**Peace River Area Monitoring Program**

# 2017-2018 Annual Report

PRAMP

PEACE RIVER AREA MONITORING PROGRAM



August 22, 2019

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*Cover Photo:* *Michael Bisaga*
*Canola near Reno, Alberta*

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# 1. HISTORICAL CONTEXT

The Peace River Area Monitoring Program (PRAMP) was created to satisfy air quality monitoring and modelling recommendations released following a proceeding called by the Alberta Energy Regulator (AER).

The proceeding was called to address odour and emissions generated by heavy oil operations in the Peace River Area of Alberta (AER 2014a). The oral proceeding started on January 21 and ended on January 31, 2014, in Peace River, Alberta.

On March 31, 2014, the panel released its report titled Report of Recommendations on Odours and Emissions in the Peace River Area. The recommendations in the report included calls for regulatory change, regional air monitoring, and ongoing stakeholder engagement in the Peace River Area. This report summarizes the air monitoring data collected in the area as a result of these recommendations.

In particular, the monitoring requirements in Paragraph 178(1) of the report recommendations accepted by the AER state, "The AER accepts this recommendation and will immediately engage with industry, residents and stakeholders to establish a regional air quality monitoring program for the Peace River Area" (AER 2014b). This report is the fourth annual report consisting of an in-depth data review and compares 2017 to 2018 monitoring results; the first, second, and third reviews are available on the PRAMP website.

## 1.1. Emissions

In the region, there are about 4,000 industrial facilities and installations including gas plants, flare stacks, wells, storage facilities, and pipeline infrastructure with the potential to emit hydrocarbons (IHS 2017; Figure 1). Operators in the Peace River area (Three Creeks, Reno, Walrus, Seal) with Cold Heavy Oil Production (CHOP) facilities are required to have emission control devices in place to mitigate or eliminate potential releases of hydrocarbons (AER 2017). Typical hydrocarbon emissions result from fugitive and combustion sources that tend to occur on a continuous basis. Emissions also occur on an episodic basis from truck filling and tank cleaning operations. While emission sources are not characterized at all locations, the impacts on air quality at three monitoring locations are presented for review.

## 1.2. Meteorology

This report outlines data collected during 2017-2018 at three monitoring locations (Figure 1). The measurements collected at the monitoring sites confirm that temporal and spatial meteorological variations occur in the Peace River Area.

## 1.3. Station Data and Trends

PRAMP has a well-established monitoring program that is critical to understanding the state of air quality in the Peace River Area. The monitoring program has been active at Station 986 since 2010, Station 842 since 2012, and the Reno Station since 2014.

This is PRAMP's fourth annual report and data analysis was completed on the two most recent annual datasets (2017 – 2018). Three types of data are presented: continuous monitoring, meteorological measurements, and discrete canister samples.

Sulphur dioxide ($SO_2$), total reduced sulphur (TRS), total hydrocarbon (THC), methane ($CH_4$), and non-methane hydrocarbons (NMHC) concentrations are monitored continuously.

Meteorological parameters (wind speed, wind direction, temperature, pressure, and relative humidity) were also monitored at the three continuous ambient air quality monitoring stations in the region.

Discrete, triggered canister samples were collected when the NMHC concentration reached a threshold of 0.3 parts per million by volume (ppmv) averaged over 5 minutes. Canisters are analyzed for over 140 volatile organic compounds (VOC). In 2017, 6 canister events were triggered but only 4 samples were sent for analyses; 2 events were missed by the operator and the samples were discarded. In 2018, 6 canister events were triggered however only 3 of these events were 'real' with the remaining 3 being false triggers caused by station operations and maintenance.

AER complaints were collected and analyzed for the correlations to monitored data.

The methods used to analyze data are outlined below.

Continuous sampling:

- continuous measured meteorology parameters (wind speed and wind direction) are presented in wind roses
- continuous measured ambient $SO_2$, TRS, THC, $CH_4$, and NMHC concentrations are present in vertical bar charts, line plots, and concentration roses
- continuous measured ambient $SO_2$, TRS, THC, $CH_4$, and NMHC concentrations (maximum, 99$^{th}$ percentile, and average by month) are presented in vertical bar charts with statistical analysis

Triggered sampling canister events:

- 4 triggered canister events in 2017 and 3 triggered canister events in 2018 were analyzed for over 140 volatile organic compounds (VOC). These data are presented in tables.

AER complaints:

- AER complaints are presented in a timeline with THC concentrations (continuous)

Based on hourly measurement data, maximum THC, NMHC, $SO_2$, and $CH_4$ concentrations generally show a reduction in the magnitude and frequency of elevated events at Stations 986, 842, and Reno between 2017 and 2018. Observations of increased THC and methane concentrations at Station 986 toward the end of 2017 and beginning of 2018 are likely due to cattle in the vicinity of the station. TRS data at Stations 986, 842, and Reno show incremental increases over the last two years of applicable data; these elevated measurements are limited to the warmer summer months and may be influenced by shallow sloughs and asphalt paving in the area. Analysis of the monitored data and examination of monthly summary statistics showed that most parameters are either decreasing or have stayed the same over the last two years.

Stations 986 and 842 monitoring results showed that the 99$^{th}$ percentile concentrations of THC were similar to other areas of the Province. The Reno station concentrations are higher than the 986 and 842 stations, however they are at about the same as concentrations measured at other stations in the province.

Data for Three Creeks suggests that PRAMP is meeting the goal of verifying that air quality is improving and odours are being minimized as a result of operational and regulatory improvements; this is particularly evident when the full record of monitoring from Station 986 and 842 are considered. Recent spatial analysis of wells and their associated infrastructure suggests the close proximity of CHOP facilities may be influencing hydrocarbon concentrations more at the Reno Station than at Stations 986 and 842.

### 1.4. Complaints

The AER recorded odour complaints from residents and assigned the location of the complaint to each of the three stations. AER complaints were collected and analyzed as follows:

- Station 986 showed no change in the number of complaints; there were 4 in 2017 and 4 in 2018 (down from a historical maximum of 33 in 2014)
- Station 842 showed an decrease in the number of complaints from 4 in 2017 to 0 in 2018 (down from a historical maximum of 44 in 2014)
- Reno Station showed a decrease in the number of complaints from 5 in 2017 to 0 in 2018 (down from a historical maximum of 11 in 2015)

In 2018, there were only 4 odour complaints across the entire network; this is the lowest number of complaints since PRAMP began compiling these data.

## 2. BACKGROUND

The Peace River Area is defined as the Three Creeks, Reno, Seal Lake, and Walrus areas (Figure 1). The air quality monitoring program operated by PRAMP is designed to operate collaboratively and transparently including representation from industry, the AER, government agencies, residents of Three Creeks and Reno areas, and environmental non-governmental organizations (AER 2014b).

PRAMP's vision is that the "Peace River Area heavy oil and bitumen operations' emissions will not cause odours that affect human health" (PRAMP 2016). The mission statement maintained by PRAMP is the "Peace River Area will have an air quality monitoring program that provides credible and comprehensive data to permit the identification and appropriate response to odour and emission-related issues" (PRAMP 2016). An overview of PRAMP's goals and objectives are listed below. PRAMP defines odours and emissions as the following:

- odours: detected in the ambient air by the people in the area
- emissions: at a source are defined by the concentration and flow rate of each compound released; upon release from the source the emissions disperse downwind and may be measured as a concentration in the ambient air by a monitoring device

PRAMP's goals are to:

- assist in verifying that air quality is improving and odours are being minimized as a result of operational and regulatory improvements
- operate transparently and give residents and stakeholders timely access to data and information in a manner that is readily understood
- demonstrate that oil and gas operators have effective control mechanisms
- verify that air quality is at acceptable levels and that emissions residents are exposed to are below toxic thresholds (PRAMP 2016)
- maintain its status as an independent Not-for-Profit Organization and Airshed that is focused on continuous improvement and responsible growth

To accomplish the goals the program would:

- characterize emissions and odours associated with industrial activity, with a focus on oil and gas operations
- identify and measure dominant sources of emissions in the area
- give timely, real-time data on ambient emissions and odours in the area (PRAMP 2017)

A review and analysis of the 2017 - 2018 annual air monitoring data collected by PRAMP is included in this report. The data includes the continuous monitoring of the 1-hour averaged TRS, $CH_4$, NMHC, THC, and $SO_2$ concentrations. Additionally, VOCs monitored using 1-hour event canisters triggered by NMHC concentrations exceeding a threshold of 0.3 ppmv were also assessed.

All monitoring was conducted at the three community stations located within PRAMP's monitoring network:

- Station 842 is located at 16-07-084-19 W5M
- Station 986 is located at 14-16-085-19 W5M
- Reno Station is located at 01-28-079-20 W5M

The locations of the three monitoring stations are shown on Figure 1, which also shows nearby industrial activities in the Peace River Area and surrounding regions including compressor stations, oil batteries, tank farms, gas gathering and processing facilities, terminals, pulp mills, and waste facilities (industrial and domestic). This figure assists in the identification of the emission sources around each station as well as the potential influence of nearby sources to the monitoring data. The heavy oil facilities in the area, operated by Baytex Energy Ltd., Murphy Oil Company Ltd. (now owned by Baytex), Penn West Petroleum Ltd. (now Obsidian Energy), and Shell Canada Ltd. (now Canadian Natural Resources Limited) are selectively shown on Figures 2 through 5.

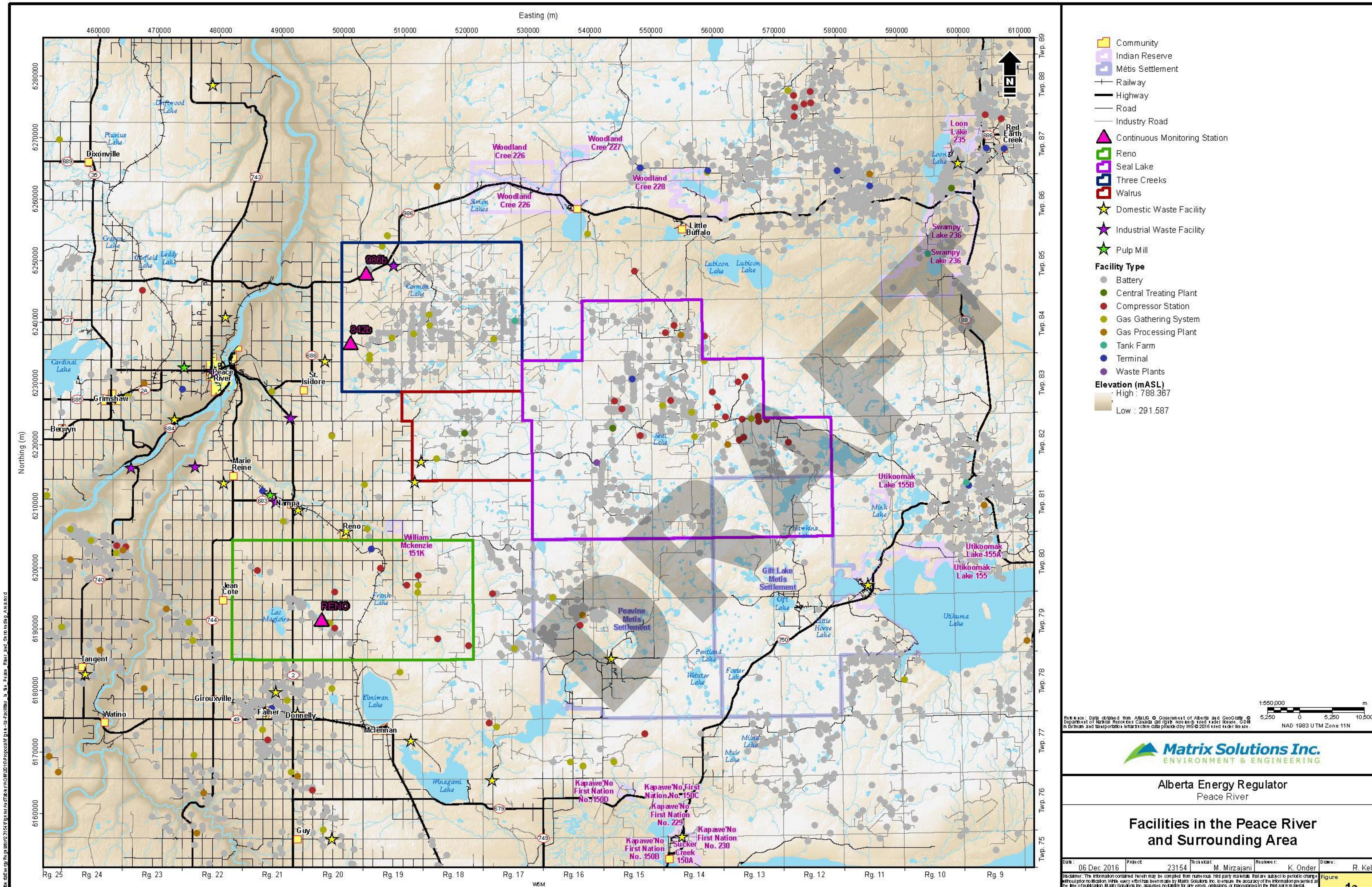



*Figure 1: Facilities in the Peace River and Surrounding Area*

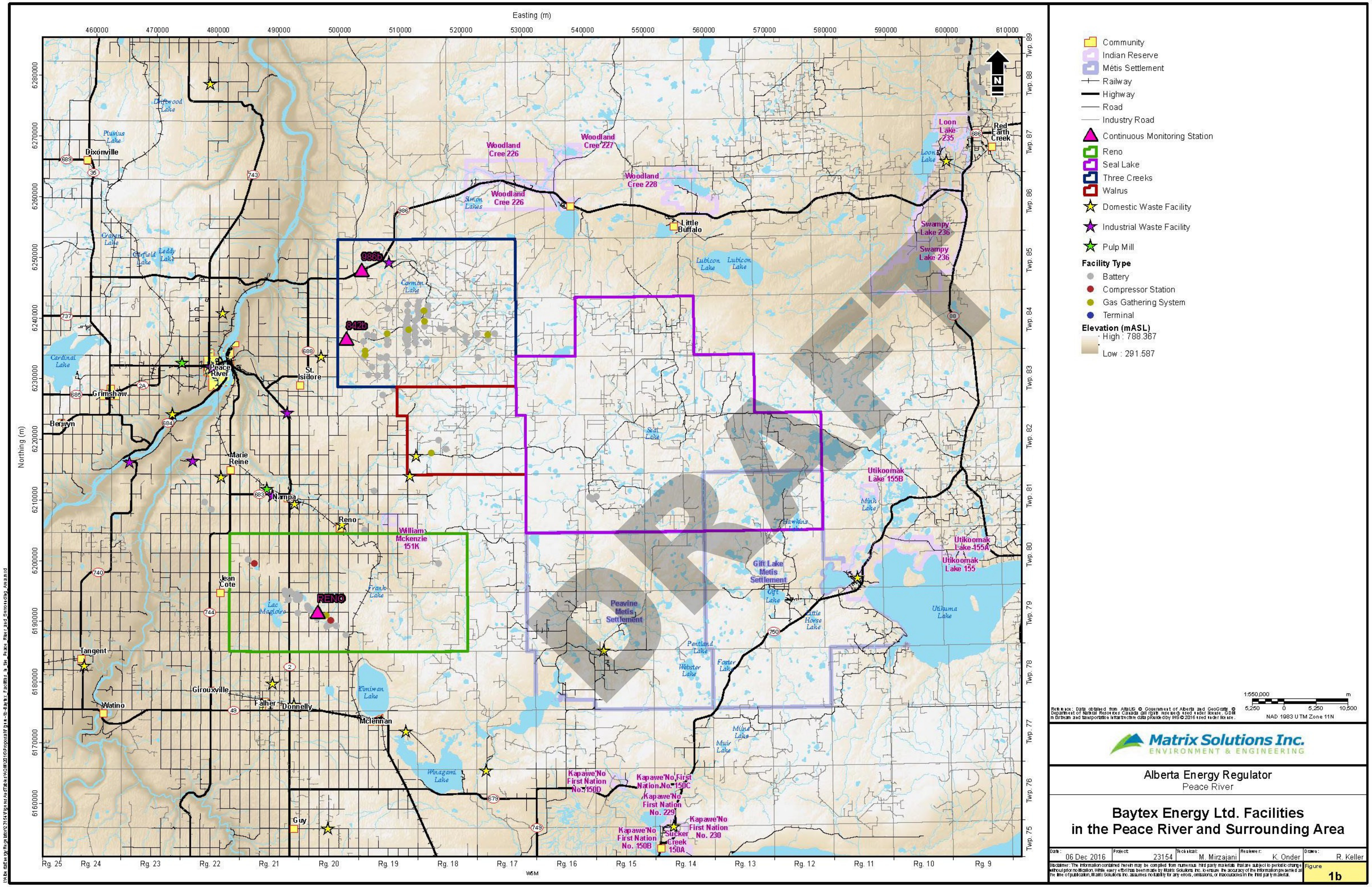



*Figure 2: Baytex Energy Ltd. Facilities in the Peace River and Surrounding Area*

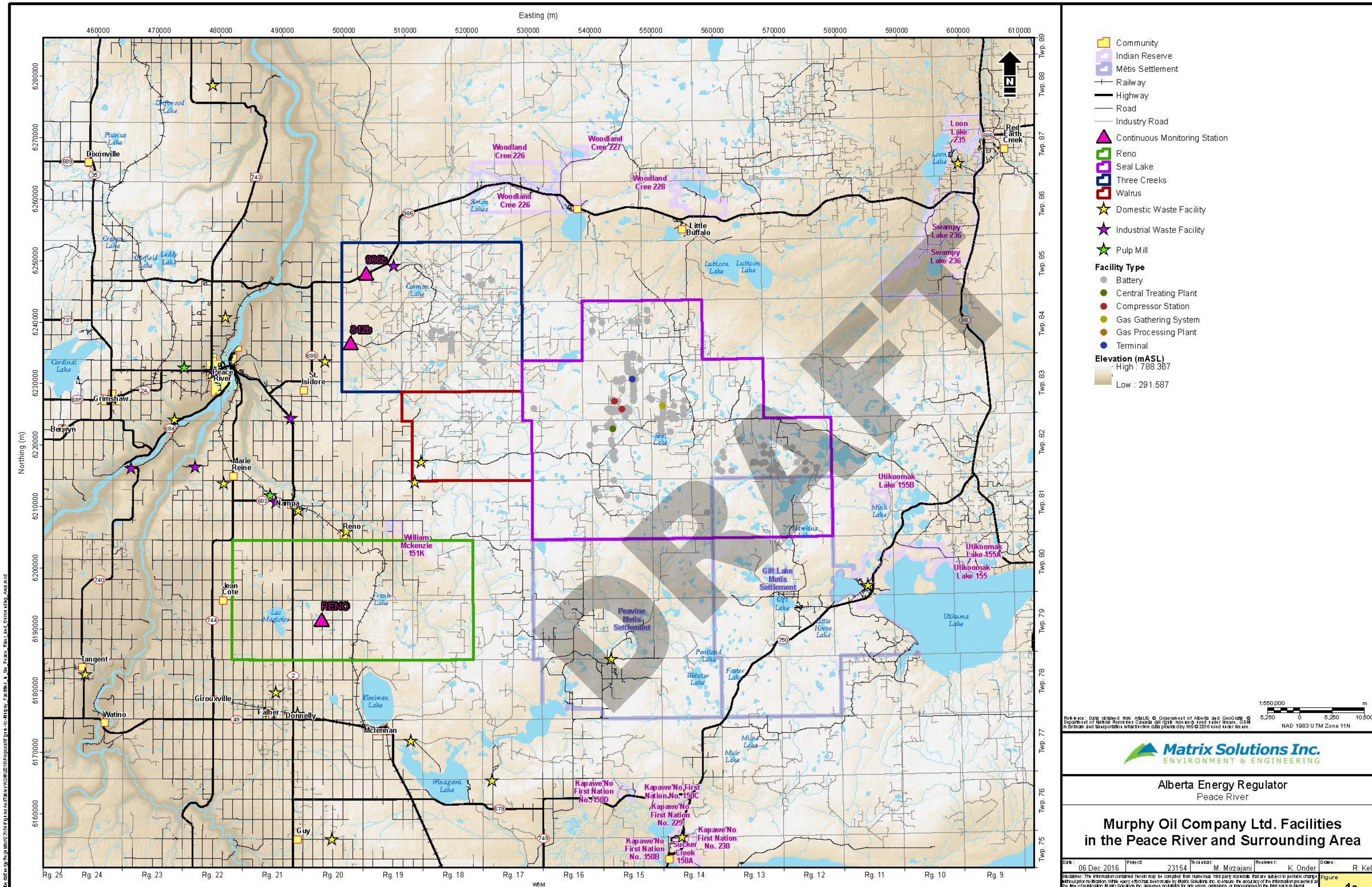



*Figure 3: Murphy Oil Company Ltd. (now Baytex) Facilities in the Peace River and Surrounding Area*

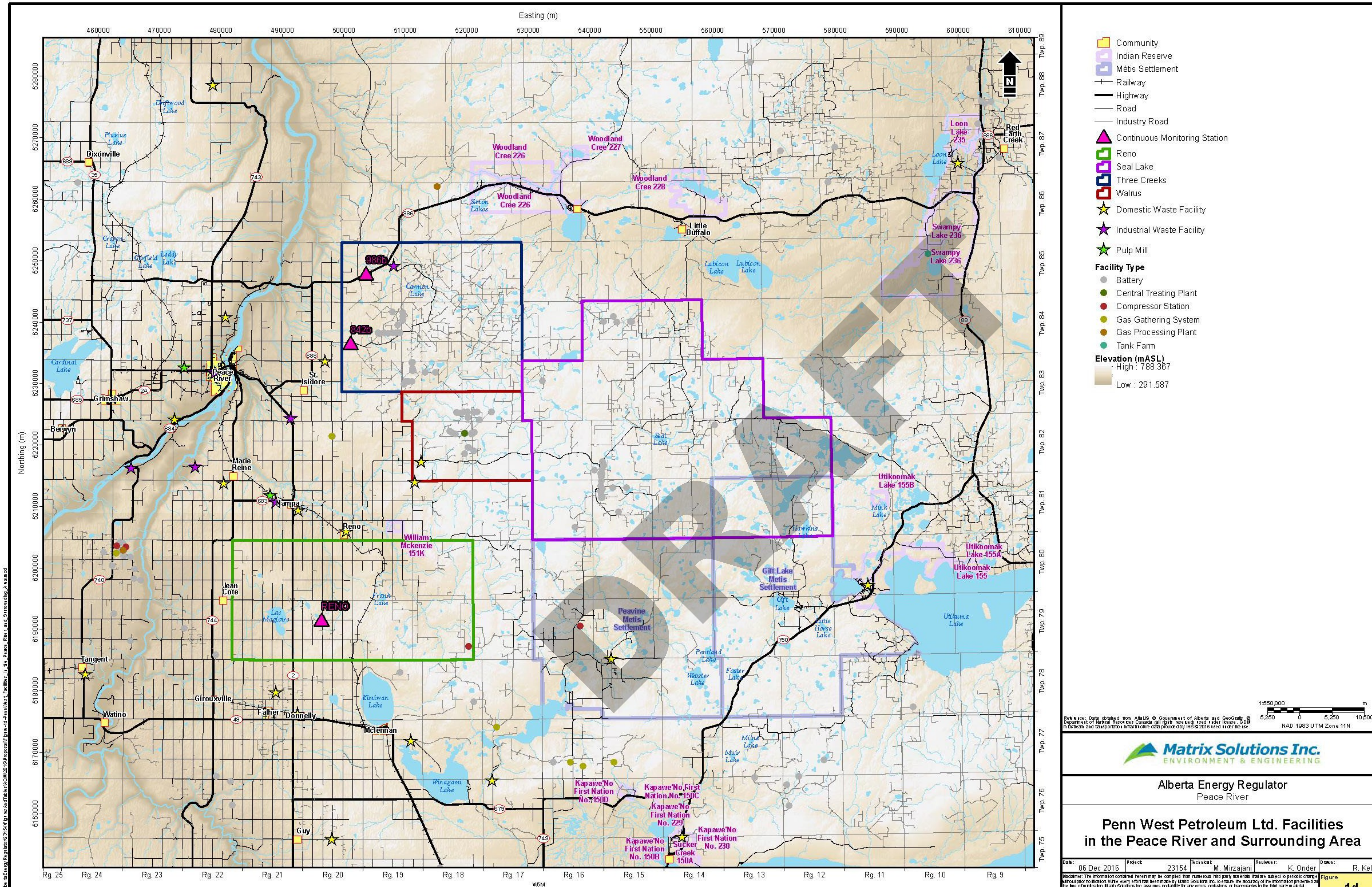



*Figure 4: Penn West Petroleum Ltd. (now Obsidian Energy) facilities in the Peace River and Surrounding Area*

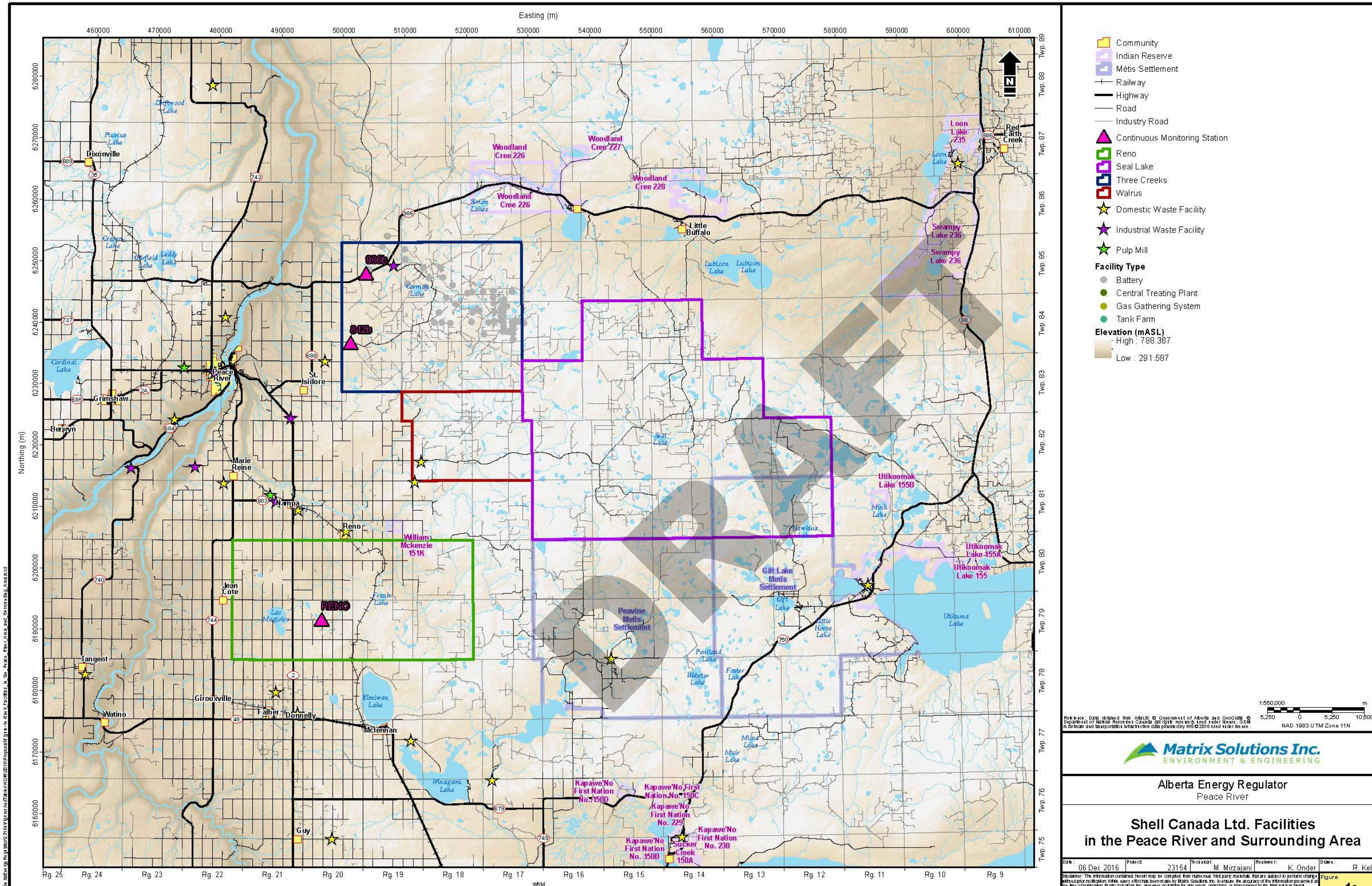



*Figure 5: Shell Canada Ltd. (now Canadian Natural Resources Limited) facilities in the Peace River and Surrounding Area*

### 2.1. Air Quality Monitoring Overview

To accomplish PRAMP's goals and to be in alignment with its mission statement, air quality in the Peace River Area was monitored through continuous and triggered canister samples.

Continuous monitoring stations use substance-specific technology to detect concentrations in a sample stream of ambient air that is taken by the instrument at a set time interval. Wind speed and direction data are also collected at the continuous monitoring stations. Assessing concentration and wind data together allows investigation into the potential sources of substances affecting the local air quality. Statistical analyses also assist in understanding the distribution of the data.

Discrete canister sampling events were triggered when continuous monitored data exceeded set thresholds. Triggered sampling events were completed using canisters to capture ambient air samples. The samples are then sent to a laboratory for analysis.

PRAMP's objectives include the comparison of monitored data to different thresholds (PRAMP 2016). The provincial government developed the Alberta Ambient Air Quality Objectives and Guidelines Summary (AAAQO; AEP 2017) to protect the environment and human health. The AAAQOs are used as threshold values for comparing substance concentrations (at appropriate averaging periods) to assess impacts.

## 3. CONTINUOUS MONITORING STATION DATA AND TRENDS

The following subsections describe the results of the monitoring, analysis, and methods used to complete this report.

### 3.1. Station Data and Trends Methodology

All hourly data collected at the three stations was compiled and interpreted. Hourly data for meteorology, THC, NMHC, TRS, $SO_2$, and $CH_4$ concentrations have been presented as follows:

- wind roses displaying the wind speed and direction for each year and at each station
- hourly data with maximum values identified for each year and station
- monthly measurement trends for the 100$^{th}$ (maximum) and 99$^{th}$ percentiles by month for each station for all time periods
- time series results for the maximum, 99$^{th}$, 90$^{th}$, and 50$^{th}$ percentiles and minimum readings collected at each station and year

This data and statistical analysis have been presented with interpretation in Sections 3.2 to 3.5.

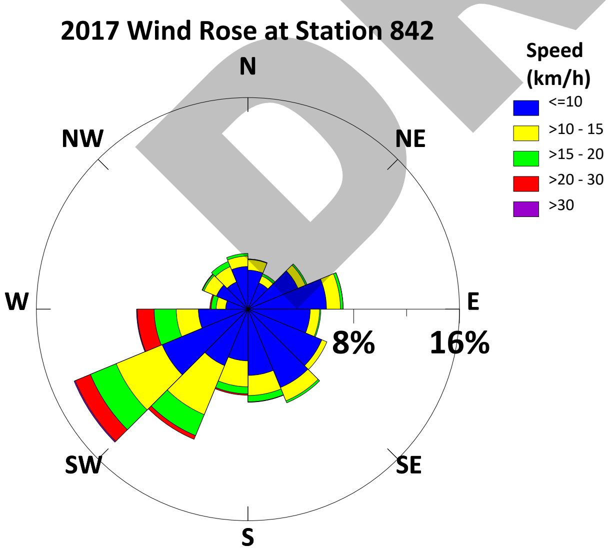
### 3.2. Wind Roses

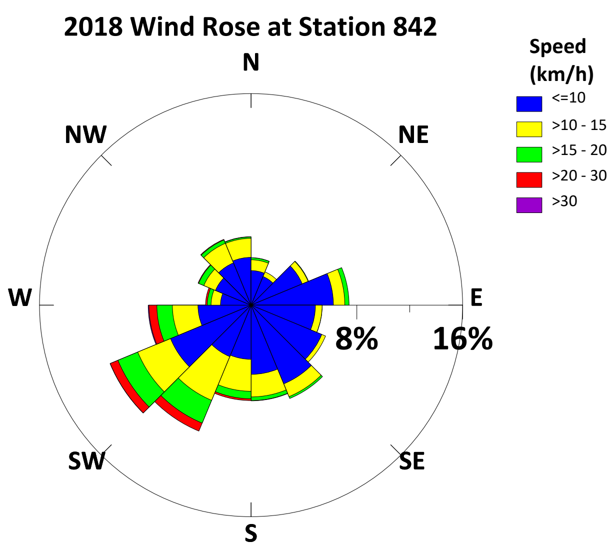
Presented in a circular format, wind roses show the frequency of winds blowing from particular directions over a specified period. The length of each ‘spoke’ around the circle is related to the frequency that the wind blows from a particular direction per unit time. Each concentric circle represents a different frequency, emanating from zero at the center to increasing frequency at the outer circles. Each spoke is broken down into colour-coded bands to show the range of wind speeds that occurred in that particular direction.

Wind roses created from meteorological measurement data for each station and year are presented to understand the predominant wind conditions at each of the three station locations (Figure 2). Trends for each station are noted as follows:

- Station 842: Winds are primarily from the southwest. Wind speeds range from less than 10 to 30 km/hour with minimal wind speeds over 30 km/hour in both 2017 and 2018. Approximately 66% of hours in 2017 and 69% of hours in 2018 were below 10 km/hour.
- Station 986: Wind direction varies, with a higher frequency of winds coming from the southeast and southwest and minimal winds coming from the northeast. Wind speeds largely range from less than 10 to 15 km/hour with minimal wind speeds over 15 km/hour in both 2017 and 2018. Approximately 85% of hours in 2017 and 88% of hours in 2018 were below 10 km/hour.
- Reno Station: Winds were primarily from the southwest. Wind speeds range from less than 10 to 20 km/hour with minimal wind speeds over 20 km/hour. Approximately 87% of hours in 2017 and 88% of hours in 2018 were below 10 km/hour.





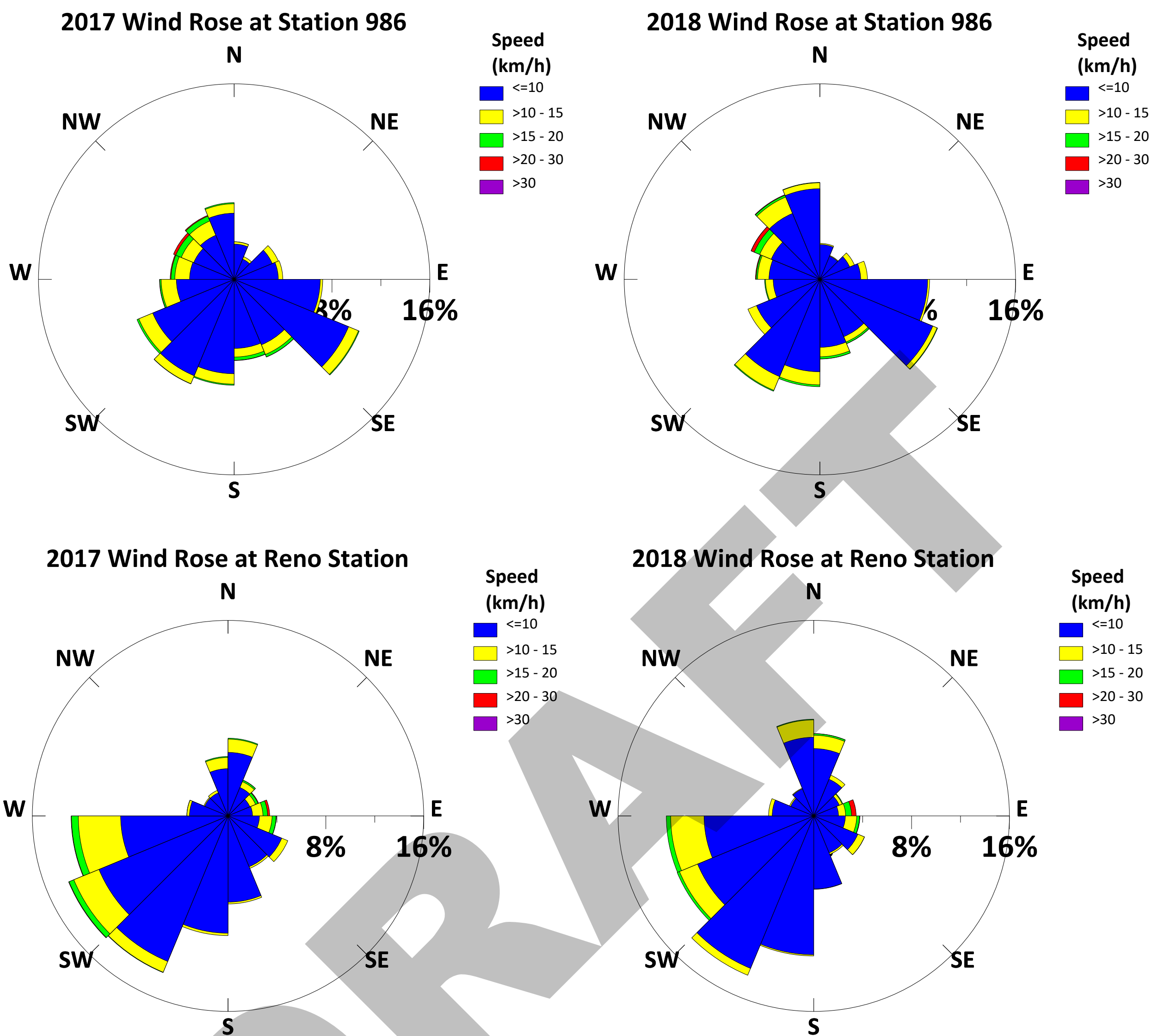



*Figure 6: Wind Roses at Stations 842, 986 and Reno*



## 3.3. Hourly Concentration Data

Hourly concentration data is presented to show all concentration data collected at the three stations for each year. Hourly concentrations are presented for total hydrocarbon (THC), non-methane hydrocarbons (NMHC), total reduced sulphur (TRS), sulphur dioxide ($SO_2$) and methane ($CH_4$) in this section. THCs are the sum of $CH_4$ and NMHC. NMHC may be emitted with methane from the man-made sources and are likely to have an odour. NMHC measurements include volatile organic compounds (VOC).

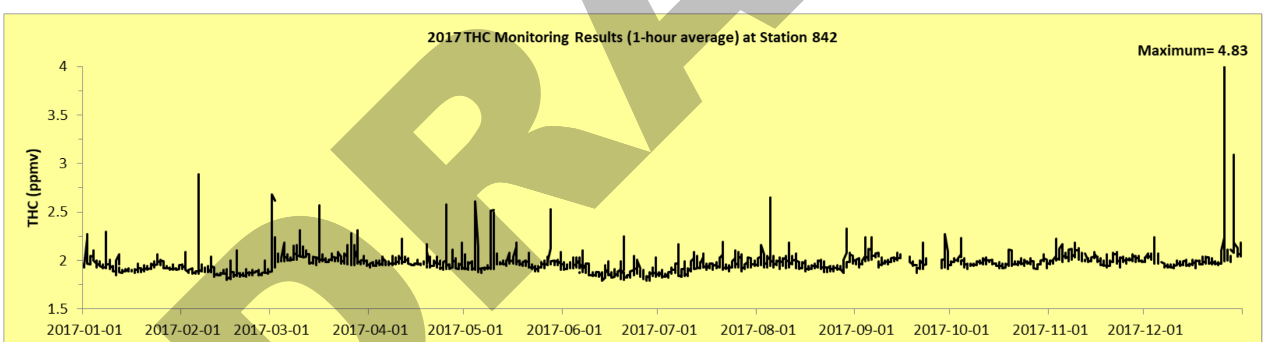
TRS compounds include hydrogen sulphide, carbonyl sulphide, carbon disulphide, and other hydrocarbon-sulphur compounds such as mercaptans and thiophenes. Some TRS compounds may have a strong offensive odour at concentrations below 1 ppbv. There are natural sources of TRS but they can also be emitted from bitumen facilities. $SO_2$ results from the combustion of sulphur compounds in fuel and flared/incinerated gas. $CH_4$ comes from natural and man-made sources and has a background concentration of typically less than 2 ppmv, depending on season and time of day. $CH_4$ does not have an odour or health effects at these low concentrations.

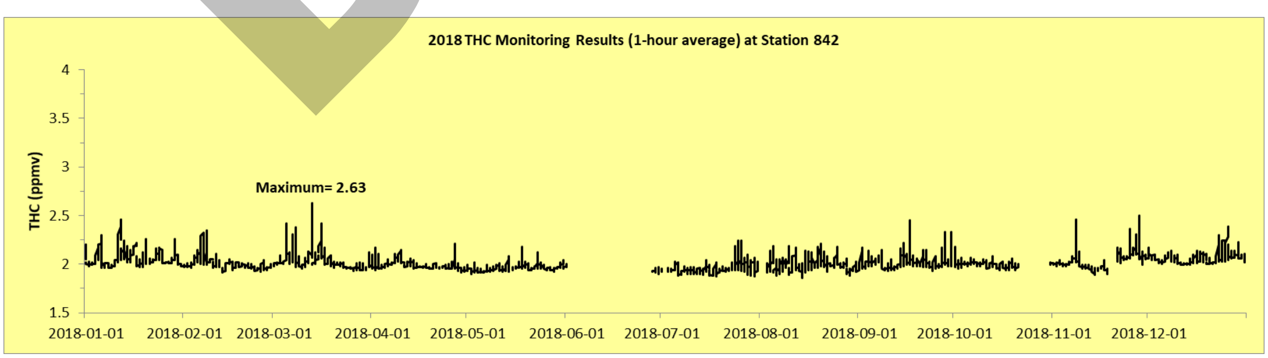
### 3.3.1. Total Hydrocarbons

THC concentrations include all NMHC and methane concentrations. There is no AAAQO for THC. Hourly data for THC from the three stations is presented in the charts below (Figure 7). Instrument malfunction resulted in data loss in June 2018 at Station 842.

The maximum hourly THC data for the Reno Station was higher in 2018 than in 2017 however the overall frequency and magnitude of elevated concentrations both decreased. Similar to the increase observed between 2016 and 2017, the maximum hourly THC concentration at Station 986 was higher in 2018 than in 2017 due to cattle grazing near the station. The maximum concentration at Station 842 was lower in 2018 than in 2017 and there was a decrease in the overall occurrence of elevated concentrations.





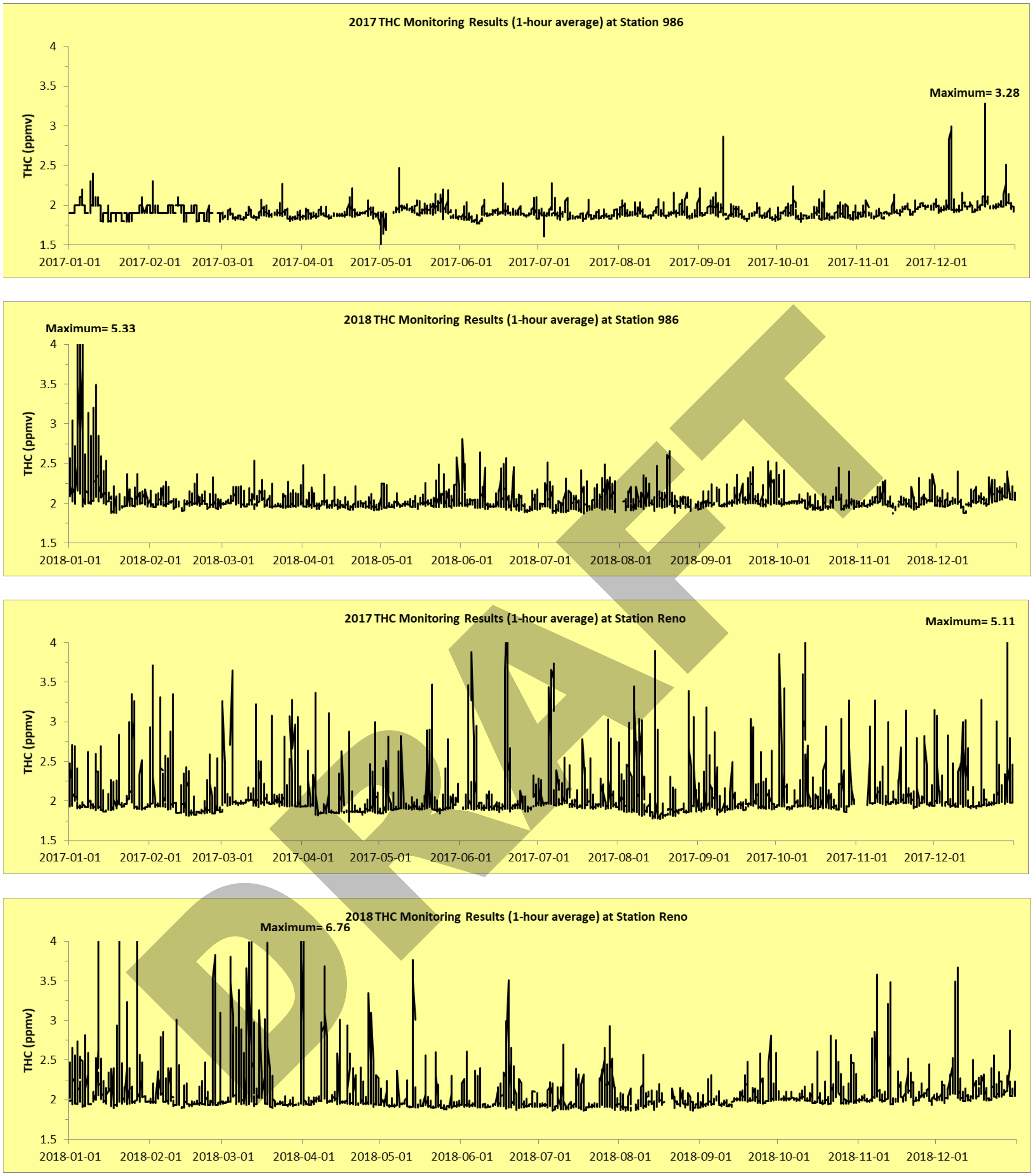




**Figure 7: Hourly Monitored Total Hydrocarbons Data**

For historical comparison purposes, Figure 8 shows the complete record of monitoring for THC at all stations. There is a clear decrease in ambient THC concentrations at Stations 986 and 842; the presence of cattle and their associated hydrocarbon emissions is noted in the 'up-tick' in concentrations towards the end of 2017 and the beginning of 2018. Note that the scale of these charts is different than the previous series because the historical concentrations of THC have been higher than measured in 2017-2018. Reno continues to show elevated THC relative to present-day measurements at the other stations; however, the concentrations are not as high as historical values measured at Stations 986 and 842.

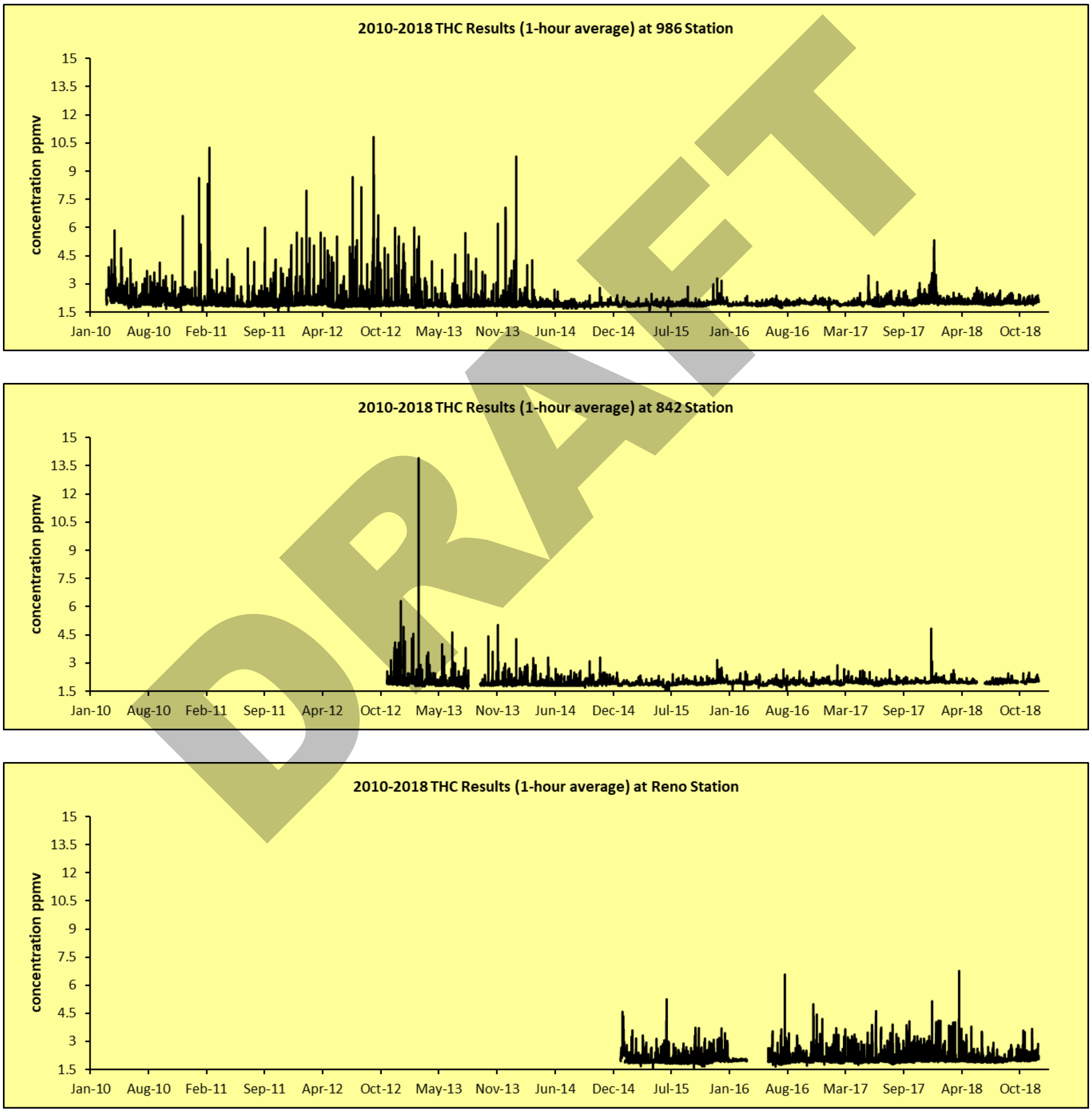
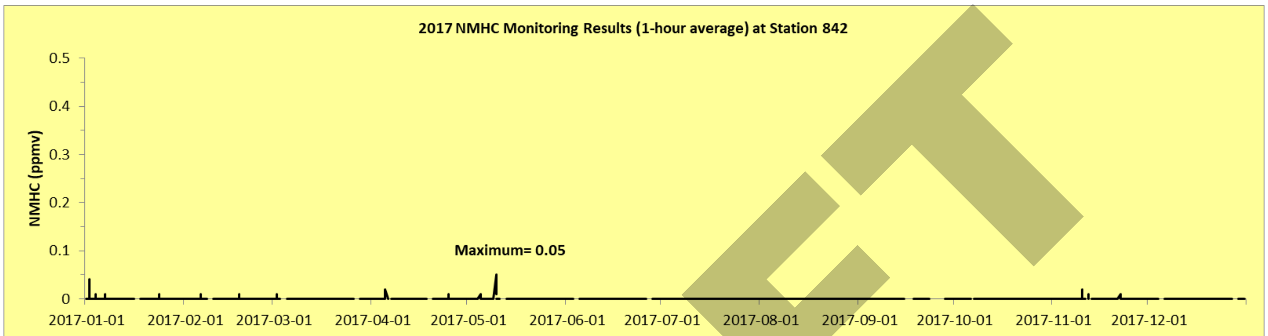


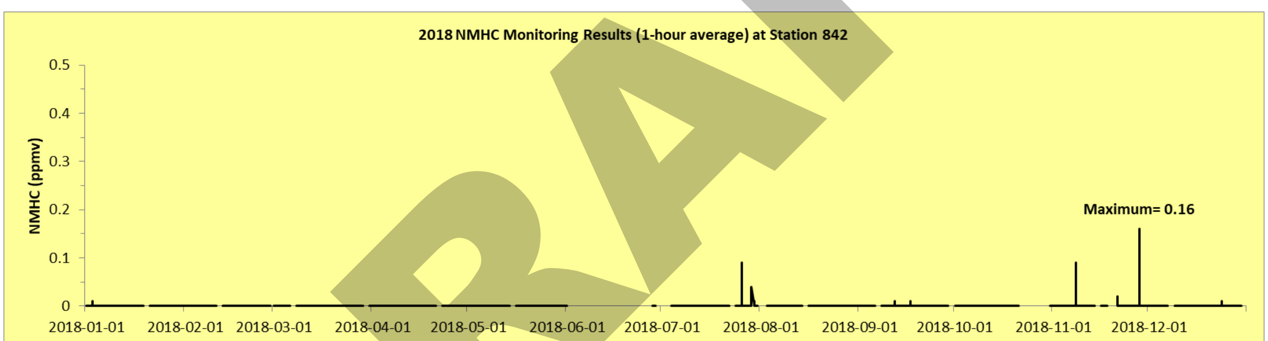


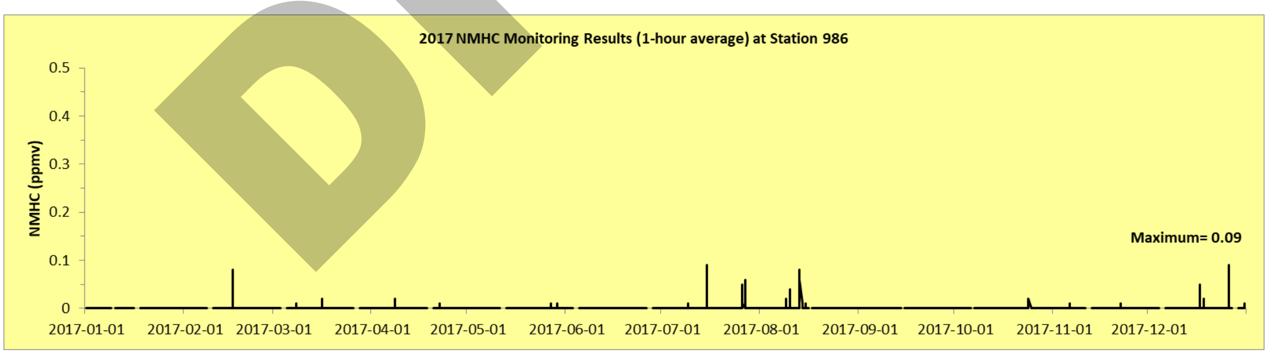

**Figure 8: Hourly Monitored Total Hydrocarbon Data from 2010-2018**

### 3.3.2. Non-methane Hydrocarbons

Hourly NMHC data for the three stations is shown in the charts below (Figure 9). There is no AAAQO for NMHC. The maximum hourly NMHC data for Station 842 increased incrementally from 2017 to 2018. The maximum hourly NMHC concentration for Station 986 increased slightly between 2017 to 2018 from 0.09 ppmv to 0.11 ppmv. The Reno Station recorded maximum NMHC concentrations of up to 0.14 ppmv in 2017 and 0.11 ppbv in 2018 with an overall decrease in the frequency of elevated NMHC events. Instrument malfunction resulted in data loss in June 2018 at Station 842.



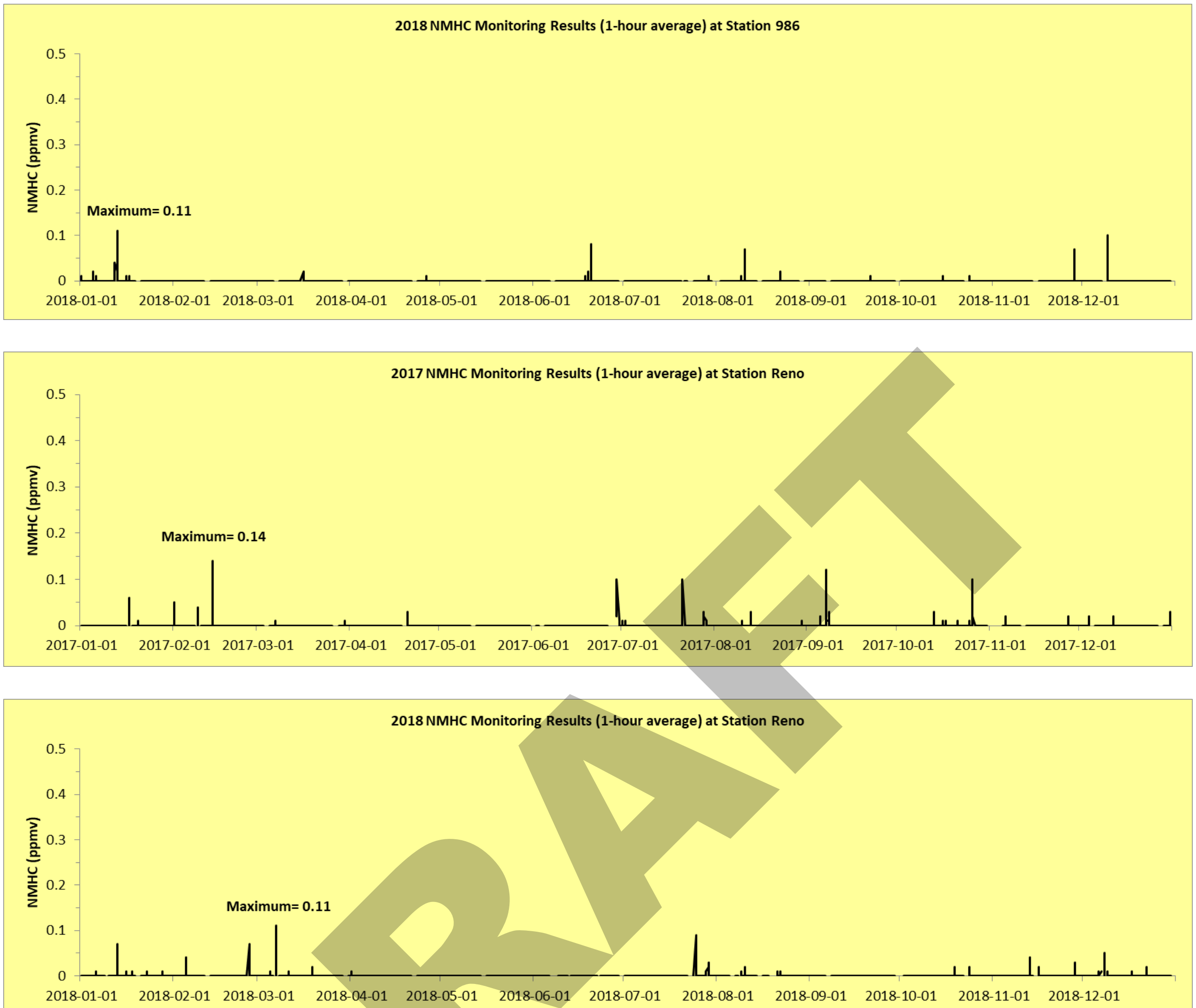
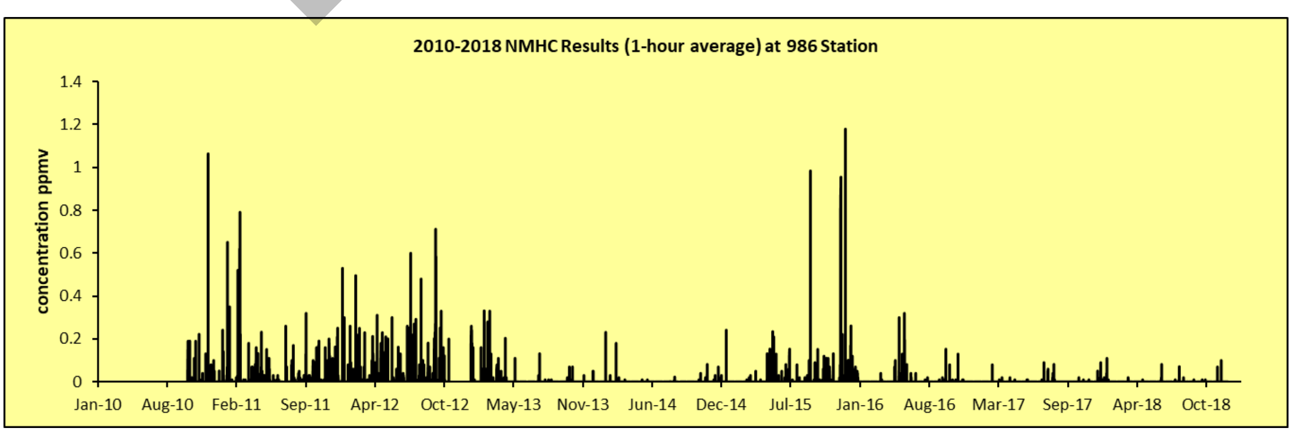
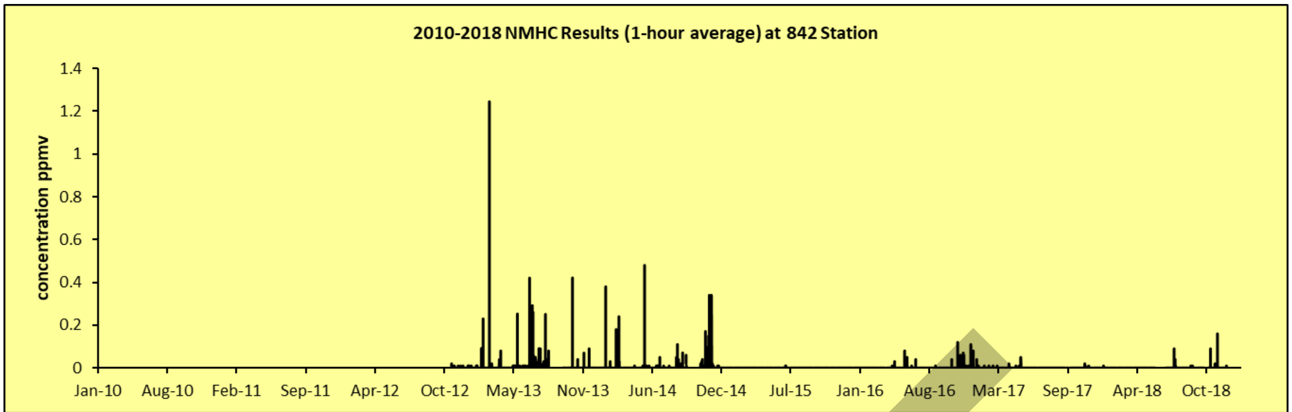



Figure 9: Hourly Monitored Non-methane Hydrocarbons Data

For historical comparison purposes, Figure 10 shows the complete record of monitoring for NMHC at all stations. There is a decrease in frequency of elevated NMHC events at Stations 986 and 842, especially when compared to the early monitoring record at both sites. Reno shows a decrease in the magnitude and frequency of elevated NMHC since monitoring began at that site in 2014.





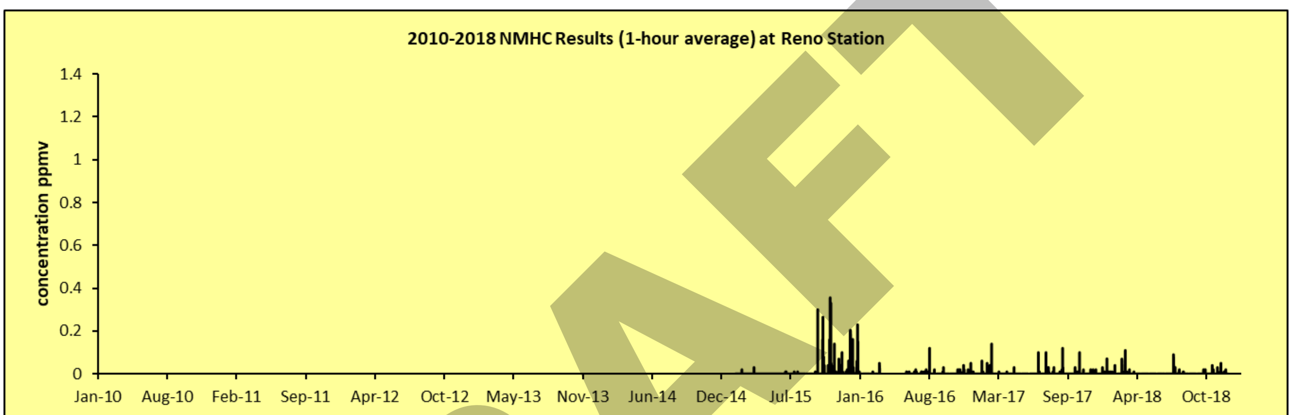
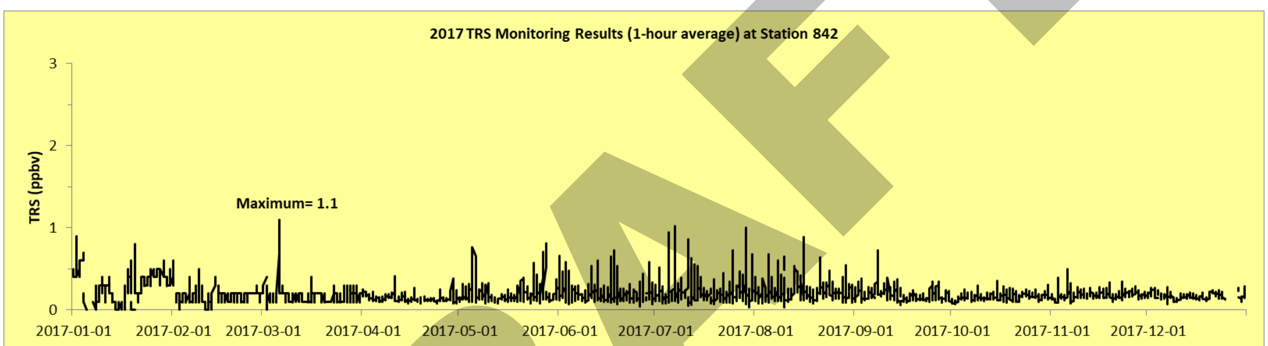



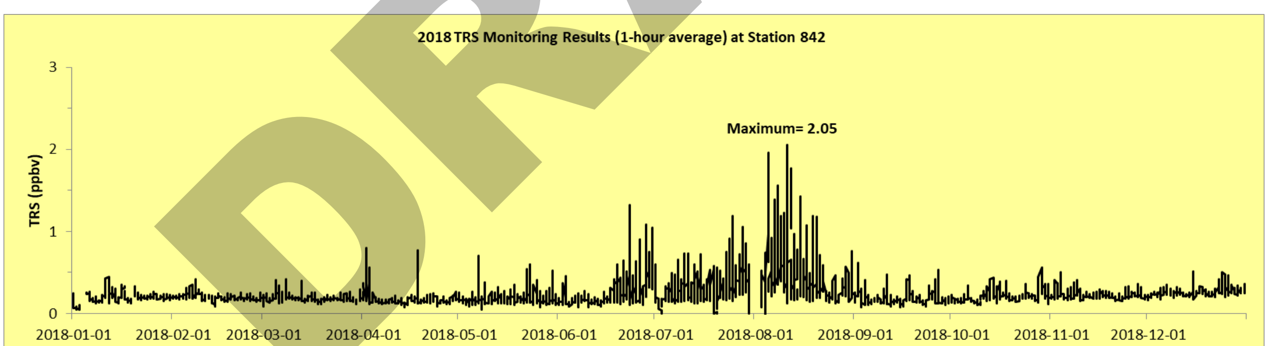

Figure 10: Hourly Monitored Non-Methane Hydrocarbons from 2010-2017

### 3.3.3. Total Reduced Sulphur

Hourly data for TRS for the three stations is shown in the charts below (Figure 11). There is no AAAQO for TRS but the AAAQO for hydrogen sulphide and carbon disulphide are both 10 ppbv; both of these substances are members of the total reduced sulphur group of compounds.

From 2017 to 2018 there is a slight increase in the maximum hourly TRS concentration at Station 842 and a slight decreases the Station 986 and the Reno Station. Elevated measurements of TRS may be caused by local industrial sources but others may also include agriculture and natural sources such as shallow lakes and sloughs. All monitoring stations show an increasing pattern of concentrations in the summer months which begin to decrease as cooler, fall weather arrives. This observation may be attributed to a few factors including sulphur compounds being released by shallow sloughs and wetlands that contain decaying vegetation and/or sulphur compounds released by asphalt paving during the summer construction period.



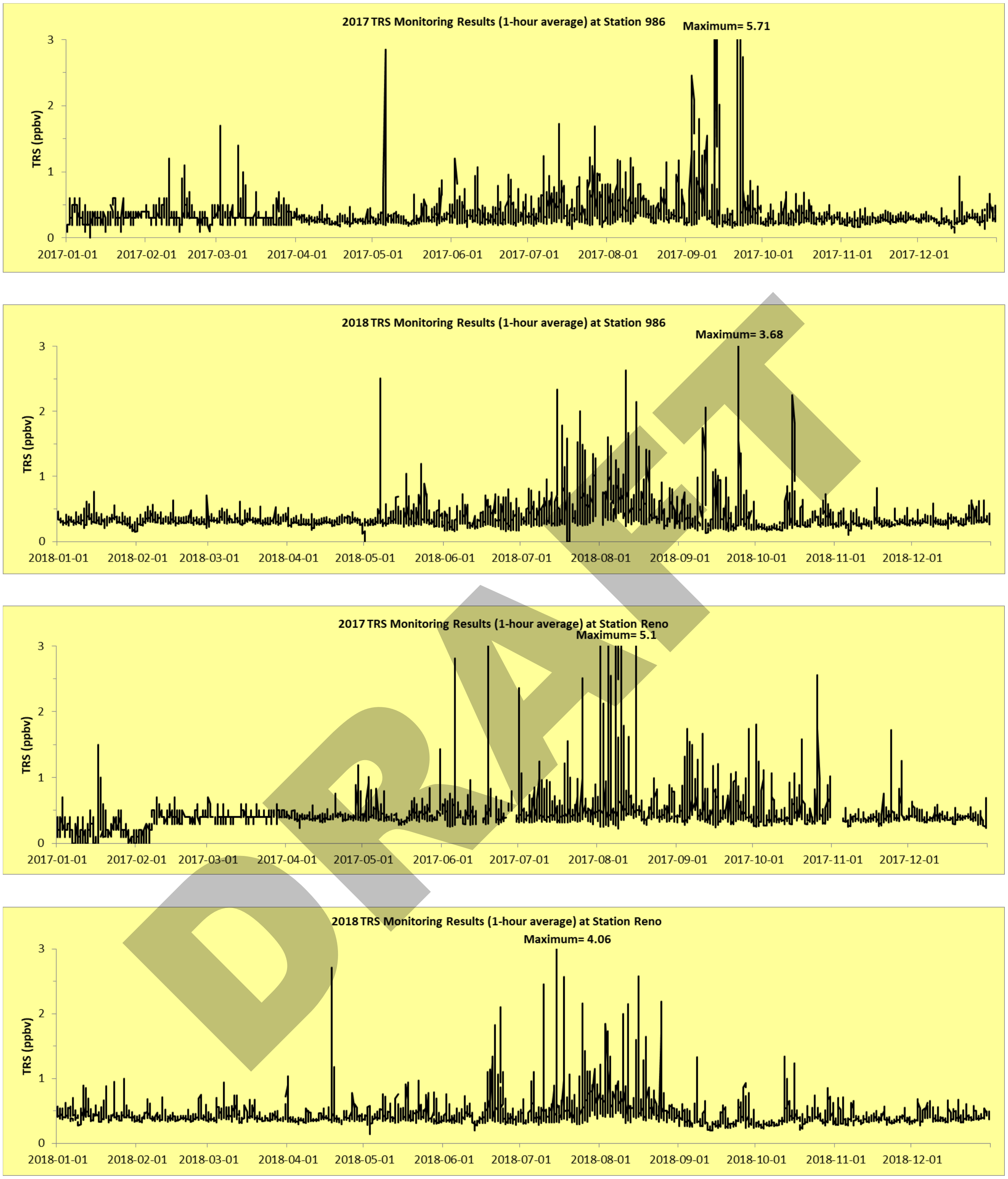
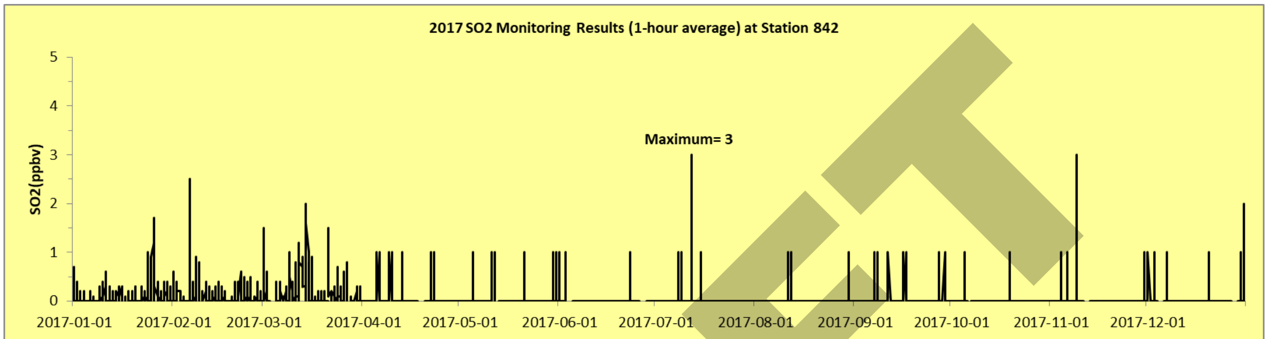


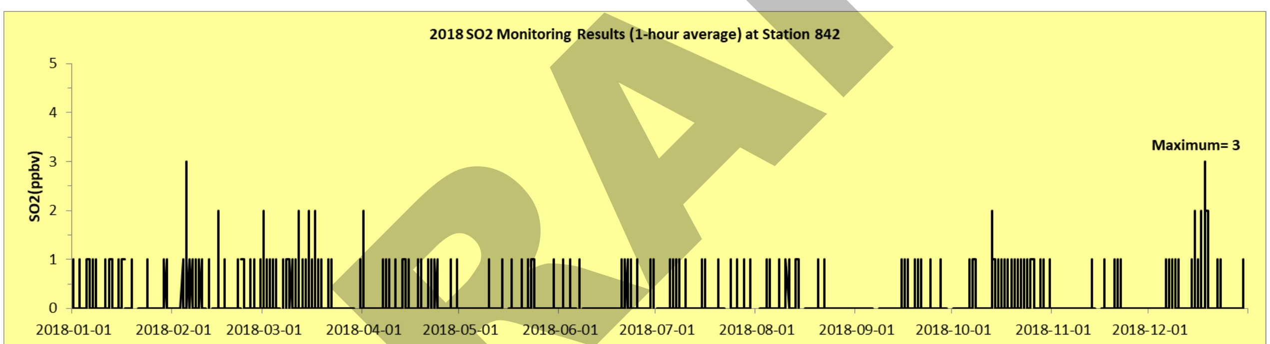

**Figure 11: Hourly Monitored Total Reduced Sulphur Data**

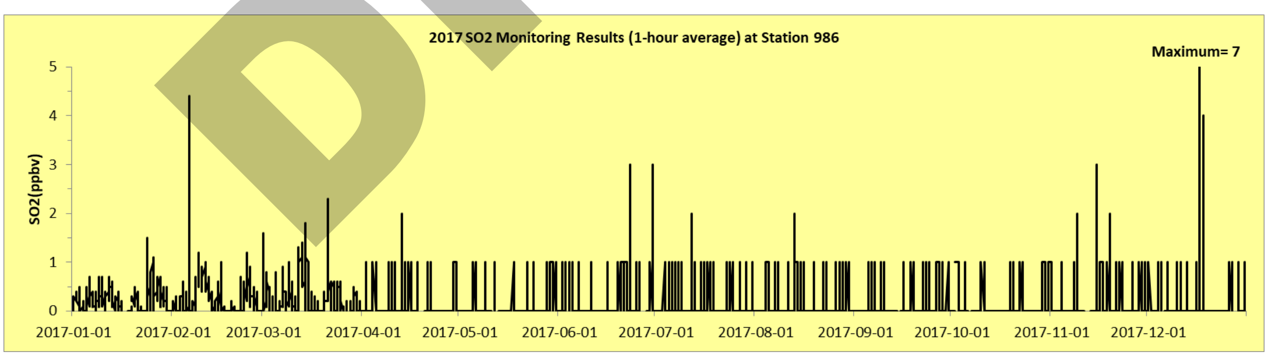
### 3.3.4. Sulphur Dioxide

Hourly data for $SO_2$ for PRAMP's stations is shown in the charts below (Figure 12). The AAAQO for $SO_2$ is 172 ppbv.

The maximum hourly $SO_2$ data for Station 842, 986, and Reno decreased or remained the same from between 2017 and 2018. Elevated concentrations at all stations and years were well below the Alberta Ambient Air Quality Objective.



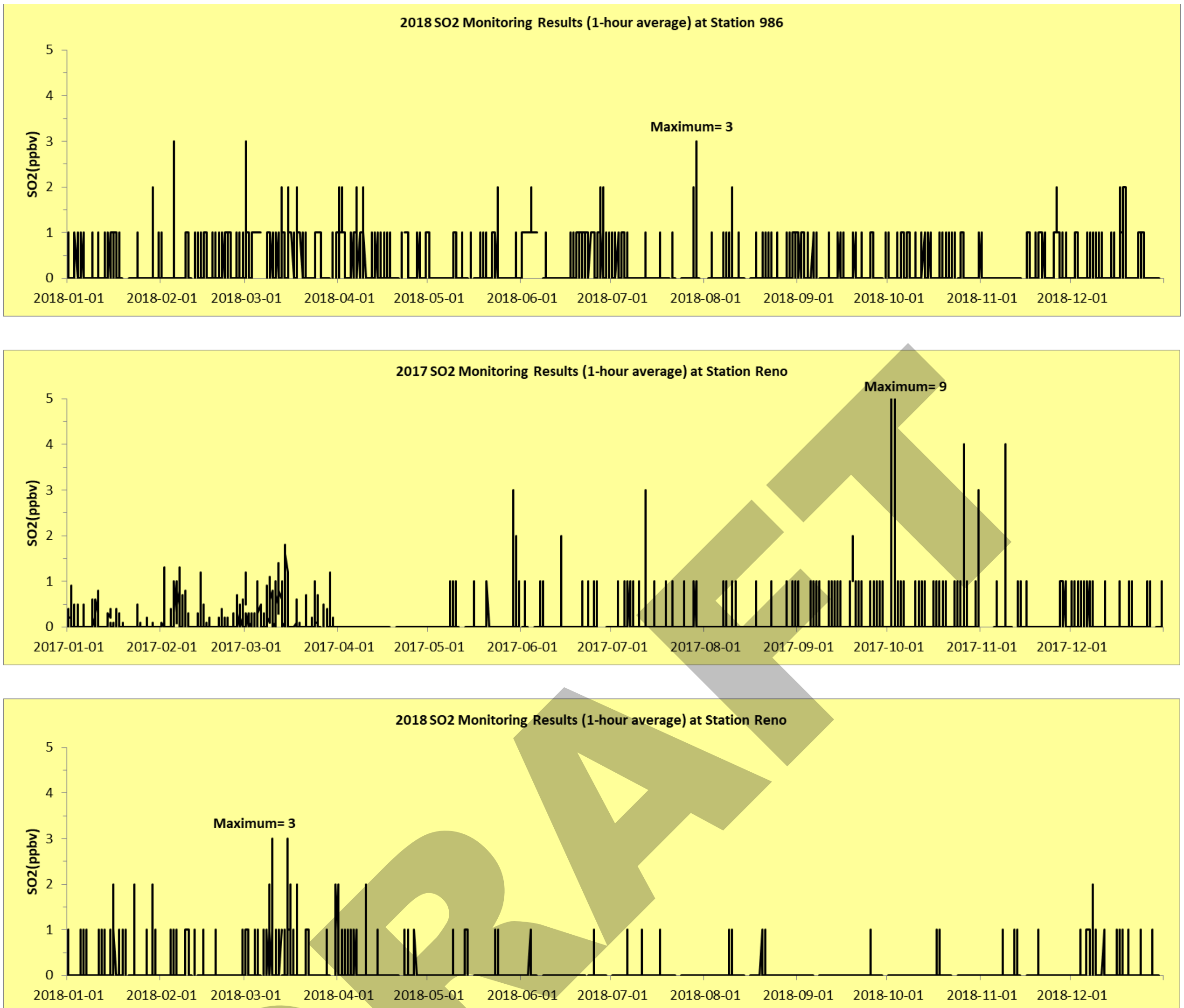
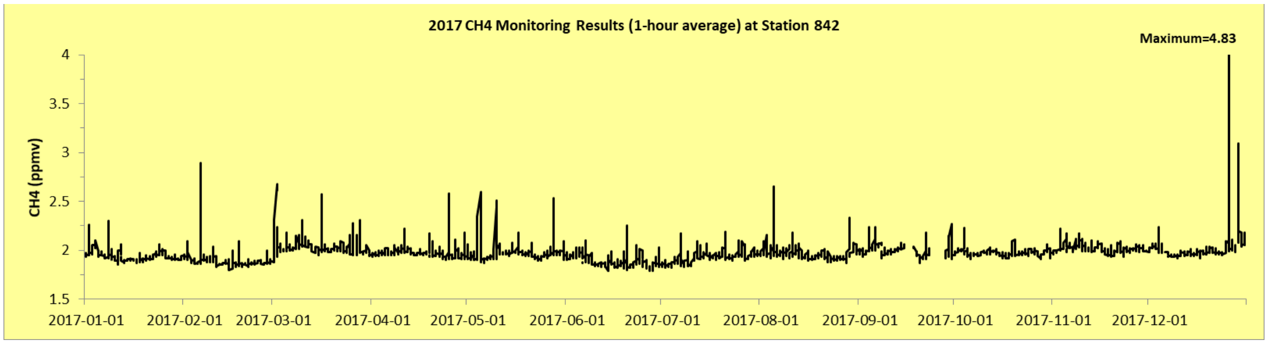


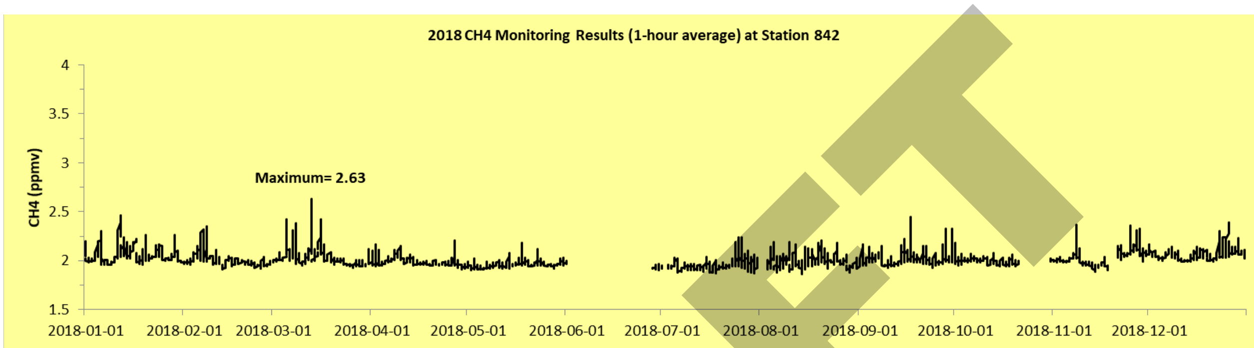

Figure 12: Hourly Monitored Sulphur Dioxide Data

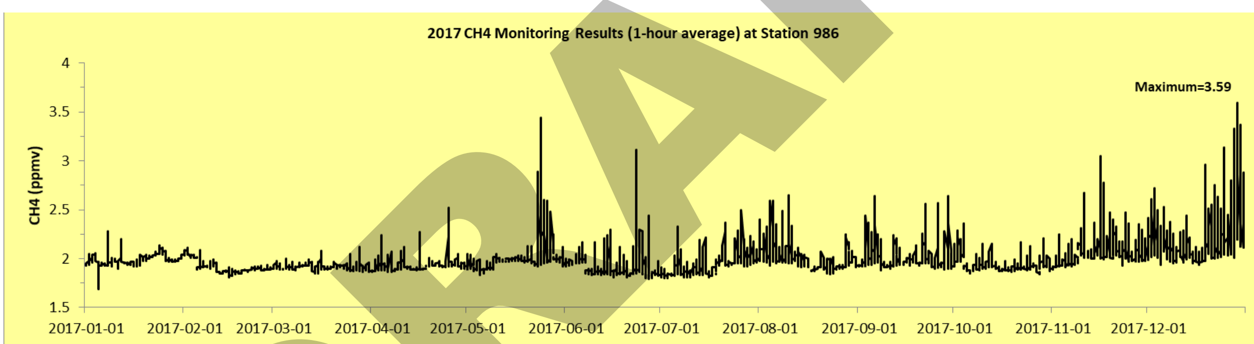
### 3.3.5. Methane

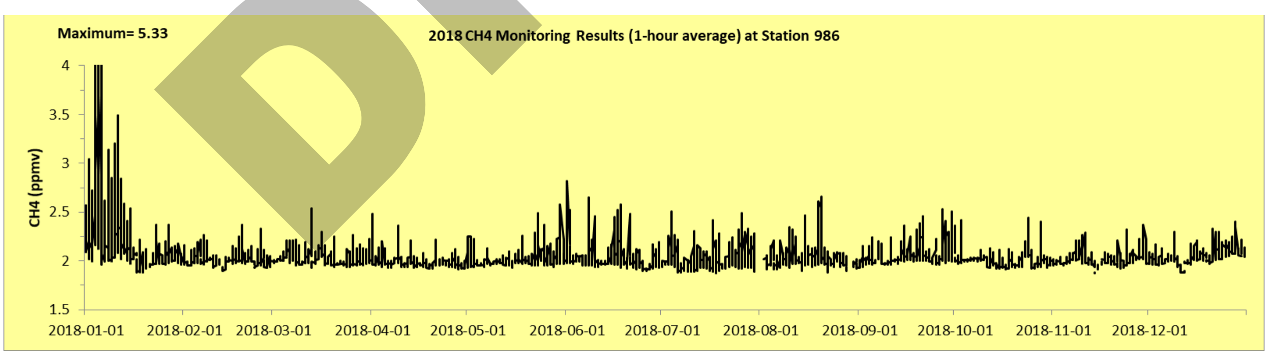
Hourly data for methane ($CH_4$) for the three stations is shown in the charts below (Figure 13). There is no AAAQO for $CH_4$. Instrument malfunction resulted in data loss in June 2018 at Station 842.

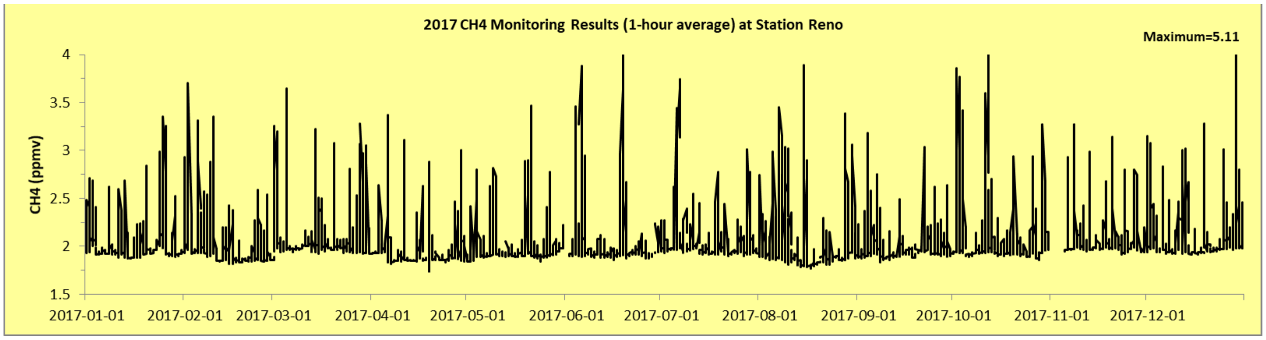
The maximum hourly $CH_4$ data for Station 842 decreased from 2016 to 2017. The maximum hourly $CH_4$ data for Station 986 increased slightly from 2016 to 2017 due to cattle grazing nearby. The Reno station shows a decrease in the number of elevated measurements of $CH_4$ between 2017 and 2018 however there was a slight increase in the maximum measured concentration.


2017 CH4 Monitoring Results (1-hour average) at Station 842
Maximum=4.83
CH4 (ppmv)
4
3.5
3
2.5
2
1.5
2017-01-01
2017-02-01
2017-03-01
2017-04-01
2017-05-01
2017-06-01
2017-07-01
2017-08-01
2017-09-01
2017-10-01
2017-11-01
2017-12-01


2018 CH4 Monitoring Results (1-hour average) at Station 842
Maximum= 2.63
CH4 (ppmv)
4
3.5
3
2.5
2
1.5
2018-01-01
2018-02-01
2018-03-01
2018-04-01
2018-05-01
2018-06-01
2018-07-01
2018-08-01
2018-09-01
2018-10-01
2018-11-01
2018-12-01


2017 CH4 Monitoring Results (1-hour average) at Station 986
Maximum=3.59
CH4 (ppmv)
4
3.5
3
2.5
2
1.5
2017-01-01
2017-02-01
2017-03-01
2017-04-01
2017-05-01
2017-06-01
2017-07-01
2017-08-01
2017-09-01
2017-10-01
2017-11-01
2017-12-01


Maximum= 5.33
2018 CH4 Monitoring Results (1-hour average) at Station 986
CH4 (ppmv)
4
3.5
3
2.5
2
1.5
2018-01-01
2018-02-01
2018-03-01
2018-04-01
2018-05-01
2018-06-01
2018-07-01
2018-08-01
2018-09-01
2018-10-01
2018-11-01
2018-12-01



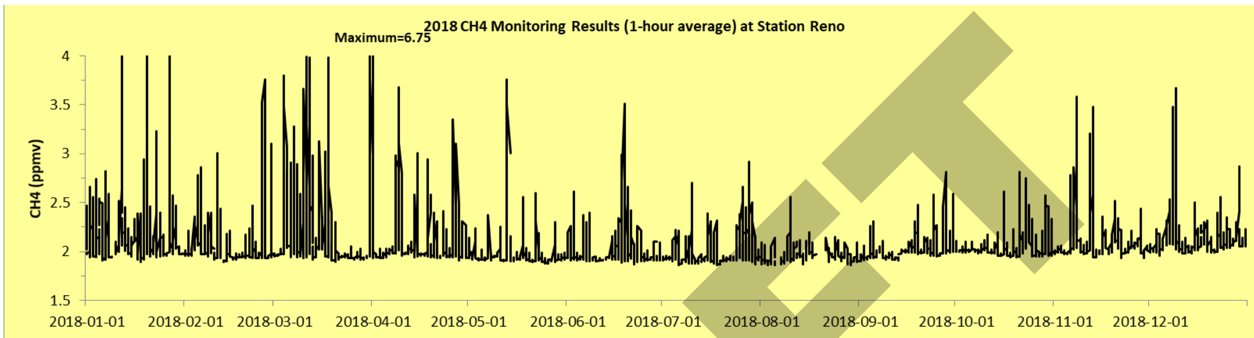




**Figure 13: Hourly Monitored Methane Data**

## 3.4. Monthly Data Analysis

The hourly data presented in this section were analyzed to determine the maximum, 99th percentile, and average of hourly concentrations for each month of data. Calculating percentiles allows data to be grouped based on the percentage of values that fall below a specific value. Arranging the data into percentile ranks can provide insight to the distribution of data and is helpful for understanding outlying values. For example, the 99th percentile value represents the value at which 99% of the data falls below.

Analyses are often carried out using a higher percentile instead of the true maximum as it is a more representative value of the full dataset and is less likely to be impacted by extreme data points. Trend lines of the non-zero series are presented to examine if the series have an increasing or decreasing behavior from January 2017 to December 2018 for all stations. Variation between the seasons is expected due to the impacts of climate on ambient concentration.

### 3.4.1. Total Hydrocarbons

The THC trends for the maximum, 99th percentile and average by month for each site are shown on the following figures. Table 1 presents the minimum and maximum monthly 99th percentile THC for each year.

**Table 1: Minimum and Maximum of 99th Percentile in Each Month of THC Concentrations (2017 and 2018)**

| Station | 2017 | | 2018 | |
|---|---|---|---|---|
| | Minimum (ppmv) | Maximum (ppmv) | Minimum (ppmv) | Maximum (ppmv) |
| **842** | 2.03 | 3.08 | 2.089* | 2.42* |
| **986** | 2.06 | 3.14 | 2.217 | 4.043 |
| **Reno** | 2.79 | 3.44 | 2.382 | 3.758 |

** 842 Station 99th Percentile for June 2018 was excluded from the calculation. Due to equipment failure, only 9.2% of valid data were collected in June 2018.*

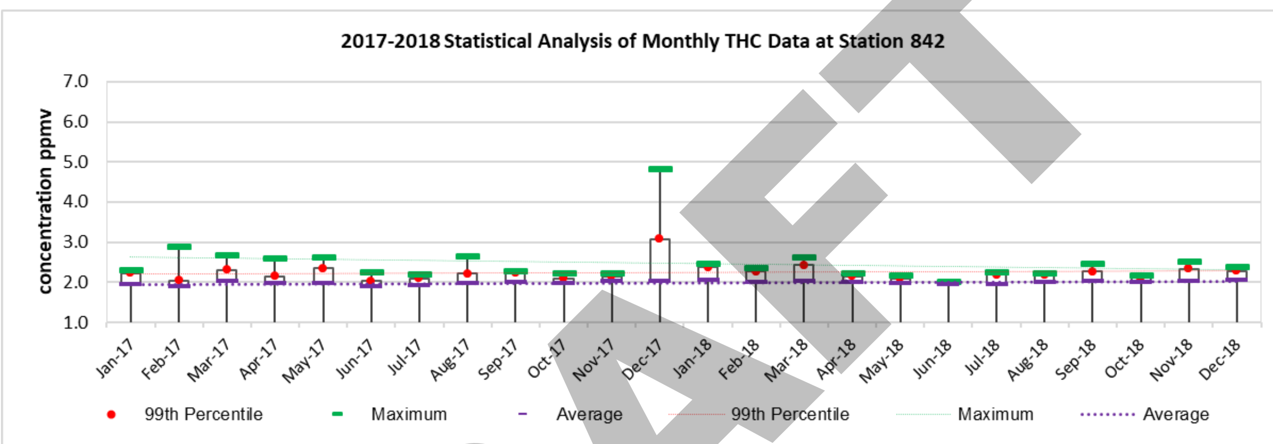



**Figure 14: Total Hydrocarbons Data and Trends at Station 842**

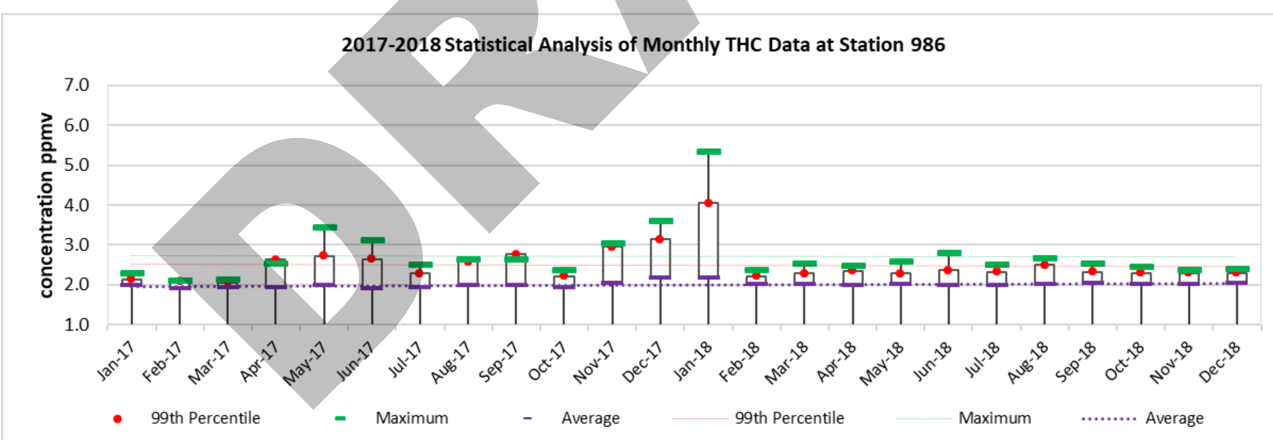



**Figure 15: Total Hydrocarbons Data and Trends at Station 896**

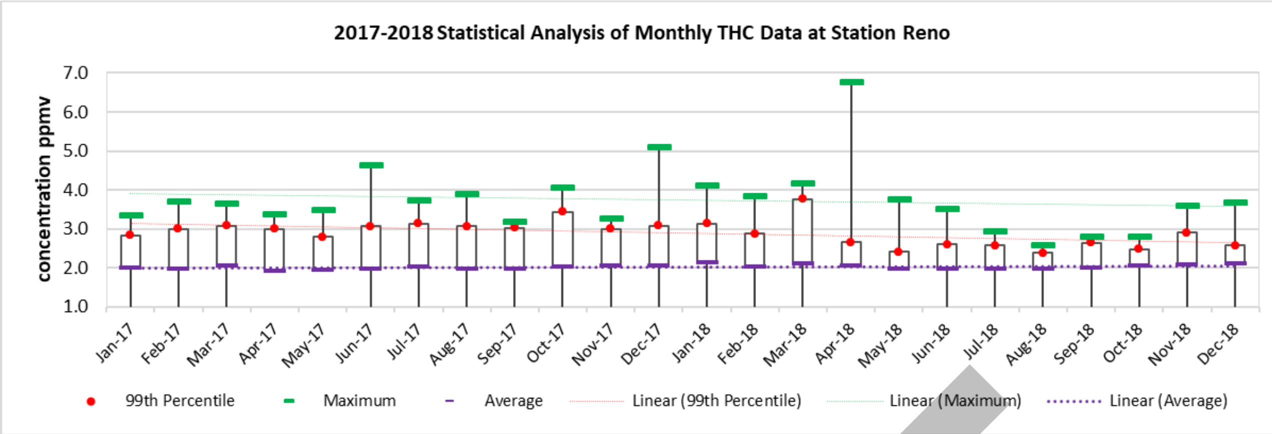



Figure 16: Total Hydrocarbons Data and Trends at Reno Station

### 3.4.2. Non-Methane Hydrocarbons

The NMHC trends for the maximum, 99th percentile, and average by month for each site are shown on the following figures.

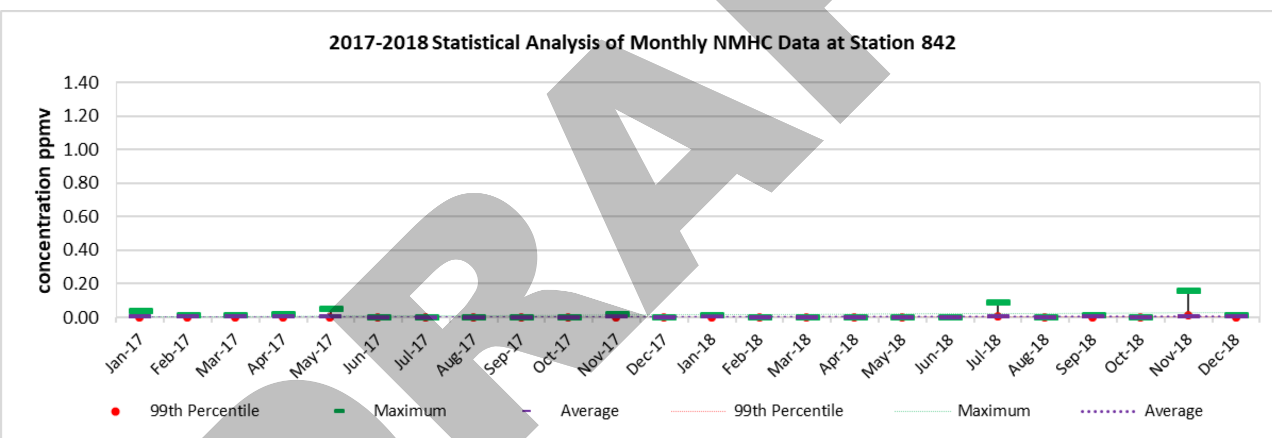



Figure 17: Non-methane Hydrocarbon Data and Trends at Station 842

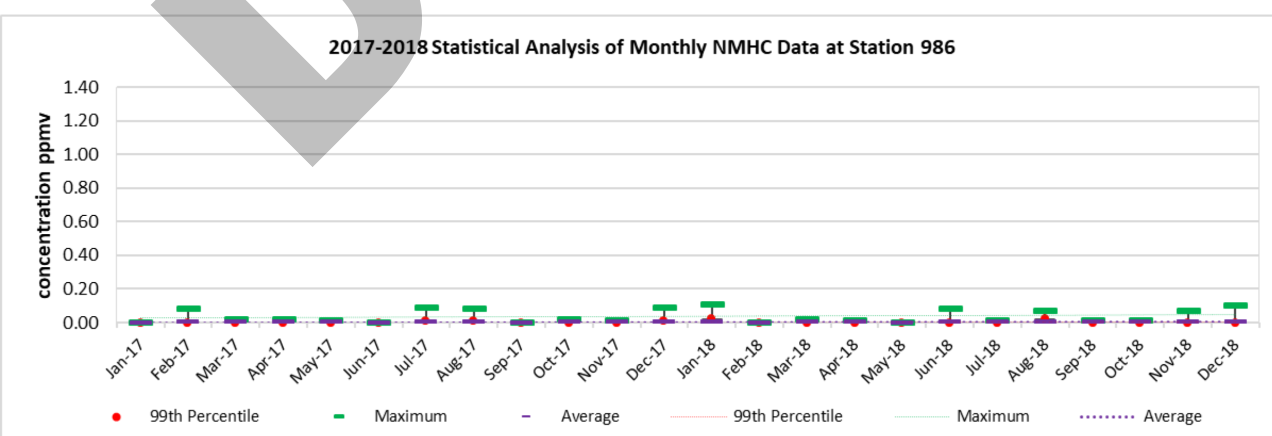



Figure 18: Non-methane Hydrocarbon Data and Trends at Station 986

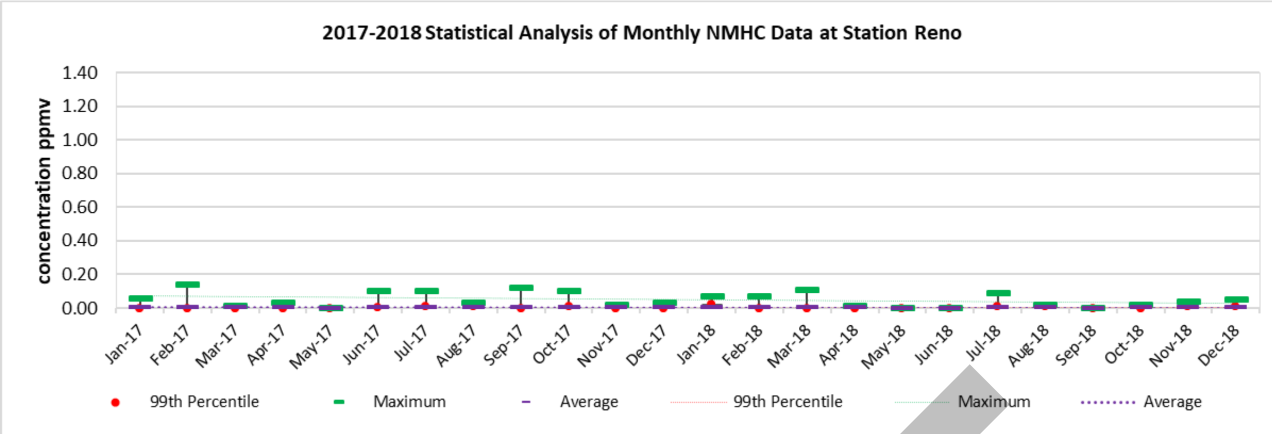



Figure 19: Non-methane Hydrocarbon Data and Trends at Reno Station

### 3.4.3. Total Reduced Sulphur

The TRS trends for the maximum, 99th percentile and average by month for each site are shown on the following figures.

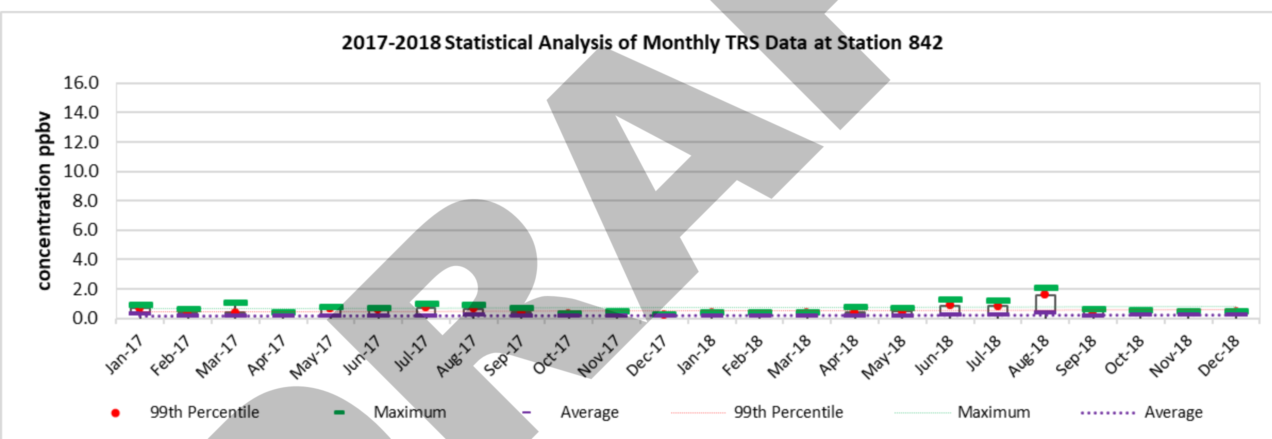



Figure 20: Total Reduced Sulphur Data and Trends at Station 842

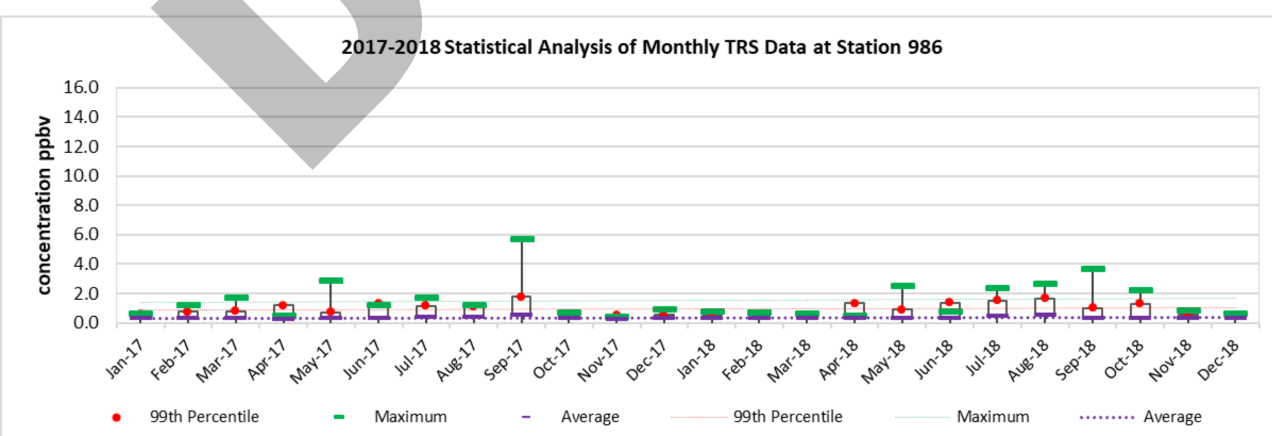



Figure 21: Total Reduced Sulphur Data and Trends at Station 986

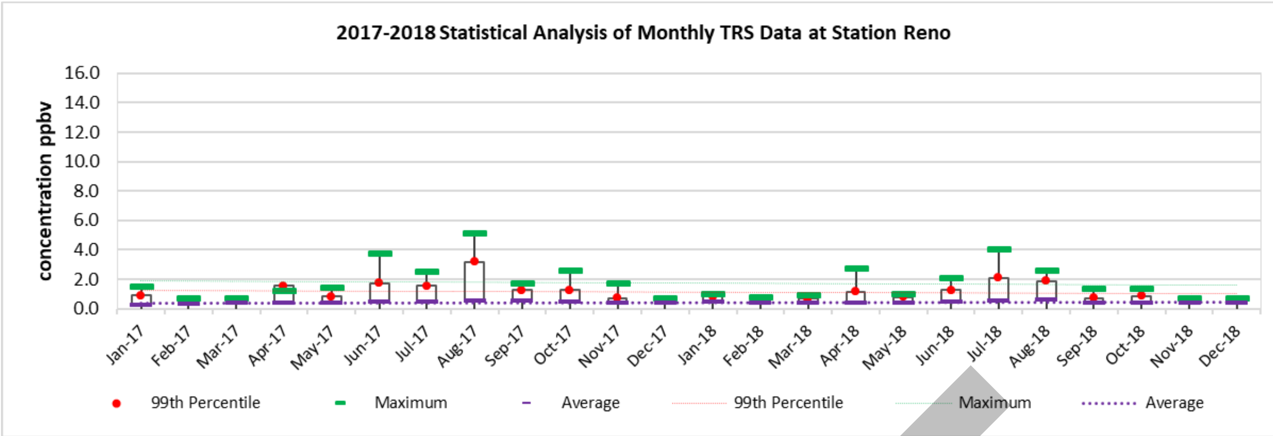



Figure 22: Total Reduced Sulphur Data and Trends at Reno Station

### 3.4.4. Sulphur Dioxide

The $SO_2$ trends for the maximum, 99th percentile and average by month for each site are shown on the following figures.

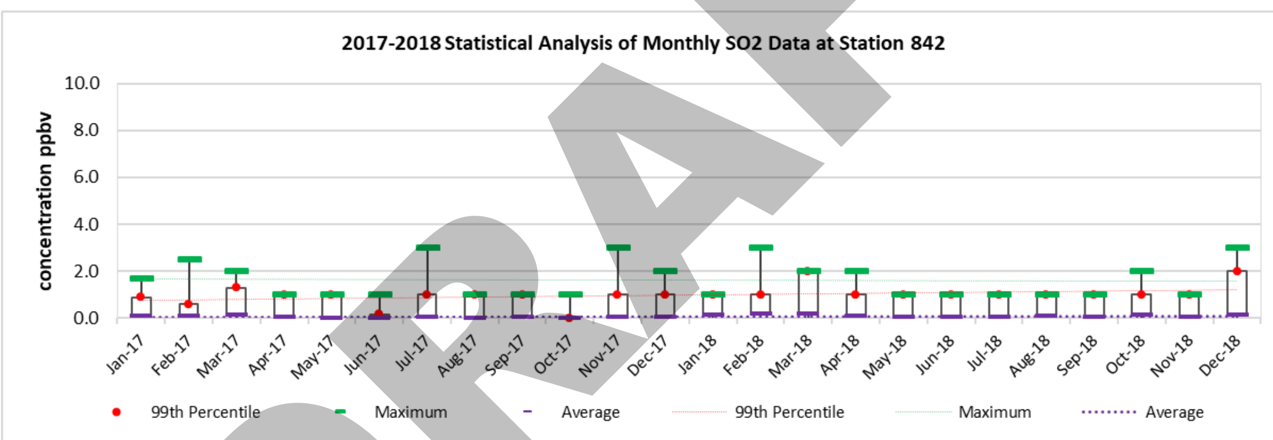



Figure 23: Sulphur Dioxide Data and Trends at Station 842

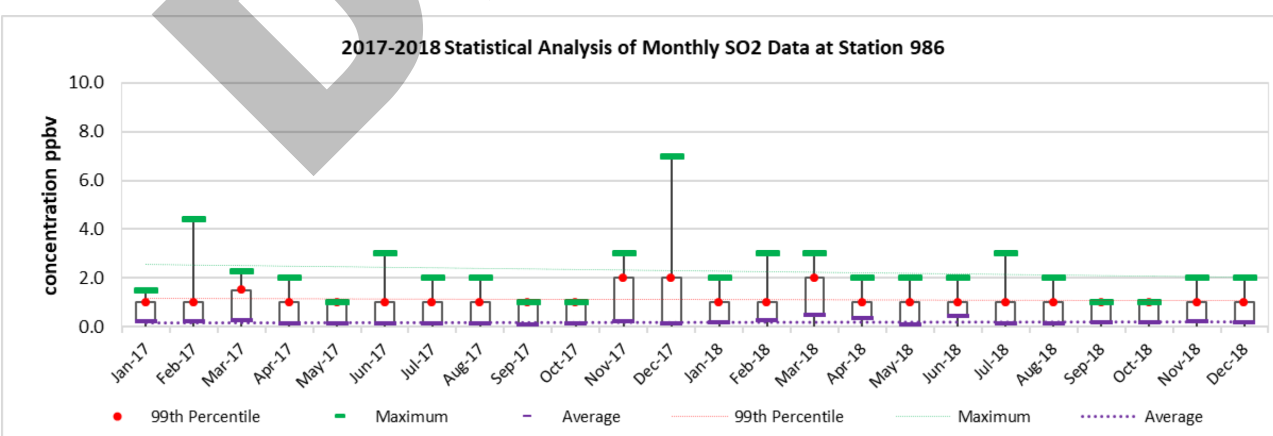



Figure 24: Sulphur Dioxide Data and Trends at Station 986

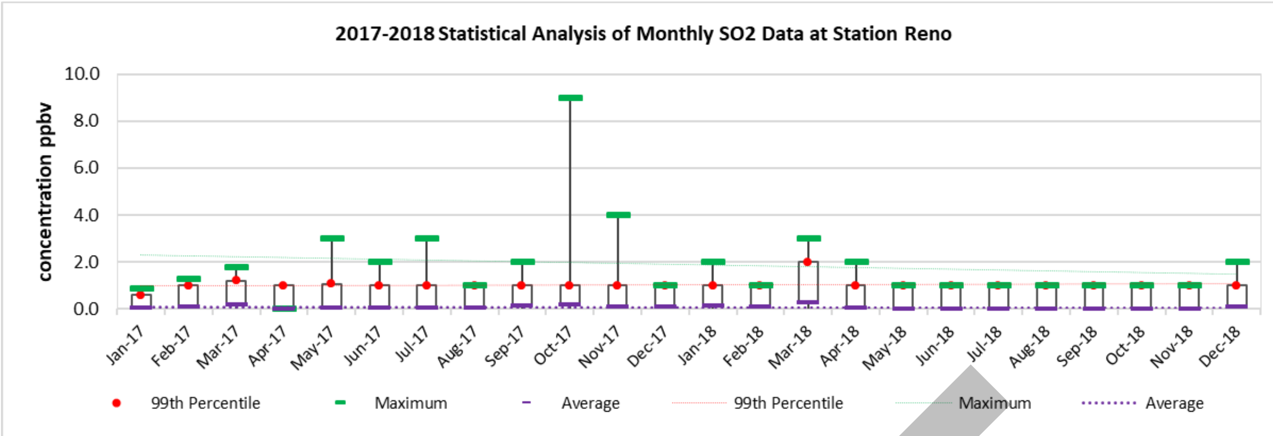



Figure 25: Sulphur Dioxide Data and Trends at Reno Station

### 3.4.5. Methane

The CH4 trends for the maximum, 99th percentile and average by month for each site are shown on the following figures.

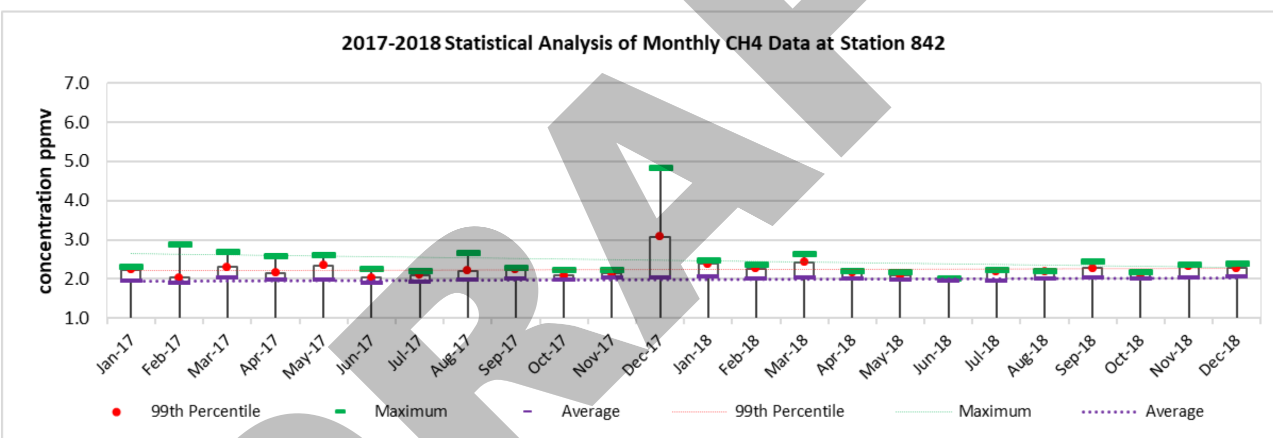



Figure 26: Methane Data and Trends at Station 842

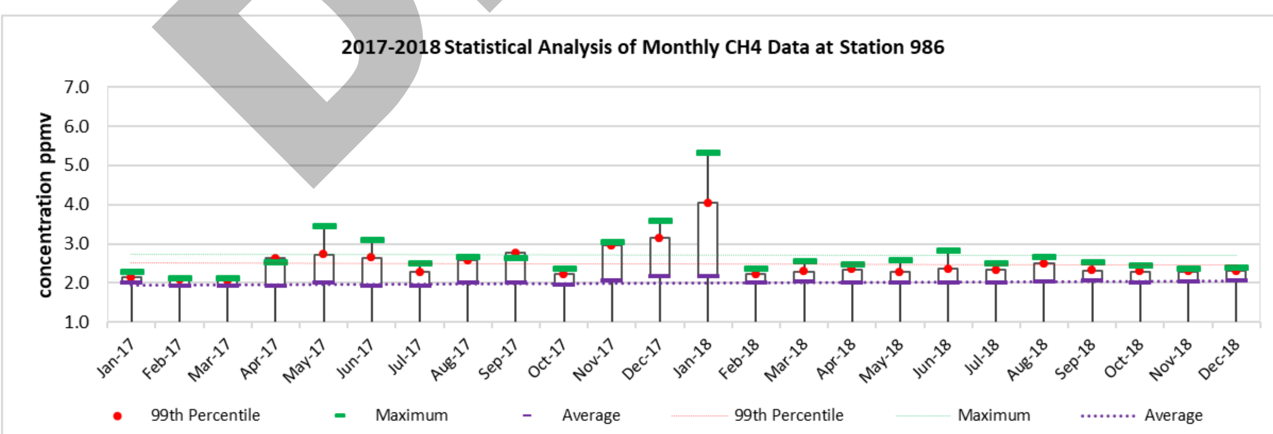



Figure 27: Methane Data and Trends at Station 986

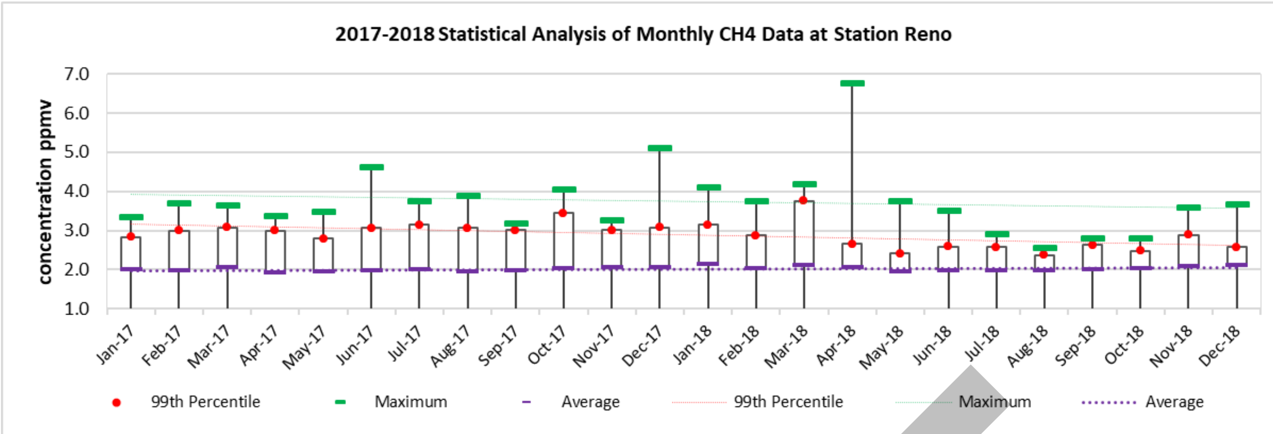



**Figure 28: Methane Data and Trends at the Reno Station**

### 3.4.6. Summary

In general, maximum and average values provide useful statistics but are often an over-simplified and inadequate representation of a dataset. For the measured results, the maximum values tend to fluctuate greatly and the average concentrations stay relatively stable and close to 0 ppmv or ppbv, for NMHC, and TRS and $SO_2$, respectively. However, as the 99$^{th}$ percentile is influenced by the distribution of the data, it provides a useful statistic for analyzing trends in a dataset.

The monthly data analysis for all stations shows that the 99$^{th}$ percentile data for all substances has decreased or stayed the same over the reporting periods.

The correlation between values and wind directions are presented in the concentration roses (Section 3.6), which will assist in identifying from where predominant winds are carrying pollutants.

## 3.5. Annual Data Analysis

Analysis was completed for each station for 2017 and 2018 by calculating the maximum, 99th, 90th, 50th percentiles and minimum value of the 1-hour concentrations for each year for THC, NMHC, TRS, $SO_2$, and $CH_4$. Similar to the 99th percentile, 90th percentile and 50th percentile metrics indicate that 90% and 50% of data fall below that value respectively. Calculating percentiles allow data to be grouped based on the percentage of values that fall below a specific value. Arranging the data into percentile ranks can provide insight to the distribution of data and is helpful for understanding outlying values. By definition, the 50th percentile represents the median of the dataset. The results of this analysis are shown in Tables 2 and 3. The annual 99th percentile concentrations for Stations 986, 842, and Reno were generally lower in in 2018 compared to 2017.

**Table 2: 2017 Monitoring Data Percentiles**

| Location | Rank | THC (ppmv) | NMHC (ppmv) | TRS (ppbv) | SO2 (ppbv) | CH4 (ppmv) |
|---|---|---|---|---|---|---|
| Station 842 | Average | 1.96 | 0.00 | 0 | 0 | 1.96 |
| | Maximum | 4.83 | 0.05 | 1 | 3 | 4.83 |
| | 99th percentile | 2.25 | 0.00 | 0 | 1 | 2.25 |
| | 90th percentile | 2.01 | 0.00 | 0 | 0 | 2.01 |
| | 50th percentile | 1.95 | 0.00 | 0 | 0 | 1.95 |
| | Minimum | 1.79 | 0.00 | 0 | 0 | 1.79 |
| Station 986 | Average | 1.97 | 0.00 | 0 | 0 | 1.97 |
| | Maximum | 3.59 | 0.09 | 6 | 7 | 3.59 |
| | 99th percentile | 2.52 | 0.00 | 1 | 1 | 2.52 |
| | 90th percentile | 2.06 | 0.00 | 0 | 1 | 2.06 |
| | 50th percentile | 1.95 | 0.00 | 0 | 0 | 1.95 |
| | Minimum | 1.69 | 0.00 | 0 | 0 | 1.69 |
| Reno | Average | 1.99 | 0.00 | 0 | 0 | 1.99 |
| | Maximum | 5.11 | 0.14 | 5 | 9 | 5.11 |
| | 99th percentile | 3.04 | 0.00 | 1 | 1 | 3.04 |
| | 90th percentile | 2.12 | 0.00 | 1 | 0 | 2.12 |
| | 50th percentile | 1.94 | 0.00 | 0 | 0 | 1.94 |
| | Minimum | 1.74 | 0.00 | 0 | 0 | 1.74 |
| AAAQO* | 1-hour | - | - | - | 172 | - |

* Source: Alberta Ambient Air Quality Objectives and Guidelines Summary ( AEP 2017)

**Table 3: 2018 Monitoring Data Percentiles**

| Location | Rank | THC (ppmv) | NMHC (ppmv) | TRS (ppbv) | SO2 (ppbv) | CH4 (ppmv) |
|---|---|---|---|---|---|---|
| **Station 842** [1] | **Average** | 2.00 | 0.00 | 0.22 | 0 | 2.00 |
| | **Maximum** | 2.63 | 0.16 | 2.05 | 3 | 2.63 |
| | **99th percentile** | 2.24 | 0.00 | 0.58 | 1 | 2.24 |
| | **90th percentile** | 2.07 | 0.00 | 0.32 | 1 | 2.07 |
| | **50th percentile** | 1.99 | 0.00 | 0.20 | 0 | 1.99 |
| | **Minimum** | 1.86 | 0.00 | 0.00 | 0 | 1.86 |
| **Station 986** | **Average** | 2.02 | 0.00 | 0.34 | 0 | 2.02 |
| | **Maximum** | 5.33 | 0.11 | 3.68 | 3 | 5.33 |
| | **99th percentile** | 2.46 | 0.00 | 0.98 | 1 | 2.46 |
| | **90th percentile** | 2.13 | 0.00 | 0.52 | 1 | 2.13 |
| | **50th percentile** | 2.00 | 0.00 | 0.32 | 0 | 2.00 |
| | **Minimum** | 1.87 | 0.00 | 0.00 | 0 | 1.87 |
| **Reno** | **Average** | 2.03 | 0.00 | 0.42 | 0 | 2.03 |
| | **Maximum** | 6.76 | 0.11 | 4.06 | 3 | 6.75 |
| | **99th percentile** | 2.75 | 0.01 | 1.02 | 1 | 2.75 |
| | **90th percentile** | 2.18 | 0.00 | 0.57 | 0 | 2.18 |
| | **50th percentile** | 1.97 | 0.00 | 0.41 | 0 | 1.95 |
| | **Minimum** | 1.86 | 0.00 | 0.14 | 0 | 1.86 |
| **AAAQO*** | **1-hour** | - | - | - | 172 | - |

[1] 842 Station 99 Percentile for June 2018 was excluded from the calculation. Due to equipment failure, only 9.2% of valid data were collected in June 2018.

* Source: Alberta Ambient Air Quality Objectives and Guidelines Summary ( AEP 2017)



## 3.6. Concentration Roses for Continuous Monitoring Data

Much the same as wind roses, concentration roses show the frequency of contaminant concentrations travelling with winds blowing from a particular direction over a specified period. The length of each ‘spoke’ around the circle is related to the frequency of that concentration of the contaminant occurring.

Concentration roses will have the same shape as wind roses. The focus is on which direction the higher concentrations come from.

### 3.6.1. Total Hydrocarbons

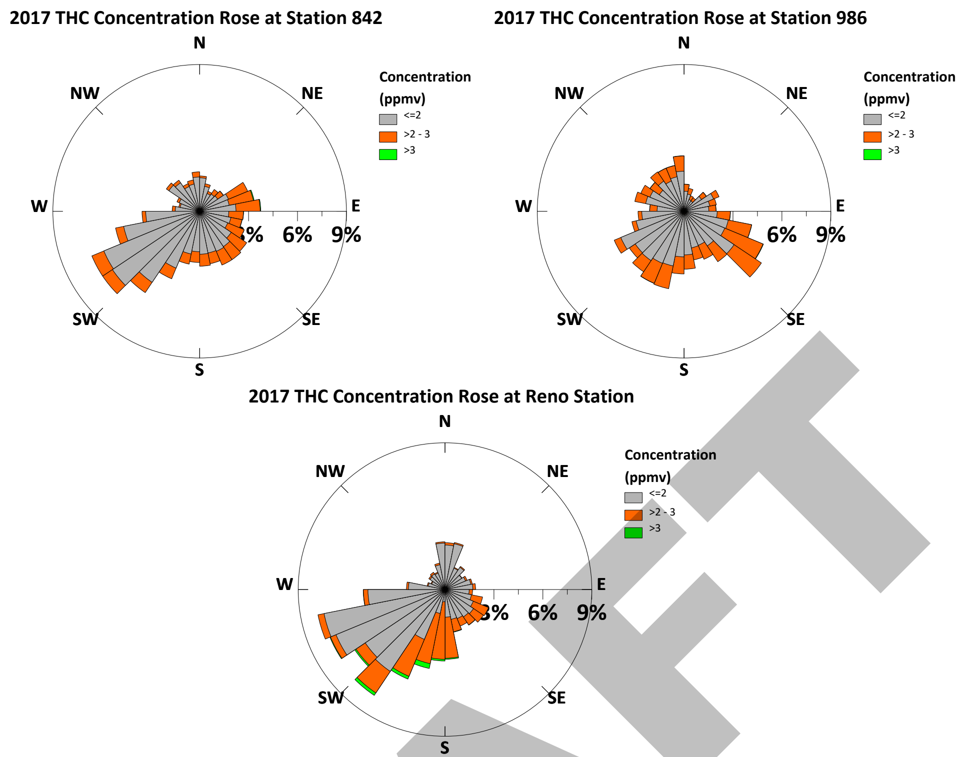



Figure 29: Total Hydrocarbons Concentration Roses for 2017 at Station 842(left), Station 986 (right), and Reno Station (bottom)

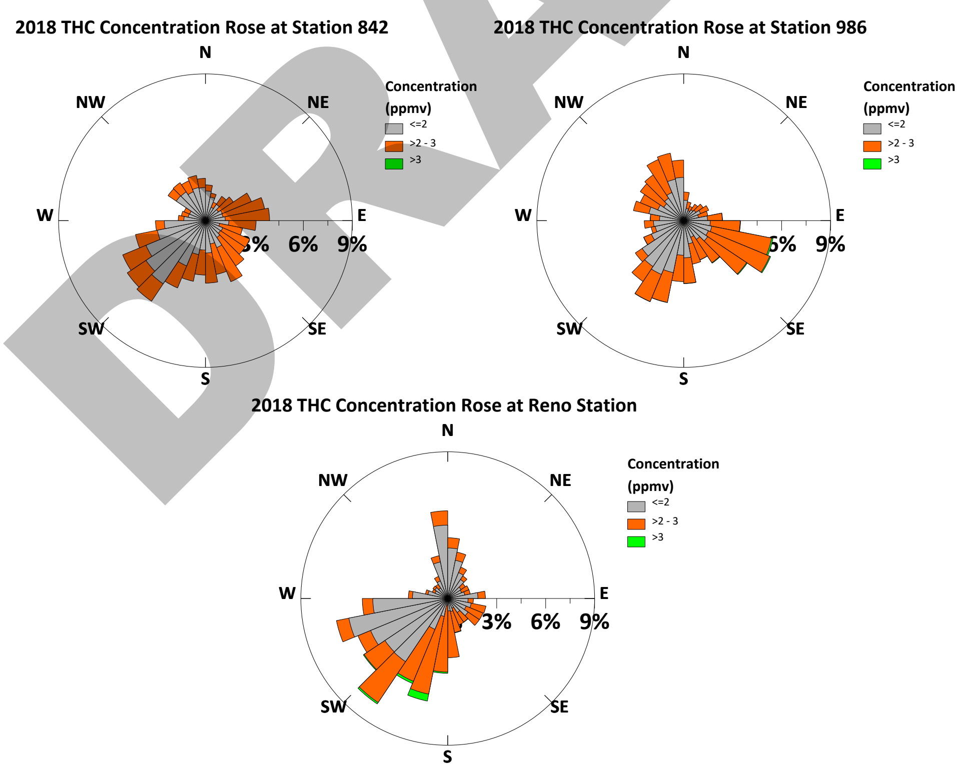



Figure 30: Total Hydrocarbons Concentration Roses for 2018 at Station 842(left), Station 986 (right), and Reno Station (bottom)

### 3.6.2. Non-methane Hydrocarbons

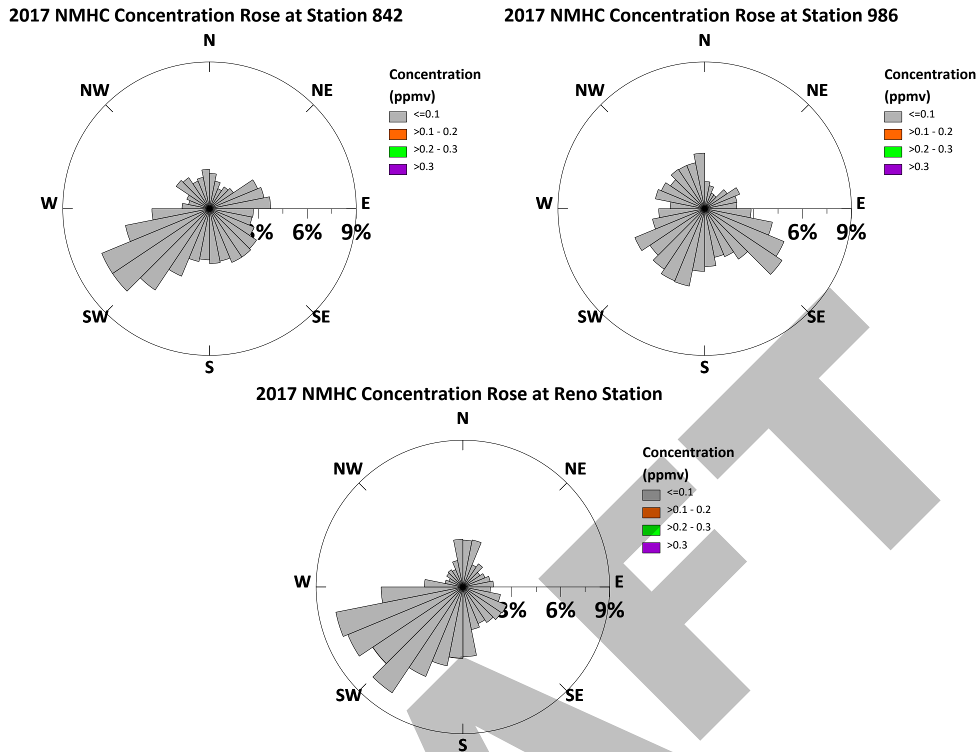



Figure 31: Non-methane Hydrocarbons Concentration Roses for 2017 at Station 842 (left), Station 986 (right), and Reno Station (bottom)

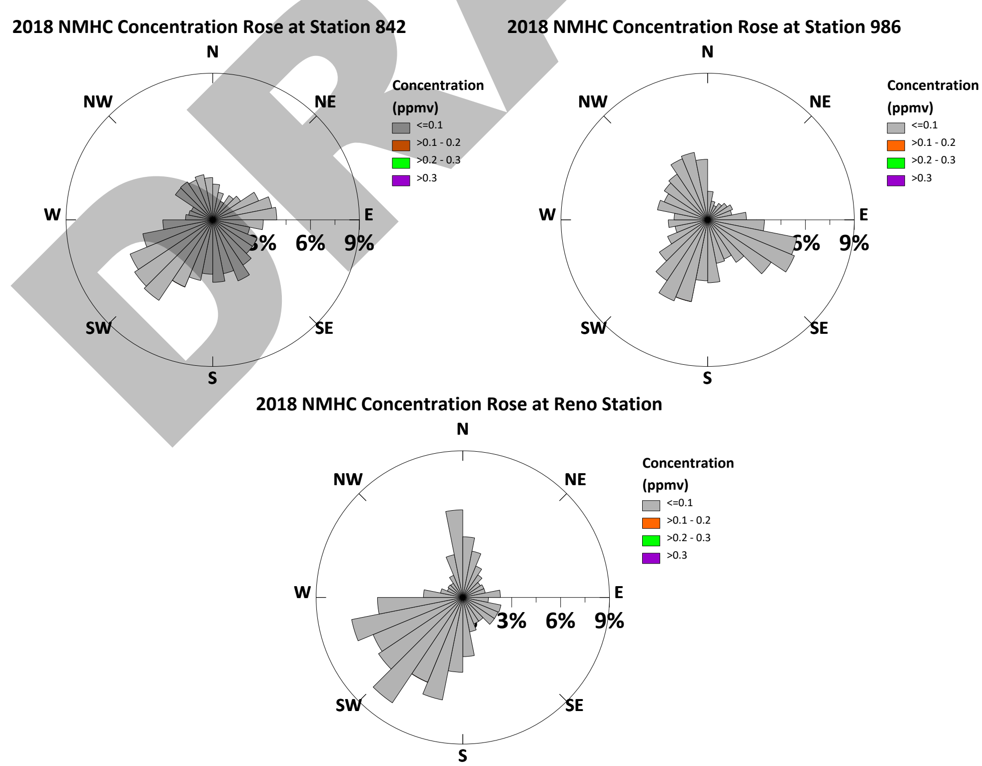



Figure 32: Non-methane Hydrocarbons Concentration Roses for 2018 at Station 842 (left), Station 986 (right), and Reno Station (bottom)

### 3.6.3. Total Reduced Sulphur

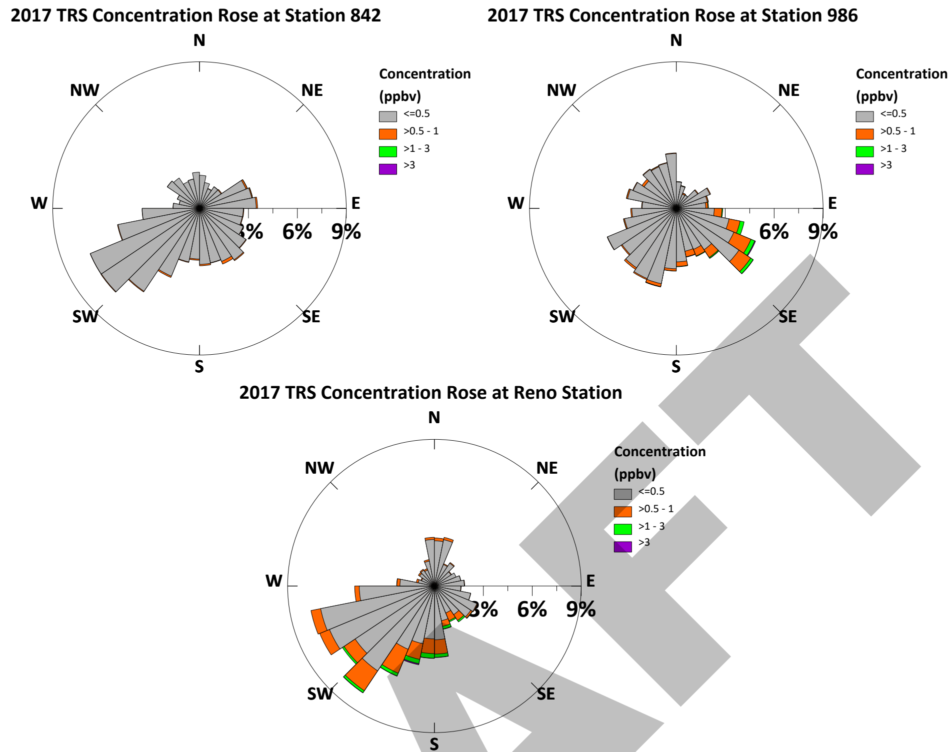



Figure 33: Total Reduced Sulphur Concentration Roses for 2017 at Station 842 (left), Station 986 (right), and Reno Station (bottom)

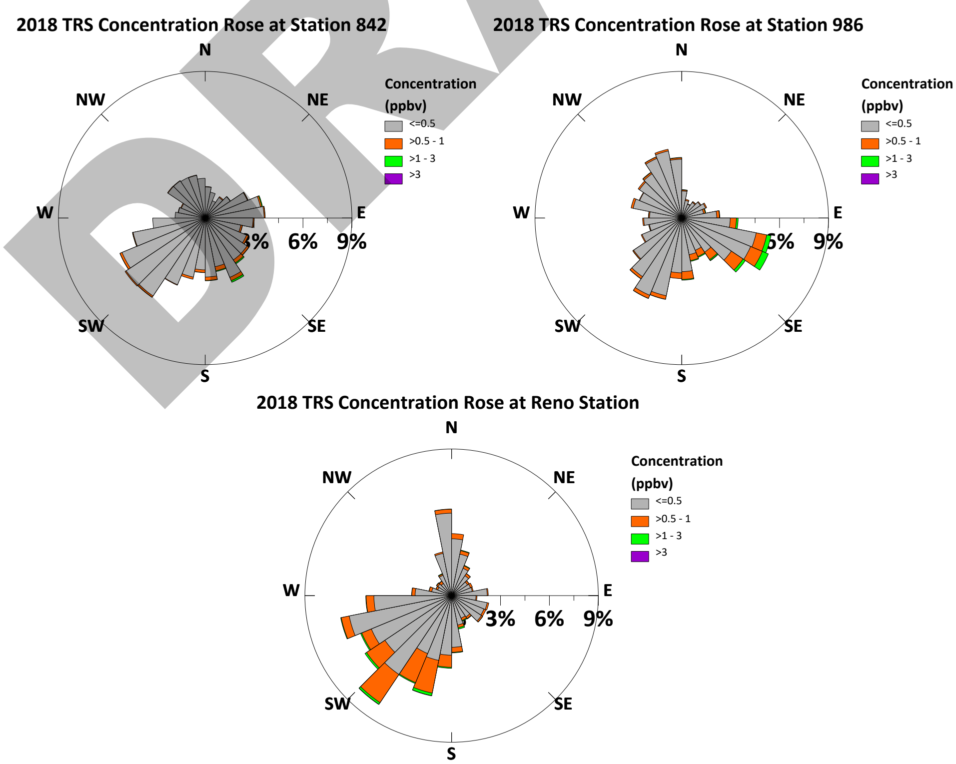



Figure 34: Total Reduced Sulphur Concentration Roses for 2018 at Station 842 (left), Station 986 (right), and Reno Station (bottom)

### 3.6.4. Sulphur Dioxide

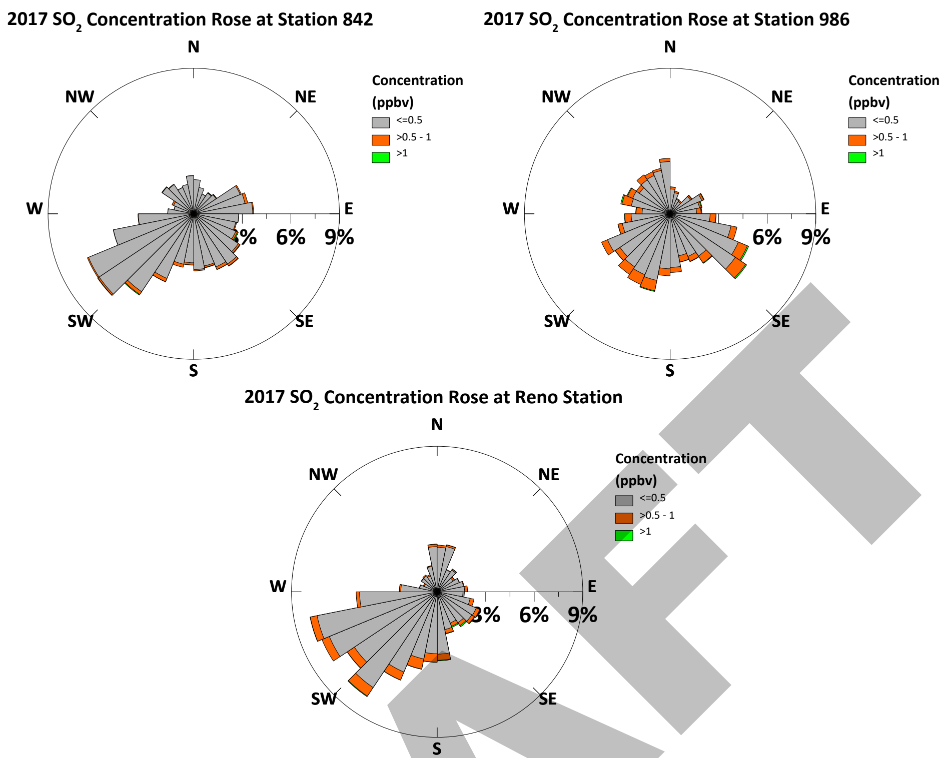



Figure 35: Sulphur Dioxide Concentration Roses for 2017 at Station 842 (left), Station 986 (right), and Reno Station (bottom)

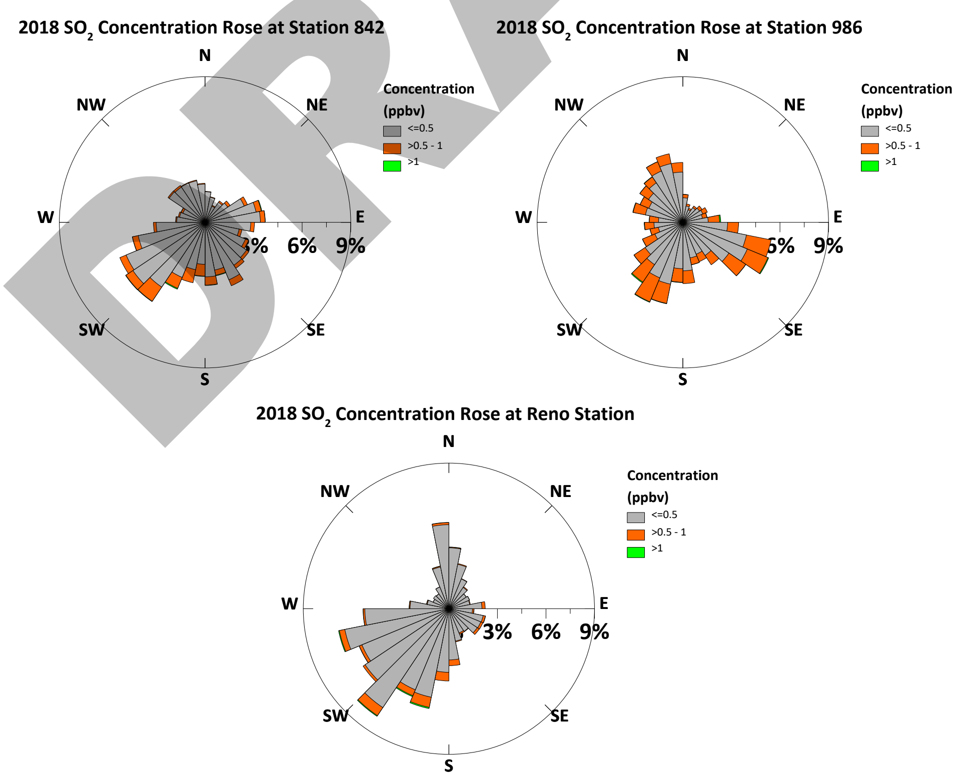



Figure 36: Sulphur Dioxide Concentration Roses for 2018 at Station 842 (left), Station 986 (right), and Reno Station (bottom)

### 3.6.5. Methane

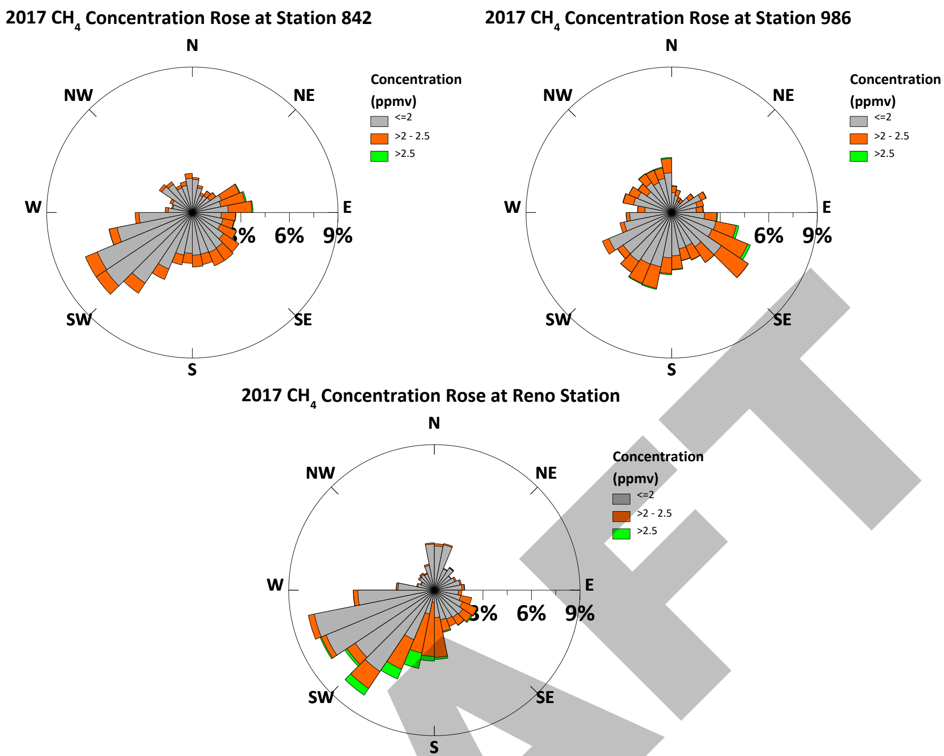



Figure 37: Methane Concentration Roses for 2017 at Station 842 (left), Station 986 (right), and Reno Station (bottom)

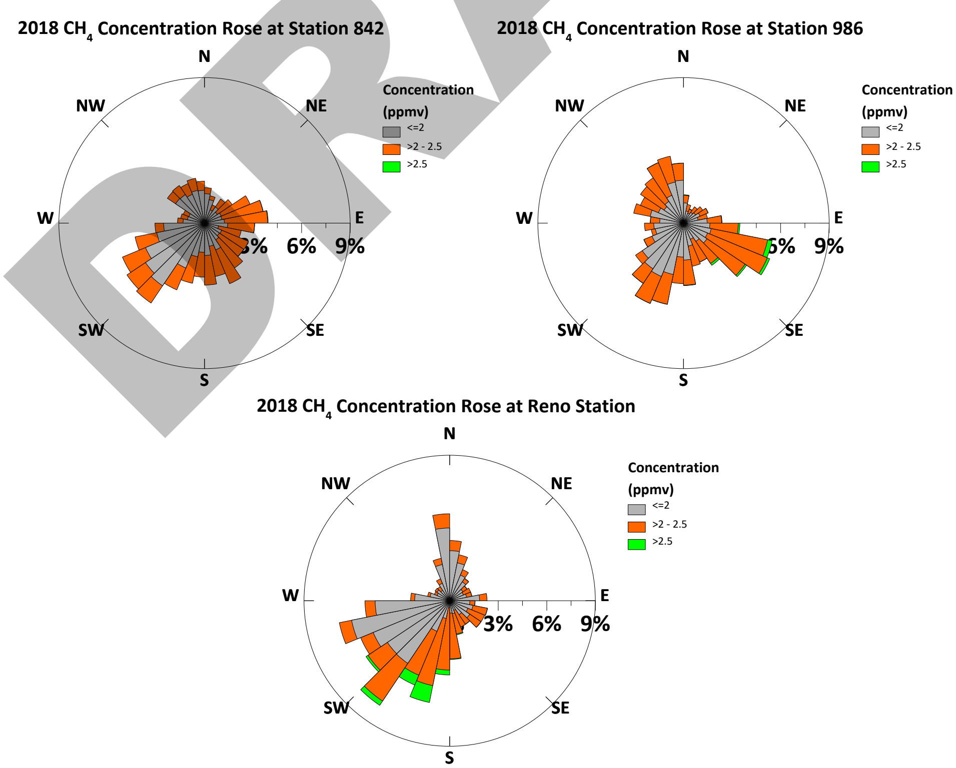



Figure 38: Methane Concentration Roses for 2018 at Station 842 (left), Station 986 (right), and Reno Station (bottom)

### 3.6.6. Summary

The concentration roses for the Reno and 842 Station indicate that the sources for most contaminants are likely the nearby heavy oil operations. Further study work is required to verify the sources, however the initial analysis suggests that proximity of wells and associated infrastructure are likely influences, particularly for hydrocarbons. The proximity of infrastructure to the Reno Station, is much closer compared to Station 986 and 842. The facilities nearest Station 986 and 842 are approximately 6km and 4km away; however at the Reno Station, similar facilities are 300 - 500m away which represents an order of magnitude difference. There appear to be other sources not related to heavy oil operations contributing the elevated readings when examining the frequency distribution of other pollutants including $SO_2$; other industry in the vicinity includes non-heavy oil facilities, land fill stations, agricultural operations and a relatively close pulp mill operation. Cattle grazing south of Station 986 are the likely source of methane when wind is coming from that direction.

# 4. TRIGGERED VOLATILE ORGANIC COMPOUND SAMPLING

Canister sampling events are triggered when NMHC concentrations at a station measure a 0.3 ppmv averaged over 5 minutes. The canister samples were collected and taken to a laboratory for analysis of over 140 VOC compounds and total reduced sulphur compounds. Time and date of the canister sampling was recorded and used to cross reference the sample to the monitored data and retrieve the associated wind direction and speed.

The 2018 triggered canister VOC sampling results at the three stations are presented in Table 4. The top twelve compounds, of the 140 compounds sampled, with highest concentrations were selected and presented in Table 4. A comparison of the data to the available AAAQO (AEP 2017) was conducted; methane ($CH_4$) is also presented in Table 4. A complete list of species for each of the samples is provided in Appendix B, Table B-1.

Three samples were collected across the entire PRAMP network in 2018; this represents the lowest number of triggered canisters collected in the network since this program began.

## 4.1. Volatile Organic Compound Results Compared to AAAQO

There were no exceedances of the AAAQOs in 2018 however it should be noted that there are few hydrocarbon species that have an associated AAAQO.

## Table 4: Volatile Organic Compound Canister Sample 1-hour Average Concentrations (ppbv)

| Station ID | Sampled Date (YYYY/MM/DD) | Sampled Time (MST) | WS (km/hr) | WD | NMHC triggered concentration (ppmv) | CH4 | Acetone | Acrolein | Benzene | Ethanol | Freon-113 | Isobutane | Isopentane | Butane | n-Butane | n-Pentane | Toluene | Pentane |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AAAQO* | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 9 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 499 | n/a |
| 842 [1] | 2018-02-16 | 10:35 | 8.4 | 4 | 0 | 2500 | 5.6 | <0.4 | <0.01 | 1.7 | <0.01 | <100 | 0.93 | n/a | <300 | 2.7 | <0.01 | n/a |
| 842 [2] | 2018-03-01 | 1:25 | 9.6 | 66 | 0.33 | <100 | 3.1 | <0.4 | 0.1 | 1.5 | 0.03 | <100 | 0.75 | n/a | <300 | 0.3 | <0.01 | n/a |
| Reno | 2018-03-07 | 21:45 | 2.5 | 202 | 0.42 | 4500 | 0.9 | <0.4 | 0.13 | 0.5 | 0.07 | <100 | 1.36 | n/a | <300 | 0.9 | 0.26 | n/a |
| Reno [3] | 2018-07-02 | 8:10 | 12.1 | 5 | 2.1 | 1700 | 4.5 | 0.5 | 0.08 | 6.3 | <0.01 | <100 | 0.11 | n/a | <300 | <0.1 | 0.18 | n/a |
| 842 | 2018-07-26 | 7:30 | 2.3 | 181 | 0.31 | 2100 | 8.3 | 0.6 | 0.6 | 5.5 | <0.02 | <100 | 0.54 | n/a | <300 | 0.3 | 0.37 | n/a |
| 986 | 2018-12-09 | 20:25 | 4.8 | 294 | 0.63 | 2000 | 25.6 | 1.7 | 1.95 | 9.1 | 0.12 | <100 | 0.48 | n/a | <300 | 0.7 | 1.33 | n/a |

* Alberta Ambient Air Quality Objectives and Guidelines Summary (bolded values exceed)
(a) Data Source: Alberta Ambient Air Quality Objectives and Guidelines Summary (AEP 2017)
n/a – data not available
1. Canister collected on February 16 is not a valid event. The sample was collected during the canister system check.
2. Canister collected on March 1 is not a valid event. The sample was a blank sample.
3. Canister collected on July 2 is not considered a valid event. The canister system was triggerd while the carrier gas was being replaced.

## 5. BACKGROUND CONCENTRATIONS OF METHANE

A background concentration is the combination of naturally occurring chemical substances and ambient concentrations of man-made chemical substances in the environment that is representative of the surrounding area. The statistical analysis of the 1-hour concentrations for each year is presented in Tables 2 and 3.

Similar to previous years, the $50^{th}$ percentile reading from each station was found to be consistent from 2017 to 2018. This suggests that the $50^{th}$ percentile represents the background concentration as it remains nearly unchanged regardless of year and location. It is reasonable to conclude that a suitable background methane ($CH_4$) concentration is approximately 1.90 ppmv for the region.

## 6. COMPARISONS OF RESULTS ACROSS ALBERTA

The following analysis was conducted for all monitoring sites in Alberta (including Stations 842, 986, and Reno) that monitored for $CH_4$, NMHC, THC, and TRS during 2017 and 2018. The 99$^{th}$ percentile is often used as an indicator of elevated concentrations that are exceeded 1% of the time. A maximum value could be used but it occurs only once. Alberta air quality management frameworks often use the annual 99$^{th}$ percentile as an indicator of prolonged exposures or of multiple episodes to high concentrations. For example, the annual 99$^{th}$ percentile target for $SO_2$ for a regional plan is set by reviewing past monitoring data.

The station data was downloaded from the Alberta Environment and Parks air data site (http://airdata.alberta.ca/aepContent/Reports/DataDownloadMain.aspx) using the one parameter at multiple stations reporting option. Additional station information reports including the airshed, location, start date, status and parameters monitored are available on the Alberta Environment and Parks air data site (http://airdata.alberta.ca/aepContent/Reports/StationInformationMain.aspx). The locations of many of the stations is shown on the air quality technical map (http://maps.srd.alberta.ca/AQHI).

The 99$^{th}$ percentile for each month was calculated along with the annual or data set 99$^{th}$ percentile and average for each station for the available data. For ease of viewing, only the maximum 99$^{th}$ percentile for each month and annual averages are presented on the figures. All of the calculated statistics are presented in the tables.

## 6.1. Methane

Figure 39 and Table 5 compare the $CH_4$ 1-hour average measurements in Alberta in 2017 and 2018 for 33 stations.

Seven new stations were added in the province in 2018: Cold Lake South, Calgary Varsity, Maskwa, St. Lina, Bonnyville -East station, Grande Prairie (Henry Pirker) and Wemnley -Portable. Two stations were decommissioned in 2018: Bonnyville station and Horn Hill.

Twenty-two sites had a full year of data in 2017. The number of months of available data is shown in brackets for the following stations missing data in 2017:

- Stony Mountain (Conklin Lookout) [11]
- Bonnyville station (Portable) [7]
- Horton Hill 1 [6]
- Horton Hill [2]

Nineteen sites had a full year of data in 2018. The number of months of available data is shown in brackets for the following stations missing data in 2018:

- Edmonton South [11]
- PRAMP 842 [11]
- Calgary Varsity [7]
- Calgary Southeast [6]
- Calgary Northwest [5]
- Cold Lake South [5]
- St. Lina [5]
- Horton Hill [4]
- Maskwa [3]
- Bonnyville-East station [2]
- Grande Prairie (Henry Pirker) [2]
- Wembley -Portable [2]

$CH_4$ readings in the Three Creeks area are comparable to other locations in Alberta and notably lower than most urban and industrial areas.

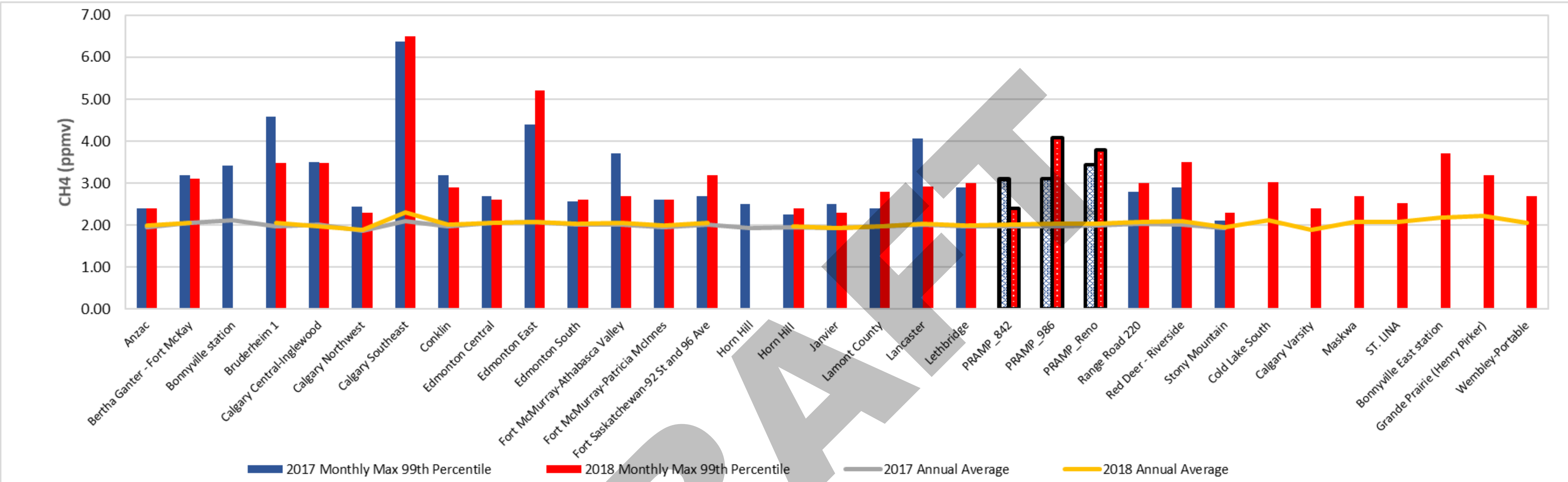



Figure 39: CH4 1-hour Average Measurements in Alberta in 2016 and 2017

**Table 5: CH4 1-hour Average Measurements in Alberta for 2017 and 2018 (ppmv)**

| Sorted Results | Anzac | Bertha Ganter - Fort McKay | Bonnyville station | Bruderheim 1 | Calgary Central-Inglewood | Calgary Northwest | Calgary Southeast | Conklin | Edmonton Central | Edmonton East | Edmonton South | Fort McMurray-Athabasca Valley | Fort McMurray-Patricia McInnes | Fort Saskatchewan-92 St and 96 Ave | Horn Hill* | Horn Hill* | Janvier | Lamont County | Lancaster | Lethbridge | PRAMP_842 | PRAMP_986 | PRAMP_Reno | Range Road 220 | Red Deer - Riverside | Stony Mountain | Cold Lake South | Calgary Varsity | Maskwa | ST. LINA | Bonnyville East station | Grande Prairie (Henry Pirker) | Wembley-Portable |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2017 Monthly Max 99th Percentile | 2.39 | 3.19 | 3.42 | 4.59 | 3.51 | 2.43 | 6.38 | 3.20 | 2.70 | 4.39 | 2.57 | 3.70 | 2.60 | 2.70 | 2.50 | 2.26 | 2.50 | 2.40 | 4.06 | 2.90 | 3.10 | 3.11 | 3.43 | 2.79 | 2.90 | 2.12 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 2018 Monthly Max 99th Percentile | 2.39 | 3.10 | n/a | 3.49 | 3.47 | 2.30 | 6.50 | 2.90 | 2.61 | 5.20 | 2.60 | 2.70 | 2.60 | 3.20 | n/a | 2.40 | 2.30 | 2.80 | 2.92 | 3.00 | 2.40 | 4.08 | 3.79 | 3.00 | 3.50 | 2.30 | 3.02 | 2.40 | 2.69 | 2.53 | 3.70 | 3.20 | 2.70 |
| 2017 Annual 99th Percentile | 2.20 | 2.70 | 3.00 | 3.50 | 2.80 | 2.10 | 4.71 | 2.60 | 2.50 | 3.00 | 2.40 | 2.50 | 2.30 | 2.50 | 2.20 | 2.20 | 2.10 | 2.30 | 2.70 | 2.44 | 2.20 | 2.60 | 3.00 | 2.53 | 2.70 | 2.10 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 2018 Annual 99th Percentile | 2.20 | 2.70 | n/a | 3.10 | 2.80 | 2.20 | 5.60 | 2.40 | 2.50 | 3.00 | 2.40 | 2.40 | 2.40 | 2.70 | n/a | 2.30 | 2.20 | 2.40 | 2.70 | 2.60 | 2.20 | 2.50 | 2.93 | 2.70 | 2.80 | 2.10 | 2.80 | 2.20 | 2.60 | 2.50 | 3.50 | 3.01 | 2.70 |
| 2017 Annual Average | 1.96 | 2.06 | 2.12 | 1.98 | 2.01 | 1.88 | 2.10 | 1.96 | 2.05 | 2.08 | 2.01 | 2.00 | 1.95 | 2.02 | 1.93 | 1.95 | 1.92 | 1.97 | 2.02 | 1.97 | 1.96 | 1.97 | 1.99 | 2.04 | 2.01 | 1.92 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 2018 Annual Average | 2.00 | 2.06 | n/a | 2.06 | 1.98 | 1.89 | 2.31 | 2.01 | 2.06 | 2.07 | 2.03 | 2.05 | 2.00 | 2.05 | n/a | 1.97 | 1.94 | 1.98 | 2.03 | 2.00 | 2.01 | 2.03 | 2.04 | 2.09 | 2.09 | 1.95 | 2.11 | 1.90 | 2.09 | 2.08 | 2.18 | 2.23 | 2.07 |

**Notes:**

*** There were two dataset that were named as Horn Hill in 2017. Only one dataset that was named Horn Hill was shown in 2018 on AirData Warehouse website.**

## 6.2. Non-methane Hydrocarbons

Figure 40 and Table 6 compare the NMHC 1-hour average measurements in Alberta in 2017 and 2018 for 33 stations.

Figure 40 shows the maximum monthly 99th percentile values for stations across Alberta. The 99th percentiles that were elevated in 2017 generally remained elevated in 2018. Annual averages are very close for 2017 and 2018 at most of the stations.

Seven new stations were added in the province in 2018: Cold Lake South, Calgary Varsity, Maskwa, St. Lina, Bonnyville-East station, Grande Prairie (Henry Pirker) and Wembley-Portable. Two stations were decommissioned in 2018: Bonnyville station and Horn Hill.

Twenty-two sites had a full year of NMHC data for 2017. The number of months of available data is shown in brackets for the following stations missing data in 2017:

- Stony Mountain (Conklin Lookout) [11]
- Bonnyville Station (Portable) [7]
- Horton Hill [6]
- Horton Hill [2]

Nineteen sites had a full year of NMHC data for 2018. The number of months of available data is shown in brackets for the following stations missing data in 2018:

- Edmonton South [11]
- PRAMP 842 [11]
- Calgary Varsity [7]
- Calgary Southeast [6]
- Calgary Northwest [5]
- Cold Lake South [5]
- St. Lina [5]
- Horton Hill [4]
- Maskwa [3]
- Bonnyville-East station [2]
- Grande Prairie (Henry Pirker) [2]
- Wembley-Portable [2]

NMHC readings in the Peace River Area remain amongst the lowest concentrations in the province.

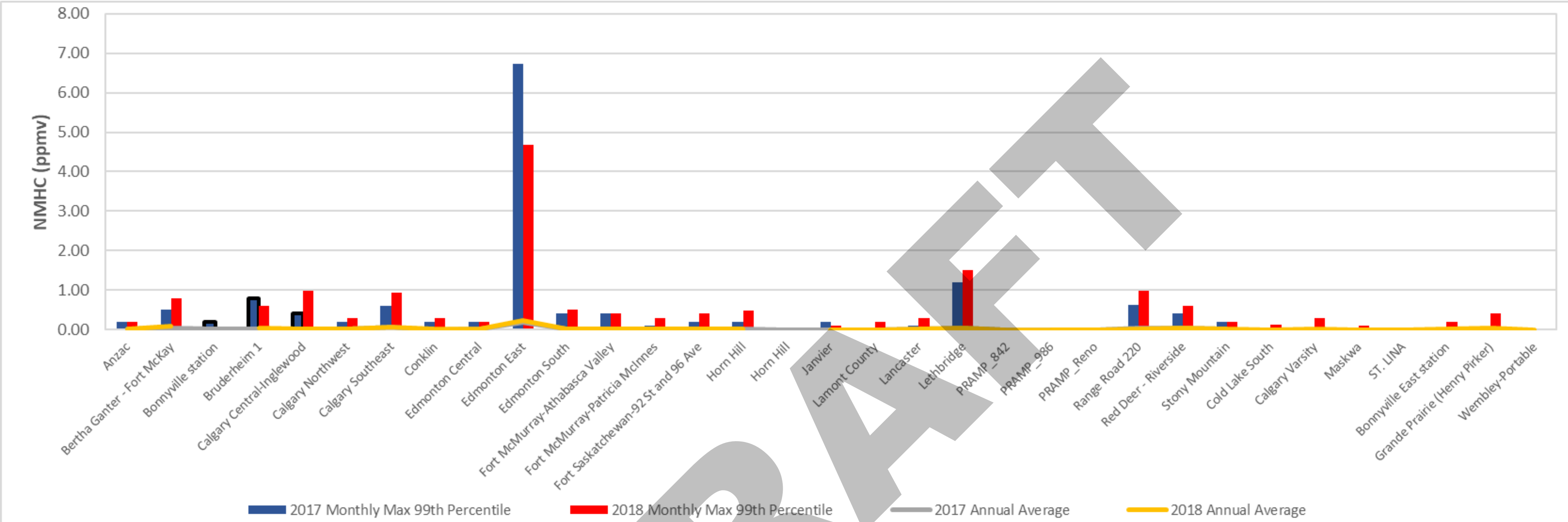


**Figure 40: NMHC 1-hour Average Measurements in Alberta in 2017 and 2018**

**Table 6: NMHC 1-hour Average Measurements in Alberta for 2017 and 2018 (ppmv)**

| Sorted Results | Anzac | Bertha Ganter - Fort McKay | Bonnyville station | Bruderheim 1 | Calgary Central-Inglewood | Calgary Northwest | Calgary Southeast | Conklin | Edmonton Central | Edmonton East | Edmonton South | Fort McMurray-Athabasca Valley | Fort McMurray-Patricia McInnes | Fort Saskatchewan-92 St and 96 Ave | Horn Hill | Horn Hill | Janvier | Lamont County | Lancaster | Lethbridge | PRAMP_842 | PRAMP_986 | PRAMP_Reno | Range Road 220 | Red Deer - Riverside | Stony Mountain | Cold Lake South | Calgary Varsity | Maskwa | ST. LINA | Bonnyville East station | Grande Prairie (Henry Pirker) | Wembley-Portable |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2017 Monthly Max 99th Percentile** | 0.20 | 0.50 | 0.20 | 0.80 | 0.40 | 0.20 | 0.60 | 0.20 | 0.20 | 6.74 | 0.40 | 0.40 | 0.10 | 0.20 | 0.20 | 0.00 | 0.20 | 0.00 | 0.10 | 1.20 | 0.00 | 0.00 | 0.00 | 0.62 | 0.40 | 0.20 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| **2018 Monthly Max 99th Percentile** | 0.20 | 0.80 | n/a | 0.60 | 0.99 | 0.30 | 0.94 | 0.30 | 0.20 | 4.69 | 0.50 | 0.40 | 0.30 | 0.40 | 0.48 | n/a | 0.10 | 0.20 | 0.30 | 1.50 | 0.00 | 0.00 | 0.00 | 0.98 | 0.60 | 0.20 | 0.12 | 0.30 | 0.10 | 0.00 | 0.20 | 0.40 | 0.00 |
| **2017 Annual 99th Percentile** | 0.10 | 0.40 | 0.10 | 0.50 | 0.20 | 0.20 | 0.50 | 0.10 | 0.10 | 1.74 | 0.30 | 0.30 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.10 | 0.50 | 0.00 | 0.00 | 0.00 | 0.40 | 0.30 | 0.10 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| **2018 Annual 99th Percentile** | 0.10 | 0.50 | n/a | 0.40 | 0.40 | 0.20 | 0.80 | 0.20 | 0.10 | 2.30 | 0.30 | 0.20 | 0.10 | 0.20 | 0.05 | n/a | 0.00 | 0.00 | 0.10 | 1.00 | 0.00 | 0.00 | 0.00 | 0.40 | 0.30 | 0.20 | 0.00 | 0.10 | 0.10 | 0.00 | 0.10 | 0.40 | 0.00 |
| **2017 Annual Average** | 0.01 | 0.05 | 0.01 | 0.02 | 0.01 | 0.01 | 0.07 | 0.00 | 0.00 | 0.17 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.04 | 0.05 | 0.02 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| **2018 Annual Average** | 0.01 | 0.08 | n/a | 0.03 | 0.02 | 0.02 | 0.06 | 0.01 | 0.00 | 0.23 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 | n/a | 0.00 | 0.00 | 0.01 | 0.05 | 0.00 | 0.00 | 0.00 | 0.03 | 0.03 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 | 0.00 |

## 6.3. Total Hydrocarbons

Figure 41 and Table 7 compare the THC 1-hour average measurements in 2017 and 2018 for 59 stations in Alberta.

Seven new stations were added in the province in 2018: Horizon, Mackay River, Muskeg River, Lacombe, Calgary Varsity, Bonnyville East station and Wembley-Portable.

Seven stations were discomissioned in 2018: Bonnyville station, Brion Mackey River, CNRL Horizon, Shell Muskeg River, Three Hills (Portable), Harmattan 2 and Nordegg.

Thirty-eight sites had a full year of THC data in 2017. The number of months of available data is shown in brackets for the following stations missing data in 2017:

- Cresent Heights [11]
- Maskwa [11]
- Rycroft-Portable [11]
- Shell Muskeg River [11]
- Stony Mountain (Conklin Lookout) [11]
- Horn Hill [8]
- Bonnyville station [7]
- Fort Hills [7]
- Surmont [4]
- Three Hills (portable) [3]
- Harmttan 2 [3]
- Nordegg [3]
- South McDougal Flats [2]
- Red Deer Range Road 272 [2].

Thirty-eight sites had a full year of THC data in 2018. The number of months of available data is shown in brackets for the following stations missing data in 2018:

- Edmonton South [11]
- Muskeg River [11]
- PRAMP 842 [11]
- Rycroft - Portable [10]
- Calgary Varsity [7]
- Calgary Southeast [6]
- Calgary Northwest [5]
- Red Deer Range Road 272 [5]
- South McDougal Flats [5]
- Horn Hill [4]
- Crescent Heights [3]
- Lacombe [2]
- Bonnyville East station [2]
- Wembley-Portable [2].

Similar to $CH_4$ readings, THC concentrations in the Three Creeks area are comparable to other locations in Alberta and notably lower than most urban and industrial areas.

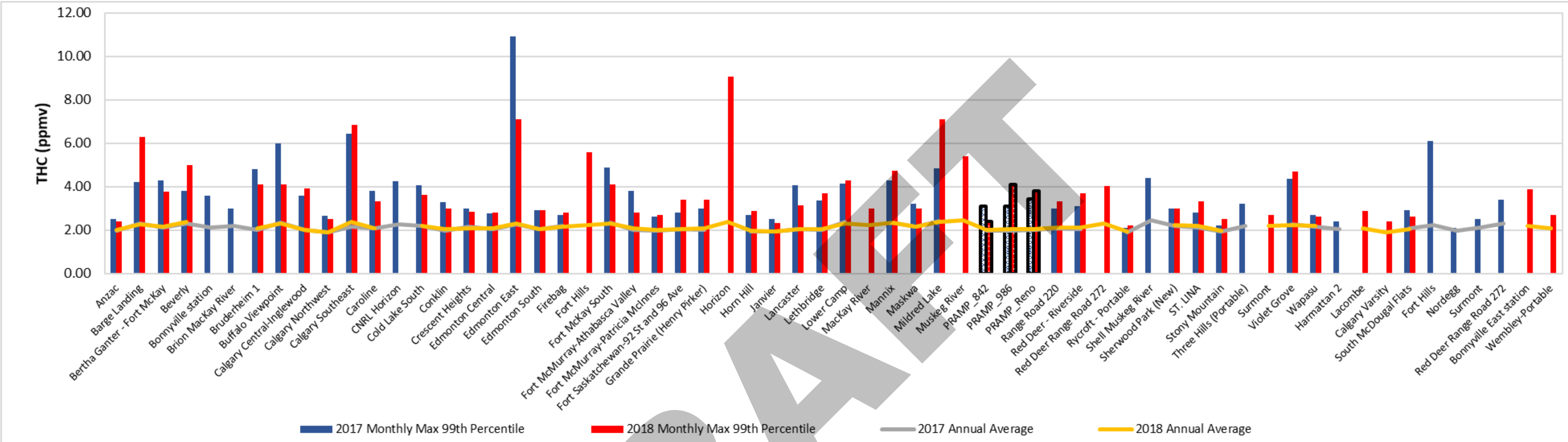



**Figure 41: THC 1-hour Average Measurements in Alberta in 2017 and 2018**

**Table 7: THC 1-hour Average Measurements in Alberta in 2017 and 2018 (ppmv)**

| Sorted Results | Anzac | Barge Landing | Bertha Ganter - Fort McKay | Beverly | Bonnyville station | Brion MacKay River | Bruderheim 1 | Buffalo Viewpoint | Calgary Central-Inglewood | Calgary Northwest | Calgary Southeast | Caroline | CNRL Horizon | Cold Lake South | Conklin | Crescent Heights |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2017 Monthly Max 99th Percentile** | 2.50 | 4.22 | 4.29 | 3.82 | 3.56 | 2.99 | 4.78 | 5.99 | 3.58 | 2.63 | 6.43 | 3.80 | 4.24 | 4.07 | 3.29 | 3.00 |
| **2018 Monthly Max 99th Percentile** | 2.40 | 6.28 | 3.78 | 4.99 | n/a | n/a | 4.08 | 4.10 | 3.90 | 2.50 | 6.83 | 3.31 | n/a | 3.62 | 3.00 | 2.82 |
| **2017 Annual 99th Percentile** | 2.30 | 3.30 | 3.00 | 3.46 | 3.10 | 2.60 | 3.90 | 3.40 | 2.90 | 2.30 | 5.00 | 2.80 | 3.69 | 3.20 | 2.60 | 2.70 |
| **2018 Annual 99th Percentile** | 2.30 | 3.30 | 3.10 | 3.59 | n/a | n/a | 3.40 | 3.30 | 3.00 | 2.30 | 5.80 | 2.70 | n/a | 3.00 | 2.60 | 2.80 |
| **2017 Annual Average** | 1.97 | 2.29 | 2.11 | 2.32 | 2.13 | 2.19 | 2.00 | 2.34 | 2.02 | 1.89 | 2.17 | 2.09 | 2.26 | 2.19 | 1.97 | 2.14 |
| **2018 Annual Average** | 2.01 | 2.25 | 2.14 | 2.38 | n/a | n/a | 2.09 | 2.29 | 2.00 | 1.91 | 2.37 | 2.08 | n/a | 2.20 | 2.03 | 2.08 |

| Sorted Results | Edmonton Central | Edmonton East | Edmonton South | Firebag | Fort Hills | Fort McKay South | Fort McMurray-Athabasca Valley | Fort McMurray-Patricia McInnes | Fort Saskatchewan-92 St and 96 Ave | Grande Prairie (Henry Pirker) | Horizon | Horn Hill | Janvier | Lancaster | Lethbridge | Lower Camp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2017 Monthly Max 99th Percentile** | 2.76 | 10.92 | 2.90 | 2.70 | n/a | 4.89 | 3.80 | 2.60 | 2.80 | 3.00 | n/a | 2.70 | 2.50 | 4.06 | 3.37 | 4.14 |
| **2018 Monthly Max 99th Percentile** | 2.80 | 7.09 | 2.90 | 2.79 | 5.59 | 4.09 | 2.80 | 2.70 | 3.39 | 3.40 | 9.06 | 2.86 | 2.30 | 3.12 | 3.68 | 4.29 |
| **2017 Annual 99th Percentile** | 2.60 | 4.30 | 2.70 | 2.50 | n/a | 3.60 | 2.70 | 2.30 | 2.50 | 2.60 | n/a | 2.20 | 2.10 | 2.70 | 2.80 | 3.60 |
| **2018 Annual 99th Percentile** | 2.50 | 5.20 | 2.60 | 2.50 | 4.00 | 3.40 | 2.60 | 2.40 | 2.90 | 3.00 | 4.70 | 2.46 | 2.20 | 2.80 | 3.20 | 3.40 |
| **2017 Annual Average** | 2.06 | 2.25 | 2.03 | 2.18 | n/a | 2.34 | 2.01 | 1.95 | 2.03 | 2.00 | n/a | 1.94 | 1.92 | 2.02 | 2.00 | 2.36 |
| **2018 Annual Average** | 2.07 | 2.30 | 2.05 | 2.16 | 2.24 | 2.30 | 2.06 | 2.00 | 2.05 | 2.09 | 2.36 | 1.98 | 1.94 | 2.04 | 2.05 | 2.31 |

| Sorted Results | MacKay River | Mannix | Maskwa | Mildred Lake | Muskeg River | PRAMP_842 | PRAMP_986 | PRAMP_Reno | Range Road 220 | Red Deer - Riverside | Red Deer Range Road 272 | Rycroft - Portable | Shell Muskeg River | Sherwood Park (New) | ST. LINA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2017 Monthly Max 99th Percentile** | n/a | 4.29 | 3.20 | 4.84 | n/a | 3.10 | 3.11 | 3.44 | 3.00 | 3.10 | n/a | 2.10 | 4.40 | 3.00 | 2.80 |
| **2018 Monthly Max 99th Percentile** | 3.00 | 4.72 | 3.00 | 7.08 | 5.40 | 2.40 | 4.08 | 3.79 | 3.30 | 3.70 | 4.03 | 2.20 | n/a | 2.99 | 3.30 |
| **2017 Annual 99th Percentile** | n/a | 3.70 | 2.90 | 4.10 | n/a | 2.20 | 2.60 | 3.00 | 2.73 | 2.90 | n/a | 2.10 | 4.00 | 2.70 | 2.70 |
| **2018 Annual 99th Percentile** | 2.70 | 3.90 | 2.80 | 4.30 | 4.20 | 2.20 | 2.50 | 2.93 | 2.90 | 3.10 | 3.50 | 2.10 | n/a | 2.70 | 2.80 |
| **2017 Annual Average** | n/a | 2.34 | 2.16 | 2.42 | n/a | 1.96 | 1.97 | 1.99 | 2.07 | 2.06 | n/a | 1.90 | 2.44 | 2.19 | 2.11 |
| **2018 Annual Average** | 2.23 | 2.32 | 2.14 | 2.38 | 2.43 | 2.01 | 2.03 | 2.04 | 2.11 | 2.12 | 2.31 | 1.94 | n/a | 2.22 | 2.19 |

| Sorted Results | Stony Mountain | Three Hills (Portable) | Surmont | Violet Grove | Wapasu | Harmattan 2 | Lacombe | Calgary Varsity | South McDougal Flats | Fort Hills | Nordegg | Surmont | Red Deer Range Road 272 | Bonnyville East station | Wembley-Portable |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2017 Monthly Max 99th Percentile** | 2.20 | 3.20 | n/a | 4.34 | 2.70 | 2.40 | n/a | n/a | 2.90 | 6.09 | 2.10 | 2.50 | 3.39 | n/a | n/a |
| **2018 Monthly Max 99th Percentile** | 2.49 | n/a | 2.70 | 4.70 | 2.60 | n/a | 2.86 | 2.40 | 2.60 | n/a | n/a | n/a | n/a | 3.89 | 2.70 |
| **2017 Annual 99th Percentile** | 2.20 | 3.00 | n/a | 3.30 | 2.50 | 2.40 | n/a | n/a | 2.75 | 4.00 | 2.10 | 2.50 | 3.30 | | n/a |
| **2018 Annual 99th Percentile** | 2.20 | n/a | 2.60 | 3.20 | 2.50 | n/a | 2.80 | 2.30 | 2.50 | n/a | n/a | n/a | n/a | 3.60 | 2.70 |
| **2017 Annual Average** | 1.94 | 2.20 | n/a | 2.27 | 2.15 | 2.02 | n/a | n/a | 2.07 | 2.21 | 1.97 | 2.10 | 2.29 | n/a | n/a |
| **2018 Annual Average** | 1.97 | n/a | 2.18 | 2.23 | 2.20 | n/a | 2.09 | 1.90 | 2.03 | n/a | n/a | n/a | n/a | 2.19 | 2.08 |

## 6.4. Total Reduced Sulphur

Figure 42 and Table 8 compare the TRS 1-hour average measurements in 2017 and 2018 for 30 stations in Alberta.

Three new stations were added in the province in 2018: Horizon, Lacombe and Wembley-Portable.

Four stations were decommissioned in 2018: CNRL Horizon, Three Hills (Portable), Harmattan 2 and Nordegg.

Nineteen sites had a full year of TRS data in 2017. The number of months of available data is shown in brackets for the following stations missing data in 2017:

- Stony Mountain (Conklin Lookout) [11]
- Rycroft - Portable [11]
- Fort Fills [7]
- Three Hills (Portable) [3]
- Harmattan 2 [3]
- Nordegg [3]
- South McDougal Flats [2]
- Red Deer Range Road 272 [2]

Twenty-one sites had a full year of TRS data in 2018. The number of months of available data is shown in brackets for the following stations missing data in 2018:

- Rycroft - Portable [10]
- Red Deer Range Road 272 [5]
- South McDougal Flats [5]
- Lacombe [2]
- Wembley-Portable [2]

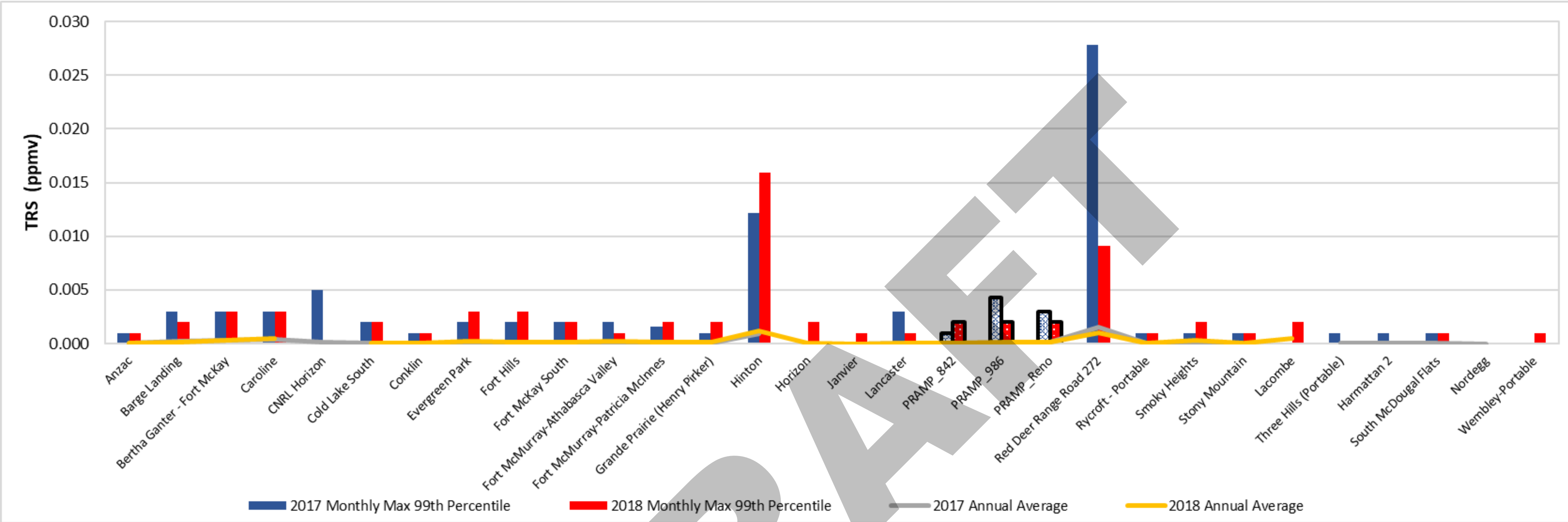



**Figure 42: TRS 1-hour Average Measurements in Alberta in 2017 and 2018**

Table 8: TRS 1-hour Average Measurements in Alberta in 2017 and 2018 (ppmv)

| Sorted Results | Anzac | Barge Landing | Bertha Ganter - Fort McKay | Caroline | CNRL Horizon | Cold Lake South | Conklin | Evergreen Park | Fort Hills | Fort McKay South | Fort McMurray-Athabasca Valley | Fort McMurray-Patricia McInnes | Grande Prairie (Henry Pirker) | Hinton | Horizon | Janvier | Lancaster | PRAMP_842 | PRAMP_986 | PRAMP_Reno | Red Deer Range Road 272 | Rycroft - Portable | Smoky Heights | Stony Mountain | Lacombe | Three Hills (Portable) | Harmattan 2 | South McDougal Flats | Nordegg | Wembley-Portable |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2017 Monthly Max 99th Percentile** | 0.001 | 0.003 | 0.003 | 0.003 | 0.005 | 0.002 | 0.001 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.001 | 0.012 | n/a | 0.000 | 0.003 | 0.001 | 0.004 | 0.003 | 0.028 | 0.001 | 0.001 | 0.001 | n/a | 0.001 | 0.001 | 0.001 | 0.000 | n/a |
| **2018 Monthly Max 99th Percentile** | 0.001 | 0.002 | 0.003 | 0.003 | n/a | 0.002 | 0.001 | 0.003 | 0.003 | 0.002 | 0.001 | 0.002 | 0.002 | 0.016 | 0.002 | 0.001 | 0.001 | 0.002 | 0.002 | 0.002 | 0.009 | 0.001 | 0.002 | 0.001 | 0.002 | n/a | n/a | 0.001 | n/a | 0.001 |
| **2017 Annual 99th Percentile** | 0.001 | 0.002 | 0.002 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.002 | 0.001 | 0.001 | 0.001 | 0.008 | n/a | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.019 | 0.000 | 0.001 | 0.000 | n/a | 0.001 | 0.001 | 0.001 | 0.000 | n/a |
| **2018 Annual 99th Percentile** | 0.000 | 0.002 | 0.002 | 0.001 | n/a | 0.001 | 0.001 | 0.001 | 0.002 | 0.001 | 0.001 | 0.001 | 0.001 | 0.010 | 0.001 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.007 | 0.001 | 0.001 | 0.000 | 0.001 | n/a | n/a | 0.001 | n/a | 0.001 |
| **2017 Annual Average** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | n/a | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.000 | 0.000 | n/a | 0.000 | 0.000 | 0.000 | 0.000 | n/a |
| **2018 Annual Average** | 0.000 | 0.000 | 0.000 | 0.001 | n/a | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | n/a | n/a | 0.000 | n/a | 0.000 |

## 7. COMPLAINTS AND THC MONITORING RESULTS

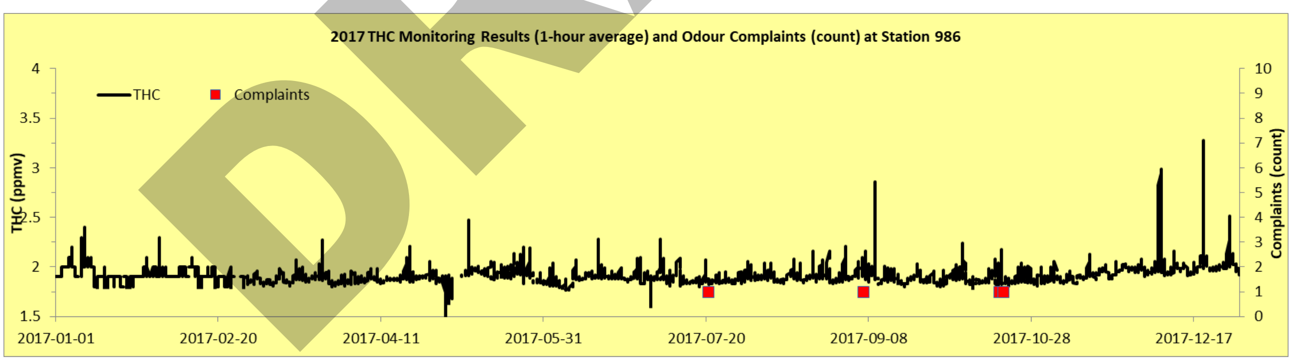
The AER recorded complaints from residents and assigned the location of the complaint to each of the three stations. AER complaints were collected and analyzed as follows:

- Station 986 showed no change in the number of complaints; there were 4 in 2017 and 4 in 2018 (down from a historical maximum of 33 in 2014)
- Station 842 showed an decrease in the number of complaints from 4 in 2017 to 0 in 2018 (down from a historical maximum of 44 in 2014)
- Reno Station showed a decrease in the number of complaints from 5 in 2017 to 0 in 2018 (down from a historical maximum of 11 in 2015)

Based on the latitude and longitude of the complaint, each complaint was assigned the station closest to where the complaint was logged. It should be noted that with the current network design, it is not possible to monitor all areas of the airshed at all times however it is possible for area residents to detect odours at any place at any time. Therefore, when a complaint is assigned to a monitoring station, it is considered to be reasonably close for correlation analysis of the complaint and wind speed, wind direction, THC concentrations, and other parameters; the complaint was not necessarily logged at the exact location of the monitoring station.

In 2018, there were only 4 odour complaints across the entire network; this is the lowest number of complaints since PRAMP began compiling these data.  Over time, there have been fewer odour complaints.  While fewer complaints is a likely outcome of the reduction in ambient hydrocarbon concentrations, PRAMP recognizes that there may be other factors involved including residents moving out of the area and complainant fatigue.





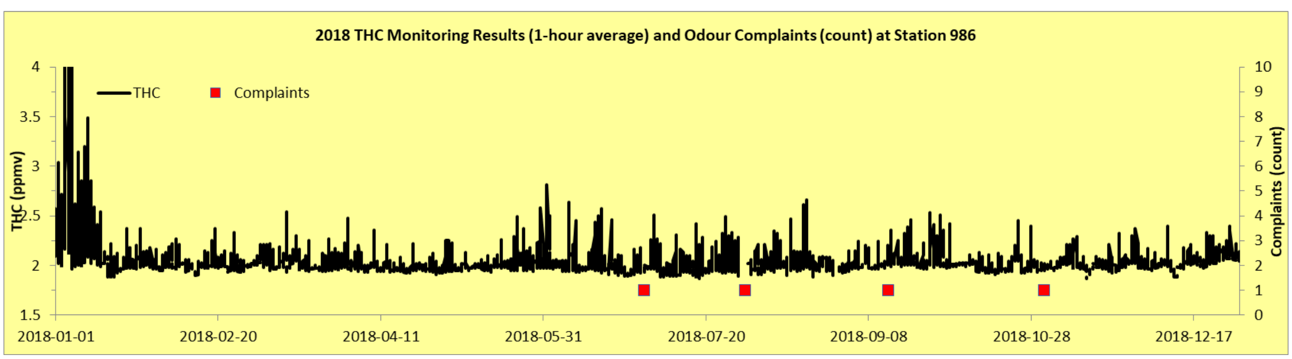
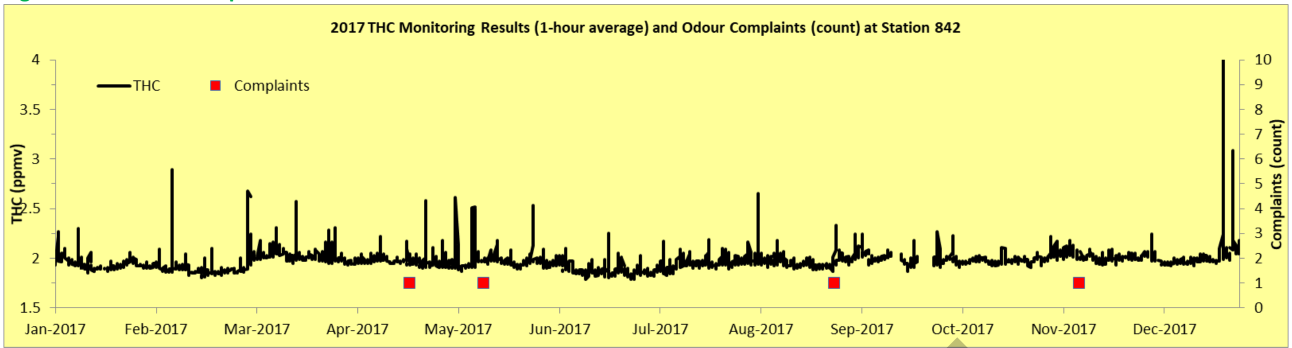



Figure 43: THC and Complaints Correlation at Station 986



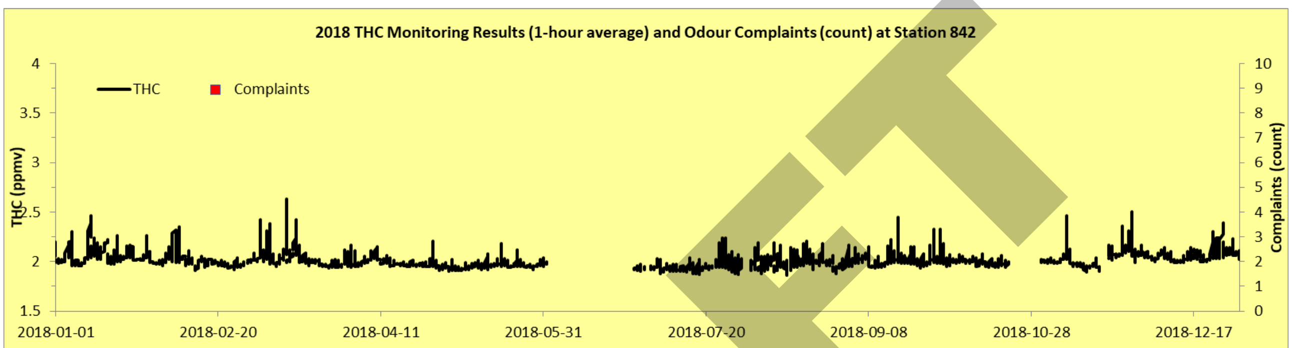




Figure 44: THC and Complaints Correlation for Station 842

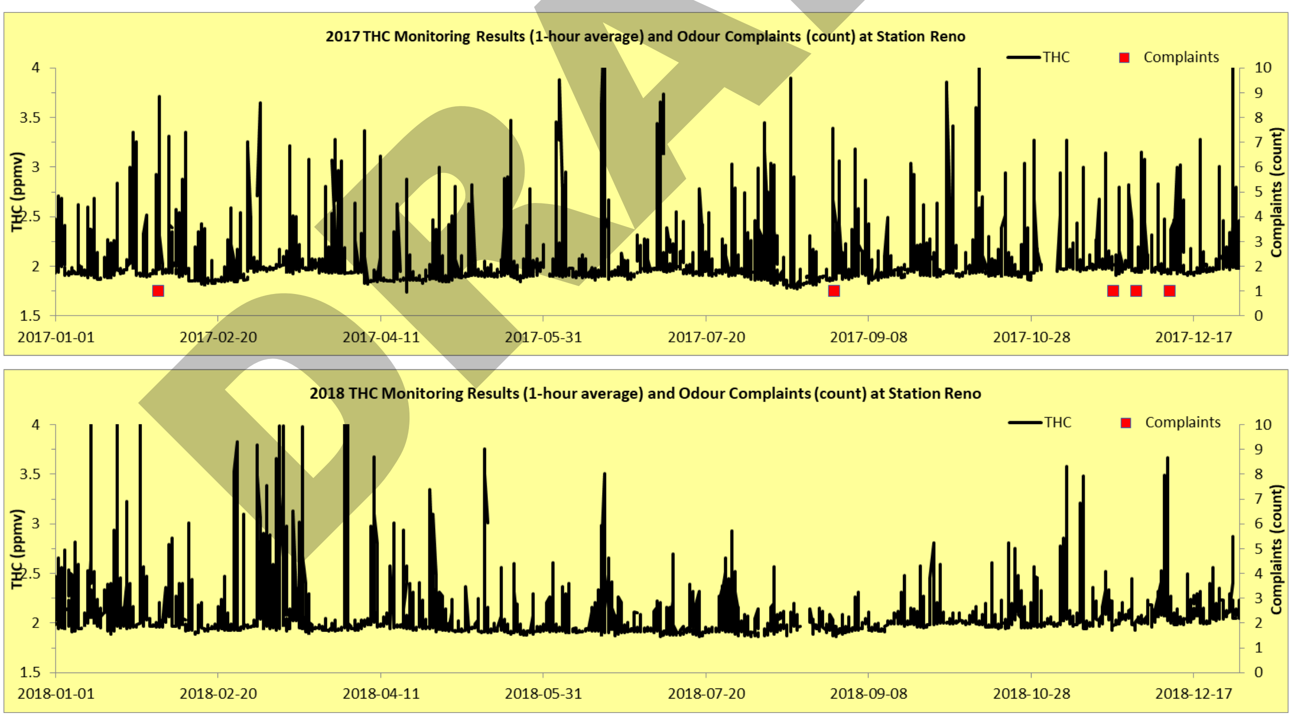



Figure 45: THC and Complaints Correlation for Reno Station

## 8. CONCLUSIONS

PRAMP collected concentration data of THC, NMHC, TRS, $SO_2$, and $CH_4$ at three continuous monitoring stations in the Peace River Area throughout 2017 and 2018. The data was summarized and analyzed using statistical methods to quantify the air quality in the area. Wind speed and direction was also monitored to further understand the potential sources of substances detected by the monitoring. Triggered sampling events provided additional concentration data.

Based on year-over-year data, hourly measurements of THC, NMHC, $SO_2$, TRS, and $CH_4$ concentrations generally show decreasing trends or patterns between 2017 and 2018 using different summary statistics (average, 99$^{th}$ percentile, 90$^{th}$ percentile, etc.). Similar to previous years' analyses, it should be noted that all of the changes are incremental, particularly when considering the historically elevated concentrations of hydrocarbons at station 986 and 842. The existing monitoring program should continue with the same measurement parameters to continue to examine trends in concentrations and to evaluate the effectiveness of ongoing improvements to CHOP emissions management.

Although the Reno monitoring station continues to show elevated hydrocarbon concentrations relative to current measurements at the other PRAMP sites, overall there has been a decrease in the magnitude and frequency of elevated concentration hydrocarbon events between 2017 and 2018. As has been noted in previous annual reports, despite being elevated, measurements at Reno are lower than the historical maximums at 986 and 842. CHOP infrastructure is much closer to the Reno Station compared to Station 986 and 842 and is likely a strong influence on the elevated measurements at that site as is the predominant southwest wind direction (putting nearby potential sources upwind of the station). The CHOP facilities nearest Station 986 and 842 are approximately 6km and 4km away; however, at the Reno Station, the same types of facilities are 300-500m away which represents an order of magnitude difference.

In 2018, there were only 4 odour complaints across the entire network; this is the lowest number of complaints since PRAMP began compiling these data. Over time, there have been fewer odour complaints. While fewer complaints is a likely outcome of the reduction in ambient hydrocarbon concentrations, PRAMP recognizes that there may be other factors involved including residents moving out of the area and complainant fatigue.

The canister program continues to be a high-profile element of PRAMP's monitoring program. The more rigorous sample handling protocol implemented in 2017 has resulted in no lost sample collection opportunities in 2018. A thorough review of the canister sample handling protocol was completed in 2017 and an electronic alarm system was installed to reduce the occurrence of missed sampling events and the associated data loss. In 2018, only 3 'real' canister events occurred (3 were false events related to station operations and maintenance); this represents the lowest number of canisters triggered since the collection program began. This low number of sampling events is a good qualitative indicator of how air quality has improved – ambient concentrations seldom approach the trigger point.

In late 2018, PRAMP decided to implement a methane-based triggered canister collection program to supplement its existing canister sampling program. Implemented in 2019, these additional air samples will be used to more accurately assess the source(s) of the methane, and to better understand any non-methane compounds that may be present when methane levels are elevated. In addition to the usual speciated hydrocarbon analysis, isotopic analysis will help identify potential sources of methane. The results of this program will be shared on the PRAMP website in 2019.

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# APPENDIX A
# Triggered Sample Results

## APPENDIX B TRIGGERED SAMPLE RESULTS

| Station | | 842 [1] | 842 [2] | Reno | Reno [3] | 842 | 986 |
|---|---|---|---|---|---|---|---|
| Sampled Date (MM/DD/YYYY) | | 2018-02-16 | 2018-03-01 | 2018-03-07 | 2018-07-02 | 2018-07-26 | 2018-12-09 |
| Sampled Time | | 10:35 | 1:25 | 21:45 | 8:10 | 7:30 | 20:25 |
| Parameter | Unit | Result | Result | Result | Result | Result | Result |
| 1-Butene | ppmv | < 0.13 | < 0.13 | < 0.13 | < 0.14 | < 0.14 | < 0.14 |
| Acetylene | ppmv | < 0.3 | < 0.3 | < 0.3 | < 0.11 | < 0.11 | < 0.12 |
| cis-2-Butene | ppmv | < 0.1 | < 0.1 | < 0.1 | < 0.05 | < 0.05 | < 0.06 |
| Ethane | ppmv | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 |
| Ethylacetylene | ppmv | < 0.08 | < 0.08 | < 0.08 | < 0.08 | < 0.08 | < 0.09 |
| Ethylene | ppmv | < 0.3 | < 0.3 | < 0.3 | < 0.10 | < 0.09 | < 0.10 |
| Isobutane | ppmv | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 |
| Isobutylene | ppmv | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 |
| Methane | ppmv | 2.5 | < 0.1 | 4.5 | 1.7 | 2.1 | 2.0 |
| n-Butane | ppmv | < 0.3 | < 0.3 | < 0.3 | < 0.3 | < 0.3 | < 0.3 |
| n-Propane | ppmv | < 0.09 | < 0.09 | < 0.09 | < 0.10 | < 0.09 | < 0.10 |
| Propylene | ppmv | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 |
| Propyne | ppmv | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 | < 0.1 |
| trans-2-Butene | ppmv | < 0.11 | < 0.11 | < 0.12 | < 0.12 | < 0.12 | < 0.13 |
| 2,5-Dimethylthiophene | ppbv | < 0.4 | < 0.4 | < 0.4 | < 0.4 | < 0.3 | < 0.4 |
| 2-Ethylthiophene | ppbv | < 0.3 | < 0.3 | < 0.3 | < 0.3 | < 0.2 | < 0.3 |
| 2-Methylthiophene | ppbv | < 0.3 | < 0.3 | < 0.3 | < 0.3 | < 0.2 | < 0.3 |
| 3-Methylthiophene | ppbv | < 0.4 | < 0.4 | < 0.4 | < 0.4 | < 0.3 | < 0.4 |
| Butyl mercaptan | ppbv | < 0.4 | < 0.4 | < 0.4 | < 0.4 | < 0.3 | < 0.4 |
| Carbon disulphide | ppbv | < 0.3 | < 0.3 | < 0.3 | < 0.3 | < 0.2 | 2.0 |
| Carbonyl sulphide | ppbv | 0.7 | 0.6 | 0.7 | < 0.4 | < 0.3 | 4.1 |
| Dimethyl disulphide | ppbv | < 0.3 | < 0.3 | < 0.3 | < 0.3 | < 0.2 | < 0.3 |
| Dimethyl sulphide | ppbv | < 0.3 | < 0.3 | < 0.3 | < 0.3 | < 0.2 | < 0.3 |
| Ethyl mercaptan | ppbv | < 0.4 | < 0.4 | < 0.4 | < 0.4 | < 0.3 | < 0.4 |

| Station | | 842 [1] | 842 [2] | Reno | Reno [3] | 842 | 986 |
|---|---|---|---|---|---|---|---|
| Sampled Date (MM/DD/YYYY) | | 2018-02-16 | 2018-03-01 | 2018-03-07 | 2018-07-02 | 2018-07-26 | 2018-12-09 |
| Sampled Time | | 10:35 | 1:25 | 21:45 | 8:10 | 7:30 | 20:25 |
| Parameter | Unit | Result | Result | Result | Result | Result | Result |
| Ethyl sulphide | ppbv | < 0.4 | < 0.4 | < 0.4 | < 0.4 | < 0.3 | < 0.4 |
| Hydrogen sulphide | ppbv | < 0.1 | < 0.1 | < 0.1 | 1.1 | < 0.1 | 1.5 |
| Isobutyl mercaptan | ppbv | < 0.4 | < 0.4 | < 0.4 | < 0.4 | < 0.3 | < 0.4 |
| Isopropyl mercaptan | ppbv | < 0.4 | < 0.4 | < 0.4 | < 0.4 | < 0.3 | < 0.4 |
| Methyl mercaptan | ppbv | < 0.3 | < 0.3 | < 0.3 | < 0.3 | < 0.2 | < 0.3 |
| Pentyl mercaptan | ppbv | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.4 | < 0.6 |
| Propyl mercaptan | ppbv | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.4 | < 0.6 |
| tert-Butyl mercaptan | ppbv | < 0.4 | < 0.4 | < 0.4 | < 0.4 | < 0.3 | < 0.4 |
| Thiophene | ppbv | < 0.3 | < 0.3 | < 0.3 | < 0.3 | < 0.2 | < 0.3 |
| 1,1,1-Trichloroethane | ppbv | < 0.03 | < 0.03 | < 0.03 | < 0.03 | < 0.04 | < 0.03 |
| 1,1,2,2-Tetrachloroethane | ppbv | < 0.03 | < 0.03 | < 0.03 | < 0.03 | < 0.04 | < 0.03 |
| 1,1,2-Trichloroethane | ppbv | < 0.03 | < 0.03 | < 0.03 | < 0.03 | < 0.04 | < 0.03 |
| 1,1-Dichloroethane | ppbv | < 0.03 | < 0.03 | < 0.03 | < 0.03 | < 0.04 | < 0.03 |
| 1,1-Dichloroethylene | ppbv | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.07 | < 0.06 |
| 1,2,3-Trimethylbenzene | ppbv | < 0.06 | < 0.06 | < 0.07 | < 0.07 | 0.78 | < 0.07 |
| 1,2,4-Trichlorobenzene | ppbv | < 1.0 | < 1.0 | < 1.1 | < 1.1 | < 1.4 | < 1.2 |
| 1,2,4-Trimethylbenzene | ppbv | < 0.06 | < 0.06 | < 0.07 | < 0.07 | 1.79 | 0.11 |
| 1,2-Dibromoethane | ppbv | < 0.03 | < 0.03 | < 0.03 | < 0.03 | < 0.04 | < 0.03 |
| 1,2-Dichlorobenzene | ppbv | < 0.04 | < 0.04 | < 0.04 | < 0.04 | < 0.05 | < 0.04 |
| 1,2-Dichloroethane | ppbv | < 0.01 | < 0.01 | < 0.01 | < 0.01 | 0.08 | 0.05 |
| 1,2-Dichloropropane | ppbv | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.02 | 0.05 |
| 1,3,5-Trimethylbenzene | ppbv | < 0.03 | < 0.03 | 0.04 | < 0.03 | 0.72 | 0.15 |
| 1,3-Butadiene | ppbv | 0.13 | 0.03 | 0.09 | 0.14 | 0.13 | 0.42 |
| 1,3-Dichlorobenzene | ppbv | < 0.4 | < 0.4 | < 0.4 | < 0.4 | < 0.5 | < 0.4 |
| 1,4-Dichlorobenzene | ppbv | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.7 | < 0.6 |
| 1,4-Dioxane | ppbv | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.7 | < 0.6 |

| Station | | 842 [1] | 842 [2] | Reno | Reno [3] | 842 | 986 |
|---|---|---|---|---|---|---|---|
| Sampled Date (MM/DD/YYYY) | | 2018-02-16 | 2018-03-01 | 2018-03-07 | 2018-07-02 | 2018-07-26 | 2018-12-09 |
| Sampled Time | | 10:35 | 1:25 | 21:45 | 8:10 | 7:30 | 20:25 |
| Parameter | Unit | Result | Result | Result | Result | Result | Result |
| 1-Butene | ppbv | 0.81 | 1.02 | 0.55 | 0.67 | 1.12 | 2.15 |
| 1-Hexene | ppbv | < 0.03 | < 0.03 | < 0.03 | < 0.03 | < 0.04 | 0.31 |
| 1-Pentene | ppbv | 0.04 | < 0.01 | < 0.01 | 0.12 | 0.11 | 0.33 |
| 2,2,4-Trimethylpentane | ppbv | < 0.01 | < 0.01 | < 0.01 | 0.06 | < 0.02 | < 0.01 |
| 2,2-Dimethylbutane | ppbv | < 0.01 | < 0.01 | 0.04 | 0.08 | 0.04 | 0.14 |
| 2,3,4-Trimethylpentane | ppbv | < 0.01 | < 0.01 | < 0.01 | 0.12 | 0.11 | 0.04 |
| 2,3-Dimethylbutane | ppbv | < 0.03 | < 0.03 | 0.13 | 0.12 | 0.22 | 0.14 |
| 2,3-Dimethylpentane | ppbv | < 0.03 | < 0.03 | 0.10 | 0.06 | 0.12 | 0.19 |
| 2,4-Dimethylpentane | ppbv | < 0.01 | < 0.01 | 0.03 | < 0.01 | < 0.02 | 0.12 |
| 2-Methylheptane | ppbv | < 0.01 | < 0.01 | < 0.01 | 0.15 | 0.21 | 0.18 |
| 2-Methylhexane | ppbv | < 0.01 | < 0.01 | 0.10 | 0.02 | 0.14 | 0.25 |
| 2-Methylpentane | ppbv | < 0.01 | 0.03 | 0.67 | < 0.01 | < 0.02 | 0.42 |
| 3-Methylheptane | ppbv | < 0.03 | < 0.03 | < 0.03 | < 0.03 | 0.20 | 0.07 |
| 3-Methylhexane | ppbv | 0.03 | < 0.03 | 0.16 | 0.05 | 0.06 | 0.17 |
| 3-Methylpentane | ppbv | < 0.01 | < 0.01 | 0.45 | 0.09 | 0.11 | 0.31 |
| Acetone | ppbv | 5.6 | 3.1 | 0.9 | 4.5 | 8.3 | 25.6 |
| Acrolein | ppbv | < 0.4 | < 0.4 | < 0.4 | 0.5 | 0.6 | 1.7 |
| Benzene | ppbv | < 0.01 | 0.10 | 0.13 | 0.08 | 0.60 | 1.95 |
| Benzyl chloride | ppbv | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.7 | < 0.6 |
| Bromodichloromethane | ppbv | < 0.03 | < 0.03 | < 0.03 | < 0.03 | 0.12 | < 0.03 |
| Bromoform | ppbv | < 0.03 | < 0.03 | < 0.03 | < 0.03 | < 0.04 | < 0.03 |
| Bromomethane | ppbv | < 0.01 | < 0.01 | < 0.01 | < 0.01 | 0.07 | < 0.01 |
| Carbon disulfide | ppbv | < 0.01 | < 0.01 | < 0.01 | < 0.01 | 0.14 | 0.21 |
| Carbon tetrachloride | ppbv | < 0.01 | 0.08 | 0.06 | 0.05 | 0.16 | 0.09 |
| Chlorobenzene | ppbv | < 0.03 | < 0.03 | < 0.03 | < 0.03 | < 0.04 | < 0.03 |
| Chloroethane | ppbv | < 0.03 | < 0.03 | < 0.03 | < 0.03 | < 0.04 | < 0.03 |

| Station | | 842 [1] | 842 [2] | Reno | Reno [3] | 842 | 986 |
|---|---|---|---|---|---|---|---|
| Sampled Date (MM/DD/YYYY) | | 2018-02-16 | 2018-03-01 | 2018-03-07 | 2018-07-02 | 2018-07-26 | 2018-12-09 |
| Sampled Time | | 10:35 | 1:25 | 21:45 | 8:10 | 7:30 | 20:25 |
| Parameter | Unit | Result | Result | Result | Result | Result | Result |
| Chloroform | ppbv | < 0.03 | < 0.03 | < 0.03 | 0.10 | 0.05 | < 0.03 |
| Chloromethane | ppbv | 0.42 | 0.79 | 0.42 | 0.45 | 0.74 | 0.79 |
| cis-1,2-Dichloroethene | ppbv | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.02 | < 0.01 |
| cis-1,3-Dichloropropene | ppbv | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.07 | < 0.06 |
| cis-2-Butene | ppbv | 0.03 | 0.14 | 0.04 | < 0.03 | 0.10 | 0.23 |
| cis-2-Pentene | ppbv | < 0.03 | < 0.03 | < 0.03 | 0.08 | 0.12 | 2.36 |
| Cyclohexane | ppbv | < 0.03 | < 0.03 | 0.83 | < 0.03 | 0.15 | 0.43 |
| Cyclopentane | ppbv | < 0.01 | 0.03 | 0.17 | 0.08 | < 0.02 | 0.08 |
| Dibromochloromethane | ppbv | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.02 | < 0.01 |
| Ethanol | ppbv | 1.7 | 1.5 | 0.5 | 6.3 | 5.5 | 9.1 |
| Ethyl acetate | ppbv | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.7 | < 0.6 |
| Ethylbenzene | ppbv | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.02 | 0.38 |
| Freon-11 | ppbv | 0.34 | 0.14 | 0.14 | 0.20 | 0.39 | 0.37 |
| Freon-113 | ppbv | < 0.01 | 0.03 | 0.07 | < 0.01 | < 0.02 | 0.12 |
| Freon-114 | ppbv | < 0.03 | < 0.03 | < 0.03 | < 0.03 | < 0.04 | 0.08 |
| Freon-12 | ppbv | 0.71 | 0.79 | 0.63 | 0.55 | 0.59 | 0.54 |
| Hexachloro-1,3-butadiene | ppbv | < 0.64 | < 0.64 | < 0.66 | < 0.68 | < 0.89 | < 0.72 |
| Isobutane | ppbv | 1.29 | 0.80 | 1.63 | 0.22 | 0.57 | 1.51 |
| Isopentane | ppbv | 0.93 | 0.75 | 1.36 | 0.11 | 0.54 | 0.48 |
| Isoprene | ppbv | 0.05 | < 0.01 | < 0.01 | 0.29 | 2.78 | 0.22 |
| Isopropyl alcohol | ppbv | < 0.5 | 0.9 | < 0.5 | 0.7 | 1.2 | 1.1 |
| Isopropylbenzene | ppbv | < 0.01 | < 0.01 | < 0.01 | < 0.01 | 0.24 | 0.10 |
| m,p-Xylene | ppbv | < 0.04 | < 0.04 | 0.13 | < 0.04 | 0.41 | 0.50 |
| m-Diethylbenzene | ppbv | < 0.05 | < 0.05 | < 0.05 | 0.13 | 0.46 | < 0.06 |
| m-Ethyltoluene | ppbv | < 0.10 | < 0.10 | < 0.11 | < 0.11 | 1.39 | 0.16 |
| Methyl butyl ketone | ppbv | < 0.64 | < 0.64 | < 0.66 | 0.70 | 1.49 | < 0.72 |

| Station | | 842 [1] | 842 [2] | Reno | Reno [3] | 842 | 986 |
|---|---|---|---|---|---|---|---|
| Sampled Date (MM/DD/YYYY) | | 2018-02-16 | 2018-03-01 | 2018-03-07 | 2018-07-02 | 2018-07-26 | 2018-12-09 |
| Sampled Time | | 10:35 | 1:25 | 21:45 | 8:10 | 7:30 | 20:25 |
| Parameter | Unit | Result | Result | Result | Result | Result | Result |
| Methyl ethyl ketone | ppbv | < 0.4 | < 0.4 | < 0.4 | < 0.4 | 0.7 | 5.1 |
| Methyl isobutyl ketone | ppbv | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.7 | 0.9 |
| Methyl methacrylate | ppbv | < 0.09 | < 0.09 | < 0.09 | < 0.10 | < 0.12 | < 0.10 |
| Methyl tert butyl ether | ppbv | < 0.04 | < 0.04 | < 0.04 | < 0.04 | 0.17 | < 0.04 |
| Methylcyclohexane | ppbv | < 0.01 | < 0.01 | 1.25 | 0.10 | 0.17 | 0.73 |
| Methylcyclopentane | ppbv | < 0.03 | < 0.03 | 0.87 | 0.07 | 0.12 | 0.27 |
| Methylene chloride | ppbv | < 0.4 | < 0.4 | < 0.4 | < 0.4 | < 0.5 | < 0.4 |
| n-Butane | ppbv | 1.91 | 2.15 | 2.18 | 0.18 | 0.81 | 1.25 |
| n-Decane | ppbv | < 0.08 | < 0.08 | < 0.08 | 0.08 | 0.33 | < 0.09 |
| n-Dodecane | ppbv | < 0.5 | < 0.5 | < 0.5 | < 0.5 | 2.8 | < 0.6 |
| n-Heptane | ppbv | < 0.01 | 0.08 | 0.08 | 0.10 | < 0.02 | 0.50 |
| n-Hexane | ppbv | < 0.01 | < 0.01 | 0.19 | 0.11 | 0.30 | 0.74 |
| n-Nonane | ppbv | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.02 | 0.15 |
| n-Octane | ppbv | < 0.03 | < 0.03 | < 0.03 | 0.12 | 0.19 | 0.17 |
| n-Pentane | ppbv | 2.7 | 0.3 | 0.9 | < 0.1 | 0.3 | 0.7 |
| n-Propylbenzene | ppbv | < 0.06 | < 0.06 | < 0.07 | < 0.07 | 0.72 | 0.16 |
| n-Undecane | ppbv | < 0.6 | < 0.6 | < 0.7 | < 0.7 | < 0.9 | < 0.7 |
| Naphthalene | ppbv | < 0.6 | < 0.6 | < 0.7 | < 0.7 | < 0.9 | < 0.7 |
| o-Ethyltoluene | ppbv | < 0.01 | < 0.01 | < 0.01 | 0.09 | 0.64 | 0.12 |
| o-Xylene | ppbv | < 0.01 | < 0.01 | < 0.01 | < 0.01 | 0.40 | 0.25 |
| p-Diethylbenzene | ppbv | < 0.05 | < 0.05 | < 0.05 | < 0.05 | 0.56 | < 0.06 |
| p-Ethyltoluene | ppbv | < 0.09 | < 0.09 | < 0.09 | < 0.10 | 0.47 | 0.11 |
| Styrene | ppbv | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.07 | 0.35 |
| Tetrachloroethylene | ppbv | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.07 | 0.17 |
| Tetrahydrofuran | ppbv | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.7 | < 0.6 |
| Toluene | ppbv | < 0.01 | < 0.01 | 0.26 | 0.18 | 0.37 | 1.33 |

| Station | | 842 [1] | 842 [2] | Reno | Reno [3] | 842 | 986 |
|---|---|---|---|---|---|---|---|
| Sampled Date (MM/DD/YYYY) | | 2018-02-16 | 2018-03-01 | 2018-03-07 | 2018-07-02 | 2018-07-26 | 2018-12-09 |
| Sampled Time | | 10:35 | 1:25 | 21:45 | 8:10 | 7:30 | 20:25 |
| Parameter | Unit | Result | Result | Result | Result | Result | Result |
| trans-1,2-Dichloroethylene | ppbv | < 0.01 | < 0.01 | < 0.01 | < 0.01 | < 0.02 | 1.37 |
| trans-1,3-Dichloropropylene | ppbv | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.07 | < 0.06 |
| trans-2-Butene | ppbv | 0.05 | 0.14 | 0.02 | < 0.01 | 0.10 | 0.30 |
| trans-2-Pentene | ppbv | < 0.03 | < 0.03 | < 0.03 | < 0.03 | 0.07 | 0.22 |
| Trichloroethylene | ppbv | < 0.05 | < 0.05 | < 0.05 | < 0.05 | < 0.07 | < 0.06 |
| Vinyl acetate | ppbv | < 0.5 | < 0.5 | < 0.5 | < 0.5 | < 0.7 | < 0.6 |
| Vinyl chloride | ppbv | < 0.03 | < 0.03 | < 0.03 | < 0.03 | < 0.04 | 0.09 |

Note:

1. Canister collected on February 16 is not a valid event. The sample was collected during the canister system check.
2. Canister collected on March 1 is not a valid event. The sample was a blank sample.
3. Canister collected on July 2 is not considered a valid event. The canister system was triggerd while the carrier gas was being replaced.