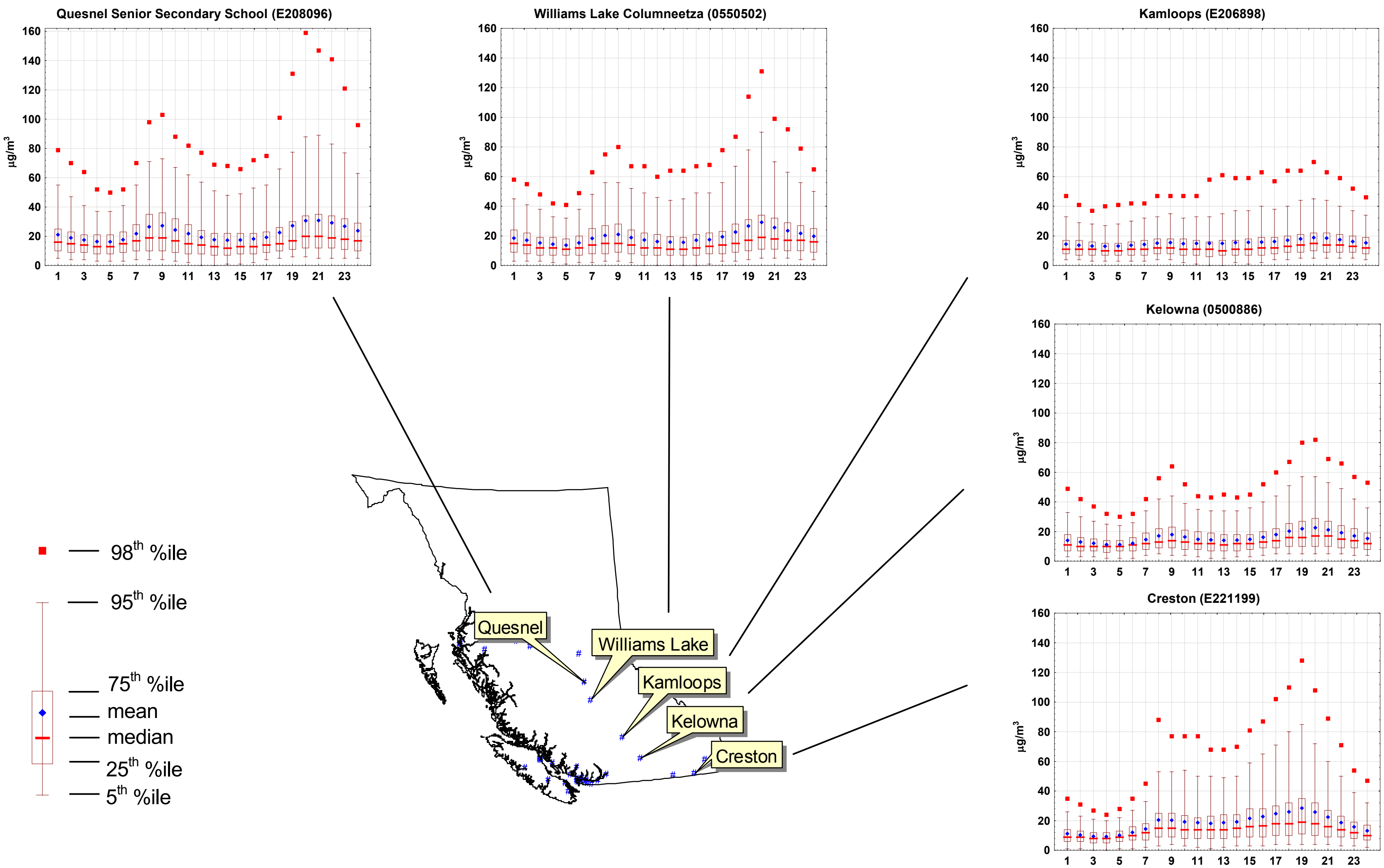


Figure 20 continued: Diurnal variations in hourly PM_{10} measurements at select TEOM sites.

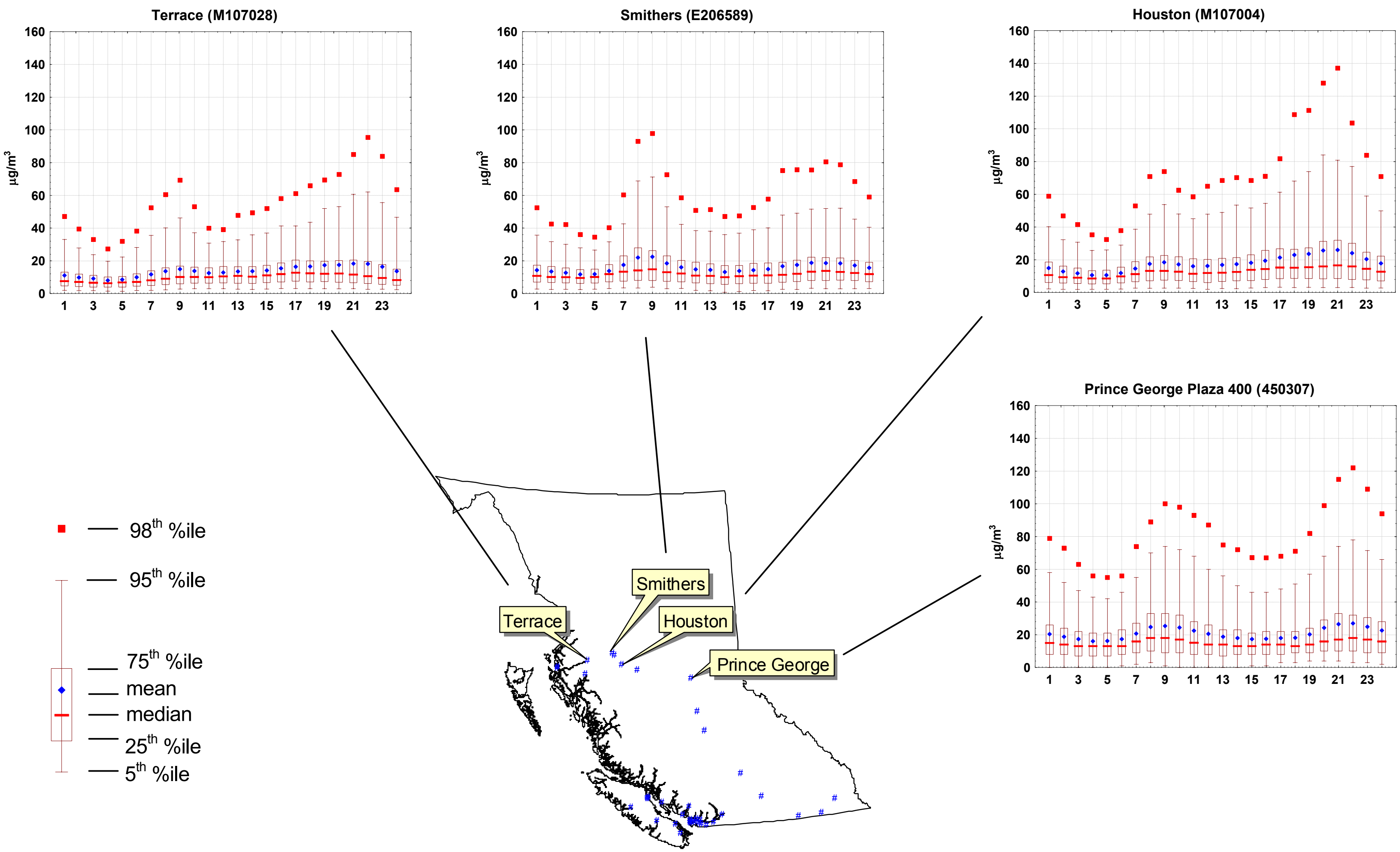


Figure 20 continued: Diurnal variations in hourly PM_{10} measurements at select TEOM sites.

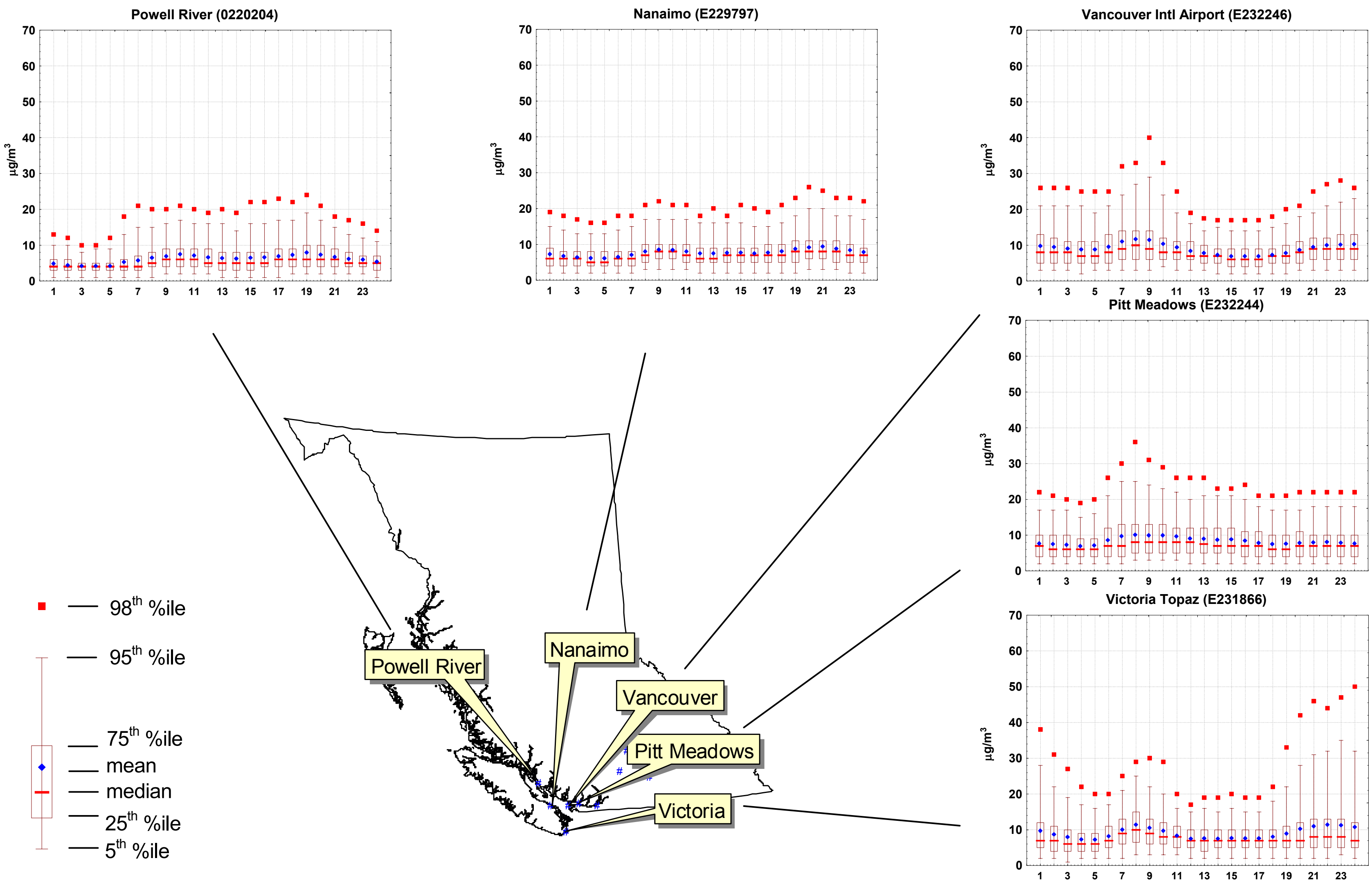


Figure 21: Diurnal variations in 24-hour average $PM_{2.5}$ measurements at select TEOM sites.

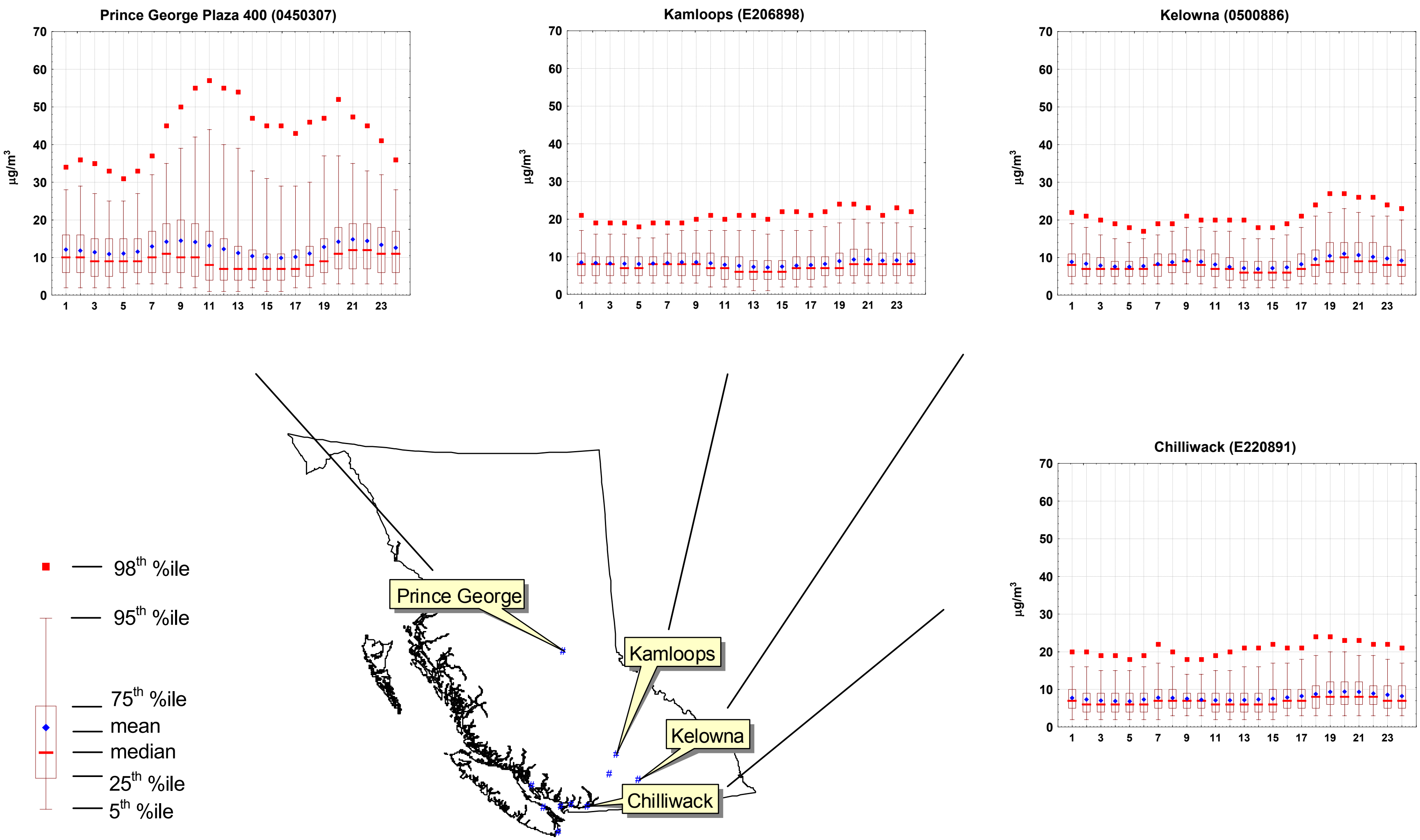


Figure 21 continued: Diurnal variations in 24-hour average $PM_{2.5}$ measurements at select TEOM sites.

Two possible explanations for the existence of morning and evening peak PM concentrations have been proposed: Throughout the night, pollution from tall stacks becomes trapped in the nocturnal inversion layer above the surface; then in the morning, the breakdown of the inversion layer transports PM down to the surface where high concentrations may last for a few hours. Alternatively, these peaks may be the result of increased vehicle and residential emissions such as home heating during the early morning and evening hours.

4.5 Annual Trends

Since most PM monitoring sites have fewer than 10 years of data, it is not possible to compute trends with confidence. Many more years of data are required in order to establish temporal trends with certainty, so trend information presented here must be considered strictly preliminary. It is also important to consider the effect of year-to-year variation in climate on PM concentrations in addition to the effects of changes in emissions. The trends presented here have not been adjusted for interannual climate variability.

Only PM_{10} sites with at least five years of data during the 1990s were included in the trend analysis. Trends in the annual mean, 75th percentile and the 98th percentile are summarized in Table 13.

Downward trends were found in the upper concentrations of PM_{10} at Houston Firehall, Prince George Plaza 400, Kelowna Okanagan College, and Williams Lake Columneetza, where the 98th percentile concentrations are declining at a rate of between three to five μg/m^3 per year, with the exception of Houston Firehall, where extreme values have decreased at a rate of approximately 16 μg/m^3 per year. Houston, Kelowna and Williams Lake were the only sites of those selected to register significant downward trends in mean, 75th percentile and 98th percentile concentrations. In contrast, annual PM_{10} concentrations at two sites in Quesnel (Pinecrest and Maple Drive) appear to be increasing, although these trends are not considered to be significant at this time.

Table 13 Annual trends in PM concentrations for select stations in British Columbia. Bold values are statistically significant at p<.05. The trend is represented by the slope in the annual values of the mean, 75th percentile, and 98th percentile 24-hour PM concentrations in μg/m³ per year. Number of years is given by n, and r is the correlation coefficient.

PM Site		Mean			75thile			98thile		
PM_{10} TEOM Site	n	Slope	r	p<.05	Slope	r	p<.05	Slope	r	p<.05
Burnaby South	6	-0.395	0.74	0.10	-0.583	0.75	0.09	-1.343	0.67	0.14
Chilliwack Airport	6	-0.505	0.65	0.16	-0.580	0.52	0.29	-1.641	0.66	0.15
Elk Falls	4	-0.064	0.18	0.82	-0.181	0.36	0.64	-0.937	0.48	0.52
Houston Firehall	6	**-0.542**	**0.84**	**0.04**	**-6.496**	**0.87**	**0.02**	**-16.078**	**0.96**	**0.00**
Kamloops	7	**-0.673**	**0.78**	**0.04**	-0.700	0.74	0.06	-2.622	0.52	0.23
Kelowna	7	**-0.829**	**0.88**	**0.01**	**-0.920**	**0.88**	**0.01**	**-4.550**	**0.86**	**0.01**
Kitsilano	7	**-0.241**	**0.76**	**0.05**	-0.269	0.60	0.16	-0.473	0.29	0.52
Prince George BCRail	4	-2.122	0.67	0.33	-1.770	0.57	0.43	-8.239	0.75	0.25
Prince George Plaza 400	7	-0.798	0.72	0.07	-0.904	0.71	0.07	**-4.612**	**0.85**	**0.01**
Port Moody	7	**-0.645**	**0.87**	**0.01**	**-0.849**	**0.86**	**0.01**	-0.979	0.61	0.15
Powell River Cran. Lake	5	-0.480	0.85	0.07	**-0.521**	**0.88**	**0.05**	-5.147	0.85	0.07
Quesnel Sr. Secondary	6	-0.111	0.12	0.81	-0.056	0.04	0.95	-0.439	0.08	0.88
Quesnel Maple Dr.	5	0.106	0.13	0.84	0.091	0.07	0.91	-1.458	0.64	0.24
Quesnel Pinecrest	5	0.305	0.30	0.62	0.699	0.38	0.53	1.738	0.57	0.32
Smithers St. Josephs	7	-0.294	0.35	0.44	**-3.851**	**0.92**	**0.00**	-4.679	0.68	0.09
Squamish	6	-0.125	0.10	0.85	-0.174	0.10	0.86	-1.360	0.34	0.51
Surrey East	7	-0.176	0.69	0.08	-0.282	0.74	0.06	-0.669	0.63	0.13
Williams Lake Colum.	7	**-0.763**	**0.90**	**0.01**	**-1.030**	**0.86**	**0.01**	**-3.459**	**0.88**	**0.01**
PM_{10} HiVol SSI Sites										
Golden Lady Grey School	8	-1.320	0.83	0.01	-1.840	0.67	0.07	-0.97	0.22	0.59
Merritt	7	-0.797	0.41	0.35	-1.214	0.36	0.42	-2.548	0.39	0.38
Victoria PAPS	5	-1.666	0.91	0.03	-2.150	0.93	0.02	-1.6000	0.58	0.30
Chetwynd	5	-0.844	0.34	0.58	-0.872	0.35	0.56	-3.661	0.27	0.66
$PM_{2.5}$ TEOM Site										
Chilliwack Airport	6	0.037	0.18	0.74	0.053	0.13	0.80	-0.162	0.19	0.72
$PM_{2.5}$ Partisol Sites										
Quesnel Senior Sec.	5	**-0.860**	**0.89**	**0.05**	-0.449	0.53	0.36	-3.693	0.75	0.15
Prince George Plaza 400	5	-0.132	0.37	0.54	**-0.501**	**0.89**	**0.04**	1.931	0.50	0.40
Williams Lake Column.	6	-0.425	0.50	0.32	0.057	0.05	0.92	-2.575	0.64	0.17
$PM_{2.5}$ Dichotomous Site										
Port Moody Rocky Pt. Pk	9	**-0.639**	**0.78**	**0.00**	**-0.639**	**0.80**	**0.00**	**-1.652**	**0.65**	**0.01**
Kitsilano Sec. School	9	**-0.784**	**0.92**	**0.00**	**-0.929**	**0.89**	**0.00**	**-2.627**	**0.78**	**0.00**

Trend analysis of $PM_{2.5}$ data is restricted to the Chilliwack TEOM site, three Partisol sites in the interior and dichotomous sampler sites in Port Moody and Kitsilano due to the limited availability of $PM_{2.5}$ data in this province. Significant downward trends were observed for Quesnel (mean concentration), Prince George Plaza 400 (75th percentile concentration) and the two dichotomous sampler sites (mean, 75th percentile and 98th percentile). No significant upward trends were observed, although increasing concentrations were noted for Chilliwack (mean and 75th percentile), Prince George Plaza 400 (98th percentile) and Williams Lake Columneetza (75th percentile).

4.6 Chemical Composition of PM

The largest database of chemically speciated PM measurements in BC is for the NAPS sites in Vancouver (Kitsilano), Port Moody and Victoria (PAPS and Topaz). Speciated data from all four sites are summarized in Tables 14 and 15 for the fine (<2.5 μm) and coarse (2.5-10 μm) fractions of PM_{10}, respectively. Of the identified species, sulphur compounds and ammonium ion are the largest constituents of the fine fraction, whereas sodium and chlorine compounds and silicon are the largest constituents of the coarse fraction.

A subset of these measurements are further summarized for individual sites in Table 16. Analysis was based on data collected from 1993 onwards, when Na and NH_4^+ measurements became routine. Measurements from the Victoria PAPS site were available up to 1997, when the site was shut down in preparation for a move to the Topaz site, which began operating in 1998.

Using a technique described by Malm et al. (1994) and used by Brook et al. (1997) in an analysis of Canadian NAPS data, mass was reconstructed ($Mass_{rec}$) for both the fine and coarse fractions using the following formula:

$$Mass_{rec} = SO_4^{2-} + NO_3^- + NH_4^+ + (1.79V + 1.24Zn + 1.12\,Ba + Pb + Br) + (Cl + Na) + SOIL + Rem$$

where

$$SOIL = 2.20Al + 2.49Si + 1.63Ca + 1.58Fe + 1.94Ti + 1.41K$$

and

$$Rem = \Sigma(\text{all remaining elements})$$

Table 14 Summary of chemical species measured (fine fraction) at NAPS sites in BC (1993-2000). DL=detection limit.

Element or Ion	No. of Samples	Typical DL (ug/m3)	% Samples >DL	Concentration (μg/m^3) Median	75th P.	95th P.
S	1230	0.0007	89	0.428	0.643	1.050
Al	1230	0.0018	73	0.020	0.049	0.345
Si	1230	0.0016	87	0.054	0.103	0.212
P	1230	0.0011	72	0.017	0.039	0.069
Cl	1230	0.0026	43	<DL	0.026	0.242
K	1230	0.0031	98	0.037	0.067	0.147
Ca	1230	0.0038	93	0.022	0.039	0.083
Sc	1230	0.0051	13	<DL	<DL	0.012
Ti	1230	0.0054	27	<DL	0.006	0.012
V	1230	0.0040	42	<DL	0.007	0.013
Cr	1230	0.0030	14	<DL	<DL	0.005
Mn	1230	0.0023	86	0.008	0.014	0.034
Fe	1230	0.0021	91	0.038	0.069	0.155
Co	1230	0.0014	7	<DL	<DL	0.002
Ni	1230	0.0011	64	0.002	0.004	0.007
Cu	1230	0.0022	76	0.009	0.017	0.031
Zn	1230	0.0008	96	0.008	0.013	0.027
Ga	1172	0.0012	59	0.005	0.011	0.021
Ge	1230	0.0006	21	<DL	<DL	0.002
As	1230	0.0005	66	0.001	0.001	0.002
Se	1230	0.0004	40	<DL	0.001	0.001
Br	1230	0.0004	86	0.001	0.002	0.007
Sr	1230	0.0003	22	<DL	<DL	0.001
Zr	1230	0.0003	17	<DL	<DL	0.001
Mo	1230	0.0003	17	<DL	<DL	0.001
Cd	1230	0.0006	13	<DL	<DL	0.002
Sn	1230	0.0007	24	<DL	0.001	0.007
Sb	1230	0.0008	22	<DL	<DL	0.004
I	1230	0.0012	17	0.000	<DL	0.003
Cs	1230	0.0013	23	<DL	0.001	0.005
Ba	1230	0.0013	50	0.001	0.004	0.009
La	1230	0.0014	35	<DL	0.003	0.009
Pb	1230	0.0010	74	0.003	0.005	0.010
Na	1230	0.0376	66	0.135	0.319	0.788
Mg	1230	0.0021	82	0.014	0.025	0.054
Ce	1230	0.0016	30	<DL	0.002	0.008
Pr	1230	0.0018	30	<DL	0.002	0.009
Nd	1230	0.0021	37	<DL	0.004	0.011
Ta	103	0.0029	59	0.004	0.007	0.010
W	1230	0.0033	48	<DL	0.009	0.014
Hg	1230	0.0010	11	<DL	<DL	0.001
Tl	103	0.0004	17	<DL	<DL	0.001
Bi	103	0.0004	35	<DL	0.001	0.001
SO4	1177	0.0140	100	1.154	1.758	2.873
NO3	1177	0.0070	80	0.088	0.167	0.469
Cl-	1177	0.0070	47	<DL	0.030	0.198
Na+	1177	0.0010	99	0.110	0.181	0.362
NH4+	1177	0.0050	99	0.334	0.518	0.911

Table 15 Summary of chemical species measured at NAPS sites (coarse fraction) in BC (1993-2000), DL=detection limit**.**

Element or Ion	No. of Samples	Typical DL (ug/m3)	% Samples >DL	Concentration (μg/m³) Median	75th P.	95th P.
S	1230	0.0006	65.6	0.065	0.095	0.146
Al	1230	0.0014	92.0	0.076	0.170	0.620
Si	1230	0.0013	97.2	0.228	0.471	1.026
P	1230	0.0009	58.7	0.006	0.023	0.046
Cl	1230	0.0022	83.7	0.147	0.425	1.196
K	1230	0.0025	95.8	0.040	0.061	0.116
Ca	1230	0.0030	98.8	0.123	0.236	0.490
Sc	1230	0.0042	12.5	<DL	<DL	0.009
Ti	1230	0.0043	82.3	0.014	0.024	0.047
V	1230	0.0032	43.7	<DL	0.005	0.009
Cr	1230	0.0024	32.3	<DL	0.003	0.006
Mn	1230	0.0018	82.6	0.005	0.008	0.016
Fe	1230	0.0017	98.5	0.161	0.280	0.563
Co	1230	0.0013	19.1	<DL	<DL	0.002
Ni	1230	0.0009	47.1	0.001	0.002	0.004
Cu	1230	0.0017	75.3	0.008	0.014	0.026
Zn	1230	0.0007	93.3	0.005	0.008	0.014
Ga	1172	0.0010	56.7	0.003	0.008	0.018
Ge	1230	0.0005	20.8	<DL	<DL	0.002
As	1230	0.0004	22.8	<DL	<DL	0.001
Se	1230	0.0003	29.5	<DL	<DL	0.001
Br	1230	0.0003	63.5	0.001	0.001	0.002
Sr	1230	0.0002	84.9	0.001	0.002	0.003
Zr	1230	0.0002	61.5	<DL	0.001	0.001
Mo	1230	0.0002	27.4	<DL	<DL	0.001
Cd	1230	0.0005	11.5	<DL	<DL	0.002
In	1230	0.0005	10.0	<DL	<DL	0.001
Sn	1230	0.0006	15.4	<DL	<DL	0.006
Sb	1230	0.0006	18.9	<DL	<DL	0.003
Cs	1230	0.0010	14.6	<DL	<DL	0.003
Ba	1230	0.0010	67.3	0.003	0.006	0.014
La	1230	0.0011	23.6	<DL	0.001	0.006
Pb	1230	0.0008	47.7	0.001	0.002	0.004
Na	1230	0.0301	73.8	0.193	0.516	1.346
Mg	1230	0.0017	92.4	0.035	0.059	0.118
Ce	1230	0.0013	18.5	<DL	<DL	0.006
Pr	1230	0.0016	21.2	<DL	<DL	0.007
Nd	1230	0.0019	30.6	<DL	0.003	0.009
Ta	103	0.0023	54.4	0.004	0.006	0.009
W	1230	0.0026	48.5	0.002	0.007	0.011
Bi	103	0.0003	43.7	<DL	0.001	0.001
SO4	1177	0.0110	97.1	0.156	0.221	0.344
NO3	1177	0.0060	94.4	0.189	0.342	0.681
Cl-	1177	0.0060	93.0	0.152	0.419	1.121
Na+	1177	0.0010	96.1	0.184	0.342	0.712
NH4+	1177	0.0040	56.8	0.007	0.017	0.042

Table 16 Median concentrations ($\mu g/m^3$) of most abundant PM_{10} species for NAPS sites in Vancouver and Victoria (1993-2000). F=fine fraction ($PM_{2.5}$). C=coarse fraction ($PM_{10-2.5}$).

	Vancouver Kitsilano		Port Moody Rocky Pt. Park		Victoria PAPS (1993-1997)		Victoria Topaz (1998-200)	
Compound\Fraction	F	C	F	C	F	C	F	C
Mass	7.10	5.66	7.13	5.29	6.83	5.27	5.76	5.92
Sulphate	1.178	0.140	1.257	0.150	1.146	0.194	0.791	0.164
Sulphur	0.443	0.065	0.452	0.052	0.433	0.075	0.316	0.063
Sodium	0.050	0.137	0.134	0.141	0.343	0.473	0.083	0.257
Ammonium	0.351	0.009	0.367	0.005	0.289	0.008	0.221	0.000
Sodium Ion	0.080	0.153	0.110	0.161	0.177	0.310	0.125	0.290
Nitrate	0.060	0.199	0.105	0.183	0.110	0.194	0.105	0.130
Silicon	0.056	0.237	0.057	0.214	0.048	0.228	0.040	0.270
Potassium	0.034	0.044	0.038	0.037	0.045	0.038	0.033	0.043
Chloride	<DL	0.081	<DL	0.123	0.026	0.389	<DL	0.306
Chlorine	0.000	0.100	0.000	0.126	0.023	0.333	0.026	0.421
Aluminum	0.020	0.083	0.020	0.075	0.020	0.075	0.018	0.079
Iron	0.055	0.208	0.041	0.150	0.019	0.120	0.015	0.157
Phosphorus	0.013	0.007	0.019	0.005	0.019	0.003	0.021	0.004
Calcium	0.021	0.114	0.029	0.157	0.018	0.112	0.018	0.122
Magnesium	0.012	0.031	0.013	0.028	0.016	0.047	0.019	0.053
Copper	0.008	0.008	0.013	0.012	0.011	0.006	0.005	0.003
Manganese	0.010	0.006	0.008	0.004	0.007	0.004	0.003	0.004
Zinc	0.008	0.005	0.009	0.005	0.007	0.004	0.006	0.004
Titanium	<DL	0.015	<DL	0.014	<DL	0.013	<DL	0.015
Sampling Days	470	470	450	450	242	242	133	133

These equations were assumed to be applicable to both the fine and coarse fractions of PM_{10}. Other assumptions included the following:

- Fine and coarse SO_4^{2-} and NO_3^- are fully neutralized (i.e. in the form of $(NH_4)_2SO_4$, Na_2SO_4, or NH_4NO_3).
- SOIL includes the predominant crustal elements in their most oxidized form plus a 14% scaling factor to account for other soil compounds.
- Al_2O_3 in soil is the only source of Al.
- Oxidized V, Ba and Zn are due to high-temperature combustion or industrial processes.
- Pb (fine) is associated with automotive emissions, and therefore Br and Cl.
- Na (coarse) is associated with Cl.
- Elements lying below detection limits were assumed equal to be 0.5 times the detection limit.
- Potential molecular forms (such as oxides) for the remaining elements were not included.

Dichotomous sampler data collected between 1993 and 2000 were used to calculate reconstructed mass estimates for each quarter of the year, based on the above equations. Results are summarized in Figure 22, from which a number of observations can be made:

- Of the identifiable components, sulphates are the predominant species in the fine fraction measured at each of the four sites.
- Relative sulphate contributions to the fine mass are greatest during the spring (AMJ) and summer (JAS).
- The missing component, which may include organic constituents such as combustion products, accounts for 60-80% of the fine mass, and appears to be greatest during the fall (OND) and winter (JFM).
- In the coarse fraction, soil is the largest identifiable component year-round, followed by sea salt (NaCl). The latter is especially prominent at the former Victoria PAPS site. The missing component is also significant, but less so than in the fine fraction.
- The remaining elements that have been identified (grouped together as "other") typically represent only a small percentage (<2%) of the total mass for both the fine and coarse fractions. The exception is at the Victoria Topaz site, where the "other" component comprises an average of 12% of the total coarse mass year-round, and as much as 24% of the total coarse mass during the period from January to March. The predominant species found in this component is Mg, which is known to be a product of tire wear (Main et al., 1995). NO_3 is a larger constituent of the coarse fraction than the fine fraction, in contrast to NH_4^+. This finding is consistent with observations during the Pacific 2001 scientific study in the Lower Fraser Valley, where the coarse particle NO_3 is believed to be associated with the aging of sea salt to form $NaNO_3$ (K. Anlauf, pers. comm.).

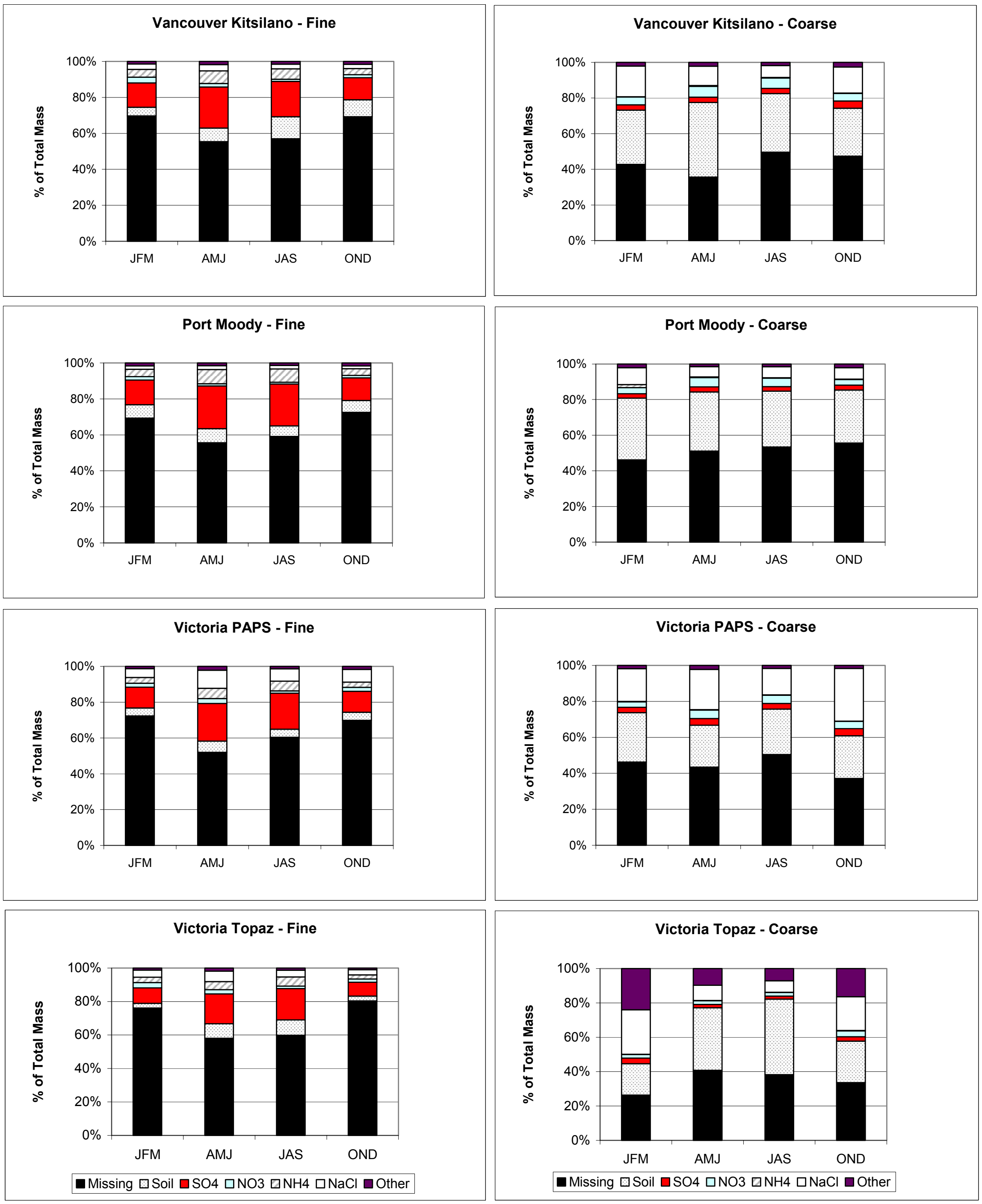


Figure 22 Reconstructed mass estimates of fine and coarse fractions of PM_{10} at NAPS sites in BC.

4.7 Relationship between PM_{10} and $PM_{2.5}$

Collocated $PM_{2.5}$ and PM_{10} TEOM instruments existed at 5 sites in the province as of the end of 2000: Prince George, Kamloops, Kelowna, Chilliwack and Powell

River. Mean $PM_{2.5}/PM_{10}$ ratios based on all available data from 1995-2000 are presented in Table 17. Values are remarkably similar among the sites, with $PM_{2.5}$ accounting for 64 to 68% of PM_{10}. Such high values suggest that combustion sources and/or secondary PM formation are important sources of PM_{10} in these communities.

Table 17 Ratio of $PM_{2.5}$ mass to PM_{10} mass from five collocated TEOM sites (1995-2000).

Site ID	Name	No. Hrs	Mean PM_{10} (μg/m^3)	Mean $PM_{2.5}$ (μg/m^3)	Mean $PM_{2.5}/PM_{10}$ Ratio
0220204	Powell River	20910	9.8	6.1	0.68
0450307	Prince George	28725	20.5	12.3	0.67
0500886	Kelowna	27835	15.5	8.6	0.64
E206898	Kamloops	27420	15.1	8.3	0.67
E220891	Chilliwack	46073	13.5	7.9	0.65

Greater site-to-site variability is observed in monthly mean ratios, as shown in Figure 23. Strong seasonal variations were observed at each site, with the highest $PM_{2.5}/PM_{10}$ ratios typically occurring in the late fall or winter when wood combustion sources are expected to be most significant. The lowest $PM_{2.5}/PM_{10}$ ratios are reported during the summer in Powell River and Chilliwack, and during the spring and summer in Kamloops. In contrast, $PM_{2.5}$ contributions to PM_{10} are lowest during the late winter/early spring in Prince George, and the late winter/early spring and summer in Kelowna. The late winter/early spring minimum likely reflects the influence of spring road dust on PM_{10} levels, as this material is largely composed of particles in the coarse fraction. Plain and Carmichael (1998) found in a study of Quesnel that the $PM_{2.5}$ fraction was most dominant after precipitation events while the coarse fraction dominated after a drying trend followed by stable meteorological conditions.

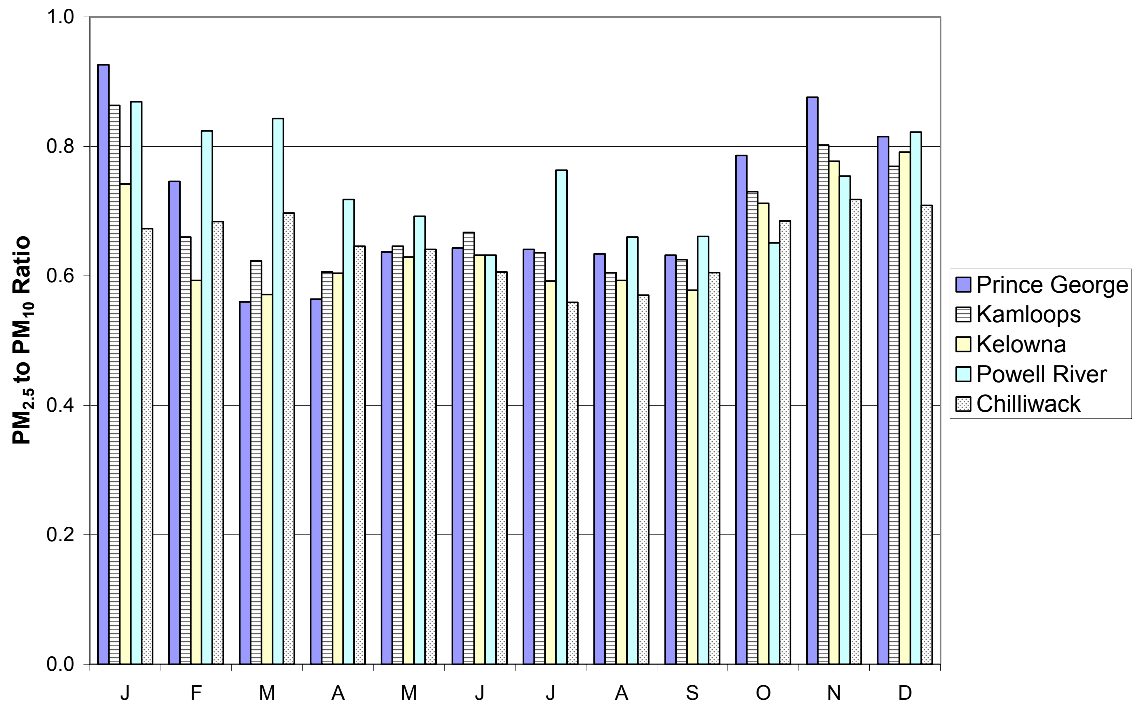


Figure 23 Monthly mean ratio of $PM_{2.5}$ to PM_{10} mass from five collocated TEOM sites (1995-2000).

$PM_{2.5}$ and PM_{10} data were also available from dichotomous samplers located at four NAPS sites in the province: Port Moody Rocky Point Park, Vancouver Kitsilano, Victoria PAPS (now closed) and Victoria Topaz. As summarized in Table 18, $PM_{2.5}$ typically accounts for 57 to 59% of PM_{10}. The exception is the Victoria Topaz site, where $PM_{2.5}$ only accounts for 48% of PM_{10}. This finding suggests that PM_{10} concentrations at the Topaz site, which lies within 200 m of a major thoroughfare, are more strongly influenced by fugitive dust sources such as road dust than the former Victoria NAPS site.

Table 18 Ratio of $PM_{2.5}$ mass to PM_{10} mass from NAPS sites (1986-2000).

Site ID	Name	No. Days	Mean PM_{10} ($\mu g/m^3$)	Mean $PM_{2.5}$ ($\mu g/m^3$)	Mean $PM_{2.5}/PM_{10}$ Ratio
0310162	Port Moody Rocky Point Park	700	16.6	10.2	0.59
0310175	Vancouver Kitsilano	795	19.7	11.6	0.57
0110030	Victoria P.A.P.S.	579	16.5	10.3	0.59
E231866	Victoria Topaz	132	14.5	6.7	0.48

Distinct seasonal variations in the $PM_{2.5}$-to-PM_{10} ratio are observed at the NAPS sites, as shown in Figure 24, where data are presented in terms of quarterly and overall means. At each of these sites, the lowest relative contributions of $PM_{2.5}$ to PM_{10} occur during the second and third quarters, from April to September, when $PM_{2.5}$ contributes an average of 38 to 55% of PM_{10}. In contrast, the highest relative contributions are found in the fourth quarter, from October to December. $PM_{2.5}$ accounts for roughly 62 to 65% of PM_{10} during these months.

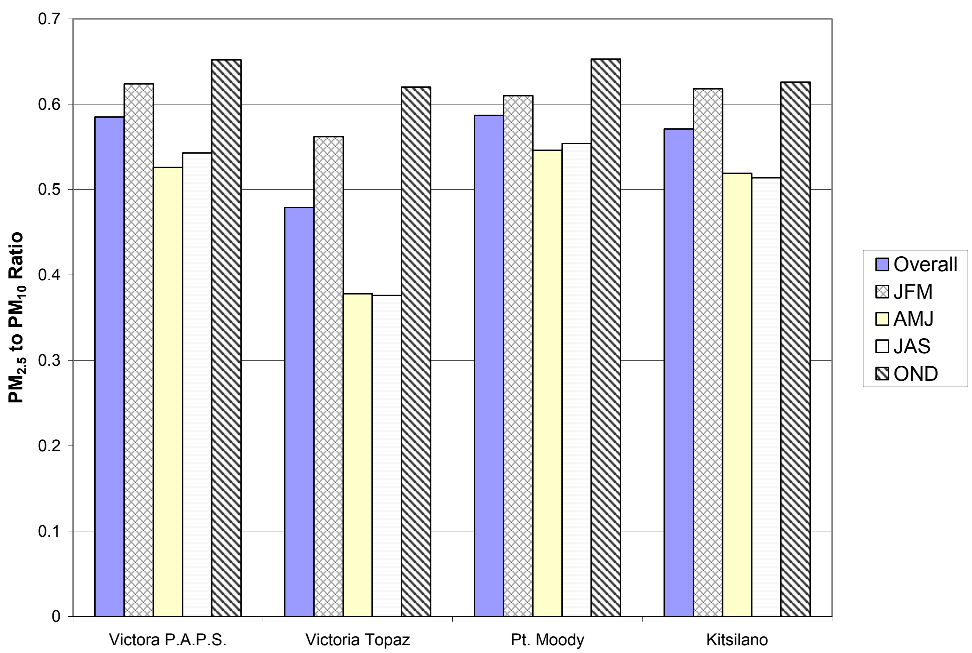


Figure 24 Mean ratio of $PM_{2.5}$ to PM_{10} mass from dichotomous samplers at NAPS sites in BC, based on data collected between 1986-2000. Shown are ratios based on all data, and on a quarterly basis (where "JFM", "AMJ", "JAS", and "OND" refer to the periods of Jan-Mar., Apr.to Jun., Jul.-Sep., and Oct.-Dec., respectively).

4.8 TEOM vs. SSI Data

Given the concerns regarding the high sampling temperatures used in TEOM instruments, and their potential to volatilize a portion of the PM mass, comparisons were made of 24-hour average PM_{10} data from collocated TEOM and SSI instruments. Table 19 summarizes a linear regression analysis of TEOM data as a function of SSI data.

The extent of concurrent TEOM and SSI sampling is rather limited. The available data do indicate that the TEOM compares relatively favourably to the SSI measurements at the two Prince George sites and Kamloops, where mean TEOM-to-SSI ratios range from 0.91 to 0.97 and R^2 coefficients vary from 0.80 to 0.85. In Trail, TEOM measurements typically overestimate SSI measurements by 12%, which is contrary to expectations given the potential of the TEOM to volatilize a portion of the collected sample. Removing the four lowest SSI concentrations, which show particularly poor correlation with TEOM measurements, the recalculated mean TEOM-to-SSI ratio is 0.96. However, there is still much scatter in the data (R^2=0.52), suggesting that there may be other factors such as temperature, particle composition, or sampling efficiency that may be affecting one or both of the monitors.

Table 19 Comparison of 24-hr average PM_{10} data from collocated TEOM and SSI instruments (1994-2000).

Station ID	Station Name	No Days	Mean PM_{10} SSI ($\mu g/m^3$)	Mean PM_{10} TEOM ($\mu g/m^3$)	Ratio TEOM/SSI	Slope	Intercept	R^2
0250009	Trail Butler Park	225	16.7	18.5	1.12	0.54	6.76	0.47
0450270	Prince George Gladstone	175	15.3	16.5	0.97	0.82	1.80	0.85
0450307	Prince George Plaza 400	383	20.5	22.6	0.93	0.79	2.54	0.80
E206898	Kamloops Brocklehurst	57	17.0	19.1	0.91	0.83	1.02	0.84

5 Episode Analysis

A preliminary analysis was conducted to identify major PM episodes across the province for future study. An episode was defined as an event that exhibits large magnitude PM_{10} and/or $PM_{2.5}$ concentrations of extended duration. Large magnitude was considered to be:

- PM_{10} > 50 μg/m^3 (24-h average),
- $PM_{2.5}$ > 30 μg/m^3 (24-h average), or
- PM_{10} > 50 μg/m^3 (24-h average) and $PM_{2.5}$ > 30 μg/m^3 (24-h average).

Extended duration was considered to be at least two consecutive days.

Episodes were first identified based on PM_{10} data only, which provided the broadest spatial coverage of PM in the province. As summarized in Table 20, PM_{10} episodes typically lasted between two and six days, although nine-day episodes were recorded in Houston in February 1996 and Golden in March 1999. The majority (95%) of episodes occurred in communities located in the interior of the province. Of the 30 sites examined, Golden Hospital had the highest frequency of PM_{10} episodes at 6% of days, followed by Prince George BCRail (5%), Quesnel Sr. Secondary, Quesnel Pinecrest, Prince George Plaza 400 and Burns Lake (3% each).

There were few or no PM_{10} episodes observed in the Lower Fraser Valley, on Vancouver Island, or along the Sunshine and northern coasts of BC. One episode recorded in the Lower Fraser Valley coincided with the Kosa dust event in 1998. This event was detected at most monitoring sites throughout the province and in other jurisdictions in the Pacific Northwest (McKendry et al., 2001).

As shown in Figure 25, PM_{10} episodes occurred in every month of the year. The fewest episodes occurred in the summer (June/July) and December, whereas the greatest number occurred during February and March. The majority of

Table 20 Summary of elevated PM_{10} events at select TEOM sites throughout the province for the entire period of record. These events meet the episode criteria for PM_{10} for magnitude (>50 $\mu g/m^3$) and duration (at least two consecutive days).

Site ID	Station Name	No.	No. Episodes	Average Duration (days)	Max. Duration (days)	Total No.	Frequency (%)
E235070	Golden Hospital	625	9	4	9	36	5.8
E224013	Prince George BCRail	1548	25	3	8	77	5.0
E208096	Quesnel Sr. Secondary	2419	25	3	7	79	3.3
0450307	Prince George Plaza 400	3043	33	3	6	91	3.0
E221885	Quesnel Pinecrest	1953	25	2	4	59	3.0
E225267	Burns Lake	1319	12	3	7	34	2.6
M107004	Houston Firehall	2214	15	3	9	48	2.2
E220203	Cranbrook PR3	1615	12	3	5	33	2.0
E221199	Creston PC School	1731	13	3	4	34	2.0
0550502	Williams Lake Columneetza	2648	17	3	5	49	1.9
E230557	Telkwa	1011	4	4	6	15	1.5
E238240	Boston Bar RCMP	533	3	3	2	8	1.5
E206589	Smithers St. Josephs	2958	10	3	6	32	1.1
E216667	Quesnel Maple Dr.	1998	6	3	5	19	1.0
0500886	Kelowna Okanagan College	2511	7	3	4	20	0.8
E206898	Kamloops Brocklehurst	2521	6	2	3	14	0.6
E237431	Merritt Granite-Garcia Mobile	376	1	2	2	2	0.5
E220891	Chilliwack Airport	2068	3	3	3	8	0.4
M107028	Terrace BC Access Centre	1459	3	2	2	6	0.4
0450270	Prince George Gladstone	1828	2	3	3	5	0.3
E232246	Vancouver International Airport	1055	1	3	3	3	0.3
0310162	Port Moody	2449	2	3	3	5	0.2
E217029	Abbotsford Library	1392	1	3	3	3	0.2
E229798	Campbell River	1103	1	2	2	2	0.2
0250009	Trail Butler Park	1751	1	2	2	2	0.1
0310172	Squamish	2176	1	3	3	3	0.1
0310177	Burnaby Kensington Park	2379	1	3	3	3	0.1
E206271	Surrey East	2486	1	3	3	3	0.1
E207417	Richmond South	2553	1	2	2	2	0.1
E207418	Burnaby South	2443	1	3	3	3	0.1

those that occurred in late April/early May in the Lower Fraser Valley were associated with the Kosa Asian dust event in 1998. Some of the most severe episodes occurred at Quesnel Senior Secondary on Mar 6-8, 2000 (3-day average 135 $\mu g/m^3$); Kamloops Brocklehurst on Dec 18-19, 1998 (2-day average 125 $\mu g/m^3$); Prince George Plaza 400 on Feb 28-Mar 2, 1996 (4-day average 122 $\mu g/m^3$); and Burns Lake on Mar 15-21, 1998 (7-day average 122 $\mu g/m^3$).

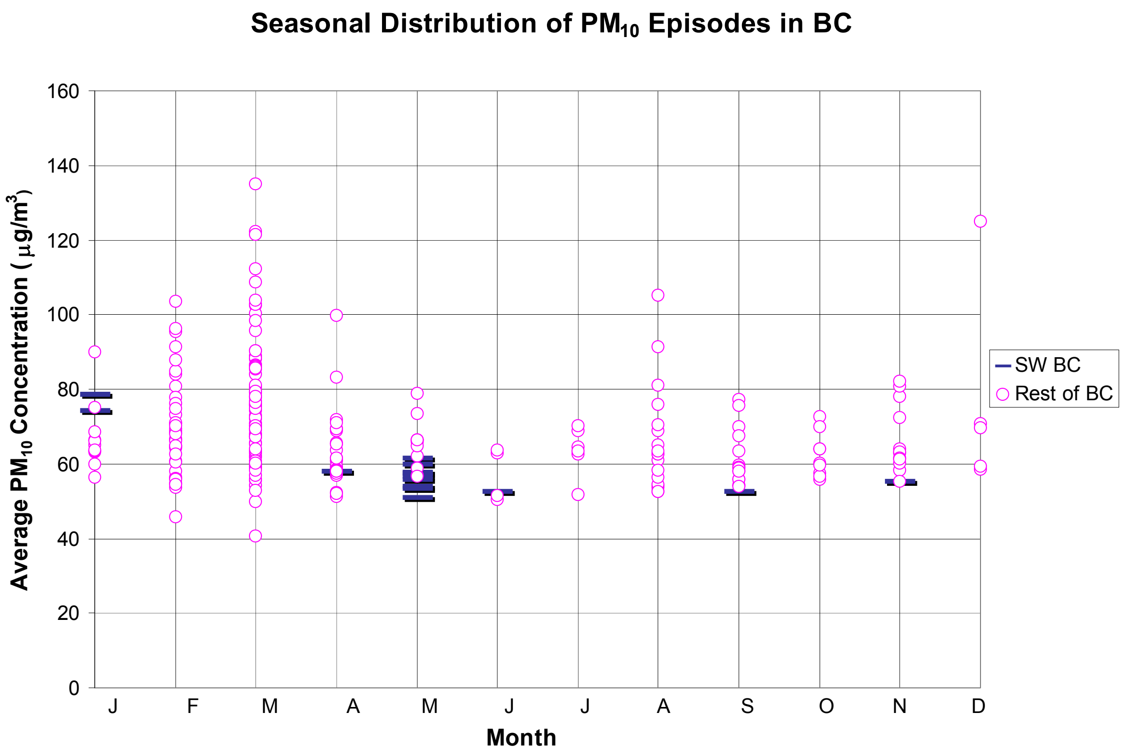


Figure 25 Seasonal distribution of PM_{10} episodes at TEOM sites throughout the province for the entire period of record. The average reported PM_{10} concentration represents the episode average. Horizontal bars represent sites on Vancouver Island and the Lower Mainland. Circles represent sites elsewhere in the province.

The longest recorded episode occurred in Golden from Mar 5-12, 1999. Daily PM_{10} concentrations during this 9-day episode averaged 109 µg/m^3.

PM episodes were then evaluated on the basis of $PM_{2.5}$ data only. This analysis was hampered by the limited spatial coverage and relatively brief monitoring history of continuous $PM_{2.5}$ monitors in the province. As summarized in Table 21, a total of 11 $PM_{2.5}$ episodes were observed. Nine of these episodes occurred in Prince George (Plaza 400), and typically lasted two days. Two four-day episodes occurred between Dec. 4-7, 1997 and Oct. 21-24, 1998. Additional $PM_{2.5}$ episodes occurred in Kelowna between Sept. 2-3, 1998, and Nanaimo between Oct. 23-24, 1998. The Kelowna episode coincided with a major forest fire in the Okanagan region that may have contributed to the elevated $PM_{2.5}$ concentrations (Ralph Adams, pers. comm.). As shown in Figure 26, $PM_{2.5}$ episodes typically occurred between September and

February. The exception is a two-day episode occurring July 27-28, 1998 in Prince George. No episodes occurred during the month of March, when PM_{10} episodes are most frequent in the province.

Table 21 Summary of elevated $PM_{2.5}$ events at TEOM sites throughout the province for the entire period of record. These events meet the episode criteria for $PM_{2.5}$ for magnitude (>30 $\mu g/m^3$) and duration (at least two consecutive days).

Site ID	Station Name	No.	No. Episodes	Average Duration (days)	Max. Duration (days)	Total No.	Frequency (%)
0450307	Prince George Plaza 400	1136	9	3	4	23	2.0
0500886	Kelowna Okanagan College	1121	1	2	2	2	<0.1
E229797	Nanaimo Labieux Rd.	1098	1	2	2	2	0.2

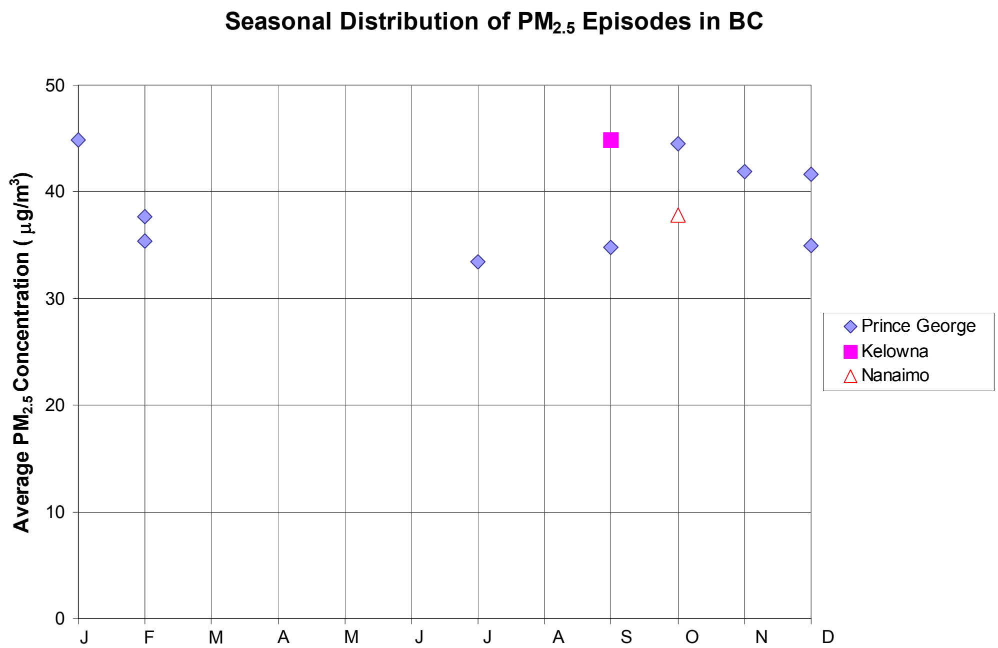


Figure 26 Seasonal distribution of $PM_{2.5}$ episodes at TEOM sites throughout the province for the entire period of record. The average reported $PM_{2.5}$ concentration represents the episode average.

Lastly, those events satisfying both the PM_{10} and $PM_{2.5}$ magnitude and the duration criteria were identified. As shown in Table 22, only two concurrent PM_{10} and $PM_{2.5}$ episodes were observed, in Prince George and Kelowna.

Table 22 Summary of concurrent PM_{10} and $PM_{2.5}$ events at TEOM sites throughout the province for the entire period of record. These events meet the magnitude criteria for PM_{10} (>50 $\mu g/m^3$) and $PM_{2.5}$ (>30 $\mu g/m^3$), and duration criteria (at least two consecutive days).

Site ID	Station Name	Dates	Duration (days)	Avg. Daily PM_{10} ($\mu g/m^3$)	Avg. Daily $PM_{2.5}$ ($\mu g/m^3$)	Avg. Daily $PM_{2.5}/PM_{10}$
0450307	Prince George Plaza 400	Oct. 22-24, 1998	3	70	49	0.71
0500886	Kelowna Okanagan College	Sep. 2-3, 1998	2	59	45	0.75

The Prince George episode occurred between Oct. 22-24, 1998. Episode days were characterized by high $PM_{2.5}$-to-PM_{10} ratios of 0.71, suggesting that combustion sources and/or secondary PM were large contributors to ambient PM_{10} concentrations. Light wind speeds (episode average of 1.4 m/s) further suggest that stagnant meteorological conditions were a potential driver for the episode. A more detailed follow-up analysis should include an evaluation of prevailing synoptic conditions.

The Kelowna episode occurred between Sep. 2-3, 1998. As previously noted, this period coincided with the occurrence of a large wildfire in the Okanagan, as reflected in the high PM_{10} and $PM_{2.5}$ concentrations as well as high $PM_{2.5}$-to-PM_{10} ratios (daily average of 0.75). As with the Prince George episode, a more detailed follow-up analysis is warranted.

6 Summary and Conclusions

- PM_{10} and $PM_{2.5}$ concentrations are highest in the interior of the province.
- PM_{10} concentrations at several locations in the province are frequently at levels that exceed the Provincial objective.
- Based on limited $PM_{2.5}$ monitoring to date, Prince George (Plaza 400) and Quesnel (Sr. Secondary) are the only sites in the province to have exceeded the CWS for $PM_{2.5}$.
- The relatively short monitoring history at most sites precludes a robust trends analysis of PM_{10} or $PM_{2.5}$ data. However, PM_{10} levels appear to be decreasing at a number of sites in the province, most notably Houston (Firehall), Kelowna (Okanagan College) and Williams Lake (Columneetza). $PM_{2.5}$ levels observed in Vancouver Kitsilano and Port Moody also appear to be decreasing. In contrast, annual PM_{10} concentrations at two sites in Quesnel (Maple Drive and Pinecrest) have appeared to increase.
- Analysis of monthly variations in PM_{10} data shows two predominant seasonal patterns. In the Lower Fraser Valley, highest concentrations are observed during the late summer and lowest concentrations are found between November and March. At interior sites, the highest concentrations are typically observed in the late winter/early spring, and the lowest concentrations occur in December and January as well as in early summer.
- Data from $PM_{2.5}$ sites consistently indicate elevated $PM_{2.5}$ concentrations during at least part of the fall. TEOM sites in the Lower Fraser Valley also experience higher concentrations during the late summer months, and lowest concentrations during at least one month of the winter. In contrast, all interior sites experience their lowest concentrations (mean and median) in June and/or July, as do NAPS dichotomous sampler sites in the Lower Fraser Valley and Victoria.

- On a hebdomadal (day-of-week) basis, mean mid-week (Tues.-Wed.) PM_{10} concentrations are 30% higher than those on Sundays, when the lowest concentrations are typically observed. Weekday/weekend differences in excess of 50% are observed at sites in Prince George, Williams Lake, and Quesnel, suggesting that industrial/commercial sources are particularly significant in these communities. Relatively little day-to-day variation (± 3 $\mu g/m^3$) was observed for $PM_{2.5}$ data, with mid-week concentrations typically higher than Sunday concentrations.

- At most sites, there is a predominant diurnal pattern of a morning peak and a more pronounced late evening peak in PM_{10} concentrations. A similar pattern exists for $PM_{2.5}$ but the diurnal variation is much less pronounced. The amplitude of variation is much lower at sites along the coast and in the Lower Fraser Valley.

- The chemical compositions of the fine and coarse fractions of PM_{10} measured at urban NAPS sites in southwestern BC are distinctly different. The fine fraction mass is dominated by S compounds and NH_4^+ ion. In contrast, the coarse fraction is characterized by large contributions of Na, Cl and Si compounds. Reconstructed mass estimates indicate that sulphates are most abundant in the fine fraction, whereas soil and sea salt are predominantly found in the coarse fraction. Nitrates, which are traditionally associated with the fine fraction, are most abundant in the coarse fraction at each of the four NAPS sites investigated.

- Initial analysis of PM episodes was limited to those events in which elevated concentrations of PM_{10} and/or $PM_{2.5}$ were observed on two or more consecutive days. PM_{10} episodes, based solely on elevated and persistent PM_{10} concentrations, occur mainly at interior sites during the late winter and early spring.

- The majority of PM_{10} episodes identified in southwestern BC were associated with an Asian dust event in the spring of 1998.

- The limited $PM_{2.5}$ data collected to-date indicates that $PM_{2.5}$ episodes are most common in Prince George, where 9 of the 11 episodes have been recorded. These episodes were most frequent between September to February, with none occurring during the month of March when PM_{10} episodes are most frequent. The springtime peak in PM_{10} is believed to be due to road dust.
- Two concurrent PM_{10} and $PM_{2.5}$ episodes have been recorded thus far, in Prince George and Kelowna. Both episodes were characterized by high average $PM_{2.5}$-to- PM_{10} ratios in excess of 0.7.

7 Implications

Our understanding of the health impacts associated with PM exposure is rapidly evolving. This has resulted in a heightened interest in the levels of PM in this province, the potential actions that may be taken to reduce these levels, and the areas that will require further study.

Based on our current understanding of PM_{10} and $PM_{2.5}$ concentrations and sources in this province:

- There are large seasonal differences in PM concentrations that exist from one region to another. These variations are particularly evident when comparing the highly urbanized Lower Fraser Valley with the interior of the province, and are a reflection of seasonal differences in source types/contributions and prevailing meteorology. Consequently, there is a need for each region to identify when it is most susceptible to higher concentrations and to develop PM management plans accordingly.
- These plans may require the cooperation of multi-levels of government, given the range of sources that have been identified as major emitters of PM_{10} and $PM_{2.5}$, and the number of jurisdictions having authority over these sources.
- Separate approaches may be required to control PM_{10} and $PM_{2.5}$, particularly where the focus is on reducing the more extreme concentrations.
- In the Lower Fraser Valley, source apportionment studies and emission inventories suggest that PM management approaches should include the control of both direct PM emissions and PM precursor emissions.
- In the interior, there is a need to apply source apportionment techniques based on the collection of speciated PM data, beginning in communities characterized by high PM concentrations and a number of different PM sources. The significance of secondary PM has yet to be demonstrated; however, it would be prudent to begin identifying measures to reduce emissions of precursor gases

such as NO_x and SO_x emissions which are overwhelmingly anthropogenic in nature.

- The long-range transport of pollutants has been shown to influence local PM levels, as demonstrated during the Kosa Asian dust event. Furthermore, the CWS for PM and Ozone contains provisions for identifying communities where background, natural or transboundary sources contribute to exceedances of the Canada Wide Standard, and for Keeping Clean Areas Clean. To meet these provisions under the CWS, and ultimately to develop emission reduction initiatives that will be effective in reducing local PM problems, it will be necessary to obtain improved estimates of background PM levels and to better understand the mechanisms for long-range transport.
- Meteorology plays a large role in the development of PM episodes. More needs to be known about the meteorological conditions and synoptic patterns most conducive to periods of poor air quality, as this will assist in our ability to predict such episodes.
- Finally, to facilitate the tracking of long-term trends, it will be necessary to develop and maintain a stable network of $PM_{2.5}$ stations that characterizes the major macroclimatic and ecologically distinct populated areas of the province.

It is hoped that the findings and information gaps identified in this report will be useful in developing plans to reduce PM concentrations wherever the quality of BC's air is threatened.

8 References

Bartlett K. (1993) *Ambient and Indoor Particulate Monitoring in Selected B.C. Communities*, Prepared for the Ministry of Health, October 1993.

Breed C. (1998) *Characterization and Source Apportionment of Particulate Matter Less than 10 microns in Diameter in the Prince George Airshed.* Masters thesis, University of Northern British Columbia, Environmental Science.

Brook J., Dann T.F. and R.T. Burnett (1997) The relationship among TSP, PM_{10}, $PM_{2.5}$, and inorganic constituents of atmospheric particulate matter at multiple Canadian locations. *Journal of Air & Waste Manage. Assoc.* 47, pp. 2-19.

Brook J.R., Lillyman C.D., Shepherd M.F. and A. Mamedov (2002a) Regional transport and urban contributions to fine particle ($PM_{2.5}$) concentrations in southeastern Canada. *Journal of Air and Waste Manage. Assoc.* 52, pp. 174-185.

Brook R.D., Brook J.R., Urch B., Vincent R., Rajagopalan S. and F. Silverman (2002b) Inhalation of fine particulate air pollution and ozone causes acute arterial vasoconstriction in health adults. *Circulation* 105, pp. 1534-1536.

Buijsman E., Maas H.G.M. and W.A.H. Asman (1987) Anthropogenic NH_3 Emissions in Europe. *Atmospheric Environment,* 21(5), pp. 1009-1022.

CCME (2000) *Canada-wide Standards for Particulate Matter (PM) and Ozone.* Canadian Council of Ministers of the Environment, June 5-6, 2000.

CCME (2002) *Guidance Document on Achievement Determination. Canada-wide Standards for Particulate Matter and Ozone. Final draft.* Canadian Council of Ministers of the Environment.

Cheng L., H.S. Sandhu, R.P. Angle, K.M. McDonald, R.H. Myrick (2000) Rural particulate matter in Alberta, Canada. *Atmospheric Environment*, **34**(20), pp. 3365-3372

Chow J.C., J.G. Watson, E,M. Fujita, Zhiqiang Lu, D.R. Lawson and L.L. Ashbaugh (1994) Temporal and spatial variations on $PM_{2.5}$ and PM_{10} aerosol in the Southern California Air Quality Study, *Atmospheric Environment*, **28**(12), pp. 2061-2080.

Chow J.C. (1995) Measurement methods to determine compliance with ambient air quality standards for suspended particles. *Journal of Air and Waste Manage. Assoc.* 45, pp. 320-382.

Cui Y. and B. Beech (1997) *Characterization of Particulate in Ambient Air, Burnaby, British Columbia.* British Columbia Ministry of Health and Ministry Responsible for Seniors.

Dann T. (1994) *PM_{10} and $PM_{2.5}$ Concentrations at Canadian Urban Sites: 1984-1993* (Report No. PMD 94-3) Pollution Measurement Division, Environmental Technology Centre, Environmental Protection service, Environment Canada.

Evans, C. and B. Thomson (1998) Kootenay Park Visibility Study. *In* Proceedings of the Third International Conference on Science and Management of Protected Areas, N. Munro and J.H.M. Willison (eds), pp 384-394.

Godleski J.J., Lovett E.G., Sioutas C., Killingsworth C.R., Kristensen S.D., Hatch C.E., Wong B., Ferguson S.T., Koutrakis P. and M.A. Vignotti (1998) Impact of inhaled concentrated ambient air particles on canine electrocardiographic patterns. 13^{th} HEI Conference, Annapolis MD, May 1998.

Gold D.R., Litonjua A., Schwartz J., Lovett E., Larson A., Nearing B., Allen G., Verrier M., Cherry R., and R. Verrier (2000) Ambient pollution and heart rate variability. *Circulation* 101, pp. 1267-1273.

GVRD (1994) *GVRD Air Quality Management Plan*, Greater Vancouver Regional District, December 1994.

Lowenthal D.H., D. Wittorff, and A.W. Gertler (1994) *CMB Source Apportionment During REVEAL - Final Report*. Air Resources Branch, British Columbia Ministry of Environment, Lands and Parks.

Main H.H., Richards L.W., Chinkin L.R., Evans V.A., Chow J.C. and F. Divita (1995) *PM_{10} Chemical Analysis and Source Receptor Modelling Study for the Seattle-Tacoma Area.* Prepared by Sonoma Technology Inc, Report STI-93140-1444-FR, for Puget Sound Air Pollution Control Agency, Seattle, WA, April 26, 1995.

Malm, W.C. (1999) *Introduction to Visibility*, Cooperative Institute for Research in the Atmosphere, Fort Collins, Colorado.

McKendry I.G. (2000) PM_{10} levels in the Lower Fraser Valley, British Columbia, Canada: An overview of spatiotemporal variations and meteorological controls. *J. Air and Waste Manage. Assoc. 50:*443-452.

McKendry I.G., J.P. Hacker, R. Stull, S. Sakiyama, D. Mignacca, and K. Reid (2001) Long range transport of Asian dust to the Lower Fraser Valley, British Columbia, Canada. *J. Geophys. Res.* 106, pp. 18361-18370.

McNeill, R. and A. Roberge (2001) The impact of visual air quality on tourism revenues in Greater Vancouver and the Lower Fraser Valley, GBEI Report Number EC/GB-00-028 Georgia Basin Ecosystem Initiative, Environment Canada.

Meyer M., J. Lijek and D. Ono (1992) Continuous PM_{10} measurements in a wood smoke environment. In: PM_{10} standards and non-traditional particulate source controls. *Transactions of an A&WMA/EPA Specialty Conference.* Vol 1. J.C. Chow & D.M Ono (eds.). A&WMA Transactions Series No. 22, Air & Waste Management Association, Pittsburgh, PA. pp. 24-38.

Meyer M.J., Rupprecht E. and H. Patashnick (1995) Considerations for the sampling and measurement of ambient particulate mass. Presented at "Particulate Matter: Health and Regulatory Issues," Pittsburgh, PA, 4-6 April 1995.

MELP (1996) *Air Monitoring Guidelines Volume I, Particulate: Non-continuous.* British Columbia Ministry of Environment, Lands, and Parks.

MELP (1998a) *British Columbia Environmental Laboratory Manual For the Analysis of Water, Wastewater, Sediment and Biological Materials. Supplement 32 to the 1994 Edition: Analysis of Discrete Ambient Air Samples*. British Columbia Ministry of Environment, Lands and Parks, Resources Inventory Branch, July 1998.

MELP (1998b) *Air Quality Report for Golden. Summary of Fine Particulate (PM_{10} Levels 1992 to 1997).* British Columbia Ministry of Environment, Lands and Parks, Kootenay Region, December 1998.

MELP (1999) *1995 British Columbia Emissions Inventory of Common Air Contaminants and Greenhouse Gases*. British Columbia Ministry of Environment, Lands and Parks, Air Resources Branch, Victoria, BC, May 1999.

MSC (2001) *Precursor Contributions to Ambient Fine Particulate Matter in Canada.* Meterological Service of Canada, Environment Canada, May 2001.

Peters A., Perz S., Doring A., Stieber J., Koenig W. and H.E. Wichmann (1999) Increases in heart rate during an air pollution episode. *Am. J. Epidemiol*. 150, pp. 1094-1098.

Plain E. and V. Carmichael (1998) *Inhalable particulate characterization during a late winter period in Quesnel.* British Columbia Ministry of Environment, Lands, and Parks.

Pope C.A., Verrier R.L., Lovett E.G. Larson AC, Raizenne ME, Kanner RE and J. Schwartz (1999) Heart rate variability associated with particulate air pollution. *Am. Heart J*. 138, pp. 890-899.

Pryor S.C. and R.J. Barthelmie (1999) *REVEAL II Characterizing fine aerosols in the Fraser Valley*. Report to Fraser Valley Regional District.

Pryor S.C. and R.J. Barthelmie (2000) REVEAL II: Seasonality and spatial variability of particle and visibility conditions in the Fraser Valley, *Science of the Total Environment*, accepted for publication.

Pryor S.C. and D. Steyn (1994) *Visibility and ambient aerosols in south-western British Columbia during REVEAL.* British Columbia Ministry of Environment, Lands and Parks.

Pryor S.C. and D. Steyn (1995) *Visibility and ambient aerosols in south-western British Columbia during REVEAL. Part 3.* British Columbia Ministry of Environment, Lands and Parks.

Sakiyama S.K. (1994) *Data Summary Report of REVEAL (Regional Visibility Experimental Assessment in the Lower Fraser Valley).* British Columbia Ministry of Environment, Lands and Parks.

Seinfeld H.H. (1986) *Atmospheric Chemistry and Physics of Air Pollution*. John Wiley & Sons, New York, NY.

Sutton M.A., Place C.J., Eager M., Fowler D. and R.I. Smith (1995) Assessment of the magnitude of ammonia emissions in the United Kingdom. *Atmospheric Environment*, 29(12), pp. 1393-1411.

Suwa, T., Hogg J.C., Quinlan K.B., Ohgami A., Vincent R. and S. F. van Eeden (2002) Particulate Air Pollution Induces Progression of Atherosclerosis. *J. Amer. Coll. Cardiol* 39 (6), pp. 935-942.

US EPA (1996) *Air quality criteria for particulate matter.* Volume I-3. EPA Report No. EPA/001 a-cF, Office of Research & Development, US Environmental Protection Agency, Washington, DC.

US EPA (1998) *Guidance for Using Continuous Monitors in $PM_{2.5}$ Monitoring Networks.* EPA-454/R-98-012, Office of Air Quality Planning and Standards, US Environmental Protection Agency, Research Triangle Park, NJ.

Vedal S. (1995) *Health Effects of Inhalable Particles: Implications for British Columbia,.* Prepared for Air Resources Branch, British Columbia Ministry of Environment, Lands, and Parks.

WGAQOG (1999a) *National Ambient Air Quality Objectives for Particulate Matter. Part 1: Science Assessment Document.* A report by the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines. Minister, Public Works and Government Services.

WGAQOG (1999b) *National Ambient Air Quality Objectives for Particulate Matter: Addendum to The Science Assessment Document.* A report by the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines. Minister, Public Works and Government Services.

Appendix I:

1995 Emissions Inventory of PM_{10}, $PM_{2.5}$, NO_X, SO_X, and VOC Emissions in the Lower Fraser Valley and the Rest of British Columbia

Table I-1 Lower Fraser Valley 1995 emission inventory summary of emissions (MELP, 1999). Revised pulp mill data (Errata sheet April 2000) have been added.

SOURCE/CATEGORY	PM_{10} (tonnes)	$PM_{2.5}$ (tonnes)	NOx (tonnes)	SOx (tonnes)	VOC (tonnes)
ANTHROPOGENIC					
Point Sources	**4,219**	**1,997**	**9,185**	**3,337**	**3,581**
Wood Products	1,077	529	239	14	627
Paper and Allied Products	48	43	187	7	31
Logging	182	182	45		204
Primary Metal Manufacturing	147	114	19	33	87
Refined Petroleum and Coal Products	244	136	685	2,412	837
Non-Metallic Mineral Products	707	291	5,244	655	27
Pipeline Transport	5	5	132	1	5
Power Generation & Other Utility	95	94	1,872	164	33
Other	1,714	603	762	51	1,730
Area Sources	**3,338**	**1,474**	**4,032**	**201**	**22,274**
Prescribed Burning	5	5	2	0	5
Space Heating	853	822	3,620	199	845
Agriculture	1,840	92	388		3,200
Oil and Gas					4,076
Solvent Evaporation					13,223
Miscellaneous Burning	46	45	18	2	80
Other	594	510	5		846
Mobile Sources	**2,503**	**2,157**	**39,238**	**2,575**	**25,384**
Light-Duty Vehicles	407	259	19,151	742	21,025
Heavy-Duty Vehicles	419	371	6,114	97	866
Railways	1,056	971	4,393	312	232
Marine Vessels	248	228	5,044	1,300	1,761
Aircraft	70	49	1,000	49	608
Off-Road	303	279	3,535	75	893
ANTHROPOGENIC SUB-TOTAL	**10,060**	**5,627**	**52,455**	**6,113**	**51,239**

Table I-1, continued: Lower Fraser Valley 1995 emission inventory summary of emissions (MELP, 1999)

SOURCE/CATEGORY	PM_{10}	$PM_{2.5}$	NOx	SOx	VOC
NATURAL					
Wildfires	37	35	4	0	12
Biogenics			153		18,832
Wildlife					4
Marine Aerosol	372	56			
NATURAL SUB-TOTAL	**409**	**90**	**157**	**0**	**18,849**
TOTAL	**10,469**	**5,718**	**52,612**	**6,113**	**70,088**
ROAD DUST					
Paved	77,586	18,552			
Unpaved	71,447	10,629			

Table I-2 British Columbia 1995 emission inventory summary of emissions, excluding the Lower Fraser Valley (MELP, 1999). Revised pulp mill data (Errata sheet April 2000) have been added.

SOURCE/CATEGORY	PM_{10}	$PM_{2.5}$	NOx	SOx	VOC
	(tonnes)	(tonnes)	(tonnes)	(tonnes)	(tonnes)
ANTHROPOGENIC					
Point Sources	**75,372**	**54,590**	**49,807**	**91,607**	**47,612**
Wood Products	41,398	28,049	6,571	530	34,836
Paper and Allied Products	18,939	14,991	11,628	12,529	4,048
Mining	3,301	1,597	9,540	5,323	1,666
Logging	4,339	4,251	167	17	1,830
Primary Metal Manufacturing	3,670	3,075	113	16,827	7
Refined Petroleum and Coal Products	431	149	1,729	6,061	421
Non-Metallic Mineral Products	437	273	1,260	760	58
Pipeline Transport	536	525	5,770	11	1,177
Power Generation & Other Utility	706	671	2,804	336	667
Crude Petroleum & Natural Gas Processing	203	162	8,934	48,642	2,306
Other	1,412	847	1,291	571	596
Area Sources	**36,769**	**30,718**	**16,544**	**51,916**	**104,489**
Prescribed burning	14,718	13,910	2,792	9	7,949
Space Heating	12,519	11,887	3,642	654	32,141
Agriculture	7,072	3,339	404		8,296
Oil and Gas	111	111	9,502	51,223	41,082
Solvent Evaporation					11,141
Miscellaneous Burning	804	730	192	30	1,118
Other	1,545	741	12		2,762
Mobile Sources	**22,131**	**20,142**	**134,658**	**24,377**	**44,671**
Light-Duty Vehicles	532	334	25,493	982	33,949
Heavy-Duty Vehicles	1,462	1,295	19,402	342	3,118
Railways	16,382	15,072	26,527	1,859	1,401
Marine Vessels	2,859	2,630	54,921	21,027	3,885
Aircraft	64	45	156	17	343
Off-Road	832	766	8,159	150	1,975
ANTHROPOGENIC SUB-TOTAL	**134,272**	**105,450**	**201,009**	**167,900**	**196,772**
NATURAL					
Wildfires	35,715	32,967	4,121	14	11,734
Biogenics			8,838		2,484,628
Wildlife					1,560
Marine Aerosol	14,441	2,490			
NATURAL SUB-TOTAL	**50,156**	**35,457**	**12,959**	**14**	**2,497,922**
TOTAL	**184,427**	**140,907**	**213,967**	**167,914**	**2,694,694**
ROAD DUST					
Paved	9,453	2,260			
Unpaved					

Appendix II:

1995 Provincial Inventory of Ammonia Emissions

Table II-1 Annual 1995 ammonia emissions inventory for BC. Source: http://www.ec.gc.ca/pdb/ape/ape_tables/NH95_e.cfm.

CATEGORY/SECTOR	tonnes
INDUSTRIAL SOURCES	
Chemicals Industry	819.1
Mining and Rock Quarrying	4.2
Petroleum Refining	1.5
Pulp and Paper Industry	78.7
Wood Industry	15.4
Other Industries	68.5
TOTAL INDUSTRIAL SOURCES	**987.5**
NON INDUSTRIAL FUEL COMBUSTION	
Commercial Fuel Combustion	21.3
Electric Power Generation (Utilities)	83.7
Residential Fuel Combustion	34.5
Residential Fuel Wood Combustion	75.8
TOTAL NON INDUSTRIAL FUEL COMBUSTION	**215.4**
TRANSPORTATION	
Air Transportation	1.3
Heavy-duty diesel vehicles	14.2
Heavy-duty gasoline trucks	17.2
Light-duty diesel trucks	2.1
Light-duty diesel vehicles	0.4
Light-duty gasoline trucks	769.4
Light-duty gasoline vehicles	1336.3
Marine Transportation	22.7
Motor cycles	0.3
Off-road use of diesel	64.1
Off-road use of gasoline	19.9
Rail Transportation	2.8

Table II-1, continued: Annual 1995 ammonia emissions inventory for BC

TOTAL TRANSPORTATION	**2250.7**
INCINERATION	
Industrial & Commercial Incineration	27.1
Municipal Incineration	5.7
Wood Waste Incineration	91.1
Other Incineration & Utilities	0.1
TOTAL INCINERATION	**124.0**
CATEGORY/SECTOR	**tonnes**
MISCELLANEOUS	
Cigarette Smoking	0.5
Human	960.2
Pesticides and Fertilizer Application[7]	3129.1
TOTAL MISCELLANEOUS	**4089.9**
OPEN SOURCES	
Agriculture (Animals)	16140.8
Forest Fires	129.1
Prescribed Burning	89.4
TOTAL OPEN SOURCES	**16359.3**
PROVINCIAL TOTAL	**24026.7**

[7] The pesticides and Fertilizer Application sector also includes the growth and decomposition of fertilized agricultural crops.

Appendix III:

Monitoring History of PM_{10} and $PM_{2.5}$ in the Provincial Monitoring Network

Table III-1 PM_{10} TEOM monitoring sites and locations (up to Dec. 31, 2000).

Station ID	City/Station Name	Street Address	Start Date	End Date	No. Daily Measurements
E238212	Abbotsford Central	32995 Bevan Avenue	18-Sep-98	-	814
E217029	Abbotsford Downtown	South Fraser Highway	19-Jul-94	15-Sep-98	1392
E238240	Boston Bar RCMP Station	47864 Old Boston Bar Road	08-Jul-99	-	533
0310177	Burnaby Kensington Park	6400 E. Hastings	13-May-94	-	2379
E207418	Burnaby South	5455 Rumble Street	29-Mar-94	-	2443
E225267	Burns Lake Fire Centre	#8 4th Avenue	08-Mar-97	-	1319
E229798	Campbell River Tyee Spit	2662 Tyee Spit	12-Dec-97	-	1103
E220891	Chilliwack Airport	Airport Road	01-Mar-95	-	2069
E206612	Chilliwack Works Yard		01-Nov-94	01-Mar-95	102
E240337	Colwood City Hall	3300 Wishart Road	01-Feb-00	14-Dec-00	141
E242577	Cranbrook Forest Fire	Forest	21-Aug-00	12-Sep-00	21
E220203	Cranbrook PR3	Adjacent to 1333 14th Avenue S	20-Apr-94	30-Nov-98	1615
E206243	Cranbrook Swimming Pool	Balment Park	01-May-92	16-Sep-93	432
E221199	Creston PC School	Prince Charles Secondary School	27-Oct-94	-	1732
E234670	Duncan Deykin Avenue	6364 Deykin Avenue	01-Nov-98	-	778
E223361	Duncan Mobile	5700 Menzies Road	01-Jul-96	24-Oct-96	115
E242166	Duncan Mobile Transfer Station	3900 Drinkwater Road	01-Jul-00	-	182
E222520	Elk Falls Dogwood	Adjacent to 660 Westmere	08-Dec-95	-	1586
0110203	Gold River Pumphouse		06-Feb-97	09-Nov-98	626
E235070	Golden Hospital	835 9th Avenue South	11-Feb-99	24-Dec-00	625
E223885	Grand Forks Mobile	625 69th Avenue	30-Oct-96	23-Apr-97	174
E225377	Harmac Cedar Woobank	1624 Woobank	07-Jul-97	-	979
E223756	Hope Airport	62715 Airport Road	03-Dec-96	-	1478
M107004	Houston Firehall	3382 11th Street	10-Feb-97	-	1381
E206898	Kamloops Brocklehurst	Mayfair Street	01-Jan-94	-	2522
0500886	Kelowna College	3333 College Way	22-Jan-94	-	2511
E223616	Kitimat Haul Road	Haulage Road	10-Aug-98	-	868

Table III-1: continued

Station ID	City/Station Name	Street Address	Start Date	End Date	No. Daily Measurements
E223827	Kitimat Rail	CN Rail Yard	17-Aug-98	-	858
E216670	Kitimat Riverlodge	651 Columbia Street	11-Aug-98	-	870
E223615	Kitimat Whitesail	1332 Lahakas Blvd. N.	20-Jun-00	20-Jul-00	29
E222778	Langdale Elementary	Forres Road	05-Jan-96	25-Dec-00	1466
E209178	Langley Central	23752 52nd Avenue	01-Jan-94	-	2396
E232245	Maple Ridge Golden Ears Elementary School	23124 118th Avenue	20-Feb-98	-	1020
0605040	Merritt City Hall	2185 Voght Street	02-Sep-98	22-Sep-98	20
E237431	Merritt Granite-Garcia Mobile	2113 Granite Street	16-May-99	29-May-00	376
E229797	Nanaimo Labieux Road	2080A Labieux Road	27-Jan-98	28-Sep-98	240
E207723	North Delta	8544 116th Street	17-Dec-93	01-Jan-00	2087
E228065	Port Alberni Townsite	5410 Argyle Street	16-Sep-97	-	1182
E225184	Port Edward Pacific	770 Pacific Street	29-Apr-98	07-Nov-00	880
0310162	Port Moody Rocky Point Park	Moody Street and Esplanade	01-Nov-93	-	2449
0220204	Powell River Cranberry Lake	Wildlife Sanctuary	11-Jan-96	-	1764
0220205	Powell River Wildwood	Wildwood Motors	18-Jun-97	-	1276
E224013	Prince George BC Rail Warehouse	1108 Industrial Way	28-Sep-96	-	1549
0450270	Prince George Gladstone School	7005 Gladstone Drive	06-Dec-95	-	1829
E224014	Prince George Glenview School	7310 Cluff	11-Jun-98	-	927
E225868	Prince George Hart Highlands	3487 East Austin Road	04-Apr-97	22-Mar-98	351
0450307	Prince George Plaza 400	1011 4th Avenue	01-Mar-92	-	3042
E231838	Prince Rupert Galloway Rapids	Highway 16	24-Apr-98	-	893
E225378	Quadra Island Lighthouse	Lighthouse Road	23-Feb-97	-	1361
E216667	Quesnel Maple Drive	950 Mountain Ash Road	24-May-95	-	1998
E221885	Quesnel Pinecrest Centre	501 Pinecrest Road	09-Jun-95	-	1954
E208096	Quesnel Senior Secondary	585 Callanan Street	16-Apr-94	-	2419
E228064	Quesnel West Correlieu School	850 Anderson	22-Nov-00	-	39
E226268	Quick Mobile	Kerr Road	07-Oct-97	01-May-98	190
E207417	Richmond South	Williams and Aragon Road	27-Oct-93	-	2553

Table III-1: continued

Station ID	City/Station Name	Street Address	Start Date	End Date	No. Daily Measurements
E233344	Salmon Arm Hospital	601 - 10th Street NE	06-Aug-98	26-Aug-98	19
E206589	Smithers St Josephs	4020 Broadway Avenue	11-Feb-97	-	1392
0310172	Squamish	38075 2nd Avenue	11-Sep-94	15-Dec-00	2176
E206271	Surrey East	19000 72nd Avenue	06-Jan-94	-	2486
E233102	Telegraph Creek	Tahltan School	23-Jul-98	02-Sep-98	40
E230557	Telkwa	1304 Birch Street	04-Feb-98	-	1011
M107028	Terrace BC Access Centre	104 - 3220 Eby Street	17-Dec-96	-	1459
0250009	Trail	Butler Park	11-Apr-94	09-May-00	1750
E232246	Vancouver International Airport #2	3153 Templeton Street	01-Feb-98	-	1056
0310175	Vancouver Kitsilano	2550 West 10th Avenue	13-Dec-93	-	2527
E222853	Vernon City Hall Mobile	3400 30th Street	23-Dec-95	28-May-96	156
0550502	Williams Lake Columneetza School	1045 Western Avenue	16-Dec-92	-	2649

Table III-2 PM_{10} SSI and Partisol monitoring sites and locations (up to Dec. 31, 2000).

Station ID	City/ Station Name	Address/ Description	SSI (S) Partisol (P)	Start Time	End Time	No. Daily Measure-ments
E218444	100 Mile House BC Access Centre	On roof of B.C. Access Centre - 100 Mile House	S	13-Mar-93	-	583
E217255	Albion - Wasa Ins. Co.	On roof of 2 story building	S	29-Oct-94	29-Oct-94	1
E217319	Albion Elementary School	On roof of building, 4m above ground level	S	01-Jun-94	28-Jan-96	106
E232263	Aldergrove - Aberdeen Elem. School	SW corner of Fraser Hwy and Bradner Road	S	21-May-98	30-Aug-98	28
E219592	Burns Lake	Conservation Officer Service Building	S	04-Oct-93	12-Oct-96	116
E231818	Trail Butler Park PM10 Partisol	Operated at same site as 0250009/	S/P	16-May-97	-	211
E206931	Castelgar at Senior Citizens Lounge	Roof of senior's lounge at 204 11th Ave.	S	23-Apr-90	-	570
E222858	Chetwynd	Roof of credit union bldg	S	05-Jan-95	-	313
E220891	Chilliwack Airport	Airport Rd; NE corner of airport field	S	19-Jun-94	22-Mar-95	56
E213114	Chilliwack Mertin's	45930 Airport Rd - On roof of bldg	S	01-Nov-90	08-May-94	205
E221080	Cranbrook - BC Environnment Office	Roof of storage compound	S/P	24-Aug-94	29-Sep-94	9
E206241	Cranbrook Amy Woodland School	Roof of gymnasium of school at 911 6th St. S	S	19-Apr-85	31-Mar-91	163
E206243	Cranbrook Swimming Pool	Roof over pool	S	04-Jul-89	17-Feb-99	555
E231457	CRD - BC Hydro	Main office, part of CRD particulate study.	S	06-Dec-97	27-Aug-98	44
E240882	CRD - Braefoot	CRD LTMP	S	19-Jan-00	-	45
E224515	CRD - Camosun College	Part of CRD particulate study	S	02-Aug-97	20-Dec-99	130
E240881	CRD - Keating	CRD LTMP	S	12-May-00	-	37
E224512	CRD - Oak Bay Rec Centre	Part of CRD particulate study	S	10-Feb-97	-	198
E213056	Creston Hospital		S	20-Sep-90	22-Jun-98	376
E206378	Crofton Air at Vernon and Shasta Streets	In vacant house on D. Crompton Farm	S	27-Oct-92	02-Apr-94	83
E206379	Crofton Air, Community Hall Roof	At junction of Roberts and Musgrove Streets	S	27-Oct-92	08-Apr-94	85
E222857	Dawson Creek	Harpers garage roof	S	15-Feb-96	27-May-96	16
E217029	Downtown Abbotsford	On roof of bldg	S	06-May-92	16-Mar-95	160
0250182	Elkford Residential Area	On roof of pumphouse on Baker Drive	S	03-Feb-88	26-Mar-93	75
E241747	Esquimalt - DND Hospital Air Station		S/P	06-May-00	-	29

Table III-2: continued

Station ID	City/ Station Name	Address/ Description	SSI (S) Partisol (P)	Start Date	End Date	No. Daily Measure-ments
E231478	Esquimalt Graving Dock Guardhouse, PWC	30m from the guardhouse.	S	04-Feb-98	20-Dec-99	115
E231477	Esquimalt Graving Dock Lookout, PWC	Lookout above the graving dock.	S	04-Feb-98	26-Nov-99	111
E231479	Esquimalt, 860 Isbister PWC	Located at the residence for comparative purposes.	S/P	12-Jan-98	29-Jul-99	101
E206787	Fort Steele-Maus Creek	Kusy residence off Bull River Rd.	S	20-Jan-87	19-Mar-91	81
E222859	Ft. St. James	Roof of Ft. St. James Senior Sec. School	S	23-Oct-94	18-Feb-00	143
E222140	Genelle	Corner of Medego Drive & 2nd St	S	06-Sep-95	-	290
E219361	Gold River	Mowachaht Reserve	S	05-Aug-93	03-Nov-93	9
E216700	Golden Lady Grey School	Lady Grey Elem. School- 10th Ave	S	21-Jan-92	11-Jul-00	461
E207520	Grand Forks City Hall	Background Monitoring Site	S	16-Jul-92	-	458
E216752	Harmac Canoxy Site	End of CanOxy's ocean loading dock	S	08-Jan-92	27-Dec-92	55
E216751	Harmac Cedar site at Nicholl's Farm]	Rooftop of 2375 Holden Corso Rd, Cedar	S	08-Jan-92	27-Dec-92	59
E223756	Hope Airport GVRD - T29		S	25-Aug-96	11-Nov-96	14
E214615	Hope Firehall	865 3rd Ave on roof at rear of bldg	S	25-Mar-91	05-Nov-96	322
E206164	Horseshoe Bay W. Van Firehall No. 2	In trailer beside fire hall	S	20-Jun-87	31-Aug-88	56
E221544	Houston Firehall	3382 - 11th Street	S	21-Jan-95	20-Feb-95	6
E218458	Houston Silverthorn School		S	12-Feb-93	15-Jan-95	82
E219639	Invermere Bridgewater	Front lawn of Martin Bridewater's home	S	30-Jul-93	27-Jan-94	16
E220202	Invermere Forest Service Compound	East side of hose tower in MOF compound	S/P	09-Mar-94	-	393
0605001	Kamloops Airport	At Fulton Field	S	05-Jan-90	27-Dec-93	222
E206898	Kamloops Brocklehurst	SE corner of city yard.	S	05-Jan-90	28-Dec-94	271
E206725	Kamloops Federal Bldg	Downtown, roof of post office	S	10-Feb-90	-	625
E206304	Kelowna Okanagan College	NAPS air station	S	17-Mar-89	17-Dec-95	386
E207547	Kimberley at Marysville Post Office	Roof of Marysville Post Office 512 305th St Kimberley	S	21-May-88	18-Mar-90	36

Table III-2: continued

Station ID	City/ Station Name	Address/ Description	SSI (S) Partisol (P)	Start Date	End Date	No. Daily Measure-ments
E207182	Kitimat Minette Sub-station	SSW OF BC Hydro Minette Sub-station on old Alcan Rd	S	26-Sep-89	05-Jun-92	36
E206671	Kitimat Nechako Dock	South of Alcan Smelters and Eurocan	S	24-Nov-89	25-Mar-91	15
E223827	Kitimat Rail	CN Railyard	P	22-Jan-97	10-Jul-98	6
E223615	Kitimat Whitesail	On the Mountain View Alliance Church lot	P	12-Sep-96	10-Jul-98	6
E216670	Kitimat-653 Columbia St. (Riverlodge)		P	11-Dec-95	10-Jul-98	6
E216669	Kitimat-Saunder's Road (9th)		P	12-Sep-96	12-Sep-96	1
E238682	Kitwanga School	On top of Kitwanga Jr. Secondary	S	06-Apr-99	23-Jul-99	14
E238321	LFV - Cyril St. FVCDC	On roof of building	P	02-Jul-99	30-Oct-99	38
E238322	LFV - Fraser St. Hrubizna	In back yard of residence	S	02-Jul-99	30-Oct-99	38
E238323	LFV - W. Railway Firehall # 6	On roof of building	S	14-Jul-99	30-Oct-99	34
E206302	Lumby Home Furnishings	Lumby air station	S	19-Apr-93	17-Mar-97	173
E238019	Merritt Airport North Field	At north end of the paved landing strip, north of main terminal.	S	18-May-99	30-May-00	56
E238020	Merritt RI Ponds	In fenced city compound near middle of east fence, Merritt rapid infiltration ponds at end of Pine St.	S	17-Jun-99	30-May-00	48
E208083	Merritt Schu	On roof of south central health unit bldg at 2099 Granite St in downtown Merritt	S	05-Jan-90	-	532
E217320	Mission Pioneer	On roof of building, 3m above ground level	S	04-Aug-92	-	495
E229537	Mission Secondary School	Central location of Mission in a residential area	S	06-Dec-97	11-Jun-00	149
E222142	Nakusp High School		P	06-Sep-95	23-Nov-95	10
E206375	Nelson Gov. Bldg	Roof of Nelson Gov. Bldg	S	23-Apr-90	-	510
E225285	New Aiyansh	Roof of the Nisga'a Valley Health Centre	S	15-Jul-97	-	88
E218578	New Hazelton DFO Bldg	Ambient air monitor for particulates	S	08-Mar-93	12-Sep-96	164
E222689	Northport - Cominco Station	Roof of instrument shed across from airport	S	17-Aug-93	-	430
E242930	Oliver STP Air	Oliver municipal compound at the Oliver STP	S	02-Nov-00	-	10
0500869	Penticton Air - Carmi School	On top of Carmi School, Penticton.	S	26-Nov-92	08-Oct-98	289

Table III-2: continued

Station ID	City/ Station Name	Address/ Description	SSI (S) Partisol (P)	Start Date	End Date	No. Daily Measure-ments
E229217	Penticton Air - MOE Office	On roof of hazardous waste storage building behind (west) of main building; 3547 Skaha Lake Road Penticton	S	12-Nov-97	-	178
E206169	Pitt Meadows Airport	In a trailer just outside the dike beside the ramp to the floatplane base	S	17-Feb-91	21-Feb-96	264
E233567	Polar Bear Lake (PA03034) - PM10 Monitor	On the school roof in the community of Bear Lake.	S	13-Jul-98	-	283
0110264	Port Alberni Air, Roof of Courthouse		S	06-Feb-85	04-May-97	527
0110263	Port Alberni at Automarine		S	01-Aug-88	20-Feb-95	127
0110254	Port Alberni Firehall	Roof of Firehall - 3699 Tenth Ave.	S	21-Oct-92	04-May-97	238
E207286	Powell River Cranberry Centre	At the old library bldg at 6792 Cranberry St	S	03-Jul-89	22-Feb-90	37
0450325	Prince George Foreman Flats	Approx. 300 m west of log house, 400 m west of Foreman Rd at Denicola Farm	S	03-Aug-90	30-May-92	101
0450270	Prince George Gladstone School Roof	College Heights Elementary School roo	S	23-Jun-92	18-Jan-99	380
E225868	Prince George Hart Highlands	Transport Canada mobile monitor on loan to MELP until July 1997; at BC Tel compound on East Austin Rd	P	07-Sep-97	07-Oct-97	6
0450324	Prince George Lakewood Sec. Rooft	On the roof directly above custodian room 218 of Lakewood Jr Secondary School	S	03-Aug-90	-	582
0450307	Prince George Plaza 400 Roof	East elevator penthouse of Plaza 400 Bldg	S/P	03-Aug-90	-	585
0450232	Prince George Van Bien School	Roof of Van Bien Elementary School	S	03-Aug-90	-	573
E218772	Prince George - BCR Engineering Bldg	On BC Rail Engineering bldg.	S	01-Apr-93	19-Aug-96	195
E218771	Prince George - CNR Site	On Lakeland Lumber bldg	S	01-Apr-93	-	443
E223128	Prince George BCR Warehouse Bldg Site	On BCR Warehouse Bldg roof	S	30-May-96	18-Jan-99	163
E206113	Quesnel Firehall	On top of Quesnel City Hall at corner of Kinchant St. and Barlow Avenue	S	01-Nov-90	08-Feb-95	221
E213032	Quesnel Pinecrest School	On the roof of portable	S	14-Oct-90	13-Mar-92	78
E228064	Quesnel West Correlieu School	On gymnasium roof of Correlieu School.	S	12-Nov-97	15-Oct-00	160
E232982	Radium PM10	In service garage of Radium office bldg	S/P	22-Jul-98	-	354

Table III-2: continued

Station ID	City/ Station Name	Address/ Description	SSI (S) Partisol (P)	Start Date	End Date	No. Daily Measure-ments
E217680	Revelstoke Firehall		S	02-Dec-92	-	458
E222523	Saanich Firehall No. 1	50ft north of buildings	S	12-Oct-95	27-Apr-96	18
E222524	Saanich Firehall No. 1	On auseway roof attached to the main firehall	S	24-Oct-95	27-Feb-96	15
E240301	Salmon Arm Firehall	141 Ross Street	S	07-Mar-00	-	39
E237978	Sechelt Trail Bay Mall	On roof of Trail Bay Mall in downtown Sechelt	S	11-Jun-99	-	87
E206786	Skookumchuck Bradford Ranch	2 km east of Crestbrook Pulpmill, turn right just before Skookumchuck Store	S	30-Nov-89	30-Dec-89	6
E207914	Skookumchuck Johnson Lake	Lakeview gravel pit rd,3 km north of Premier Lake Rd	S/P	23-Apr-90	-	508
0260104	Slocan W.E. Graham School Roof	Roof of school, approx. 1 km south of Slocan Forest Products Mill	S	08-Nov-91	-	494
E206588	Smithers BCBC Garage	On roof of BCBC garage behind government bldg on Railway Ave	S	16-Jul-90	15-Sep-91	70
E206589	Smithers St. Josephs School	On roof of school in downtown Smithers	S/P	16-Jul-90	15-Jun-97	211
E216334	Spooner- 14th Ave	Downwind from burner - in Spooner's backyard	S	02-Nov-91	24-May-92	27
0310172	Squamish Government Bldg	On roof of prov. gov. bldg on 2nd St.	S	13-Dec-90	16-Dec-94	172
E240336	Stewart	Roof of residence	S	01-Mar-00	-	32
E230557	Telkwa	On sports field near the #1 firehall	P	19-Oct-97	11-Jan-98	12
E222636	Terrace - BC Hydro Bldg	BC Hydro Building, Terrace BC	S	18-Oct-95	-	229
E222818	Terrace - Clarence Michael School		S	15-Feb-96	26-Jun-96	23
0435079	Terrace Air at Firehall	Rooftop above firehall	S	22-Oct-93	22-Mar-96	131
0250009	Trail Butler Park	Roof of concrete bldg, East Trail	S	23-Apr-90	-	516
0260022	Trail Cominco Stn at Oasis	On bench approx. 500 ft. above Columbia, approx. 3mi NW of Trail in S Portion of Oasis Residential Area	S	01-Jan-93	03-Sep-00	453
E222141	Trail West	Corner of Bay Ave and Wilms Lane	S	05-Jan-98	-	174
E234293	Valemount	On the firehall building roof.	S/P	01-Jan-00	-	52
0605096	Valleyview BC Tel	1875 Trans-Canada Highway, East Kamloops	S	05-Jan-90	29-Apr-90	20
E222775	Vernon - 724 Mission Rd.	East of Vernon Airport at 724 Mission Road	S	05-Jun-95	17-May-96	60

Table III-2: continued

Station ID	City/ Station Name	Address/ Description	SSI (S) Partisol (P)	Start Date	End Date	No. Daily Measure-ments
E229817	Vernon - Coldstream Ranch	South of main office, in Environment Canada climate station.	S	05-Jan-98	-	152
0500827	Vernon Air	Vernon City Hall	S	01-Oct-89	-	443
E231866	Victoria - Topaz	Behind S.J. Willis School on Topaz Avenue	S	23-May-98	-	155
0110030	Victoria PAPS-01	RM 222, 1250 Quadra St., Victoria (on rooftop)	S	03-Apr-88	29-Dec-97	276
E208805	Westsyde BC Tel	Westsyde Rd and Lyne Rd, on roof	S	05-May-90	29-Dec-96	390
E227431	Whistler Meadow Park	On roof of Meadow Park Sport Centre	S	07-Oct-97	-	109
0605116	Williams Lake - Annie Stevenson Jr. Secondary School	On roof of Annie Stevenson Secondary School.	S	20-May-87	06-Jan-88	9
E217364	Williams Lake - Glendale Garden Shop	On elevated terrain to the West of Williams Lake.	S	18-Aug-92	26-Feb-93	2
E216767	Williams Lake - Hodgson Residence	Elevated location on Schmidt Road	S	29-Feb-92	29-Feb-92	1
E216754	Williams Lake - Ross Residence		S	26-Feb-92	26-Feb-92	1
E229457	Williams Lake 168 Mile House	1365 168 Mile Rd.	S	06-Dec-97	-	185
E206112	Williams Lake Firehall	On Firehall roof, Borland St. Williams Lake.	S/P	20-May-87	-	597
E216730	Williams Lake Golf and Tennis Club		S	22-Feb-92	21-Sep-93	3
E216736	Williams Lake Grisdale Residence		S	20-Feb-92	20-Feb-92	1
0605020	Williams Lake Skyline School	On roof of Skyline Alternative School, corner of Hodgson Rd., and S. Lakeside, opposite Lignum Ltd.	S	25-Mar-92	-	517
E222242	Williams Lake Water Tower	Watertower located on elevated terrain ESE of proposed MDF plant at the end of Midnight Drive	S	11-Nov-95	-	296

Table III-3 $PM_{2.5}$ TEOM monitoring sites and locations (up to Dec. 31, 2000).

Station ID	City/Station Name	Address	Start Date	End Date	No. Daily Measure-ments
E220891	Chilliwack Airport	Airport Road	01-Jun-95	-	1963
E240337	Colwood City Hall	3300 Wishart Road	01-Feb-00	14-Dec-00	148
E242577	Cranbrook Forest Fire	Forest	21-Aug-00	12-Sep-00	21
E242166	Duncan Mobile Transfer Station	3900 Drinkwater Road	01-Jul-00	-	182
E206898	Kamloops Brocklehurst	Mayfair Street	01-Oct-97	-	1102
0500886	Kelowna College	3333 College Way	01-Nov-97	-	1121
E237431	Merritt Granite-Garcia Mobile	2113 Granite Street	16-May-99	29-May-00	375
E229797	Nanaimo Labieux Road	2080A Labieux Road	12-Dec-97	-	1098
E232244	Pitt Meadows Meadowlands Elem. School	18477 Dewdney Trunk Road	14-Jan-99	-	707
0220204	Powell River Cranberry Lake	Wildlife Sanctuary	20-Sep-98	-	791
0450307	Prince George Plaza 400	1011 4th Avenue	13-Nov-97	-	1136
E221885	Quesnel Pinecrest Centre	950 Mountain Ash Road	10-Mar-00	-	294
E208096	Quesnel Senior Secondary	585 Callanan Street	10-Mar-00	-	284
E228064	Quesnel West Correlieu School	850 Anderson	22-Nov-00	-	39
E232246	Vancouver International Airport #2	3153 Templeton Street	16-Mar-99	-	656
0110031	Victoria Royal Roads University	2005 Sooke Road	01-Dec-00	-	31
E231866	Victoria Topaz	923 Topaz	01-May-98	-	907

Table III-3 $PM_{2.5}$ Partisol monitoring sites and locates (up to Dec. 31, 2000)

Station ID	Station Name	Address	Start Date	End Date	No. Daily Measure-ments
E206241	Cranbrook Amy Woodland School	Roof of gymnasium of school at 911 6th St. S in Cranbrook	20-Jan-87	04-Jan-91	32
E241747	Esquimalt DND Hospital Air Station		06-Mar-00	30-Apr-00	7
E206787	Fort Steele-Maus Creek at Kusy Residence	Off Bull River Rd.	20-Jan-87	22-Mar-88	31
0500827	Kelowna Okanaga College	3333 College Way	23-Dec-95	17-May-96	72
E207547	Kimberley at Marysville Post Office	Roof of Marysville Post Office, 512 305th St Kimberley	05-Nov-88	04-Jan-89	4
E222142	Nakusp High School		24-Sep-95	23-Dec-95	11
0110264	Port Alberni Air	Roof of courthouse	23-Mar-89	12-Dec-89	10
0450307	Prince George Plaza 400	1011 4th Avenue	05-Sep-94	-	353
E208096	Quesnel Sr. Secondary School	585 Callanan Street	29-Nov-95	-	288
E226268	Quick Mobile		13-Sep-97	31-Oct-97	7
E206589	Smithers St. Josephs School	4020 Broadway Avenue	21-Apr-96	01-Mar-99	149
E230557	Telkwa	On sports field in the village of Telkwa near the #1 firehall	18-Oct-97	17-Jan-98	16
E231817	Trail Butler Park	Roof of concrete bldg, East Trail	16-May-97	04-Jun-98	51
0500827	Vernon Air	Vernon City Hall	23-Dec-95	17-May-96	72
0605116	Williams Lake Annie Stevenson Jr. Sec. School	On roof of school.	26-May-87	25-Sep-87	5
E221197	Williams Lake Columneetza	On ambient trailer behind Columneetza School	04-Oct-94	-	342