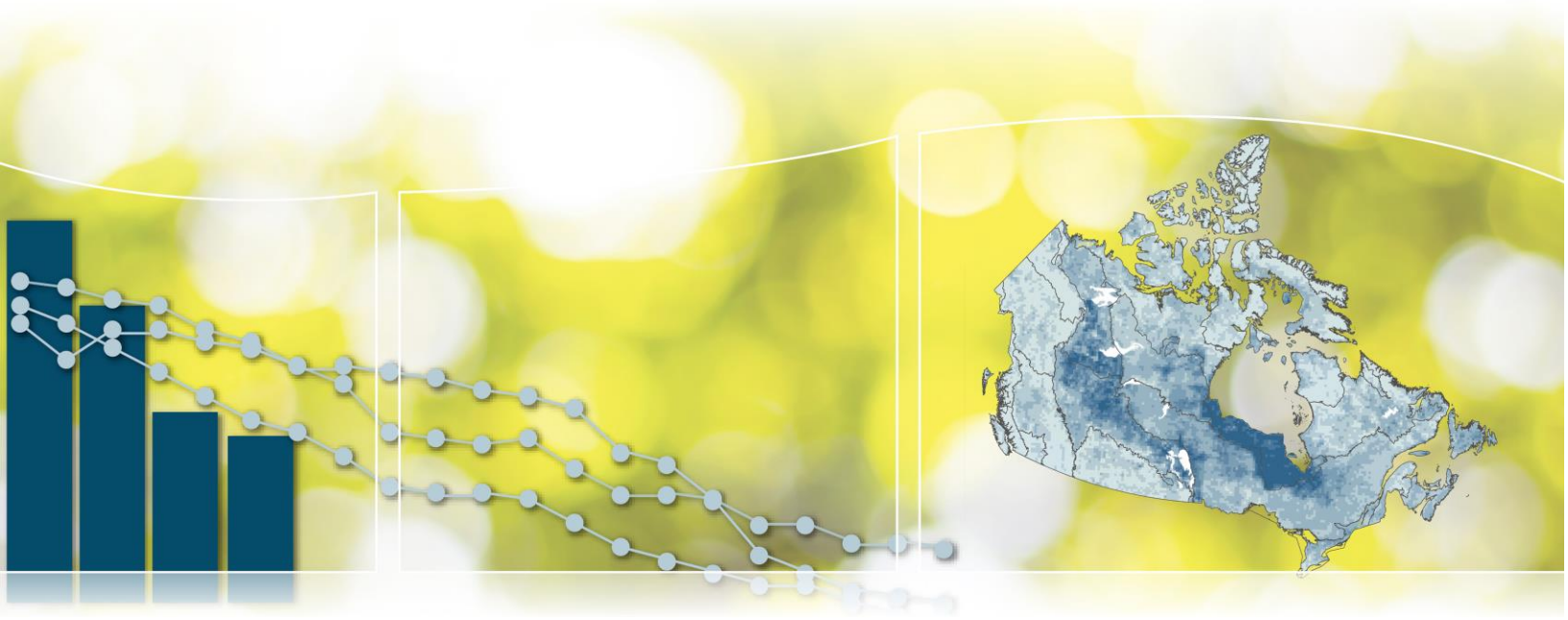
Environment and Climate Change Canada
Environnement et Changement climatique Canada

# Canadian Environmental Sustainability Indicators

# Air Quality



Canada

**Suggested citation for this document:** Environment and Climate Change Canada (2016) Canadian Environmental Sustainability Indicators: Air Quality. Consulted on *Month day, year*. Available at: www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=7DCC2250-1.

Cat. No.: En4-144/57-2016E-PDF
ISBN: 978-0-660-06016-3



Environment and Climate Change Canada
Public Inquiries Centre
7th floor, Fontaine Building
200 Sacré-Coeur boul.
Gatineau, QC K1A 0H3
Telephone: 819-938-3860
Toll Free: 1-800-668-6767 (in Canada only)
Fax: 819-994-1412
TTY: 819-994-0736
Email: ec.enviroinfo.ec@canada.ca



Aussi disponible en français

# Canadian Environmental Sustainability Indicators

# Air Quality

**December 2016**

## Table of Contents

**List of Figures**



**List of Tables**

# Part 1. Air Quality Indicators

Air quality can deteriorate due to the presence of one or more air pollutants such as ground-level ozone ($O_3$), sulphur oxides ($SO_X$), nitrogen oxides ($NO_X$), volatile organic compounds (VOCs) and solid and liquid particles called fine particulate matter ($PM_{2.5}$). Ground-level ozone and $PM_{2.5}$ are the main components of smog. The levels of these pollutants in outdoor air are influenced by many factors, including the proximity to local emission sources, weather conditions, chemical reactions in the air and the transport of air pollutants over long distances by winds.

The Air Quality indicators provide information on the outdoor concentrations of five air pollutants: $PM_{2.5}$, $O_3$, sulphur dioxide ($SO_2$), nitrogen dioxide ($NO_2$) and VOCs. These air pollutants were selected because they are among the pollutants that most Canadians are exposed to and they can cause adverse health and environmental effects. Some of them also contribute to the formation of acid deposition.

The $PM_{2.5}$ and the $O_3$ peak air quality indicators are reported relative to the associated 2015 Canadian Ambient Air Quality Standards (the Standards).[1] In May 2013, the Standards were established as objectives under the Canadian Environmental Protection Act, 1999.

## Summary

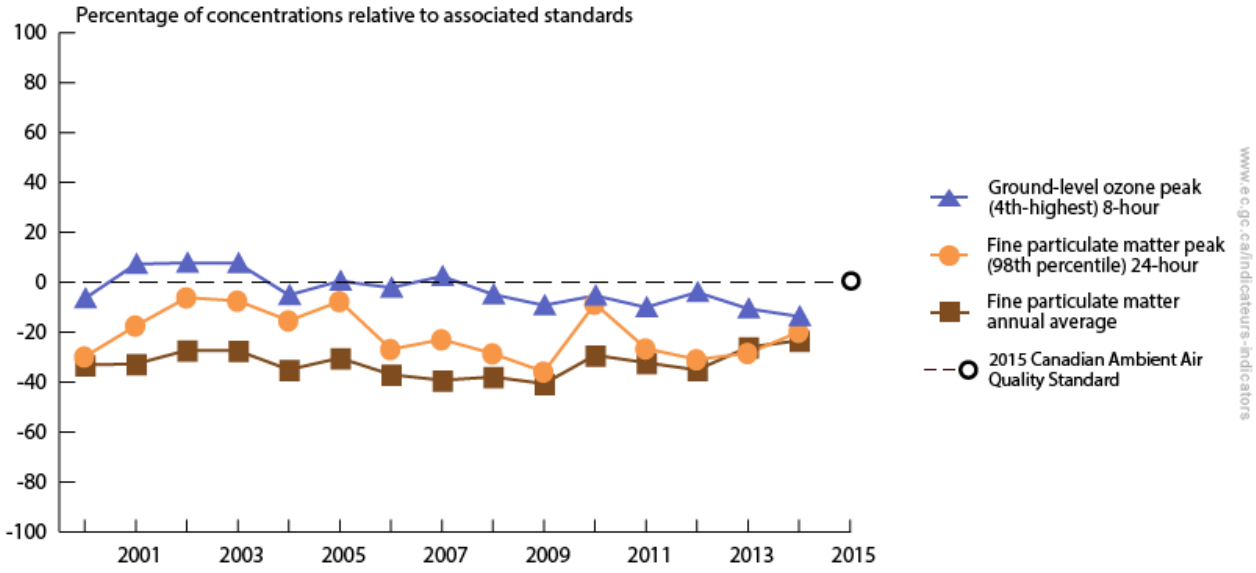
Between 2000 and 2014, the two national indicators of $PM_{2.5}$, the annual average and peak (98th percentile) 24-hour, were below the 2015 Standards.

In 2014 the $PM_{2.5}$ annual average and peak (98th percentile) indicators were 23% and 20% below the respective 2015 Standards.

The national $O_3$ peak (4th-highest) 8-hour indicator was close to the Standard from 2000 to 2007 and dropped below it from 2008 to 2014. In 2014, the $O_3$ peak indicator was 14% below the 2015 Standard.

[1] Consult the Canadian Ambient Air Quality Standards section in the Data Sources and Methods for details.

**Figure 1. Fine particulate matter and ground-level ozone air quality indicators relative to the 2015 Canadian Ambient Air Quality Standards, Canada, 2000 to 2014**




Data for Figure 1

**Note:** The horizontal dashed line at 0% represents the 2015 Canadian Ambient Air Quality Standard for each indicator and is shown for indicative purposes only. New fine particulate matter monitoring equipment was progressively introduced across Canada to replace older monitoring equipment from the mid-2000's to 2014. These new instruments measure a portion (semi-volatile) of the fine particulate matter mass not captured by the older instruments. Due to the differences between the new and the old monitoring equipment, concentrations measured with the new monitors may not be directly comparable with measurements from years in which older instruments were used.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program and the Canadian Air and Precipitation Monitoring Network.

## Ambient Levels of Fine Particulate Matter

Fine particulate matter ($PM_{2.5}$) is composed of minute solid particles and tiny liquid droplets that remain suspended in air. It is emitted directly to air from cars, trucks, home firewood-burning, industry, forest fires and waste burning. It can also form in air as a result of reactions involving pollutants such as sulphur oxides, nitrogen oxides, volatile organic compounds and ammonia. Along with ground-level ozone, $PM_{2.5}$ is one of the two major components of smog. When inhaled deeply into the lungs, even small amounts of $PM_{2.5}$ can cause serious health problems (e.g., cardiovascular and respiratory diseases).[2] Fine particulate matter can damage vegetation and structures, contribute to haze, and reduce visibility.

[2] See the Air Health Indicator for more information on health problems related to $PM_{2.5}$.

There are two national $PM_{2.5}$ indicators, which are aligned with the 2015 Canadian Ambient Air Quality Standards (the Standards).[3]

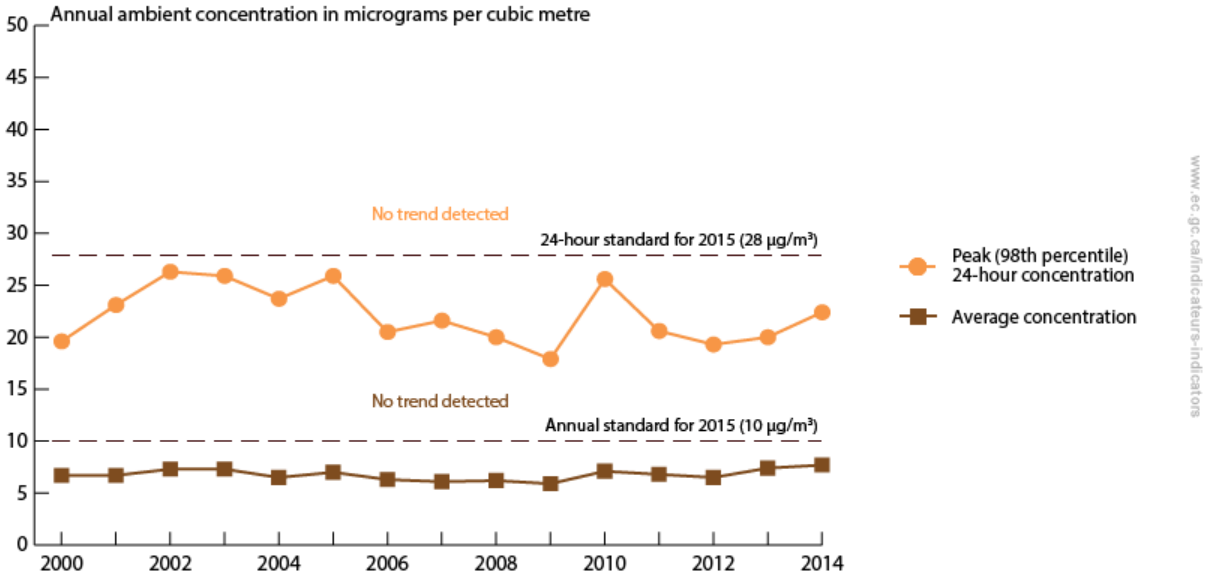
1. An annual average concentration indicator that is based on the annual average of the daily 24-hour average concentrations for $PM_{2.5}$ is used to capture prolonged or repeated exposures over longer periods or chronic exposure.
2. An annual peak 24-hour indicator that is based on the 98th percentile of the daily 24-hour average concentrations for $PM_{2.5}$ is used to capture immediate or acute short-term exposures.

## National ambient levels of fine particulate matter

In 2014, the national annual average concentration of $PM_{2.5}$ was 7.7 micrograms per cubic metre ($\mu g/m^3$), or 4% higher than in 2013. The annual peak (98th percentile) 24-hour concentration of $PM_{2.5}$ in 2014 was 22.4 $\mu g/m^3$, or 12% higher than in 2013.

Between 2000 and 2014, both indicators were below the 2015 Standards and no significant trend was found. Some of the factors that may have contributed to the concentration changes include variations in weather conditions that influence $PM_{2.5}$ formation, dispersion, regional transport and variation in transboundary pollution from the United States, and the progressive introduction of monitoring equipment[4] based on newer technologies.

**Figure 2. Fine particulate matter concentrations, Canada, 2000 to 2014**




Data for Figure 2

[3] For $PM_{2.5}$, there are two Standards: an annual standard and a 24-hour standard. The metric of the annual standard is defined as the 3-year average of the annual average concentrations. The metric of the 24-hour standard is defined as the 3-year average of the annual 98th percentile of the daily 24-hour average concentrations. The two $PM_{2.5}$ indicators are aligned with these standards, with the exception that while the Standards are based on 3-year averages, the two $PM_{2.5}$ indicators presented here are calculated as 1-year averages.

[4] Fine particulate matter monitoring equipment based on newer technologies was deployed across the National Air Pollution Surveillance program to replace older instruments. This deployment began in mid-2000's and was completed in 2013. These newer monitors measure a portion (semi-volatile) of the $PM_{2.5}$ mass that was not captured by the older instruments. As such, concentrations measured with the new monitors may not be directly comparable with the measurements from years in which older instruments were used. For more information, consult the Data Sources and Methods section.

**Note:** The national annual average fine particulate matter concentration indicator is based on annual average concentrations recorded at 69 monitoring stations across Canada. The national annual peak (98th percentile) 24-hour fine particulate matter indicator is based on the average of the 98th percentile of the daily 24-hour average concentrations recorded at 73 monitoring stations across Canada. The horizontal dashed lines represent the value of the 2015 Canadian Air Ambient Quality Standards. The Canadian Air Ambient Quality Standards are shown for indicative purposes only and not for evaluation of the achievement status of the standards. New fine particulate matter monitoring equipment was progressively introduced across Canada to replace older monitoring equipment from the mid-2000's to 2013. These new instruments measure a portion (semi-volatile) of the fine particulate matter mass not captured by the older instruments. Due to the differences between the new and the old monitoring equipment, concentrations measured with the new monitors may not be directly comparable with measurements from years in which older instruments were used.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

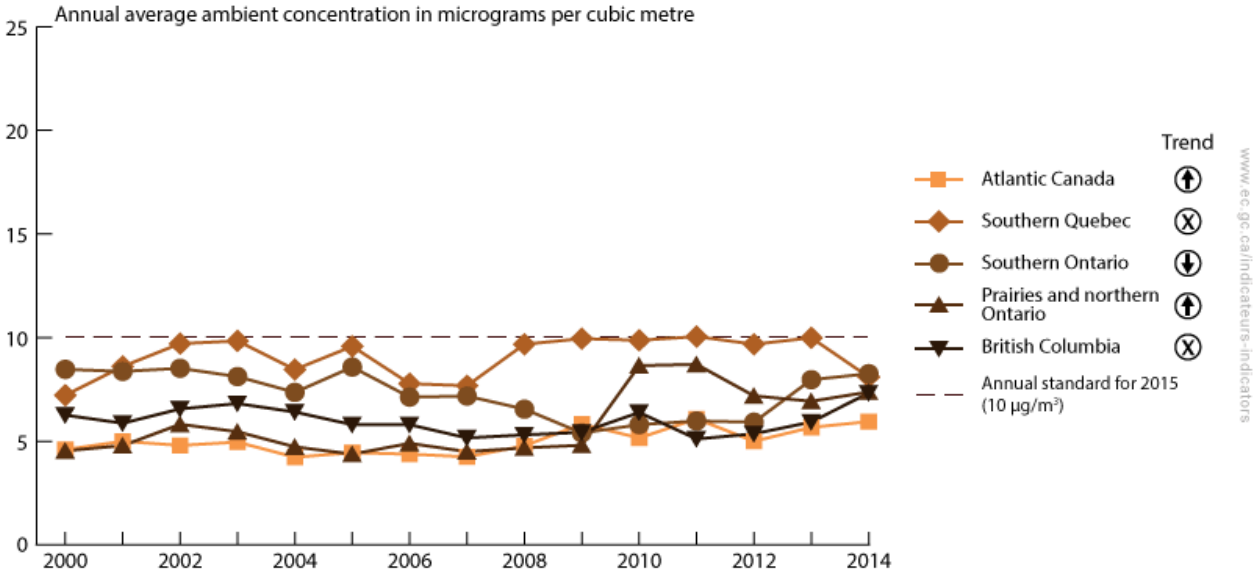
## Regional ambient levels of fine particulate matter

## Annual average concentration

In 2014, average $PM_{2.5}$ concentrations for all regions were below the 2015 Standard. The region with the highest concentration of $PM_{2.5}$ was southern Ontario with 8.3 µg/m$^3$, while Atlantic Canada had the lowest concentration at 6.0 µg/m$^3$. In southern Quebec, the annual average concentration of $PM_{2.5}$ in 2014 was 19% lower than in 2013, while all other regions experienced levels between 4% to 24% higher than in 2013.

Since 2000, annual average $PM_{2.5}$ concentrations have consistently remained below the 2015 Standard across all regions of Canada. An exception occurred in 2011, when the concentration was above the standard in the southern Quebec region. Increasing concentration trends were detected for Atlantic Canada (0.10 µg/m$^3$ per year) and the Prairies and northern Ontario (0.18 µg/m$^3$ per year) regions. A decreasing trend of 0.20 µg/m$^3$ per year was found for southern Ontario. No trends were detected for southern Quebec and British Columbia.

**Figure 3. Regional average fine particulate matter concentrations, Canada, 2000 to 2014**




Data for Figure 3

**Note:** The annual average fine particulate matter concentration indicator is based on annual average concentrations recorded at 6 monitoring stations in Atlantic Canada, 10 in southern Quebec, 25 in southern Ontario, 14 in the Prairies and northern Ontario and 14 in British Columbia. The horizontal dashed line

represents the value of the annual standard of the 2015 Canadian Ambient Air Quality Standards. The Canadian Ambient Air Quality Standard is shown for indicative purposes only and not for evaluation of the achievement status of the standard. New fine particulate matter monitoring equipment was progressively introduced across Canada to replace older monitoring equipment from the mid-2000's to 2013. These new instruments measure a portion (semi-volatile) of the fine particulate matter mass not captured by the older instruments. Due to of the differences between the new and the old monitoring equipment, concentrations measured with the new monitors may not be directly comparable with measurements from years in which older instruments were used.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

## Annual peak (98th percentile) 24-hour concentration

In 2014, the annual peak (98th percentile) 24-hour concentrations of $PM_{2.5}$[5] in each region were below the 2015 Standard. The highest concentration was found in the Prairies and northern Ontario region at 25.6 µg/m$^3$, or 22% higher than in 2013. This was followed closely by British Columbia[6] with 24.8 µg/m$^3$, or 53% higher than in 2013. Atlantic Canada had the lowest annual peak concentration of $PM_{2.5}$ with 13.8 µg/m$^3$ in 2014, 16% lower than in 2013.

Since 2000, all annual peak $PM_{2.5}$ concentrations for Atlantic Canada, the Prairies and northern Ontario region and British Columbia were below the 2015 Standard, except for British Columbia in 2010 and the Prairies and northern Ontario region in 2011. For these two exceptions, the concentrations were above the standard largely due to forest fire activity. In southern Quebec, the concentrations were below the 2015 Standard for 53% of the reported years, including the most recent year, 2014. In southern Ontario,[7] the concentrations fell below the standard in 2006 and have remained below it ever since.

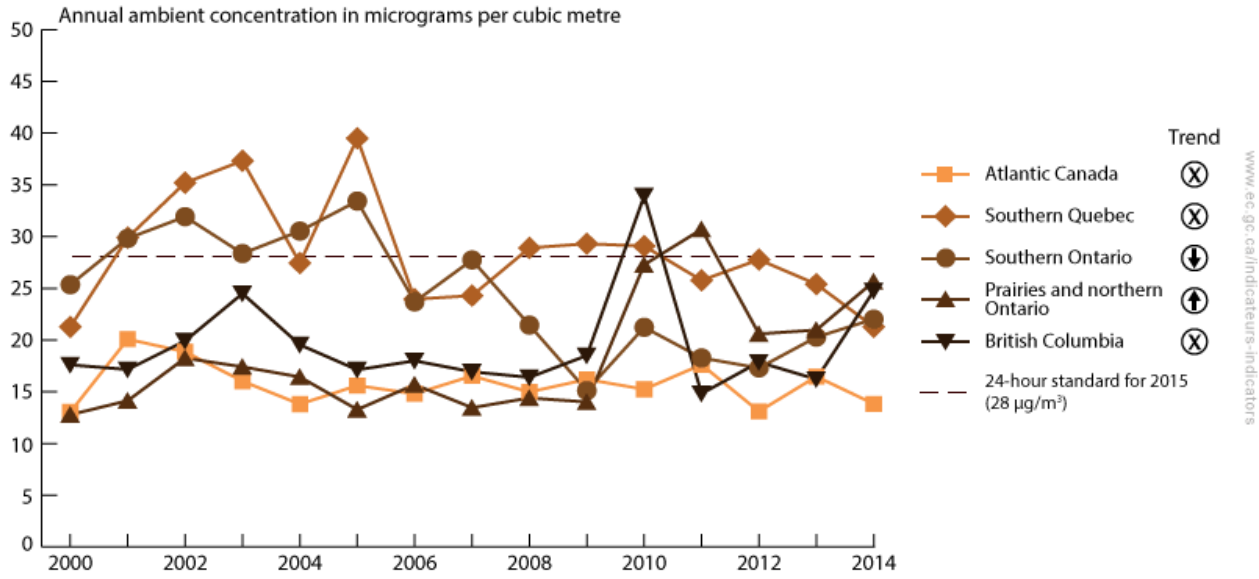
No trends were detected for Atlantic Canada, southern Quebec and British Columbia. A decreasing trend of 0.95 µg/m$^3$ per year was found in southern Ontario, while an increasing trend was detected in the Prairies and northern Ontario region (0.63 µg/m$^3$ per year).

[5] Fine particulate matter monitoring equipment based on newer technologies was deployed across the National Air Pollution Surveillance program to replace older instruments. This deployment began in mid-2000's and was completed in 2013. These newer monitors measure a portion (semi-volatile) of the $PM_{2.5}$ mass that was not captured by the older instruments. As such, concentrations measured with the new monitors may not be directly comparable with the measurements from years in which older instruments were used. For more information, consult the Data Sources and Methods section.

[6] In 2013, British Columbia and Metro Vancouver began to transition their entire $PM_{2.5}$ monitoring network to new equipment. These new instruments measure a portion (semi-volatile) of the $PM_{2.5}$ mass not captured by the older instruments.

[7] In 2013, Ontario transitioned its entire $PM_{2.5}$ monitoring network to new equipment. These new instruments measure a portion (semi-volatile) of the $PM_{2.5}$ mass not captured by the older instruments.

**Figure 4. Regional peak fine particulate matter concentrations, Canada, 2000 to 2014**




Data for Figure 4

**Note:** The annual peak (98th percentile) 24-hour fine particulate matter indicator is based on the average of the 98th percentile of the daily 24-hour average concentrations recorded at 6 monitoring stations in Atlantic Canada, 12 in southern Quebec, 27 in southern Ontario, 14 in the Prairies and northern Ontario and 14 in British Columbia. The horizontal dashed line represents the value of the 24 hour standard of the 2015 Canadian Ambient Air Quality Standards. The Canadian Ambient Air Quality Standard is shown for indicative purposes only and not for evaluation of the achievement status of the standard. New fine particulate matter monitoring equipment was progressively introduced across Canada to replace older monitoring equipment from the mid-2000's to 2013. These new instruments measure a portion (semi-volatile) of the fine particulate matter mass not captured by the older instruments. Due to the differences between the new and the old monitoring equipment, concentrations measured with the new monitors may not be directly comparable with measurements from years in which older instruments were used.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

## Ambient levels of fine particulate matter at monitoring stations

The National Air Pollution Surveillance program measures air pollutant concentrations at monitoring stations across Canada. The Canadian Environmental Sustainability Indicators provide this information through an interactive indicator map. With the interactive map, you can drill down to the average $PM_{2.5}$ concentrations and peak $PM_{2.5}$ concentrations at specific monitoring stations.

# Ambient Levels of Ozone

Ozone ($O_3$) in the upper atmosphere (10 to 50 kilometres above the earth's surface) protects the earth from the sun's harmful ultraviolet radiation. In the lower atmosphere and at ground level, $O_3$ is harmful to human health. It can cause breathing problems, reduce lung function and aggravate asthma and other lung diseases.[8] Ozone is not directly emitted, but is formed in the lower atmosphere when precursor gases such as nitrogen oxides ($NO_X$) and volatile organic compounds (VOCs) react in sunlight. Ground-level $O_3$ is one of two major components of summertime smog, the other being fine particulate matter. Ground-level $O_3$ can damage vegetation, and materials such as rubber.

There are two national $O_3$ indicators:

1. An annual average concentration indicator that is based on the annual average concentrations (of the daily maximum 8-hour averages) is used to capture prolonged or repeated exposures over longer periods or chronic exposure.
2. An annual peak (4th-highest) 8-hour indicator that is based on the annual 4th-highest daily maximum 8-hour average concentrations is used to capture immediate or acute short-term exposure. The peak $O_3$ indicator is calculated using an approach that is aligned with the 2015 Canadian Ambient Air Quality Standards (the Standards).[9]

## National ambient levels of ozone

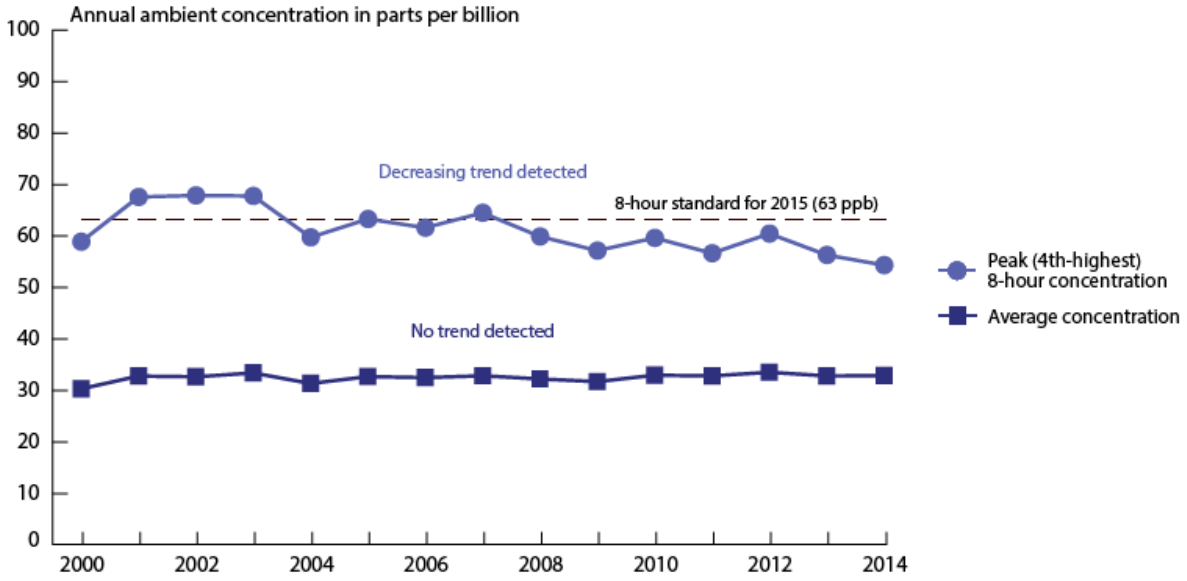
In 2014, the national annual average concentration of ground-level $O_3$ was 32.9 parts per billion (ppb), or 0.1% higher than in 2013. The annual peak (4th-highest) 8-hour $O_3$ concentration in 2014 was 53.4 ppb, or 3.5% lower than in 2013. Although the annual peak concentration of $O_3$ was frequently above the 2015 Standard before 2008, it has consistently been below for the last seven years.

Since 2000, a decreasing trend of 0.82 ppb per year was detected in the peak $O_3$ concentration. No trend was detected in the annual average $O_3$ concentration. The reduction in emissions of ground-level $O_3$ precursor gases ($NO_X$ and VOCs) from Canada and the United States is an important factor in this downward trend.

[8] See the Air Health Indicator for more information on health problems related to $O_3$.

[9] For $O_3$, there is one Canadian Ambient Air Quality Standard, which is based on an 8-hour averaging period. The metric of the standard is defined as the 3-year average of the annual 4th-highest daily maximum 8-hour average concentrations. The peak (4th-highest) 8-hour $O_3$ indicator is aligned with the $O_3$ standard, with the exception that, while the standard is based on a 3-year average, the peak $O_3$ indicator is only calculated for a single calendar year.

**Figure 5. Ozone concentrations, Canada, 2000 to 2014**




Data for Figure 5

**Note:** The national annual average ozone concentration indicator is based on the annual average of the daily maximum 8-hour average concentrations recorded at 142 monitoring stations across Canada. The national annual peak (4th-highest) 8-hour ozone indicator is based on the average of the 4th-highest daily maximum 8-hour average concentrations recorded at 146 monitoring stations across Canada. The horizontal dashed line represents the value of the 8-hour standard of the 2015 Canadian Ambient Air Quality Standards. The Canadian Ambient Air Quality Standard is shown for indicative purposes only and not for evaluation of the achievement status of the standard.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program and the Canadian Air and Precipitation Monitoring Network.

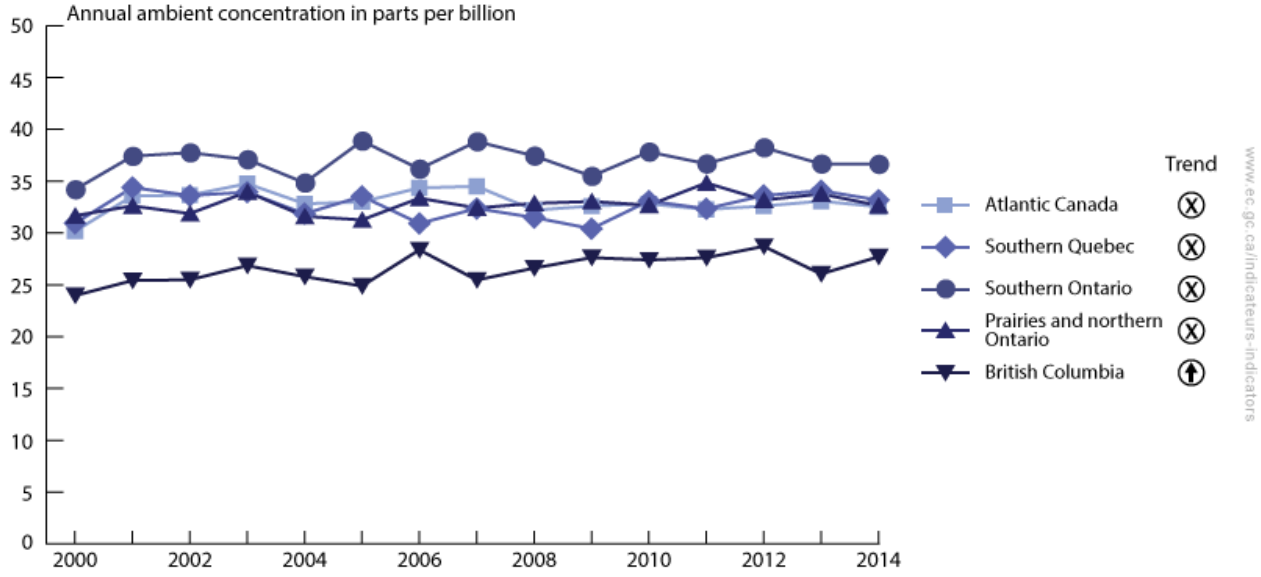
## Regional ambient levels of ozone

### Annual average concentration

In 2014, the annual average concentrations of $O_3$ in the air varied by region from 27.7 ppb in British Columbia to 36.6 ppb in southern Ontario. Annual average concentrations were lower in 2014 than in 2013 for all regions except British Columbia, where it was 6% higher.

Since 2000, an increasing trend of 0.21 ppb per year was detected in the annual average concentration of $O_3$ in the region of British Columbia. No trends were detected in the other regions.

**Figure 6. Regional average ozone concentrations, Canada, 2000 to 2014**




Data for Figure 6

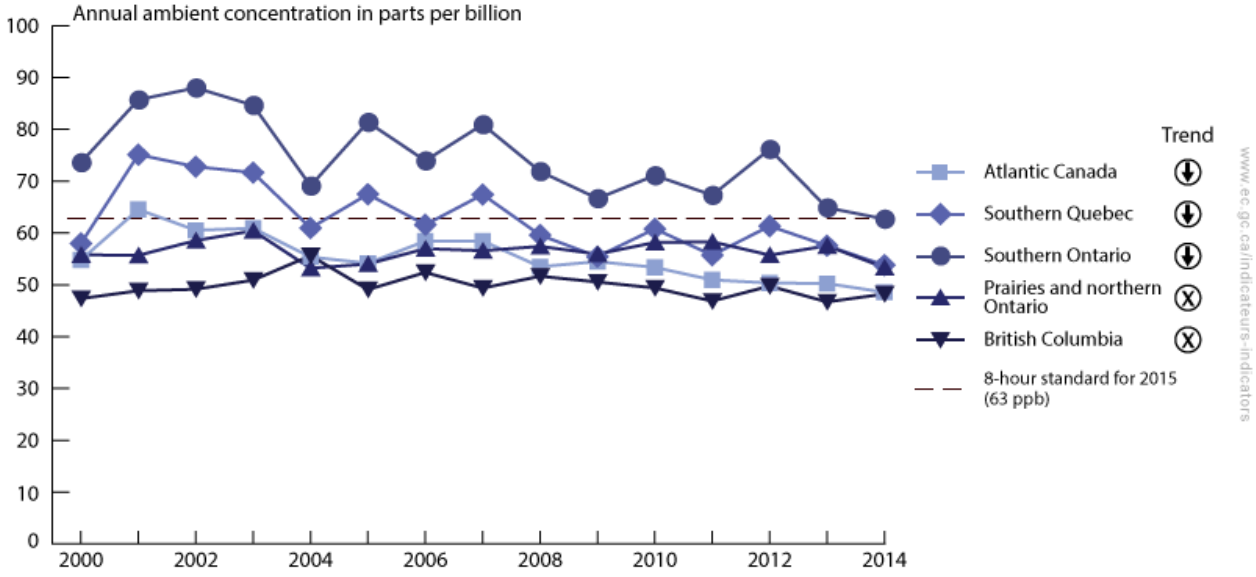
**Note:** The annual average ozone concentration indicator is based on the annual average of the daily maximum 8-hour average concentrations recorded at 17 monitoring stations in Atlantic Canada, 37 in southern Quebec, 34 in southern Ontario, 24 in the Prairies and northern Ontario and 29 in British Columbia.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program and the Canadian Air and Precipitation Monitoring Network.

## Annual peak (4th-highest) 8-hour concentration

In 2014, the highest annual peak (4th-highest) 8-hour concentration of $O_3$ was recorded in southern Ontario at 62.7 ppb. British Columbia recorded the lowest concentration level at 48.2 ppb, or 3% higher than in 2013. Annual peak concentrations of $O_3$ were 3% to 7% lower in the four other regions compared to 2013.

Since 2000, the annual peak concentrations of $O_3$ were below the 2015 Standard for the Prairies and northern Ontario region, British Columbia and Atlantic Canada, with the exception of Atlantic Canada in 2001. From 2008 to 2014, the annual peak concentrations of $O_3$ were also below the 2015 Standard in southern Quebec. The annual peak concentrations for southern Ontario were above the standard for all years, except 2014. From 2000 to 2014, decreasing trends of 1.0 ppb, 1.2 ppb and 1.4 ppb per year were detected for Atlantic Canada, southern Quebec and southern Ontario, respectively. No trends were detected for British Columbia and the Prairies and northern Ontario region.

**Figure 7. Regional peak ozone concentrations, Canada, 2000 to 2014**




Data for Figure 7

**Note:** The annual peak (4th-highest) 8-hour ozone indicator is based on the average of the 4th-highest daily maximum 8-hour average concentrations recorded at 19 monitoring stations in Atlantic Canada, 37 in southern Quebec, 36 in southern Ontario, 24 in the Prairies and northern Ontario and 29 in British Columbia. The horizontal dashed line represents the value of the 8-hour standard of the 2015 Canadian Ambient Air Quality Standards. The Canadian Ambient Air Quality Standard is shown for indicative purposes only and not for evaluation of the achievement status of the standard.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program and the Canadian Air and Precipitation Monitoring Network.

## Ambient levels of ozone at monitoring stations

The National Air Pollution Surveillance and the Canadian Air and Precipitation Monitoring Network programs measure air pollutant concentrations at monitoring stations across Canada. The Canadian Environmental Sustainability Indicators provide this information through an interactive indicator map. With the interactive map, you can drill down to the average $O_3$ concentrations and peak $O_3$ concentrations at specific monitoring stations.

# Ambient Levels of Sulphur Dioxide

Sulphur dioxide ($SO_2$) belongs to a group of sulphur-containing gases called sulphur oxides ($SO_X$). Representing most of the $SO_X$ released from human activities, $SO_2$ is emitted when a fuel or raw material containing sulphur is burned or used in industrial processes, such as metal ore smelting. The major sources of sulphur oxide emissions in Canada are the combustion of fuel for electricity generation and heating, and processes in both the non-ferrous smelting and refining industry and the oil and gas industry. Sulphur dioxide emissions contribute to acid deposition and are a major precursor to fine particulate matter. High concentrations of $SO_2$ can adversely affect the respiratory systems of humans and animals and can damage vegetation.

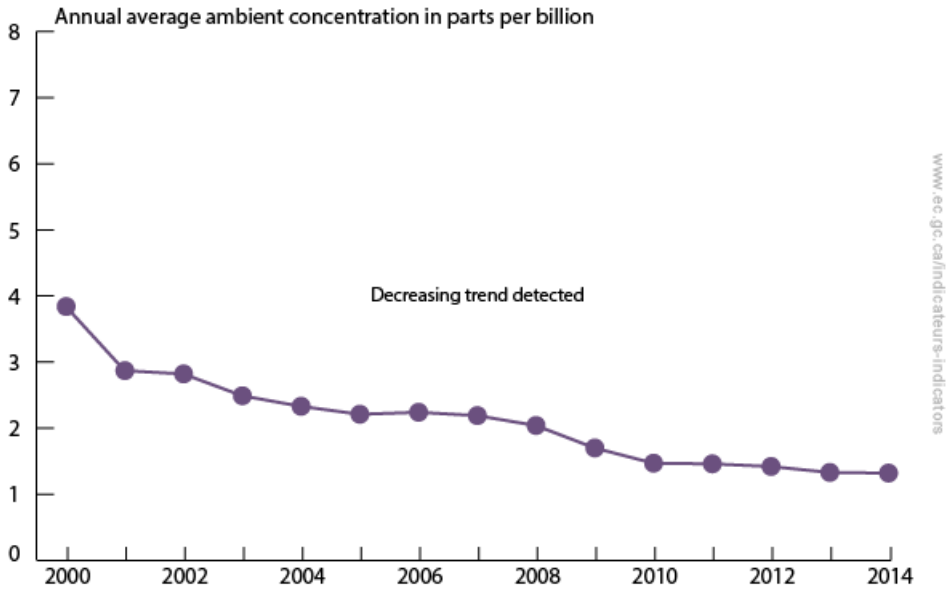
The annual average $SO_2$ concentration indicators are based on the annual average of hourly $SO_2$ concentrations.

## National ambient levels of sulphur dioxide

In 2014, the national annual average concentration of $SO_2$ was 1.3 parts per billion (ppb), a level similar to 2013.

Since 2000, a decreasing trend of 0.13 ppb per year has been detected. This trend was mainly due to reductions in sulphur oxide emissions in Canada and the United States, resulting from efforts to curb acid rain and ambient particulate matter. Efforts included the implementation of federal regulations on sulphur content in fuels.

**Figure 8. Sulphur dioxide concentrations, Canada, 2000 to 2014**




Data for Figure 8

**Note:** The national annual average sulphur dioxide concentration indicator is based on the hourly concentrations recorded at 63 monitoring stations across Canada. The location of monitoring stations near emission sources may affect measured sulphur dioxide levels.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

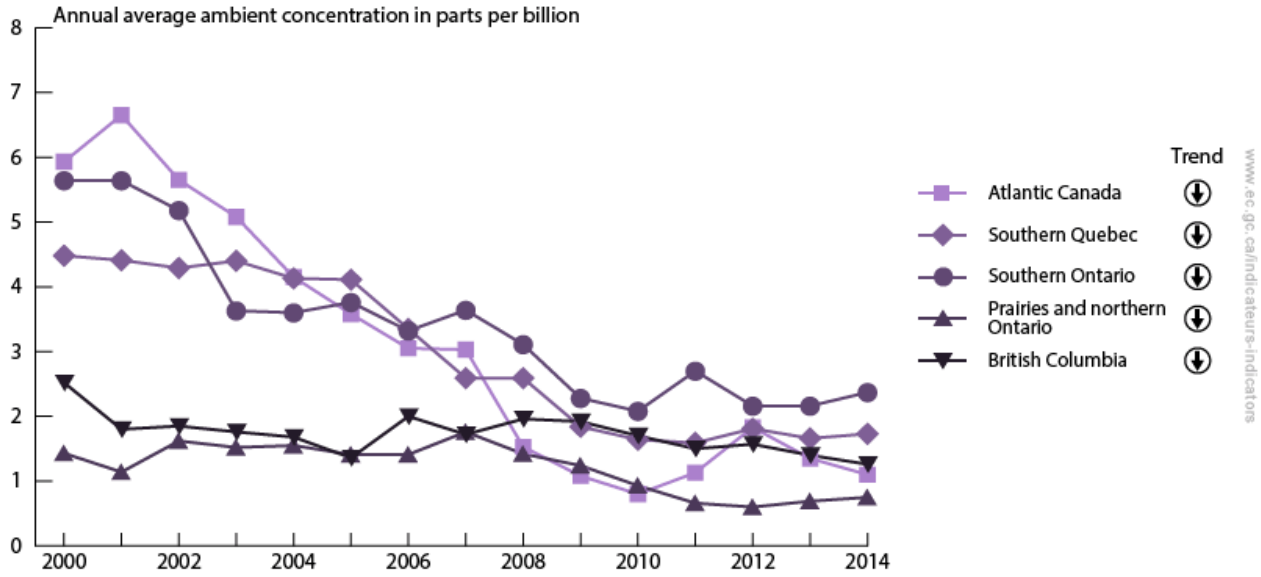
## Regional ambient levels of sulphur dioxide

In 2014, the annual average concentrations of $SO_2$ in the air varied by region from 0.8 ppb in the Prairies and northern Ontario region to 2.4 ppb in southern Ontario. Concentrations of

$SO_2$ in 2014 were lower than in 2013 for Atlantic Canada and British Colombia, and higher or similar in the other three regions.

Since 2000, decreasing trends in $SO_2$ concentrations were observed for all regions of Canada. Decreasing trends of 0.44 ppb and 0.25 ppb per year were detected for Atlantic Canada and the southern Quebec regions, respectively. Southern Ontario had a decreasing trend of 0.24 ppb per year, while decreasing trends of 0.07 ppb and 0.04 ppb per year were observed for the Prairies and northern Ontario region and British Columbia, respectively.

**Figure 9. Regional sulphur dioxide concentrations, 2000 to 2014**




Data for Figure 9

**Note:** The annual average sulphur dioxide concentration indicator is based on the hourly concentrations recorded at 4 monitoring stations in Atlantic Canada, 8 in southern Quebec, 10 in southern Ontario, 18 in the Prairies and northern Ontario and 22 in British Columbia. The location of monitoring stations near emission sources may affect measured sulphur dioxide levels.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

## Ambient levels of sulphur dioxide at monitoring stations

The National Air Pollution Surveillance program measures air pollutant concentrations at monitoring stations across Canada. The Canadian Environmental Sustainability Indicators provide this information through an interactive indicator map. With the interactive map, you can drill down to $SO_2$ concentrations at specific monitoring stations.

# Ambient Levels of Nitrogen Dioxide

Nitrogen dioxide ($NO_2$) belongs to a group of substances called nitrogen oxides ($NO_X$).[10] Nitrogen oxides are emitted into the atmosphere from high-temperature combustion processes such as vehicle engines, power plants and industrial processes. The major sources of nitrogen oxides in Canada are on-road and off-road vehicles, the oil and gas industry, and the use of fuel for electricity generation and heating. Nitrogen dioxide plays an important role in the formation of ozone in the atmosphere. It is a precursor to fine particulate matter, and contributes to acid deposition and eutrophication. Nitrogen dioxide also has adverse health effects: it can irritate the lungs, decrease lung function and increase susceptibility to allergens for people with asthma.

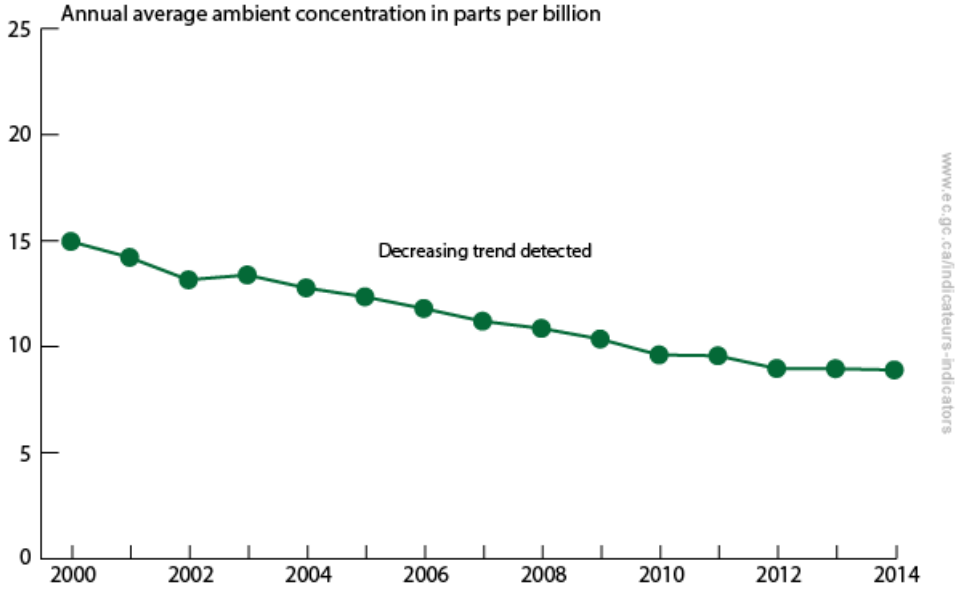
The annual average $NO_2$ concentration indicators are based on the annual average of hourly $NO_2$ concentrations.

## National ambient levels of nitrogen dioxide

In 2014, the national annual average concentration of $NO_2$[11] was 8.9 parts per billion (ppb), or 0.7% lower than in 2013.

Since 2000, a decreasing trend of 0.5 ppb per year was detected. This was largely due to the federal government introducing progressively more stringent emissions standards that led to $NO_X$ emission reductions from cars and trucks.

**Figure 10. Nitrogen dioxide concentrations, Canada, 2000 to 2014**




Data for Figure 10

**Note:** The national annual average nitrogen dioxide concentration indicator is based on the annual average of the hourly concentrations recorded at 85 monitoring stations across Canada.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

[10] Although the majority of the emitted $NO_X$ is nitrogen oxide (NO), once in the air NO reacts with volatile organic compounds and ozone to form $NO_2$.

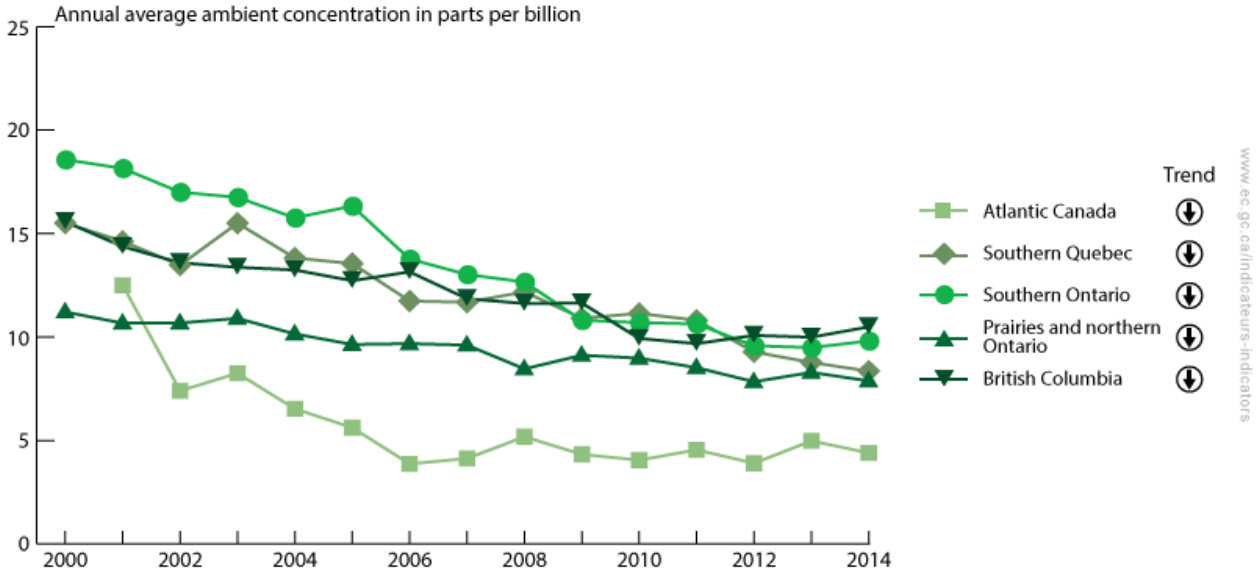
[11] Nitrogen dioxide is not directly measured by the monitors. The $NO_2$ indicator is estimated by subtracting the NO measured concentration from the $NO_X$ measured concentration.

## Regional ambient levels of nitrogen dioxide

In 2014, the annual average concentrations of $NO_2$ in the air varied from 4.4 ppb in Atlantic Canada to 10.5 ppb in British Columbia. Concentrations of $NO_2$ were lower in Atlantic Canada, southern Quebec and the Prairies and northern Ontario region than in 2013. However, concentrations were higher in southern Ontario and British Columbia in 2014 compared to the previous year.

Since 2000, decreasing trends in $NO_2$ concentrations were observed for all regions in Canada. Southern Ontario had the largest decreasing trend at 0.7 ppb per year, followed by southern Quebec and British Columbia with 0.5 ppb per year and 0.4 ppb per year, respectively. Atlantic Canada had a decreasing trend of 0.3 ppb per year, while the Prairies and northern Ontario region had a decreasing trend of 0.2 ppb per year.

**Figure 11. Regional nitrogen dioxide concentrations, 2000 to 2014**




Data for Figure 11

**Note:** The annual average nitrogen dioxide concentration indicator is based on the annual average of the hourly concentrations recorded at 5 monitoring stations in Atlantic Canada, 14 in southern Quebec, 20 in southern Ontario, 21 in the Prairies and northern Ontario and 25 in British Columbia. There was no value for the Atlantic Canada region in 2000 because there were only two stations with reported concentrations. At least three stations are required to report a concentration value for a given year.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

## Ambient levels of nitrogen dioxide at monitoring stations

The National Air Pollution Surveillance program measures air pollutant concentrations at monitoring stations across Canada. The Canadian Environmental Sustainability Indicators provide this information through an interactive indicator map. With the interactive map, you can drill down to $NO_2$ concentrations at specific monitoring stations.

# Ambient Levels of Volatile Organic Compounds[12]

Volatile organic compounds (VOCs) are carbon-containing gases and vapours such as gasoline fumes and solvents.[13] Volatile organic compounds are emitted to air by natural sources (e.g., vegetation, forest fires), as well as from human activity (e.g., emissions from the oil and gas industry, solvent usage and transportation). Although VOC emissions from natural sources are higher during the vegetation-growing season, human activities are the main contributors of VOCs in urban areas. A number of VOCs are classified as toxic air pollutants under the Canadian Environmental Protection Act, 1999 because they can cause cancer and other serious health problems. While there are hundreds of VOC species in the outdoor air, only those that are considered important contributors to ozone formation and/or potentially toxic are routinely measured by the National Air Pollution Surveillance program.[14]

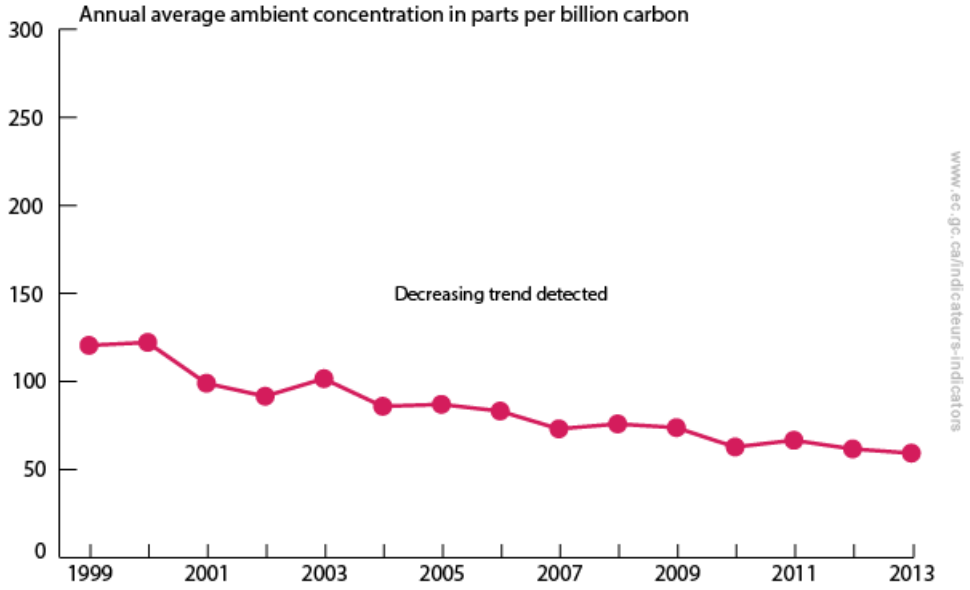
The annual average VOC concentration indicators are based on the annual average of daily VOC concentrations.

## National ambient levels of volatile organic compounds

In 2013, the national annual average concentration of VOCs in the air was 59.3 parts per billion carbon (ppbC), or 4% lower than in 2012.

From 1999 to 2013, a decreasing trend of 3.7 ppbC per year was detected in VOC concentrations. This is consistent with the reduction of VOC emissions from cars and trucks, resulting from the introduction of more stringent emissions standards and reduction measures related to the production and use of solvents and paints.

**Figure 12. Volatile organic compound concentrations, Canada, 1999 to 2013**




Data for Figure 12

[12] At the time of compiling the Air Quality indicators the volatile organic compounds (VOC) concentrations for 2014 were not available. The VOC indicators in this document are the same as previously published.

[13] Volatile organic compounds do not include carbon dioxide, carbon monoxide, methane or chlorofluorocarbons.

[14] For a complete list of the VOCs measured consult Annex E.

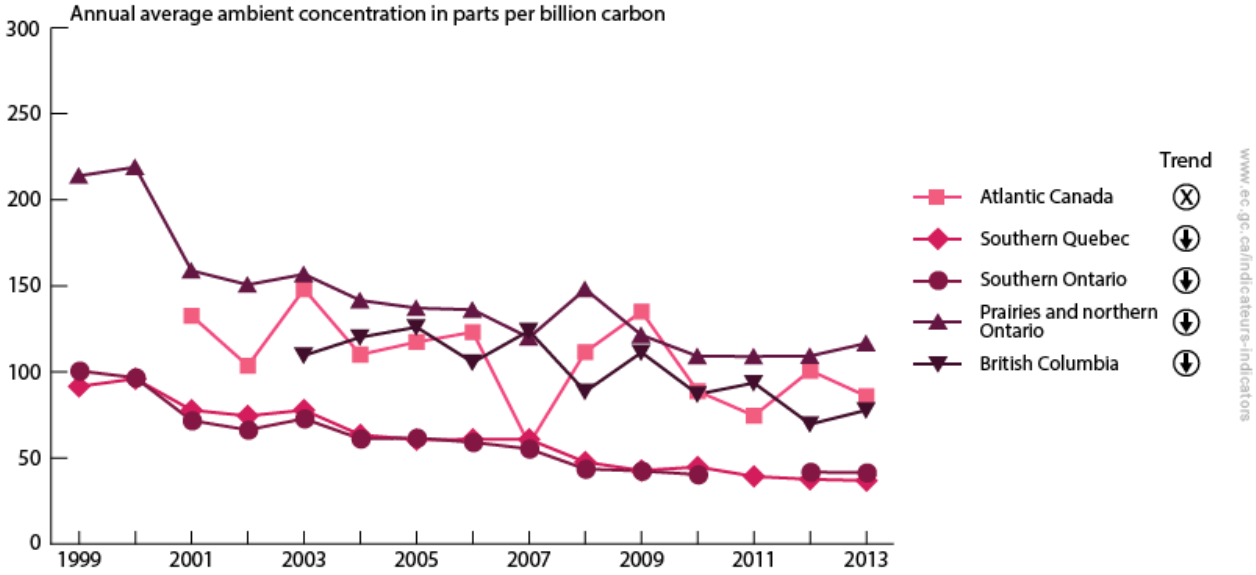
**Note:** The national annual average volatile organic compound concentration indicator is based on the annual average of the daily concentrations recorded at 34 monitoring stations across Canada.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

## Regional ambient levels of volatile organic compounds

In 2013, annual average concentrations of VOCs in the air vary from 36.8 ppbC in southern Quebec to 116.6 ppbC in the Prairies and northern Ontario region. Concentrations of VOCs in 2013 were lower than in 2012 in Atlantic Canada, southern Quebec and southern Ontario and higher in the other two regions.

Decreasing trends were observed for all regions in Canada, except for Atlantic Canada where no trend was detected. From 1999 to 2013, decreasing trends of 4.1 ppbC, 3.8 ppbC, 5.4 ppbC and 4.6 ppbC per year were detected for southern Quebec, southern Ontario, the Prairies and northern Ontario region and British Columbia (Metro Vancouver), respectively.

**Figure 13. Regional volatile organic compound concentrations, Canada, 1999 to 2013**




Data for Figure 13

**Note:** The annual average volatile organic compound concentration indicator is based on the annual average of the daily concentrations recorded at 5 monitoring stations in Atlantic Canada, 9 in southern Quebec, 12 in southern Ontario, 5 in the Prairies and northern Ontario and 3 in British Columbia. At least three stations are required to report a concentration value for a given year. There were no values for 1999 and 2000 in Atlantic Canada and for 1999 to 2002 in British Columbia because there were only two stations with reported concentrations. For southern Ontario, no data were available for 2011.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

## Ambient levels of volatile organic compounds at monitoring stations

The National Air Pollution Surveillance program measures air pollutant concentrations at monitoring stations across Canada. The Canadian Environmental Sustainability Indicators provide this information through an interactive indicator map. With the interactive map, you can drill down to VOC concentrations at specific monitoring stations.

Safe and healthy communities

This indicator supports the measurement of progress towards the long-term goal of the 2016–2019 Federal Sustainable Development Strategy: All Canadians live in clean, sustainable communities that contribute to their health and well-being.

# Part 2. Data Sources and Methods for the Air Quality Indicators

## Introduction

The Air Quality indicators are part of the Canadian Environmental Sustainability Indicators (CESI) program, which provides data and information to track Canada's performance on key environmental sustainability issues. These indicators are also used to report and measure progress towards the goals of the 2016–2019 Federal Sustainable Development Strategy.

## Description and rationale of the Air Quality indicators

### Description

The Air Quality indicators track ambient concentrations of fine particulate matter ($PM_{2.5}$), ground-level ozone ($O_3$), sulphur dioxide ($SO_2$), nitrogen dioxide ($NO_2$), and volatile organic compounds (VOC) at the national and regional level and at local monitoring stations.

**Table 1. Air Quality indicators definitions**

| Pollutant | Indicator | Indicator form | Concentration measurement unit[A] |
|---|---|---|---|
| $PM_{2.5}$ | Annual average | Annual average of the daily 24-hour average concentrations | $\mu g/m^3$ |
| $PM_{2.5}$ | Peak (98th percentile) 24-hour | Annual 98th percentile of the daily 24-hour average concentrations | $\mu g/m^3$ |
| $O_3$ | Annual average | Annual average of the daily maximum 8-hour average concentrations | ppb |
| $O_3$ | Peak (4th-highest) 8-hour | Annual 4th-highest of the daily maximum 8-hour average concentrations | ppb |
| $SO_2$ | Annual average | Annual average of the hourly concentrations | ppb |
| $NO_2$ | Annual average | Annual average of the hourly concentrations | ppb |
| VOC | Annual average | Annual average of the daily 24-hour average concentrations | ppbC |

**Note:** [A] Units: $\mu g/m^3$ = micrograms per cubic metre, ppb = parts per billion, ppbC = parts per billion carbon.

### Canadian Ambient Air Quality Standards

In October 2012, the Ministers of the Environment, with the exception of Quebec,[15] agreed to begin implementing the new Air Quality Management System. The Air Quality Management System provides a comprehensive, cross-Canada framework for collaborative action to further protect human health and the environment through continuous improvement of air quality. The drivers for air quality management across the country are the Canadian Ambient Air Quality Standards (the Standards). The Standards are health- and environment-based air quality objectives for pollutant concentrations in outdoor air. Together with the management levels,[16] the Standards act as a benchmark to support continuous improvement of air quality. In May 2013, the Federal government established the Standards as objectives under the Canadian Environmental Protection Act, 1999.

Calculations of the Air Quality indicators follow the same data-handling conventions as those used for calculating the Standards' values. It is important to note that the achievement of the Standards for $PM_{2.5}$ and $O_3$ is calculated using three-year averages of the measured concentrations at the local level, while the indicator values are calculated at the national and regional levels using a single year only. As such, comparison of the indicator values to the Standards is provided for indicative purposes only and not for assessing whether the Standards are achieved. Table 2 provides details of the standards.

**Table 2. Canadian Ambient Air Quality Standards for fine particulate matter and ground-level ozone**

| Pollutant | Averaging time | 2015 Standard (numerical value) | 2020 Standard (numerical value) | Metric |
|---|---|---|---|---|
| $PM_{2.5}$ | 24-hour (calendar day) | 28 µg/m$^3$ | 27 µg/m$^3$ | The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations |
| $PM_{2.5}$ | Annual (calendar year) | 10.0 µg/m$^3$ | 8.8 µg/m$^3$ | The 3-year average of the annual average concentrations |
| $O_3$ | 8-hour | 63 ppb | 62 ppb | The 3-year average of the annual 4th-highest daily maximum 8-hour average concentrations |

## Rationale

Canadians are exposed to air pollutants on a daily basis, and this exposure can cause adverse health and environmental effects. Fine particulate matter and $O_3$, two of the most widespread air pollutants, are key components in the formation of smog. Exposure to these pollutants, even at low concentrations, has been associated with pulmonary and cardiovascular diseases. Furthermore, science indicates that there is no known threshold that does not cause adverse health effects for these two pollutants.

[15] Although it will not implement Air Quality Management System, Quebec supports its general objectives and collaborates with other jurisdictions on developing some elements of the system, notably air zones and airsheds.

[16] Management levels refer to the air zone management framework and threshold values level. More information can be found in the Canadian Council of Ministers of the Environment's Guidance document on air zone management (PDF; 226 KB).

While causing adverse health effects of its own, $SO_2$ also contributes to the formation of $PM_{2.5}$ and acid deposition. Similarly, $NO_2$ contributes to the formation of $O_3$, $PM_{2.5}$, acid deposition and eutrophication. Volatile organic compounds are one of the main contributors to $O_3$ and also contribute to the formation of $PM_{2.5}$. There are thousands of individual VOC species. Some of the VOCs are defined as toxic under the Canadian Environmental Protection Act, 1999. Over a life-time, exposure to these pollutants can increase the risk of developing cancer and other serious health issues.

These indicators are state/condition indicators intended to inform decision-makers and the public about the state of the environment and progress towards improved ambient air quality in Canada.

### Recent changes to the indicators

The stations used to calculate the indicators vary slightly between editions of the indicators. For more information, consult Table 9 in the Revisions to station selections section. Some air quality data of previous years were reassessed and corrected. Volatile organic compound concentrations were not updated in this edition due to data not being available at the time of compilation of the indicators.

## Data

### Data source

The Air Quality indicators are calculated from the concentrations stored in the Canada-wide Air Quality Database maintained by Environment and Climate Change Canada's National Air Pollution Surveillance Program. The Canada-wide Air Quality Database contains data collected through the following monitoring networks:

1. The National Air Pollution Surveillance Network, a collaboration established in 1969 between Environment and Climate Change Canada and provincial, territorial and municipal (Metro Vancouver and Montréal) environmental agencies.
2. For ground-level ozone, the Canadian Air and Precipitation Monitoring Network operated by Environment and Climate Change Canada. The Canadian Air and Precipitation Monitoring Network stations were established to research and monitor air pollution outside urban areas.
3. Other provincial, territorial and municipal monitoring stations that report their air quality data to the Canada-wide Air Quality Database.

### Spatial coverage

Air quality monitoring stations are spread across the country, but are more concentrated in urban areas.[17] The indicators for fine particulate matter ($PM_{2.5}$), ground-level ozone ($O_3$), sulphur dioxide ($SO_2$), nitrogen dioxide ($NO_2$) and volatile organic compounds (VOCs) are provided nationally and by region. Table 3 lists the regions used for these indicators. See Annex B for the full list of stations used to calculate the national and regional indicators.

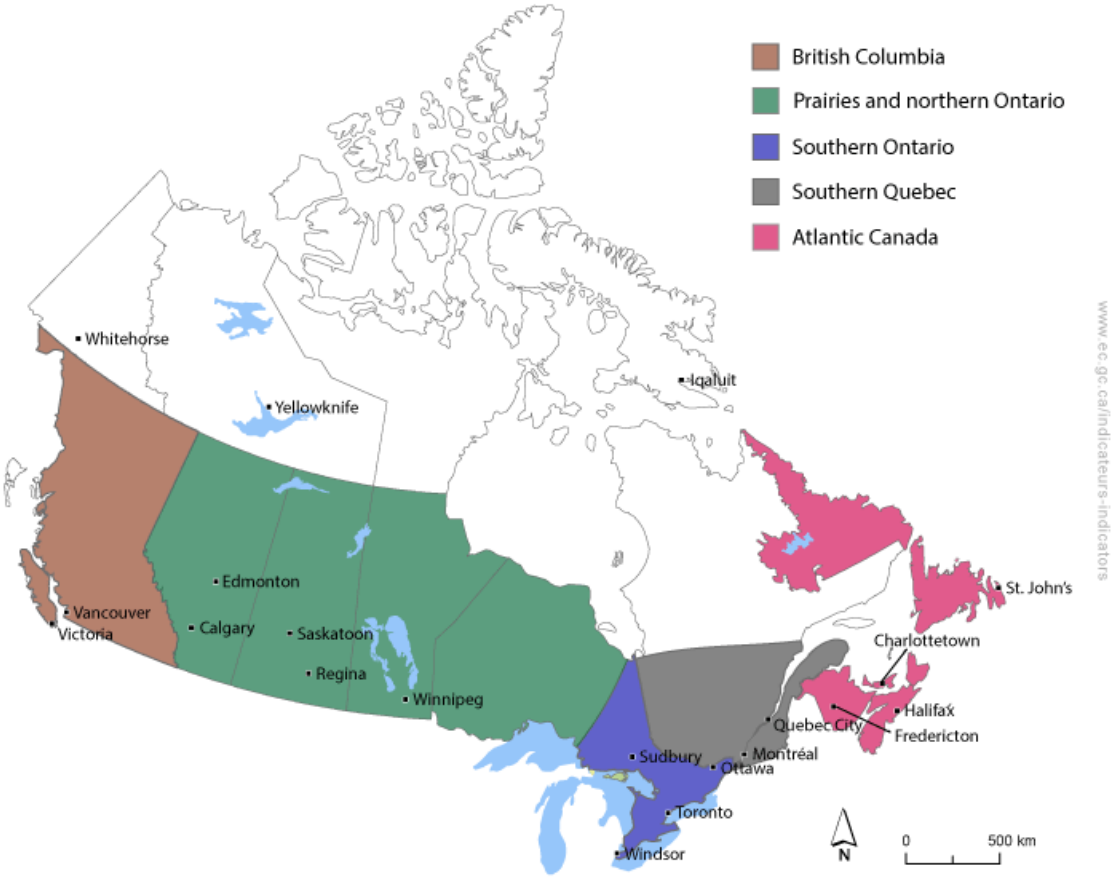
[17] An urban area is defined as an area with a population of at least 1000 and no fewer than 400 persons per square kilometre.

**Table 3. Regions used for the regional Air Quality indicators**

| Region | Region code |
|---|---|
| Atlantic Canada | ATL |
| Southern Quebec | SQC |
| Southern Ontario | SON |
| Prairies and northern Ontario | PNO |
| British Columbia[A] | BCO |

**Note:** [A] For VOCs, only stations from the metro Vancouver area were available to be used for the British Columbia regional indicator.

**Figure 14. Regions used for the regional Air Quality indicators**




Ambient levels of $PM_{2.5}$, $O_3$, $SO_2$, $NO_2$ and VOC by monitoring station are also shown in the Canadian Environmental Sustainability Indicators interactive indicator maps.

## Temporal coverage

The Air Quality indicators were calculated for the most recent fifteen years with available data (from 2000 to 2014 for $O_3$, $PM_{2.5}$, $SO_2$ and $NO_2$, and from 1999 to 2013 for VOCs). Although minute-by-minute data are recorded by some monitoring instruments, only hourly average readings are transmitted and stored as the working data in the Canada-wide Air Quality Database.

## Data completeness

The monitoring stations do not all have the same time series of data available, nor have they all been operating continuously over the reported time series. There are a number of reasons for this, including short-term technical problems, maintenance and routine repairs, calibration and checks, and the commissioning or decommissioning of stations. However, data gaps for short periods have little effect on long-term averages at individual stations. Stations with excessive data gaps are excluded using specific data completeness criteria (see the Data completeness criteria section).

## Data timeliness

There is usually a 15-month lag between the last year of data available and the compilation of the Air Quality indicators. This lag is due to several factors, including data verification, transmission of the data into the Canada-wide Air Quality Database, compilation at the national level from all partners, and data analysis, review and reporting. The validation of approximately 44 000 measurements at a single station measuring all five pollutants is required for each year of data used for the compilation of the indicators.

# Methods

## Data quality assurance and quality control

Monitoring agencies contributing to the National Air Pollution Surveillance Program all strive to adhere to established quality assurance and quality control standards, developed by Environment and Climate Change Canada in consultation with provincial and territorial environmental agencies.

Controlling data quality requires the identification of the appropriate data quality indicators and of methodologies that can provide estimates of these indicators. The key data quality indicators for the National Air Pollution Surveillance network are:

- Representativeness, referring to the degree to which data measurements represent a pollutant concentration of interest.
- Comparability, a measure of confidence with which one data set or method can be compared to another at other participating National Air Pollution Surveillance sites across Canada.
- Accuracy or the measurement of the overall agreement of a measurement to a known value. Accuracy can include measures of agreement among repeated measurements (precision) and measures of positive or negative systematic errors (bias).
- Completeness or the assessment as to whether enough information is being collected to ensure confidence in the conclusion or decisions made with data.

**Table 4. Accuracy data quality indicator for fine particulate matter, ground-level ozone, sulphur dioxide, nitrogen dioxide monitors and volatile organic compound samples**

| Parameter | Accuracy |
|---|---|
| Fine particulate matter | ± 15% |
| Ground-level ozone | ± 15% |
| Sulphur dioxide | ± 15% |
| Nitrogen dioxide | ± 15% |
| Volatile organic compounds | Species-dependent |

Routine assessments of network operations are used to provide a level of confidence that the monitoring systems and data processing procedures are within an acceptable level of data quality to meet the National Air Pollution Surveillance guidelines and to identify where improvements might be necessary. Three main streams of audits and assessment are used in the National Air Pollution Surveillance network:

- Performance and systems audits, which are conducted externally either by an Environment and Climate Change Canada auditor or by another agency separate from the monitoring agency. These audits are performed using independently verified reference standards, and provide an unbiased quantitative assessment to defend the quality of the data.
- Interagency measurement program, which involve analysis by the monitoring agency of an unknown sample concentration provided by Environment and Climate Change Canada. These tests help verify instrument accuracy, and help determine data comparability across sites.
- Data quality assessments, which involve the statistical analysis of environmental data to determine if collected and reported data are meeting network and data quality objectives.

Additional audits/assessments are also performed by Environment and Climate Change Canada's air quality laboratories in Ottawa for the analysis of manual/integrated VOC samples.

## Data collection and validation

Data obtained from National Air Pollution Surveillance monitoring stations are converted to a format compatible for entry into the Canada-wide Air Quality Database. All data in the Canada-wide Air Quality Database have a comparable level of quality, because jurisdictions adhere to established quality assurance and quality control procedures as outlined in the National Air Pollution Surveillance Quality Assurance and Quality Control Guidelines. Some of these procedures include site and sampling system design, use of monitoring methods which meet defined minimum performance specifications, operation, maintenance and calibrations, and data validation techniques. National Air Pollution Surveillance monitoring organizations are responsible for reporting quality-assured data, as per the specifications in the Guidelines, to the Canada-wide Air Quality Database.

## Data completeness criteria

The following criteria are used to determine which stations have sufficient hourly and daily measurements in each year to be considered valid for inclusion in the indicators. In general, they follow the same criteria as those found in the Canadian Council of Ministers of the Environment's Guidance Document on Achievement Determination: Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone.

For fine particulate matter ($PM_{2.5}$):

- A valid day has data for at least 18 hours (75%); and
- A station is included only when
    - at least 75% of days in the year are valid; and
    - at least 60% of days in each quarter (three months)[18] of a calendar year are valid.

[18] The quarters are: quarter one from January 1 to March 31; quarter two from April 1 to June 30; quarter three from July 1 to September 30 and quarter four from October 1 to December 31.

For the peak (98th percentile) 24-hour $PM_{2.5}$ indicator, a station is also included if it exceeds the 24-hour standard of 28.0 micrograms per cubic metre ($\mu g/m^3$), even if the above data completeness criteria are not satisfied.

For ground-level ozone ($O_3$):

- A valid 8-hour period has data for at least 6 hours (75%);
- A valid day requires data for at least 18 hours (75%); and
- A station is included only when at least 75% of days in the combined second and third quarters (April 1 to September 30) are valid.

For the peak (4th-highest) 8-hour $O_3$ indicator, a station is also included if it exceeds the 8-hour standard of 63 parts per billion (ppb), even if the above data completeness criteria are not satisfied.

For sulphur dioxide ($SO_2$) and nitrogen dioxide ($NO_2$):

- A valid month requires that at least 50% of the hours have valid measurements;
- A valid quarter (three months) requires data for at least two valid months; and
- A station is included only if 50% of hours in year are valid and has four valid quarters.

There are fewer data for volatile organic compounds (VOCs), and therefore data completeness criteria are different. At urban monitoring stations, VOC samples are usually collected over a 24-hour period once every six days, and, at rural stations, samples are collected over a 4-hour sampling period (12:00 to 16:00) once every three days. For VOCs, data completeness criteria are as follows:

- A valid day requires data for a consecutive 24 hours in an urban station and for a consecutive 4 hours in a rural station;
- A valid quarter (three months) requires data for at least five samples; and
- A station is included only if the year has three valid quarters.

**Table 5. Number of stations that satisfied the data completeness criteria for 2014**

| Air pollutant | Number of stations |
|---|---|
| Peak (98th percentile) 24-hour $PM_{2.5}$ | 172 |
| Annual average $PM_{2.5}$ | 177 |
| Peak (4th-highest) 8-hour $O_3$ | 191 |
| Annual average $O_3$ | 191 |
| $SO_2$ | 107 |
| $NO_2$ | 135 |
| VOCs[A] | 45 |

**Note:** [A] Value for VOCs is for 2013 because the 2014 information was not available at the time of update.

After the data completeness criteria have been applied, the pollutant concentrations are calculated for the selected stations.

## Pollutant-specific calculations

### Fine particulate matter

The $PM_{2.5}$ annual average and annual peak (98th percentile) 24-hour indicators are based on the 24-hour daily average concentrations (daily average) for the whole year. The daily average value for $PM_{2.5}$ is measured from midnight to midnight.

For a given station, the annual average indicator is calculated by summing all valid daily averages and dividing by the number of valid days. The annual peak (98th percentile) 24-hour indicator is obtained by determining the 98th percentile value of all 24-hour daily values for a given year. The 98th percentile value corresponds to the concentration for which 98% of all the daily 24-hour values are less than it and 2% are greater than or equal to it. For example, the 98th percentile value of 25 µg/m$^3$ at a given station means that, of all daily 24-hour average concentrations, 98% were less than 25 µg/m$^3$, and that only 2% were equal to or greater than 25 µg/m$^3$. Table 6 provides the rank of the 98th percentile value depending on the number of available daily measurements.

**Table 6. 98th percentile rank based on the number of available measurements[19]**

| Number of available daily measurements in a year | 98th percentile rank |
|---|---|
| 274–300 | 6th highest |
| 301–350 | 7th highest |
| 351–366 | 8th highest |

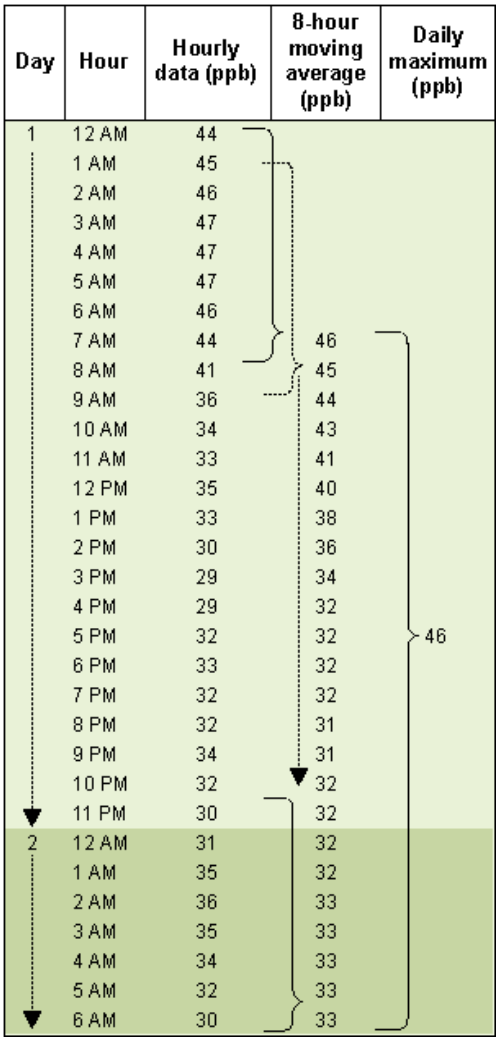
The regional and national indicators (annual average and annual peak [98th percentile] 24-hour) for $PM_{2.5}$ are calculated by averaging the station-level annual average and station-level annual peak values, respectively, for selected stations within either the region or throughout Canada.

### Ground-level ozone

Ozone concentrations are calculated in parts per billion (ppb). There are 24 consecutive 8-hour average concentrations (8-hour rolls) that can be possibly calculated for each day. The highest value of the 24 averaged concentrations is the daily maximum. See Figure 15 for an illustration of the 8-hour averages.

[19] To obtain the 98th percentile values in this table, the calculation method proposed in section 4.1.2 of the Canadian Council of Ministers of the Environment's Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone (PDF; 264 KB) was used.

**Figure 15. Calculation of the ground-level ozone daily maximum 8-hour average concentration**



| Day | Hour | Hourly data (ppb) | 8-hour moving average (ppb) | Daily maximum (ppb) |
|---|---|---|---|---|
| 1 | 12 AM | 44 | | |
| | 1 AM | 45 | | |
| | 2 AM | 46 | | |
| | 3 AM | 47 | | |
| | 4 AM | 47 | | |
| | 5 AM | 47 | | |
| | 6 AM | 46 | | |
| | 7 AM | 44 | 46 | |
| | 8 AM | 41 | 45 | |
| | 9 AM | 36 | 44 | |
| | 10 AM | 34 | 43 | |
| | 11 AM | 33 | 41 | |
| | 12 PM | 35 | 40 | |
| | 1 PM | 33 | 38 | |
| | 2 PM | 30 | 36 | |
| | 3 PM | 29 | 34 | |
| | 4 PM | 29 | 32 | |
| | 5 PM | 32 | 32 | 46 |
| | 6 PM | 33 | 32 | |
| | 7 PM | 32 | 32 | |
| | 8 PM | 32 | 31 | |
| | 9 PM | 34 | 31 | |
| | 10 PM | 32 | 32 | |
| | 11 PM | 30 | 32 | |
| 2 | 12 AM | 31 | 32 | |
| | 1 AM | 35 | 32 | |
| | 2 AM | 36 | 33 | |
| | 3 AM | 35 | 33 | |
| | 4 AM | 34 | 33 | |
| | 5 AM | 32 | 33 | |
| | 6 AM | 30 | 33 | |

For each station, the annual average $O_3$ indicator is calculated by taking the average of the daily maximum 8-hour averages from January 1 to December 31. The regional and national annual averages for $O_3$ are obtained by averaging the station-level annual averages for selected stations within either the region or throughout Canada, respectively.

For each station, the annual peak (4th-highest) 8-hour $O_3$ indicator is based on the 4th-highest of the daily maximum 8-hour average concentrations measured over a given year. All of the daily maximum 8-hour average concentrations are ordered in an array from highest to lowest, with equal values repeated as often as they occur. Each value is assigned a rank. For that year, the 4th-highest ranking value in the array is identified as the annual peak (4th-highest) 8-hour $O_3$ concentration for that station. The regional and national annual peak $O_3$ indicators are obtained by averaging all 4th-highest values from selected stations within the region and throughout Canada, respectively.

**Sulphur dioxide, nitrogen dioxide and volatile organic compounds**

The $SO_2$, $NO_2$ and urban VOC station indicators are calculated from daily average concentrations (24-hour average concentrations) and rural VOC station indicators are calculated from daily 4-hour average concentrations. The daily 24-hour average concentrations are based on measurements taken from midnight to midnight. For a station, the annual average indicator is calculated by taking the average of the daily concentrations throughout a given year.

The regional and national annual average indicators for $SO_2$, $NO_2$ and VOCs are obtained by averaging the station-level annual averages from selected stations within the region and throughout Canada, respectively.

While the concentration unit for individual VOCs is usually parts per billion volume (ppb), parts per billion carbon (ppbC) is used in this indicator to assess the quantity of mixed VOC species.

Because of data availability issues, the regional southern Ontario VOC annual average was not estimated for 2011.

## Station selection criteria for inclusion in national and regional indicators (time-series)

Station-level indicators were calculated for the years 2000 to 2014 for all air pollutants except VOC, for which indicators were calculated for the years 1999 to 2013. Each station was then assessed for its suitability (sufficient data, no large gaps at the beginning or end) for inclusion in the national and regional time series. The specific criteria are as follows:

- For the national and regional time series, a station is included if it satisfies the data completeness criteria described in the Data completeness criteria section for at least 11 of the 15 years.
- Stations are excluded if data are missing for at least two consecutive years at the beginning or end of the time series. This measure avoids use of data from stations that were commissioned or decommissioned at the beginning or end of the time series.

In addition to the time series selection criteria, a minimum of three monitoring stations are required to calculate the indicator for a region, for a given year.

## Imputation

Stations that do not have enough measurements to meet the time series criteria for every year are excluded from the national and regional indicators. However, in some cases, monitoring stations are located close enough to others to allow data from neighbouring stations to be used to supplement missing data. Stations that were moved but remain relatively close to their previous location were also imputed. Annex C provides details on the stations that were used for imputation in the calculation of the time series.

## Station selection results

The following table indicates the number of monitoring stations that satisfied the selection criteria (data completeness and time series) and that were thus included in the national and regional Air Quality indicators for the time series. Further details on the stations selected are available in Annex B.

**Table 7. Number of stations selected for the national and regional Air Quality indicators for 2014**

| Air pollutant | Canada | Atlantic Canada | Southern Quebec | Southern Ontario | Prairies and northern Ontario | British Columbia |
|---|---|---|---|---|---|---|
| Peak (98th percentile) 24-hour $PM_{2.5}$ | 73 | 6 | 12 | 27 | 14 | 14 |
| Average $PM_{2.5}$ | 69 | 6 | 10 | 25 | 14 | 14 |
| Peak (4th-highest) 8-hour $O_3$ | 146 | 19 | 37 | 36 | 24 | 29 |
| Average $O_3$ | 142 | 17 | 37 | 34 | 24 | 29 |
| $SO_2$ | 63 | 4 | 8 | 10 | 18 | 22 |
| $NO_2$ | 85 | 5 | 14 | 20 | 21 | 25 |
| VOCs[A] | 34 | 5 | 9 | 12 | 5 | 3 |

**Note:** [A] Values for 2013. The sum of the regional stations for $SO_2$ and $O_3$ do not match the national $SO_2$ and $O_3$ station number because stations from the Northwest Territories were added to the national totals.

Local (station-level) indicators for $O_3$, $PM_{2.5}$, $SO_2$, $NO_2$ and VOCs are also presented in the Canadian Environmental Sustainability Indicators interactive indicator maps. All stations displayed on the map satisfy the data completeness criteria.

## Monitoring equipment

### Fine particulate matter monitoring equipment

Four types of monitoring equipment are used to monitor ambient $PM_{2.5}$ concentrations:

- Older technology: Rupprecht & Patashnick Tapered element oscillating microbalance (TEOM) monitor.
- Current technology: Thermo Scientific TEOM 1400a with the Series 8500C Filter Dynamics Measurement System (FDMS) monitor.
- Current technology: Met-One BAM-1020 Beta Attenuation Mass monitor.
- Current technology: Thermo Scientific 5030 or 5030i Sharp monitor.

The new technologies have been approved by the United States Environmental Protection Agency as Class III Federal Equivalent Methods and have been deployed across the National Air Pollution Surveillance network replacing older TEOM instruments that have been found to exclude a portion of the $PM_{2.5}$ mass from measurement. Further details on this technological transition are available in Annex D.

### Ground-level ozone monitoring equipment

Ozone measurements are made using ultraviolet photometry. Sample air passes through a beam of light from an ultraviolet lamp, which is absorbed by $O_3$. The amount of ultraviolet light absorbed is proportional to the amount of $O_3$ in the sample.

### Sulphur dioxide monitoring equipment

Sulphur dioxide measurements are made using pulse-fluorescence ultraviolet adsorption instruments. This technology is based on the principle that $SO_2$ molecules absorb ultraviolet light at one wavelength and emit ultraviolet light at a different wavelength. The intensity of the emitted light is proportional to the number of $SO_2$ molecules in the sample gas.

**Nitrogen dioxide monitoring equipment**

Nitrogen dioxide is measured by subtraction following measurement of the total of nitrogen oxide (NO) + $NO_2$ and NO alone with analyzers that reduce nitrogen oxides ($NO_X$) to NO with a catalytic converter, and then use chemiluminescence to measure the gas phase reaction of NO with $O_3$.

**Volatile organic compound monitoring equipment**

The air samples are collected in either 6-litre or 3.2-litre stainless steel canisters. The canisters are then shipped to the Environment and Climate Change Canada analysis laboratory in Ottawa. A combined gas chromatography-flame ionization detector system is used for quantification of VOCs containing 2 carbons, while a combined gas chromatography-mass selective detector system operating in selected ion monitoring mode is used for quantification of VOCs containing 3 to 12 carbons. Approximately 120 VOCs (including a number of biogenic species such as isoprene and pinenes) are targeted for quantification in the samples, but not all VOCs are detectable in each sample. The total concentration of VOCs in parts per billion carbon (ppbC) is calculated from the total mass of all species detected in the sample. The list of VOCs targeted for quantification is provided in Annex E.

## Statistical analysis

Non-parametric statistical tests were carried out on temporal concentration data to detect the presence of a linear trend and, if present, to determine the orientation (positive or negative) and magnitude of the rate of change (slope). The standard Mann-Kendall trend test was used to detect trend presence and orientation, while the Sen's pairwise slope method was used to estimate the slope. Results of the tests are available in Annex F. Both tests were applied to the regional and national levels for data on $O_3$, $PM_{2.5}$, $SO_2$, $NO_2$ and VOCs. A trend was reported when the Mann-Kendall test indicated the presence of a trend at the 95% confidence level over the 15-year time series.

Table 8 presents the rate of change per year (slopes expressed in median annual percentage change, relative to the value in the first year of each time series) for the national and regional Air Quality indicators over the reported time series of 2000–2014 (1999–2013 for VOCs).

**Table 8. Rate of change per year for the national and regional Air Quality indicators, 2000 to 2014**

| Area | $PM_{2.5}$ annual average (median annual percent change) | $PM_{2.5}$ peak (98th percentile) 24-hour (median annual percent change) | $O_3$ annual average (median annual percent change) | $O_3$ peak (4th-highest) 8-hour (median annual percent change) | $SO_2$ annual average (median annual percent change) | $NO_2$ annual average (median annual percent change) | VOCs[B] annual average (median annual percent change) |
|---|---|---|---|---|---|---|---|
| National | [A] | [A] | [A] | -1.22 | -4.35 | -3.18 | -3.38 |
| Atlantic Canada | 2.17 | [A] | [A] | -1.59 | -7.37 | -4.25 | [A] |
| Southern Quebec | [A] | [A] | [A] | -1.67 | -5.18 | -3.17 | -4.62 |
| Southern Ontario | -2.39 | -3.10 | [A] | -1.69 | -4.72 | -3.95 | -4.46 |
| Prairies and northern Ontario | 3.86 | 4.84 | [A] | [A] | -3.95 | -2.08 | -3.11 |
| British Columbia | [A] | [A] | 0.86 | [A] | -2.12 | -2.57 | -3.24 |

**Note:** [A] Indicates that the Mann-Kendall method failed to reject the null hypothesis at the 95% confidence level, meaning a trend was not detected.
[B] Values for 1999 to 2013.

# Caveats and limitations

## Data completeness

Some data collected at stations cannot be used in calculating the indicators because the data do not meet the data completeness criteria (see the Data completeness criteria section). These criteria are based on standard practices supported by expert opinion and are used by a number of organizations, such as the World Health Organization, the Canadian Council of Ministers of the Environment and the United States Environmental Protection Agency. The criteria allow some data gaps.

## Revisions to station selections

Monitoring stations are selected with the help of time series criteria [see the Station selection criteria for inclusion in national and regional indicators (time series section] for the calculation of the Air Quality indicators. Because of these criteria, the number of stations selected may vary from one edition to the next and may change the historical trends. Caution is advised when comparing different editions of the Air Quality indicators.

Table 9 shows the number of stations removed, added or relocated for fine particulate matter ($PM_{2.5}$), ground-level ozone ($O_3$), sulphur dioxide ($SO_2$), nitrogen dioxide ($NO_2$), and volatile organic compound (VOC) indicators. The combined stations column shows the imputed number of stations (see the Imputation section).

**Table 9. Number of stations removed and number of new stations compared to February 2016 release of the Air Quality indicators**

| Air pollutant | Number of stations removed[A] | Number of new or relocated stations | Combined Stations |
|---|---|---|---|
| Peak (98th percentile) 24-hour $PM_{2.5}$ | 5 | 5 | 9 |
| Average $PM_{2.5}$ | 0 | 9 | 10 |
| Peak (4th-highest) 8-hour $O_3$ | 4 | 17 | 20 |
| Average $O_3$ | 1 | 13 | 17 |
| $SO_2$ | 2 | 4 | 9 |
| $NO_2$ | 2 | 7 | 11 |
| VOCs[B] | n/a | n/a | n/a |

**Note:** n/a = not applicable.
[A] These stations no longer respect the time series criteria and were removed from the calculation of the national and regional indicators for the whole time series.
[B] VOCs values (1999 to 2013) are the same than what was previously released in February 2016.

## Effect on trend of new fine particulate matter measurement technologies

Since 2005, the Rupprecht & Patashnick Tapered element oscillating microbalance (TEOM) monitors used in the National Air Pollution Surveillance program have gradually been replaced by newer monitoring technologies (Federal Equivalency Method-approved instruments). Many studies conducted in Canada, the United States and other countries have found that the TEOM monitors under-report concentrations compared with the newer monitors, especially when the air contains a large proportion of semi-volatile particulate matter, which may be the case during cooler seasons when the air contains a greater proportion of ammonium nitrate and semi-volatile organic compounds.

Because of the deployment of these newer monitors across the National Air Pollution Surveillance network, some of the year-to-year variations in the $PM_{2.5}$ air quality indicator may be due, in part, to the introduction of the newer monitoring technologies rather than to changes in actual ambient concentrations only. As such, any trend in $PM_{2.5}$ concentrations may have been masked because of the replacement of TEOM monitors (see Annex D).

# Part 3. Annexes

## Annex A. Data tables for the figures presented in this document

**Table A.1. Data for Figure 1. Fine particulate matter and ground-level ozone air quality indicators relative to the 2015 Canadian Ambient Air Quality Standards, Canada, 2000 to 2014**

| Year | Ground-level ozone peak (4th-highest) 8-hour (relative to the 2015 Standard in percent) | Fine particulate matter annual average (relative to the 2015 Standard in percent) | Fine particulate matter peak (98th percentile) 24-hour (relative to the 2015 Standard in percent) |
|---|---|---|---|
| 2000 | -6.5 | -33.1 | -29.8 |
| 2001 | 7.3 | -32.7 | -17.4 |
| 2002 | 7.8 | -27.3 | -6.2 |
| 2003 | 7.6 | -27.4 | -7.5 |
| 2004 | -5.2 | -35.0 | -15.4 |
| 2005 | 0.5 | -30.4 | -7.7 |
| 2006 | -2.2 | -37.0 | -26.8 |
| 2007 | 2.4 | -39.3 | -23.0 |
| 2008 | -4.9 | -38.0 | -28.6 |
| 2009 | -9.3 | -40.7 | -35.9 |
| 2010 | -5.3 | -29.2 | -8.7 |
| 2011 | -10.1 | -32.3 | -26.6 |
| 2012 | -4.0 | -35.2 | -31.0 |
| 2013 | -10.6 | -26.0 | -28.4 |
| 2014 | -13.7 | -23.4 | -19.9 |

**Note:** New fine particulate matter monitoring equipment was progressively introduced across Canada to replace older monitoring equipment from the mid-2000's to 2014. These new instruments measure a portion (semi-volatile) of the fine particulate matter mass not captured by the older instruments. Due to the differences between the new and the old monitoring equipment, concentrations measured with the new monitors may not be directly comparable with measurements from years in which older instruments were used.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program and the Canadian Air and Precipitation Monitoring Network.

**Table A.2. Data for Figure 2. Fine particulate matter concentrations, Canada, 2000 to 2014**

| Year | Annual average concentration (micrograms per cubic metre) | Annual peak (98th percentile) 24-hour concentration (micrograms per cubic metre) |
|---|---|---|
| 2000 | 6.7 | 19.6 |
| 2001 | 6.7 | 23.1 |
| 2002 | 7.3 | 26.3 |
| 2003 | 7.3 | 25.9 |
| 2004 | 6.5 | 23.7 |
| 2005 | 7.0 | 25.9 |
| 2006 | 6.3 | 20.5 |
| 2007 | 6.1 | 21.6 |
| 2008 | 6.2 | 20.0 |
| 2009 | 5.9 | 17.9 |
| 2010 | 7.1 | 25.6 |
| 2011 | 6.8 | 20.6 |
| 2012 | 6.5 | 19.3 |
| 2013 | 7.4 | 20.0 |
| 2014 | 7.7 | 22.4 |
| **2015 standard** | 10.0 | 28.0 |
| **Annual trend** | No trend | No trend |

**Note:** The national annual average fine particulate matter concentration indicator is based on annual average concentrations recorded at 69 monitoring stations across Canada. The national annual peak (98th percentile) 24-hour fine particulate matter indicator is based on the average of the 98th percentile of the daily 24-hour average concentrations recorded at 73 monitoring stations across Canada. The 2015 Canadian Air Ambient Quality Standards are provided for indicative purposes only and not for evaluation of the achievement status of the standards. New fine particulate matter monitoring equipment was progressively introduced across Canada to replace older monitoring equipment from the mid-2000's to 2013. These new instruments measure a portion (semi-volatile) of the fine particulate matter mass not captured by the older instruments. Due to the differences between the new and the old monitoring equipment, concentrations measured with the new monitors may not be directly comparable with measurements from years in which older instruments were used.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

**Table A.3. Data for Figure 3. Regional average fine particulate matter concentrations, Canada, 2000 to 2014**

| Year | Atlantic Canada annual average concentration (micrograms per cubic metre) | Southern Quebec annual average concentration (micrograms per cubic metre) | Southern Ontario annual average concentration (micrograms per cubic metre) | Prairies and northern Ontario annual average concentration (micrograms per cubic metre) | British Columbia annual average concentration (micrograms per cubic metre) |
|---|---|---|---|---|---|
| 2000 | 4.6 | 7.2 | 8.5 | 4.5 | 6.3 |
| 2001 | 5.0 | 8.6 | 8.4 | 4.8 | 5.9 |
| 2002 | 4.8 | 9.7 | 8.5 | 5.8 | 6.6 |
| 2003 | 5.0 | 9.8 | 8.1 | 5.5 | 6.8 |
| 2004 | 4.2 | 8.5 | 7.4 | 4.7 | 6.4 |
| 2005 | 4.5 | 9.6 | 8.6 | 4.4 | 5.8 |
| 2006 | 4.4 | 7.8 | 7.1 | 4.9 | 5.8 |
| 2007 | 4.3 | 7.7 | 7.2 | 4.5 | 5.2 |
| 2008 | 4.8 | 9.7 | 6.5 | 4.7 | 5.3 |
| 2009 | 5.8 | 10.0 | 5.4 | 4.8 | 5.4 |
| 2010 | 5.2 | 9.9 | 5.8 | 8.6 | 6.4 |
| 2011 | 6.1 | 10.1 | 6.0 | 8.7 | 5.1 |
| 2012 | 5.0 | 9.7 | 5.9 | 7.2 | 5.4 |
| 2013 | 5.7 | 10.0 | 8.0 | 6.9 | 5.9 |
| 2014 | 6.0 | 8.1 | 8.3 | 7.4 | 7.3 |
| **2015 standard** | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| **Annual trend** | 0.10 | No trend | -0.20 | 0.18 | No trend |

**Note:** The annual average fine particulate matter concentration indicator is based on annual average concentrations recorded at 6 monitoring stations in Atlantic Canada, 10 in southern Quebec, 25 in southern Ontario, 14 in the Prairies and northern Ontario and 14 in British Columbia. The 2015 Canadian Ambient Air Quality Standard is provided for indicative purposes only and not for evaluation of the achievement status of the standard. New fine particulate matter monitoring equipment was progressively introduced across Canada to replace older monitoring equipment from the mid-2000's to 2013. These new instruments measure a portion (semi-volatile) of the fine particulate matter mass not captured by the older instruments. Due to of the differences between the new and the old monitoring equipment, concentrations measured with the new monitors may not be directly comparable with measurements from years in which older instruments were used.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

**Table A.4. Data for Figure 4. Regional peak fine particulate matter concentrations, Canada, 2000 to 2014**

| Year | Atlantic Canada annual peak (98th percentile) concentration (micrograms per cubic metre) | Southern Quebec annual peak (98th percentile) concentration (micrograms per cubic metre) | Southern Ontario annual peak (98th percentile) concentration (micrograms per cubic metre) | Prairies and northern Ontario annual peak (98th percentile) concentration (micrograms per cubic metre) | British Columbia annual peak (98th percentile) concentration (micrograms per cubic metre) |
|---|---|---|---|---|---|
| 2000 | 13.0 | 21.3 | 25.3 | 12.8 | 17.6 |
| 2001 | 20.1 | 29.9 | 29.8 | 14.1 | 17.2 |
| 2002 | 18.9 | 35.2 | 31.9 | 18.3 | 19.9 |
| 2003 | 16.0 | 37.3 | 28.4 | 17.4 | 24.5 |
| 2004 | 13.8 | 27.4 | 30.5 | 16.4 | 19.5 |
| 2005 | 15.6 | 39.5 | 33.4 | 13.3 | 17.1 |
| 2006 | 14.8 | 23.9 | 23.7 | 15.7 | 18.0 |
| 2007 | 16.5 | 24.3 | 27.7 | 13.5 | 16.9 |
| 2008 | 15.0 | 28.9 | 21.4 | 14.4 | 16.4 |
| 2009 | 16.2 | 29.3 | 15.1 | 14.0 | 18.5 |
| 2010 | 15.2 | 29.1 | 21.2 | 27.3 | 33.9 |
| 2011 | 17.6 | 25.8 | 18.3 | 30.7 | 14.8 |
| 2012 | 13.1 | 27.8 | 17.3 | 20.6 | 17.9 |
| 2013 | 16.5 | 25.4 | 20.3 | 21.0 | 16.2 |
| 2014 | 13.8 | 21.3 | 22.0 | 25.6 | 24.8 |
| **2015 standard** | 28.0 | 28.0 | 28.0 | 28.0 | 28.0 |
| **Annual trend** | No trend | No trend | -0.95 | 0.63 | No trend |

**Note:** The annual peak (98th percentile) 24-hour fine particulate matter indicator is based on the average of the 98th percentile of the daily 24-hour average concentrations recorded at 6 monitoring stations in Atlantic Canada, 12 in southern Quebec, 27 in southern Ontario, 14 in the Prairies and northern Ontario and 14 in British Columbia. The 2015 Canadian Ambient Air Quality Standard is provided for indicative purposes only and not for evaluation of the achievement status of the standard. New fine particulate matter monitoring equipment was progressively introduced across Canada to replace older monitoring equipment from the mid-2000's to 2013. These new instruments measure a portion (semi-volatile) of the fine particulate matter mass not captured by the older instruments. Due to the differences between the new and the old monitoring equipment, concentrations measured with the new monitors may not be directly comparable with measurements from years in which older instruments were used.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

**Table A.5. Data for Figure 5. Ozone concentrations, Canada, 2000 to 2014**

| Year | Annual average concentration (parts per billion) | Annual peak (4th-highest) 8-hour concentration (parts per billion) |
|---|---|---|
| 2000 | 30.3 | 58.9 |
| 2001 | 32.8 | 67.6 |
| 2002 | 32.7 | 67.9 |
| 2003 | 33.4 | 67.8 |
| 2004 | 31.4 | 59.8 |
| 2005 | 32.7 | 63.3 |
| 2006 | 32.5 | 61.6 |
| 2007 | 32.9 | 64.5 |
| 2008 | 32.3 | 59.9 |
| 2009 | 31.7 | 57.2 |
| 2010 | 33.0 | 59.6 |
| 2011 | 32.8 | 56.7 |
| 2012 | 33.6 | 60.5 |
| 2013 | 32.8 | 56.3 |
| 2014 | 32.9 | 54.3 |
| **2015 standard** | Not applicable | 63 |
| **Annual trend** | No trend | -0.82 |

**Note:** The national annual average ozone concentration indicator is based on the annual average of the daily maximum 8-hour average concentrations recorded at 142 monitoring stations across Canada. The national annual peak (4th-highest) 8-hour ozone indicator is based on the average of the 4th-highest daily maximum 8-hour average concentrations recorded at 146 monitoring stations across Canada. The 2015 Canadian Ambient Air Quality Standard is provided for indicative purposes only and not for evaluation of the achievement status of the standard.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program and the Canadian Air and Precipitation Monitoring Network.

**Table A.6. Data for Figure 6. Regional average ozone concentrations, Canada, 2000 to 2014**

| Year | Atlantic Canada annual average concentration (parts per billion) | Southern Quebec annual average concentration (parts per billion) | Southern Ontario annual average concentration (parts per billion) | Prairies and northern Ontario annual average concentration (parts per billion) | British Columbia annual average concentration (parts per billion) |
|---|---|---|---|---|---|
| 2000 | 30.2 | 30.9 | 34.2 | 31.7 | 24.0 |
| 2001 | 33.6 | 34.4 | 37.4 | 32.6 | 25.4 |

| Year | Atlantic Canada annual average concentration (parts per billion) | Southern Quebec annual average concentration (parts per billion) | Southern Ontario annual average concentration (parts per billion) | Prairies and northern Ontario annual average concentration (parts per billion) | British Columbia annual average concentration (parts per billion) |
|---|---|---|---|---|---|
| 2002 | 33.6 | 33.6 | 37.8 | 31.9 | 25.5 |
| 2003 | 34.8 | 33.9 | 37.1 | 34.0 | 26.8 |
| 2004 | 32.8 | 31.9 | 34.8 | 31.6 | 25.8 |
| 2005 | 33.0 | 33.5 | 38.9 | 31.3 | 24.9 |
| 2006 | 34.4 | 30.9 | 36.2 | 33.4 | 28.4 |
| 2007 | 34.5 | 32.4 | 38.8 | 32.4 | 25.5 |
| 2008 | 32.2 | 31.5 | 37.4 | 32.9 | 26.6 |
| 2009 | 32.6 | 30.4 | 35.5 | 33.0 | 27.6 |
| 2010 | 32.8 | 33.1 | 37.8 | 32.7 | 27.4 |
| 2011 | 32.3 | 32.3 | 36.7 | 34.8 | 27.6 |
| 2012 | 32.6 | 33.6 | 38.2 | 33.2 | 28.7 |
| 2013 | 33.1 | 34.1 | 36.7 | 33.8 | 26.0 |
| 2014 | 32.5 | 33.2 | 36.6 | 32.7 | 27.7 |
| **Annual trend** | No trend | No trend | No trend | No trend | 0.21 |

**Note:** The annual average ozone concentration indicator is based on the annual average of the daily maximum 8-hour average concentrations recorded at 17 monitoring stations in Atlantic Canada, 37 in southern Quebec, 34 in southern Ontario, 24 in the Prairies and northern Ontario and 29 in British Columbia.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program and the Canadian Air and Precipitation Monitoring Network.

**Table A.7. Data for Figure 7. Regional peak ozone concentrations, Canada, 2000 to 2014**

| Year | Atlantic Canada annual peak (4th-highest) 8-hour concentration (parts per billion) | Southern Quebec annual peak (4th-highest) 8-hour concentration (parts per billion) | Southern Ontario annual peak (4th-highest) 8-hour concentration (parts per billion) | Prairies and northern Ontario annual peak (4th-highest) 8-hour concentration (parts per billion) | British Columbia annual peak (4th-highest) 8-hour concentration (parts per billion) |
|---|---|---|---|---|---|
| 2000 | 54.8 | 58.0 | 73.6 | 55.8 | 47.3 |
| 2001 | 64.5 | 75.1 | 85.7 | 55.7 | 48.9 |
| 2002 | 60.5 | 72.8 | 88.0 | 58.5 | 49.1 |
| 2003 | 60.9 | 71.7 | 84.7 | 60.4 | 50.9 |

| Year | Atlantic Canada annual peak (4th-highest) 8-hour concentration (parts per billion) | Southern Quebec annual peak (4th-highest) 8-hour concentration (parts per billion) | Southern Ontario annual peak (4th-highest) 8-hour concentration (parts per billion) | Prairies and northern Ontario annual peak (4th-highest) 8-hour concentration (parts per billion) | British Columbia annual peak (4th-highest) 8-hour concentration (parts per billion) |
|---|---|---|---|---|---|
| 2004 | 55.4 | 60.9 | 69.1 | 53.2 | 55.6 |
| 2005 | 54.2 | 67.5 | 81.4 | 54.0 | 49.1 |
| 2006 | 58.4 | 61.6 | 73.9 | 57.0 | 52.4 |
| 2007 | 58.5 | 67.4 | 80.9 | 56.6 | 49.4 |
| 2008 | 53.5 | 59.6 | 71.9 | 57.4 | 51.6 |
| 2009 | 54.5 | 55.4 | 66.7 | 55.9 | 50.5 |
| 2010 | 53.4 | 60.8 | 71.1 | 58.2 | 49.4 |
| 2011 | 50.9 | 55.7 | 67.3 | 58.3 | 46.9 |
| 2012 | 50.3 | 61.3 | 76.2 | 55.7 | 49.8 |
| 2013 | 50.3 | 57.5 | 64.9 | 57.5 | 46.7 |
| 2014 | 48.6 | 53.8 | 62.7 | 53.3 | 48.2 |
| **2015 standard** | 63 | 63 | 63 | 63 | 63 |
| **Annual trend** | -1.0 | -1.2 | -1.4 | No trend | No trend |

**Note:** The annual peak (4th-highest) 8-hour ozone indicator is based on the average of the 4th-highest daily maximum 8-hour average concentrations recorded at 19 monitoring stations in Atlantic Canada, 37 in southern Quebec, 36 in southern Ontario, 24 in the Prairies and northern Ontario and 29 in British Columbia. The 2015 Canadian Ambient Air Quality Standard is provided for indicative purposes only and not for evaluation of the achievement status of the standard.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program and the Canadian Air and Precipitation Monitoring Network.

**Table A.8. Data for Figure 8. Sulphur dioxide concentrations, Canada, 2000 to 2014**

| Year | Annual average concentration (parts per billion) |
|---|---|
| 2000 | 3.8 |
| 2001 | 2.9 |
| 2002 | 2.8 |
| 2003 | 2.5 |
| 2004 | 2.3 |
| 2005 | 2.2 |
| 2006 | 2.2 |
| 2007 | 2.2 |

| Year | Annual average concentration (parts per billion) |
|---|---|
| 2008 | 2.0 |
| 2009 | 1.7 |
| 2010 | 1.5 |
| 2011 | 1.5 |
| 2012 | 1.4 |
| 2013 | 1.3 |
| 2014 | 1.3 |
| **Annual trend** | -0.13 |

**Note:** The national annual average sulphur dioxide concentration indicator is based on the hourly concentrations recorded at 63 monitoring stations across Canada. The location of monitoring stations near emission sources may affect measured sulphur dioxide levels.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

**Table A.9. Data for Figure 9. Regional sulphur dioxide concentrations, 2000 to 2014**

| Year | Atlantic Canada annual average concentration (parts per billion) | Southern Quebec annual average concentration (parts per billion) | Southern Ontario annual average concentration (parts per billion) | Prairies and northern Ontario annual average concentration (parts per billion) | British Columbia annual average concentration (parts per billion) |
|---|---|---|---|---|---|
| 2000 | 5.9 | 4.5 | 5.6 | 1.4 | 2.5 |
| 2001 | 6.7 | 4.4 | 5.6 | 1.1 | 1.8 |
| 2002 | 5.7 | 4.3 | 5.2 | 1.6 | 1.9 |
| 2003 | 5.1 | 4.4 | 3.6 | 1.5 | 1.8 |
| 2004 | 4.2 | 4.1 | 3.6 | 1.5 | 1.7 |
| 2005 | 3.6 | 4.1 | 3.8 | 1.4 | 1.4 |
| 2006 | 3.1 | 3.4 | 3.3 | 1.4 | 2.0 |
| 2007 | 3.0 | 2.6 | 3.6 | 1.8 | 1.7 |
| 2008 | 1.5 | 2.6 | 3.1 | 1.4 | 2.0 |
| 2009 | 1.1 | 1.8 | 2.3 | 1.2 | 1.9 |
| 2010 | 0.8 | 1.6 | 2.1 | 0.9 | 1.7 |
| 2011 | 1.1 | 1.6 | 2.7 | 0.7 | 1.5 |
| 2012 | 1.8 | 1.8 | 2.2 | 0.6 | 1.6 |
| 2013 | 1.4 | 1.7 | 2.2 | 0.7 | 1.4 |
| 2014 | 1.1 | 1.7 | 2.4 | 0.8 | 1.3 |
| **Annual trend** | -0.44 | -0.25 | -0.24 | -0.07 | -0.04 |

**Note:** The annual average sulphur dioxide concentration indicator is based on the hourly concentrations recorded at 4 monitoring stations in Atlantic Canada, 8 in southern Quebec, 10 in southern Ontario, 18 in the Prairies and northern Ontario and 22 in British Columbia. The location of monitoring stations near emission sources may affect measured sulphur dioxide levels.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

### Table A.10. Data for Figure 10. Nitrogen dioxide concentrations, Canada, 2000 to 2014

| Year | Annual average concentration (parts per billion) |
|---|---|
| 2000 | 15.0 |
| 2001 | 14.2 |
| 2002 | 13.2 |
| 2003 | 13.4 |
| 2004 | 12.8 |
| 2005 | 12.3 |
| 2006 | 11.8 |
| 2007 | 11.2 |
| 2008 | 10.9 |
| 2009 | 10.4 |
| 2010 | 9.6 |
| 2011 | 9.6 |
| 2012 | 9.0 |
| 2013 | 9.0 |
| 2014 | 8.9 |
| **Annual trend** | -0.5 |

**Note:** The national annual average nitrogen dioxide concentration indicator is based on the annual average of the hourly concentrations recorded at 85 monitoring stations across Canada.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

**Table A.11. Data for Figure 11. Regional nitrogen dioxide concentrations, 2000 to 2014**

| Year | Atlantic Canada annual average concentration (parts per billion) | Southern Quebec annual average concentration (parts per billion) | Southern Ontario annual average concentration (parts per billion) | Prairies and northern Ontario annual average concentration (parts per billion) | British Columbia annual average concentration (parts per billion) |
|---|---|---|---|---|---|
| 2000 | - | 15.5 | 18.6 | 11.2 | 15.6 |
| 2001 | 12.5 | 14.6 | 18.2 | 10.7 | 14.4 |
| 2002 | 7.4 | 13.5 | 17.0 | 10.7 | 13.6 |
| 2003 | 8.3 | 15.5 | 16.8 | 10.9 | 13.4 |
| 2004 | 6.5 | 13.8 | 15.8 | 10.1 | 13.2 |
| 2005 | 5.6 | 13.6 | 16.3 | 9.6 | 12.7 |
| 2006 | 3.9 | 11.7 | 13.8 | 9.7 | 13.2 |
| 2007 | 4.1 | 11.7 | 13.0 | 9.6 | 11.8 |
| 2008 | 5.2 | 12.2 | 12.7 | 8.5 | 11.6 |
| 2009 | 4.3 | 10.9 | 10.8 | 9.1 | 11.6 |
| 2010 | 4.1 | 11.1 | 10.7 | 9.0 | 9.9 |
| 2011 | 4.6 | 10.8 | 10.6 | 8.5 | 9.7 |
| 2012 | 3.9 | 9.3 | 9.6 | 7.8 | 10.1 |
| 2013 | 5.0 | 8.8 | 9.5 | 8.3 | 10.0 |
| 2014 | 4.4 | 8.4 | 9.8 | 7.9 | 10.5 |
| **Annual trend** | -0.3 | -0.5 | -0.7 | -0.2 | -0.4 |

**Note:** The annual average nitrogen dioxide concentration indicator is based on the annual average of the hourly concentrations recorded at 5 monitoring stations in Atlantic Canada, 14 in southern Quebec, 20 in southern Ontario, 21 in the Prairies and northern Ontario and 25 in British Columbia. There was no value for the Atlantic Canada region in 2000 because there were only two stations with reported concentrations. At least three stations are required to report a concentration value for a given year.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

**Table A.12. Data for Figure 12. Volatile organic compound concentrations, Canada, 1999 to 2013**

| Year | Annual average concentration (parts per billion carbon) |
|---|---|
| 1999 | 120.5 |
| 2000 | 122.2 |
| 2001 | 99.0 |
| 2002 | 91.6 |

| Year | Annual average concentration (parts per billion carbon) |
|---|---|
| 2003 | 101.6 |
| 2004 | 85.9 |
| 2005 | 87.0 |
| 2006 | 83.2 |
| 2007 | 73.1 |
| 2008 | 75.9 |
| 2009 | 73.8 |
| 2010 | 62.8 |
| 2011 | 66.6 |
| 2012 | 61.7 |
| 2013 | 59.3 |

**Note:** The national annual average volatile organic compound concentration indicator is based on the annual average of the daily concentrations recorded at 34 monitoring stations across Canada.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

**Table A.13. Data for Figure 13. Regional volatile organic compound concentrations, Canada, 1999 to 2013**

| Year | Atlantic Canada annual average concentration (parts per billion carbon) | Southern Quebec annual average concentration (parts per billion carbon) | Southern Ontario annual average concentration (parts per billion carbon) | Prairies and northern Ontario annual average concentration (parts per billion carbon) | British Columbia annual average concentration (parts per billion carbon) |
|---|---|---|---|---|---|
| 1999 | - | 91.5 | 100.6 | 213.9 | - |
| 2000 | - | 96.0 | 96.6 | 218.9 | - |
| 2001 | 132.6 | 77.7 | 71.7 | 158.8 | - |
| 2002 | 103.6 | 74.4 | 66.3 | 150.6 | - |
| 2003 | 148.1 | 77.8 | 72.8 | 156.7 | 109.5 |
| 2004 | 110.0 | 63.4 | 61.1 | 141.5 | 120.1 |
| 2005 | 117.3 | 60.6 | 61.6 | 137.1 | 126.0 |
| 2006 | 123.1 | 60.8 | 59.1 | 136.1 | 105.5 |
| 2007 | 58.0 | 60.8 | 55.3 | 119.9 | 123.8 |
| 2008 | 111.5 | 47.6 | 43.6 | 148.0 | 88.6 |
| 2009 | 135.0 | 42.7 | 42.4 | 121.4 | 111.3 |
| 2010 | 88.7 | 44.8 | 40.3 | 109.1 | 87.0 |
| 2011 | 74.5 | 39.3 | - | 108.9 | 93.6 |

| Year | Atlantic Canada annual average concentration (parts per billion carbon) | Southern Quebec annual average concentration (parts per billion carbon) | Southern Ontario annual average concentration (parts per billion carbon) | Prairies and northern Ontario annual average concentration (parts per billion carbon) | British Columbia annual average concentration (parts per billion carbon) |
|---|---|---|---|---|---|
| 2012 | 100.7 | 37.6 | 41.8 | 109.2 | 69.6 |
| 2013 | 85.8 | 36.8 | 41.4 | 116.6 | 77.7 |
| **Annual trend** | No trend | -4.1 | -3.8 | -5.4 | -4.6 |

**Note:** The annual average volatile organic compound concentration indicator is based on the annual average of the daily concentrations recorded at 5 monitoring stations in Atlantic Canada, 9 in southern Quebec, 12 in southern Ontario, 5 in the Prairies and northern Ontario and 3 in British Columbia. At least three stations are required to report a concentration value for a given year. There were no values for 1999 and 2000 in Atlantic Canada and for 1999 to 2002 in British Columbia because there were only two stations with reported concentrations. For southern Ontario, no data were available for 2011.
**Source:** Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program.

# Annex B. Monitoring stations selected in the Canadian Environmental Sustainability Indicators national and regional Air Quality indicators

**Table B.1. Legend for Table B.3.**

| Column | Description |
|---|---|
| NAPS ID | National Air Pollution Surveillance monitoring station identifier. Please consult the National Air Pollution Surveillance Data Products web page for the location and parameters of the National Air Pollution Surveillance stations. |
| Average fine particulate matter | The station contributes data to the time series trend analysis for annual average fine particulate matter in the national indicator and regional indicator of the identified region, unless the cell contains n/a (not available). |
| Peak fine particulate matter | The station contributes data to the time series trend analysis for annual peak (98th percentile) 24-hour fine particulate matter in the national indicator and regional indicator of the identified region, unless the cell contains n/a (not available). |
| Average ozone | The station contributes data to the time series trend analysis for annual average ozone in the national indicator and regional indicator of the identified region, unless the cell contains n/a (not available). |
| Peak ozone | The station contributes data to the time series trend analysis for annual peak (4th-highest) 8-hour ozone in the national indicator and regional indicator of the identified region, unless the cell contains n/a (not available). |
| Sulphur dioxide | The station contributes data to the time series trend analysis for annual average sulphur dioxide in the national indicator and regional indicator of the identified region, unless the cell contains n/a (not available). |
| Nitrogen dioxide | The station contributes data to the time series trend analysis for annual average nitrogen dioxide in the national indicator and regional indicator of the identified region, unless the cell contains n/a (not available). |
| Volatile organic compounds | The station contributes data to the time series trend analysis for annual average volatile organic compounds in the national indicator and regional indicator of the identified region, unless the cell contains n/a (not available). |

**Table B.2. Acronyms for Table B.3.**

| Acronym | Description |
|---|---|
| ATL | Atlantic Region regional indicator |
| SQC | Southern Quebec regional indicator |
| SON | Southern Ontario regional indicator |
| PNO | Prairies and northern Ontario regional indicator |
| BCO | British Columbia regional indicator |
| NAT | Stations only used in calculation of the national indicator |

**Table B.3. Air quality monitoring stations used in calculation of national and regional indicators**

| NAPS ID | Peak fine particulate matter | Average fine particulate matter | Peak ozone | Average ozone | Sulphur dioxide | Nitrogen dioxide | Volatile organic compounds |
|---|---|---|---|---|---|---|---|
| 10102 | ATL | ATL | ATL | ATL | ATL | ATL | ATL |
| 10301 | n/a | n/a | n/a | n/a | n/a | ATL[A] | n/a |
| 10401 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 10602 | n/a | n/a | n/a | n/a | n/a | ATL[A] | n/a |
| 30118 | n/a | n/a | ATL | ATL | ATL[A] | n/a | ATL |
| 30120 | ATL | ATL | n/a | n/a | ATL[A] | n/a | n/a |
| 30302 | n/a | n/a | ATL[A] | ATL[A] | n/a | n/a | n/a |
| 30310 | n/a | n/a | ATL[A] | ATL[A] | n/a | n/a | n/a |
| 30501 | n/a | n/a | ATL | ATL | n/a | n/a | n/a |
| 30701 | n/a | n/a | ATL | ATL | n/a | n/a | n/a |
| 40103 | ATL | ATL | ATL | ATL | n/a | ATL | n/a |
| 40203 | ATL | ATL | ATL | ATL | ATL | n/a | ATL |
| 40206 | n/a | n/a | ATL | ATL | ATL | ATL | n/a |
| 40207 | n/a | n/a | ATL | ATL | n/a | n/a | n/a |
| 40208 | n/a | n/a | n/a | n/a | n/a | n/a | ATL |
| 40302 | ATL | ATL | ATL | ATL | n/a | ATL | n/a |
| 40401 | n/a | n/a | ATL | n/a | n/a | n/a | n/a |
| 40501 | n/a | n/a | ATL | ATL | n/a | n/a | ATL |
| 40601 | n/a | n/a | ATL | ATL | n/a | n/a | n/a |
| 40701 | n/a | n/a | ATL | ATL | n/a | n/a | n/a |
| 40801 | n/a | n/a | ATL | ATL | n/a | n/a | n/a |
| 40901 | ATL | ATL | ATL | ATL | n/a | n/a | n/a |
| 41101 | n/a | n/a | ATL | ATL | n/a | n/a | n/a |
| 41201 | n/a | n/a | ATL | ATL | n/a | n/a | n/a |
| 50103 | n/a | n/a | SQC | SQC | SQC | SQC | SQC |
| 50104 | n/a | n/a | SQC[A] | SQC[A] | n/a | n/a | SQC[A] |
| 50105 | SQC | SQC | n/a | n/a | n/a | n/a | n/a |
| 50109 | SQC | n/a | SQC | SQC | n/a | SQC | n/a |
| 50110 | SQC | n/a | SQC[A] | SQC[A] | n/a | SQC | n/a |
| 50113 | n/a | n/a | SQC | SQC | n/a | SQC | n/a |
| 50115 | n/a | n/a | SQC | SQC | SQC | SQC | SQC |
| 50116 | n/a | n/a | SQC | SQC | n/a | SQC | n/a |
| 50119 | n/a | n/a | SQC | SQC | n/a | SQC | n/a |
| 50121 | n/a | n/a | SQC | SQC | SQC | SQC | SQC |

| NAPS ID | Peak fine particulate matter | Average fine particulate matter | Peak ozone | Average ozone | Sulphur dioxide | Nitrogen dioxide | Volatile organic compounds |
|---|---|---|---|---|---|---|---|
| 50126 | SQC | SQC | SQC | SQC | n/a | SQC | n/a |
| 50128 | SQC | SQC | SQC | SQC | n/a | SQC | n/a |
| 50129 | SQC | SQC | SQC | SQC | n/a | n/a | SQC |
| 50131 | SQC | SQC | n/a | n/a | n/a | n/a | n/a |
| 50134 | n/a | n/a | SQC[A] | SQC[A] | n/a | n/a | SQC[A] |
| 50135 | n/a | n/a | SQC[A] | SQC[A] | n/a | n/a | n/a |
| 50204 | n/a | n/a | SQC | SQC | SQC | SQC | n/a |
| 50308 | SQC | SQC | SQC | SQC | SQC | SQC | n/a |
| 50309 | n/a | n/a | SQC[A] | SQC[A] | n/a | n/a | n/a |
| 50310 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |
| 50311 | n/a | n/a | SQC[A] | SQC[A] | n/a | n/a | n/a |
| 50602 | n/a | n/a | n/a | n/a | SQC[A] | n/a | n/a |
| 50604 | n/a | n/a | n/a | n/a | SQC[A] | n/a | n/a |
| 50801 | SQC[A] | SQC[A] | SQC[A] | SQC[A] | SQC[A] | n/a | n/a |
| 50802 | SQC[A] | SQC[A] | SQC[A] | SQC[A] | SQC[A] | n/a | n/a |
| 50902 | n/a | n/a | n/a | n/a | SQC | n/a | n/a |
| 51501 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |
| 52001 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |
| 52201 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |
| 52301 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |
| 52401 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |
| 52601 | n/a | n/a | SQC | SQC | n/a | SQC | n/a |
| 53201 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |
| 53301 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |
| 53501 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |
| 53601 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |
| 53701 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |
| 53801 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |
| 53901 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |
| 54102 | n/a | n/a | n/a | n/a | n/a | n/a | SQC |
| 54301 | n/a | n/a | n/a | n/a | n/a | n/a | SQC[A] |
| 54401 | SQC | SQC | SQC | SQC | n/a | n/a | SQC |
| 54501 | SQC | SQC | SQC | SQC | n/a | n/a | SQC |
| 54801 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |
| 54901 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |

| NAPS ID | Peak fine particulate matter | Average fine particulate matter | Peak ozone | Average ozone | Sulphur dioxide | Nitrogen dioxide | Volatile organic compounds |
|---|---|---|---|---|---|---|---|
| 55001 | n/a | n/a | SQC | SQC | n/a | n/a | n/a |
| 55201 | n/a | n/a | SQC | SQC | n/a | n/a | SQC[A] |
| 55301 | SQC | SQC | SQC | SQC | n/a | SQC | n/a |
| 60104 | SON | SON | SON | SON | SON | SON | SON |
| 60204 | SON | SON | SON | SON | SON | SON | n/a |
| 60211 | SON | n/a | SON | SON | SON | SON | SON |
| 60302 | n/a | n/a | SON[A] | SON[A] | n/a | n/a | n/a |
| 60303 | n/a | n/a | SON[A] | SON[A] | n/a | n/a | n/a |
| 60403 | SON[A] | SON[A] | SON[A] | SON[A] | SON[A] | SON[A] | SON[A] |
| 60410 | SON | SON | SON | SON | n/a | SON | n/a |
| 60413 | n/a | n/a | n/a | n/a | n/a | n/a | SON |
| 60415 | SON[A] | SON[A] | SON[A] | SON[A] | SON[A] | n/a | n/a |
| 60421 | SON | SON | SON | SON | n/a | SON | n/a |
| 60424 | SON[A] | SON[A] | SON[A] | SON[A] | n/a | SON[A] | n/a |
| 60428 | SON | SON | SON | SON | n/a | SON | SON |
| 60429 | SON[A] | SON[A] | SON[A] | SON[A] | n/a | SON[A] | SON[A] |
| 60430 | SON | SON | n/a | n/a | SON[A] | n/a | n/a |
| 60432 | SON[A] | SON[A] | SON[A] | SON[A] | SON[A] | n/a | n/a |
| 60433 | SON[A] | SON[A] | SON[A] | SON[A] | n/a | SON[A] | n/a |
| 60434 | SON[A] | SON[A] | SON[A] | SON[A] | SON[A] | n/a | n/a |
| 60435 | SON[A] | SON[A] | SON[A] | SON[A] | n/a | SON[A] | SON[A] |
| 60512 | SON | SON | SON | SON | SON | SON | SON |
| 60513 | SON | SON | SON | SON | SON | n/a | n/a |
| 60607 | n/a | n/a | SON[A] | SON[A] | SON[A] | n/a | n/a |
| 60609 | n/a | n/a | SON[A] | SON[A] | SON[A] | n/a | n/a |
| 60610 | n/a | n/a | SON[A] | SON[A] | SON[A] | n/a | n/a |
| 60707 | n/a | n/a | SON[A] | SON[A] | SON[A] | SON[A] | n/a |
| 60708 | SON[A] | SON[A] | n/a | n/a | n/a | n/a | n/a |
| 60709 | SON[A] | SON[A] | SON[A] | SON[A] | SON[A] | SON[A] | n/a |
| 60807 | n/a | n/a | SON[A] | SON[A] | n/a | SON[A] | n/a |
| 60809 | n/a | n/a | SON[A] | SON[A] | n/a | SON[A] | n/a |
| 60903 | SON[A] | SON[A] | SON[A] | SON[A] | n/a | SON[A] | SON |
| 60904 | SON[A] | SON[A] | SON[A] | SON[A] | n/a | SON[A] | n/a |

| NAPS ID | Peak fine particulate matter | Average fine particulate matter | Peak ozone | Average ozone | Sulphur dioxide | Nitrogen dioxide | Volatile organic compounds |
|---|---|---|---|---|---|---|---|
| 61004 | SON | n/a | SON | SON | SON | SON | SON |
| 61104 | SON | SON | SON | SON | n/a | SON | n/a |
| 61201 | n/a | n/a | SON | SON | n/a | n/a | n/a |
| 61302 | SON | SON | SON | SON | n/a | SON | n/a |
| 61502 | SON | SON | SON | SON | n/a | SON | SON |
| 61602 | n/a | n/a | SON[A] | SON[A] | n/a | SON[A] | n/a |
| 61603 | n/a | n/a | SON[A] | SON[A] | n/a | SON[A] | n/a |
| 61701 | SON[A] | SON[A] | SON[A] | SON[A] | n/a | SON[A] | n/a |
| 61702 | SON[A] | SON[A] | SON[A] | SON[A] | n/a | SON[A] | n/a |
| 61802 | SON | SON | SON | SON | n/a | n/a | n/a |
| 62001 | SON | SON | SON | SON | n/a | n/a | n/a |
| 62501 | SON | SON | SON | SON | n/a | n/a | n/a |
| 62601 | SON | SON | SON | SON | n/a | n/a | SON |
| 62701 | n/a | n/a | SON[A] | SON[A] | n/a | n/a | n/a |
| 63001 | SON | SON | SON | SON | n/a | SON | n/a |
| 63201 | n/a | n/a | SON[A] | SON[A] | n/a | SON[A] | SON[A] |
| 63301 | SON | SON | SON | SON | n/a | n/a | n/a |
| 63601 | n/a | n/a | n/a | n/a | n/a | n/a | SON |
| 63701 | n/a | n/a | SON | SON | n/a | n/a | n/a |
| 64001 | n/a | n/a | PNO | PNO | n/a | n/a | n/a |
| 64101 | n/a | n/a | SON | SON | n/a | n/a | n/a |
| 64401 | n/a | n/a | SON | SON | n/a | n/a | n/a |
| 65001 | SON | SON | SON | SON | n/a | SON | n/a |
| 65101 | SON | SON | SON[A] | SON[A] | n/a | SON[A] | SON[A] |
| 65201 | n/a | n/a | SON | n/a | n/a | n/a | n/a |
| 65301 | n/a | n/a | SON[A] | SON[A] | n/a | n/a | n/a |
| 65401 | n/a | n/a | SON | n/a | n/a | n/a | n/a |
| 70118 | PNO | PNO | PNO | PNO | n/a | PNO | n/a |
| 70119 | PNO | PNO | PNO | PNO | n/a | PNO | PNO |
| 70203 | PNO | PNO | PNO | PNO | n/a | PNO | n/a |
| 70301 | n/a | n/a | n/a | n/a | PNO | n/a | n/a |
| 80110 | PNO[A] | PNO[A] | PNO[A] | PNO[A] | PNO | PNO | PNO |
| 80111 | PNO[A] | PNO[A] | PNO[A] | PNO[A] | n/a | n/a | n/a |
| 80211 | n/a | n/a | PNO | PNO | PNO | PNO | n/a |
| 80901 | n/a | n/a | PNO | PNO | n/a | n/a | n/a |

| NAPS ID | Peak fine particulate matter | Average fine particulate matter | Peak ozone | Average ozone | Sulphur dioxide | Nitrogen dioxide | Volatile organic compounds |
|---|---|---|---|---|---|---|---|
| 90121 | PNO | PNO | PNO | PNO | PNO | PNO | PNO |
| 90130 | PNO | PNO | PNO | PNO | n/a | PNO | PNO |
| 90222 | n/a | n/a | PNO | PNO | n/a | PNO | n/a |
| 90227 | PNO[A] | PNO[A] | PNO[A] | PNO[A] | n/a | PNO[A] | PNO[A] |
| 90228 | PNO[A] | PNO[A] | PNO[A] | PNO[A] | n/a | PNO[A] | PNO[A] |
| 90302 | PNO | PNO | PNO | PNO | PNO | PNO | n/a |
| 90601 | PNO | PNO | PNO | PNO | PNO | PNO | n/a |
| 90701 | PNO | PNO | PNO | PNO | PNO | PNO | n/a |
| 90702 | PNO | PNO | PNO | PNO | PNO | PNO | n/a |
| 90801 | PNO | PNO | PNO | PNO | PNO | PNO | n/a |
| 90803 | n/a | n/a | n/a | n/a | PNO | n/a | n/a |
| 90804 | n/a | n/a | n/a | n/a | PNO | n/a | n/a |
| 90805 | n/a | n/a | n/a | n/a | PNO | n/a | n/a |
| 91001 | n/a | n/a | PNO | PNO | n/a | n/a | n/a |
| 91301 | PNO | PNO | PNO | PNO | PNO | PNO | n/a |
| 91401 | n/a | n/a | PNO | PNO | PNO | PNO | n/a |
| 91501 | n/a | n/a | PNO | PNO | PNO | PNO | n/a |
| 91601 | n/a | n/a | PNO | PNO | PNO | PNO | n/a |
| 91801 | PNO | PNO | PNO | PNO | PNO | PNO | n/a |
| 91901 | n/a | n/a | PNO | PNO | PNO | PNO | n/a |
| 100110 | n/a | n/a | BCO | BCO | BCO | BCO | n/a |
| 100111 | n/a | n/a | BCO | BCO | BCO | BCO | BCO |
| 100112 | n/a | n/a | BCO | BCO | BCO | BCO | n/a |
| 100118 | n/a | n/a | BCO | BCO | BCO | BCO | n/a |
| 100119 | n/a | n/a | BCO | BCO | BCO | BCO | BCO |
| 100121 | n/a | n/a | BCO | BCO | BCO | BCO | n/a |
| 100125 | n/a | n/a | BCO | BCO | n/a | BCO | n/a |
| 100126 | n/a | n/a | BCO | BCO | n/a | BCO | n/a |
| 100127 | n/a | n/a | BCO | BCO | n/a | BCO | n/a |
| 100128 | n/a | n/a | BCO | BCO | BCO | BCO | n/a |
| 100132 | n/a | n/a | BCO | BCO | BCO | BCO | n/a |
| 100133 | n/a | n/a | n/a | n/a | n/a | n/a | BCO |
| 100134 | BCO | BCO | BCO | BCO | BCO | BCO | n/a |
| 100135 | n/a | n/a | BCO | BCO | n/a | BCO | n/a |
| 100136 | n/a | n/a | n/a | n/a | BCO | n/a | n/a |
| 100137 | n/a | n/a | n/a | n/a | BCO | n/a | n/a |

| NAPS ID | Peak fine particulate matter | Average fine particulate matter | Peak ozone | Average ozone | Sulphur dioxide | Nitrogen dioxide | Volatile organic compounds |
|---|---|---|---|---|---|---|---|
| 100202 | BCO | BCO | BCO | BCO | BCO | BCO | n/a |
| 100304 | BCO | BCO | BCO | BCO | BCO | BCO | n/a |
| 100401 | BCO[A] | BCO[A] | n/a | n/a | BCO[A] | n/a | n/a |
| 100402 | BCO[A] | BCO[A] | n/a | n/a | BCO[A] | n/a | n/a |
| 100701 | BCO | BCO | BCO | BCO | BCO | BCO | n/a |
| 101003 | n/a | n/a | BCO | BCO | BCO | BCO | n/a |
| 101101 | BCO | BCO | BCO | BCO | BCO | BCO | n/a |
| 101202 | BCO | BCO | BCO | BCO | BCO | BCO | n/a |
| 101301 | BCO | BCO | BCO | BCO | n/a | BCO | n/a |
| 101401 | n/a | n/a | BCO | BCO | n/a | BCO | n/a |
| 101501 | n/a | n/a | BCO | BCO | n/a | BCO | n/a |
| 101601 | n/a | n/a | BCO | BCO | BCO | n/a | n/a |
| 101701 | BCO | BCO | n/a | n/a | n/a | n/a | n/a |
| 101702 | BCO | BCO | n/a | n/a | n/a | n/a | n/a |
| 101704 | BCO | BCO | n/a | n/a | n/a | n/a | n/a |
| 102001 | n/a | n/a | BCO | BCO | n/a | n/a | n/a |
| 102102 | BCO | BCO | BCO | BCO | n/a | n/a | n/a |
| 102201 | n/a | n/a | n/a | n/a | BCO | n/a | n/a |
| 102301 | n/a | n/a | n/a | n/a | n/a | BCO | n/a |
| 102401 | n/a | n/a | BCO | BCO | n/a | n/a | n/a |
| 102701 | BCO | BCO | BCO | BCO | n/a | n/a | n/a |
| 102801 | n/a | n/a | BCO | BCO | n/a | BCO | n/a |
| 104301 | n/a | n/a | n/a | n/a | BCO | n/a | n/a |
| 105001 | n/a | n/a | BCO | BCO | n/a | n/a | n/a |
| 105101 | BCO | BCO | n/a | n/a | n/a | n/a | n/a |
| 105301 | n/a | n/a | n/a | n/a | BCO | BCO | n/a |
| 129002 | n/a | n/a | NAT[A] | NAT[A] | NAT[A] | n/a | n/a |
| 129003 | n/a | n/a | NAT[A] | NAT[A] | NAT[A] | n/a | n/a |

**Note:** n/a = not available.
[A] The pollutant concentrations for the station were merged for imputation with concentrations from stations located nearby to satisfy data completeness criteria. See Annex C for details.

# Annex C. Monitoring station imputations

**Table C.1. Imputations of neighbouring stations for the fine particulate matter national and regional annual average indicators**

| NAPS ID | Province | City | Years | Comb. ID[A] |
|---|---|---|---|---|
| 50801 | Quebec | Trois-Rivières | 2000–2010 | A |
| 50802 | Quebec | Trois-Rivières | 2012–2013 | A |
| 60403 | Ontario | Toronto | 2000 | B |
| 60432 | Ontario | Mississauga | 2005–2007 | B |
| 60434 | Ontario | Mississauga | 2008–2014 | B |
| 60415 | Ontario | Mississauga | 2000–2003 | C |
| 60429 | Ontario | Toronto | 2005–2008 | C |
| 60435 | Ontario | Toronto | 2010–2014 | C |
| 60424 | Ontario | Toronto | 2001 | D |
| 60433 | Ontario | Toronto | 2003–2014 | D |
| 60708 | Ontario | Sault Ste. Marie | 2000 | E |
| 60709 | Ontario | Sault Ste. Marie | 2004–2014 | E |
| 60903 | Ontario | London | 2001, 2003–2009, 2011, 2012 | F |
| 60904 | Ontario | London | 2013–2014 | F |
| 61701 | Ontario | Oshawa | 2000–2004 | G |
| 61702 | Ontario | Oshawa | 2006–2014 | G |
| 80110 | Saskatchewan | Regina | 2001–2013 | H |
| 80111 | Saskatchewan | Regina | 2014 | H |
| 90227 | Alberta | Calgary | 2000–2007 | I |
| 90228 | Alberta | Calgary | 2010–2011, 2013–2014 | I |
| 100401 | British Columbia | Kamloops | 2011–2014 | J |
| 100402 | British Columbia | Kamloops | 2000–2009 | J |

**Note:** [A] Station combination grouping ID code.

**Table C.2. Imputations of neighbouring stations for the fine particulate matter national and regional annual peak (98th percentile) 24-hour indicators**

| NAPS ID | Province | City | Years | Comb. ID[A] |
|---|---|---|---|---|
| 50801 | Quebec | Trois-Rivières | 2000–2010 | A |
| 50802 | Quebec | Trois-Rivières | 2012–2013 | A |
| 60403 | Ontario | Toronto | 2000 | B |
| 60429 | Ontario | Toronto | 2001, 2003–2008 | B |
| 60435 | Ontario | Mississauga | 2010–2014 | B |
| 60415 | Ontario | Mississauga | 2000–2003 | C |
| 60432 | Ontario | Mississauga | 2005–2007 | C |

| NAPS ID | Province | City | Years | Comb. ID[A] |
|---|---|---|---|---|
| 60434 | Ontario | Mississauga | 2008–2014 | C |
| 60424 | Ontario | Toronto | 2001–2002 | D |
| 60433 | Ontario | Toronto | 2003–2014 | D |
| 60708 | Ontario | Sault Ste. Marie | 2000 | E |
| 60709 | Ontario | Sault Ste. Marie | 2004–2014 | E |
| 60903 | Ontario | London | 2001, 2003–2009, 2011–2012 | F |
| 60904 | Ontario | London | 2013–2014 | F |
| 61701 | Ontario | Oshawa | 2000–2004 | G |
| 61702 | Ontario | Oshawa | 2006–2014 | G |
| 80110 | Saskatchewan | Regina | 2001–2013 | H |
| 80111 | Saskatchewan | Regina | 2014 | H |
| 90227 | Alberta | Calgary | 2000–2007 | I |
| 90228 | Alberta | Calgary | 2010–2011, 2013–2014 | I |
| 100401 | British Columbia | Kamloops | 2011–2014 | J |
| 100402 | British Columbia | Kamloops | 2000–2009 | J |

**Note:** [A] Station combination grouping ID code.

**Table C.3. Imputations of neighbouring stations for the ground-level ozone national and regional annual average indicators**

| NAPS ID | Province | City | Years | Comb. ID[A] |
|---|---|---|---|---|
| 30302 | Nova Scotia | Sydney | 2009–2010 | A |
| 30310 | Nova Scotia | Sydney | 2002–2008, 2011, 2013–2014 | A |
| 50104 | Quebec | Montréal | 2000–2007 | B |
| 50134 | Quebec | Montréal | 2009–2014 | B |
| 50309 | Quebec | Québec | 2000–2004 | C |
| 50311 | Quebec | Québec | 2005–2014 | C |
| 50110 | Quebec | Montréal | 2001–2012 | D |
| 50135 | Quebec | Montréal | 2014 | D |
| 50801 | Quebec | Trois-Rivières | 2000–2010 | E |
| 50802 | Quebec | Trois-Rivières | 2013 | E |
| 63201 | Ontario | Stouffville | 2000–2001 | F |
| 65101 | Ontario | Newmarket | 2002–2014 | F |
| 60302 | Ontario | Kingston | 2000–2005 | G |
| 60303 | Ontario | Kingston | 2007–2013 | G |
| 60403 | Ontario | Toronto | 2000 | H |
| 60429 | Ontario | Toronto | 2002–2008 | H |
| 60435 | Ontario | Mississauga | 2010–2014 | H |

| NAPS ID | Province | City | Years | Comb. ID[A] |
|---|---|---|---|---|
| 60415 | Ontario | Mississauga | 2000–2003 | I |
| 60432 | Ontario | Mississauga | 2005–2007 | I |
| 60434 | Ontario | Mississauga | 2008–2014 | I |
| 60424 | Ontario | Toronto | 2000–2002 | J |
| 60433 | Ontario | Toronto | 2003–2014 | J |
| 60607 | Ontario | Sudbury | 2000–2003 | K |
| 60609 | Ontario | Sudbury | 2005–2012 | K |
| 60610 | Ontario | Sudbury | 2013–2014 | K |
| 60707 | Ontario | Sault Ste. Marie | 2000–2003 | L |
| 60709 | Ontario | Sault Ste. Marie | 2004–2014 | L |
| 60807 | Ontario | Thunder Bay | 2000–2003 | M |
| 60809 | Ontario | Thunder Bay | 2004–2014 | M |
| 60903 | Ontario | London | 2000–2012 | N |
| 60904 | Ontario | London | 2013–2014 | N |
| 61602 | Ontario | Oakville | 2000–2002 | O |
| 61603 | Ontario | Oakville | 2004–2014 | O |
| 61701 | Ontario | Oshawa | 2000–2004 | P |
| 61702 | Ontario | Oshawa | 2006–2007, 2009–2014 | P |
| 62701 | Ontario | Long Point | 2000–2001 | Q |
| 65301 | Ontario | Port Stanley | 2003–2014 | Q |
| 80110 | Saskatchewan | Regina | 2001–2006, 2008–2013 | R |
| 80111 | Saskatchewan | Regina | 2014 | R |
| 90227 | Alberta | Calgary | 2000–2007 | S |
| 90228 | Alberta | Calgary | 2009–2014 | S |
| 129002 | Northwest Territories | Yellowknife | 2001 | T |
| 129003 | Northwest Territories | Yellowknife | 2003–2014 | T |

**Note:** [A] Station combination grouping ID code.

**Table C.4. Imputations of neighbouring stations for the ground-level ozone national and regional annual peak (4th-highest) 8-hour indicators**

| NAPS ID | Province | City | Years | Comb. ID[A] |
|---|---|---|---|---|
| 30302 | Nova Scotia | Sydney | 2009–2010 | A |
| 30310 | Nova Scotia | Sydney | 2001–2006, 2008, 2011, 2013–2014 | A |
| 50104 | Quebec | Montréal | 2001–2012 | B |
| 50134 | Quebec | Montréal | 2013–2014 | B |
| 50110 | Quebec | Montréal | 2000–2008 | C |
| 50135 | Quebec | Montréal | 2009–2014 | C |

| NAPS ID | Province | City | Years | Comb. ID[A] |
|---|---|---|---|---|
| 50309 | Quebec | Quebec | 2000–2005 | D |
| 50311 | Quebec | Quebec | 2006–2014 | D |
| 50801 | Quebec | Trois-Rivières | 2000–2010 | E |
| 50802 | Quebec | Trois-Rivières | 2012–2013 | E |
| 60302 | Ontario | Kingston | 2000–2005 | F |
| 60303 | Ontario | Kingston | 2007–2013 | F |
| 60403 | Ontario | Toronto | 2000 | G |
| 60429 | Ontario | Toronto | 2001–2009 | G |
| 60435 | Ontario | Mississauga | 2010–2014 | G |
| 60415 | Ontario | Mississauga | 2000–2003 | H |
| 60432 | Ontario | Mississauga | 2004–2007 | H |
| 60434 | Ontario | Mississauga | 2008–2014 | H |
| 60424 | Ontario | Toronto | 2000–2002 | I |
| 60433 | Ontario | Toronto | 2003–2014 | I |
| 60607 | Ontario | Sudbury | 2000–2003 | J |
| 60609 | Ontario | Sudbury | 2005–2012 | J |
| 60610 | Ontario | Sudbury | 2013–2014 | J |
| 60707 | Ontario | Sault Ste. Marie | 2000–2003 | K |
| 60709 | Ontario | Sault Ste. Marie | 2004–2014 | K |
| 60807 | Ontario | Thunder Bay | 2000–2003 | L |
| 60809 | Ontario | Thunder Bay | 2004–2014 | L |
| 60903 | Ontario | London | 2000–2012 | M |
| 60904 | Ontario | London | 2013–2014 | M |
| 61602 | Ontario | Oakville | 2000–2002 | N |
| 61603 | Ontario | Oakville | 2003–2014 | N |
| 61701 | Ontario | Oshawa | 2000–2004, 2008 | O |
| 61702 | Ontario | Oshawa | 2005–2007, 2009–2014 | O |
| 62701 | Ontario | Long Point | 2000–2001 | P |
| 65301 | Ontario | Port Stanley | 2002–2014 | P |
| 63201 | Ontario | Stouffville | 2000 | Q |
| 65101 | Ontario | Newmarket | 2001–2014 | Q |
| 80110 | Saskatchewan | Regina | 2001–2006, 2008–2013 | R |
| 80111 | Saskatchewan | Regina | 2014 | R |
| 90227 | Alberta | Calgary | 2000–2007 | S |
| 90228 | Alberta | Calgary | 2008–2014 | S |
| 129002 | Northwest Territories | Yellowknife | 2000–2002 | T |
| 129003 | Northwest Territories | Yellowknife | 2003–2014 | T |

**Note:** [A] Station combination grouping ID code.

**Table C.5. Imputations of neighbouring stations for the sulphur dioxide national and regional annual average indicators**

| NAPS ID | Province | City | Years | Comb. ID[A] |
|---|---|---|---|---|
| 30118 | Nova Scotia | Halifax | 2000–2006, 2011–2013 | A |
| 30120 | Nova Scotia | Dartmouth | 2007, 2009–2010, 2014 | A |
| 50602 | Quebec | Rouyn-Noranda | 2000, 2002 | B |
| 50604 | Quebec | Rouyn-Noranda | 2001, 2003–2014 | B |
| 50801 | Quebec | Trois-Rivières | 2000–2010 | C |
| 50802 | Quebec | Trois-Rivières | 2012–2013 | C |
| 60403 | Ontario | Toronto | 2000 | D |
| 60430 | Ontario | Toronto | 2003–2014 | D |
| 60415 | Ontario | Mississauga | 2000–2001, 2003 | E |
| 60432 | Ontario | Mississauga | 2005 | E |
| 60434 | Ontario | Mississauga | 2008–2014 | E |
| 60607 | Ontario | Sudbury | 2000–2004 | F |
| 60609 | Ontario | Sudbury | 2005–2012 | F |
| 60610 | Ontario | Sudbury | 2013–2014 | F |
| 60707 | Ontario | Sault Ste. Marie | 2000–2003 | G |
| 60709 | Ontario | Sault Ste. Marie | 2004–2013 | G |
| 100401 | British Columbia | Kamloops | 2011–2014 | H |
| 100402 | British Columbia | Kamloops | 2001–2008 | H |
| 129002 | Northwest Territories | Yellowknife | 2000–2001 | I |
| 129003 | Northwest Territories | Yellowknife | 2003–2014 | I |

**Note:** [A] Station combination grouping ID code.

**Table C.6. Imputations of neighbouring stations for the nitrogen dioxide national and regional annual average indicators**

| NAPS ID | Province | City | Years | Comb. ID[A] |
|---|---|---|---|---|
| 10301 | Newfoundland and Labrador | Corner Brook | 2002–2007, 2010 | A |
| 10602 | Newfoundland and Labrador | Corner Brook | 2010–2014 | A |
| 60403 | Ontario | Toronto | 2000 | B |
| 60429 | Ontario | Toronto | 2003–2008 | B |
| 60435 | Ontario | Mississauga | 2010–2014 | B |
| 60424 | Ontario | Toronto | 2000–2002 | C |
| 60433 | Ontario | Toronto | 2003–2014 | C |
| 60707 | Ontario | Sault Ste. Marie | 2000–2001, 2003 | D |
| 60709 | Ontario | Sault Ste. Marie | 2006–2014 | D |
| 60807 | Ontario | Thunder Bay | 2000–2003 | E |
| 60809 | Ontario | Thunder Bay | 2007–2014 | E |

| NAPS ID | Province | City | Years | Comb. ID[A] |
|---|---|---|---|---|
| 60903 | Ontario | London | 2000–2002, 2004–2012 | F |
| 60904 | Ontario | London | 2013–2014 | F |
| 61602 | Ontario | Oakville | 2000–2002 | G |
| 61603 | Ontario | Oakville | 2004–2014 | G |
| 61701 | Ontario | Oshawa | 2000–2004 | H |
| 61702 | Ontario | Oshawa | 2006–2007, 2009–2014 | H |
| 63201 | Ontario | Stouffville | 2000 | I |
| 65101 | Ontario | Newmarket | 2002–2014 | I |
| 90227 | Alberta | Calgary | 2000–2007 | J |
| 90228 | Alberta | Calgary | 2009–2014 | J |

**Note:** [A] Station combination grouping ID code

**Table C.7. Imputations of neighbouring stations for the volatile organic compound national and regional annual average indicators**

| NAPS ID | Province | City | Years | Comb. ID[A] |
|---|---|---|---|---|
| 50104 | Quebec | Montréal | 1999–2008 | A |
| 50134 | Quebec | Montréal | 2009–2013 | A |
| 54301 | Quebec | Ste-Françoise | 1999 | B |
| 55201 | Quebec | Lemieux | 2000–2013 | B |
| 60403 | Ontario | Toronto | 1999–2000 | C |
| 60429 | Ontario | Toronto | 2002–2008 | C |
| 60435 | Ontario | Mississauga | 2009–2010, 2012–2013 | C |
| 63201 | Ontario | Stouffville | 1999–2005 | D |
| 65101 | Ontario | Newmarket | 2006–2010, 2012–2013 | D |
| 90227 | Alberta | Calgary | 1998–2007 | E |
| 90228 | Alberta | Calgary | 2008–2013 | E |

**Note:** [A] Station combination grouping ID code.

# Annex D. Fine particulate matter measurement technological transition

Four types of fine particulate matter ($PM_{2.5}$) monitors are used to measure the 1-hour concentrations of $PM_{2.5}$ concentrations:

- Older technology: Rupprecht & Patashnick Tapered element oscillating microbalance (TEOM) monitor.
- Current technology: Thermo Scientific TEOM 1400a with the Series 8500C Filter Dynamics Measurement System (FDMS) monitor.
- Current technology: Met One BAM-1020 Beta Attenuation Mass monitor.
- Current technology: Thermo Scientific 5030 or 5030i Sharp monitor.

The Thermo Scientific 1400a, Met One BAM-1020 and the Thermo Sharp monitors have been approved by the United States Environmental Protection Agency as Class III Federal Equivalent Methods (FEMs) and are being deployed across the National Air Pollution Surveillance network to replace older TEOM instruments, which in some circumstances may underestimate the $PM_{2.5}$ concentrations. Since 2005, the TEOM monitors have gradually been replaced by the FEM monitors. These new FEM monitors measure a portion (semi-volatile) of the $PM_{2.5}$ mass not captured by the older instruments. Because of the differences between the new and the old monitoring equipment, concentrations measured with the new monitors may not be directly comparable with the measurements from years in which older instruments were used.

The following table lists the stations used for the national and regional indicators that are operating with new technologies, along with the type of equipment and year of installation.

**Table D.1. Stations included in the national and regional indicators that use new monitoring technologies for fine particulate matter**

| NAPS ID | Province | City | New equipment, first year provided |
|---|---|---|---|
| 10102 | Newfoundland and Labrador | St. John's | BAM, 2010 |
| 30120 | Nova Scotia | Dartmouth | BAM, 2009 |
| 40103 | New Brunswick | Fredericton | BAM, 2008 |
| 40203 | New Brunswick | Saint John | BAM, 2008 |
| 40302 | New Brunswick | Moncton | BAM, 2008 |
| 40901 | New Brunswick | St. Andrews | BAM, 2008 |
| 50105 | Quebec | Montréal | FDMS, 2008 |
| 50109 | Quebec | Montréal | FDMS, 2008 |
| 50110 | Quebec | Montréal | FDMS, 2008 |
| 50126 | Quebec | Montréal | FDMS, 2008 |
| 50128 | Quebec | Montréal | FDMS, 2008 |
| 50129 | Quebec | Montréal | FDMS, 2008 – SHARP, 2014[A] |
| 50131 | Quebec | Montréal | FDMS, 2008 |
| 50308 | Quebec | Quebec City | BAM, 2009 |
| 50801 | Quebec | Trois-Rivières | BAM, 2009 |
| 50802 | Quebec | Trois-Rivières | BAM, 2011 |
| 54401 | Quebec | Saint-Anicet | BAM, 2008 |

| NAPS ID | Province | City | New equipment, first year provided |
|---|---|---|---|
| 54501 | Quebec | L'Assomption | BAM, 2008 |
| 55301 | Quebec | Saint-Jean-sur-Richelieu | BAM, 2008 |
| 60104 | Ontario | Ottawa | SHARP, 2013 |
| 60204 | Ontario | Windsor | SHARP, 2013 |
| 60211 | Ontario | Windsor | SHARP, 2013 |
| 60410 | Ontario | Toronto | SHARP, 2013 |
| 60421 | Ontario | Toronto | SHARP, 2013 |
| 60428 | Ontario | Brampton | SHARP, 2013 |
| 60430 | Ontario | Toronto | SHARP, 2013 |
| 60433 | Ontario | Toronto | SHARP, 2013 |
| 60434 | Ontario | Mississauga | SHARP, 2013 |
| 60435 | Ontario | Mississauga | SHARP, 2013 |
| 60512 | Ontario | Hamilton | SHARP, 2013 |
| 60513 | Ontario | Hamilton | SHARP, 2013 |
| 60709 | Ontario | Sault Ste. Marie | SHARP, 2013 |
| 60904 | Ontario | London | SHARP, 2013 |
| 61004 | Ontario | Sarnia | SHARP, 2013 |
| 61104 | Ontario | Peterborough | SHARP, 2013 |
| 61302 | Ontario | St. Catharines | SHARP, 2013 |
| 61502 | Ontario | Kitchener | SHARP, 2013 |
| 61702 | Ontario | Oshawa | SHARP, 2013 |
| 61802 | Ontario | Guelph | SHARP, 2013 |
| 62001 | Ontario | North Bay | SHARP, 2013 |
| 62501 | Ontario | Tiverton | SHARP, 2013 |
| 62601 | Ontario | Simcoe | SHARP, 2013 |
| 63001 | Ontario | Burlington | SHARP, 2013 |
| 63301 | Ontario | Dorset | SHARP, 2013 |
| 65001 | Ontario | Barrie | SHARP, 2013 |
| 65101 | Ontario | Newmarket | SHARP, 2013 |
| 70118 | Manitoba | Winnipeg | SHARP, 2011 |
| 70119 | Manitoba | Winnipeg | SHARP, 2011 |
| 70203 | Manitoba | Brandon | SHARP, 2011 |
| 80110 | Saskatchewan | Regina | BAM, 2009 |
| 80111 | Saskatchewan | Regina | BAM, 2014 |
| 90121 | Alberta | Edmonton | FDMS, 2010 |
| 90130 | Alberta | Edmonton | FDMS, 2010 |
| 90228 | Alberta | Calgary | FDMS, 2010–2011, BAM, 2013 |
| 90302 | Alberta | Red Deer | FDMS, 2010–2013, SHARP, 2014 |

| NAPS ID | Province | City | New equipment, first year provided |
|---|---|---|---|
| 90601 | Alberta | Fort Saskatchewan | SHARP, 2013 |
| 90701 | Alberta | Fort McMurray | SHARP, 2013 |
| 90702 | Alberta | Fort McMurray | SHARP, 2013 |
| 90801 | Alberta | Fort Mackay | SHARP, 2012 |
| 91801 | Alberta | Fort Chipewyan | SHARP, 2014[A] |
| 100134 | British Columbia | Richmond | SHARP, 2014 |
| 100202 | British Columbia | Prince George | SHARP, 2014 |
| 100304 | British Columbia | Victoria | BAM, 2010 |
| 100401 | British Columbia | Kamloops | BAM, 2010 |
| 100701 | British Columbia | Kelowna | SHARP, 2014[A] |
| 101101 | British Columbia | Chilliwack | SHARP, 2013 |
| 101202 | British Columbia | Pitt Meadows | SHARP, 2013 |
| 101301 | British Columbia | Langley | SHARP, 2014 |
| 101701 | British Columbia | Quesnel | SHARP, 2014[A] |
| 102102 | British Columbia | Nanaimo | BAM, 2014[A] |
| 102701 | British Columbia | Williams Lake | SHARP, 2014[A] |
| 105101 | British Columbia | Houston | SHARP, 2014 |

**Note:** [A] These stations changed technology during the indicated year.

**Table D.2. Number of stations included in the national and regional indicators that use the most recent monitoring technologies for reporting fine particulate matter, 2014**

| Fine particulate matter | National | Atlantic Canada | Southern Quebec | Southern Ontario | Prairies and northern Ontario | British Columbia |
|---|---|---|---|---|---|---|
| Peak (98th percentile) 24-hour concentration | 65 | 6 | 9 | 26 | 13 | 11 |
| Average concentration | 61 | 6 | 8 | 24 | 13 | 10 |

# Annex E. Volatile organic compounds targeted for quantification

**Table E.1. Volatile organic compounds targeted for quantification**

| Compound | CAS registry number |
|---|---|
| 1,2,3-Trimethylbenzene | 526-73-8 |
| 1,2,4-Trimethylbenzene | 95-63-6 |
| 1,2-Diethylbenzene | 135-01-3 |
| 1,3,5-Trimethylbenzene | 108-67-8 |
| 1,3-Butadiene | 106-99-0 |
| 1,3-Diethylbenzene | 141-93-5 |
| 1,4-Diethylbenzene | 105-05-5 |
| 1-Butene | 115-11-7 |
| 1-Butyne | 107-00-6 |
| 1-Decene | 872-05-9 |
| 1-Heptene | 592-76-7 |
| 1-Hexene | 592-41-6 |
| 1-Methylcyclohexene | 591-49-1 |
| 1-Methylcyclopentene | 693-89-0 |
| 1-Nonene | 124-11-8 |
| 1-Octene | 111-66-0 |
| 1-Pentene | 109-67-1 |
| 1-Propyne | 74-99-7 |
| 1-Undecene | 821-95-4 |
| 2,2,3-Trimethylbutane | 464-06-2 |
| 2,2,4-Trimethylpentane | 540-84-1 |
| 2,2,5-Trimethylhexane | 3522-94-9 |
| 2,2-Dimethylbutane | 75-83-2 |
| 2,2-Dimethylhexane | 590-73-8 |
| 2,2-Dimethylpentane | 590-35-2 |
| 2,2-Dimethylpropane | 463-82-1 |
| 2,3,4-Trimethylpentane | 565-75-3 |
| 2,3-Dimethylbutane | 79-29-8 |
| 2,3-Dimethylpentane | 565-59-3 |
| 2,4-Dimethylhexane | 589-43-5 |
| 2,4-Dimethylpentane | 108-08-7 |
| 2,5-dimethylheptane | 2216-30-0 |

| Compound | CAS registry number |
|---|---|
| 2,5-Dimethylhexane | 592-13-2 |
| 2-Ethyl-1-butene | 760-21-4 |
| 2-Ethyltoluene | 611-14-3 |
| 2-methyl-1-butene | 563-46-2 |
| 2-Methyl-1-Pentene | 763-29-1 |
| 2-Methyl-2-butene | 513-35-9 |
| 2-Methyl-2-pentene | 625-27-4 |
| 2-Methylheptane | 592-27-8 |
| 2-Methylhexane | 591-76-4 |
| 2-Methylpentane | 107-83-5 |
| 3,6-Dimethyloctane | 15869-94-0 |
| 3-Ethyltoluene | 620-14-4 |
| 3-Methyl-1-Butene | 563-45-1 |
| 3-Methyl-1-pentene | 760-20-3 |
| 3-Methylheptane | 589-81-1 |
| 3-Methylhexane | 589-34-4 |
| 3-Methyloctane | 2216-33-3 |
| 3-Methylpentane | 96-14-0 |
| 4-Ethyltoluene | 622-96-8 |
| 4-Methyl-1-pentene | 691-37-2 |
| 4-Methylheptane | 589-53-7 |
| 4-Methyloctane | 2216-34-4 |
| Acetylene | 74-86-2 |
| a-Pinene | 80-56-8 |
| Benzene | 71-43-2 |
| b-Pinene | 127-91-3 |
| Butane | 106-97-8 |
| Camphene | 79-92-5 |
| cis-1,2-Dimethylcyclohexane | 2207-01-04 |
| cis-1,3-Dimethylcyclohexane | 638-04-0 |
| cis-2-Butene | 590-18-1 |
| cis-2-Heptene | 6443-92-1 |
| cis-2-Hexene | 7688-21-3 |
| cis-2-Octene | 7642-04-08 |
| cis-2-Pentene | 627-20-3 |
| cis-3-Heptene | 7642-10-06 |
| cis-3-Methyl-2-pentene | 922-61-2 |

| Compound | CAS registry number |
|---|---|
| cis-4-Methyl-2-pentene | 4461-48-7 |
| Cyclohexane | 110-82-7 |
| Cyclohexene | 110-83-8 |
| Cyclopentane | 287-92-3 |
| Cyclopentene | 142-29-0 |
| Decane | 124-18-5 |
| d-Limonene | 5989-27-5 |
| Dodecane | 112-40-3 |
| Ethane | 74-84-0 |
| Ethylbenzene | 100-41-4 |
| Ethylene | 74-85-1 |
| Heptane | 142-82-5 |
| Hexane | 110-54-3 |
| Hexylbenzene | 1077-16-3 |
| Indane | 496-11-7 |
| Isobutane | 75-28-5 |
| iso-Butylbenzene | 538-93-2 |
| Isopentane | 78-78-4 |
| Isoprene | 78-79-5 |
| iso-Propylbenzene | 98-82-8 |
| m and p-Xylene | 108-38-3 |
| Methylcyclohexane | 108-87-2 |
| Methylcyclopentane | 96-37-7 |
| n-Butylbenzene | 104-51-8 |
| Nonane | 111-84-2 |
| n-Propylbenzene | 103-65-1 |
| Octane | 111-65-9 |
| o-Xylene | 95-47-6 |
| p-Cymene | 99-87-6 |
| Pentane | 109-66-0 |
| Propane | 74-98-6 |
| Propylene | 115-07-1 |
| sec-Butylbenzene | 135-98-8 |
| Styrene | 100-42-5 |
| tert-Butylbenzene | 1998-06-06 |
| Toluene | 108-88-3 |
| trans-1,2-Dimethylcyclohexane | 6876-23-9 |

| Compound | CAS registry number |
|---|---|
| trans-1,4-Dimethylcyclohexane | 2207-04-07 |
| trans-2-Butene | 624-64-6 |
| trans-2-Heptene | 14686-13-6 |
| trans-2-Hexene | 4050-45-7 |
| trans-2-Octene | 13389-42-9 |
| trans-2-Pentene | 646-04-8 |
| trans-3-Heptene | 14686-14-7 |
| trans-3-Methyl-2-pentene | 616-12-6 |
| trans-4-Methyl-2-pentene | 674-76-0 |
| Undecane | 1120-21-4 |

# Annex F. Mann-Kendall and Sen's pairwise statistical parameters used for the analysis of trends

**Table F.1. Legend for tables in Annex F**

| Field | Description |
|---|---|
| First year | Starting year of each time series. |
| Last year | Ending year of each time series. |
| n | Number of annual values in the calculation, excluding missing values. |
| Test Z | The absolute value of Z is compared to the standard normal cumulative distribution to define if there is a trend at the selected level α of significance. A positive (negative) value indicates an upward (downward) trend. |
| Significant | The smallest significance level *α* at which the test shows that the null hypothesis of no trend can be rejected. For the three tested significance levels, the following symbols are used:<br>[A] if trend at α = 0.001 level of significance,<br>[B] if trend at α = 0.01 level of significance, and<br>[C] if trend at α = 0.05 level of significance. |
| Q | Sen's estimator for the true slope of linear trend, i.e., change per unit time period (in this case a year). |
| Qmin95 | The lower limit of the 95% confidence interval of Q (α = 0.05). |
| Qmax95 | The upper limit of the 95% confidence interval of Q (α = 0.05). |

**Table F.2. Mann-Kendall and Sen's tests results for the national and regional annual average fine particulate matter indicators**

| Statistics | National | Atlantic Canada | Southern Quebec | Southern Ontario | Prairies and northern Ontario | British Columbia |
|---|---|---|---|---|---|---|
| First year | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Last Year | 2014 | 2014 | 2014 | 2014 | 2014 | 2014 |
| n | 15 | 15 | 15 | 15 | 15 | 15 |
| Test Z | -1.39 | 2.03 | 1.58 | -2.08 | 1.98 | -0.99 |
| Significant | No | Yes[C] | No | Yes[C] | Yes[C] | No |
| Q | -0.25 | 0.10 | 0.06 | -0.20 | 0.18 | -0.06 |
| Qmin95 | -0.68 | 0.00 | -0.03 | -0.28 | 0.00 | -0.13 |
| Qmax95 | 0.13 | 0.16 | 0.21 | -0.01 | 0.38 | 0.07 |

**Table F.3. Mann-Kendall and Sen's tests results for the national and regional annual peak (98th percentile) 24-hour fine particulate matter indicators**

| Statistics | National | Atlantic Canada | Southern Quebec | Southern Ontario | Prairies and northern Ontario | British Columbia |
|---|---|---|---|---|---|---|
| First year | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Last Year | 2014 | 2014 | 2014 | 2014 | 2014 | 2014 |
| n | 15 | 15 | 15 | 15 | 15 | 15 |
| Test Z | 0.20 | -0.40 | -1.14 | -2.57 | 2.08 | -0.59 |
| Significant | No | No | No | Yes[C] | Yes[C] | No |
| Q | 0.01 | -0.12 | -0.41 | -0.95 | 0.63 | -0.10 |
| Qmin95 | -0.08 | -0.44 | -1.18 | -1.41 | 0.07 | -0.46 |
| Qmax95 | 0.10 | 0.24 | 0.37 | -0.31 | 1.41 | 0.49 |

**Table F.4. Mann-Kendall and Sen's tests results for the national and regional annual average ground-level ozone indicators**

| Statistics | National | Atlantic Canada | Southern Quebec | Southern Ontario | Prairies and northern Ontario | British Columbia |
|---|---|---|---|---|---|---|
| First year | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Last Year | 2014 | 2014 | 2014 | 2014 | 2014 | 2014 |
| n | 15 | 15 | 15 | 15 | 15 | 15 |
| Test Z | 1.68 | -0.94 | 0.00 | 0.20 | 1.68 | 2.67 |
| Significant | No | No | No | No | No | Yes[B] |
| Q | 0.04 | -0.05 | 0.00 | 0.05 | 0.11 | 0.21 |
| Qmin95 | -0.02 | -0.16 | -0.20 | -0.16 | -0.02 | 0.07 |
| Qmax95 | 0.19 | 0.15 | 0.24 | 0.23 | 0.23 | 0.36 |

**Table F.5. Table E6. Mann-Kendall and Sen's tests results for the national and regional annual peak (4th-highest) 8-hour ground-level ozone indicators**

| Statistics | National | Atlantic Canada | Southern Quebec | Southern Ontario | Prairies and northern Ontario | British Columbia |
|---|---|---|---|---|---|---|
| First year | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Last Year | 2014 | 2014 | 2014 | 2014 | 2014 | 2014 |
| n | 15 | 15 | 15 | 15 | 15 | 15 |
| Test Z | -2.77 | -3.76 | -2.77 | -2.97 | 0.10 | -0.49 |
| Significant | Yes[B] | Yes[A] | Yes[B] | Yes[B] | No | No |
| Q | -0.82 | -1.00 | -1.22 | -1.41 | 0.01 | -0.07 |

| Statistics | National | Atlantic Canada | Southern Quebec | Southern Ontario | Prairies and northern Ontario | British Columbia |
|---|---|---|---|---|---|---|
| Qmin95 | -1.15 | -1.23 | -1.90 | -2.11 | -0.35 | -0.47 |
| Qmax95 | -0.21 | -0.51 | -0.32 | -0.62 | 0.27 | 0.19 |

**Table F.6. Mann-Kendall and Sen's tests results for the national and regional annual average sulphur dioxide indicators**

| Statistics | National | Atlantic Canada | Southern Quebec | Southern Ontario | Prairies and northern Ontario | British Columbia |
|---|---|---|---|---|---|---|
| First year | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Last Year | 2014 | 2014 | 2014 | 2014 | 2014 | 2014 |
| n | 15 | 15 | 15 | 15 | 15 | 15 |
| Test Z | -5.05 | -3.96 | -4.26 | -3.76 | -2.57 | -2.57 |
| Significant | Yes[A] | Yes[A] | Yes[A] | Yes[A] | Yes[C] | Yes[C] |
| Q | -0.13 | -0.44 | -0.25 | -0.24 | -0.07 | -0.04 |
| Qmin95 | -0.16 | -0.57 | -0.32 | -0.32 | -0.10 | -0.09 |
| Qmax95 | -0.11 | -0.30 | -0.16 | -0.14 | -0.03 | -0.01 |

**Table F.7. Mann-Kendall and Sen's tests results for the national and regional annual average nitrogen dioxide ($NO_2$) indicators**

| Statistics | National | Atlantic Canada | Southern Quebec | Southern Ontario | Prairies and northern Ontario | British Columbia |
|---|---|---|---|---|---|---|
| First year | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| Last Year | 2014 | 2014 | 2014 | 2014 | 2014 | 2014 |
| n | 15 | 15 | 15 | 15 | 15 | 15 |
| Test Z | -5.05 | -2.77 | -4.45 | -4.85 | -4.26 | -4.16 |
| Significant | Yes[A] | Yes[B] | Yes[A] | Yes[A] | Yes[A] | Yes[A] |
| Q | -0.46 | -0.34 | -0.48 | -0.73 | -0.23 | -0.38 |
| Qmin95 | -0.50 | -0.60 | -0.58 | -0.80 | -0.27 | -0.47 |
| Qmax95 | -0.41 | -0.13 | -0.42 | -0.62 | -0.20 | -0.30 |

**Table F.8. Mann-Kendall and Sen's tests results for the national and regional annual average volatile organic compound indicators**

| Statistics | National | Atlantic Canada | Southern Quebec | Southern Ontario | Prairies and northern Ontario | British Columbia |
|---|---|---|---|---|---|---|
| First year | 1999 | 2001 | 1999 | 1999 | 1999 | 2003 |
| Last Year | 2013 | 2013 | 2013 | 2013 | 2013 | 2013 |
| n | 15 | 13 | 15 | 14 | 15 | 11 |
| Test Z | -4.45 | -1.65 | -4.45 | -4.38 | -3.96 | -2.34 |
| Significant | Yes[A] | No | Yes[A] | Yes[A] | Yes[A] | Yes[C] |
| Q | -3.69 | -3.38 | -4.15 | -3.78 | -5.41 | -4.62 |
| Qmin95 | -4.90 | -7.58 | -4.83 | -5.51 | -8.30 | -7.88 |
| Qmax95 | -3.16 | 1.45 | -3.42 | -2.52 | -4.00 | -1.33 |

# Annex G. References and additional information

## References and further reading


Canadian Council of Ministers of the Environment (2000) Canada-wide Standards for Particulate Matter and Ozone (PDF; 38 KB). Retrieved on May 6, 2016.

Canadian Council of Ministers of the Environment (2011) Ambient Air Monitoring Protocol for $PM_{2.5}$ and Ozone (PDF; 787 KB). Retrieved on May 6, 2016.

Canadian Council of Ministers of the Environment (2012) Air Quality Management System. Retrieved on May 6, 2016.

Dann T (2012) CESI $PM_{2.5}$ Air Indicator Using Transformed Data. Prepared for Environment Canada.

Dann T (2013) Comparison of CESI $PM_{2.5}$ Air Indicators with Transformed Data (FEM Basis). Prepared for Environment Canada.

Environment Canada (2004) National Air Pollution Surveillance Network Quality Assurance and Quality Control Guidelines (PDF; 1.13 MB). Retrieved on May 6, 2016.

Environment and Climate Change Canada (2016) National Air Pollution Surveillance Program. Retrieved on May 6, 2016.


## Related information

Canadian Smog Science Assessment Highlights and Key Messages

Drivers and Impacts of Air Pollution

International Comparison of Urban Air Quality

Smog

## www.ec.gc.ca

Additional information can be obtained at:

Environment and Climate Change Canada
Public Inquiries Centre
7th Floor, Fontaine Building
200 Sacré-Coeur boul.
Gatineau, QC K1A 0H3
Telephone: 1-800-668-6767 (in Canada only) or 819-938-3860
Fax: 819-994-1412
TTY: 819-994-0736
Email: ec.enviroinfo.ec@canada.ca