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2010 PROGRESS REPORT ON THE CANADA-WIDE STANDARDS FOR PARTICULATE MATTER AND OZONE

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The Canadian Council of Ministers of the Environment (CCME) is the primary minister-led intergovernmental forum for collective action on environmental issues of national and international concern.

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EXECUTIVE SUMMARY

Under the Canada-wide Standards (CWS) for Particulate Matter (PM) and Ozone participating jurisdictions committed to report on the achievement status of the CWS ambient targets for fine particulate matter ($PM_{2.5}$) and ozone and produce a comprehensive 5-year progress report in 2010. Annual reporting on achievement is required beginning for the year 2011. This *2010 Progress Report on the Canada-wide Standards for Particulate Matter and Ozone* (the "*Progress Report*") represents a hybrid version of the comprehensive progress reports to be produced at 5-year intervals and the annual reports.

The CWS specify ambient targets for $PM_{2.5}$ and ozone. The targets are 30 $\mu g/m^3$ for $PM_{2.5}$ (as a 24-hour average), and 65 ppb for ozone (as an 8-hour average), to be achieved by 2010. The achievement of these targets is determined based on the value of the 3-year average of the annual 98th percentile measurement for $PM_{2.5}$, and of the annual 4th highest measurement for ozone. These specific 3-year average values are referred to as *metric values*. For achievement determination in 2010, it is the metric values for the years 2008, 2009 and 2010 which are used.

Results indicate that the $PM_{2.5}$ target was achieved in all monitored communities in Canada except for one community in British Columbia. Non-achievement of the $PM_{2.5}$ target in this community was due to the influence of smoke from forest fires. The ozone target was not achieved in a number of CWS-reporting communities in Ontario and one community in Alberta. For the communities in Ontario, it is likely that transboundary air pollution transported from the U.S. influenced the non-achievement. For the community in Alberta, it is likely that a combination of high background and natural influences contributed to the non-achievement. Many monitoring stations in Alberta, a few communities in British Columbia, and one in Atlantic Canada were within 10% or less of the target.

Long-term trends were calculated for the ambient levels of $PM_{2.5}$ and ozone, and for the annual average of sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and volatile organic compounds (VOC); the latter three air pollutants are precursors to $PM_{2.5}$ and ozone. For $PM_{2.5}$, for the 11-year period 2000 to 2010, the national average of the 3-year rolling average of the 98th percentiles experienced a statistically significant (at the 95% confidence level) downward trend. Downward trends were also experienced in all provinces considered in this report; however the downward trend was only statistically significant in Ontario.

Over the 15-year period from 1996 to 2010, the national average of the 3-year rolling average of the annual 4th highest value for ozone showed a statistically significant downward trend. In provinces the trends were, for the most part, either flat or decreasing, though Ontario was the only province where the downward trend was statistically significant. The only exception was Saskatchewan, which showed an upward trend, though it was not statistically significant.

The national average ambient concentrations of SO_2, NO_2 and VOC decreased almost continuously throughout the 15-year period from 1995 to 2009, with statistically significant downward trends. The reductions in ambient levels of these three pollutants are consistent with reductions in their emissions.

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1.0 INTRODUCTION

The Canada-wide Standards for Particulate Matter (PM) and Ozone[1] were endorsed by the Canadian Council of Ministers of the Environment (CCME) in June, 2000, with the exception of Québec[2]. Under the Canada-wide Standards (CWS) for Particulate Matter (PM) and Ozone[3] participating jurisdictions committed to report on the achievement status of the CWS ambient targets for fine particulate matter ($PM_{2.5}$) and ozone and produce a comprehensive 5-year progress report in 2010. Annual reporting on achievement is required beginning for the year 2011. This *2010 Progress Report on the Canada-wide Standards for Particulate Matter and Ozone* (the "*Progress Report*") represents a hybrid version of the comprehensive progress reports to be produced at 5-year intervals and the annual reports.

The purpose of this Progress Report is to satisfy some of the major reporting obligations of the comprehensive reports under the CWS agreement. These include reporting on the achievement status of the CWS ambient targets in 2010; identification of areas approaching the targets (defined as being within 10% or less below the targets); reporting on trends in ambient levels of $PM_{2.5}$, ozone, and their precursors across Canada; reporting on ambient levels and trends of $PM_{2.5}$ and ozone in border regions of Canada and the U.S.; reporting on actions undertaken by jurisdictions during the period 2006-2010 in support of achieving the targets; and reporting on emission trends of $PM_{2.5}$ and some of the precursors[4] to $PM_{2.5}$ and ozone. This information is presented in sections 3 to 7. Section 2 provides information on selected key provisions of the CWS, and background information for sections 3 to 7.

2.0 MAIN PROVISIONS OF THE CWS

This section provides information on some of the main provisions of the CWS.

2.1 Ambient Targets for $PM_{2.5}$ and Ozone

The CWS established ambient targets for $PM_{2.5}$ and ozone as presented in Table 1. The "*metric*" is the statistical form of the targets. The key element of the $PM_{2.5}$ metric is the

[1] http://www.ccme.ca/assets/pdf/pmozone_standard_e.pdf

[2] The Province of Québec, while not a signatory to the CWS, has undertaken analogous efforts as those covered by the CWS and has also developed working inter-jurisdictional arrangements for many provisions of the CWS. Data related to the CWS for PM and Ozone can be found at www.mddep.gouv.qc.ca/air/particules_ozone/index.htm.

[3] http://www.ccme.ca/assets/pdf/pmozone_standard_e.pdf

[4] Precursors are atmospheric substances that chemically transform into other substances. Precursors include nitrogen oxide (NO_X, consisting mostly of nitric oxide, or NO, and nitrogen dioxide or NO_2), sulphur dioxide(SO_2), and volatile organic compounds (VOC).

annual 98th percentile of the daily 24-hour $PM_{2.5}$ concentrations, and the key element of the ozone metric is the annual 4th highest of the daily maximum 8-hour average ozone concentrations.

The 3-year average of the annual $PM_{2.5}$ 98th percentiles based on actual measured concentrations is referred to as the *$PM_{2.5}$ metric value*, and the 3-year average of the annual ozone 4th highest concentration is referred to as the *ozone metric value*. It is the metric values that are to be compared to the corresponding targets to determine the achievement status[5].

Table 1: The $PM_{2.5}$ and Ozone CWS ambient targets

Pollutant	Averaging time	Targets (concentration)	Metric
$PM_{2.5}$	24-hour (calendar day)	30 µg/m^3	The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations.
Ozone	8-hour	65 ppb	The 3-year average of the annual 4th-highest daily maximum 8-hour average concentrations.

2.2 Guidance Document and Monitoring Protocol

To evaluate the achievement status of the targets, the CWS called for the development of a Guidance Document on Achievement Determination (GDAD) and a monitoring protocol. The GDAD was first published in 2002 and updated in 2007[6]. The GDAD is intended as a reference tool that allows jurisdictions and the public to determine if the targets have been achieved. Adherence to the GDAD aids in data consistency and comparability among the various jurisdictions.

Under GDAD and the CWS, a community approach to reporting is used. Communities are based on Census Metropolitan Areas (CMA), Census Agglomerations (CA) and Census

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5 For example, given a CWS-reporting community with a single CWS-reporting station where the $PM_{2.5}$ annual 98th percentiles were 25.5 µg/m^3 in 2008, 27.1 µg/m^3 in 2009 and 24.9 µg/m^3 in 2010. The $PM_{2.5}$ metric value for the period 2008-2010 is the average of these three annual percentiles, which is 26 µg/m^3 after rounding [(25.5 + 27.1 + 24.9)/3 = 25.83, which rounds to 26 µg/m^3]. Since the metric value is less than the CWS $PM_{2.5}$ target, the target is said to be achieved.

6 Available at: http://www.ccme.ca/assets/pdf/1391_gdad_e.pdf

Subdivisions (CSD) as defined by Statistics Canada. As a basic requirement, jurisdictions are to report the $PM_{2.5}$ and ozone metric values for communities with population of 100,000 or more. However, a number of provinces and territories also report metric values for smaller communities.

The monitoring protocol was published in 2011[7] and is also intended as a reference tool for jurisdictions and the public on the operation and coordination of ambient air monitoring programs in support of the CWS.

2.3 Continuous Improvement and Keeping Clean Areas Clean

The CWS required the development of *implementation plans* to assist in achieving the targets by 2010. For parts of the country with metric values below the targets, the CWS required the implementation of *continuous improvement* (CI) and *keeping clean areas clean* (KCAC) initiatives. A guidance document on CI and KCAC was also developed[8].

2.4 Transboundary Flows, High Background and Natural Events

The CWS recognize that there may be special circumstances where the PM or ozone targets may not be achieved because of influences over which jurisdictions have little to no control. These special circumstances include transboundary flows of air pollution, high background levels and natural sources (for more information, please refer to the GDAD).

Under the CWS, a jurisdiction can report that a given community would have achieved a given target if not for the influence(s) of transboundary flows of air pollution, high background levels or natural sources. To make this claim, the jurisdiction would have to demonstrate, following the procedures specified in the GDAD, that in the absence of one or more of these influences the resulting metric value would have been below the target.

For this report, no formal analyses were conducted to evaluate if special circumstances influenced the achievement status of the CWS targets. The reported metric values in section 3 are the "as measured" metric values without consideration of any possible influences from transboundary flows of air pollution, high background levels or natural sources.

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[7] Available at: http://www.ccme.ca/assets/pdf/pm_oz_cws_monitoring_protocol_pn1456_e.pdf

[8] http://www.ccme.ca/assets/pdf/1389_ci_kcac_e.pdf

3.0 METRIC VALUES IN CANADA, 2008 TO 2010

This section presents the metric values for $PM_{2.5}$ and ozone for the period 2008-2010 for the CWS reporting communities[9] and on a monitoring-station basis. The metric values for CWS reporting communities may differ from those calculated based on monitoring stations[10]. Metric values are based on three years of data (see Table 1) measured in 2008, 2009 and 2010 as provided by provinces and territories.

Because of issues currently inherent in the measurement of $PM_{2.5}$, the achievement status for the $PM_{2.5}$ target should be considered preliminary, and caution is to be used when comparing any two $PM_{2.5}$ metric values, even within the same jurisdiction. For a discussion of these issues, please refer to Appendix A.

3.1 $PM_{2.5}$ Metric Values

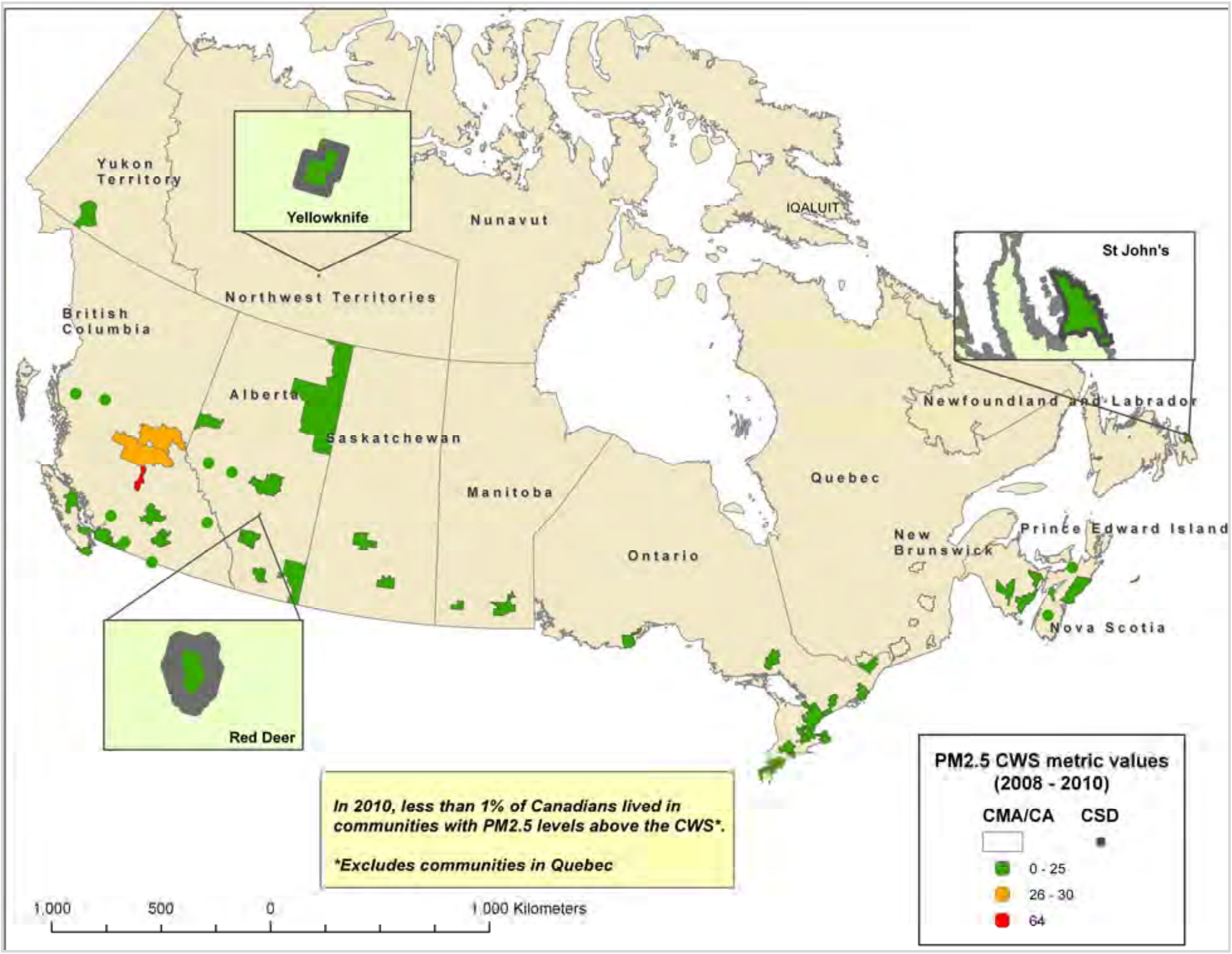
Figure 1 presents the $PM_{2.5}$ metric values for the period 2008 to 2010 for communities across Canada. Figure 2 presents the same community information in chart format and also includes metric values on a monitoring station basis. In Figure 2, the data from rural stations are included for information purposes only, since under the CWS rural stations are not to be used for achievement determination.

For the period 2008 to 2010 all communities, with the exception of Williams Lake in British Columbia, recorded $PM_{2.5}$ metric values that were below the CWS target. Williams Lake recorded the highest metric value at 64 $\mu g/m^3$. However, this high level was found to be due to the influence of smoke from forest fires.

[9] CWS reporting communities are the responsibility of provinces and territories.

[10] The GDAD specifies the procedures to follow to obtain the metric values for communities with multiple and single CWS-reporting stations.

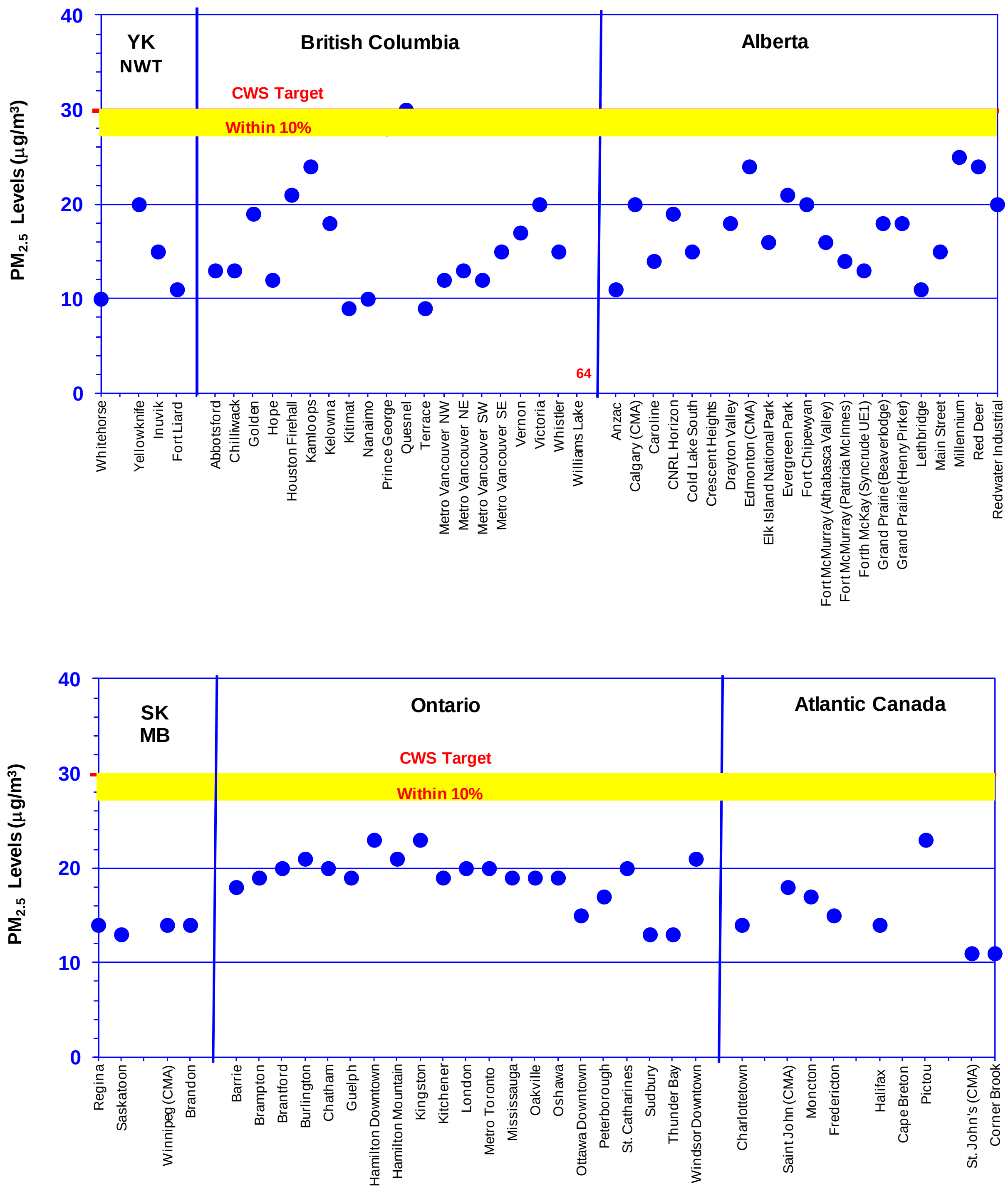
Figure 1: $PM_{2.5}$ metric values for communities across Canada, 2008-2010



Note: These are the metric values before accounting for any possible transboundary air pollution, high background levels and natural events.

In Yukon and the Northwest Territories (NT), most metric values were less than 20 μg/m^3. In British Columbia, one location was within 10% or less below the CWS target (Figure 2) and a second one equaled the value of the CWS target. Other locations mostly recorded $PM_{2.5}$ metric values between 10 and 20 μg/m^3. In Alberta, most locations recorded metric values between 10 and 20 μg/m^3, and others between 21 and 26 μg/m^3. In Saskatchewan and Manitoba, most locations recorded metric values between 12 and 15 μg/m^3. In Ontario, most metric values were between 18 and 24 μg/m^3, with a few locations near 15 μg/m^3. In Atlantic Canada, most locations recorded metric values between 12 and 18 μg/m^3.

Figure 2: $PM_{2.5}$ metric values for the period 2008-2010



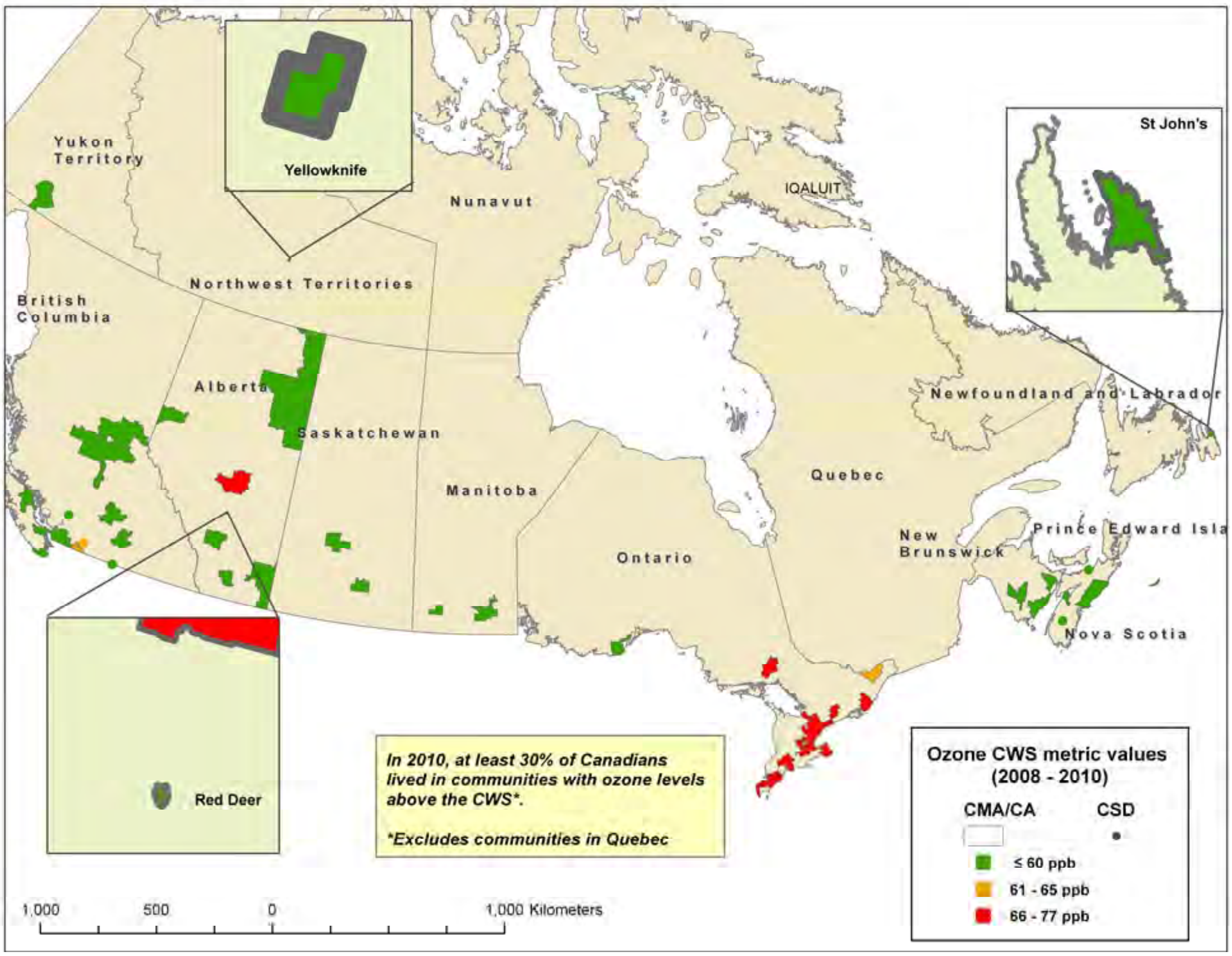
Note: These are the metric values before accounting for any possible transboundary air pollution, high background levels and natural events. The rural stations are included for information purposes only and not for achievement determination. The metric value for Williams Lake is indicated in the chart.

3.2 Ozone Metric Values

Figure 3 presents the ozone metric values for the period 2008 to 2010 for communities across Canada. Figure 4 presents the same community information in a chart format and also includes metric values on a monitoring station basis. In Figure 4, the data from rural stations are included for information purposes only since under the CWS rural stations are not to be used for achievement determination.

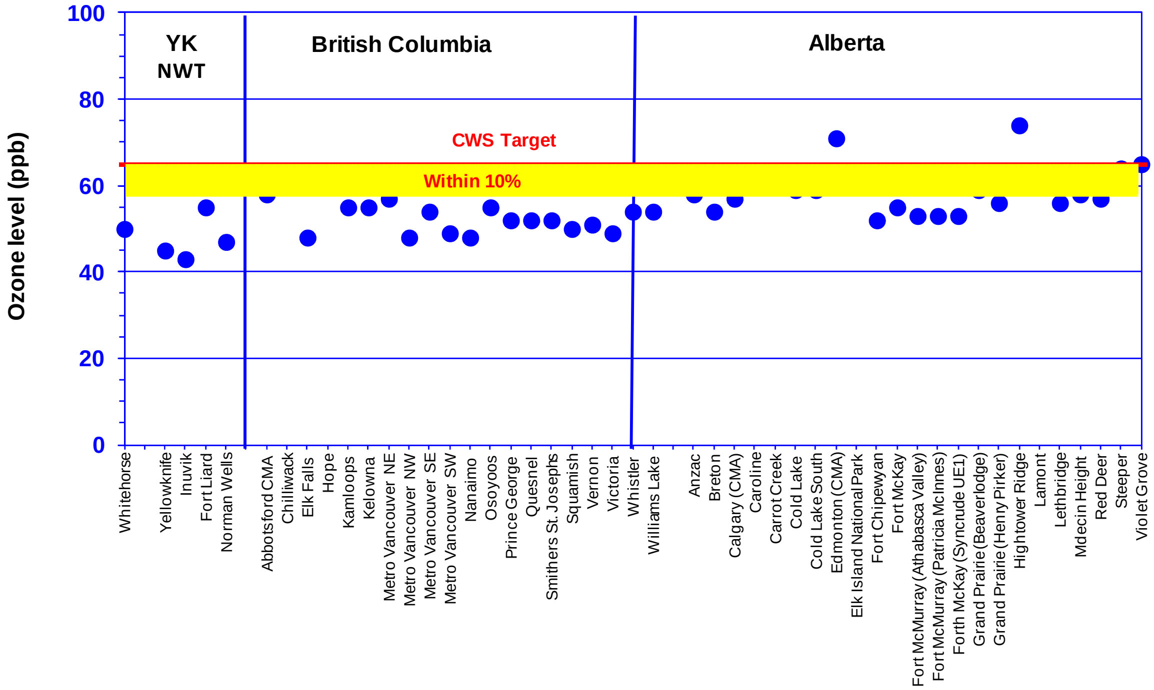
For the monitoring period 2008-2010, *at least* 30% of Canadians (excluding Québec) lived in communities where the ozone metric value was above the ozone CWS target.

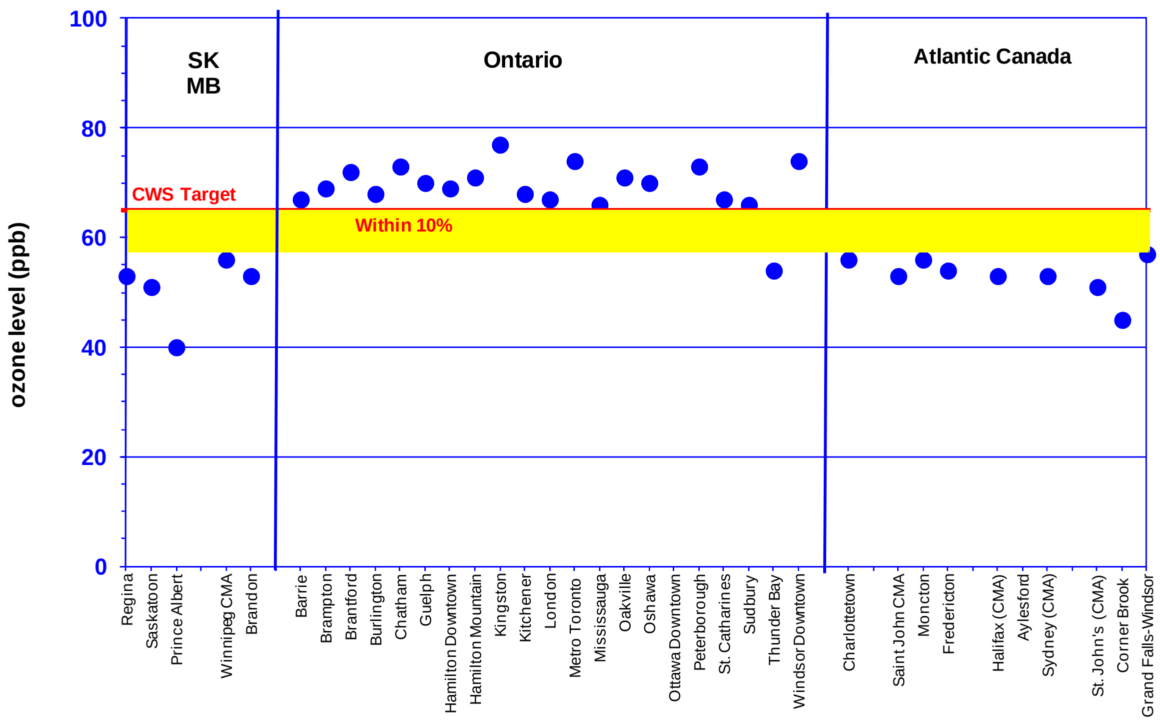
Figure 3: Ozone metric values for communities across Canada, 2008-2010



Note: These are the metric values before accounting for any possible transboundary air pollution, high background levels and natural events.

Figure 4: Ozone metric values for the period 2008-2010





Note: These are the metric values before accounting for any possible transboundary air pollution, high background levels and natural events. The rural stations are included for information purposes only and not for achievement determination.

Ozone metric values at most locations in Ontario were above the ozone CWS target (65 ppb), with values ranging between 65 and 77 ppb. In other parts of Canada, metric values were only above the target at two locations in Alberta, in the Edmonton Census Metropolitan Area and at High Tower Ridge, a rural area at approximately 1500 m above sea level. At this elevation, ozone levels are typically higher than at lower elevations, and the levels also display less of the diurnal variations which are typically observed in ozone levels produced by local emissions of precursors. In other parts of Alberta, many of the ozone metric values were either within 10% of the target, or close to it.

At locations in Yukon and the Northwest Territories (NWT), ozone metric values mostly ranged between 40 and 50 ppb, with the highest value (55 ppb) recorded at Fort Liard in NWT. In British Columbia, metric values ranged mostly between 50 and 55 ppb, with three communities being within 10% or less below the target. In Saskatchewan and Manitoba most metric values were around the 55 ppb level and below. In Atlantic Canada, only one location recorded metric values within 10% or less below the target (Aylesford Mountain, Nova Scotia).

It is possible that the higher metric values at locations in Ontario were influenced by air pollution from the U.S. At the High Tower Ridge and Aylesford Mountain sites, high elevation likely influenced the measured concentrations. For Edmonton, during those days with levels above the value of the CWS target, higher levels were also observed at rural stations within the Edmonton CMA. Although more analysis would be required to confirm this, there is the potential that natural sources and background levels may have influenced the non-achievement in Edmonton.

4.0 TRENDS IN $PM_{2.5}$, OZONE AND THEIR PRECURSORS IN CANADA

This section presents the national and provincial[11] averages and trends of the following variables:

i) The 3-year rolling average of the annual 98th percentile values of the daily 24-hour average $PM_{2.5}$ concentrations
ii) The 3-year rolling average of the annual 4th highest daily maximum 8-hour average ozone concentrations
iii) The annual average of 1-hour sulphur dioxide (SO_2) concentrations
iv) The annual average of the 1-hour nitrogen dioxide (NO_2) concentrations

[11] Territories were not included because of insufficient data.

v) The annual average of the 24-hour average volatile organic compounds (VOC) concentrations

Details on the data completeness requirements, calculation and trends procedures are presented in Appendix B.

The monitoring stations used for the above variables are those that report to the Canada-wide Database operated by Environment Canada. This database includes data from the National Air Pollution Surveillance (NAPS) network, the Canadian Air and Precipitation Monitoring Network (CAPMoN), and provincial and municipal networks. This database includes data that serve different monitoring purposes and reflect various land-use types surrounding the stations.

For an indication of the broad station-type used in the calculation of the national and provincial averages, the station type was classified as Large Urban (stations in urban areas with a population of at least 100,000), Small Urban (stations in urban areas with a population of less than 100,000), and Non-urban station. The Non-urban stations are primarily in rural areas, but a number are downwind of major urban centres. The numbers of each of these station types are identified in the $PM_{2.5}$ and ozone trend charts to provide an indication of the station type used. For the trends in SO_2 and VOC, a few industrial-influenced stations were also used.

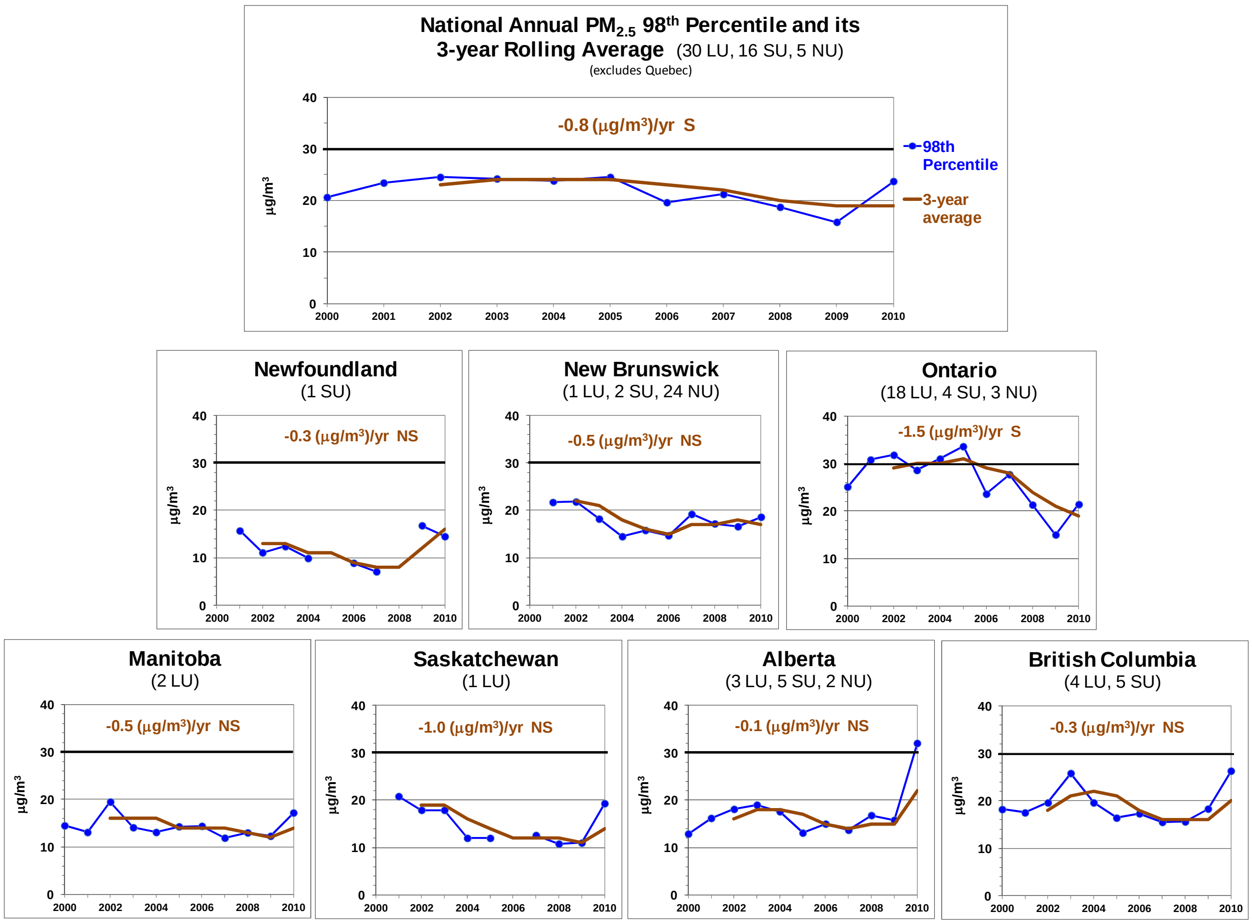
The purpose of this section is to present the trends in the data. An in-depth assessment of the possible causes of the trends is beyond the scope of this Progress Report.

4.1 Trends in the $PM_{2.5}$ 98^{th} Percentile Values

Figure 5 presents the national and provincial averages of the annual $PM_{2.5}$ 98^{th} percentiles and their 3-year rolling average for the 11-year period from 2000 to 2010. It should be noted that some of the annual changes in the variables may be due to the deployment of different $PM_{2.5}$ monitors (see Appendix A) over the years.

Average $PM_{2.5}$ levels exhibited annual fluctuations, but overall the 3-year rolling average showed a downward trend nationally and in all considered provinces. However, the downward trend was statistically significant only at the national level and in Ontario. In Ontario the 2010 average remained below the average in all other years with the exception of 2009.

Figure 5: National and provincial averages of the $PM_{2.5}$ 98th percentile concentrations and its 3-year rolling average, 2000-2010



Note: LU, SU and NU denote Large Urban, Small Urban and Non-Urban monitoring stations respectively. The indicated trends are for the 3-year rolling averages. NS indicates a non-statistically significant trend (at the 95% confidence level). S indicates that the trend is statistically significant. The black horizontal line is at the level of the PM2.5 CWS target and is indicated for illustrative purposes only.

With the exception of Newfoundland and Labrador, the average 98th percentiles were higher in 2010 than in 2009. For Alberta, forest fires and the switch to newer technology monitors (see Appendix A) at some stations may account for some of the increase in levels in 2010. For British Columbia, forest fires may account for some of the increase in 2010 and the peak in 2003. The increase in 2010 in other regions of the country may be partly related to weather conditions. In the eastern half of the country, the summer of 2010 was generally hotter and drier than in 2009 and 2008, and this may account for the increase in levels in 2010.

Ontario and the Maritime Provinces are often affected by southerly airflows, which carry pollution from the U.S. It is possible that the decrease in levels in Ontario and the Maritime Provinces may be partly attributable to reductions in emissions from the U.S.

These reductions may have resulted from the implementation of the NO_X Budget Trading Program under the NO_X State Implementation Plan[12] (which began in 2003), and the first phase of the 2005 Clean Air Interstate Rule (CAIR)[13], which places permanent caps on emissions of SO_2 and NO_2 in the eastern U.S. CAIR was replaced by the Cross-State Air Pollution Rule[14] in 2011, which places more stringent caps on emissions.

Reductions in the emissions of SO_2 and NO_X in eastern Canada from industry and the electricity sector, and reductions in emissions of NO_X and VOC from the transportation sector across Canada, may also have contributed to the decrease in $PM_{2.5}$ levels. The economic downturn in recent years in both Canada and the U.S. may have also contributed somewhat to the decrease in ambient $PM_{2.5}$ levels.

4.2 Trends in the Annual 4th Highest Ozone Values

Figure 6 presents the national and provincial averages of the annual 4^{th} highest daily maximum 8-hour average ozone concentrations ("the annual 4^{th} highest concentration") and their 3-year rolling averages for the fifteen year period from 1996 to 2010.

At the national level, the average annual 4^{th} highest concentration exhibited small annual fluctuations with levels close to the ozone CWS target, and with the 3-year rolling averages exhibiting a statistically significant downward trend. Since 2008, the national average of the annual 4^{th} highest concentration has remained below the CWS target of 65 ppb.

The trends of the 3-year rolling averages were either flat (in Newfoundland and Labrador, Alberta and British Columbia) or downward, with statistically significant downward trends in Nova Scotia, New Brunswick and Ontario. Saskatchewan was the only exception, where the 3-year average exhibited an upward trend, though it was not statistically significant.

In Ontario, while average levels decreased, the 3-year averages still remain just above the CWS target, and were the highest in Canada throughout the eleven year-period. Alberta experienced the second highest average levels.

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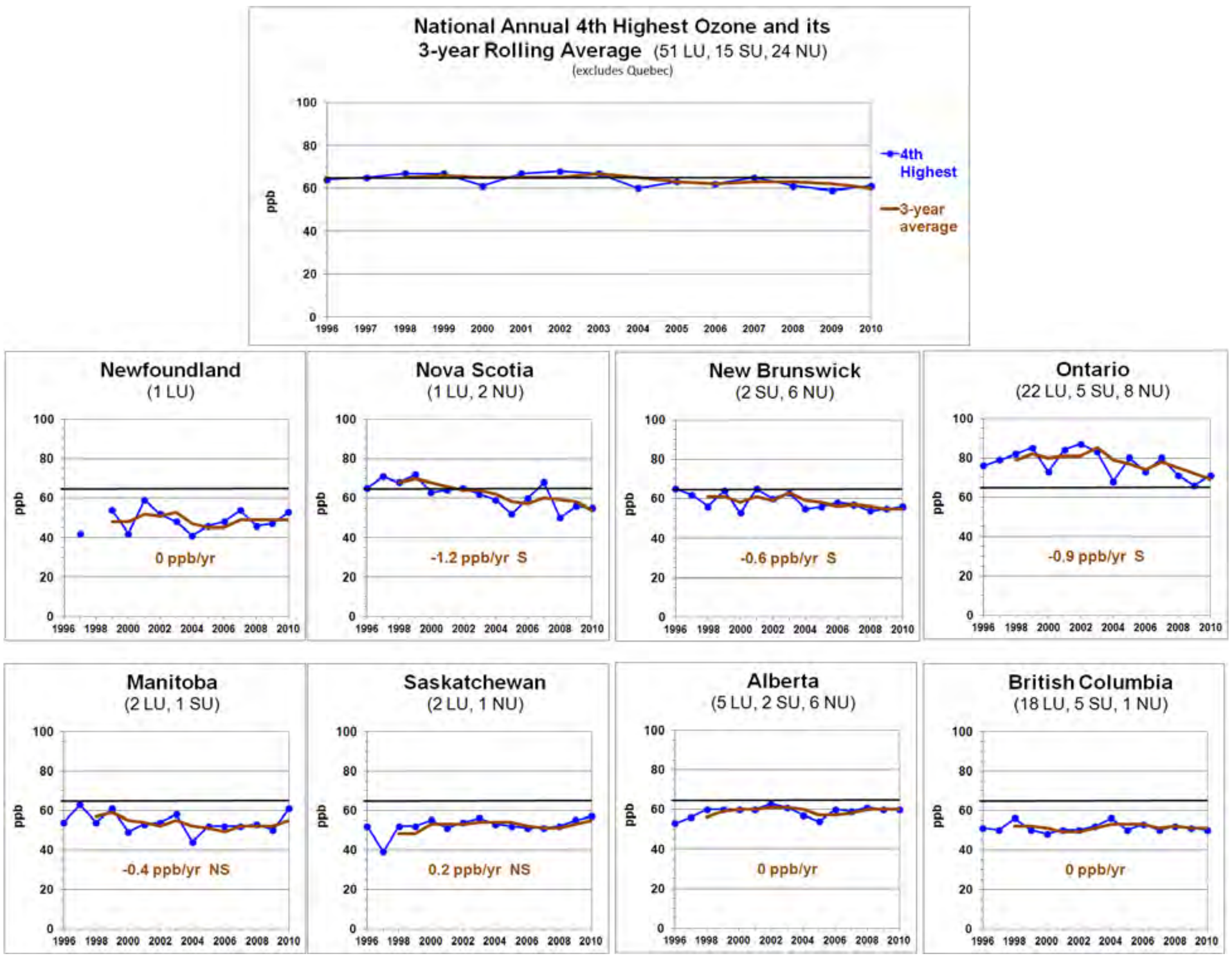
[12] http://www.epa.gov/airmarkets/progsregs/nox/sip.html

[13] http://www.epa.gov/cair/

[14] http://www.epa.gov/airtransport/

The statistically significant downward trends in Ontario, New Brunswick and Nova Scotia may be an indication of a causal effect, despite the influence of weather conditions. As mentioned in section 4.1, some of the possible causes for the downward trends may include reductions in precursor emissions from U.S. programs, reductions in NO_X emissions in eastern Canada from the electricity sector over the last decade, reductions in emissions of NO_X and VOC from the transportation sector in Canada, and the recent economic downturn in both Canada and the U.S.

Figure 6: National and provincial averages of the 4th highest ozone concentrations and its 3-year rolling average, 1996-2010



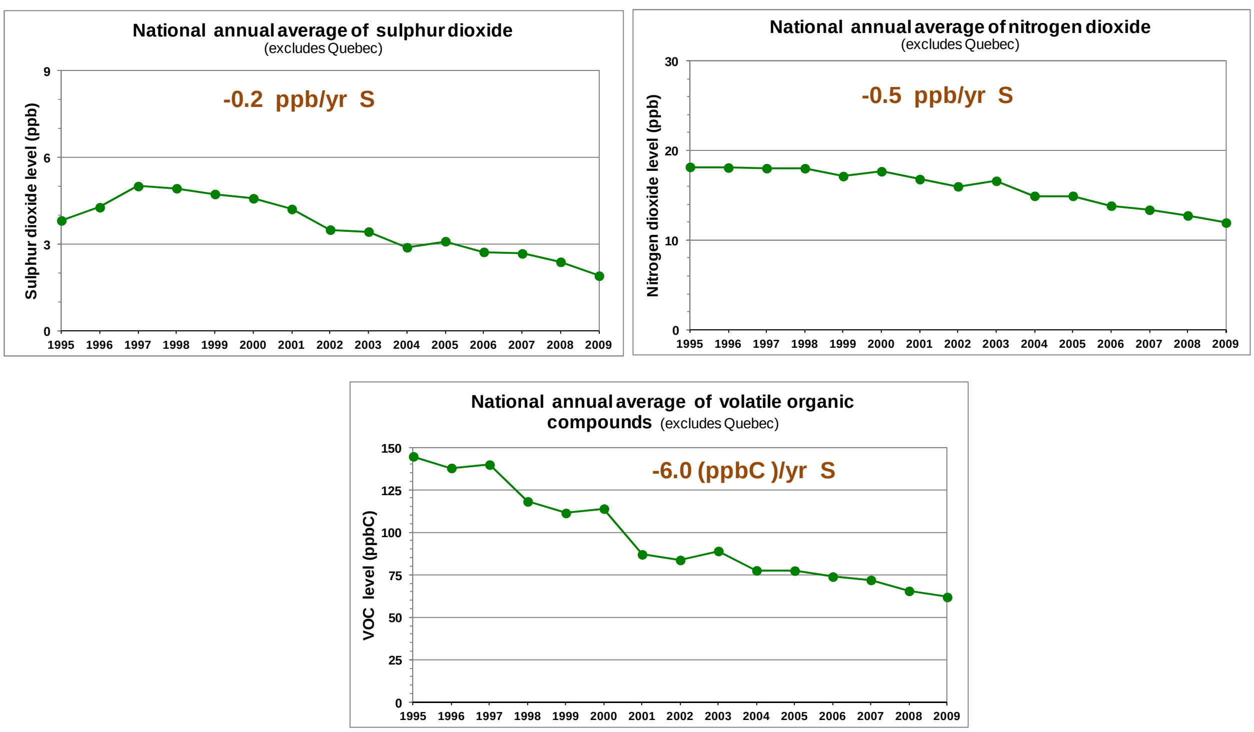
Note: LU, SU and NU denote Large Urban, Small Urban and Non-Urban monitoring stations respectively. The indicated trends are for the 3-year rolling averages. NS indicates a non-statistically significant trend (at the 95% confidence level). S indicates that the trend is statistically significant. The black horizontal line is at the level of the ozone CWS target and is indicated for illustrative purposes only.

4.3 Trends in Ambient SO_2, NO_2 and VOC

Figure 7 presents the trends in the national annual averages of sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and volatile organic compounds (VOC) for the 15-year period from 1995 to 2009.

National annual average levels of ambient SO_2, NO_2 and VOC have decreased fairly consistently between 1995 and 2009, with statistically significant downward trends for all three pollutants. This is consistent with the reductions in emissions of these air pollutants as discussed in section 7. The reductions in ambient levels of NO_2 and VOC in urban areas may partly be attributable to reductions in emissions from the transportation sectors as a result of federal regulations on engines and fuels. The various policies and regulations implemented by provincial, territorial and federal governments regarding industrial sources and the electricity sector, may also have contributed to the reductions in ambient levels of all three pollutants, especially SO_2.

Figure 7: Trends in the national annual averages of ambient SO_2, NO_2 and VOC



5. METRIC VALUES AND TRENDS IN BORDER AREAS

Under the CWS, the federal government committed to report on the ambient levels of $PM_{2.5}$ and ozone in border areas. This section presents the $PM_{2.5}$ and ozone metric values for the period 2008-2010 for monitoring stations located within approximately 500 km of the Canada-U.S. border, and trends in the annual 4th highest ozone[15].

The $PM_{2.5}$ and ozone metrics have the same form in both Canada and the U.S. The U.S. has National Ambient Air Quality Standards (NAAQS) which are 35 μg/m^3 for $PM_{2.5}$ and 75 ppb for ozone, compared to the CWS targets of 30 μg/m^3 for $PM_{2.5}$ and 65 ppb for ozone. The metric values presented in this section are on a station-basis, and are not necessarily representative of the attainment status of the NAAQS in the U.S. and the achievement status of the CWS targets in Canada.

5.1 $PM_{2.5}$ Metric Values, 2008-2010

The $PM_{2.5}$ metric values are presented in Figure 8[16]. Overall, metric values tended to be higher and show less spatial variability in the eastern provinces and states, especially near and around the Great Lakes area. Levels were mostly in the 26-30 μg/m^3 range (in the U.S.), although some stations had metric values above 30 μg/m^3, especially along the U.S. east coast. For the period 2008-2010 the western provinces and states had some of the highest $PM_{2.5}$ metric values and higher spatial variability in levels.

As shown in Figure 8, metric values were generally higher in the U.S. in areas bordering southern Ontario. It is likely that some of this difference may be due to the use of different monitoring methods (see Appendix A). Although not shown, the metric values for the period 2008-2010 in the eastern parts of Canada and the U.S. are much lower than the metric values recorded for the period 2003-2005.

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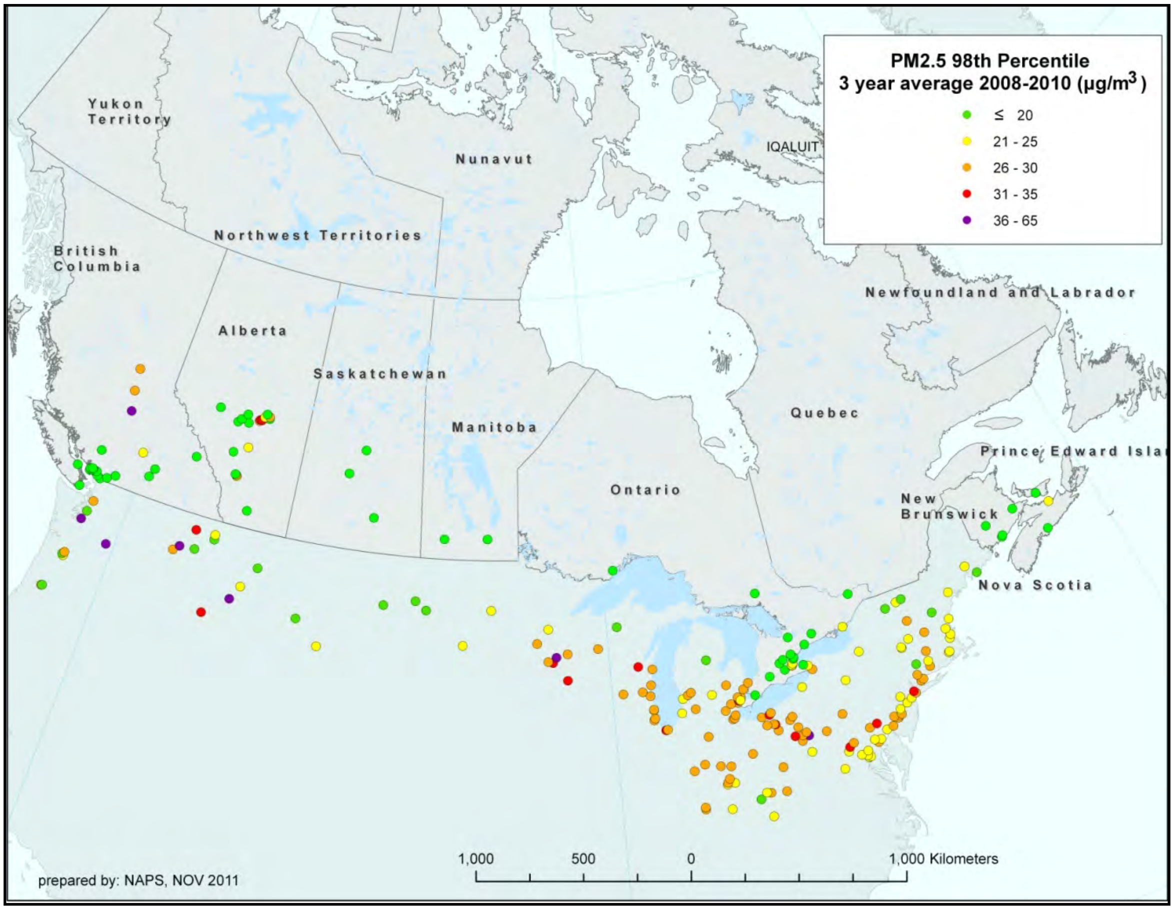
[15] The metric values in this section are not necessarily comparable to those in Figures 1 and 3 of Section 3. Figures 1 and 3 presented metric values for CWS reporting communities, while in this section they are presented on a station basis.

[16] For some Canadian communities the data presented in Figure 8 differ from the data in Figures 1 and 2. This is because the data in Figure 8 are on a station-basis, while in Figures 1 and 2 the data are on a community-basis for those communities with more than one $PM_{2.5}$ monitoring station. This is consistent with the procedures specified in the GDAD.

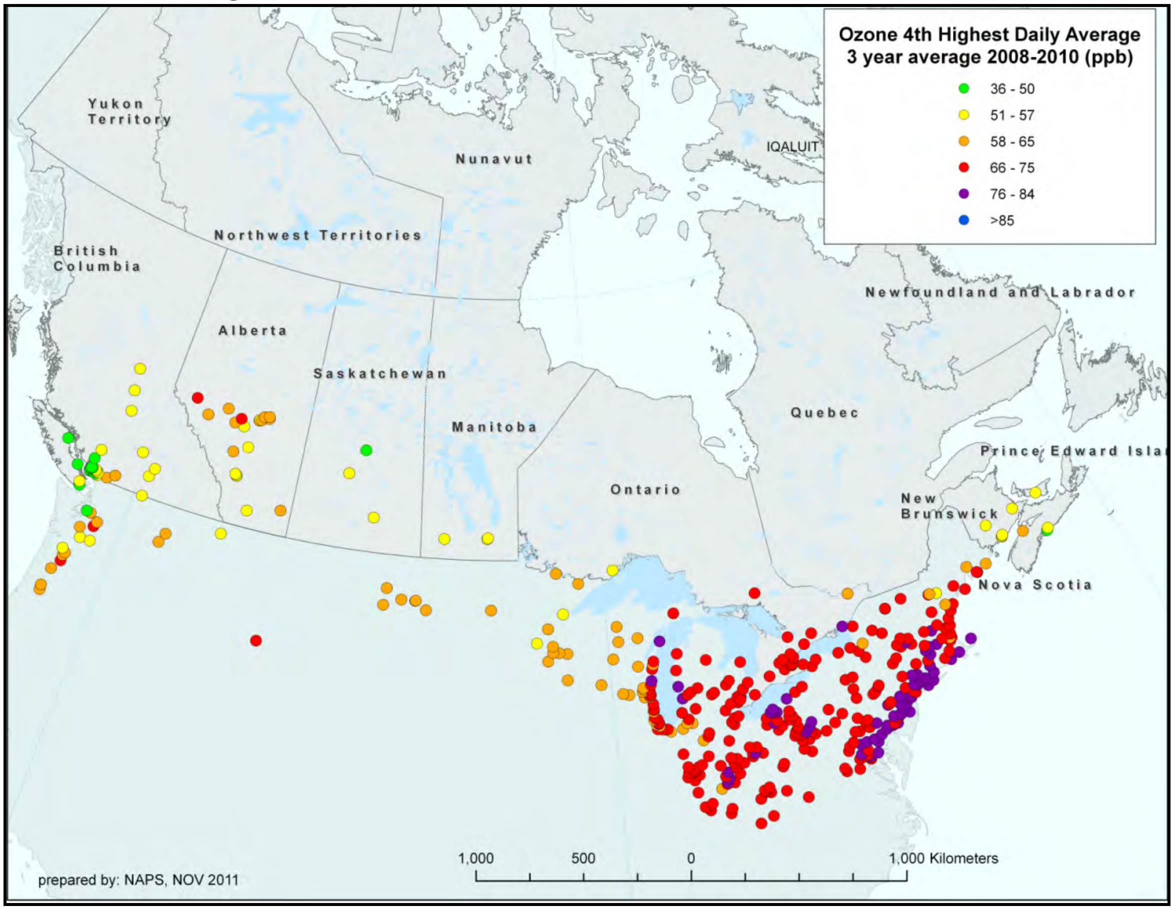
Figure 8: $PM_{2.5}$ metric values in the U.S. and Canada, 2008-2010



5.2 Ozone Metric Values, 2008-2010

Figure 9 presents the ozone metric values for the period 2008-2010. In general, metric values were higher around the four southern Great Lakes, in the Ohio Valley and especially along the U.S. east coast. These regions contain very large urban centers and are highly industrialized, especially the Ohio Valley. The higher ozone levels around Lake Michigan and eastward, in both the U.S. and Canada, are similar to previous years.

Figure 9: Ozone metric values in the U.S. and Canada, 2008-2010

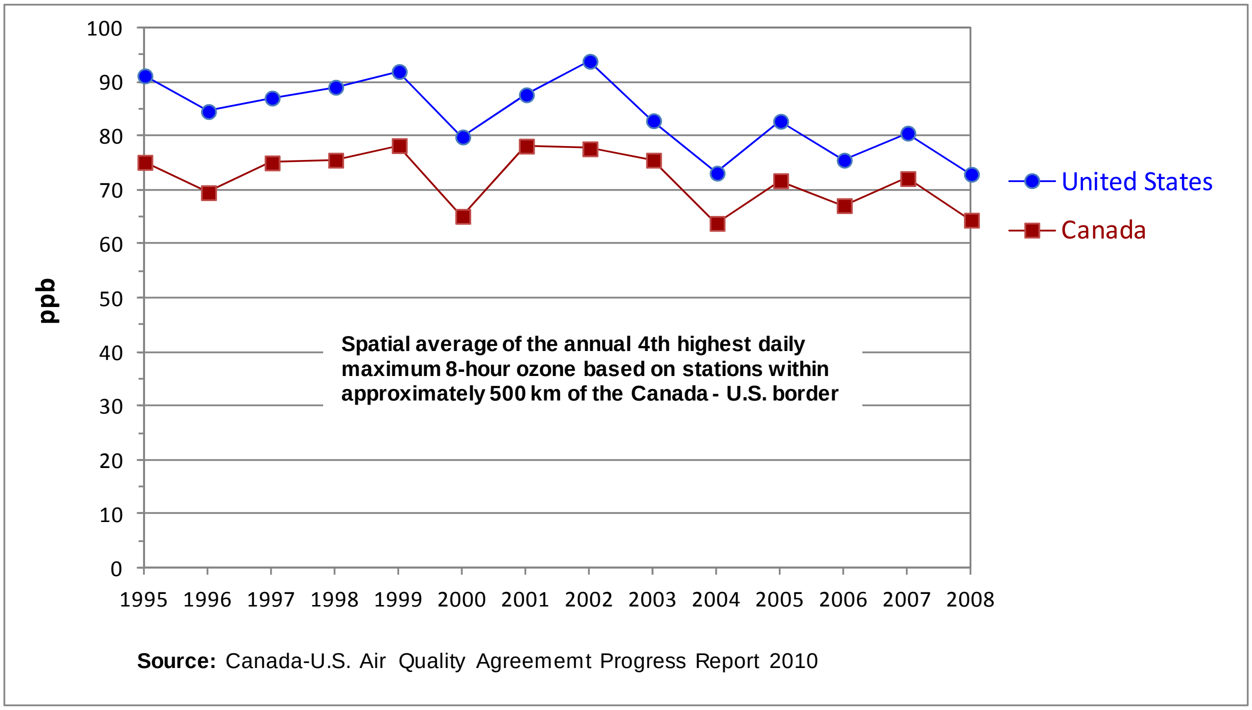


5.3 Trends in the Annual 4th Highest Ozone Values

Figure 10 presents the spatial annual average of the annual 4th highest ozone concentrations for monitoring stations located within approximately 500 km of the Canada-U.S. border, for the 14-year period 1995 to 2008.

As can be seen in Figure 10, average levels in border regions of Canada and the U.S. have generally followed a similar downward trending pattern over the years, with levels since 2004 generally being lower than levels at the start of 14-year period. In the calculation of spatial averages (e.g. a national average), the ozone levels measured in regions with a dense network of monitoring stations will have a greater influence on the resulting spatial average than regions having few monitoring stations. As such, one possible reason for the similar pattern in both border regions is the influence of the greater number of monitoring stations near the Great Lakes area which were considered in the calculation of the border spatial averages. Adding to this effect is the fact that during smog episodes, the lower Great Lakes areas in Canada and the U.S. are often affected by the same weather systems, with winds and air pollution typically moving from the U.S. into Canada.

Figure 10: Trends in the annual spatial average of the 4th highest ozone concentrations for border areas of Canada and the U.S.



6.0 MEASURES IN SUPPORT OF PM AND OZONE REDUCTIONS

This section provides an overview of some of the initiatives undertaken by jurisdictions in support of the CWS for PM and ozone, and air quality in general, with focus on the period 2006-2010. The section begins with collaborative actions by federal, provincial and territorial governments, followed by sections from each jurisdiction.

6.1 Collaborative Actions

In 2007, the Government of Canada proposed the *Regulatory Framework for Air Emissions* (the Framework) which addressed industrial emissions of several pollutants including PM, and precursors to $PM_{2.5}$ and ozone. Following consultations on the Framework, a multi-stakeholder working group was formed which included provincial and territorial governments, industry representatives and non-government environmental organisations. This working group was tasked with addressing the challenges of air quality management on a more comprehensive basis, including all sources, instead of being confined to industrial emissions only. The outcome of the work of the group was the release (in April, 2010) of the *Comprehensive Air Management System*[17] (CAMS) which proposed a path forward for addressing all sources of air pollutants.

On October 20, 2010 CCME agreed to move forward with a new collaborative Air Quality Management System (AQMS) to better protect human health and the environment, building on the work done under CAMS. Ministers directed officials to develop the major elements of the system in 2011, with implementation expected to begin in 2013. The AQMS contains several key elements, including: (i) the development of Canadian Ambient Air Quality Standards (CAAQS) for $PM_{2.5}$ and ozone, which will be more stringent and supersede the CWS targets for $PM_{2.5}$ and ozone; (ii) the development and implementation of base-level industrial emissions requirements; (iii) the management of air quality through local air zones and regional airsheds.

The AQMS is championed (led) by Environment Canada, Ontario Ministry of the Environment and the Alberta Ministry of Environment and Water under the auspices of CCME. The development of the various elements of the AQMS is currently progressing as envisioned by the Ministers in October, 2010.

6.2 Alberta

This section discusses some of the initiatives and measures that have been or are being undertaken in Alberta since 2005 in support of the CWS and air quality in general.

The Clean Air Strategic Alliance (CASA) Particulate Matter and Ozone Management Framework is Alberta's jurisdictional framework for implementing Canada Wide Standards for PM and Ozone.[18] Under this framework, the area from Calgary to the greater Edmonton area was assigned to the Management Plan Action Level for ozone based on annual assessments conducted since 2003.[19] The Management Plan Action Level means that ozone levels at air monitoring stations have exceeded the Planning Trigger of 58 parts per billion as dictated by the Framework. Note that the assessment value is assigned after the consideration of transboundary air pollution, high background and natural events.

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[17] http://www.ccme.ca/assets/pdf/cams_proposed_framework_e.pdf

[18] http://www.casahome.org/DesktopModules/Bring2mind/DMX/Download.aspx?Command=Core_Download&EntryId=636&PortalId=0&TabId=78

[19] http://www.casahome.org/DesktopModules/Bring2mind/DMX/Download.aspx?Command=Core_Download&EntryId=636&PortalId=0&TabId=78

The action required for the Management Plan Action Level is that stakeholders need to work together to develop a plan that will assure that ozone levels do not exceed the Canada-wide Standard in the future. In response, stakeholder driven airsheds in the Calgary, Red Deer and the Capital Region have developed air quality management plans. These management plans can be viewed at the following web sites:

Capital Airshed Partnership which includes Alberta Capital Airshed Alliance, Fort Air Partnership and West Central Airshed Society – http://www.capitalairshed.ca/
Parkland Airshed Management Zone - http://www.pamz.org/
Calgary Region Airshed Zone - http://www.craz.ca/

The following are some examples of ozone management activities being undertaken for regional airsheds in Alberta:

- The Capital Airshed Partnership (CAP) conducted air monitoring upwind and downwind of the Edmonton area for ozone, nitrogen oxides and volatile organic compounds to better understand the impact of urban sources on photochemical smog. Monitoring has been conducted for two ozone seasons. The partnership is also in the process of developing a contingency plan to be used in the event that ozone levels exceed the CWS in the future.

- The Parkland Airshed Management Zone (PAMZ) has conducted primarily education and outreach activities to help municipalities, industry and the public better understand their impacts on air quality and steps they can take to improve air quality. One activity being undertaken by PAMZ is the Action HERO (Action for a Healthy Environment by Reducing Ozone) recognition program. This recognition is given to a company or organization that has taken action by reducing use of motorized vehicles or equipment, implemented anti-idling programs or replacing older fleet vehicles.

- The Calgary Region Airshed Zone (CRAZ) has done work on a Community Based Social Marketing program aimed at examining the barriers to public engagement in activities that will lessen their impact on air quality. For example, barriers hindering the public’s ability or desire to utilize public transit or car pool when commuting from the suburbs to downtown for work are being addressed.

- Stakeholders in Alberta are awaiting the new Canadian Ambient Air Quality Standards (see section 6.1) as these standards may lead to the requirement for more stringent emission controls not only on industrial sources, but all other sources found to significantly contribute to the measured concentrations of $PM_{2.5}$ and ozone.

6.3 British Columbia

The British Columbia *Air Action Plan* (www.bcairsmart.ca/), released in June 2008, outlines 28 actions to reduce air pollution from all sources by promoting clean transportation, clean industry and clean communities. This plan addresses air quality issues in general and also provides support for the PM and Ozone CWS.

To date, 27 of the 28 actions are either under way or completed. Targeting reductions in emissions of PM, and PM and ozone precursors, these actions included *Clean Industry*, *Clean Transportation* and *Clean Communities*.

Clean Industry

- Development of a smoke management framework, outlining a cross-government response to reducing human exposure to smoke from biomass burning
- Funding to FP Innovations – Forest Engineering Research Institute of Canada (FERIC) to support demonstration of improved biomass burning techniques and technologies
- Introduction of new emission standards for industrial boilers
- Elimination of beehive burners in most populated areas of province (all beehive burners to be shut down by December 31, 2016)
- Reduction in emissions from flaring in the oil and gas sector

Clean Transportation

- Implementation of a diesel retrofit program for public transit buses and school buses has been completed
- Mandatory retrofits of 1989-1993 on-road heavy-duty diesel vehicles will be implemented in 2012
- Creation of a provincial idle reduction initiative to coordinate and promote anti-idling initiatives
- Enhancement of the British Columbia *SCRAP-IT* Program to increase incentives and expand the vehicle scrappage program
- Construction of a truck stop electrification demonstration site and promotion of idle reduction for heavy duty diesel vehicles

- Contribution to the Vancouver Fraser Port Authority to help implement their commitments in the North West Ports Clean Air Strategy
- Support for the Green Fleet partnership initiative to improve energy efficiency and reduce vehicle emissions in private and public sector heavy duty diesel fleets

Clean Communities

- Initiation of a provincial wood-stove exchange program, providing partnership funding for programs in 23 communities around B.C. to encourage the switch to low-emission appliances
- Review of regulations related to open burning and solid wood fuel burning domestic appliances (e.g. wood stoves)
- Funding support for local governments involved in airshed management and clean air initiatives
- Establishment of the CLEAR Fund to assist and promote clean air and human health research

To guide airshed planning initiatives in British Columbia and to support implementation of the CWS for PM and ozone, the Ministry of Environment also established a provincial framework for airshed planning, and adopted new provincial air quality objectives for 24-hour and annually averaged $PM_{2.5}$. For information on these and additional air management activities in British Columbia, visit: www.bcairquality.ca.

6.4 Canada

Since 2006, the Government of Canada has moved forward with a number of initiatives in support of reducing ambient levels of PM and ozone and improving air quality in general. This section presents some of the measures and initiatives announced or implemented by the Government of Canada for the period 2006 to 2010.

Industrial Measures

In 2006, Environment Canada released the *Environmental Code of Practice for Base Metals Smelters and Refineries*[20] (the Code). The Code describes operational activities and associated environmental concerns of this industrial sector. Recommendations for the environmental performance of these facilities are presented to mitigate these concerns. The recommended practices in the Code include the development and implementation of

[20] http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=D4E090B4-E6A0-4543-AF67-E214BBABA972

environmental management systems and the prevention and control of atmospheric emissions, wastewater effluents and wastes. These recommended practices may be used as requirements for new facilities and as goals for continual improvements for existing facilities. These measures will help reduce emissions of direct $PM_{2.5}$ and of precursors to $PM_{2.5}$ and ozone.

On August 19, 2011 Environment Canada released the text of proposed regulations to reduce greenhouse gas emissions from the coal-fired electricity sector[21]. The proposed regulations apply a stringent performance standard to new coal-fired electricity generation units and those coal-fired units that have reached the end of their economic life. Although this proposed regulation was developed with the intent to reduce emissions of greenhouse gases, it will also help to reduce emissions of $PM_{2.5}$ and ozone.

Transportation Measures

The federal government has moved forward with a number of measures on transportation. Transportation includes on-road and off-road (tractors, construction equipment, etc.) vehicles, rail, aviation and marine. This section provides an outline of some of these measures.

On-road and Off-road Engines and Fuels

The federal government, through Environment Canada, has developed a number of air pollutant emissions regulations[22] under the *Canadian Environmental Protection Act (CEPA), 1999* and more regulatory work is now being undertaken to keep pace with new U.S. federal standards. Regulations to reduce on- and off-road vehicles and engines emissions are created under authorities granted by *CEPA, 1999*. These regulations are aligned with the U.S. to maximize environmental and economic benefits and recognize that the North American transportation sector is highly integrated. Alignment provides a level playing field for Canadian industry. The regulations also fulfil international obligations such as the Canada-U.S. Air Quality Agreement which includes a significant transportation focus.

Under *CEPA, 1999*, Environment Canada regulates air pollutant emissions from the following transportation sources:

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[21] http://www.ec.gc.ca/default.asp?lang=En&n=56D4043B-1&news=E9162F74-3B55-49AE-B.C.DA-2D4A83331591

[22] Most regulations mentioned in section 4.1 can be found at the following web site: www.ec.gc.ca/CEPAregistry/regulations/

- On-road vehicles, such as cars, trucks, motorcycles, and buses (Tier 2)
- Small spark-ignition engines, such as lawnmowers and chainsaws (Phase 2)
- Off-road diesel engines in construction, mining and farming (Tier 3)
- Snowmobiles, personal watercraft, outboard motors and off-road motorcycles.

The On-Road Vehicle and Engine Emission Regulations were published in the Canada Gazette Part II in 2003. The regulations were amended in 2006 to broaden their scope to include all motorcycles. The Regulations apply to all 2004 and later model year on-road vehicles and engines, and are aligned with the U.S. Tier 2 program.

On-road heavy-duty vehicles are also subject to the On-road Vehicle and Engine Emission Regulations. Emissions standards are aligned with current U.S. Environmental Protection Agency (EPA) standards. Heavy-duty on-board diagnostic requirements are presently under development.

The Off-Road Small Spark-Ignition Engine Emission Regulations were published in Canada Gazette Part II in 2003 and apply to all 2005 and later year spark-ignition engines such as lawn movers and chain saws. The Regulations are aligned with the U.S. Phase 2 program.

The Off-Road Compression-Ignition Engine Emission Regulations were published in Canada Gazette Part II in 2005. The regulations, which apply to 2006 and later model year off-road compression ignition engines such as for construction, mining and farming, are aligned with the U.S. Tier 3 program.

The Marine Spark-Ignition Engine, Vessel and Off-Road Recreational Vehicle Emission Regulations, published in Canada Gazette Part II in 2011, apply to snowmobiles, personal watercraft, outboard motors and off-road motorcycles. The regulations, which are aligned with U.S. EPA standards, will take effect for most products in the 2012 model year and will be fully phased in by the 2015 model year.

In July 2008, a report was released by the Audit and Evaluation Branch of Environment Canada (*Evaluation of the Regulation of Smog-Causing Emissions from the Transportation Sector*[23]) regarding the evaluation of regulations for smog-causing emissions in the transportation sector. The five regulations examined included Sulphur in Gasoline Regulations, Sulphur in Diesel Fuel Regulations, On-Road Vehicle and Engine Emission Regulations, Off-Road Small Spark-Ignition Engine Emission Regulations and Off-Road Compression-Ignition Engine Emission Regulations.

[23] http://www.ec.gc.ca/doc/ae-ve/2008-09/710/tdm-toc_eng.htm

The report states that all five regulations are on track to achieving their intended environmental outcomes. Some of the standards set out by the regulations have been achieved by the sulphur in fuels regulations, and are beginning to be achieved in the case of on-road vehicles. Off-road engines are starting to undergo compliance verification testing to assess the emission performance of products sold in Canada.

It is expected that these achievements will contribute to the ultimate outcome sought by the regulations which is to reduce risks to Canadians, their health and their environment from air pollutants.

Marine

On March 26, 2010 International Marine Organization Member States formally adopted the North American Emission Control Area (ECA) proposal. Large ships within the waters of Canada, the U.S. and France (Saint-Pierre and Miquelon), south of 60 degrees north and extending 200 nautical miles offshore, will be subject to strict air pollutant standards. Ships will be required to significantly reduce their air pollutant emissions of sulphur oxides (SOx), particulate matter (PM), and nitrogen oxides (NOx) within the ECA by August 1, 2012.

Environment Canada played a pivotal role in the ECA submission, conducting the emissions inventories, air quality modelling, and ecosystem modelling. EC is now supporting Transport Canada in developing regulations to implement Canada's portion of the ECA.

The ECA will help reduce emissions of harmful pollutants and will contribute to improve air quality, reduce acid rain and decrease adverse health effects. Globally, the ECA demonstrates the effectiveness of working with the international community to put in place new, more stringent emissions standards for marine vessels, to protect the health of Canadians and the environment.

Rail

In 2007, Environment Canada, Transport Canada and the Railway Association of Canada signed a Memorandum of Understanding (MOU) identifying commitments by Canadian railway companies to voluntarily reduce greenhouse gas and criteria air contaminant polluting emissions. This MOU expired on December 31, 2010.

Transport Canada is responsible for regulating rail operations in Canada. In 2006, Transport Canada committed, as part of the Government’s Clean Air Regulatory Agenda, to develop and implement new regulations to limit the release of air pollutants from the rail sector, under the *Railway Safety Act*. Preliminary stakeholder consultations on the proposed regulatory approach were held from December 1, 2010 to February 14, 2011. The proposed regulations would be aligned with U.S. standards.

Consumer and Commercial Products

In March 2004, the Minister of the Environment and the Minister of Health published a Notice of Intent in *Canada Gazette Part I* which presented Canada's *Federal Agenda for Reduction of Emissions of Volatile Organic Compounds from Consumer and Commercial Products*. The VOC Federal Agenda outlines a number of initiatives for the Government of Canada to take in order to reduce VOC emissions from consumer and commercial products and covers the 2004 to 2010 period. In April 2010, the federal government committed to the continuation of this agenda by releasing a discussion paper for addressing VOC emissions from consumer and commercial products and covers the 2010 to 2020 period (*Renewal of the Federal Agenda on the Reduction of Volatile Organic Compound (VOC) Emissions from Consumer and Commercial Products: A Discussion Paper for the 2010 to 2020 Period*[24]).

In relation to the VOC Agenda, the Government of Canada published three regulations regarding emissions of VOC from the following consumer and commercial products: (1) architectural paints; (2) auto refinish products; and (3) certain consumer products to reduce emissions of volatile organic compounds. These regulations will reduce emissions of VOC, which is a precursor to both $PM_{2.5}$ and ozone.

Chemicals Management Plan

The Government of Canada's Chemicals Management Plan will improve the degree of protection against hazardous chemicals. It includes a number of new, proactive measures to make sure that chemical substances are managed properly. The management of the chemicals will also help to reduce ambient PM and ozone levels and improve air quality since a large number of these chemicals are precursors to both $PM_{2.5}$ and ozone. More information on the Chemicals Management Plan can be found at: http://www.chemicalsubstanceschimiques.gc.ca/plan/context-eng.php

Transboundary Air Pollution

The Canada – U.S. Air Quality Agreement

The Canada-U.S. Air Quality Agreement (AQA) was signed in 1991 to address the transboundary transport of acidifying emissions of SO_2 and NO_X in both countries. In

[24] http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=C58D8825-CAFB-42BF-BB.C.5-C0DCB7EEB531

December 2000, the AQA was expanded with the addition of an Ozone Annex to address the transboundary transport of ozone and its precursors between the two countries.

Canada and the U.S. recognize the significant human health and ecosystem effects (including acid rain) associated with $PM_{2.5}$ and its precursors. Both countries engaged in discussions in 2007-2008 towards the development of a PM Annex under the AQA. Intercessional work on PM has continued, while both countries refine their domestic policy approaches to managing PM emissions. This work has focused on exchanging information on emissions and ambient monitoring and reporting obligations in each country, and increasing the understanding of potential emission reduction commitments for stationary (i.e. point) sources.

Although not part of the AQA, the U.S. EPA finalized the *Cross-State Air Pollution Rule* (CSAPR)[25] on July 6, 2011, that will require 27 states to significantly improve air quality by reducing power plant emissions that contribute to ozone and $PM_{2.5}$. The CSAPR replaces EPA's 2005 Clean Air Interstate Rule (CAIR). Since some regions of Canada are affected by the transport of air pollutants emitted in many of the states formerly covered by CAIR and now by CSAPR, it is expected that the continued implementation of CSAPR will have significant air quality benefits for those regions.

United Nations Convention on Long-range Transboundary Air Pollution

As a Party to the United Nations Convention on Long-range Transboundary Air Pollution (CLRTAP), Canada has participated actively at an international level to address air quality globally. Canada continues to be in compliance with the established caps for SO_2 and NO_X set in three of the Convention protocols related to acid rain. In fact, for 2010 Canada was below the national SO_2 cap by 57%, and below the NO_X national cap by 18%. For the Sulphur Oxide Management Area, Canada was 72% below the SO_2 cap stipulated in the 1994 United Nations Economic Commission for Europe Protocol on Further Reductions of Sulphur Emissions.

Canada is also an active participant in the negotiations for revisions to the Gothenburg Protocol, a CLRTAP multi-pollutant agreement on acidification, eutrophication and ozone. Canada has helped to develop the draft revised text to this annex.

Canada's Energy Efficiency Act

Canada's *Energy Efficiency Act*[26] (under Natural Resources Canada) provides for the making and enforcement of regulations concerning minimum energy performance levels

[25] http://www.epa.gov/airtransport/

[26] http://oee.nrcan.gc.ca/regulations/process.cfm

for energy-using products, as well as the labelling of energy-using products and the collection of data on energy use.

The Energy Efficiency Regulations establish energy efficiency standards for a wide range of energy-using products, with the objective of eliminating the least energy-efficient products from the Canadian market. They apply to regulated energy-using products imported into Canada or manufactured in Canada and shipped from one province to another. Changes to the EnerGuide label are also made through amendments to the Regulations.

Since many of these energy-using products emit air pollutants and greenhouse gases, the Energy Efficiency Regulations will reduce emissions and will therefore help improve $PM_{2.5}$ and ozone air quality. For a complete list of regulations, please refer to the following web site: http://oee.nrcan.gc.ca/regulations/guide.cfm?attr=0

Air Quality Monitoring

Air quality monitoring measures the level of pollutants present in the air. This information is then used for a variety of purposes, including evaluation of the effectiveness of emission reduction measures, trends, notification of smog advisories, health studies and comparison with standards.

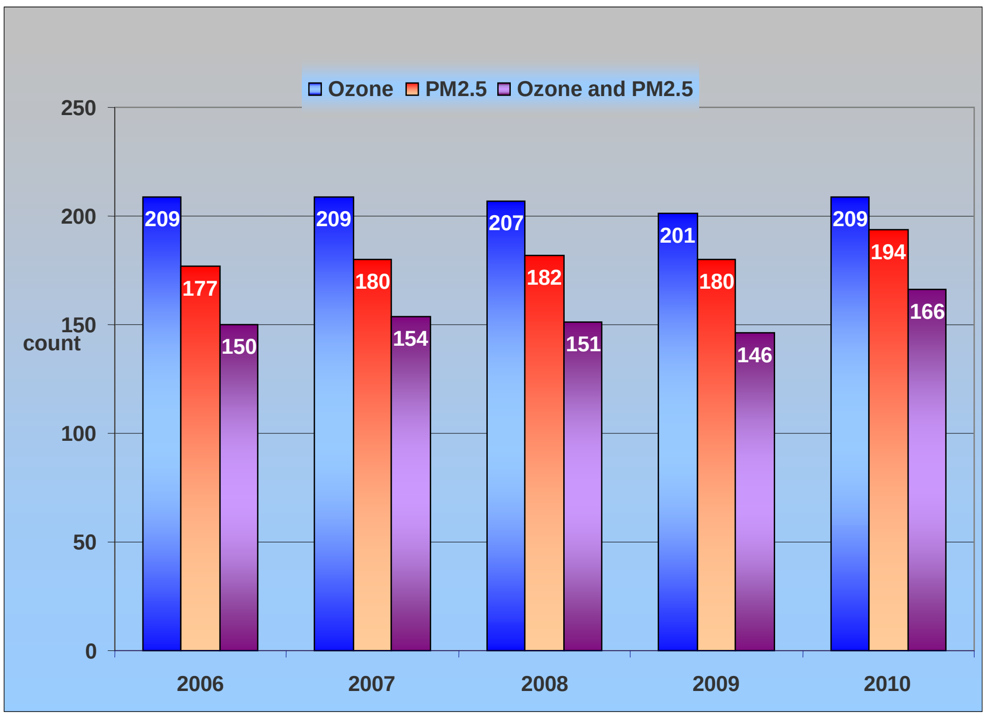
The National Air Pollution Surveillance (NAPS) network and the Canadian Air and Precipitation Monitoring Network (CAPMoN) are the two major programs for routine ambient air monitoring in Canada. The NAPS program is a joint federal, provincial, territorial and municipal initiative. The purpose of this monitoring program is to coordinate the collection of air quality data from existing provincial, territorial and municipal air quality monitoring networks and provide accurate and long-term air quality data of a uniform standard in a unified Canada-wide air quality database.

The associated provincial/territorial/regional monitoring networks reporting data to the Canada-wide database comprises (as of 2011) 318 air monitoring stations located in 217 communities. In total, over 800 instruments, including continuous analyzers for SO_2, carbon monoxide, nitrogen oxides, ozone, and fine particulate matter are used to provide continuous air quality measurements. For some substances, to measure their concentrations in the air, an air sample over a continuous 24-hour period is first collected. Various laboratory analyses are then conducted on the sample to obtain the concentration of the substances. These include toxic substances such as polycyclic aromatic hydrocarbons, dioxins and furans, and heavy metals such as arsenic, lead and mercury. Depending on the location, samples are collected once every 3, 6 or 12 days.

CAPMoN consists of 30 stations located in rural or remote areas, including one station in the U.S. The objectives of CAPMoN differ from those of NAPS in that CAPMoN measurements provide data for research into: (1) regional-scale spatial and temporal variations of air pollutants and deposition; (2) long range transport of air pollutants (including transboundary transport); and (3) atmospheric processes, and chemical transport model evaluation. To meet these objectives and to best complement the NAPS network the CAPMoN sites are located in rural and remote areas.

Figure 11 shows the number of $PM_{2.5}$ and ozone sites reporting to the Canada-wide air quality database since 2005, including the 16 CAPMoN sites that measure ground-level ozone. These sites are located in over 100 communities (CMA, CA, RSA or CSD) including all communities with a population greater than 100,000. In total, these communities account for about 75% of the Canadian population.

Figure 11: Number of stations reporting to the Canada-wide air quality database for ozone and $PM_{2.5}$



In addition to the continuous $PM_{2.5}$ monitors, there were 41 filter-based samplers in operation which meet the NAPS $PM_{2.5}$ Reference Method criteria. The mass concentrations from these samplers are used for comparison with the continuous $PM_{2.5}$ instruments, and the filter media also undergo chemical analysis. A subset of these sites (13) make up the $PM_{2.5}$ speciation network which measures major ions, organic and elemental carbon, metals and gas phase species including ammonia and nitric acid. The principle gaseous precursors to secondary $PM_{2.5}$ and ozone formation, SO_2, NO_X and VOC are monitored at 152, 176 and 53 sites, respectively, reporting to the unified database. Measurements from these instruments are used to analyze source attribution and the development of effective management strategies.

Recent investments to the air monitoring networks include:

- A multi-million dollar investment to ensure that monitoring instruments are properly maintained and replaced when an instrument has reached its end of life. The average age of monitoring instruments has been reduced from more than 15 years to 5 years during the past decade which ensures that Canada meets the highest technical standards for air quality measurements.
- Conversion of the existing continuous $PM_{2.5}$ instruments to U.S. Class III Federal Equivalent Method instruments.
- Modernization of federal, provincial and municipal data logging and data reporting systems to allow more timely reporting of data and improve quality of real time data used to report air quality indices (e.g., AQHI) and real-time mapping websites (e.g., AIRNOW).
- New samplers have been purchased to replace the existing $PM_{2.5}$ chemical speciation network and existing measurement programs for volatile organic compounds (VOC) have also been enhanced.
- Expansion of the laboratories and analytical equipment used to carry out detailed chemical analysis such as VOC and $PM_{2.5}$ speciation.
- For the CAPMoN network, a comprehensive comparison study of commercially available $PM_{2.5}$ instruments was initiated in late 2008. This study was undertaken to assess the best $PM_{2.5}$ monitoring technology to be used at remote locations in harsh Canadian weather conditions to monitor lower $PM_{2.5}$ levels considered as background – ensuring accurate data, robustness of operation and reliable data telemetry.

Advancements in Environmental Science

Over the past five years, Environment Canada has led the development of and contributed to a number of science assessments, conducted intensive field measurement campaigns and research studies, developed and applied state-of-the-art air quality models, as well as led the federal-provincial-territorial NAPS network and the CAPMoN network. Below are highlights of advancements in environmental science.

Canadian Smog Science Assessment - Highlights and Key Messages (2011)[27]

The Canadian Smog Science Assessment is a collaborative effort, co-authored by Environment Canada and Health Canada. The Assessment represents the first time ever that scientific information related to both PM and ozone, and their effects on Canadians and the environment, are captured in a single document. The *Highlights and Key Messages* document provides a summary of the scientific information intended to guide policy and decision-making in Canada.

Atmospheric Chemistry and Physics Special Issue on the Border Air Quality and Meteorology Study Campaign (2011)[28]

A compilation of 19 peer-reviewed scientific papers based upon an intensive field study conducted in the summer of 2007. This work provides a better understanding of the role of local and transboundary sources in the observed fine particulate matter and ground-level ozone levels in southwestern Ontario.

Canadian National Air Pollution Surveillance $PM_{2.5}$ speciation program: Methodology and $PM_{2.5}$ chemical composition for the years 2003 to 2008 (2011)[29]

Outlined the improved sampling and analytical methods used in the Canadian $PM_{2.5}$ speciation program and analyzed seasonal and geographical variations in the major components of $PM_{2.5}$ samples collected at eight urban and three rural sites across Canada for the period of 2003 to 2008.

Setting regional trends and baseline levels for ground-level ozone in Canada (2010, 2009)[30]

Studies have been undertaken to provide comprehensive analyses of decadal, seasonal and daily variations of regional-scale ambient and baseline ozone in different regions of Canada and the U.S. for the period of 1997 to 2006. These studies contribute to evaluating trends as well as background tropospheric ozone levels in Canada.

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[27] Canada. Environment Canada and Health Canada. 2011. *Canadian Smog Science Assessment - Highlights and Key Messages.* (Cat. No. En88-5/2011E).

[28] http://www.ec.gc.ca/scitech/default.asp?lang=En&n=6A2D63E5-1&xsl=privateArticles2,viewfull&po=1F50EB9A

[29] Dabek-Zlotorzynska, E., Dann, T.F., Kalyani Martinelango, P., Celo, V., Brook, J.R. Mathieu, D., Ding, L., Austin, C.C. Canadian National Air Pollution Surveillance (NAPS) $PM_{2.5}$ speciation program: Methodology and $PM_{2.5}$ chemical composition for the years 2003-2008 (2011) Atmospheric Environment, 45 (3), pp. 673-686.

[30] Chan, E. and Vet, R.J. Baseline levels and trends of ground level ozone in Canada and the United States. Atmos. Chem. Phys., 16 September 2010. 2010 Atmospheric Chemistry and Physics 10 (18), pp. 8629-8647. & Chan, E. Regional ground-level ozone trends in the context of meteorological influences across Canada and the eastern United States from 1997 to 2006, J.Geophys. Res., 114 D05301, doi:10.1029/2008JD010090.

The National Agri-Environmental Standards Initiative (2009)

The National Agri-Environmental Standards Initiative (NAESI) was a collaborative partnership between Agriculture and Agri-Food Canada and Environment Canada. Significant research and development activities were undertaken to address the scientific gaps in understanding the role of ammonia in the formation of particulate matter. A key activity was improving the national ammonia emission inventory to reflect actual Canadian agricultural practices. The result of NAESI was the proposal of non-regulatory ambient ammonia standards. For the air component, these standards were based on regional sensitivity of particulate matter levels to reductions in ammonia emissions.

Advancing Local-scale Modelling through Inclusion of Transportation Emission Experiments (2009 to present)

The federal Program of Energy Research and Development funds a collaborative program to improve the understanding of transportation-related emissions of particulate matter and related constituents in the atmosphere.

Transboundary Contributions to Canada's Air Quality from Global Sources[31]

Studies have been undertaken at a high altitude site to characterize particles and gaseous pollutants in order to quantify and track the transport across the Pacific of air pollutants and dust impacting air quality, visibility and deposition in Canada.

Impact of Air Pollution on the Health of Canadians[32]

Collaborative studies on population and personal exposure to critical air pollutants contribute to the on-going scientific evidence of impacts of air pollutants on the health of Canadians.

Air Quality and Meteorological Modelling and Forecasts

Between 2006 and 2010 Environment Canada moved forward on a number of items regarding air quality and meteorological modelling, both in model development and modelling air quality changes in response to specific changes in emission sources.

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31 http://www.ec.gc.ca/air-sc-r/default.asp?lang=En&n=1155EA54-1

32 Examples of relevant peer-reviewed papers: Shin H.H., Stieb D.M., Jessiman B., Goldberg M.S., Brion O., Brook J., Ramsay T., Burnett R.T. 2008. A temporal, multicity model for estimate the effects of short-term exposure to ambient air pollution on health. Environmental Health Perspectives. 116 (9):1147-1153. Brook R.D., Urch B., Dvonch J.T., Bard R.L., Speck M., Keeler G., Morishita M., Kaciroti N., Harkema J, Corey P., Silverman F., Wellenius G., Gold D., Mittleman M., Rajagopalan S., Brook J.R. (2009) Insights into the mechanisms and mediators of the effects of air pollution exposure on blood pressure and vascular function in healthy humans. *Hypertension* 54:659-667

The Meteorological Service of Canada has developed an air quality modelling platform based on its operational meteorological forecast model GEM[33] and the chemical transport model AURAMS developed by the Air Quality Research Division of Environment Canada. The platform provides transparency and consistency for assessing the air quality response to changes in emissions. The platform uses the 2006 Canadian emission inventory and the 2005 U.S. emission inventory provided by the U.S. Environmental Protection Agency. The results obtained using the modelling platform provide input to public health and exposure assessments, as well as environmental assessments.

The platform was used for a variety of studies between 2006 and 2010, including the following:

- The Environment Canada and Health Canada *Smog Science Assessment*[34], the proposed Coal-fired Electricity Generating Units Regulation[35]
- A study on the impact of biodiesel on human health
- A study that led to the joint proposal by Canada and the United States to the International Marine Organization, of an Emission Control Area designation for the control of emissions from ships for specific portions of our coastal waters (see the sub-section entitled *Marine* above)

Updates to the model component of the platform (AURAMS) were delivered by the Air Quality Research Division of Environment Canada, including continuous model improvements with respect to resolution and chemical and physical interactions of pollutants in the atmosphere, and continuous assessments of AURAMS' capacity against European and U.S. models. Further enhancements resulted in an expansion of the modelling capacity to address intercontinental transport of pollutants and supported the development of the next generation air quality model GEM-MACH. Canada became the first country to adopt a meteorological model with embedded chemistry for national use.

In its first application, GEM-MACH replaced Environment Canada's operational model in November 2009, providing air quality forecasts from coast to coast twice a day. GEM-MACH is now being further enhanced to support the assessment of air emission regulations as part of an updated platform.

[33] GEM is the model used by EC to make official daily weather forecasts.

[34] Currently, this document is available on request.

[35] http://www.ec.gc.ca/default.asp?lang=En&n=714D9AAE-1&news=E5B59675-BE60-4759-8FC3-D3513EAA841C

Air Quality Health Index

Though the AQHI is not directly related to the CWS for PM and Ozone, the purpose of the AQHI is consistent with the long-term goals of the CWS, which is to minimize the risks posed by $PM_{2.5}$ and ozone on human health and the environment over the long-term. The AQHI assists Canadians in making decisions on reducing their immediate (current and next day) health risks from exposure to $PM_{2.5}$, ozone and NO_2.

The AQHI was developed, tested and is being implemented jointly by Environment Canada and Health Canada, in collaboration with provinces, local health authorities and non-governmental organizations. Over the last several years, the number of participating jurisdictions has progressively increased.

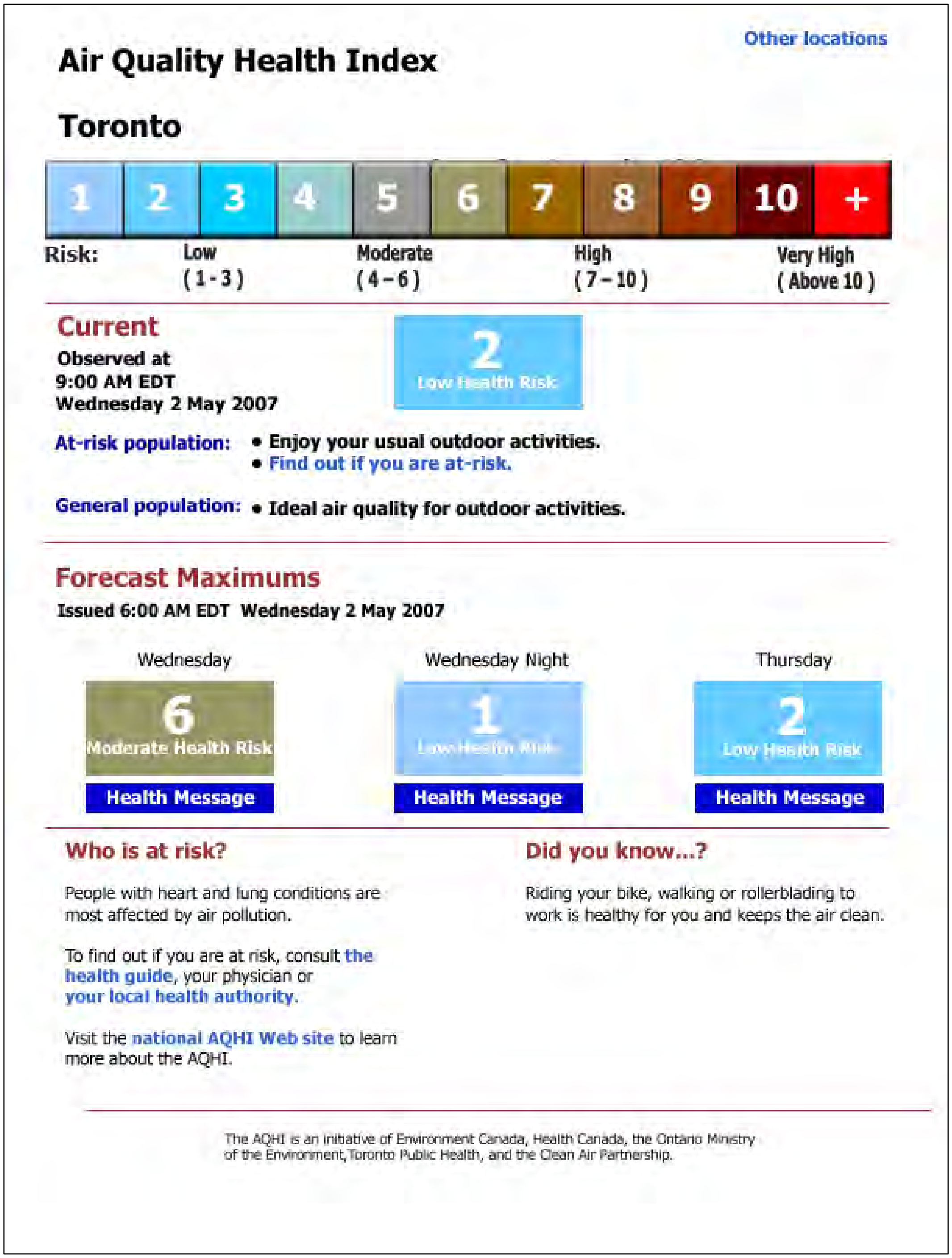
The AQHI ranges from a scale of 1 to 10 and above. The higher the AQHI number, the higher the associated health risks. However, the actual risk may vary depending on an individual's age (the young and elderly are more vulnerable) and overall health (individuals with existing breathing or cardiac conditions may be more vulnerable). To facilitate communication, the AQHI is separated into four categories of health risks:

- **Low –** AQHI number from 1 to 3
- **Moderate –** AQHI number of 4 to 6
- **High –** AQHI number of 7 to 10
- **Very high –** AQHI number of more than 10

The AQHI has been integrated into Environment Canada's weather dissemination infrastructure which supports sustained distribution on internet platforms such as Weather Office, the AQHI national portal (airhealth.ca) as well as other technologies such as smart-phone applications and automated telephone and answering devices.

The AQHI is disseminated nationally through the following Environment Canada's web site: http://www.weatheroffice.gc.ca/airquality/pages/landing_e.html. Many provinces and territories also provide the AQHI on their own web sites, and the Weather Network provides AQHI readings twice per hour. The AQHI from Environment Canada provides both a real-time index value on an hourly basis, and also forecast values for the current and following day for various communities across Canada (Figure 12 provides an example). The dissemination of the AQHI and forecasts by Environment Canada could not be possible without the collaboration of participating provinces and territories. Environment Canada is grateful to these provinces and territories.

Figure 12: Example of current AQHI reading and forecast



6.5 Manitoba

Manitoba's actions have been, and will continue to be, on continuous improvement and keeping clean areas clean given that $PM_{2.5}$ and ozone metric values in Manitoba are below the CWS targets. Measures undertaken since 2005 in support of the PM and Ozone CWS, and air quality in general, are discussed below.

Regulations

As part of the environmental regulatory process, the government of Manitoba is working with and encouraging significant sources in the province to reduce emissions of all pollutants. Examples of specific activities have included:

- Requiring portable hot-mix asphalt and concrete batch plants to comply with PM emission standards starting January 1, 2010
- Reduction of PM emissions from northern base metal smelters per (federal) pollution prevention planning requirements and in anticipation of future operations
- Developing legislation (new Thermal Treatment Systems Regulation) that will implement a lower PM emission limit
- Ongoing environmental assessment of facilities during licensing.

Actions on Climate Change

There are also co-benefits on air pollutants emission from actions undertaken to reduce Manitoba's greenhouse gas emissions. Many of the current and proposed programs in the previous action plan and the most recent initiative entitled *Next Steps: 2008 action on climate change*[36] have the potential to concomitantly reduce PM, NOx and VOC emissions from various sectors. In most of these cases, the emission reductions arise from the reduced need to burn fossil fuels locally or the displacement of energy generation sources elsewhere that depend on fossil fuels and have associated emission releases. Examples of some of the programs and policies include:

- The *Climate Change and Emission Reduction Act*, which came into effect in June 2008, requiring Manitoba Hydro to phase out the use of coal and not use it as fuel to generate electricity after December 31, 2009, except to support emergency operations
- Construction of the Wuskwatim (200 MW) Hydroelectric Generation Project in Northern Manitoba and the announced future development of Manitoba Hydro's Keeyask (695 MW) Hydroelectric generating station

[36] NEXT STEPS: 2008 ACTION ON CLIMATE CHANGE: BEYOND KYOTO, MANITOBA'S GREEN FUTURE -- Winnipeg, MB. Manitoba Science, Technology, Energy and Mines, Climate and Green Initiatives Branch, 2008.

- Development and operation of wind farms for electric power generation in Southern Manitoba (St Joseph and St. Leon Wind Farms with a total capacity of 237 MW)
- City of Winnipeg's demonstration project using ethanol-blended diesel fuel in 10 transit buses
- Continuation of Manitoba Hydro's Power Smart energy conservation programs.

Actions by Other Governmental Departments

Actions undertaken by other Manitoba government departments will assist in improving ambient $PM_{2.5}$ and ozone air quality. Examples of these actions include the following:

- Manitoba Health/Manitoba Conservation: development of an implementation plan to deal with the province's biomedical waste incinerators. Manitoba Health announced in August 2010 the construction of a centralized biomedical waste incinerator facility which will lead to the closure of smaller incinerator facilities scattered throughout the Province
- Manitoba Agriculture, Food and Rural Initiatives/Manitoba Conservation: on-going delivery and enforcement of a program to manage agricultural crop residue burning in southern Manitoba with the goal of reducing the exposure to smoke (PM emissions).

Mandated Requirements

In January 1, 2008, Manitoba implemented a mandate requiring fuel suppliers in the province to replace at least 8.5% of their gasoline available for sale with ethanol. This mandate will have the effect of reducing PM emissions from individual vehicles by between 25% and 32%, depending on the vehicle.

In November 1, 2009, Manitoba implemented the biodiesel mandate that requires, on average, 2% biodiesel in all diesel fuel sold in a year by fuel suppliers in the province. Compared with petroleum diesel, emissions of hydrocarbons and PM are reduced when using biodiesel.

Manitoba's Green Strategic Framework

In 2005, the Manitoba government formally released a green strategic framework which will guide the province in its efforts to preserve and protect the environment, promote the health and well-being of Manitoba families, and stimulate and manage sustainable economic growth.[37] Among the seven priorities identified are "acting on energy and

[37] Province of Manitoba, "Green and Growing: Building a Green and Prosperous Future for Manitoba Families", December 2005.

climate change", "growing a sustainable, prosperous economy", and "greening the provincial government". A key component common to these three priorities is the reduction in fossil fuel use, with a concomitant decrease in emissions of PM and ozone precursors. Reduced fossil fuel use will be achieved through the development and promotion of alternative energy sources (*e.g.,* wind, geothermal, hydroelectricity) and increases in energy efficiency.

Closures

In 2010, both the Tembec newsprint mill in Pine Falls, Manitoba and the Hudson Bay Mining and Smelting Co., Limited copper smelting facility in Flin Flon, Manitoba permanently closed their facilities. This is expected to result in a significant reduction of PM emissions from these point sources and some reduction also in other ozone precursor releases.

6.6 Metro Vancouver

Metro Vancouver is responsible for managing its outdoor air quality. An important part of this task is developing and implementing regional air quality and greenhouse gas management plans. With input from businesses, residents, and other government agencies, these plans establish the vision, goals, strategies and actions that guide air quality management in the Metro Vancouver region.

In 1994 the GVRD (as Metro Vancouver was then known) was the first major metropolitan area in Canada to adopt an Air Quality Management Plan. Plans are reviewed and updated on a regular basis to ensure the region's needs are still being met. The following actions were implemented as part of Metro Vancouver's 2005 Air Quality Management Plan:

Non-road Engines

Non-road engines (bulldozers, backhoes, forklifts, cranes, locomotives, etc.) can be a significant source of air contaminants in our neighborhoods. To reduce the impacts of these sources, Metro Vancouver:

- Developed a non-road diesel engine bylaw to reduce diesel particulate matter emissions from industrial and construction machines.
- Initiated the B.C. Locomotive and Rail Air Quality Working Group to promote emission reductions from the rail industry.

Cars, Trucks and Buses

Despite recent improvements in vehicle emission control technology, vehicles continue to be a major source of air contaminants. Over one third of nitrogen oxide emissions in the region come from cars, trucks and buses. To protect regional air quality, Metro Vancouver has:

- Recommended that the Provincial Government extend the *AirCare* program to 2020
- Assisted TransLink (the regional transportation authority) to develop an Emissions Policy for their fleet and the regional transportation system.

Industrial, Commercial and Institutional Sources

This category of sources covers industrial facilities, businesses and public buildings such as universities and hospitals. Depending on the operational process, these sources can emit particulate matter, nitrogen oxides, greenhouse gases, volatile organic compounds, sulphur oxides and harmful air contaminants. To reduce emissions from these sources, Metro Vancouver:

- Increased regulatory fees for facilities covered by Metro Vancouver permits, emission regulations or approvals to encourage reductions of the most harmful air contaminants
- Implemented a bylaw which specifies emission requirements for natural gas and wood-fired boilers and process heaters.

Communities and Regional Planning

Local residents can also influence air quality. To reduce community impacts, Metro Vancouver has:

- Exchanged over 170 old wood stoves with cleaner burning units through the Wood Stove Exchange Program, in partnership with the provincial government
- Included consideration of air quality impacts in the Regional Growth Strategy
- Worked with TransLink, municipalities and other partners to make sure air quality impacts are considered in regional transportation planning.

Marine Vessels and Ports

Metro Vancouver continues to work with other agencies to protect our region's air quality. Port Metro Vancouver, Port of Seattle and Port of Tacoma are taking action through the Northwest Ports Clean Air Strategy.

Visual Air Quality

Residents and tourists appreciate the ability to have clear, haze-free views of the spectacular scenery in our region. To improve visual air quality, Metro Vancouver has initiated a visual air quality pilot for the Lower Fraser Valley, in partnership with other government agencies.

6.7 New Brunswick

In New Brunswick, a broad range of point and area sources within the province, including industry, transportation and residential wood combustion, can influence local air quality. New Brunswick's *Clean Air Act* provides the authority to regulate many of these sources.

Air quality in New Brunswick is strongly influenced by the transboundary flow of air pollution. Transboundary pollution typically originates from large urban and industrialized areas of the U.S. and Canada to the west and south of the province. Natural events within the region, such as large forest fires, can also cause PM levels to rise, resulting in deterioration of air quality.

This section describes the actions being taken and ongoing efforts to reduce emissions from various sources in New Brunswick.

CWS Implementation Plan

New Brunswick's CWS implementation plan was published in December of 2008. It describes monitoring programs, emissions profiles and emission trends, emission reduction initiatives, future plans and related actions in support of the PM and Ozone Canada-Wide Standards. For details, please visit the following website: http://www2.gnb.ca/content/gnb/en/departments/elg/environment/content/air_quality.html

Emission reductions have been and will continue to be achieved from many sources in New Brunswick. Significant reduction in direct emissions of $PM_{2.5}$ were achieved in the pulp and paper sector in the 1990s with the addition of pollution control devices, including electrostatic precipitators. As part of a national effort to curb emissions that contribute to acid rain, New Brunswick Power and other industries in the province have made considerable progress in reducing overall emissions of SO_2. In 2008, the Irving Oil

Refinery installed a new Hydrogenation Amine Tail Gas Unit, which has resulted in significant reductions in SO_2 emissions. Further reductions are planned as New Brunswick meets its 2010 commitment to reduce SO_2 emissions by 50% from the previous provincial cap set in 1992. Recent estimates show that between 1990 and 2008, total SO_2 emissions in the province were reduced from 189 to 48.4 kilotonnes

Over the past two decades, more stringent vehicle and engine performance standards have resulted in significantly lower emissions of NOx and VOCs. These emissions are expected to continue to decrease as the fleet of older cars and trucks are replaced by newer less polluting vehicles. There have also been a number of industry closures in recent years, which have contributed to increased reductions in emissions.

New Brunswick's *Clean Air Act* provides the legislative authority to protect and improve air quality in the province. The Act is supported by several regulations including the Air Quality Regulation that sets out detailed requirements and provisions in a wide range of areas including industrial approvals, open fires, sulphur content in fuels, and the designation of air quality standards and objectives. Approvals for the largest industrial facilities are subject to public review and comment as prescribed by the Public Participation Regulation under the *Clean Air Act*. Also, in 2008 amendments were made to the New Brunswick Ozone Depleting Substances Regulation: http://www2.gnb.ca/content/gnb/en/departments/elg/environment/content/air_quality.html

The Department also continuously works with industry to ensure a more consistent and systematic approach to managing air emissions from industrial sources toward the overall goal of continuous improvement in ambient air quality. This is in keeping with CCME's *Guidance Document on Continuous Improvement and Keeping Clean Areas Clean*.

Outside of the industrial sector, other initiatives or programs exist that either directly or indirectly help to lower emissions and improve air quality such as: anti-idling programs and policies; restrictions and public awareness campaigns on open burning; federal vehicle and engine emission standards; federal and provincial fuel quality standards; and a vehicle scrappage program.

Other measures which have co-benefits for reducing ambient $PM_{2.5}$ and ozone include: the New Brunswick Climate Change Action Plan; the Acid Rain Strategy; and the New England Governors/Eastern Canadian Premiers Acid Rain Action Plan and the Mercury Action Plan.

Public Outreach

Many industrial facilities in the province are required to take prescribed steps to reduce emissions when air quality levels deteriorate. These steps are typically described in facility-specific episode response plans and required as conditions within operating approvals. Additionally, Medical Officers of Health can issue air quality public health advisories as required.

During the summer months when smog episodes are more common, Environment Canada, in cooperation with the New Brunswick Departments of Health and Environment, issues daily air quality forecasts and air quality and health advisories as required. There are also controls on prescribed burns, with burning allowed only when ventilation provides good dispersion of smoke (e.g. CFB Gagetown, ventilation index).

The New Brunswick Lung Association is actively involved in many outreach programs such as the promotion of anti-idling, operation of vehicle scrappage, and raising public awareness as to the effects of poor wood burning practices.

Cooperation in Monitoring and Science

The Department of the Environment of New Brunswick participates with other agencies on a number of air quality issues, including:

- Working in partnership with Environment Canada, applying atmospheric modelling, conducting special studies and air quality measurements to assess the influence of transboundary flow on ambient air quality and particularly during regional episodes of poor air quality
- Working with Environment Canada, through NAPS, for the province's air quality instrumentation and analytical capability for assessing VOC and PM speciation
- Supplying, in real-time, the $PM_{2.5}$ and ozone levels to AIRNOW for public mapping applications (http://airnow.gov/index.cfm?action=airnow.canada)
- Participating in Environment Canada inter-comparison monitoring network for continuous $PM_{2.5}$ monitors
- Partnering with New Brunswick Power in operating the New Brunswick Precipitation Monitoring Network to monitor acid rain in the province
- Participation in the AQHI Program since 2008

Air Quality Monitoring

New Brunswick has operated an extensive air quality monitoring network for ozone since the early 1990s, and most ozone monitors at existing stations have been progressively updated to more recent models since 2005. With regard to monitoring of ambient $PM_{2.5}$, New Brunswick continues to expand and improve the network in large part due to the advent of continuous monitors and a desire to improve the level of monitoring. Examples include the addition of a monitoring station at Castle Street in Saint John in 2007, and the continuous upgrading of monitoring technologies at the other stations.

Air quality monitoring in New Brunswick also includes measurements of carbon monoxide, NO_X, VOC and SO_2, with the latter three gases also being precursors to ozone and $PM_{2.5}$.

These monitoring programs are supported by Environment Canada through NAPS and are important for health and environmental research studies, for determining long-term trends and for performing source contribution analysis. Additionally, some monitoring stations in New Brunswick are part of the national inter-comparison network which tests the performance of different types of continuous $PM_{2.5}$ monitors.

Figure 13 shows the $PM_{2.5}$ and ozone monitoring network in New Brunswick. Results from this network and other air quality monitoring programs, including ambient monitoring conducted by industry, are reported in the Department's Annual Air Quality Monitoring Results report which are available on the Department's website at: http://www2.gnb.ca/content/gnb/en/departments/elg/environment/content/air_quality.htm

Figure 13: The New Brunswick $PM_{2.5}$ and ozone monitoring network

In addition to the fixed monitoring network the Department of the Environment also operates a mobile air quality monitoring vehicle which can be deployed almost anywhere across the province for an initial evaluation of local air quality issues.

6.8 Newfoundland and Labrador

Newfoundland and Labrador continued to work with the major industrial facilities in the province to reduce primary and secondary emissions of $PM_{2.5}$ during the 2006-2010 timeframe and will continue to work with these industries to reduce emissions over the next several years. Additionally, numerous time-dated provisions in the Air Pollution Control Regulations (2004) are now implemented or are nearing their implementation date, which will result in the reduction of pollutants which are precursors to ozone formation.

Specific initiatives in Newfoundland and Labrador to reduce primary and secondary emissions of $PM_{2.5}$ and the precursors to ozone formation include the following:

Sulphur Reduction in the Fuel Combusted at the Thermal Generating Station

Limits for the sulphur content in the fuel combusted at the Holyrood Thermal Generating Station were introduced. In 2006 the limit was reduced from 2.0% sulphur down to 1.0% sulphur. In 2010, the limit was further reduced from 1.0% sulphur to 0.7% sulphur. The secondary formation of sulphates, which are $PM_{2.5}$ in size, is proportional to the percentage sulphur content of the fuel. The net effect of these reductions is a 70% decrease in $PM_{2.5}$ emissions from the facility between 2006 and 2010.

Sulphur Dioxide Emission Reduction Strategy at North Atlantic Refining Limited

North Atlantic Refining Limited is required to reduce emissions of SO_2 by five hundred tonnes annually. The SO_2 reductions have resulted in a decrease in the measured $PM_{2.5}$ concentrations in the three nearby communities. The strategy will result in continued reductions of SO_2.

Iron Ore Pelletizing Emission Reduction Strategy

The Government of Newfoundland and Labrador is negotiating with the Iron Ore Company of Canada on a strategy that will see particulate emissions from the facility be significantly reduced. Particulate emissions from the facility rank them as one of the top ten emitters in the country.

Woodstove Certification

Under the Air Pollution Control Regulations (2004) all wood-burning appliances manufactured or sold in the province must meet either U.S. EPA or Canadian emission standards for particulate as of 2008. A survey of major retailers indicated compliance with the initiative.

VOC Limitations from Aboveground Tanks and Gasoline Vapour Recovery

By 2012 all facilities with aboveground storage tanks or gasoline transfer points are regulated under the Air Pollution Control Regulations (2004). The facilities are to take the necessary actions to reduce VOC emissions. It is anticipated that the combined measures will significantly reduce the emissions of VOCs in the province.

6.9 Northwest Territories

As mentioned in section 2.2, at minimum jurisdictions are to report on achievement of the CWS targets for communities with population of 100,000 or more. In the Northwest Territories (NWT), the largest community is the City of Yellowknife, with a population of approximately 20,000. Although the Government of the Northwest Territories (GNWT) is not obligated to report on the achievement status of the CWS targets, it has reported the metric values for the locations where there is monitoring (Yellowknife, Inuvik, Norman Wells and Fort Liard) for information purposes only.

Air Quality in NWT – An Overview

Air quality throughout much of the NWT is considered pristine. Even in communities, monitoring equipment measures pollutant concentrations only slightly above background levels. The major influence on community air quality is smoke from forest fires which can result in episodes of very high $PM_{2.5}$ concentrations, and the re-suspended dust from gravel roads or residual gravel on paved roads following the spring thaw, which contributes to elevated PM_{10} levels and occasionally $PM_{2.5}$. From an anthropogenic perspective, the major impact to air quality in the NWT will likely come from the industrial sector, due to the ongoing expansion of oil and gas and mining activities. However, much of this resource development activity is remote from northern communities.

Air Quality Management

The GNWT Department of Environment and Natural Resources (ENR) has primary responsibility for environmental management on Commissioner’s Land (community lands and highways), unless the source is a federal facility or is federally authorized. The vast majority of development activities are occurring outside of Commissioner's Land in the NWT and ENR does not issue authorizations for these activities. The Government of Canada is currently responsible for the management of federal land, water, mineral and oil and gas resources in the NWT. Authorizations are issued through federal agencies and boards established under federal legislation which have the responsibility to ensure that the impact of these development activities are minimized.

Emission Sources

Currently, the main industrial emission sources in the NWT are from the mining sector (principally the 3 operating diamond mines) and the upstream oil and gas sector (principally 3 producing fields). Emissions from both these sectors are likely to increase in the future as ongoing resource development activity proceeds in the NWT. However, the current emission sources are primarily located in remote areas of the NWT and their influence on community air quality appears negligible. They are however, located in pristine, sensitive ecosystems where minimizing emissions is highly desirable and the CWS principles of Continuous Improvement and Keeping Clean Areas Clean (CI/KCAC) should apply. Future development activities in these two sectors are likely to continue the pattern of locating in remote areas. The GNWT does not have regulatory authority over these remote development activities but actively participates in the federal review and assessment processes to encourage the federal regulatory agencies to ensure CWSs are considered in their development authorizations.

Within communities, the main emission sources are linked to fuel combustion, including residential and commercial heating, vehicle exhaust and the burning of diesel for electrical power generation. Current ambient monitoring data does not indicate that these emission sources result in unacceptable impacts to community air quality. However, if population and community development continue to increase, impacts may appear and the GNWT is actively pursuing emission mitigation strategies including alternative energy sources. Overall, non-point source emissions continue to dominate the territorial emission inventories, especially so-called 'open sources' such as forest fires and dust from unpaved and paved roads. The impact of forest fire smoke on community air quality was discussed earlier, but there is little that can be done to curb this naturally occurring emission source.

Air Quality Monitoring

Since 2003, the GNWT has gradually expanded its air quality monitoring network in collaboration with NAPS. The network has expanded from a single station (in Yellowknife) to four stations. Monitoring stations for $PM_{2.5}$ and ozone were added at Inukvik, Norman Wells and Fort Liard. In addition to $PM_{2.5}$ and ozone, other criteria air pollutants are also monitored in some of these stations.

Next Steps – Path Forward

The current focus for the GNWT will continue on monitoring of community air quality, including seeking opportunities to improve and expand the Territorial air quality monitoring network to provide the necessary data for policy and planning decisions.

The major challenge for the Territories will be retaining the CWS principles of continuous improvement and keeping clean areas clean (see section 2.3) in the face of expanding oil and gas and mining activities which could result in considerable impacts to air quality in "pristine" airsheds and communities. The GNWT will continue to actively encourage the federal government, boards and agencies to incorporate CWS targets and criteria into its assessment and authorization processes for these resource development projects, which are federally regulated. The GNWT will fulfill its responsibilities to implement the CWS throughout the Northwest Territories once resource management and related environmental protection responsibilities are devolved to the Territorial Government or through intergovernmental agreements, which include appropriate roles for resource management institutions established pursuant to Aboriginal claims agreements.

6.10 Nova Scotia

In recognition of continuous improvement and keeping clean areas clean principles, Nova Scotia is undertaking a broad range of initiatives to help reduce PM and ozone, even though PM and ozone levels in the Census Metropolitan Areas (CMA) are typically below the CWS targets. The activities described below are Nova Scotia-based, as it has been shown that emission reductions occurring in the province will have a beneficial impact on pollutant levels. However, Nova Scotia is also affected by transboundary pollutants and is actively participating in national and regional work to reduce air emissions.

The Province of Nova Scotia has recognized the importance of integrating reductions in air pollutants with reductions in greenhouse gases. As a result, the province's Climate Change Action Plan (January 2009) contains a number of actions directly related to air quality. Many of the activities described below are addressed in the Climate Change Action Plan (CCAP).

Actions Targeting Specific Pollutants

Sulphur dioxide (SO_2)

Reductions in SO_2 are important because a large part of secondary PM in Nova Scotia is sulphate based. Work has already been undertaken to reduce SO_2 emissions and includes the following:

- Updated provincial emission cap for SO2 initiated on March 1, 2005
- SO_2 emission reduction plans showing how facilities that emitted over 90 tonnes of SO_2 in 2001 planned to reduce their emissions by 25% by 2010
- 2% sulphur content limit for heavy fuel oil
- Emission allocations for the electrical power utility for SO_2 for 2010.

The overall goal of these commitments was to reduce SO_2 emissions by 50% by the year 2010 from sources existing in 2001.

Further reductions are planned beyond 2010, including:

- New tighter SO_2 emission allocations for the electrical power utility for 2015 and 2020.

This will result in a 75% reduction in SO_2 emissions from 2001 levels by 2020.

There is a commitment in the CCAP to assess the effectiveness of sulphur reduction efforts by 2011. All of the actions previously taken to reduce SO_2 will be included in this assessment. This will support future actions on reducing SO_2.

Nitrogen oxides (NO_X)

Reductions in NO_X are important because these pollutants contribute to the formation of both PM and ozone. Nitrogen oxides also contribute to acid precipitation. A large portion of NO_X emissions in Nova Scotia come from electricity generation and boiler operation.

Work that has already been done on reducing NO_X emissions includes:

- Emission allocations for the electrical power utility for NO_X by 2009 (resulting in 20% reduction from 2001 levels).

Further reductions are planned beyond 2010, including:

- New, tighter NO_X emission allocations for the electrical power utility for 2015 and 2020.

This will result in a 44% reduction in NO_X emissions from 2000 levels by 2020.

As well, there is a commitment to continue to require all utility and industrial boilers to install low-NO_X burner technology during upgrades. A clearer definition of "low-NO_X" will strengthen this requirement.

Airshed planning

In its CCAP, Nova Scotia committed to using an airshed approach to manage the province's air quality. Nova Scotia will participate in the development of air zones as part of the Air Quality Management System.

Incentives

ecoNova Scotia, which was a program jointly administered by the departments of Energy and Environment, supported projects that reduce air emissions. Projects and initiatives under ecoNova Scotia started rolling out in November 2007 with the financial assistance of the Canada Trust, a Government of Canada Program. Support for projects was available until March 31, 2010. This fund targeted municipalities, businesses, and researchers. It is estimated that the projects supported by Nova Scotia will reduce air pollutant emissions by 1,200,000 kilograms/year by 2020.

Other initiatives

Programs

There are a number of programs undertaken by the Nova Scotia government that are not directly aimed at reducing the air pollutants that contribute to PM and ozone, but will nonetheless contribute to their reduction. For example, the former provincial government agency Conserve Nova Scotia offered the following incentives that had an impact on air quality:

- Grants for energy efficiency improvements to residences
- Rebates of 15% off the installed cost of a solar water heating system or solar air heating systems for residential or commercial use
- Rebates for EPA-approved wood stoves.

There is a new independent organization responsible for helping Nova Scotians reduce their energy consumption and improve their energy efficiency at home and at work. This new organization, Efficiency Nova Scotia, was established by legislation in late 2009 and offers a variety of energy saving programs for residences and businesses, such as:

- Free energy upgrades for low-income homeowners
- Rebates for solar air heating and solar water heating for residential buildings
- A program to help small businesses switch from traditional lights to more efficient technology.

Regulations

In 2008, the Energy-efficient Appliances Regulations were amended to add standards for solid fuel burning heating appliances (e.g. wood stoves). More efficient wood appliances will contribute to a reduction in particulate matter.

Public outreach

Education and outreach activities have helped the public increase their understanding of air quality issues and encourage them to take action to reduce air pollution. The following are examples of education and outreach activities Nova Scotia Environment has completed or supported:

- Development of websites and brochures
- Presentations to the public
- Delivery of anti-idling outreach activities
- Support of public outreach by local NGOs.

Related Climate Change Action Plan activities

There are actions outlined in Nova Scotia’s Climate Change Action Plan that are not under the heading of air quality but will nevertheless lead to reductions in air pollutants. These actions are included in the categories of cleaner energy, energy efficiency, renewable energy, transportation, leadership by example, and engagement and education. Actions will have a positive effect on air quality and increase overall energy efficiency in the province by 20% over 2008 levels by 2020 and transform the electricity system so that 40% of provincial electricity needs will come from renewable energy sources by 2020.

Air Quality Monitoring and Reporting

Monitoring Network

Improvements have been made to the provincial ambient air monitoring network to allow for the measuring of achievement and a better scientific understanding of air quality data. Recent improvements include a new data management software system (DR DAS) and the replacement of the old station in Sydney with a new one in May 2008. Additionally, the Pictou station was replaced in the fall of 2009 and the Port Hawkesbury station was replaced in the spring of 2010. Table 2 shows the existing and planned locations for monitors of ozone, $PM_{2.5}$ and their precursors.

Table 2: Existing monitoring for ozone, $PM_{2.5}$ and their precursors in Nova Scotia

Location	**Ozone**	**$PM_{2.5}$**	**SO_2**	**NO_X**	**VOC**
Halifax (HRM) - Downtown	X	X	X	X	X
Halifax (HRM) - Lake Major	X	X	X	X	
Sydney (CBRM)	X	X	X	X	
Aylesford	X	X		X	
Sable Island	X	X	X	X	
Pictou	X	X		X	X
Port Hawkesbury	X	X	X	X	
Kejimkujik Park (EC)	X	X			X
Dayton (EC)	X				
Kentville (EC)	X				

X = existing monitors; EC = operated by Environment Canada

Air Quality Health Index

The AQHI has been available in the Halifax Regional Municipality since November 2008, in Sydney and Kentville since April 2009 and in Pictou and Port Hawkesbury since 2010. Upgrades to the monitoring equipment and data management software (as discussed above) were necessary to the implementation of the AQHI.

6.11 Nunavut

In Nunavut, there is presently one $PM_{2.5}$ manual sampler operated by the Government of Nunavut. Since the sampling frequency does not meet the *daily* frequency requirement to report on achievement of the $PM_{2.5}$ CWS target, the $PM_{2.5}$ metric value is not reported.

Moving forward, a monitoring station is planned for installation at Iqaluit during 2012 in collaboration with NAPS. The station will have a continuous $PM_{2.5}$ monitor, an ozone monitor and NO_X monitors. This station will then allow the assessment of the achievement of the new Canadian Ambient Air Quality Standards for $PM_{2.5}$ and ozone, with implementation of actions according to the corresponding management level.

6.12 Ontario

Ontario has implemented a number of successful measures to reduce emissions of direct $PM_{2.5}$ and precursors to $PM_{2.5}$ and ozone across major sectors, such as power generation, manufacturing and transportation.

Ontario also works with neighboring provinces, the federal government, and U.S. states to address transboundary air pollution, and is one of the leading jurisdictions in developing the proposed new Air Quality Management System.

Specific Ontario initiatives to reduce direct emissions of $PM_{2.5}$ and precursors to $PM_{2.5}$ and ozone include the following:

Phase-out of Coal-Fired Electricity Generation

Aims to reduce emissions of smog precursors and greenhouse gases. This initiative is complemented by the *Green Energy Act*, which provides a framework to boost investment in renewable energy projects in Ontario, and is supported by the conservation targets in Ontario’s Long-Term Energy Plan.

Emissions Trading Regulations

Caps emissions of smog precursors (sulphur dioxide and nitrogen oxides) from large electricity generators and specified facilities in seven industrial sectors in Ontario, including petroleum refining, cement, glass, pulp and paper, iron and steel, carbon black and base metal smelting sectors.

Drive Clean Program

The vehicle emissions inspection and maintenance program ensures Ontario's vehicles comply with provincial emissions standards, helping to reduce emissions of smog precursors (oxides of nitrogen and hydrocarbons), as well as carbon monoxide. Drive Clean is complemented by the Vehicle Emissions and Enforcement Program which provides on-road enforcement of the province's vehicle emissions requirements.

Ontario Regulation 419/05: Local Air Quality

Is the main tool used to protect local communities in the vicinity of industrial emissions by setting effects-based air standards or technology-based emissions controls for over 120 contaminants, several of which are smog precursors.

In addition to these initiatives, Ontario also operates the Air Quality Index and Smog Alert Program, based on a network of 40 ambient air monitoring stations across the province that supply real-time ambient air quality information to the public. This monitoring program helps inform the public about their air quality, enabling them to respond accordingly.

6.13 Yukon

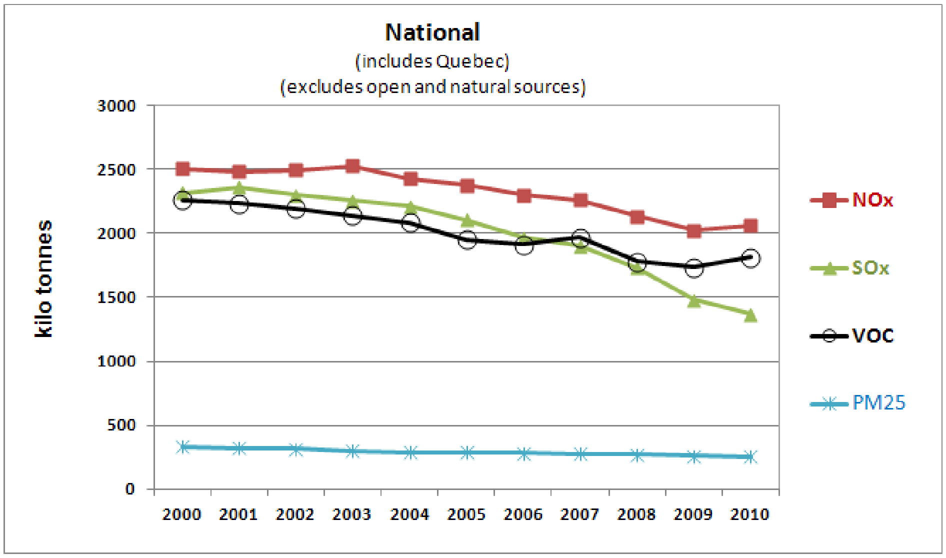
Yukon's actions to reduce PM and ozone have centered on examining the potential link between Yukon's Air Emissions Regulations and ambient concentrations of these pollutants. Under the Air Emissions Regulations the Yukon Government can issue permits to various sources, as listed in the Regulations; however it is less clear how the permits can be used to enforce the ambient standards given that the permitted source may be only one of a number of sources impacting local air quality. Environment Yukon continues to work with stakeholders to develop acceptable approaches to address this issue.

7.0 EMISSIONS TRENDS

This section provides information on national emissions of nitrogen oxides (NO_X), sulphur oxides (SO_X), volatile organic compounds (VOC) and direct $PM_{2.5}$ emissions for the 11-year period from 2000 to 2010. NO_X and VOC are precursors to ozone, and NO_X, SO_X and VOC are precursors to $PM_{2.5}$. For information on the emission inventory compilation, please refer to Appendix C.

The total annual quantities of NO_X, SO_X, VOC and $PM_{2.5}$ emitted in Canada by human activities during the period of 2000 to 2010 are presented in Figure 14. Nationally, the emissions for all four pollutants decreased almost continuously between 2000 and 2010. Compared to the 2000 emissions, the 2010 annual emissions were 18% lower for NO_X, 41% lower for SO_X, 20% lower for VOC, and 23% lower for $PM_{2.5}$.

Figure 14: National emissions of NO_X, SO_X, VOC and $PM_{2.5}$



% Reduction in 2010 from 2000	
NO_X	18
SO_X	41
VOC	20
$PM_{2.5}$	23

A large part of the reductions in NO_X emissions, and part of the reductions in emissions of VOC and $PM_{2.5}$ are due to decreased emissions from the transportation sector resulting from the implementation of federal regulations on engines and fuels over the last decade. Smaller VOC reductions also resulted from decreased emissions from a variety of industrial sectors and consumer and commercial products.

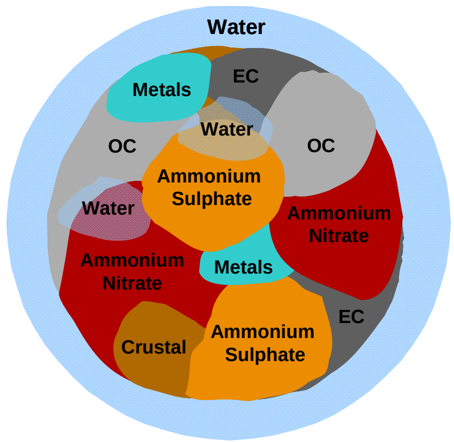
The reductions in emissions of SO_X are mostly due to reductions from fossil fuel-fired electricity generating utilities and base metal smelters, which includes the closure of two smelter facilities in 2009. The reductions from these sectors also contributed to the reductions in $PM_{2.5}$ emissions, as did a decrease in the emissions from the wood products and pulp and paper industries.

Appendix A – $PM_{2.5}$ Monitoring Issues

This Appendix explains why the achievement status of the $PM_{2.5}$ CWS target is preliminary, and why caution should be used when comparing metric values.

Most atmospheric particles are composed of a complex mixture of substances in solid and liquid form. Solid particles often contain an outer water layer, called *particle-bound water*.[38] When measuring $PM_{2.5}$ concentrations, this particle-bound water has to be removed because it is not considered particulate material. Most monitoring methods attempt to remove this water before the measurement is made. Issues arise when the instrument does not completely remove the particle-bound water, or in addition to removing the particle-bound water, the instrument removes some or all of the semi-volatile particulate material (e.g. ammonium nitrate).[39] Relative to the "true" ambient $PM_{2.5}$ concentrations, these two issues could lead to over-reporting or under-reporting of the true concentrations.

Schematic of a particle



by H. Miller

Ideally, the "perfect" $PM_{2.5}$ measurement instrument would remove all particle-bound water, while concurently retaining all semi-volatile material. Unfortunately, there is no such perfect instrument. As an alternative, environmental agencies around the world have each defined *reference* PM measurement methods against which all other methods are compared. Reference methods are mostly *manual samplers* in which a filter is used to collect a PM sample, usually over a 24-hour period. The difference in weight of the filter before and after the collection of the sample is then converted to a concentration value. The reference method also specifies strict filter handling and conditioning conventions.[40]

Since the early 1990s, a number of continuous monitoring methods have been developed and deployed in monitoring networks to replace the resource-intensive manual samplers. Across Canada (and also elsewhere in the world) a number of different continuous monitoring methods are used to measure the 1-hour $PM_{2.5}$ concentrations and, in some cases, the methods differ even within the jurisdiction. Compared to the National Air

[38] Particle-bound water is to be distinguished from "chemically-bound" water. Chemically-bound water is chemically bonded to particulate material and is more difficult to remove.

[39] Semi-volatile substances are substances that can exist in the air in both the gaseous or solid phase depending on the meteorological conditions.

[40] In practice, because of limited resources the filter handling and conditioning conventions are seldom adhered to.

Pollution Surveillance (NAPS)[41] $PM_{2.5}$ reference method, many of these continuous monitors under-report the 24-hour average concentrations (because in the process of removing the particle-bound water they also remove some or all of the semi-volatile materials), and few over-report the concentrations.

To address this issue and to obtain $PM_{2.5}$ data that is comparable across Canada, the CWS monitoring protocol specifies the performance criteria that continuous monitors should satisfy to be used in reporting on the achievement status of the $PM_{2.5}$ CWS target. These performance criteria are similar to the criteria that the U.S. Environmental Protection Agency (EPA) uses to designate continuous monitors (Class III) as federal equivalent methods (FEM) for reporting on compliance with their National Ambient Air Quality Standards (NAAQS).

Because of the similar performance criteria, NAPS managers have agreed that any continuous monitor designated by the EPA as an FEM can be used in Canada to report on achievement of the $PM_{2.5}$ CWS target. The first instrument to receive Class III FEM designation was in spring of 2008. Four additional instruments were designated in 2010 and a sixth instrument was designated in 2011. Although some stations in Alberta, Québec and Atlantic Canada have monitoring stations with monitors that eventually received the FEM designation (following modifications to the monitors), on a strict criteria basis all $PM_{2.5}$ metric values in this report are not based on FEM data.

Current monitoring stations are being progressively updated with $PM_{2.5}$ monitors that satisfy these performance criteria. However, most monitors used in the period 2008-2010 did not satisfy the criteria. For this reason the achievement status of the $PM_{2.5}$ CWS target reported in this Progress Report is preliminary, and caution is to be used when comparing $PM_{2.5}$ metric values between any communities or stations, even within a given jurisdiction.

[41] NAPS is a collaborative monitoring network operated jointly by federal, provincial, territorial and municipal governments.

Appendix B – Station Selection Criteria and Trend Calculation Method

The national and provincial[42] averages and their trends were calculated for the following variables.

i) The 3-year rolling average of the annual 98th percentile values of the daily 24-hour average $PM_{2.5}$ concentrations

ii) The 3-year rolling average of the annual 4th highest daily maximum 8-hour average ozone concentrations, and their rolling 3-year averages

iii) The annual average of 1-hour sulphur dioxide (SO_2) concentrations

iv) The annual average of the 1-hour nitrogen dioxide (NO_2) concentrations

v) The annual average of the 24-hour average volatile organic compounds (VOC) concentrations.

Data Completeness criteria

For each of the above variables, only the stations that satisfied the following data completeness criteria were considered:

(i) The value of the variable had to be available for eleven years of a 15-year period, and for 8 years of an 11-year period, and

(ii) The value of the variable was not missing for more than two years at the start or end of a 15-year period and not more than once for an 11-year period.

Because of these criteria, trends could not be calculated for all provinces. Also, in some provinces, only a limited number monitoring stations satisfied the criteria for a given variable. In such cases, the presented annual averages of the variable represent the average levels for the considered stations, instead of the whole province.

Calculation of National and Provincial Averages

For the 3-year rolling averages of $PM_{2.5}$ and ozone, the first step involved calculating the annual national and provincial averages. For a given year, the national and provincial averages were obtained by calculating the average of all the station-specific values of the $PM_{2.5}$ 98th percentile and the ozone 4th highest for that year. The 3-year rolling averages were then calculated from these annual national and provincial averages. For SO_2, NO_2

[42] Territories were not included because of insufficient data.

and VOC, the national and provincial averages for a given year were obtained by calculating the average of the station-specific annual averages for the given year.

The $PM_{2.5}$ annual 98^{th} percentile values and the ozone annual 4^{th} highest values for a given monitoring station were calculated based on the procedures and data completeness requirements specified in the CCME 2007 Guidance Document on Achievement Determination (GDAD).

Calculation of Trends

The trend, or the annual rate of change of a variable, and its statistical significance at the 95% level of confidence were obtained based on the non-parametric Mann-Kendall approach and the non-parametric Sen's method, respectively.

Non-statistically significant trends are those for which random variations alone may be the cause of the calculated trend; *statistically significant trends* may imply an underlying systematic cause for the trends.

References

Canadian Council of Ministers of the Environment (2007). *Guidance Document on Achievement Determination: Canada-wide Standards for Particulate Matter and Ozone (Revised)*. PN 1391.

T. Salami, A. Määttä, P. Anttila, T. Ruoho-Airola, T. Amnell (2002). *Detecting trends of annual values of atmospheric pollutants by the Mann-Kendall test and Sen's slope estimates*. Finnish Meteorological Institute: Publications on Air Quality #31, Helsinki, 2002.

Appendix C – Emission Inventory Compilation

Environment Canada collects emissions information for pollutants defined as *toxic* under the *Canadian Environmental Protection Act, 1999 (CEPA 1999)* which are emitted at annual quantities above a given pollutant-specific threshold quantity. This information is collected and made publicly available through the federal National Pollutant Release Inventory (NPRI).[43] Pollutants defined as toxic under *CEPA 1999* include $PM_{2.5}$, nitrogen oxides (NO_X), sulphur oxides (SO_X) and volatile organic compounds (VOC). NO_X, SO_X and VOC are precursors of $PM_{2.5}$ while NO_X and VOC are ozone precursors.

Building upon the NPRI information, Environment Canada then develops annual national emissions inventory, in consultation with provinces and territories, which include all sources of emissions. The emission inventories are used for a variety of purposes, including:

- To help identify pollution prevention priorities
- To support the assessment and risk management of chemicals
- To fulfill national and international reporting obligations
- To assist in developing targeted emission reductions measures
- To encourage actions to reduce the release of pollutants into the environment by improving public understanding
- To predict future air quality through the use of air quality modelling.

[43] http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=4A577BB9-1