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HAMLET OF CLAIRMONT

AIR QUALITY SUMMARY REPORT

JUNE 2014 TO SEPTEMBER 2015

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Executive Summary

The Hamlet of Clairmont, Alberta is located about 10 km north of Grande Prairie in a rural region of mainly agriculture activity. The Peace Airshed Zone Association (PAZA) conducted an air quality survey within Clairmont from June 2014 to September 2015. The air quality survey was undertaken as a response to emergent local concerns around air quality stemming from industrial activity in the area.

A continuous monitoring station was used to measure total reduced sulphur compounds (TRS), sulphur dioxide (SO_2), nitric oxide (NO), nitrogen dioxide (NO_2), total oxides of nitrogen (NO_x), ozone (O_3), fine particulate matter ($PM_{2.5}$), total hydrocarbon (THC) concentrations as well as meteorology during that period.

There were no exceedances of Alberta Ambient Air Quality Objectives (AAAQO) for TRS components, SO_2, NO_2, or O_3 measured at the monitoring station. Of NO, NO_2 and NO_x, only NO_2 has an AAAQO. The $PM_{2.5}$ measurements show that the Alberta Ambient Air Quality Guideline (AAAQG) and AAAQO were exceeded infrequently during the monitoring period. The results are summarized as follows:

- The overall TRS measurements may be influenced by local municipal or agricultural activities in the area but in general measurements are indicative of low background levels.
- The data indicates that SO_2 levels in the area are generally low inferring that there are no significant sources of SO_2 in the area. The bias of higher average concentrations toward certain wind directions may be a sign of influence from long range transport from other industrial sources.
- The ambient NO_2 data measured in Clairmont appears to suggest that local residential emissions (home heating, vehicles, etc.) could be the main contributor to the measurements which is not unexpected given the location of the monitor within the community.
- Ozone measurements are comparable with other areas in province. A typical diurnal profile is present in the ozone measurements and relates with the diurnal patterns of NO and NO_2. This pattern shows slight photo-chemical formation and destruction of ozone through complex reactions with NO_x and volatile organic compounds. The Clairmont monitor operated for only 16 months and any measurements that were influenced by exceptional events have not been removed, and therefore, the results cannot be explicitly related to the Canadian Ambient Air Quality Standards (CAAQS) for O_3.
- Exceedances of the 1-hour $PM_{2.5}$ AAAQG were measured which in turn, led to calculated exceedances of the 24-hour AAAQO. It is likely that the elevated measurements were due to forest fires and do not indicate on-going air quality problems in the region; however, this was not investigated. The Clairmont monitor operated for only 16 months and any measurements that were influenced by exceptional events have

not been removed, and therefore, the results cannot be explicitly related to the CAAQS. In general, $PM_{2.5}$ measurements were slightly lower than other areas in the province.

- Ambient measurements of THC in the area indicate the levels are slightly higher than other monitors in the province for the same time period. The significance of this observation was not investigated. Concentrations of specific hydrocarbons cannot be inferred from the data collected.
- Meteorology measurements indicate that the most frequent winds were from the south-southwest. As well, the highest wind speeds most frequently occur from the northerly directions.

The summary of the air quality survey in Clairmont is limited to the parameters measured in this study. Air quality surrounding the monitor may be affected by other compounds that PAZA was not equipped to measure such as speciated volatile organic compounds (VOCs) or ammonia.

The volume of data collected indicates that the air quality in this area is relatively good and is comparable to other areas in Alberta. The location of the monitor within a small community may have had an influence on the measurements specifically NO_2. Concentrations in excess of the AAAQO, AAAQG or CAAQS are likely due to exceptional events (forest fires) and do not necessarily indicate poor air quality in the area but do suggest that there are events and emissions sources that can influence the quality of the local air from time to time. It is recommended that PAZA consider looking into the possible contributors to the elevated $PM_{2.5}$ measurements to definitely determine if exceptional events were the cause.

Although the slightly elevated THC measurements (compared to other areas of the province) are not necessarily a cause for concern, it is recommended that PAZA consider looking into the reasons for this as the analysis of the data only cannot determine the significance. Canister sampling for specific VOCs such as benzene, may provide further helpful information.

Table of Contents

List of Figures

List of Tables

1. INTRODUCTION

The Peace Airshed Zone Association (PAZA) is a nonprofit, multi-stakeholder organization that conducts ambient air quality monitoring in northwestern Alberta. PAZA is an unbiased, open and transparent organization, and our members collaborate to provide local solutions to local air quality concerns.

PAZA was formed in March 1999 in response to air quality concerns in the Peace region. As an independent third-party, PAZA has invested ten years into building trust among members of the public, industry, non-governmental organizations, Alberta Environment and Parks (AEP), Alberta Energy Regulator (AER), and Alberta Health Services.

The air quality monitoring program is a resource for the public to become informed about local air quality. Members work collaboratively to produce scientifically defensible data that can be used by stakeholders to ensure continuous improvement of regional air quality, protect environmental health, and influence public policy.

In 2003, PAZA became the fifth airshed zone in Alberta recognized by the Clean Air Strategic Alliance (CASA).

PAZA operates under the guidelines developed in the *CASA Airshed Zone Guidelines*. These guidelines include management by consensus, representation from affected stakeholders and public accessibility to data and information from monitoring activities.

Consensus is reached when there is unanimous agreement among our stakeholders, ensuring each one can live with the outcome of the decision. Stakeholders may not achieve all their goals, but the objective is to find the optimal solution that includes something for everyone. Decisions made through consensus processes are likely to be more innovative and longer lasting than those reached through traditional negotiation or top-down hierarchy.

Airshed zones are a key component in Alberta's strategy for the management of air quality within Alberta.

PAZA is funded by compulsory and voluntary membership through a funding mechanism which is based on calculated relative impacts to air quality within the PAZA boundaries. For more information about PAZA and regional air quality, please visit PAZA's web site[1].

PAZA operates a network of seven continuous monitoring stations and 46 passive monitoring stations that collectively monitor air quality across the airshed. One of these continuous stations is a portable or roving continuous monitoring station that is used to respond to various concerns. This roving station was setup from June 2014 to September 2015 near the Hamlet of Clairmont (Clairmont) as a response to emergent local concerns around air quality stemming from industrial activity in the area.

[1] http://www.paza.ca/

2. SITE SETTING

The air quality monitoring station was proposed to be located near Clairmont and the final site location was based on the following considerations while accounting for AEP's siting criteria. The PAZA siting criteria can be obtained from PAZA

- Considerations
  - Current and future landowner(s)
  - Potential future land use change (avoid roads and right-of-ways)
  - All weather access
  - Power availability
  - Maximum security
- AEP Air Monitoring Directive (AMD) Siting Criteria
  - Away from nearby emission sources such as roads, oil and gas wells/batteries, gas processing plants, maintenance/fueling areas, etc.
  - Avoid low-lying areas and high areas to prevent local air flow biases
  - An open area away from buildings and tree canopies to ensure representative flows are recorded and to ensure passive samplers are suitable exposed
  - Stations cannot be located in pastures because of potential damage

Accounting for the above criteria and considerations, the monitor that was used for the air quality survey was placed on crown land in the middle of the Hamlet, just north of the intersection of 97 St and 104 Ave. The community school is located directly west. The geographic and projected coordinates of the site are:

- 55° 15' 43.53" N, 118° 47' 9.29" W (NAD 83)
- 55.262091° N, 118.785914° W (NAD 83)
- 386,510 m E, 6,125,411 m N (UTM Zone 11 – NAD 83)

The Clairmont monitor is about 10 km north of Grande Prairie A regional area map is shown in Figure 2.1. The PAZA monitoring network is shown in Figure 2.2.

Photos of the monitoring station and views from it are shown in Figure 2.3. Residential housing occurs 25 m to the west of the monitor and the community school is located 80 m to the east.

Figure 2.4 shows the local setting around the monitoring station. Figure 2.5shows the location of the monitor within Clairmont. Agriculture is the major activity in the local area. There are many small energy related facilities in the regional area but the closest facility to the monitor is 4.5 km to the north. The closest major road is Highway 2 which runs south to north about 700 m west of the monitor. According to Alberta Transportation, the Average Annual Daily Traffic Volume on that section of Highway 2 in 2015[2] ranged from 12,480 to 23,450 vehicles/day depending on the exact section of the highway near Clairmont.

[2] http://www.transportation.alberta.ca/Content/docType181/production/Traffic%20Volume%20History%202006-2015.pdf

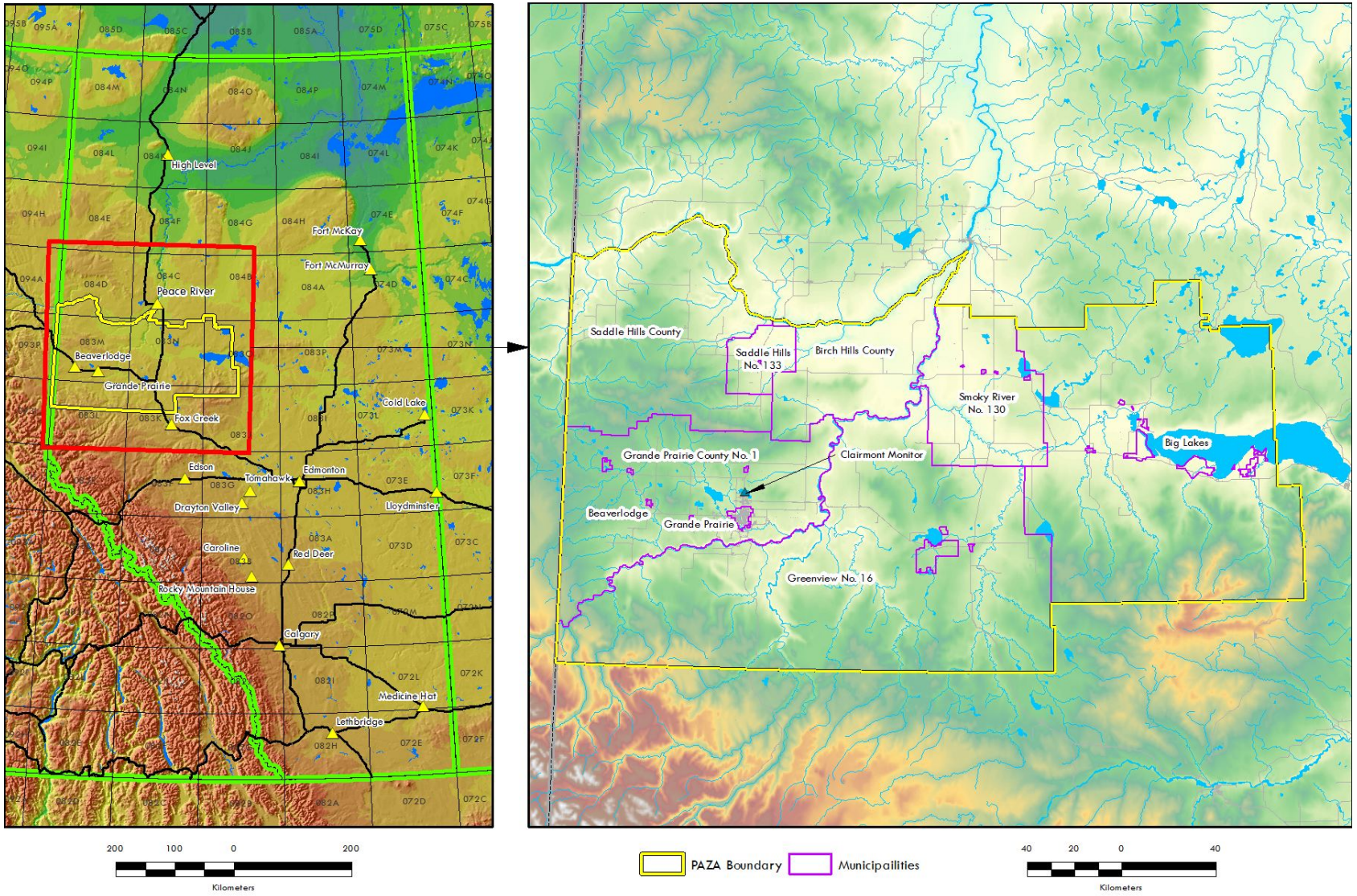

Figure 2.1 Regional Area Map showing location Clairmont and PAZA

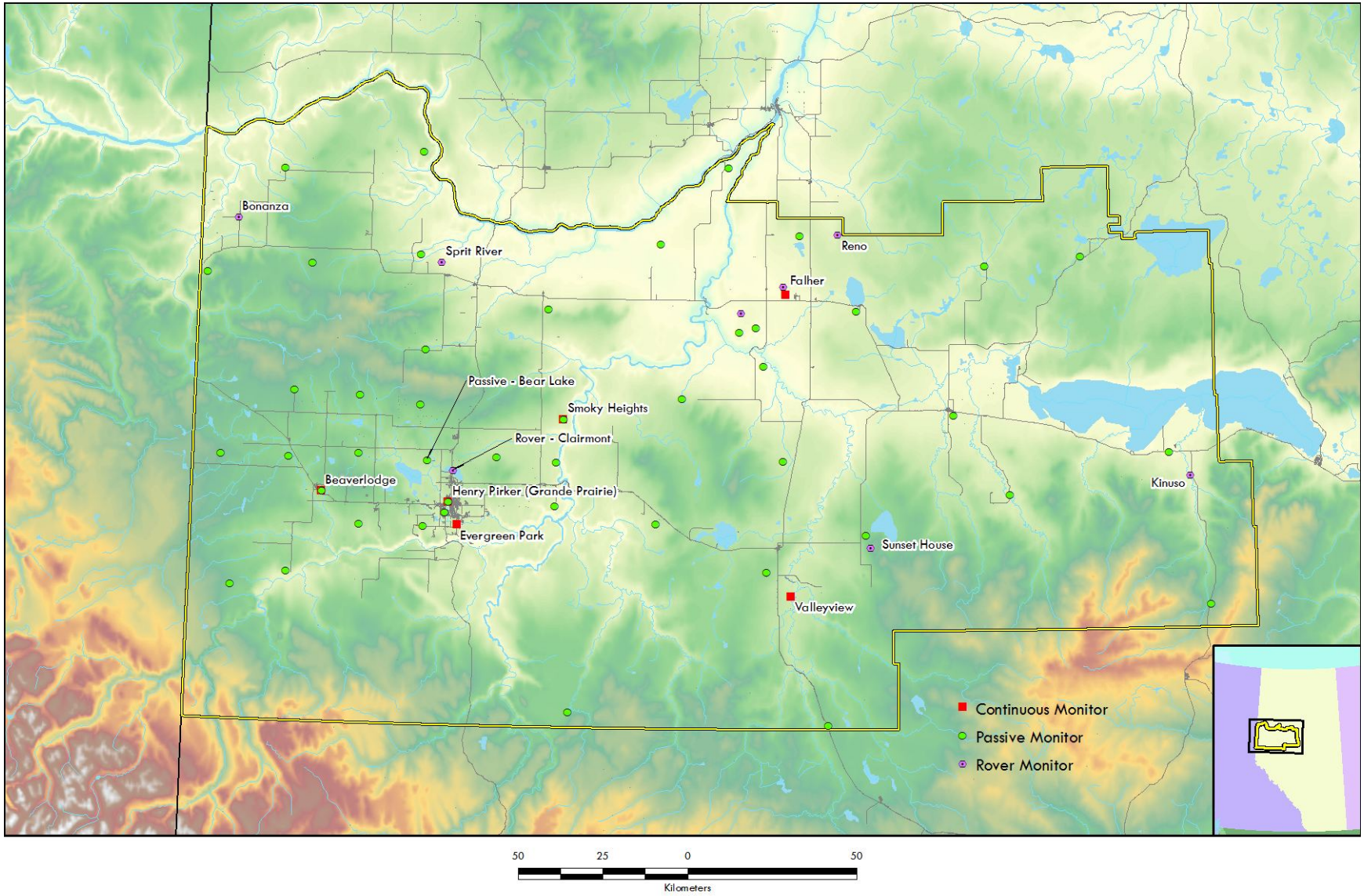

Figure 2.2 PAZA Monitoring Locations

Looking North

Looking South

Looking East

Looking West

Monitoring Trailer

Monitoring Trailer (on right)

Figure 2.3 Views from and of Clairmont Monitoring Station

Figure 2.4 Local setting around Clairmont Monitor

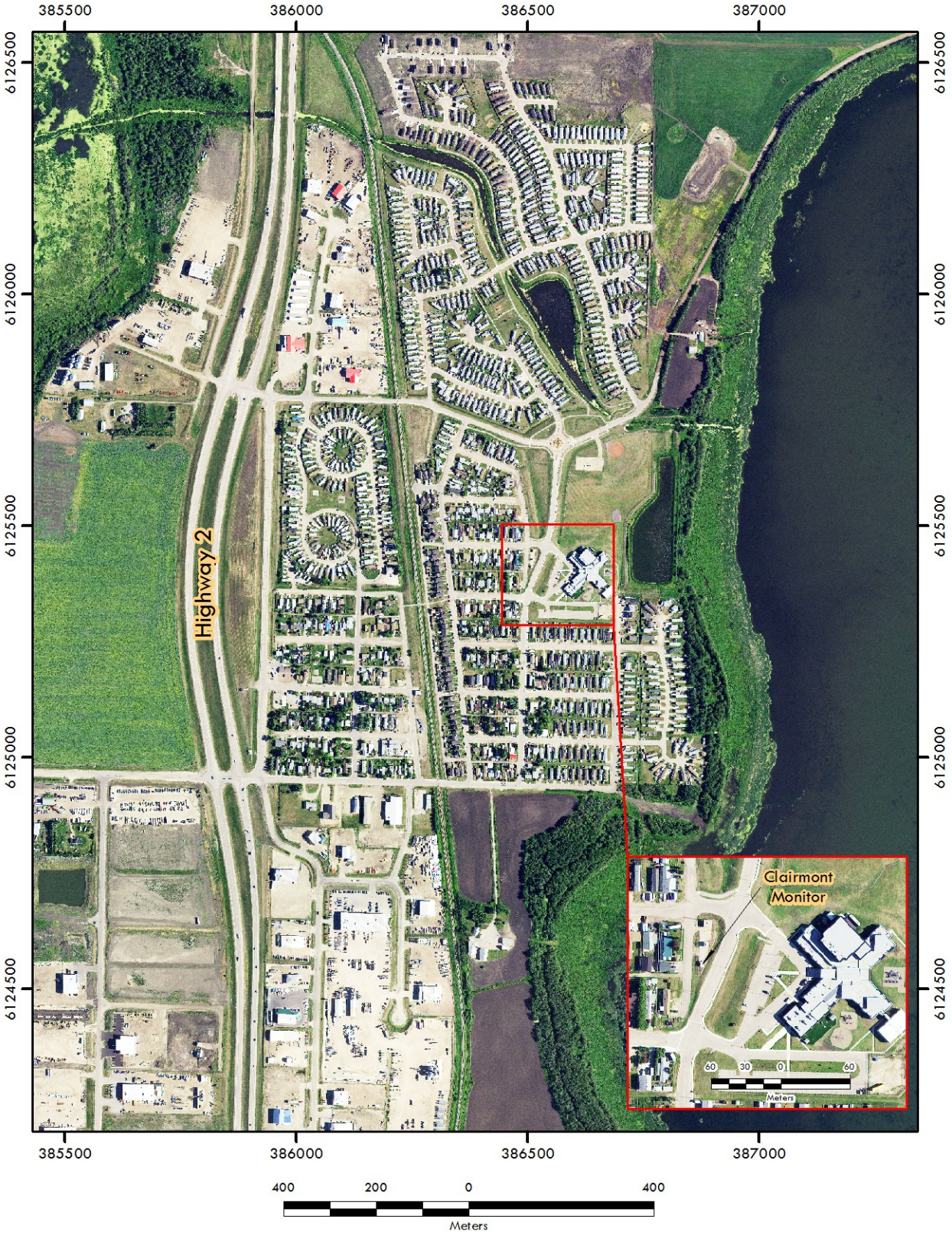

Figure 2.5 Location of Clairmont Monitor

3. AIR MONITORING (PARAMETERS, EQUIPMENT, ETC)

The monitoring station equipment is described in Table 3.1. The continuous monitoring station sampled for Total Reduced Sulphur (TRS), sulphur dioxide (SO_2), total oxides of nitrogen (NO_x), nitric oxide (NO), nitrogen dioxide (NO_2), ozone (O_3), fine particulate matter ($PM_{2.5}$), total hydrocarbons (THC) and meteorology (wind speed, wind direction, and ambient temperature). Sampling occurred every second and 1-hour averages were calculated from the 1 second samples. The data acquisition system used was the Focus DACS-CR3000. The monitoring station operated from June 19, 2014 17:00 to September 25, 2015 11:00 (11,107 hours). The continuous monitoring equipment was operated according to the AEP Air Monitoring Directive[3] (AMD) including daily instruments checks, monthly multipoint calibrations, and annual audits conducted by AEP. The monitoring station was not audited by AEP while located in Clairmont.

The Contractor's Standard Operating Procedures (SOPs) contain information on completeness, lower detection limits, ranges, accuracy, detection and calibration methods, and zero and span deviations.. SOPs for each of the parameters measured are listed in Table 3.1. For more information on SOPs please contact PAZA.

Continuous monitoring equipment uptime and downtime during the Clairmont air quality monitoring survey is presented in Table 3.2.

[3] http://aep.alberta.ca/air/legislation/air-monitoring-directive/default.aspx

Table 3.1 Monitoring Station Equipment Description

Parameter	Instrument Make and Model	Units of Measure	Sampling Height (m)	Standard Operating Procedures Document
TRS	TEI/43C with converter	Parts per billion (ppb)	4	FAQP-1.002
SO_2	TECO/43C	ppb	4	FAQP-1.001
NO_x	TECO/42i	ppb	4	FAQP-1.003
O_3	TECO/49c	ppb	4	FAQP-1.004
$PM_{2.5}$	TEOM, Thermo/ 1400AB; Sensor Unit	$\mu g/m^3$	4	FAQP-1.011
THC	TECO/51CLT	Parts per million (ppm)	4	FAQP-1.006
Wind Speed	Met One 50.5H Sonic	km/hr	10	FAQP-2.001
Wind Direction	Met One 50.5H Sonic	Degrees direction from	10	FAQP-2.001
Temperature	Met One 062	°C	4	FAQP-2.006

Table 3.2 Monitoring Equipment Uptime

Measurement	TRS	SO_2	NO_x	O_3	$PM_{2.5}$	THC	Temperature	Wind Speed and Direction
Valid Reading	94.19%	94.69%	94.70%	98.72%	94.81%	92.46%	99.95%	97.59%
Not in Service	0.41%	0.18%	0.17%	0.00%	0.22%	0.38%	0.00%	0.00%
Daily Automated Zero/Span Sequence	4.27%	4.30%	4.31%	0.00%	4.31%	4.21%	0.00%	0.00%
Calibration	0.62%	0.56%	0.77%	0.08%	0.41%	0.63%	0.00%	0.05%
Not Valid[a]	0.14%	0.00%	0.00%	0.86%	0.00%	2.19%	0.00%	2.35%
Maintenance	0.13%	0.04%	0.05%	0.32%	0.03%	0.12%	0.03%	0.00%
Span (Used for Manual Span)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Power Failure	0.23%	0.23%	0.01%	0.02%	0.23%	0.01%	0.02%	0.02%
Data Acquisition Failure	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

a) Not Valid is defined as data collected when the instrument is operating outside normal conditions

4. ALBERTA AMBIENT AIR QUALITY OBJECTIVES

The Alberta Ambient Air Quality Objectives (AAAQOs) and Guidelines (AAAQGs) for the pollutants that were measured are shown in Table 4.1[4]. Objectives are used to determine adequacy of facility design, to establish required stack heights and other release conditions and to assess compliance and evaluate facility performance. Guidelines may be used for airshed planning and management, as a general performance indicator, and to assess local concerns.

There are currently no AAAQOs for TRS. However, hydrogen sulphide (H_2S) and carbon disulphide (CS_2) are classified as reduced sulphur compounds and have AAAQOs. Of the NO_x compounds measured, only NO_2 has AAAQOs.

There are currently 1-hour, 24-hour , monthly, and annual AAAQO for SO_2. Canadian Ambient Air Quality Standards (CAAQS) for SO_2 for the 1-hour and annual averaging times have been recently introduced that will take effect in 2020.

Although, there is currently a 1-hour AAAQO for O_3, compliance or achievement is usually determined by the Canadian Ambient Air Quality Standards (CAAQS) for O_3 which is currently an 8-hour average of 63 ppb based on the 4th highest daily 8-hr measurement annually, averaged over 3 consecutive years.

Similarly for $PM_{2.5}$, there is currently a 24-hour AAAQO of 30 $\mu g/m^3$ but compliance or achievement is usually determined by the 24-hour average CAAQS for $PM_{2.5}$ of 28 $\mu g/m^3$ which is based on the 3-year average of the annual 98th percentile of the daily 24-hour average concentrations. As well, there is an annual average CAAQS for $PM_{2.5}$ of 10 $\mu g/m^3$ which is based on the 3-year average of the annual average concentrations. There is currently a 1-hour AAAQG of 80 $\mu g/m^3$ for $PM_{2.5}$. Since the Clairmont monitoring station only operated for about 16 months, direct comparison to the CAAQS cannot be made.

There are no AAAQOs for THC or some of its main constituents such as methane, ethane or propane, but AAAQOs do exist for specific hydrocarbons such as benzene. However, concentrations of specific hydrocarbons cannot be inferred from the data collected.

[4] http://aep.alberta.ca/air/legislation/ambient-air-quality-objectives/documents/AAQO-Summary-Jun2016.pdf

Table 4.1 Alberta Ambient Air Quality Objectives.

Pollutant	Averaging Period				
	1-hr (ppb)	8-hr (ppb)	24-hr (ppb)	30 day (ppb)	Annual (ppb)
TRS	10 (H_2S) 10 (CS_2)	-	3 (H_2S)		
SO_2	172 70 (CAAQS)[1]	-	48	11	8 5 (CAAQS)[2]
NO_2	159	-	-	-	24
O_3	82	63 (CAAQS)[3]	-	-	-
$PM_{2.5}$	80 ($\mu g/m^3$) (AAAQG)	-	30 ($\mu g/m^3$) 28 ($\mu g/m^3$) (CAAQS)[4]	-	10 ($\mu g/m^3$) (CAAQS)[5]

Note

1. The 1-hour Canadian Ambient Air Quality Standard (CAAQS) for SO_2 is based on the 3-year average of the annual 99th percentile of the SO_2 daily maximum 1-hour average concentrations and is effective 2020.
2. The annual CAAQS for SO_2 is based on the arithmetic average over a single calendar year of all 1-hour average SO_2 concentrations and is effective 2020.
3. The 8-hour CAAQS for O_3 is based on the 3-year average of the annual 4th- highest daily maximum 8-hour average concentrations.
4. The 24-hour CAAQS for $PM_{2.5}$ is based on the 3-year average of the annual 98th percentile of the daily 24-hour average concentrations.
5. The annual CAAQS for $PM_{2.5}$ is based on the 3-year average of the annual average concentrations.

5. MONITORING RESULTS

This report provides an overall summary of the monitoring data; the detailed one-hour monitoring data results are available on the PAZA website, monthly and annual reports and at the AEP Air Data Warehouse[5].

In the sections that follow, several summary statistics are used in the discussion of monitoring results including the average, maximum, minimum, and percentile concentrations. An n^{th} percentile concentration indicates that n percent of data are less than that concentration, and (100 – n) percent of data are greater than that concentration. For example, a dataset with a 90^{th} percentile concentration of 50 ppb indicates that 90 % of the data will be less than 50 ppb and 10 % percent of the data will be greater than 50 ppb.

Frequency distributions and data distributions by wind direction known as wind, pollution or data roses depending on the data being analyzed are presented to help identify potential sources of pollutants.

Comparison with other areas of the province was undertaken using ambient measurements from the following locations for the same time period as the Clairmont monitoring except where noted. The locations of these stations are shown in Figure 2.1 and Figure 2.2.

- Beaverlodge (PAZA)
  - Small urban
- Evergreen Park (PAZA) (TRS only)
  - Small urban
- Henry Pirker (PAZA) (TRS only)
  - Small urban
- Caroline
  - Rural
- Calgary NW
  - Urban
- Cold Lake South
  - Small urban
- Fort McKay
  - Rural – near oil sands
- Tomahawk
  - Rural

Also included is a comparison of monthly averages from the closest PAZA passive monitoring station for SO_2, NO_2, and O_3. The closest passive station to the Clairmont monitoring location is the Bear Lake passive monitoring station which is 8.3 km to the west-northwest.

[5] http://airdata.alberta.ca/

5.1 Meteorology

The following figures illustrate the meteorological conditions recorded at the Clairmont monitoring station during the period June 19, 2014 17:00 to September 25, 2015 11:00. Figure 5.1 shows that the most frequent winds were from the west-southwest. As well, the highest average wind speeds occur from the northerly directions. Figure 5.2 shows the monthly temperature and wind speed distributions.

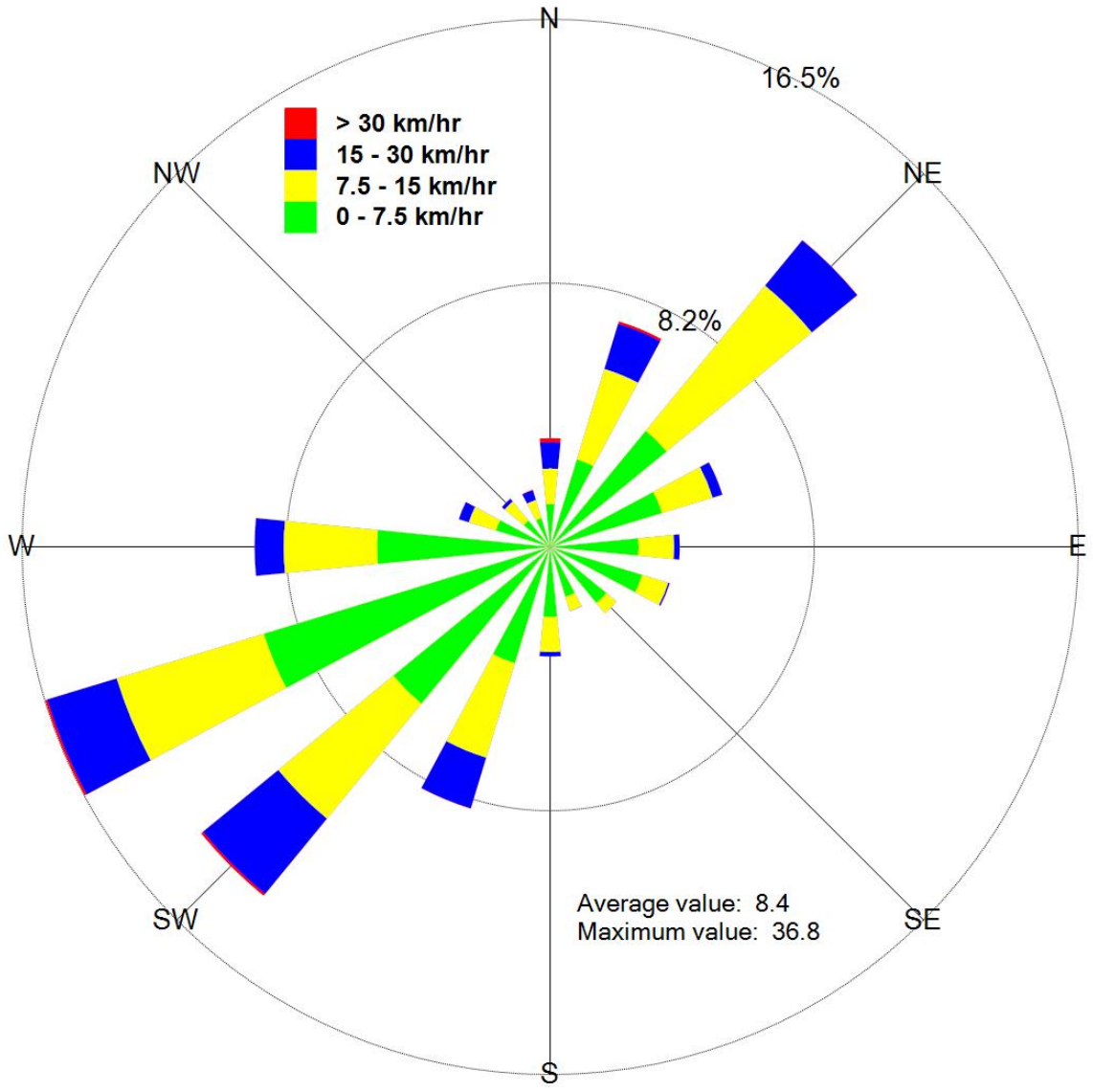

Figure 5.1 Wind Frequency Distribution at Clairmont Monitoring Station

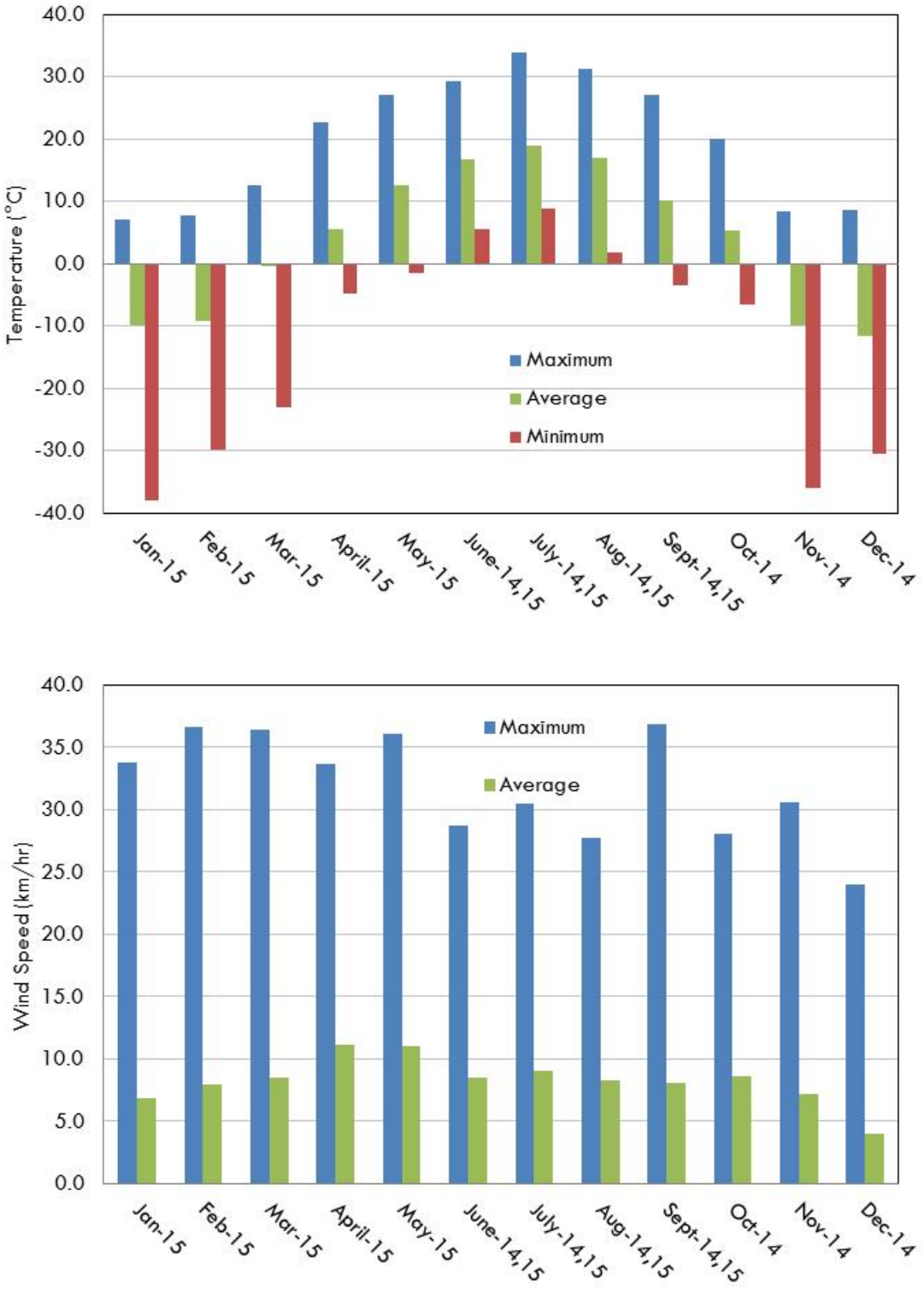

Figure 5.2 Monthly Temperature and Wind Speed Distribution Measured at Clairmont Monitoring Station

5.2 Total Reduced Sulphur Compounds

Reduced sulphur compounds are a complex family of substances. They are defined by the presence of sulphur in a reduced state and are generally characterized by strong odours at relatively low concentrations. Total reduced sulphur compounds (TRS) includes hydrogen sulphide (H_2S), carbon disulphide (CS_2), mercaptans, dimethyl sulphide, dimethyl disulphide and other sulphur compounds. Sulphur dioxide (SO_2) is not a reduced sulphur compound.

As noted earlier in Table 4.1, currently there are no AAAQO for TRS. However, there are AAAQOs for H_2S and CS_2 which are based on odour thresholds. H_2S is known to have highly toxic properties, and can cause negative health effects at low concentrations.[6]

Natural sources of reduced sulphur compounds in air include volcanoes and sulphur springs, oceans and estuaries, and exposed faces of sulphur-containing oil and coal deposits. The primary anthropogenic sources include sour oil and gas processing facilities, kraft pulp mills, chemical manufacturing plants, and livestock operations. TRS can be produced when manure undergoes anaerobic (absence of oxygen) fermentation.

In the area around the monitor, the main sources of TRS emissions would likely be agricultural practices. Municipal sources such as landfills and sewage lagoons can also emit TRS; however, the existence of such sources near the monitor was not investigated. As well, swamps and sloughs can be natural sources of TRS. It is noted that there is oil and gas oil activity beyond 4 km of the monitor.

A summary of TRS measurements are shown in Table 5.1 and the time series of measurements are shown in Figure 5.3. The measurements show that the AAAQO for H_2S and CS_2 were not exceeded during the monitoring period. Only two occurrences in excess of 5 ppb were measured.

Figure 5.4 shows that concentrations above 0.5 ppb were not frequently recorded but the most frequent of those measurements occurred for winds from the west-southwest. Figure 5.5 shows that the maximum and average recorded TRS concentrations while Figure 5.6 shows the 99th, 95th, 90th and 50th percentile concentrations as a function of wind direction. Although the maximum measurement occurred for winds from the northeast, the highest average and specific percentile TRS concentrations show a bias toward west to southwest.

Figure 5.7 presents the maximum and average measured TRS concentrations as a function of month and hour of day. No discernible trend in the data is noted for the maximum concentrations; however the average concentrations tended to be higher in the morning and lower in the afternoon.

Figure 5.8 provides a comparison of TRS measurements from other monitoring stations in the province for the same time period. TRS is not a commonly measured suite of pollutants and

[6] http://aep.alberta.ca/focus/state-of-the-environment/air/condition-indicators/documents/HealthEffectsHydrogenSulphide-2003.pdf

would usually be measured in areas where TRS compounds are present and considered important from an air quality perspective. The figure shows that the measurements at Clairmont are comparable to other areas where TRS are measured; however, it is noted that the average concentration is slightly higher. The ambient TRS data measured at Clairmont appears to adequately reflect the general rural setting.

Table 5.1 Summary of TRS Measurements (ppb) at Clairmont Monitoring Station

1-hour AAAQO	10 (H_2S and CS_2)
Maximum 1-hour Measurement	7.7
99.9th Percentile Measurement	3.6
99th Percentile Measurement	1.8
90th Percentile Measurement	0.7
Median (50th Percentile) Measurement	0.35
Average Measurement	0.43
24-hour AAAQO	3 (H_2S)
Maximum 24-hour Average Measurement	1.39

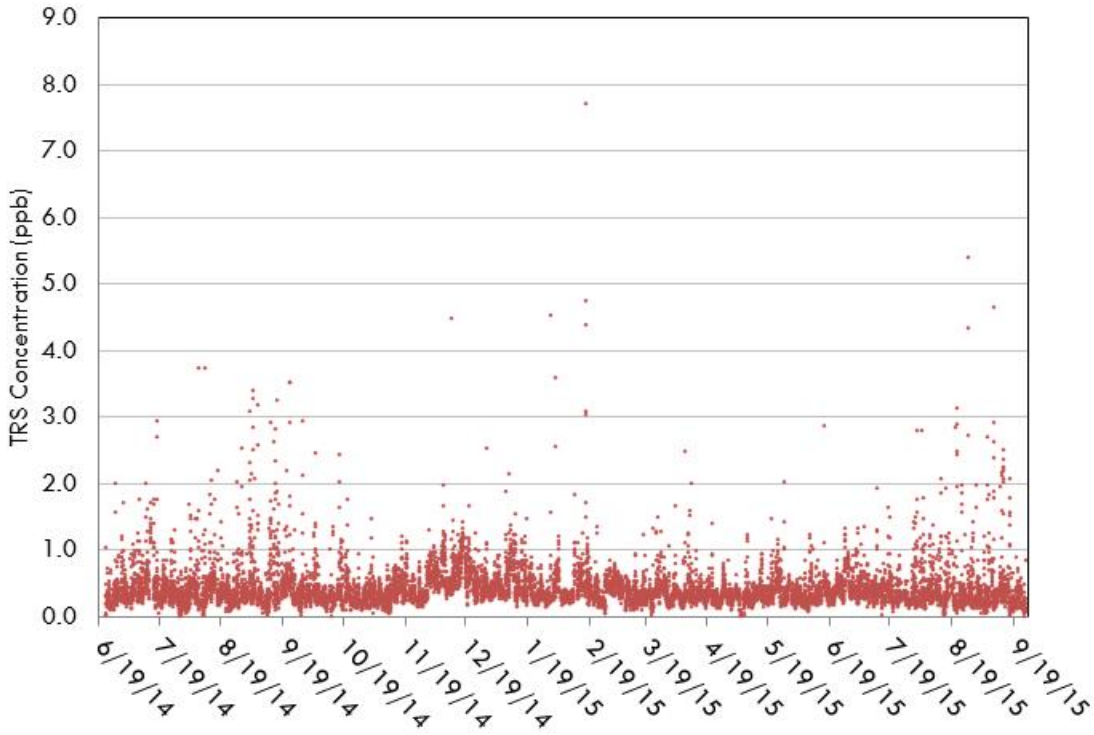

Figure 5.3 Time Series of the Hourly TRS Measurements

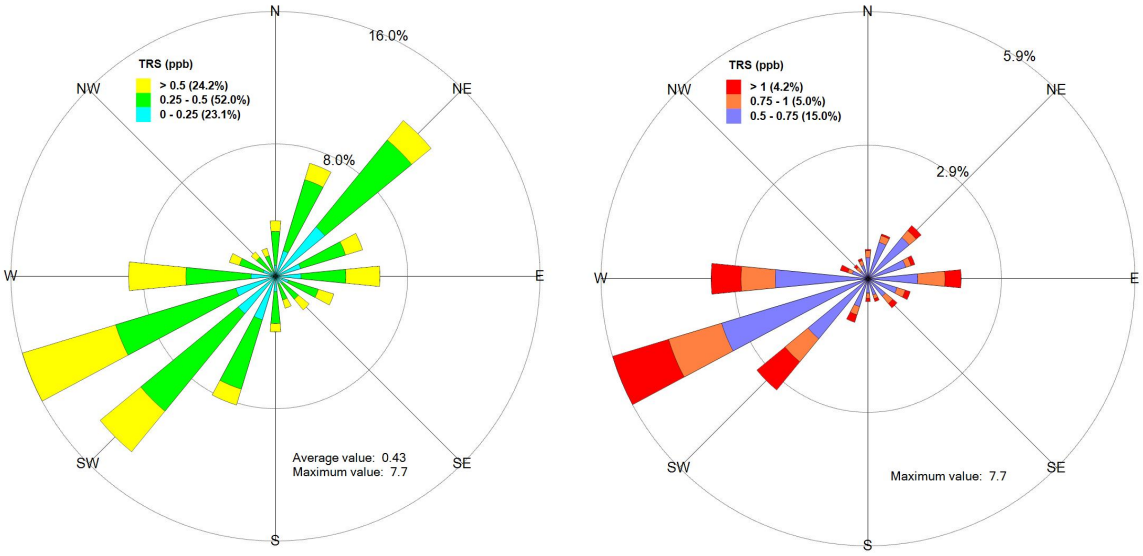

Figure 5.4 Frequency Distribution of TRS Measurements by Wind Direction

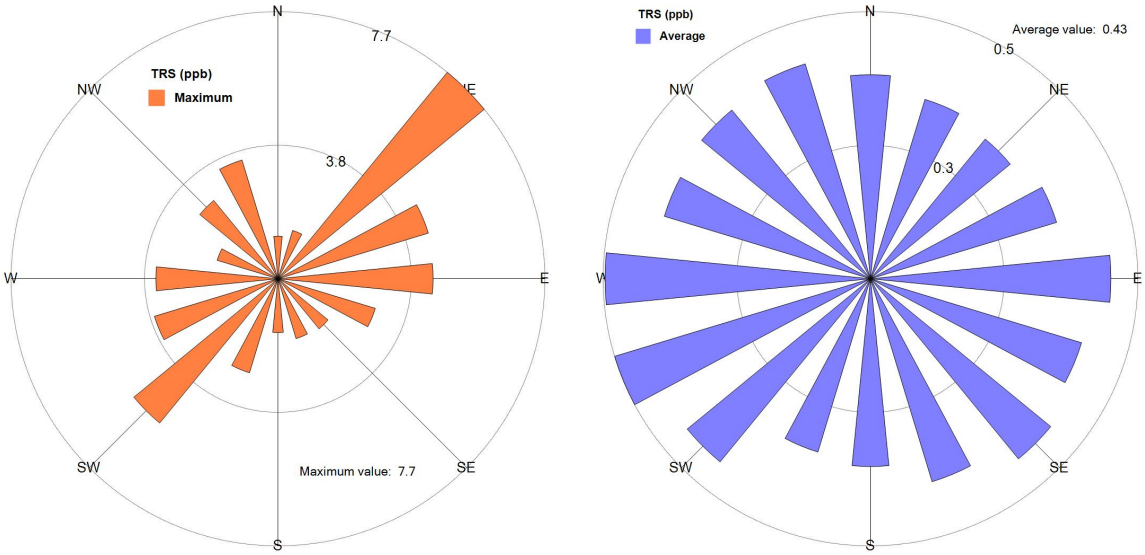

Figure 5.5 Maximum and Average TRS measurements by Wind Direction

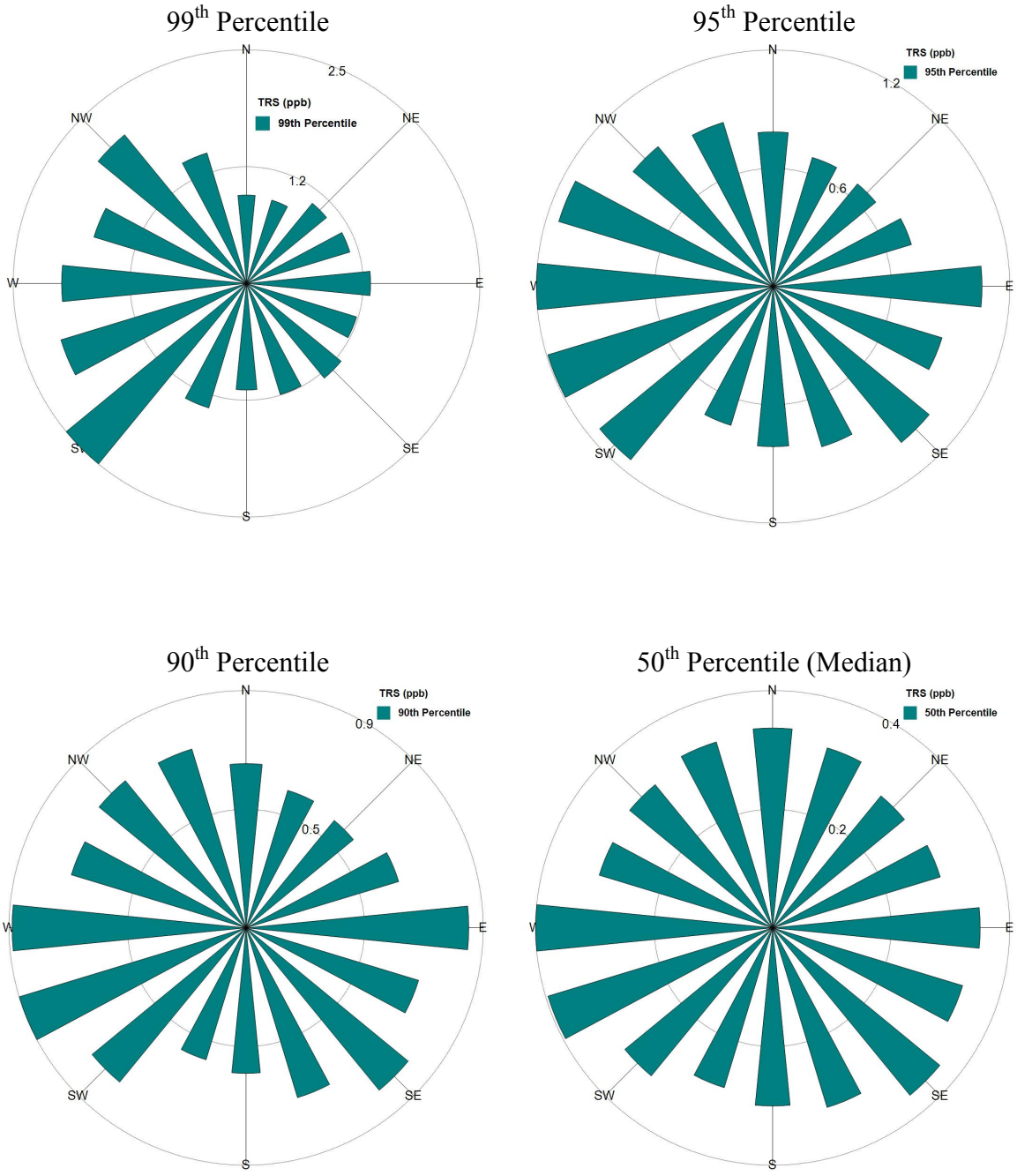

Figure 5.6 Percentile TRS Measurements by Wind Direction

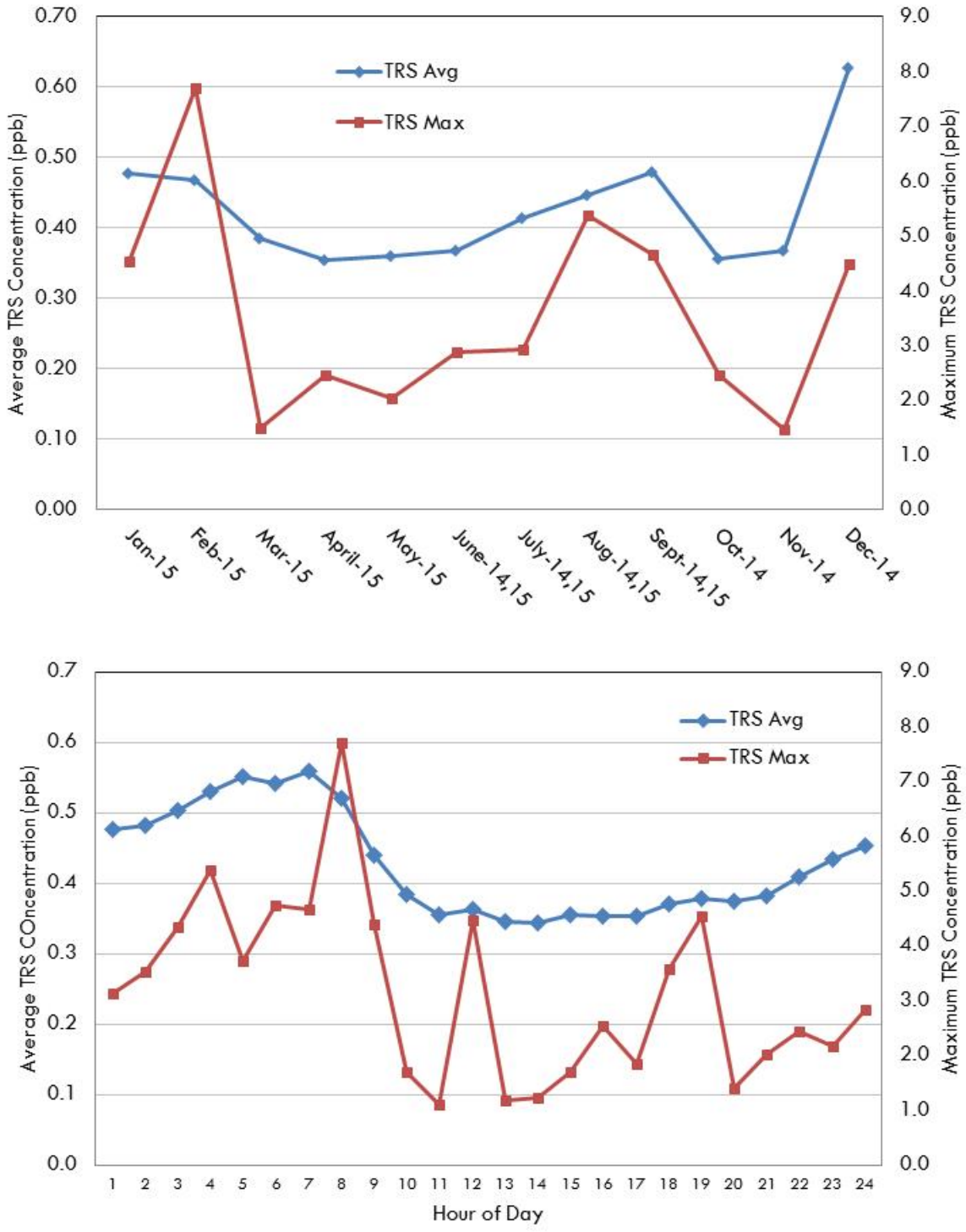

Figure 5.7 Maximum and Average TRS Measurements by Month and Hour of Day

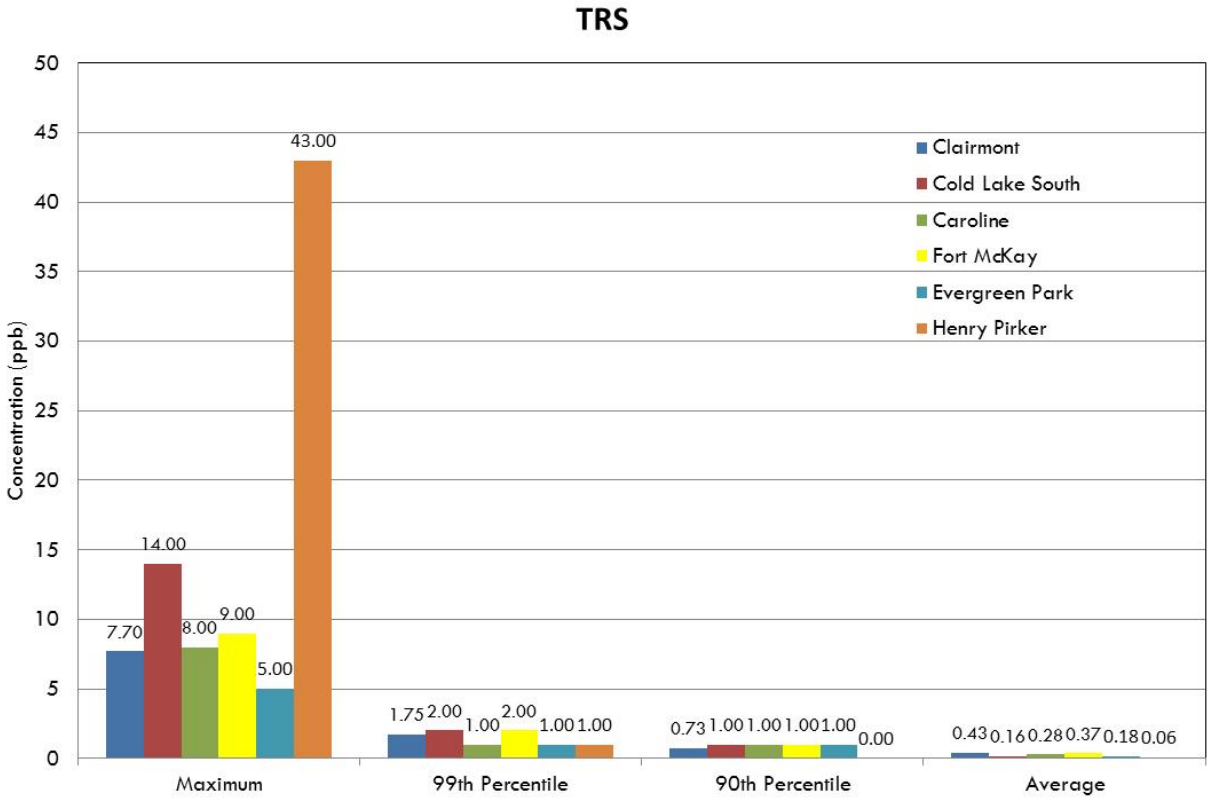

Figure 5.8 Comparison of TRS Measurements from other Continuous Monitoring Stations

5.3 Sulphur Dioxide

Sulphur dioxide is a colourless, non-flammable gas with a sharp, pungent odour. Natural sources include volcanoes, decaying organic matter and solar action on seawater. The most significant anthropogenic emission sources of sulphur dioxide are from combustion of sulphur-containing fossil fuels, smelting sulphide ores, and petroleum refining. Other less significant sources include chemical and allied products manufacturing, metal processing, other industrial processes, and vehicle emissions.

Once sulphur dioxide is released into the atmosphere, it may be converted to other compounds and/or removed from the atmosphere by various mechanisms. Processes such as oxidation, wet deposition, dry deposition, absorption by vegetation and by soil, dissolution into water and other processes contribute to the removal of sulphur dioxide from the atmosphere. Exposure to high enough concentrations of SO_2 can affect human and environmental health.[7]

[7] http://aep.alberta.ca/air/legislation/ambient-air-quality-objectives/documents/AAQO-SulphurDioxide-Feb2011.pdf

A summary of SO_2 measurements are shown in Table 5.2 and the time series of measurements are shown in Figure 5.9. The measurements were well below the SO_2 AAAQO in all instances. Figure 5.10 shows that most concentrations were less than 0.5 ppb. Figure 5.11 shows that the maximum and average recorded TRS concentrations while Figure 5.12 shows the 99th, 95th, 90th and 50th percentile concentrations as a function of wind direction. There appears to be a slight bias of higher measurements occurring for winds from the northern quadrant.

Figure 5.13 presents the maximum and average measured SO_2 concentrations as a function of month and hour of day. The figures show the average concentrations have a slight bias toward higher concentrations in the middle of the day. No other discernible trends are noted. The figure shows that for the most part the average monthly concentrations are remarkably consistent with the measurements from the closest passive monitor. This likely indicates that there are no major sources of SO_2 within the community.

Figure 5.12 provides a comparison of SO_2 measurements from other monitoring stations in the province for the same time period. The figure shows that the measurements at Clairmont were comparable to other areas where SO_2 is measured.

The data indicates that SO_2 levels around Clairmont are generally low inferring that there are no significant sources of SO_2 in the area. The slight bias of higher concentrations toward certain wind direction may be a sign of influence from long range transport from other industrial sources.

Table 5.2 Summary of SO_2 Measurements (ppb) at Clairmont Monitoring Station

1-hour AAAQO	172
30-day AAAQO	11
Annual AAAQO	8
1-hour CAAQS (Effective 2020)	70
Annual CAAQS (Effective 2020)	5
Maximum 1-hour Measurement	12.4
99.9th Percentile Measurement	4.9
99th Percentile Measurement	2.4
90th Percentile Measurement	0.9
Median (50th Percentile) Measurement	0.23
Average Measurement	0.38
Maximum Month Average	0.77
24-hour AAAQO	48
Maximum 24-hour Average Measurement	2.3

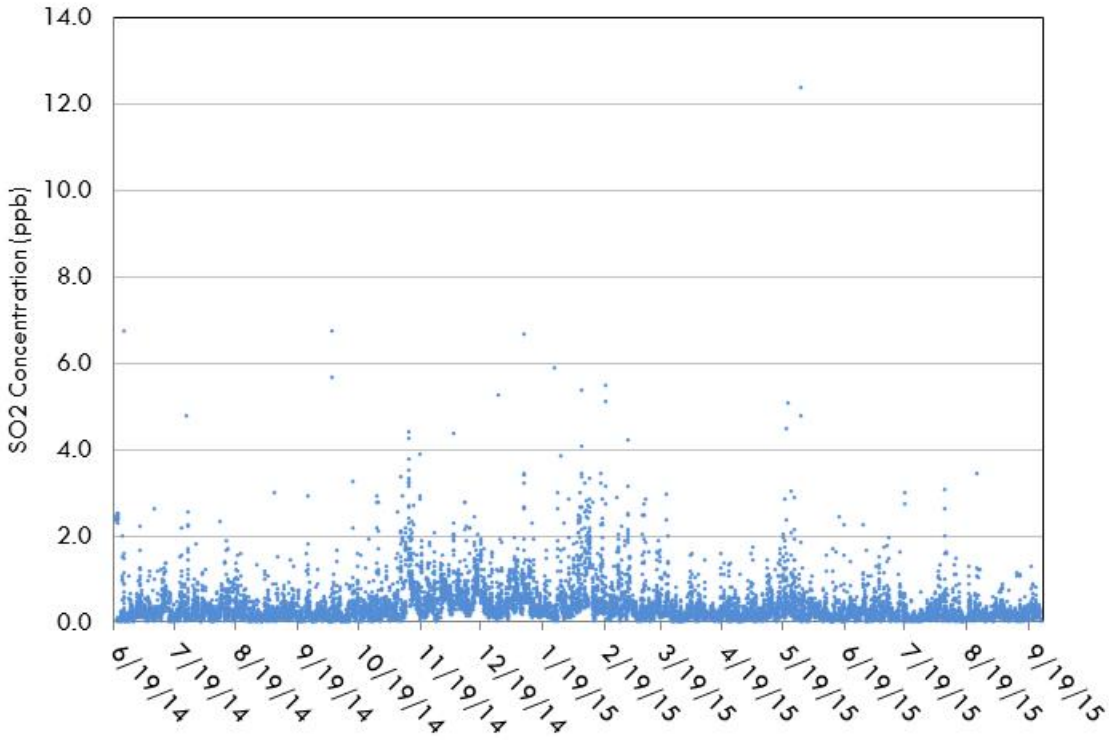

Figure 5.9 Time Series of the Hourly SO_2 Measurements

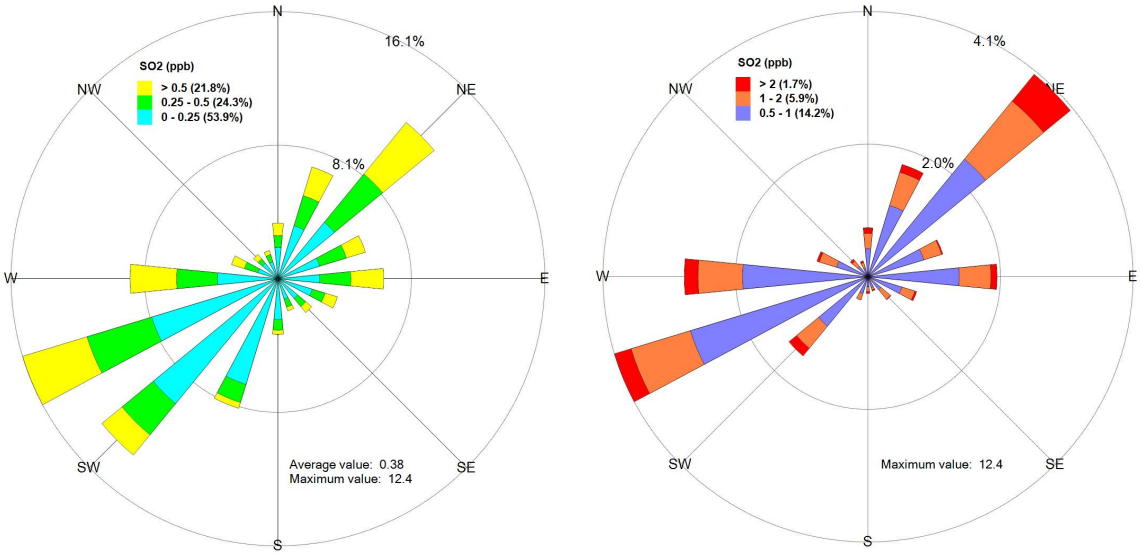

Figure 5.10 Frequency Distribution of SO_2 Measurements by Wind Direction

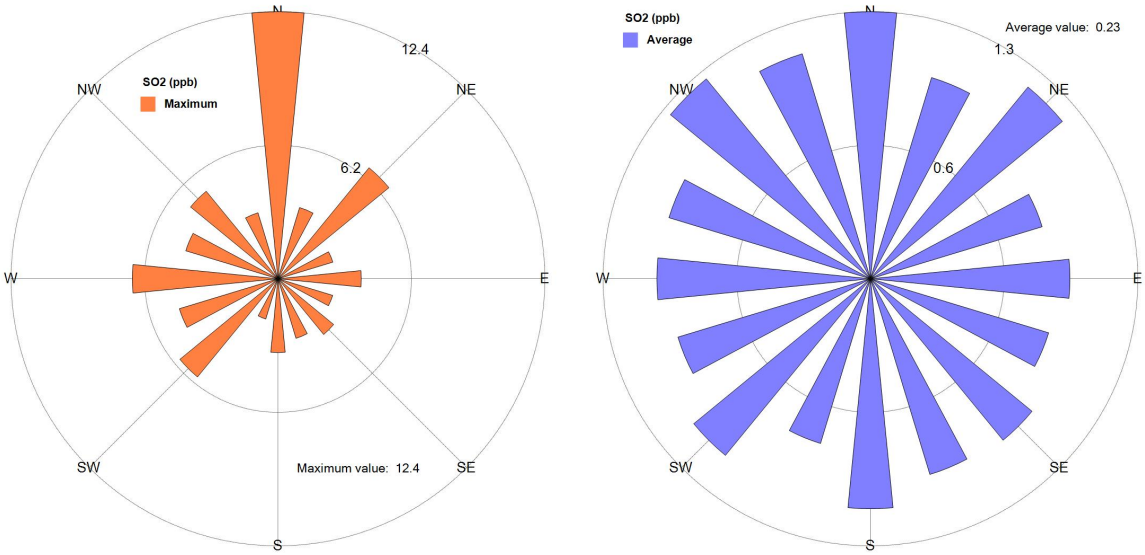

Figure 5.11 Maximum and Average SO_2 measurements by Wind Direction

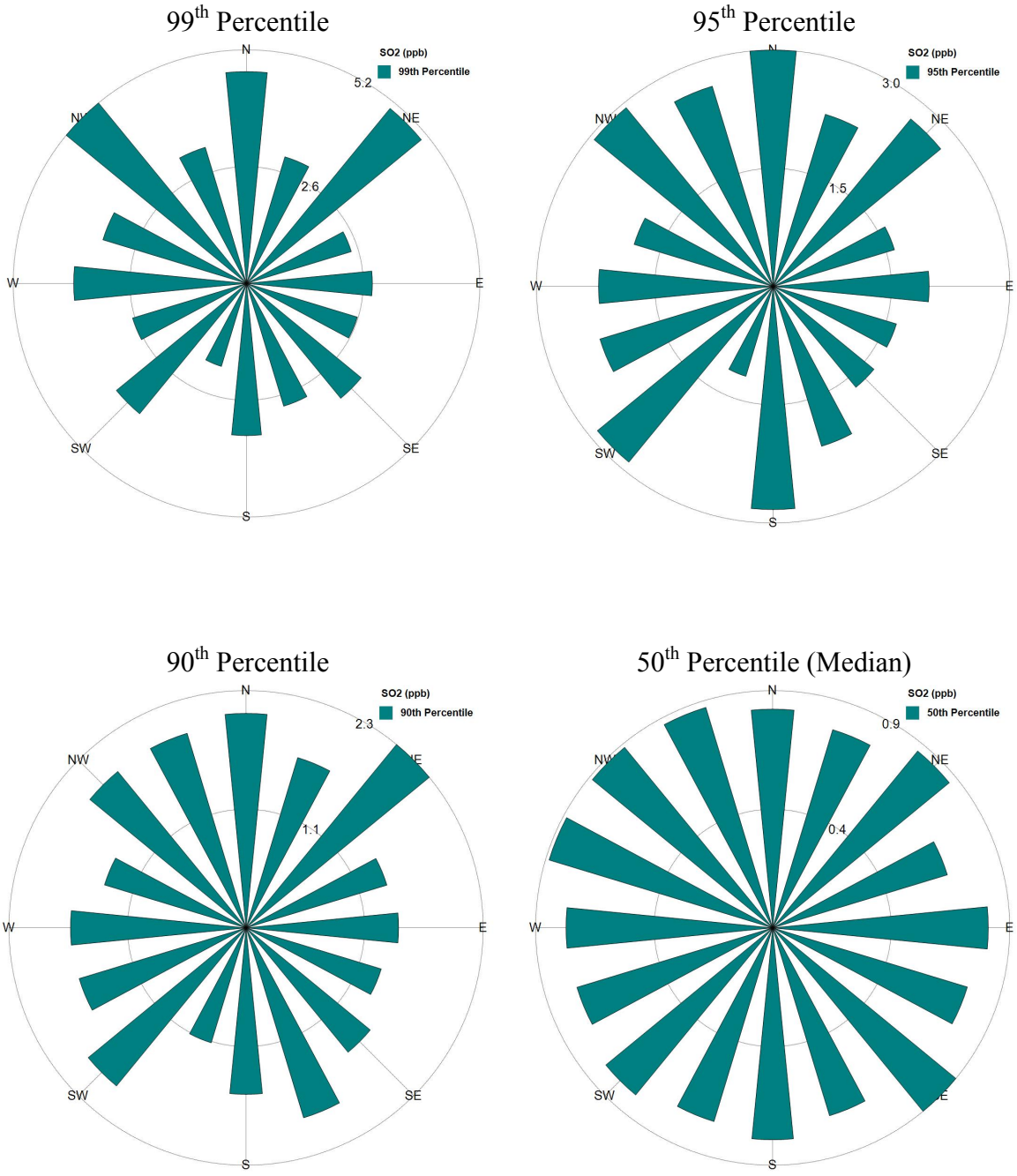

Figure 5.12 Percentile SO_2 Measurements by Wind Direction

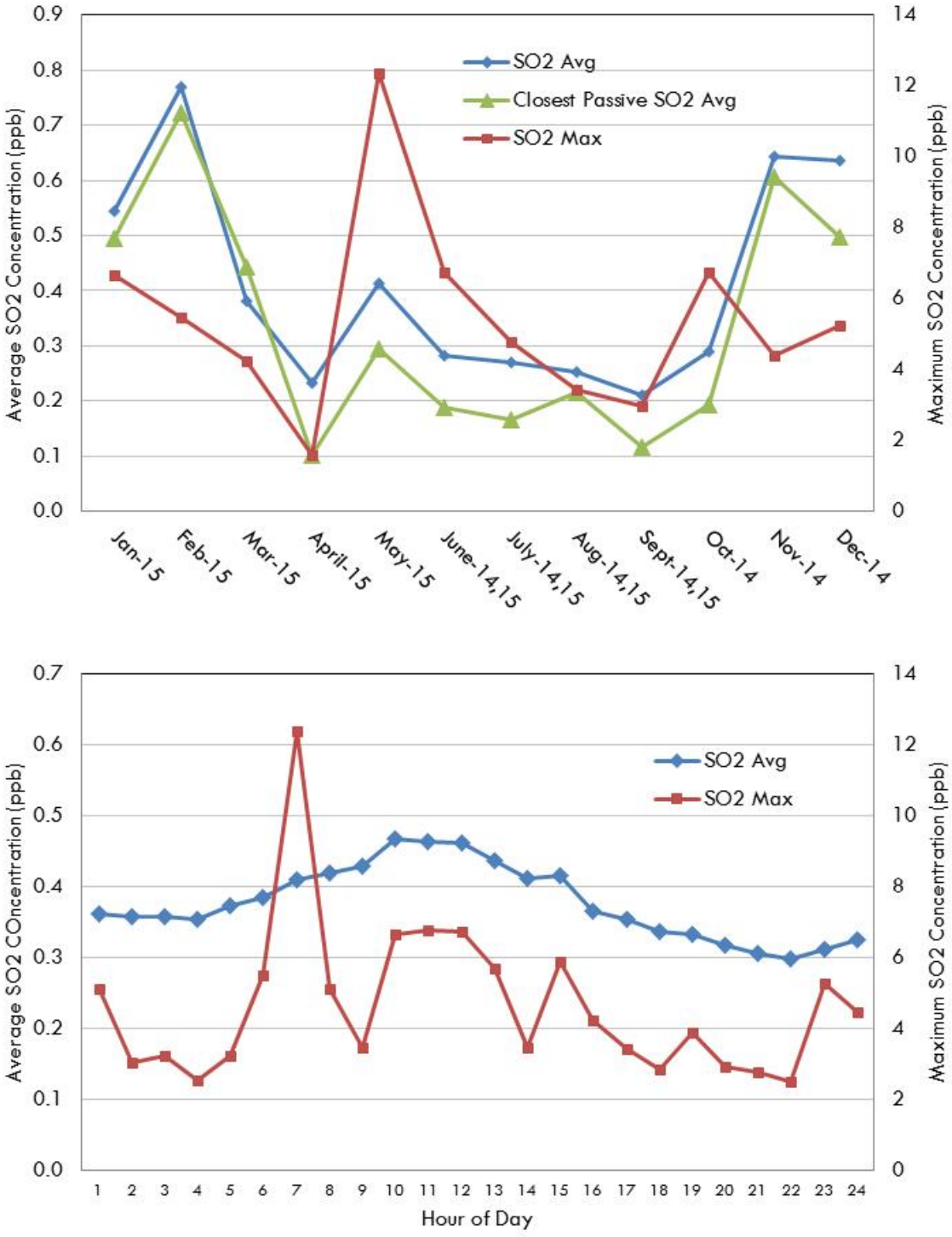

Figure 5.13 Maximum and Average SO_2 Measurements by Month and Hour of Day

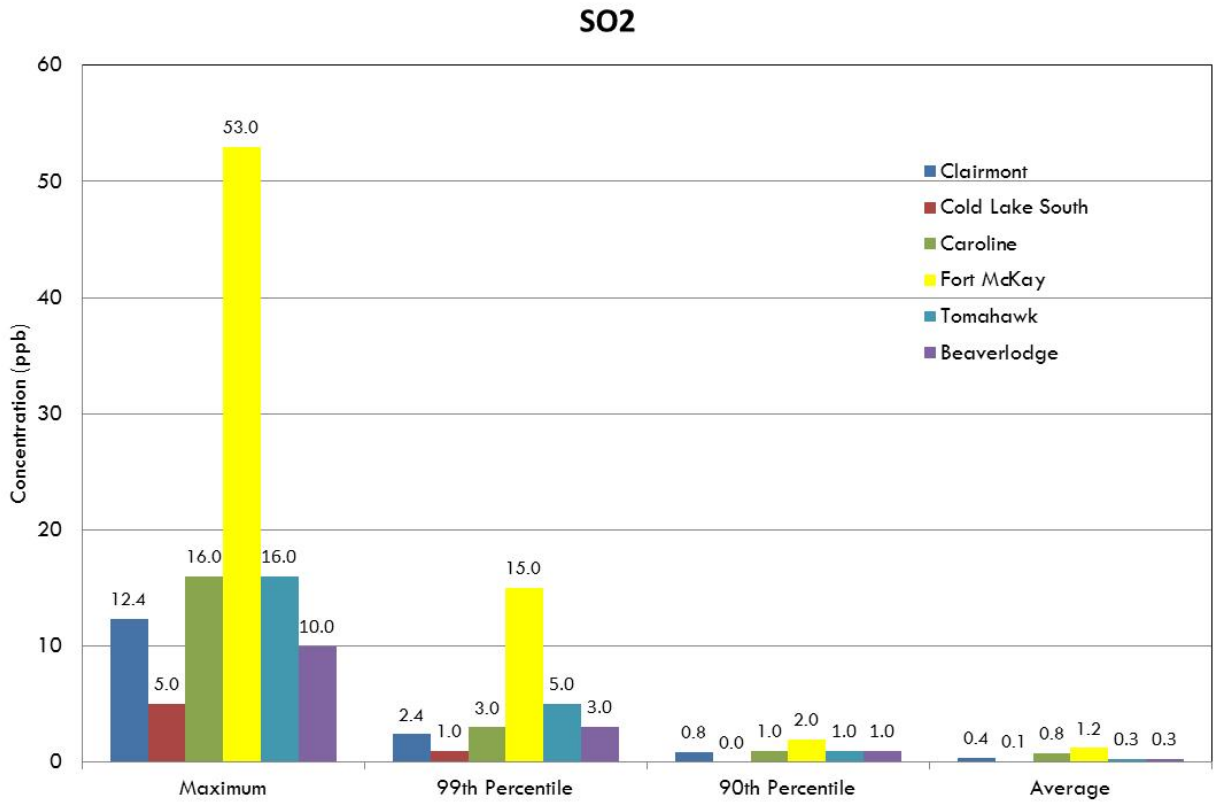

Figure 5.14 Comparison of SO_2 Measurements from other Continuous Monitoring Stations

5.4 Nitrogen Oxides

Nitrogen dioxide (NO_2) and nitric oxide (NO) are known collectively as oxides of nitrogen (NO_x). NO_x occurs naturally in the environment as a result of forest fires, atmospheric lightning discharges and biogenic oxidation of nitrogen containing compounds present in soil. Anthropogenic NO_x emissions are mainly the result of combustion processes, such as the combustion of fuel for vehicles or the combustion of coal, oil and natural gas for industrial processes. Emissions of NO_x from combustion processes are initially about 90 to 95% NO and about 5 to 10% NO_2. NO is oxidized to NO_2 in the atmosphere, and through further complex atmospheric chemical reactions can lead to the formation of ozone (see next section), nitric acid and nitrate-containing particles.

Of the NO_x species, an AAAQO exists for NO_2 only. Therefore, a summary of the NO_x measurements is restricted to NO_2. NO_2 is a reddish-orange-brown gas with an irritating, acrid, characteristic pungent odour. It is corrosive, highly oxidizing and non-combustible. At high enough concentrations, NO_2 can have respiratory effects on humans on which the 1-hour

AAAQO is based. On a long term basis, NO_2 can have detrimental effects on vegetation which is reflected in the annual AAAQO.[8]

A summary of NO_2 measurements are shown in Table 5.3 and the time series of measurements are shown in Figure 5.15. The measurements were below the NO_2 AAAQO in all instances. Figure 5.16 shows a frequency distribution of NO_2 measurements by wind direction.. Figure 5.17 shows that the maximum and average recorded TRS concentrations while Figure 5.18 shows the 99^{th}, 95^{th}, 90^{th} and 50^{th} percentile concentrations as a function of wind direction.

The figures indicate that there is a slight bias of higher concentrations with winds from the southeast quadrant. Other than the maximum measurement under a southeast wind, the maximum concentrations by wind direction are fairly constant although the maximum measurement is occurring from the Figure 5.16 indicates that the most frequent high concentrations are occurring for winds from the south sector. The average NO_2 concentrations as seen in Figure 5.17 also show the influence from the south quadrant.

Figure 5.19 presents the maximum and average measured NO_2 concentrations as a function of month and hour of day. There is discernible trend of higher concentrations (both maximum and average) in the colder months which suggests that local emissions could be contributing to the measurements. Colder months would tend to have higher residential heating requirements and poorer dispersion of ground based sources. The diurnal pattern of average NO_2 values shows a definite decrease during the daytime suggesting that complex atmospheric processes in sunlight (discussed in the ozone section) may be occurring and /or local emissions could be impacting the monitor.

The figure shows that the average monthly concentrations are consistently higher than the closest passive monitor especially in the colder months. This again likely shows the influence of local NO_x emissions on the measurements.

Figure 5.17 provides a comparison of NO_2 measurements from other monitoring stations in the province for the same time period. The figure shows that NO_2 levels at Clairmont were slightly higher than other rural areas in the province.

The ambient NO_2 data measured in Clairmont appears to suggest that local residential emissions (home heating, vehicles, etc.) could be the main contributor to the measurements which is not unexpected given the location of the monitor.

[8] http://aep.alberta.ca/air/legislation/ambient-air-quality-objectives/documents/AAQO-NitrogenDioxide-Jun2011.pdf

Table 5.3 Summary of NO_2 Measurements (ppb) at Clairmont Monitoring Station

1-hour AAAQO	159
Annual AAAQO	24
Maximum 1-hour Measurement	102.1
99.9th Percentile Measurement	48.0
99th Percentile Measurement	37.2
90th Percentile Measurement	17.7
Median (50th Percentile) Measurement	3.3
Average Measurement	6.5

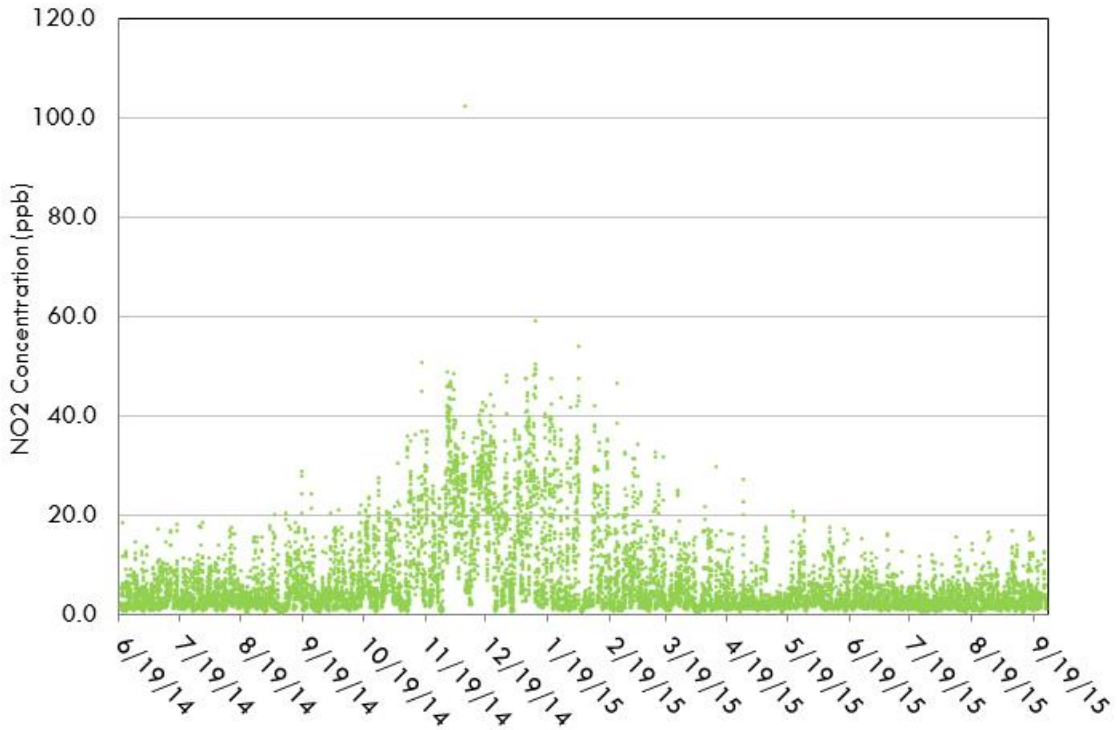

Figure 5.15 Time Series of the Hourly NO_2 Measurements

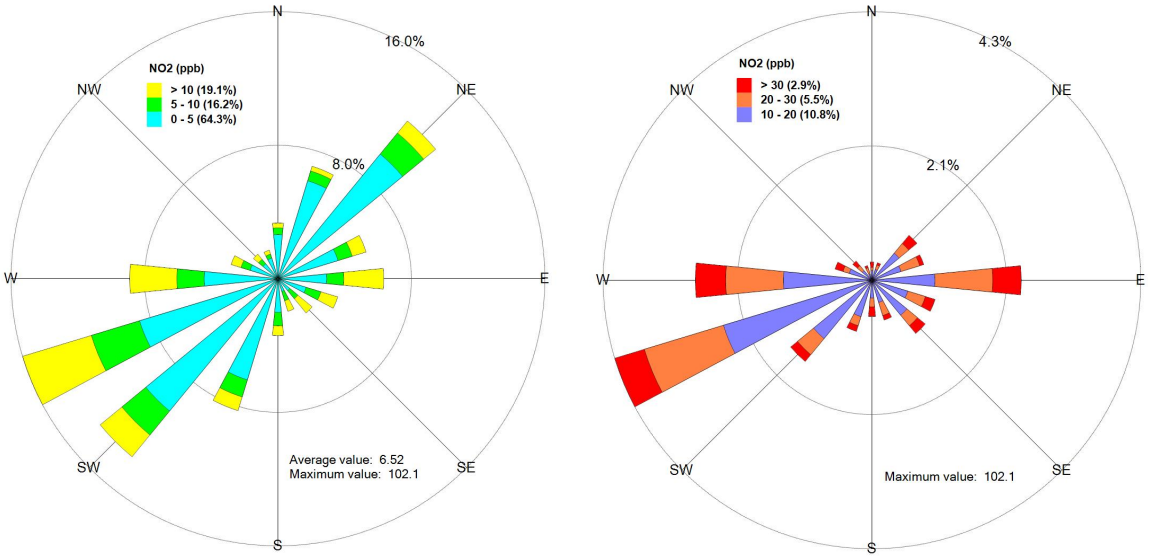

Figure 5.16 Frequency Distribution of NO_2 Measurements by Wind Direction

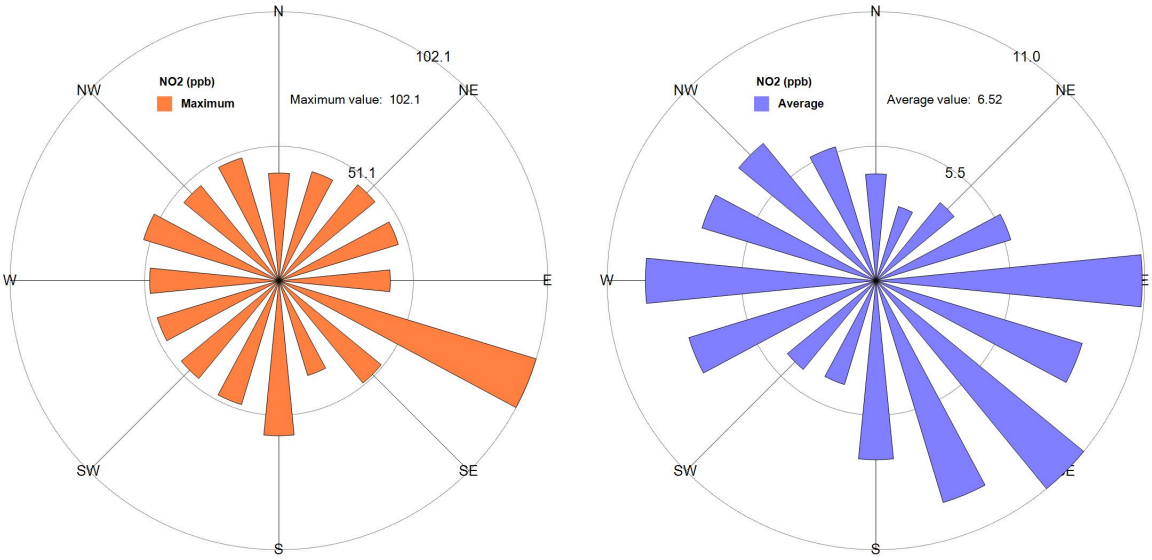

Figure 5.17 Maximum and Average NO_2 measurements by Wind Direction

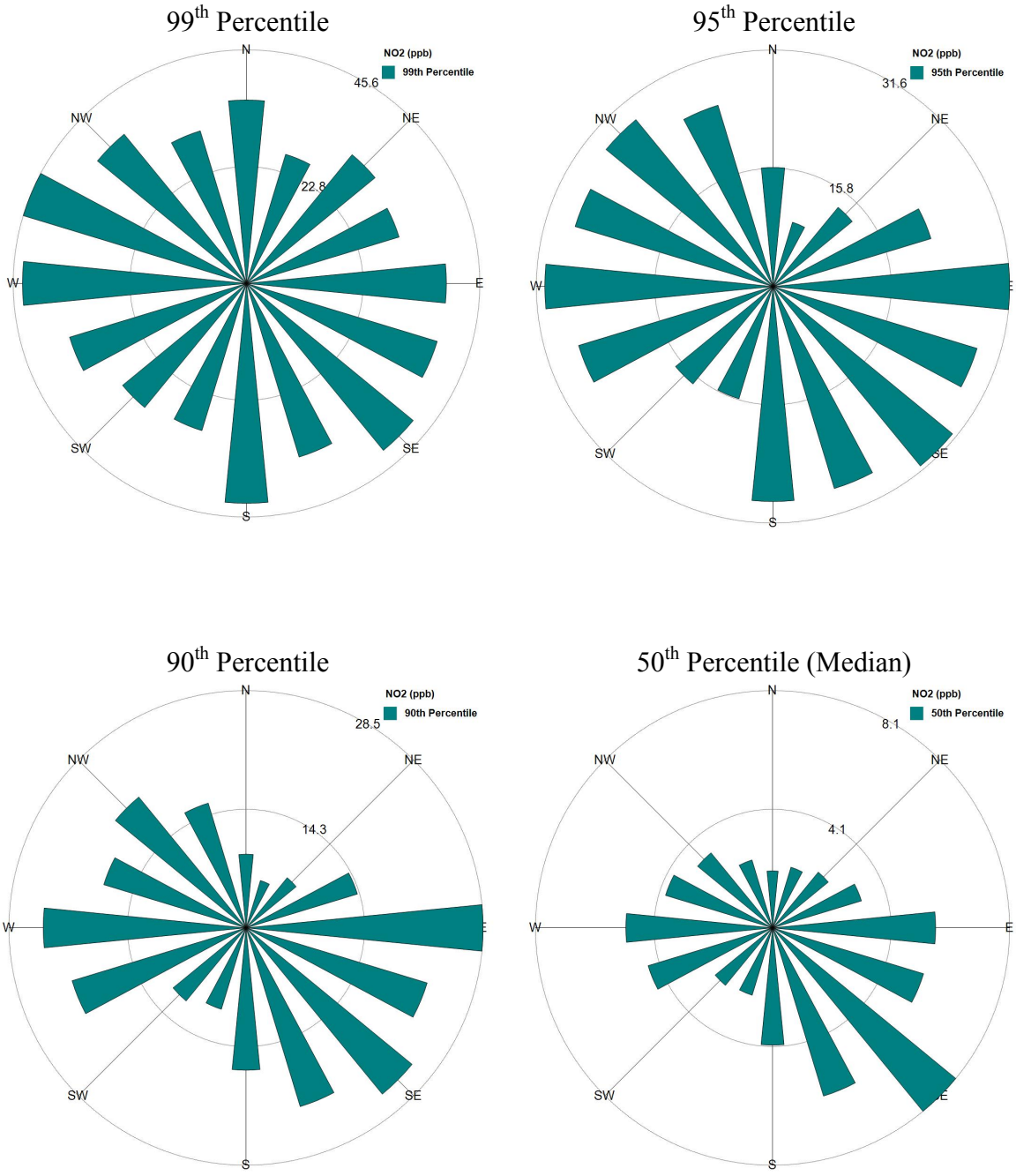

Figure 5.18 Percentile NO_2 Measurements by Wind Direction

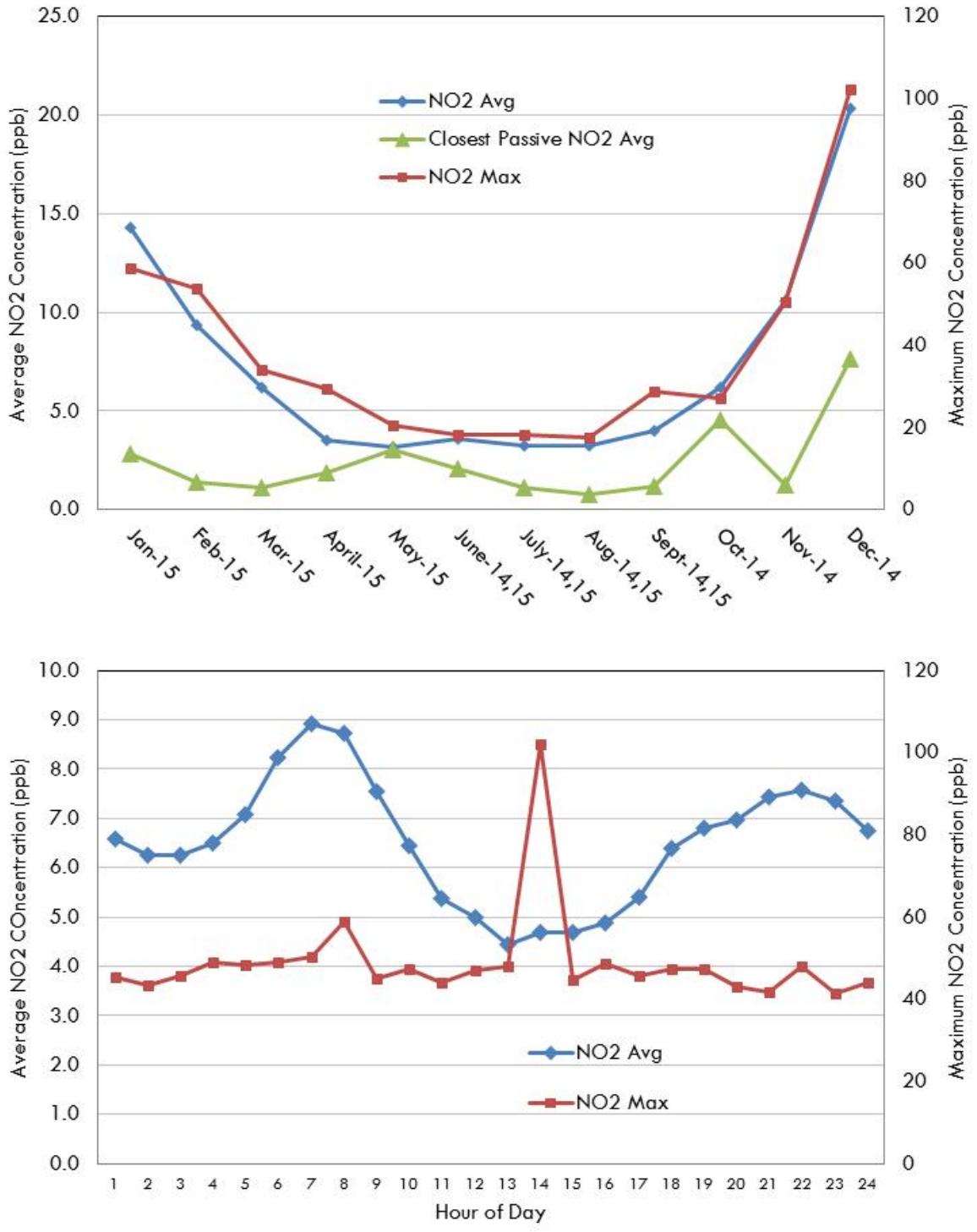

Figure 5.19 Maximum and Average NO_2 Measurements by Month and Hour of Day

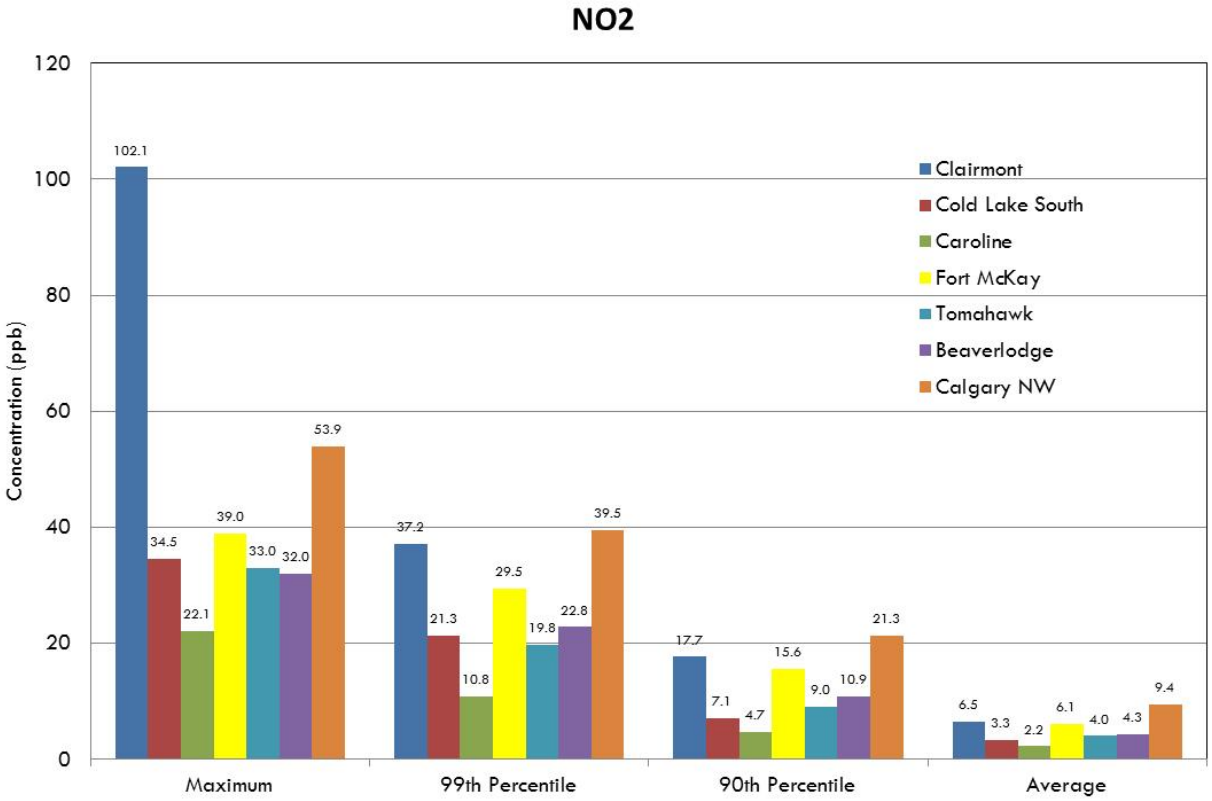

Figure 5.20 Comparison of NO_2 Measurements from other Continuous Monitoring Stations

5.5 Ozone

Ozone is a chemical whose effect on the environment is either beneficial or detrimental depending on where it occurs. Stratospheric ozone protects us from the sun's ultraviolet light, but can be toxic in the troposphere (atmospheric layer encompassing ground level). Ozone is a highly reactive, colourless gas. It has a sharp, clean odour that can often be detected around running electric motors, after lightning storms, and around new mown hay.

Ozone is not emitted by anthropogenic or natural processes. It is normally present in the troposphere as a result of naturally occurring photochemical and meteorological processes. Ground level ozone is formed through complex chemical reactions between precursor emissions of volatile organic compounds (VOCs) and NO_x in the presence of heat and sunlight. Combustion exhausts emit both VOCs and NO_x and in rural areas, trees and other vegetation naturally emit VOCs that can contribute to ozone formation. Changing weather patterns contribute to yearly differences in ozone concentrations from city to city. Ozone and the

precursor substances that cause ozone also can be transported into an area from pollution sources hundreds of miles upwind.

Extensive scientific studies indicate that there can be significant health and environmental effects associated with ozone. Potential short-term effects include pulmonary function reductions, increased airway sensitivities, and airway inflammation on which the 1-hour AAAQO for ozone is based. [9]

A summary of O_3 measurements are shown in Table 5.4 and the time series of measurements are shown in Figure 5.21. The measurements were below the 1-hour AAAQO in all instances., The 4th highest 8-hr daily average over the monitoring period is greater than the CAAQS of 63 ppb. The CAAQS criteria is based on 3 year averages and removes all elevated measurements due to exceptional events such as forest fires. The Clairmont monitor operated for only 16 months and any measurements that were influenced by exceptional events have not been removed, and therefore, the results cannot be explicitly related to the CAAQS.

Figure 5.22 presents the frequency distribution of O_3 measurements by wind direction. Figure 5.23 presents the maximum and average O_3 measurements by wind direction. Figure 5.24 shows the 99th, 95th, 90th and 50th percentile concentrations as a function of wind direction. There appears to be a bias of higher values occurring with winds from the northeast quadrant.

Figure 5.25 presents the maximum and average measured O_3 concentrations as a function of month and hour of day. The highest measurements are occurring during the spring and early summer. Also seen, is a typical diurnal pattern of O_3 where O_3 is decomposed to O_2 through a reaction with NO in the early morning and then created during the day in complex reactions with VOCs and NO_2 in the presence of sunlight. The average monthly concentrations appear to show the same trend as the closest passive monitor except for the colder months where the monthly concentrations are lower than at the closest passive monitor. This again likely shows the influence of local NO_x emissions on O_3 concentrations which would tend to be higher and poorly dispersed in the colder months leading to higher decomposition of O_3.

Figure 5.26 provides a comparison of O_3 measurements from other monitoring stations in the province for the same time period. The figure shows that other O_3 levels at Clairmont were comparable to other areas in the province.

Figure 5.27 presents the diurnal relationships between NO, NO_2, and O_3 at the Clairmont monitoring station for the entire period, and for the months of December, April and August. The figures show the complex relationship between these pollutants that lead to O_3 formation.

The ambient O_3 data measured in Clairmont appears to adequately reflect the general rural setting; however, the ozone measurements may be affected by local NO_x emissions as the data is showing ozone formation and decomposition due to complex relationship with atmospheric NO_x and VOC. Regardless, the O_3 measurements are below the AAAQO.

[9] http://aep.alberta.ca/air/legislation/ambient-air-quality-objectives/documents/AAQO-Ozone-Feb2007.pdf

Table 5.4 Summary of O_3 Measurements (ppb) at Clairmont Monitoring Station

1-hour AAAQO	82
Maximum 1-hour Measurement	74.9
99.9th Percentile Measurement	68.3
99th Percentile Measurement	57.8
90th Percentile Measurement	40.6
Median (50th Percentile) Measurement	24.9
Average Measurement	24.6
8-hour CAAQS	63
4th Highest Daily 8-hour Measurement[a]	65.8

a. This value was calculated for presentation purposes only and cannot be directly compared to the CAAQS

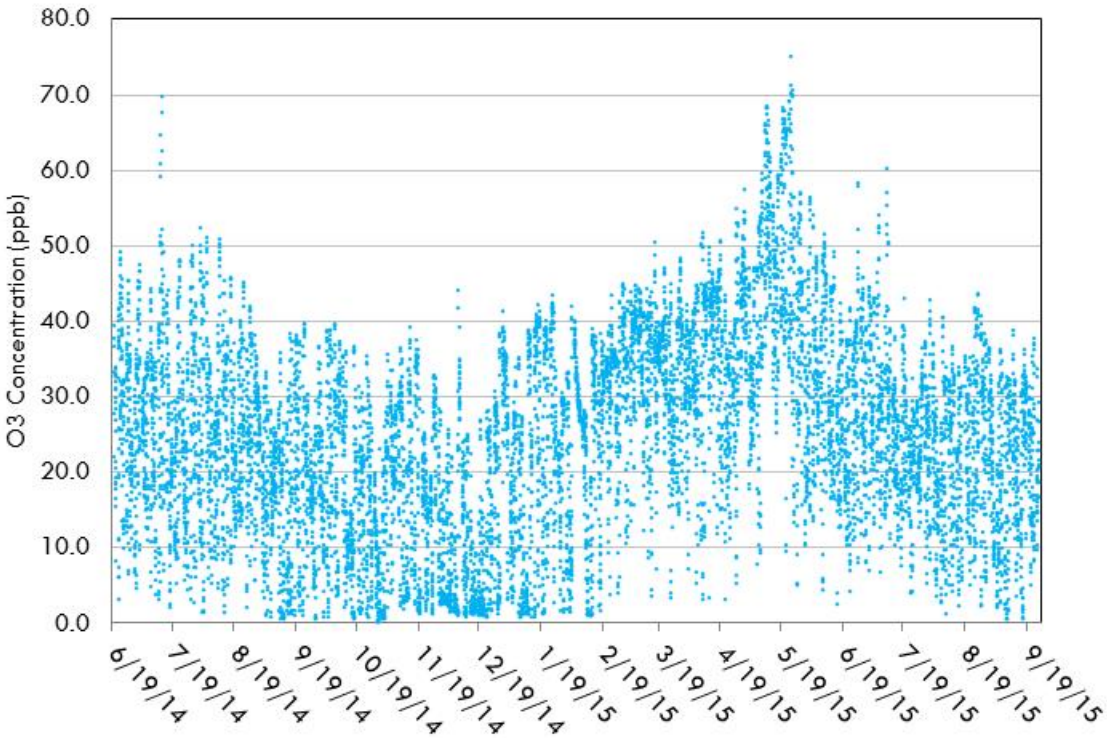

Figure 5.21 Time Series of the Hourly O_3 Measurements

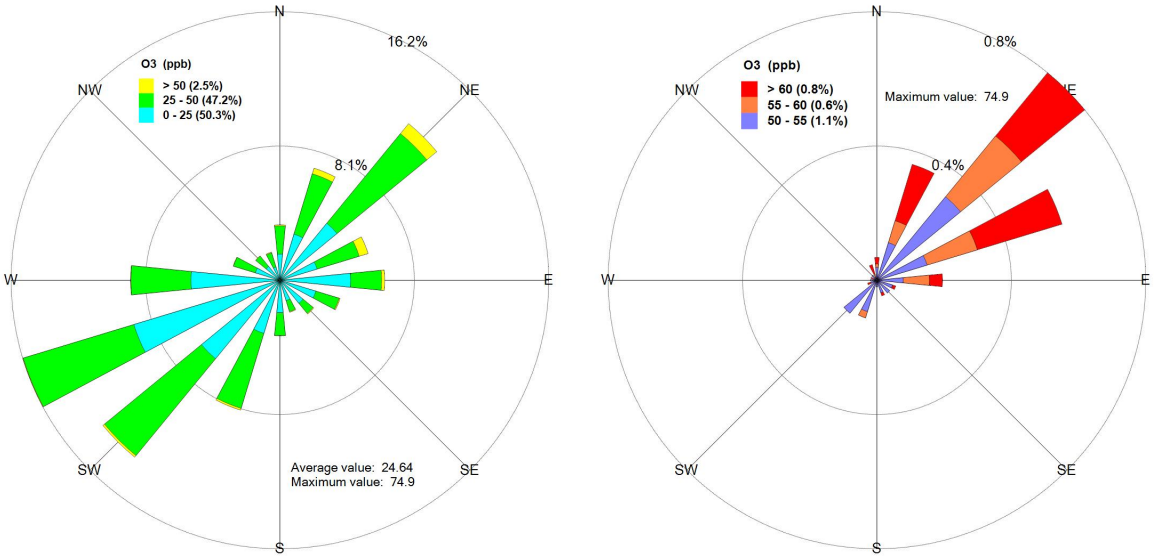

Figure 5.22 Frequency Distribution of O_3 Measurements by Wind Direction

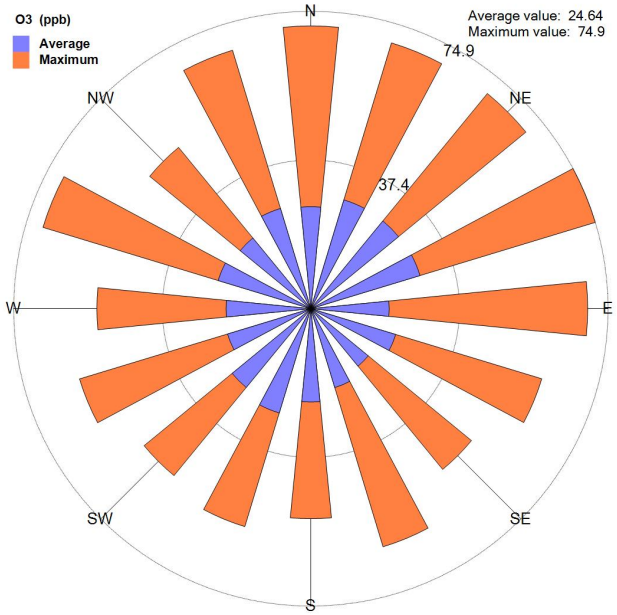

Figure 5.23 Maximum and Average O_3 Measurements by Wind Direction

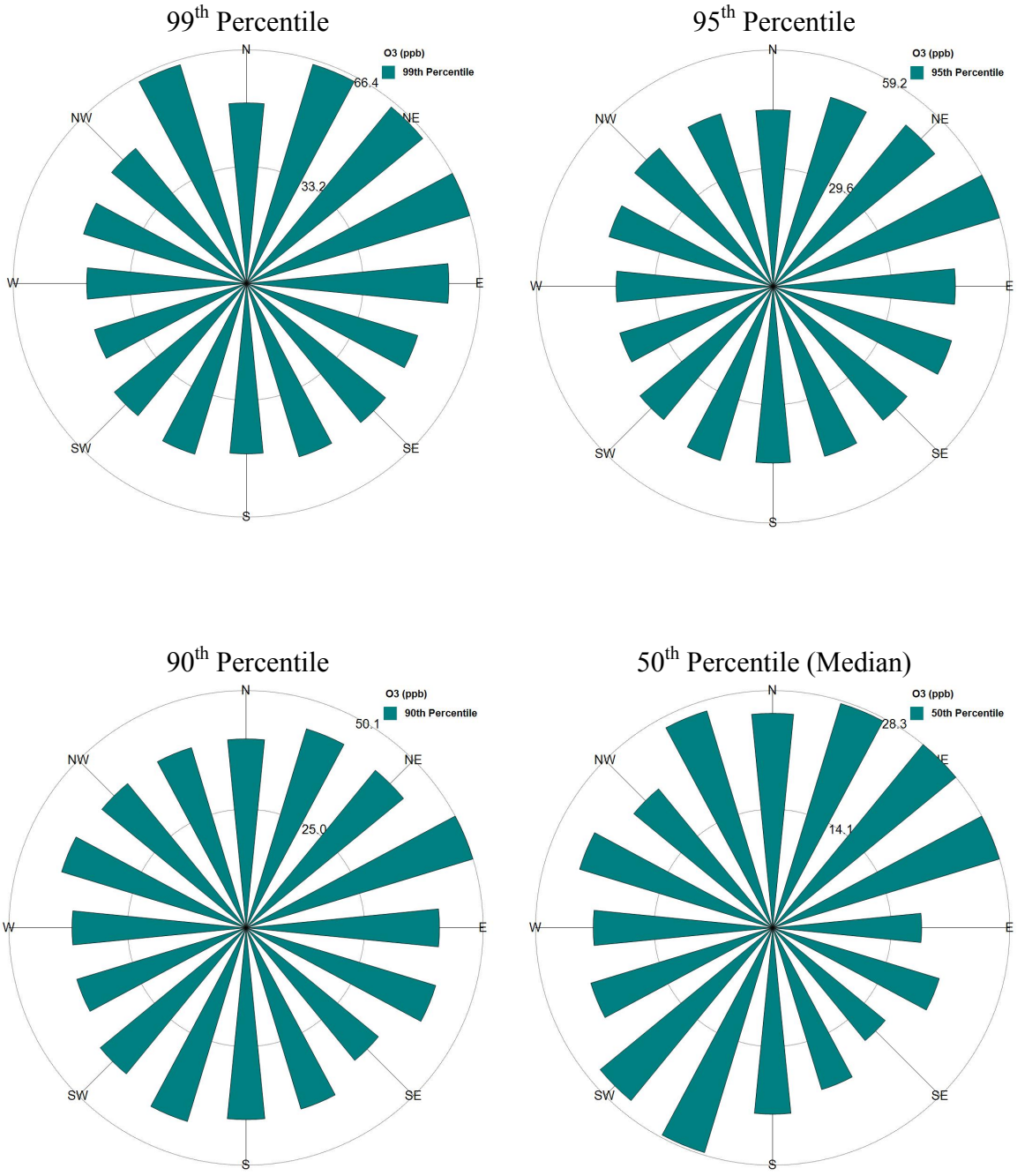

Figure 5.24 Percentile O_3 Measurements by Wind Direction

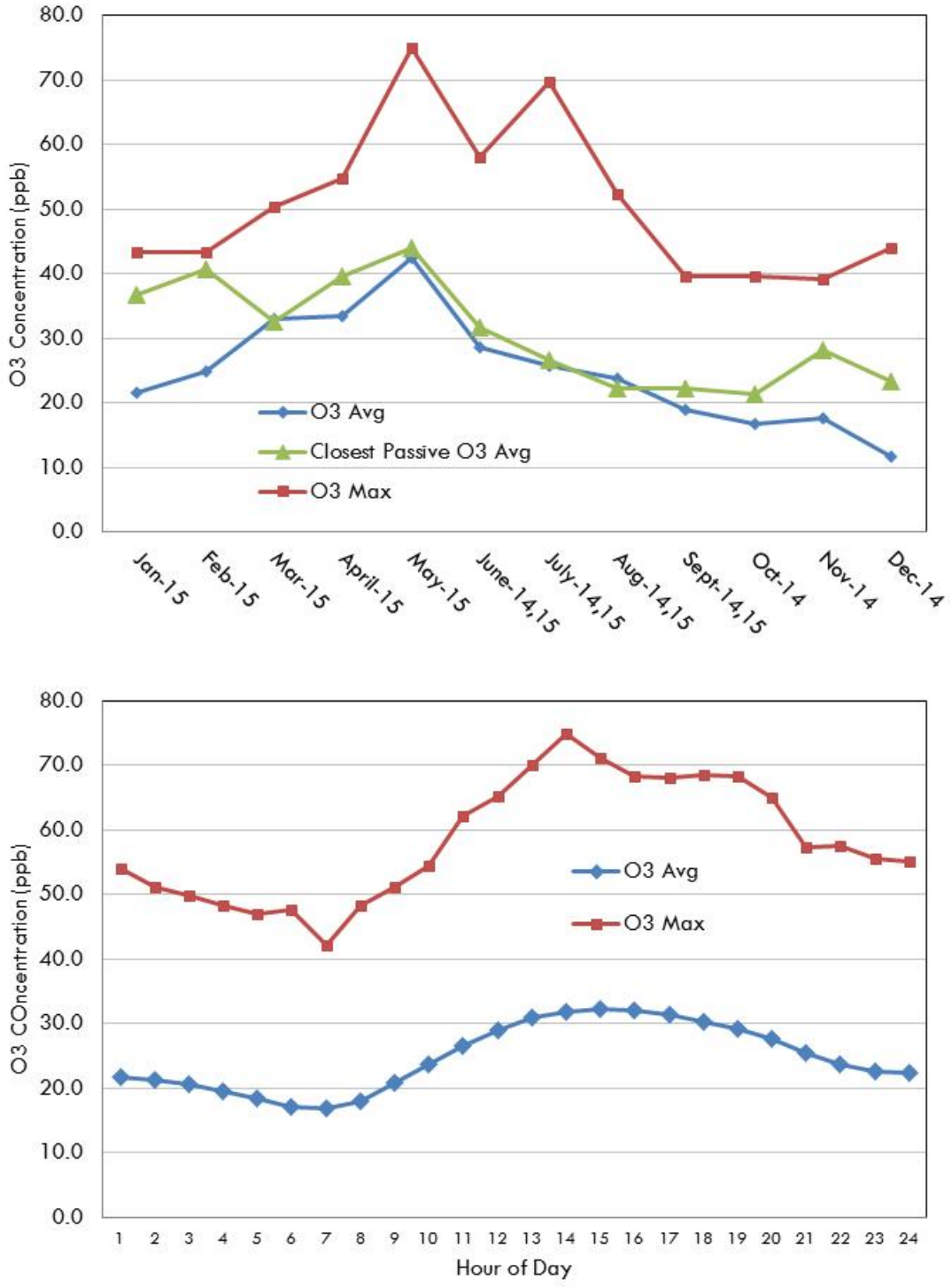

Figure 5.25 Maximum and Average O_3 Measurements by Month and Hour of Day

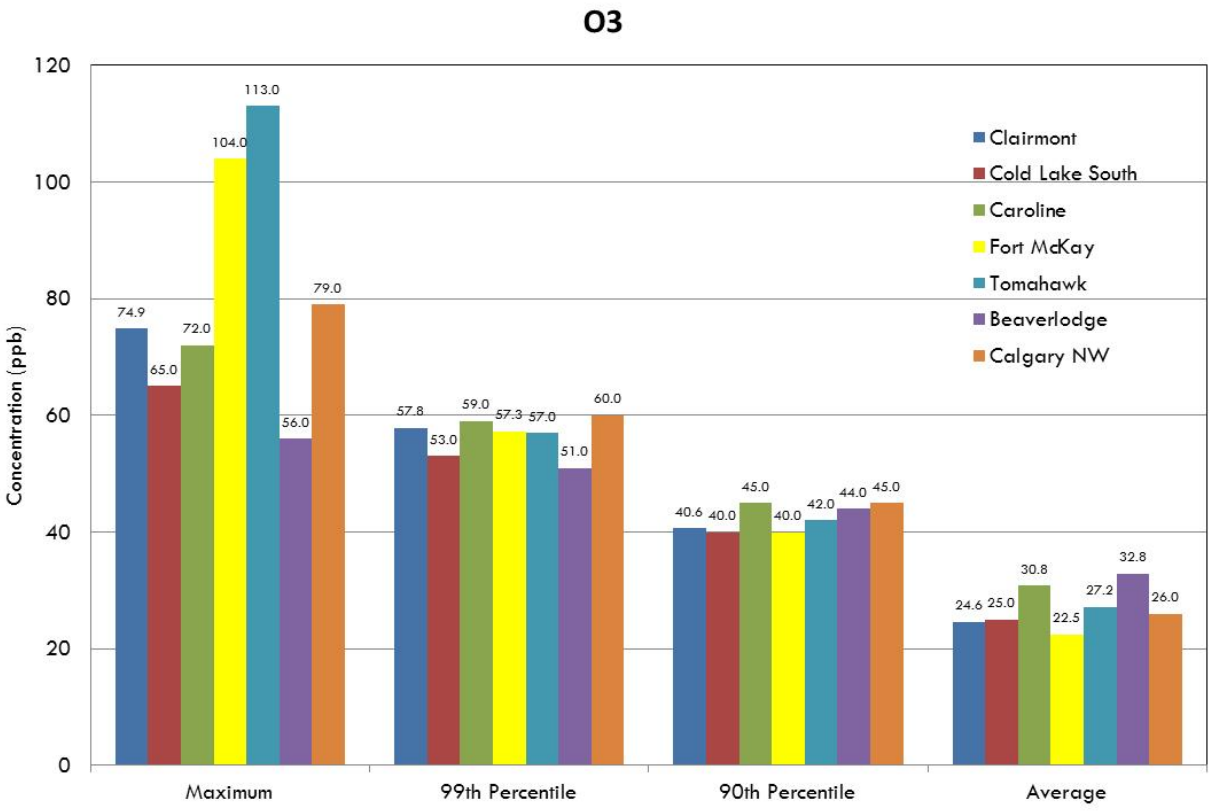

Figure 5.26 Comparison of O_3 Measurements from other Continuous Monitoring Stations

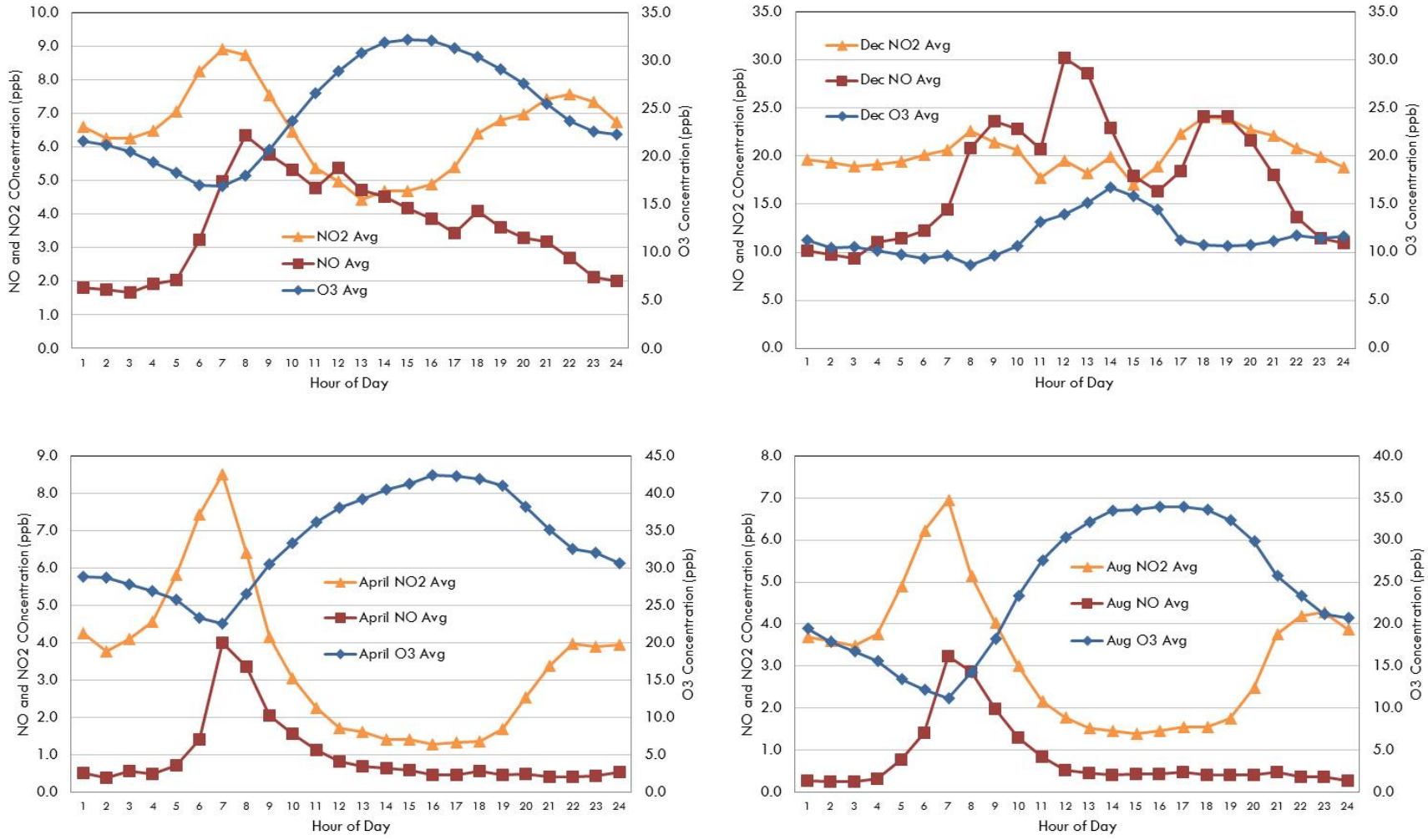

Figure 5.27 Diurnal Relationship between Measured O_3, NO, and NO_2 concentrations for entire period and selected months.

5.6 Fine Particulate Matter ($PM_{2.5}$)

Fine particulate matter ($PM_{2.5}$) refers to airborne solid or liquid particles that are 2.5×10^{-6}m (microns) or less in diameter. It is either emitted directly (primary PM) or formed in the atmosphere from precursor emissions (secondary PM). Important precursors of secondary PM are nitrogen oxides, sulphur dioxide, ammonia, and volatile organic compounds. The chemical composition of particles can vary widely and depends on location, time of year, and weather. Primary $PM_{2.5}$ is formed by combustion processes including: forest fires or residential wood fires; burning of fossil fuels in motor vehicles, furnaces, boilers, and heaters; and certain industrial processes. Secondary fine particles are created when chemicals react in the atmosphere and grow through particle-particle or gas-particle interactions.[10]

A summary of $PM_{2.5}$ measurements are shown in Table 5.5 and the time series of measurements are shown in Figure 5.28. The maximum and 99.9th percentile measurement exceeded the 1-hr AAAQG. The maximum 24-hr measurement exceeded the 24-hr AAAQO.

The 98th percentile 24-hour average over the monitoring period is below the CAAQS of 28 µg/m^3. The average $PM_{2.5}$ measurement is below is the annual CAAQS of 10 µg/m^3. The CAAQS criteria is based on 3 year averages and removes all elevated measurements due to exceptional events such as forest fires. The Clairmont monitor operated for only 16 months and any measurements that were influenced by exceptional or natural events have not been removed, and therefore, the results cannot be explicitly related to the CAAQS.

Figure 5.29 shows that most concentrations were less than 10 µg/m^3. Figure 5.30 presents the maximum and average O_3 measurements by wind direction. Figure 5.31shows the 99th, 95th, 90th and 50th percentile concentrations as a function of wind direction. These figures indicate that although the maximum measurement occurred under a south-southwest wind, there is slight bias that the highest measurements are occurring for winds from the southeast quadrant. It is not known what source(s) or event(s) led to the highest $PM_{2.5}$ measurements. Determination of source contribution is outside the scope of this report.

Figure 5.32 presents the maximum and average measured $PM_{2.5}$ concentrations as a function of month and hour of day. No discernible trend is noted in the monthly data. The highest average measurements tend to occur in mid-morning and in early evening. This would tend to indicate that emissions from residential sources could be influencing the measurements.

Figure 5.33 provides a comparison of $PM_{2.5}$ measurements from other monitoring stations in the province for the same time period. The figure shows $PM_{2.5}$ levels at Clairmont were slightly lower when compared to other areas in the province. The ambient $PM_{2.5}$ data measured in Clairmont appears to adequately reflect the general rural setting .

[10] http://aep.alberta.ca/air/legislation/ambient-air-quality-objectives/documents/AAQO-FineParticulateMatter-Feb2007.pdf

Table 5.5 Summary of $PM_{2.5}$ Measurements ($\mu g/m^3$) at Clairmont Monitoring Station

1-hour AAAQG	80
24-hour AAAQO	30
24-hour CAAQS	28
Annual CAAQS	10
Maximum 1-hour Measurement	143.9
99.9th Percentile Measurement	87.1
99th Percentile Measurement	39.4
90th Percentile Measurement	11.9
Median (50th Percentile) Measurement	2.5
Average Measurement	4.9
Maximum 24-hour Average Measurement	39.9
98th Percentile 24-hour Average Measurement[a]	23.3

a. This value was calculated for presentation purposes only and cannot be directly compared to the CAAQS

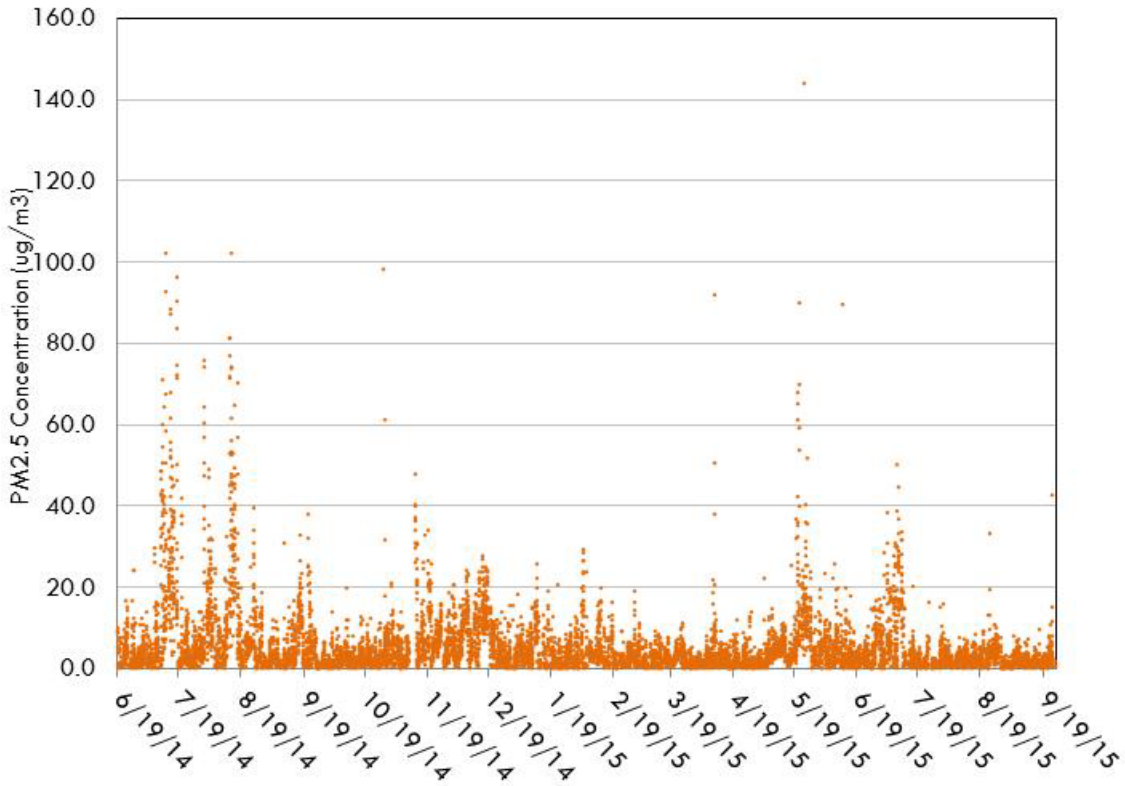

Figure 5.28 Time Series of the Hourly $PM_{2.5}$ Measurements

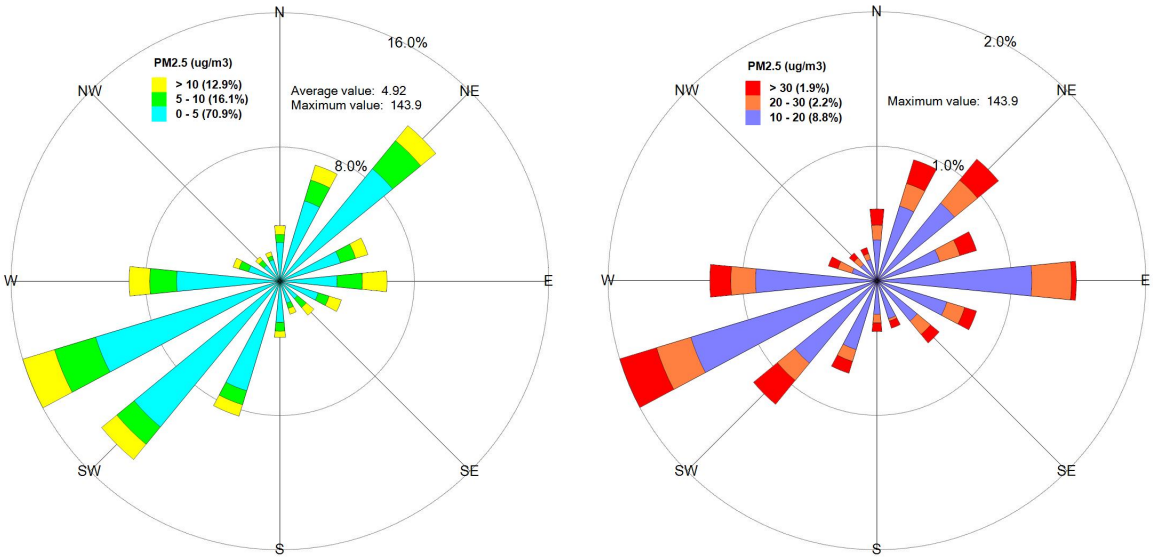

Figure 5.29 Frequency Distribution of $PM_{2.5}$ Measurements by Wind Direction

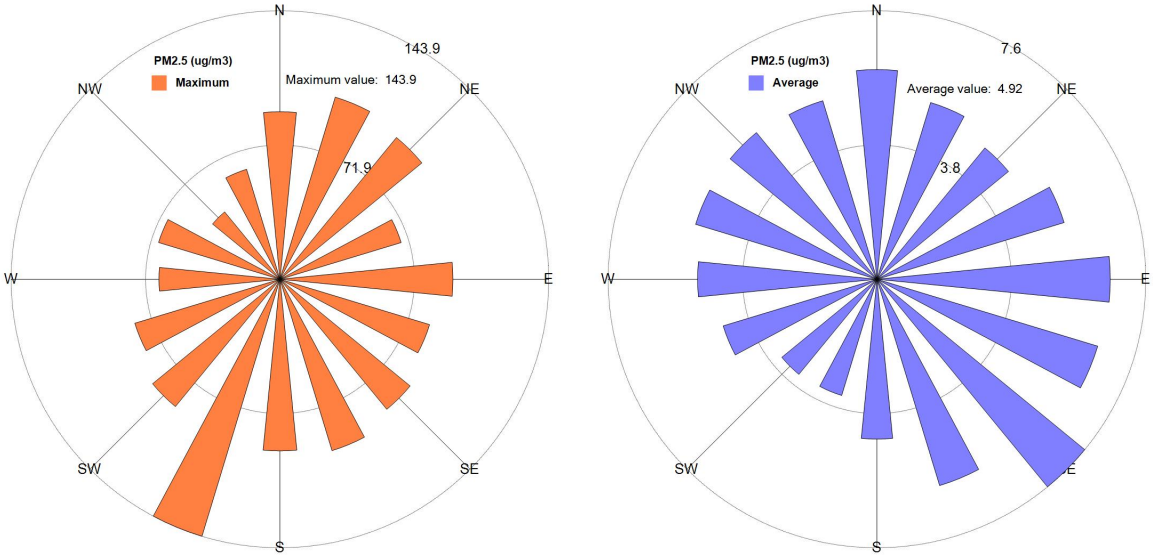

Figure 5.30 Maximum and Average $PM_{2.5}$ measurements by Wind Direction

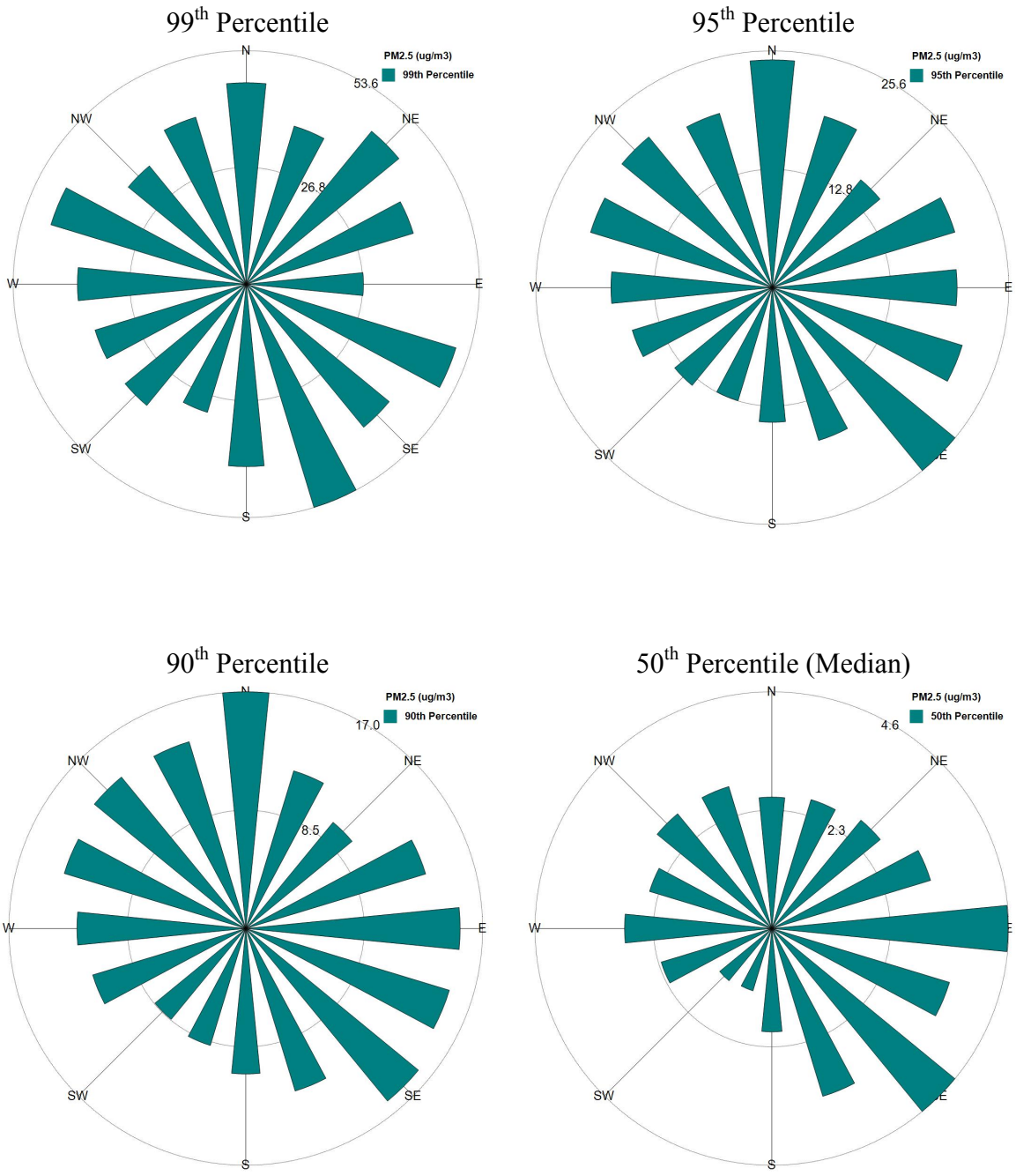

Figure 5.31 Percentile $PM_{2.5}$ Measurements by Wind Direction

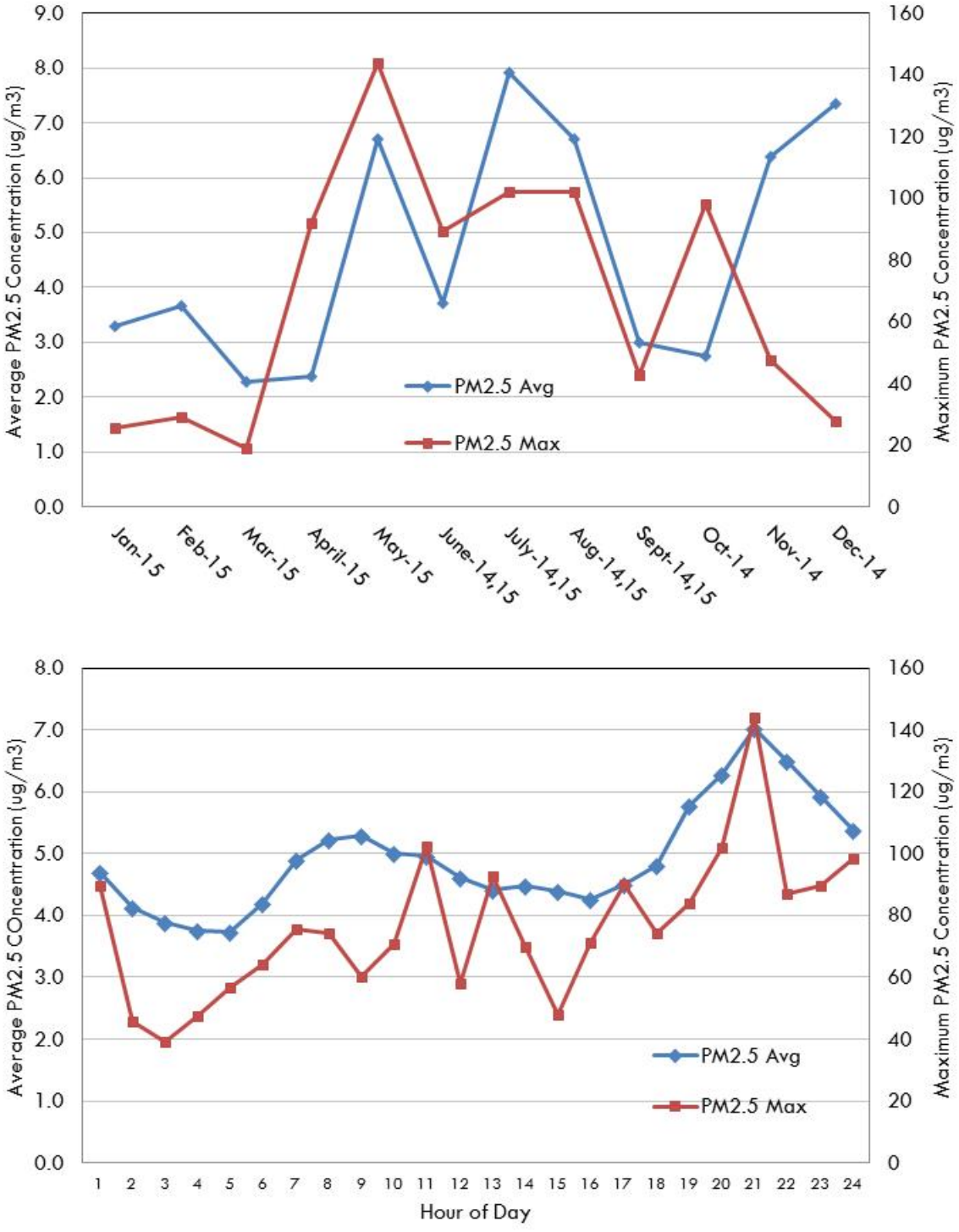

Figure 5.32 Maximum and Average $PM_{2.5}$ Measurements by Month and Hour of Day

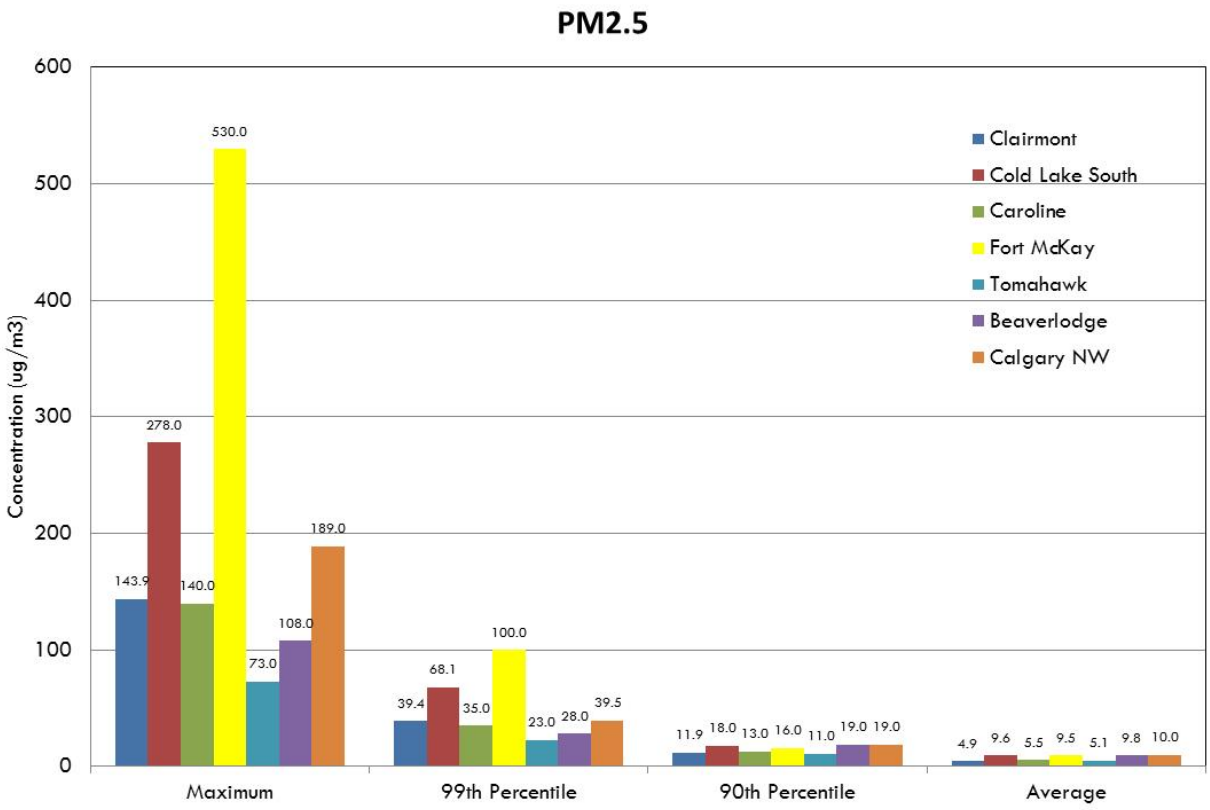

Figure 5.33 Comparison of $PM_{2.5}$ Measurements from other Continuous Monitoring Stations

5.7 Total Hydrocarbons

THC is a broad term used to describe compounds which contain hydrogen and carbon atoms. Anthropogenic sources of hydrocarbons include vehicle emissions, oil and gas facilities (combustion and fugitive sources), chemical industries, dry cleaning, and natural gas combustion. Natural sources of hydrocarbons include decomposition of organic material, and livestock.

Hydrocarbons are divided into two broad categories, "non-reactive" and "reactive" hydrocarbons. The major non-reactive hydrocarbon is the atmosphere is methane, which is a naturally occurring colourless, odourless gas recognized as a major contributor to the greenhouse effect. The reactive hydrocarbons consist of many VOCs, some of which react with oxides of nitrogen in the atmosphere to form ozone. They generally occur at much lower concentrations than methane. THC include both reactive and non-reactive hydrocarbons

There are no AAAQOs for THC or the major constituents of THC (methane) but AAAQOs do exist for specific hydrocarbons such as benzene. However, concentrations of specific hydrocarbons cannot be inferred from the data collected. Background hydrocarbons are primarily composed of methane (1.5 – 2.0 ppm in rural Alberta) small contribution from non-methane hydrocarbons (about 0.2 ppm) [11].

A summary of THC measurements are shown in Table 5.6 and the time series of measurements are shown in Figure 5.34.Almost all measurements were above 1.8 ppm. Average and median values were 2.2 and 2.1 ppm, respectively.

Figure 5.35 presents the frequency distribution of THC measurements by wind direction. Figure 5.36 presents the maximum and average THC measurements by wind direction. Figure 5.37 presents the maximum and average O_3 measurements by wind direction. shows the 99th, 95th, 90th and 50th percentile concentrations as a function of wind direction Although the maximum measurement occurred under a northwest wind, the data indicates a slight bias for higher measurements under easterly winds.

Figure 5.38 presents the maximum and average measured THC concentrations as a function of month and hour of day. The winter months tend to show slight higher maximums and average values (except for the absolute maximum). Diurnal profiles indicate the highest average THC measurements tend to occur in mid-morning and gradually decline to the late afternoon before gradually increasing to mid-morning. This may indicate some of the THCs are involved in the formation of ground level ozone; however, further investigation into that possibility is beyond the scope of this report.

Figure 5.39 provides a comparison of THC measurements from other monitoring stations in the province for the same time period. The figure shows that THC levels at Clairmont were slightly

[11] http://capitalairshed.ca/total-hydrocarbons

higher than other areas in the province. It is unclear whether this is significant or not, and the investigation is outside the scope of this report.

Table 5.6 Summary of THC Measurements (ppm) at Clairmont Monitoring Station

Maximum 1-hour Measurement[a]	7.5
99.9th Percentile Measurement	4.4
99th Percentile Measurement	3.7
90th Percentile Measurement	2.7
Median (50th Percentile) Measurement	2.1
Average Measurement	2.2
Normal THC background levels in Rural Alberta	1.5 – 2.0[12]

a. There are no AAAQOs for THC are its main constituent (Methane)

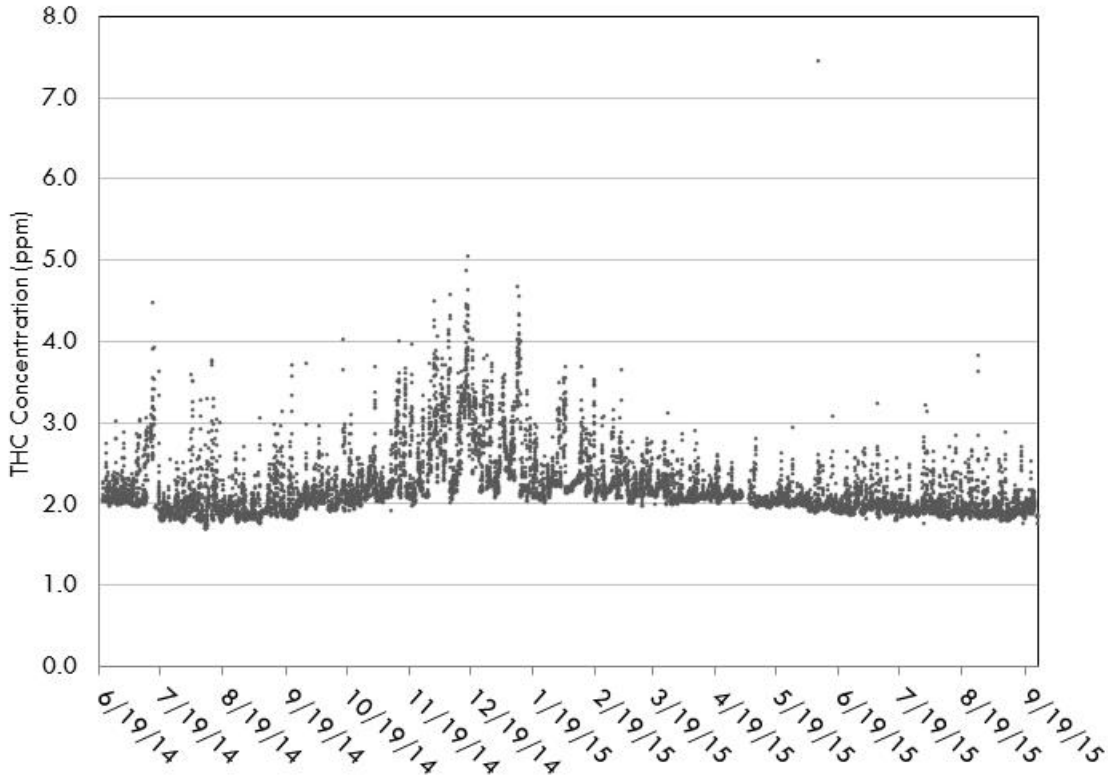

Figure 5.34 Time Series of the Hourly THC Measurements

[12] http://capitalairshed.ca/total-hydrocarbons

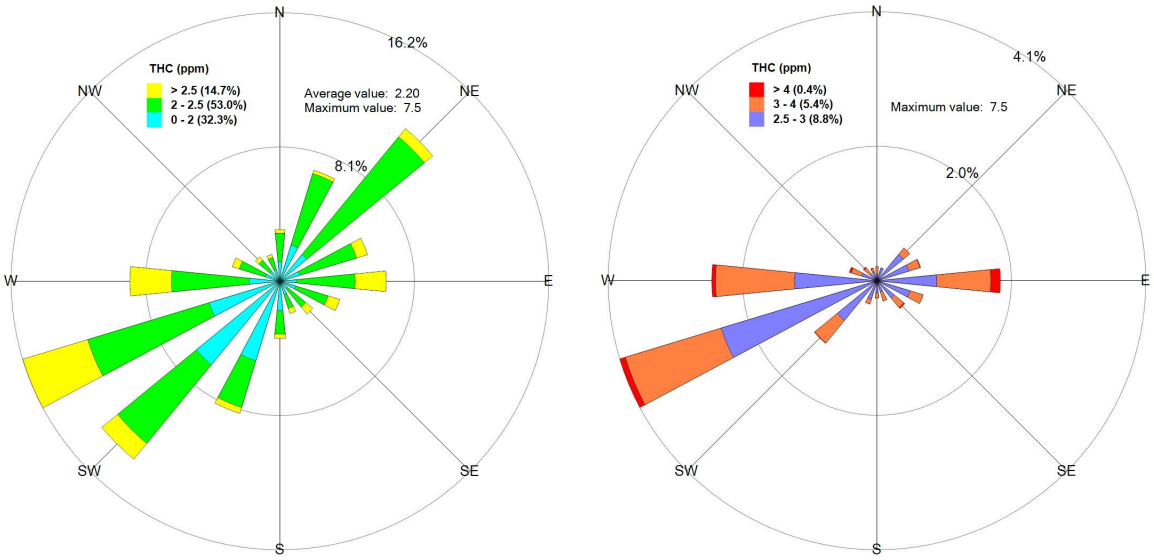

Figure 5.35 Frequency Distribution of THC Measurements by Wind Direction

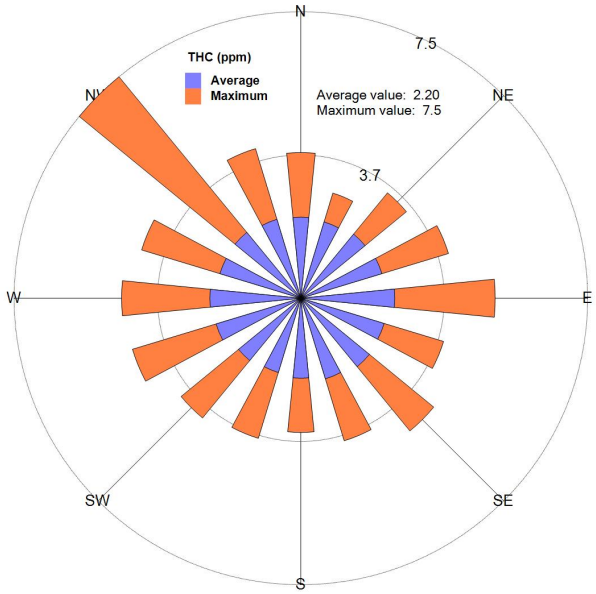

Figure 5.36 Maximum and Average THC Measurements by Wind Direction

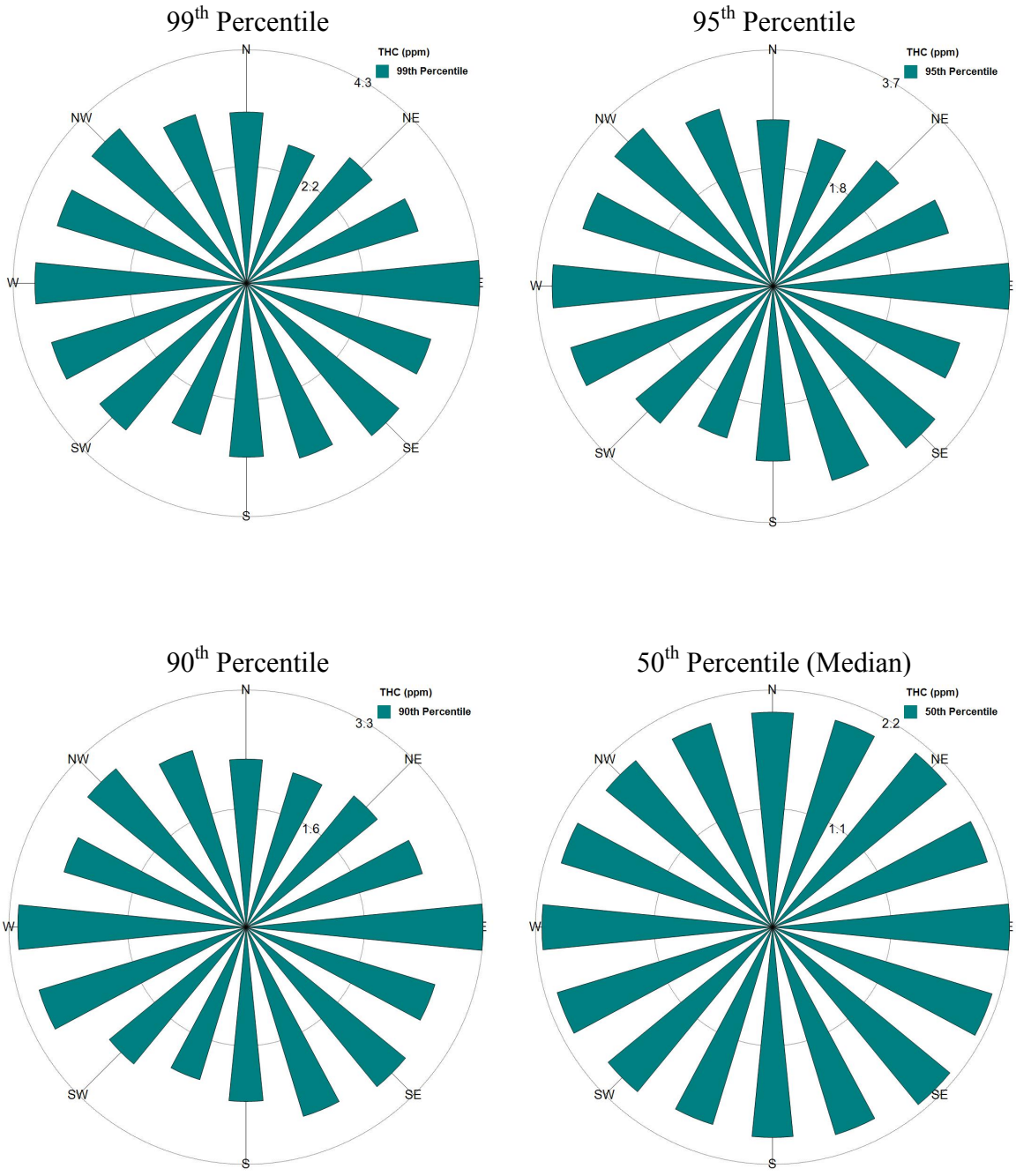

Figure 5.37 Percentile THC Measurements by Wind Direction

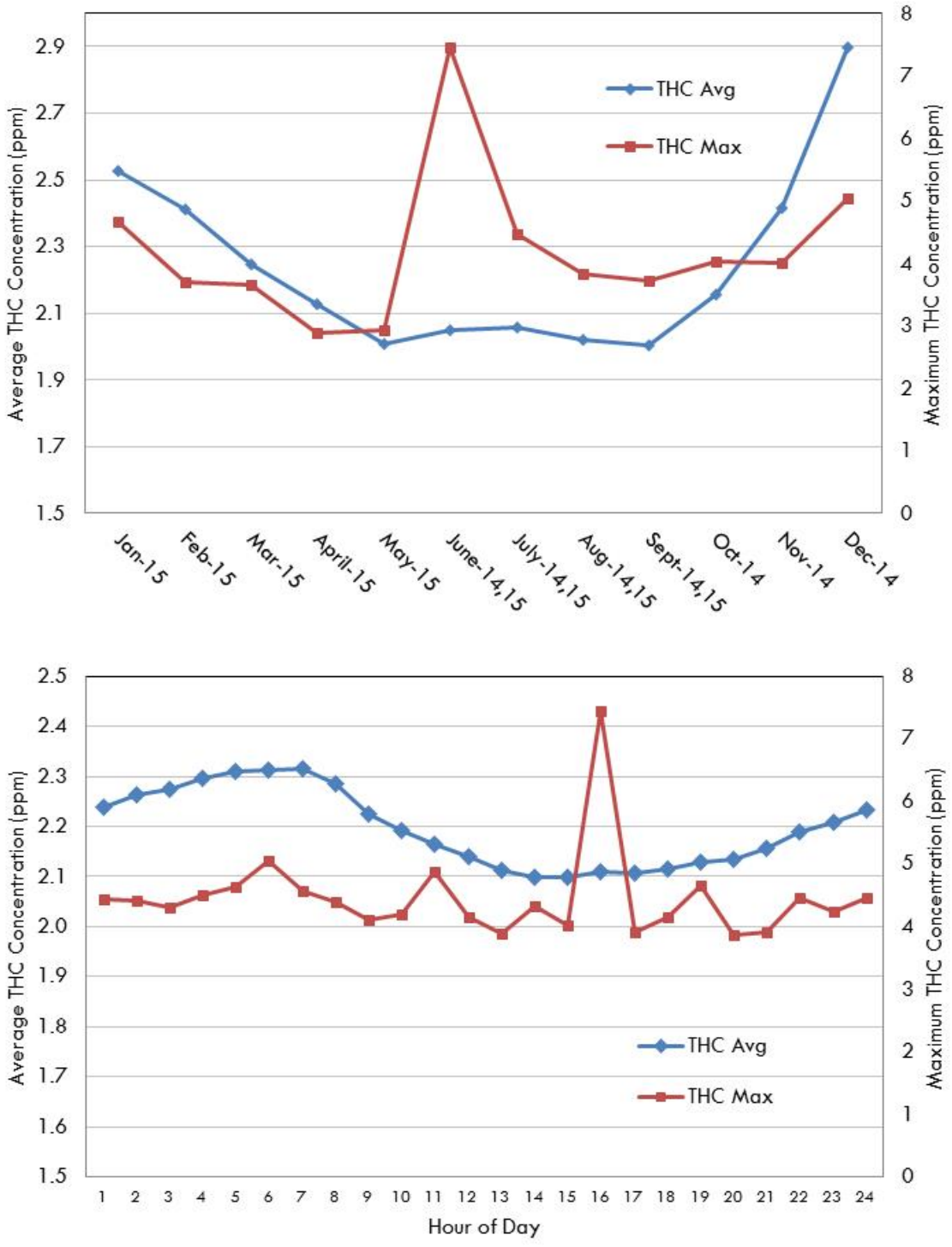

Figure 5.38 Maximum and Average THC Measurements by Month and Hour of Day

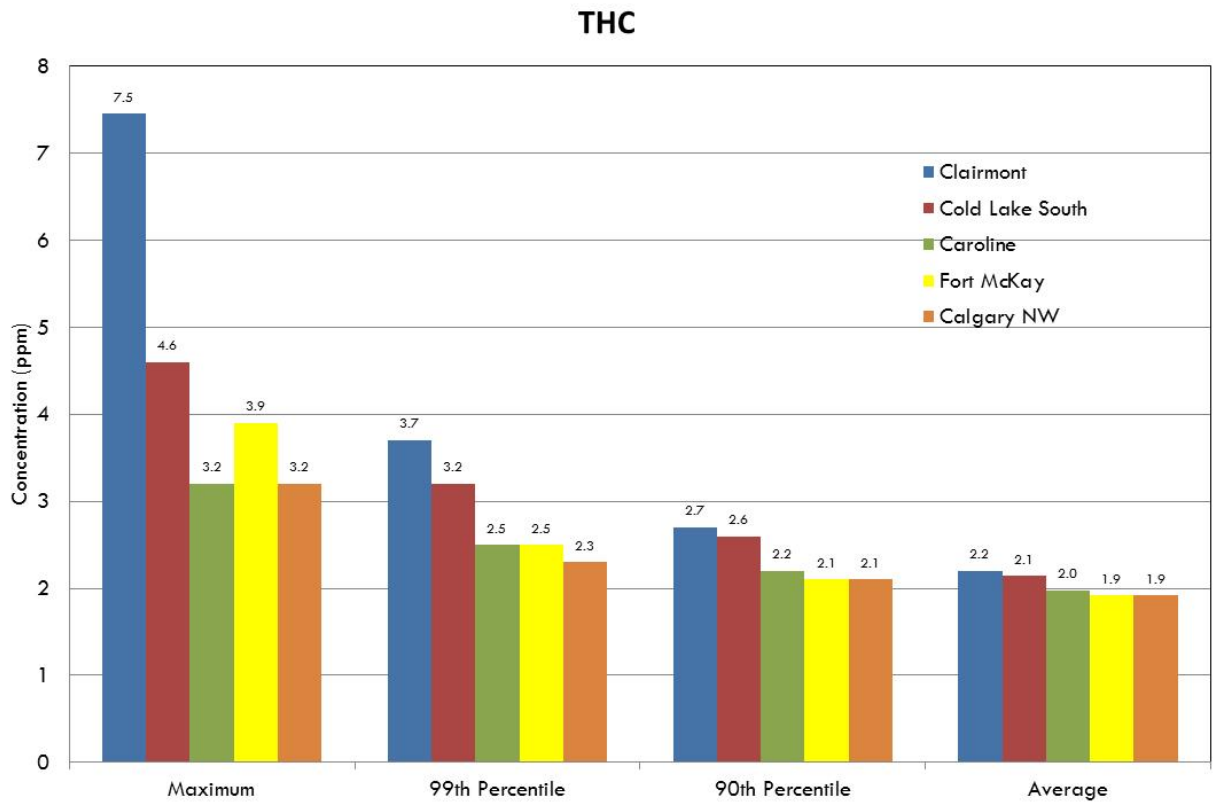

Figure 5.39 Comparison of THC Measurements from other Continuous Monitoring Stations

6. SUMMARY AND RECOMMENDATIONS

The monitoring data that PAZA collected through the Clairmont monitoring project suggests that the air quality in the area is relatively good. Measured concentrations of TRS, SO_2, NO_2, and O_3 were below the applicable or other representative AAAQOs. Diurnal profiles of O_3 and NO_2 measurements appear to show slight photo-chemical O_3 formation and decomposition.

Measurements of $PM_{2.5}$ indicated that the AAAQG and AAAQO were exceeded infrequently during the monitoring period which were likely due to forest fires and did not appear to be reminiscent of general poor air quality. It is recommended that PAZA consider looking into the possible contributors to the elevated $PM_{2.5}$ measurements to definitely determine if exceptional events were the cause.

Concentrations of THCs measured in the area were slightly higher than other areas in province for the same monitoring period were noted. The levels did not appear to be suggestive of air quality problems but a definitive conclusion cannot be made through data analysis alone. It is recommended that PAZA consider looking into the reasons for these slightly elevated THC measurements. Canister sampling for specific VOCs such as benzene, may provide further helpful information in this regard.

The summary of the Clairmont air quality survey is limited to the parameters measured in this study. Air quality in the area may be affected by other compounds some of which PAZA was not equipped to measure such as speciated volatile organic compounds (VOCs) or ammonia.