Technical Memorandum

Aamjiwnaang First Nation
Community Air Monitoring Station

5-Year Report:
Results for the Period September 2008 – December 2013

June 2015

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Southwestern Region Technical Support Section
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Contents

Executive Summary

The Aamjiwnaang First Nation community air monitoring station was established in the fall of 2008 in partnership between the Aamjiwnaang First Nation and the provincial and federal governments. The station is equipped to monitor a range of air contaminants. Some air contaminants are sampled on an hourly basis, while others are sampled for 24 hours either once every six days or once every twelve days, depending upon the monitor. The monitoring data may be used for long-term air quality studies and to assist in community health assessments.

The purpose of this report is to present an analysis of the data collected over the first five years of operation at the station (September 2008-December 2013), and to highlight key results, such as observed trends in contaminant levels and exceedances of benchmark concentrations. Monitoring results were compared with Ontario's Ambient Air Quality Criteria (AAQC), where such existed.

Continuous (hourly) monitoring data are presented for:

- Sulphur dioxide (SO_2)
- Total reduced sulphur (TRS) compounds
- Nitrogen dioxide (NO_2)
- Ground-level ozone (O_3)
- Fine particulate matter ($PM_{2.5}$)
- Specific volatile organic compounds (VOC)

Non-continuous (collected on a six or twelve-day schedule) monitoring data are presented for:

- Suspended particulate (SP) and certain SP constituents – primarily metals
- A wider range of VOC
- Polycyclic aromatic hydrocarbons (PAH)

Key results discussed in this report:

- The average concentrations of SO_2, TRS, NO_2, and $PM_{2.5}$ have decreased over the five-year period. Results are not presented for carbon monoxide (CO), as the measurements remained below the detection limit over the entire monitoring period.
- The average and maximum O_3 concentrations, as well as the number of exceedances of the ministry's AAQC for O_3, have increased over the five-year period. This observation is consistent with the provincial trend in increasing ozone annual means over the last 10 years, as detailed in the ministry's Air Quality in Ontario 2013 Report.
- The ministry's continuous VOC monitoring showed that benzene and 1,3-butadiene were the only VOC to exceed their 24-hour AAQC in the five-year period. None of the other nine VOC continuously monitored by the ministry exceeded their AAQC.

- There were no AAQC exceedances for any of the suspended particulate or its metal constituents in the five-year period. The results do not suggest any increases in average or maximum concentrations for any of the suspended particulate or metals between 2009 and 2013.
- The non-continuous and continuous VOC datasets both showed decreases in the annual average benzene concentrations and exceedances of the 24-hr AAQC over the five-year period. However, different determinations of the annual AAQC exceedances were reached. The annual averages calculated using the non-continuous monitoring data showed that benzene exceeded the annual AAQC every year in the five-year period, and the continuous data indicated that the benzene annual AAQC was only exceeded in 2009.
- The average annual benzo[a]pyrene concentrations exceeded the ministry's AAQC each year over the five year period. Neither an increasing nor decreasing trend was seen in the average annual benzo[a]pyrene concentrations.

Introduction

The Aamjiwnaang First Nation is situated in the heart of the heavily industrialized area located along the St. Clair River to the south of the City of Sarnia. The Aamjiwnaang First Nation community air monitoring station is located on the Aamjiwnaang First Nation at the intersection of Tashmoo Avenue and Lasalle Road, west of Highway 40.

The Aamjiwnaang First Nation station consists of a secured and fenced building containing monitoring equipment targeting a range of air contaminants. The equipment installed at the station monitors the following individual compounds on a continuous basis:

- Ground-level ozone (O_3)
- Sulphur dioxide (SO_2)
- Nitrogen oxides ($NO/NO_2/NO_x$)
- Total reduced sulphur (TRS) compounds
- Carbon monoxide (CO)
- Fine particulate matter ($PM_{2.5}$)
- Volatile organic compounds (VOC) using a Gas Chromatograph/Mass Spectrometer (GC/MS)

In addition to the continuous monitoring, a wider range of air contaminants are measured by monitors that collect a sample over a 24-hour period, which is sent to an off-site laboratory for

analysis. The non-continuous sampling can often detect lower concentrations of target contaminants than that of the continuous sampling. The following air contaminants are measured non-continuously at the Aamjiwnaang First Nation station, either on a six-day or twelve-day cycle:

- Volatile organic compounds (VOC)
- Suspended particulate (SP) <44 µm and metals
- Polycyclic aromatic hydrocarbons (PAH)

Meteorological data, including temperature, wind speed, and wind direction, are also collected at the station.

In this report, monitoring results were compared with Ontario's Ambient Air Quality Criteria (AAQC), where such existed. An AAQC is a desirable concentration of a contaminant in the air, based on protection against adverse effects on health or the environment. The AAQC were used for comparisons as they are intended to assess general air quality from all sources. In contrast, Ontario's air standards are meant to assess the contribution of any single source, such as emissions from an individual facility.

Some monitoring results were also compared to the Air Quality Index (AQI), which is a rating scale for outdoor air in Ontario, with a lower AQI indicating better air quality. The six key air pollutants that make up the AQI are SO_2, TRS, NO_2, O_3, CO, and $PM_{2.5}$. Results are not presented for carbon monoxide (CO), as the measurements remained below the detection limit over the entire monitoring period.

Monitoring results were compared with data from other ministry or Environment Canada monitoring stations in Southwestern Ontario, including Sarnia, Windsor, and London, where available. Comparison sites were chosen at which most of the same pollutants were monitored and which reflected a similar urban environment.

The monitoring results are reported in two different concentration units. Particulate matter, metal, PAH, and canister VOC results are reported in metric concentration units (micrograms per cubic metre (µg/m^3) or nanograms per cubic metre (ng/m^3), while most of the hourly results are reported in parts per billion (ppb). Where results are reported in ppb and are to be compared to ministry AAQC (which are published in µg/m^3), the ministry's AAQC values are converted to ppb assuming a temperature of 20° C and an atmospheric pressure of 1 atmosphere (101.3 kilopascals [kPa]).

The ministry has previously published Technical Memoranda providing summaries and analyses of data collected at the Aamjiwnaang First Nation station. The results of the first year of operation included the period September 2008 – August 2009, and the results of the second year of operation covered the period September 2009 to December 2010. Unless otherwise stated, in this report, "2009" will refer to the September 2008 – August 2009 reporting period

(Year 1), and “2010” will refer to the September 2009 – December 2010 reporting period (Year 2). The 2011, 2012, and 2013 results are based on calendar years. This convention has been adopted in order to facilitate comparison to the results presented in the ministry’s previously published Technical Memoranda.

This report includes monitoring data presented using pollution roses, which are diagrams showing how pollutant levels are related to wind direction. All wind data and directions are given based on the direction from which the wind was blowing; i.e., a westerly wind is a wind blowing from the west.

For the calculation of averages of PAH, non-continuous VOC, suspended particulate and metals, half of the detection limit is used where the monitoring data shows non-detects (or “0” values). For the calculation of averages of the AQI pollutants and the continuous VOC, non-detects are included as “0”. Additional information on this averaging convention is given in the *Data Averaging and Unit Conversion* appendix.

Hourly Data – Air Quality Index Pollutants

Sulphur Dioxide (SO_2)

Sulphur dioxide (SO_2) is emitted from industrial facilities and sources that burn sulphur-containing fuel. Industrial sources include electric power generators, iron and steel mills, petroleum refineries, and pulp and paper mills. Small sources includes residential, commercial, and industrial space heating. SO_2 and nitrogen oxides are the main contributors to acid rain. Health effects caused by exposure to high levels of SO_2 include eye and respiratory tract irritation, and worsening cardiovascular disease. SO_2 can travel a considerable distance downwind in certain meteorological conditions.

The ministry has a 1-hour AAQC for SO_2 of 250 ppb, a 24-hr AAQC of 100 ppb, and an annual AAQC of 20 ppb.

The table below shows the average and maximum hourly SO_2 concentrations observed in each reporting year, as well as the number of exceedances of the 1-hr AAQC of 250 ppb. Data collected at the ministry's Sarnia and Windsor West AQI stations are shown as well.

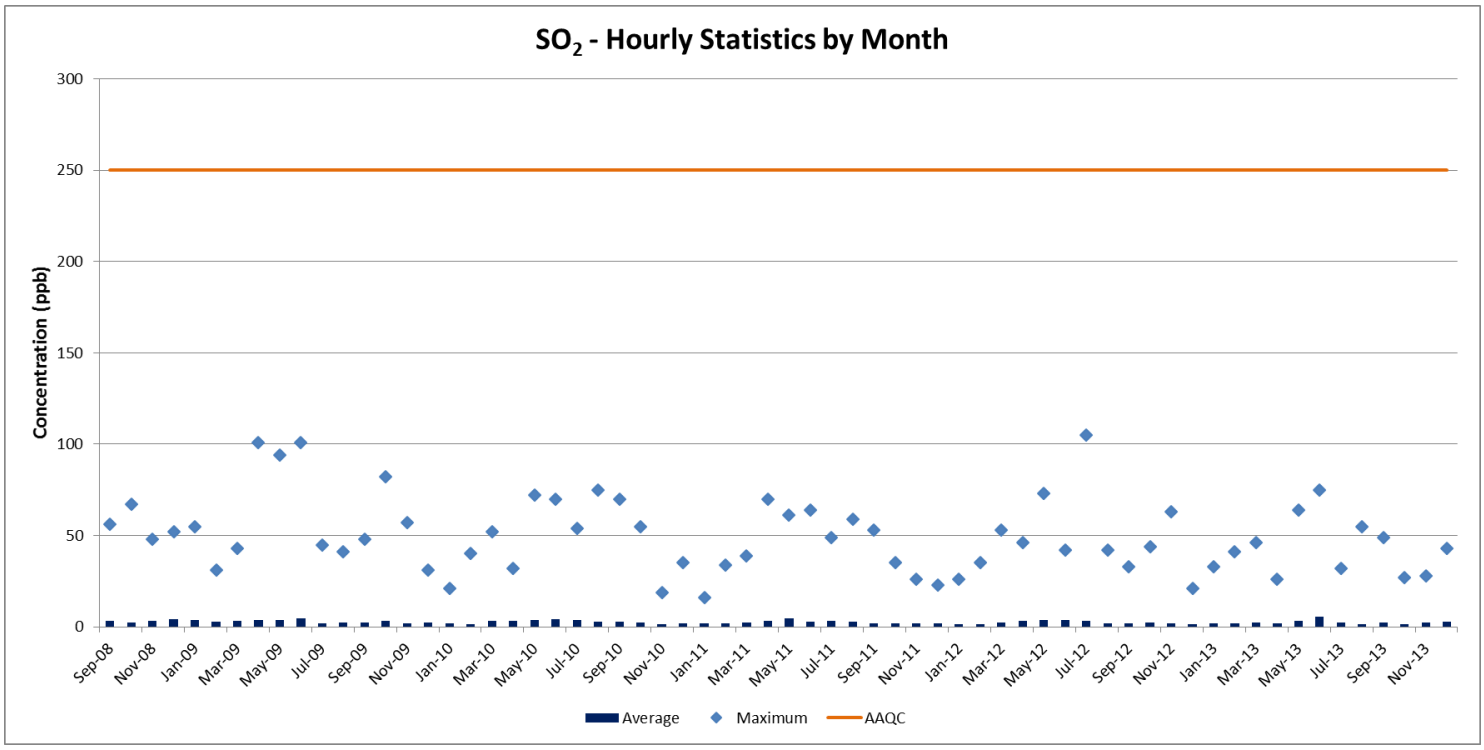
Hourly SO_2 Concentrations and 1-hr AAQC (250 ppb) Exceedances 2009-2013					
	2009	2010	2011	2012	2013
Aamjiwnaang First Nation Station					
Average (ppb)	3.0	2.7	2.5	2.4	2.4
Max (ppb)	101	82	70	105	75
AAQC Exceedances	0	0	0	0	0
Sarnia AQI Station					
Average (ppb)	5.6	4.1	5.3	4.1	3.8
Max (ppb)	189	103	94	110	144
Exceedances	0	0	0	0	0
Windsor West AQI Station					
Average (ppb)	3.7	3.4	3.4	2.8	2.6
Max (ppb)	65	74	75	69	52
Exceedances	0	0	0	0	0

Key results for SO_2 at the Aamjiwnaang First Nation Station:

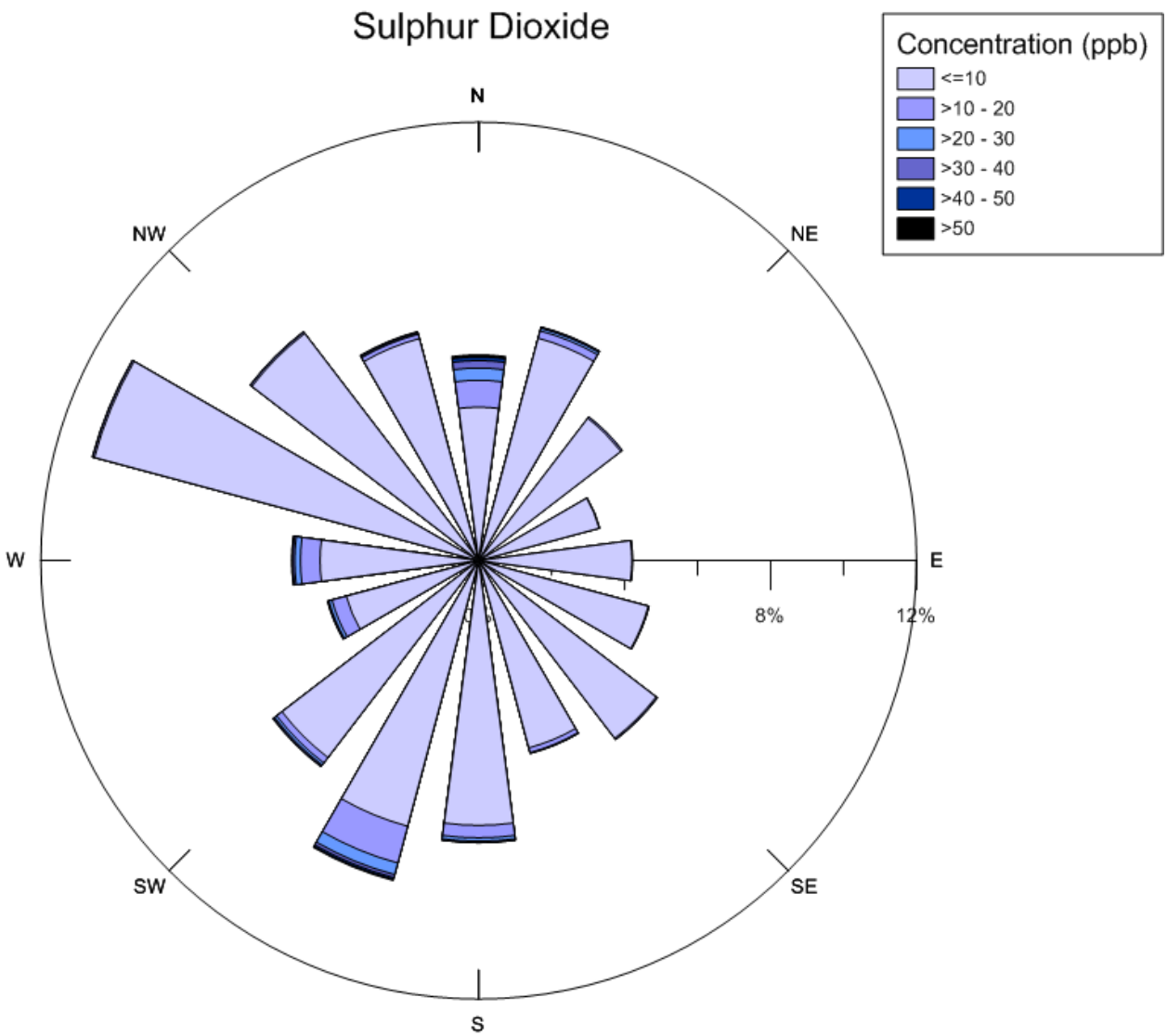
- There were no exceedances of the ministry's 1-hour or annual AAQC for SO_2 between 2009 and 2013.

- The average hourly concentrations measured in 2011-2013 are slightly lower than in 2009-2010, suggesting a minor decrease in the average SO_2 concentrations over the five-year period.
- The average SO_2 concentrations measured at the Aamjiwnaang First Nation station were lower than those observed at the Sarnia and Windsor West AQI stations every year between 2009 and 2013.

The figure below shows the monthly statistics of the hourly SO_2 concentrations; that is, the average hourly concentration for each month, and the maximum hourly concentration observed in each month, over the five-year period. SO_2 concentrations generally increased in the spring, were highest over the summer months, decreased in the fall, and were lowest over the winter months.



The pollution rose below shows the SO_2 concentration variation with wind direction for 2009-2013. The highest concentrations each year were generally seen from the north and southwest. In the five year period, 99-100% of the SO_2 measurements led to a *Very Good* SO_2 AQI sub-index (0-79 ppb).



Total Reduced Sulphur (TRS)

Total Reduced Sulphur (TRS) is a group of sulphur-based compounds including hydrogen sulphide and various mercaptans. TRS have a variety of industrial sources, such as petrochemical facilities and sewage treatment plants, and natural sources, such as swamps and marshes. TRS compounds are not typically considered a health hazard at typical environmental concentrations, however, they are a primary cause of odours.

The ministry does not have a 1-hour AAQC for TRS, so the results were compared to 27 ppb, the highest concentration which would lead to a *Moderate* AQI classification. The ministry has a health-based 24-hour AAQC for TRS of 7 µg/m^3 (4.8 ppb), and an odour-based 10-min AAQC of 13 µg/m^3 (8.9 ppb).

The table below shows the average and maximum hourly TRS concentrations measured between 2009 and 2013, as well as the number of exceedances of the *Moderate* AQI threshold, at the Aamjiwnaang First Nation station and at the Sarnia and Windsor West AQI stations.

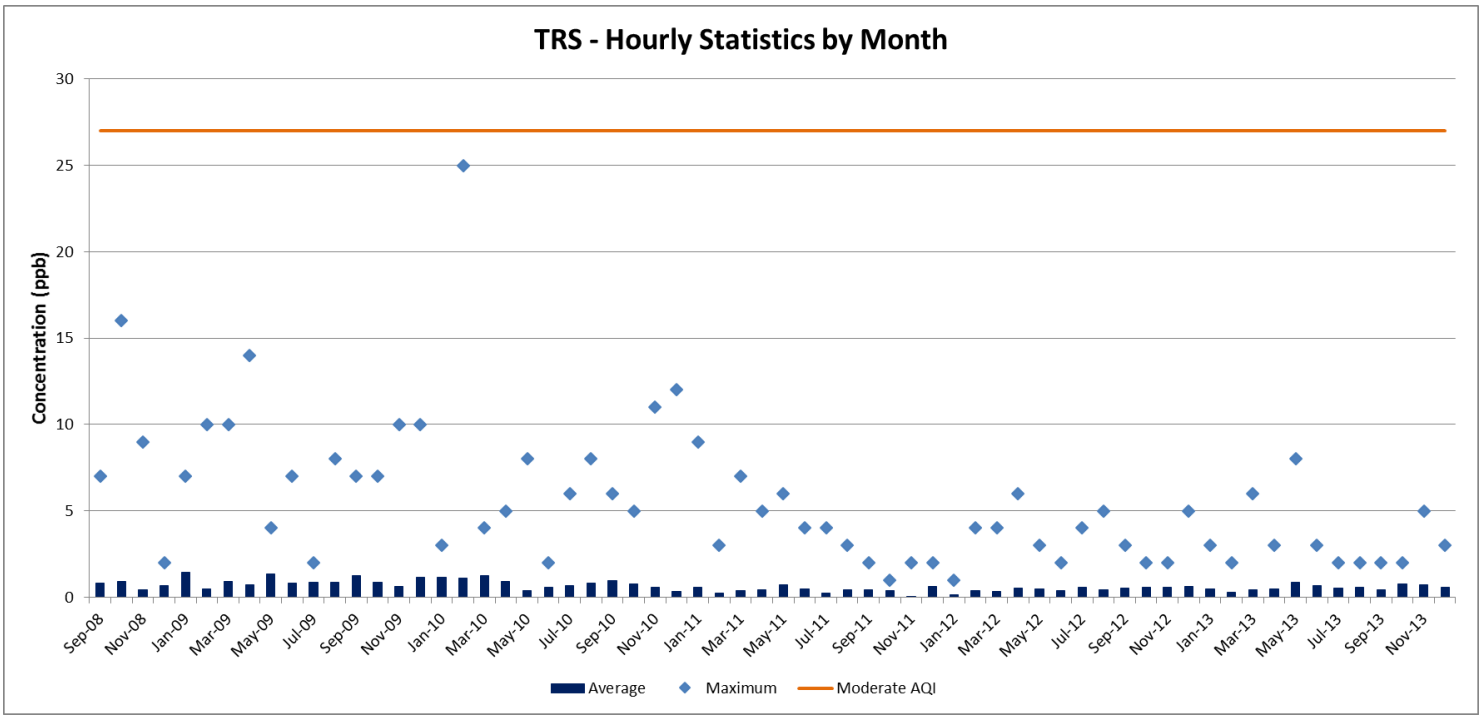
Hourly TRS Concentrations and *Moderate* AQI (27 ppb) Exceedances 2009-2013					
	2009	**2010**	**2011**	**2012**	**2013**
Aamjiwnaang First Nation Station					
Average (ppb)	0.9	0.8	0.4	0.5	0.6
Max (ppb)	16	25	9	6	8
Exceedances	0	0	0	0	0
Sarnia AQI Station					
Average (ppb)	0.1	0.06	0.2	0.7	0.1
Max (ppb)	6	4	4	5	15
Exceedances	0	0	0	0	0
Windsor West AQI Station					
Average (ppb)	0.6	0.6	0.2	0.5	0.3
Max (ppb)	10	34	18	13	16
Exceedances	0	0	0	0	0

Key findings for TRS at the Aamjiwnaang First Nation station:

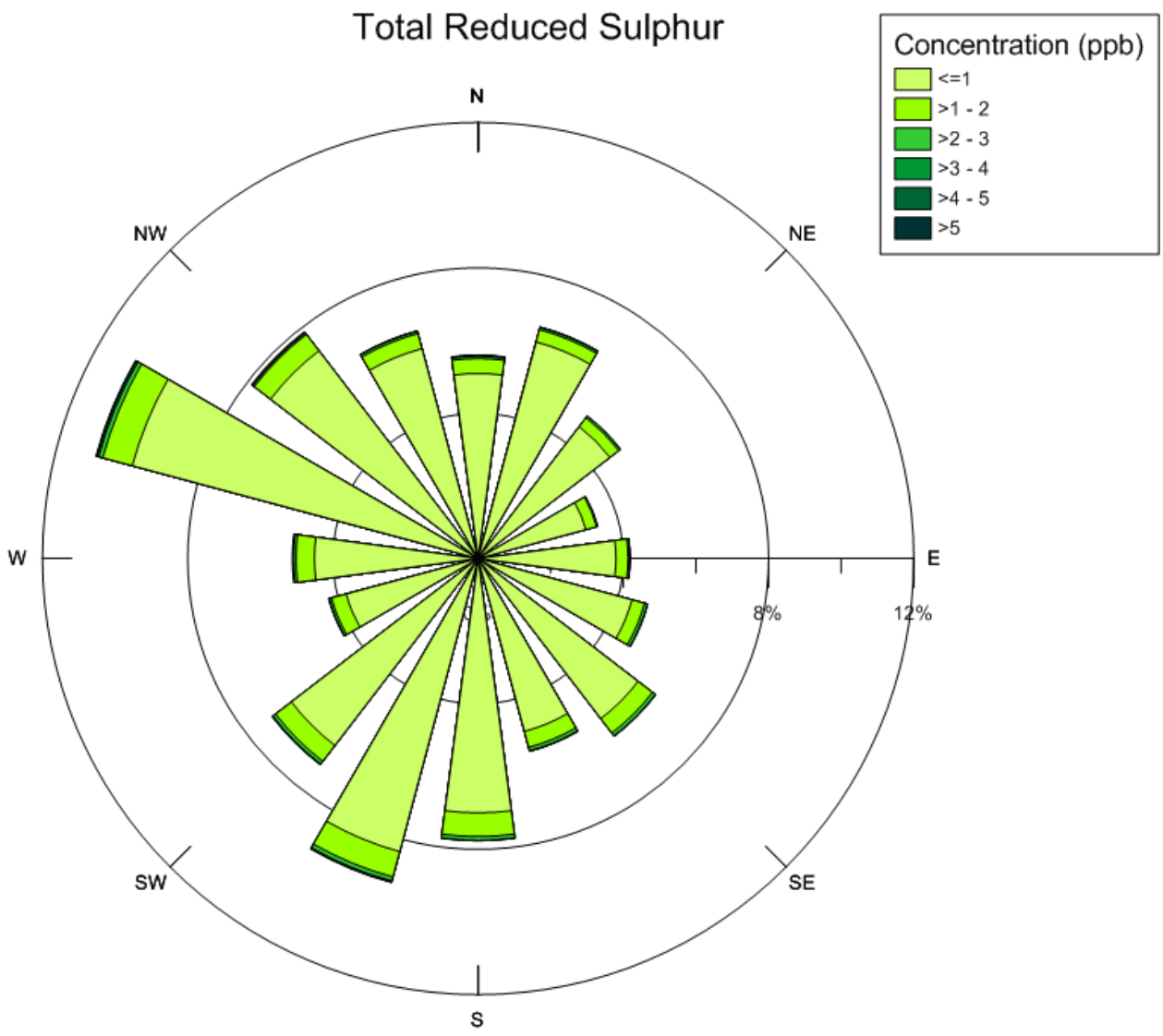
- There were no exceedances of the ministry's *Moderate* AQI threshold for TRS between 2009 and 2013.
- The average and maximum concentrations in 2011-2013 are slightly lower than those measured in 2009-2010, suggesting a decrease in TRS concentrations over the five year period.

- The average concentration was higher than the values for the Sarnia and Windsor West AQI station every year between 2009-2013 except 2012.

The figure below shows the average and maximum hourly TRS concentration for each month over the five-year period. There was minimal variation in the average monthly results. The maximum values were generally highest in the winter months and in early spring.



The pollution rose below shows the TRS concentration variation with wind direction for 2009-2013. The pollution rose does not show a dominant source of TRS, but indicates that there may be a number of smaller sources in the area. In the five year period, 98% to 100% of the TRS measurements led to a “Very Good” TRS AQI sub-index (0-5 ppb), with the remainder of the measurements falling into the “Good” range (6-10 ppb), and a few hours in 2009 falling into the “Moderate” range (11-27 ppb).


Total Reduced Sulphur
Concentration (ppb)
<=1
>1 - 2
>2 - 3
>3 - 4
>4 - 5
>5
N
NE
E
SE
S
SW
W
NW
8%
12%

Nitrogen Dioxide (NO_2)

Nitrogen Dioxide (NO_2) is a common combustion product. The main sources are motor vehicles, thermal power generation, metal production, and incineration. NO_2 reacts in the atmosphere to form a number of compounds, some of which have adverse health or environmental effects. It is a component of smog and one of the causes of acid rain. NO_2 can lead to lung irritation and lower resistance to respiratory infection. Sensitivity to NO_2 is higher for people with asthma and bronchitis.

The ministry has a 1-hour AAQC for NO_2 of 200 ppb, and a 24-hr AAQC of 100 ppb.

The table below lists the average and the maximum hourly NO_2 concentrations observed in each reporting year, and the number of hours that the concentration of NO_2 exceeded the 1-hour AAQC of 200ppb during the reporting period. Data is shown for the Windsor West, Sarnia, and London AQI stations as well. The London AQI station moved in 2013, so there may be slight differences in year to year trends as a result of this change in location.

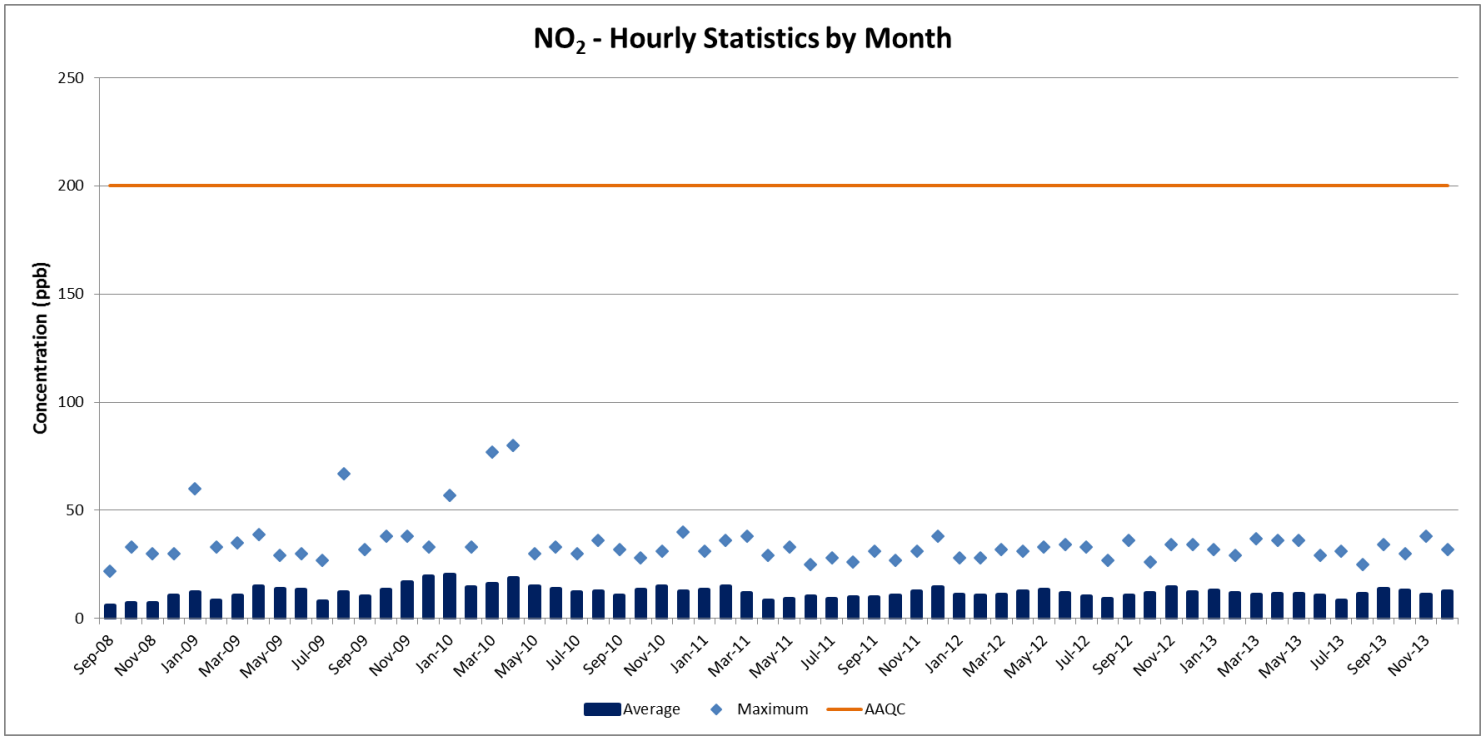
Hourly NO_2 Concentrations and 1-hr AAQC (200 ppb) Exceedances 2009-2013					
	2009	**2010**	**2011**	**2012**	**2013**
Aamjiwnaang First Nation Station					
Average (ppb)	13.7	14.6	11	11.5	11.5
Max (ppb)	67	80	38	36	38
AAQC Exceedances	0	0	0	0	0
Sarnia AQI Station					
Average (ppb)	8.9	8	8.6	8.6	8.1
Max (ppb)	48	60	55	53	46
AAQC Exceedances	0	0	0	0	0
Windsor West AQI Station					
Average (ppb)	14.1	14.4	12.9	11.4	11.5
Max (ppb)	67	80	93	51	65
AAQC Exceedances	0	0	0	0	0
London AQI Station					
Average (ppb)	10.3	8.6	8.3	6.3	6.4
Max (ppb)	52	68	50	36	38
AAQC Exceedances	0	0	0	0	0

Key results for NO_2 at the Aamjiwnaang First Nation Station:

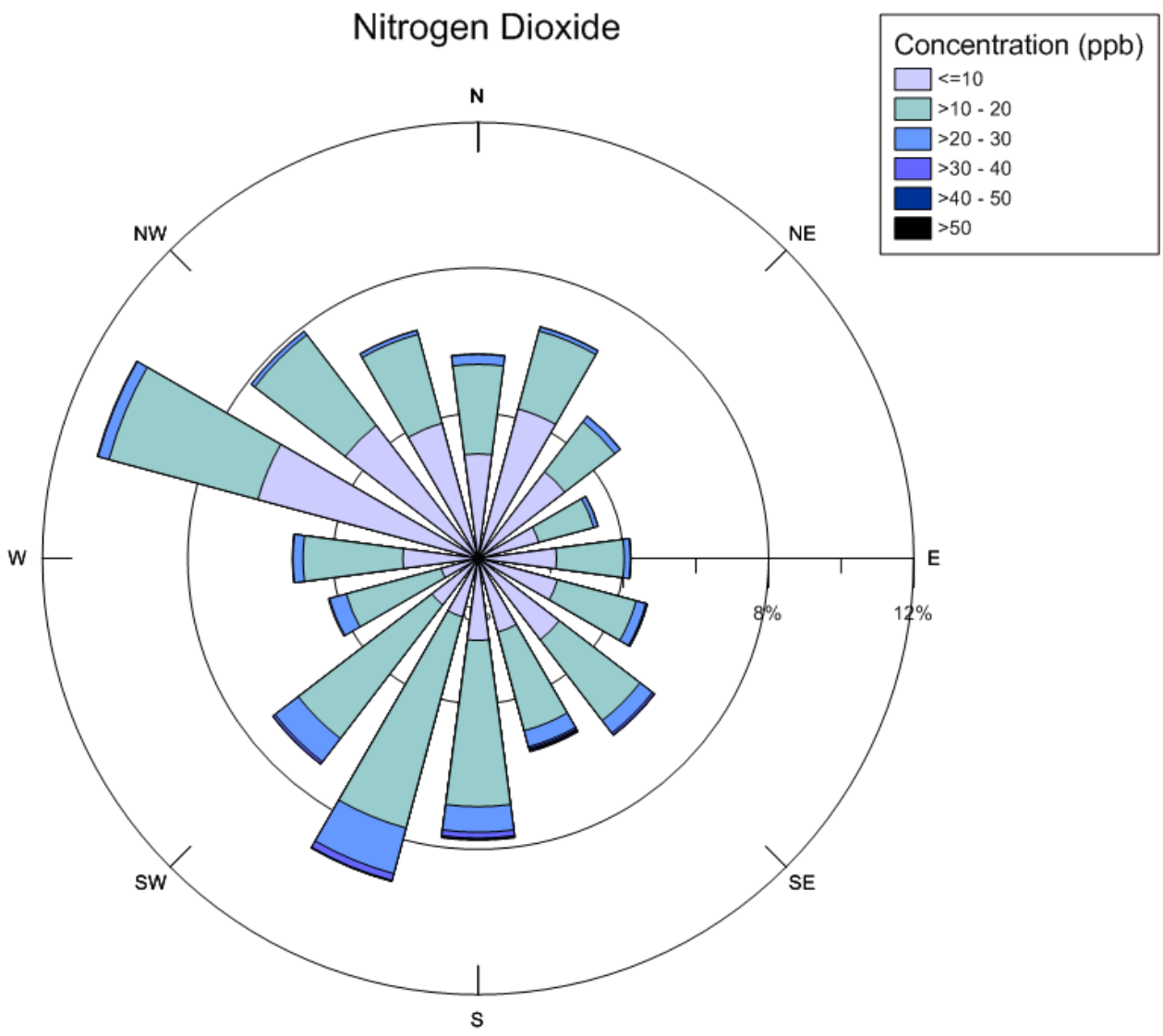
- There were no exceedances of the ministry's 1-hour AAQC for NO_2 between 2009 and 2013.

- A review of the 24-hour statistics for NO_2 (not shown in the above table) determined that there were no exceedances of the ministry's 24-hour AAQC for NO_2 between 2009 and 2013.
- The average and maximum concentrations in 2011-2013 are lower than those measured in 2009-2010, indicating a decline in NO_2 concentrations over the five-year period.
- The average NO_2 concentration was higher than the Sarnia and London station every year between 2009 and 2013; however, the maximum concentration was equal to or lower than the Sarnia, Windsor, and London stations between 2011 and 2013.

The figure below shows the average and maximum hourly concentration observed in each month over the five-year period. Minimal variation was seen, and no strong seasonal trends were apparent in any year.



The pollution rose below shows that higher NO_2 concentrations, relative to the concentrations measured at the Aamjiwnaang First Nation station, were seen from all directions, however, they were more frequent when the wind came from the south. The NO_2 AQI subindex was in the *Very Good* range (0-50 ppb) for all of 2011, 2012, and 2013, and over 99% of the time in 2009 and 2010.


Nitrogen Dioxide
Concentration (ppb)
<=10
>10 - 20
>20 - 30
>30 - 40
>40 - 50
>50
N
NE
E
SE
S
SW
W
NW
8%
12%

Ground-level Ozone (O_3)

Ground-level ozone (O_3) is not emitted directly into the atmosphere, rather, it is formed in the presence of sunlight in reactions between nitrogen oxides (NO_x) and volatile organic compounds (VOC). The formation and transport of ozone is strongly dependent on meteorological conditions. Signficant amounts of ozone and ozone-forming compounds travel from the United States into Ontario. Strong sunlight and warm conditions speed up production, and so concentrations tend to rise during the day, and fall at night. In Ontario, the highest ozone levels usually occur in the summer, between noon and early evening. Year to year variations in ozone concentrations are greatly dependant on wind and weather patterns.

Ground-level ozone is a component of smog and can have human health impacts, particularly respiratory tract irritation. It also adversely affects certain crops, plants, and trees.

The ministry has a health-based 1-hour AAQC for O_3 of 80 ppb.

The table below shows the average and maximum hourly O_3 concentrations observed in each reporting year, and the number of hours that the concentration of O_3 exceeded the 1-hour AAQC of 80 ppb during the respective reporting periods. Data is shown for the Sarnia, Windsor West, and London AQI stations as well.

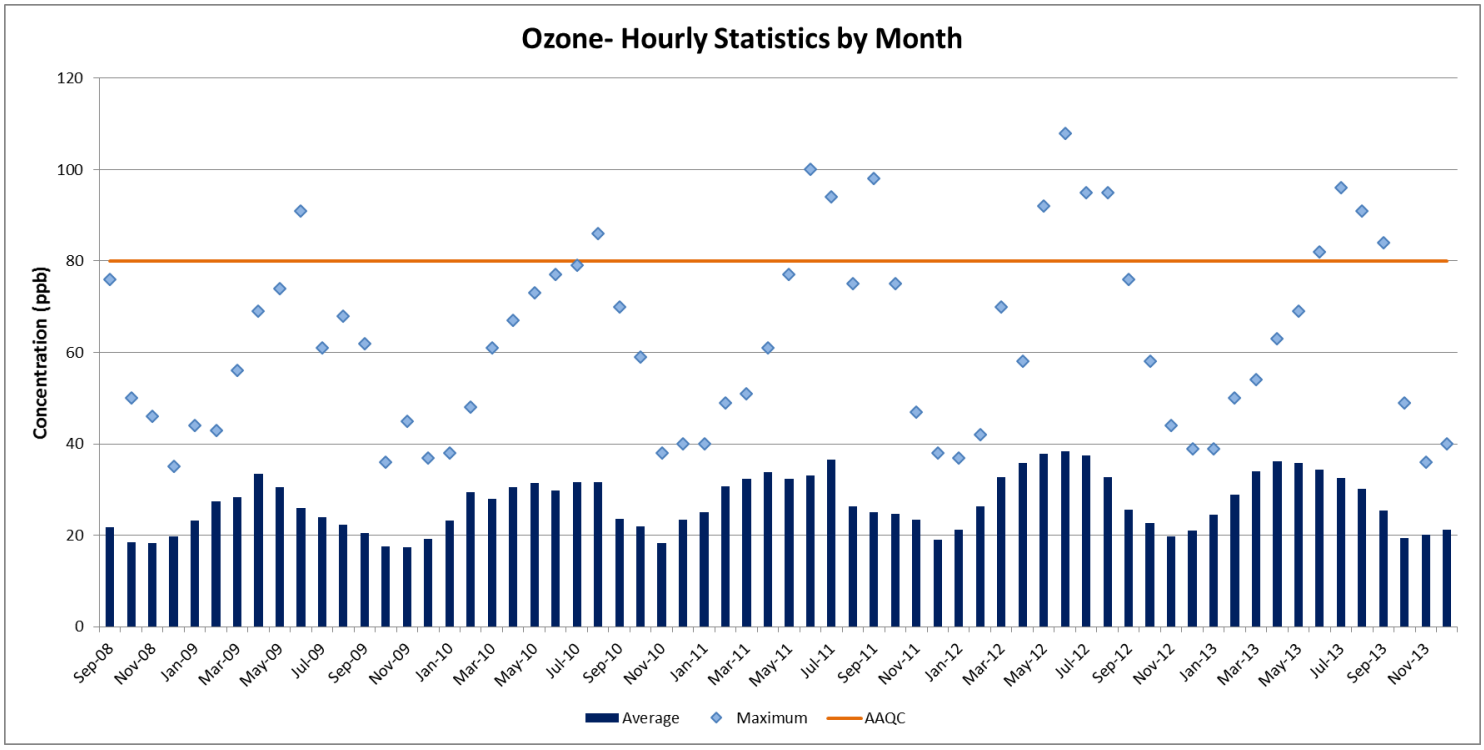
Hourly O_3 Concentrations and 1-hr AAQC (80 ppb) Exceedances 2009-2013					
	2009	2010	2011	2012	2013
Aamjiwnaang First Nation Station					
Average (ppb)	24.1	24.8	28.6	29.4	28.4
Max (ppb)	91	86	100	108	96
AAQC Exceedances	1	2	28	50	12
Sarnia AQI Station					
Average (ppb)	27.1	28.1	29.6	29.7	28.6
Max (ppb)	93	90	94	101	83
AAQC Exceedances	8	14	12	41	4
Windsor West AQI Station					
Average (ppb)	24.9	24.5	26.4	28	26.7
Max (ppb)	93	96	101	128	87
AAQC Exceedances	3	6	31	41	3
London AQI Station					
Average (ppb)	25.6	25.8	26.8	27.7	28.7
Max (ppb)	79	77	83	88	82
AAQC Exceedances	0	0	2	26	2

Key results for O_3 at the Aamjiwnaang First Nation Station:

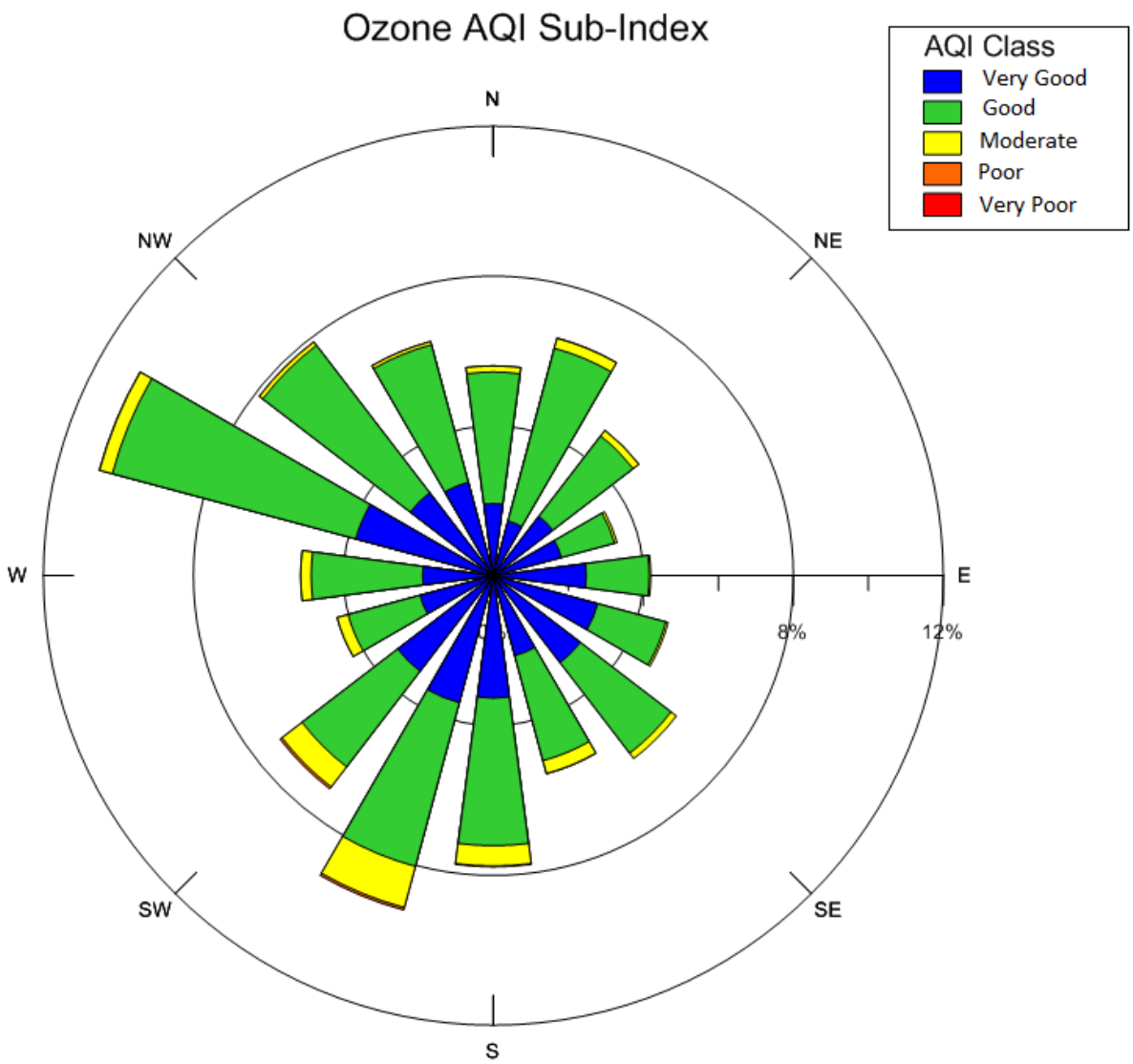
- The average and maximum concentrations observed in 2011-2013, as well as the number of exceedances of the AAQC, were higher than in 2009-2010, suggesting an increase in average O_3 concentrations over the five-year period.
- In most years, the average concentration was slightly lower at the Aamjiwnaang First Nation station than at the Sarnia and London stations, but greater than Windsor West.
- In contrast, the maximum concentrations at the Aamjiwnaang First Nation station were higher than those measured at the London station every year, higher than Sarnia in 2011-2013, and higher than Windsor only in 2013.
- The highest average and maximum concentrations at the Aaamjiwnaang First Nation, Sarnia, and Windsor stations, as well as the greatest number of exceedances, occurred in 2012.

The trends in increased ozone concentrations and AAQC exccedances are consistent with the findings of the ministry's Air Quality in Ontario 2013 report, which discusses the provincial trend in increasing ozone annual means over 2004-2013. Elevated ozone levels in southwestern Ontario are generally attributed to the long-range transport of pollutants from the United States.

The figure below shows the average and maximum hourly concentration observed in each month over the five-year period. The average and maximum concentrations increased each year in the late spring and summer. This seasonal trend is seen because ozone formation is directly linked to heat and sunlight.



The pollution rose below shows that higher frequencies of *Moderate* and *Poor* O_3 AQI sub-indices are related to winds from the south-southwest. There were no *Very Poor* sub-indices, however, exceedances led to instances of *Poor* sub-indices in the summer each year.



Fine Particulate Matter ($PM_{2.5}$)

The atmosphere contains a wide variety of liquid and solid particles, ranging considerably in size. Fine particulate matter, also called respirable particulate or $PM_{2.5}$, is the fraction of atmospheric particulate that is smaller than 2.5 microns in aerodynamic diameter. These particles are important because their small size enables them to bypass the body's natural defences and reach the deepest parts of the lung. $PM_{2.5}$ often forms from chemical processes in the atmosphere, and acts much like a gas due to its small size. As a result, fine particulate may be transported hundreds of kilometres from where its constituents were emitted.

The ministry does not have a 1-hour AAQC for $PM_{2.5}$. "Exceedances" for $PM_{2.5}$ were determined based on the highest concentration that would lead to a *Moderate* AQI classification(45 µg/m^3). The $PM_{2.5}$ AQI sub-index is based upon a 3-hour running average, so for consistency, the statistics presented below were calculated for 3-hour running averages.

3-hr $PM_{2.5}$ Concentrations and *Moderate* AQI (45 µg/m^3) Exceedances 2009-2013					
	2009	**2010**	**2011**	**2012**	**2013**
Aamjiwnaang First Nation Station					
Average (µg/m^3)	10.1	10.2	9.8	9.1	8.4
Max (µg/m^3)	61	73	54.3	63.7	54.7
Exceedances	19	37	15	10	3
Sarnia AQI Station					
Average (µg/m^3)	10	10.3	10.5	10.2	8.5
Max (µg/m^3)	54	65	52.7	53.7	42
Exceedances	8	4	1	8	0
Windsor West AQI Station					
Average (µg/m^3)	7.7	7.7	7.8	7.6	10
Max (µg/m^3)	79	49	40.7	54	45.3
Exceedances	9	3	0	2	1
London AQI Station					
Average (µg/m^3)	6.1	6	6.2	6.5	9.1
Max (µg/m^3)	51	44	35.3	58	45.3
Exceedances	8	0	0	3	1

Key findings for $PM_{2.5}$ at the Aamjiwnaang First Nation Station:

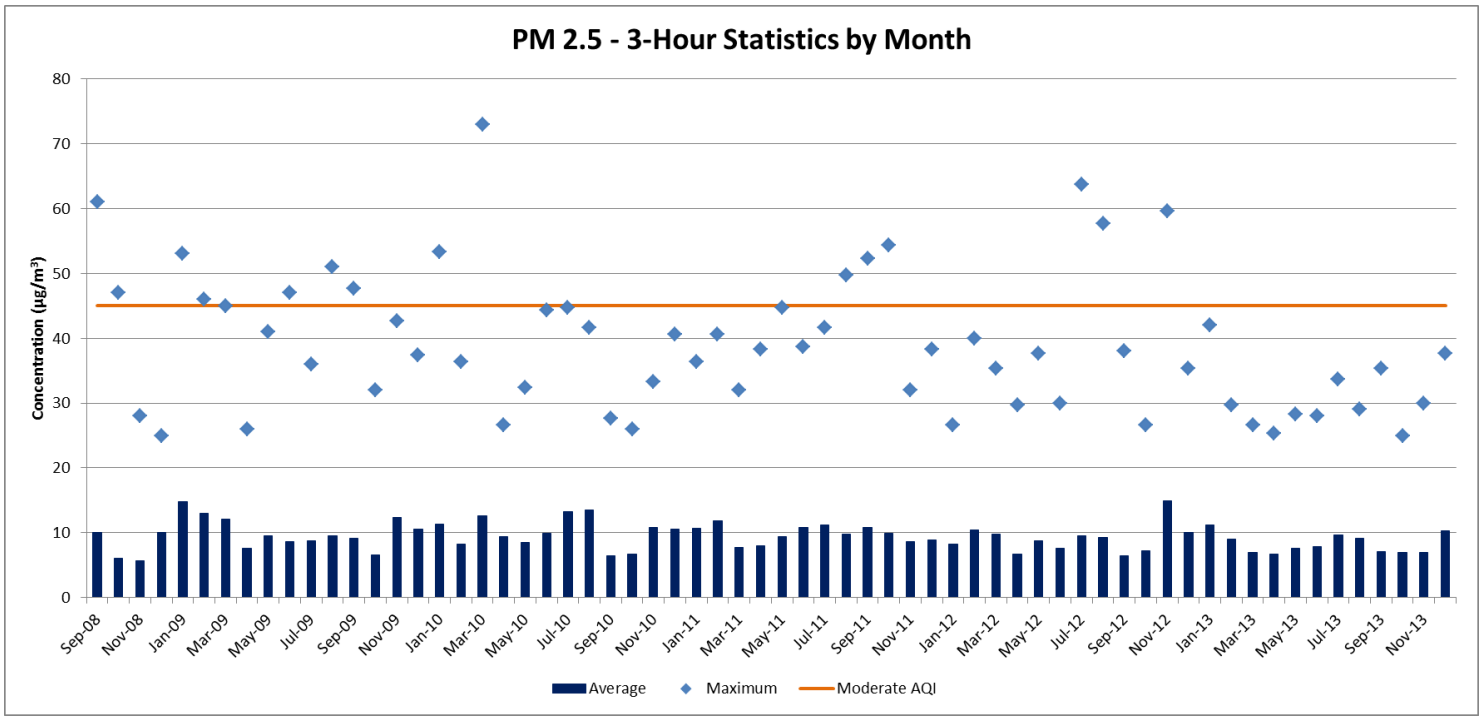
- The number of exceedances of $PM_{2.5}$ in 2011-2013 was lower than in 2009-2010.
- The average $PM_{2.5}$ concentration decreased between 2009-2013, however, the maximum concentration has varied; the highest maximum concentration was observed

in 2010. The greatest number of exceedances was also observed in 2010. The ministry's Aamjiwnaang First Nation report for Year 2 (2010 reporting period) noted that all $PM_{2.5}$ exceedances in 2010 occurred over a 3-day period with winds from the southeast.

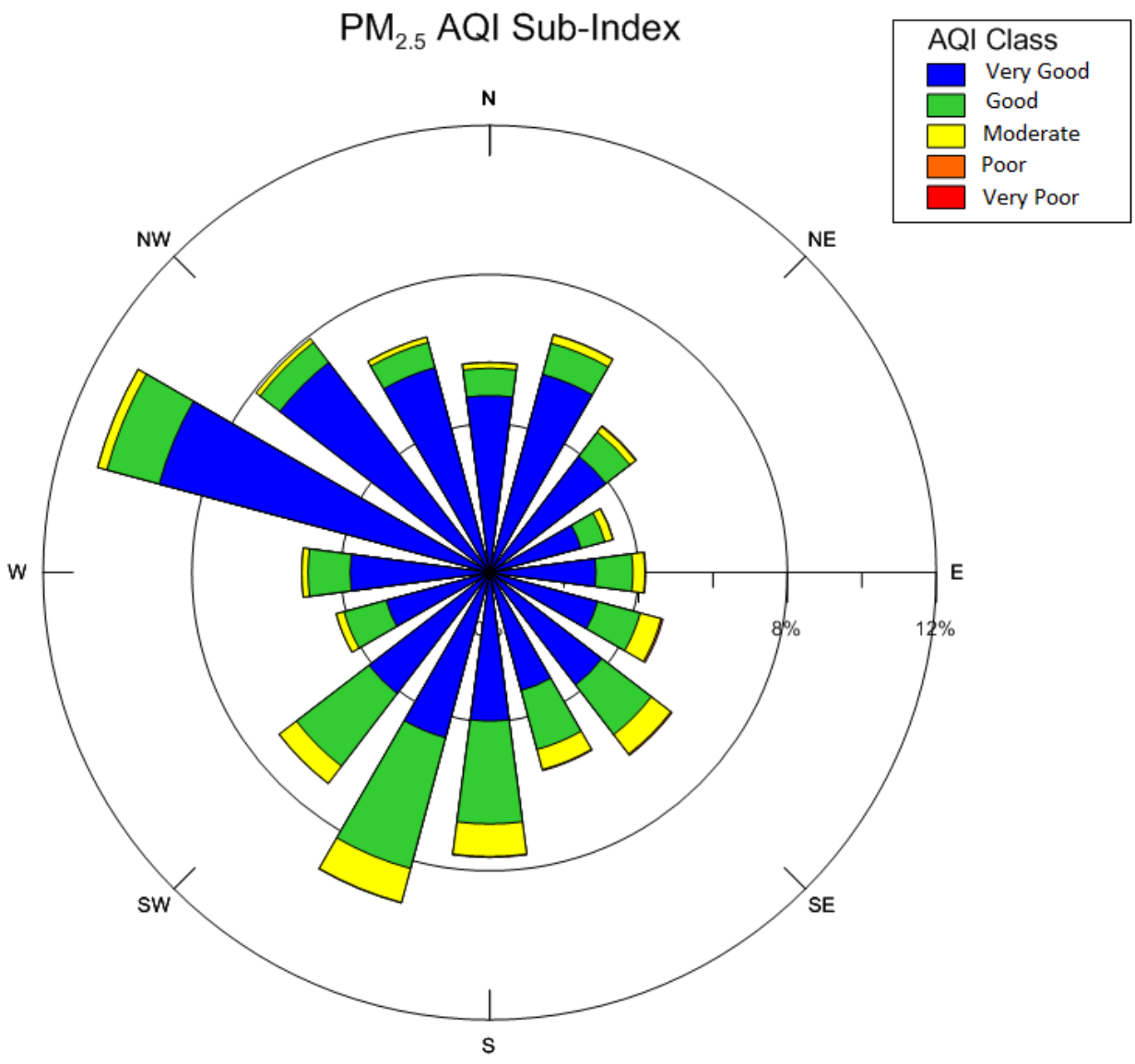
- The lowest average concentration, and lowest number of exceedances, occurred in 2013.
- The average concentration each year was generally equivalent to or less than the Sarnia AQI station, but greater than the average concentrations at Windsor West and London.
- The maximum concentration was greater than those at Sarnia, Windsor and London in 2010-2012.

In 2013, the ministry installed new monitors at its Air Quality Index stations that are expected to provide a more accurate measurement of fine particulate matter. A more in-depth discussion of this may be found in the ministry's Air Quality in Ontario 2013 Report. The new monitors reported higher annual means for London and Windsor West stations than had been seen in the previous year, but the maximum for the Sarnia AQI station was lower. While part of these differences may be due to the new monitors, it is not uncommon to see changes from year to year.

The figure below shows the monthly average and maximum 3-hour $PM_{2.5}$ concentrations over the five year period. The higher average and maximum concentrations were generally seen in colder months.



The pollution rose below shows that *Moderate* $PM_{2.5}$ AQI sub-indices are related to wind from all directions, and *Poor* sub-indices are generally related to winds from the south. There were no *Very Poor* sub-indices between 2009 and 2013. *Poor* sub-indices were seen in March of 2010, and the summer and late fall of 2011 and 2012. *Moderate* sub-indices were seen in every month between 2009 and 2013.



Hourly Data – Volatile Organic Compounds (VOC)

Volatile organic compounds (VOC) are organic (carbon containing) chemicals with a high vapour pressure at typical atmospheric conditions. VOC are emitted into the atmosphere from a variety of natural sources (primarily vegetation), and anthropogenic (man-made) sources, including vehicles, fossil fuel combustion, petroleum refining, industrial and residential solvent use, synthetic material manufacturing, agricultural activities, and wood burning. Certain VOC play a role in the formation of ground-level ozone and $PM_{2.5}$. Other, less reactive VOC may be transported long distances in the atmosphere. Some VOC can have health and environmental impacts.

A list of the VOC measured, their sources, and potential health and environmental impacts are included in the Appendices.

Hourly levels of VOC were measured at the Aamjiwnaang First Nation station using a Gas Chromatograph/Mass Spectrometer (GC/MS). The GC/MS that monitors VOC at the Aamjiwnaang First Nation station was the first in Ontario to be placed in the field in continuous operation. This station is one of the few air monitoring stations in Ontario that is able to measure several specific VOC. Over the 5-year period, there have been some changes to the initial list of target compounds that were measured - some compounds were added, and others were removed, based on the monitoring results. Vinyl chloride was not detected in the first 15 months of monitoring, and was discontinued in April 2010. Two new compounds, chloromethane and hexane, were added. Chloroform was added to the target list in mid-2011, based on the findings of the ministry's mobile monitoring survey, however, it was not detected in 2012 or 2013, and was removed. Carbon disulphide, acrylonitrile were not detected between 2009 and 2012, and were removed in 2013. Carbon tetrachloride, trichloroethylene, and tetrachloroethylene were added in 2013. Carbon tetrachloride and trichloroethylene were not detected, and so these results are not shown.

The table below summarizes the results from 2009-2013, showing the average and maximum hourly concentrations of the compounds that were detected each year, as well as the percentage of measurements that were above the method detection limit (mdl):

1-Hour VOC Measurements – Average and Maximum Concentrations (ppb) and Measurements above mdl (%)															
	2009			2010			2011			2012			2013		
	Avg (ppb)	Max (ppb)	% > mdl	Avg (ppb)	Max (ppb)	% > mdl	Avg (ppb)	Max (ppb)	% > mdl	Avg (ppb)	Max (ppb)	% > mdl	Avg (ppb)	Max (ppb)	% > mdl
Propylene	0.13	95.14	0.30%	0.27	234.02	0.57%	0.52	151.44	2.16%	1.04	141.90	7.04%	2.96	255.48	19.94%
Chloromethane	-	-	-	0.02	71.00	0.07%	0.18	56.35	1.17%	0.26	47.17	2.11%	0.22	63.23	2.30%
1,3-Butadiene	0.00	0.00	0.00%	0.16	702.25	0.05%	0.05	111.95	0.15%	0.01	26.97	0.23%	0.04	82.12	0.17%
Hexane	-	-	-	0.00	2.64	0.06%	0.26	54.87	2.69%	0.40	91.61	4.00%	0.52	125.78	4.92%
Cyclohexane	0.07	48.89	0.60%	0.15	50.08	1.16%	0.17	58.78	2.03%	0.25	60.91	3.80%	0.33	46.90	7.35%
Benzene	0.14	12.60	4.90%	0.06	24.02	1.92%	0.12	23.15	3.20%	0.12	16.48	4.07%	0.12	15.70	7.69%
Toluene	0.28	29.11	15.70%	0.12	29.63	4.50%	0.17	45.28	7.21%	0.12	52.06	6.09%	0.09	15.06	10.91%
Ethyl Benzene	0.08	9.52	6.90%	0.04	18.76	3.52%	0.07	17.10	3.39%	0.03	13.80	2.84%	0.01	2.80	2.39%
m & p-Xylene	0.14	16.97	6.70%	0.08	29.20	3.42%	0.05	11.16	3.20%	0.03	6.56	2.64%	0.02	4.80	2.38%
o-Xylene	0.09	10.70	6.60%	0.04	19.83	3.59%	0.04	6.72	2.89%	0.02	3.35	2.40%	0.02	2.55	2.50%
Styrene	0.02	6.11	1.00%	0.00	2.87	0.21%	0.00	1.24	0.09%	0.00	1.55	0.11%	0.00	0.89	0.36%

Key results for VOC at the Aamjiwnaang First Nation Station:

- Most of the VOC were detected intermittently. VOC are typically present in the environment, though in general, at very low levels. When they are not detected, they still may be present at low concentrations.
- The average propylene concentration, as well as the percent of samples above the mdl, has increased each year between 2009 and 2013. Increases in percentage of samples above the method detection limit could be due to improvements in the instrument, variations in the wind direction, or changes in processes at local plants.
- The average and maximum hexane concentrations have increased each year between 2009 and 2013.
- The average cyclohexane concentration was higher in 2012 and 2013 than in 2009-2011; however, the maximum concentration observed in 2013 was the lowest in the 5-year period.
- The 24-hour averages for propylene, hexane, and cyclohexane are given on the following page, showing that the average and maximum concentrations observed were well below their respective AAQC.
- The highest average benzene concentration was observed in 2009, and the highest maximum concentrations were observed in 2010-2011.
- The maximum toluene concentrations increased from 2009-2012, and then dropped in 2013 to the lowest maximum value in the 5-year period. The average toluene

concentrations observed in 2012 and 2013 decreased from the average concentrations observed in 2009-2011, with the lowest average toluene concentration found in 2013.

- Ethyl benzene, m&p-Xylene, and o-Xylene were detected in more than 5% of the samples only in 2009. The average concentrations for these three compounds decreased from 2009 to 2013, with the lowest average concentrations occurring in 2013.
- Styrene was detected in 1% or less of the samples each year in the 5-year period.

24-hour averages of the hourly measurements were calculated and compared with the ministry's 24-hour AAQC. The table below gives the maximum 24-hour average concentration calculated for each year, and the number of exceedances of the 24-hour AAQC. Because the GC/MS reports measured values in parts per billion (ppb), the ministry's AAQC presented in the table below have been converted from micrograms per cubic metre (µg/m^3) to parts per billion (ppb), for the purpose of comparison.

24-hour averages of VOC in comparison to the ministry's 24-hour AAQC												
			2009		2010		2011		2012		2013	
	24-hour AAQC (µg/m^3)	24-hour AAQC (ppb)	Max 24-hr Avg (ppb)	#> AAQC	Max 24-hr Avg (ppb)	#> AAQC	Max 24-hr Avg (ppb)	#> AAQC	Max 24-hr Avg (ppb)	#> AAQC	Max 24-hr Avg (ppb)	#> AAQC
Propylene	4000	2287	20.91	0	24.86	0	23.88	0	21.77	0	27.05	0
Chloromethane	320	152	***	n/a	6.09	0	6.22	0	9.33	0	8.99	0
1,3-Butadiene	10	4.3	**	n/a*	68.1	2*	12.3	1	1.17	0	9.93	1
Hexane	7500	2093	***	n/a	0.14	0	11.07	0	23.24	0	45.13	0
Cyclohexane	6100	1743	4.57	0	8.2	0	5.23	0	8.02	0	8.65	0
Benzene	2.3	0.7	2.72	38*	2.13	18*	3.3	23	2.85	23	2.38	22
Toluene	2000	522	5.25	0	6.26	0	3.75	0	8.52	0	1.43	0
Ethyl Benzene	1000	226	2.99	0	3.28	0	4.04	0	2.18	0	0.47	0
m&p-Xylene	730	165	4.88	0	7.17	0	2.39	0	0.92	0	0.95	0
o-Xylene	730	165	3.19	0	2.12	0	1.9	0	0.52	0	0.46	0
Styrene	400	92	1.6	0	0.13	0	0.08	0	0.07	0	0.15	0

*24-hour AAQC not in effect at this time; presented for comparison purposes only
**not detected during monitoring period
***compound not measured during monitoring period

Benzene and 1,3-butadiene were the only VOC to exceed their 24-hour AAQC in the five-year period.

There was one exceedance of the 24-hour AAQC for 1,3-butadiene in 2013, one in 2011, and two in the 2010 reporting period. The highest 24-hour average was observed in the 2010 reporting period; this 24-hour average of 68.1 ppb corresponded to a 4-hour event beginning

September 30, 2009 at 22:00, where elevated 1,3-butadiene concentrations were measured, with hourly concentrations reaching 702 ppb and decreasing to 54.5 ppb over the 4-hour period. The exceedance in 2013 corresponded to a 7-hour event beginning on March 26, 2013 at 19:00, where hourly concentrations reached 82.1 ppb, and decreased to levels below the method detection limit after the 7 hours.

Benzene and 1,3-butadiene have annual AAQC. The annual averages of the hourly measurements for these two compounds are given in the table below, along with their respective annual AAQC.

Average Annual Concentration (ppb) in comparison to Annual AAQC 2009-2013						
	Annual AAQC (ppb)	**2009**	**2010**	**2011**	**2012**	**2013**
Benzene	0.134	0.142*	0.06*	0.125	0.115	0.124
1,3-Butadiene	0.859	**	0.016*	0.046	0.010	0.045

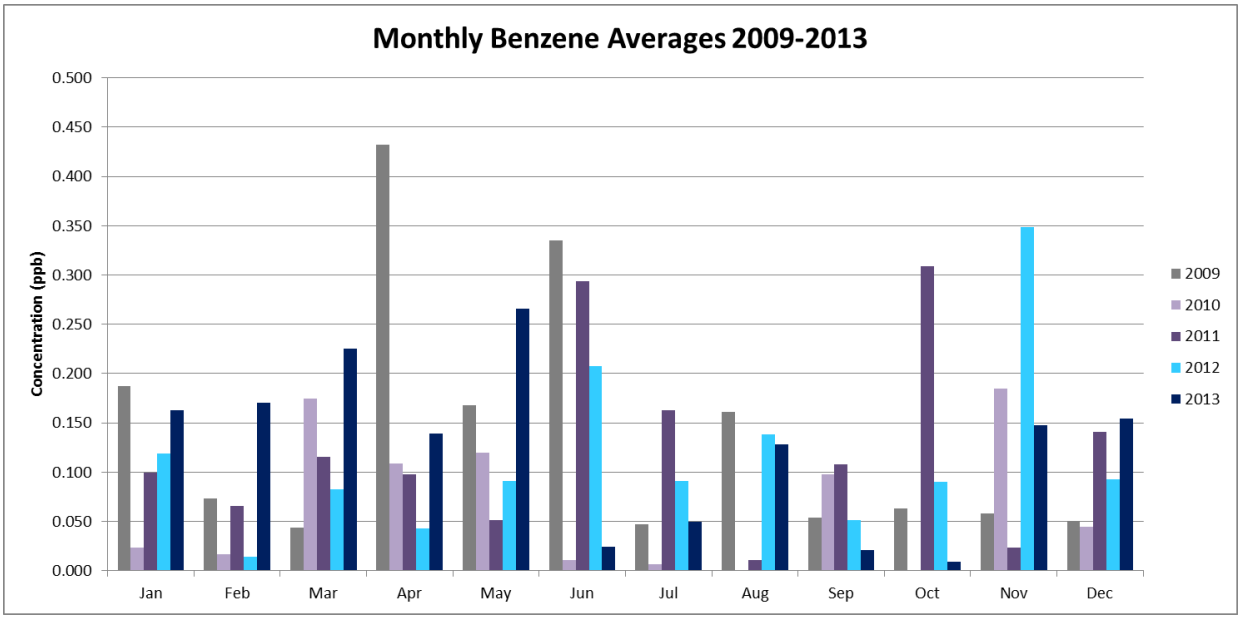
*24-hour AAQC not in effect at this time; presented for comparative purposes only

**not detected during monitoring period

Red font indicates exceedance of AAQC

The annual 1,3-butadiene concentration did not exceed its AAQC in the 5-year period. The annual benzene concentration was above the annual AAQC in 2009 and below the annual AAQC in 2010-2013. The annual benzene concentrations observed in 2010-2013 are lower than the annual concentration in 2009.

The figure below shows the monthly variation in benzene concentrations over the five-year period. In some years, benzene increased in spring and decreased in the summer, and in other years, benzene increases were seen in late fall.


Monthly Benzene Averages 2009-2013
Concentration (ppb)
0.500
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2009
2010
2011
2012
2013

Non-Continuous Data

Suspended Particulate (SP) and Metals

In addition to hourly measurements of respirable particulate, twenty-four hour samples of suspended particulate (SP) are taken every sixth day following the same schedule used by Environment Canada and most other sampling networks in Ontario. This sampling method determines particulate mass concentrations and an analysis for a variety of particulate constituents, such as metals. Samples are taken midnight to midnight EST. A list of the metals analyzed, their sources, and potential health and environmental impacts are included in the Appendices.

The table below includes the average and maximum hourly concentrations for suspended particulate (SP) and its constituent metals, as well as the number of samples for each test that were greater than the detection limit. Averages are not reported when more than half the samples in the reporting period are below this level. September-December 2008 data is not included in this section, and so the results presented are based on calendar years.

Suspended Particulate Monitoring Results ($\mu g/m^3$)															
	2009			2010			2011			2012			2013		
	Avg	Max	No > mdl	Avg	Max	No > mdl	Avg	Max	No > mdl	Avg	Max	No > mdl	Avg	Max	No > mdl
SP	15.386	54	55	12.241	95	56	15.325	296	54	10.69	40	59	12.22	30.9	53
Silicon	0.412	1.7	56	0.386	4.7	57	0.258	2.1	53	0.29	2.4	59	0.32	1.6	51
Calcium	0.796	4.2	56	0.713	6.7	56	0.517	2.1	57	0.47	2.1	59	0.52	2	53
Vanadium	0.004	0.046	32	-	0.058	19	-	0.013	13	-	0.056	19	-	0.011	14
Chromium	-	0.005	9	-	0.002	4	-	0.002	3	-	0.001	0	-	0.003	2
Manganese	-	0.014	26	-	0.027	10	-	0.012	13	-	0.015	12	-	0.012	18
Iron	0.151	0.63	56	0.14	1.4	57	0.107	0.52	56	0.119	0.73	59	0.131	0.47	53
Nickel	-	0.019	20	-	0.004	12	-	0.005	3	-	0.005	6	-	0.007	10
Copper	-	0.007	19	-	0.01	14	-	0.006	18	-	0.006	14	-	0.016	14
Zinc	0.014	0.093	47	0.007	0.044	38	0.006	0.026	44	0.007	0.04	43	0.006	0.014	40
Cadmium	0.004	0.006	48	-	0.006	27	-	0.008	11	-	0.004	18	-	0.006	8
Lead	0.006	0.01	50	-	0.009	12	-	0.012	3	-	0.006	9	-	0.009	5

Key results for SP and metals at the Aamjiwnaang First Nation Station:

- Averages were not reported for many of the parameters (vanadium, chromium, manganese, nickel, copper, cadmium and lead) for at least four of the five years, as more than half the samples in the reporting period were below the detection limit.

- The results do not suggest any increases in average or maximum concentrations for any of the parameters over the five-year period.
- The ministry has a 24-hour AAQC for suspended particulate and for most of the determined particulate constituents. There were no AAQC exceedances for any of the parameters between 2009 and 2013, with the exception of one SP result in 2011, which was believed to be an error.

The table below gives the maximum concentration for each parameter observed over the five-year period as a percentage of the 24-hr AAQC, and the respective year that this concentration was observed. Several parameters (vanadium, chromium, nickel, copper, zinc, and lead) had maximum concentrations that did not exceed 5% of their respective AAQC at any point over the five-year period.

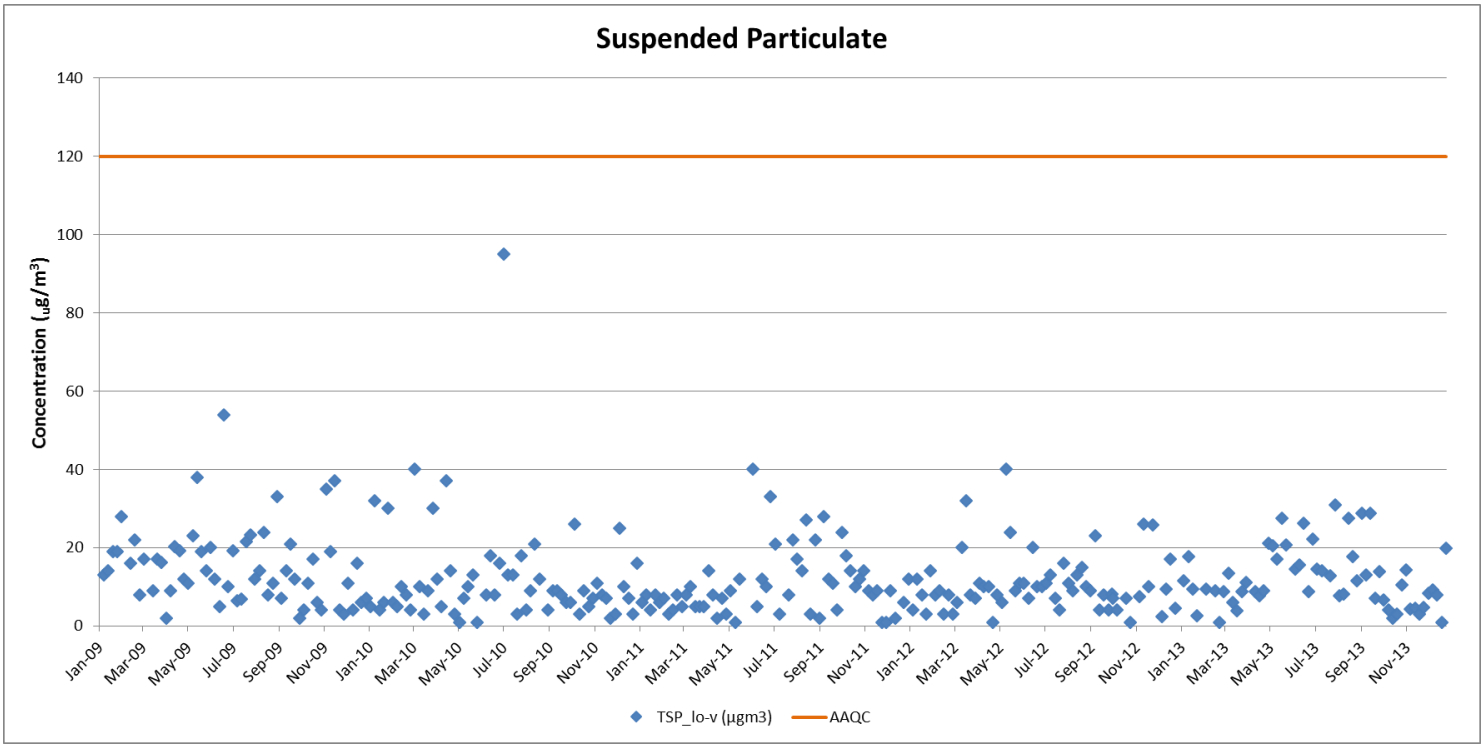
Maximum SP and Metal Concentrations in 2009-2013 Compared to 24-hour AAQC			
Test	**AAQC (µg/m^3)**	**% of AAQC**	**Year**
SP	120	*(246.67%)** 79.17%	*2011* 2010*
Silicon	-	-	-
Calcium	-	-	-
Vanadium	2	2.90%	2010
Chromium	0.5	0.60%	2013
Manganese (in TSP)	0.4	6.75%	2010**
Iron	4	18.25%	2012
Nickel (in TSP)	0.2	2.50%	2010**
Copper	50	0.03%	2013
Zinc	120	0.078%	2009
Cadmium	0.025	32.00%	2011
Lead	0.5	2.40%	2011

*Note - the highest SP value over the five-year period was found in 2011 (246.67% of the AAQC). However, this value was thought to be an error, as the ministry's laboratory labelled the result as unusual, and results from the hourly particulate monitor at the Aamjiwnaang First Nation station averaged less than a tenth of this value over the same period. The next highest SP value has been shown in the above table.

**The AAQC for chromium, manganese, and nickel were revised during the 5-year period; new 24-hr AAQC came into effect in 2011. The above table gives the percentages of the "new" AAQC value for all years, for comparison purposes.

SP attained the highest percentage of the respective 24-hour AAQC for each test, though it did not exceed the AAQC. The figure below shows the SP concentration measured over the five-

year period, in comparison to the 24-hour AAQC. The suspected erroneous SP value of 296 µg/m^3 was excluded from this figure. SP levels did not show a great degree of monthly variation, however, levels generally increased in late spring, were highest between May and September, and declined in late fall. SP levels were, on average, at 10% of the 24-hour AAQC between 2009 and 2013.



In addition to the 24-hour AAQC, some parameters have annual AAQC, which are given in the table below. There were no exceedances of the annual AAQC for suspended particulate matter, nickel, or cadmium over the five-year period.

Parameter	Annual AAQC (µg/m^3)	Exceedances (2009-2013)
Suspended particulate matter (< 44 µm diameter)	60 (geometric mean)	0
Nickel	0.04	0
Cadmium	0.005	0

Wind direction for the non-continuous data is not shown. Directional information is normally of limited use for 24-hour samples, as the wind variation may allow sources in different directions to contribute to a single sample and it is not possible to separate their contribution.

Volatile Organic Compounds (VOC)

In addition to the hourly VOC monitoring conducted by the ministry at the Aamjiwnaang First Nation station, Environment Canada (EC) collected 24-hour samples every twelfth day. EC collected samples using specially prepared evacuated canisters and analysed the samples at their laboratory in Ottawa. This method permits determination of a range of 161 target compounds and detection at much lower concentrations. Forty-six of the target compounds have a 24-hour AAQC.

Four other compounds have AAQC for other averaging periods. One, octane, has a 10-minute AAQC, while the other three, decane, 1,2-dichlorobenzene, and chlorobenzene, each have a 1-hour AAQC. In cases where AAQC do not exist for the appropriate time scale, the ministry uses a method outlined in O.Reg. 419/05 to calculate an equivalent concentration for comparison purposes. This benchmark level was determined for each of these four compounds and the monitoring results were compared to these converted values. The converted values are summarized in the table below.

Environment Canada VOC Concentrations Compared to Other AAQC			
Compound	**AAQC ($\mu g/m^3$)**	**AAQC Averaging time**	**Equivalent 24 hour benchmark ($\mu g/m^3$)**
Octane	61800	10 minutes	15000
Decane	60000	1 hour	25000
1,2-Dichlorobenzene	30500	1 hour	12500
Chlorobenzene	3500	1 hour	1400

The monitoring results for the compounds with their respective 24-hour AAQC are given in the table on the following page. 1,1-dichloroethane, was not detected between 2009-2013, and has been excluded from the table. The table shows the maximum and average concentrations for the compounds as a percentage of their 24-hour AAQC. The results are colour-coded based on their concentration as a percentage of the AAQC (see the legend below).

Legend: Percentage of AAQC				
$x < 0.1\%$	$0.1\ \% < x < 1.0\ \%$	$1.0\% < x < 10\%$	$10\% < x <$ AAQC	$x >$AAQC

Environment Canada VOC Results 2009-2013											
Compounds	24 Hr	2009		2010		2011		2012		2013	
(All values in µg/m^3)	AAQC	Max	Average	Max	Average	Max	Average	Max	Average	Max	Average
Freon113	800000	0.0001%	0.0001%	0.0001%	0.0001%	0.0001%	0.0001%	0.0001%	0.0001%	0.0001%	0.0001%
Freon114	700000	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%
Freon12	500000	0.0006%	0.0005%	0.0006%	0.0005%	0.0006%	0.0005%	0.0006%	0.0005%	0.0006%	0.0005%
Freon22	350000	0.0003%	0.0002%	0.0003%	0.0002%	0.0003%	0.0002%	0.0004%	0.0002%	0.0003%	0.0002%
1,1,1-Trichloroethane	115000	0.0001%	0.0000%	0.0002%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%
Octane	15000	0.0037%	0.0012%	0.0071%	0.0010%	0.0018%	0.0008%	0.0034%	0.0008%	0.0000%	0.0000%
1-Decene	60000	0.0001%	0.0000%	0.0001%	0.0000%	0.0001%	0.0000%	0.0002%	0.0000%	0.0001%	0.0000%
Decane	25000	0.0017%	0.0005%	0.0042%	0.0005%	0.0009%	0.0003%	0.0028%	0.0005%	0.0000%	0.0000%
Acetylene	56000	0.0022%	0.0009%	0.0022%	0.0010%	0.0022%	0.0009%	0.0015%	0.0008%	0.0017%	0.0008%
1-Octene	50000	0.0002%	0.0001%	0.0003%	0.0001%	0.0003%	0.0001%	0.0003%	0.0001%	0.0004%	0.0001%
1,2-Dichlorobenzene	12500	0.0001%	0.0000%	0.0001%	0.0000%	0.0004%	0.0000%	0.0001%	0.0000%	0.0000%	0.0000%
Heptane	11000	0.0087%	0.0029%	0.0087%	0.0021%	0.0038%	0.0018%	0.0086%	0.0022%	0.0041%	0.0016%
Hexane	7500	0.1540%	0.0230%	0.3300%	0.0385%	0.3839%	0.0409%	0.2350%	0.0286%	0.3120%	0.0188%
Methyltertbutylether	7000	0.0001%	0.0000%	0.0004%	0.0000%	0.0001%	0.0000%	0.0001%	0.0000%	0.0002%	0.0000%
Cyclohexane	6100	0.1626%	0.0249%	0.1867%	0.0248%	0.1276%	0.0131%	0.1975%	0.0380%	0.2570%	0.0290%
Freon11	6000	0.0320%	0.0260%	0.0306%	0.0268%	0.0326%	0.0256%	0.0315%	0.0265%	0.0331%	0.0262%
Chloroethane	5600	0.0017%	0.0006%	0.0011%	0.0004%	0.0012%	0.0005%	0.0009%	0.0004%	0.0008%	0.0005%
Propylene	4000	0.2061%	0.0446%	0.3067%	0.0619%	0.1561%	0.0387%	0.2163%	0.0545%	0.2195%	0.0561%
Chlorobenzene	1400	0.0030%	0.0010%	0.0020%	0.0008%	0.0012%	0.0008%	0.0021%	0.0010%	0.0000%	0.0000%
1,2-Dichloropropane	2400	0.0008%	0.0005%	0.0219%	0.0013%	0.0013%	0.0007%	0.0012%	0.0006%	0.0013%	0.0007%
Toluene	2000	0.2748%	0.0848%	0.2542%	0.0712%	0.1413%	0.0606%	0.2544%	0.0692%	0.1579%	0.0581%
Bromomethane	1350	0.0047%	0.0039%	0.0116%	0.0040%	0.0080%	0.0043%	0.0161%	0.0045%	0.0082%	0.0040%
Ethylbenzene	1000	0.1142%	0.0332%	0.1364%	0.0301%	0.0584%	0.0226%	0.0680%	0.0188%	0.0657%	0.0139%
m- & p-Xylene	730	0.1856%	0.0745%	0.2099%	0.0633%	0.1445%	0.0562%	0.1551%	0.0504%	0.0955%	0.0375%
o-Xylene	730	0.0833%	0.0284%	0.0776%	0.0227%	0.0499%	0.0197%	0.0520%	0.0186%	0.0377%	0.0150%
Styrene	400	20.4554%	0.8408%	0.1542%	0.0348%	0.1132%	0.0166%	0.1459%	0.0196%	0.5698%	0.0363%
1,2,4-Trichlorobenzene	400	0.0149%	0.0038%	0.0093%	0.0027%	0.0137%	0.0028%	0.0071%	0.0022%	0.0028%	0.0013%
iso-Propylbenzene	400	0.1452%	0.0120%	0.0134%	0.0041%	0.0087%	0.0033%	0.0092%	0.0032%	0.0129%	0.0030%
Tetrachloroethylene	360	0.0610%	0.0196%	0.1156%	0.0228%	0.2098%	0.0249%	0.0441%	0.0154%	0.1131%	0.0181%
Chloromethane	320	5.1944%	1.0799%	5.8412%	0.9763%	3.1569%	0.8008%	5.1066%	0.6608%	6.1828%	0.6456%
1,2,4-Trimethylbenzene	220	0.5332%	0.0966%	0.4004%	0.0762%	0.1522%	0.0528%	0.1457%	0.0563%	0.0844%	0.0394%
1,2,3-Trimethylbenzene	220	0.0911%	0.0388%	0.1147%	0.0297%	0.0482%	0.0185%	0.0515%	0.0198%	0.0254%	0.0134%
1,3,5-Trimethylbenzene	220	0.0930%	0.0244%	0.1110%	0.0215%	0.0418%	0.0148%	0.0402%	0.0153%	0.0226%	0.0106%
Dichloromethane	220	0.3550%	0.1132%	0.1896%	0.1100%	0.1644%	0.1058%	0.1601%	0.1120%	0.2309%	0.1322%
trans-1,2-Dichloroethylene	105	0.0165%	0.0016%	0.0155%	0.0028%	0.0104%	0.0035%	0.0425%	0.0070%	0.8298%	0.0457%
cis-1,2-Dichloroethylene	105	0.3406%	0.0153%	0.3984%	0.0180%	0.0055%	0.0010%	0.0030%	0.0008%	0.0023%	0.0003%
1,4-Dichlorobenzene	95	0.0577%	0.0183%	0.0476%	0.0200%	0.3005%	0.0256%	0.0369%	0.0155%	0.0441%	0.0142%
Bromoform	55	0.0622%	0.0291%	0.0705%	0.0305%	0.1709%	0.0356%	0.1353%	0.0302%	0.0411%	0.0235%
Ethylene	40	62.6078%	10.6938%	62.9670%	12.2948%	27.4868%	7.8478%	71.3810%	11.7595%	36.2418%	10.9391%
Naphthalene	22.5	0.9969%	0.3951%	1.7151%	0.3902%	0.8027%	0.3564%	0.9711%	0.3604%	0.6631%	0.2903%
Trichloroethylene	12	0.9667%	0.2417%	0.9075%	0.2450%	0.9675%	0.1842%	0.5292%	0.1733%	0.3008%	0.1239%
1,3-Butadiene	10	5.3830%	1.0720%	13.7900%	1.8430%	3.8360%	0.9090%	6.1030%	0.9490%	36.3340%	1.9390%
1,1-Dichloroethylene	10	0.0880%	0.0070%	0.2570%	0.0140%	0.0250%	0.0020%	0.0210%	0.0040%	0.0150%	0.0015%
Ethylene dibromide	3	0.1733%	0.0300%	0.1033%	0.0200%	0.1567%	0.0267%	0.1367%	0.0200%	0.0367%	0.0038%
Carbon tetrachloride	2.4	25.9125%	23.1625%	27.9167%	23.3583%	28.2625%	22.4708%	29.9542%	22.9292%	28.6625%	21.6399%
Benzene	2.3	254.1652%	59.2261%	180.3870%	53.6348%	124.7130%	52.3304%	150.3522%	48.7783%	153.8826%	43.3277%
1,2-Dichloroethane	2	4.9350%	3.1600%	11.7050%	4.0300%	6.5000%	3.4400%	7.3400%	3.6500%	5.2600%	3.4553%
Chloroform	1	14.8500%	8.0300%	13.4900%	8.2000%	14.1200%	8.7700%	14.6200%	9.4500%	15.4800%	9.0097%
Vinyl chloride	1	41.8600%	1.9900%	2.8400%	0.5000%	2.9800%	0.4300%	1.1000%	0.2800%	0.6700%	0.2734%

The AAQC for benzene came into effect in 2011, however, the 2009 and 2010 benzene results were assessed against this AAQC for the purpose of comparison.

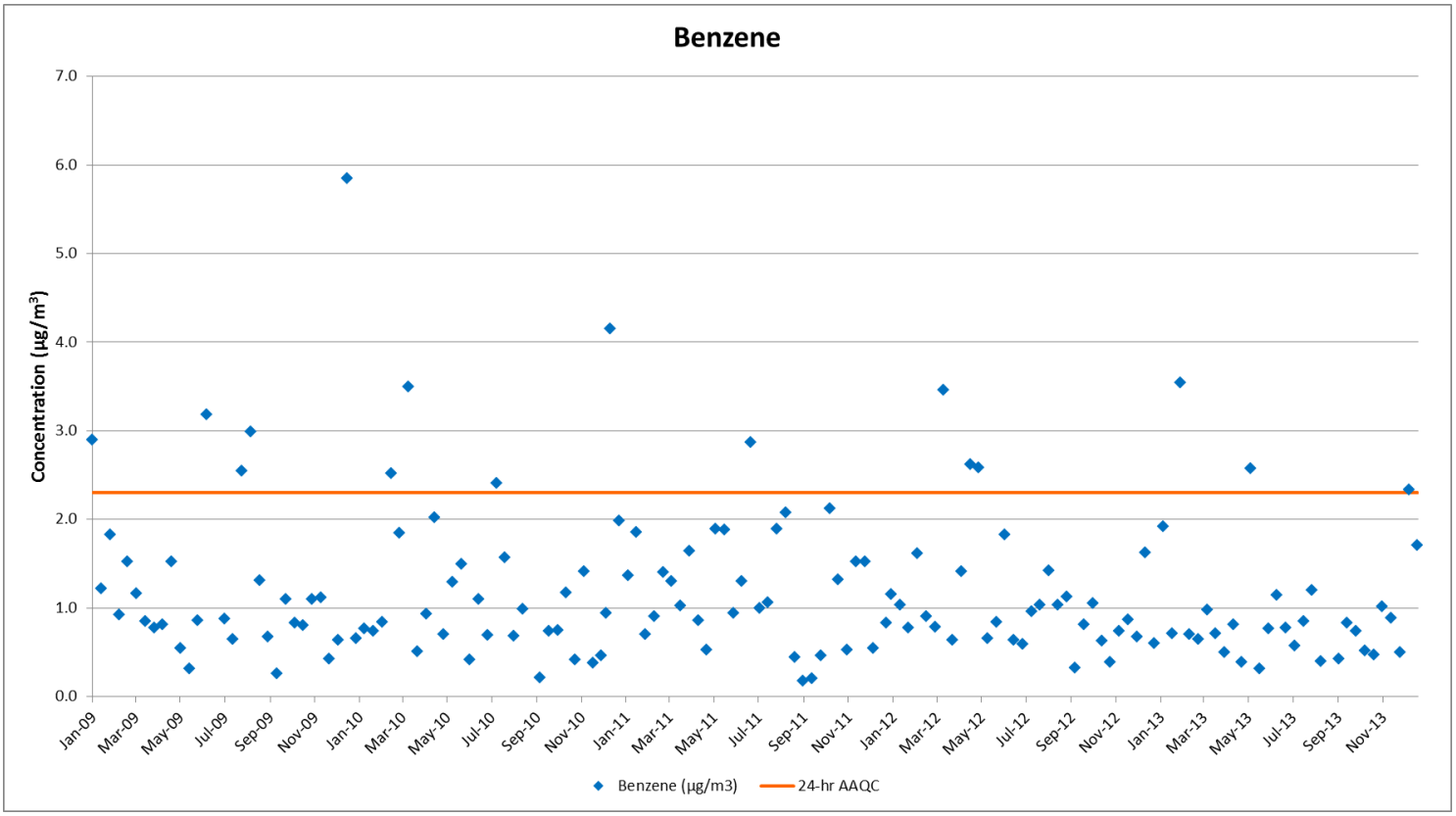
Key observations for VOC at the Aamjiwnaang First Nation station:

- Styrene, dichloromethane, napthalene, and trichloroethlyene reached average concentrations of greater than 0.1% of their 24-AAQC at least once between 2009 and 2013;
- Chloromethane, 1,3-butadiene, 1,2-dichloroethane, chloroform, and vinyl chloride reached average concentrations of greater than 1.0% of their 24-AAQC at least once between 2009 and 2013;
- Ethylene, carbon tetrachloride, and benzene reached average concentrations of greater than 10% of their 24-hour AAQC at least once between 2009 and 2013.
- Benzene was the only compound to exceed its 24-hr AAQC. The maximum benzene concentrations exceeded the 24-hr AAQC each year between 2009 and 2013. However, the average benzene concentrations were below the 24-hr AAQC each year, and the average benzene concentration has decreased each year over the five-year period.
- Average and maximum concentrations of vinyl chloride notably decreased after 2009. The maximum concentration of vinyl chloride was approximately 41% of the AAQC in 2009; the maximum concentrations dropped considerably to 2.84% of the AAQC in 2010, and decreased each successive year. The average vinyl chloride concentrations have shown a consistent decline as well. This result is consistent with the ministry's Technical Memorandum for the 2009 reporting period, which notes that with the closure of a polymer plant in 2009, the major source of vinyl chloride in the Sarnia airshed would be eliminated.
- The highest maximum and average styrene concentrations were observed in 2009. Between 2010 and 2013, the average styrene concentrations have remained less than 0.1% of the AAQC, showing a ten-fold decrease from the 2009 concentrations.
- The average chloromethane concentrations have slightly decreased each year between 2009-2013.
- The maximum and average 1,3-butadiene concentrations increased from 2009 to 2010, dropped in 2011, and increased again between 2012 and 2013, with the highest values observed in 2013.
- The average chloroform concentration remained below 10% of the AAQC each year; however, there was a marginal increase between 2009 and 2012, with a small decrease in 2013. The maximum chloroform concentration was measured between 13-16% of the AAQC each year; with the highest maximum concentration measured in 2013.

The following table shows the total number of exceedances of the 24-hr AAQC for benzene between 2009 and 2013 in relation to the total number of samples taken. Details of the exceedances are provided as well, including the month that the exceedance occurred, and the corresponding concentration:

Comparison of benzene concentrations to 24-hr AAQC (2.3 µg/m^3) 2009-2013					
	2009	**2010**	**2011**	**2012**	**2013**
Total number of samples	29	31	30	31	29
Total number of 24-hr AAQC exceedances	5	4	1	3	3
Percentage of samples that exceeded 24-hr AAQC	17%	13%	3%	10%	10%
Month of exceedance(s) and corresponding concentration (µg/m^3):					
	January 2.89	February 2.52	June 2.87	March 3.46	February 3.54
	June 3.18	March 3.49		April 2.62	May 2.57
	July 2.55	July 2.4		May 2.58	December 2.33
	August 2.99	December 4.15			
	December 5.85				

The figure below shows the benzene concentrations measured between 2009 and 2013 in comparison to the 24-hr benzene AAQC. The exceedances detailed in the above table can be seen in this figure.



Six of the measured VOC have annual AAQC; the average concentrations of these compounds are summarized in the table below, and compared to their respective annual AAQC:

Annual Averages of VOC in Comparison to Annual AAQC						
Compound	**Annual AAQC (µg/m³)**	**Average (µg/m³)**				
		2009	**2010**	**2011**	**2012**	**2013**
1,3-Butadiene	2	0.1072*	0.1843*	0.0909	0.0949	0.1939
Benzene	0.45	1.3622*	1.2336*	1.2036	1.1219	0.9965
Vinyl chloride	0.2	0.0199	0.005	0.0043	0.0028	0.0027
Dichloromethane	44	0.249	0.2419	0.2327	0.2463	0.2908
Chloroform	0.2	0.0803	0.082	0.0877	0.0945	0.0901
1,2-Dichloroethane	0.4	0.0632	0.0806	0.0688	0.073	0.0691

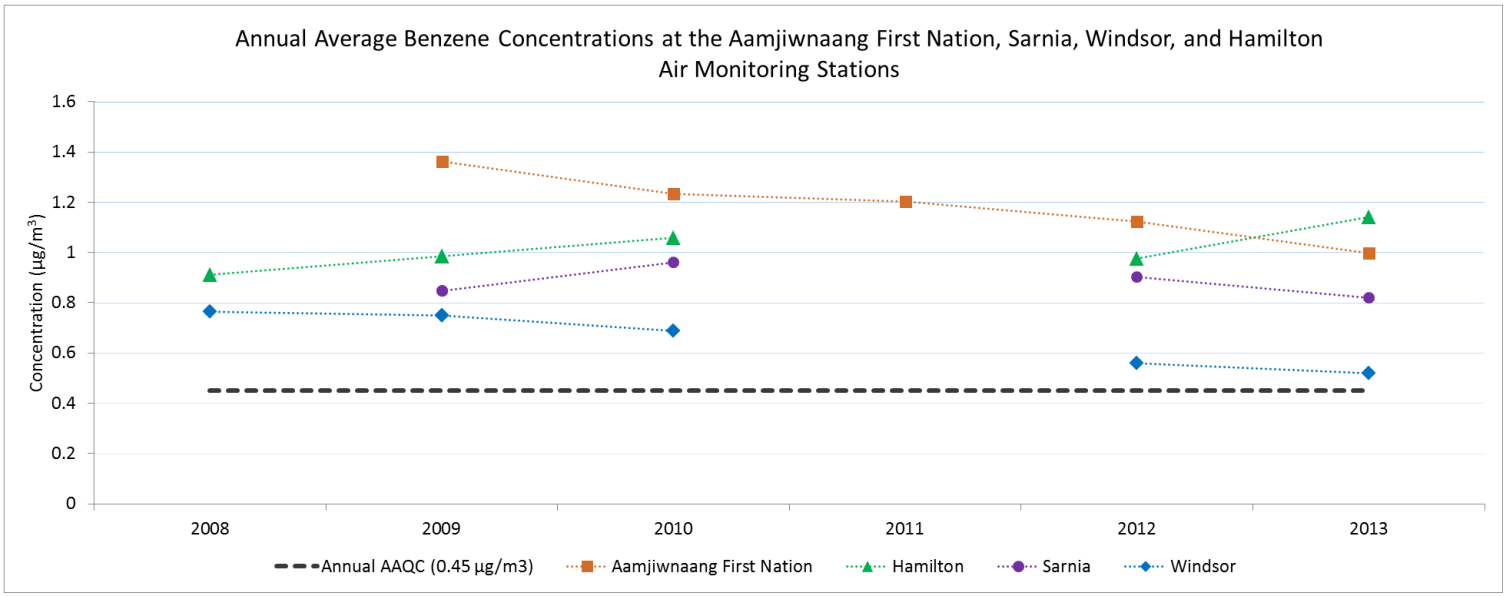
*24-hour AAQC not in effect at this time; presented for comparison purposes only

Red font indicates an exceedance of the AAQC.

Benzene is the only VOC to have exceeded its annual AAQC in the five-year period, which it did each year between 2009 and 2013. However, the average benzene concentration has decreased each year between 2009 and 2013, and the 2013 average concentration has decreased by 26.8% from the 2009 average concentration. As previously discussed, the vinyl

chloride concentrations have decreased from 2009. The other values have remained relatively consistent over the five-year period.

The following figure presents the annual average benzene concentration at the Aamjiwnaang First Nation station, as well as at the Sarnia, Windsor West, and Hamilton Downtown Environment Canada monitoring stations. The annual average benzene concentrations at Aamjiwnaang First Nation were higher than those at Sarnia and Windsor every year between 2009 and 2013, and higher than Hamilton every year except 2013. The annual benzene AAQC was exceeded at all four monitoring stations every year over the five year period.



Comparison of Continuous and Non-Continuous Benzene Monitoring Results

The continuous monitoring of VOC performed by the MOECC and the non-continuous monitoring of VOC performed by EC included several of the same compounds. The benzene monitoring results attained using the two methods were compared in order to determine whether the same trends were apparent, and whether the same conclusions about exceedances of the AAQC for benzene were reached.

The table below provides a comparison of the number of exceedances of the 24-hr AAQC detected using the two methods. The EC monitoring is non-continuous, with measurements occurring every twelfth day (29-31 samples taken each year), and the MOECC sampling is continuous (hourly, 365 days per year), so the percentage of samples taken that exceeded the 24-hr AAQC is given in brackets for comparative purposes. In every year except 2011, the

percentage of exceedances of the 24-hr AAQC found with the MOECC continuous monitoring was lower than that of the EC non-continuous monitoring.

The annual average concentration calculated using both methods is presented in the table as well. Different conclusions about annual AAQC exceedances were reached. The annual averages calculated using the non-continuous monitoring data showed that benzene exceeded the annual AAQC every year in the five-year period. However, the continuous data showed that the benzene annual AAQC was only exceeded in 2009. The annual average concentration calculated using the EC monitoring data is greater than the annual average using the MOECC hourly data by a factor of 3-6.

Despite these differences, both datasets showed declines in the annual average benzene concentration and exceedances of the 24-hr AAQC over the five-year period.

Comparison of Environment Canada (EC) VOC non-continuous results to continuous MOECC results for benzene (AAQC: 0.134 ppb)					
	Number of exceedances of 24-hr AAQC (and as a % of total 24-hr samples)		**Annual Average Concentration (ppb)**		
	EC VOC	**MOECC Hourly VOC**	**EC VOC**	**MOECC Hourly VOC**	***Ratio (EC/MOECC)***
2009	5 (17%)	38* (10%)	0.405	0.142	2.9
2010	4 (13%)	18* (5%)	0.367	0.06	6.1
2011	1 (3%)	23 (6%)	0.358	0.125	2.9
2012	3 (10%)	23 (6%)	0.334	0.115	2.9
2013	3 (10%)	22 (6%)	0.297	0.124	2.4

*24-hour AAQC for benzene not in effect at this time; presented for comparative purposes only

Red font indicates an exceedance of the AAQC

The dates of the benzene 24-hr AAQC exceedances found in the EC samples were compared to the MOECC monitoring results, to determine whether the "same" exceedances were detected by both methods.

There were several days over the five-year period where exceedances of the 24-hr AAQC were detected by the EC monitoring, but not by the MOECC continuous monitoring. In a couple of these cases, the MOECC instrument was non-operational on the day of the EC monitoring.

There were also instances where the MOECC continuous monitoring data showed an exceedance of the 24-hour AAQC on a day that EC monitoring occurred, which was not reflected in the EC results. To determine the cause of these discrepancies, the MOECC hourly data was reviewed. In several of these cases, the MOECC hourly data showed elevated benzene

concentrations during the day prior to the EC non-continuous monitoring, so the exceedance was reflected in the MOECC 24-hour running average concentration calculation, but not in the EC monitoring results.

Previous MOECC Aamjiwnaang First Nation reports have noted that the two methods for the VOC have been found to be poorly correlated, suggesting a number of potential contributing factors:

- The non-continuous sampling conducted by EC takes one sample over the course of the entire day, allowing for a much larger volume to be sampled. As a result, for relatively steady concentrations, this method leads to much lower detection limits (several orders of magnitude below that of the ministry's method). Therefore, the non-continuous sampling may see low levels that are not detectable by the continuous monitor.
- As the non-continuous sampling "bulks" the sample over twenty-four hours, short term spikes in concentration of a particular species will be diluted by the comparatively low concentration observed for the rest of the day.
- While the continuous sampling device takes one sample each hour, it only actually samples the air stream for between 10-15 minutes per hour, with the rest of the time used to process the sample and purge the system. As a result, transient spikes may be missed if they occur largely between sampling windows.

The MOECC may undertake further study to assess the correlation between the results attained for benzene and the other VOC using the two methods, and to investigate the potential causes for the variability.

The EC non-continuous monitoring method has a high precision and low detection limit, so this method can be expected to provide accurate annual averages, though it may not be able to detect short-term spikes in concentrations of particular species. In contrast, the precision of the MOECC continuous monitoring is not as high as the EC method, but it has a good temporal resolution, and can provide information that the non-continuous method cannot give. For example, there were a few periods every year between 2009 and 2013 where multiple (2-7) days of elevated benzene concentrations were observed by the MOECC continuous monitoring, but not by the EC non-continuous monitoring, as these events occurred within the 12-day window between EC samples. The MOECC hourly monitoring was therefore able to "capture" exceedances that occurred outside of the EC non-continuous monitoring, in addition to providing information on the duration of the elevated concentrations. The EC and MOECC monitoring methods have different capabilities, and produce complementary results which together provide a better picture of VOC at the Aamjiwnaang First Nation station.

Polycyclic Aromatic Hydrocarbons (PAH)

The ministry samples for several polycyclic aromatic hydrocarbons (PAH) at the Aamjiwnaang First Nation station every twelfth day, on the same schedule as the National Air Pollution Surveillance (NAPS) program. PAH are a group of complex hydrocarbons formed by incomplete combustion of organic compounds. They are common products of industrial processes and domestic activities, including burning fuel such as coal or wood, and barbecuing. Some PAH are known to be carcinogenic. PAH samples are collected over a 24-hour period using a filter based sampler, and are analyzed by the MOECC. PAH are found in very low concentrations in the atmosphere, and so concentrations are given in nanograms per cubic metre, a unit that is one thousand times smaller than the unit used for most other measurements in this report.
The PAHs monitored, and their abbreviations, are given in the table below:

Abbreviations for PAH			
Benz[a]anthracene	B[a]A	Benzo[a]pyrene	B[a]P
Chrysene	Chry	Indeno[1,2,3-c,d]Pyrene	I[1,2,3]P
Triphenylene	TPh	Dibenz[a,b]Anthracene	D[a,b]A
Benzo[b]fluoranthene	B[b]F	Dibenz[a,h]Anthracene	D[a,h]A
Benzo[k]fluoranthene	B[k]F	Benzo[g,h,i]perylene	B[g,h,i]P

The results of the PAH monitoring for the 2009-2013 period are summarized in the table below, showing the average and maximum concentrations for the compounds, as well as the percentage of samples which were greater than the method detection limit (mdl). The table also presents a comparison of the Aamjiwnaang First Nation results with those obtained at a ministry monitoring station in Windsor. The comparison site in Windsor for most other substances is the Windsor West AQI site (College Ave. and South St.), however, there is not a PAH monitor at this site. The PAH data come from the West Windsor Industrial monitor located at the Lou Romano Water Reclamation Plant, about 2.5 km to the southwest of the West Windsor AQI site.

In general, the maximum and average concentrations for the PAH were greatest in 2011, declined in 2012, and slightly rose in 2013. This trend was observed for all compounds except for B[a]A, which had the highest maximim in 2012. The lowest maximum and average concentrations for the compounds over the five-year period were generally observed in 2010.

The maximum and average concentrations were higher in 2013 than in 2009 for several compounds, including B[a]A, B[a]P, and B[g,h,i]P. The maximum and average concentrations at the Aamjiwnaang First Nation station were lower than the concentrations reported from the West Windsor Industrial monitoring station, with the exception of the maximum B[a]A and Chry concentrations in 2013.

Polycyclic Aromatic Hydrocarbons Monitoring Results 2009-2013								
	B(a)A	Chry/ Tph	B(b)F	B(k)F	B(a)P	I(1,2,3)P	D(a,h)A/ D(a,b)A	B(g,h,i)P
Aamjiwnaang First Nation 2009								
Avg (ng/m^3)	0.035	0.112	0.154	0.061	0.057	0.085		0.087
Max (ng/m^3)	0.12	0.44	0.62	0.2	0.14	0.25	0.03	0.21
%> mdl	76.00%	96.00%	100.00%	96%	96.00%	100.00%	40.00%	100.00%
Aamjiwnaang First Nation 2010								
Avg (ng/m^3)	0.052	0.104	0.158	0.061	0.071	0.092		0.102
Max (ng/m^3)	0.37	0.46	0.53	0.32	0.35	0.37	0.31	0.45
%> mdl	62.10%	93.10%	96.60%	82.80%	93.10%	93.10%	48.30%	93.10%
Aamjiwnaang First Nation 2011								
Avg (ng/m^3)	0.058	0.147	0.251	0.074	0.069	0.123	0.024	0.134
Max (ng/m^3)	0.6	1.9	2.75	0.7	0.63	1.25	0.23	1.23
%> mdl	75.90%	82.80%	89.70%	89.70%	79.30%	89.70%	41.40%	89.70%
Aamjiwnaang First Nation 2012								
Avg (ng/m^3)	0.032	0.078	0.126	0.046	0.043	0.076	0.017	0.08
Max (ng/m^3)	0.151	0.378	0.485	0.17	0.163	0.278	0.053	0.3
%> mdl	80.60%	93.50%	93.50%	93.50%	90.30%	93.50%	77.40%	93.50%
Aamjiwnaang First Nation 2013								
Avg (ng/m^3)	0.043	0.09	0.145	0.053	0.061	0.095	0.018	0.106
Max (ng/m^3)	0.444	0.769	0.866	0.322	0.48	0.572	0.098	0.569
%> mdl	70.00%	93.30%	93.30%	93.30%	93.30%	93.30%	63.30%	93.30%
West Windsor Industrial 2009								
Avg (ng/m^3)	0.44	0.65	1.1	0.43	0.53	0.64	0.14	0.51
Max (ng/m^3)	3.82	4.31	8.3	3.34	4.66	6.03	1.39	3.65
West Windsor Industrial 2010								
Avg (ng/m^3)	0.429	0.664	0.971	0.358	0.487	0.478	0.157	0.484
Max (ng/m^3)	2.48	2.83	3.66	1.4	2.38	1.84	0.75	1.62
West Windsor Industrial 2011								
Avg (ng/m^3)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Max (ng/m^3)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
West Windsor Industrial 2012								
Avg (ng/m^3)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Max (ng/m^3)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Windsor West Industrial 2013								
Avg (ng/m^3)	0.077	0.14	0.286	0.111	0.123	0.22	0.042	0.406
Max (ng/m^3)	0.301	0.741	1.17	0.456	0.515	0.838	0.132	2.19

The ministry previously had a 24-hour AAQC for B[a]P of 1.1 ng/m^3; none of the samples over the five-year period exceeded this former AAQC. A new, lower 24-hour AAQC of 0.05 ng/m^3 came into effect in 2011, as well as a new, lower annual AAQC of 0.01 ng/m^3.

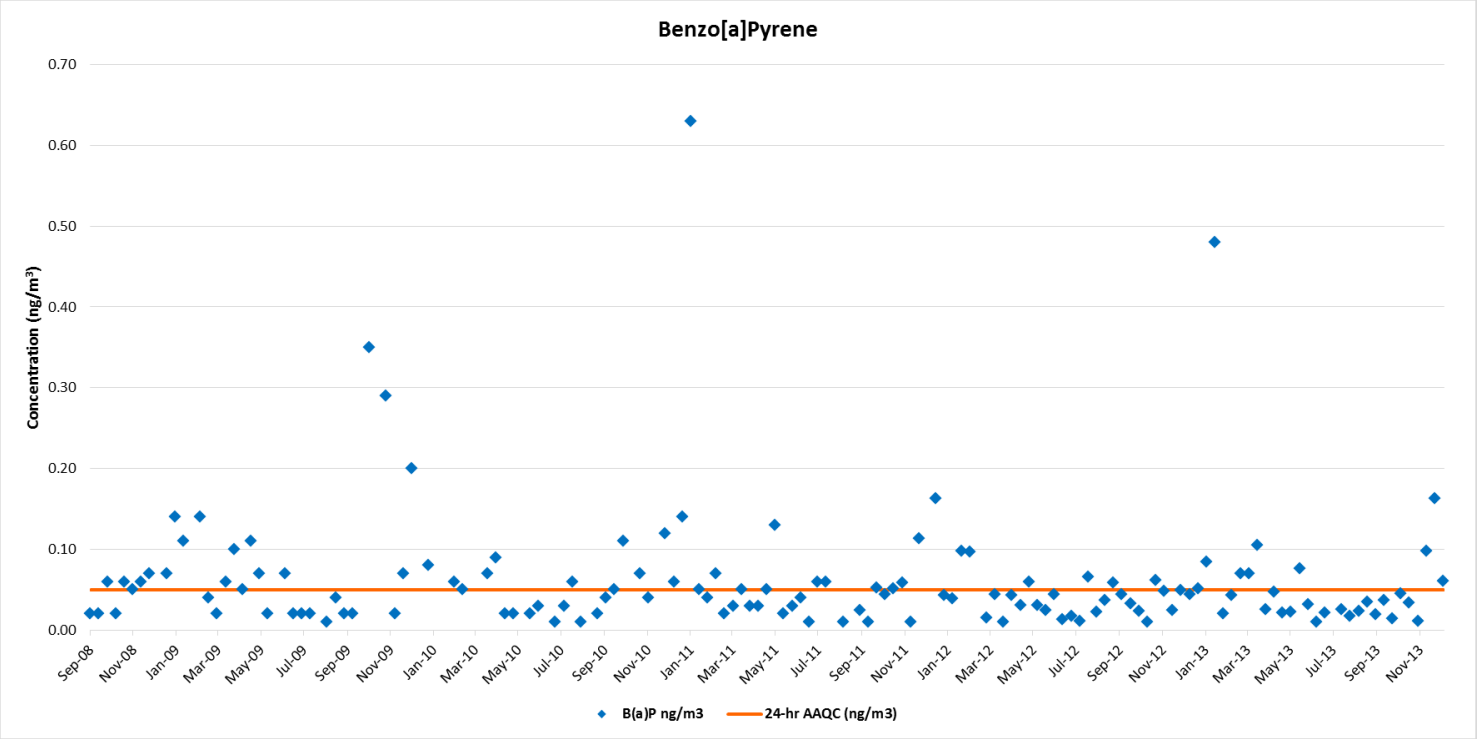
The table below shows the number of exceedances of the new 24-hr AAQC for B[a]P that occurred over the 5-year period. The annual average is summarized below as well. Although the AAQC came into effect in 2011, the 2009 and 2010 data in the table have been assessed against the new AAQC, for ease of comparison. The average annual B[a]P concentrations exceeded the ministry's current AAQC each year over the five-year period. Neither an increasing nor decreasing trend in the average annual benzo[a]pyrene concentrations were apparent.

Average annual B[a]P concentrations and AAQC exceedances 24-hr AAQC = 0.05 ng/m^3 Annual AAQC = 0.01 ng/m^3		
Year	**Number of exceedances of 24-hr AAQC**	**Annual average (ng/m^3)**
2009	13*	0.059*
2010	9*	0.05*
2011	10	0.069
2012	7	0.043
2013	10	0.061

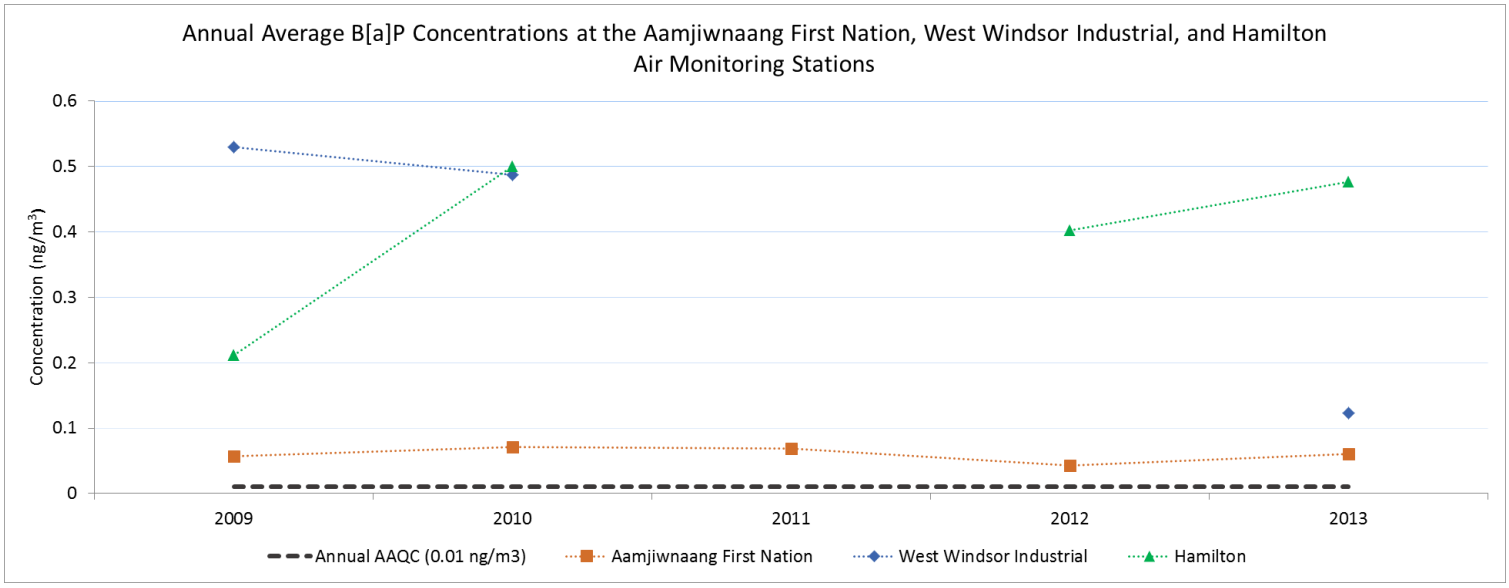
*New AAQC not in effect

Red font indicates an exceedance of the 2011 AAQC

The monitoring results for B[a]P over the five-year period are shown in the figure below. B[a]P concentrations tended to be highest in the winter months (November-March). This seasonal trend was found in the results for the other PAHs as well, which sugggests that building heating may be contributing to local PAH concentrations.



The following figure presents the annual average B[a]P concentrations at the Aamjiwnaang First Nation station, along with available data from the ministry's West Windsor Industrial station and the Environment Canada Hamilton Downtown monitoring station. B[a]P data was unavailable from the West Windsor Industrial Station in 2011 and 2012 and from Hamilton in 2011. The annual average B[a]P concentrations at the Aamjiwnaang First Nation station were lower than those at West Windsor Industrial and Hamilton stations every year between 2009 and 2013. The annual B[a]P AAQC was exceeded at all three monitoring stations every year over the five year period.


Annual Average B[a]P Concentrations at the Aamjiwnaang First Nation, West Windsor Industrial, and Hamilton Air Monitoring Stations
Concentration (ng/m3)
0.6
0.5
0.4
0.3
0.2
0.1
0
2009
2010
2011
2012
2013
Annual AAQC (0.01 ng/m3)
Aamjiwnaang First Nation
West Windsor Industrial
Hamilton

Conclusions

This report presented an analysis of the data collected over the first five years of operation at the Aamjiwnaang Air Monitoring station (September 2008-December 2013). Monitoring results were compared with Ontario's Ambient Air Quality Criteria (AAQC), where such existed, and with data from the ministry's Sarnia, Windsor West, and London monitoring stations, where available.

Continuous (hourly) monitoring data were presented for volatile organic compounds (VOC) and Air Quality Index (AQI) parameters (SO_2, TRS, NO_2, O_3, $PM_{2.5}$). Non-continuous monitoring data were presented for suspended particulate (SP) and metals, a wider range of VOC, and polycyclic aromatic hydrocarbons (PAH).

Key observations and trends were highlighted, including:

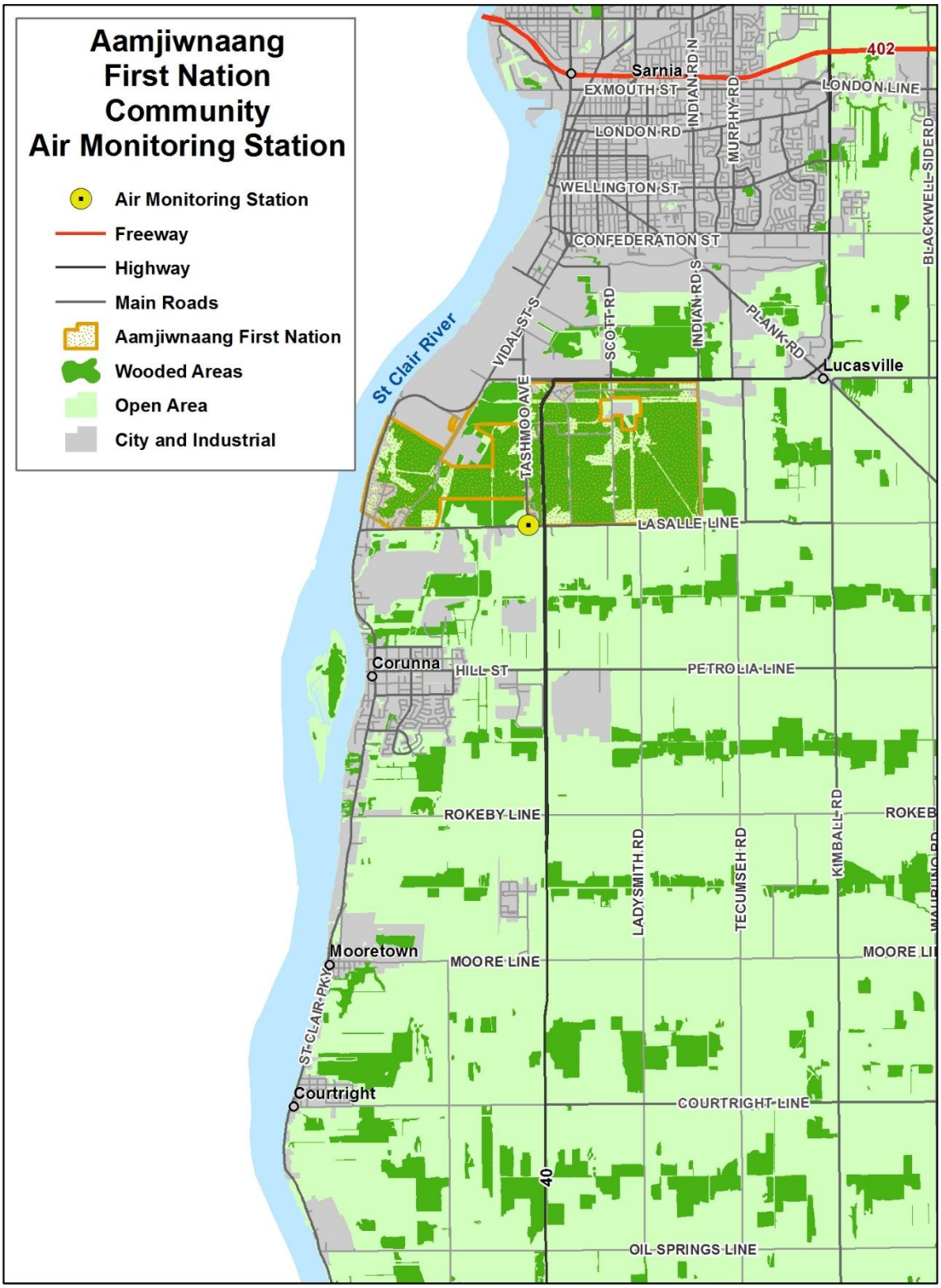
- The average concentrations of SO_2, TRS, NO_2, and $PM_{2.5}$ have decreased over the five-year period.
- The average and maximum O_3 concentrations, as well as the number of exceedances of the AAQC, have increased over the five-year period. This observation is consistent with the provincial trend in increasing ozone annual means over 2004-2013, as discussed in the ministry's Air Quality in Ontario 2013 Report.
- The ministry's continuous VOC monitoring showed that benzene and 1,3-butadiene were the only VOC to exceed their 24-hour AAQC in the five-year period.
- There were no AAQC exceedances for any of the suspended particulate or its metal constituents in the five-year period. The results do not suggest any increases in average or maximum concentrations for any of the suspended particulate or metals between 2009 and 2013.
- The non-continuous and continuous datasets both show decreases in the annual average benzene concentrations and exceedances of the 24-hr AAQC over the five-year period. However, different conclusions about annual AAQC exceedances were reached. The annual averages calculated using the non-continuous monitoring data show that benzene exceeded the annual AAQC every year in the five-year period, and the continuous data show that the benzene annual AAQC was only exceeded in 2009.
- The average annual benzo[a]pyrene concentrations exceeded the ministry's AAQC each year over the five-year period. The data does not show an increasing or decreasing trend in the average annual benzo[a]pyrene concentrations.

The MOECC may undertake additional studies to assess the correlation between the results of the non-continuous and continuous VOC monitoring results for benzene, in order to investigate the cause of these differences, and to increase understanding of how these datasets may complement one another.

Additionally, further studies may seek to review known releases in the Sarnia area over the five year period, in order to examine the responses seen in Aamjiwnaang First Nation monitoring station data.

Appendices

Map



Glossary

Ambient Air Quality Criteria (AAQC): Maximum desirable average concentrations for specific atmospheric contaminants. AAQC are based upon the effects on the most sensitive endpoint: health, environmental effects, odours, or soiling. Where more than one significant effect occurs, the ministry may have multiple AAQC for the same substance. The averaging time is initially set based on the underlying effect and is sometimes adjusted in order to allow for evaluation of air quality over different averaging periods.

Air Quality Index (AQI): An indicator of air quality, based on air pollutants that have adverse effects on human health and the environment. The pollutants are ozone, fine particulate matter, nitrogen dioxide, carbon monoxide, sulphur dioxide and total reduced sulphur compounds. The air quality is reported as both a number (the index) and one of five classifications based upon the index: *Very Good, Good, Moderate, Poor,* or *Very Poor.* More information may be found by following the links on the ministry's air quality web site http://www.airqualityontario.com/.

Air Quality Sub-index: A value related to the concentration of each AQI pollutant based upon their individual health and environmental effects. A sub-index is calculated every hour for each AQI pollutant measured at a station. The maximum is reported as the AQI for that station for that hour.

AQI station: Continuous monitoring station used to inform the public of general ambient air quality levels over an entire region (not a localized area) on a real-time basis; station reports on criteria pollutant levels that are not unduly influenced by a single emission source, but rather are the result of emissions from multiple sources, including those in neighbouring provinces and states.

Ambient air: Outdoor or open air.

Detection Limit (DL): The smallest amount of a substance which an instrument can differentiate from 0. This is related to the Method Detection Limit (MDL) which is the lowest amount of a substance that an entire analysis method (media preparation, sampling, extraction, and instrumental analysis) can reliably determine.

Exceedance: A concentration of a parameter that is higher than the AAQC, standard, or other benchmark for that substance.

Micrograms per cubic metre ($\mu g/m^3$): A concentration unit used to report pollutant concentrations in the atmosphere. One microgram is a millionth of a gram.

Micron (µm): One millionth of a metre = one thousandth of a millimetre = about three millionths of a foot. A human hair ranges from 40 to 120 microns thick.

NAPS: Environment Canada's *National Air Pollution Surveillance Program* was established in 1969 provide accurate and long-term air quality data of a uniform standard across Canada. More information may be found at http://www.ec.gc.ca/rnspa-naps.

Nanograms per cubic metre (ng/m^3): A concentration unit used to report pollutant concentrations in the atmosphere. One nanogram is a thousandth of a micron.

Part per billion (ppb): A concentration unit used by various instruments to report gas concentrations in the atmosphere. This is the approximate equivalent of 50 drops of water in an Olympic size swimming pool. Similarly "**ppm**" means "part per million" a unit which is 1000 times larger.

Polycyclic Aromatic Hydrocarbons (PAH): A class of molecules composed of fused six-sided carbon rings. They form during most combustion processes when conditions do not allow all the carbon to be oxidised.

Volatile Organic Compounds (VOC): Organic (containing carbon) chemicals that exist as a gas (at least partially), at normal environmental temperatures and pressures.

Volatile Organic Compounds (VOC)

Acrylonitrile is a colorless, liquid, man-made chemical with a sharp, onion- or garlic-like odour. It is used to make other chemicals such as plastics, synthetic rubber, and acrylic fibres. Breathing high concentrations of acrylonitrile will cause nose and throat irritation, tightness in the chest, difficulty breathing, nausea, dizziness, weakness, headache, impaired judgment, and convulsions. Acrylonitrile is classified as a possible human carcinogen by the International Agency for Research on Cancer (IARC).

Benzene has a strong, often pleasant scent and is primarily used in the production of plastics and other chemical products. Large quantities of benzene are obtained from petroleum, either by direct extraction from certain types of crude oils or by chemical treatment of gasoline. Benzene is classified as a known human carcinogen by IARC.

1,3-Butadiene is a chemical made from the processing of petroleum. It is a colourless gas with a mild gasoline-like odour. About 75% of the manufactured 1,3-butadiene is used to make synthetic rubber. Synthetic rubber is widely used for tires on cars and trucks. It is also used to make plastics including acrylics. Small amounts are found in gasoline. Breathing low levels of 1,3-butadiene may cause irritation of the eyes, nose, and throat. 1,3-butadiene is classified as a known human carcinogen by IARC.

Carbon disulphide is made for commercial use by combining carbon and sulphur at very high temperatures. It used in the manufacture of regenerated cellulose rayon and cellophane. It has

also been used to protect fresh fruit from insects and fungus during shipping, in adhesives for food packaging, and in the solvent extraction of growth inhibitors. Carbon disulphide has been highly suitable for other industrial applications including the manufacture of rubber and rubber accessories; the production of resins, plywood adhesives, and flotation agents; solvent and spinning-solution applications, primarily in the manufacture of rayon and polymerization inhibition of vinyl chloride; conversion and processing of hydrocarbons; petroleum well cleaning; brightening of precious metals in electroplating; rust removal from metals; and removal and recovery of metals and other elements from waste water and other media. In agriculture, carbon disulfide has been widely used as a fumigant to control insects in stored grain, and to remove botfly larva infestations from the stomachs of horses, and ectoparasites from swine.

Exposure can cause changes in breathing, chest pain, muscle pain, weakness, loss of feeling in the hands or feet, eye problems, skin blisters, chronic fatigue, loss of memory, personality changes, irritability, dizziness, anorexia, weight loss, psychosis, polyneuropathy, gastritis, kidney and liver damage, dermatitis, mental deterioration, and Parkinsonian paralysis. Carbon disulphide may damage the developing foetus. It may decrease fertility in men and women, causing sperm abnormalities and spontaneous abortions.

Cyclohexane is a nonpolar solvent used in the chemical industry and also as a raw material for the industrial production of intermediates used in the production of nylon. Exposure to cyclohexane causes irritation to the respiratory tract. Symptoms may include coughing, and shortness of breath. High concentrations have a narcotic effect. It may produce abdominal pain and nausea. Aspiration into lungs can produce severe lung damage and is a medical emergency.

Ethyl benzene is a colorless liquid that smells like gasoline. Ethyl benzene can be smelled in the air at concentrations as low as 2 parts per million parts of air by volume (ppm). It evaporates at room temperature and burns easily. Ethyl benzene occurs naturally in coal tar and petroleum. It is also used in many products, including paints, inks, and insecticides. Gasoline contains about 2% (by weight) ethyl benzene. Ethyl benzene is used primarily in the production of styrene. It is also used as a solvent, a component of asphalt and naphtha, and in fuels. In the chemical industry, it is used in the manufacture of acetophenone, cellulose acetate, diethyl benzene, ethyl anthraquinone, ethyl benzene sulfonic acids, propylene oxide, and methylbenzyl alcohol. Consumer products containing ethyl benzene include pesticides, carpet glues, varnishes and paints, and tobacco products.

At sufficiently high levels, exposure to ethyl benzene can be harmful to health. People exposed to high levels of ethyl benzene in the air for short periods have complained of eye and throat irritation. Persons exposed to higher levels have shown more severe effects such as decreased movement and dizziness. Ethyl benzene is classified as a possible human carcinogen by IARC.

Propylene is produced primarily as a by-product of petroleum refining and of ethylene production by steam cracking of hydrocarbon feed stocks. It is used in plastics (injection

moulding), fibres (carpets), production of synthetic rubber, and as a propellant or component in aerosols. It is also a product of combustion of organic matter (biomass burning, motor vehicle exhausts, and tobacco smoke) and is released during production and use. Acute exposure to propylene can cause cardiac arrests, cerebral edema, and seizures. Exposure to propylene can cause hypotension, apnoea, decreases in vision, frothy mucous, an increased pulse rate, hyperventilation, cyanosis, bronchoconstriction, respiratory depression, pulmonary edema, lung congestion, headache, dizziness, numbness of the extremities, sleepiness, mental confusion, and memory loss.

Styrene, also known as vinyl benzene it is an organic compound. Under normal conditions, this aromatic hydrocarbon is an oily liquid which evaporates easily and has a sweet smell. It often contains other chemicals that can result in a sharp, unpleasant smell. Styrene is primarily a synthetic chemical that is used extensively in the manufacture of plastics, rubber, and resins. Styrene contains carcinogen(s) or cancer suspect agent(s). Acute health effects of styrene are generally irritation of the skin, eyes, and the upper respiratory tract. Acute exposure also results in gastrointestinal effects. Chronic exposure affects the central nervous system showing symptoms such as depression, headache, fatigue, weakness, and may cause minor effects on kidney function. Styrene is classified as a possible human carcinogen by IARC.

Toluene is an aromatic hydrocarbon that is used to make chemicals, explosives, dyes and many other compounds. It is used as a solvent for inks, paints, lacquers, resins, cleaners, glues and adhesives. Toluene is found in gasoline and aviation fuel. Studies reveal that toluene affects the central nervous system of humans and animals; however, there is little evidence to classify it as a carcinogen.

Vinyl chloride is a colorless gas. It burns easily and it is not stable at high temperatures. It has a mild, sweet odour. It does not occur naturally. Vinyl chloride is used to make polyvinyl chloride (PVC) which is used to make a variety of plastic products, including pipes, wire and cable coatings, and packaging materials. Vinyl chloride can be released from plastics industries, hazardous waste sites, and landfills. Breathing high levels of vinyl chloride can cause dizziness or sleepiness; breathing very high levels can cause unconsciousness, and breathing extremely high levels can cause death. Vinyl chloride is classified as a known human carcinogen by IARC.

Xylene is a mixture of three isomers (ortho [o-xylene], meta [m-xylene] and para [p-xylene]). It is also referred to as mixed xylenes. Like benzene and toluene, xylene is an aromatic hydrocarbon. Xylene is produced from petroleum and coal tar and is formed during forest fires. Xylene is used as a solvent and in the printing, rubber, and leather industries, and as a cleaning agent, paints thinner and in paints and varnishes. Xylene is a central nervous system depressant. Xylene has not been classified as a carcinogen.

Metals

Cadmium is a relatively abundant bluish white metal. It was formerly used in paint pigments, corrosion resistant steel and plastic stabilizers though most of these uses are declining. It is still used in rechargeable batteries. Tobacco smoke is the most important single exposure source to the average person. Cadmium compounds are classified as known human carcinogens by IARC and cause other toxic effects including renal and pulmonary diseases.

Calcium is a soft grey metal and one of the most common elements on Earth. It is essential for all living things and is the most common metal by weight in many animals. Ingestion of certain amounts of calcium are required for good health. It is used in a wide number of common products including concrete, vitamins, blackboard chalk, paints, and ice remover.

Chromium is a steely grey lustrous metal. It is hard and has a high corrosion resistance. This has led to its use in stainless steel and chrome plating. It has also been used in preservatives, tanning, dyes, and various industrial processes as a catalyst or refractory metal. While very small amounts of certain chemical forms are required in human metabolism, excess amounts may cause respiratory effects. Hexavalent chromium is a form of chromium that is toxic and is classified as a known human carcinogen by IARC.

Copper is a soft orange /red metal. If left it exposed it oxidizes producing a dull green finish. It has a wide variety of everyday applications including wiring, piping, cookware, coinage, and roofing. Copper is toxic if ingested in high concentrations but is required in trace amounts by higher animals and people.

Iron is a well-known lustrous and reactive metal. It is seldom found in pure form as it tends to oxidize quickly in the presence of oxygen and water. It has numerous usages in manufacturing and electronics. Iron is an essential element to most organisms but can be toxic in high quantities. This can be the result of over ingestion of iron-containing supplements, especially among young children.

Lead is a soft malleable and very heavy metal. It has been in use for thousands of years. Its current uses include lead-acid (car) batteries, bullets, glazes, lead crystal, and radiation shielding. Lead is a neurotoxin which can accumulate in the body. Evidence of toxicity dates back to the ancient Romans and Greeks as well as in ancient China. Inorganic lead is classified as a probable human carcinogen by IARC.

Manganese is a grey iron-like metal. In its pure form it is somewhat brittle. It is an important component of stainless steel, adding to its corrosion resistance. It has also been used in batteries, pigments and various other alloys. Elevated exposures have been linked to impaired motor skills and cognitive disorders.

Nickel is a silvery lustrous metal. It is used in alloys with other metals to reduce corrosion and improve mechanical strength. It is also used in coins, rechargeable batteries, and guitar strings.

Nickel compounds may lead to lung fibrosis, and IARC classifies nickel compounds as known human carcinogens.

Silicon is a very common element found in much of the Earth's crust. Unlike the other substances in this list, it is characterized as a metalloid rather than a metal. This means it exhibits certain properties that are not metal-like, notably it is a semiconductor. This leads to its common use in computer chips. Besides this, silicon is a common constituent of various glasses and ceramics and a major component of various plastics often referred to as silicones. It is an essential element in the biology of plants, particularly many grasses. Certain compounds, silicates, can form long needle-like crystals which, upon inhalation, can lead to respiratory diseases commonly known as silicosis.

Vanadium is a soft silvery grey metal. It is most often used as an additive in steel as it gives a significant increase in the steel's strength. It has uses in the nuclear industry. Vanadium pentoxide is used as a catalyst in various chemical processes. Inhalation of vanadium can lead to the irritation of the respiratory system causing pneumonia or bronchitis. Long exposure to high levels has a variety of other health effects.

Zinc is a dull grey metallic element. It has been known since antiquity being one of the components of brass. It has been used in batteries, plating, dandruff shampoos and deodorants. Zinc is an essential mineral in human health, its deficiency being linked to a variety of diseases. However, excessive zinc levels suppress uptake of copper and iron which are also required by the body.

Data Averaging and Unit Conversion

The ministry has established procedures for dealing with concentrations that are reported as "0". In general, if an instrument has a well-defined detection limit (DL), which is the lowest concentration at which it can say a substance is present, then anything below that will be recorded as 0. However, the real value of that concentration could be anywhere between this level (DL) and 0.

A standard practice in situations such as this is to use half of the DL when calculating averages. This usually offers a reasonably good estimate if the number of values below DL is relatively small. However, since the uncertainty of the average grows with the number of these values, an average will not be reported if more than half of these values are below DL. This protocol is followed for the PAH, non-continuous VOC, and suspended particulate and metals.

However this is not the practice that is followed for the continuous monitors. The ministry has been reporting results from AQI (continuous) monitors for years and including non-detects as 0 in average calculations. The ministry has chosen to use the same methodology in this report so that these results may be compared to those found in AQI reports. While most real-time instruments will record a "0" from time to time, this decision will only have a noticeable impact on SO_2, and TRS which usually exhibit very low levels.

The practice of including non-detects as 0 in average calculations was also adopted for the real time VOC monitor but for very different reasons. Because of the experimental nature of the instrument, we have not been able to determine a detection limit for each of the species involved. Therefore there is no value of which one can take half for use in performing calculations. In addition, since detectable levels are seen infrequently, averages could not be presented as they cannot be considered representative. This would greatly limit our ability to discuss the results.

Some of the ministry's instruments report in parts per billion (ppb) or parts per million (ppm). Other results are expressed in micrograms per cubic metre ($\mu g/m^3$) or nanograms per cubic metre (ng/m^3). Nearly all ministry air standards and AAQC are published in mass per cubic metre.

Comparisons require that the two things being compared be in the same units, and so to compare monitoring data to ministry AAQC in this report, it was necessary to convert units for several measurements. These conversions vary with atmospheric conditions, as they depend on the temperature and pressure as well as the molecular weight.

However, since most measurements rely on samples taken over a period of time (e.g. 24-hour periods), it is possible for both the temperature and pressure to change. Since we do not have instantaneous measurements of all these parameters, there is no practical way to correct for this. In addition, since most instruments reside inside shelters, temperatures of the sample will be affected as they are drawn into the sampler.

As a result, assumptions about the parameter conversion have to be made. Conversions presented in this report were calculated with the temperature assumed to be 20 ° C and the pressure to be 1 atmosphere (101.3 kilopascals [kPa]).

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