

HAMLET OF RENO

AIR QUALITY SUMMARY REPORT

NOVEMBER 2013 TO JUNE 2014

Date: October 5, 2015

Executive Summary

The Hamlet of Reno, Alberta is located just outside the north central border of the Peace Airshed Zone in a rural region of mainly heavy oil and agriculture activity. The Peace Airshed Zone Association (PAZA) conducted an air quality survey just south of Reno (but within the Peace Airshed Zone) from November 2013 to June 2014. 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 ($\text{PM}_{2.5}$), total hydrocarbon (THC) concentrations as well as meteorology during that period.

There were no exceedances of Alberta Ambient Air Quality Objectives (AAAQO) or Guidelines (AAAQG), or Canadian Ambient Air Quality Standards (CAAQS) for any of the measured compounds. The results are summarized as follows:

- The overall TRS measurements may be influenced by industry 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 Reno appears to adequately reflect the general rural setting. The NO_2 levels may be influenced from vehicular traffic on Highway 2 or from the larger communities to the south. However, NO_2 levels in the area were slightly lower when compared to other areas in the province.
- 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 Reno monitor operated for only 8 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 for O_3 .
- Levels of measured $\text{PM}_{2.5}$ in the area during the monitoring period were generally low. The Reno monitor operated for only 8 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 from $\text{PM}_{2.5}$. However, $\text{PM}_{2.5}$ measurements in the area were slightly lower than other areas in the province.
- Ambient measurements of THC in the area indicate the levels, for the most part, are typical of average rural Alberta. However, it is noted that the average THC values were

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-southeast. As well, the highest wind speeds most frequently occur from the southwest to northwest quadrant.

The summary of the air quality monitoring data is limited to the parameters measured in this study. Air quality surrounding the monitor may be affected by other compounds some of which 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 rural Alberta areas. The data does not necessarily support further monitoring in the area. Although less than a full year of data was collected, it is unlikely that a full year or more of monitoring data would yield different conclusions. If PAZA chooses to conduct additional monitoring in the area, it is recommended to consider adding passive hydrogen sulphide monitoring to determine trends, and canister sampling for specific VOCs such as benzene.

Table of Contents

1.	INTRODUCTION	1
2.	SITE SETTING	2
3.	AIR MONITORING (PARAMETERS, EQUIPMENT, ETC)	7
4.	ALBERTA AMBIENT AIR QUALITY OBJECTIVES.....	9
5.	MONITORING RESULTS	11
5.1	Meteorology	12
5.2	Total Reduced Sulphur Compounds	14
5.3	Sulphur Dioxide	18
5.4	Nitrogen Oxides	23
5.5	Ozone	28
5.6	Fine Particulate Matter (PM _{2.5}).....	35
5.7	Total Hydrocarbons	40
6.	SUMMARY AND RECOMMENDATIONS	46

List of Figures

Figure 2.1	Regional Area Map showing location Reno and PAZA.....	3
Figure 2.2	PAZA Monitoring Locations	4
Figure 2.3	Views from and of Reno Monitoring Station.....	5
Figure 2.4	Local setting around Reno Monitor	6
Figure 5.1	Wind Frequency Distribution at Reno Monitoring Station.....	12
Figure 5.2	Monthly Temperature and Wind Speed Distribution Measured at Reno Monitoring Station	13
Figure 5.3	Time Series of the Hourly TRS Measurements.....	15
Figure 5.4	Frequency Distribution of TRS Measurements by Wind Direction	16
Figure 5.5	Maximum and Average TRS measurements by Wind Direction	16
Figure 5.6	Maximum and Average TRS Measurements by Month and Hour of Day	17
Figure 5.7	Comparison of TRS Measurements from other Continuous Monitoring Stations	18
Figure 5.8	Time Series of the Hourly SO ₂ Measurements	20
Figure 5.9	Frequency Distribution of SO ₂ Measurements by Wind Direction	21
Figure 5.10	Maximum and Average SO ₂ measurements by Wind Direction	21
Figure 5.11	Maximum and Average SO ₂ Measurements by Month and Hour of Day	22
Figure 5.12	Comparison of SO ₂ Measurements from other Continuous Monitoring Stations	23
Figure 5.13	Time Series of the Hourly NO ₂ Measurements	25
Figure 5.14	Frequency Distribution of NO ₂ Measurements by Wind Direction.....	26
Figure 5.15	Maximum and Average NO ₂ measurements by Wind Direction.....	26
Figure 5.16	Maximum and Average NO ₂ Measurements by Month and Hour of Day	27

Figure 5.17	Comparison of NO ₂ Measurements from other Continuous Monitoring Stations	28
Figure 5.18	Time Series of the Hourly O ₃ Measurements.....	30
Figure 5.19	Frequency Distribution of O ₃ Measurements by Wind Direction	31
Figure 5.20	Maximum and Average O ₃ Measurements by Wind Direction	31
Figure 5.21	Maximum and Average O ₃ Measurements by Month and Hour of Day	32
Figure 5.22	Comparison of O ₃ Measurements from other Continuous Monitoring Stations.....	33
Figure 5.23	Diurnal Relationship between Measured O ₃ , NO, and NO ₂ concentrations for entire period and selected months.	34
Figure 5.24	Time Series of the Hourly PM _{2.5} Measurements	36
Figure 5.25	Frequency Distribution of PM _{2.5} Measurements by Wind Direction.....	37
Figure 5.26	Maximum and Average PM _{2.5} measurements by Wind Direction.....	37
Figure 5.27	Maximum and Average PM _{2.5} Measurements by Month and Hour of Day	38
Figure 5.28	Comparison of PM _{2.5} Measurements from other Continuous Monitoring Stations	39
Figure 5.29	Time Series of the Hourly THC Measurements	42
Figure 5.30	Frequency Distribution of THC Measurements by Wind Direction	43
Figure 5.31	Maximum and Average THC Measurements by Wind Direction	43
Figure 5.32	Maximum and Average THC Measurements by Month and Hour of Day	44
Figure 5.33	Comparison of THC Measurements from other Continuous Monitoring Stations	45

List of Tables

Table 3.1	Monitoring Station Equipment Description	8
Table 3.2	Monitoring Equipment Uptime.....	8
Table 4.1	Alberta Ambient Air Quality Objectives.	10
Table 5.1	Summary of TRS Measurements (ppb) at Reno Monitoring Station	15
Table 5.2	Summary of SO ₂ Measurements (ppb) at Reno Monitoring Station.....	20
Table 5.3	Summary of NO ₂ Measurements (ppb) at Reno Monitoring Station.....	25
Table 5.4	Summary of O ₃ Measurements (ppb) at Reno Monitoring Station	30
Table 5.5	Summary of PM _{2.5} Measurements (µg/m ³) at Reno Monitoring Station.....	36
Table 5.6	Summary of THC Measurements (ppm) at Reno Monitoring Station	42

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.

Air Quality Management 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 site¹.

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 on November 2013 to June 2014 near the Hamlet of Reno (Reno) 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 the Hamlet of Reno 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 in a resident's yard about 10 km south of Reno on the northeast corner of Township Roads 800 and Range Road 201. Highway 2, running south to north, is located about 8 km to the west. The geographic and projected coordinates of the site are:

- 55° 53' 54.08" N, 117° 0' 5.53" W (NAD 83)
- 55.898356° N, 117.001535° W (NAD 83)
- 499,904 m E, 6,194,767 m N (UTM Zone 11 – NAD 83)

The Reno monitor is about 140 km northeast 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. Other than the resident's house and farming structures to the north, no significant airflow restrictions were noted. The resident's house is approximately 25 m from the monitor.

Figure 2.4 shows the local setting around the monitoring station. Agriculture is the major activity around the monitor. There are many small heavy oil facilities in the regional area but the closest facility to the monitor is 4 km to the south. The Hamlet of Reno is the closest community located 10 km north. The intersection of Township Road 800 and Range Road 201 is about 100 m southwest of the monitor. The closest major road is Highway 2 which runs south to north about 8 km west of the monitor. According to Alberta Transportation, the Average Annual Daily Traffic Volume on that section of Highway 2 in 2014² was 2,690 vehicles/day.

² <http://www.transportation.alberta.ca/Content/docType181/production/LinkTrafficVolumeVehicleClassTravelESAL2014.pdf>

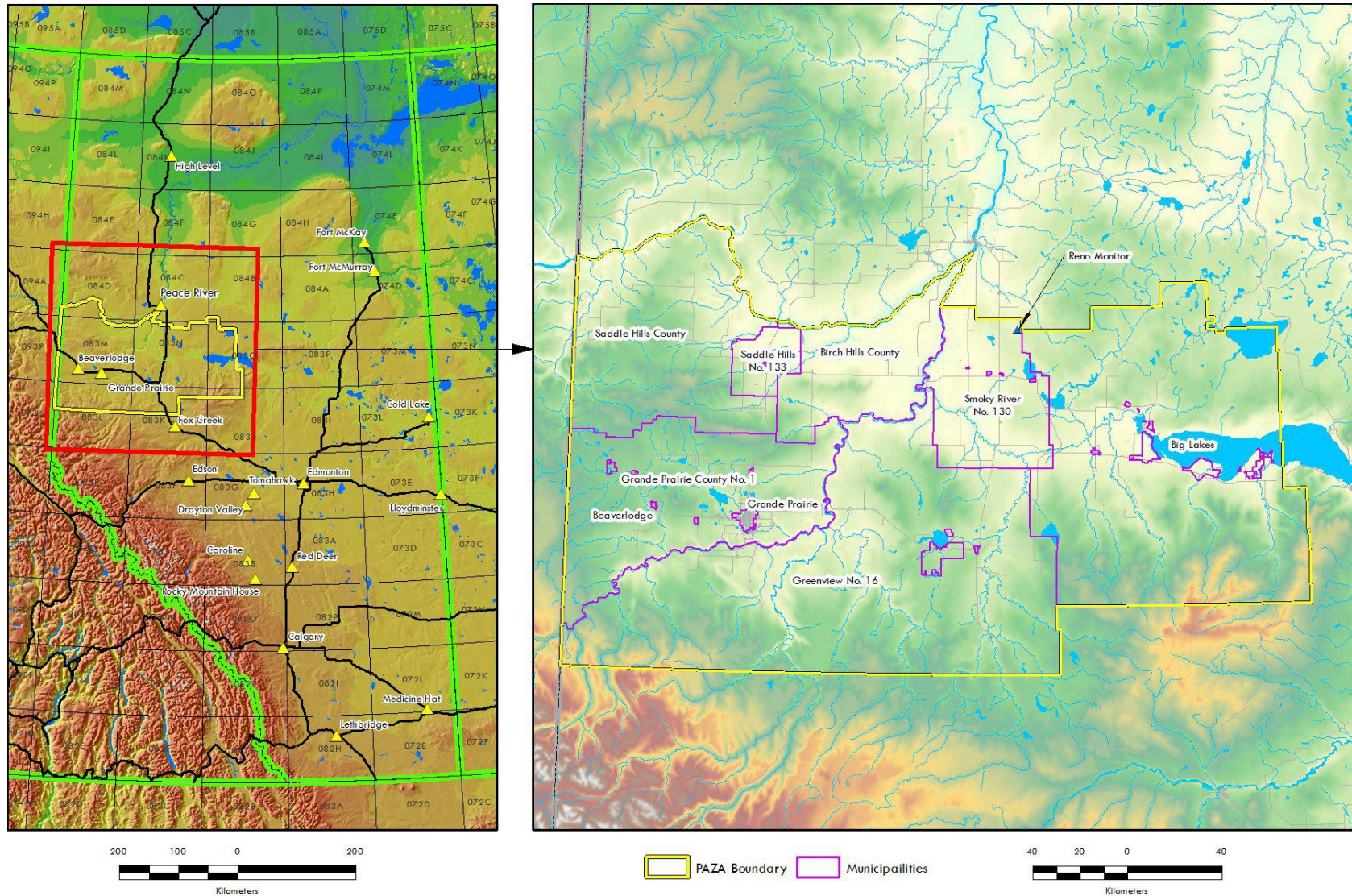


Figure 2.1 Regional Area Map showing location Reno and PAZA

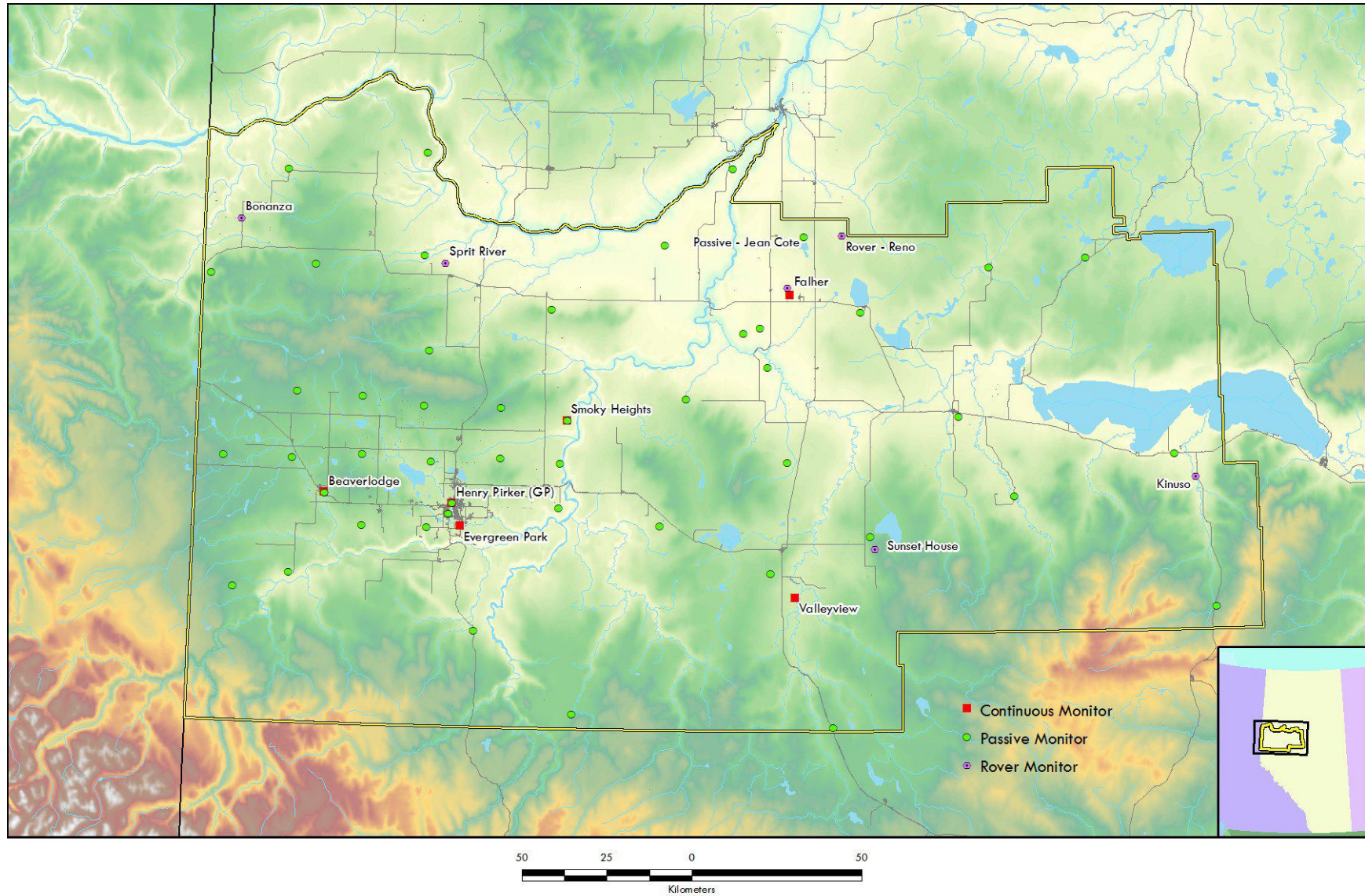


Figure 2.2 PAZA Monitoring Locations



Looking North



Looking South



Looking East



Looking West



Monitoring Trailer



Monitoring Trailer

Figure 2.3 Views from and of Reno Monitoring Station

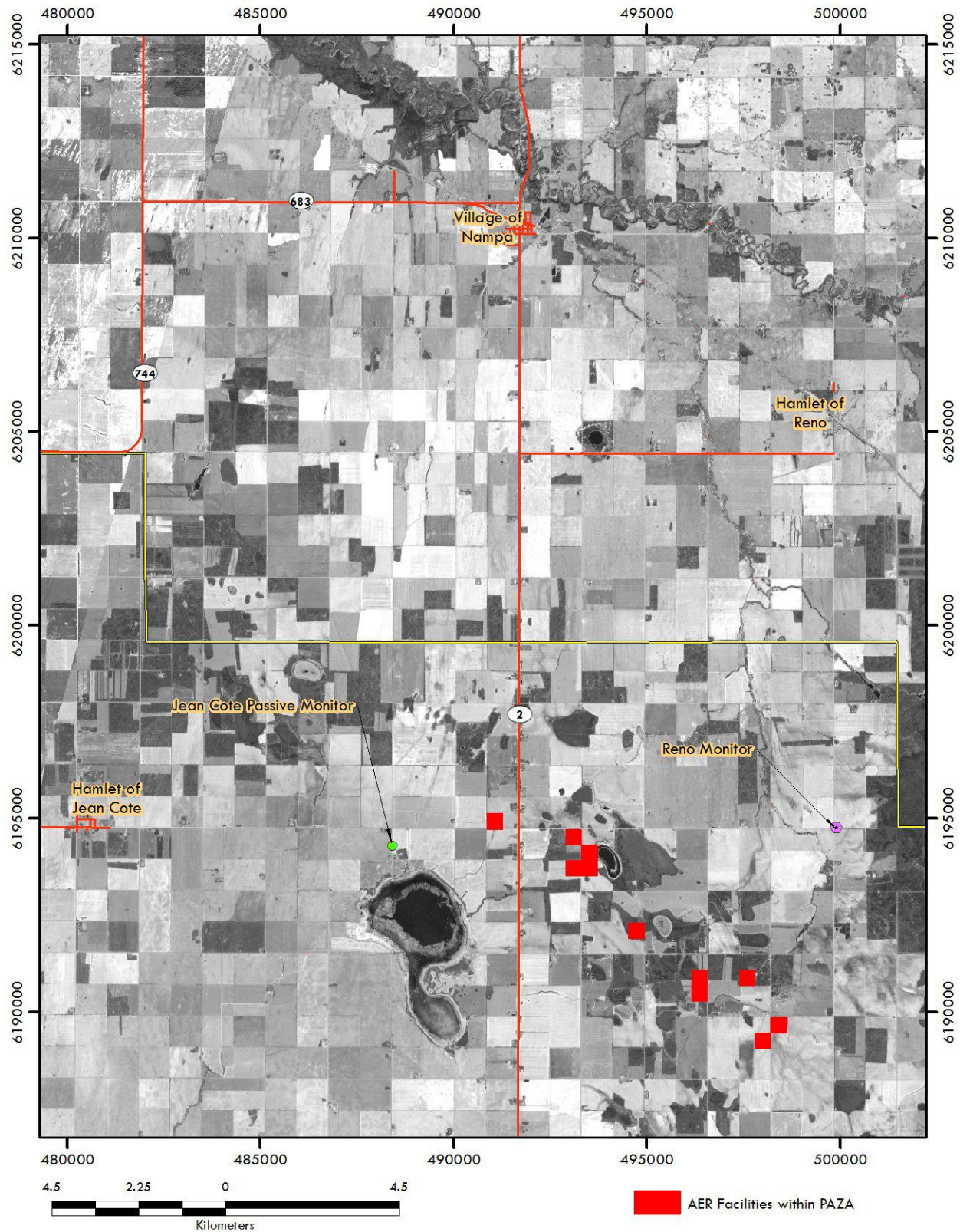


Figure 2.4 Local setting around Reno Monitor

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 (SO₂), total oxides of nitrogen (NO_x), nitric oxide (NO), nitrogen dioxide (NO₂), ozone (O₃), 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 November 1, 2013 00:00 to June 19, 2014 09:00 (5530 hours). The continuous monitoring equipment was operated according to the AEP Air Monitoring Directive³ (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 Reno.

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 Reno air quality monitoring survey is presented in Table 3.2.

³ <http://aep.alberta.ca/air/objectives-directives-policies-and-standards/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	µg/m ³	4	FAQP-1.011
THC	TECO/51CLT	Parts per million (ppm)	4	FAQP-1.006
Wind Speed	Met One 010C	km/hr	10	FAQP-2.001
Wind Direction	Met One 020C	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	94.03%	89.06%	93.74%	94.20%	86.67%	79.80%	98.92%	92.88%
Not in Service	0.00%	0.00%	0.00%	0.00%	0.00%	14.54%	0.00%	0.00%
Daily Automated Zero/Span Sequence	4.27%	4.01%	4.25%	4.27%	0.00%	3.60%	0.00%	0.00%
Calibration	0.60%	0.72%	0.90%	0.47%	0.16%	0.67%	0.00%	0.00%
Not Valid ^a	0.00%	5.17%	0.00%	0.02%	11.86%	0.42%	0.04%	6.09%
Maintenance	0.05%	0.02%	0.05%	0.00%	0.25%	0.04%	0.00%	0.00%
Span (Used for Manual Span)	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
Power Failure	0.94%	0.90%	0.94%	0.94%	0.94%	0.92%	0.94%	0.94%
Data Acquisition Failure	0.09%	0.09%	0.09%	0.09%	0.09%	0.00%	0.09%	0.07%
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 4.1⁴. 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 (H₂S) and carbon disulphide (CS₂) are classified as reduced sulphur compounds and have AAAQOs. Of the NO_x compounds measured, only NO₂ has AAAQOs. Although, there is currently a 1-hour AAAQO for O₃, compliance or achievement is usually determined by the Canadian Ambient Air Quality Standards (CAAQS) for O₃ 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 µg/m³ but compliance or achievement is usually determined by the 24-hour average CAAQS for PM_{2.5} of 28 µg/m³ 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 µg/m³ which is based on the 3-year average of the annual average concentrations. There is currently a 1-hour AAAQG of 80 µg/m³ for PM_{2.5}. Since the Reno monitoring station only operated for about 8 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/objectives-directives-policies-and-standards/documents/AmbientAirQualityObjectives-Aug2013.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 ₂ S) 10 (CS ₂)	-	3 (H ₂ S)		
SO ₂	172	-	48	11	8
NO ₂	159	-	-	-	24
O ₃	82	63 (CAAQS) ¹	-	-	-
PM _{2.5}	80 (µg/m ³) (AAAQG)	-	30 (µg/m ³) 28 (µg/m ³) (CAAQS) ²	-	10 (µg/m ³) (CAAQS) ³
Note 1. Canadian Ambient Air Quality Standard (CAAQS) for O ₃ is based on the 3-year average of the annual 4th-highest daily maximum 8-hour average concentrations. 2. 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. 3. 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 CASA Data Warehouse⁵.

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 90th 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 Reno 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 SO₂, NO₂, and O₃. The closest passive station to the Reno monitoring location is the Jean Cote passive monitoring station which is 11.5 km to the west.

⁵ <http://www.casadata.org/Reports/SelectCategory.asp>

5.1 Meteorology

The following figures illustrate the meteorological conditions recorded at the Reno monitoring station during the period November 1, 2013 00:00 to June 19, 2014 09:00. Figure 5.1 shows that the most frequent winds were from the south-southeast. As well, the highest wind speeds most frequently occur from the southwest to northwest quadrant. Figure 5.2 shows the monthly temperature and wind speed distributions.

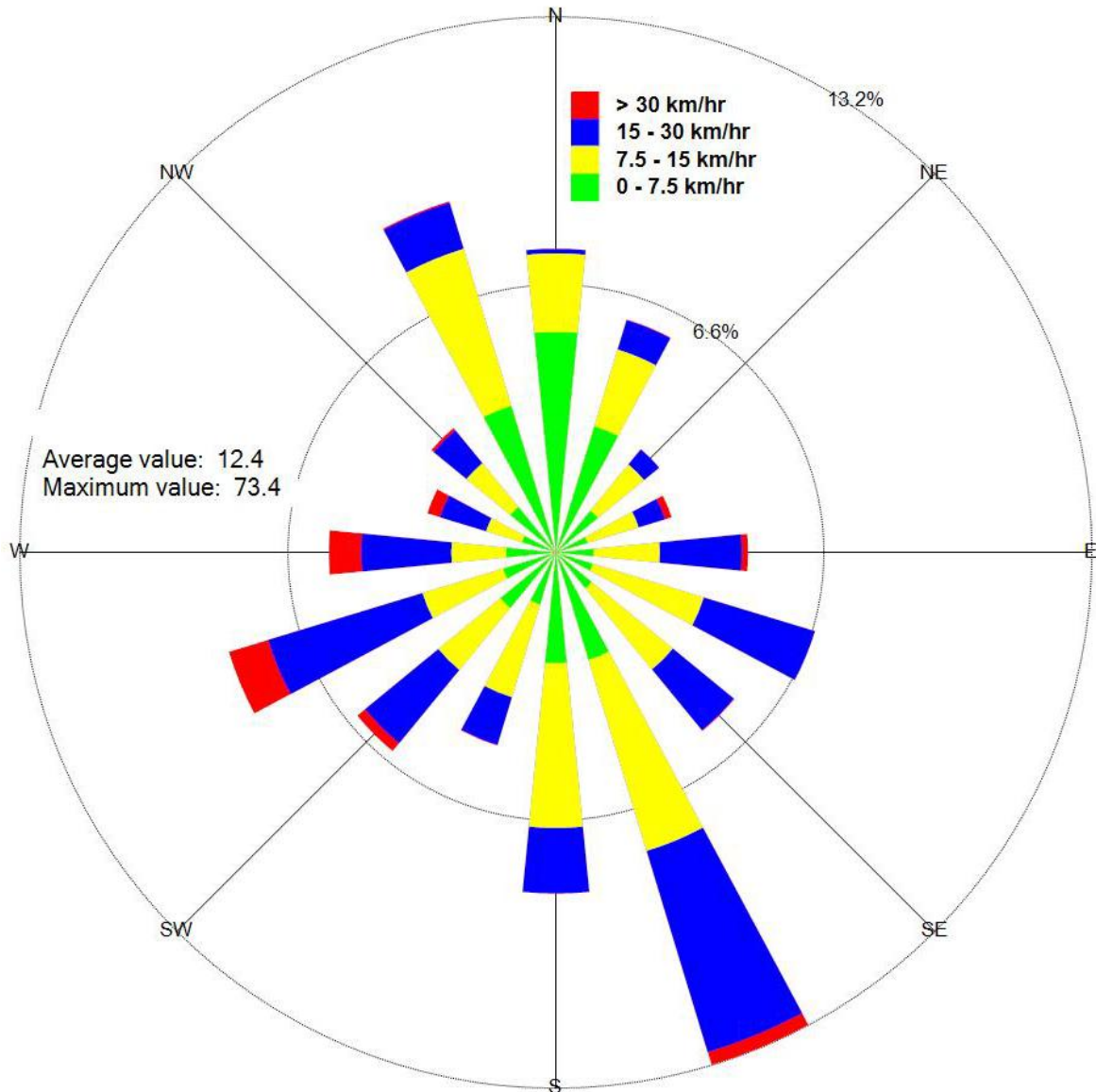


Figure 5.1 Wind Frequency Distribution at Reno Monitoring Station

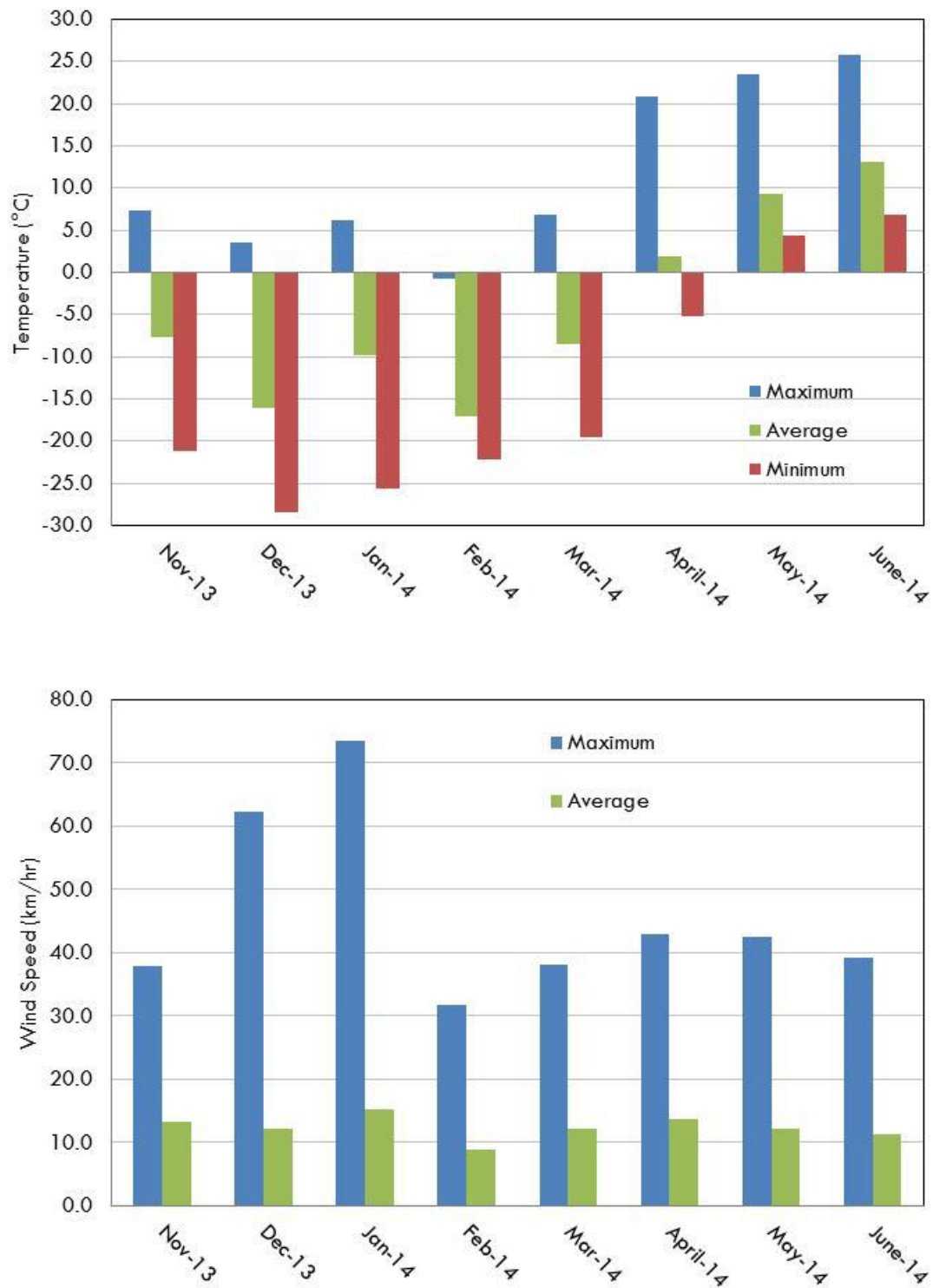


Figure 5.2 Monthly Temperature and Wind Speed Distribution Measured at Reno Monitoring Station

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 heavy 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 one occurrence in excess of 1 ppb (1.1 ppb) was 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 south-southeast. Figure 5.5 shows that the maximum recorded TRS concentration occurred for winds from the east-southeast but the average TRS concentrations do not appear to show a wind direction bias. Figure 5.6 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.

Figure 5.7 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 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 Reno are comparable to other areas where TRS are measured. The ambient TRS data measured at Reno appears to adequately reflect the general rural setting.

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

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

1-hour AAAQO	10 (H ₂ S and CS ₂)
Maximum 1-hour Measurement	1.1
99.9 th Percentile Measurement	0.81
99 th Percentile Measurement	0.63
90 th Percentile Measurement	0.41
Median Measurement	0.27
Average Measurement	0.28
24-hour AAAQO	3 (H ₂ S)
Maximum 24-hour Average Measurement	0.57

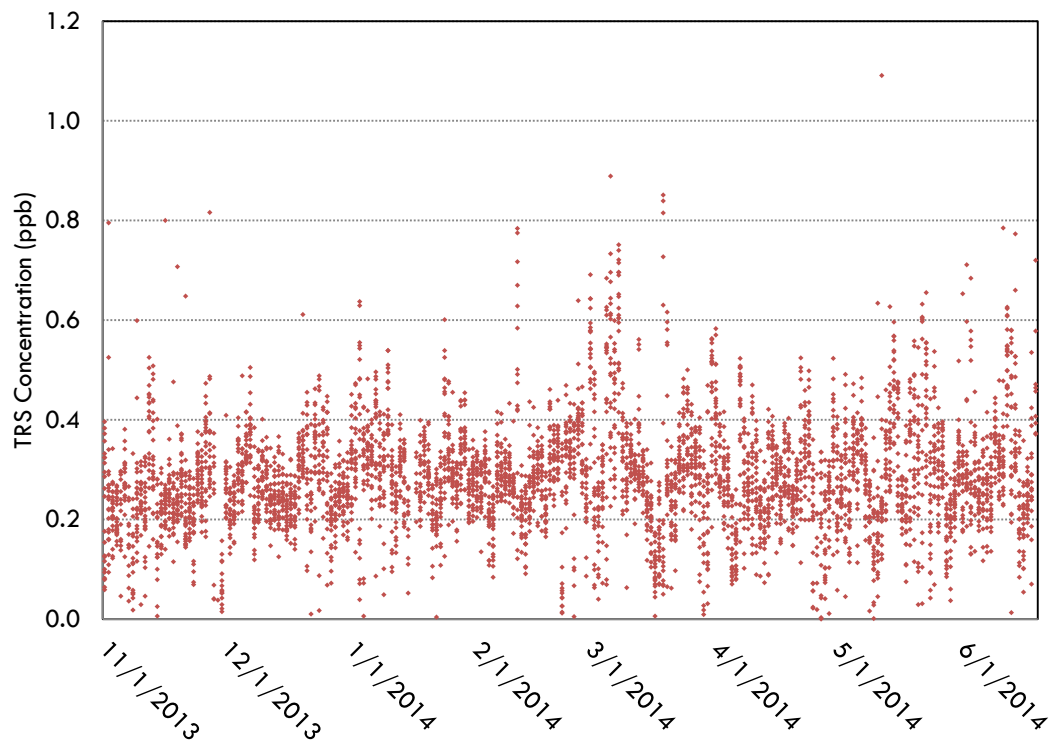


Figure 5.3 Time Series of the Hourly TRS Measurements

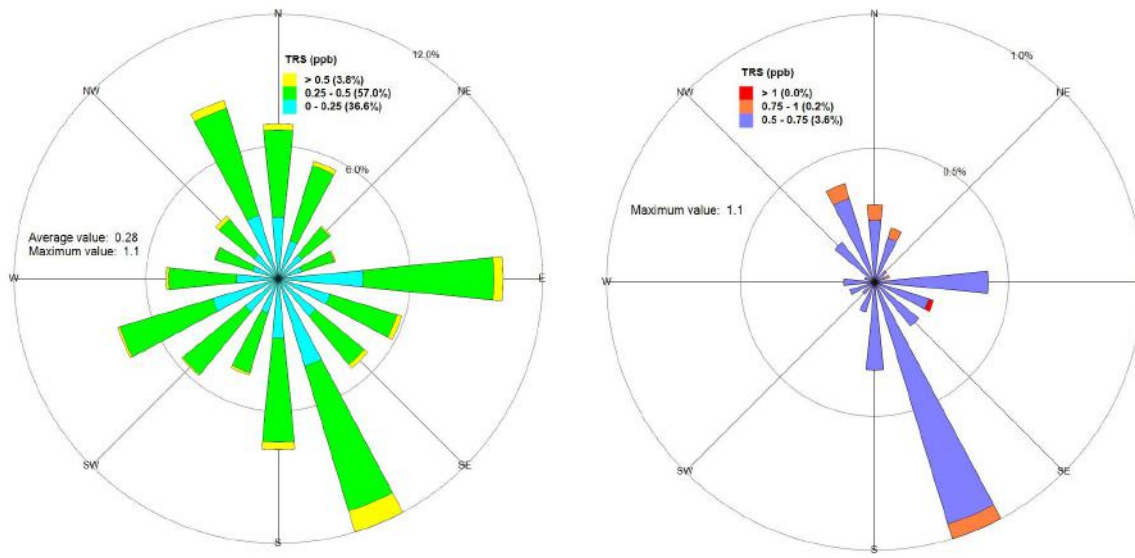


Figure 5.4 Frequency Distribution of TRS Measurements by Wind Direction

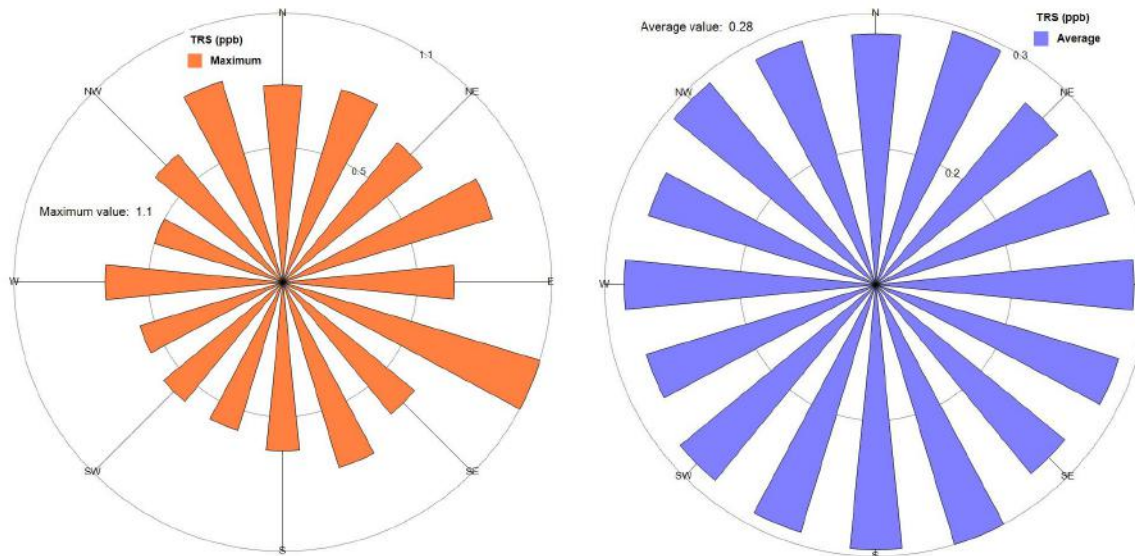


Figure 5.5 Maximum and Average TRS measurements by Wind Direction

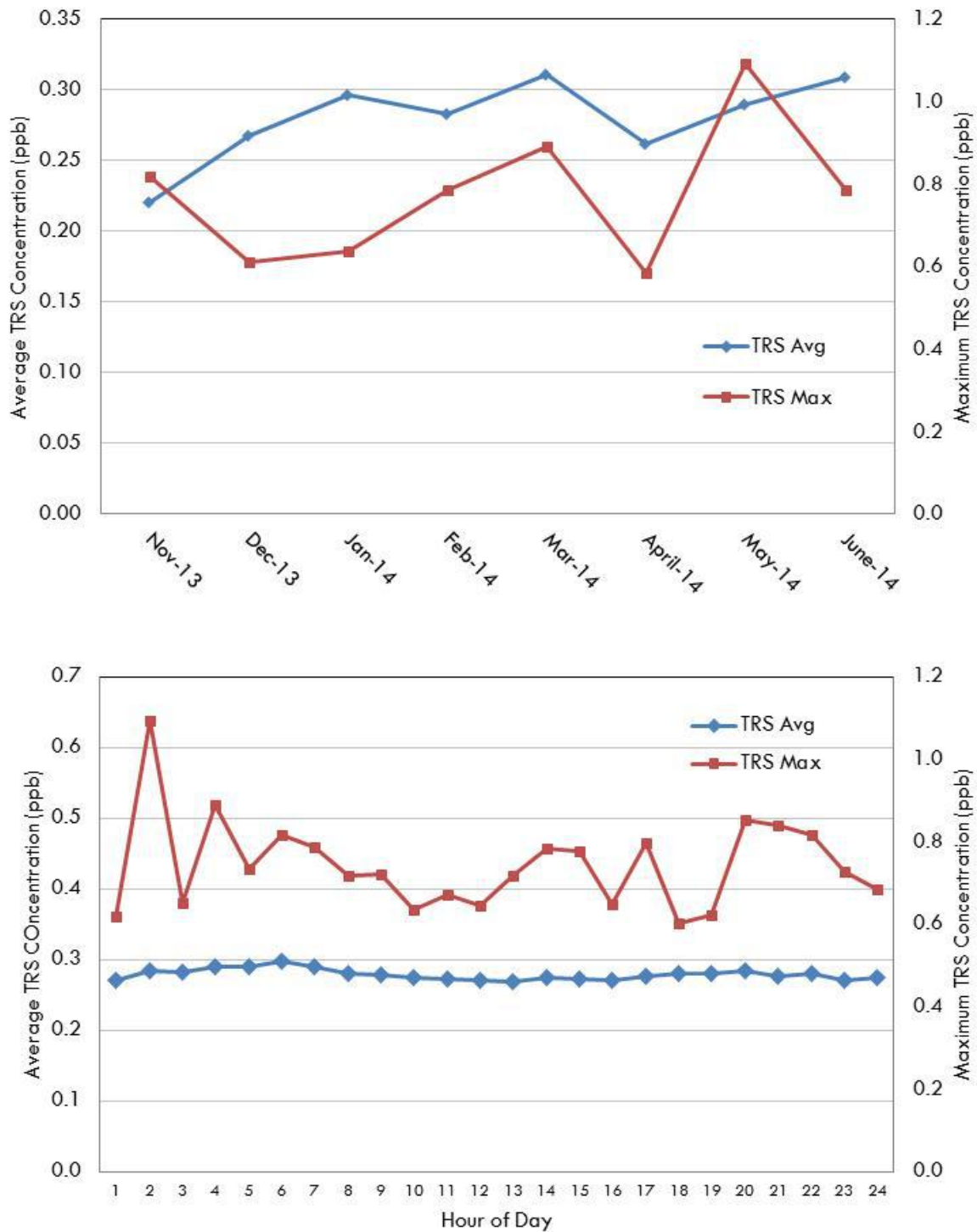


Figure 5.6 Maximum and Average TRS Measurements by Month and Hour of Day

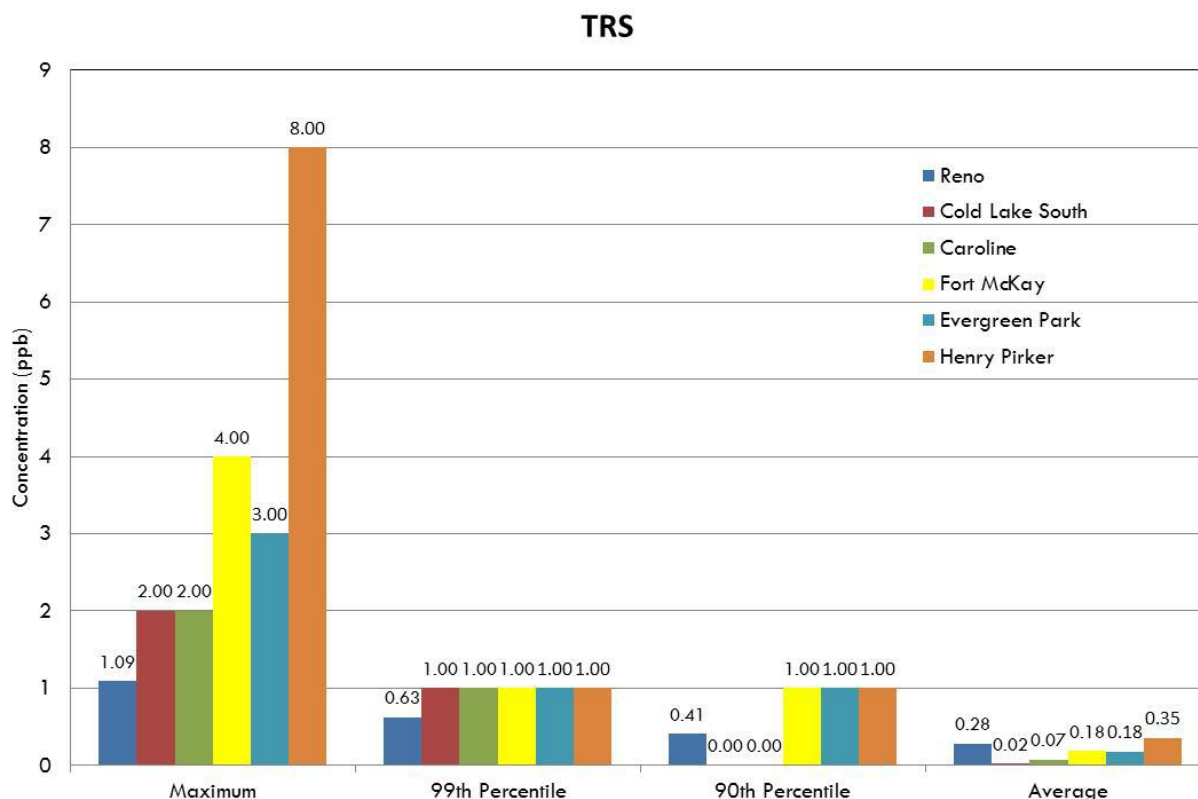


Figure 5.7 Comparison of TRS Measurements from other Continuous Monitoring Stations

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 SO₂ can affect human and environmental health.⁷

⁷ <http://aep.alberta.ca/air/objectives-directives-policies-and-standards/documents/AAQO-SulphurDioxide-Feb2011.pdf>

A summary of SO₂ measurements are shown in Table 5.2 and the time series of measurements are shown in Figure 5.8. The measurements were well below the SO₂ AAAQO in all instances. Figure 5.9 shows that most concentrations were less than 0.5 ppb. Figure 5.9 and Figure 5.10 indicate that the maximum measured SO₂ concentrations occur for winds from the southern sector. Highest average SO₂ concentrations show a slight trend to the southerly directions.

Figure 5.11 presents the maximum and average measured SO₂ 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 not consistent with the measurements from the closest passive monitor. The reasons for this were not investigated.

Figure 5.12 provides a comparison of SO₂ measurements from other monitoring stations in the province for the same time period. The figure shows that the measurements at Reno were lower when compared to other areas where SO₂ is measured.

The data indicates that SO₂ levels around Reno are generally low inferring that there are no significant sources of SO₂ in the area. The bias of higher concentrations toward certain wind direction may be a sign of influence from long range transport from other industrial sources within or outside of PAZA.

Table 5.2 Summary of SO₂ Measurements (ppb) at Reno Monitoring Station

1-hour AAAQO	172
30-day AAAQO	11
Annual AAAQO	8
Maximum 1-hour Measurement	5.1
99.9 th Percentile Measurement	3.3
99 th Percentile Measurement	1.8
90 th Percentile Measurement	0.6
Median Measurement	0.11
Average Measurement	0.24
Maximum Month Average	0.43
24-hour AAAQO	48
Maximum 24-hour Average Measurement	1.5

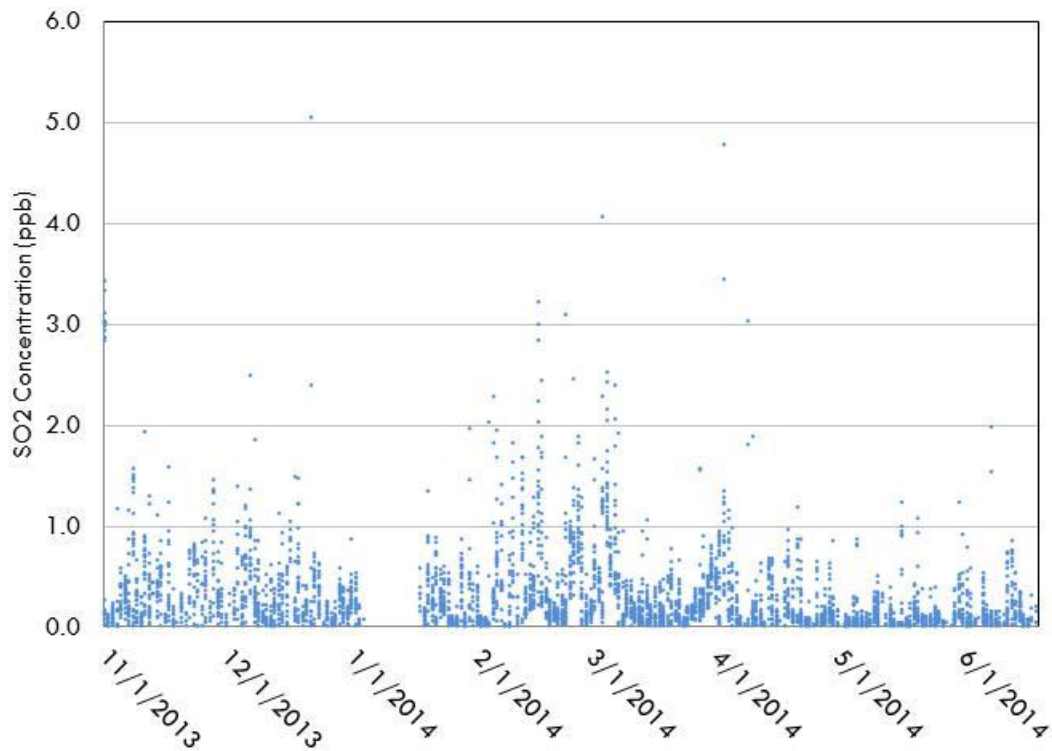


Figure 5.8 Time Series of the Hourly SO₂ Measurements

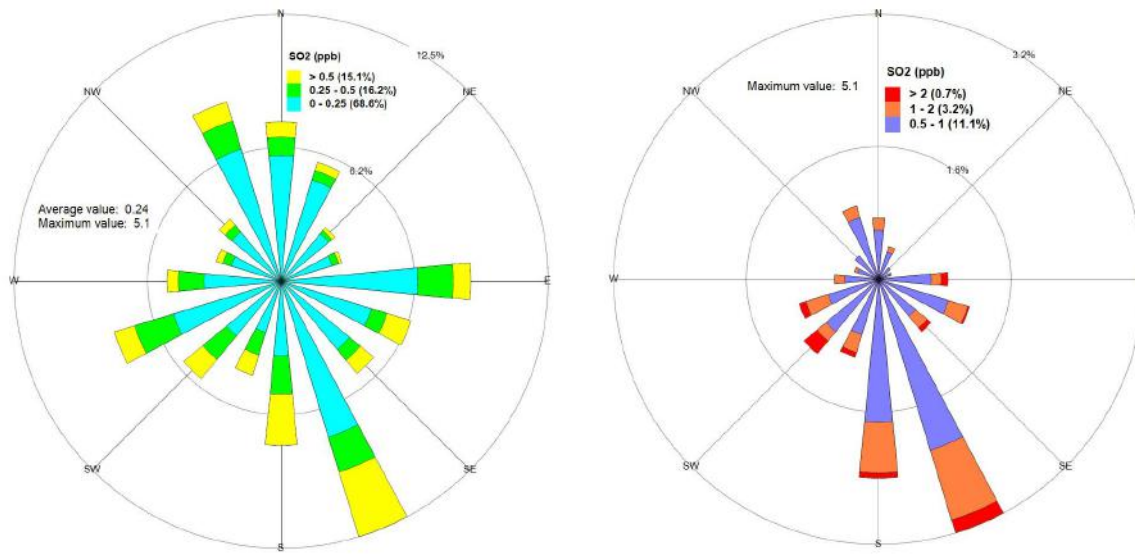


Figure 5.9 Frequency Distribution of SO₂ Measurements by Wind Direction

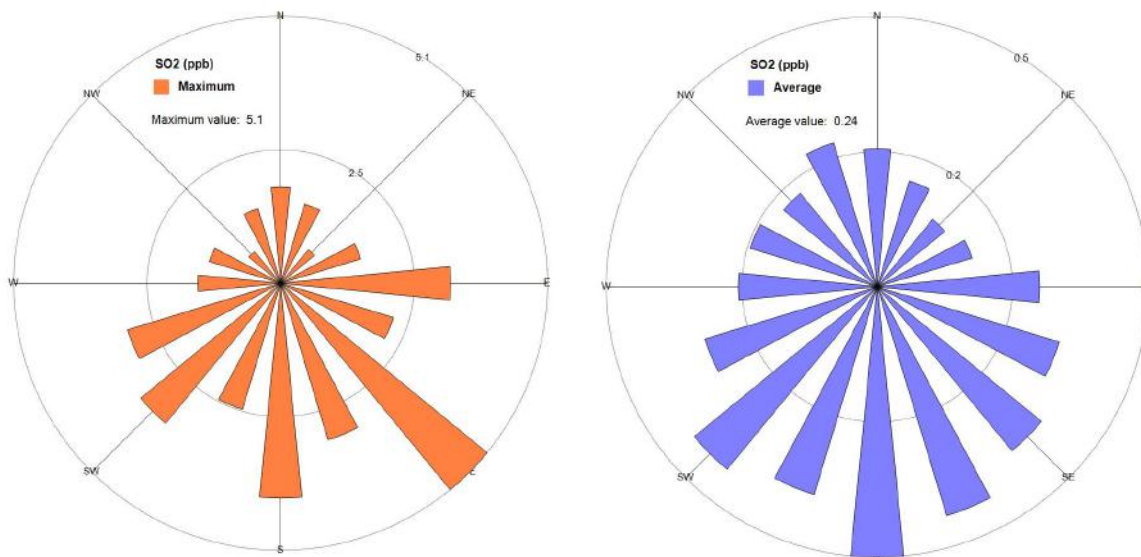


Figure 5.10 Maximum and Average SO₂ measurements by Wind Direction

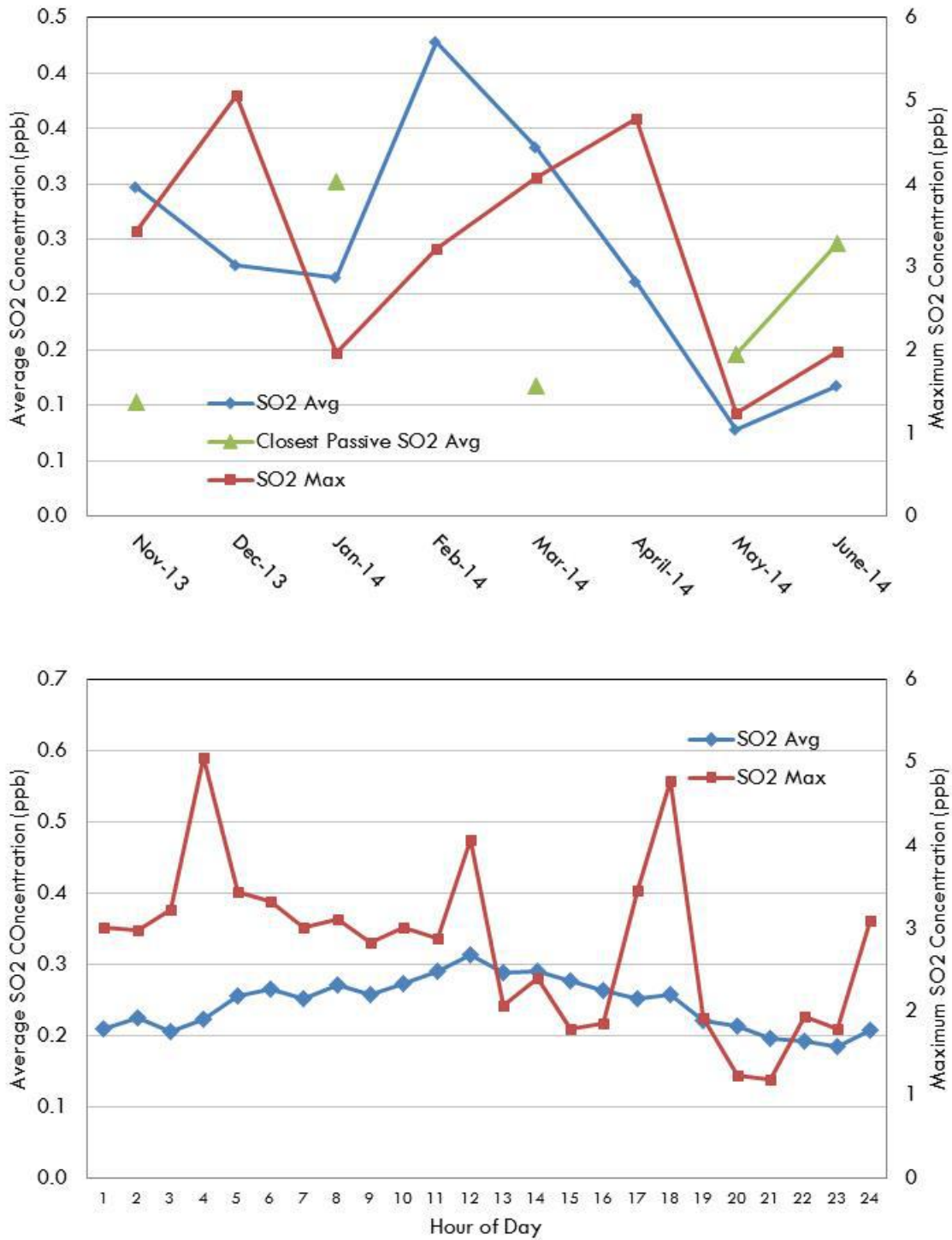


Figure 5.11 Maximum and Average SO₂ Measurements by Month and Hour of Day

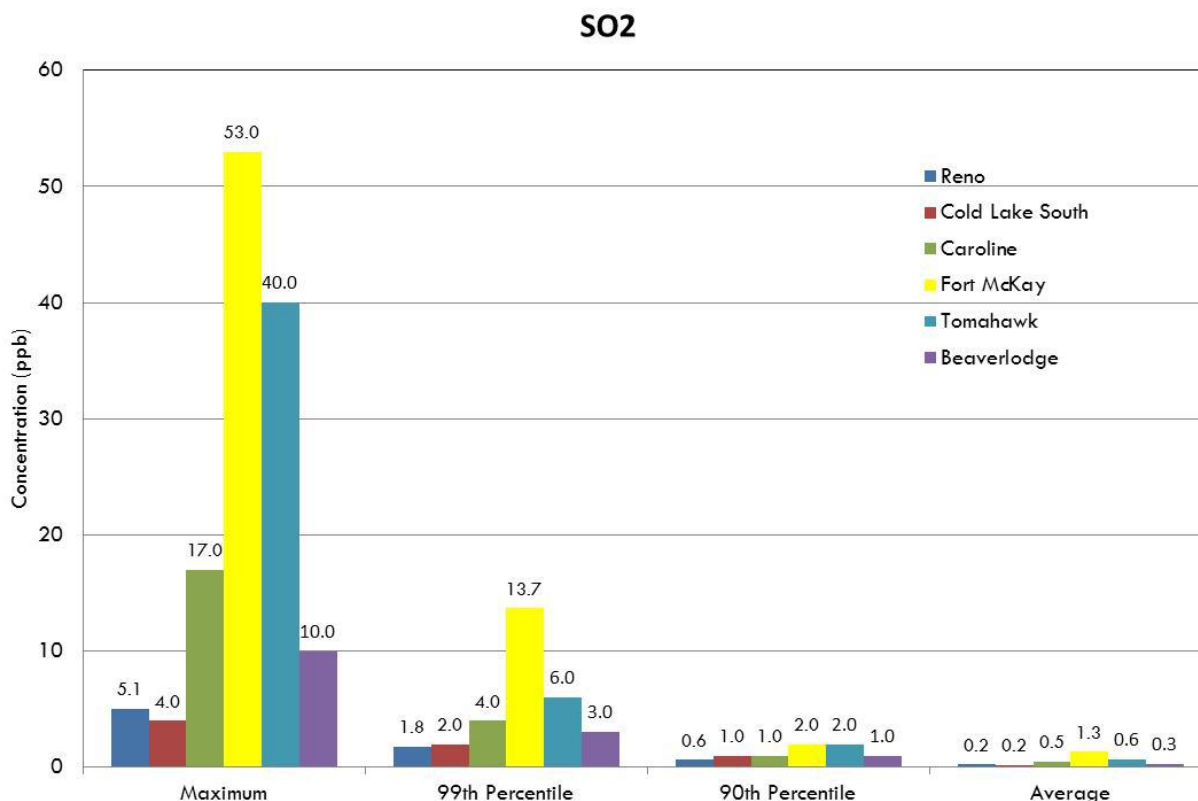


Figure 5.12 Comparison of SO₂ Measurements from other Continuous Monitoring Stations

5.4 Nitrogen Oxides

Nitrogen dioxide (NO₂) 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% NO₂. NO is oxidized to NO₂ 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 NO₂ only. Therefore, a summary of the NO_x measurements is restricted to NO₂. NO₂ 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, NO₂ can have respiratory effects on humans on which the 1-hour

AAAQO is based. On a long term basis, NO₂ can have detrimental effects on vegetation which is reflected in the annual AAAQO.⁸

A summary of NO₂ measurements are shown in Table 5.3 and the time series of measurements are shown in Figure 5.13. The measurements were below the NO₂ AAAQO in all instances. Figure 5.14 shows that most concentrations were less than 5 ppb. Figure 5.14 indicates that the most frequent high concentrations are occurring for winds from the south sector. The average NO₂ concentrations as seen in Figure 5.15 also show the influence from the south quadrant.

Figure 5.16 presents the maximum and average measured NO₂ concentrations as a function of month and hour of day. No discernible trend is noted in the monthly data. The diurnal pattern of average NO₂ values shows a definite decrease during the daytime suggesting that complex atmospheric processes in sunlight (discussed in the ozone section) may be occurring. The figure shows that the average monthly concentrations are consistently higher (except for April and May) than the closest passive monitor. The reasons for this were not investigated.

Figure 5.17 provides a comparison of NO₂ measurements from other monitoring stations in the province for the same time period. The figure shows that NO₂ levels at Reno were lower when compared to other areas in the province.

The ambient NO₂ data measured in Reno appears to adequately reflect the general rural setting. The bias of higher concentrations with southerly winds may suggest that the larger communities of Falher, Donnelly and McLennan may be contributing to the measurements.

⁸ <http://aep.alberta.ca/air/objectives-directives-policies-and-standards/documents/AAQO-NitrogenDioxide-Jun2011.pdf>

Table 5.3 Summary of NO₂ Measurements (ppb) at Reno Monitoring Station

1-hour AAAQO	159
Annual AAAQO	24
Maximum 1-hour Measurement	23.7
99.9 th Percentile Measurement	17.9
99 th Percentile Measurement	11.5
90 th Percentile Measurement	5.9
Median Measurement	1.7
Average Measurement	2.6

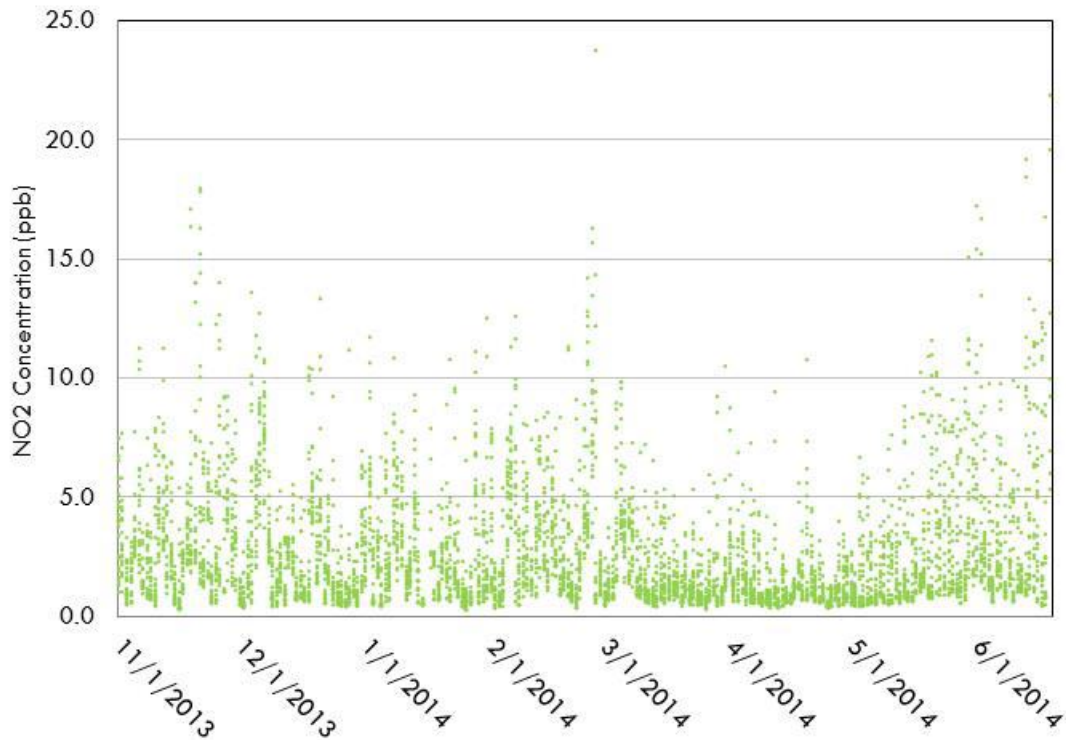


Figure 5.13 Time Series of the Hourly NO₂ Measurements

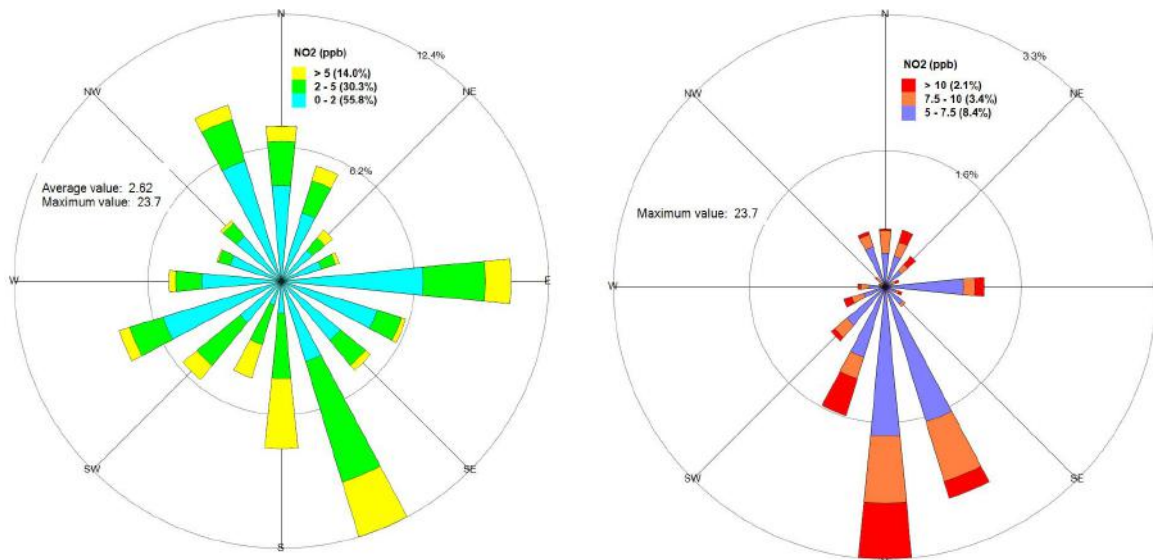


Figure 5.14 Frequency Distribution of NO₂ Measurements by Wind Direction

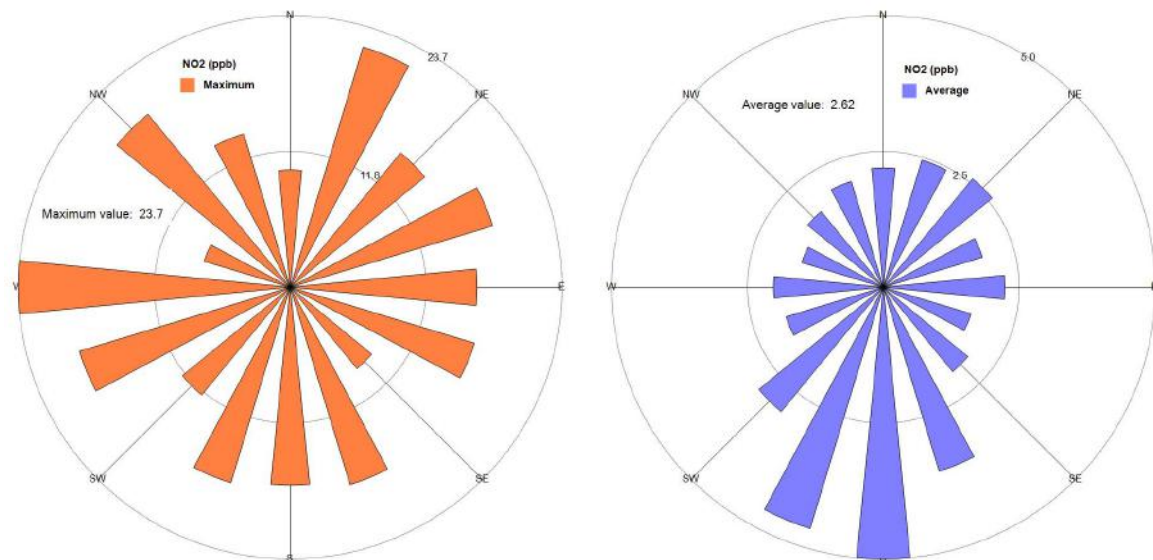


Figure 5.15 Maximum and Average NO₂ measurements by Wind Direction

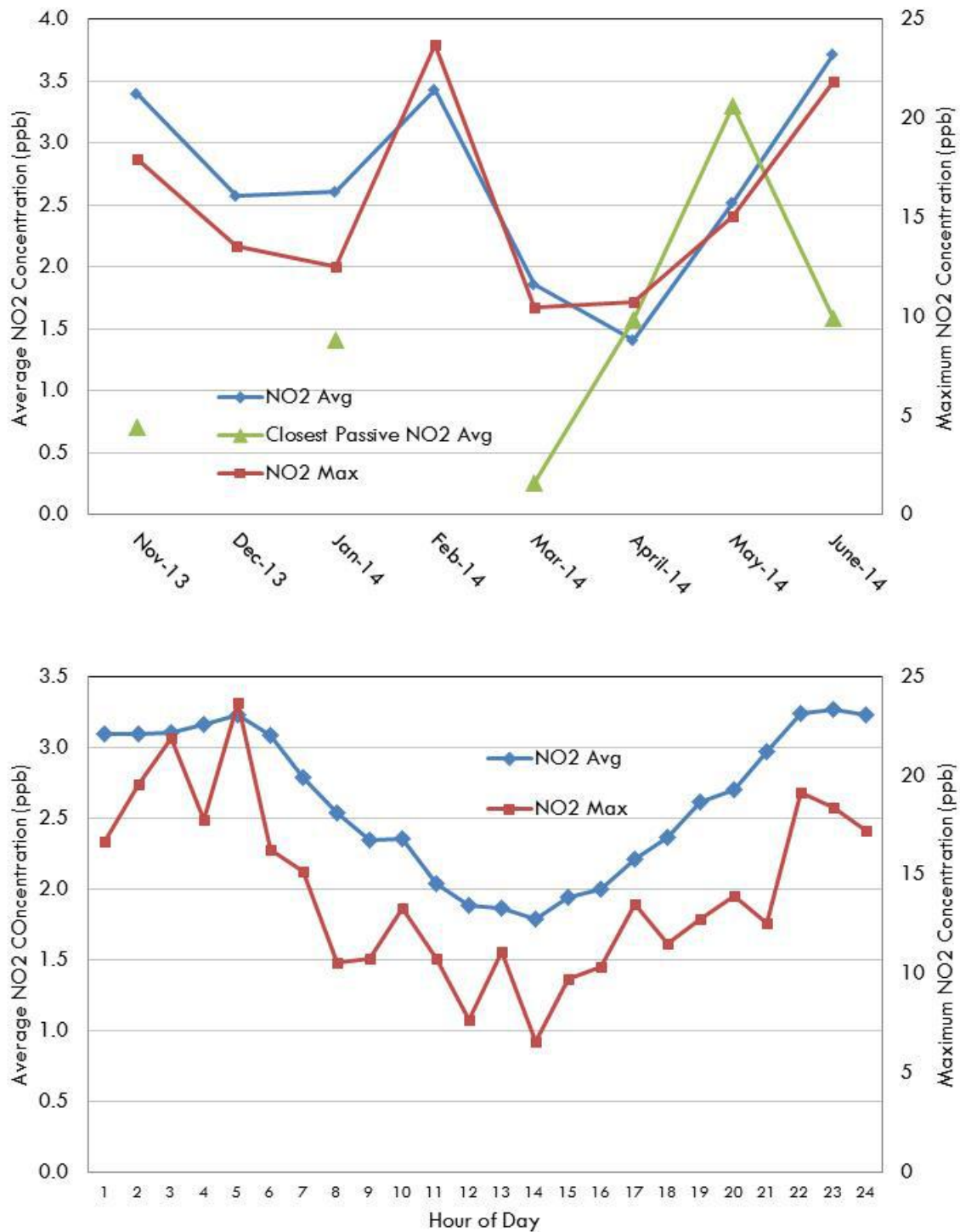


Figure 5.16 Maximum and Average NO₂ Measurements by Month and Hour of Day

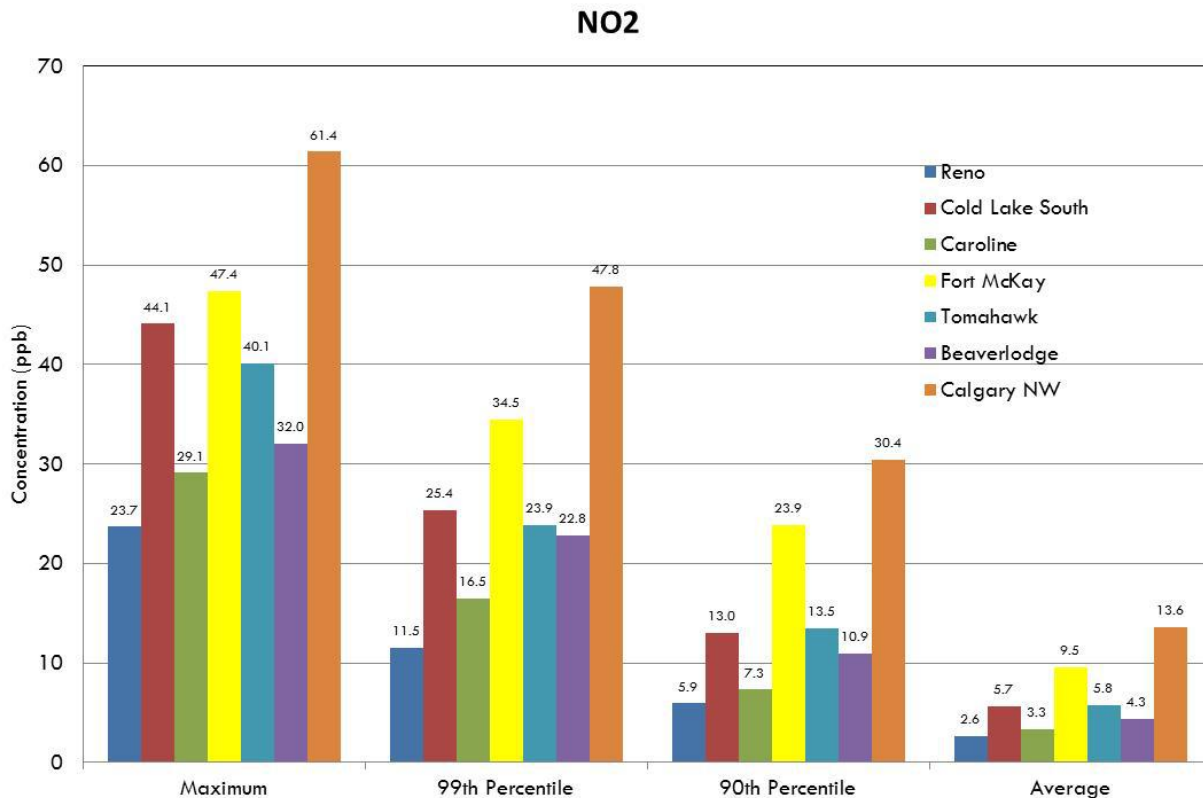


Figure 5.17 Comparison of NO₂ Measurements from other Continuous Monitoring Stations

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 O₃ measurements are shown in Table 5.4 and the time series of measurements are shown in Figure 5.18. The measurements were below the 1-hour AAAQO in all instances. The 4th highest 8-hr daily average over the monitoring period is less 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 Reno monitor operated for only 8 months and any measurements that were influenced by natural sources have not been removed, and therefore, the results cannot be explicitly related to the CAAQS.

It is noted that the measurements starting in the middle of May 2014 show a wider range of values that was not typically seen in the other months nor in other previous rover data. This is an indicator of maintenance required on the analyser, which was performed subsequent to station shutdown. The significance of this on the results was not investigated nor considered.

Figure 5.19 presents the frequency distribution of O₃ measurements by wind direction. Figure 5.20 presents the maximum and average O₃ measurements by wind direction. There appears to be a slight bias of higher average values with westerly winds. The most frequent O₃ concentrations above 40 ppb are occurring during winds from the west-southwest.

Figure 5.21 presents the maximum and average measured O₃ concentrations as a function of month and hour of day. Also seen, is a typical diurnal pattern of O₃ where O₃ is decomposed to O₂ through a reaction with NO in the early morning and then created during the day in complex reactions with VOCs and NO₂ in the presence of sunlight. The figure shows that the average monthly concentrations appear to show the same trend as the closest passive monitor.

Figure 5.22 provides a comparison of O₃ measurements from other monitoring stations in the province for the same time period. The figure shows that other O₃ levels at Reno were comparable to other areas in the province.

Figure 5.23 presents the diurnal relationships between NO, NO₂, and O₃ at the Reno monitoring station for the entire period, and for the months of December, March and May. The figures show the complex relationship between these pollutants that lead to O₃ formation.

The ambient O₃ data measured in Reno appears to adequately reflect the general rural setting. Although the data is showing ozone formation and decomposition due to complex relationship with atmospheric NO_x and VOC, the O₃ levels are below the AAAQO.

⁹ <http://aep.alberta.ca/air/objectives-directives-policies-and-standards/documents/AAQO-Ozone-Feb2007.pdf>

Table 5.4 Summary of O₃ Measurements (ppb) at Reno Monitoring Station

1-hour AAAQO	82
Maximum 1-hour Measurement	55.8
99.9 th Percentile Measurement	54.1
99 th Percentile Measurement	51.7
90 th Percentile Measurement	43.5
Median Measurement	33.1
Average Measurement	32.4
8-hour CAAQS	63
4 th Highest Daily 8-hour Measurement ^a	52.0
a. This value was calculated for presentation purposes only and cannot be directly compared to the CAAQS	

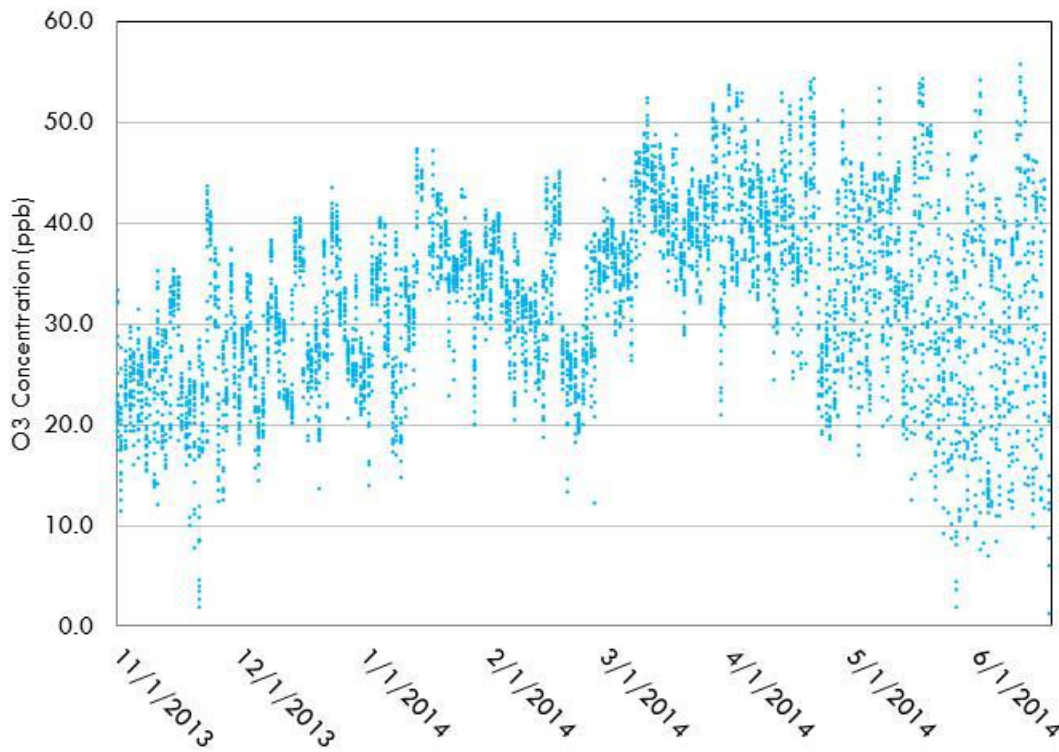


Figure 5.18 Time Series of the Hourly O₃ Measurements

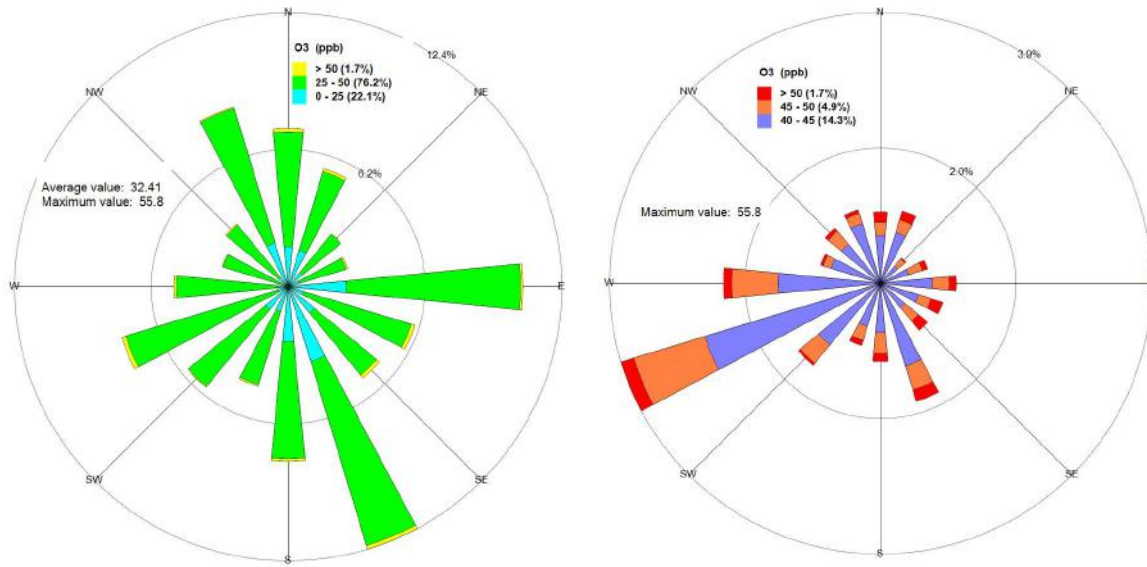


Figure 5.19 Frequency Distribution of O₃ Measurements by Wind Direction

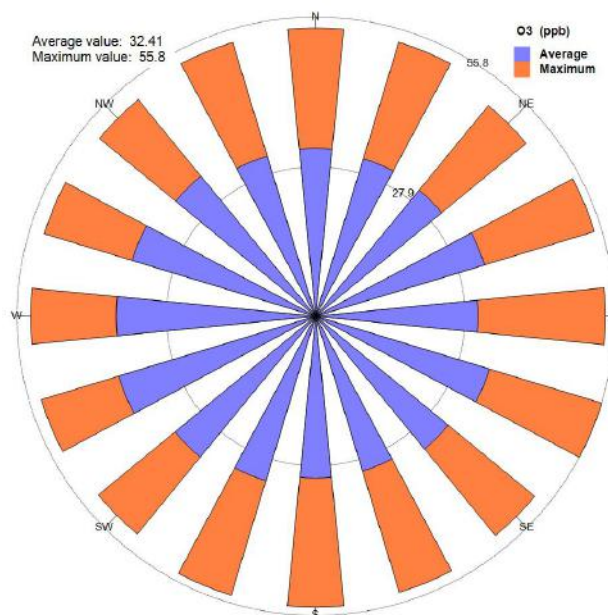


Figure 5.20 Maximum and Average O₃ Measurements by Wind Direction

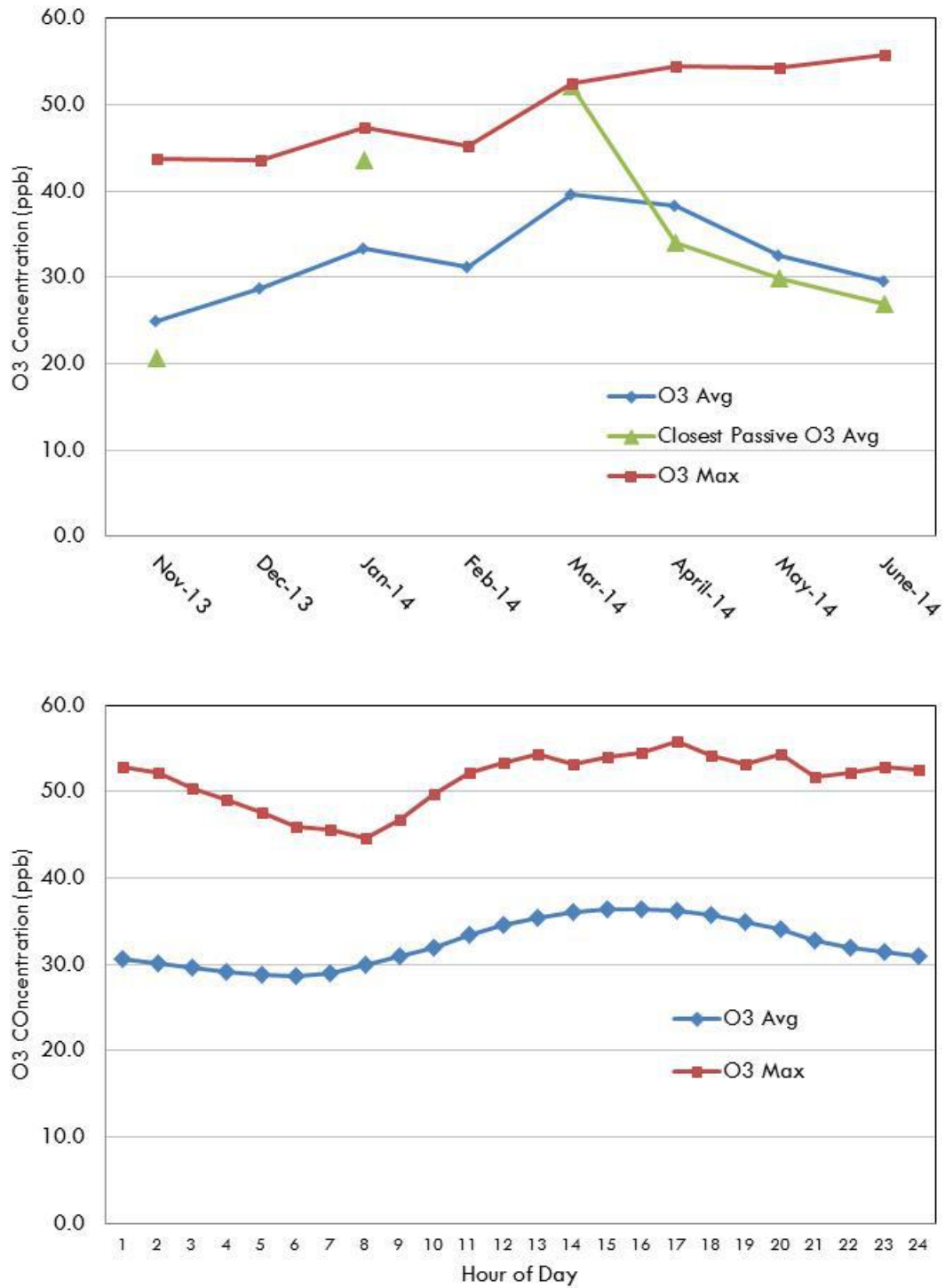


Figure 5.21 Maximum and Average O₃ Measurements by Month and Hour of Day

O₃

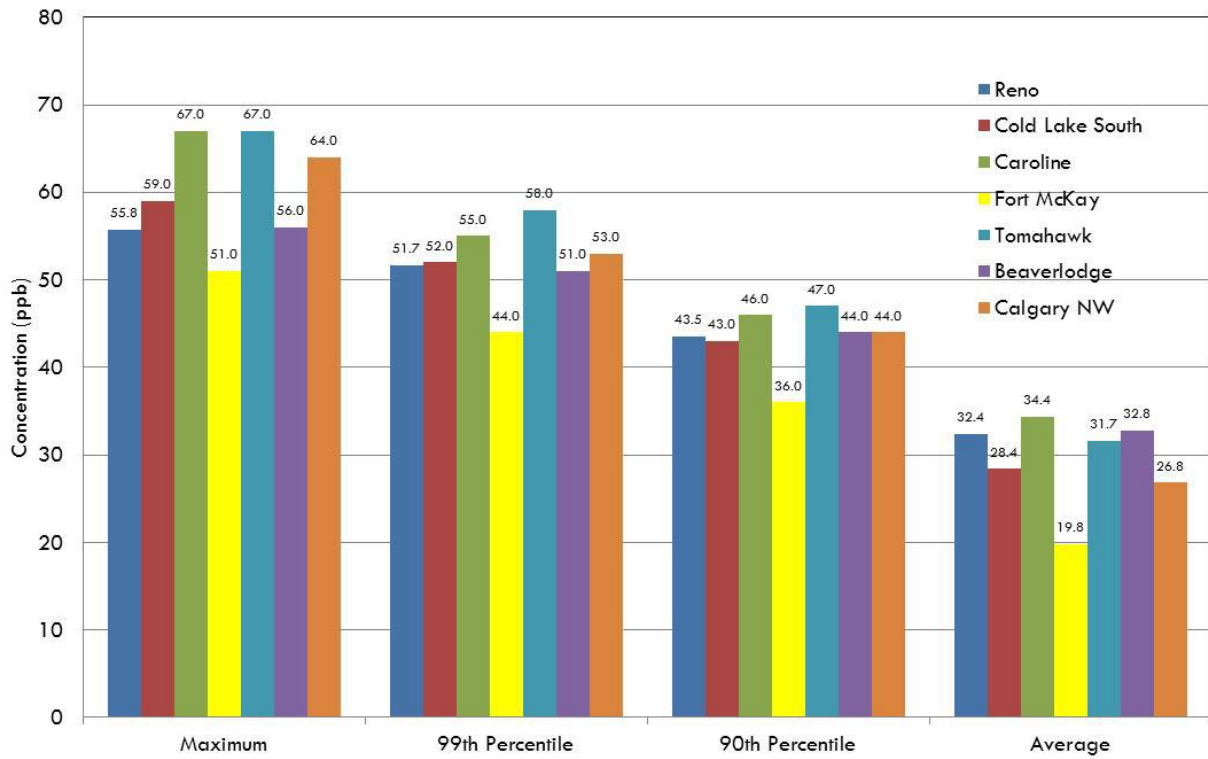


Figure 5.22 Comparison of O₃ Measurements from other Continuous Monitoring Stations

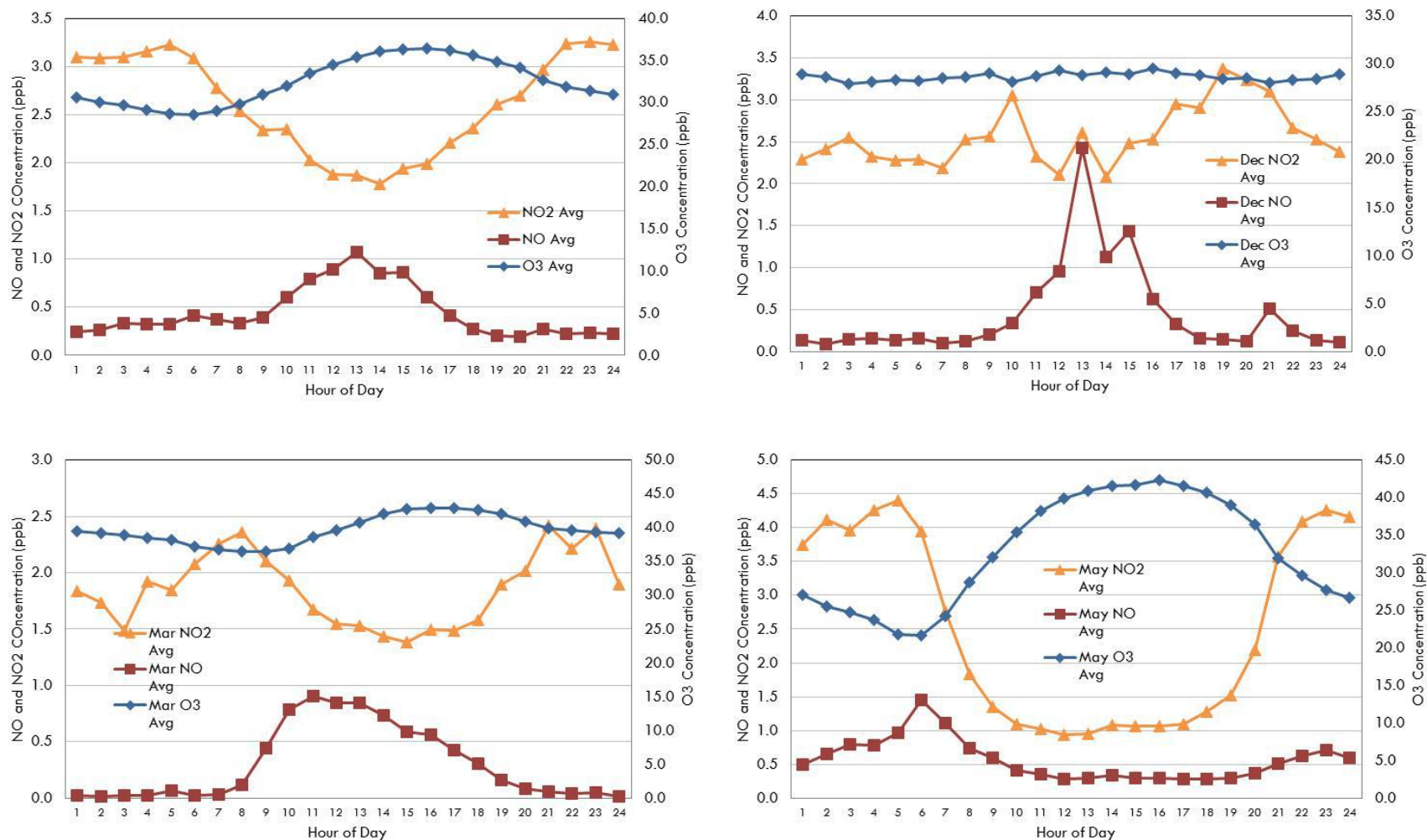


Figure 5.23 Diurnal Relationship between Measured O₃, NO, and NO₂ concentrations for entire period and selected months.

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 5.24. (All measurements before November 26, 2013 18:00 were classified as “not valid” due to a dying sensor). All measurements were below the 1-hour AAAQG. Calculations of the 24-hour averages from the 1-hour measurements indicate that the 24-hour PM_{2.5} AAAQO was not exceeded during the monitoring period.

The 98th percentile 24-hour average over the monitoring period is below the CAAQS of $28 \mu\text{g}/\text{m}^3$. The average PM_{2.5} measurement is below the annual CAAQS of $10 \mu\text{g}/\text{m}^3$. The CAAQS criteria is based on 3 year averages and removes all elevated measurements due to exceptional events such as forest fires. The Reno monitor operated for only 8 months and any measurements that were influenced by natural sources have not been removed, and therefore, the results cannot be explicitly related to the CAAQS.

Figure 5.25 shows that most concentrations were less than $10 \mu\text{g}/\text{m}^3$ and indicates that the highest concentrations occur for northerly and southerly winds. Figure 5.26 confirms that the maximum and highest average measurements also occur for northerly and southerly winds. 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 5.27 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.

Figure 5.28 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 Reno were lower when compared to other areas in the province.

The ambient PM_{2.5} data measured in Reno appears to adequately reflect the general rural setting.

¹⁰ <http://aep.alberta.ca/air/objectives-directives-policies-and-standards/documents/AAQO-FineParticulateMatter-Feb2007.pdf>

Table 5.5 Summary of PM_{2.5} Measurements (µg/m³) at Reno Monitoring Station

1-hour AAAQG	80
24-hour AAAQO	30
24-hour CAAAQ	28
Annual CAAQS	10
Maximum 1-hour Measurement	28.6
99.9 th Percentile Measurement	17.5
99 th Percentile Measurement	10.2
90 th Percentile Measurement	4.6
Median Measurement	1.4
Average Measurement	2.0
Maximum 24-hour Average Measurement	10.3
98 th Percentile 24-hour Average Measurement	5.6

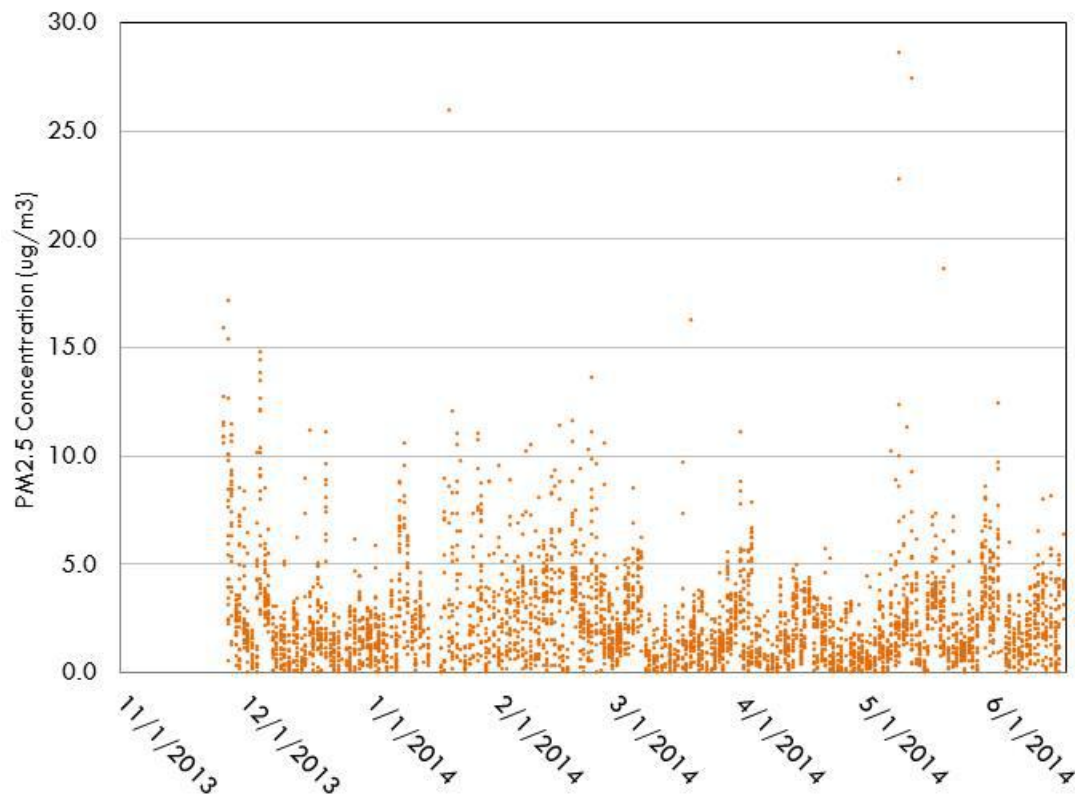


Figure 5.24 Time Series of the Hourly PM_{2.5} Measurements

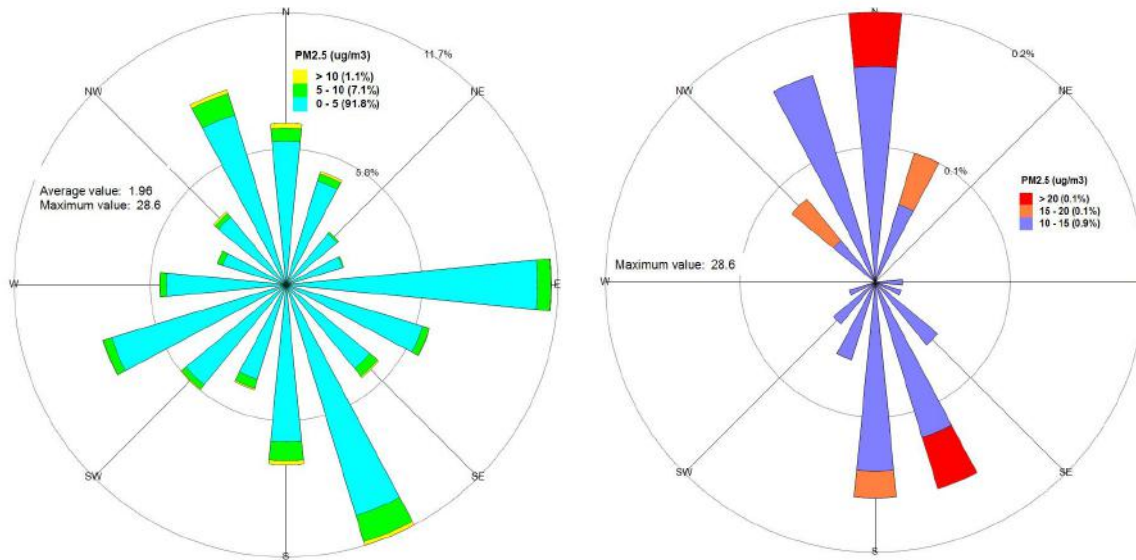


Figure 5.25 Frequency Distribution of PM_{2.5} Measurements by Wind Direction

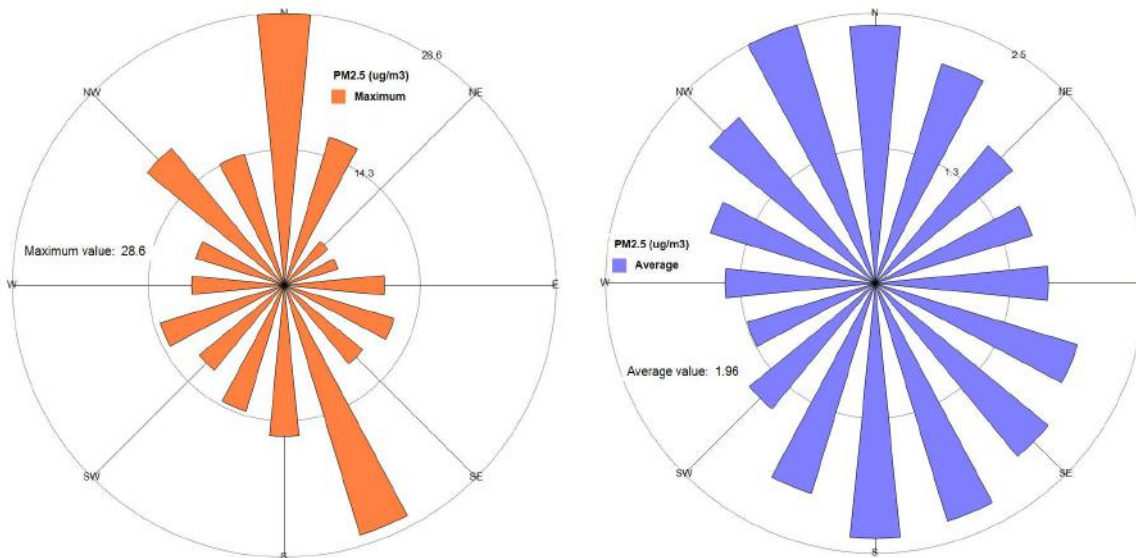


Figure 5.26 Maximum and Average PM_{2.5} measurements by Wind Direction

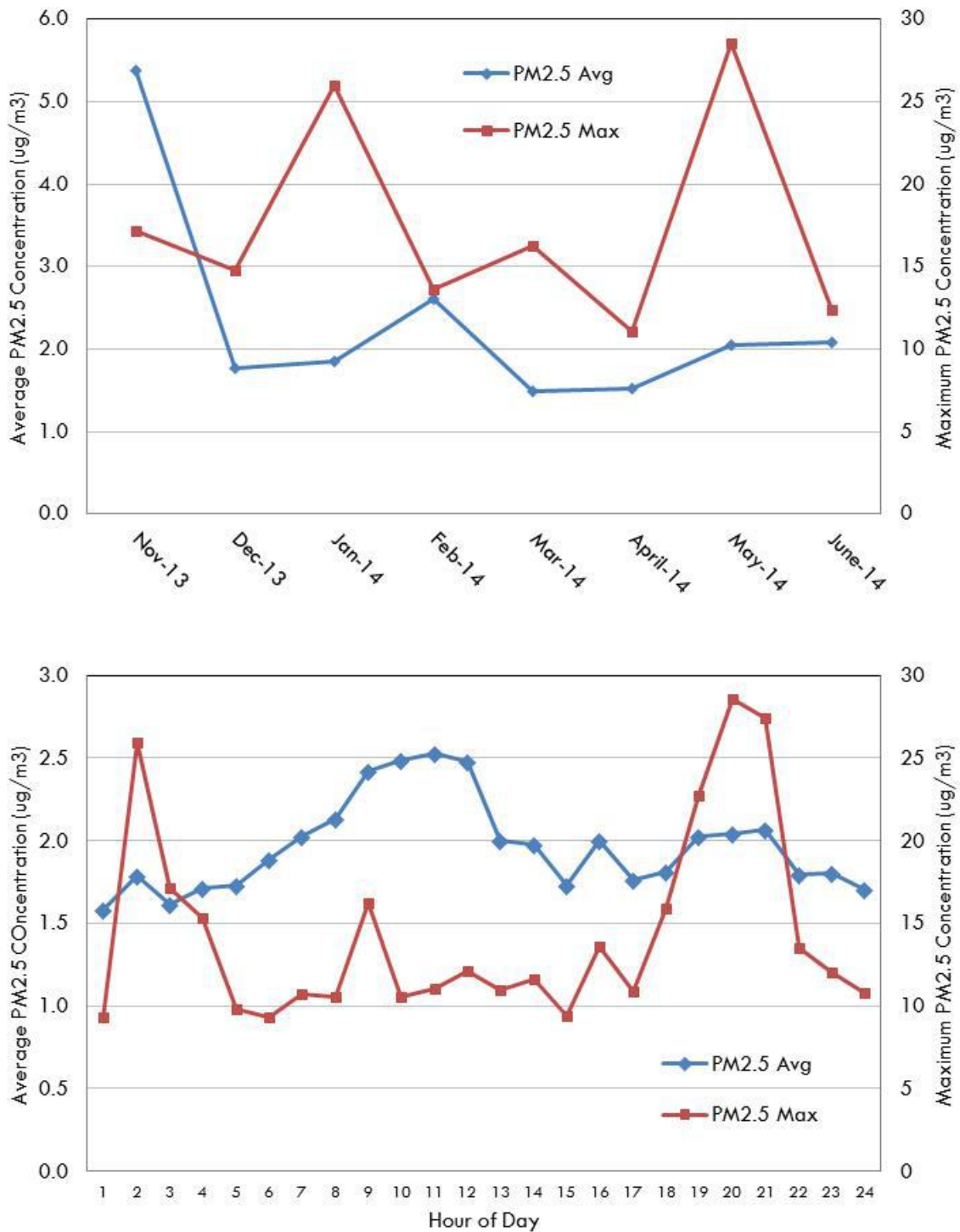


Figure 5.27 Maximum and Average PM_{2.5} Measurements by Month and Hour of Day

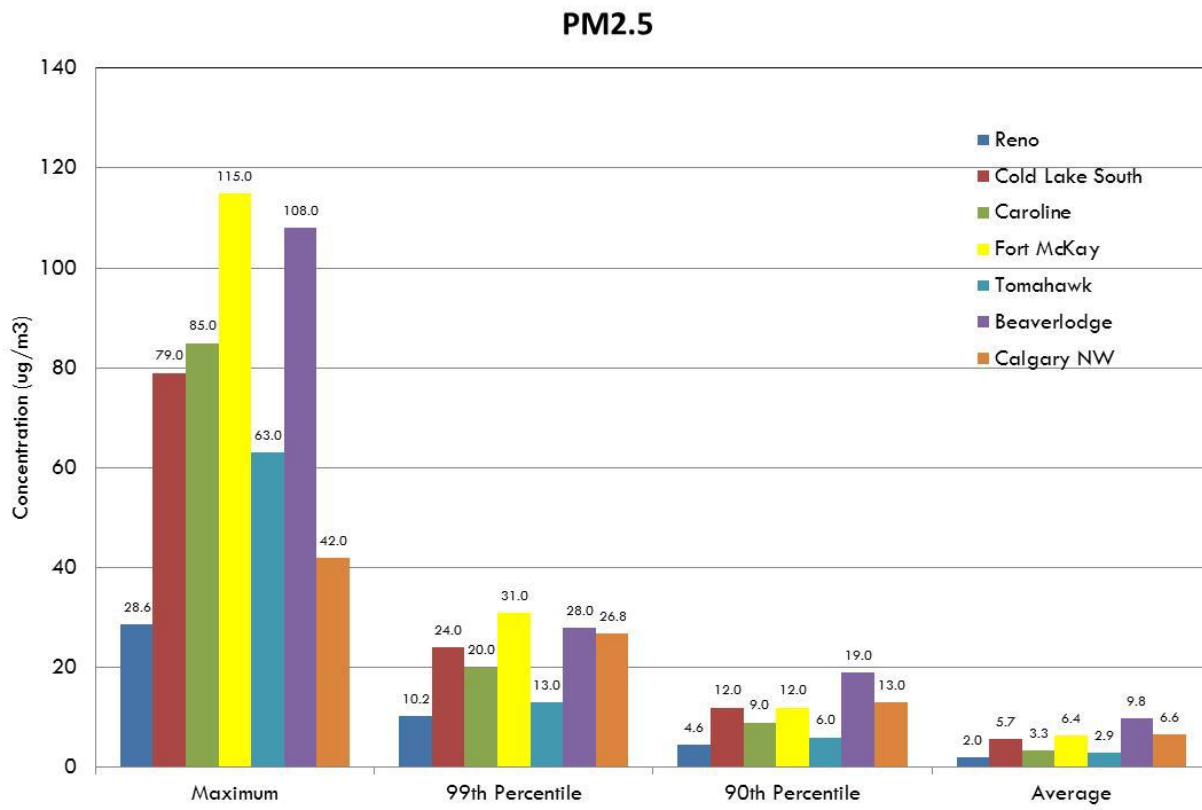


Figure 5.28 Comparison of PM_{2.5} Measurements from other Continuous Monitoring Stations

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 in 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 5.29. Sampling of THC did not begin until December 4, 2013 18:00. Almost all measurements were above 1.8 ppm. Average and median values were both 2.1 ppm.

Figure 5.30 presents the frequency distribution of THC measurements by wind direction. Figure 5.31 presents the maximum and average THC measurements by wind direction. The data indicates that the maximum values occur from the north or from the east. The average values are consistent over all wind directions.

Figure 5.32 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. Diurnal profiles indicate average THC values to be consistent over all hours.

Figure 5.33 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 Reno were comparable to other areas in the province. However, it is noted that the average THC level at Reno was marginally higher than the other 3 sites.

The ambient THC data measured in Reno appears to adequately reflect the general rural setting. Although the THC data measured is consistent with average rural Alberta, and other sites in

¹¹ <http://www.casadata.org/pollutants/hydrocarbons.asp>

province, average values were very slightly higher. 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 Reno Monitoring Station

Maximum 1-hour Measurement ^a	3.6
99.9 th Percentile Measurement	2.9
99 th Percentile Measurement	2.6
90 th Percentile Measurement	2.3
Median Measurement	2.1
Average Measurement	2.1
Normal THC background levels in Rural Alberta	1.5 – 2.0 ¹²
a. There are no AAAQOs for THC are its main constituent (Methane)	

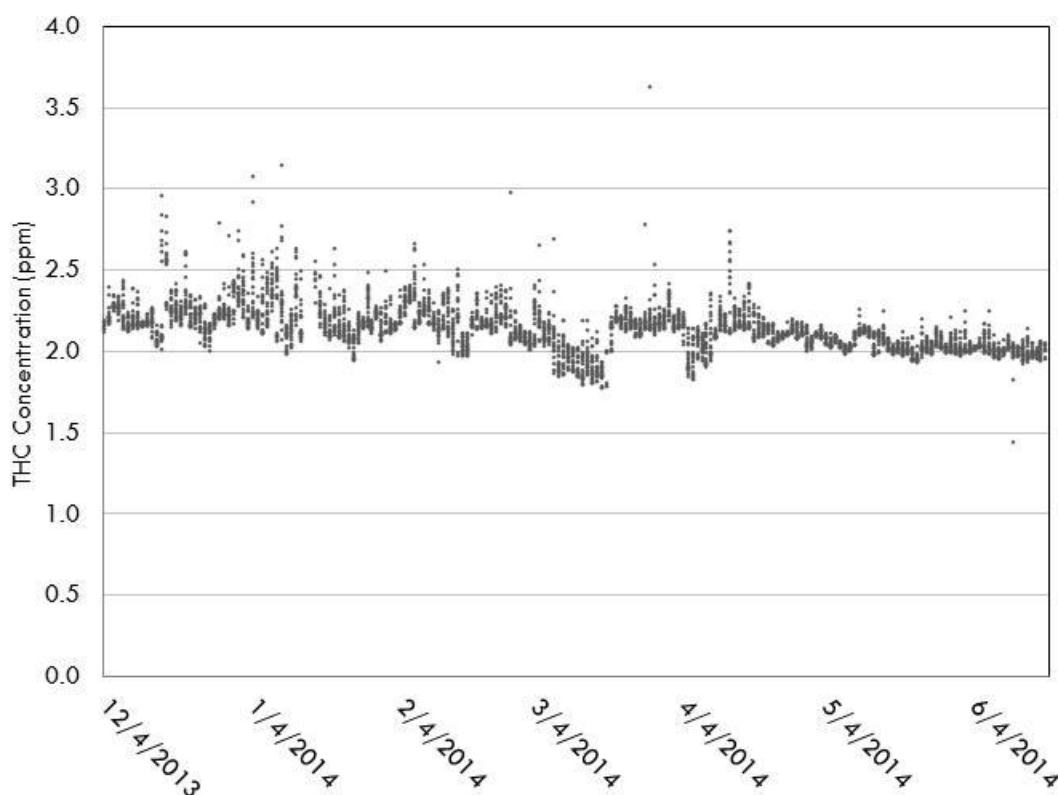


Figure 5.29 Time Series of the Hourly THC Measurements

¹² <http://www.casadata.org/pollutants/hydrocarbons.asp>

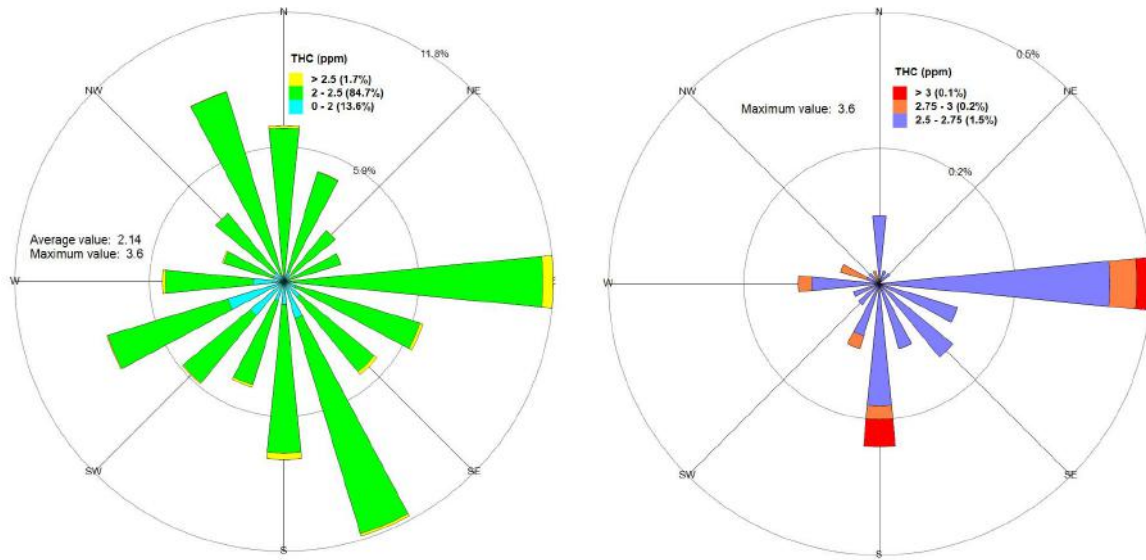


Figure 5.30 Frequency Distribution of THC Measurements by Wind Direction

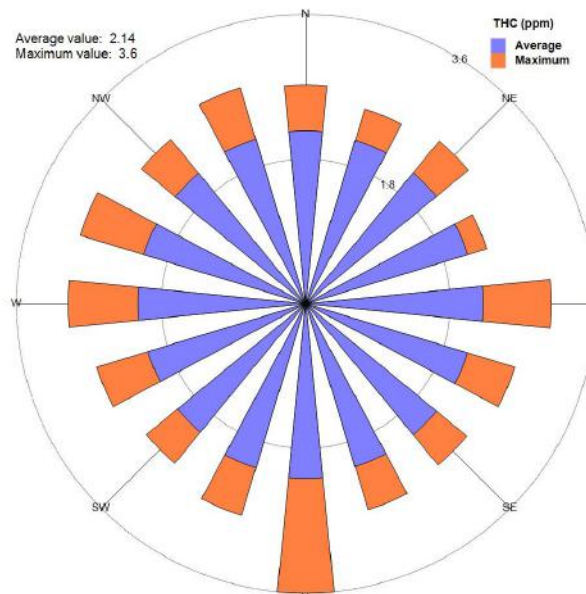


Figure 5.31 Maximum and Average THC Measurements by Wind Direction

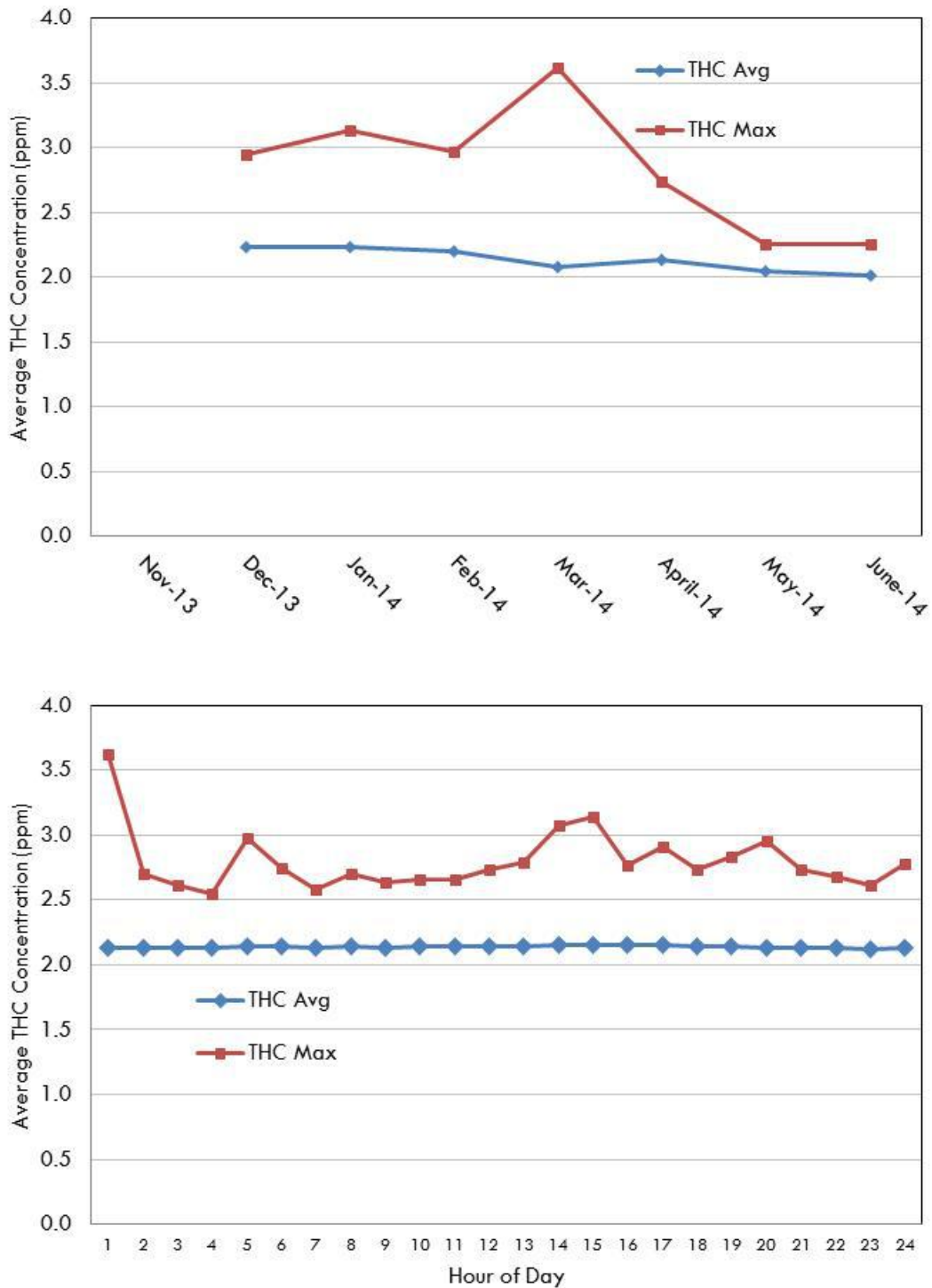


Figure 5.32 Maximum and Average THC Measurements by Month and Hour of Day

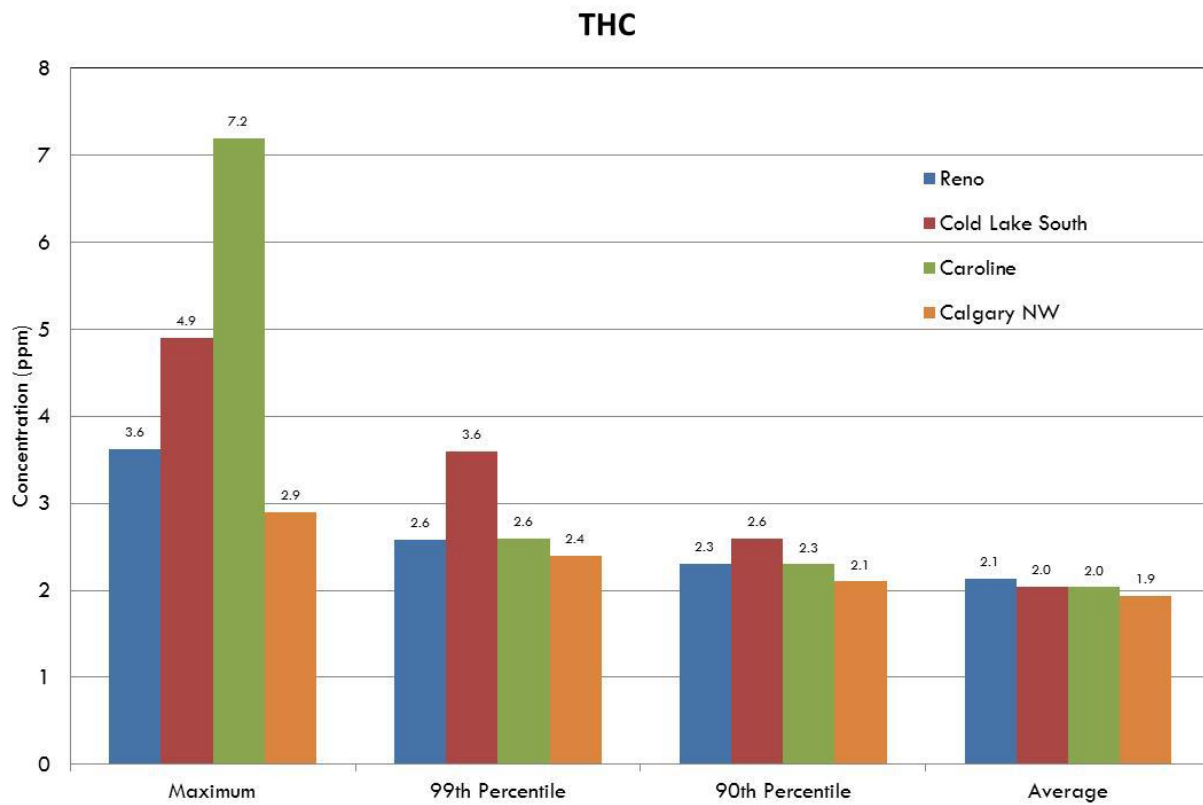


Figure 5.33 Comparison of THC Measurements from other Continuous Monitoring Stations

6. SUMMARY AND RECOMMENDATIONS

The monitoring data that PAZA collected through the Reno monitoring project suggests that the air quality in the area is relatively good. Measured concentrations of TRS, SO₂, NO₂, O₃, and PM_{2.5} were below the applicable or other representative AAAQOs and AAAQGs. Diurnal profiles of O₃ and NO₂ measurements appear to show slight photo-chemical O₃ formation and decomposition.

Concentrations of THCs measured in the area were typical of rural Alberta background levels; however, average THC concentrations that were very 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.

The summary of the air quality monitoring data 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.

The majority of measurements do not support further continuous monitoring in the area. Although less than a full year of data was collected, it is unlikely that a full year or more of monitoring would yield different conclusions. If PAZA chooses to conduct additional monitoring in the area, it is recommended to consider adding passive hydrogen sulphide monitoring to determine trends, and canister sampling for specific VOCs such as benzene.