Girouxville Area

Ambient Air Quality Monitoring

Summary Report

March 2011

PASZA

Peace AirShed Zone Association

Executive Summary

There is an ongoing history of odour and air quality complaints regarding confined feeding operations (CFOs) south of Girouxville, Alberta. Over a period of three years starting in 2004, Alberta Environment conducted air quality surveys around these CFOs to provide 'snapshots' of the area's air quality. In 2007, the Peace Airshed Zone Association (PASZA) responded to landowner concerns by implementing a sub-regional monitoring network consisting of six strategically distributed hydrogen sulphide passive monitors and one continuous monitoring station equipped to monitor hydrogen sulphide, total reduced sulphur compounds, sulphur dioxide, ammonia, and meteorology.

Most of the data collected by PASZA indicated the concentrations of ammonia, hydrogen sulphide and total reduced sulphurs were very low, often at or below the detection limit of the instruments used in the study. Continuous measurements of ammonia and hydrogen sulphide both appear to show a seasonal pattern of elevated concentrations in the fall and spring months which may coincide with manure spreading activities. Overall, the passive monitoring network also showed hydrogen sulphide to have a seasonal pattern however due to the integration time of passive sampling (one-month average samples) it may be contributed to weather inversions and poor pollutant dispersion along with topography which may affect air patterns. During the project there were no exceedences of the one-hour ammonia or 24-hour hydrogen sulphide Alberta Ambient Air Quality Objectives (AAAQO), however there was one exceedance (14.9 parts per billion) of the one-hour hydrogen sulphide AAAQO (10.0 parts per billion).

Comparisons to continuous measurements of hydrogen sulphide, ammonia, and total reduced sulphur compounds at other locations in Alberta show similar median, maximum, and average one-hour concentrations to those measured by PASZA in the Girouxville project.

The monitoring data that PASZA collected through the Girouxville monitoring project suggest that the network responded in a predictable manner considering the location of the stations in relation to confined feeding operations and prevailing meteorological conditions.

If PASZA chooses to conduct additional monitoring in the Girouxville area, it is recommended that PASZA consider reducing the passive monitoring network to form an west-east transect of sites (aligned with predominant wind direction); augment the transect with co-located continuous monitoring in the future (should continuous monitoring return to the area), and; include specialized integrated sampling technology, to collect air samples for analysis of speciated volatile organic compounds and speciated reduced sulphur compounds.

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1. The Peace Airshed Zone Association

The Peace Airshed Zone Association (PASZA) is a non-profit organization which monitors ambient air quality in the Peace Region. PASZA is a multi-stakeholder organization consisting of industry, local government, non-government organizations, Alberta Health, Energy & Resources Conservation Board, Natural Resources Conservation Board, the public and Alberta Environment. Members work together to produce scientifically defensible data that can be used to manage air quality, protect environmental health, and influence public policy.

PASZA was formed in March 1999 in response to concerns about air quality in the Grande Prairie Region. The desire of industry, government, non-government organizations and the public to work together to better understand air quality drives the organization.

PASZA operates under the guidelines developed in the Clean Air Strategic Alliance's (CASA) Airshed Zone Guidelines. These guidelines include management by consensus, representation from affected stakeholders and public accessibility to data and information from monitoring activities. Air Quality Management Zones are a key component in CASA's strategy for the management of air quality within Alberta.

As a non-profit society PASZA relies on voluntary funding from members. Funding of PASZA is proportioned fairly amongst members at levels consistent with their relative impact on the zone's air quality. This is determined by accessing annual emission inventories.

The Peace Airshed Zone covers a 38,500 square kilometer area of north-western Alberta. Bordered on the North by the Peace River and stretching south to Township 64. The zone includes two major centers, Grande Prairie and High Prairie. Approximately 100,000 people live and work in this area. The zone's major industries are oil and gas, forestry, agriculture and tourism.

For more information about PASZA and regional air quality, please visit:

www.PASZA.ca

2. Air Quality Concerns and Confined Feeding Operations

By the end of 2004, a number of odour complaints had been filed with the Natural Resources Conservation Board (NRCB), the Municipal District of Smoky River No. 130, the Peace Health Region, PASZA, and Alberta Environment regarding confined feeding operations (CFOs) south of Girouxville, Alberta. Confined feeding operations are operational throughout the year, however most odour complaints were associated with manure spreading taking place in the spring and fall. Odour complaints from CFOs were associated with numerous sources including barn ventilation, effluent injection in the fields, carcass incinerators and/or from on-site lagoons which contain animal waste.

3. Short-term Monitoring by Alberta Environment

As a service to the NRCB and the Peace Country Health Region, Alberta Environment conducted air quality surveys in the fall of 2004, the spring of 2005 and the spring of 2006. The air quality surveys were unannounced and used the department's Mobile Air Monitoring Laboratory (MAML). Pollutants measured by the MAML include ammonia, carbon monoxide, hydrocarbons, oxides of nitrogen, ozone, particulate matter, reduced sulphur compounds and sulphur dioxide. Of these, hydrogen sulphide and ammonia were associated with odour from livestock waste.

The specific objectives of the air quality survey were: (1) Identify and quantify air pollutants in the area of confined feeding operations, (2) evaluate the distribution of pollutants away from confined feeding operations and (3) compare concentrations measured to Alberta Ambient Air Quality Objectives (AAAQOs).

3.1. Alberta Environment Monitoring Results

Monitoring was conducted near the group of swine rearing facilities south of Girouxville. Mobile and stationary measurements were conducted at various distances from these CFOs. Stationary measurements were conducted for at least one hour to facilitate comparison with one-hour AAAQOs. Data collected during mobile monitoring was used to evaluate the distribution of ammonia and hydrogen sulphide as you move away from a confined feeding operation.

Ammonia (NH_3), hydrogen sulphide (H_2S) and polycyclic aromatic hydrocarbons (PAHs) were elevated close to confined feeding operations (CFOs). However, mobile measurements indicate that concentrations of these pollutants rapidly decrease with increasing distance from the feeding operations.

NH_3 concentrations were the highest measured in close proximity to the CFO facilities. Median[1] one-hour NH_3 concentrations were 170 parts per billion (ppb) for the spring 2006 survey and 99 ppb for fall 2004 survey. Elevated median one-hour NH_3 of 122 ppb was measured during the spring 2005 survey. These concentrations were notably higher than background levels (< 16 ppb), but were lower than the 2000 ppb AAAQO and odour thresholds for ammonia.

Like NH_3, H_2S concentrations were the highest measured in close proximity to the CFO facilities. At certain locations, the median one-hour average concentration was 6 ppb for the fall 2004 survey, while at the same location during the spring 2006 survey the concentration was more than double (15 ppb). The one-hour average concentration was similarly high during the 2005 with a concentration of 13 ppb. These elevated concentrations measured during the spring 2005 and 2006 survey exceeded the AAAQO and H_2S odour thresholds of 10 ppb. In contrast, one-hour average H_2S concentrations at the background sites ranged from below detection limit to 1 ppb.

[1] The median concentration is a common way of representing the central value for environmental data. Most environmental data usually consist of a distribution that is skewed to the right; that is most data values are low and only a few are high. For such data sets, the arithmetic mean will be biased by the high concentrations; the resulting value may not be representative of the central value for the data set. For example, a data distribution consisting of five numbers: 1, 2, 2, 3 and 10. The arithmetic mean of these data is 3.6 and the median is 2. In this case, the arithmetic mean is biased high by the extreme value of 10. The median is the middlemost value in the data set; thus more representative of the central value of the data distribution. Fifty percent of the values in the dataset are below the median and fifty percent are above.

Elevated polycyclic aromatic hydrocarbons (PAH) were measured near (<500 m) confined feeding operations. The median one-hour average concentration of 8 nanograms per cubic meter (ng/m^3) was measured during the fall 2004 survey; the average concentration at the same site during the spring 2005 survey was 18 ng/m^3. In comparison, one-hour average background concentrations were below equipment detection limit (<1 ng/m^3). PAHs are formed by incomplete combustion of carbon-containing fuels such as wood, coal, diesel, animal and vegetable fats, and tobacco; the public are commonly exposed to PAHs by breathing air contaminated by wild fire smoke or coal tar, or by eating foods that have been grilled (ATSDR 1995). Elevated PAHs during the spring 2006 and fall 2004 survey were most probably due to an active onsite incinerator.

Alberta Environment concluded that hydrogen sulphide most probably contributed to the odour perceived near (<500 m) confined feeding operations. Elevated concentrations that exceed the odour threshold were measured near (<500 m) the CFO fence/property line and a short distance (<1.5 km) downwind. Odour complaints were filed by residents much further downwind of these facilities. Thus, it is more likely that objectionable odours in the area resulted from a combination of compounds some of which may have been below odour detection individually, or be due to higher concentrations occurring during periods when the MAML was not present.

For more information about Alberta Environment's monitoring around confined feeding operations in the vicinity of Girouxville, please visit:

http://environment.gov.ab.ca/info/posting.asp?assetid=7772&categoryid=1

4. PASZA's Regional Monitoring Network

As part of its routine air quality monitoring program, PASZA operates and maintains six (6) continuous monitoring stations and forty-eight (48) passive monitoring stations across the region.

Continuous stations monitor air quality by continually drawing ambient air through an analyzer. Each analyzer is calibrated monthly to monitor for specific chemical compounds. The benefit of continuous analyzers is that they measure air quality constantly and provide nearly instantaneous measurements of several chemical pollutants. Air pollutants that PASZA monitors on a continuous basis include: carbon monoxide, oxides of nitrogen, ozone, sulphur dioxide, hydrogen sulphide, total reduced sulphur, particulate matter, total hydrocarbons, wind speed, wind direction, temperature, humidity, and solar radiation.

Passive monitors measure air pollution by exposing a reactive membrane to the air where pollutants diffuse across the surface. The samplers are left at a sampling location for approximately one month and then sent to a laboratory for analysis. Passive samplers require no electricity and work effectively when monitoring in remote locations. Air pollutants that PASZA monitors using passive methods include ozone, sulphur dioxide, nitrogen dioxide, and hydrogen sulphide.

4.1. Monitoring Plan for Confined Feeding Operations

Although the CFOs located near Girouxville are within the boundaries of PASZA's monitoring network described in the previous section, the PASZA network was not designed to address micro-scale issues such as those presented by CFO air emission sources. A special study that had both a focused set of monitoring parameters and a high-density monitoring grid would be better suited for improving the collective understanding of pollutant concentrations, frequency distributions, seasonal patterns, and meteorology near the CFOs. In response to ongoing landowner concerns in the Girouxville area, PASZA decided to implement a sub-regional monitoring program to help gain a better understanding of the impact that CFOs are having on local air quality.

The primary purpose of PASZA's Girouxville Air Monitoring Study was to provide stakeholders with a better understanding of the air quality surrounding CFOs, a first step in the process of developing, implementing, and evaluating strategies to *"ensure continuous improvement of regional air quality, protect environmental health, and influence policy"* as outlined in PASZA's mission statement.

Other objectives include:

- Measurement against the AAAQO to determine compliance
- Collect air quality data that can be used to evaluate the impact of air quality pollutants associated with CFOs
- Collect data that can be used by health experts to evaluate if there are health impacts associated with air quality

In October 2007, PASZA implemented a monitoring plan to address these objectives. The network consisted of 6 passive monitoring stations and 1 continuous monitoring station. Monitoring station location and air quality monitoring parameters are outlined in Figure 1, Table 1 and Table 2.

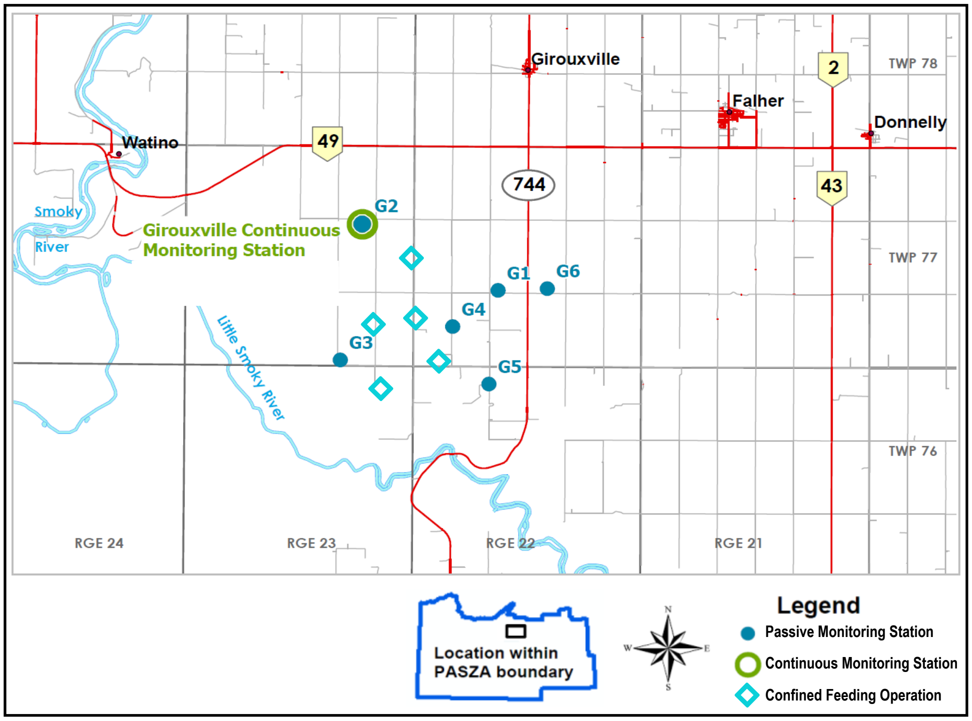


Figure 1: PASZA Confined Feeding Operations Air Monitoring Network

Note: The Confined Feeding Operations NRCB permit numbers 17-09-98, FA02008, FA03004, FA03009, FA05005 locations were verified by accessing the Natural Resources Conservation Board website at www.nrcb.gov.ab.ca

Table 1: Monitoring Station Locations

Monitoring Station	Latitude hddd°mm'ss.s"	Longtitude hddd°mm'ss.s"
Continuous Station NW-23-77-23W6	55 41 23.67	117 27 19.16
Passive 1 (G1)	55 39 58.56	117 21 31.44
Passive 2 (G2)	55 41 23.67	117 27 19.16
Passive 3 (G3)	55 38 18.09	117 27 56.68
Passive 4 (G4)	55 39 06.69	117 23 21.51
Passive 5 (G5)	55 37 44.80	117 21 52.29
Passive 6 (G6)	55 40 01.46	117 19 30.35

Table 2: Monitoring Station Parameters

Monitoring Station	Hydrogen Sulphide	Total Reduced Sulphurs	Ammonia	Sulphur Dioxide	Meteorology
Continuous Monitoring	x	x	x	x	x
Passive 1 (G1)	x				
Passive 2 (G2)	x				
Passive 3 (G3)	x				
Passive 4 (G4)	x				
Passive 5 (G5)	x				
Passive 6 (G6)	x				

5. Monitoring Methods

5.1. Overview

The hydrogen sulphide passive monitoring stations, installed in October 2007, were distributed around the area of concern (where access allowed) to collect upwind and downwind data at various distances from the CFOs; these stations continue to operate today (December 2010). The passive samples were collected monthly and sent to an accredited laboratory for analysis according to industry standards (Maxxam 2010).

The continuous monitoring station, described in Table 3, was located at a residence where historically there was air quality concerns related to the CFO air emissions. A variety of other sites were considered however the site chosen presented the best option considering access and power supply while also meeting air monitoring site criteria specified in the Alberta Air Monitoring Directive (AMD). The continuous monitoring station sampled for hydrogen sulphide, total reduced sulphur compounds, ammonia, sulphur dioxide, and meteorology; the continuous monitoring station operated from October 2007 - September 2008. The continuous monitoring equipment was operated according to the AMD (AENV 2006) including daily instruments checks, monthly multipoint calibrations, and annual audits conducted by Alberta Environment. During its operation, the Girouxville monitoring station was audited by Alberta Environment in June 2008. Continuous monitoring equipment uptime is presented in Table 4.

Table 3: Continuous Monitoring Station Equipment Description

Parameter	Instrument Make and Model	Units of Measure	Sampling Frequency	Range	Lower Detection Limit	Method of Detection	Calibration Method
Sulphur Dioxide (SO_2)	Teco 43A	ppb	1-second samples. Data stored in 1 hr, 1 min and 30 sec averages	0 - 1000 ppb	1 ppb	Pulsed fluorescence	Multipoint mass flow dilution of EPA protocol gas
Ammonia (NH_3)	Teco 42	ppb	1-second samples. Data stored in 1 hr, 1 min and 30 sec averages	0 - 2000 ppb	1 ppb	Chem-iluminescence with total nitrogen converter	Dynamic dilution using compressed gas
Total Reduced Sulphur (TRS)	Teco 45A	ppb	1-second samples. Data stored in 1 hr, 1 min and 30 sec averages	0 - 100 ppb	1 ppb	Pulsed fluorescence with converter and scrubber	Multipoint mass flow dilution of EPA protocol gas
Hydrogen Sulphide (H_2S)	Teco 45A	ppb	1-second samples. Data stored in 1 hr, 1 min and 30 sec averages	0 - 100 ppb	1 ppb	Pulsed fluorescence with converter and scrubber	Multipoint mass flow dilution of EPA protocol gas
Wind speed Wind Direction (WS/WD)	Windflo	km/hr degrees	1-second samples. Data stored in 1 hr, 1 min and 30 sec averages	0 - 160 km/hr, 0 - 360 degrees	1 degree, 0.1 Km/Hr	Cup anemometer and wind vane with translator	physical - turn WS shaft with certified RPM generator, WD increments

Table 4: Continuous Monitoring Equipment Uptime (in percent)

Analyzer	Sulphur Dioxide (SO_2)	Ammonia (NH_3)	Total Reduced Sulphur (TRS)	Hydrogen Sulphide (H_2S)	Wind Speed Scalar (WSs)	Wind Speed Vector (WSv)	Wind Direction (WD)
Sep-07	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Oct-07	100.0	100.0	100.0	100.0	99.1	99.6	99.6
Nov-07	99.7	99.7	99.5	99.7	60.7	60.7	60.7
Dec-07	100.0	100.0	100.0	100.0	nm *	nm *	62.9
Jan-08	100.0	100.0	100.0	100.0	nm *	nm *	82.9
Feb-08	99.9	99.9	99.9	99.9	nm *	nm *	100.0
Mar-08	98.8	100.0	100.0	100.0	96.9	96.9	96.9
Apr-08	96.8	99.9	99.6	99.6	100.0	100.0	100.0
May-08	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Jun-08	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Jul-08	89.9	89.9	89.8	89.8	89.9	89.9	89.9
Aug-08	94.9	94.6	94.9	94.9	95.0	95.0	95.0
Sep-08	99.5	98.9	99.5	99.5	99.6	99.6	99.6
Oct-08	99.8	99.8	99.8	99.8	100.0	100.0	100.0
Average	**98.5**	**98.8**	**98.8**	**98.8**	**74.4**	**74.4**	**92.0**

*** nm - not monitored due to equipment operational downtime; refer to section 6.1 of the report for details**

5.2. Selection of Monitoring Parameters

The Girouxville project monitored for ammonia, hydrogen sulphide, total reduced sulphur compounds, and sulphur dioxide. The rationale for including each of these parameters in the monitoring project is described below.

5.2.1. Ammonia

Livestock production is a major contributor of ammonia emissions. Ammonia is produced inside livestock buildings, in open feedlots, in manure storage facilities, during manure handling, and treatment and when manure is applied to soils. Ammonia in livestock facilities results primarily from the breakdown of urea (present in urine) by the enzyme urease (excreted in feces). Ammonia has a sharp, distinct, penetrating odour detectable at very low concentrations. At moderate levels of concentration, ammonia can irritate the eyes and respiratory tract; at high concentrations, it can cause ulceration to the eyes and severe irritation to the respiratory tract (AAFRD 2006).

5.2.2. Hydrogen Sulphide and Total Reduced Sulphur Compounds

Hydrogen sulphide and total reduced sulphur compounds are produced when manure undergoes anaerobic (absence of oxygen) fermentation. Total reduced sulphur includes hydrogen sulphide, mercaptans, dimethyl sulphide, dimethyl disulphide and other sulphur compounds. Total reduced sulphur does not include sulphur dioxide. Hydrogen sulphide is produced continuously in all un-aerated manure storage systems, including shallow barn gutters, underground storage tanks, or outside manure storage. Hydrogen sulphide is considered both an odour nuisance and a health hazard. Hydrogen sulphide is a deadly gas if people are exposed to a high concentration. Long term exposure to low concentrations of hydrogen sulfide may cause irritation to the eyes, nose, or throat. It may also cause difficulty in breathing for some asthmatics (ATSDR 2006). It is also corrosive, which can cause corrosion and deterioration of concrete structures of livestock buildings and equipment. The concentration of hydrogen sulphide is usually very low in livestock buildings compared with other gases like ammonia, but when manure stored inside livestock buildings is agitated, large volumes of hydrogen sulphide can be released in a short time. Hydrogen sulphide is heavier than air, soluble in water, and can accumulate in underground pits and unventilated areas of livestock buildings. It has a rotten-egg odour and can be easily detected at low concentrations (AAFRD 2004).

5.2.3. Sulphur Dioxide

Sulphur dioxide is a colourless, non-flammable gas. 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 (AENV 2003).

Sulphur Dioxide monitoring in the Girouxville project was conducted based on PASZA's desire to learn more about sulphur dioxide concentrations in this area and not related to confined feeding operations. In the years leading up to PASZA's deployment of the sub-regional monitoring near Girouxville, the larger regional passive network (which monitors for sulphur dioxide, ozone, and nitrogen dioxide) indicated sulphur dioxide measurements in an area northeast of the Girouxville monitoring station. The purpose of this report is to provide a monitoring summary of ambient concentrations of compounds associated with confined feeding operations. Since sulphur dioxide is not a compound related to livestock production and confined feeding operations, the sulphur dioxide monitoring has been summarized in a separate publication titled *Girouxville Monitoring Project, Sulphur Dioxide Summary*. For more information the publication can be accessed at www.pasza.ca.

6. Monitoring Results

This report provides an overall summary of the monitoring data; the detailed one-hour monitoring data results are available on the PASZA website at www.pasza.ca or the CASA Data Warehouse at www.casadata.org.

In the sections that follow, several summary statistics are used in the discussion of monitoring results including the average, maximum, minimum, and median concentrations. While the first three measures are commonly understood, the *less often* used median is valuable when examining environmental data; it is prudent to review how the median is determined before reviewing the following sections.

The median concentration is a common way of representing the central value for environmental data. Most environmental data usually consist of a distribution that is skewed to the right; that is most data values are low and only a few are high. For such data sets, the arithmetic mean will be biased by the high concentrations; the resulting value may not be representative of the central value for the data set. For example, a data distribution consisting of five numbers: 1, 2, 2, 3 and 10. The arithmetic mean of these data is 3.6 and the median is 2. In this case, the arithmetic mean is biased high by the extreme value of 10. The median is the middlemost value in the data set; thus more representative of the central value of the data distribution. Fifty percent of the values in the dataset are below the median and fifty percent are above.

6.1. Meteorology

The following figures illustrate meteorological conditions during the period of time that PASZA was operating the continuous monitoring station for the Girouxville project (October 2007-September 2008).

The original wind speed and wind direction system installed in the continuous monitoring station unfortunately had several operational problems including a non-responsive wind sensor. The result is no wind speed data from November 29th 2007 to March 3rd 2008, and the wind direction data had one period of missing data (December 20th 2007 to January 6th 2008). The following frequency distributions include wind speed and wind direction data from Spirit River to provide a general indication of wind patterns in the Girouxville area. A comparison of the two sites revealed a close likeness of wind data.

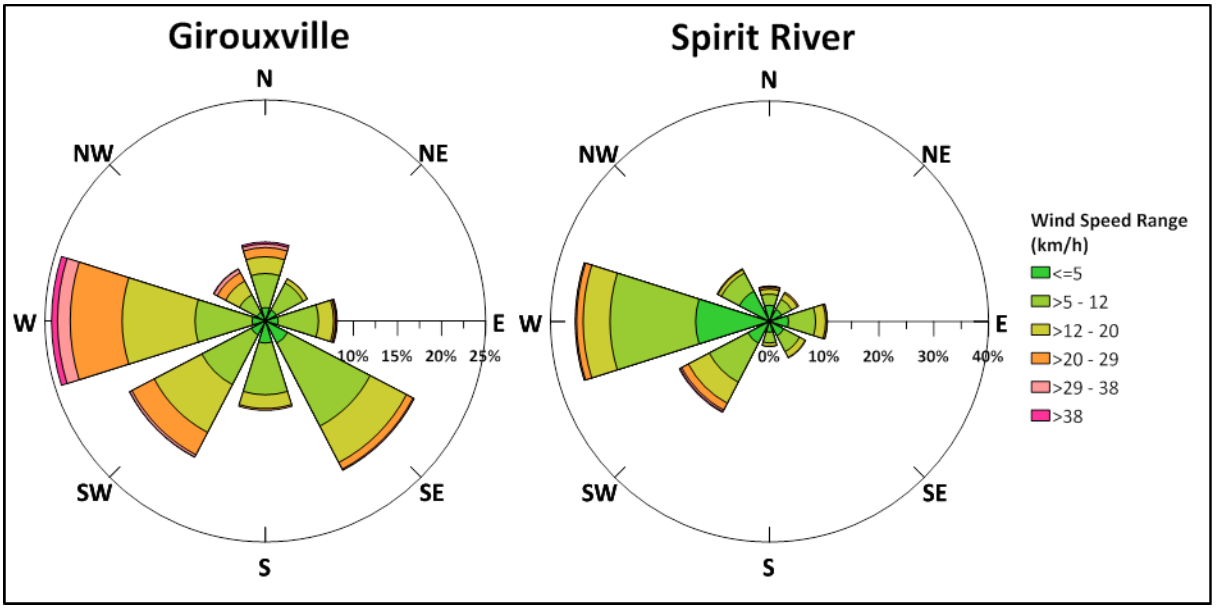


Figure 2: Wind Speed and Wind Direction Frequency Distributions for Girouxville and Spirit River (October 2007 – September 2008)

6.2. Ammonia

During the project, a maximum one-hour ammonia concentration of 665.80 parts per billion (ppb) was measured on September 5, 2008; the overall median one-hour concentration was 0.03 ppb. For over 93% of the study, ammonia concentrations were generally at or below the detection limit of the instrument at the station (1 part per billion). The one-hour ambient Alberta Ambient Air Quality Objective for Ammonia is 2000 ppb.

The pattern of one-hour ammonia measurements is illustrated in Figure 3. In general, ammonia concentrations were the highest at the beginning and at end of the monitoring project (October 2007 and September 2008). Although it requires further investigation, elevated ammonia concentrations appear to occur during the early fall months (September & October) and may be related to manure spreading operations or emptying the manure slurry lagoons.

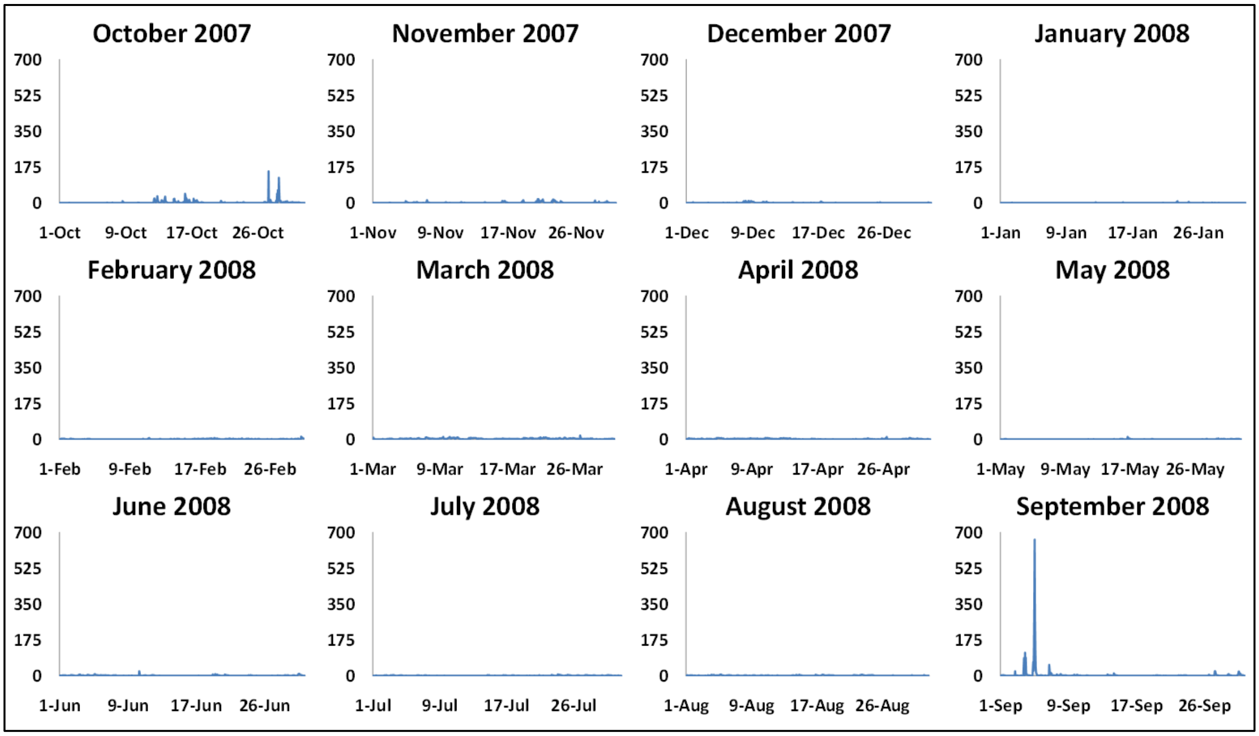


Figure 3: One-hour Ammonia Concentrations (in parts per billion)

The frequency distribution of all one-hour measurements indicates that over 93% of the ammonia measurements were at or below 5 parts billion.

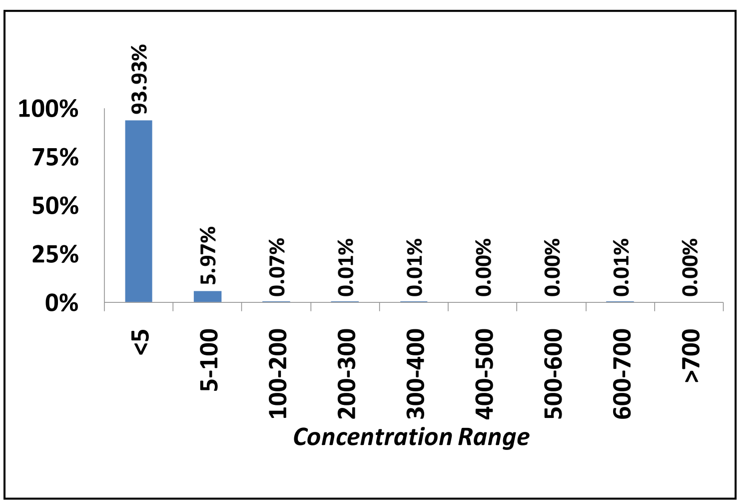


Figure 4: Frequency Distribution of one-hour Ammonia Concentrations (in parts per billion)

The frequency distribution for one-hour ammonia measurements (Figure 5) generally indicates that elevated concentrations of ammonia are coming from the south and southeast which is in agreement with the monitoring station's location in relation to the confined feeding operations.

This is more clearly illustrated in Figure 6 when looking at the frequency distribution where measurements at or below 5 ppb have been removed. 5 ppb was selected as the cutoff for illustrative purposes in Figure 6 to remove what appears to be the area's background values from the data set and to highlight what directions the elevated concentrations of ammonia are coming from. Ammonia is ubiquitous in the environment however further investigation and monitoring is required to establish a true background value (Lowry et. al. 2004).

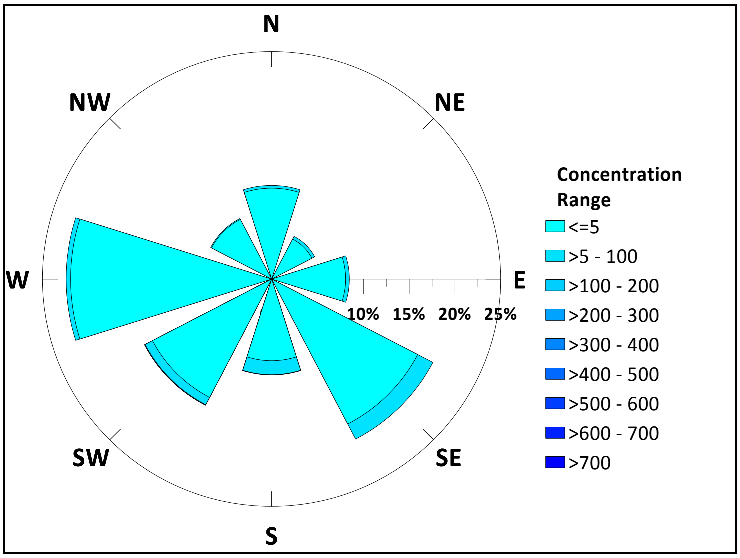


Figure 5: Frequency Distribution for one-hour Ammonia Concentrations (in parts per billion)

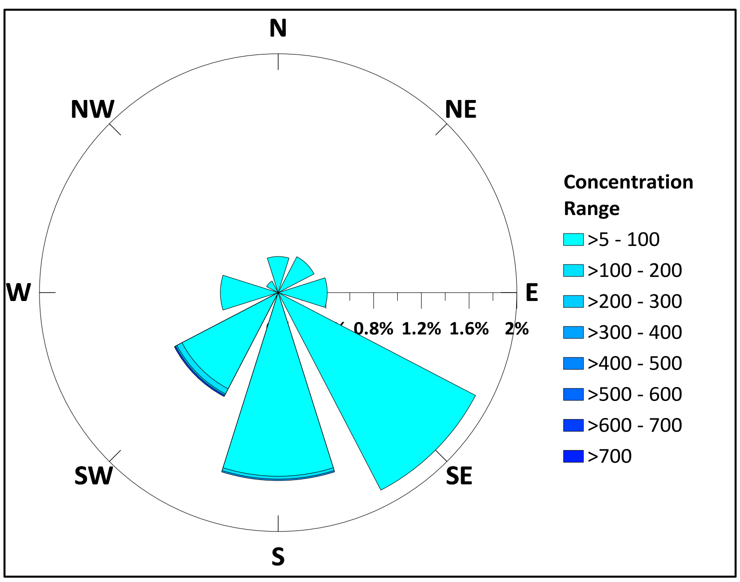


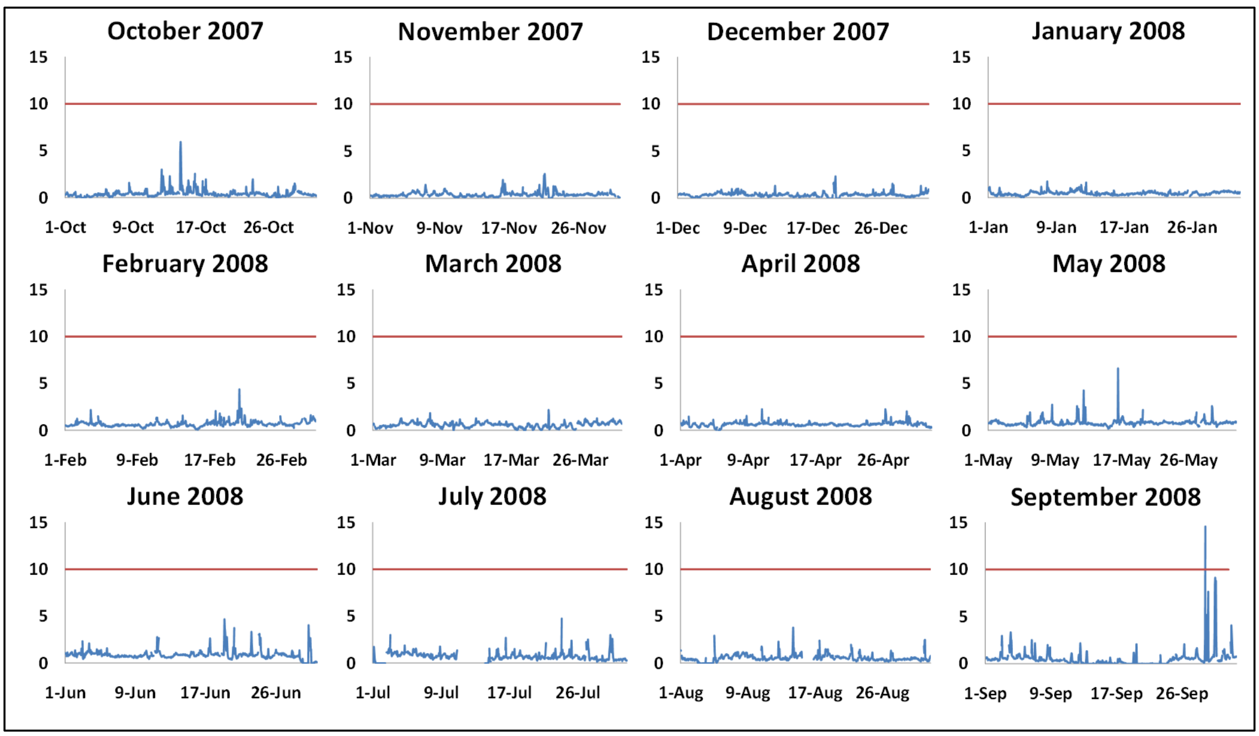
Figure 6: Frequency Distribution For one-hour Ammonia Concentrations (in parts per billion) – Measurements below 5 Parts per Billion Removed

6.3. Hydrogen Sulphide

6.3.1. Continuous Measurements

During the project, a maximum one-hour hydrogen sulphide concentration of 14.90 ppb was measured on September 29, 2008 which exceeds the 1-hour Ambient Air Quality Objective of 10 ppb; the overall median one-hour concentration was 0.55 ppb. Similar to ammonia, the highest concentrations were generally at the end of the monitoring project (September 2008). For over 90% of the study, hydrogen sulphide concentrations were at or below the detection limit of the instrument at the station.

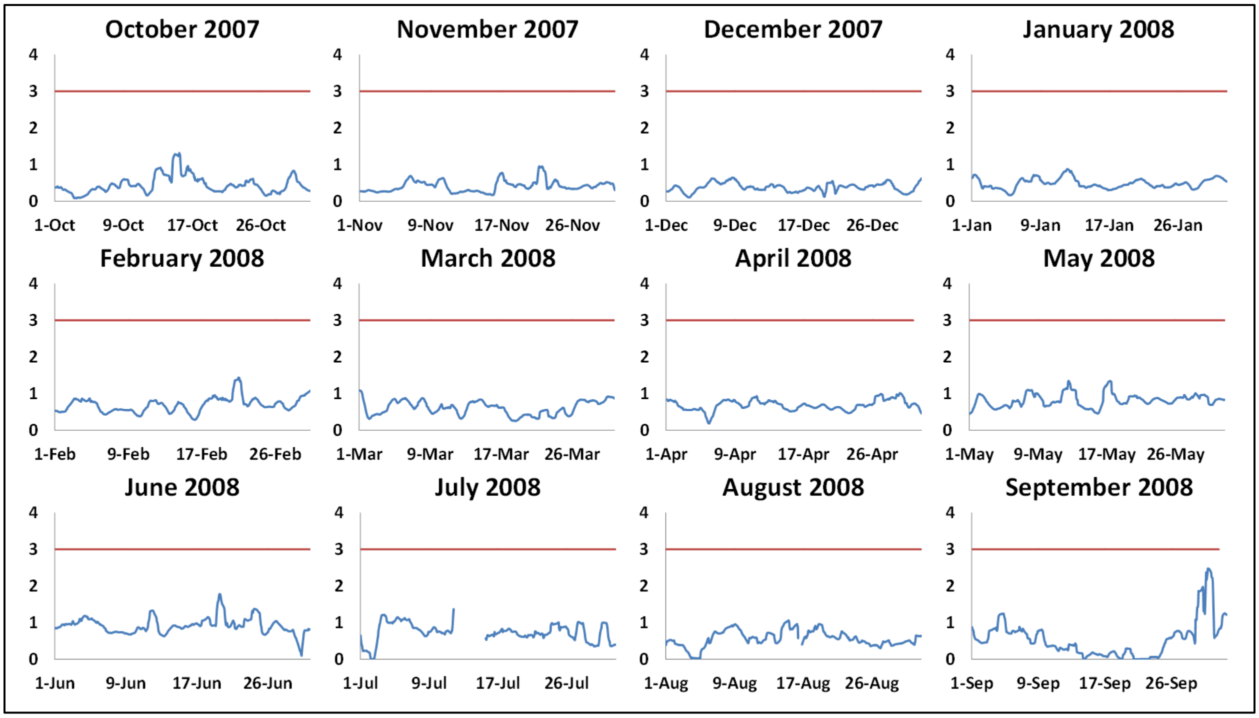
The pattern of one-hour hydrogen sulphide measurements is illustrated in Figure 7. Similar to ammonia, elevated hydrogen sulphide concentrations appear to occur during the early fall months (September & October) and again in the late spring months (May & June) and may be related to manure spreading operations or emptying the manure slurry lagoons.



(note: red line indicates the 1-hour Alberta Ambient Air Quality Objective of 10 ppb)

Figure 7: One-hour Hydrogen Sulphide Concentrations (in parts per billion)

For the purpose of comparing 24-hour average hydrogen sulphide measurements to the 24-hour Alberta Ambient Air Quality Objective for hydrogen sulphide, the applicable data are presented in (Figure 8). The seasonal pattern is similar to the one-hour hydrogen sulphide values; however it is muted due to a longer data averaging time of 24 hours.



(note: red line indicates the 24-hour Alberta Ambient Air Quality Objective of 3ppb)

Figure 8: 24-Hour Hydrogen Sulphide Concentrations (in parts per billion)

The frequency distribution of all one-hour measurements indicates that over 90% of the hydrogen sulphide measurements were at or below the detection limit of the instrument (1 part per billion).

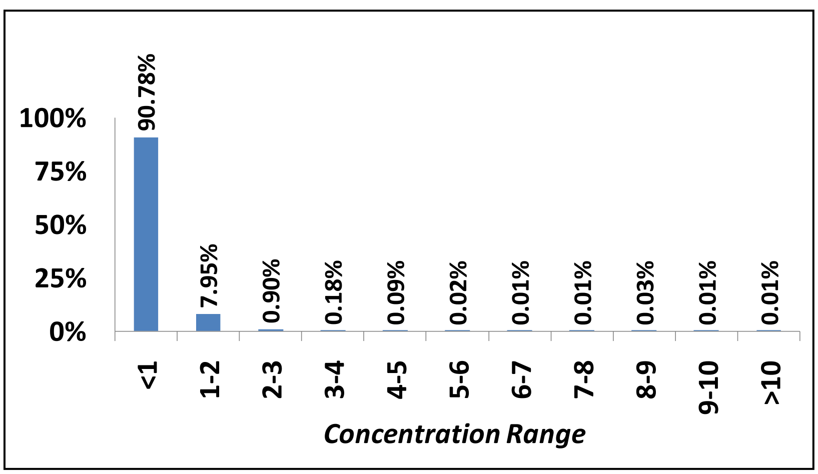


Figure 9: Frequency Distribution of one-hour Hydrogen Sulphide Concentrations (in parts per billion)

Like ammonia, the frequency distribution for one-hour hydrogen sulphide measurements (Figure 10) indicates that elevated concentrations of hydrogen sulphide are coming from the south and southeast which is in agreement with the monitoring station's location in relation to the confined feeding operations. This is more clearly illustrated in Figure 11 when looking at the frequency distribution where measurements at or below the detection limit of the instrument are removed from the data set.

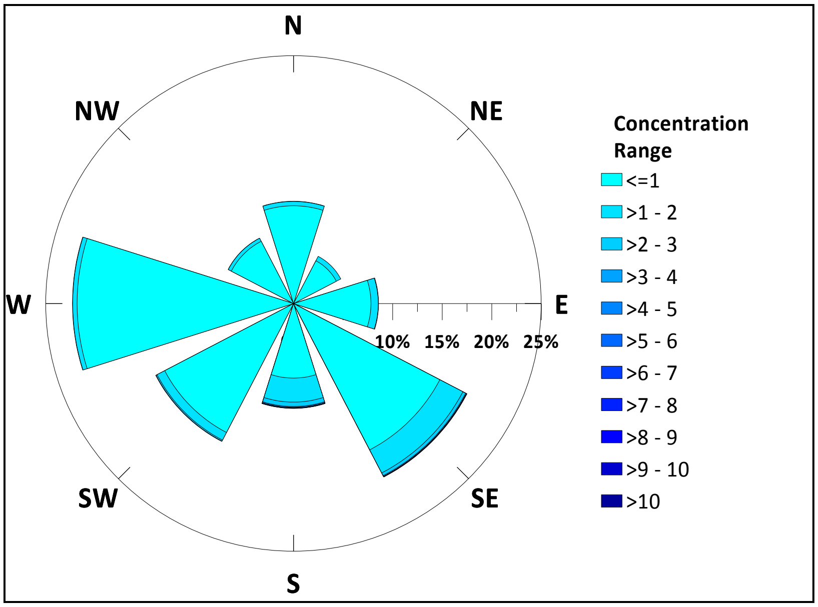


Figure 10: Frequency Distribution for one-hour Hydrogen Sulphide Concentrations (in parts per billion)

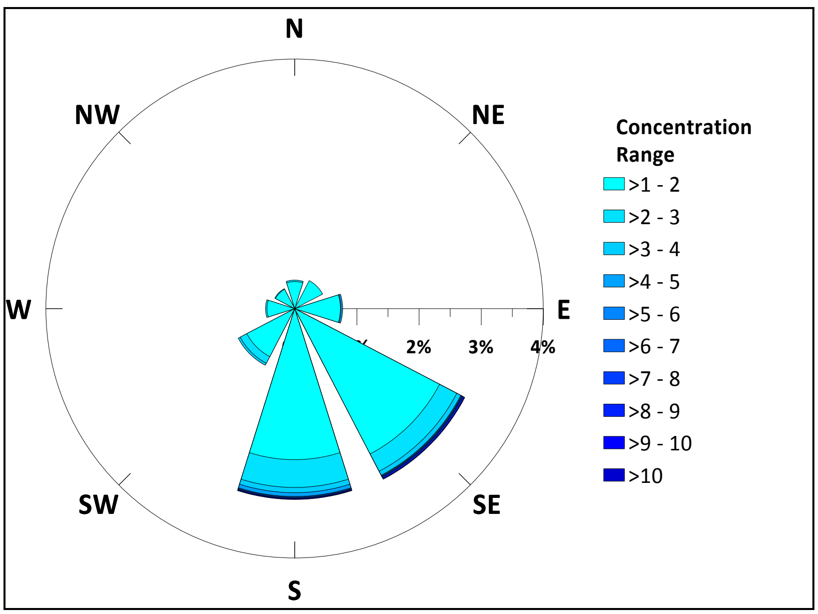


Figure 11: Frequency Distribution for one-hour Hydrogen Sulphide Concentrations – Measurements at or below Detection Limit Removed (in parts per billion)

6.3.2. Passive Measurements

Unlike continuous measurements, passive stations measure average concentrations over a one-month period. These types of measurements are valuable in determining long-term regional trends, seasonal patterns, and potential locations for future continuous monitoring. The median one month concentrations at Passive Stations G1, G2, G3, G4, G5, and G6 were 0.16, 0.18, 0.29, 0.25, 0.16, and 0.14 ppb respectively (Figure 12). Throughout the year, Passive 3 and Passive 4 had the highest concentrations while Passive 6 had the lowest concentrations. Proximity to the CFOs is likely an important factor in this observation given that Passives 4 and 3 are the two stations closest to the cluster of CFOs while Passive 6 is furthest away.

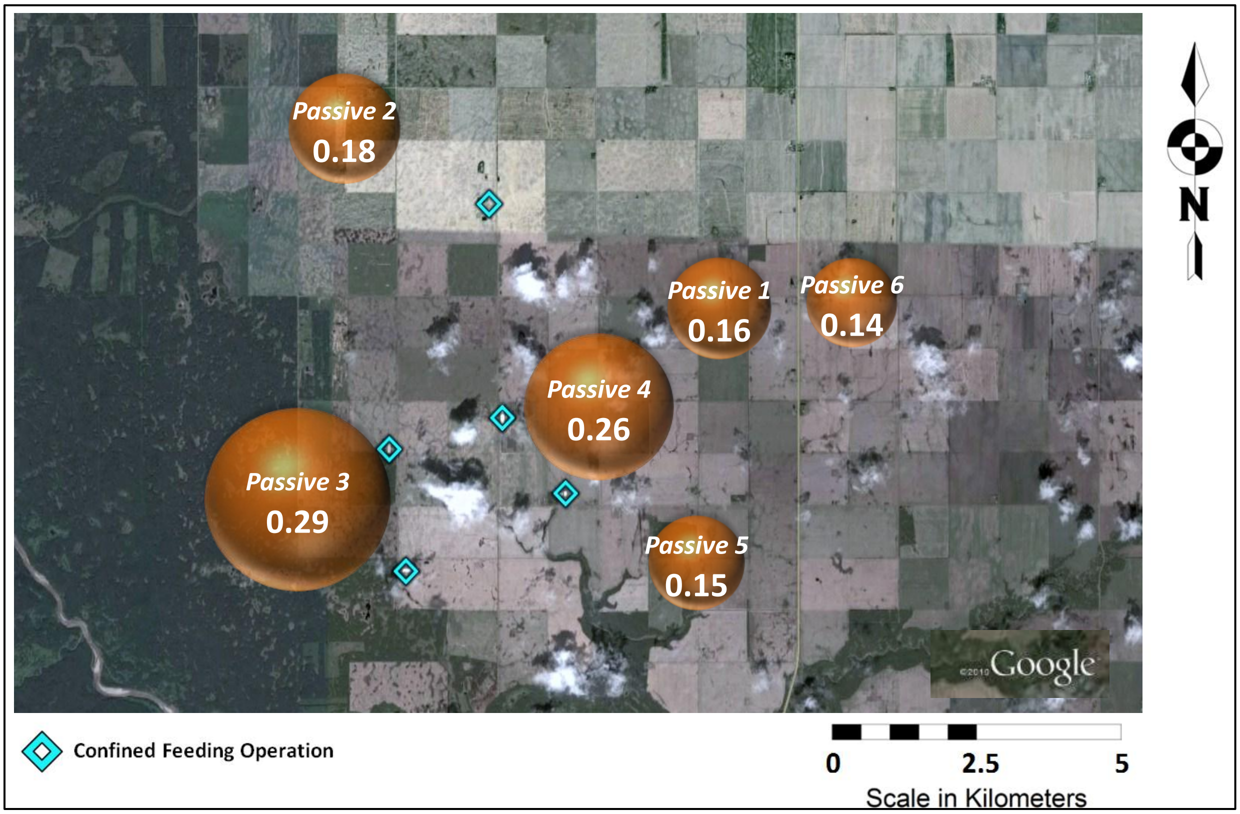


Figure 12: Overall Median Hydrogen Sulphide Passive Monitoring Concentrations (in parts per billion)

Generally speaking, in Alberta most primary pollutants have their highest concentrations during the winter months when meteorological conditions are ideal for poor dispersion, particularly during temperature inversions. Upon looking more closely at the data, a subtle seasonal hydrogen sulphide pattern appears to emerge in the network (Figure 13). The passive monitoring data for hydrogen sulphide indicates that there are overall slightly higher concentrations in the winter than there are in the summer.

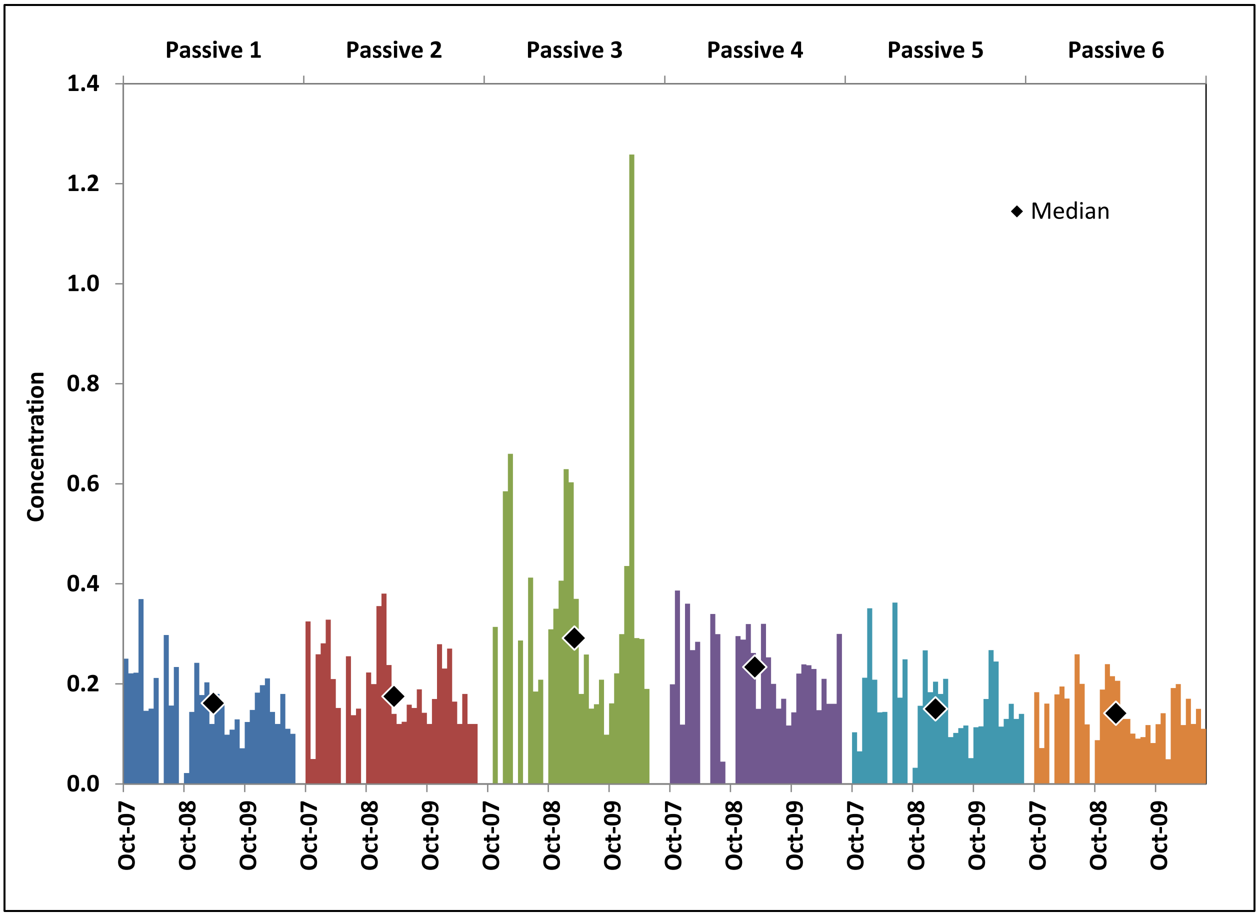


Figure 13: Time-Series of Hydrogen Sulphide Passive Monitoring Measurements Sorted By Site (in parts per billion).

Unlike in the analysis of continuous monitoring data, it is very difficult to make correlations between wind direction and a given monthly concentration measured at a passive monitoring site. Despite this, there are examples in PASZA's Girouxville passive monitoring network that show a subtle relationship between overall monthly wind direction and concentrations measured at a passive monitoring station; examples are presented in Figure 14. January 2008 and February 2008 had winds from the southeast more frequently (approximately 25% of the time) than from other directions; as a result, it appears that Passive Site 3 was most influenced by the upwind CFO emission sources. Another example indicates that in July 2008 when winds were coming from the west more frequently (approximately 25% of the time) than from other directions, Passive Site 4 was most influenced by the upwind CFOs.

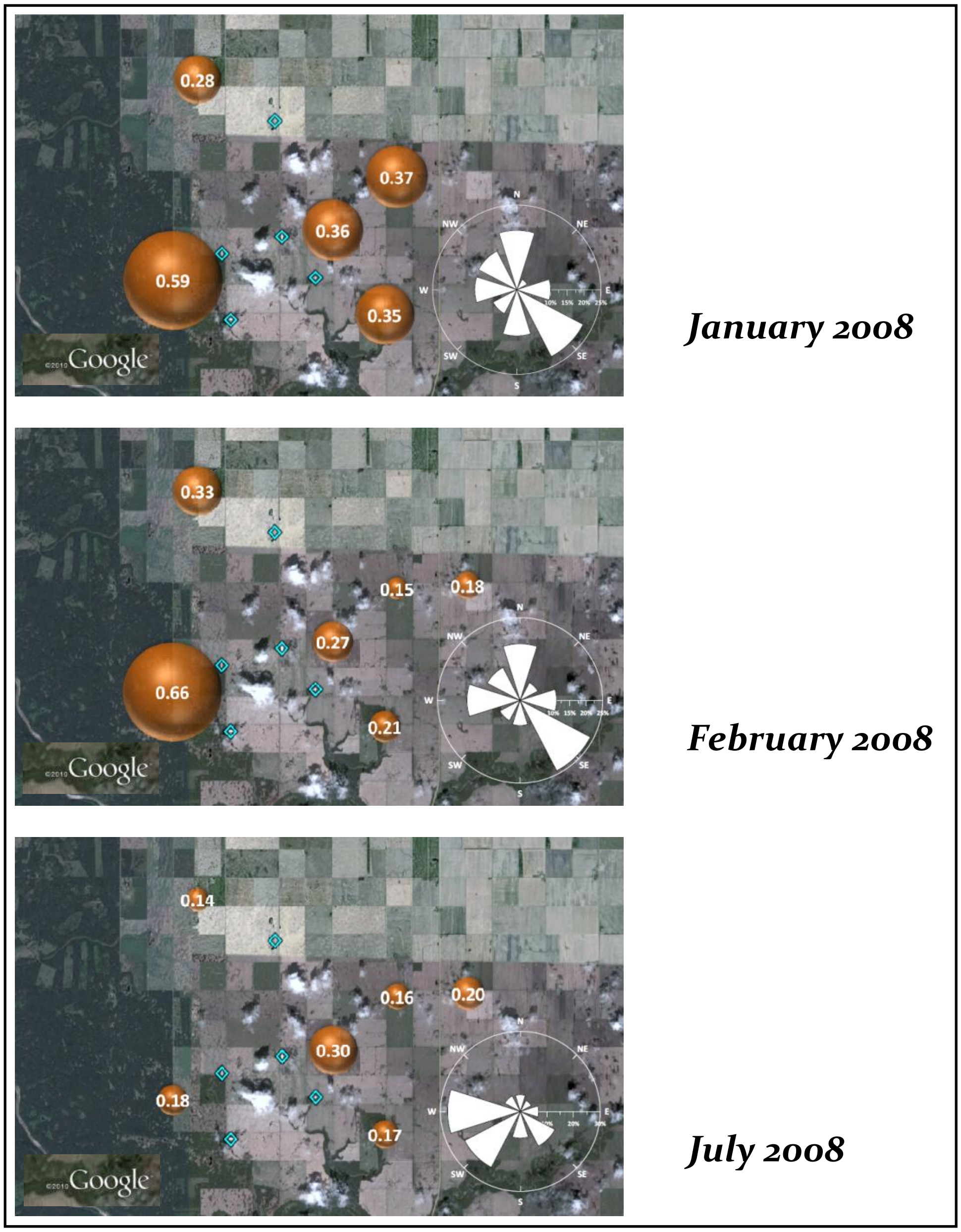


Figure 14: January, February, And July 2008 Hydrogen Sulphide Concentrations (in parts per billion) With Monthly Wind Direction Frequency Distribution Superimposed

6.4. Total Reduced Sulphur Compounds

A maximum one-hour total reduced sulphur compounds concentration of 7.90 ppb was measured on September 29, 2008; the overall median one-hour concentration was 0.27 ppb. For over 96% of the study, total reduced sulphur concentrations were generally at or below the detection limit of the instrument at the station (1 ppb). There is no one-hour ambient Alberta Ambient Air Quality Objective for total reduced sulphur.

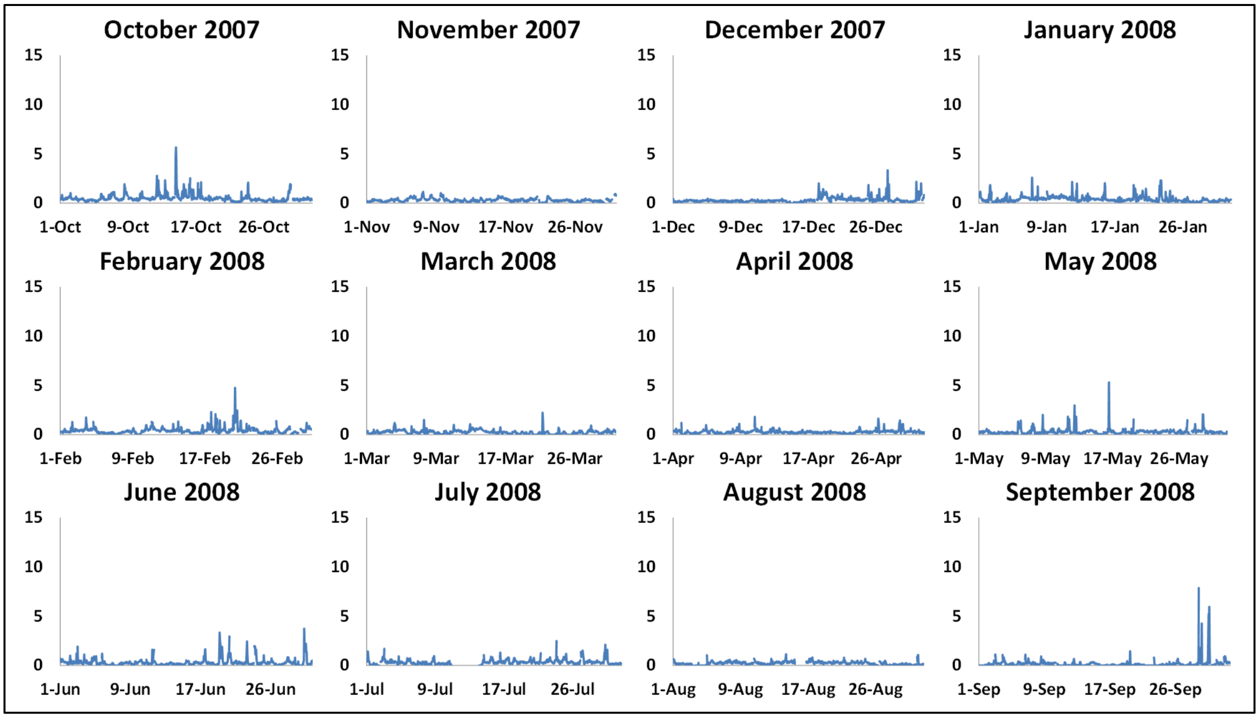


Figure 15: One-hour Total Reduced Sulphur Concentrations (in parts per billion)

The frequency distribution of all one-hour measurements indicates that over 96% of the total reduced sulphur compound concentrations were at or below the detection limit of the instrument.

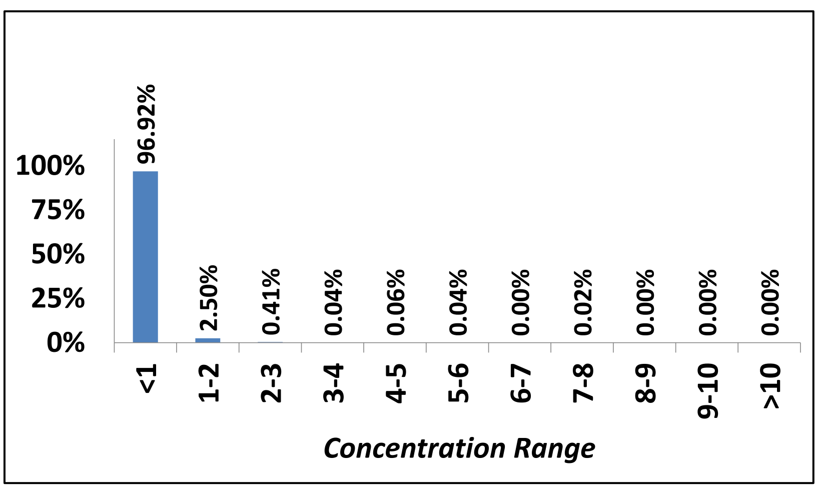


Figure 16: Frequency Distribution of one-hour Total Reduced Sulphur Concentrations (in parts per billion)

The frequency distribution for one-hour sulphur dioxide measurements (Figure 17) indicates that elevated concentrations of hydrogen sulphide are coming from the south and southeast which is in agreement with the monitoring station's location in relation to the confined feeding operations. This is more clearly illustrated in Figure 18 when looking at the frequency distribution where measurements at or below the detection limit of the instrument are removed from the data set.

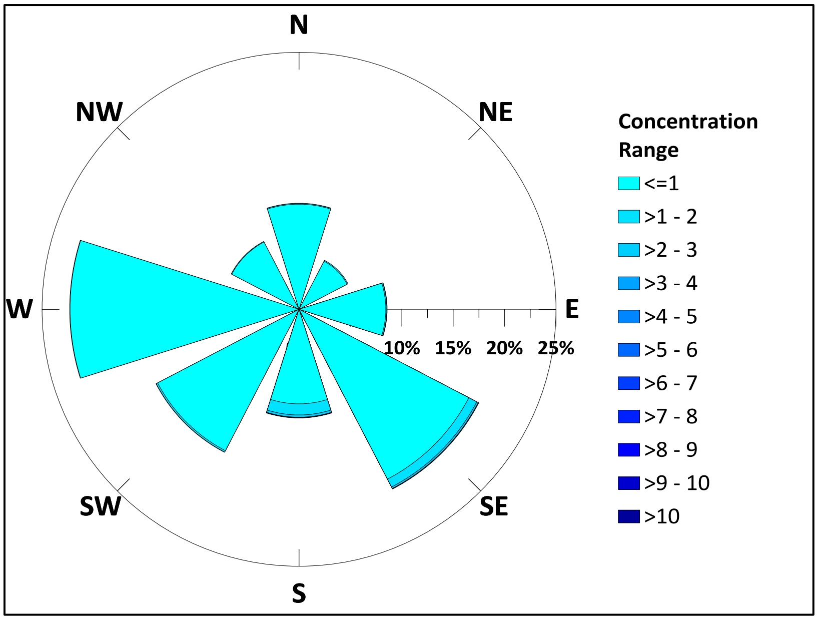


Figure 17: Frequency Distribution for one-hour Total Reduced Sulphur Concentrations (in parts per billion)

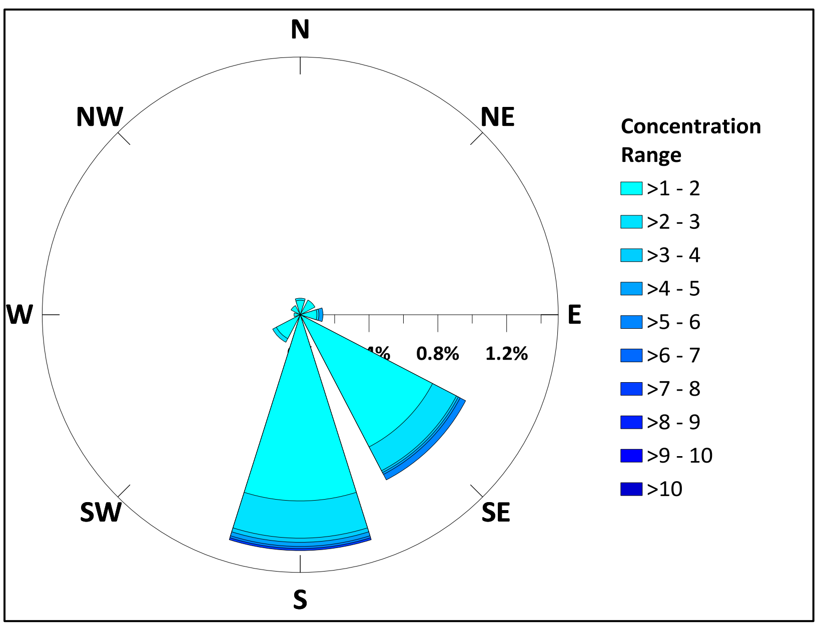


Figure 18: Frequency Distribution for one-hour Total Reduced Sulphur Concentrations – Measurements at or below Detection Limit Removed (in parts per billion)

7. Data from other Alberta Stations

Data collected at other stations from across Alberta were polled from the CASA Data Warehouse for comparison purposes. Only data collected during the same time period that the PASZA

Girouxville monitoring project was operating are presented; for more information about Alberta's monitoring stations and the availability of other data, please visit: www.casadata.org.

7.1. Ammonia

In comparison to other industrial emissions such as sulphur dioxide, ammonia is not a widely monitored substance in Alberta. It is monitored in Lethbridge mainly due to the presence of nearby large-scale cattle confined feeding operations. It is also monitored by the Fort Air Partnership at the Fort Saskatchewan, Range Road 220, Ross Creek, Station 401, and Redwater Industrial stations however it is a substance of interest in that Airshed because of the fertilizer production industry.

For all of the stations polled, nearly all minimum and median concentrations were at or near the detection limit of the instrument. Generally, ammonia is measured at very low concentrations most of the time. For monitoring stations in Alberta, the maximum concentrations ranged from 177 ppb (Fort Saskatchewan) to 731 ppb (Redwater Industrial) while the Girouxville project saw a maximum concentration of 665 ppb (Figure 19). The one-hour Alberta Ambient Air Quality Objective for ammonia is 2000 ppb.

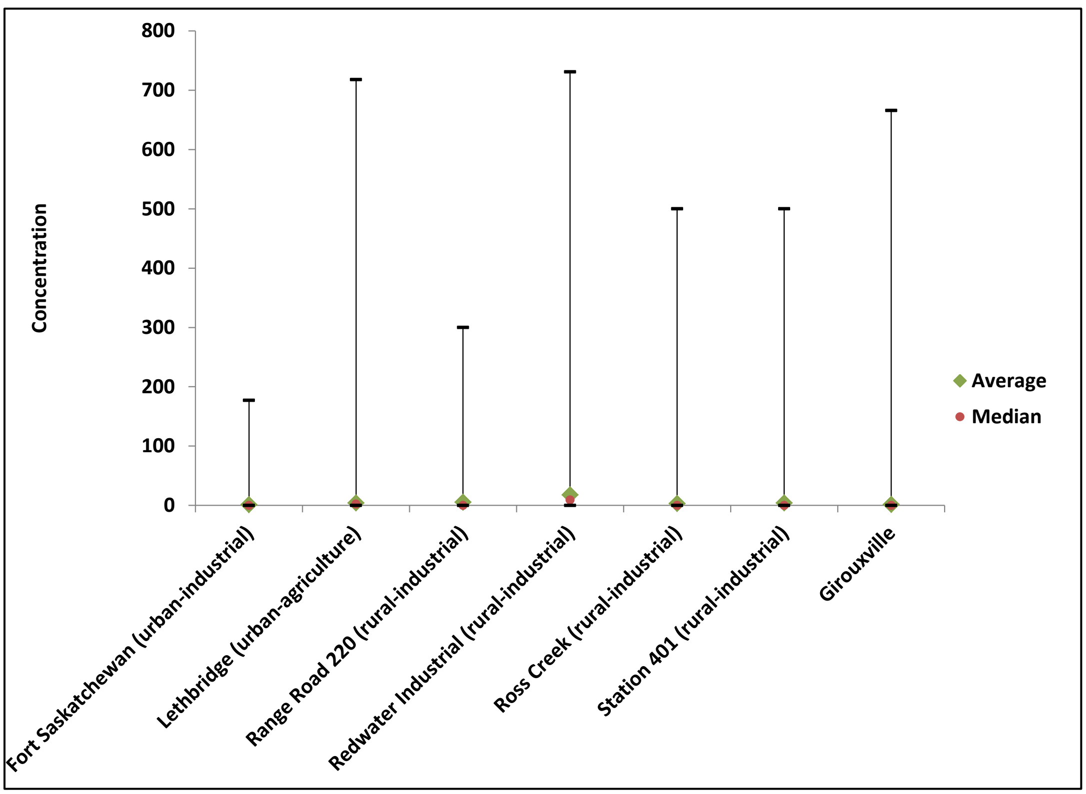


Figure 19: Minimum, Median, Average, and Maximum Ammonia Concentrations from Continuous Monitoring Stations in Alberta (in parts per billion)

7.2. Hydrogen Sulphide

7.2.1. Continuous Monitoring

Hydrogen sulphide is monitored continuously at a number of stations across Alberta. It is monitored at Edmonton East, Fort Saskatchewan, Mannix, Mildred Lake, Scotford, Valleyview, Buffalo Viewpoint, and Lower Camp mainly due to the oil and gas industry (a mix of both upstream and downstream sources). Similar to ammonia, hydrogen sulphide is of interest in Lethbridge because of the nearby confined feeding operations. It is measured in Calgary East and Red Deer mainly because these are 'super stations' that are fully equipped to measure several parameters.

For all of the stations polled, nearly all minimum and median concentrations were at or near the detection limit of the instrument. Generally, hydrogen sulphide is measured at very low concentrations most of the time. It appears that the median concentration measured at Girouxville is higher than at all other locations however this may be the result of how different monitoring organizations are treating data that are at or below the detection limit; this requires further investigation. The maximum concentrations ranged from 6 ppb (Fort Saskatchewan) to 91 ppb (Mildred Lake) while the Girouxville project saw a maximum concentration of 14.9 ppb (Figure 17). The one-hour Alberta Ambient Air Quality Objective for hydrogen sulphide is 10 ppb.

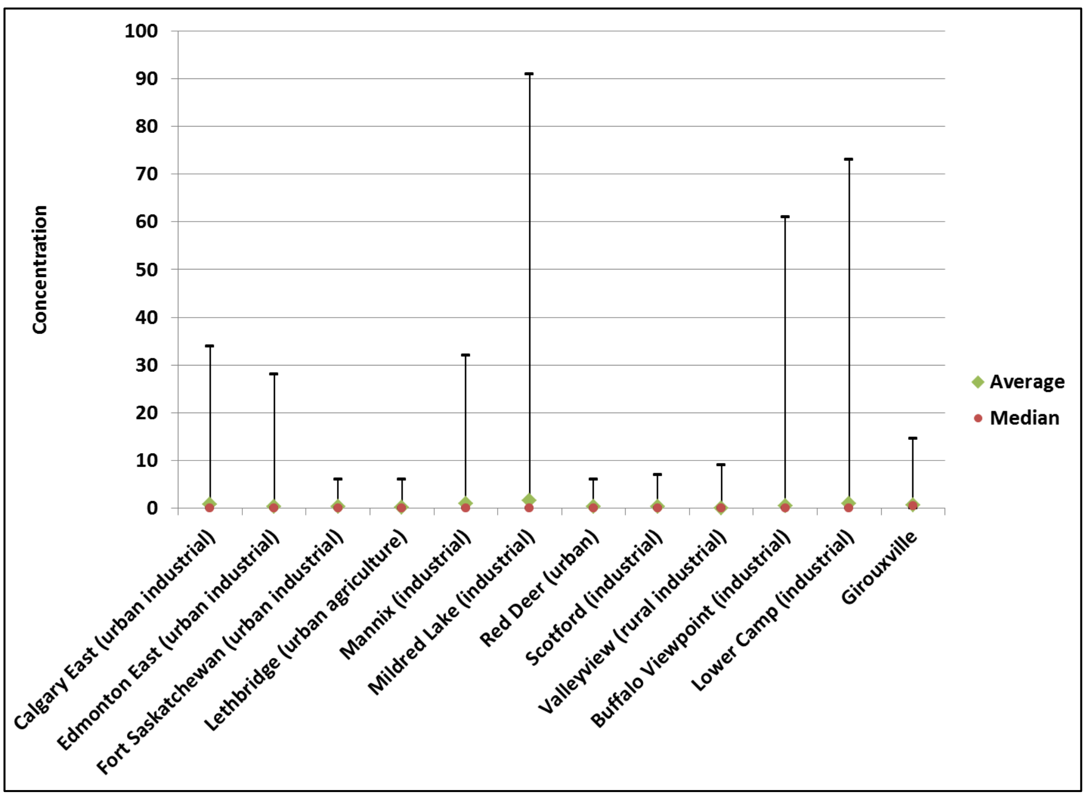


Figure 20: Minimum, Median, Average and Maximum Hydrogen Sulphide Concentrations from Continuous Monitoring Stations in Alberta (in parts per billion)

7.2.2. Passive Monitoring

Unlike continuous hydrogen sulphide monitoring, the opportunities for comparing the Girouxville passive monitoring data to other Alberta stations is limited. The Lakeland Industry and Community Association (LICA) Airshed is only monitoring organization in Alberta that samples for hydrogen sulphide with the passive method on a routine basis. The LICA monitoring network samples for hydrogen sulphide at 15 of its 27 passive monitoring stations; these stations represent a mix of land uses including industrial (oil sands), rural, and urban (the City of Cold Lake). LICA's overall average and median one-month average concentrations across the entire network are slightly lower than measurements in the Girouxville network however the absolute difference between these summary statistics is less than 0.3 ppb. Most of the oil and gas and oilsands activity in the LICA Airshed is associated with "sweet oil production" and therefore has low hydrogen sulphide concentrations. Elevated hydrogen sulphide concentrations in the LICA network are generally measured in the spring and late summer when local sloughs or ponds release hydrogen sulphide gas produced by decaying organic matter.

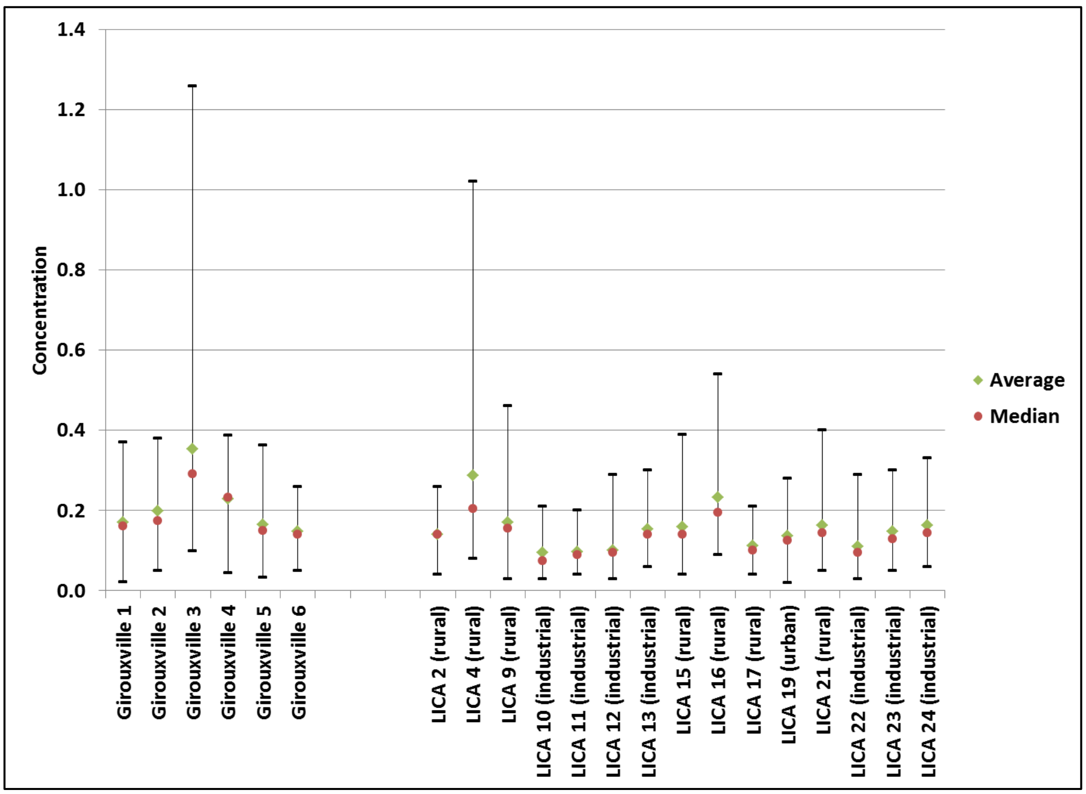


Figure 21: Minimum, Median, Average and Maximum Hydrogen Sulphide Concentrations from Passive Monitoring Stations in the Girouxville Network and the Lakeland Industry and Community Association Regional Network (in parts per billion)

7.3. Total Reduced Sulphur Compounds

Reduced sulphur compounds are monitored at a number of stations across Alberta. They are monitored in small and medium sized urban centres such as Cold Lake South, Grande Prairie, Evergreen Park, and Fort McMurray because generally there is a mix of potential sulphur-containing emission sources and this data can be used as a screening tool for identifying or quantifying odour issues (examples of total reduced sulphur compounds include mercaptans, dimethyl sulphide, and dimethyl disulphide which are highly odorous at low concentrations.

For all of the stations polled, nearly all minimum and median concentrations were at or near the detection limit of the instrument. Similar to hydrogen sulphide, it does appear that some of the summary statistics calculated for Girouxville are higher than other locations however this may be the result of how different monitoring organizations are treating data that is at or below the detection limit. The maximum concentrations ranged from 10 ppb (Evergreen Park) to 2 ppb (Henry Pirker – Grande Prairie) while the Girouxville project saw a maximum concentration of 7.9 ppb. There is no Alberta Ambient Air Quality Objective for total reduced sulphur compounds.

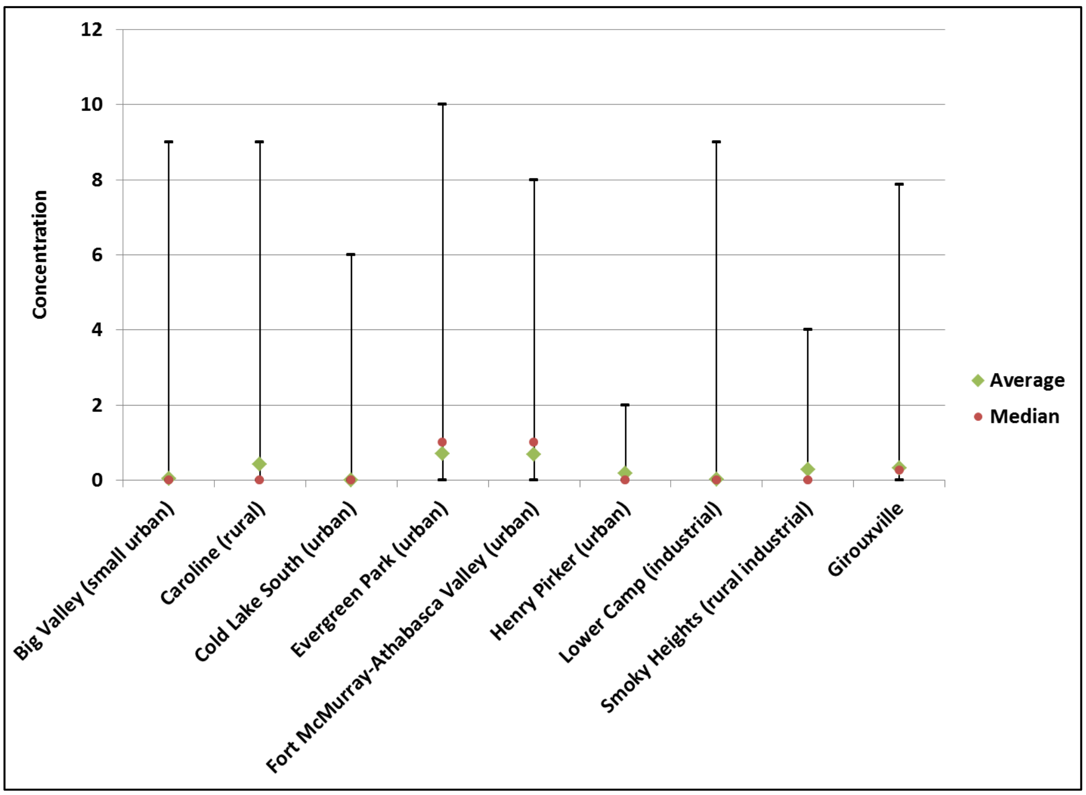


Figure 22: Minimum, Median, Average and Maximum Reduced Sulphur Compound Concentrations From Continuous Monitoring Stations In Alberta (in parts per billion)

8. Summary and Recommendations

The monitoring data that PASZA collected through the Girouxville monitoring project suggests that the network responded in a predictable manner considering the location of the stations in relation to confined feeding operations and prevailing meteorological conditions. Passive monitoring stations furthest away from the sources showed the lowest hydrogen sulphide concentrations while stations closest to the cluster of confined feeding operations detected the highest concentrations. Meteorology, both wind direction and temperature, played an important role in concentrations measured by PASZA.

During the project there were no exceedences of the one-hour ammonia or 24-hour hydrogen sulphide Alberta Ambient Air Quality Objectives (AAAQO), however there was one exceedance (14.9 parts per billion) of the one-hour hydrogen sulphide AAAQO (10.0 parts per billion).

Based on the monitoring results, it is recommended that PASZA consider rationalizing the passive monitoring network down to three stations (Passive 3, 4, and 6). Considering the predominant wind direction from west to east, the results of PASZA's study, and the location of the confined feeding operations, these three stations will provide a transect across the area, ideally from an area of high concentration to low concentration. The ongoing monitoring at these three sites will also provide PASZA the data it needs to assess changes in air quality in the area over time as technology and farm practices change. Although more difficult to find, there are accredited laboratories that are able to conduct analyses of ammonia passive monitors; PASZA may consider the passive ammonia sampling technology if more data are required.

If PASZA elects to return to the area with continuous monitoring in the future, it is recommended that the monitoring be co-located along the transect mentioned above, ideally at one of the passive stations slated to remain in the network. It may also be beneficial to monitor at different points along the transect to better under understand pollutant dispersion.

The summary of the air quality monitoring data is limited to the parameters measured in this study. Air quality surrounding confined feeding operations may be affected by other compounds associated with confined feeding operations some of which PASZA was not equipped to measure such as, volatile organic compounds (VOCs) and particulate matter. Monitoring considerations may include specialized integrated sampling technology, namely canister samplers (non-reactive silicone-coated interior), to collect samples for analysis of speciated VOCs and primarily, speciated reduced sulphur compounds to better understand the impact the CFOs are having on nearby air quality.

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