Technical Memorandum

Aamjiwnaang First Nation
Community Air Monitoring Station

Results for September 2008 – August 2009

January 5, 2011

Ontario Ministry of the Environment
Southwestern Region Technical Support Unit
Air Pesticides and Environmental Planning Section

EXECUTIVE SUMMARY

The Aamjiwnaang First Nation community air monitoring station was established in late 2008 as the tangible result of the partnership between the provincial and federal governments and the Aamjiwnaang First Nation. The Aamjiwnaang First Nation exists in the heart of the heavily industrialized area located along the St. Clair River just to the south of the City of Sarnia.

The station was designed and equipped to monitor a range of pollutants to support local, long-term air quality studies and to assist in community health assessments. Air quality information has been collected at the station and has been analyzed by the Ontario Ministry of the Environment for this report. The period covered by this report is from September 1, 2008, to August 31, 2009. The first year of operation has shown the following air quality results.

- All of the measured concentrations at the station for the entire reporting period, with the exception of particulate matter and ozone, were well below their respective standard or guideline levels where such levels exist.

- Six pollutants make up Ontario's Air Quality Index (AQI) (sulphur dioxide, ground-level ozone, nitrogen dioxide, total reduced sulphur compounds, carbon monoxide and fine particulate matter). Of these, only fine particulate matter and ozone were recorded as having a significant number of hours in the "moderate" or "poor" air quality range.

- Fine particulate matter ($PM_{2.5}$) went above the *Moderate* AQI category in only 24 hours over the twelve month period. This represents about 0.3% of the available sampling hours. Ground-level ozone (O_3) went above the *Moderate* AQI category in less than 0.1% of the available sampling hours.

- Throughout the monitoring period the station measured levels significantly above the minimum detection limit but well within ministry standards for the following parameters:
    - Sulphur Dioxide
    - Total Reduced Sulphur
    - Nitrogen Dioxide
    - Ozone
    - Fine particulate matter
    - Specific Volatile Organic Compounds (VOC)

- Non-continuous 24-hour monitoring of VOC at the site showed no results above the respective standards or guideline. A small number of compounds (specifically vinyl chloride, styrene, chloromethane and ethylene) occasionally showed slightly elevated levels, possibly due to local industry sources.

- The 24 hour sample results for total suspended particulate, metals in particulate matter and Polycyclic Aromatic Hydrocarbons (PAH), did not show any values above their respective standards.

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PURPOSE

The purpose of this report is to provide a summary and analysis of the air quality monitoring results from the Aamjiwnaang First Nation community air monitoring station. It also provides background on common air quality pollutants and explains why they are of interest to the ministry and to readers of this report.

The audience for this report includes the Aamjiwnaang First Nation, local industry, government agencies and the general public. The results outlined in this report will be discussed with the station partners to assess how the Aamjiwnaang First Nation community air monitoring station is working and how the reporting process, frequency and format meets the needs of the partners and the community.

INTRODUCTION

The southwest Ontario and southeast Michigan air sheds share many common air issues. Both regions historically have experienced exceedances of national ambient air quality standards for fine particulate matter and ozone. Air quality is influenced by both distant and local sources. Long range transport of air pollutants (often transboundary) from a range of sources can affect air quality on both sides of the border. Lake effects and local meteorology may exacerbate poor air quality in this region.

In urban centres, such as the Sarnia/Port Huron area, local transportation networks can have a significant impact on local air quality. Sarnia and Port Huron share one of the busiest international border crossings between Canada and the United States. Local coal-fired power plants, petroleum refineries, chemical manufacturing, and auto manufacturing are also major local sources of air pollutants. These sources include the Sarnia Chemical Complex, which is a large industrialized petrochemical area along the east shore of the St. Clair River just south of the City of Sarnia.

The Ontario Ministry of the Environment has been monitoring air quality in the Sarnia area for many years to determine levels of air contaminants. This monitoring includes maintaining a long term Air Quality Index (AQI) station in downtown Sarnia as part of the provincial network of AQI stations. In addition, the ministry has been working with the Sarnia–Lambton Environmental Association (SLEA) which maintains a network of stations to monitor local industry in the Sarnia area.

In September 2008, the ministry established an air monitoring station in partnership with the Aamjiwnaang First Nation and the federal government to enhance air sampling capabilities in the vicinity, to support local long-term air quality studies by the ministry, and to assist in a community health assessment study by the local public health unit, municipality, and Aamjiwnaang First Nation.

The Aamjiwnaang First Nation community air monitoring station (AFNS) is located on the Aamjiwnaang First Nation at the intersection of Tashmoo Avenue and Lasalle Road, just to the west of Highway 40.

Figure 1: Location of Aamjiwnaang First Nation community air monitoring station

This station consists of a secured and fenced building containing high precision monitoring equipment targeting a range of air pollutants. The equipment installed at the station includes a Gas Chromatograph/Mass Spectrometer (GC/MS), which is a complex analytical device capable of monitoring a wide range of individual compounds on a continuous basis. This type of equipment is rarely used in air monitoring stations. Meteorological data, including temperature, wind speed and wind direction, are also collected at the station. The following is a list of equipment and contaminants that are monitored at the AFNS

Contaminants Measured by Continuous Samplers

The following air contaminants are measured continuously and data is reported on a regular basis. Reporting times are in minutes to hours for these types of monitors as the analysis of the air is conducted automatically on site.

- **Ground-level Ozone (O_3)**, a major component of smog, it results when nitrogen oxides and volatile organic compounds decompose in the presence of sunlight. It is measured through an ultraviolet (UV) light absorption analyzer.
- **Sulphur Dioxide (SO_2)** is emitted from electricity generation and industrial facilities, it contributes to acid rain, and can have human health impacts at higher concentrations. It is detected using a UV fluorescence analyzer.
- **Nitrogen Oxides ($NO/NO_2/NO_x$)** result from transportation, power generation, metal production and incineration sources. NO_2 is a major contributor to the production of ground-level ozone, and acid rain, and can irritate lungs in sensitive people. Nitrogen oxides are analyzed using a chemiluminescence analyzer.

- **Total Reduced Sulphur (TRS)** compounds result from both industrial and natural sources and produce offensive odours similar to rotten eggs or cabbage. These odours are generally viewed as nuisances rather than as health hazards. TRS compounds are analyzed using a UV fluorescence analyzer with a thermal converter attachment.
- **Carbon Monoxide (CO)** is a poisonous gas that often results from incomplete combustion of fossil fuels. Local air sources can include transportation and primary metals production. CO is detected using an infrared (IR) analyzer
- **Particulate Matter (PM)** is a broad term for the wide variety of fine particles in the air, including dust, smoke, haze, aerosols, fumes and mists. Measured PM is typically broken down into three fractions based on the size of the particles:
    - **Total Suspended Particulate (TSP)** includes all airborne particulate regardless of size. Most particles greater than 10 microns (one micron is one thousandth of a millimetre) will be caught in the nose and throat before reaching the lungs.
    - **Inhalable Particulate (PM_{10})** includes all particulate that is 10 microns or less in diameter. Particles of this size are likely to enter the upper respiratory tract only.
    - **Respirable or Fine Particulate ($PM_{2.5}$)** includes all particulate that is 2.5 microns or less. $PM_{2.5}$ is able to penetrate deeper in the lungs and is most closely linked with negative health effects.

  TSP, PM_{10} and $PM_{2.5}$ fractions are measured using a GRIMM Particulate Matter Analyzer.
- **Volatile Organic Compounds (VOC)** are emitted into the atmosphere from a variety of sources including fossil fuel combustion, solvent use, paint application, chemical and material manufacturing, and natural vegetation sources. Some VOC contribute to the formation of ground-level ozone and $PM_{2.5}$. Other VOC can have various health and environmental impacts. The chemical and petrochemical industries in the Sarnia area are significant emitters of VOC. Individual VOC are targeted and measured at the station using a Gas Chromatograph/Mass Spectrometer (GC/MS).

Contaminants Measured by Non-Continuous Samplers

These air contaminants are measured by monitors that collect a single sample over a 24-hour period which must then be sent to an off-site laboratory for analysis. Samples can take several weeks to be processed, however a wide range of target contaminants can be detected and lower concentrations can often be reached than is possible through continuous sampling.

- **Volatile Organic Compounds (VOCs)** are measured at the station using a canister sampler. This sampler collects an air sample over a 24-hour period, once every twelve days. The sample is then analyzed by Environment Canada at an offsite analytical laboratory for a range of VOC.
- **Total Suspended Particulate (TSP) and Metals** are collected at the station using a filter-based PQ-100 particulate sampler which takes a sample over a 24-hour period once every six days. The sample is analyzed by the MOE at an offsite laboratory for TSP and a range of trace metals, including lead, mercury, chromium, iron and nickel. While some

metals are essential for good health in trace amounts, larger concentrations can cause a range of health problems.

- **Polycyclic Aromatic Hydrocarbons (PAH)** are semi-volatile organic compounds that consist of two or more fused aromatic rings of six carbon atoms joined together in a hexagonal shape. PAH occur in oil, coal, and tar deposits, and can be produced by burning. Some PAH have been identified as cancer-causing substances. PAH samples are collected over a 24-hour period every 12 days using a filter-based sampler. Filters are analyzed for PAH concentrations by the MOE.

The Air Quality Index (AQI)

Of the above listed pollutants, six are monitored by the MOE as part of the province-wide Air Quality Index (AQI) monitoring network. The AQI 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:

- Sulphur Dioxide (SO_2)
- Ozone (O_3)
- Nitrogen Dioxide (NO_2)
- Total Reduced Sulphur Compounds (TRS)
- Carbon Monoxide (CO)
- Fine Particulate Matter ($PM_{2.5}$)

Based on data from its network of air monitoring stations, the MOE reports an hourly AQI for many communities across Ontario, including Sarnia, to all major media outlets and on the ministry web site. The data collected from AFNS is not currently part of this network, although the station does measure the six pollutants that make up the AQI.

RESULTS

Station Performance

The AFNS has been operational since the middle of September, 2008. The continuous monitors measuring AQI pollutants (SO_2, TRS, NO_2, O_3, CO, and $PM_{2.5}$) have been running since the station was first operational and have been functioning well. Calibrations are performed on these monitors approximately once per month to ensure they are providing accurate results.

The GC/MS that monitors VOC at the station is the first of its kind to be placed in the field in continuous operation, anywhere in the province. It has performed very well, operating nearly 95% of the time. The monitor initially required a significant amount of time and effort to set up. In September and October 2008, calibration curves for twelve VOCs were produced to create the calibration library for the station. In October an air leak in the injection port caused some data to be lost, however this repair was quickly made and the issue resolved. Starting in December, colder conditions caused some problems in controlling the temperature of the station. As the GC/MS needs to operate at a steady, specified temperature to ensure accurate detection of the VOC, the temperature fluctuations caused some loss of data. These problems were also quickly resolved. The GC/MS is calibrated on a bi-weekly basis.

The PQ-100 particulate sampler has been working well and all samples have been submitted to the MOE lab for analysis. While these samples have been collected every six days starting in September 2008 and analyzed for TSP, metals analysis on the samples began January 2009. The particulate sampler is calibrated on a regular basis.

The 24-hour, every 12 day PAH and VOC canister samples have been collected regularly starting in September 2008. These samplers are also calibrated on a regular basis.

Data Results and Analysis

The figures and tables on the following pages summarize the monitoring results in a number of ways.

Tables containing monthly averages and maximum values for each contaminant are shown along with graphs illustrating changes in concentrations over time. For the continuous monitors, all results are based upon hourly readings. Monthly averages reflect day to day long-term exposure while maximum values are useful for assessing overall risk or impacts related to a particular release, if one occurs. To put the analytical results in perspective, they will be compared to the appropriate standards or guidelines, and to other relevant monitoring stations, where they exist.

For each of the six AQI parameters the data is also broken down into the percentage of time the concentration falls into each of the five AQI classes.

Emissions of nitrogen oxides (NO_x) consist mainly of nitric oxide (NO), with some nitrogen dioxide (NO_2). In ambient air, NO converts to NO_2. In addition, NO_2 has adverse effects at much

lower concentrations than NO. Recognizing these factors, for the purposes of this report, NO and NO_x are considered covered in the analysis of the NO_2 data. Similarly, the greatest effect on health from particulate matter is from particles 2.5 microns or less in diameter because the particles penetrate further into the respiratory system than larger particles. Therefore, in this report only the $PM_{2.5}$ data from the continuous sampler is analyzed; TSP and PM_{10} are not.

The analyses will include pollution roses – diagrams which show how the pollutant levels are related to wind direction[i]. There appears to be some loss of northerly winds due to screening from nearby vegetation, which is a common artefact in wind data. Less obstructed wind data is available from the station at the Sarnia airport, but this data is not recorded with the same precision. It also may not reflect effects of local topography.

Carbon monoxide (CO) always measured below the detection limit at the monitoring station. As a result, no discussion of it will be presented.

[i] All wind data and directions in this document are given based upon the direction from which the wind was blowing, thus, for example, a southerly wind is a wind from the south.

Sulphur Dioxide (SO_2)

Results are listed in Table 1 and illustrated in Figure 2. The table includes monthly and yearly averages of the hourly data, maximum hourly data, and the number of hours the concentration exceeded the Ambient Air Quality Criteria (AAQC) of 250 parts per billion (ppb) during the reporting period. For comparison it also includes data for the same reporting period for three other AQI stations in southwestern Ontario.

No exceedances for the AAQC were detected at the AFNS during the reporting period, which is consistent with the other reporting stations for the same period. The maximum value that was recorded at the station for the period was 101 ppb, which is less than one half of the AAQC. The maximum value recorded at the Sarnia AQI station was substantially higher at 189 pbb, while those at the Windsor and London AQI stations were lower at 65 and 23 ppb respectively.

The average SO_2 concentrations at the station are significantly less than those detected at the local Sarnia AQI station. Given that the Sarnia AQI station is much closer to the urban centre and the border crossing to the United States, this difference may be due to local traffic influences. It may also be the result of a relatively unimpeded trajectory from sources along the St Clair River. However as the averages are very low, the difference is not likely to be environmentally significant. Based on the available information the SO_2 levels at the station appear to be generally similar to those from the Windsor station and somewhat higher than those seen at the London station. This is probably the result of a combination of more industry in the Sarnia air shed and closer proximity to the United States of America.

Table 1: AFNS Monthly Sulphur Dioxide Monitoring Results

Date	Average (ppb)	Maximum (ppb)	AAQC Exceedances (250 ppb)
Sep-08	3.2	56	0
Oct-08	2.5	67	0
Nov-08	3.4	48	0
Dec-08	4.1	52	0
Jan-09	3.6	55	0
Feb-09	2.6	31	0
Mar-09	3.1	43	0
Apr-09	3.6	101	0
May-09	3.6	94	0
Jun-09	4.8	101	0
Jul-09	2.0	45	0
Aug-09	2.4	41	0
Period Sep 08 - Aug 09	**3.3**	**101**	**0**
Sarnia AQI	5.6	189	0
Windsor West AQI	3.7	65	0
London AQI	1.5	23	0

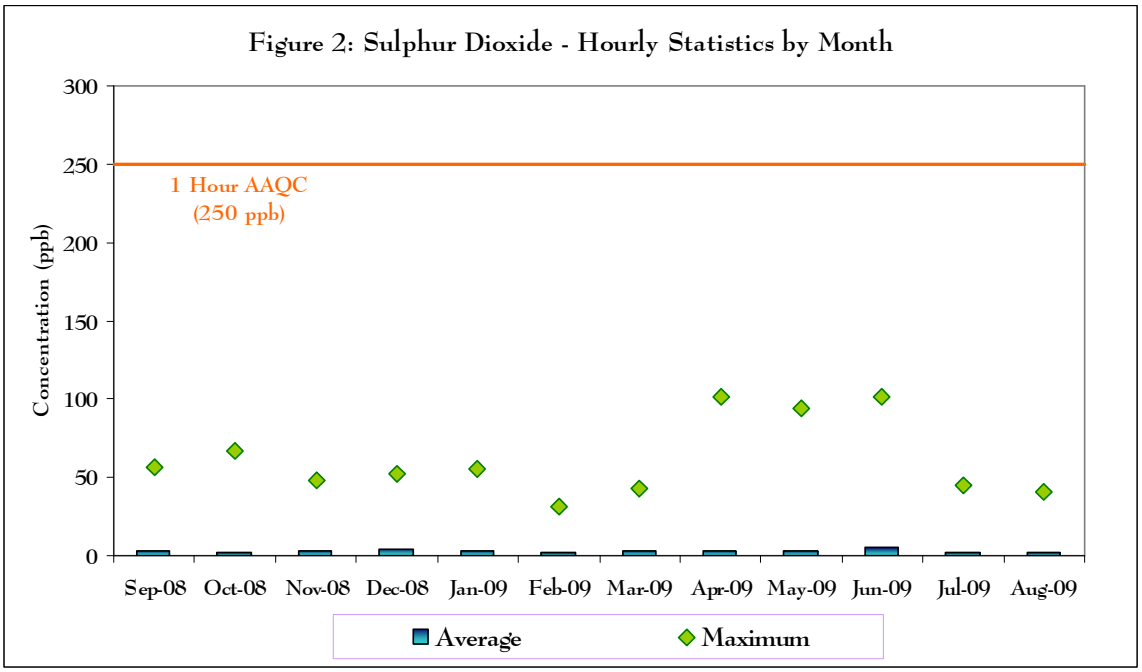
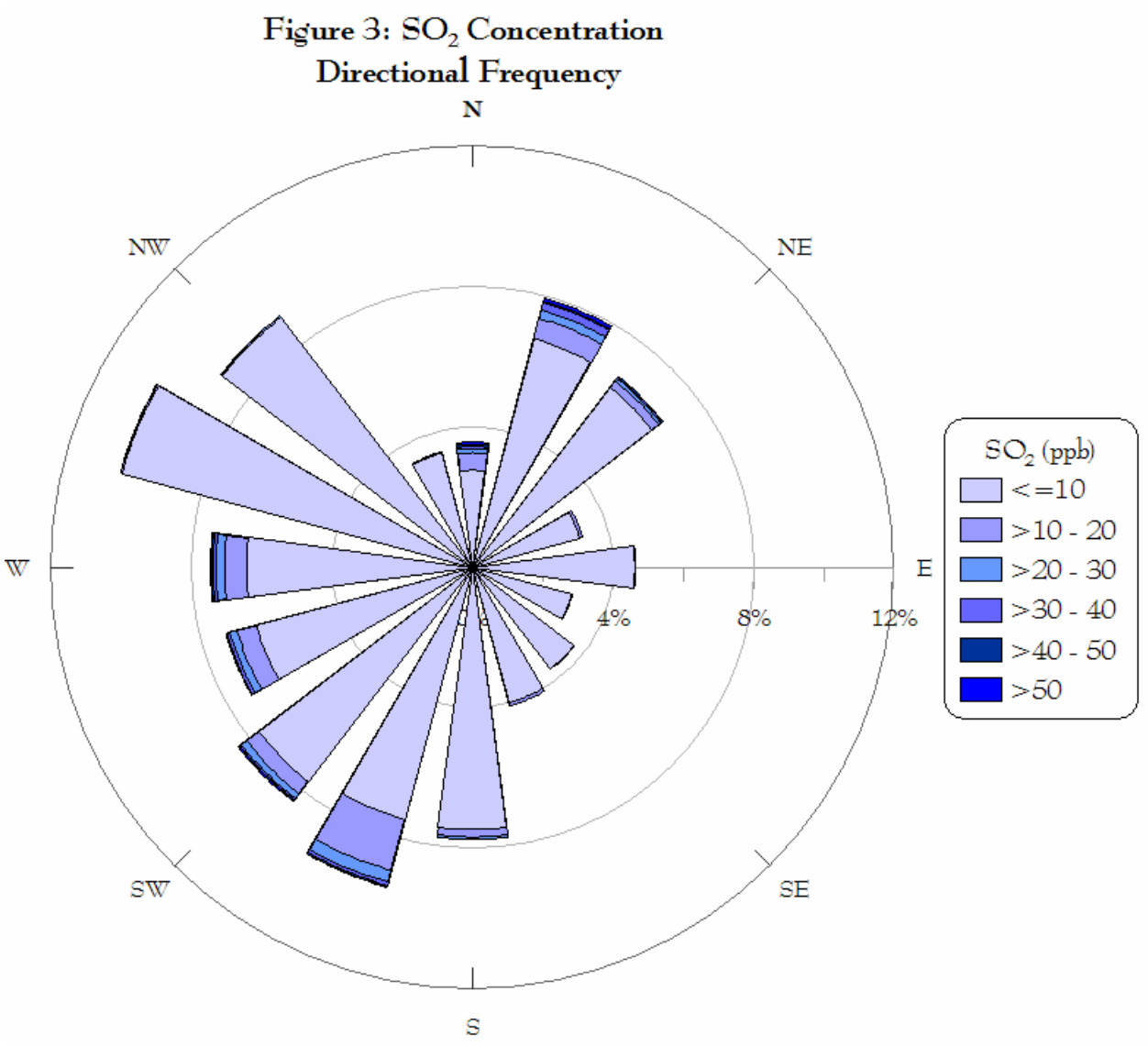


Table 2 shows the breakdown of the SO_2 sub-index by AQI category for each month during the reporting period and gives a more generalized assessment of the air quality. Sulphur dioxide was low during the vast majority of the monitoring period resulting in consistent *Very Good* air quality. Only for four hours during the entire year was the level of SO_2 high enough to not warrant a *Very Good* rating. The four hours of *Good* air quality occurred when the wind was blowing from the north.

Table 2: Sulphur Dioxide - Percentage of Available Hours in Each AQI Category

Date	Very Good	Good	Moderate	Poor	Very Poor
Sep-08	100.0%	0.0%	0.0%	0.0%	0.0%
Oct-08	100.0%	0.0%	0.0%	0.0%	0.0%
Nov-08	100.0%	0.0%	0.0%	0.0%	0.0%
Dec-08	100.0%	0.0%	0.0%	0.0%	0.0%
Jan-09	100.0%	0.0%	0.0%	0.0%	0.0%
Feb-09	100.0%	0.0%	0.0%	0.0%	0.0%
Mar-09	100.0%	0.0%	0.0%	0.0%	0.0%
Apr-09	99.9%	0.1%	0.0%	0.0%	0.0%
May-09	99.9%	0.1%	0.0%	0.0%	0.0%
Jun-09	99.7%	0.3%	0.0%	0.0%	0.0%
Jul-09	100.0%	0.0%	0.0%	0.0%	0.0%
Aug-09	100.0%	0.0%	0.0%	0.0%	0.0%
Period	100.0%	0.0%	0.0%	0.0%	0.0%

Figure 3 shows a pollution rose for SO_2 concentrations. While nearly all of these measurements fell in the *Very Good* AQI category, there are some small relationships between directions and concentration. Larger values show a preference for two large quadrants – one in the south west, the other in the north to northeast.



Ground Level Ozone (O_3)

Unlike many other AQI pollutants, O_3 is usually lower in the winter months. This seasonal variation is linked to ozone's nature as a pollutant. It is formed in the atmosphere in the presence of heat and strong sunlight. Results for O_3 are listed in Table 3 and illustrated in Figure 4. The table includes monthly and yearly averages of the hourly data, maximum hourly data, and the number of hours the concentration exceeded the 1-hour AAQC for O_3, which is 80 ppb, during the reporting period. For comparison it also includes data for the same reporting period for three other AQI stations in southwestern Ontario. Only one exceedance of the AAQC was detected at the station during the reporting period. Average ozone concentrations peaked in April, while maximum values were recorded in June. This pattern is somewhat unusual and is probably due to the abnormally cool and wet summer in 2009.

Overall, the average O_3 concentration at the station was slightly lower than the Sarnia and London AQI stations and about the same as the Windsor AQI station. While relative consistency is expected as O_3 concentrations tend to reflect regional rather than local trends, they are not immune to local influences. Vegetation and pollutants such as car exhaust react with O_3. Historically, O_3 levels in Ontario are highest at Grand Bend because the long travel time over the lake during westerly and northwesterly winds is ideal for the formation of O_3. There are no other influences and the reactant gases that form O_3 are subjected to high sunlight levels because of the lack of vegetation and reflection from the water. The slightly lower numbers detected at the AFN station as compared to the Sarnia AQI station may be due to being surrounded by vegetation and farther from the lake.

Table 3: AFNS Monthly Ozone Monitoring Results

Date	Average (ppb)	Maximum (ppb)	AAQC Exceedances (80 ppb)
Sep-08	21.8	76	0
Oct-08	18.4	50	0
Nov-08	18.2	46	0
Dec-08	19.7	35	0
Jan-09	23.3	44	0
Feb-09	27.5	43	0
Mar-09	28.3	56	0
Apr-09	33.5	69	0
May-09	30.6	74	0
Jun-09	26.0	91	1
Jul-09	24.0	61	0
Aug-09	22.3	68	0
Period Sept 08 - Aug 09	**24.4**	**91**	**1**
Sarnia AQI	27.1	93	8
Windsor West AQI	24.9	93	3
London AQI	25.6	79	0

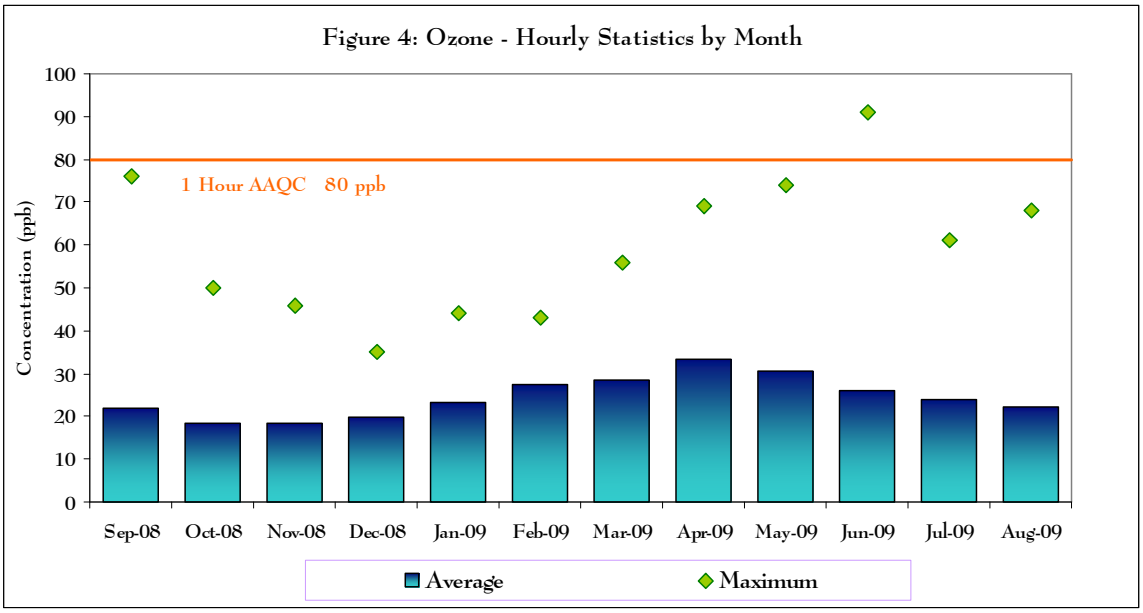
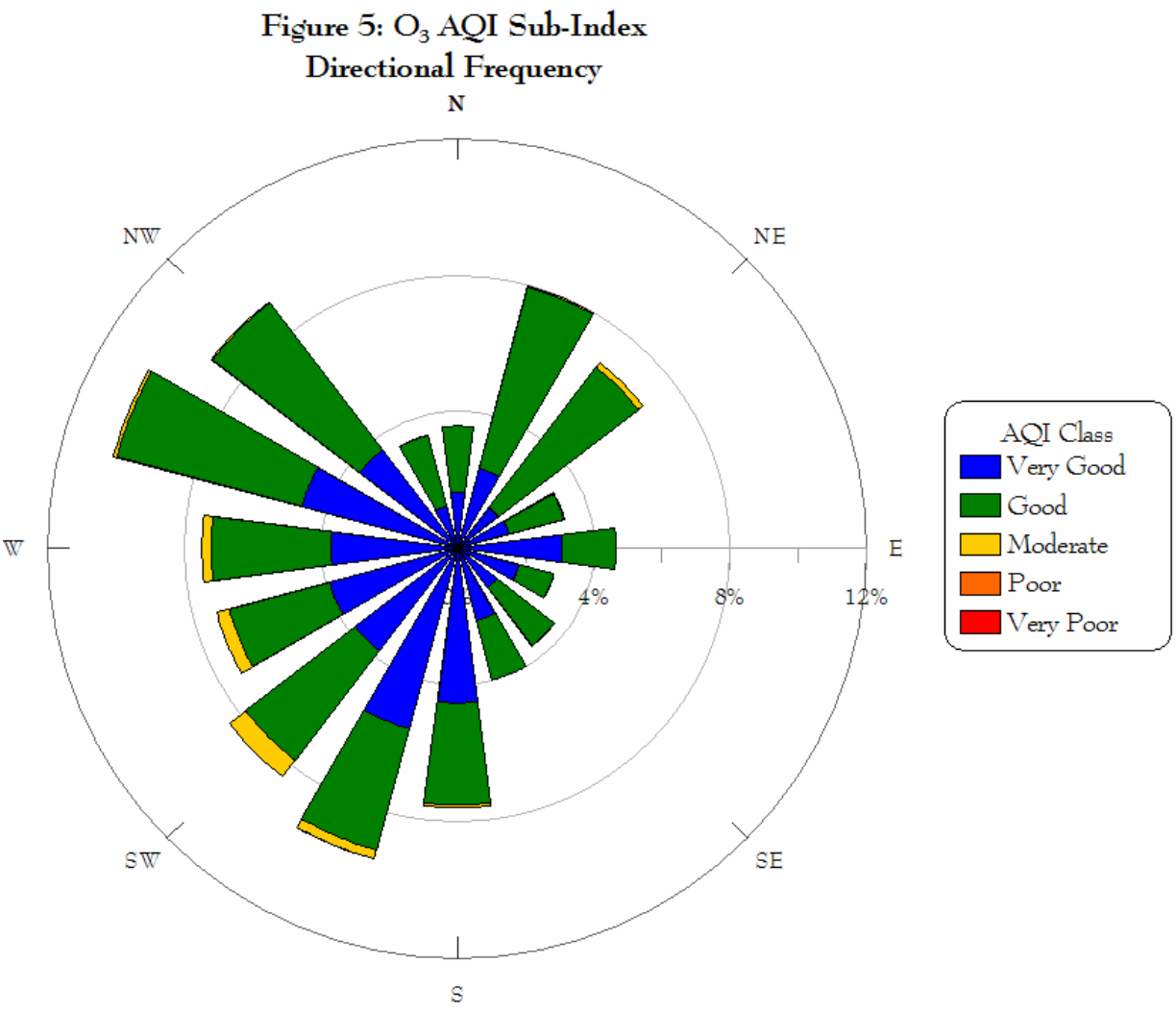


Table 4 shows the breakdown of the O_3 sub-index by AQI category for each month during the reporting period and gives a more generalized assessment of the air quality. As can be seen in Table 4, Ozone values lie predominantly in the *Very Good* category during the fall months but as spring approaches the number of *Good* and *Moderate* hours increase while *Very Good* hours decrease. When O_3 concentrations reach the *Moderate* category, sensitive people may experience respiratory irritation during vigorous exercise, while people with heart/lung disorders and very sensitive plants may be at increased risk.

Table 4: Ozone - Percentage of Available Hours in Each AQI Category

Date	Very Good	Good	Moderate	Poor	Very Poor
Sep-08	59.5%	37.0%	3.5%	0.0%	0.0%
Oct-08	72.1%	27.9%	0.0%	0.0%	0.0%
Nov-08	76.5%	23.5%	0.0%	0.0%	0.0%
Dec-08	69.8%	30.2%	0.0%	0.0%	0.0%
Jan-09	45.6%	54.4%	0.0%	0.0%	0.0%
Feb-09	26.3%	73.7%	0.0%	0.0%	0.0%
Mar-09	22.4%	76.8%	0.8%	0.0%	0.0%
Apr-09	14.7%	81.7%	3.6%	0.0%	0.0%
May-09	29.9%	62.8%	7.3%	0.0%	0.0%
Jun-09	42.3%	53.8%	3.8%	0.1%	0.0%
Jul-09	51.5%	45.4%	3.1%	0.0%	0.0%
Aug-09	55.3%	42.5%	2.2%	0.0%	0.0%
Period	47.5%	50.5%	2.0%	0.0%	0.0%

Figure 5 shows a pollution rose for the ozone sub-index arranged by AQI category. Most of the *Moderate* hours are associated with southwesterly winds, which is typical for all of southwestern Ontario, as significant amounts of O_3 and its precursors are transported into Ontario from the United States. There are some *Moderate* hours associated with northeasterly flow. Typically higher levels of ozone are connected to airflows over vegetated (but not forested) rural areas or large bodies of water. Thus the values from the north east are most probably related to flows coming from Lake Huron.



Nitrogen Dioxide (NO_2)

Results are listed in Table 5 and illustrated in Figure 6. The table includes monthly and yearly averages of the hourly data, maximum hourly data, and number of hours the concentration of NO_2 exceeded the 1-hour AAQC, which is 200 ppb, during the reporting period. For comparison it also includes data for the same reporting period for three other AQI stations in southwestern Ontario.

No concentrations exceeding the AAQC were detected at the station or at any of the other AQI stations during the reporting period.

On average, the NO_2 concentrations at the station are slightly higher than the Sarnia AQI station, slightly lower than the Windsor West AQI station and comparable to the London AQI station. These minor variations are likely due to small geographic influences, but are not environmentally significant. The highest 1-hour measurement at the AFN station was 67 ppb, in August, although April had a higher overall average.

Table 5: AFNS Monthly Nitrogen Dioxide Monitoring Results

Date	Average (ppb)	Maximum (ppb)	AAQC Exceedances (200 ppb)
Sep-08	5.9	22	0
Oct-08	7.2	33	0
Nov-08	7.2	30	0
Dec-08	10.7	30	0
Jan-09	12.1	60	0
Feb-09	8.0	33	0
Mar-09	10.5	35	0
Apr-09	14.6	39	0
May-09	13.5	29	0
Jun-09	13.2	30	0
Jul-09	7.8	27	0
Aug-09	12.2	67	0
Period Sept 08 - Aug 09	**10.3**	**67**	**0**
Sarnia AQI	8.9	48	0
Windsor West AQI	14.1	67	0
London AQI	10.3	52	0

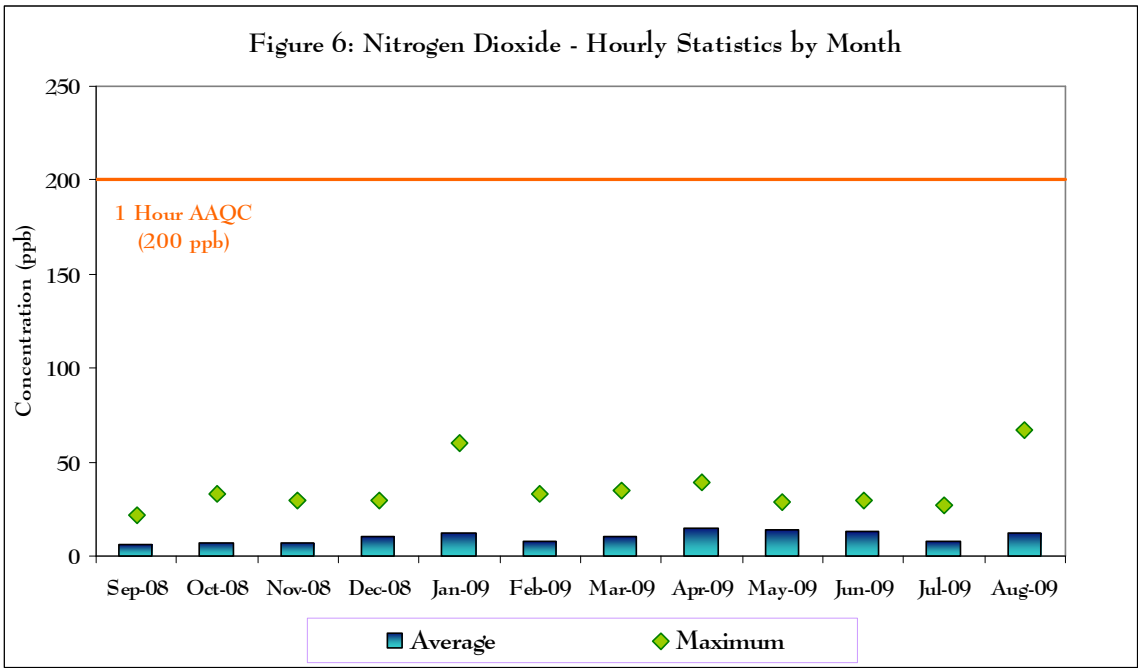
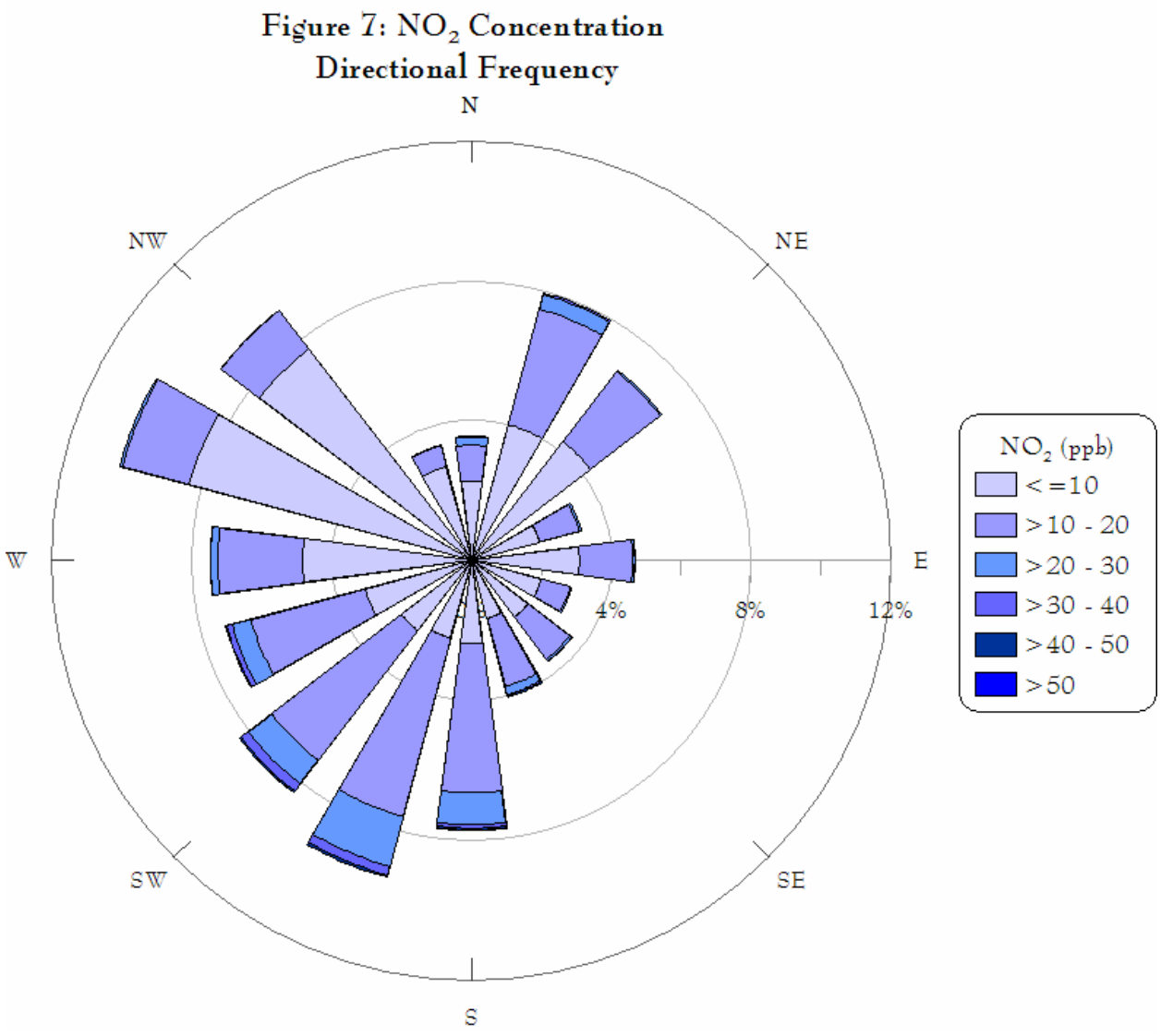


Table 2 shows the breakdown of the NO_2 sub-index by AQI category for each month during the reporting period and gives a more generalized assessment of the air quality. As with SO_2, NO_2 values were largely confined to the *Very Good* air quality category with only five hours in the entire reporting period having values that warranted a *Good* rating.

Table 6: Nitrogen Dioxide Percentage of Available Hours in Each AQI Category

Date	Very Good	Good	Moderate	Poor	Very Poor
Sep-08	100.0%	0.0%	0.0%	0.0%	0.0%
Oct-08	100.0%	0.0%	0.0%	0.0%	0.0%
Nov-08	100.0%	0.0%	0.0%	0.0%	0.0%
Dec-08	100.0%	0.0%	0.0%	0.0%	0.0%
Jan-09	99.6%	0.4%	0.0%	0.0%	0.0%
Feb-09	100.0%	0.0%	0.0%	0.0%	0.0%
Mar-09	100.0%	0.0%	0.0%	0.0%	0.0%
Apr-09	100.0%	0.0%	0.0%	0.0%	0.0%
May-09	100.0%	0.0%	0.0%	0.0%	0.0%
Jun-09	100.0%	0.0%	0.0%	0.0%	0.0%
Jul-09	100.0%	0.0%	0.0%	0.0%	0.0%
Aug-09	99.7%	0.3%	0.0%	0.0%	0.0%
Period	99.9%	0.1%	0.0%	0.0%	0.0%

Figure 7 is a pollution rose for NO_2 concentrations. Its shape closely resembles the SO_2 pollution rose as it relies on the same wind data, though the distribution of pollutant concentrations varies somewhat, potentially indicating a different range of sources. While the resolution of the diagram makes it difficult to see, the hours of increased concentrations occurred during generally southwesterly flows and may be the result of local industry or long range transport of pollution.



Total Reduced Sulphur (TRS)

Results are listed in Table 7 and illustrated in Figure 8. The table includes monthly and yearly averages of the hourly data, maximum hourly data, and number of hours an exceedance was registered during the reporting period. Unlike the previous AQI parameters, TRS does not have a 1 hour AAQC, so for the purposes of this report, the exceedance value has been set at the highest value that would still receive a *Moderate* rating under the AQI framework, 27 ppb. This approach will permit TRS to be evaluated in a manner consistent with the other AQI parameters. The table also includes data from the Sarnia and Windsor West AQI stations for comparison. The London AQI station does not currently collect TRS data.

No exceedances of the 27 ppb threshold were detected at the station during the reporting period. The highest measurement was 16 ppb, in October, while the highest average occurred in January. The lowest maximum was 2 ppb in December, while the lowest average occurred in November. Although the overall average at the AFNS was higher than either the Sarnia or the Windsor West AQI station, the average is so low, at less than 1 ppb, that the differences are not environmentally significant. As TRS is very often directly associated with industrial releases, the data was also scanned for levels above background to see if there was any correlation with known releases in the Sarnia area. One such event that occurred on October 15-16 2008 was detected by the AFNS, which registered TRS levels up to 16 ppb (*Moderate* air quality under the AQI framework) for approximately 12 hours. These results correspond with an accidental release from the Suncor facility during maintenance and repair activities. There were no anticipated impacts from this release.

Table 7: AFNS Monthly Total Reduced Sulphur Monitoring Results

Date	Average (ppb)	Maximum (ppb)	AQI Poor/ Very Poor Ratings (27 ppb)
Sep-08	0.8	7	0
Oct-08	0.9	16	0
Nov-08	0.4	9	0
Dec-08	0.7	2	0
Jan-09	1.5	7	0
Feb-09	0.5	10	0
Mar-09	0.9	10	0
Apr-09	0.7	14	0
May-09	1.3	4	0
Jun-09	0.8	7	0
Jul-09	0.9	2	0
Aug-09	0.9	8	0
Period Sept 08 - Aug 09	**0.9**	**16**	**0**
Sarnia AQI	0.1	6	0
Windsor West AQI	0.6	10	0
London AQI	N/A	N/A	N/A

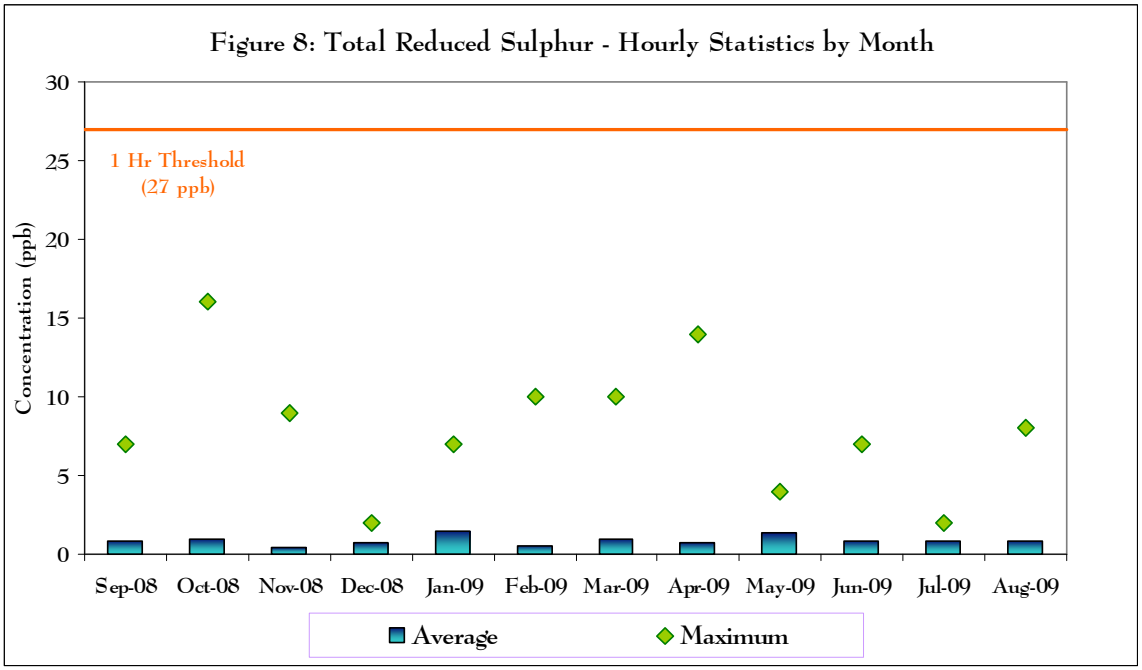


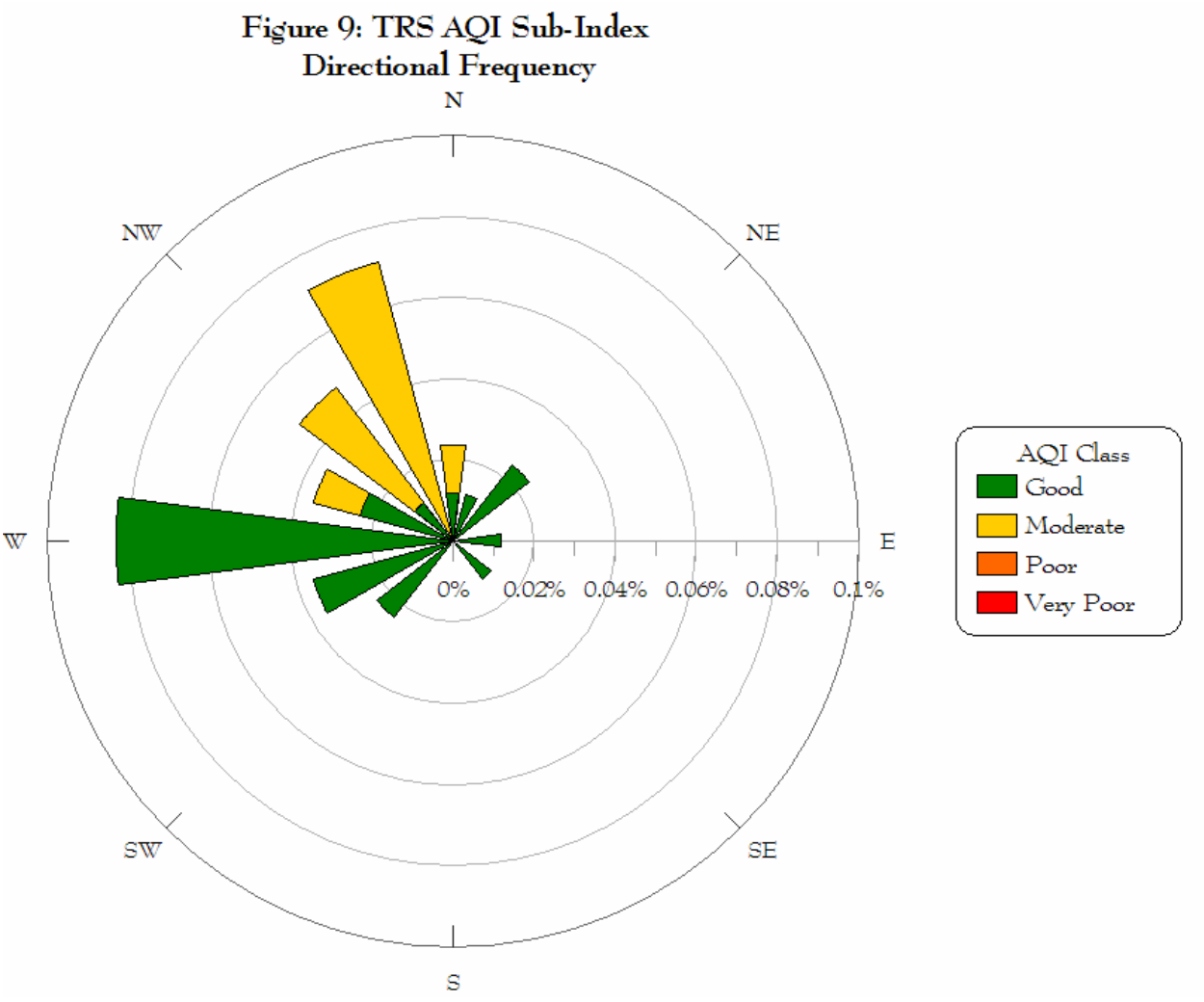
Table 8 shows the breakdown of the TRS sub-index by AQI category for each month during the reporting period. TRS concentrations led to very few *Moderate* hours and no *Poor* or *Very Poor* during the reporting period, with the vast majority of hours falling in the *Very Good* range.

Table 8: TRS Percentage of Available Hours in Each AQI Category

Date	Very Good	Good	Moderate	Poor	Very Poor
Sep-08	99.9%	0.1%	0.0%	0.0%	0.0%
Oct-08	98.4%	0.3%	1.3%	0.0%	0.0%
Nov-08	99.7%	0.3%	0.0%	0.0%	0.0%
Dec-08	100.0%	0.0%	0.0%	0.0%	0.0%
Jan-09	98.7%	1.3%	0.0%	0.0%	0.0%
Feb-09	99.8%	0.2%	0.0%	0.0%	0.0%
Mar-09	99.9%	0.1%	0.0%	0.0%	0.0%
Apr-09	99.6%	0.3%	0.1%	0.0%	0.0%
May-09	100.0%	0.0%	0.0%	0.0%	0.0%
Jun-09	99.9%	0.1%	0.0%	0.0%	0.0%
Jul-09	100.0%	0.0%	0.0%	0.0%	0.0%
Aug-09	99.9%	0.1%	0.0%	0.0%	0.0%
Period	99.6%	0.1%	0.0%	0.0%	0.0%

Figure 9 is a pollution rose for the TRS sub-index according to AQI categories. In this rose, *Very Good* hours have been left off as they will point in all directions, showing only the local variations of the wind. The small percentage of *Good* and *Moderate* hours is much more visible using this approach.

It is apparent from the pollution rose that the few hours associated with TRS at the *Moderate* AQI level all occurred during North to Northwest winds. This suggests that the elevated TRS levels detected at the site are from one or more local sources to the northwest of the site, however the small number of hours when elevated TRS was detected along with relatively low concentrations make it difficult for a specific source to be identified. When the TRS AQI sub-index levels are in the *Good* to *Moderate* range some people may detect a slight to moderate odour related to the TRS, however TRS at these levels are not generally considered a health hazard.



Fine Particulate Matter ($PM_{2.5}$)

Unlike the other AQI parameters, the evaluation of exposure to $PM_{2.5}$ is not based upon a 1 hour average concentration; rather the AQI sub-index for $PM_{2.5}$ is based on a 3-hour running average concentration. In addition, the federal and provincial government have jointly developed a Canada-Wide Standard (CWS) for $PM_{2.5}$ of 30 $\mu g/m^3$ over a 24-hour period. Achievement of the CWS in various airsheds is to be based on the 98th percentile of the 24-hour average concentration, annually averaged over three consecutive years. As such it is difficult to accurately apply the CWS to the measurements obtained at the Aamjiwnaang First Nation community air monitoring station. For the purposes of this report, $PM_{2.5}$ will be evaluated similar to TRS, in that the exceedance value will be set at the highest value that would still produce a *Moderate* rating in the AQI system. This value is 45 $\mu g/m^3$, calculated on a 3-hour running average.

Table 9 and Figure 10 present the data as 3 hour running averages. The table includes average and maximum data for the three other AQI stations in southwestern Ontario for the same reporting period. Higher than average values are recorded during the winter months and are associated with residential and commercial heating. Compared to the other AQI parameters, and to the other stations there is a larger number of exceedances recorded at the station during the reporting period, specific to 3 months (September, January and August), however the maximums are comparable to the other stations. The overall average is very close to the Sarnia AQI station average but is higher than London and Windsor. This suggests that the concentration of $PM_{2.5}$ is generally higher in the Sarnia air shed than in either London or Windsor, possibly due to a combination of local industry, transportation sources and proximity to the United States.

Table 9: AFNS Monthly Fine Particulate Matter Monitoring Results

Date	Average ($\mu g/m^3$)	Maximum ($\mu g/m^3$)	AQI Poor/ Very Poor Ratings (>45 $\mu g/m^3$)
Sep-08	10.1	60	6
Oct-08	6.1	33	0
Nov-08	5.7	27	0
Dec-08	10.0	24	0
Jan-09	14.9	51	9
Feb-09	13.0	44	0
Mar-09	12.0	44	0
Apr-09	7.6	24	0
May-09	9.4	38	0
Jun-09	8.7	45	0
Jul-09	8.7	35	0
Aug-09	9.5	51	9
Period Sept 08 - Aug 09	**9.5**	**60**	**24**
Sarnia AQI	10.0	54	8
Windsor West AQI	7.7	79	9
London AQI	6.1	51	8

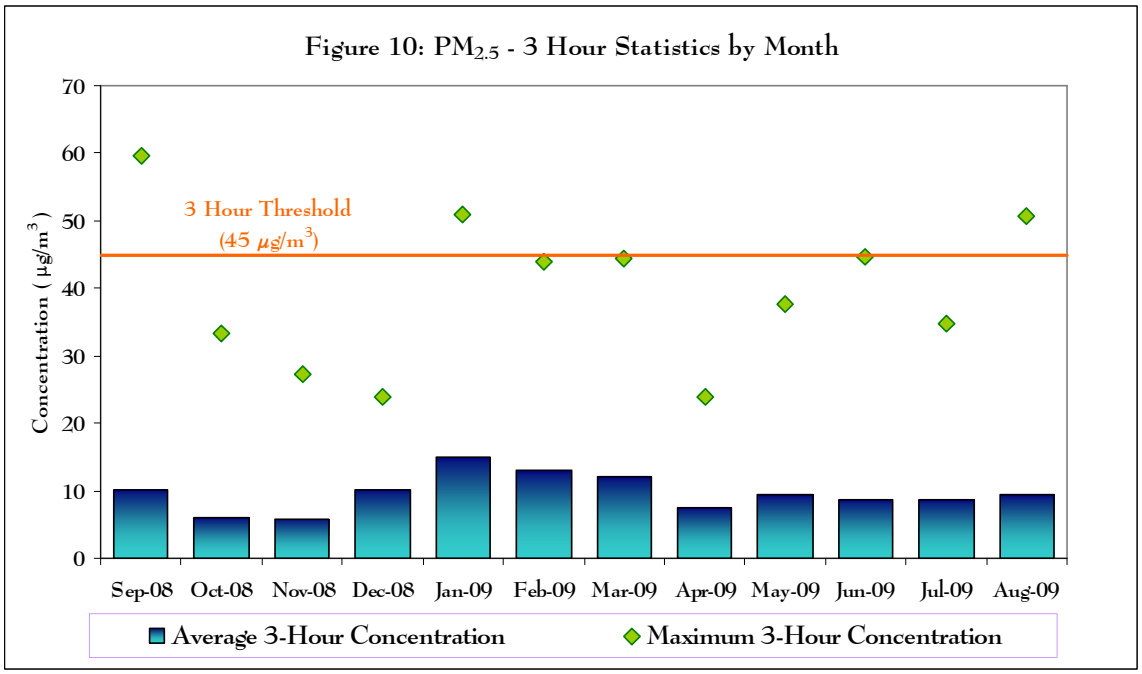


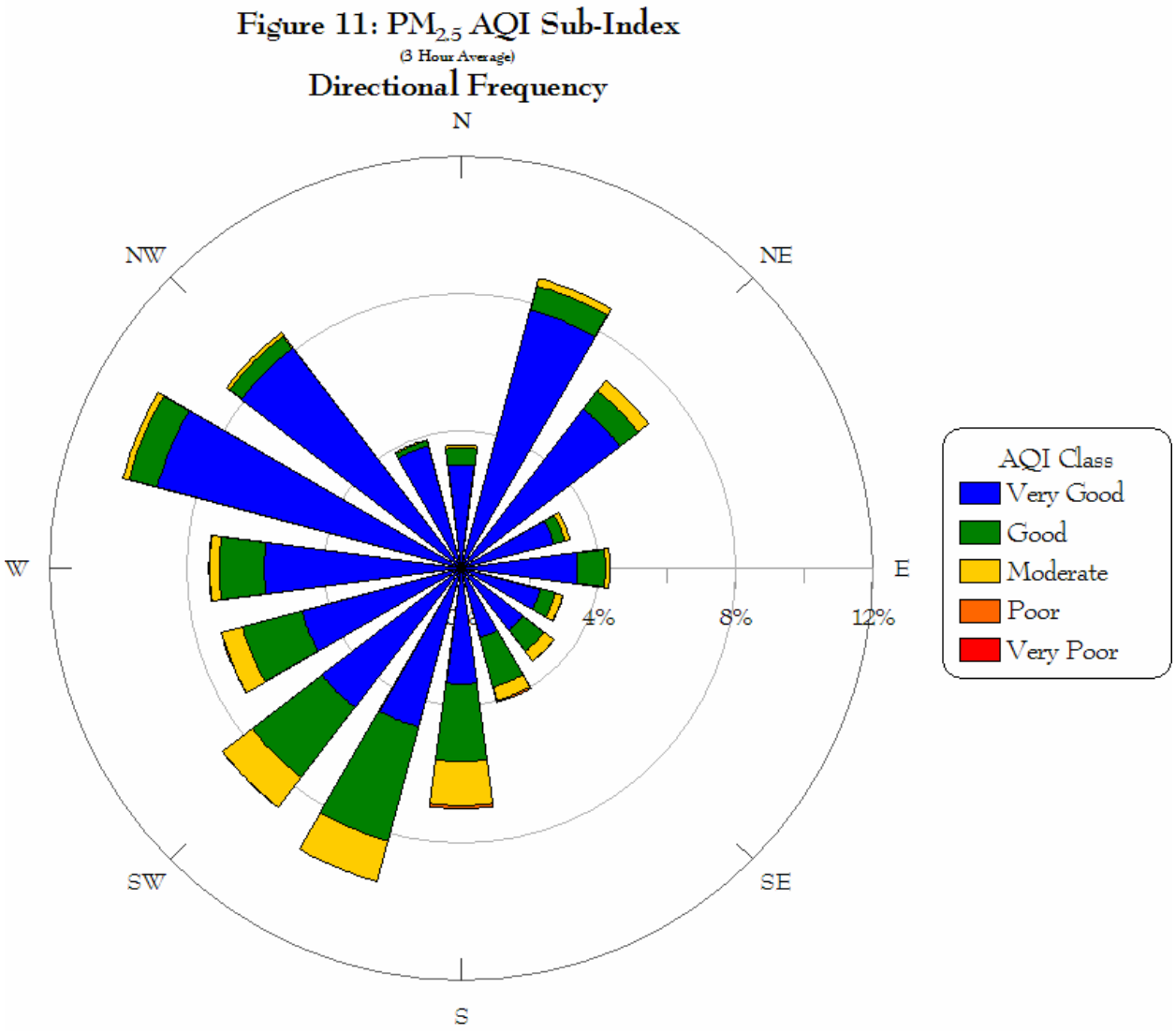
Table 10 shows that, unlike the other AQI pollutants, $PM_{2.5}$ sub-indices were not always in the desirable range. The lowest percentage of *Very Good* periods occurred in January, while the largest percentages of both *Moderate* periods were in February. This reflects, in part, the fact that much of the fine particulate in Ontario is formed during combustion or from the gases emitted during combustion, including combustion for heating purposes.

Table 10: $PM_{2.5}$ Percentage of Monitored Periods in Each AQI Category

Date	Very Good	Good	Moderate	Poor	Very Poor
Sep-08	73.1%	19.1%	7.0%	0.9%	0.0%
Oct-08	90.4%	7.4%	2.2%	0.0%	0.0%
Nov-08	88.1%	10.3%	1.5%	0.0%	0.0%
Dec-08	70.4%	29.0%	0.6%	0.0%	0.0%
Jan-09	48.7%	33.4%	16.7%	1.2%	0.0%
Feb-09	54.6%	27.4%	18.1%	0.0%	0.0%
Mar-09	60.1%	25.0%	14.9%	0.0%	0.0%
Apr-09	86.3%	13.3%	0.4%	0.0%	0.0%
May-09	76.9%	17.2%	6.0%	0.0%	0.0%
Jun-09	81.5%	12.9%	5.5%	0.0%	0.0%
Jul-09	76.1%	19.9%	4.0%	0.0%	0.0%
Aug-09	75.6%	16.5%	6.6%	1.3%	0.0%
Period	74.3%	18.7%	6.8%	0.3%	0.0%

Figure 11 shows the directional breakdown of the data. These results reflect the nature of particulate in the Sarnia area. In 2007 and 2008, the ministry's monitoring indicated that the

highest average of fine particulate levels in the province was found at the Sarnia AQI station.[ii] A significant proportion of fine particulate is associated with anthropogenic sources, both industrial and domestic. As a result, much of the higher concentration time is associated with southerly winds related to higher populations and industrial concentrations. Ministry studies have shown that, during the summer, over half of the concentration of smog-related pollutants in Southwestern Ontario air is related to transborder pollutant migration.



[ii] http://www.ene.gov.on.ca/en/publications/air/index.php#2 ; Air Quality in Ontario 2008 Report

Volatile Organic Compounds (VOC) – Continuous Sampling

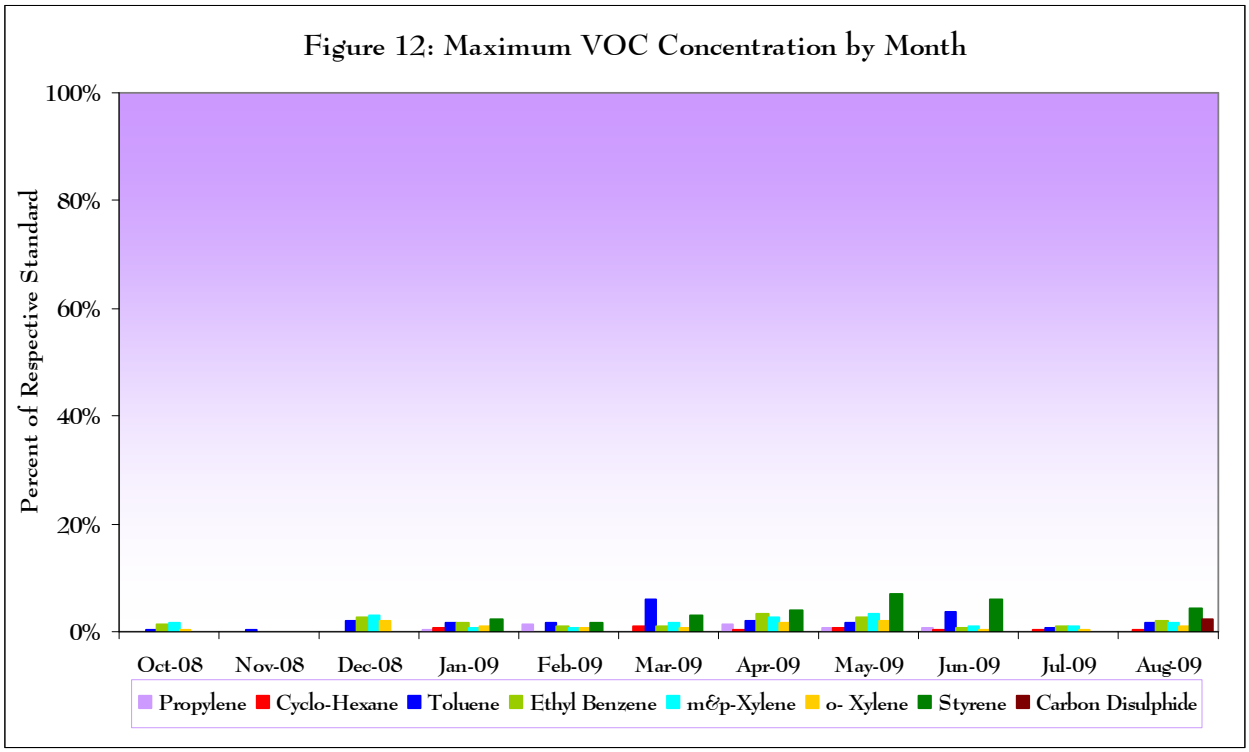
Of the 12 VOC species measured on a continuous basis, 3 were not detected during the reporting period: vinyl chloride, 1,3- butadiene, and acrylonitrile. Concentrations of the remaining nine compounds were not measured to be above their respective standards during the reporting period, where such standards exist. Benzene is the only measured compound that currently has no standard or guideline.

Table 11 shows the monthly average VOC concentrations for those hours where a reading greater than zero was recorded. When no concentration above the minimum detection limit was seen in a month, the average is set at zero. Table 12 gives the maximum 1 hour VOC concentrations. Most of the average concentrations were quite low, although higher peaks are seen from time to time. Figure 12 shows the monthly maximum as a percentage of their respective standards. None of the 11 VOCs with standards or guidelines exceeded 10% of their respective standard or guideline at any time.

Table 11: Monthly Average VOC Concentrations (ppb)

Date	Propylene	Carbon Disulphide	Cyclo-Hexane	Benzene	Toluene	Ethyl Benzene	m&p-Xylene	o- Xylene	Styrene
Sep-08	0.000	0.000	0.000	0.000	0.000	0.077	0.000	0.000	0.000
Oct-08	0.000	0.000	0.000	0.020	0.028	0.022	0.070	0.009	0.000
Nov-08	0.000	0.000	0.000	0.017	0.004	0.000	0.000	0.000	0.000
Dec-08	0.000	0.000	0.011	0.097	0.000	0.072	0.046	0.034	0.000
Jan-09	0.067	0.000	0.098	0.187	0.308	0.027	0.028	0.015	0.006
Feb-09	0.901	0.000	0.000	0.073	0.103	0.027	0.040	0.047	0.003
Mar-09	0.000	0.000	0.067	0.044	0.158	0.028	0.058	0.039	0.006
Apr-09	0.406	0.000	0.118	0.432	0.466	0.237	0.385	0.239	0.021
May-09	0.158	0.000	0.170	0.168	0.595	0.215	0.455	0.313	0.074
Jun-09	0.194	0.000	0.111	0.335	1.210	0.179	0.331	0.142	0.064
Jul-09	0.000	0.000	0.043	0.047	0.048	0.018	0.045	0.019	0.000
Aug-09	0.000	0.004	0.150	0.161	0.247	0.087	0.183	0.122	0.025
Period	0.133	0.000	0.066	0.142	0.283	0.083	0.145	0.087	0.017

Table 12: Maximum 1-Hour VOC Concentrations (ppb)									
Date	**Propylene**	**Carbon Disulphide**	**Cyclo-Hexane**	**Benzene**	**Toluene**	**Ethyl Benzene**	**m&p-Xylene**	**o- Xylene**	**Styrene**
Sep-08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oct-08	0.0	0.0	0.0	2.7	2.4	3.8	8.2	1.8	0.0
Nov-08	0.0	0.0	0.0	9.8	2.2	0.0	0.0	0.0	0.0
Dec-08	0.0	0.0	4.5	9.3	9.7	8.3	14.3	10.7	0.0
Jan-09	33.5	0.0	35.9	12.6	8.0	5.1	3.7	4.1	2.1
Feb-09	95.1	0.0	0.0	9.7	7.9	2.9	3.8	3.3	1.6
Mar-09	0.0	0.0	48.9	7.7	29.1	3.1	8.9	3.5	2.7
Apr-09	91.1	0.0	21.5	8.3	9.8	9.5	13.5	8.7	3.6
May-09	49.4	0.0	42.7	6.5	7.6	8.4	17.0	9.8	6.1
Jun-09	54.5	0.0	16.7	6.7	17.9	2.1	4.2	1.7	5.3
Jul-09	0.0	0.0	13.0	4.0	3.8	2.9	4.4	2.3	0.0
Aug-09	0.0	2.4	17.2	6.2	7.9	5.6	7.9	5.5	4.0
Period	95.1	2.4	48.9	12.6	29.1	9.5	17.0	10.7	6.1



Most of the VOC species were detected only sporadically. Table 13 shows how often each compound was measured above the detection limit on a monthly basis. The most frequently detected compound (toluene) only appeared about 16% of the time during the period covered by this report. As previously mentioned, vinyl chloride, 1,3- butadiene, and acrylonitrile were not measured above the detection limit at all during the reporting period. Propylene, cyclohexane, carbon disulphide, and styrene were detected less than 1% of the time. It should be noted that extremely low background levels of these compounds are expected. When they are not detected they are likely beneath the detection limit of the monitor, rather than not being present at all, as these compounds are normally ubiquitous in the environment.

Table 13: % of Time Above 0 for Hourly VOCs

Date	Propylene	Carbon Disulphide	Cyclo hexane	Benzene	Toluene	Ethyl Benzene	m&p Xylene	o Xylene	Styrene
Sep-08	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Oct-08	0.0%	0.0%	0.0%	1.5%	1.8%	1.5%	1.5%	1.0%	0.0%
Nov-08	0.0%	0.0%	0.0%	0.4%	0.3%	0.0%	0.0%	0.0%	0.0%
Dec-08	0.0%	0.0%	0.3%	2.3%	3.7%	1.2%	1.2%	1.2%	0.0%
Jan-09	0.2%	0.0%	1.8%	5.4%	15.7%	1.6%	1.6%	1.2%	0.4%
Feb-09	1.7%	0.0%	0.0%	2.1%	8.3%	2.9%	2.9%	3.3%	0.2%
Mar-09	0.0%	0.0%	0.1%	1.4%	8.3%	2.2%	2.2%	2.2%	0.3%
Apr-09	1.1%	0.0%	0.7%	12.6%	29.4%	14.6%	14.6%	14.0%	1.4%
May-09	0.6%	0.0%	0.9%	8.0%	37.1%	13.5%	13.5%	13.5%	3.2%
Jun-09	0.6%	0.0%	1.3%	16.2%	71.3%	35.8%	32.8%	32.8%	4.6%
Jul-09	0.0%	0.0%	0.7%	2.1%	3.0%	1.7%	1.7%	1.7%	0.0%
Aug-09	0.0%	0.2%	2.2%	6.5%	9.8%	6.8%	6.8%	6.8%	1.2%
Period	0.3%	0.0%	0.6%	4.9%	15.7%	6.9%	6.7%	6.6%	1.0%

The following two diagrams group pollution roses for the VOC compounds. Figure 13 compares the pollution roses for two xylene results (o, m&p), benzene, and ethyl benzene. These have been grouped as they show similar patterns and frequencies suggesting that the same sources are responsible for most of these occurrences. It should be remembered, when looking at these diagrams that the length of the petals indicates duration, while the changing colour shows concentration. Figure 13 suggests a possible low-level source for these compounds originating to the north-north-east of the monitoring station.

Figure 13: Pollution Roses for o-Xylene, m&p-Xylene, Benzene, and Ethyl Benzene

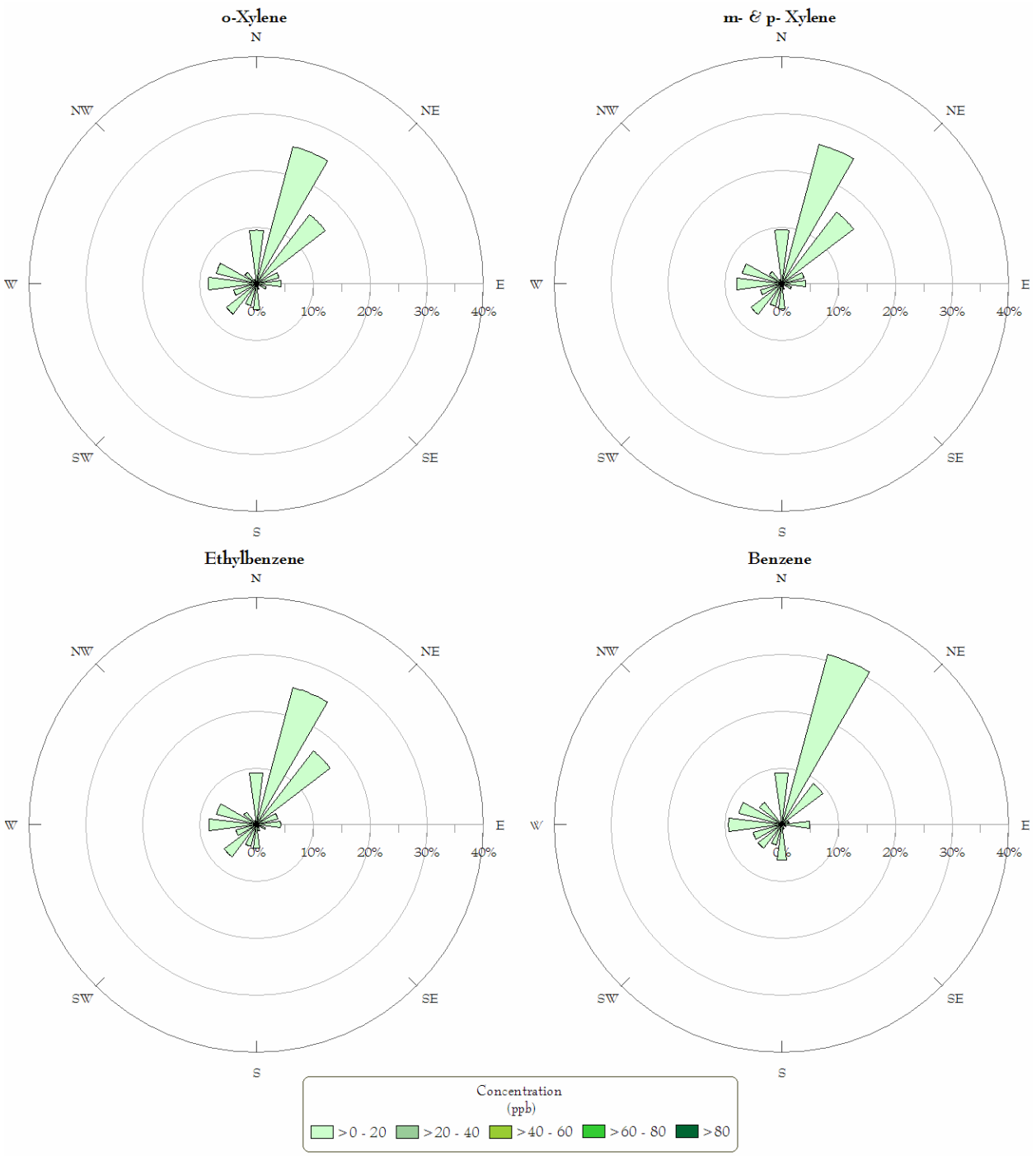
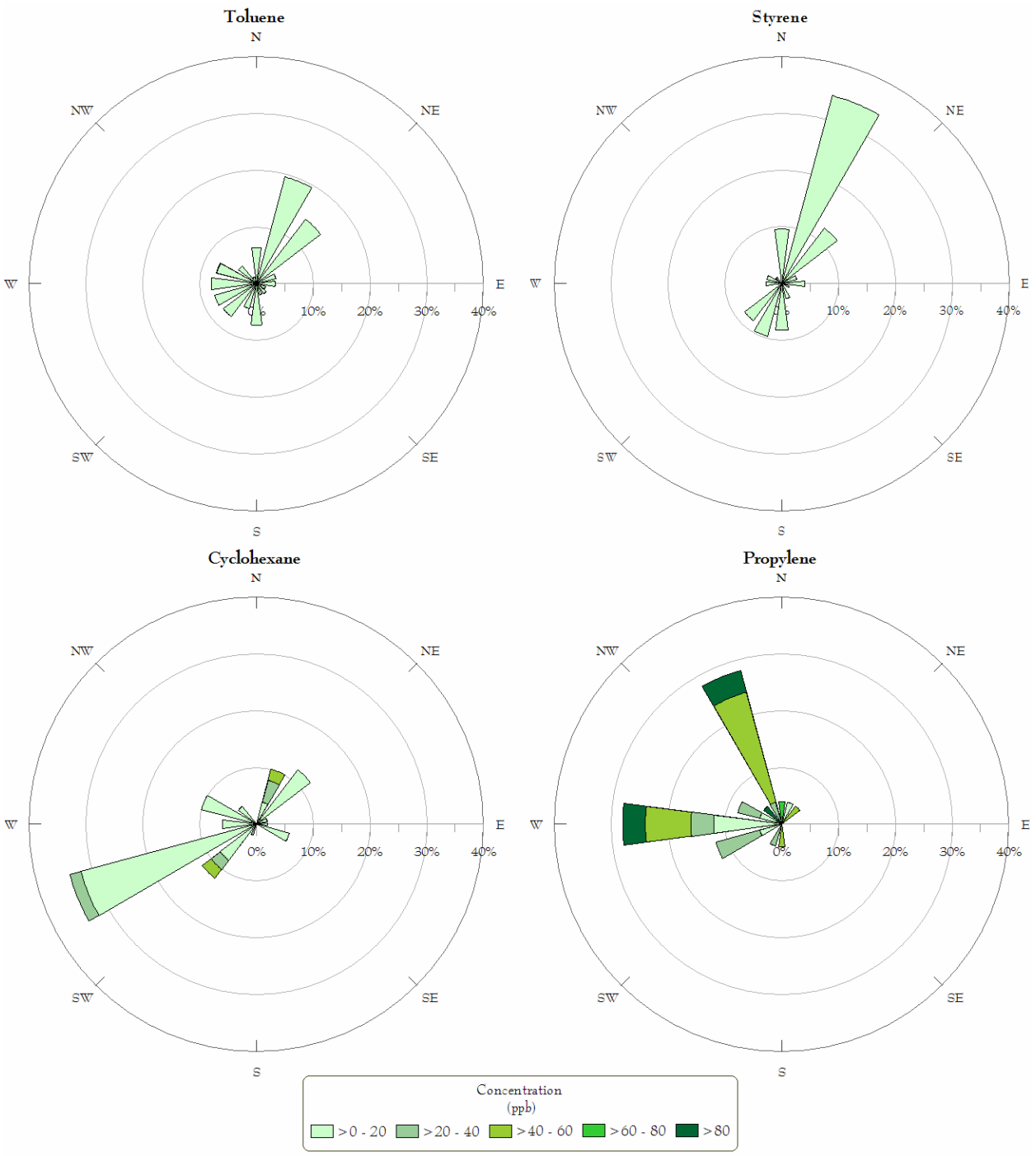


Figure 14 shows the directional distribution for the other four compounds. Much stronger differences are seen here among the other four compounds. These diagrams suggest that while some of the toluene and styrene may share a common source with the four compounds shown in Figure 13, cyclohexane, and propylene seem to be largely independent of the others, and may result from different sources.

Figure 14: Pollution Roses for Toluene, Styrene, Cyclohexane and Propylene



Volatile Organic Compounds (VOC) – Non-Continuous Sampling

Environment Canada (EC), in cooperation with the Aamjiwnaang First Nation and the ministry, samples for a wide range of VOC at the AFNS as part of the National Air Pollution Surveillance (NAPS) network. Air is sampled using specially prepared evacuated canisters which collect one twenty-four hour sample every twelfth day. Once the sample is collected, the canister is sent to an offsite analytical laboratory to be analyzed for 160 species of VOC. Due to the very low detection limits possible with this method, most of the compounds on the target list are often detectable at least some of the time as background levels. There were 31 twenty-four hour samples taken during the reporting period.

Many of the VOC analysed by EC under the NAPS program have no identified standards or guidelines in Ontario, making it difficult to draw conclusions about their effects on human health or the environment, although in general, compounds that do not have a standard are often less hazardous than those that do. Compounds analyzed by EC that have either a current Regulation 419 standard or an AAQC in Ontario are compared to the respective standard in the following two tables.

Table 14 compares the sampling results to the current list of AAQC. None of the measured values exceeded their respective AAQC. The most prominent average values on this list include ethylene and carbon tetrachloride. Ethylene, styrene, chloromethane, vinyl chloride, chloroform and carbon tetrachloride show maximum values as a significant percentage of their AAQC, with 1,2 dichloroethane showing a maximum of about 5 percent of it's AAQC.

Table 14: Environment Canada VOC Concentrations Compared to AAQC

Compounds	AAQC ($\mu g/m^3$)	Maximum (% of AAQC)	Average (% of AAQC)
Ethylene	40.0	62.608%	13.044%
Acetylene	56000.0	0.002%	0.001%
Propylene	4000.0	0.206%	0.050%
Hexane	7500.0	0.346%	0.037%
Cyclohexane	6100.0	0.237%	0.032%
Heptane	11000.0	0.009%	0.003%
Toluene	2000.0	0.275%	0.093%
Octane	61800.0	0.001%	0.000%
Ethylbenzene	1000.0	0.114%	0.036%
Styrene	400.0	20.455%	0.850%
iso-Propylbenzene	400.0	0.145%	0.012%
1,3,5-Trimethylbenzene	220.0	0.093%	0.026%
1-Decene	60000.0	0.000%	0.000%
1,2,4-Trimethylbenzene	220.0	0.533%	0.100%
Decane	60000.0	0.001%	0.000%
1,2,3-Trimethylbenzene	220.0	0.091%	0.033%
Naphthalene	22.5	1.453%	0.482%

Table 14: Environment Canada VOC Concentrations Compared to AAQC			
Compounds	**AAQC (μg/m^3)**	**Maximum (% of AAQC)**	**Average (% of AAQC)**
MTBE	7000.0	0.000%	0.000%
Freon22	350000.0	0.000%	0.000%
Chloromethane	320.0	10.003%	1.309%
Freon114	700000.0	0.000%	0.000%
Freon113	800000.0	0.000%	0.000%
Vinyl chloride	1.0	41.860%	2.617%
Bromomethane	1350.0	0.017%	0.004%
Chloroethane	5600.0	0.002%	0.001%
Freon11	6000.0	0.032%	0.025%
Freon12	500000.0	0.001%	0.000%
1,1-Dichloroethylene	165.0	0.005%	0.001%
Dichloromethane	220.0	0.355%	0.112%
trans-1,2-Dichloroethylene	105.0	0.016%	0.002%
1,1-Dichloroethane	165.0	0.000%	0.000%
cis-1,2-Dichloroethylene	105.0	0.341%	0.020%
Chloroform	1.0	15.450%	8.210%
1,2-Dichloroethane	2.0	4.935%	3.152%
1,1,1-Trichloroethane	115000.0	0.000%	0.000%
Carbontetrachloride	2.4	25.913%	22.195%
1,2-Dichloropropane	2400.0	0.001%	0.000%
Trichloroethylene	12.0	0.967%	0.238%
EDB	3.0	0.320%	0.031%
Tetrachloroethylene	360.0	0.061%	0.019%
Chlorobenzene	3500.0	0.001%	0.000%
Bromoform	55.0	0.157%	0.033%
1,4-Dichlorobenzene	95.0	0.058%	0.021%
1,2-Dichlorobenzene	30500.0	0.000%	0.000%
1,2,4-Trichlorobenzene	400.0	0.025%	0.006%

Table 15 shows how the measurements compare to the Regulation 419 Standards. None of the measurements exceeded any of the ministry's standards. The two highest maximum values were styrene at about 20% of its standard and vinyl chloride at 14%. In both cases the high values appear to be due to isolated detections above baseline levels. Styrene showed one high value, while vinyl chloride showed one high peak and one moderate one. The highest average is that for carbon tetrachloride which appears to be fairly constant in the area though it never reaches 10% of the standard. Only two other substances, chloroform and 1,2-dichloroethane average above 1% of their respective standards.

Table 15: Environment Canada VOC Concentrations Compared to O. Reg. 419 Standards			
Compounds	**½ Hr Std ($\mu g/m^3$)**	**Maximum (% of Standard)**	**Average (% of Standard)**
Acetylene	56000	0.002%	0.001%
Propylene	12000	0.069%	0.017%
Hexane	22500	0.115%	0.012%
Cyclohexane	18300	0.079%	0.011%
Heptane	33000	0.003%	0.001%
Toluene	2000	0.275%	0.093%
Ethylbenzene	1400	0.082%	0.025%
Styrene	400	20.455%	0.850%
iso-Propylbenzene	100	0.581%	0.049%
1,3,5-Trimethylbenzene	660	0.031%	0.009%
1,2,4-Trimethylbenzene	660	0.178%	0.033%
1,2,3-Trimethylbenzene	660	0.030%	0.011%
Chloromethane	960	3.334%	0.436%
Freon113	2400000	0.000%	0.000%
Vinyl chloride	3	13.953%	0.872%
Chloroethane	16800	0.001%	0.000%
1,1-Dichloroethylene	30	0.029%	0.003%
Dichloromethane	660	0.118%	0.037%
1,1-Dichloroethane	495	0.000%	0.000%
Chloroform	3	5.150%	2.737%
1,2-Dichloroethane	6	1.645%	1.051%
1,1,1-Trichloroethane	350000	0.000%	0.000%
Carbon tetrachloride	7	8.638%	7.398%
1,2-Dichloropropane	2400	0.001%	0.000%
Trichloroethylene	36	0.322%	0.079%
Tetrachloroethylene	1080	0.020%	0.006%
1,4-Dichlorobenzene	285	0.019%	0.007%

Some of the listed compounds may have originated locally while others may travel larger distances or be the result of a combination of sources. As with most other 24-hour samples, it is usually difficult to ascribe a source direction to a particular measurement, as wind direction tends to vary considerably over the course of the day.

Table 16 compares the compounds showing higher concentrations at the AFNS with results from some other NAPS sites in Southern Ontario. It should be noted that the results cover only approximately the same time span as later results were not available for all sites. Similarly, the comparison stations often had a higher number of measurements as a result of special studies at the sites.

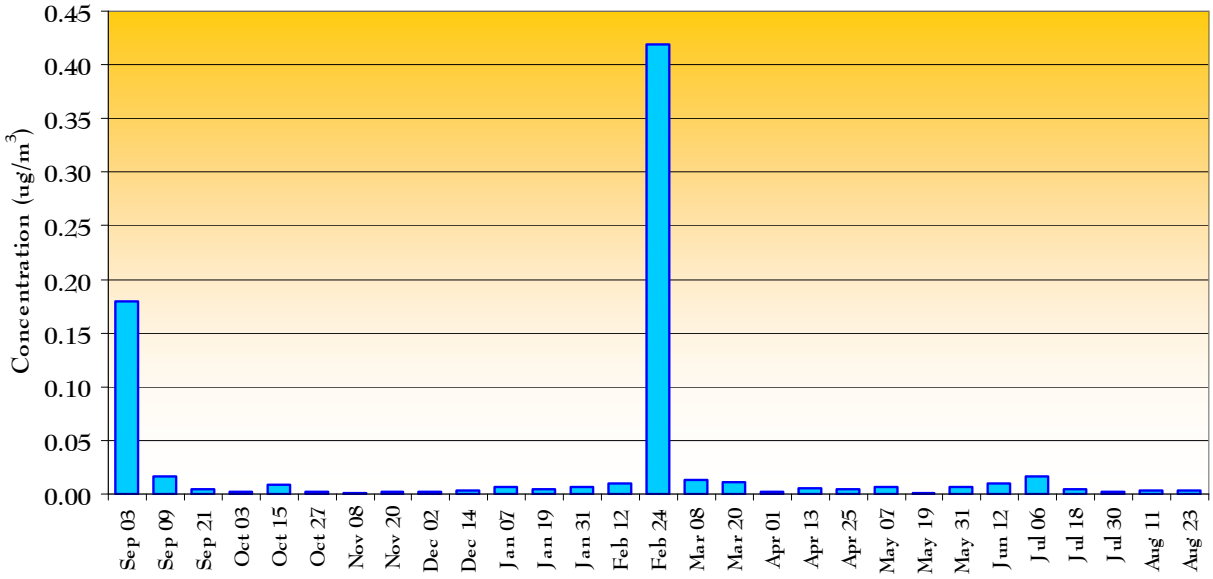
Table 16: Comparison of Selected VOC Concentrations at NAPS Sites (µg/m^3)

VOC		AFNS	Longwoods	Pt Petre	Toronto	Wallaceburg	Windsor
Ethylene	Avg.	4.67	0.44	0.29	1.50	0.50	1.31
	Max.	25.04	2.36	1.04	3.12	3.22	4.31
Styrene	Avg.	2.78	0.06	0.06	0.11	0.03	0.04
	Max.	81.82	0.44	0.31	0.39	0.25	0.24
Chloromethane	Avg.	3.93	1.15	1.14	1.16	1.19	1.20
	Max.	32.01	1.59	1.42	1.40	2.20	1.47
Vinyl chloride	Avg.	0.02	0.00	0.00	0.00	0.00	0.00
	Max.	0.42	0.01	0.01	0.01	0.01	0.01
Chloroform	Avg.	0.08	0.07	0.07	0.13	0.08	0.09
	Max.	0.15	0.10	0.13	0.37	0.33	0.34
1,2-Dichloroethane	Avg.	0.06	0.06	0.06	0.06	0.06	0.06
	Max.	0.10	0.10	0.08	0.08	0.13	0.08
Carbon tetrachloride	Avg.	0.54	0.59	0.57	0.52	0.59	0.53
	Max.	0.62	0.81	0.66	0.66	0.74	0.63
First Sample		03 Sep	03 Sep	03 Sep	03 Sep	09 Sep	03 Sep
Last Sample		23 Aug	30 Aug	29 Aug	18 Jun	29 Aug	06 Jun
Number of Samples		29	106	116	49	104	43

It is apparent that chloroform, 1,2-dichloroethane, and carbon tetrachloride levels are generally the same as or lower than those seen elsewhere around Southern Ontario. This suggests that measurements of these compounds at the AFNS reflect background concentrations in southern Ontario. Ethylene, styrene, chloromethane and vinyl chloride show relatively high averages and maximum compared to other locations, and are investigated in more detail below.

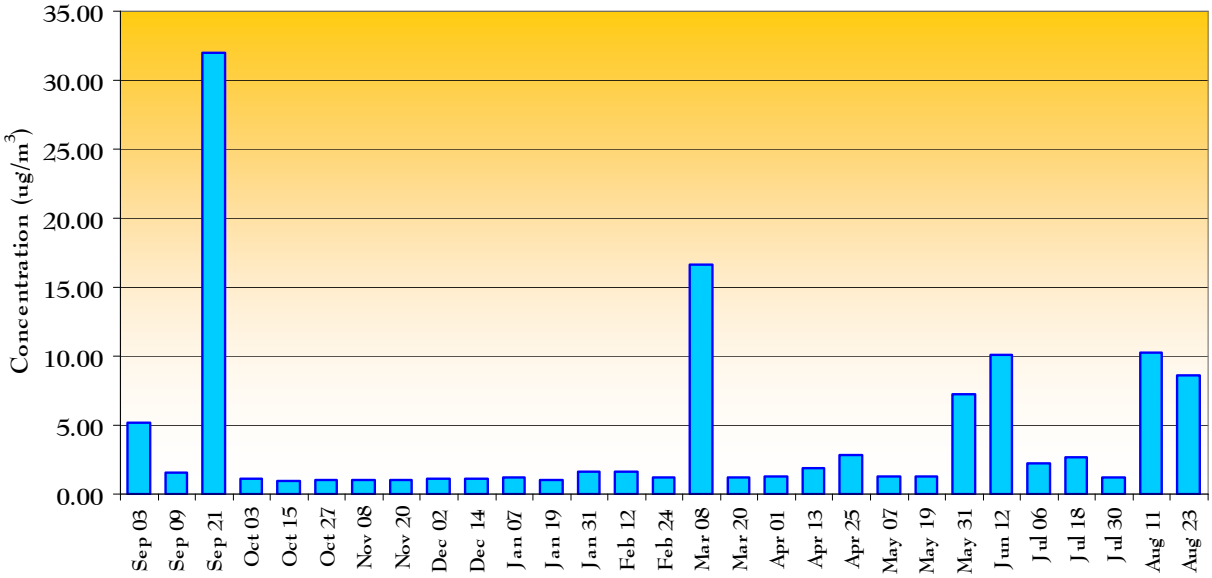
The detailed AFNS results for vinyl chloride are displayed in Figure 15, which shows a low background concentration with two peaks, the higher one representing about 42% of the 24 hour AAQC for vinyl chloride. This compound is not widely used in the chemical industry, and with the closing of the Royal Polymers plant in 2009, it is expected that major sources of vinyl chloride in the Sarnia airshed would be eliminated. The wind direction during the sampling does not specifically indicate the source of the vinyl chloride to be the Royal Polymers facility, however as noted it can be difficult to tie a twenty four hour result to a particular facility, as wind directions tend to vary considerably over the course of the day.

Figure 15: Twenty-four Hour Vinyl Chloride Concentrations at AFNS



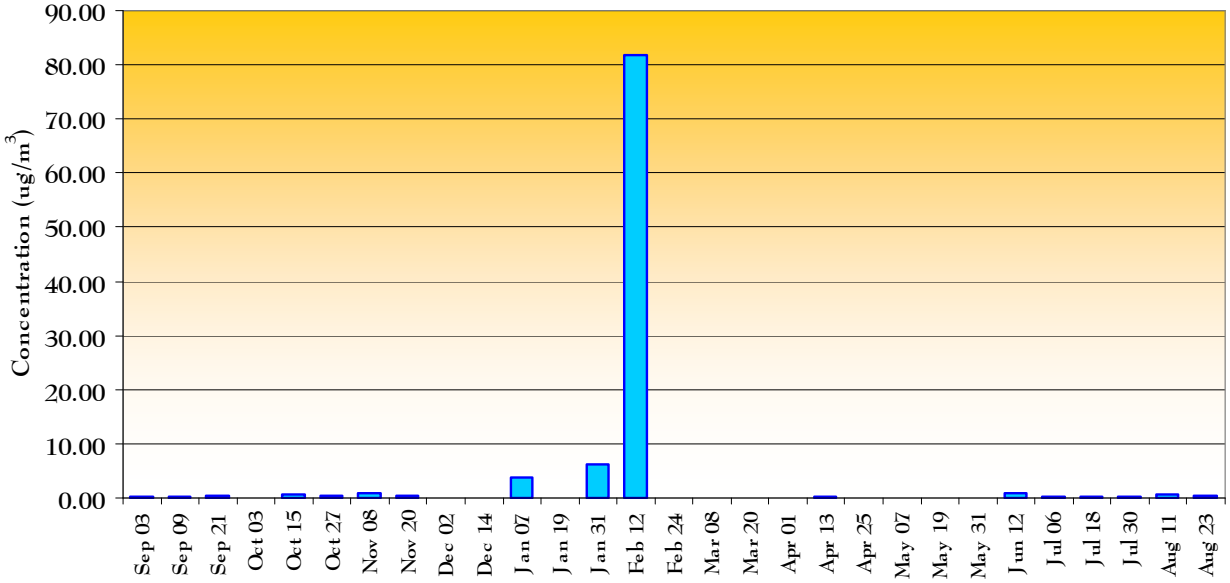
Chloromethane concentrations are illustrated in Figure 16. They also exhibit variable levels, however in this case higher levels occur more frequently. Since it is commonly used by local industry and the levels are substantially below the 24 hour AAQC of 320 µg/m^3, these peaks are likely the result of normal changes in processes at one or more local plants.

Figure 16: Twenty-four Hour Chloromethane Concentrations at AFNS



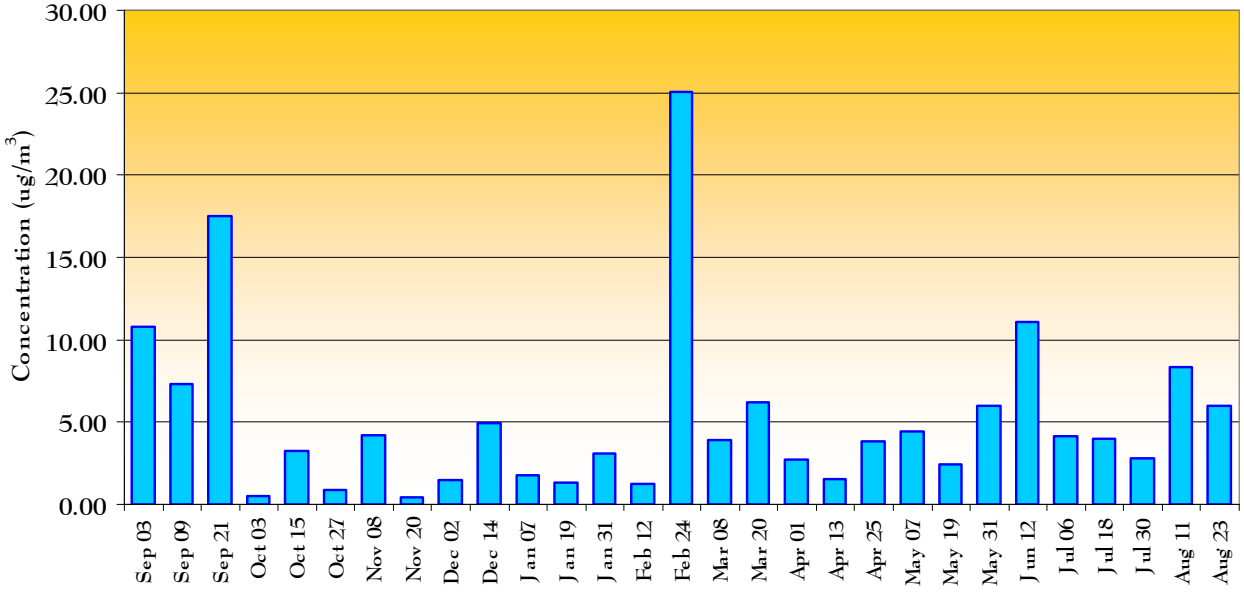
Styrene levels at AFNS were generally low with one significant exception as illustrated in Figure 17. The high peak is likely related to an industrial release but since this peak did not occur at the same time as those for the previous two substances, it is probably from a different source. Winds were strong and generally from the west on that day, which could indicate a number of potential sources in both the Canadian and United States.

Figure 17: Twenty-four Hour Styrene Concentrations at AFNS



Ethylene concentrations are illustrated in Figure 18. As can be seen there is considerable variation from sample to sample. The regular occurrence of ethylene is most probably due to its widespread use in the chemical industry; only very small amounts are produced naturally by vegetation. Both the average and maximum are a relatively high percentage of the AAQC, however the AAQC is set based on damage to plants, rather than human health issues.

Figure 18: Twenty-four Hour Ethylene Concentrations at AFNS



The continuous monitoring of VOC performed by MOE and the non-continuous monitoring of VOC performed by EC included several of the same species, allowing for a comparison of the two methods. A basic correlation between the two methods for the VOC that were analyzed by both methods was conducted, however the correlation between the two methods proved to be poor.

There are several factors that may contribute to this:

- 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-hour 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.

Table 19 gives a comparison of the maximum for selected compounds for each of the two methods with 24-hour averages that are calculated from the one hour measurements. While the values often do not correlate well, most are within a factor of 10. Both sets of measurements show that none of the current ministry standards and AAQC have been exceeded. It should be noted that this type of variability is not uncommon when dealing with very low levels of air contaminants assessed by multiple methods, however further work is recommended to explain the sources of the variability that exists between the methods at the AFNS site.

Table 19: Comparison of 24-Hour VOC Maxima (µg/m^3)

VOC	Non-continuous Sampling (EC)	Continuous Sampling (MOE)
1,3-Butadiene	0.73	Not Seen
Benzene	3.18	4.37
Cyclohexane	14.47	5.53
Ethylbenzene	1.14	7.98
m and p-Xylene	1.35	12.30
o-Xylene	0.61	8.83
Propylene	8.24	6.26
Styrene	81.82	1.40
Toluene	5.50	6.26
Vinyl chloride	0.42	Not Seen

Polycyclic Aromatic Hydrocarbons (PAH)

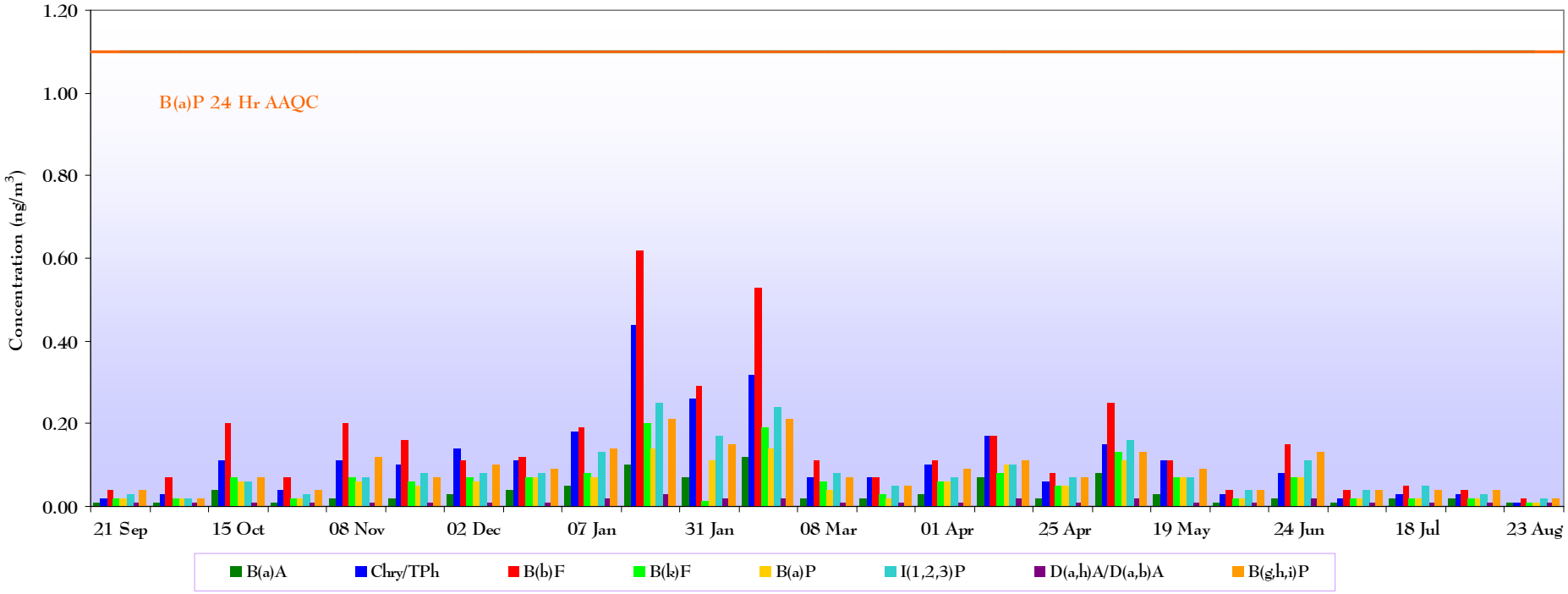
During the reporting period the ministry collected and analyzed 17 samples on a one in twelve day cycle for several PAH compounds. Averages and maxima from the AFNS are presented by compound in Table 20. For comparison, values are included from the West Windsor station (WWS) for the same periods.

Table 20: PAH Concentrations (ng/m^3)					
PAH		**Average**		**Maximum**	
Full Name	**Abbreviation**	**AFNS**	**WWS**	**AFNS**	**WWS**
Benzo(a)Anthracene	**B(a)A**	0.04	0.44	0.12	3.82
Chrysene / Triphenylene	**Chry / TPh**	0.11	0.65	0.44	4.31
Benzo(b)Fluoranthene	**B(b)F**	0.15	1.10	0.62	8.30
Benzo(k)Flouranthene	**B(k)F**	0.06	0.43	0.20	3.34
Benzo(a)Pyrene	**B(a)P**	0.06	0.53	0.14	4.66
Indeno(1,2,3-c,d)Pyrene	**I(1,2,3)P**	0.09	0.64	0.25	6.03
Dibenzo(a,h)Anthracene Dibenzo(a,b)Anthracene	**D(ah)A / D(ab)A**	0.01	0.14	0.03	1.39
Benzo(g,h,i)Perylene	**B(ghi)P**	0.09	0.51	0.21	3.65

Concentrations at the Aamjiwnaang station were consistently significantly lower that those reported from the West Windsor station during the reporting period in both average and maximum for all the PAH types. In addition, no exceedances of the B(a)P AAQC of were seen, nor did any of the other PAHs reach that level. Overall the levels of PAHs detected were very low and lower than those detected in other border communities.

The results are illustrated in Figure 19 below. In general, the quantity of the different PAH seems to go up and down together but the exact ratios vary somewhat from sample to sample. Chrysene/triphenylene and Benzo(b)fluoranthene tend to be the most common of the compounds. Since the highest peaks appear during the winter some of the emissions may be related to building heating.

Figure 19: PAH Concentrations



Total Suspended Particulate (TSP) & Metals – Non-Continuous Sampling

While particulate sampling started in September of 2008, metal analysis did not begin until January of 2009. As a result, while there were 57 valid particulate samples, there were only 37 results for metal analysis.

In general, both the particulate levels and the metal values were quite low. The results are summarized in Table 21 below. No standards or guidelines were exceeded and many of the metals were measured to be below the minimum detection limit (MDL) more than half of the time. This may reflect the wet winter and spring that occurred in the area or may (in part) be the result of the relatively sheltered nature of the sampling site.

Table 21: Particulate/Metals Sampling Results

TSP/Metal	# Samples	# <MDL	Maximum ($\mu g/m^3$)	Average ($\mu g/m^3$)	AAQC ($\mu g/m^3$)
TSP	57	0	54	15.351	120
Silicon	37	0	1.7	0.441	--
Calcium	37	0	4.2	0.826	--
Vanadium	37	9	0.046	0.005	2
Chromium	37	21	0.005	--	1.5
Manganese	37	16	0.010	0.004	2.5
Iron	37	0	0.630	0.148	4
Nickel	37	11	0.019	0.003	2
Copper	37	20	0.007	--	50
Zinc	37	2	0.093	0.015	120
Cadmium	37	35	0.006	--	0.025
Lead	37	34	0.010	--	0.5

CONCLUSIONS AND RECOMMENDATIONS

Overall, the results of the air sampling conducted at Aamjiwnaang First Nation community air monitoring suggest that air quality at the site during the sampling period is similar to air quality in surrounding communities. Aside from particulate matter and ozone, there were no exceedances of any ministry standard or guideline recorded at the station from September 2008 to August 2009. For the vast majority of the reporting period, SO_2, NO_2, O_3, TRS and CO levels rated as *Very Good* in the provincial AQI reporting system. In fact, CO was not detected at all at the site for the entire reporting period. $PM_{2.5}$ and O_3 were rated as *Very Good* or *Good* for most of the period, and was very rarely rated *Poor* and never as *Very Poor*. When elevated levels did occur, they were typically the result of cross border air quality events that affected the entire region, and were not specific to AFNS.

Three of the twelve VOC that were continuously monitored at the site did not show any level of measurement above the minimum detection limit for the entire monitoring period. The remaining nine VOC occasionally showed detectable levels, but were never at a level close to the applicable standard or guideline, and were mostly regarded as representative of background levels. Non-continuous 24-hour monitoring of VOC at the site confirmed no results were above a standard or guideline. A small number of compounds (specifically vinyl chloride, styrene, chloromethane and ethylene) occasionally showed slightly elevated levels, possibly due to local industry sources.

Monitoring of PAH also showed low levels for all of the compounds analyzed, but these levels were again quite low and representative of background levels in an industrial area. When compared against data from the ministry's Windsor PAH monitoring station, the PAH levels from the Aamjiwnaang First Nation community air monitoring station are considerably lower.

The results of the metals analysis were again quite low and there were no exceedances of ministry standards or guidelines.

Future work with the information collected from the Aamjiwnaang First Nation community air monitoring station could involve comparing and correlating with known point sources or modeled results.

Appendix A – Ontario Air Standards and Guidelines

Table 1 and Table 2 summarize air standards and related cautionary levels for air pollutants. The same information is presented in both tables but in two separate units parts per million (ppm) and micrograms per cubic metre ($\mu g/m^3$). Both of these units are used in air monitoring for historical reasons but they are not simply related. One needs to know the weight of the substance and the ambient temperature and pressure to convert between the two. Thus the two tables present an approximate conversion that is appropriate to each substance for 20 ^{o} C and 1013 millibars – normal temperature and pressure (NTP) conditions.

Table 1: Summary of Standards and Guidelines - Local Air Quality
µg/m³ *

	O. Reg 419			AAQC		Occupational		
COMPOUND	**Sch. 1 1/2 Hour**	**Sch. 2 1/2 Hour**	**Sch. 3 24 Hour**	**1/2 Hour**	**24 Hour**	**Short Term STEL**	**Work Week TWA**	**Immediately Dangerous to Life and Health IDLH**
Sulphur dioxide (SO_2)	830	830	275		275		14,000	270,000
Total Reduced Sulphur (TRS) **				40				
Hydrogen sulphide (H_2S)	30	30	7		7		15,000	150,000
Nitric oxide (NO)								
Nitrogen oxide (NO_X)								
Nitrogen dioxide (NO_2)	500	500	200		200	2000	10,000	38,000
Ammonia (NH_3)	3600	300	100		100	25,000	17,000	210,000
Formaldehyde (CH_2O)	65	65	65	65	65	120	20	25,000
Methane (CH_4)								
Ozone (O_3)	200	200	375	200	375		200	10,000
Acrylonitrile	180	1.8	0.6			22,000	2,200	190,000
Benzene						3,200	320	1,600,000
Butadiene, 1,3						11,000	2,200	4,400,000
Carbon disulphide		330	330			32,000	3,200	1,600,000
Cyclohexane		18,300	6,100				1,050,000	
Ethyl benzene	3,000	1,400	1,000			5,500,000	440,000	3,500,000
Propylene		12,000	4,000					
Styrene	400	400	400			220,000	430,000	3,000,000
Toluene	2,000	2,000				570,000	380,000	1,900,000
Vinyl chloride	3	3	1			39,000	2,600	
Xylenes, *m,p,o*	2,300	2,200	730				440,000	4,000,000
	Health		Odour					

* Occupational health warning levels are usually published in parts per million (ppm). As well many instruments used by the ministry report in this form.
** Total reduced sulphur is converted from ppm to µg/m³ as though it were entirely hydrogen sulphide

Table 2: Summary of Standards and Guidelines - Local Air Quality

ppm *

COMPOUND	O. Reg 419			AAQC		Occupational		
	Sch. 1 1/2 Hour	Sch. 2 1/2 Hour	Sch. 3 24 Hour	1/2 Hour	24 Hour	Short Term STEL	Work Week TWA	Immediately Dangerous to Life and Health IDLH
Sulphur dioxide (SO_2)	0.31	0.31	0.1		0.1		5	100
Total Reduced Sulphur (TRS) **				0.028				
Hydrogen sulphide (H_2S)	0.02	0.02	0.005		0.005		10	100
Nitric oxide (NO)								
Nitrogen oxide (NO_X)								
Nitrogen dioxide (NO_2)	0.26	0.26	0.1		0.10	1	5	20
Ammonia (NH_3)	5	0.4	0.1		0.1	35	25	300
Formaldehyde (CH_2O)	0.05	0.05	0.05	0.05	0.05	0.1	0.037	20
Methane (CH_4)								
Ozone (O_3)	0.1	0.1	0.08	0.1	0.08		0.1	5
Acrylonitrile	0.08	0.0008	0.0002			10	1	85
Benzene						1	0.1	500
Butadiene, 1,3						5	1	2,000
Carbon disulphide		0.1	0.1			10	1	500
Cyclohexane		5.2	1.75				300	
Ethyl benzene	0.7	0.3	0.2			125	100	800
Propylene		6.9	2					
Styrene	0.09	0.09	0.09			50	100	700
Toluene	0.5	0.5				150	100	500
Vinyl chloride	0.001	0.001	0.0004			15	1	
Xylenes, *m,p,o*	0.5	0.5	0.15				100	900
	Health		Odour					

* Occupational health warning levels are usually published in parts per million (ppm). As well many instruments used by the ministry report in this form.

** Total reduced sulphur is converted from ppm to $\mu g/m^3$ as though it were entirely hydrogen sulphide

Appendix B – Background Information on Monitored Pollutants

The Air Quality Index (AQI)

The AQI is a rating scale for outdoor air in Ontario. The lower the AQI, the better the air quality.

Based on data from its network of air monitoring stations, the Ministry of the Environment reports an hourly AQI for many communities across Ontario to all major media outlets and on the Ministry web site.

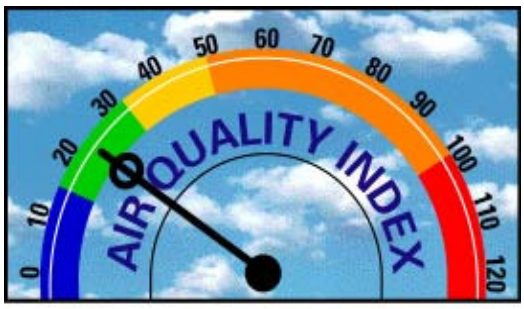
Six key air pollutants are monitored by the ministry as part of the AQI:

- Sulphur Dioxide (SO_2)
- Ozone (O_3)
- Nitrogen Dioxide (NO_2)
- Total Reduced Sulphur Compounds (TRS)
- Carbon Monoxide (CO)
- Fine Particulate Matter ($PM_{2.5}$)

These pollutants were chosen because at elevated levels they have an adverse effect on humans and the environment.

The air monitoring data are collected at the ministry. Data are compared to air quality standards for each of the six air pollutants. These scientifically-based standards, which are updated from time to time, indicate the maximum safe level for a pollutant. Above this level, the pollutant begins to have an undesirable impact on people and the environment.

The monitoring data are converted into the AQI scale. The scale ranges from 0-15 (very good) to 100+ (very poor).



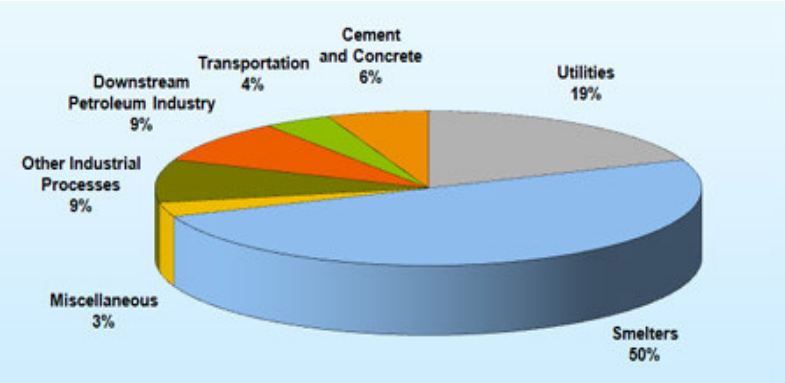
Each hour, an AQI is calculated for each of the six pollutants. This makes it simpler to compare the relative impacts of the pollutants on human health and the environment. The pollutant with the highest AQI sub-index, therefore, has the greatest impact. It becomes the "overall" AQI for a particular location.

For example, if the AQI sub-index for ozone is 20, and this is the highest of the six pollutant AQI sub-indices , it is then used as the overall AQI for a particular location. Specifically, it would be reported as an "AQI of 20, reason: ozone."

Sulphur Dioxide

Sulphur Dioxide (SO_2) is a colourless gas. It smells like burnt matches. It can be oxidized to sulphur trioxide which, in the presence of water vapour, is readily transformed to sulphuric acid mist. SO_2 can be oxidized to form acid aerosols. SO_2 is a also a precursor of sulphates, which are one of the main components of respirable particles in the atmosphere.

Approximately 69 per cent of the SO_2 emitted in Ontario in 2007 came from smelters and utilities, especially electrical generation. Other industrial sources include iron and steel mills, petroleum refineries, and pulp and paper mills. Small sources include residential, commercial and industrial space heating.



Health effects caused by exposure to high levels of SO_2 include breathing problems, respiratory illness, changes in the lung's defences, and worsening respiratory and cardiovascular disease. People with asthma or chronic lung or heart disease are the most sensitive to SO_2. It also damages trees and crops. SO_2, along with nitrogen oxides, are the main precursors of acid rain. This contributes to the acidification of lakes and streams, accelerated corrosion of buildings and reduced visibility. SO_2 also causes formation of microscopic acid aerosols, which have serious health implications as well as contributing to climate change.

Health Effects of Different Air Quality Index (AQI) Levels Caused by Sulphur Dioxide (SO_2)			
Category	AQI	Concentration $\mu g/m^3$ {ppb}	Sulphur Dioxide (SO_2)
Very Good	0 – 15	0-212 {0-79}	No health effects are expected in healthy people.
Good	16 - 31	212-451 {80-169}	Damages some vegetation in combination with ozone.
Moderate	32 – 49	451-667 {170-250}	Damages some vegetation.
Poor	50 – 99	667-5324 {251-1999}	Odour; increasing vegetation damage.
Very Poor	100 or over	>5324 {>1999}	Increasing sensitivity for asthmatics and people with bronchitis.

Ground-Level Ozone

Ground-Level Ozone (O_3) is a colourless, odourless gas at ambient concentrations and is a major component of smog. Ground-level ozone is not emitted directly into the atmosphere. It results from photochemical reactions between oxides of nitrogen (NO_x) and volatile organic compounds (VOC) in the presence of sunlight. High levels typically occur from May to September, between noon and early evening.

Significant amounts of ozone and ozone-forming compounds are carried into Ontario from the U.S. During periods of widespread elevated levels of ozone, it is estimated that more than 50 per cent of Ontario's ground-level ozone comes from the U.S.

O_3 irritates the respiratory tract and eyes. Exposure to high levels of O_3 results in chest tightness, coughing and wheezing. People with respiratory and heart problems are at a higher risk. Ozone has been linked to increased hospital admissions and premature death. Ozone causes agricultural crop loss each year in Ontario and noticeable leaf damage in many crops, garden plants and trees.

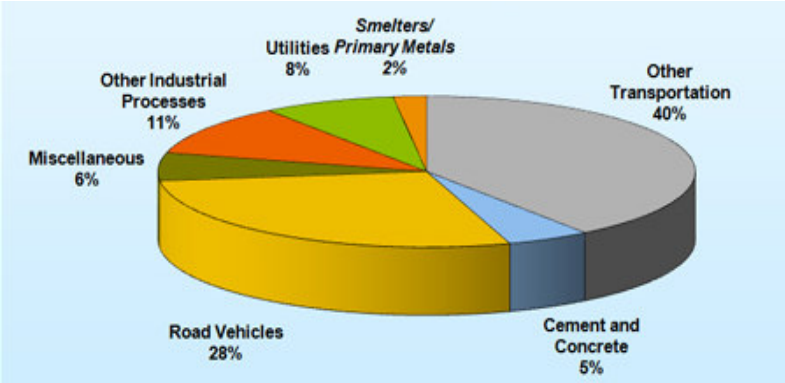
The following table shows the health effects of different Air Quality Index (AQI) levels caused by ground-level ozone.

Health Effects of Different Air Quality Index (AQI) Levels Caused by Ground Level Ozone (O_3)			
Category	AQI	Concentration $\mu g/m^3$ {ppb}	Ground Level Ozone (O_3)
Very Good	0 – 15	0-47 {0-23}	No health effects are expected in healthy people.
Good	16 - 31	47-101 {24-50}	No health effects are expected in healthy people.
Moderate	32 – 49	101-370 {51-80}	Respiratory irritation in sensitive people during vigorous exercise; people with heart/lung disorders at some risk; damage to very sensitive plants.
Poor	50 – 99	370-297 {81-149}	Sensitive people may experience irritation when breathing and possible lung damage when physically active; people with heart/lung disorders at greater risk; damage to some plants.
Very Poor	100 or over	>297 {>149}	Serious respiratory effects, even during light physical activity; people with heart/lung disorders at high risk; more vegetation damage.

Nitrogen Dioxide (NO_2)

Nitrogen Dioxide (NO_2) is a reddish-brown gas with a pungent and irritating odour. It transforms in the air to form gaseous nitric acid and toxic organic nitrates. NO_2 also plays a major role in atmospheric reactions that produce ground-level ozone, a major component of smog. It is a precursor to various nitrates, some of which contribute to the formation of respirable particles in the atmosphere.

All combustion in air produces oxides of nitrogen (NO_x), of which NO_2 is a major component. Approximately 63 per cent of NO_x comes from the transportation and a large part of the remaining 37 per cent comes from power generation, primary metal production and incineration.



NO_2 can irritate the lungs and lower resistance to respiratory infection. Sensitivity to NO_2 is higher for people with asthma and bronchitis. NO_2, when chemically transformed to nitric acid, can corrode metals, fade fabrics and degrade rubber. It can damage trees and crops, resulting in substantial losses.
The following table shows the health effects of different Air Quality Index levels caused by nitrogen dioxide.

Health Effects of Different Air Quality Index (AQI) Levels Caused by Nitrogen Dioxide (NO_2)			
Category	AQI	Concentration $\mu g/m^3$ {ppb}	Nitrogen Dioxide (NO_2)
Very Good	0 – 15	0-97 {0-50}	No health effects are expected in healthy people.
Good	16 - 31	97-211 {51-110}	Slight odour.
Moderate	32 – 49	211-383 {111-200}	Odour.
Poor	50 – 99	383-1003 {201-524}	Air smells and looks brown. Some increase in bronchial reactivity in asthmatics.
Very Poor	100 or over	>1003 {>524}	Increasing sensitivity for asthmatics and people with bronchitis.

Total Reduced Sulphur (TRS)

Total Reduced Sulphur Compounds (TRS) produce offensive odours similar to rotten eggs or cabbage.

Industrial sources of TRS include the steel industry, pulp and paper mills, refineries and sewage treatment facilities. Natural sources include swamps, bogs and marshes.

TRS compounds are not normally considered a health hazard. They are, however, a primary cause of odours.

The following table shows the health effects of different Air Quality Index (AQI) levels caused by total reduced sulphur compounds.

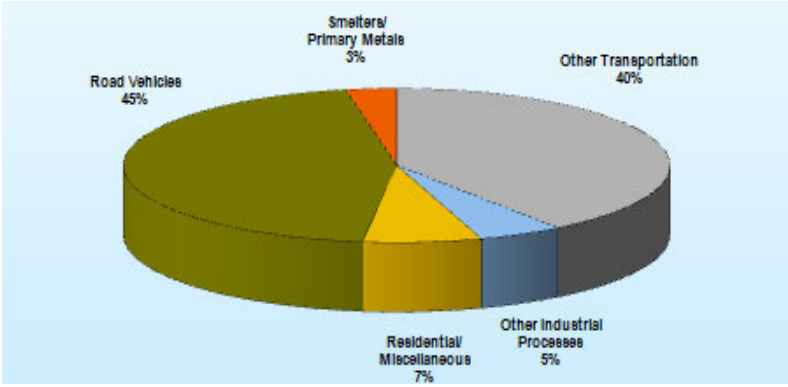
Health Effects of Different Air Quality Index (AQI) Levels Caused by Total Reduced Sulphur Compounds (TRS)			
Category	AQI	Concentration $\mu g/m^3$ * {ppb}	Total Reduced Sulphur Compounds (TRS)
Very Good	0 – 15	0-7.8 {0-5.49}	No health effects are expected in healthy people.
Good	37 - 31	7.8-14.9 {5.50-10.49}	Slight odour.
Moderate	32 – 49	14.9-39.0 {10.50-27.49}	Odour.
Poor	50 – 99	39.0-1437 {27.5-999.49}	Strong Odour
Very Poor	100 or over	>1437 {>999.49}	Severe odour; some people may experience nausea and headaches.

*The AQI is based upon measurement in ppm. The conversion to $\mu g/m^3$ assumes that it is all Hydrogen Sulphide. Other compositions will yield slightly different values.

Carbon Monoxide (CO)

Carbon Monoxide (CO) is a colourless, odourless and tasteless but poisonous gas produced primarily by incomplete burning of fossil fuels.

The transportation sector accounts for 65 per cent of all CO emissions from human activity in Ontario as seen in the table and diagram below. A large part of the remainder comes from primary metal producers (24 per cent) and from fuel combustion in space heating and industrial processes (6 per cent).



CO enters the blood stream and reduces oxygen delivery to the organs and tissues. People with heart disease are particularly sensitive. Exposure to high levels is linked with impairment of vision, work capacity, learning ability and performance of difficult tasks.

The following table shows the health effects of different Air Quality Index levels caused by carbon monoxide.

Health Effects of Different Air Quality Index (AQI) Levels Caused by Carbon Monoxide (CO)			
Category	AQI	Concentration $\mu g/m^3$ [ppm]	Carbon Monoxide (CO)
Very Good	0 – 15	0--14600 [0-12.49]	No health effects are expected in healthy people.
Good	37 - 31	14600-26200 [12.50-22.49]	No health effects are expected in healthy people.
Moderate	32 – 49	26200-35500 [22.50-30.49]	Blood chemistry changes but no noticeable impairment.
Poor	50 – 99	35500-57600 [30.5-49.49]	Increased symptoms in smokers with heart disease.
Very Poor	100 or over	>57600 [49.49]	Increasing symptoms in non-smokers with heart disease; blurred vision; some clumsiness.

Particulate Matter

The atmosphere contains a wide variety of very fine particles. These may be called particulate matter, dust, smoke, haze, aerosol, fumes, mist or other names, depending on the type of particle and who is describing it. These particles come both from man-made and natural sources, are composed of many different compounds and range considerably in size. Generally, the size (diameter) of individual particles ranges from 100 microns (1 micron = 1 μm = 1 millionth of a metre) down to one one-hundredth of a micron, or so. They may be liquid or solid and may be formed locally or come from long distances away. Larger particles tend to settle out of the atmosphere much more quickly and hence are more often associated with local sources. Fine particles, on the other hand, may travel a considerable distance. Particulate can be responsible for corrosion, soiling, damage to vegetation, reduction in visibility and may be injurious to health.

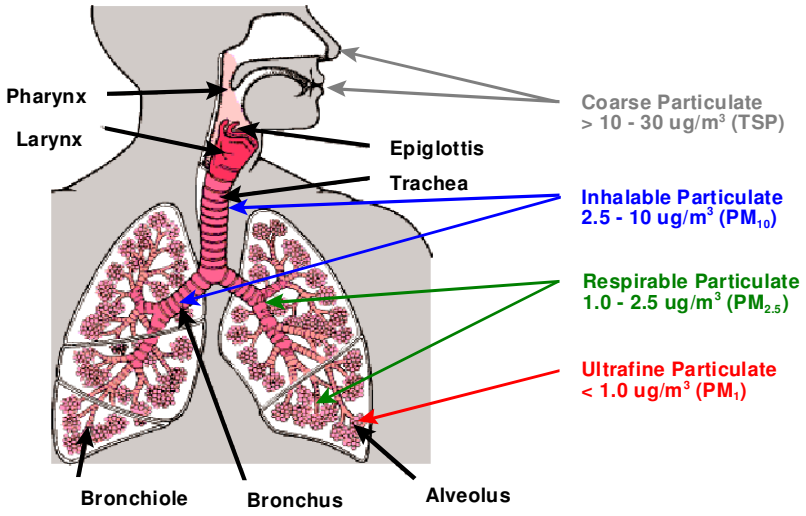
Total Suspended Particulate (TSP) is a generic term for all airborne particulate. Composition varies with place and season but normally includes soil particles, organic matter and nongaseous sulphur, metals and nitrogen compounds. The particles' diameters vary considerably from approximately 0.1 to 100 microns. Most particles greater than about 10 microns will be caught in the nose and throat, never reaching the lungs.

The term PM_{10} (inhalable particulate) has been given to those particles that have a diameter of ten microns or less. Particles of this size are more likely to bypass the body's natural defences and reach the upper respiratory tract. Many, however, will be caught by cilia lining the walls of the bronchial tubes, which will move particles up and out. PM_{10} can result from industrial activity, vehicle exhaust, residential wood combustion and entrainment of road dust. Natural sources include soil erosion, forest fires, volcanic activity and ocean spray.

The term $PM_{2.5}$ (respirable particulate) refers to that fraction of particulate whose diameter is 2.5 microns or less. $PM_{2.5}$ is able to penetrate deeper into the lungs, into regions where there are no cilia. Some removal mechanisms operate in this (pulmonary) region but because retention times range from one to two years, $PM_{2.5}$ is most closely linked with negative health effects. Ambient $PM_{2.5}$ is usually formed from chemical reactions in the atmosphere and combustion processes. However, mechanical and natural mechanisms may also lead to its formation. Particulate control equipment is usually less efficient at removing small particles.

The small size of $PM_{2.5}$ means that it settles very slowly from the atmosphere, and so it can travel long distances from its point of origin,

The following illustration shows how far different particle sizes can penetrate into the respiratory system. Because human lungs have a large surface area and because people consume so much air, lungs are the greatest source of exposure to air pollution. Several recently published community health studies indicate that significant respiratory and cardiovascular-related problems are associated with exposure to particle levels well below the existing particulate matter standards. These negative effects include premature death, hospital admissions from respiratory causes, and increased respiratory symptoms.

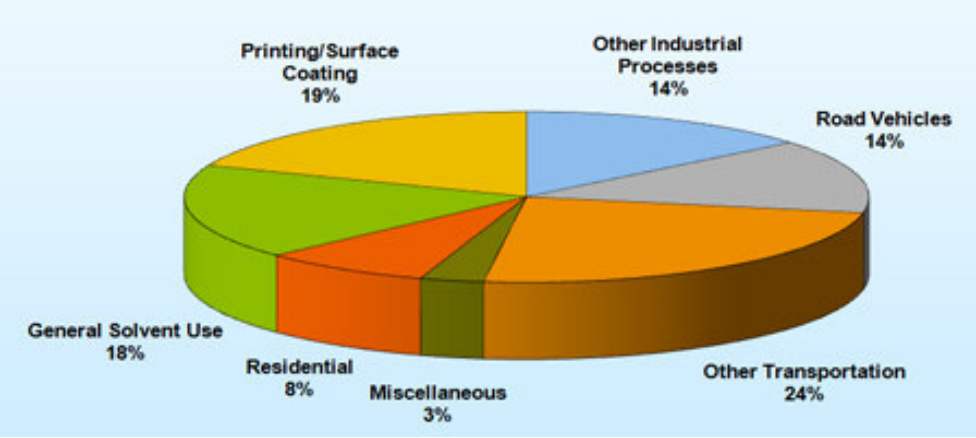


The following table outlines the health effects of different AQI levels caused by fine particulate matter.

Health Effects of Different Air Quality Index (AQI) Levels Caused by Fine Particulate Matter ($PM_{2.5}$)			
Category	AQI	Concentration $\mu g/m^3$ (3 hour average)	Fine Particulate Matter ($PM_{2.5}$)
Very Good	0 – 15	1 - 11	Sensitive populations may want to exercise caution.
Good	37 - 31	12-22	Sensitive populations may want to exercise caution.
Moderate	32 – 49	23-45	People with respiratory disease at some risk.
Poor	50 – 99	46-90	People with respiratory disease should limit prolonged exertion; general population at some risk.
Very Poor	100 or over	>90	Serious respiratory effects even during light physical activity; people with heart disease, the elderly and children at high risk; increased risk for general population.

Volatile Organic Compounds (VOC)

The Aamjiwnaang air monitoring station is one of the few air monitoring stations in Ontario that is able to measure several specific volatile organic carbon compounds. Volatile organic compounds (VOC) are emitted into the atmosphere from a variety of anthropogenic and natural sources. Some of the major anthropogenic sources include vehicles, fossil fuel combustion, steel-making, petroleum refining, refuelling, industrial and residential solvent use, paint application, manufacturing of synthetic materials (e.g. plastics, carpets), food processing, agricultural activities and wood processing and wood burning.



Vegetation sources are the main natural contributor of VOC emissions. Certain VOC warrant special concern because they play an important role in the formation of ground-level ozone and $PM_{2.5}$. VOC that contribute to the formation of ozone typically have a short life spans in the atmosphere. In contrast, VOC that are less reactive to ozone formation are capable of being transported very long distances as they have a long half-life in the troposphere.

Benzene, toluene and xylene (BT) Motor vehicle exhaust is the major source of BT in Ontario. These compounds are very active in the formation of ground-level ozone and $PM_{2.5}$.

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 human carcinogen.

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.

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 naturally 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.

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 you to feel dizzy or sleepy. Breathing very high levels can cause you to pass out, and breathing extremely high levels can cause death.

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 vulcanization and 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, Parkinsonian paralysis, and insanity.

Carbon disulphide may damage the developing foetus. It may decrease fertility in men and women, causing sperm abnormalities and spontaneous abortions.

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 oedema, and seizures. Exposure to propylene can cause hypotension, apnoea, decreases in vision, frothy mucous, an increased pulse rate, hyperventilation, cyanosis, bronchoconstriction, respiratory depression, pulmonary oedema, lung congestion, headache, dizziness, numbness of the extremities, sleepiness, mental confusion, and memory loss.

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, 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.

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. These symptoms usually disappear when exposure is stopped.

There is evidence that children are much more sensitive to acrylonitrile than adults. In a few cases, children have died following exposure to acrylonitrile vapours that caused only minor nose and throat irritation in adults.

1,3-Butadiene is a chemical made from the processing of petroleum. It is a colorless 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. We also do not know what levels in the air will cause these effects in people when breathed over many years.

Ethyl benzene is a colorless liquid that smells like gasoline. You can smell ethyl benzene 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 found 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.

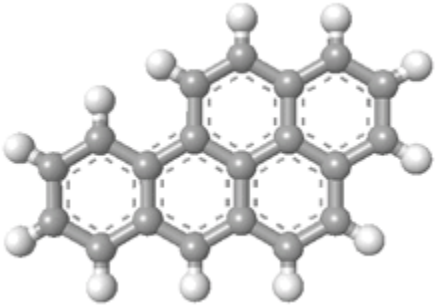
At certain levels, exposure to ethyl benzene can harm your health. People exposed to high levels of ethyl benzene in the air for short periods have complained of eye and throat irritation. Persons exposed to higher levels have shown signs of more severe effects such as decreased movement and dizziness.

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 classified as a possible human carcinogen by the Environmental Protection Agency (EPA) and by the International Agency for Research on Cancer (IARC). 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.

Polycyclic Aromatic Hydrocarbons (PAH)

Polycyclic Aromatic Hydrocarbons (PAH), sometimes called Polynuclear Aromatic Hydrocarbons or Polyaromatic Hydrocarbons are a group of compounds are a class of chemicals that consist of two or more fused aromatic rings. An aromatic ring is six carbon atoms joined together in a hexagonal shape, each having a single hydrogen atom also attached. Fused rings generally share two carbon atoms, each of which then loses its attached hydrogen. The figure below depicts benzo(a)pyrene, a five ring PAH. [3] In this figure the darker grey represents carbon, the lighter grey, hydrogen. The dotted lines indicate that the atoms "share" electrons – this is the meaning of the "aromatic" in the molecule name.



PAH are semi-volatile organics. This means that while they may be emitted as gases they tend to solidify or (more often) become attached to particulate in the atmosphere. The relative amount of gaseous PAH varies by individual type and with ambient conditions but most will be found on particulate. In general the heavier the molecules – those with more rings of carbon atoms - tend to be found more preferentially on particulate. This behaviour of existing in both gaseous and solid form is know as partitioning.

The ministry samples for particulate-bound PAH. Samples are taken for twenty four hours, every twelfth day, from midnight to midnight Eastern Standard Time. The list of reported species is given below. Because of the similarity in some of their properties, certain pairs of PAH (coloured pairs) are not distinguishable with the ministry's analytical techniques. As a result, they are reported together. The list also includes abbreviations that will be used to simplify graphs.

PAH occur in oil, coal, and tar deposits, and are produced as byproducts of fuel burning (whether fossil fuel or biomass). PAH are also found in foods. As a pollutant, they are of concern because some of them have been identified as carcinogenic, mutagenic, and teratogenic. Studies indicate, however that some are more potent than others. The relative ability of several PAH to cause cancer have been calculated by various agencies. Those available have been included in the table. These are not risk values, just relative ratings.

Currently there are no air standards for PAH. The ministry has a AAQC for BaP. It is 1.1 ng/m^3 (24 hours) and 0.22 ng/m^3 (annual) for a single source and 0.3 ng/m^3 (annual) for all sources. [4]

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[3] originally http://jchemed.chem.wisc.edu/journal/issues/2004/Feb/images/JCE2004p0245fig3.gif

[4] ng/m^3 = nanogram per cubic metre. A nanogram is a thousandth of a microgram or a billionth of a gram.

Ministry PAH in Air Target List		
Compound	**Abbreviation**	**Estimated Relative Potency**
Benzo(a)Anthracene	B(a)A	0.1
Chrysene	Chry	0.001
Triphenylene	TPh	n /a
Benzo(b)Fluoranthene	B(b)F	0.1
Benzo(k)Flouranthene	B(k)F	0.01
Benzo(a)Pyrene	B(a)P	1.0
Indeno(1,2,3-c,d)Pyrene	I(123)P	0.1
Dibenzo(a,h)Anthracene	D(ah)A	1.0
Dibenzo(a,b)Anthracene	D(ab)A	n / a
Benzo(g,h,i)Perylene	B(ghi)P	n / a

Sampling is done at very few sites because of the low environmental levels and the high cost of analysis. As a result, concentrations from this station will be compared to those found in west Windsor for the same time span.

Unlike the other substances on this list, B(a)P is reported as "corrected". Corrected values are obtained as follows.

When the sample media is returned from the field to the laboratory, the sampled substances are extracted from the filter through a chemical process and the extract used to determine the relative concentration of various substances through processes such as chromotography and mass spectroscopy.

It is to be expected that a certain amount of substance may be lost during the handling. So a known amount of several uncommon isotopes is added to the sample at the beginning of the process – these are called "spikes". At the end of the analysis it is determined how much of each of these substances has been recovered and this is reported as part of the analytical findings. Based up on the recoveries of the spikes one may "correct" sample levels to allow for loss during analysis.

In the case of PAH, our laboratory used four substances in which ten hydrogen atoms had been replaced with deuteurium (a heavy form of hydrogen) and two in which twelve hydrogen atoms had been replaced with deuteurium.

TSP and Metals

In addition to hourly fine particulate, the ministry measures Total Suspended Particulate (TSP), which is also referred to simply as Suspended Particulate. Unlike fine particulate, there is a ½-hr standard for TSP, 100 ug/m^3, as well as a 24-hr AAQC of 120 ug/m^3 . These levels are based upon soiling rather than health.

In addition to this, the ministry has set standards for several metals often found in particulate. The list below gives the metals for which the lab normally determines concentrations, when requested and their standards – where they exist.

Many metals occur in very small amounts even when compared to the mass of particulate collected on ministry samples. Sometimes the amount is too small to be reliably detected by the ministry's analytical methods. In these cases, results are marked "<MDL" which means "less than the method detection limit". In these cases all that can be said about a value is its concentration upper limit. The exact value varies from compound to compound. The table below includes the values for the compounds included in TSP sampling where <MDL concentrations are reported.

Standards, Guidelines and MDL for Metals in TSP (All concentrations in µg/m^3)					
	½ Hr Standard	**24-Hr AAQC**	**Other Criteria**		**Approximate MDL**
			Value	**Type**	
Cadmium		.025	.7	U R T[5]	0.005
Calcium	-	-	-	-	
Chromium[6]	-	1.5	-	-	0.001
Copper	100	50	-	-	0.002
Iron[7]	10	4	-	-	
Lead[8]	6	.5	-	-	0.007
Manganese	-	2.5	7.5	½ Hr Guideline	0.003
Nickel	5	2	-	-	0.001
Silicon	-	-	-	-	
Vanadium	-	1	-	-	0.0007
Zinc	100	120	-	-	0.002

Calculating averages with <MDL values poses some problems; data sets with these type of values are said to be "left censored" as part of the left hand side of the data distribution is missing. While mathematical techniques exist for estimating averages of data with some censoring, the values obtained become less and less reliable as the percentage increases, especially if the remaining values are also low. These techniques also rely on sufficient non-censored data to provided a reliable estimate of the data distribution. However past experience

[5] Regulation 419/ 05 Upper Risk Threshold
[6] Di- and tri- valent forms
[7] Metallic iron
[8] Until Feb 2010. It then became 1.5 µg/m^3

by ministry staff has shown that for small amounts of censored data, using half the MDL can provide a reasonable estimate for averages. Therefore for the purposes of this report, if more than half the data is above the MDL, averages will use one half the MDL where necessary. However if at least half of the data is below the MDL, no average will be reported.

Cadmium is a relatively abundant bluish white metal. It was formerly used in paint pigments, corrosion resistant steel and plastic stablizers though most of these uses are declining. It is still used in recharable batteries. Tobacco smoke is the most important single exposure source to the average person. It is a carcinogen and shows 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 lead 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, other forms are toxic and carcinogenic.

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 most 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 maleable and very heavy metal. It has been in use for thousands of years. Its current uses include lead-acid (car) batteries, bullets, solder, glazes, lead crystal, and radiation shielding. Lead is a neurtotoxin which can accumulate in the body with prolonged exposure. Evidence of toxicity dates back to the ancient Romans and Greeks as well as in ancient China.

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. While less toxic than some metals, elevated exposures have been linked to impared 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, rechargable batteries, and guitar strings.

Nickle sulphide and certain other nickel compounds are believed to be carcinogenic. Certain individuals show allergic reaction to metallic nickle.

Silicon is a very common element being 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 deodourants. 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.