Integration of 2014 Odour Data for the Human Exposure Monitoring Program (HEMP)

FINAL REPORT

Prepared For

Wood Buffalo Environmental Association

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November 9, 2015

The content and opinions expressed by the author in this report do not necessarily reflect the views of the Wood Buffalo Environmental Association (WBEA) or of HEMP.

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Executive Summary

The Wood Buffalo Environmental Association (WBEA) is a not-for-profit society registered under the Societies Act of Alberta. WBEA monitors human exposure to selected air quality constituents through the Human Exposure Monitoring Program or HEMP. In 2009 odours had become a prominent issue in some communities within the Wood Buffalo region. As a result, HEMP's direction was refocused from personal exposure studies in communities to one of odour detection and chemical characterization. HEMP's current community of focus is Fort McKay, some sixty kilometers north of Fort McMurray. The need to effectively communicate the meaning behind the data collected under the odour projects of HEMP resulted in the HEMP Committee's members requesting an initial integrated data review using 2012 data. A second review was carried out using 2013 data and this is the third review and encompasses the 2014 data sets. The objective of this data integration is to provide HEMP further information on what the combined data from all of the collection methods are indicating and to provide a means of sharing information on the state of odours in the region with public individuals and stakeholders.

Odour assessment is a complex undertaking as the ability of humans to distinguish different odour intensities is highly subjective with changes in concentration of the order of over 25% needed for an individual to recognize different odour intensities. There is also a wide variation in sensitivity towards odours between individuals and a factor of 100 between the thresholds of two subjects for the same substance is not uncommon. The sensitivity to odours is specific rather than general and the sensitivity of a person to one odour or group of odours does not predict their sensitivity towards other odours.

For the community sites there were no hours with TRS greater than 10 ppb (Alberta AAQO). For the industrial sites there were a total of 34 hours with TRS or H_2S greater than 10 ppb with 14 hours recorded at Mannix and 7 hours at Mildred Lake. There was a large reduction in maximum TRS concentration from 2012 to 2013 with a slight increase at Bertha Ganter-Fort McKay from 2013 to 2014 and a decrease at Anzac. Hours with TRS greater than 3 ppb decreased by more than 90% at Bertha Ganter-Fort McKay, Patricia McInnes and Athabasca Valley from 2012 to 2014 and by 50% at the Anzac site. No sites in the network (industrial or community) exceeded the Alberta 1h AAQO for SO_2 of 172 ppb or the annual average AAQO of 8 ppb.

For the COMP (Fort McMurray) project there were a total of 138 unique complaints recorded in 2014. Approximately half (43%) of the observations identified the odour as asphalt/tar or hydrocarbon/solvent which is a similar percentage to the odour types reported in 2013. Most complaints were associated with NNE or NE wind directions and with wind speeds greater than 7 km/h and no precipitation.

For the Alberta Hotline there were a total of 32 unique complaints recorded on 20 separate dates. Twenty-seven of the complaints were recorded between January-March with only six complaints in the later months. In 2013 there were 93 complaints and it appears that the Alberta hotline may have stopped being used by residents during 2014 as the COMP complaints did not show a similar drop-off in frequency.

At the Fort McMurray sites there was no consistent association between any of the measured air quality parameters and reported odours although higher concentration values were most commonly reached for TRS and then $PM_{2.5}$. At the Bertha Ganter site five of the nine complaints to the Alberta Hotline were associated with TRS concentrations greater than 1.5 ppb and these complaint hours also showed high SO_2. Complaint hours had winds either from the south/southwest (south southeast at Lower Camp tower) or northwest.

The Community Odour Monitoring Program provides more consistent observations of odours and is providing a valuable data set. Because of the reduction in reports to the Alberta Hotline obtaining a similar record of community complaints from Fort McKay and Anzac would be highly beneficial.

Fort McKay's air and health scientists recently developed a "community-specific" Fort McKay Air Quality Index (FMAQI) which attempts to provide a general indication and measure of the air quality in the community based on the continuous measurements of a variety of parameters from the Bertha Ganter-Fort McKay measurement site. The FMAQI index should have a better relationship to odours than the AQHI and has been endorsed by Alberta Environment and Parks and WBEA as a useful communication tool with results routinely posted on the WBEA website for Fort McKay. Using the FMAQI, air quality was characterized as poor or very poor in Fort McKay for approximately 3% of hours in 2014. THC and AQHI both accounted for the highest sub index 39% of the time with TRS accounting for the highest sub index 22% of the time and SO_2 only 0.3% of the time. Five of the nine hours with a complaint to Alberta Hotline had a calculated FMAQI greater than six.

The usefulness of the eNose system as an indicator of odours is not apparent regardless of which data processing technique is employed. The lack of directionality in results and the poor correlation with all other measured parameters resulted in the data being of very limited value. There are two other eNose systems operated in Fort McKay by the community and it would be very useful to compare the results from the three different units. Results from the two PFGC systems were again very variable with many step changes in response to VOC species and to groups of species through the course of the year. Detection percentages for both COS and CS_2 were very low compared to previous years. The PFGC program was terminated in April 2015.

Detection levels for the canister sampling are too high to identify any of the most odorous target species and either the measurements should be terminated or improvements in detection levels should be sought. The cartridge sampling program which commenced in 2015 by HEMP may produce much more useful results for RSC species. The continuous NMHC measurements appeared variable and the lack of correlation amongst the various NMHC/VOC measurement methods is cause for concern. Since many of the complaints refer to hydrocarbon odours, additional effort is required to identify and routinely measure odorous and/or indicator VOC species.

There is a disconnect between odour complaints and occurrence of elevated levels of currently measured ambient species suggesting that the specific compounds responsible for complaints are not being measured and/or detected. It may be more beneficial to carry out source emission characterization for a list of candidate odorous compounds than to implement new ambient measurement programs. The strong directionality of odour complaints at all community sites suggests that there are specific sources responsible for the odour complaints. Data on source and control equipment operations during complaint periods should be obtained to see if there are any linkages to odour complaints. This is a vital piece of information to improve our understanding of why odours occur and thus potentially reduce the number of odour complaints in the future.

1 Background

The Wood Buffalo Environmental Association (WBEA) is a not-for-profit society registered under the Societies Act of Alberta. WBEA is the second regional airshed management zone to be developed in the province and has the most extensive airshed monitoring network in Alberta and the largest non-urban network in Canada. The Athabasca Oil Sands Region (AOSR) is within the municipality, and includes both traditional bitumen mining operations and in situ oil production. The region also encompasses the communities of Fort McMurray, Fort Chipewyan, Fort McKay, Anzac, Janvier and Conklin. WBEA is committed to reporting accurate and timely high quality data from their Air, Terrestrial and Human Exposure Monitoring Programs to ensure regional stakeholders have the information they need to make informed environmental decisions. WBEA monitors human exposure to selected air quality constituents through the Human Exposure Monitoring Program or HEMP (WBEA, 2014).

In 2009 odours had become a prominent issue in some communities within the Wood Buffalo Region. As a result, HEMP's direction was refocused from personal exposure studies in communities to one of odour detection and chemical characterization. HEMP's current community of focus is Fort McKay, some sixty kilometers north of Fort McMurray. WBEA has operated an air quality monitoring station, AMS#1, (re-named Bertha Ganter-Fort McKay in 2012), in Fort McKay since 1998. Two specialized odour detection, evaluation and quantification instruments operate alongside other WBEA analyzers at this air monitoring station. In the Wood Buffalo region, volatile organic compounds (VOCs) and sulphur containing compounds, such as reduced sulphur compounds (RSCs) are well known to cause odours, either individually or in combination (WBEA, 2014).

The need to effectively communicate the meaning behind the data collected under the odour projects of HEMP resulted in the HEMP Committee's members requesting an initial integrated data review using 2012 data (Dann, 2013). A second review was carried out using 2013 data and this is the third review and encompasses the 2014 data sets. These yearly reports support the vision that as new data sets are collected annually from HEMP projects and other odour monitoring efforts, integrated data reviews will be conducted to build on previous year's data sets, recommendations and correlations to provide more insight and to maintain a unified complete monitoring data set of odours and related environmental variables in the Wood Buffalo region.

2 Odour and Odour Characterization

2.1 Perception of Odours

Of the five senses, the sense of smell is the most complex and unique in structure and organization. While human olfaction supplies 80% of flavor sensations during eating, the olfactory system plays a major role as a defense mechanism by creating a natural aversion response to malodours and irritants. Human response to odourant perception follows certain characteristic patterns common among sensory systems. For example, olfactory acuity in the population conforms to a normal distribution. Most people have a "normal" sense of smell whereas two percent of the population is hypersensitive and two percent insensitive.

Whether an odour has an objectionable or offensive effect will depend on the frequency, intensity, duration, offensiveness and location of the odour event. These factors are collectively known as the FIDOL factors (MOE NZ, 2003):

Frequency: How often an individual is exposed to odour

Intensity: The strength of the odour

Duration: The length of a particular odour event

Offensiveness/character: The character relates to the 'hedonic tone' of the odour, which may be pleasant, neutral or unpleasant

Location: The type of land use and nature of human activities in the vicinity of an odour source

Different combinations of these factors can result in adverse effects. Odours may occur frequently in short bursts, or for longer, less-frequent periods, and may be defined as having 'chronic' or 'acute' effects. Depending on the severity of the odour event, one single occurrence may be sufficient to deem that a significant adverse effect has occurred. However, in other situations the duration may be sufficiently low and the impact on individuals sufficiently minor that the frequency of events would need to be higher before an adverse effect would be deemed to have occurred. (MOE NZ, 2003)

2.2 Parameters associated with Odours

2.2.1 Odour Threshold

The detectability of an odour is related to its concentration. The concentration at which an odour is first perceived is often referred to as the odour threshold or detection threshold. It is important to note that this value varies from individual to individual, sometimes by as much as two orders of magnitude, due to variations in individual sensitivities. Moreover, other factors such as exposure duration can drastically affect the odour threshold because of olfactory fatigue, and acclimatization (B.C. 2002).

Odour thresholds are related to detectability and refer to the theoretical minimum concentration of odorous substance necessary for detection in a specified percentage of the population. This percentage is often defined as the mean, 50%, i.e. the lowest odour concentration that can be detected by 50% of the population. Threshold values are not fixed physiological facts or physical constants, but rather, a statistical point representing the best estimate from a tested population. Two types of thresholds are evaluated: the detection threshold, which is the lowest concentration at which an odour is detected, with no recognition of the odour quality; and the recognition threshold, which is the minimum concentration that is recognized as having a characteristic odour quality. Typically, the concentration at which an odour is first recognized as having a certain characteristic quality (recognition threshold) is 1.5 to 10 times higher than the detection threshold, depending on the individual and the odorous compound (B.C. 2002).

2.2.2 Character of Odour (Hedonic Tone)

Once the odour is at a sufficiently high concentration to allow recognition, the quality of the odour may be described. The odour quality is a purely subjective descriptor of an odour's aesthetic impression, such as sweet, sour, musty, rancid, etc. The intensity of a given odour is defined as its perceived strength, but is not necessarily related to its concentration. For example, a particularly pungent odour at a very low concentration may be perceived to be more intense than a less pungent substance at a higher concentration. The odour acceptability, which is also known as the Hedonic tone, is an indication of the pleasantness or unpleasantness of the odour. The acceptability of a particular odour varies with the individual, and may be affected by experience, frequency of occurrence, duration, and odour intensity and character. It should also be noted that environmental conditions, including temperature and relative humidity have also been found to alter the sensory perception of odours.

Another factor is the portion of the population who are sensitized to a particular odour as a result of repeated exposure. This is distinct from olfactory fatigue or adaptation to odour after prolonged exposure. It should be noted that these terms describe a temporary desensitization after smelling an odour. For example, after exposure to a strong odour an individual may be unable to detect a weaker one. The response of humans to mixtures of odorous compounds is difficult to predict, since the odour threshold of the mixture is rarely an additive combination of the individual odours. All odours have the ability to mask the odours of other compounds, and odorous constituents may react with each other, changing the odour character or intensity.

Another phenomenon, which may lead to confusion in odour sensing, is the ability of an odour to change character with concentration. For example, carbonyl sulphide has a “burnt” character at concentrations below 1 part per million (ppm), but takes on a “rotten egg” smell at higher concentrations. It is obvious that many of the discrepancies in odour complaints are due in part to this property of odour, in combination with individual variability and geography. The ability of humans to distinguish different odour intensities is highly subjective. Studies indicate that changes in concentration of the order of 25 to 33% are needed for an individual to recognize different odour intensities. There is a wide variation in sensitivity towards odours between individuals and that a factor of 100 between the thresholds of two subjects for the same substance is not uncommon. The sensitivity to odours is specific rather than general and the sensitivity of a person to one odour or group of odours does not predict their sensitivity towards other odours. Perceived odour quality varies with the individual and also with the strength of an odour. An individual's background will influence their attitude towards odours. A person with a rural background may find an agricultural odour acceptable whereas a person with an urban background may find the same odour offensive. Other psychological factors may influence an individual's perception of an odour. A visual stimulation, for example, may influence an individual's response to an odour stimulus (B.C. 2002).

2.2.3 Odour Units and Reported Thresholds

The parameter “odour unit” is frequently encountered in the field of odour measurement: in simplest terms, it is the amount of dilution required to bring a specific species (or species group) of chemical in a given air sample to its detectable threshold. The greater the amount of dilution required, the more odorous the sample and the lower the odour threshold. The analysis is performed by a selected human panel and the result is presented as ppb (for pure single substance samples) or Odour Units (o.u.) /m^3. The measurement of odour concentration is standardized in a European Committee for Standardization method (CEN, 2003). Many publications carry tables of odour thresholds for single substances but there is often conflict between these and often the threshold is reported as a range rather than a specific number. Comparing a chemical quantification to the odour threshold of a simple one to two species odour can be somewhat effective, but as the chemical mix of the odour becomes more complex, the odour threshold of specific components is of little use (SEPA, 2010).

As a reference, 2 to 3 o.u./m^3 generally corresponds to the level at which 50% of the population can start to recognize an odour in an odourless environment. In general, odour presenting concentrations above 5 o.u./m^3 are considered discernable (can be identified) above the ambient background. For example, a perfumed person could represent 20-50 o.u./m^3, freshly cut grass would be around 250 o.u./m^3 and old garbage could reach 500 o.u./m^3. (Odotech, 2014).

Estimated odour thresholds (ppb) and their reported range are provided in Table 1 for those species currently measured at one or more WBEA sites (continuous or integrated measurement) and other species of interest. A number of references are used and it should be noted that there is a wide variation in reported odour thresholds depending on the reference. Much of the reported data comes from studies carried out decades ago but a more recent set of data from Japan (Nagata, 2003) using a triangular bag method is also included in the Table.

Hydrogen sulphide is a good example of variable reported odour thresholds with values ranging from 0.5 to 12 ppb. Amoore (1985) analyzed a large number of reports from the scientific literature and found that reported thresholds for H_2S detection were log-normally distributed, with a geometric mean of 8 ppb. Detection thresholds for individuals were reported to be log-normally distributed in the general population, with a geometric standard deviation of 4.0, i.e. 68% of the general population would be expected to have a detection threshold for hydrogen sulphide between 2 and 32 ppb. He also predicted that at 8 ppb, 50% of the general population would be able to detect the odor of hydrogen sulphide under controlled conditions, but only 5% would find it annoying at this level. At 35 ppb, 50% would find the odor annoying. As noted in Table 2 the Alberta 1h ambient air quality objective (AAQO) for H_2S is set at 10 ppb based on odour.

Table 1: Examples of Odour Thresholds for Selected Compounds measured at WBEA sites (consolidated and adapted from Woodfield and Hall 1994, the U.K. Royal Society of Chemistry Chemical Data Sheets 1989 -1992, Ruth, 1986 and Nagata, Y., 2003).

Compound	Descriptor where available	Reported threshold Range (ppb)	Odour threshold (ppb) (Bokawa, 2014)	Odour Threshold (ppb) (Nagata, 2003)
Acetone	chemical/sweet	450 – 13,000	4,000-5,000	42
Allyl sulphide		15		0.22
Ammonia	sharp, pungent	144 – 16,700	700	1,500
Benzene	solvent	400 – 29,000		2,700
Benzyl mercaptan	garlic, leeks	2.6		
1,3-Butadiene	mild, gasoline	190 – 450		230
Butyl mercaptan	stinks	0.5 – 1.0		0.0028
Carbon disulphide	disagreeable, sweet	11 – 700	26-38	210
Carbonyl sulphide				55
m-Cresol	coal-tar			0.1
o-Cresol	coal-tar			0.28
p-Cresol	coal-tar			0.054
Dimethyl sulphide	decayed cabbage	0.8 – 15	2.8	3
Dimethyl disulphide		0.3 – 90	1.9	2.2
2,5-dimethyl thiophene		None Found		
Ethyl mercaptan		0.1 – 36		0.0087
2-ethyl thiophene		None Found		
Hydrogen sulphide	rotten eggs	0.5 - 12	0.05-0.07	0.41
Isobutyl mercaptan		0.8		0.0068
Isopropyl mercaptan	skunk like	0.3		0.006
Methyl mercaptan	sulphur	0.02 – 42	0.15	0.07
2-methyl thiophene	sulphur	None Found		
3-methyl thiophene		None Found		
Naphthalene	mothballs	38		
Nitrogen dioxide	acrid, pungent	10 – 1,000		
Pentane	gasoline			1,400
Propyl mercaptan		0.06 – 24		0.013
sec-Butyl mercaptan		None Found		0.03
Sulphur dioxide	suffocating	340 – 8000		870
Styrene	penetrating, rubbery, plastic	38		35
tert-Butyl mercaptan		0.3		0.029
Thiophene	aromatic, gasoline	0.4 - 4		0.56
Toluene	floral, pungent, moth balls	125 – 210	89-117	330

2.3 Other Air Quality Criteria and Potential Toxicity of Odourous Species

Humans instinctively react to odour whether the odour is pleasant or offensive. The most common reaction is a disturbance in mood. For example, agreeable odours can induce feelings of relaxation and pleasure while offensive odours can induce feelings of anger, or even fatigue. Since odours can cause quantifiable increases in measurable stress responses such as blood pressure and blood sugar levels, the effects of odour on mood disturbances are not entirely psychological (Martin, 1996).

In some cases, reactions to offensive odours can actually result in physical symptoms. Such ailments are said to be annoyance-mediated. That is, the physical symptoms of illness are a result of a psychological reaction to odour and not any toxin-mediated irritation. For instance, individuals exposed to irritating odours may report headaches, nausea, and irritation of the eyes, nose, and throat and other self-reported physical symptoms. Therefore, humans can respond both mentally and physically to unpleasant odours. The two types of reactions, however, may not be mutually exclusive. In fact, one study examining odours associated with a hazardous waste site described the relationship between worry (a mood disturbance) and physical symptoms such as headaches, and eye and throat irritations as one where physical and psychological effects of the irritating odour acted synergistically to produce overall reactions (Shusterman et al, 1991).

Many odorous substances do have toxic properties at high concentrations and jurisdictions have established air quality criteria for the substance to prevent adverse health effects. Table 2 contains Alberta ambient air quality objectives (AAQO) for all relevant species as of February 2014. Species for which the AAQO is based on odour are listed first in the Table. For some species, health effects do potentially occur at levels below their odour threshold whereas for most species the odour threshold is below the known adverse effect level.

Table 2: Alberta Ambient Air Quality Objectives (AAQO) for measured WBEA species.

Contaminant	AAQO (µg/m³)	AAQO (ppb)	Averaging Time	Basis	Date	Limiting Effect
Ammonia	1,400	2,000	1 Hour			***Odour***
Carbon disulphide	30	10	1 Hour		2005	***Odour***
Hydrogen sulphide	4	3	24 Hour		1975	***Odour***
	14	10	1 Hour			***Odour***
Acetaldehyde	90	50	1 Hour	Adopted from Texas	1999	Health
Acetone	5,900	2,400	1 Hour	Adopted from Texas	2005	Health
Benzene	3	0.9	Annual		2012	Carcinogenic effects
	30	9	1 Hour			Haematological effects
Carbon monoxide	6,000	5,000	8 Hour		1975	Health
	15,000	13,000	1 Hour			Oxygen carrying capacity of blood
Ethyl benzene	2000	460	1 Hour	Adopted from Texas	2005	Health
Ethylene	30	26	Annual		2004	Conifers and perennials
	45	40	3 day			Crop yield
	1,200	1,050	1 Hour			Crop yield
Ethylene oxide	15	8	1 Hour	Adopted from Ontario	1999	Health
Formaldehyde	65	53	1 Hour	Adopted from Texas	2007	Health
n-Hexane	7,000	1,990	24 Hour	Adopted from California	2008	Health
	21,000	5,960	1 Hour	Derived from 24-hr California objective		Health
Hydrogen chloride	75	50	1 Hour	Adopted from Texas	1999	Health
Isopropanol	7,850	3,190	1 Hour	Adopted from Texas	2005	Health
Methanol	2,600	2,000	1 Hour	Adopted from Texas	1999	Health
Nitrogen dioxide	45	24	Annual		2009	Respiratory effects
	300	159	1 Hour			Vegetation
Ozone	160	82	1 Hour		2007	Health
Phenol	100	26	1 Hour	Adopted from Ontario	1999	Health
Styrene	215	52	1 Hour	Adopted from Texas	1999	Health
Sulphur dioxide	20	8	Annual		2008	Adopted from European Union - ecosystems
	30	11	30 day			Vegetation
	125	48	24 Hour			Adopted from European Union – human health
	450	172	1 Hour			Pulmonary function
Toluene	400	106	24 Hour	Adopted from Michigan and Washington	2005	Health
	1,880	499	1 Hour	Adopted from Texas		Health
Vinyl chloride	130	51	1 Hour	Adopted from Texas	1999	Health
Xylenes	700	161	24 Hour	Adopted from Ontario	2005	Health
	2,300	530	1 Hour	Adopted from California		Health

3 Emission Sources in the WBEA Area

3.1 Total Reduced Sulphur Species

In the National Pollutant Release Inventory (NPRI) total reduced sulphur (TRS) refers to a gaseous mixture of compounds containing one or more sulphur atom in its reduced state. For the purposes of reporting to the National Pollutant Release Inventory (NPRI), the class of substances is restricted to the substances listed in Table 3. Three of the TRS compounds (hydrogen sulphide (H_2S), carbon disulphide (CS_2) and carbonyl sulphide (COS)) are also listed individually and if any of these substances meets the 10 tonne reporting threshold alone, then it must also be reported individually. When determining the reporting threshold and reporting to the NPRI, TRS must be expressed in terms of H_2S. TRS quantities can be determined using several methods, including summing H_2S equivalencies, emissions monitoring or source testing. To use the equivalence factor method, the equivalency of the individual TRS compounds in tonnes of H_2S must be determined and added together to determine if TRS is required to be reported. The H_2S equivalence factors are included in Table 3 (NPRI, 2014). Estimated emissions of TRS (tonnes) for 2013 (latest data available) for sources in the WBEA region are shown in Table 4. Overall, 26% of TRS emissions were from fugitive sources in 2013.

Table 3: Total reduced sulphur species in the NPRI.

Substance Name	Formula	Hydrogen Sulphide Equivalence Factor
Hydrogen sulphide	H_2S	1.000
Carbon disulphide	CS_2	0.895
Carbonyl sulphide	COS	0.567
Dimethyl sulphide	C_2H_6S	0.548
Methyl mercaptan	CH_4S	0.708
Dimethyl disulphide	$C_2H_6S_2$	0.724

Table 4: Emissions of TRS (tonnes) from sources in the WBEA airshed - 2013 (NPRI Estimates).

Company Name	Facility Name	Latitude	Longitude	Stack Emissions	Fugitive Emissions	Storage / Handling	Total
Syncrude Canada Ltd.	Mildred Lake Plant Site	57.04	-111.62	90	34		124
Suncor Energy Oil Sands Limited Partnership	Suncor Energy Inc. Oil Sands	57.00	-111.47	52	14	2	69
Canadian Natural Resources Limited	Horizon Oil Sands Processing Plant and Mine	57.34	-111.76	28	4	2	34
Syncrude Canada Ltd.	Aurora North Mine Site	57.30	-111.50		10		10
Suncor Energy Oil Sands Limited Partnership	Firebag	57.23	-110.90	1		4	5
TOTAL				172	62	8	242

A breakdown of TRS emissions for Syncrude and Suncor into the species H_2S, COS and CS_2 is shown in Table 5. For both Syncrude and Suncor, emissions of H_2S accounted for 36% of total reported TRS emissions. There were no reported emissions of carbon disulphide from the Suncor plant in 2013.

Table 5: Emissions of H_2S, carbonyl sulphide, carbon disulphide and TRS from two largest emission sources in the WBEA area (tonnes of H_2S) - 2013 (NPRI Estimates).

Company Name	Facility Name	Compound	Stack Emissions	Fugitive Emissions	Other	Total
Suncor Energy Oil Sands Limited Partnership	Suncor Energy Inc. Oil Sands	COS	45	6	0	52
		CS_2				
		H_2S	17	7	1	25
		TRS	**52**	**14**	**2**	**69**
Syncrude Canada Ltd.	Mildred Lake Plant Site	COS	40	12		52
		CS_2	9	16		25
		H_2S	40	5	0	45
		TRS	**90**	**34**	**0**	**124**

3.2 Sulphur Dioxide and VOC Emissions

Estimated emissions of SO_2 and VOC (tonnes) for 2013 for sources in the WBEA region are shown in Tables 6 and 7. Emissions of selected VOC species are shown in Table 8. SO_2 emissions were essentially all from stacks whereas 77% of VOC emissions were from fugitive sources. The split between stack and fugitive emissions for VOC species was quite variable depending on the facility and the compound.

Table 6: Emissions of SO_2 (tonnes) from major sources in the WBEA airshed (> 150 tonnes) – 2013 (NPRI Estimates).

Company Name	Facility Name	Lat.	Long.	Stack Emissions
Syncrude Canada Ltd.	Mildred Lake Plant Site	57.04	-111.62	62,869
Suncor Energy Oil Sands Limited Partnership	Suncor Energy Inc. Oil Sands	57.00	-111.47	14,104
Canadian Natural Resources Limited	Horizon Oil Sands Processing Plant and Mine	57.34	-111.76	4,073
Nexen Inc.	Long Lake Project	56.41	-110.94	2,878
Devon Canada Corporation	Jackfish 1 SAGD Plant	55.53	-110.87	755
Devon Canada Corporation	Jackfish 2 SAGD Plant			630
Suncor Energy Oil Sands Limited Partnership	Firebag	57.22	-110.90	347
Japan Canada Oil Sands Ltd.	Hangingstone SAGD Demonstration Facility	55.58	-110.89	204
Cenovus	Christina Lake SAGD Battery			197
ConocoPhillips Canada Resources Corp.	Surmont SAGD Commercial Battery	56.19	-110.95	197
Suncor Energy Oil Sands Limited Partnership	Mackay River In-Situ Plant	57.04	-111.91	152

TOTAL	86,895

Table 7: Emissions of VOC (tonnes) from major sources in the WBEA airshed (> 500 tonnes) – 2013 (NPRI Estimates).

Company Name	Facility Name	Lat.	Long.	Stack Emissions	Fugitive Emissions	Other	Total
Syncrude Canada Ltd.	Mildred Lake Plant Site	57.04	-111.62	511	7,513	267	8,291
Suncor Energy Oil Sands Limited Partnership	Suncor Energy Inc. Oil Sands	57.00	-111.47	2,420	2,682	1,666	6,768
Canadian Natural Resources Limited	Horizon Oil Sands Processing Plant and Mine	57.34	-111.76	99	4,226	3	4,328
Shell Canada Energy	Shell Albian Sands Muskeg River Mine and Jackpine Mine	57.35	-111.52	106	2,507	1	2,614
Syncrude Canada Ltd.	Aurora North Mine Site	57.30	-111.50	12	2,559	1	2,572
Imperial Oil	Kearl Oil Sands Processing Plant and Mine	57.40	-111.07	41	2,459	45	2,546
Devon Canada Corp.	Jackfish 2 SAGD Plant	55.50	-110.99	1,446	15	0	1,461
Nexen Energy ULC	Long Lake Project	56.41	-110.94	172	397	37	606
TOTAL				4,806	22,358	2,021	29,185

Table 8: Emissions of selected VOC species (tonnes) from major sources in the WBEA airshed – 2013 (NPRI Estimates).

Company Name	Facility Name	VOC Compound	Stack Emissions	Fugitive Emissions
Syncrude Canada Ltd.	Mildred Lake Plant Site	Cyclohexane	0.3	91.1
		Ethylbenzene	0.2	47.4
		Ethylene	52.8	7.8
		n-Hexane	0.1	121.1
		Toluene	1.9	134.4
		Xylenes	0.7	274.1
Suncor Energy Oil Sands Limited Partnership	Suncor Energy Inc. Oil Sands	Cyclohexane	56.6	21.6
		Ethylbenzene	3.8	31.8
		Ethylene	68.6	12.6
		n-Hexane	60.9	101.8
		Toluene	11.1	130.7
Canadian Natural Resources Limited	Horizon Oil Sands Processing Plant and Mine	Cyclohexane	0.0	223.7
		Ethylbenzene	0.1	8.1
		n-Hexane	0.0	41.7
		Toluene	1.6	20.2
		Xylenes	0.2	40.3
Devon Canada Corp.	Jackfish 2 SAGD Plant	Cyclohexane	7.6	0.0
		n-Hexane	166.0	1.5
		Toluene	0.7	0.0
		Xylenes	0.2	

Major source locations for TRS, SO_2 and VOC are provided in Figure 1 and Figure 2.

Figure 1: Location of major TRS, SO_2 and VOC emission sources in the WBEA airshed.

Figure 2: Location of major TRS, SO_2 and VOC emission sources near Fort McKay.

3.3 Comparison of NPRI Emission Estimates for 2011 through 2013.

A comparison of total emissions of TRS, SO_2 and VOC for 2011, 2012 and 2013 for the major sources is provided in Table 9. In general, estimated emissions increased from most facilities in 2012 as compared to 2011 and then decreased in 2013. Emissions from Suncor, in particular, showed a large decrease between 2012 and 2013. Final NPRI emission data for 2014 are not yet available.

Table 9: Comparison of total emissions of TRS, SO_2 and VOC (tonnes) from major sources and all sources in the WBEA airshed for 2011, 2012 and 2013 (NPRI Estimates).

Company Name	TRS			SO_2			VOC		
	2011	2012	2013	2011	2012	2013	2011	2012	2013
Syncrude –Mildred Lake	117	118	124	64,727	72,971	62,869	7,704	7,495	8,291
Suncor	87	288	69	20,258	18,538	14,104	12,649	16,087	6,768
CNRL	22	18	34	1,988	2,423	4,073	3,432	11,875	4,328
Syncrude - Aurora	11	11	10	-	-	-	4,702	4,692	2,572
Shell Albian Sands, Muskeg River, Jackpine	-	-	-	-	-	-	2,050	2,259	2,614
Nexen Long Lake	-	-	-	1,744	3,076	2,878	-	-	-
All Sources	237	435	242	90,124	98,322	86,895	30,537	43,225	30,441

4 Discussion of Available Data for 2014

4.1 Monitoring Sites and Locations and Measured Parameters

A listing of WBEA sites and measured air quality and meteorological parameters (as used in this report) is found in Table 10 and site locations are shown in Figure 3. The Wapasu (AMS#17) site began reporting data in November 2013 and the Firebag site (AMS#18) began operation in July 2014. The HEMP mobile site (AMS#104) was located originally at the Mildred Lake site but was relocated to Anzac (AMS#104A) on September 9, 2014.

Parameters routinely measured in the WBEA network on a continuous basis and used in this report include sulphur dioxide (SO_2), hydrogen sulphide (H_2S) or total reduced sulphur (TRS), nitric oxide (NO), nitrogen dioxide (NO_2), particulate matter less than 2.5 µm aerodynamic diameter ($PM_{2.5}$) and total hydrocarbons (THC). Methane (CH_4) and total non-methane hydrocarbons (NMHC) are measured at the four community sites (AMS#1, AMS#6, AMS#7 and AMS#14). Hourly data were used from all sites and five-minute data was also used for the community sites for TRS, SO_2 and NMHC in order to look at within hour variability of concentrations.

A number of other specialized measurements are made at AMS#1 including a pneumatic focusing dual detector GC (PFGC) for volatile organic compounds (VOC) and volatile reduced sulphur compounds (RSC) and an Odotech electronic nose (eNose) system. An additional PFGC instrument was installed in the special study site (AMS#104). The AMS#104 site also measures TRS, methane, NMHC, THC and meteorological parameters. The location of the site relative to AMS#2 (prior to relocation to Anzac) is shown in Figure 4. Ammonia (NH_3) is measured continuously at two community sites – AMS#1 and AMS#6. Table 10 also shows the sites where integrated 24-hour samples are collected for VOC and RSC using evacuated canisters. Data for all parameters for 2014 were obtained directly from WBEA staff.

Environment Canada (EC) also measures VOC in canisters at Fort McKay South. Environment Canada has operated a monitoring site in Fort McKay since 2013 as part of the Joint Oil Sands Monitoring Program. The site is known as Fort McKay Oski ôtin (Cree for new wind) and is located approximately 0.6 km south of Bertha Ganter-Fort McKay. Measurements from this site were also available for total sulphur, benzene, toluene, ethylbenzene, xylenes (BTEX), black carbon and particulate PAH for a portion of 2014 and have been used in this report. Data were downloaded from the Canada-Alberta Oil Sands Environmental Monitoring Information Portal (EC, 2015) and are described as data quality level "0" ("a reasonably complete data set of unspecified quality that consists of research products subjected to minimum processing in the field and/or in the laboratory by project").

All data have been processed as described below and stored in a unified data system.

Table 10: WBEA monitoring sites, continuous parameters reported in 2014 and canister sample locations (only those sites and parameters used in this report).

WBEA ID	PURPOSE	STATION NAME	TRS	H_2S	SO_2	NO/NO_2	$PM_{2.5}$	THC	Methane NMHC	Other*	Canister VOC/RSC
1	COMMUNITY	BERTHA GANTER- FORT MCKAY	X		X	X	X	X	X	X	X
2	INDUSTRIAL	MILDRED LAKE		X	X			X			
3	METEOROLOGY	LOWER CAMP MET TOWER									
4	INDUSTRIAL	BUFFALO VIEWPOINT		X	X			X			
5	INDUSTRIAL	MANNIX		X	X			X			
6	COMMUNITY	FORT MCMURRAY PATRICIA MCINNES	X		X	X	X	X	X	X	X
7	COMMUNITY	FORT MCMURRAY ATHABASCA VALLEY	X		X	X	X	X	X		X
9	INDUSTRIAL	BARGE LANDING	X					X			X
11	INDUSTRIAL	LOWER CAMP		X	X			X			
12	INDUSTRIAL	MILLENNIUM	X		X	X	X	X			X
13	INDUSTRIAL	FORT MCKAY SOUTH	X		X	X	X	X			X, EC
14	COMMUNITY	ANZAC	X		X	X	X	X	X		X
15	INDUSTRIAL	CNRL HORIZON	X		X	X	X	X			X
16	INDUSTRIAL	SHELL MUSKEG RIVER			X	X	X	X			
17	INDUSTRIAL	WAPASU		X	X	X	X	X			
18	INDUSTRIAL	FIREBAG		X	X	X		X			
104	SPECIAL STUDY	AMS#104-Mildred Lake	X						X	X	
104A	SPECIAL STUDY	AMS#104-Anzac	X						X	X	

* other measurements include OdoCheck, PFGC and ammonia at AMS#1, ammonia at AMS#6 and PFGC at AMS#104.

Figure 3: WBEA continuous monitoring network (excluding Fort Chipewyan).

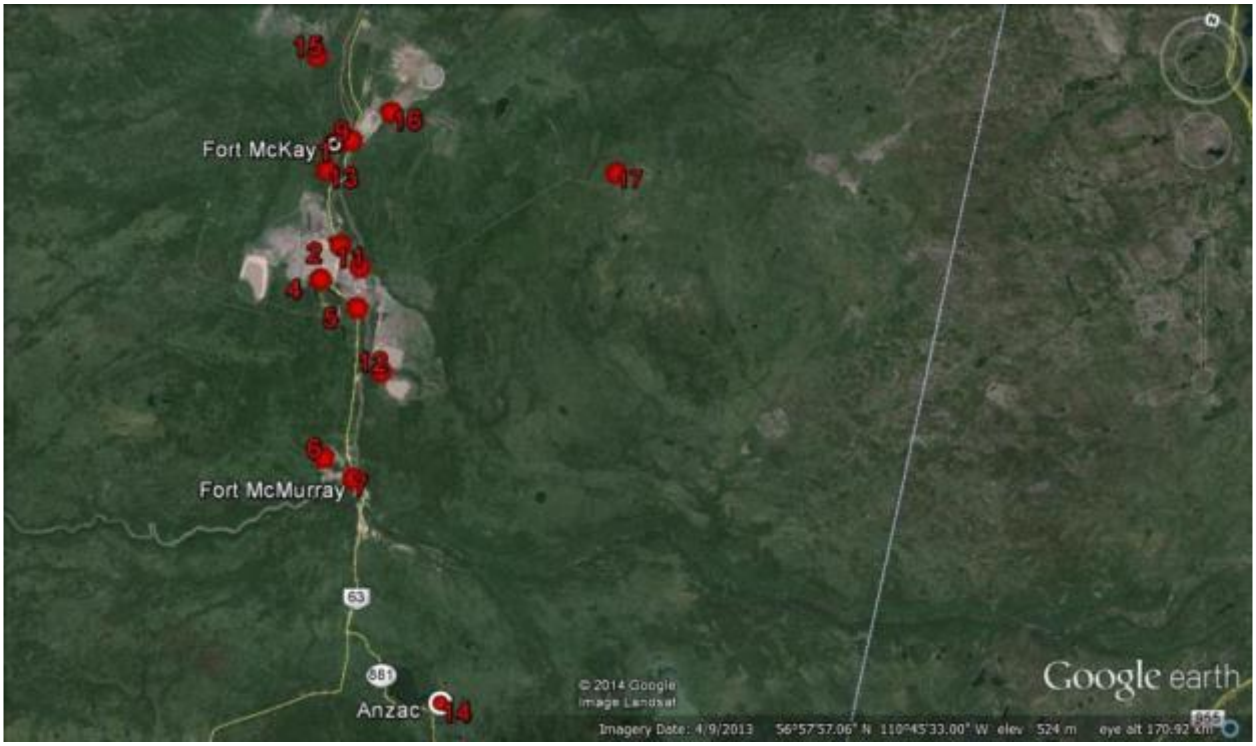


Figure 4: AMS#104 special study site (AMS#2 on the right).

4.2 Routine Continuous Measurements: TRS, H_2S, SO_2, NO, NO_2, $PM_{2.5}$, THC, NMHC, Methane and Ammonia

4.2.1 Measurement Methods

As shown in Table 8 the air pollutants continuously measured by WBEA in the air network and used in this report include H_2S, TRS, SO_2, NO, NO_2, $PM_{2.5}$, total hydrocarbons (THC), methane (CH_4), non-methane hydrocarbons (NMHC) and ammonia. Sulphur dioxide is measured continuously using pulsed fluorescence gas analyzers, operated on the 0 to 1000 ppb range. The detection limits observed under field conditions vary from 0.5 to 1 ppb. The oxides of nitrogen analyzers are based on the principle that nitric oxide (NO) and ozone (O_3) react to produce a characteristic luminescence with intensity linearly proportional to the NO concentration. NO_2 is measured by first converting it to NO using a heated molybdenum converter (325 °C). Detection limits are typically less than 1 ppb. The ammonia analyzers operate on the same principle as the oxide of nitrogen analyzers but an additional heated stainless steel converter (725 °C) is used to convert both NO_2 and NH_3 to NO. The ammonia concentration is determined by difference and typical detection levels are 1 ppb. $PM_{2.5}$ measurements are made using SHARP 5030 analyzers.

Total hydrocarbons are measured using a flame ionization detector (FID) operated on a 0 - 25 ppm range, with a detection limit of 0.1 ppm. Methane and NMHC are co-measured using a back-flush chromatography system that provides a direct measurement of non-methane hydrocarbons. The minimum detection limits are 0.05 ppm for CH_4, and 0.05 ppm for NMHC as propane.

Hydrogen sulphide and TRS are measured with pulsed fluorescence technology that detects SO_2 formed by the catalytic conversion of hydrogen sulphide or other sulphur compounds. Analyzer ranges are set at 0-100 ppb. H_2S is the regulated substance but TRS is a better measure of odour. The H_2S measurement is non-specific; hence there is still potential for positive interference from other reduced sulphur compounds (Percy, 2013). The response of TRS analyzers to other sulphur compounds is not necessarily proportional to their response to H_2S.

The Environment Canada measurement process for total sulphur uses a Thermo Environmental (TECO) 43 trace level SO_2 analyzer with a thermal oxidizer/converter at the air inlet operated at 950 °C with no particle filtration. The instrument is thus measuring gas phase SO_2, H_2S, COS, CS_2 and mercaptans along with some particle bound oxidized sulphur. Black carbon absorption and particle scattering is measured using a PAX (Photoacoustic Extinctiometer) Black Carbon Monitor and surface bound polycyclic aromatic hydrocarbons (qualitative measurement) are measured using an Ecochem PAS 2000 (Phototoelectric aerosol sensor). Measurement data for these species was available as one-minute averages. BTEX species are measured semi-continuously using a Syntech Spectra GC 955 611 Analyzer.

4.2.2 Results for 2014

All 2014 continuous monitoring data were obtained directly from WBEA in the form of station files. The WBEA data files typically contain a higher level of precision than files from the CASA data warehouse.

Summary statistics for 2014 for 1-hour TRS/H_2S, SO_2, NO, NMHC and ammonia are provided in Tables 11, 12, 13, 14 and 15 respectively.

For the community sites there were no hours with TRS greater than 10 ppb (Alberta AAQO). For the industrial sites there were a total of 34 hours with TRS or H_2S greater than 10 ppb with 14 hours recorded at Mannix and 7 hours at Mildred Lake. The five-minute data show that there are some occurrences of TRS over 10 ppb that occur only for short periods of time. These will be examined in more detail for complaint days.

The highest maximum and mean SO_2 concentrations were measured at Mannix. Of the community sites, Bertha Ganter recorded the highest annual mean SO_2 concentration of 1.4 ppb and Athabasca Valley recorded the highest one-hour value of 88 ppb. No sites in the network (industrial or community) exceeded the Alberta 1h AAQO for SO_2 of 172 ppb or the annual average AAQO of 8 ppb.

Nitric oxide is emitted from all types of light duty and heavy duty motor vehicles, industrial combustion sources and industrial mining equipment. Since NO is rapidly converted to NO_2 in the atmosphere, high NO concentrations can be a useful indicator of fresh and nearby emissions. Of the community sites, the highest mean and 90th percentile NO concentrations were measured at the Athabasca Valley site. Of the industrial sites, the highest mean and 90th percentile concentrations were measured at the Millennium and Shell Muskeg River sites.

The highest mean NMHC concentrations were measured at Anzac but mean NMHC levels were very low at all sites as measured by the continuous method. Of the community sites, Bertha Ganter had the highest maximum NMHC concentration of 1.4 ppm but also recorded the lowest 95th percentile. The AMS104 site at Mildred Lake recorded a maximum NMHC value of 7 ppm. Further discussion related to the inter-comparison of NMHC data from various measurement methods is provided in Section 4.5.

For the ammonia measurements, only three hours were above detection at Bertha Ganter-Fort McKay and twenty-six hours at Patricia McInnes.

Table 11: Summary statistics for 1-hour TRS/H_2S (ppb) – 2014.

Location	Parameter	N	Percentiles 90th	95th	98th	Max.	Mean	Std. Dev.	Exceed-ances
INDUSTRIAL SITES									
MILDRED LAKE	H_2S	8325	1.2	1.8	3.0	17.3	0.6	0.9	7
BUFFALO VIEWPOINT	H_2S	7296	0.7	1.0	1.6	38.7	0.3	0.7	3
MANNIX	H_2S	8311	1.4	2.2	3.9	27.7	0.7	1.1	14
BARGE LANDING	TRS	8291	0.6	0.9	1.2	3.8	0.3	0.3	0
LOWER CAMP	H_2S	8289	1.1	1.5	2.4	16.4	0.6	0.7	4
MILLENNIUM	TRS	8325	0.7	1.0	1.4	13.3	0.4	0.4	1
FORT MCKAY SOUTH	TRS	8317	0.6	0.8	1.2	15.6	0.3	0.4	2
CNRL HORIZON	TRS	8316	0.4	0.6	0.8	10.0	0.2	0.2	0
WAPASU	H_2S	8327	0.4	0.5	0.7	5.4	0.3	0.2	0
FIREBAG	H_2S	3772	0.6	0.8	1.0	3.1	0.3	0.2	0
AMS104-MILDRED L.	TRS	5087	1.2	2.0	3.4	12.5	0.5	0.9	3
COMMUNITY SITES									
BERTHA GANTER	TRS	8272	0.8	1.0	1.4	9.4	0.4	0.4	0
PATRICIA MCINNES	TRS	8195	0.6	0.8	1.0	3.5	0.4	0.2	0
ATHABASCA VALLEY	TRS	8329	0.6	0.7	1.0	4.0	0.3	0.2	0
ANZAC	TRS	8332	0.5	0.7	1.2	9.3	0.3	0.4	0
AMS104A-ANZAC	TRS	1734	0.6	1.0	1.6	5.3	0.3	0.4	0

Table 12: Summary statistics for 1-hour SO_2 (ppb) – 2014.

Location	N	Percentiles 90th	95th	98th	Max.	Mean	Std. Dev.
INDUSTRIAL SITES							
MILDRED LAKE	8321	4.1	8.6	17.8	81.8	2.0	5.2
BUFFALO VIEWPOINT	7331	0.8	1.9	5.4	66.7	0.6	2.4
MANNIX	8313	5.0	11.7	22.7	162.4	2.3	6.5
LOWER CAMP	8238	2.9	5.7	11.4	59.8	1.4	3.5
MILLENNIUM	8320	1.4	3.8	11.2	107.2	1.1	4.3
FORT MCKAY SOUTH	8238	2.1	4.7	11.3	77.3	1.3	3.5
CNRL HORIZON	8252	2.2	4.7	9.4	70.6	1.1	3.0
SHELL MUSKEG RIVER	8286	2.2	5.1	10.9	89.9	1.1	3.5
WAPASU	8311	2.0	4.5	7.8	113.1	1.0	2.8
FIREBAG	3790	2.5	4.9	8.7	43.8	1.0	2.6
COMMUNITY SITES							
BERTHA GANTER	8260	2.3	4.9	10.0	52.5	1.4	3.0
PATRICIA MCINNES	8179	2.7	5.2	8.9	87.9	1.1	2.6
ATHABASCA VALLEY	8312	1.7	3.4	6.5	37.0	0.9	1.7
ANZAC	8315	1.4	2.6	4.6	63.8	0.6	1.5

Table 13: Summary statistics for 1-hour NO (ppb) – 2014.

Location	N	Percentiles 90th	95th	98th	Max.	Mean	Std. Dev.
INDUSTRIAL SITES							
MILLENNIUM	8297	30.2	49.1	78.8	321.5	10.2	22.4
FORT MCKAY SOUTH	8282	9.6	19.9	34.8	142.2	3.4	9.5
CNRL HORIZON	8262	6.7	15.2	31.4	273.3	3.1	11.3
SHELL MUSKEG RIVER	8289	21.6	34.9	59.9	210.4	8.2	15.8
WAPASU	8224	1.8	3.2	6.3	37.4	1.0	1.8
FIREBAG	3790	5.4	9.6	16.4	105.6	1.9	5.0
COMMUNITY SITES							
BERTHA GANTER	8240	9.3	18.4	29.6	103.3	3.2	7.9
PATRICIA MCINNES	8106	6.0	11.3	20.3	95.8	2.6	5.8
ATHABASCA VALLEY	8277	23.5	41.4	70.0	489.9	8.7	18.9
ANZAC	8272	1.4	2.6	5.4	45.5	0.6	1.8

Table 14: Summary statistics for 1-hour NMHC (ppm) – 2014.

Location	N	Percentiles 90th	95th	98th	Max.	Mean	Std. Dev.
NMHC							
BERTHA GANTER	8212	0.00	0.01	0.12	1.37	0.01	0.04
PATRICIA MCINNES	8022	0.01	0.03	0.12	0.69	0.01	0.04
ATHABASCA VALLEY	8305	0.04	0.07	0.12	0.44	0.01	0.03
ANZAC	6674	0.09	0.12	0.15	0.46	0.03	0.04
AMS104A-ANZAC	1664	0.08	0.15	0.27	0.78	0.03	0.08
AMS104-MILDRED L.	5127	0.02	0.06	0.18	7.01	0.01	0.13

Table 15: Summary statistics for 1-hour Ammonia (ppb) – 2014.

Location	N	Percentiles 90th	95th	98th	Max.	Mean	Std. Dev.
NMHC							
BERTHA GANTER	7728	0.00	0.00	0.00	10.75	0.00	0.21
PATRICIA MCINNES	7703	0.00	0.00	0.00	19.70	0.05	0.81

Summary statistics for the 5-minute data for the community sites are shown in Tables 16, 17 and 18 for TRS, SO_2 and NMHC respectively. In 2013 Alberta Environment and Parks began a trial odour index program for the WBEA region which is based on 5-minute values of TRS and SO_2 (Alberta Environment, 2015). The current trial system indicates a potential for odour when 5-minute TRS exceeds 2.55 ppb for 2 out of 3 five-minute adjacent measurements or when SO_2 exceeds 40.5 ppb for 2 out of 3 five-minute adjacent measurements. Tables 16 and 17 show the number of times these thresholds were exceeded in 2014. The 5-minute TRS threshold was exceeded from 52 times at Patricia McInnes to 381 and 432 times at Bertha Ganter and Anzac respectively. The 5-minute SO_2 threshold was exceeded from 5 times at Athabasca Valley to 110 times at Bertha Ganter. There is no current threshold for NMHC but a value of 0.6 ppm was used for a threshold with the number of 5-minute values greater than this value shown in Table 18. This 5-minute threshold was exceeded from 13 times at Anzac to 182 times at Bertha Ganter.

Table 16: Summary statistics for 5-minute TRS (ppb) – 2014.

Location	N	Percentiles 90th	95th	98th	Max.	5-min values > 2.55 ppb
BERTHA GANTER	99,407	0.8	1.1	1.4	33.6	381
PATRICIA MCINNES	98,609	0.7	0.8	1.0	7.2	52
ATHABASCA VALLEY	100,046	0.6	0.8	1.0	12.0	130
ANZAC	100,110	0.4	0.7	1.2	18.0	432

Table 17: Summary statistics for 5-minute SO_2 (ppb) – 2014.

Location	N	Percentiles 90th	95th	98th	Max.	5-min values > 40.5 ppb
BERTHA GANTER	99,219	2.2	4.7	10.4	95.5	110
PATRICIA MCINNES	98,390	2.6	5.3	9.1	286.4	29
ATHABASCA VALLEY	99,841	1.7	3.5	6.6	92.3	5
ANZAC	99,891	1.3	2.7	4.7	131.5	19

Table 18: Summary statistics for 5-minute NMHC (ppm) – 2014.

Location	N	Percentiles 90th	95th	98th	Max.	5-min values > 0.6 ppm
BERTHA GANTER	98,303	0.00	0.00	0.13	1.83	182
PATRICIA MCINNES	96,240	0.00	0.02	0.14	8.06	92
ATHABASCA VALLEY	99,744	0.04	0.07	0.12	2.58	110
ANZAC	79,906	0.09	0.12	0.15	2.33	13

Table 19 shows summary statistics for total sulphur measured at the EC Fort McKay site in 2014. Results are available through October 31, 2014 only and are described as not fully quality assured.

Table 19: Summary statistics for 1-minute Total Sulphur (ppb) from EC Fort McKay site – 2014.

Location	N	Percentiles 90th	95th	98th	Max.	Mean	Std. Dev.	1-min values > 45 ppb
EC FORT MCKAY	437,340	4	7	14	101	1.9	4.4	796

4.2.3 Comparison of TRS results between from 2012 to 2014 for Community Sites

A comparison of 2012, 2013 and 2014 TRS results (hours greater than 3 and 10 ppb and maximum) is provided in Table 20 for the community sites. There was a large reduction in maximum TRS concentration from 2012 to 2013 with a slight increase at Bertha Ganter-Fort McKay from 2013 to 2014 and a decrease at Anzac. Hours with TRS greater than 3 ppb decreased by more than 90% at Bertha Ganter-Fort McKay, Patricia McInnes and Athabasca Valley from 2012 to 2014 and by 50% at the Anzac site.

Table 20: Comparison of 1-hour TRS results for community sites for 2012, 2013 and 2014.

SITE	Maximum (ppb)			Hours > 3 ppb			Hours > 10 ppb		
	2012	2013	2014	2012	2013	2014	2012	2013	2014
BERTHA GANTER	87	5	9	126	13	10	2	0	0
PATRICIA MCINNES	9	3	3	27	4	0	0	0	0
ATHABASCA VALLEY	9	4	4	28	9	1	0	0	0
ANZAC	14	12	9	36	25	18	2	1	0

4.2.4 Fifteen year trends in TRS and H_2S values at WBEA sites

All TRS and H_2S data for 2000 to 2014 were downloaded from the CASA website in order to examine 15 year trends in concentrations particularly at the community monitoring sites. Figure 5 shows the trend in the 99th percentile of daily maximum 1-hour TRS concentrations (ppb) at the sites while Figures 6 and 7 show the trend in number of hours greater than or equal to 3 ppb and 10 ppb respectively. Figure 8 shows the number of hours with H_2S greater than or equal to 10 ppb at the industrial sites for 1999 to 2014. The year 2009 was a peak year in almost all the site records whereas the years 2013 and 2014 are two of the lowest years in the records. The Anzac site is an exception with the highest values recorded in 2007 with little change through 2013. In 2013 and 2014 Anzac recorded the highest 99th percentile and the most hours greater than 3 ppb of the community sites.

Figure 5: 99th Percentile of daily maximum 1-h TRS concentrations (ppb) for 2000 to 2014 for community sites.

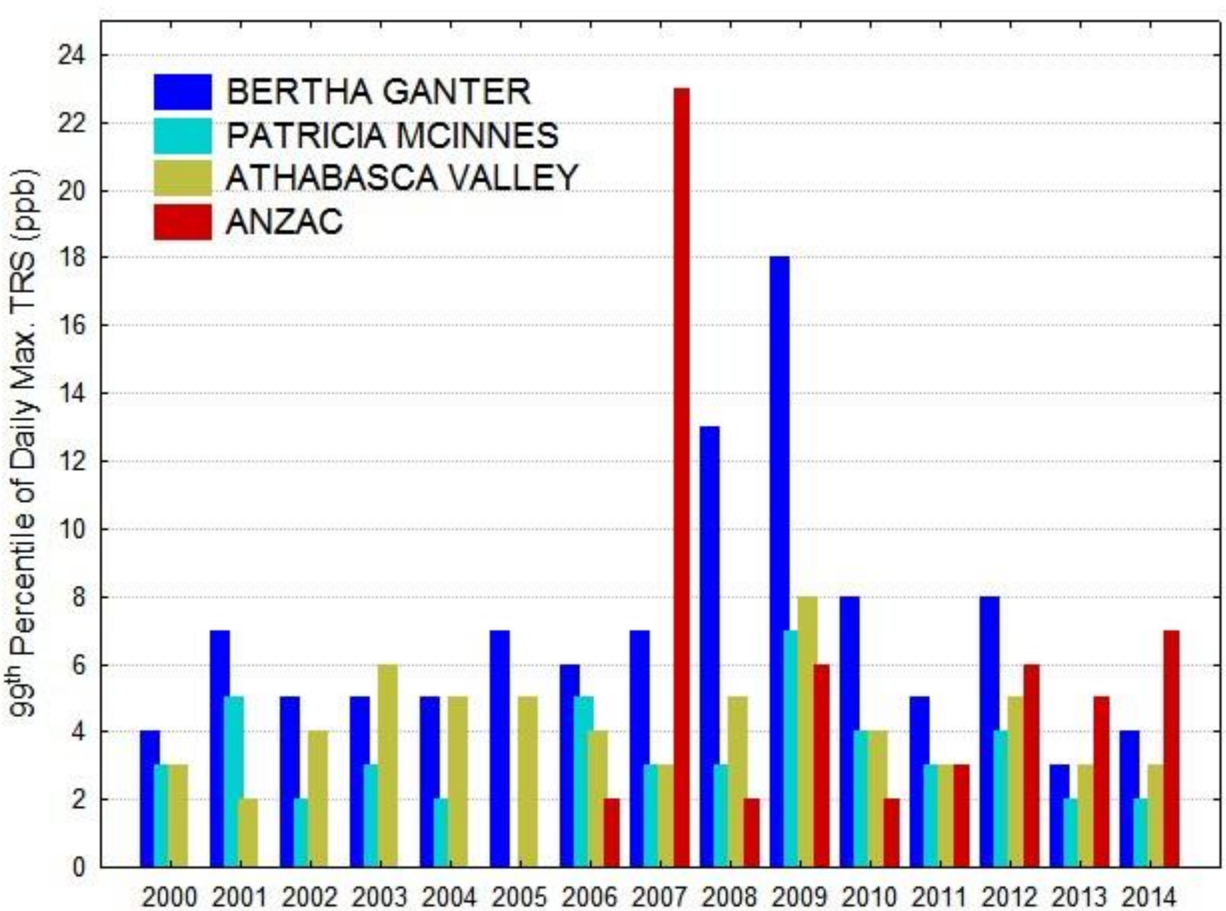


Figure 6: Count of hours with TRS concentrations greater than or equal to 3 ppb for 2000 to 2014 for community sites.

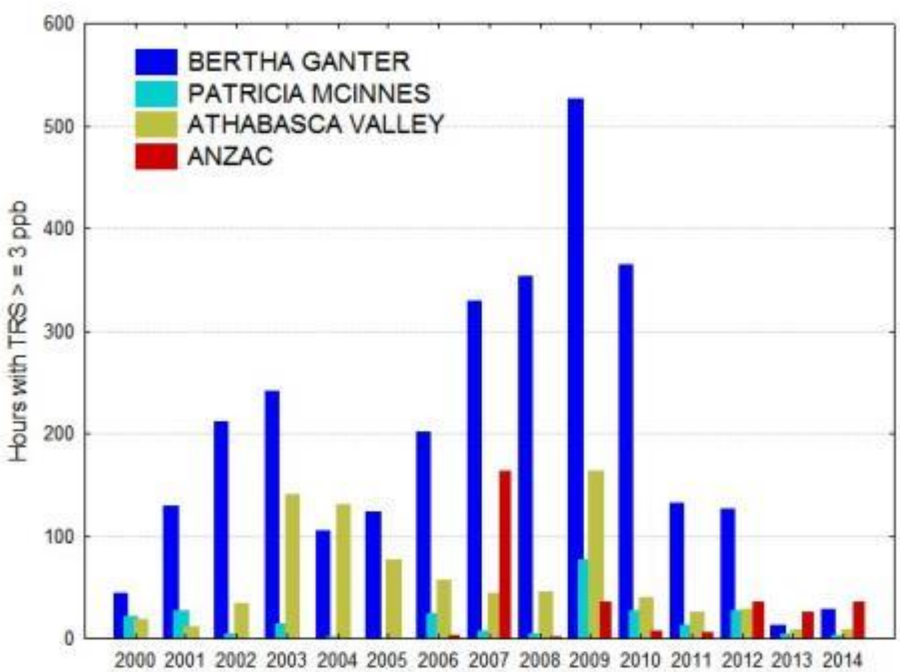


Figure 7: Count of hours with TRS concentrations greater than or equal to 10 ppb for 2000 to 2014 for community sites.

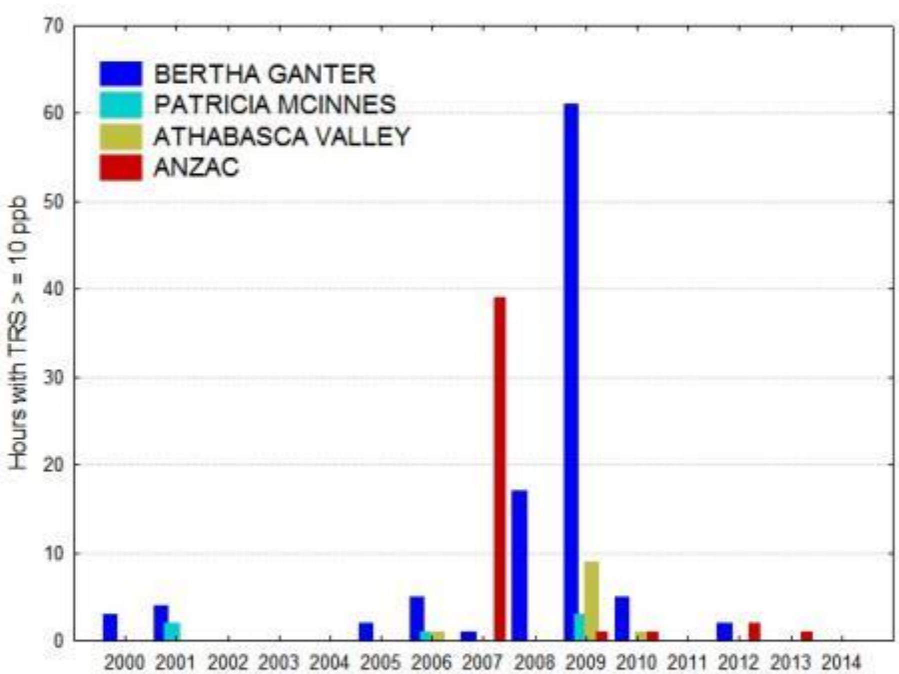
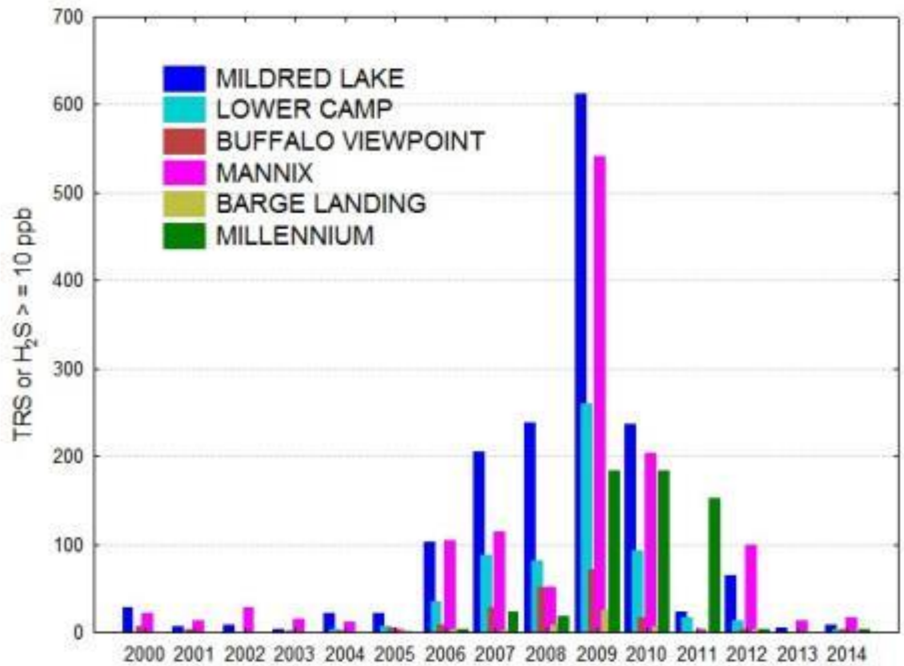


Figure 8: Count of hours with TRS or H_2S concentrations greater than or equal to 10 ppb for 2000 to 2014 for industrial sites.



4.2.5 Fort McKay Air Quality Index

Fort McKay's air and health scientists recently developed a "community-specific" Fort McKay Air Quality Index (FMAQI) which attempts to provide a general indication and measure of the air quality in the community based on the continuous measurements of a variety of parameters from the Bertha Ganter-Fort McKay measurement site.

The goal in developing the "community-specific" Fort McKay Air Quality Index (FMAQI) was to create an index that a) is based on health and general air quality considerations that reflect air quality in the context of Fort McKay's location and expectations; b) cover the air quality parameters that are most relevant to Fort McKay; c) reflect air quality limits and criteria that are a reasonable and defensible measure of air quality and d) is accepted by community members as a reliable indicator and reasonable representation of community air quality. In developing the FMAQI, existing provincial and federal AQIs were evaluated. The AQHI was considered a good index and is incorporated in the FMAQI. The AQHI, however, was felt to only cover some of the air quality parameters of interest and relevance to Fort McKay. Fort McKay scientists felt that Alberta AAQOs were not strictly health based, and don't necessarily reflect good air quality.

The developed Fort McKay Air Quality Index (FMAQI) uses both a sub-index based on the AQHI and additional sub-indices based on three additional parameters that are not included in the AQHI, namely SO_2, TRS and total hydrocarbons (THC). Four sub-indices are calculated (AQHI, SO_2, TRS and THC) and the highest is reported as the FMAQI for the hour. Similar to the AQHI, the FMAQI is reported on a scale of 0-10 with air quality characterized as Good, Fair, Poor or Very Poor. The sub-indices reach a value of 10 with concentrations of TRS of 3.5 ppb, THC of 3.9 ppm and SO_2 of 114 ppb. Assuming background levels of THC of 1.9 ppm and/or of TRS of 0.5 ppb the lowest index that would be reported is 2. The FMAQI index should have a better relationship to odours than the AQHI and has been endorsed by Alberta Environment and Parks and WBEA as a useful communication tool with results routinely posted on the WBEA website for Fort McKay. Table 21 shows the frequency of occurrence of the various FMAQI air quality levels at the Bertha Ganter-Fort McKay site for 2014 and Table 22 shows which of the four sub-indices was highest over the year. Using the FMAQI, air quality was characterized as poor or very poor in Fort McKay for approximately 3% of hours in 2014. THC and AQHI both accounted for the highest sub index 39% of the time with TRS accounting for the highest sub index 22% of the time and SO_2 only 0.3% of the time.

Table 21: Occurrence of the various FMAQI air quality levels at the Bertha Ganter-Fort McKay site for 2014.

	Air Quality			
	Good	**Fair**	**Poor**	**Very Poor**
Count of Hours	6,717	1,721	217	38
Percentage of Hours	77.3%	19.8%	2.5%	0.4%

Table 22: Percent of time that the highest reported sub-index for the FMAQI was due to the individual 4 sub-index values at the Bertha Ganter-Fort McKay site for 2014.

	TRS	**THC**	**SO_2**	**AQHI**
Count of Hours	1,886	3,396	27	3,370
Percentage of Hours	21.7%	39.1%	0.3%	38.8%

4.3 Meteorological Measurements

4.3.1 Background

As an air pollutant is transported from a source to a community, the pollutant mixes with, and is dispersed into the surrounding air so that it generally arrives at a much lower concentration than it was on leaving the source. The concentration of an air pollutant at a given place, often referred to as a receptor location, is a function of a number of variables, including the amount of the pollutant released at the source (the upwind emission rate), the height of the source, the distance from the community to the source, topography and local weather conditions. The most important weather influences are wind speed, wind direction, precipitation (both rain and snow), sunlight and the amount of turbulence in the atmosphere.

Atmospheric turbulence mixes pollutants into the surrounding air. For example, during a hot summer day, the air near the surface can be much warmer than the air above. Sometimes large volumes of this warm air will rise to great heights and resulting in vigorous vertical mixing. Alternately at night when the earth cools, vertical motion is suppressed resulting in a stable or non-turbulent atmosphere. Sometimes the condition of the atmosphere is very stable and there is very little mixing. This occurs when the air near the surface of the earth is cooler than the air above (a temperature inversion). This cooler air is heavier and will not easily mix with the warmer air above. Any pollutants released near the surface will get trapped and build up in the cooler layer of air near the surface. Such temperature inversions often form during calm clear nights with light winds. They can even persist throughout the day during the winter. In the Oil Sands region, prolonged wintertime periods of very cold, Arctic air with light wind can lead to some of the highest pollutant levels at receptors on the ground.

Increases in wind speed enhance turbulence and wind also contributes to how quickly pollutants are carried away from their original source. Generally, strong winds disperse pollutants, whereas light winds can allow pollutants to build up over an area. However, sometimes strong winds during more stable conditions can transport pollutants from a distant source, such as the smoke from forest fires, to arrive at a receptor in higher concentrations. High wind speeds can also generate dust from roadways, surface mining operations and tailings piles. The direction of the wind determines where emissions are transported. Wind direction can vary hour by hour and day by day and lead to complex downwind pollutant patterns. Precipitation can remove pollutants from the air and can also reduce emissions through reductions in the amount of dust raised by mining operations and by vehicles. Topography can create conditions that allow the trapping of pollutants and also funneling of winds in preferred directions, such as along river valleys. At night when conditions are typically calmer, cold air tends to drain downhill, settling into low-lying basins and valleys. Unable to rise, the cool air settles and accumulates in these valleys, trapping air pollutants.

Many pollutants undergo chemical reactions when they encounter water vapour and other pollutants in the air. The products of these chemical reactions are called secondary pollutants, as opposed to primary pollutants that are emitted directly into the atmosphere. Ground-level ozone is an example of a secondary pollutant that forms when nitrogen dioxide (NO_2) and volatile organic compounds (VOCs) mix in the presence of sunlight. Chemical reactions are enhanced by sunlight and moisture, including fog and clouds.

4.3.2 Meteorological Parameters used in this Report

The meteorological parameters temperature and wind speed/direction were used in the project and 2014 data for all sites were obtained from WBEA. Wind direction, wind speed and temperature at 20, 45, 100 and 167 m for Lower Camp Tower (AMS#3) and wind direction, wind speed and temperature at 20, 45, 75 and 90 m for the Mannix tower (AMS#5) were also obtained from WBEA. For episode/complaint analysis the following were used: wind speed and direction at 100 m from Lower Camp tower and wind speed and direction at 45 m from the Mannix tower. For complaint hours, a calculation of the average wind direction, standard deviation of wind direction and wind speed for the previous 6 hours was made using the Yamartino method. An estimation of inversion strength was also made using the temperature difference between 90 m and 20 m at Mannix and between 167 m and 20 m at Lower Camp Tower. Inversion strength is a useful predictor of the amount of atmospheric turbulence.

4.3.3 Wind Roses

Wind roses for the community sites are shown in Figure 9 and wind roses for all heights at the Lower Camp tower and the Mannix tower are shown in Figures 10 and 11. Wind roses for all other sites are found in Figures 12 and 13. Wind direction patterns reflect site location relative to the local river valleys as well as the size and orientation of the clearing around each site. Most of the WBEA sites are in river valleys where winds near the surface are subject to channeling especially for the stations at lower elevations. The upper level tower measurements are less affected by local flows.

Figure 9: Wind roses for Bertha Ganter-Fort McKay, Patricia McInnes, Athabasca Valley and Anzac – 2014.

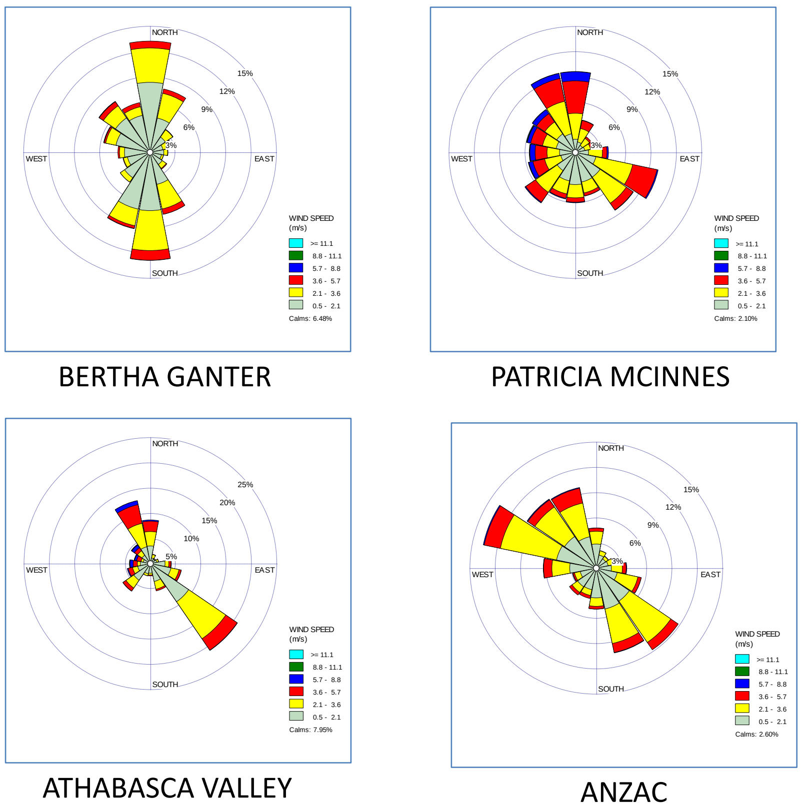


Figure 10: Wind roses by height for Lower Camp met tower (2014).

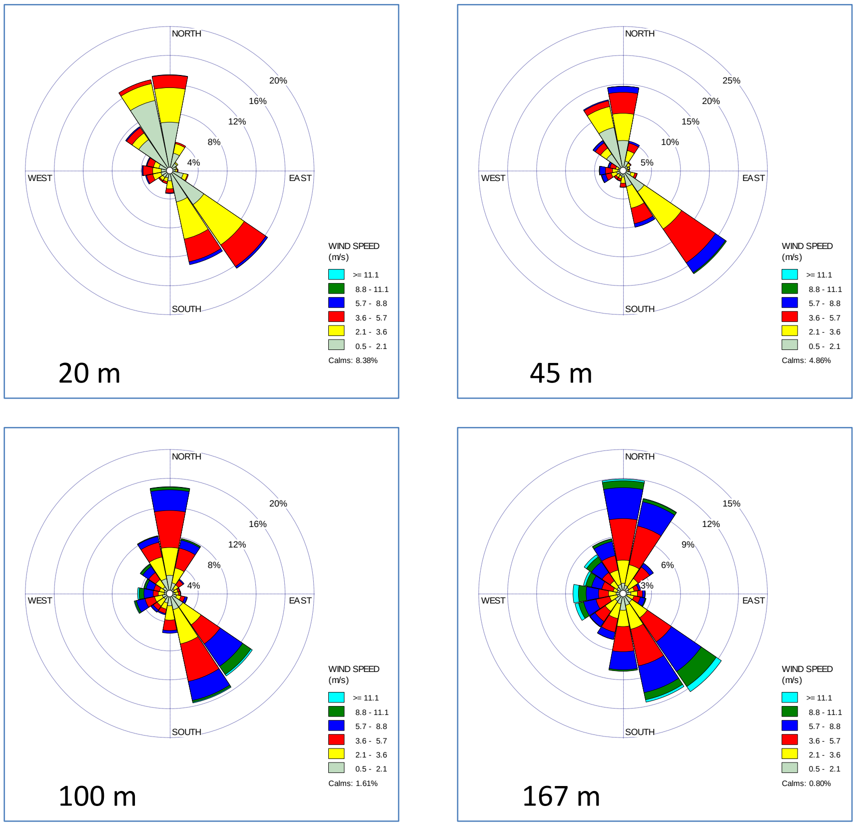


Figure 11: Wind roses by height for Mannix met tower (2014).

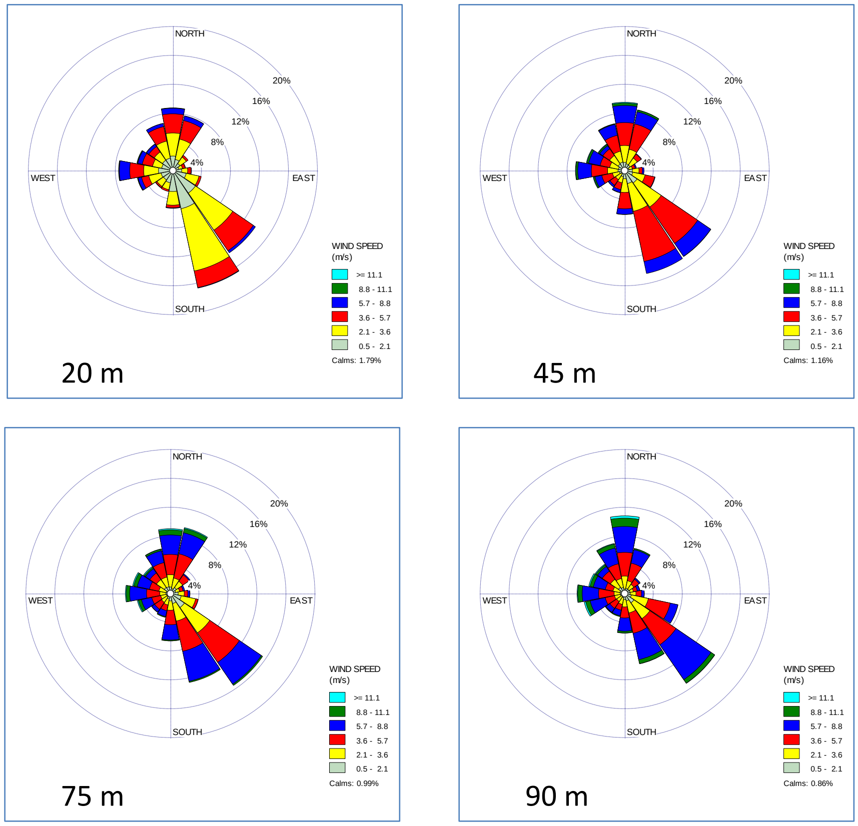


Figure 12: Wind roses for WBEA industrial sites (AMS2, AMS4, AMS5, AMS9, AMS11 and AMS12).

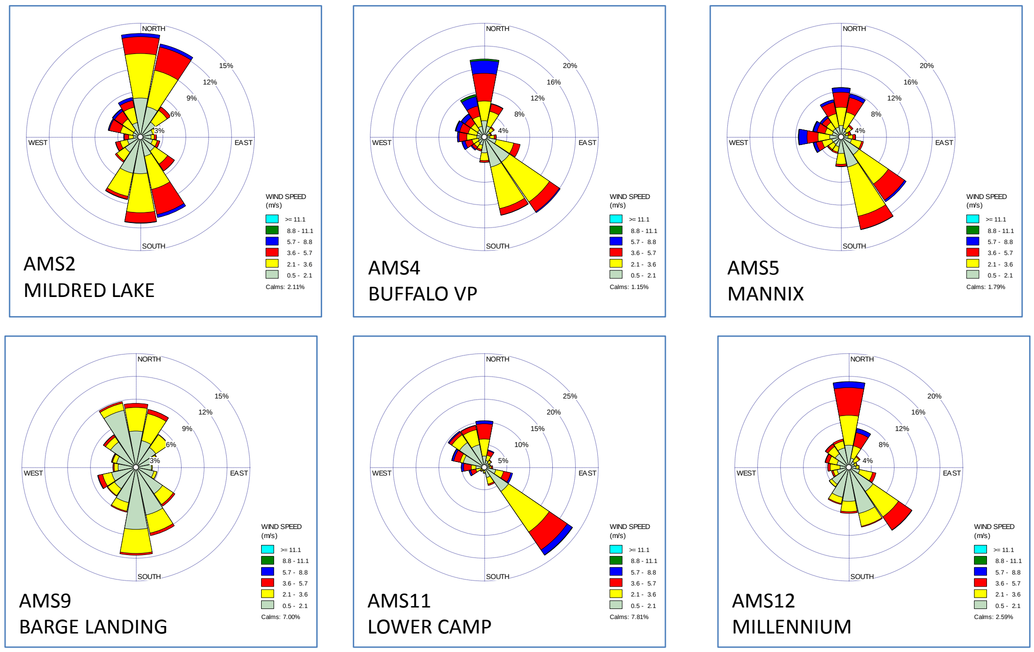
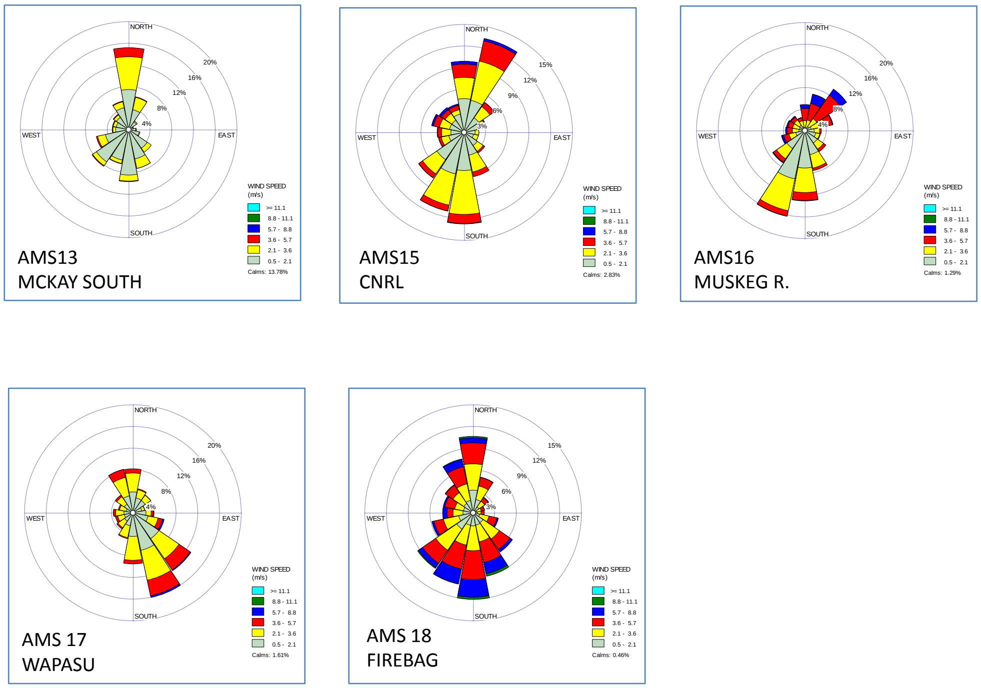


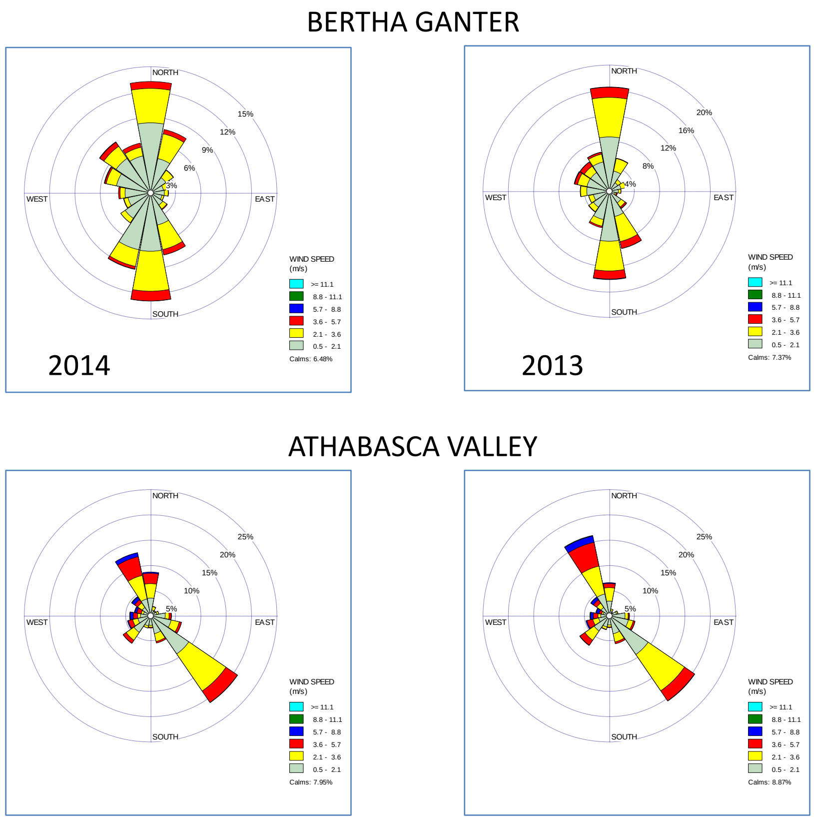
Figure 13: Wind roses for WBEA industrial sites (AMS13, AMS15, AMS16, AMS17 and AMS18).



4.3.4 Wind Roses for 2014 vs. 2013

Comparison of wind direction and wind speed in 2014 and 2013 for the Bertha Ganter-Fort McKay and Athabasca Valley sites are provided in Figure 14. There were no major differences in predominant wind direction between the two years for these sites.

Figure 14: Comparison of wind roses for Bertha Ganter-Fort McKay and Athabasca Valley sites for 2014 and 2013.



4.3.5 Inversion Strength at Tower Sites

As noted previously an estimation of inversion strength was also made using the temperature difference between 90 m and 20 m at Mannix and between 167 m and 20 m at Lower Camp Tower. Figures 15 and 16 show the temperature difference as a function of hour of the day and categorized by season: Winter (D,J,F), Spring (M,A,M), Summer (J,J,A) and Fall (S,O,N). A positive delta indicates a stable atmosphere and a temperature inversion. The figures show that temperature inversions can occur at night during all seasons.

Figure 15: Inversion strength by hour of day and season based on temperature difference between 167 and 20 m at Lower Camp Tower (2014).

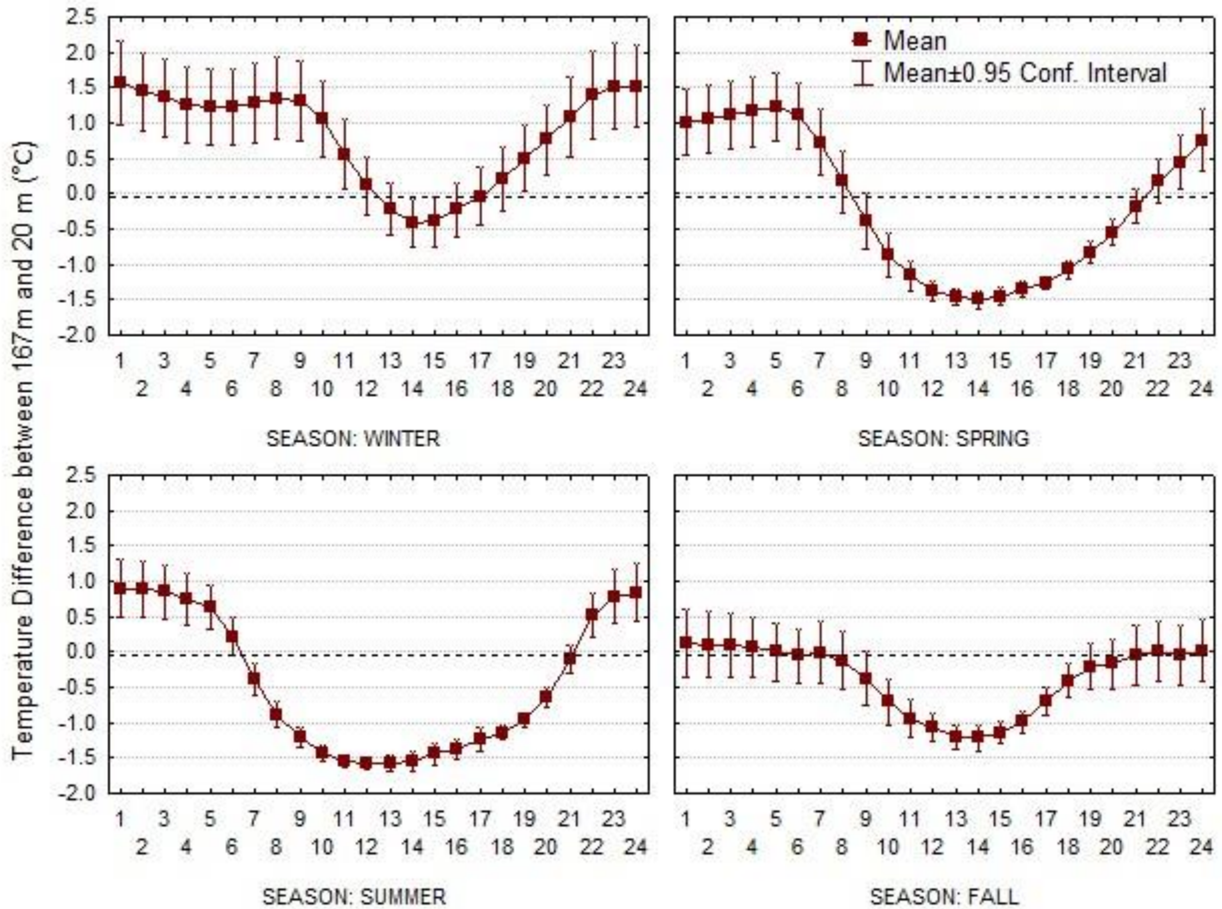
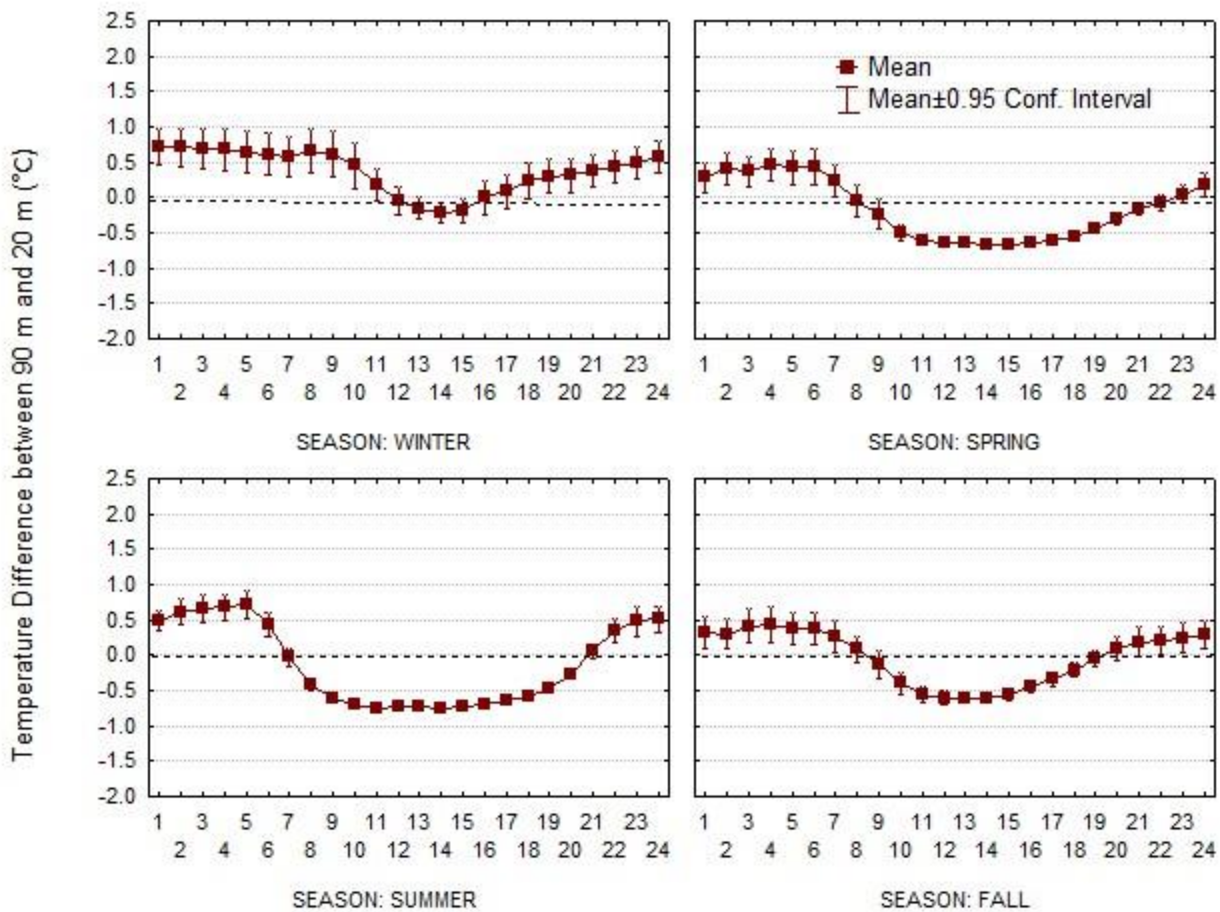


Figure 16: Inversion strength by hour of day and season based on temperature difference between 90 and 20 m at Mannix Tower (2014).



4.4 OdoCheck System (eNose)

4.4.1 Background

The OdoCheck system from Odotech is composed of an electronic nose (eNose) which consists of a continuous sampling device that collects air samples and directs it thru 16 non-specific sensors located inside a flow chamber that react to the different odorous compounds present in the air. The instrument is located at the Bertha Ganter-Fort McKay site and is connected to the same glass manifold that supplies ambient air to the other analyzers at the site. The eNose responses are collected every 4 minutes and stored in a local computer onsite. Data are accessed and extracted remotely by Odotech. The instrument nominally reports in odour units (o.u./m^3) but as stated by the manufacturer: "*Odour measurements in ambient air provide information on odour variability in the vicinity of the system rather than fixed odour concentration comparable to the above perception scale. In this project, because of the location of the eNose in ambient air, the number of potential odour sources and calibration methodology, the odour concentration values should be interpreted carefully as these are related to indicators of variability rather than absolute concentrations." (Odotech, 2014).*

Each sensor of the eNose is calibrated according to a specific range based on the odour samples used. Measures outside the calibrated range may occur and lead to inconclusive results in terms of odour concentrations (Odotech, 2014). Pollutants, interactions, temperatures and humidity are all factors that may contribute to sensors responses. Null concentrations are indicative of captor responses outside their calibrated range and tend to indicate odour concentrations lower than the odour concentrations on which the calibration is based on.

4.4.2 Operation and Results for 2014

Monthly data files were received from WBEA and processed into one annual data file including all four-minute readings. There were some short periods of missing data in 2014 as shown in Table 23. For the year, the total recovered data amounted to 93% and total eNose runtime was 99.6%. Data outside the calibration range (usually null values) were recorded mostly in January (14%), February (10%), November (46%) and December (13%) (Odotech, 2015). Bag samples were collected for calibration purposes on May 25, 2014 and sent to the Odotech lab in Montreal for olfactometric analysis using a panel of jurors. The olfactometric results for both 2013 and 2014 were very high for ambient air and as compared to 2012 results. Odotech suspected the high 2013 results might have been due to the collection bags and sampling equipment and did not update the calibration library for the eNose using them. The 2014 results were even higher than 2013 and it is not clear if the results were used.

Table 23: Periods of missing eNose data in 2014.

Start Date	End Date	Issue
January 15	January 16	Power outage/surge.
January 19	January 20	Replacement UPS.
May 15	May 15	Power outage.
October 16	October 16	Shutdown of eNose computer.

As noted "*the odour concentrations should not be interpreted as being absolute but should rather be used to assess the variations*". Accordingly, for this project the data were reprocessed to calculate hourly averages, the integer value of the difference between the maximum four-minute reading and the mean of all readings for each hour (DELTA) and the ratio of the standard deviation of the four-minute averages to their hourly mean (coefficient of variation or CV). These latter two calculated values provide a measure of variability instead of an absolute reading and were also used in subsequent episode analysis along with the original eNose hourly mean and maximum readings. Plots of the data before (maximum reported four-minute readings each hour) and after processing (DELTA and CV by hour) are shown in Figures 17, 18 and 19 (separate scales). The baseline output from the eNose was more stable than in previous years. The greatest discontinuity in output occurred between May 19 and May 25 (high readings) and between November 6 and November 30 (low readings).

Figure 17: Maximum reported four-minute readings from eNose at Bertha Ganter-Fort McKay by hour in odour units.

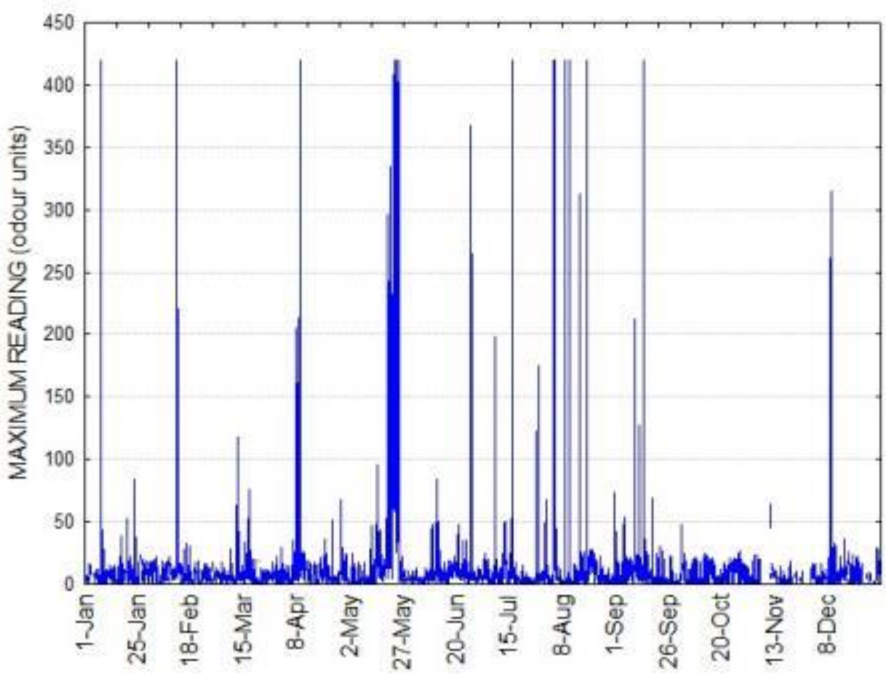


Figure 18: Difference between maximum and mean (DELTA) reported readings from eNose at Bertha Ganter-Fort McKay by hour in odour units.

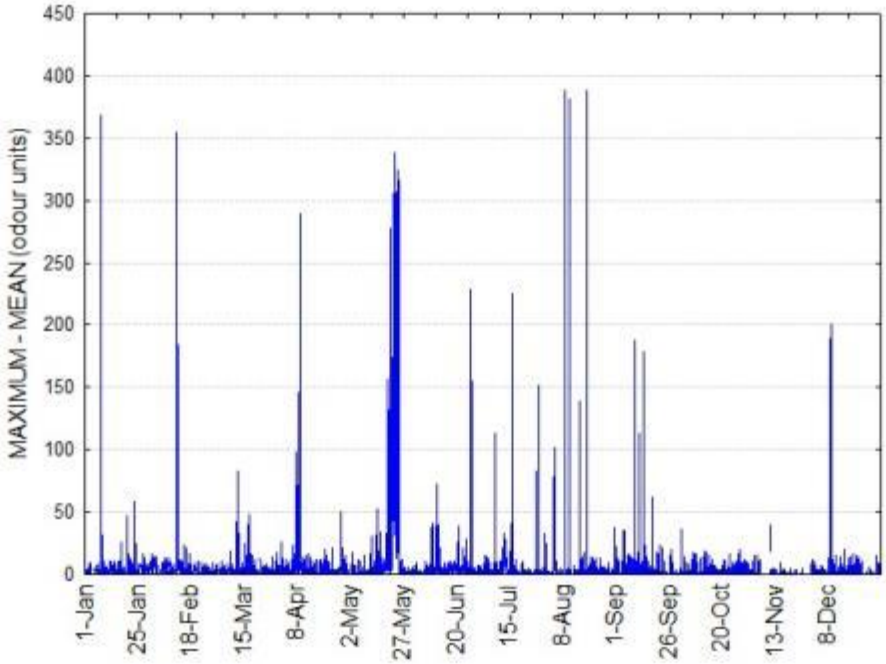
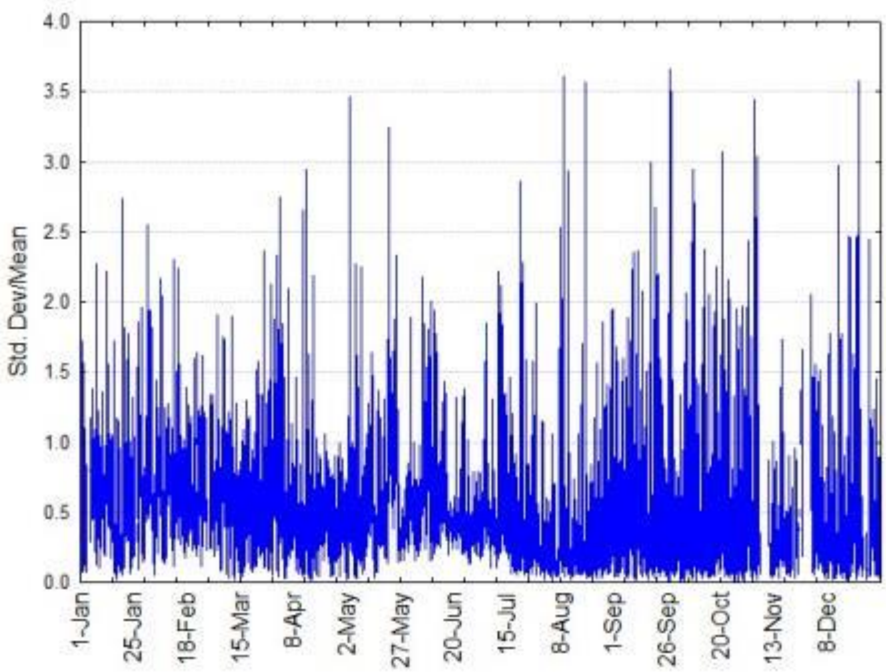


Figure 19: Ratio of standard deviation to mean of 4-minute reported readings (CV) from eNose at Bertha Ganter-Fort McKay by hour.



4.4.3 Remaining Questions on eNose

The following questions have been raised relating to the eNose over the past three years and complete answers are still outstanding:

1. What is the upper bound of calibrated range? What extremes of temperature and/or humidity might affect response?
2. There are large differences in the 'look' of data for different periods i.e. avg. and max response, baseline etc. – is there an explanation for this?
3. "The odour concentration values should be interpreted carefully as these are related to indicators of variability rather than absolute concentrations" –"It is the magnitude of the sensors responses that is translated into an interpreted odour concentration"– can this be simplified or expressed more clearly?
4. "Even if the type of sensors is the same as before, their responses to similar stimuli can be slightly different" – how do the multitude of eNose sensors in Fort McKay compare in terms of absolute outputs and simultaneous response to odours?
5. Were 2014 calibration results used and if not how does the lack of calibration in 2013 or 2014 affect the results?

4.4.4 Other

There are two additional eNose monitoring sites in Fort McKay: one on Target Road and one near the river on the North end of the Community. These are Fort McKay's monitors and are owned and operated by the community (Spink, 2015).

4.5 Pneumatic Focusing Gas Chromatograph (PFGC)

VOC Technologies (VOCTEC) operates a Pneumatic Focusing Gas Chromatograph (PFGC) at the Bertha Ganter-Fort McKay site which includes dual detection with both a flame ionization detector (FID) for volatile organic compounds and a sulphur chemiluminescence detector (SCD) for sulphur-containing compounds. Details of the principles, operating procedures and calibration of this instrument are found in O'Brien (2013) and O'Brien (2014). Typical VOC detection levels from the FID are estimated to be 0.1 ppb. The SCD was added in 2012 and has the capability to measure the concentrations of reduced sulphur compounds (RSCs) at levels below 50 parts-per-trillion (ppt). A second PFGC instrument was operated in the AMS#104 trailer, which was first located at Mildred Lake and then relocated to Anzac on September 8, 2014 and began collecting data at the new site on October 15, 2014. Integrated data files for both instruments were received from VOC Technologies and were processed into annual data files with readings assigned by hour retained for VOC and RSC. The instrument typically collects a 5-minute sample every 70 minutes resulting in 19 to 20 observations per 24-hour period. These 5-minute samples were assigned to the hour in which they were collected.

There were a variety of operational problems with both PFGC instruments with substantial data loss for the SCD measurements. The SCD at AMS104 was typically not responding to COS or CS_2 during the year and at Bertha Ganter-Fort McKay the SCD only detected COS or CS_2 intermittently.

Summary statistics for all identified VOC species from Bertha Ganter-Fort McKay and the two AMS104 locations are provided in Tables 24 to 26 (values below detection were set to zero). The sum of VOC species are also broken into naphtha, aromatic, high molecular weight (HEAVY) and all. There was no differentiation in the provided data sets as to which hours were missing/invalid versus below detection and all were coded to zero. Benzene was not detected by either PFGC instrument over the course of the year and propane was only detected at AMS104-Anzac. Toluene was most frequently detected at AMS104-Mildred Lake. After relocation to Anzac the PFGC instrument only appeared to respond to propane.

Hourly results for naphtha, aromatic and heavy molecular weight compounds at Bertha Ganter-Fort McKay for 2014 are shown in Figure 20 for January to December. The instrument was predominantly measuring naphtha and lower molecular weight species with aromatics and heavy molecular weight compounds only detected between June and September. Figure 21 shows similar results for AMS104-Mildred Lake for January to September and Figure 22 shows results for AMS104-Anzac for October to December. Naphtha species were detected consistently by the PFGC while at Mildred Lake but not after relocation to Anzac.

Figures 23 to 25 compare the sum of all identified species at the three sites with the total NMHC results from the continuous analyzers. The two measurements would not be expected to agree in absolute values because of differences in calibration, in time resolution (5 minutes for PFGC versus 1 hour for NMHC) and because of differences in species included in the totals. Some agreement in peaks would be expected, however.

Table 24: Identified VOC compounds, frequency of detection and summary statistics (ppbC) for all measurements at Bertha Ganter-Fort McKay for January – December 2014.

Compound	Class	Frequency of Detection	95th Percentile	Maximum	Mean	Std. Dev.	Median
Propane		0.0%	0.0	93.9	0.0	1.3	0.0
Butanes		14.7%	3.5	51.7	0.5	2.2	0.0
Acetone		22.0%	28.0	668.6	4.3	15.5	0.0
Isoprene		19.5%	17.6	180.9	2.6	8.8	0.0
i-Pentane	N	38.0%	13.8	138.0	2.7	7.8	0.0
n & c-Pentane	N	53.0%	23.4	851.0	6.0	23.8	0.3
Benzene	A	0.0%					
2-Me-Pentane	N	33.1%	16.4	193.0	3.0	9.5	0.0
3-Me-Pentane	N	22.6%	3.8	50.9	0.6	2.0	0.0
n & c-Hexane	N	33.2%	13.4	113.0	2.2	5.6	0.0
Toluene	A	6.2%	0.5	91.5	0.4	3.3	0.0
2-Me-Hexane		6.4%	1.3	160.3	0.5	4.0	0.0
Heptanes		3.9%	0.0	445.7	0.6	8.1	0.0
n-Heptane		5.3%	0.4	115.4	0.8	5.1	0.0
i-Octane	H	3.5%	0.0	172.6	0.5	4.8	0.0
Ethylbenzene	H	0.0%					
m & p-Xylene	H	0.0%					
o-Xylene & Octanes	H	0.0%					
n-Octane	H	0.0%					
NAPHTHA		62.4%	63.8	851.0	14.0	36.6	2.0
AROMATIC		6.2%	0.5	91.5	0.4	3.3	0.0
HEAVY		3.5%	0.0	172.6	0.5	4.8	0.0
SUM OF ALL		69.2%	91.6	1064.1	24.7	47.3	9.3

Table 25: Identified VOC Compounds, frequency of detection and summary statistics (ppbC) for all measurements at AMS104 (Mildred Lake) for January – September 2014.

Compound	Class	Frequency of Detection	95th Percentile	Maximum	Mean	Std. Dev.	Median
Propane		0.0%	0.0	0.0	0.0	0.0	0.0
Butanes		28.9%	7.2	193.2	1.3	5.6	0.0
Acetone		28.0%	17.9	985.7	3.6	22.2	0.0
Isoprene		18.9%	17.0	94.3	2.4	7.8	0.0
i-Pentane	N	38.6%	9.1	227.8	2.0	8.8	0.0
n & c-Pentane	N	42.3%	12.3	376.7	3.1	14.9	0.0
Benzene	A	0.0%					
2-Me-Pentane	N	35.3%	10.7	136.4	1.9	7.1	0.0
3-Me-Pentane	N	26.8%	3.4	69.1	0.7	2.9	0.0
n & c-Hexane	N	34.8%	7.5	127.3	1.4	5.3	0.0
Toluene	A	24.7%	3.4	36.4	0.6	2.3	0.0
2-Me-Hexane		26.1%	4.2	109.8	0.8	4.1	0.0
Heptanes		33.3%	9.5	229.1	1.8	7.5	0.0
n-Heptane		34.2%	8.1	354.0	1.7	9.2	0.0
i-Octane	H	8.8%	0.8	118.2	0.4	3.4	0.0
Ethylbenzene	H	0.6%	0.0	14.2	0.0	0.3	0.0
m & p-Xylene	H	0.5%	0.0	32.8	0.0	0.7	0.0
o-Xylene & Octanes	H	0.6%	0.0	57.1	0.1	1.2	0.0
n-Octane	H	0.5%	0.0	51.4	0.1	1.5	0.0
NAPHTHA		61.4%	35.9	709.9	8.3	30.3	0.8
AROMATIC		24.7%	3.4	36.4	0.6	2.3	0.0
HEAVY		9.3%	0.9	131.7	0.5	4.5	0.0
SUM OF ALL		67.9%	84.6	1779.0	21.8	52.7	7.1

Table 26: Identified VOC Compounds, frequency of detection and summary statistics (ppbC) for all measurements at AMS104 (Anzac) for October – December 2014.

Compound	Class	Frequency of Detection	95^{th} Percentile	Maximum	Mean	Std. Dev.	Median
Propane		88.5%	20.7	132.0	4.7	10.2	1.3
Butanes		0.0%					
Acetone		0.4%	0.0	2.0	0.0	0.1	0.0
Isoprene		0.0%					
i-Pentane	N	0.5%	0.0	1.0	0.0	0.1	0.0
n & c-Pentane	N	13.6%	1.0	4.0	0.2	0.5	0.0
Benzene	A	0.0%					
2-Me-Pentane	N	0.0%					
3-Me-Pentane	N	0.0%					
n & c-Hexane	N	0.0%					
Toluene	A	0.0%					
2-Me-Hexane		0.0%					
Heptanes		0.0%					
n-Heptane		0.0%					
i-Octane	H	0.0%					
Ethylbenzene	H	0.0%					
m & p-Xylene	H	0.0%					
o-Xylene & Octanes	H	0.0%					
n-Octane	H	0.0%					
NAPHTHA		13.6%	1.0	4.0	0.2	0.6	0.0
AROMATIC		0.0%					
HEAVY		0.0%					
SUM OF ALL		89.2%	20.7	132.0	4.9	10.2	1.5

Figure 20: Hourly variation in sum of naphtha, aromatic and heavy MW species (ppbC) from PFGC at Bertha Ganter-Fort McKay – 2014.

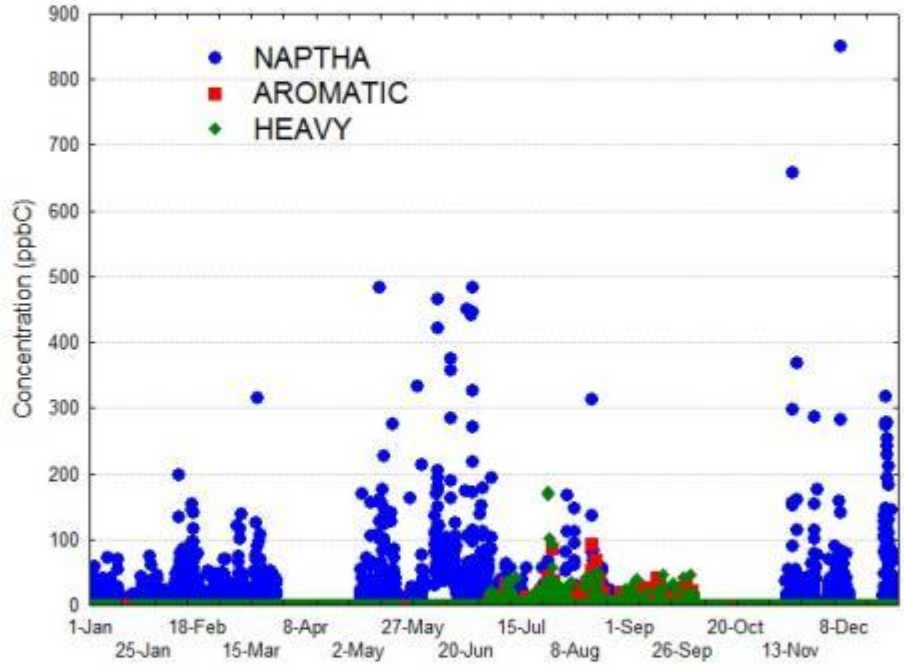


Figure 21: Hourly variation in sum of naphtha, aromatic and heavy MW species (ppbC) from PFGC at AMS104 – Mildred Lake location for 2014.

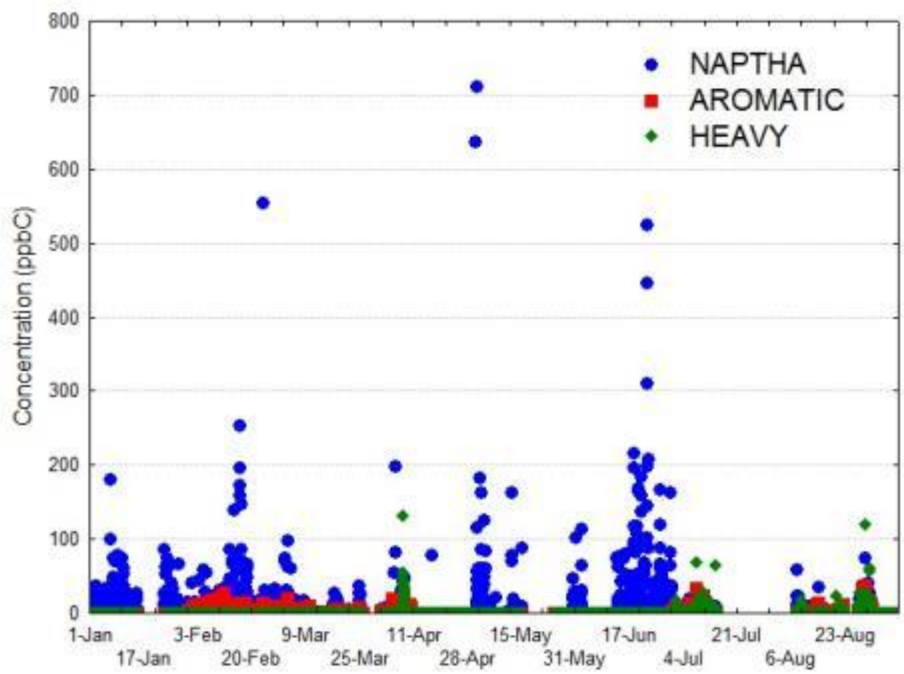


Figure 22: Hourly variation in sum of propane and naphtha (ppbC) from PFGC at AMS104 – Anzac location for 2014.

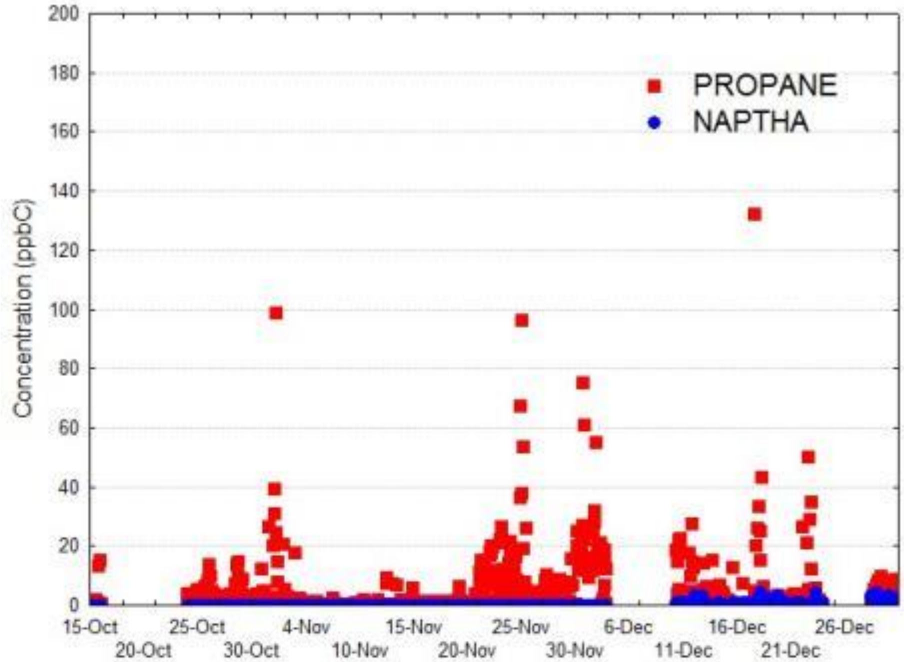


Figure 23: Comparison of hourly NMHC (ppbC) and PFGC sum of species (ppbC) at Bertha Ganter-Fort McKay for 2014.

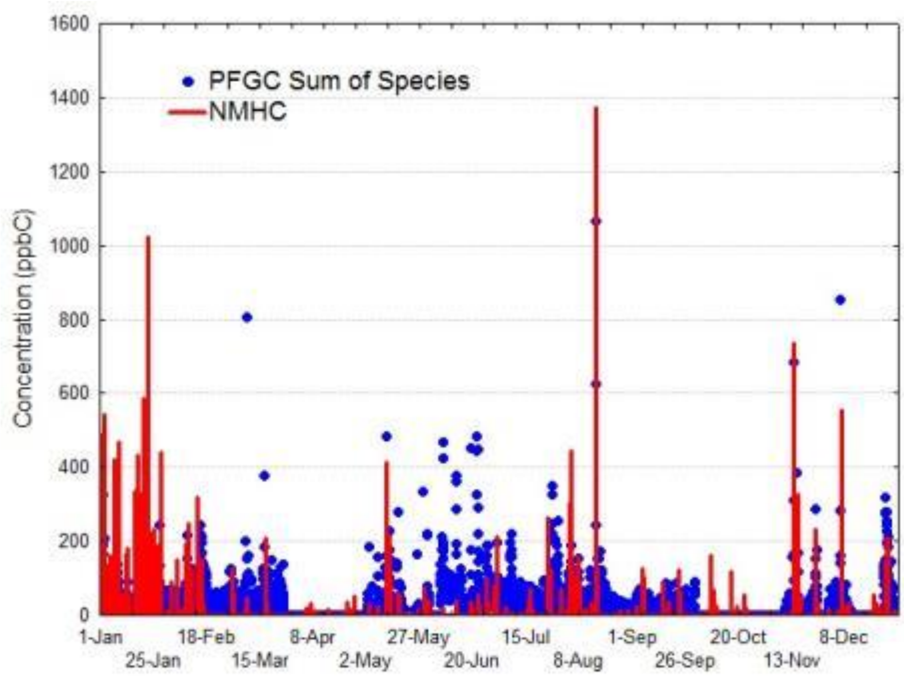


Figure 24: Comparison of hourly NMHC (ppbC) and PFGC sum of species (ppbC) at AMS104-Mildred Lake for Jan. – Sep. 2014.

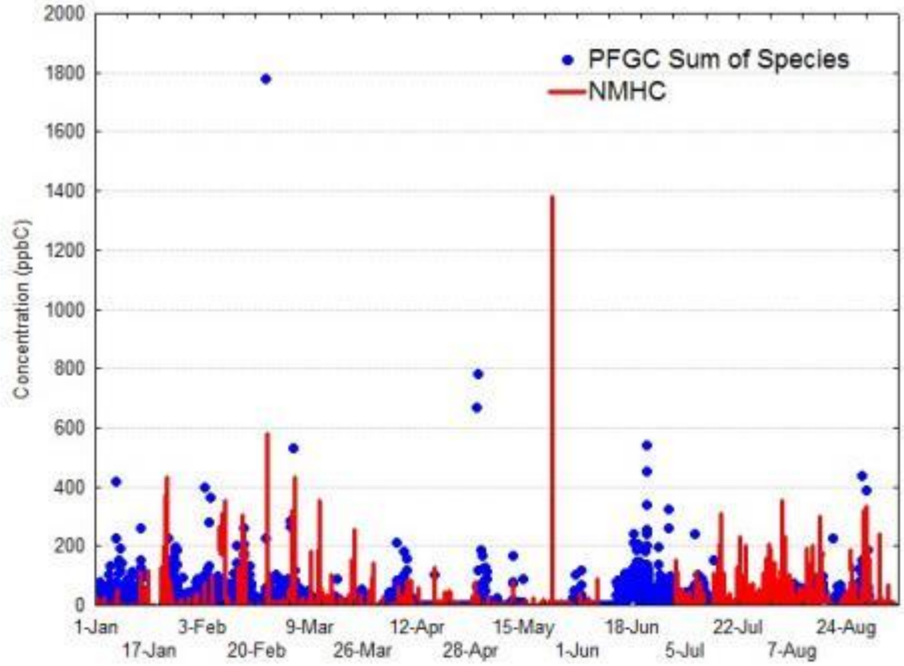
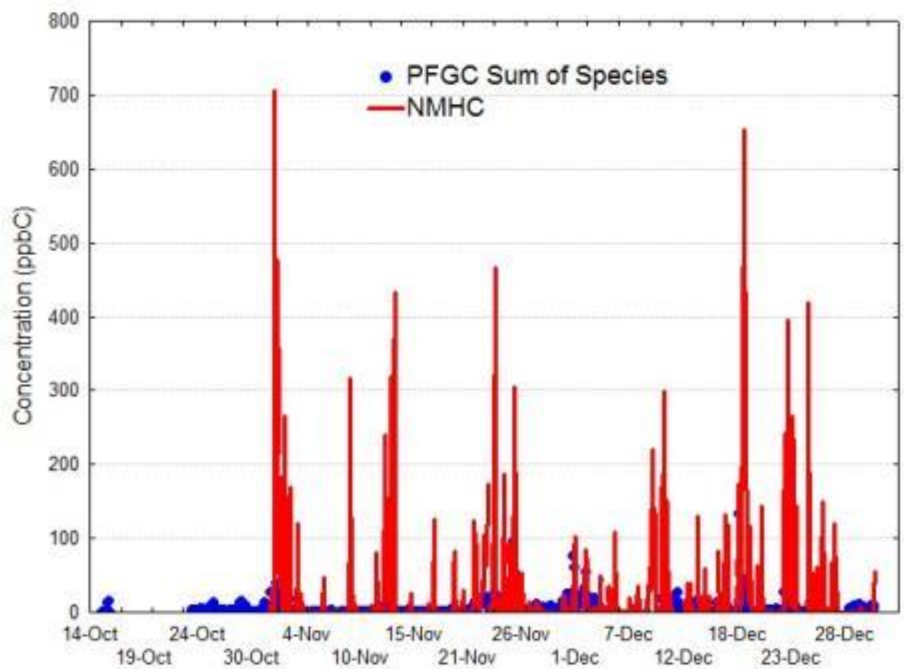


Figure 25: Comparison of hourly NMHC (ppbC) and PFGC sum of species (ppbC) at AMS104-Anzac for Oct. – Dec. 2014.

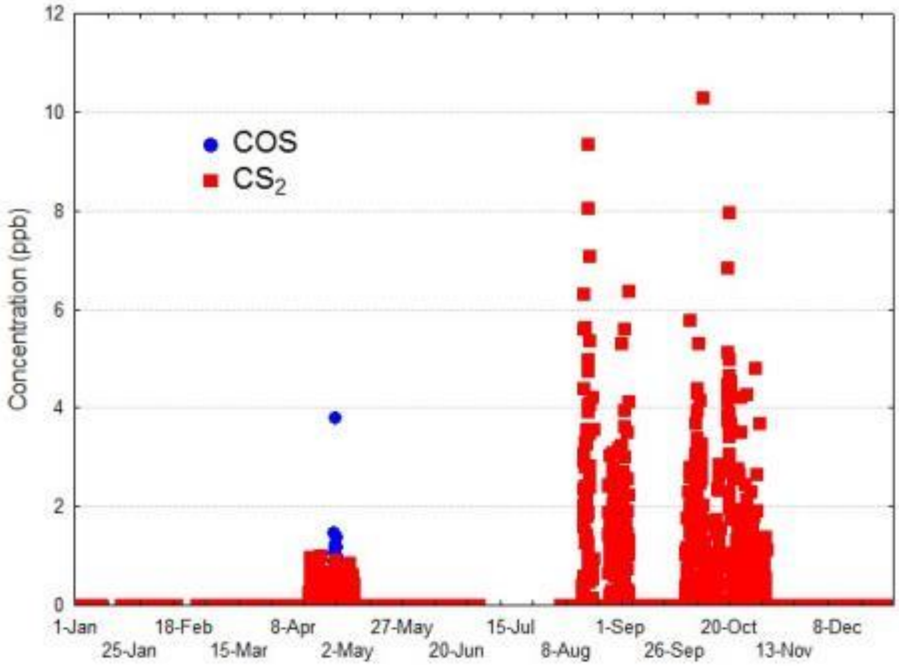


Summary statistics for carbonyl sulphide and carbon disulphide from the SCD measurements at Bertha Ganter-Fort McKay, AMS104-Mildred Lake and AMS104-Anzac are provided in Table 27 (values below detection were set to zero). Except for one observation at AMS104-Mildred Lake, the other target species: thiophene, 2-methyl thiophene, 3-methyl thiophene, 2-ethyl thiophene, 2,5-dimethyl thiophene and 2,4-dimethyl thiophene were never found above detection during the year for the SCD. Detection percentages for both COS and CS_2 were very low compared to previous years. Carbonyl sulphide is the most abundant sulfur compound naturally present in the atmosphere because it is emitted from oceans, volcanoes and deep sea vents. It is a significant compound in the global sulfur cycle and its reported background level in the atmosphere is 0.5±0.05 ppb (Kettle, 2002). The fact that it was not detected by the SCD indicates that the SCD was not responding to the compound, not that COS was not present in the atmosphere. No values above detection for COS, CS_2 or the thiophenes (one sample recorded detectable levels of 2-methyl and 3-methyl thiophene) were recorded at the AMS104-Mildred Lake site and COS was detected in only 4% of samples at AMS104-Anzac. A plot of carbonyl sulphide and carbon disulphide concentrations by hour for Bertha Ganter-Fort McKay is provided in Figure 26. The species were not detected routinely but measured COS concentrations were as high as 10 ppb during periods of detection.

Table 27: Carbonyl sulphide and carbon disulphide frequency of detection and summary statistics (ppb) – all measurements at Bertha Ganter-Fort McKay, AMS104-Mildred Lake and AMS104-Anzac.

Compound and Location	Frequency of Detection	95th Percentile	Max.	Mean	Std. Dev.
Bertha Ganter (Jan. - Dec.)					
Carbonyl sulphide (COS)	1.6%	0.00	3.79	0.01	0.09
Carbon disulphide (CS_2)	21.3%	1.52	10.28	0.22	0.71
AMS104-Mildred Lake (Jan. – Sep.)					
Carbonyl sulphide (COS)	0.0%				
Carbon disulphide (CS_2)	0.0%				
AMS104-Anzac (Oct. – Dec.)	0.0%				
Carbonyl sulphide (COS)	4.3%	0.00	1.37	2.54	0.05
Carbon disulphide (CS_2)	0.0%				

Figure 26: Hourly Variation in carbonyl sulphide (COS) and carbon disulphide (CS_2) (ppb) from SCD at Bertha Ganter-Fort McKay – 2013.



4.5.1 Cartridge Samples Analyzed by GC-MS

As part of the PFGC program GC-MS cartridge samples are routinely collected. The initial protocol was to trigger a cartridge sample with the PFGC whenever TRS or NMHC readings reached a preset concentration. The goal was to identify compounds seen as unknown peaks in either or both the SCD and FID chromatograms. Cartridge samples have greater sensitivity than the SCD because cartridges can sample several liters of air while the PFGC has an upper limit of about 0.33 liter. In the PFGC program the cartridge samples were used only to identify compounds, not to quantify them, which would have required a different protocol. Multiple GC-MS cartridge samples were taken at all three sites during 2014 and these samples consistently found from several up to 13 (all possible C_7) substituted thiophenes as listed in Table 28. In the latter part of 2014 two additional RSCs were discovered in cartridge samples, cyclohexyl-isothiocyanate and benzothiozole. These were first observed at AMS104-Anzac and were later confirmed at Bertha Ganter-Fort McKay as well (O'Brien, 2015).

The results indicate that these substances are present in the atmosphere but at concentrations below the detection level of the SCD (and the canister samples). Beginning in 2015 HEMP will undertake a program to systematically collect cartridge samples at the Bertha Ganter-Fort McKay and AMS104 sites and subject them to GC-MS analysis in an effort to both identify and quantify trace level RSC species in the airshed. The samples will be triggered by elevated levels of TRS and/or NMHC.

Table 28: Substituted thiophenes found in all or in part at Bertha Ganter-Fort McKay, Mildred Lake and Anzac.

PFGC Peak Order	Number of Carbon Atoms	Substituted Thiophene Identity
1	4	Thiophene (C_4H_4S)
2	5	2-methyl Thiophene
3	5	3-methyl Thiophene
4	6	2-ethyl Thiophene
5	6	2,5-dimethyl Thiophene
6	6	3-ethyl Thiophene
7	6	2,4-dimethyl Thiophene
8	6	2,3-dimethyl Thiophene
9	6	3,4-dimethyl Thiophene
10	7	2-npropyl Thiophene
11	7	2-ethyl,5-methyl Thiophene
12	7	2-isopropyl Thiophene
13	7	2,3,4-trimethyl Thiophene

4.6 Canister VOC and RSC data

Twenty-four hour canister samples were also collected at a number of the sites (see Table 10) and analyzed for VOC and RSC by gas chromatography/mass spectrometry. For the Bertha Ganter-Fort McKay site, measured RSC species and summary statistics for 2014 are provided in Table 29. Reported detection levels for RSC changed from 1 ppb for January-April samples to 0.1 ppb for May to December samples.

Carbonyl sulphide was the most frequently detected RSC but because it was only detected in 26% of samples at Bertha Ganter (despite a background concentration of ~0.5 ppb), it is likely that the effective detection level was more likely 1 ppb for the entire year for RSC's in the canister samples. For all samples at community sites the overall detection frequency for carbonyl sulphide was 20%, for carbon disulphide 11%, for hydrogen sulphide 3%, thiophene 3%, dimethyl sulphide 2%, 2 and 3-methyl thiophene 1%, 2-ethyl thiophene 1%, 2,5-dimethyl thiophene 1% and all other RSC were detected less than 1% of the time. Detection frequencies were similar at the industrial sites.

A comparison of mean and maximum hydrogen sulphide, carbonyl sulphide and carbon disulphide concentrations from all canister sites is provided in Figure 27. There were few detectable concentrations of the other sulphur species (mercaptans, sulphides and thiophenes) at any of the sites.

For the Bertha Ganter-Fort McKay site measured VOC species and summary statistics for 2014 are provided in Table 30. Detection levels were typically 0.03 ppb for VOC. The most frequently detected VOC species were acetone, benzene, isopentane, toluene, butane and isobutane. Alpha pinene and isoprene were also frequently detected and originate from coniferous and deciduous trees respectively. Methanol and acetone both have a large natural component and acetaldehyde is largely formed in the atmosphere from photochemical reactions of other VOC.

A comparison of mean and maximum concentrations of some selected abundant VOC (pentane, hexane, benzene and toluene) is provided in Figure 28 for all canister sites. Mean concentrations of benzene ranged from 0.2 to 0.9 ppb across the sites with the highest mean recorded at Anzac. Mean toluene concentrations showed more variability ranging from 0.2 ppb at CNRL Horizon to 0.9 ppb at Bertha Ganter. Mean hexane concentrations ranged from 0.3 ppb at Anzac to 2.4 ppb at Millennium.

Since some of the same species are reported by both the PFGC and the canisters, a comparison of calculated 24 h average PFGC concentrations (at least 12 samples required for the day) for days with canister measurements was made for Bertha Ganter-Fort McKay and the results are shown in Figure 29 for selected VOC and for carbonyl sulphide and carbon disulphide in Figure 30. The comparisons are quite mixed with suggestions that both the canister and PFGC results are uncertain during some periods of the data record. The PFGC did not record any detectable levels of benzene whereas it was almost always detected in canister samples.

Table 29: RSC species and reported 24 h concentrations (ppb) in canister samples at Bertha Ganter-Fort McKay for 2014 (a total of 61 samples - detection limits were 0.1 to 1 ppb).

Compound	% Detect	95th Percentile	Max.	Mean	Std. Dev.	Median
Hydrogen sulphide	3.3%	< 0.1	1.70	0.04	0.24	< 0.1
Carbonyl sulphide	26.7%	2.00	2.10	0.32	0.60	< 0.1
Carbon disulphide	16.7%	0.70	3.20	0.12	0.44	< 0.1
Dimethyl sulphide	0.0%					
Allyl sulphide	0.0%					
Ethyl sulphide	0.0%					
Dimethyl disulphide	3.3%	< 0.1	4.00	0.08	0.52	< 0.1
Methyl mercaptan	0.0%					
Ethyl mercaptan	0.0%					
Isopropyl mercaptan	1.7%	< 0.1	0.90	0.02	0.12	< 0.1
tert-Butyl mercaptan	0.0%					
Propyl mercaptan	0.0%					
Pentyl mercaptan	0.0%					
Butyl mercaptan	0.0%					
tert-Pentyl mercaptan	0.0%					
Isobutyl mercaptan	0.0%					
sec-Butyl mercaptan	0.0%					
Thiophene	1.7%	< 0.1	0.70	0.01	0.09	< 0.1
2-methyl Thiophene	3.3%	< 0.1	4.10	0.08	0.54	< 0.1
3-methyl Thiophene	3.3%	< 0.1	4.30	0.09	0.57	< 0.1
2-ethyl Thiophene	0.0%					
2,5-dimethyl Thiophene	1.7%	< 0.1	2.00	0.03	0.26	< 0.1

Figure 27: Minimum, mean and maximum hydrogen sulphide, carbonyl sulphide and carbon disulphide concentrations (ppb) from all canister sites – 2014.

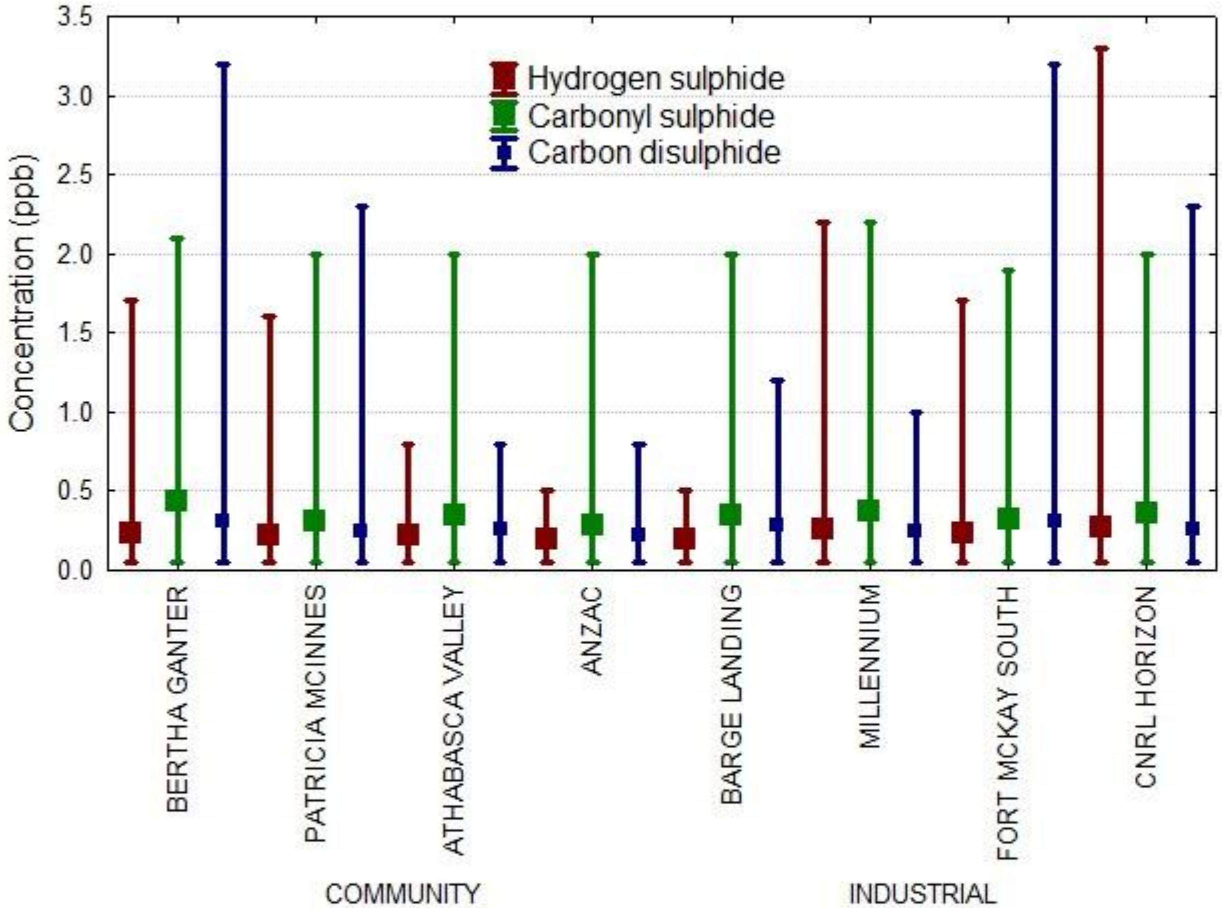


Table 30: VOC species and reported 24 h concentrations (ppb) in canister samples at Bertha Ganter-Fort McKay for 2014 – sorted by frequency of detection (a total of 61 samples - detection limit was 0.03 ppb).

Compound	% Detect	95th Percentile	Max.	Mean	Std. Dev.	Median
Acetone	83.6%	7.58	63.80	3.34	8.22	1.82
Benzene	75.4%	0.51	1.43	0.21	0.23	0.19
Isopentane	73.8%	3.50	22.20	1.37	2.98	0.51
Toluene	68.9%	2.87	16.50	0.91	2.92	0.14
Butane	62.3%	5.95	105.00	2.91	13.61	0.61
Isobutane	50.8%	2.41	59.60	1.36	7.61	0.09
Methanol	50.8%	31.00	39.60	5.64	9.51	1.57
Acetaldehyde	49.2%	6.54	8.43	1.87	2.34	< 0.03
Pentane	37.7%	4.51	19.50	1.19	2.80	< 0.03
3-Methylpentane	31.1%	0.87	16.60	0.46	2.16	< 0.03
Hexane	27.9%	4.46	56.30	1.39	7.32	< 0.03
m, p-Xylene	27.9%	0.52	3.97	0.14	0.53	< 0.03
alpha Pinene**	27.9%	0.40	0.62	0.08	0.14	< 0.03
2-Methylpentane	26.2%	1.08	8.69	0.36	1.32	< 0.03
Isoprene**	23.0%	2.43	4.39	0.41	0.98	< 0.03
Methylcyclohexane	23.0%	0.52	1.22	0.11	0.23	< 0.03
Methylcyclopentane	19.7%	0.68	18.70	0.40	2.40	< 0.03
Ethyl benzene	19.7%	0.32	1.38	0.06	0.21	< 0.03
Heptane	18.0%	0.62	1.67	0.11	0.31	< 0.03
Octane	18.0%	0.72	1.86	0.11	0.30	< 0.03
1-Butene	16.4%	0.57	2.20	0.10	0.33	< 0.03
Cyclohexane	16.4%	0.61	2.13	0.11	0.35	< 0.03
2-Methylheptane	16.4%	0.45	0.52	0.06	0.14	< 0.03
3-Methylhexane	14.8%	0.45	0.98	0.07	0.18	< 0.03
o-Xylene	14.8%	0.11	1.27	0.03	0.17	< 0.03
2,3-Dimethylbutane	11.5%	0.28	0.43	0.04	0.10	< 0.03
Nonane	9.8%	0.14	0.35	0.02	0.07	< 0.03
beta Pinene**	9.8%	0.67	3.57	0.15	0.64	< 0.03
2,2-Dimethylbutane	8.2%	0.09	0.40	0.02	0.07	< 0.03
Cyclopentane	8.2%	0.36	1.09	0.05	0.18	< 0.03
2-Methylhexane	8.2%	0.15	1.15	0.04	0.20	< 0.03
Isopropyl alcohol	5.0%	6.17	10.10	0.41	1.85	< 0.03
3-Methylheptane	4.9%	< 0.03	0.28	0.01	0.05	< 0.03
1,3,5-Trimethylbenzene	4.9%	< 0.03	0.29	0.01	0.04	< 0.03
1,2,4-Trimethylbenzene	4.9%	< 0.03	0.38	0.01	0.05	< 0.03
Methyl ethyl ketone	4.9%	< 0.03	1.85	0.04	0.25	< 0.03
Decane	4.9%	< 0.03	0.34	0.01	0.05	< 0.03
Dodecane	4.9%	< 0.03	0.21	0.01	0.04	< 0.03
Naphthalene	4.9%	< 0.03	0.37	0.01	0.07	< 0.03
trans-2-Butene	3.3%	< 0.03	0.91	0.02	0.13	< 0.03
cis-2-Butene	3.3%	< 0.03	0.36	0.01	0.05	< 0.03
2,3-Dimethylpentane	3.3%	< 0.03	0.22	0.01	0.03	< 0.03
2,3,4-Trimethylpentane	3.3%	< 0.03	0.08	0.00	0.01	< 0.03

Undecane	3.3%	< 0.03	0.22	0.01	0.04	< 0.03
1,3-Butadiene	2.4%	< 0.03	1.12	0.03	0.17	< 0.03
Compound	**% Detect**	**95th Percentile**	**Max.**	**Mean**	**Std. Dev.**	**Median**
Ethanol	2.4%	< 0.03	1.47	0.04	0.23	< 0.03
trans-2-Pentene	1.6%	< 0.03	0.18	0.00	0.02	< 0.03
2-Methyl-2-Butene	1.6%	< 0.03	0.19	0.00	0.02	< 0.03
2,2,4-Trimethylpentane	1.6%	< 0.03	0.22	0.00	0.03	< 0.03
Isopropylbenzene	1.6%	< 0.03	0.14	0.00	0.02	< 0.03
3-Methyl-1-Butene	0.0%					
1-Pentene	0.0%					
cis-2-Pentene	0.0%					
Cyclopentene	0.0%					
4-Methyl-1-pentene	0.0%					
2-Methyl-1-pentene	0.0%					
trans-2-Hexene	0.0%					
cis-2-Hexene	0.0%					
2,4-Dimethylpentane	0.0%					
Styrene	0.0%					
n-Propylbenzene	0.0%					
Formaldehyde	0.0%					
Methyl isobutyl ketone	0.0%					

** biogenic species

Figure 28: Minimum, mean and maximum concentrations (ppb) of selected VOC from all canister sites – 2014.

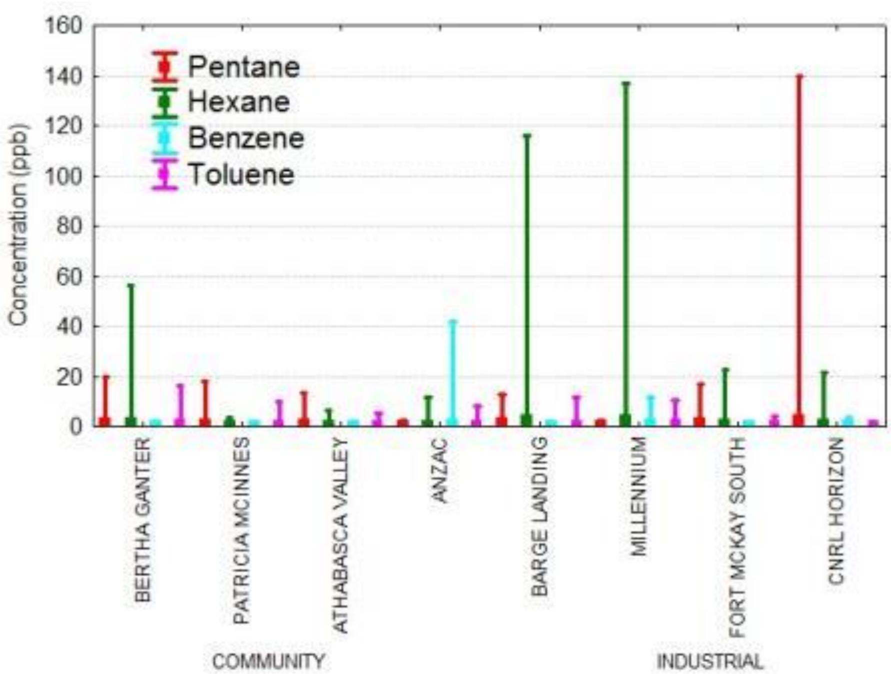


Figure 29: Comparison of 24h canister VOC with PFGC 24-h averages (ppbC) for selected species at Bertha Ganter-Fort McKay for all days with coincident measurements in 2014 (Note: Different scales used for each plot. PFGC pentane includes n-pentane and cyclopentane; PFGC hexane includes n-hexane and cyclohexane).

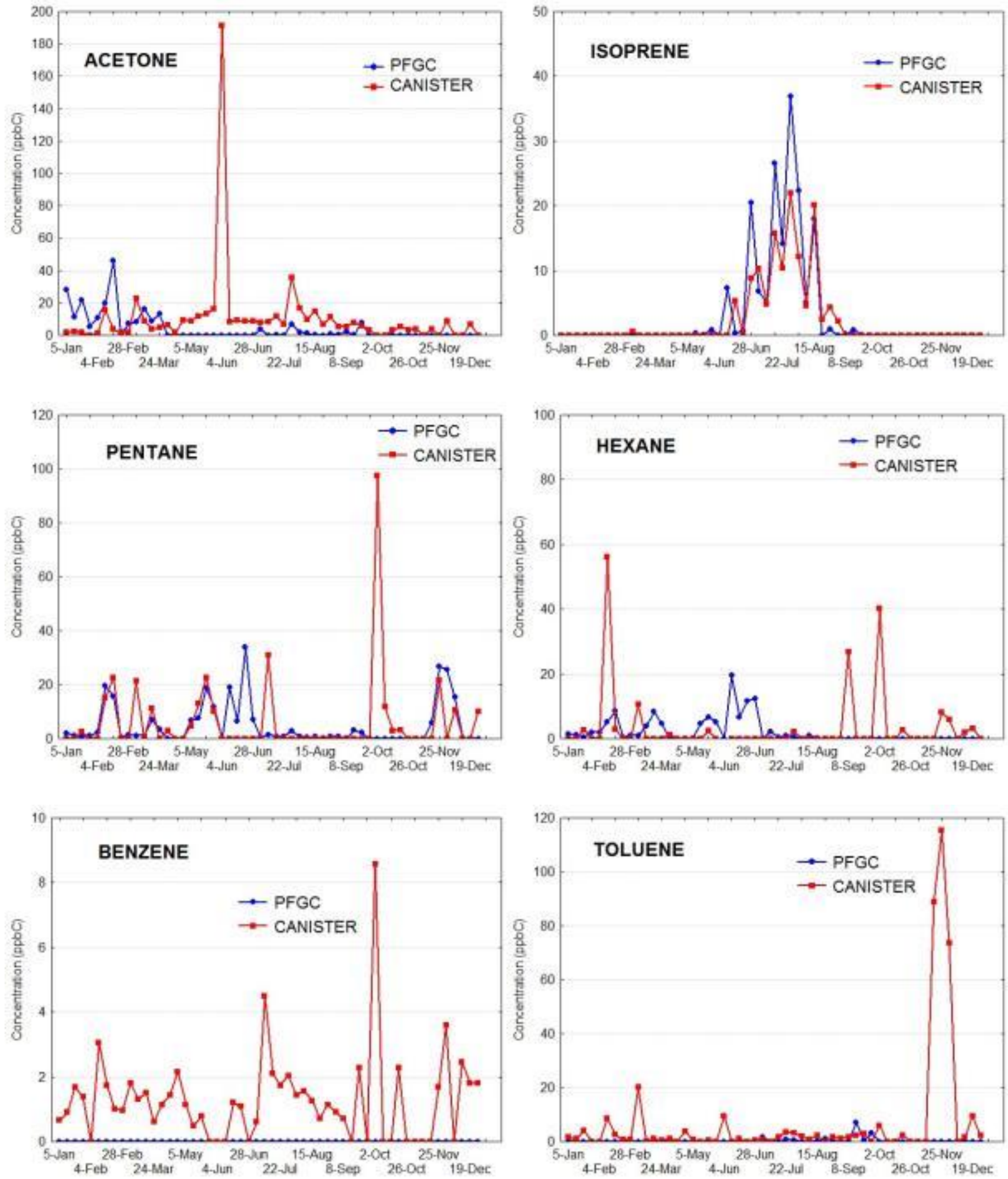
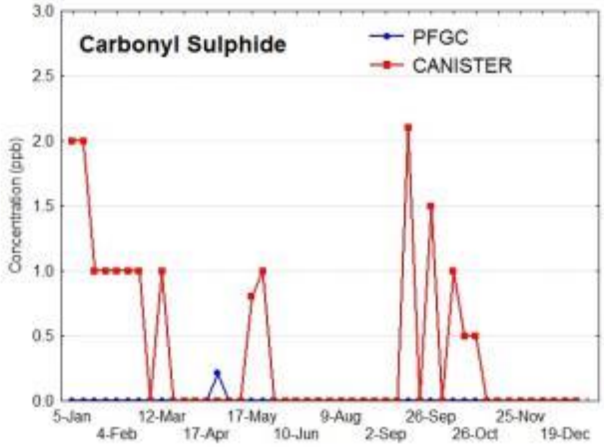
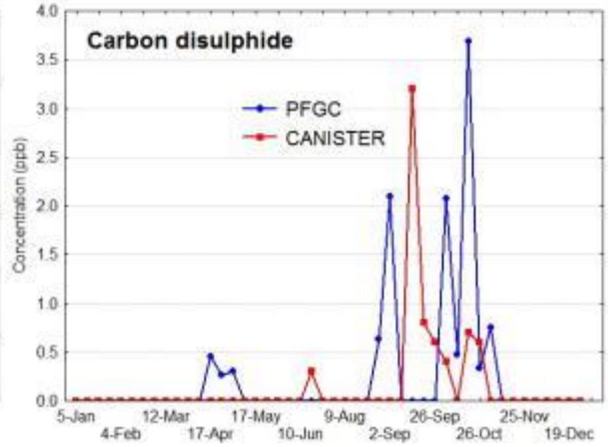


Figure 30: Comparison of 24h canister carbonyl sulphide and carbon disulphide with PFGC 24-h averages (ppb) at Bertha Ganter-Fort McKay for all days with coincident measurements in 2014 (Note: Different scales used for each plot).





4.7 Odour Complaints

4.7.1 Community Odour Monitoring Project (COMP)

In 2013 HEMP began a community-based odour monitoring project. For this initiative, WBEA recruited volunteer participants from the community of Fort McMurray. The main objective of the Community Odour Monitoring Project (COMP) is to involve the community in identifying and monitoring odours in the air in order to determine the impact on residents. The project was launched in February 2013 and training for the volunteers was conducted in May 2013. An odour committee was formed and is based on the participation of volunteers from the region that supply specific information about the various odours they perceive during their day-to-day activities. They provide observations through a designated website, by mail or through a cell phone application. The committee meets on a quarterly basis to review the results of their observations. There were 36 participants registered as volunteers at the end of the fourth quarter of the first year of the project (HEMP, 2014). COMP launched a second year of odour monitoring in Fort McMurray with an information meeting and training sessions for the new volunteers held in May 2014. The observation phase started in June 2014 and continued until the end of May 2015. There were 27 participants in the program as of December 2014.

All recorded observations for the months of January through December 2014 were received in an electronic file which included the parameters noted in Table 31. The recorded latitude and longitude of each complaint were used to identify the nearest WBEA monitoring site (Patricia McInnes or Athabasca Valley) and the distance from the participant to the monitoring site. There were 138 unique complaints recorded in 2014. Some of these observations spanned multiple hours and the total reported hours with odour issues amounted to 312 over the year.

As shown in Table 31 for each observation, the participant can report one or more types of odour perceived. The participants also reported on intensity of odour (weak, medium, high, very high) and on odour appreciation (neutral, unpleasant, very unpleasant). The breakdown of observations based on type of odour, intensity and odour appreciation is shown in Figure 31. As shown in Figure 31 and Table 32, approximately half (43%) of the observations identified the odour as asphalt/tar or hydrocarbon/solvent which is a similar percentage to the odour types reported in 2013.

Since odour observations are provided by volunteers during their day to day activities, observations are more likely to coincide with daytime and evening than nighttime and also reflect the time for which the volunteer remains at the location of the perceived odour (HEMP, 2014). Time spent outdoors is very seasonal. The distributions of complaints by hour of day and by month are shown in Figure 32. Eighty-two percent of odour reports were recorded during the months of May to September and eighty-six percent between the hours of 7:00 AM to 9:00 PM. Of the approximately 37 participants in the program, eighteen reported odours on one or more occasion and the distribution of complaints by participant is also shown in Figure 32.

Specific odour episodes will be discussed and analyzed further in Section 5.2.

As shown in Figure 33 odour reports were usually associated with light winds and no precipitation. Wind roses have been constructed for all complaint hours as shown in Figure 34 for the Patricia McInnes, Athabasca Valley and Lower Camp Tower (100m height) sites. The majority of odour reports by volunteers were reported during periods when winds were from a northerly quadrant.

Table 31: Information contained in odour complaint logs for COMP.

Parameters Recorded	
Date	Q1. Current Physical State of Respondent
User Name	Q2. Weather Condition
Time From	Q3. Wind Condition
Time to	Q4. Type of Odour Perceived
Comments	Q5. Intensity of Odour Perceived
Source: Website/e-mail	Q6. Odour Appreciation
Latitude	
Longitude	

Table 32: Percentage distribution of types of odours reported in odour complaint logs for COMP for 2014.

Type of Odour Perceived	Percent
Burnt / smoke	28
Asphalt / tar	24
Fuel / solvent	19
Ammonia / Cat's pee	9
Other/mixed	6
Fecal / septic	5
Rotten Egg	4
Sewage/manure	3
Chemical / Plastic	2

Figure 31: Distribution of complaints by COMP participants by odour type, intensity and odour appreciation in 2014.

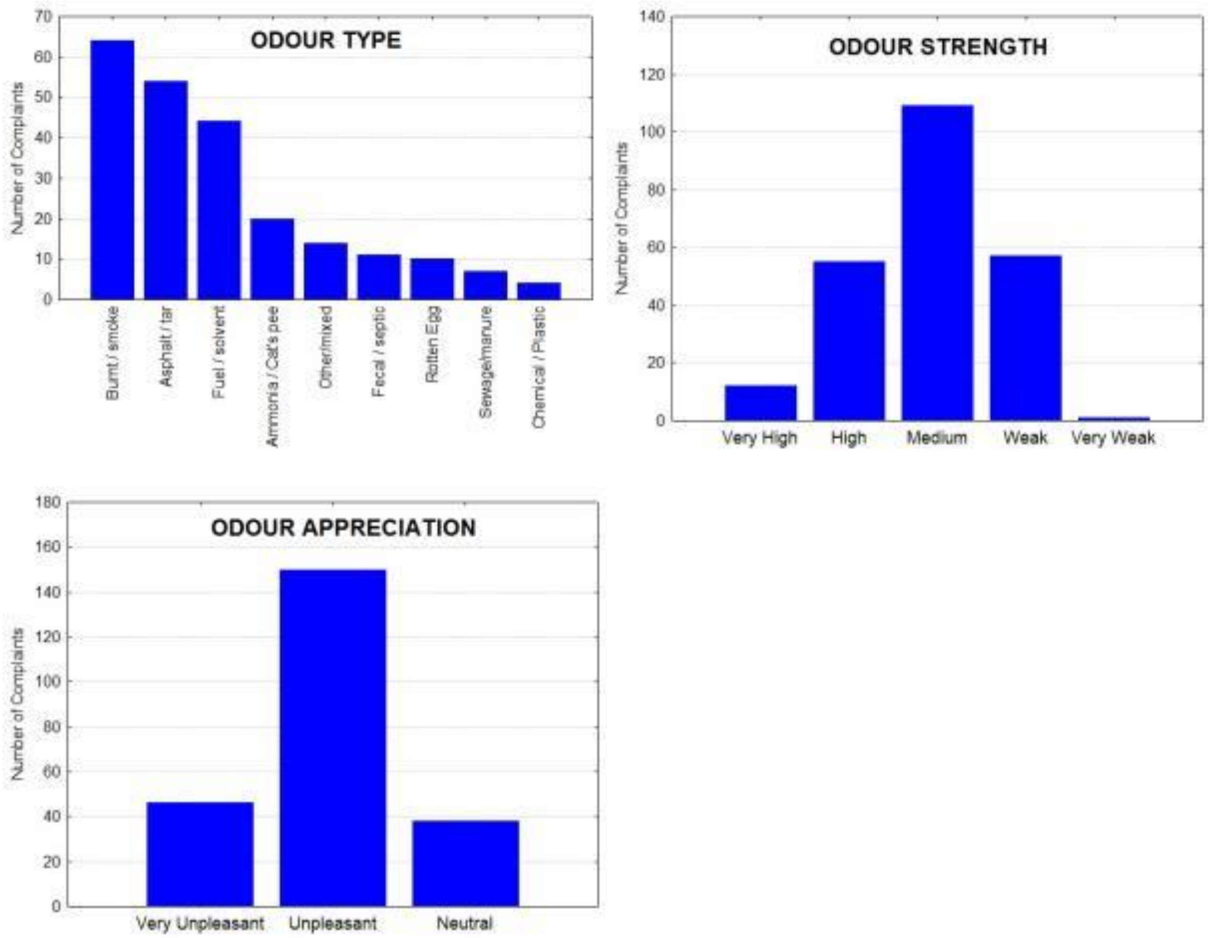


Figure 32: Number of Complaint Hours by COMP participants by time of day, by month and by participant for 2014.

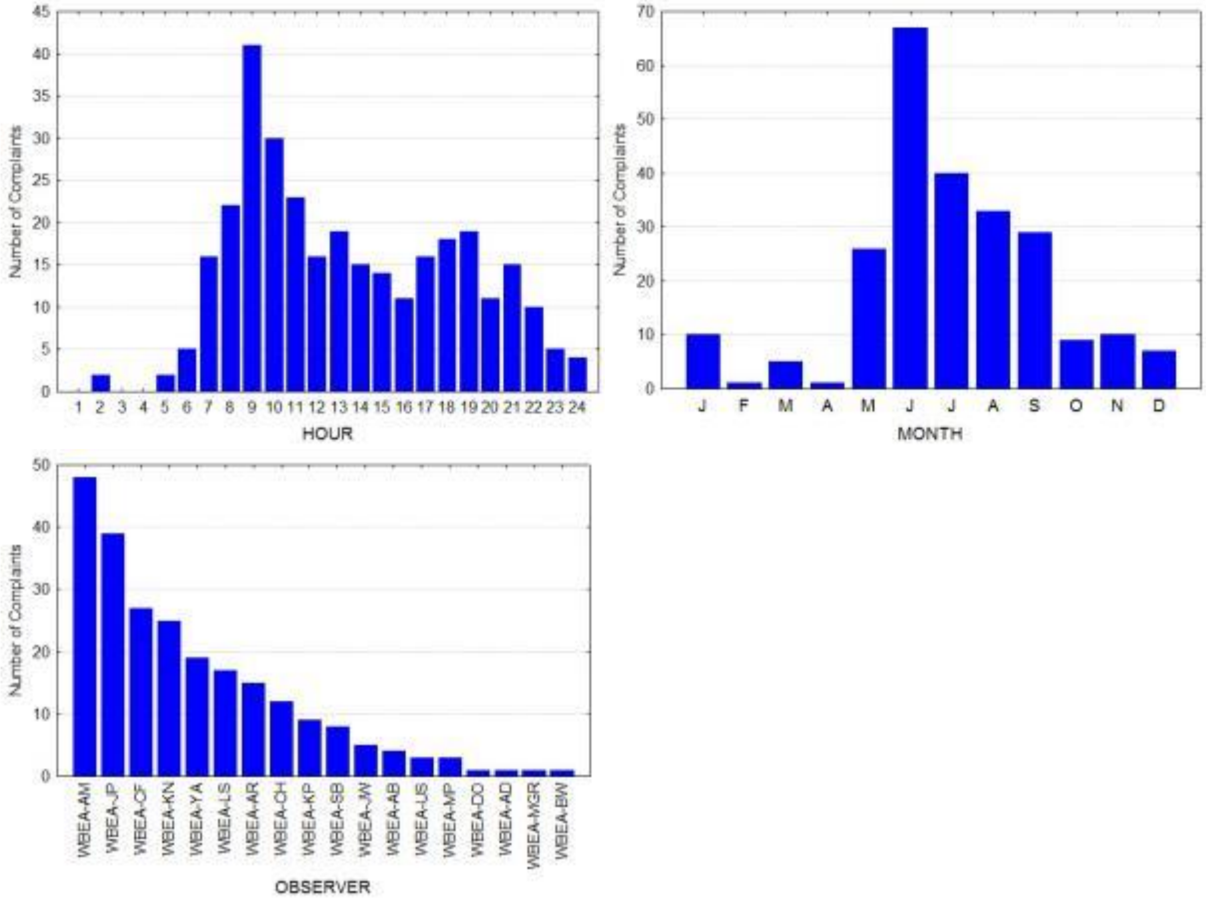


Figure 33: Distribution of complaints by COMP participants by weather condition and wind condition for 2014.

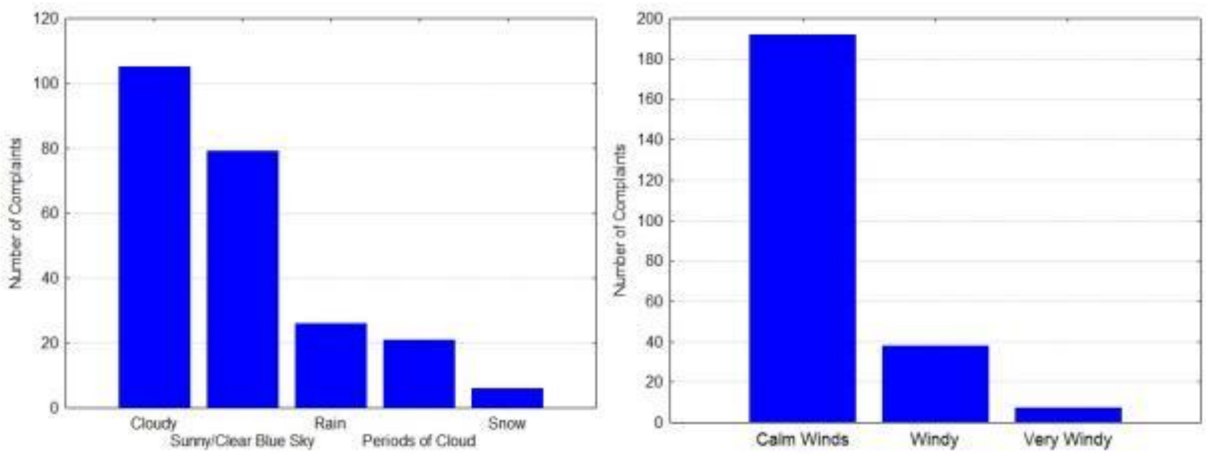
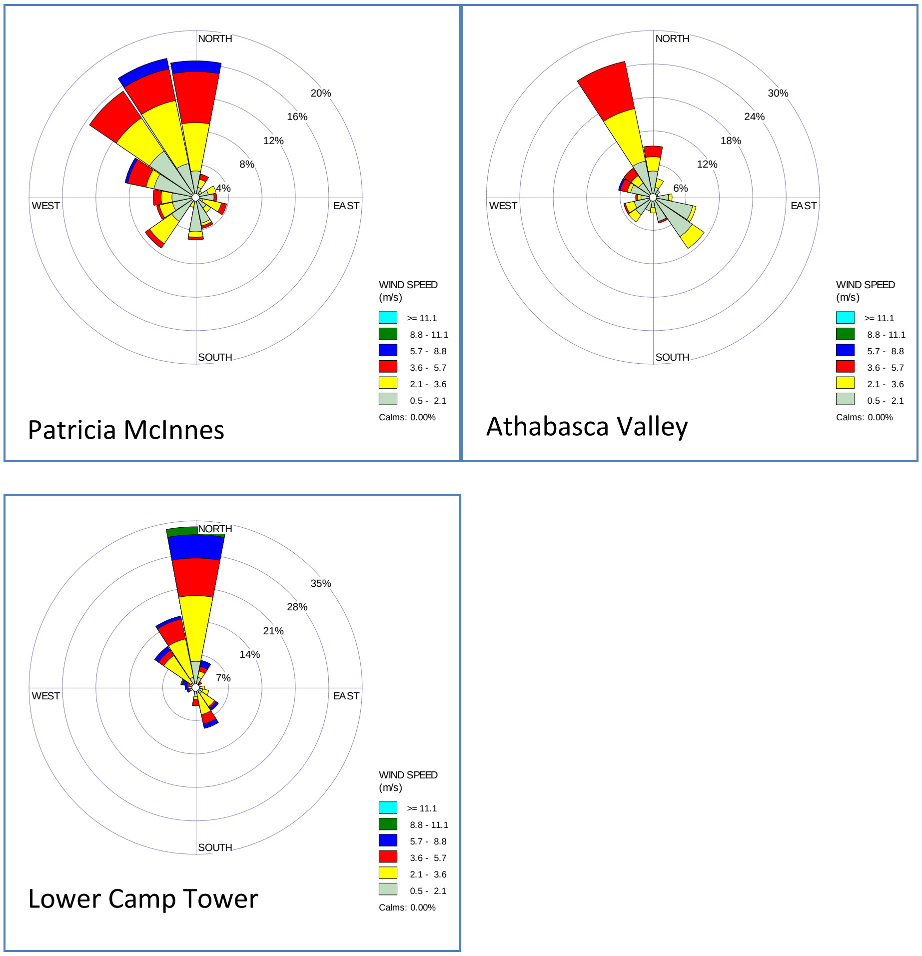


Figure 34: Wind roses for COMP complaint hours at Patricia McInnes, Athabasca Valley and Lower Camp Tower (100 m height) monitoring sites (2014).



4.7.2 Alberta Ministry of Environment and Parks Hotline

The quantification of offensive odour is often inherently difficult because it seeks to relate concentrations of chemical species in air to human sensory perception. For the most part, members of the public will not complain about a specific compound but of a generally foul odour.

The Alberta Ministry of Environment and Parks operates a 24-hour hotline where residents can call and report any odour complaints. Logs of complaints dealing with odours in the Fort McMurray, Fort McKay and Anzac area were obtained in hard copy form and all details were entered into a spreadsheet and stored by date and hour. These were then entered into the integrated data base. There were a total of 32 unique complaints recorded on 20 separate dates with the location of complaints shown in Table 33. Twenty-seven of the complaints were recorded between January-March with only six complaints in the later months. In 2013 there were 93 complaints and it appears that the Alberta hotline may have stopped being used by residents during 2014 as the COMP complaints did not show a similar drop-off in frequency. It is also possible that some reports of odours did not find their way onto the hard copy records (Abel, 2015). This is still being investigated at time of writing of this report.

The three Alberta hotline complaint days in Fort McMurray coincided with COMP complaint days. The log also contained a description of odour but responses were not standardized as in COMP. Table 34 contains the percentage of odour types reported. A breakdown of complaints by hour and month is provided in Figure 35. Wind roses for each community and for the other cases for complaint hours are shown in Figure 36. An analysis of individual odour complaints in the communities and especially of episode days for which there were multiple complaints will be provided in Section 5.2.

Table 33: Number of complaints to Alberta Hotline by location in 2014.

Location	Number
Fort McKay	9 (5 on same date)
Fort McMurray	3
Anzac	5 (3 on same date)
Other (mostly Hwy 63)	14

Table 34: Percentage distribution of types of odours reported to Alberta Environment and Parks Hotline for January to December, 2014.

Type of Odour Perceived	Percent
Hydrocarbon/oil/petroleum/bitumen	42
SO_2, Hydrogen sulphide/rotten egg	26
Ammonia/cat's pee	10
Other/not specified	23

Figure 35: Number of Complaints to Alberta Hotline by Time of Day and by Month for 2014.

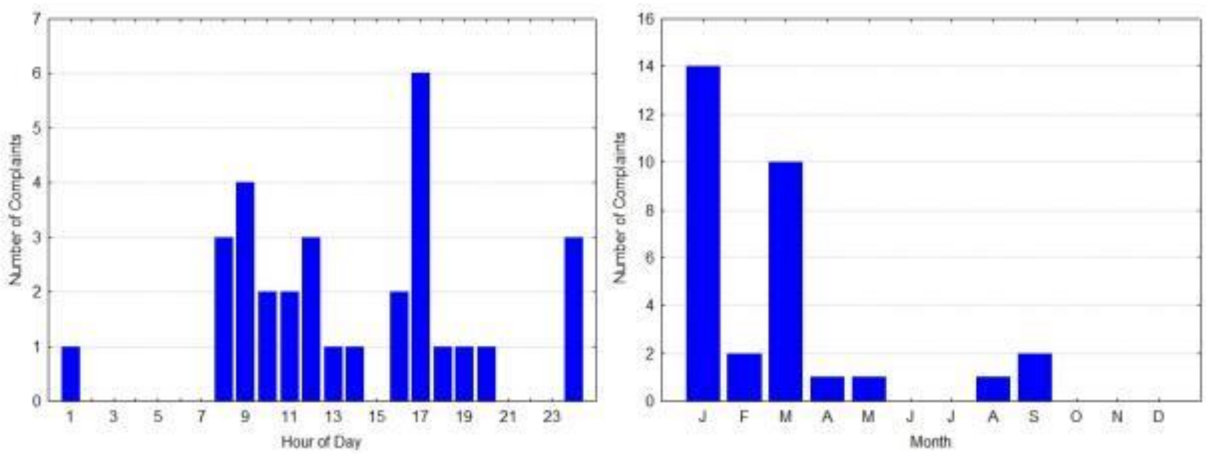
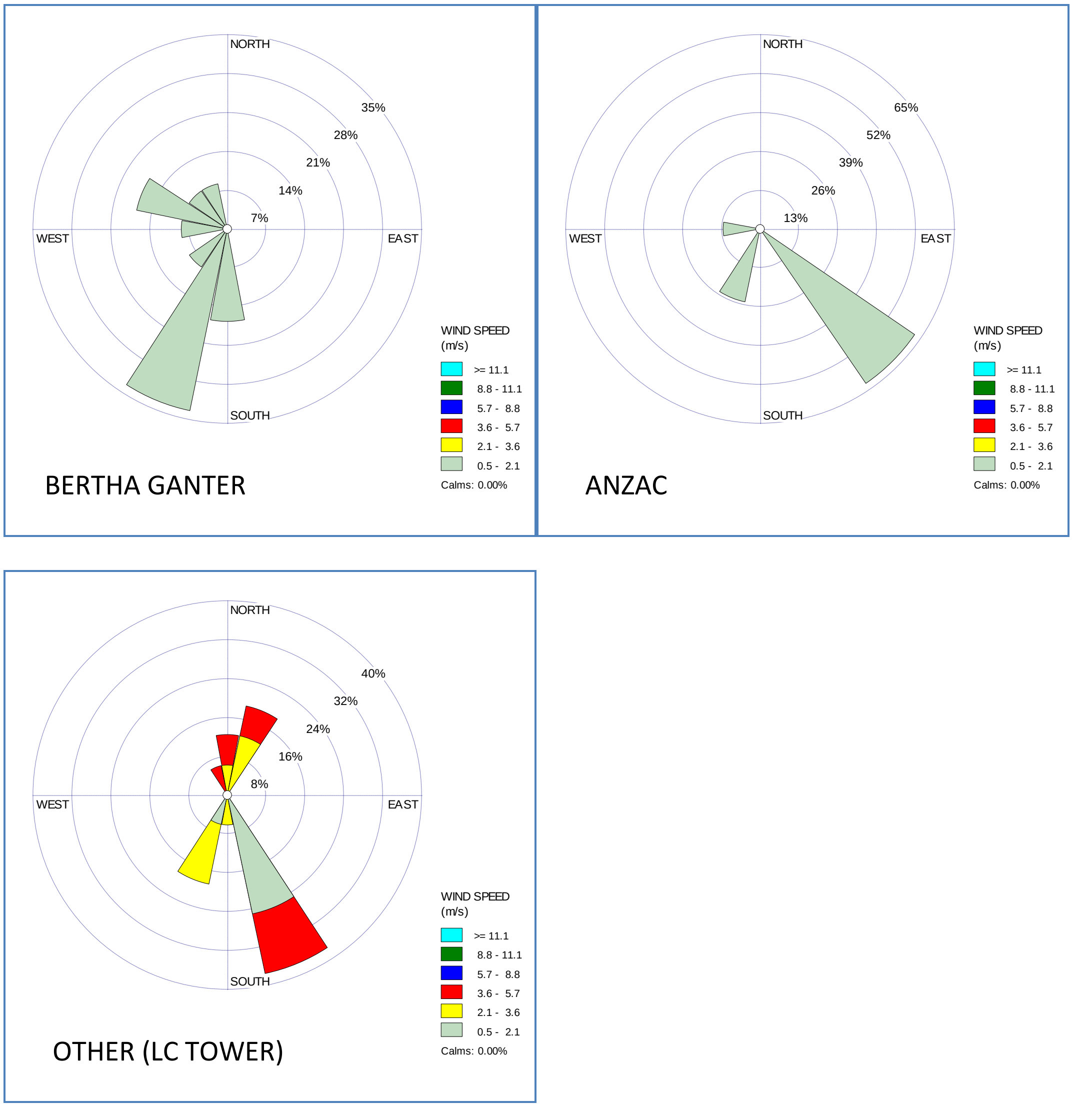


Figure 36: Wind Roses for Complaint Hours for Bertha Ganter-Fort McKay, Anzac and Other (Lower Camp Tower 100 m) for Alberta Hotline Complaints 2014.



5 Data Analysis

5.1 Parameters by Wind Direction

5.1.1 TRS and H_2S by Concentration Value and Wind Direction

All community sites were characterized in terms of occurrences of TRS concentrations greater than 1.5, 3, 5 and 10 ppb for 2014 and the results are shown in Table 35. Although 10 ppb is the 1h Alberta ambient air quality objective for H_2S, previous work in Fort McKay had suggested that odour complaints could occur with TRS levels much lower than this value. The results are further subdivided into occurrences by average wind direction (previous 6 hours) in Table 36. A visual representation of occurrences of TRS values greater than 1.5, 3, 5 and 10 ppb are shown in Figures 37 to 40 for the community sites of Bertha Ganter-Fort McKay, Patricia McInnes, Athabasca Valley and Anzac. The table and figures clearly show that for each site there are only a few wind directions associated with elevated TRS levels.

Figure 41 shows TRS/H_2S dose (the product of concentration times the frequency of wind direction) for all hours in 2014. The dose plots provide a visual representation with the wind directions contributing most of the TRS/H_2S at the sites as well as the magnitude of the mean dose at each site.

Table 35: Number of hours with TRS concentrations greater than 1.5, 3, 5 and 10 ppb for community sites in 2014.

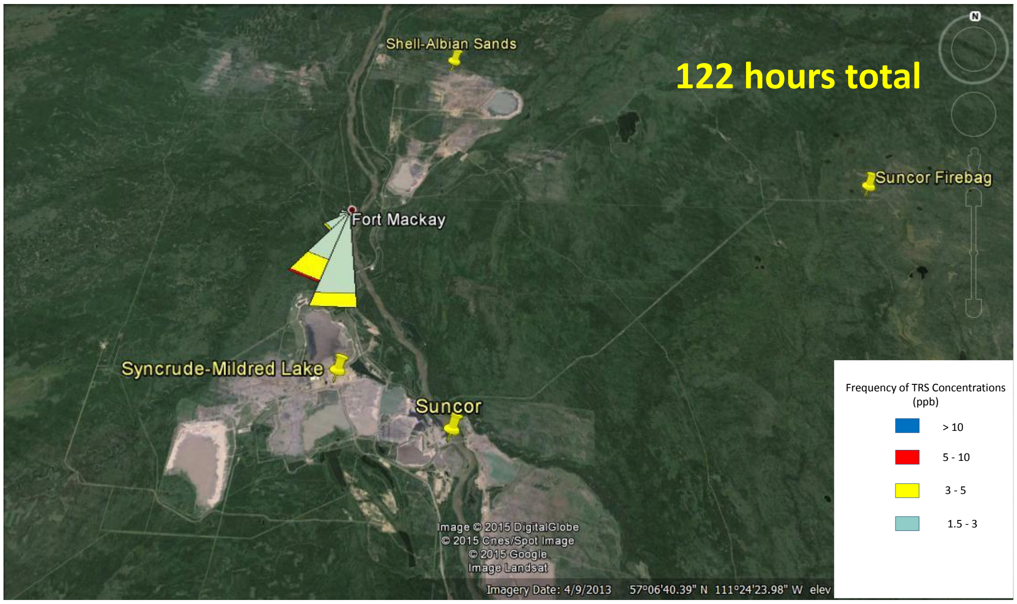
ID	SITE NAME	1.5 to 3 (ppb)	3 to 5 (ppb)	5 to 10 (ppb)	> 10 (ppb)	Sum
1	BERTHA GANTER- FORT MCKAY	108	15	1	0	124
6	PATRICIA MCINNES	29	1	0	0	30
7	ATHABASCA VALLEY	27	1	0	0	28
14	ANZAC	83	13	10	0	106

Table 36: Count of occurrences of TRS concentrations by average wind direction and location.

SITE	TRS (ppb)	*	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
BERTHA GANTER	1.5-3	2	0	1	1	0	1	0	1	3	43	32	12	5	4	0	2	1
	3-5	0	0	0	0	0	0	0	0	0	5	9	1	0	0	0	0	0
	5-10	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	>10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PATRICIA MCINNES	1.5-3	1	10	4	2	0	1	1	0	0	0	0	0	0	0	1	5	4
	3-5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ATHABASCA VALLEY	1.5-3	0	1	1	2	0	4	2	0	1	0	0	0	1	2	3	0	10
	3-5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	5-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ANZAC	1.5-3	10	0	0	0	1	0	4	50	10	2	2	0	0	1	3	0	0
	3-5	1	0	0	0	0	0	2	7	1	0	1	0	0	0	0	1	0
	5-10	5	0	0	0	0	0	1	2	2	0	0	0	0	0	0	0	0
	>10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* Missing wind direction data

Figure 37: Counts of TRS Values greater than 1.5, 3, 5 and 10 ppb by Wind Direction at Bertha Ganter-Fort



McKay.

Figure 38: Counts of TRS values greater than 1.5, 3, 5 and 10 ppb by wind direction at Patricia McInnes.

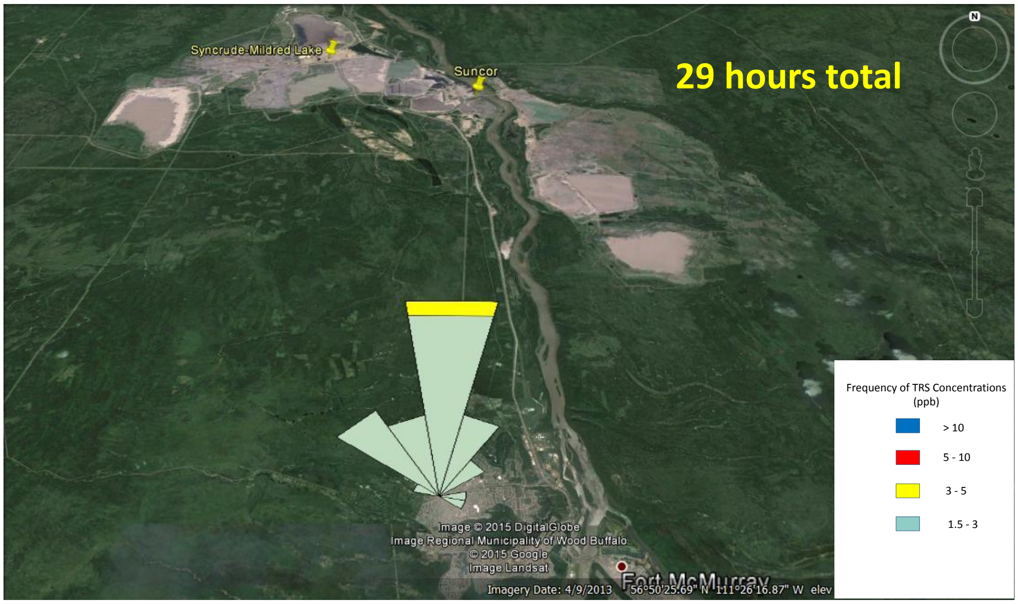


Figure 39: Counts of TRS values greater than 1.5, 3, 5 and 10 ppb by wind direction at Athabasca Valley.

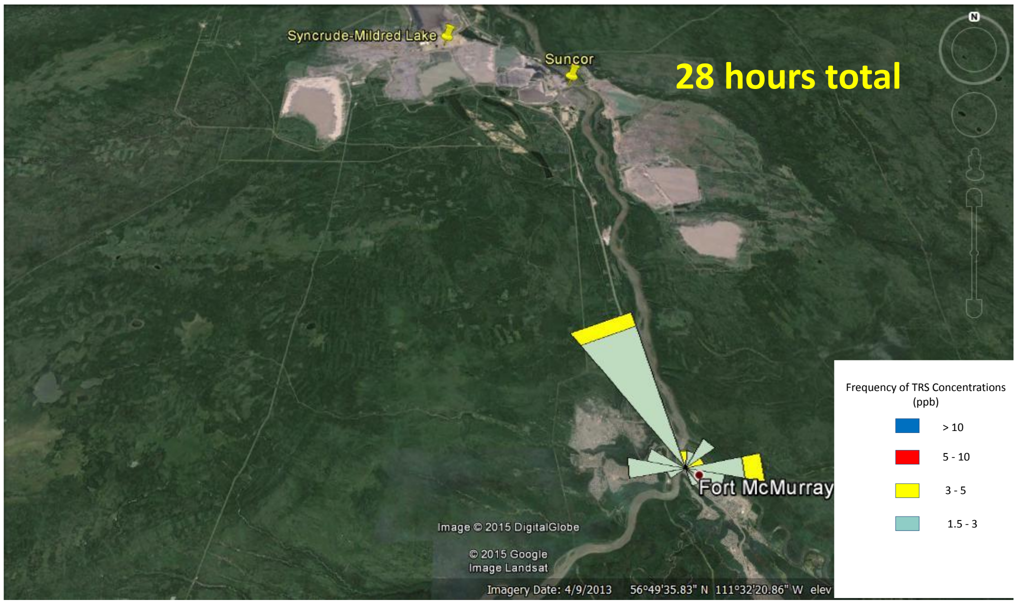


Figure 40: Counts of TRS Values greater than 1.5, 3, 5 and 10 ppb by wind direction at Anzac.

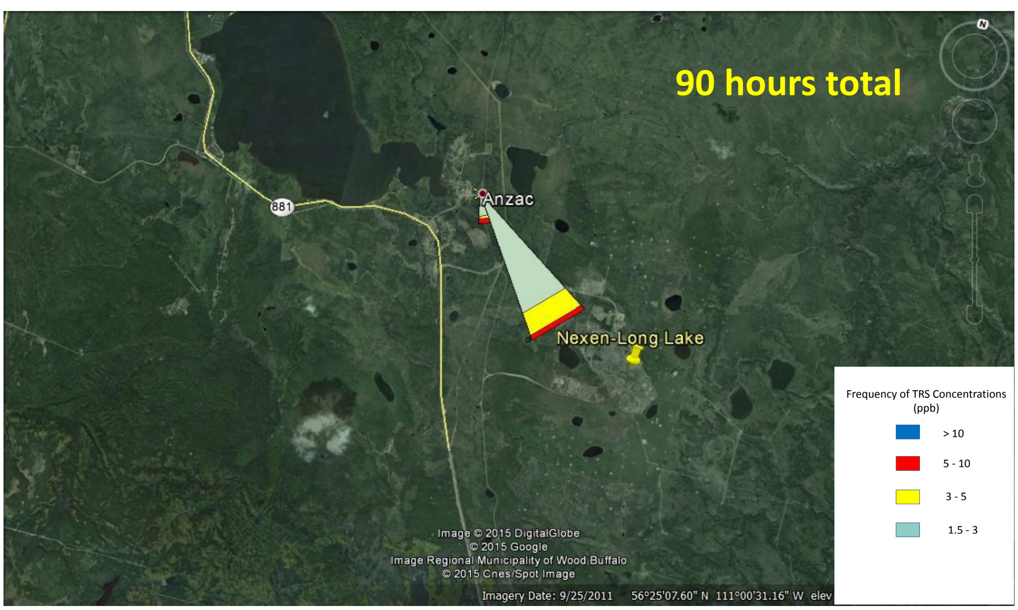
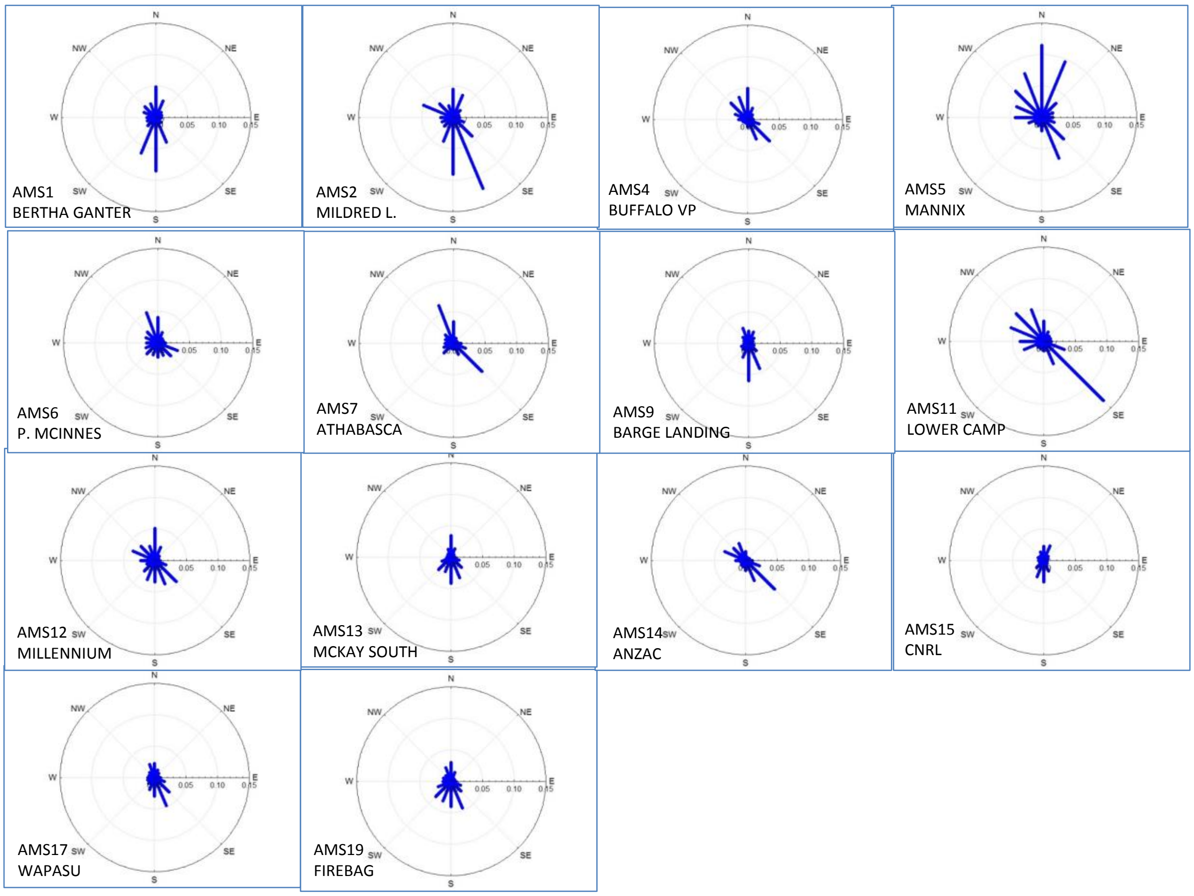


Figure 41: TRS/H_2S dose (ppb) at WBEA monitoring sites for 2014 (all hours).



5.1.2 SO_2, NMHC, nitric oxide and SO_2 to TRS/H_2S Ratio by Wind Direction

A similar analysis of SO_2, NMHC (for community sites, AMS104 and AMS104A) and nitric oxide dose is found in Figures 42 to 44. The ratio of mean SO_2 to TRS/H_2S Concentration by wind direction for each site is shown in Figure 45. Despite an NPRI estimated emission ratio of SO_2 to TRS of greater than 200 (molar basis) the ambient ratios were never higher than 20 for any specific wind direction at any site and more typically in the range of 2 to 5. This suggests that SO_2 emissions may be overestimated or that TRS emissions are underestimated.

Figure 42: SO_2 dose (ppb) at WBEA monitoring sites for 2014 (all hours).

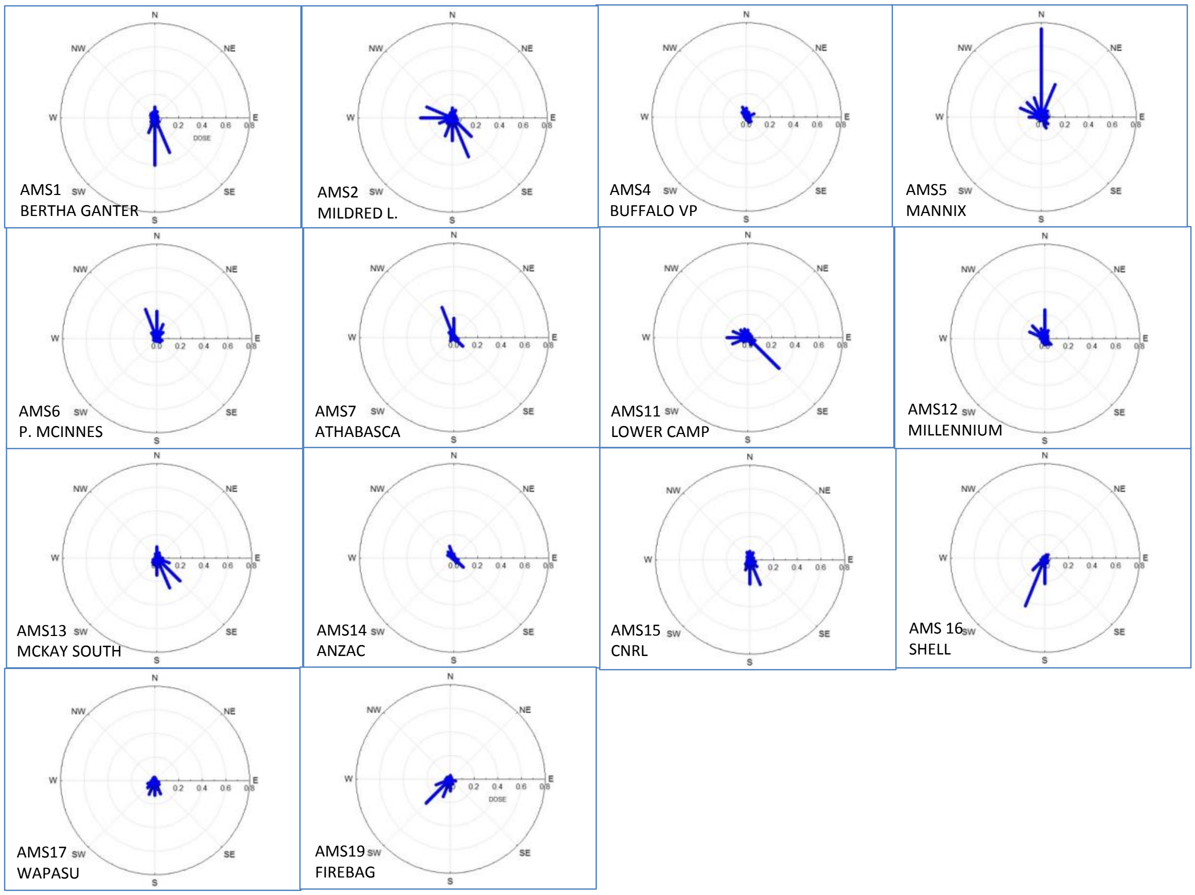


Figure 43: NMHC dose (ppm) at WBEA monitoring sites for 2014 (All Hours).

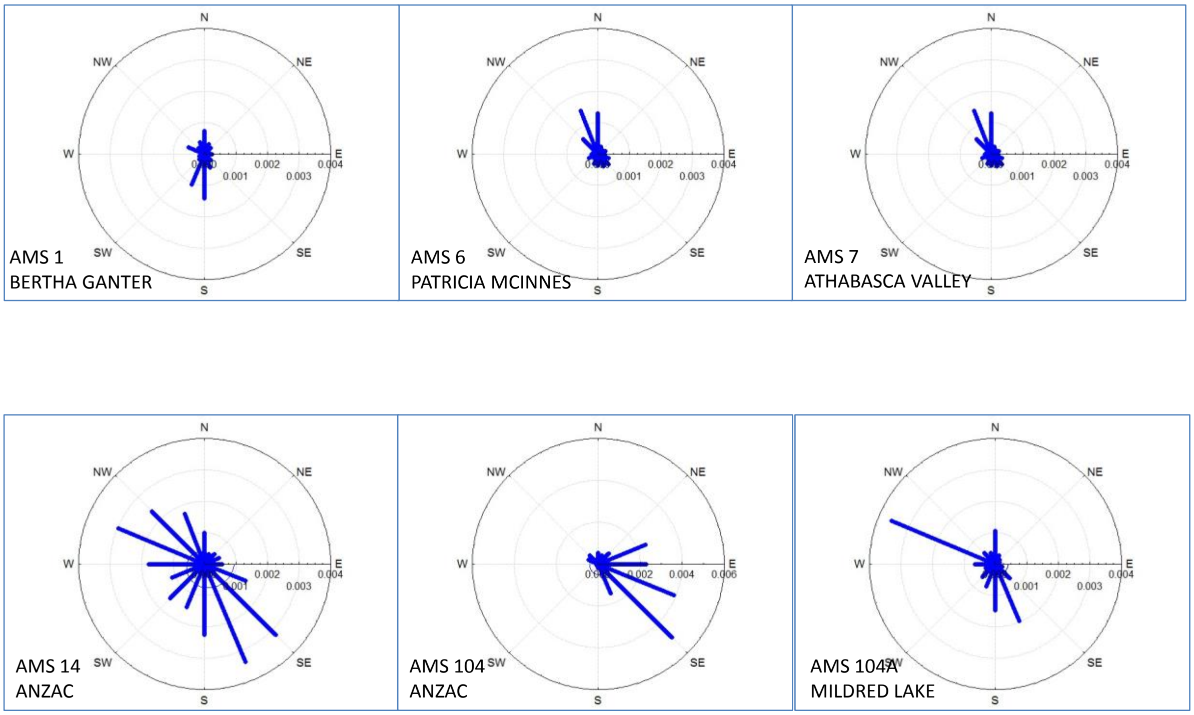


Figure 44: Nitric oxide dose (ppb) at WBEA monitoring sites for 2014 (all hours).

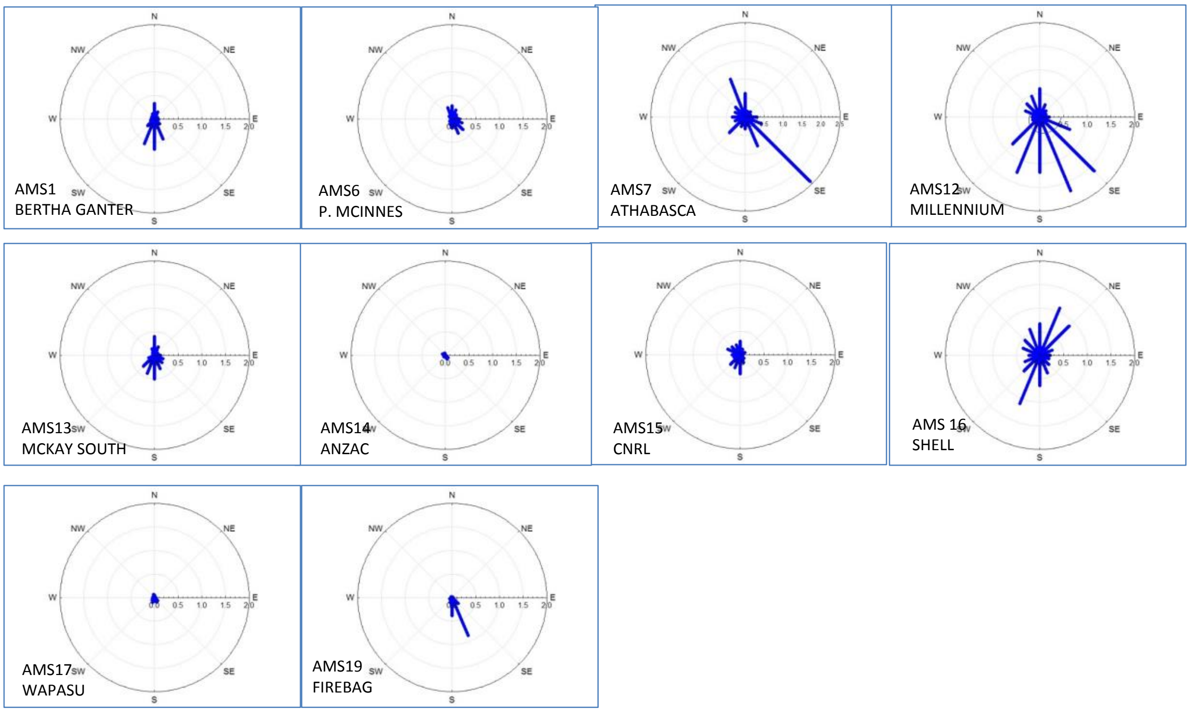
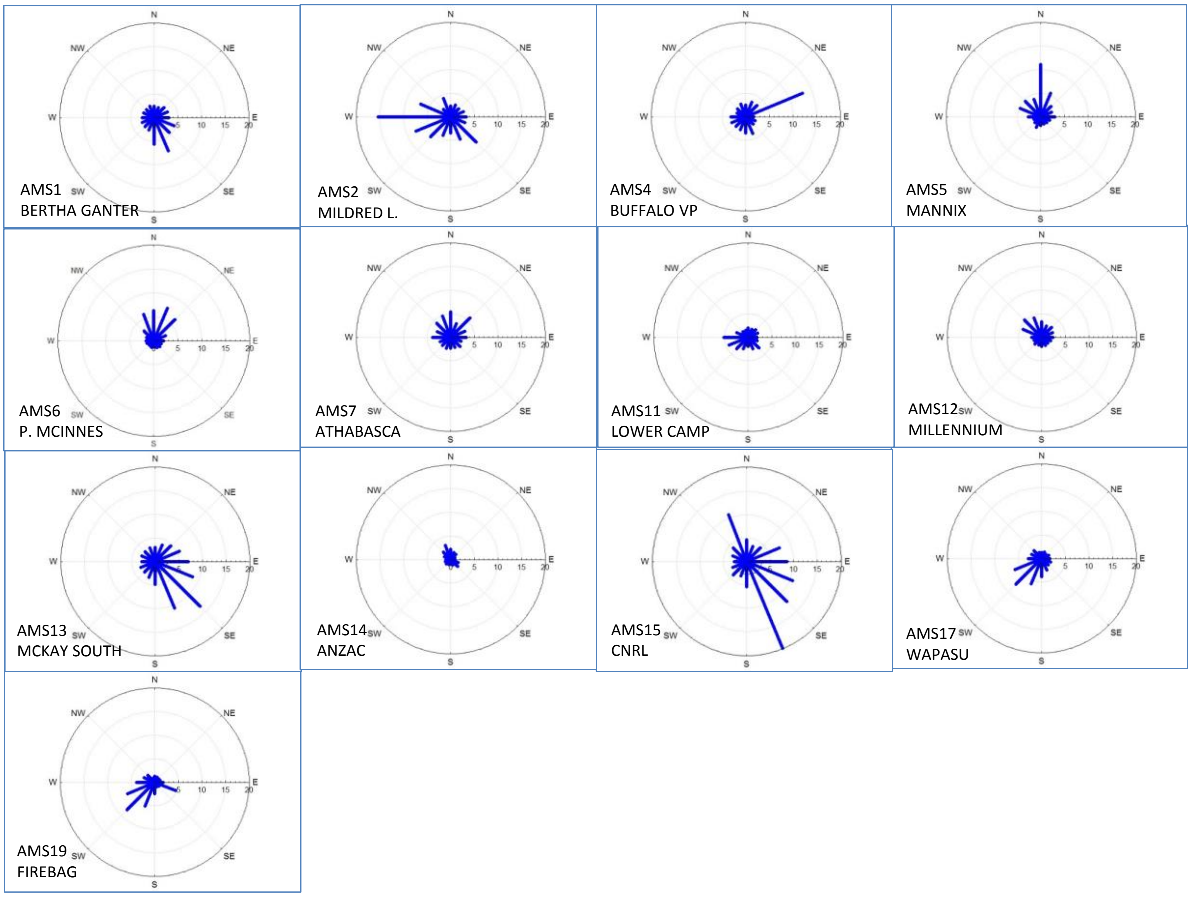


Figure 45: Ratio of mean SO_2 to mean TRS/H_2S by wind direction at WBEA monitoring sites for 2014 (all hours).



5.1.3 PFGC and eNose Readings by Wind Direction

For the eNose system a graphical comparison of mean odour units, maximum odour units, maximum odour units for hours greater than the 90th percentile value of 18, DELTA and CV by wind direction are provided in Figure 46. The amount of 'directionality' in the plots is quite variable with the DELTA and maximum plots tending to show the most variation with wind direction. Many of the directions with higher eNose values are not in the direction of the major industrial sources in the area.

For the PFGC, the concentration of the sum of naphtha species by wind direction, the sum of aromatic species (benzene plus toluene) and sum of all identified species by wind direction are provided in Figure 47. The highest naphtha concentrations were associated with winds from the northeast through southeast whereas aromatics were associated with winds from the southwest.

Figure 46: Mean and maximum eNose reading (odour units), mean DELTA and mean CV at Bertha Ganter-Fort McKay by wind direction for 2014 (note different scales).

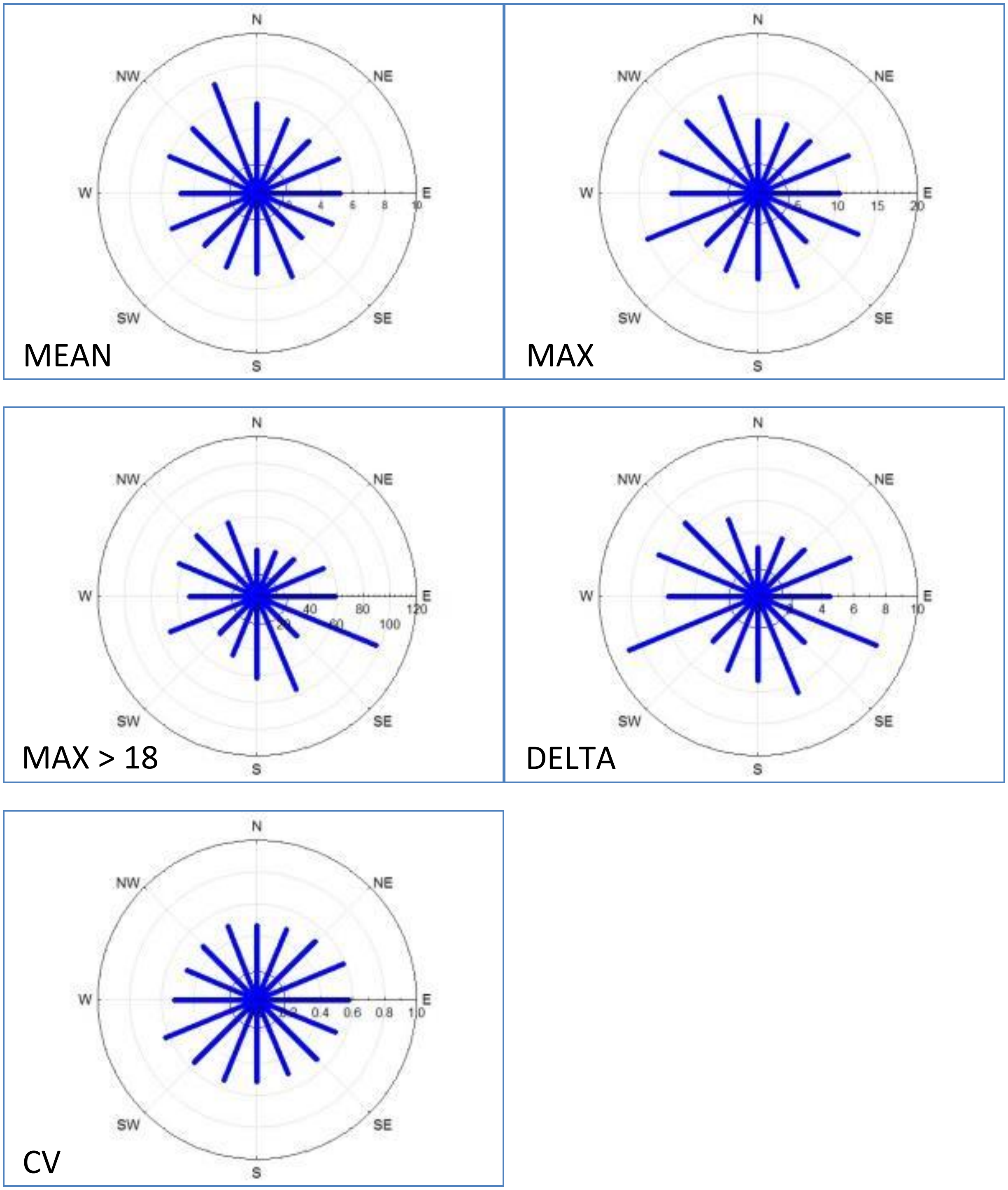
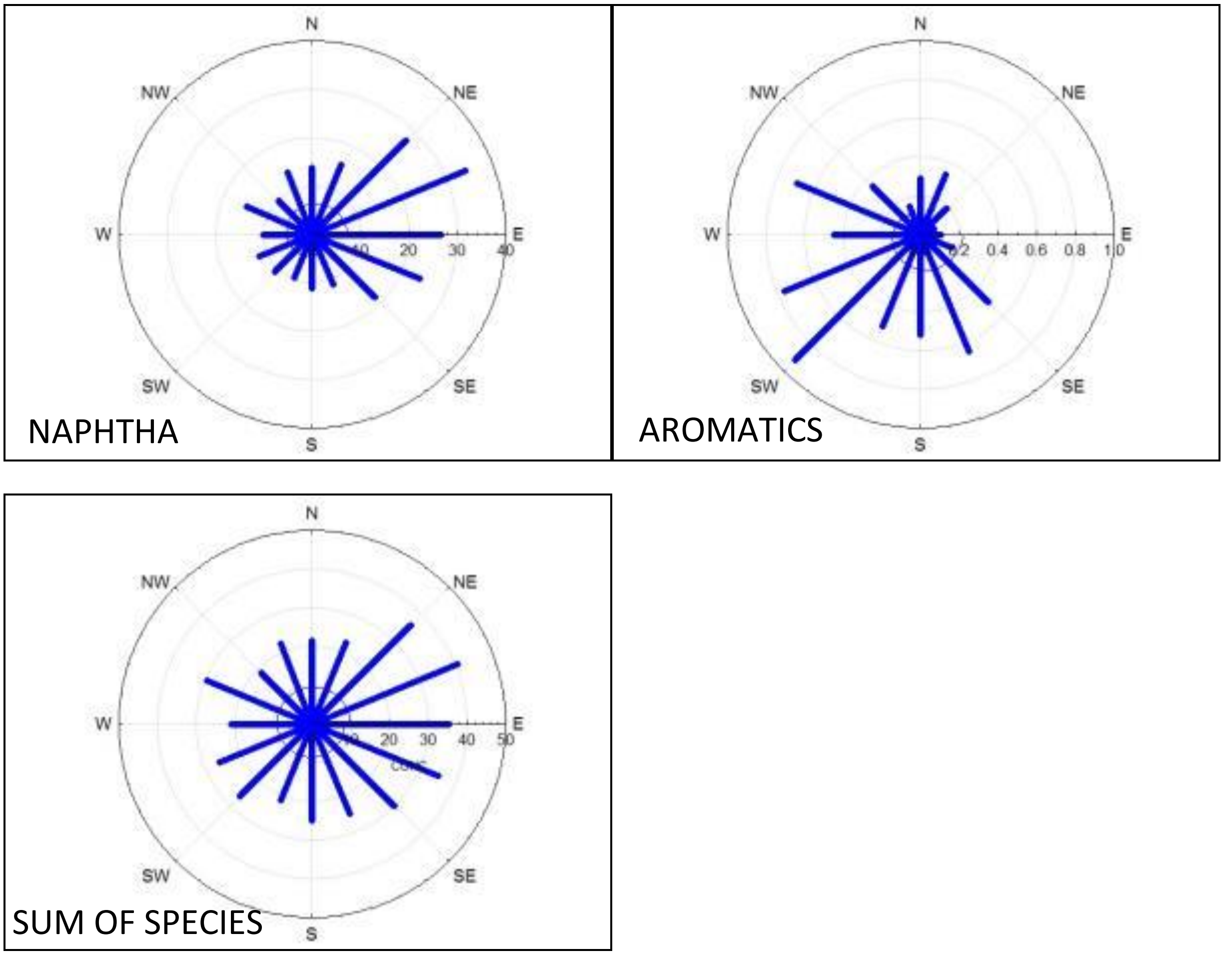


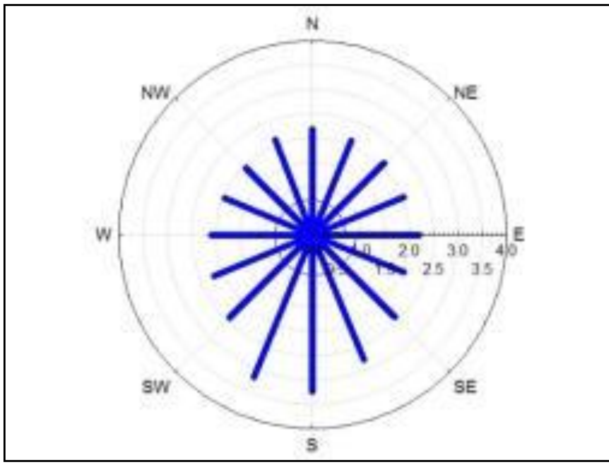
Figure 47: Mean naphtha, aromatics and sum of all species (ppbC) by wind direction at Bertha Ganter-Fort McKay for 2014.

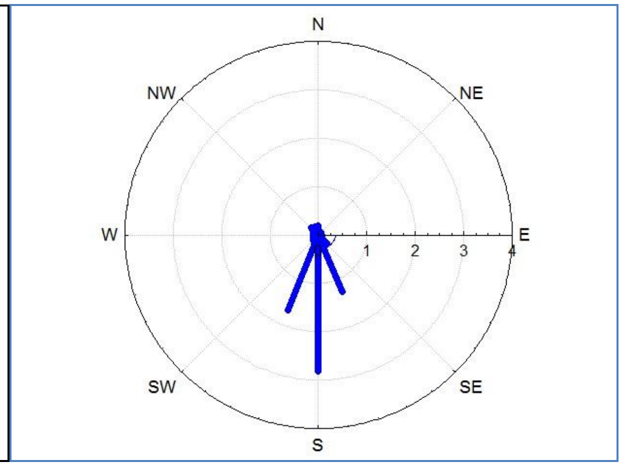


5.1.4 Fort McKay Air Quality Index (FMAQI)

A plot of hourly FMAQI by wind direction is provided in Figure 48 for all hours and for hours where FMAQI was 6 or greater.

Figure 48: Hourly FMAQI values by wind direction at Bertha Ganter-Fort McKay for 2014. (All hours and hours with FMAQI > 6).





ALL HOURS

HOURS WITH FMAQI > 6

5.1.5 Measurements from Environment Canada (EC) site Fort McKay Oski ôtin

The Fort McKay Oski ôtin EC site is located approximately 0.6 km south of Bertha Ganter-Fort McKay. As discussed earlier, measurements from this site were available for total sulphur (1-minute averages), black carbon (1-minute averages), particulate PAH (1-minute averages) and BTEX species (two measurements per hour) for January through August/October 2014 and pollution dose plots have been created using calculated hourly averages and wind direction data from Bertha Ganter (meteorological data were not found online for Fort McKay Oski ôtin). These plots are provided in Figures 49 and 50 (note different units and scales).

Figure 49: Total Sulphur dose (ppb), black carbon absorption dose (inverse megametres) and particulate PAH dose (ng/m³ –qualitative) at Fort McKay Oski ôtin.

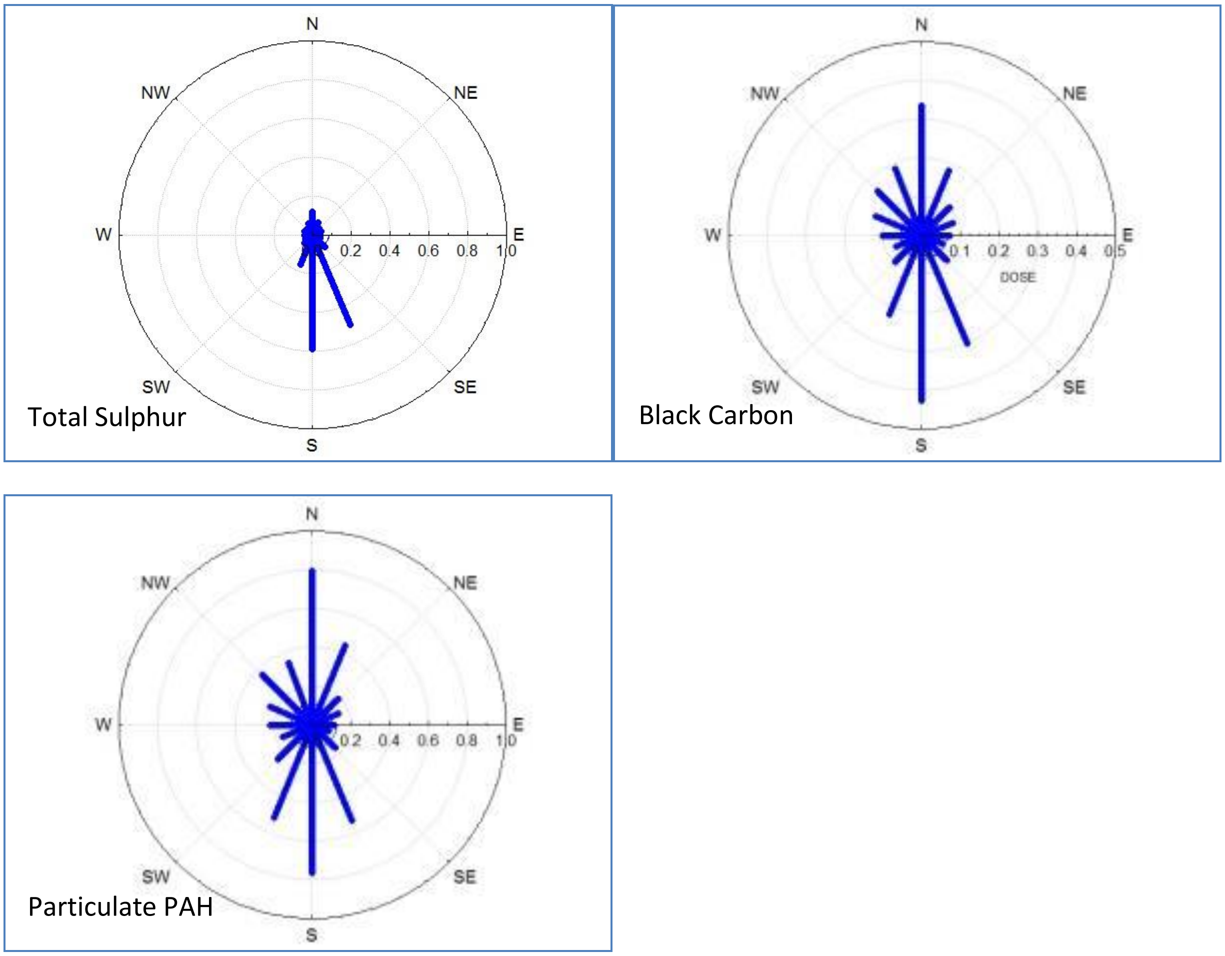
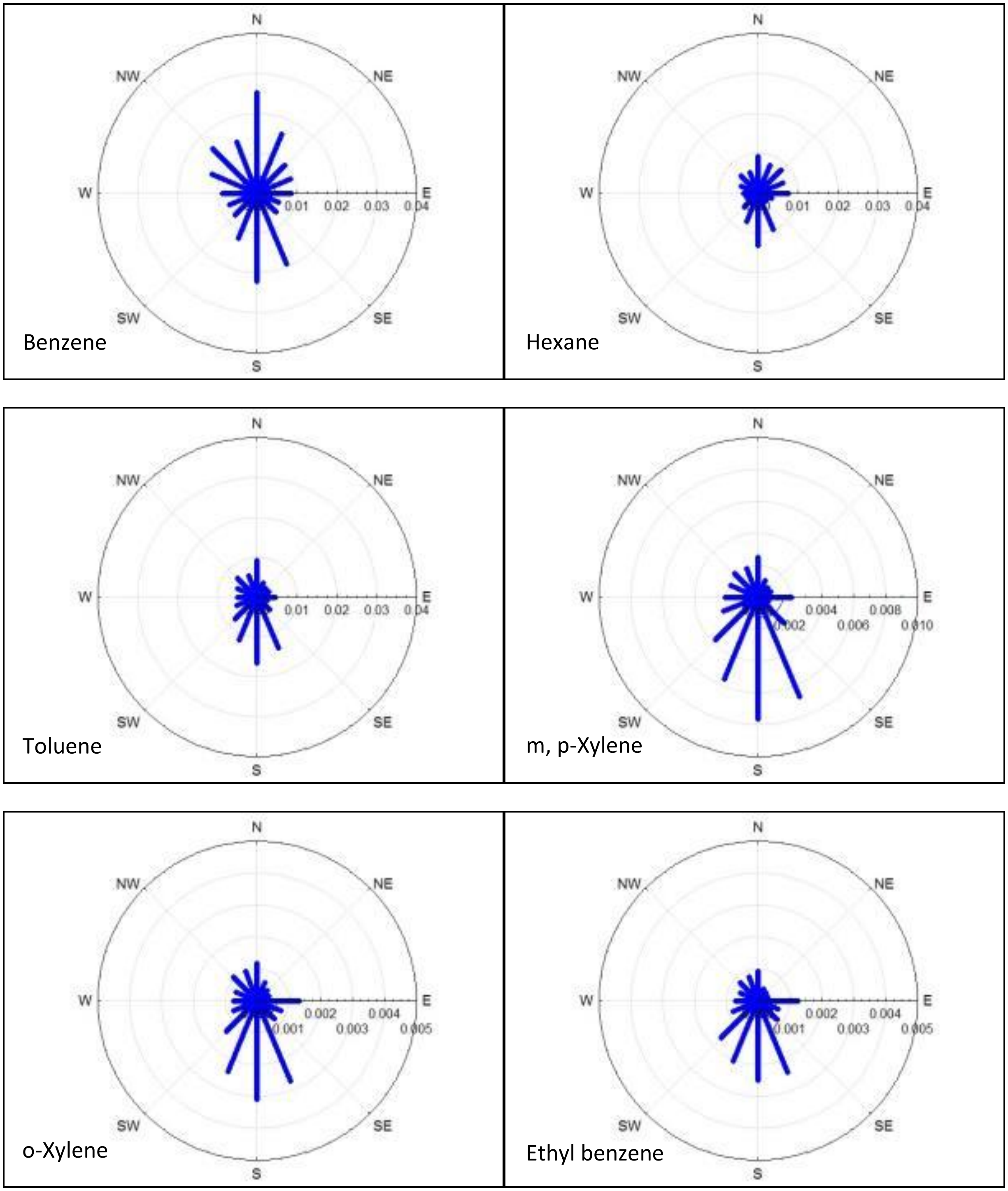


Figure 50: BTEX species dose (ppb) at Fort McKay Oski ôtin (January – October, 2014).



5.2 Integration of Data to Aid in Odour Complaint Characterization

5.2.1 Community Odour Monitoring Project (COMP) Complaints

As discussed in Section 4.7.1, for the COMP project there were a total of 138 unique complaints recorded in 2014. Some of these observations spanned multiple hours and the total hours with potential odour complaints amounted to 312 over the year. Table 37 provides a listing of the observations and hourly average of TRS, NMHC, SO_2, nitric oxide and $PM_{2.5}$ concentrations at the Patricia McInnes (AMS#6) and Athabasca Valley (AMS#7) monitoring sites for each hour. TRS, NMHC and SO_2 should be indicators of industrial emissions resulting in odours while nitric oxide can be an indicator of stagnant air and $PM_{2.5}$ is an indicator of smoke and potential forest fires. Table 38 shows the percentage of complaint hours that were associated with the individual air quality parameters being measured at the 95^{th} percentile value or higher. Twelve of the complaint hours were associated with TRS values greater than or equal to 1.5 ppb at Patricia McInnes and five hours at Athabasca Valley. Very high $PM_{2.5}$ values were measured on a number of days with odour complaints with the majority of odours described as "burnt/smoke". Some of the more interesting episodes are discussed in the following section.

Detailed meteorological data for the episode hours are found in Table A-1 of Appendix A. Table A-2 shows the five-minute maximum TRS, NMHC and SO_2 values for each complaint hour. The proposed Alberta odour indicator threshold for 5-minute TRS of 2.55 was reached for only 3 percent of complaint hours and the SO_2 and the suggested NMHC thresholds were never reached.

The wind roses for the two sites for COMP complaint hours were shown in Figure 34. Most complaints were associated with NNE or NE wind directions and with wind speeds greater than 7 km/h.

Table 37: Concentrations of air quality parameters for COMP complaint hours in Fort McMurray (measurements greater than or equal to 95th percentile are highlighted).

Date	Hour	#	Type of Odour	Intensity	Appreciation	TRS		NMHC		SO_2		NO		$PM_{2.5}$	
						AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
95th Percentile						0.8	0.7	0.03	0.07	5.2	3.4	11.3	41.0	20.0	22.0
1/9/14	6	1	Burnt / smoke	Weak	Unpleasant	0.3	0.5	0.00	0.02	0.5	0.4	8.0	27.5	11.7	11.9
1/9/14	18	2	Asphalt / tar	Medium	Unpleasant	0.6	0.8	0.20	0.06	0.6	0.6	12.8	45.3	13.6	17.9
1/10/14	7	3	Fuel / solvent	Weak	Unpleasant	0.4	0.7	0.09	0.04	4.2	2.8	1.9	4.0	5.4	7.0
1/10/14	15	4	Fuel / solvent	Weak	Unpleasant	0.4	0.7	0.05	0.16	0.6	2.1	4.8	34.1	6.0	10.9
1/17/14	16	5	Fecal / septic	Medium	Unpleasant	0.3	0.3	0.00	0.01	0.2	0.6	0.0	26.5	1.1	5.0
1/18/14	15	6	Burnt / smoke	Medium	Neutral	0.3	0.6	0.20	0.09	0.5	0.6	13.0	61.9	2.9	11.4
1/18/14	16	6	Burnt / smoke	Medium	Neutral	0.5	1.0	0.12	0.04	2.1	0.6	12.0	60.1	5.8	13.6
1/18/14	17	7	Asphalt / tar	Very High		0.7	1.0	0.22	0.06	4.0	2.3	7.0	38.5	6.1	12.8
1/18/14	18	7	Asphalt / tar	Very High		0.7	0.8	0.23	0.01	6.7	4.3	1.9	12.2	8.8	9.0
1/18/14	19	8	Fuel / solvent	Medium	Unpleasant	0.8	0.9	0.32	0.00	6.5	3.7	2.5	12.3	9.5	8.2
1/19/14	11	9	Asphalt/tar, Ammonia / Cat's pee,	High	Very Unpleasant	0.5	1.2	0.14	0.06	1.3	0.9	3.3	48.6	9.3	18.7
1/25/14	15	10	Chemical / Plastic	High	Very Unpleasant	0.4	0.5	0.05	0.00	6.5	3.2	1.9	18.6	8.8	6.0
2/14/14	12	11	Fecal / septic	Medium	Unpleasant		0.9		0.11	11.4	8.0	39.1	45.6	14.9	17.9
3/13/14	18	12	Asphalt / tar	High	Very Unpleasant	0.4	0.3	0.02	0.00	7.4	1.9	4.9	1.0	8.1	4.0
3/17/14	9	13	Asphalt / tar, Fuel / solvent,	Weak	Unpleasant	0.4	0.9	0.19	0.11	0.4	0.8	6.8	39.7	7.0	6.4
3/17/14	10	13	Asphalt / tar, Fuel / solvent,	Weak	Unpleasant	0.3	0.4	0.02	0.00	4.3	1.5	3.3	3.3	5.4	6.1
3/17/14	11	13	Asphalt / tar, Fuel / solvent,	Weak	Unpleasant	0.3	0.3	0.00	0.00	2.5	2.1	0.9	4.4	3.9	5.5
3/17/14	12	13	Asphalt / tar, Fuel / solvent,	Weak	Unpleasant	0.3	0.4	0.00	0.00	2.1	7.0		2.4	2.7	5.0
3/17/14	13	13	Asphalt / tar, Fuel / solvent,	Weak	Unpleasant	0.3	0.4	0.00	0.00	12.5	7.3	3.2	3.8	5.1	5.1
3/17/14	14	13	Asphalt / tar, Fuel / solvent,	Weak	Unpleasant	0.2	0.4	0.00	0.00	2.5	9.2	0.9	3.0	2.8	6.0
3/17/14	16	14	Fuel / solvent	Weak	Unpleasant	0.2	0.4	0.00	0.00	2.8	6.8	1.4	1.9	3.4	7.5
3/18/14	18	15	Fuel / solvent	Weak	Unpleasant	0.2	0.3	0.01	0.00	1.5	1.5	10.3	1.4	3.1	4.6
3/19/14	7	16	Fecal / septic	Weak	Unpleasant	0.3	0.3	0.16	0.00	0.4	0.3	34.5	15.1	5.6	5.1
4/3/14	8	17	Fuel / solvent	Weak	Unpleasant	0.5	0.6	0.00	0.00	3.4	1.2	13.4	54.7	4.3	10.0
5/1/14	2	18	Ammonia / Cat's pee	Medium	Unpleasant	0.1	0.1		0.00		0.2		0.0	2.6	5.5
5/1/14	7	19	Asphalt / tar	Medium	Very Unpleasant	0.1	1.0	0.00	0.00	0.3	1.0	0.2	0.9	3.3	11.7
5/1/14	9	20	Asphalt / tar	Medium	Unpleasant	0.1	0.4	0.00	0.00	0.6	1.3	0.4	0.9	3.8	7.9
5/3/14	2	21	Chemical / Plastic	Medium	Very Unpleasant	0.2	0.7		0.00		1.8		0.0	2.0	1.8
5/7/14	9	22	Fuel / solvent	Medium	Unpleasant	0.4	0.5	0.00	0.00	1.3	5.5	2.8	6.0	2.6	6.2

DATE	HOUR	#	Type of Odour	Intensity	Appreciation	TRS		NMHC		SO_2		NO		$PM_{2.5}$	
						AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
5/7/14	9	23	Fuel / solvent	Weak	Unpleasant	0.4	0.5	0.00	0.00	1.3	5.5	2.8	6.0	2.6	6.2
5/9/14	9	24	Asphalt / tar	Medium	Unpleasant	0.3	0.4	0.00	0.00	3.6	4.9	1.3	7.7	4.0	5.9
5/9/14	10	25	Fuel / solvent	Weak	Unpleasant	0.2	0.2	0.00	0.00	1.4	2.4	0.1	0.3	1.3	4.1
5/10/14	19	26	Fuel / solvent	Weak	Unpleasant	0.2	0.4	0.00	0.00	0.2	4.8	0.5	0.2	1.4	2.5
5/14/14	9	27	Other: sewage	Medium	Unpleasant	0.2	0.3	0.00	0.00	0.3	0.5	1.4	2.5	2.1	5.3
5/15/14	9	28	Other: Smells like manure / fecal	and burning animal hair	Medium	0.2	1.0	0.01	0.00	0.1	0.3	1.9	0.9	5.4	5.7
5/17/14	10	29	Other: sewer	Medium	Unpleasant	0.1	0.2	0.00	0.00	0.3	0.4	0.6	1.7	3.7	6.6
5/17/14	22	30	Fecal / septic	High	Unpleasant	0.6	0.1	0.00	0.00	0.2	0.3	0.4	0.1	9.7	8.9
5/18/14	14	31	Fuel / solvent	Medium	Unpleasant	0.3	0.2	0.00	0.00	3.8	1.9	1.0	0.7	7.2	7.8
5/21/14	11	32	Other: sewer	High	Very Unpleasant	0.2	0.4	0.00	0.00	0.1	0.3	0.2	0.5	2.1	4.9
5/26/14	9	33	Other: sewage	High	Very Unpleasant	0.2	0.2	0.00	0.00	0.1	0.2	0.9	2.0	10.7	6.7
5/26/14	9	34	Burnt / smoke	Weak	Unpleasant	0.2	0.2	0.00	0.00	0.1	0.2	0.9	2.0	10.7	6.7
5/26/14	10	33	Other: sewage	High	Very Unpleasant	0.2	0.3	0.00	0.00	0.2	0.2	0.6	1.0	7.8	7.1
5/28/14	19	35	Other: Smells a little like manure	Weak	Unpleasant	0.1	0.1	0.00	0.00	0.1	0.3	1.3	0.7	6.1	8.5
5/29/14	9	36	Rotten Egg	Medium	Unpleasant	0.1	0.6	0.00	0.00	0.1	0.3	1.3	1.4	4.2	2.5
5/29/14	14	37	Asphalt / tar	High	Very Unpleasant	0.5	1.2	0.01	0.03	0.4	0.3	2.7	6.7	1.6	9.8
5/29/14	15	37	Asphalt / tar	High	Very Unpleasant	0.5	0.5	0.01	0.01	0.4	0.3	1.6	4.5	1.3	6.6
5/29/14	16	38	Rotten Egg	Medium	Unpleasant	0.7	0.9	0.00	0.00	1.0	0.5		1.2	1.3	6.4
5/29/14	17	39	Fuel / solvent	Weak	Unpleasant	0.3	0.6	0.02	0.00	2.4	1.8		1.5	2.2	9.7
5/29/14	18	40	Ammonia / Cat's pee	Medium	Very Unpleasant	0.2	0.1	0.04	0.00	2.9	1.4		0.2	4.6	10.7
5/31/14	9	41	Asphalt / tar	Medium	Unpleasant	0.7	1.1	0.00	0.00	6.9	10.6	3.3	5.0	8.6	7.0
5/31/14	10	42	Asphalt / tar	High	Unpleasant	0.7	0.6	0.00	0.00	10.1	6.1	3.8	2.4	6.3	6.4
5/31/14	12	43	Fuel / solvent	Weak	Unpleasant	0.5	0.4	0.01	0.00	10.3	5.8	3.7	2.2	4.7	5.9
6/1/14	13	44	Other: smells like rotten dead animal	Weak	Unpleasant	0.2	0.2	0.00	0.00	0.1	0.5	0.4	0.5	5.4	7.9
6/2/14	7	45				0.1	0.1	0.00	0.00	0.1	0.2	0.5	4.9	2.5	4.7
6/2/14	19	46	Asphalt / tar	Medium	Unpleasant	0.2	0.2	0.00	0.00	2.1	1.5	0.8	0.3	7.6	5.6
6/2/14	22	47	Other: hydrocarbon	Weak	Unpleasant	0.3	0.4	0.02	0.00	0.1	0.3	0.1	0.1	10.7	5.4
6/2/14	22	48	Asphalt / tar	Medium	Unpleasant	0.3	0.4	0.02	0.00	0.1	0.3	0.1	0.1	10.7	5.4
6/3/14	6	49	Asphalt / tar	Medium	Unpleasant	0.8	0.5	0.26	0.01	0.3	0.3	10.4	4.8	11.4	9.6
6/3/14	7	49	Asphalt / tar	Medium	Unpleasant	0.5	1.0	0.03	0.00	0.2	0.3	5.5	7.3	10.6	9.1
6/3/14	8	49	Asphalt / tar	Medium	Unpleasant	0.5	1.3	0.00	0.00	0.2	0.8	5.2	8.4	10.8	9.1
6/3/14	8	50	Asphalt / tar	High	Very Unpleasant	0.5	1.3	0.00	0.00	0.2	0.8	5.2	8.4	10.8	9.1
6/3/14	8	51	Asphalt / tar	High	Very Unpleasant	0.5	1.3	0.00	0.00	0.2	0.8	5.2	8.4	10.8	9.1
6/3/14	8	52	Fuel / solvent	Medium	Unpleasant	0.5	1.3	0.00	0.00	0.2	0.8	5.2	8.4	10.8	9.1
6/3/14	20	53	Ammonia / Cat's pee	Medium	Very Unpleasant	0.3	0.4	0.00	0.00	1.4	1.6	0.6	0.2	7.4	13.1
6/3/14	24	54	Asphalt / tar	High	Very Unpleasant	0.2	0.9	0.00	0.00	1.5	1.4	0.0	0.0	9.6	6.8
6/4/14	8	55	Asphalt / tar	Weak	Unpleasant	0.2	1.1	0.00	0.00	1.9	2.6	1.2	1.6	3.0	5.2

DATE	HOUR	#	Type of Odour	Intensity	Appreciation	TRS		NMHC		SO_2		NO		$PM_{2.5}$	
						AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
6/4/14	13	56	Fuel / solvent	Medium	Unpleasant	0.2	0.5		0.00		1.5		1.0	2.2	2.9
6/5/14	9	57	Fuel / solvent	Weak	Unpleasant	0.2	0.3	0.00	0.00	1.5	1.3	1.0	0.4	0.6	1.2
6/6/14	10	58	Fuel / solvent	Weak	Unpleasant		0.4	0.00	0.00	7.9	3.4	3.7	1.9	7.7	4.0
6/6/14	19	59	Fecal / septic	Medium	Unpleasant	0.3	0.3	0.00	0.00	4.4	4.5	2.1	0.7	5.6	9.9
6/7/14	13	60	Asphalt / tar	Medium	Unpleasant	0.4	0.2	0.00	0.00	5.2	1.3	3.0	2.6	7.0	8.5
6/8/14	10	61	Ammonia / Cat's pee	Medium	Unpleasant	0.2	0.2	0.00	0.00	0.9	0.9	0.2	1.3	3.2	7.3
6/10/14	7	62	Asphalt / tar	Weak	Very Unpleasant	0.2	0.4	0.00	0.00	0.2	0.4	1.5	2.1	5.4	3.4
6/12/14	11	63	Fecal / septic	High	Very Unpleasant	0.3	0.6	0.00	0.00	2.1	2.7	2.0	0.9	5.6	10.4
6/14/14	10	64				0.3	0.4	0.00	0.01	0.2	0.7	0.8	2.4	3.8	9.6
6/16/14	7	65	Other: smells like manure	Medium	Unpleasant	0.3	0.4	0.00	0.00	0.1	0.3	4.9	5.4	16.0	14.3
6/16/14	15	66	Skunk	Very Weak	Very Unpleasant	0.2	0.1	0.00		0.1		0.4		3.2	7.5
6/16/14	16	67	Fecal / septic	Weak	Unpleasant	0.2	0.2	0.00	0.00	0.2	0.4	0.4	0.4	3.2	6.4
6/16/14	20	68		High	Very Unpleasant	0.2	0.2	0.00	0.01	0.2	0.3	1.1	1.4	4.9	15.2
6/17/14	19	69	Skunk	Weak	Unpleasant	0.2	0.2	0.00	0.00	0.1	0.3	4.0	0.3	1.9	4.5
6/19/14	8	70	Rotten Egg	High	Very Unpleasant	0.2	0.3	0.00	0.02	0.3	0.4	2.2	7.4	7.9	14.0
6/20/14	9	71	Asphalt / tar	Medium	Unpleasant	0.5	0.3	0.00	0.05	0.7	0.4	6.6	6.7	14.8	5.7
6/20/14	9	72	Fuel / solvent	Medium	Unpleasant	0.5	0.3	0.00	0.05	0.7	0.4	6.6	6.7	14.8	5.7
6/20/14	9	73	Asphalt / tar	Medium	Unpleasant	0.5	0.3	0.00	0.05	0.7	0.4	6.6	6.7	14.8	5.7
6/21/14	7	74	Asphalt / tar	Weak	Unpleasant	0.5	0.3		0.03	0.9	0.7	1.0	2.0	5.5	8.0
6/21/14	8	74	Asphalt / tar	Weak	Unpleasant	0.8	0.6		0.03	1.3	0.7	0.5	1.4	8.2	9.4
6/21/14	9	74	Asphalt / tar	Weak	Unpleasant	0.6	0.5		0.03	0.5	0.4	0.4	1.1	8.0	6.8
6/21/14	8	75	Asphalt / tar	Medium	Unpleasant	0.8	0.6		0.03	1.3	0.7	0.5	1.4	8.2	9.4
6/21/14	9	76	Rotten Egg	High	Unpleasant	0.6	0.5		0.03	0.5	0.4	0.4	1.1	8.0	6.8
6/21/14	9	77	Asphalt / tar	Medium	Unpleasant	0.6	0.5		0.03	0.5	0.4	0.4	1.1	8.0	6.8
6/21/14	9	78	Asphalt / tar	Weak	Unpleasant	0.6	0.5		0.03	0.5	0.4	0.4	1.1	8.0	6.8
6/21/14	10	78	Asphalt / tar	Weak	Unpleasant	0.5	0.4		0.02	0.5	0.5	0.6	0.8	6.1	9.1
6/21/14	11	79	Asphalt / tar	High	Very Unpleasant	0.4	0.4		0.03	1.4	0.4	0.6	0.7	6.2	6.6
6/21/14	12	80	Ammonia / Cat's pee	High	Very Unpleasant	0.4	0.5		0.02	0.9	0.4	0.5	0.1	3.6	6.4
6/22/14	14	81	Fuel / solvent	Medium	Unpleasant	0.5	0.3		0.02	7.1	3.4	1.6	1.5	8.3	7.9
6/23/14	6	82	Asphalt / tar	Weak	Unpleasant	0.6	0.2		0.04	0.4	0.3	2.9	8.7	10.0	15.3
6/23/14	7	82	Asphalt / tar	Weak	Unpleasant	0.6	0.3		0.04	0.5	0.4	10.9	8.1	10.6	14.0
6/23/14	8	83	Chemical / Plastic	High	Unpleasant	0.6	0.2		0.04	0.7	0.3	8.8	9.8	12.8	13.2
6/23/14	9	84	Other: smoke/bitumen	Medium	Unpleasant	0.7	0.3		0.10	1.3	0.4	7.3	10.2	16.6	12.9
6/26/14	21	85	Burnt / smoke	Weak	Neutral	0.3	0.5	0.00	0.02	0.8	0.4	1.2	0.3	3.3	3.5
6/26/14	21	86	Burnt / smoke	Weak	Neutral	0.3	0.5	0.00	0.02	0.8	0.4	1.2	0.3	3.3	3.5
6/26/14	22	87	Burnt / smoke	Very High	Very Unpleasant	0.6	0.5	0.00	0.03	1.0	0.4	0.2	0.4	5.0	5.1
6/26/14	22	88	Asphalt / tar	Very High	Very Unpleasant	0.6	0.5	0.00	0.03	1.0	0.4	0.2	0.4	5.0	5.1
6/26/14	22	89	Asphalt / tar	Medium	Unpleasant	0.6	0.5	0.00	0.03	1.0	0.4	0.2	0.4	5.0	5.1
6/26/14	23	90	Asphalt / tar	High	Very Unpleasant	0.8	0.7	0.00	0.04	1.0	0.4	0.3	0.0	8.7	7.9

DATE	HOUR	#	Type of Odour	Intensity	Appreciation	TRS		NMHC		SO_2		NO		$PM_{2.5}$	
						AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
6/27/14	8	91	Asphalt / tar	Medium	Very Unpleasant	0.3	0.5	0.00	0.03	0.6	0.3	5.9	6.4	11.6	8.4
6/27/14	9	91	Asphalt / tar	Medium	Very Unpleasant	0.2	0.6	0.00	0.06	0.6	0.3	4.9	5.5	10.4	9.0
6/27/14	10	92	Asphalt / tar	Medium	Unpleasant	0.2	0.6	0.01	0.04	0.6	0.5	1.4	3.1	5.3	6.3
6/27/14	12	93	Burnt / smoke	High	Unpleasant	0.2	0.5	0.00	0.01	0.5	0.4	0.7	0.0	5.3	5.1
6/27/14	13	93	Burnt / smoke	High	Unpleasant	0.1	0.5	0.00	0.01	0.5	0.5	0.7	1.5	4.8	6.6
6/27/14	13	94	Burnt / smoke	Weak	Unpleasant	0.1	0.5	0.00	0.01	0.5	0.5	0.7	1.5	4.8	6.6
6/27/14	14	93	Burnt / smoke	High	Unpleasant	0.2	0.5	0.00	0.01	0.5	0.4	0.8	2.3	5.8	4.9
6/27/14	15	93	Burnt / smoke	High	Unpleasant	0.2	0.6	0.00	0.01	0.6	0.3	0.4	2.1	5.0	5.8
6/27/14	16	93	Burnt / smoke	High	Unpleasant	0.1	0.5	0.00	0.02	0.4	0.4	0.8	1.0	3.9	4.2
6/27/14	17	93	Burnt / smoke	High	Unpleasant	0.2	0.5	0.00	0.01	0.5	0.3	0.2	0.3	2.8	7.8
6/27/14	18	95	Burnt / smoke	High	Very Unpleasant	0.2	0.6	0.00	0.01	0.6	0.4	0.6	0.0	5.5	5.8
6/28/14	8	96	Fuel / solvent	Weak	Unpleasant	0.7	0.7	0.00	0.06	0.7	0.4	11.6	9.9	7.8	16.7
6/29/14	8	97	Burnt / smoke	Medium	Neutral	0.8	1.6	0.00	0.13	4.7	0.8	2.6	8.5	25.9	23.3
6/29/14	10	98	Burnt / smoke	Medium	Neutral	0.9	0.6	0.00	0.02	9.8	2.2	2.0	0.1	26.2	27.9
6/29/14	11	99	Ammonia / Cat's pee	High	Unpleasant	0.4	0.5	0.00	0.02	2.3	0.9	0.3	0.0	22.5	23.7
6/29/14	12	99	Ammonia / Cat's pee	High	Unpleasant	0.5	0.4	0.00	0.00	4.2	0.9	0.3	0.0	33.2	30.5
6/29/14	13	100	Burnt / smoke	Medium	Neutral	0.3	0.4	0.00	0.00	2.6	0.9	0.3	0.0	36.0	37.0
6/29/14	14	101	Fecal / septic	Medium	Unpleasant	0.4	0.3	0.00	0.00	1.6	0.7	0.1	0.1	29.0	31.9
6/29/14	15	102	Burnt / smoke	Weak	Unpleasant	0.3	0.4	0.00	0.00	1.2	0.3	0.1	0.0	16.8	17.6
6/29/14	16	102	Burnt / smoke	Weak	Unpleasant	0.4	0.3	0.00	0.00	1.4	0.6	0.1	0.1	25.4	20.6
6/29/14	17	102	Burnt / smoke	Weak	Unpleasant	0.4	0.4	0.00	0.01	2.2	1.2	0.2	0.0	37.1	26.6
6/29/14	18	103	Burnt / smoke	Medium	Unpleasant		0.5		0.02		1.6		0.0		23.6
6/29/14	19	104	Burnt / smoke	Medium	Unpleasant		0.4		0.01		2.5		0.0		24.3
6/29/14	20	104	Burnt / smoke	Medium	Unpleasant		0.5		0.01		3.1		0.0		22.6
6/29/14	21	104	Burnt / smoke	Medium	Unpleasant	0.3	1.8		0.02	0.8	1.1	0.2	0.0	26.8	18.6
6/29/14	22	105	Ammonia / Cat's pee	High	Very Unpleasant	1.3	0.6	0.00	0.01	5.1	0.6	0.1	0.0	26.8	16.0
6/29/14	23	106	Fuel / solvent, fecal / septic	High	Unpleasant	0.9	1.5	0.00	0.03	5.7	1.5	0.1	0.0	30.9	15.9
6/30/14	8	107	Burnt / smoke	Medium	Neutral	0.7	1.2	0.00	0.07	5.0	4.2	2.2	1.4	44.7	40.4
6/30/14	9	108		Weak	Neutral	0.7	0.7	0.00	0.03	8.3	4.3	1.6	0.1	32.7	27.1
6/30/14	10	109	Fuel / solvent	High	Unpleasant	0.5	0.9	0.00	0.04	2.5	6.5	1.1	1.5	20.6	23.2
6/30/14	11	109	Fuel / solvent	High	Unpleasant	0.4	1.0	0.00	0.04	3.6	6.9	0.9	1.0	13.7	15.3
6/30/14	12	109	Fuel / solvent	High	Unpleasant	0.4	0.6	0.00	0.02	2.9	3.2	0.5	0.1	13.7	14.4
6/30/14	13	110	Burnt / smoke	Medium	Neutral	0.4	0.5	0.00	0.01	2.6	1.7	0.9	0.0	13.1	15.7
7/1/14	8	111	Rotten Egg	High	Unpleasant	0.6	0.5	0.00	0.08	0.7	0.5	1.8	6.6	14.2	11.4
7/1/14	9	111	Rotten Egg	High	Unpleasant	0.4	0.6	0.00	0.04	0.7	0.5	1.1	7.8	11.7	16.3
7/1/14	10	111	Rotten Egg	High	Unpleasant	0.3	0.5	0.00	0.04	0.8	0.5	0.8	6.2	11.0	15.8
7/1/14	11	111	Rotten Egg	High	Unpleasant	0.3	0.5	0.00	0.03	1.0	0.7	0.7	2.2	8.0	12.1
7/1/14	12	112	Fecal / septic	Medium	Unpleasant	0.2	0.5	0.00	0.02	1.1	1.0	0.6	0.6	7.1	13.1

DATE	HOUR	#	Type of Odour	Intensity	Appreciation	TRS		NMHC		SO_2		NO		$PM_{2.5}$	
						AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
7/3/14	24	113	Fuel / solvent	Medium	Unpleasant	0.8	0.7	0.00	0.06	0.7	0.4	0.9	0.0	16.9	18.0
7/7/14	7	114	Burnt / smoke	Weak	Unpleasant	0.3	0.3	0.00	0.01	0.3	0.4	0.1	8.8	39.1	23.0
7/7/14	7	115	Burnt / smoke	Weak	Neutral	0.3	0.3	0.00	0.01	0.3	0.4	0.1	8.8	39.1	23.0
7/7/14	8	116	Burnt / smoke	High	Unpleasant	0.4	0.3	0.00	0.02	0.4	0.4	0.1	2.2	34.8	28.7
7/7/14	9	116	Burnt / smoke	High	Unpleasant	0.4	0.4	0.00	0.04	0.6	0.4	0.2	1.7	53.8	35.7
7/7/14	10	116	Burnt / smoke	High	Unpleasant	0.4	0.4	0.00	0.05	0.6	0.9	0.3	1.4	59.5	60.7
7/7/14	10	117	Burnt / smoke	Weak	Neutral	0.4	0.4	0.00	0.05	0.6	0.9	0.3	1.4	59.5	60.7
7/7/14	10	118	Burnt / smoke	Medium	Unpleasant	0.4	0.4	0.00	0.05	0.6	0.9	0.3	1.4	59.5	60.7
7/7/14	10	119	Burnt / smoke	Medium	Unpleasant	0.4	0.4	0.00	0.05	0.6	0.9	0.3	1.4	59.5	60.7
7/7/14	11	116	Burnt / smoke	High	Unpleasant	0.5	0.7	0.00	0.05	1.9	1.8	0.6	0.9	50.0	81.1
7/7/14	12	116	Burnt / smoke	High	Unpleasant	0.5	0.6	0.00	0.05	1.7	2.6	0.4	0.7	48.5	74.1
7/7/14	13	120	Burnt / smoke	Medium	Neutral	0.3	0.3	0.00	0.04	0.3	1.2	0.1	0.1	45.0	59.3
7/7/14	14	120	Burnt / smoke	Medium	Neutral	0.3	0.4	0.00	0.03	0.3	0.8	0.1	0.0	46.2	51.9
7/7/14	15	120	Burnt / smoke	Medium	Neutral	0.3	0.3	0.00	0.03	0.2	0.6	0.1	0.0	50.7	56.7
7/7/14	16	120	Burnt / smoke	Medium	Neutral	0.3	0.4	0.00	0.04	0.4	0.6	0.6	0.6	45.1	43.8
7/7/14	17	121	Burnt / smoke	Medium	Neutral	0.3	0.4	0.00	0.03	0.4	0.6	1.0	0.1	36.9	35.2
7/8/14	15	122		Weak	Neutral	0.2	0.4	0.00	0.01	0.1	0.3	0.2	0.7	19.0	26.9
7/8/14	21	123	Skunk	Medium	Unpleasant	0.2	0.4	0.00	0.10	0.1	0.3	0.7	6.5	5.8	11.3
7/8/14	21	124	Skunk	Medium	Unpleasant	0.2	0.4	0.00	0.10	0.1	0.3	0.7	6.5	5.8	11.3
7/11/14	13	125	Ammonia / Cat's pee	Medium	Unpleasant	0.1	0.9	0.00	0.02	0.6	0.6	0.2	104.1	7.1	11.4
7/12/14	9	127	Burnt / smoke	Medium	Unpleasant	1.9	1.2	0.00	0.04	7.1	2.0	3.0	6.6	23.2	26.1
7/12/14	10	126	Fuel / solvent	Medium	Unpleasant	1.1	1.2	0.00	0.05	3.9	3.4	1.3	3.4	36.2	32.1
7/12/14	11	126	Fuel / solvent	Medium	Unpleasant	0.5	1.1	0.00	0.04	3.4	4.7	0.8	2.6	35.1	36.0
7/12/14	12	128	Burnt / smoke	Medium	Unpleasant	0.4	0.8	0.00	0.02	7.0	5.9	1.1	1.8	35.4	35.6
7/12/14	22	129	Burnt / smoke	High	Unpleasant	0.4	0.7	0.00	0.07	1.4	1.6	0.0	0.0	59.9	62.8
7/16/14	9	130	Burnt / smoke	Medium	Unpleasant	0.2	0.6	0.00	0.12	0.4	0.6	2.3	5.0	21.7	27.0
7/16/14	10	130	Burnt / smoke	Medium	Unpleasant	0.3	0.6	0.00	0.14	0.3	0.6	1.0	6.9	21.7	26.4
7/16/14	11	130	Burnt / smoke	Medium	Unpleasant	0.6	0.7	0.00	0.15	1.1	0.6	0.5	6.4	27.4	34.3
7/16/14	12	131	Asphalt / tar	Medium	Unpleasant	1.1	1.0	0.00	0.15	2.5	1.0	1.2	2.8	32.1	44.5
7/16/14	13	131	Asphalt / tar	Medium	Unpleasant	0.7	0.9	0.01	0.14	2.5	1.0	0.4	0.4	30.5	55.4
7/16/14	14	132	Burnt / smoke	Medium	Neutral	0.8	1.5	0.00	0.09	7.1	2.0	2.1	0.5	47.5	76.5
7/17/14	9	133	Fuel / solvent	Medium	Neutral	0.6	0.9	0.00	0.07	0.5	0.9	5.3	6.8	14.9	10.4
7/17/14	15	134	Fuel / solvent	Weak	Unpleasant	0.2	0.4	0.00	0.03	0.3	0.6	0.1	0.0	10.8	10.2
7/18/14	8	135	Asphalt / tar	High	Unpleasant	1.0	0.8	0.00	0.07	0.7	0.6	3.2	6.4	9.1	10.6
7/18/14	8	136	Asphalt / tar, burnt / smoke,	Medium	Unpleasant	1.0	0.8	0.00	0.07	0.7	0.6	3.2	6.4	9.1	10.6
7/19/14	18	137	Burnt / smoke	Medium	Unpleasant	0.2	0.6	0.00	0.04	0.2	0.3	0.1	0.0	7.8	7.8
7/19/14	19	137	Burnt / smoke	Medium	Unpleasant	0.2	0.6	0.00	0.03	0.2	0.3	0.0	0.0	8.3	8.8
7/19/14	20	137	Burnt / smoke	Medium	Unpleasant	0.5	0.9	0.00	0.04	3.2	1.2	0.1	0.0	27.2	19.5

DATE	HOUR	#	Type of Odour	Intensity	Appreciation	TRS		NMHC		SO_2		NO		$PM_{2.5}$	
						AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
7/19/14	21	138	Fuel / solvent, asphalt / tar,	Very High	Very Unpleasant	0.5	0.6	0.00	0.03	2.8	0.5	0.1	0.0	50.1	50.0
7/19/14	22	137	Burnt / smoke	Medium	Unpleasant	0.4	0.6	0.00	0.02	1.3	0.5	0.0	0.0	59.8	50.3
7/20/14	10	139	Burnt / smoke	Medium	Neutral	0.3	0.5	0.00	0.04	5.7	0.6	0.4	1.9	38.3	32.1
7/20/14	11	139	Burnt / smoke	Medium	Neutral	0.3	0.6	0.00	0.04	4.1	3.6	0.2	0.7	34.2	35.5
7/20/14	12	140	Burnt / smoke	Medium	Neutral	0.3	0.6	0.00	0.04	6.1	9.5	0.4	0.6	41.2	43.2
7/25/14	7	141	Asphalt / tar	High	Unpleasant	1.1	0.3	0.00	0.01	0.7	0.4	1.5	2.1	7.9	5.7
7/25/14	8	142	Asphalt / tar	Medium	Unpleasant	0.3	0.3	0.00	0.01	0.4	0.3	1.3	0.2	8.3	8.2
7/30/14	11	143	Asphalt / tar	High	Unpleasant	0.4	0.5	0.00	0.06	0.7	0.9	0.3	2.5	7.8	8.5
7/30/14	23	144	Burnt / smoke	Very High	Very Unpleasant	0.5	0.3	0.00	0.00	1.4	0.9	0.2	0.0	9.0	6.0
7/31/14	21	145	Burnt / smoke	High	Very Unpleasant	2.5	1.5	0.00	0.09	4.3	1.3	0.3	0.0	99.9	60.9
7/31/14	17	146	Burnt / smoke	Very High	Very Unpleasant	1.6	1.4	0.00	0.11	2.7	2.2	0.3	0.0	157.7	227.3
7/31/14	18	146	Burnt / smoke	Very High	Very Unpleasant	2.2	1.1	0.00	0.14	2.9	0.9	0.5	0.1	218.1	192.4
7/31/14	18	147	Burnt / smoke. Other: oil sands	High	Unpleasant	2.2	1.1	0.00	0.14	2.9	0.9	0.5	0.1	218.1	192.4
7/31/14	18	148	Burnt / smoke	Medium	Unpleasant	2.2	1.1	0.00	0.14	2.9	0.9	0.5	0.1	218.1	192.4
7/31/14	19	146	Burnt / smoke	Very High	Very Unpleasant	1.3	1.6	0.00	0.15	2.6	2.2	0.7	0.8	175.4	127.5
7/31/14	20	146	Burnt / smoke	Very High	Very Unpleasant	1.7	1.2	0.00	0.13	3.6	1.6	1.3	0.8	143.8	94.5
7/31/14	20	149	Ammonia / Cat's pee	High	Very Unpleasant	1.7	1.2	0.00	0.13	3.6	1.6	1.3	0.8	143.8	94.5
7/31/14	21	149	Ammonia / Cat's pee	High	Very Unpleasant	2.5	1.5	0.00	0.09	4.3	1.3	0.3	0.0	99.9	60.9
7/31/14	22	149	Ammonia / Cat's pee	High	Very Unpleasant	1.3	1.4	0.00	0.06	1.4	2.1	0.3	0.0	52.8	35.9
7/31/14	23	149	Ammonia / Cat's pee	High	Very Unpleasant	1.5	1.1	0.01	0.07	3.3	1.6	0.1	0.0	71.3	37.8
7/31/14	24	150	Burnt / smoke	Medium	Unpleasant	3.5	1.3	0.00	0.15	12.0	1.1	0.1	0.0	101.5	78.2
8/1/14	9	151	Burnt / smoke	Medium	Very Unpleasant	0.6	0.5	0.00	0.04	0.4	0.9	1.0	1.5	26.4	25.6
8/2/14	17	152	Burnt / smoke	Weak	Unpleasant	0.3	0.2	0.00	0.01	0.2	0.6	0.2	0.3	16.2	15.7
8/4/14	18	153	Burnt / smoke	High	Very Unpleasant	0.7	0.7	0.00	0.13	0.7	1.4	0.3	0.0	124.0	142.6
8/4/14	18	154	Burnt / smoke	High	Neutral	0.7	0.7	0.00	0.13	0.7	1.4	0.3	0.0	124.0	142.6
8/4/14	19	154	Burnt / smoke	High	Neutral	0.6	0.7	0.01	0.15	0.6	1.0	0.2	0.0	90.4	103.4
8/4/14	20	155	Burnt / smoke	High	Unpleasant	0.5	0.5	0.00	0.18	0.4	0.9	0.1	0.0	70.3	75.9
8/4/14	21	156	Burnt / smoke	Medium	Neutral	0.6	0.5	0.00	0.17	0.3	0.8	0.1	0.2	71.4	60.7
8/5/14	8	157	Burnt / smoke	Medium	Neutral	0.6	0.6	0.00	0.06	0.4	0.4		3.1	123.0	95.0
8/5/14	9	158	Burnt / smoke	High	Very Unpleasant	0.7	0.6	0.00	0.08	0.5	0.5		2.7	168.2	112.5
8/5/14	10	159	Burnt / smoke			0.8	0.6	0.00	0.15	0.7	0.8		1.8	191.6	137.3
8/5/14	11	159	Burnt / smoke			0.8	0.6	0.00	0.12	0.9	0.8		1.1	177.8	144.4
8/5/14	12	159	Burnt / smoke			0.7	0.5	0.00	0.13	0.8	0.9		1.8	149.5	136.3
8/5/14	13	160	Burnt / smoke	High	Unpleasant	0.5	0.3	0.00	0.10	0.6	1.0		0.9	118.4	108.2
8/5/14	14	160	Burnt / smoke	High	Unpleasant	0.4	0.4	0.01	0.08	0.4	0.9		0.5	84.2	87.8
8/5/14	15	161	Burnt / smoke	Medium	Neutral	0.4	0.3	0.00	0.06	0.6	1.1		0.8	66.4	70.2
8/7/14	7	162	Burnt / smoke	Medium	Neutral	0.4	0.5	0.00	0.03	0.1	0.2	0.2	0.7	14.6	27.5
8/7/14	11	163	Fuel / solvent	Medium	Unpleasant	0.2	0.3	0.00	0.00	0.0	0.3	1.0	0.1	0.9	3.4

DATE	HOUR	#	Type of Odour	Intensity	Appreciation	TRS		NMHC		SO_2		NO		$PM_{2.5}$	
						AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
8/8/14	11	164	Asphalt / tar, fuel / solvent,	Medium	Unpleasant	0.5	0.4	0.00	0.02	4.4	10.8	3.6	4.5	5.1	7.6
8/12/14	17	165	Rotten Egg	High	Unpleasant	0.5	0.3	0.00	0.03	0.6	0.8	2.0	0.7	3.5	7.3
8/14/14	12	166	Burnt / smoke	Medium	Unpleasant	0.8		0.00	0.10	10.7	4.3	0.6	0.8	34.9	42.4
8/14/14	13	166	Burnt / smoke	Medium	Unpleasant	0.6		0.00	0.06	4.4	6.8	0.3	0.2	33.9	49.0
8/14/14	13	167	Burnt / smoke	Medium	Neutral	0.6		0.00	0.06	4.4	6.8	0.3	0.2	33.9	49.0
8/14/14	14	166	Burnt / smoke	Medium	Unpleasant	0.6		0.00	0.04	4.8	4.2	1.0	0.1	30.3	35.3
8/16/14	10	168	Burnt / smoke	Medium	Neutral	0.6	0.2	0.00	0.05	0.4	0.2	1.1	3.4	32.6	25.0
8/17/14	10	169	Burnt / smoke	Medium	Unpleasant	0.5	0.2	0.00	0.02	5.4	7.8	0.6	0.9	3.9	8.9
8/17/14	11	169	Burnt / smoke	Medium	Unpleasant	0.5	0.3	0.00	0.02	1.7	10.7	0.2	0.9	2.6	9.0
8/18/14	16	170	Burnt / smoke	Medium	Neutral	0.6	0.3	0.00	0.06	0.3	0.7	0.2	14.3	18.8	23.9
8/18/14	17	170	Burnt / smoke	Medium	Neutral	1.1	1.1	0.00	0.09	0.3	0.7	0.7	1.2	16.7	24.3
8/18/14	18	171	Asphalt / tar	Weak	Neutral	0.8	1.3	0.00	0.11	0.9	1.2	0.3	1.1	16.6	26.9
8/18/14	19	172	Fuel / solvent	Weak	Unpleasant	0.5	0.7	0.00	0.09	0.4	1.9	0.2	0.0	16.1	27.9
8/19/14	7	173	Asphalt / tar	Weak	Neutral	0.8	0.5	0.00	0.06	2.2	1.8	2.0	8.1	26.2	17.0
8/20/14	13	174	Rotten Egg	High	Unpleasant	2.1	0.7	0.00	0.00	3.7	7.5	1.7	39.3	9.1	6.2
8/20/14	14	174	Rotten Egg	High	Unpleasant	1.6	1.0	0.00	0.03	2.9	10.5	1.3	10.6	7.6	7.4
8/21/14	19	175	Asphalt / tar, fuel / solvent,	High	Unpleasant	0.5	0.3	0.00	0.02	2.8	1.1	0.9	0.9	3.4	12.4
8/21/14	20	175	Asphalt / tar, fuel / solvent,	High	Unpleasant	0.3	0.3	0.00	0.04	0.2	0.5	0.5	0.8	4.0	12.2
8/23/14	21	176	Asphalt / tar	High	Unpleasant	0.5	0.5	0.00	0.02	0.3	0.4	1.5	1.2	11.2	26.2
8/24/14	8	177	Fuel / solvent	Medium	Unpleasant	1.5	1.0	0.00	0.02	0.4	0.5	19.0	13.2	13.6	10.4
8/24/14	9	178	Fuel / solvent	High	Very Unpleasant	1.5	1.0	0.00	0.09	0.5	0.6	11.0	22.1	11.4	13.3
8/24/14	10	179	Ammonia / Cat's pee	Weak	Unpleasant	0.9	0.7	0.00	0.10	0.4	0.7	11.4	14.3	9.1	13.1
8/24/14	11	179	Ammonia / Cat's pee	Weak	Unpleasant	0.6	1.0	0.00	0.06	0.3	0.7	4.8	12.1	5.3	11.6
8/26/14	14	180	Burnt / smoke	Weak	Unpleasant	0.3	0.2	0.01	0.04	0.3	0.7	0.3	33.2	17.1	32.8
8/26/14	21	181	Other: hydrocarbon	Medium	Unpleasant	0.5	0.5	0.00	0.08	0.6	0.6	0.6	0.3	13.0	20.6
8/26/14	21	182	Asphalt / tar	High	Very Unpleasant	0.5	0.5	0.00	0.08	0.6	0.6	0.6	0.3	13.0	20.6
8/30/14	10	183	Asphalt / tar	Medium	Unpleasant	0.4	0.1	0.00	0.01	0.1	0.4	0.3	1.7	8.0	11.3
9/2/14	21	184	Fuel / solvent	Weak	Unpleasant	0.4	0.7	0.00	0.02	1.4	3.1	0.2	5.5	3.8	10.2
9/4/14	19	185	Rotten Egg	Medium	Unpleasant	1.1	0.3	0.00	0.00	0.5	0.2	0.2	0.0	3.5	8.6
9/8/14	9	186	Fuel / solvent	Medium	Unpleasant	1.0	0.1	0.00	0.00	2.9	0.2	2.8	5.2	1.1	0.8
9/8/14	9	187	Fuel / solvent	Medium	Unpleasant	1.0	0.1	0.00	0.00	2.9	0.2	2.8	5.2	1.1	0.8
9/8/14	16	188	Ammonia / Cat's pee	Very High	Very Unpleasant	0.5	0.4	0.00	0.00	5.1	4.8	0.7	27.3	8.5	7.6
9/8/14	17	188	Ammonia / Cat's pee	Very High	Very Unpleasant	1.1	0.3	0.00	0.00	8.0	1.9	0.9	4.1	9.5	8.8
9/8/14	18	190	Unpleasant smell	High	Unpleasant	0.6	0.1	0.00	0.00	1.1	0.7	1.2	0.9	10.5	7.3
9/8/14	19	189	Ammonia / Cat's pee	Medium	Neutral	0.4	0.1	0.00	0.00	0.3	0.3	0.4	1.0	3.7	11.8
9/8/14	19	192	Ammonia / Cat's pee	Medium	Unpleasant	0.4	0.1	0.00	0.00	0.3	0.3	0.4	1.0	3.7	11.8
9/9/14	19	193	Fuel / solvent	Medium	Unpleasant	0.6	0.3	0.00	0.00	5.0	4.1	0.6	4.0	8.7	26.9

DATE	HOUR	#	Type of Odour	Intensity	Appreciation	TRS		NMHC		SO_2		NO		$PM_{2.5}$	
						AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
9/8/14	20	191	Ammonia / Cat's pee	Very High	Very Unpleasant	0.4	0.0	0.00	0.00	0.3	0.2	0.1	0.8	2.4	10.0
9/12/14	6	194	Asphalt / tar	Medium	Unpleasant		0.1	0.00	0.00	0.0	0.5	0.5	7.1	2.3	6.7
9/12/14	7	194	Asphalt / tar	Medium	Unpleasant	0.4	0.1	0.00	0.01	0.0	0.6	0.2	25.8	2.1	9.6
9/12/14	8	194	Asphalt / tar	Medium	Unpleasant	0.4	0.2	0.00	0.01	0.1	0.6	0.8	29.6	2.8	8.9
9/12/14	9	194	Asphalt / tar	Medium	Unpleasant	0.4	0.2	0.00	0.03	3.5	0.6	3.5	34.9	5.5	11.2
9/12/14	10	194	Asphalt / tar	Medium	Unpleasant	0.5	0.2	0.00	0.01	11.4	1.0	3.2	30.8	7.2	13.0
9/13/14	23	195	Burnt / smoke	Weak	Unpleasant	0.4	0.3	0.00	0.03	0.1	0.3	1.0	4.5	17.8	19.3
9/14/14	20	196	Burnt / smoke	Medium	Unpleasant	0.3	0.4	0.00	0.04	0.2	0.3	1.0	1.2	8.6	12.2
9/15/14	13	197	Ammonia / Cat's pee	High	Very Unpleasant	0.5	0.3	0.00	0.00	0.5	5.9	0.3	4.3		10.8
9/15/14	13	198	Fuel / solvent	Weak	Unpleasant	0.5	0.3	0.00	0.00	0.5	5.9	0.3	4.3		10.8
9/16/14	5	199	Ammonia / Cat's pee	Very High	Very Unpleasant	1.2		0.00	0.00	0.6	0.3	9.8	1.3	13.8	13.4
9/16/14	5	200	Fuel / solvent	Weak	Unpleasant	1.2		0.00	0.00	0.6	0.3	9.8	1.3	13.8	13.4
9/16/14	6	199	Ammonia / Cat's pee	Very High	Very Unpleasant	0.7	0.4	0.00	0.04	0.3	0.4	6.7	2.1	14.3	12.6
9/16/14	7	199	Ammonia / Cat's pee	Very High	Very Unpleasant	0.5	0.1	0.00	0.03	0.2	0.3	4.0	3.5	14.0	10.8
9/18/14	11	201	Fuel / solvent	Medium	Unpleasant	0.6	0.9	0.00	0.03	0.6	1.0	6.6	26.8	8.6	9.1
9/21/14	11	202	Fuel / solvent	Medium	Unpleasant	0.5	0.3	0.00		0.3	0.4	0.4		1.5	2.3
9/22/14	10	203	Chemical / Plastic	Medium	Unpleasant	0.6	0.4	0.00	0.01	0.6	0.5	1.1	5.2	4.1	4.1
9/23/14	11	204	Fuel / solvent	Medium	Unpleasant	0.8	2.1	0.00	0.16	5.2	11.3	6.0	8.8	5.1	18.0
9/23/14	12	205	Fuel / solvent	Weak	Unpleasant	0.9	1.1	0.00	0.06	3.3	5.6	2.7	2.8	3.4	9.3
9/23/14	19	206	Burnt / smoke	High	Neutral	0.5	0.5	0.01	0.00	0.9	0.7	0.1	2.5	9.8	9.6
9/24/14	20	207	Fecal / septic	Medium	Unpleasant	0.5	0.3	0.00	0.03	0.3	0.5	1.0	0.7	2.5	
9/25/14	17	208	Ammonia / Cat's pee	Medium	Unpleasant	0.9	0.4	0.00	0.00	2.6	4.0	0.7	0.3	3.2	3.7
9/25/14	18	208	Ammonia / Cat's pee	Medium	Unpleasant	0.9	0.4	0.00	0.00	0.5	1.4	0.3	0.0	2.3	3.0
9/25/14	19	209	Ammonia / Cat's pee	High	Very Unpleasant	0.8	0.4	0.00	0.00	0.5	0.7	0.4	0.6	4.0	3.5
9/28/14	15	210	Burnt / smoke	High	Neutral	0.5	0.1	0.00	0.00	0.2	0.6	0.4	1.0	1.4	5.9
9/30/14	15	211	Asphalt / tar, fuel / solvent,	Very High	Very Unpleasant	0.8	0.7	0.00	0.04	8.3	2.8	4.9	8.5	6.3	10.7
9/30/14	16	212	Asphalt / tar, fuel / solvent,	Medium	Neutral	0.6	0.6	0.00	0.03	2.8	7.9	3.5	8.7	3.9	8.2
10/5/14	14	213	Asphalt / tar	High	Unpleasant	0.4	0.2	0.00	0.00	0.2	0.4	0.1	2.4	0.4	3.8
10/6/14	18	214	Rotten Egg	Weak	Unpleasant	0.5	0.5	0.00	0.04	0.3	1.8	0.2	6.4	0.4	6.4
10/7/14	10	215	Other: Burnt tires	High	Very Unpleasant	0.4	0.1		0.00		0.4		0.9	0.2	2.9
10/7/14	11	215	Other: Burnt tires	High	Very Unpleasant	0.4	0.2		0.00		0.2		0.1	0.1	2.9
10/7/14	12	215	Other: Burnt tires	High	Very Unpleasant		0.1		0.00		0.3		0.0	0.3	2.8
10/18/14	14	216	Burnt / smoke	High	Unpleasant	0.4	0.0	0.00	0.00	0.4	0.7	0.8	2.0	3.3	4.9
10/22/14	11	217	Natural gas	Weak	Unpleasant	0.7	0.3	0.00	0.02	0.2	0.6	3.2	7.6	2.5	3.6
10/23/14	9	218	Other: Furnace Exhaust	High	Very Unpleasant	0.9	4.0	0.00	0.03	0.4	1.2	8.4	44.7	8.5	25.3
10/27/14	21	219	Ammonia / Cat's pee	Very High	Very Unpleasant	0.5	0.4	0.00	0.00	0.2	0.6	0.2	0.1	3.3	4.4
10/29/14	9	220	Other: Smells like burning tire	Weak	Unpleasant	0.4	0.1	0.00	0.00	0.2	0.5	1.1	1.1	1.3	1.7

DATE	HOUR	#	Type of Odour	Intensity	Appreciation	TRS		NMHC		SO_2		NO		$PM_{2.5}$	
						AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
10/31/14	17	221	Rotten Egg	Medium	Unpleasant	0.5	0.2	0.00	0.03	0.2	0.6	9.1	13.4	16.4	11.8
11/3/14	9	222	Fuel / solvent, fecal / septic,	Weak	Unpleasant	0.4	0.2	0.00	0.00	0.0	0.4	1.2	3.8	4.7	6.9
11/3/14	15	223	Other: see comments	Weak	Unpleasant	1.1	0.3	0.00	0.02	0.6	0.5	20.5	12.9	13.2	7.0
11/5/14	9	224	Burnt / smoke	Weak	Unpleasant	0.4	0.3	0.00	0.01	0.2	0.3	0.6	0.4	16.5	18.1
11/7/14	21	225	Asphalt / tar	High	Unpleasant		0.3		0.00		5.2		0.0	3.1	10.1
11/12/14	24	226	Fuel / solvent	Medium	Unpleasant	0.4	0.3	0.00	0.00	0.2	0.4	2.6	5.2	5.5	5.4
11/14/14	17	227	Fecal / septic	Medium	Unpleasant	0.6	0.3	0.00	0.00	3.4	3.8	1.3	0.1	5.6	11.4
11/19/14	14	228	Asphalt / tar	Medium	Unpleasant	0.5	0.1	0.00	0.00	0.3	0.3	0.4	0.6	0.8	4.2
11/21/14	17	229	Ammonia / Cat's pee	Medium	Unpleasant	0.5	0.2	0.00	0.00	2.3	1.1	1.4	1.8	1.9	2.7
11/23/14	17	230	Asphalt / tar	Medium	Neutral	0.5	0.2	0.02	0.00	0.4	0.4	11.9	8.8	45.6	7.5
11/26/14	10	231	Burnt / smoke	Weak	Neutral	1.0	0.5	0.00		0.7		9.6		18.8	14.5
12/4/14	13	232	Fuel / solvent	Very High	Very Unpleasant	0.9	0.6	0.00	0.00	0.9	0.8	13.2	9.4	6.8	8.5
12/10/14	19	233	Asphalt / tar	Medium	Neutral	1.0	1.0	0.01	0.11	4.4	3.6	8.2	24.8	10.6	9.8
12/13/14	9	234	Burnt / smoke	Medium	Neutral	1.0	0.4	0.00	0.02	1.2	1.0	4.3	5.3	47.8	41.1
12/13/14	17	235	Burnt / smoke	Weak	Unpleasant	0.8	0.4	0.00	0.08	0.5	0.9	4.7	24.8	38.8	42.0
12/14/14	13	236	Asphalt / tar	Medium	Neutral	1.2	0.4	0.00	0.00	6.1	1.6	13.4	6.4	18.1	13.5
12/15/14	9	237	Fuel / solvent Other: fuel, gas smell,	Medium	Unpleasant	0.5	0.1	0.00	0.04	0.3	0.5	1.2	3.9	1.3	3.2
12/26/14	18	238	Fuel / solvent	Weak	Unpleasant	1.4	1.1	0.01	0.17	2.6	4.3	32.6	39.3	18.3	15.6

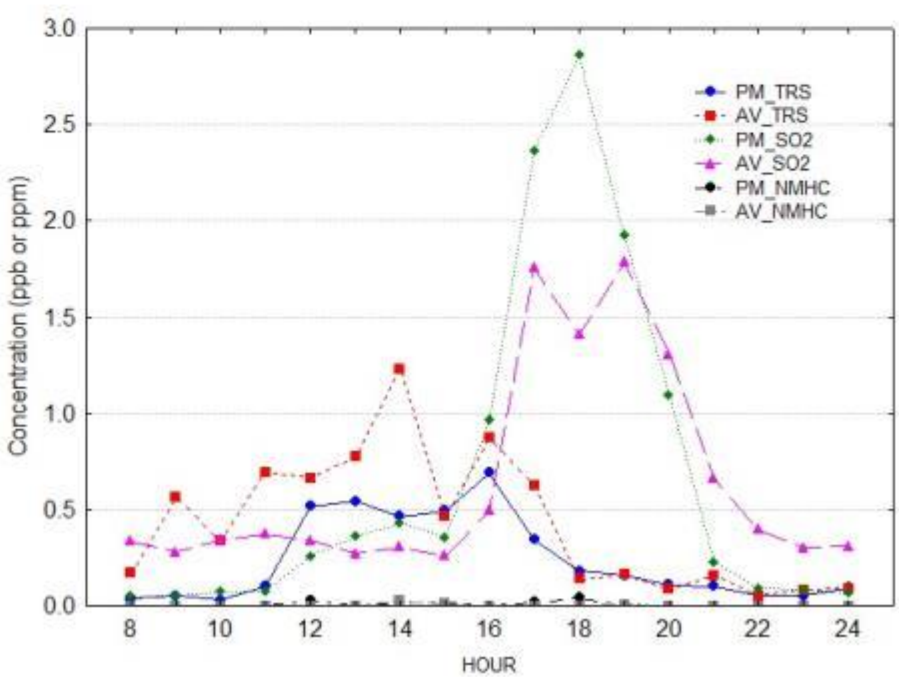
Table 38: Percentage of COMP complaint hours associated with parameter values greater than their 95th percentile at Patricia McInnes and/or Athabasca Valley.

	TRS	NMHC	SO_2	NO	$PM_{2.5}$	One or more parameters
Number of Hours	106	66	61	22	94	194
Percentage of all Hours	34.0%	21.2%	19.6%	7.1%	30.1%	62.1%

Discussion of Selected COMP Complaint Days:

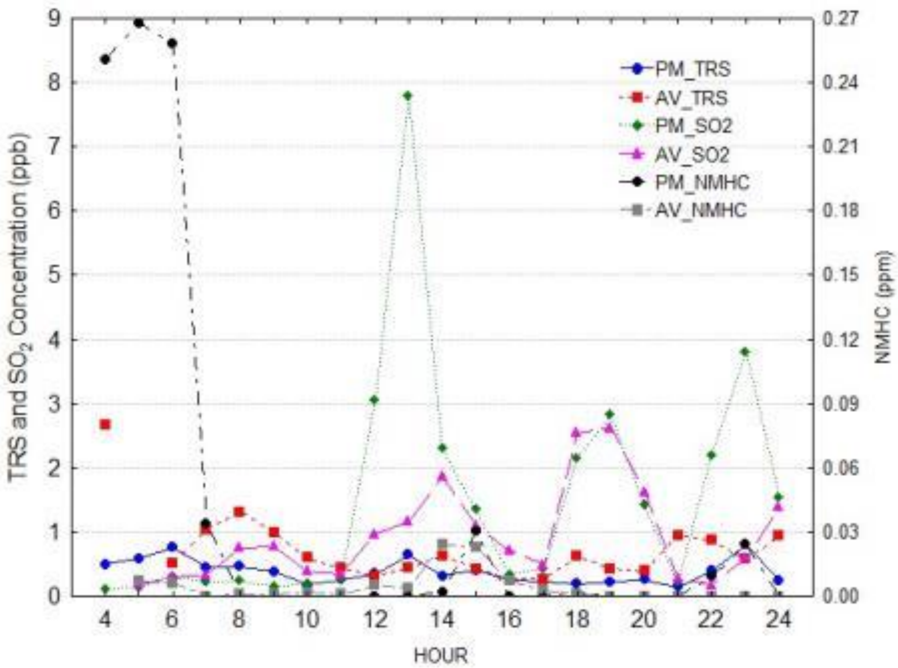
May 29, 2014: On this date five different observers reported odours with complaints being recorded between the hours of 9:00 AM and 6:00 PM. Description of odours varied from “rotten egg” to “asphalt/tar” and “ammonia/cat’s pee” and were assessed as “very unpleasant”. Winds were from the north and north northwest with a small standard deviation and wind speeds were 10 to 15 km/hour. As shown in Figure 51, levels of pollutants were low at both sites with TRS reaching 1.2 ppb at Athabasca Valley (5 minute maximum reached 1.9) and only 0.7 ppb at Patricia McInnes. The odour most likely originated from the industrial area north of Fort McMurray but none of the measured parameters would have suggested that a major odour event was taking place. As shown in last year’s assessment, an increase in SO_2 at a site is often an indicator of industrial emissions impacting the site and can be associated with an odour episode.

Figure 51: Measurements of TRS, NMHC and SO_2 at Patricia McInnes and Athabasca Valley on May 29, 2014.



June 3, 2014: On this date six different observers reported odours between the hours of 6:00 and 8:00 AM and again later in the day between 8PM and midnight with most descriptions of odour being “asphalt/tar” and the appreciation being “unpleasant” and “very unpleasant”. Winds were predominantly from the north and north northwest with very light wind speeds of 3 to 5 km/hour early in the day and increasing to 20 km/hour later in the day. As shown in Figure 52, levels of TRS were high in the early morning at Athabasca Valley (2.6 ppb) and levels of NMHC were high at Patricia McInnes. There were three separate spikes of SO_2 at Patricia McInnes during the day. Levels of TRS remained below 1 ppb at Patricia McInnes for the entire day and NMHC levels were below detection from 07:00 onwards.

Figure 52: Measurements of TRS, NMHC and SO_2 at Patricia McInnes and Athabasca Valley on June 3, 2014.



July 31, 2014: This day also had six complaints recorded from five different observers between the hours of 5:00 PM to midnight. The early complaints were related to a “burnt/smoke” odour and then the later complaints referred to an “ammonia/cat’s pee” odour and were described as “very unpleasant”. Winds were from the north and north northwest at 15 to 20 km/hour. This is an interesting episode as some of the highest $PM_{2.5}$ levels of the year were measured on July 31 due to forest fire impacts. It is also one of the longest time periods with TRS levels remaining above 1 ppb at both sites. Figure 53 shows TRS, SO_2 and $PM_{2.5}$ concentrations at the sites for the day and Figure 54 shows the location of smoke and fires and 24 hour back trajectories to Fort McMurray from the AIRNOW website. NMHC levels were at 95th percentile levels throughout the episode at Athabasca Valley but below detection at Patricia McInnes. SO_2 peaked at 12 ppb at Patricia McInnes at midnight.

Figure 53: Measurements of TRS, $PM_{2.5}$ and SO_2 at Patricia McInnes and Athabasca Valley on July 31, 2014.

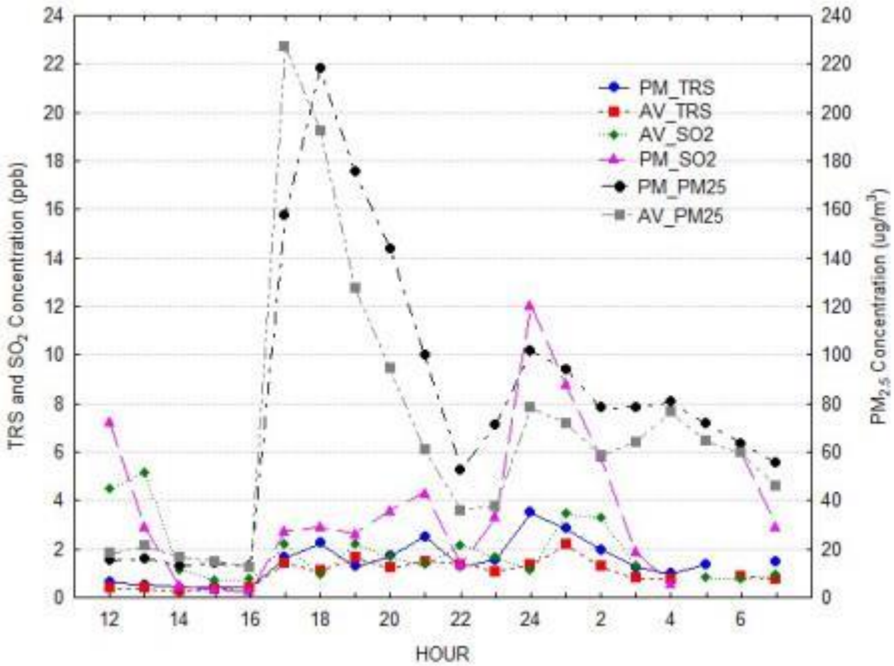
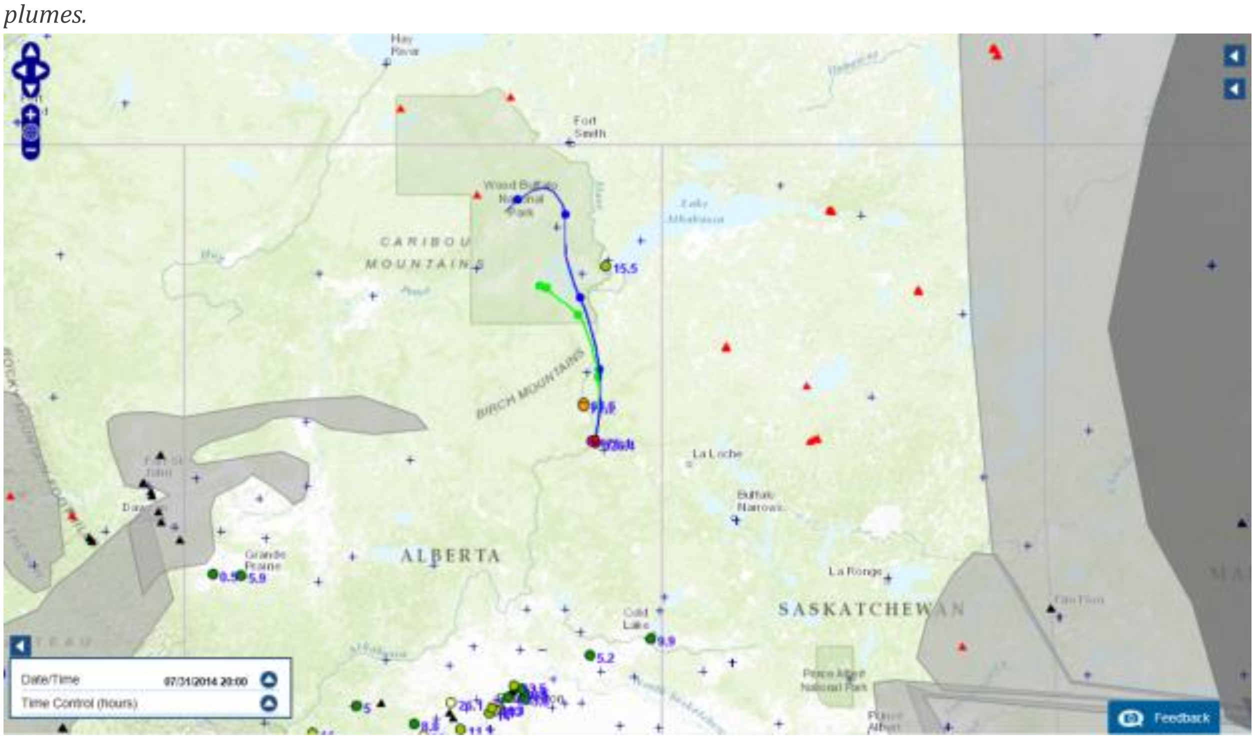


Figure 54: Twenty four-hour back trajectories for Fort McMurray at 50m (green) and at 100 m (blue) for July 31, 2014 at 18:00 from AirNow-Tech Navigator. Expanded view to show fire locations (red triangles) and smoke plumes.



August 4 & 5, 2014: There were a total of nine complaints from four different observers on these days with all descriptions as “burnt/smoke” and with odour appreciations from “neutral” to very “unpleasant”. Winds were from the north and north northeast at the start of the episode and from the east and southeast on August 5. Winds were very light throughout most of the twenty-four period. As shown in Figure 55, there was a spike of SO_2 at the start of the episode at both sites with 5-minute maximums of 92 ppb measured at Athabasca Valley and 34 ppb at Patricia McInnes. TRS values were below 1 ppb at both sites. Figure 56 shows the location of smoke and fires and 24 hour back trajectories to Fort McMurray as provided by the AIRNOW website for August 4 and August 5. The amount of smoke in the area is more obvious than for the July 31 episode despite similar $PM_{2.5}$ concentration levels.

Figure 55: Measurements of TRS, $PM_{2.5}$ and SO_2 at Patricia McInnes and Athabasca Valley on August 4 and 5, 2014.

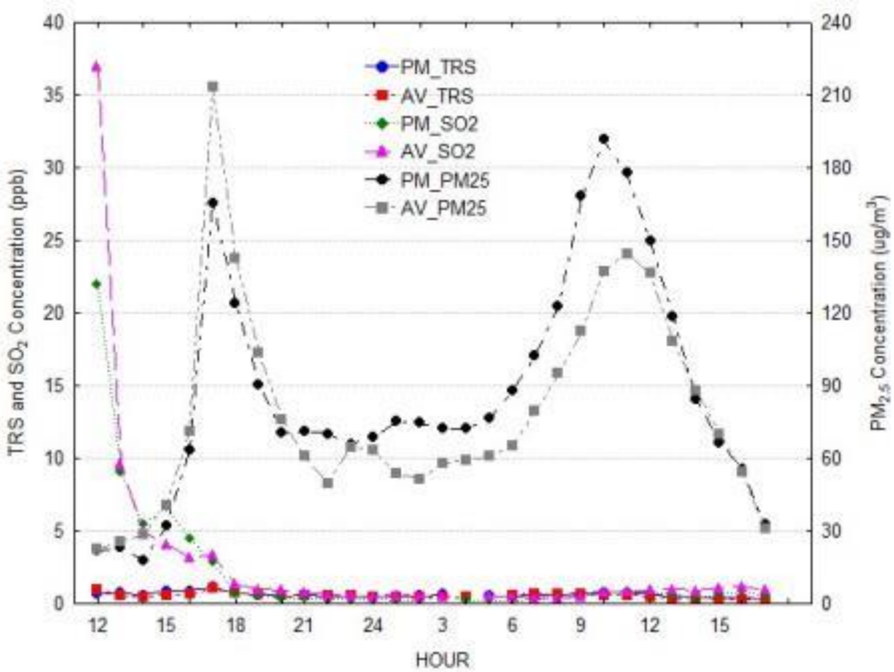
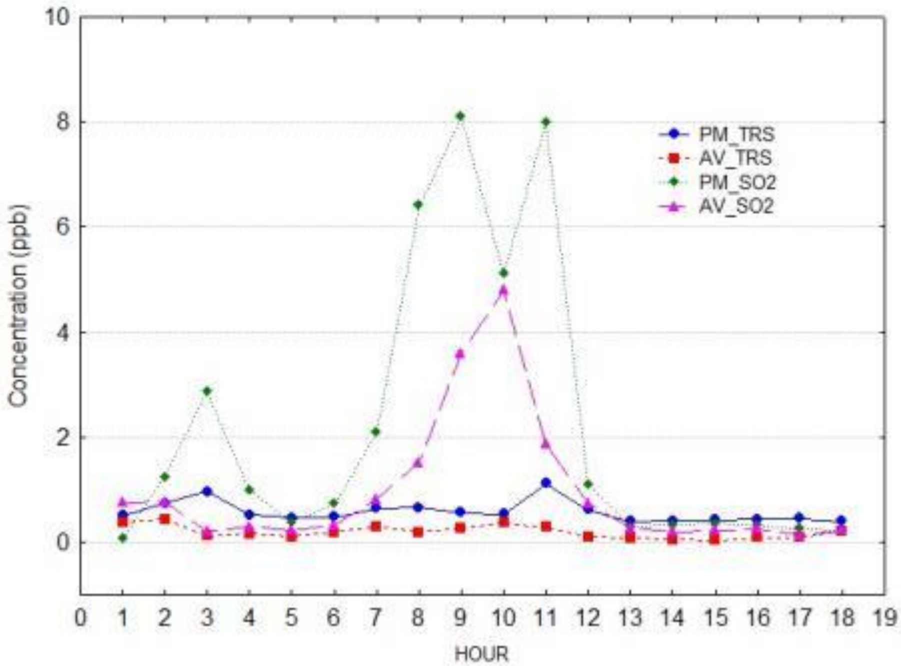


Figure 56: Twenty four-hour back trajectories for Fort McMurray at 50m (green) and at 100 m (blue) for August 4, 2014 at 18:00 and August 5 at 12:00 from AirNow-Tech Navigator. Expanded view to show fire locations (red triangles) and smoke plumes.

September 8, 2014: There were seven complaints from six different observers with complaints beginning at 9:00 AM and continuing to 8:00 PM. The initial complaints were described as fuel/solvent" with the later complaints referred to as "ammonia/cat's pee" and were described as "unpleasant" or "very unpleasant". Winds were from the north and north northwest at 7 to 10 km/hour. Figure 57 shows TRS and SO_2 concentrations at the two sites during the complaint period (NMHC levels were below or very close to detection at both sites). TRS levels were less than 0.5 ppb at the Athabasca Valley site and ranged between 0.4 and 1.1 ppb at Patricia McInnes. Again SO_2 spikes were an early indicator of industrial emissions impacting the sites and subsequent odour complaints.

Figure 57: Measurements of TRS and SO_2 at Patricia McInnes and Athabasca Valley on September 8, 2014.



5.2.1 Alberta Hotline Complaints

As noted in Section 4.7.2 all complaint hours from the Alberta Hotline have been catalogued and assigned to a community (or to the OTHER category). For each of these hours by community the prevailing average wind direction, wind speed and wind standard deviation (previous 6 hours) have been determined. The average wind direction for the Lower Camp Tower (100 m) and inversion strength (Delta) were also determined. In addition the concentrations of the air quality parameters TRS, SO_2, NMHC and $PM_{2.5}$ were determined for each hour for the nearest monitoring site(s). For the Bertha Ganter site, results from the eNose, the PFGC and measurements from the Environment Canada site in Fort McKay were also used.

For the entire year there were only a total of 32 unique complaints to the Hotline recorded on 20 separate dates with twenty-seven of the complaints recorded between January-March and only six complaints in the later months. This is a sharp drop-off from previous years and it appears that the Alberta hotline may have stopped being used by residents during 2014 and thus renders the results less useful for investigating odours in the region.

Fort McKay: A listing of all hours with complaints to the Alberta Hotline from Fort McKay is shown in Table 39. An additional incident that occurred on September 22 is also included in Table 39 based on information received from Fort McKay. This incident did not appear in the submitted public odour complaint logs but the Alberta Energy Regulator (AER) has indicated that it did generate an additional eight telephone complaints (see note on next page). The table includes the concentration of the parameters measured at the Bertha Ganter monitoring site including the PFGC (naphtha), eNose measurements and selected parameters measured by Environment Canada at their Fort McKay site. The highlighted values are equal to or greater than the 95^{th} percentile of all hourly measurements for the year.

Excluding Sept. 22, five of the nine complaints were associated with TRS concentrations greater than 1.5 ppb and these complaint hours also showed high SO_2 and high total sulphur (from the EC site). Four of the complaints were recorded with no parameters greater than their 95^{th} percentile values. A high eNose reading was associated with one of the complaints. Table 40 shows the meteorological parameters associated with the complaints with winds either from the south/southwest (south southeast at Lower Camp tower) or northwest. Temperature inversions of 1 °C or greater at the Lower Camp Tower were recorded for all hours. The table also shows the calculated FMAQI values with five of the nine hours having a FMAQI greater than six. The September 22 event had the highest TRS hourly average of all the complaint hours (and for the year) with 5-min TRS values exceeding 33 ppb and a FMAQI of greater than 10. Winds were moderate and from the south.

Figure 58 shows pollutant values for the March 2, 2014 event which accounted for five of the nine complaints for the year. All of the measured parameters except NMHC showed elevated concentrations with very light winds from the south southeast, very cold temperatures (-20°C) and a very strong temperature inversion. Nitric oxide concentrations reached almost 100 ppb while $PM_{2.5}$ concentrations reached 52 µg/m^3. SO_2 and TRS recorded only moderate peaks of 11 and 2.9 ppb respectively. Total sulphur measured at the EC site peaked at a level of 24 ppb suggesting that a number of other sulphur compounds besides TRS and SO_2 were present in the air.

Table 41 shows pollutant values and eNose reading for the April 30 odour complaint for Fort McKay. For this complaint the eNose tracked the other pollutants well. This event also had five minute SO_2 and TRS levels that exceeded the Alberta odour indicator thresholds.

NOTE: The 2014 public odour complaint logs accounted for and used in this report were distributed and obtained under the formerly named Alberta Environment & Sustainable Resource Development (ESRD). All other 2014 public odour complaint calls received under the management of the Alberta Energy Regulators (AER) during 2014, have not been released for distribution, due to the pending outcome of transitional internal tasks decisions being made to formatting odour complaints logs for public use. Thus those odour complaints were not able to be accounted for in data integration numbers in this report.

Table 39: Concentrations of air quality parameters for Alberta Hotline Complaint hours in Fort McKay (measurements greater than 95th percentile are highlighted).

Incident Date	Incident Time	Reported Odour by Complainant	SO_2	TRS	NMHC	$PM_{2.5}$	EC Measurements				PFGC	eNose	
							Total Sulphur	PAH	Hexane	Benzene	Naphtha	Max. Conc.	Delta
95th Percentile			4.9	1.0	0.01	21.9	12.8	16.8	0.44	0.39	63.8	23.4	13
1/7/14	10:00	Very Strong Tar, Oil or burning Rubber	0.5	0.4	0.10	7.7	2.3	7.8				2.9	1
2/8/14	08:15	Strong SO2 and H2S	0.5	0.2	0.00	5.3	1.0	6.3				18.9	9
3/2/14	10:59	Strong Bitumen	3.9	2.8	0.00	34.9	15.4	27.6	0.44	0.38	25.6	5.2	3
3/2/14	11:15	Diesel and raw bitumen	6.0	2.9	0.00	51.5	19.2	21.0	0.38	0.37		0.3	0
3/2/14	11:23	Diesel and raw bitumen	6.0	2.9	0.00	51.5	19.2	21.0	0.38	0.37		0.3	0
3/2/14	11:30	Oil and gas	11.3	1.9	0.00	20.5	23.7	9.3	0.53	0.44	70.7	11.0	8
3/2/14	00:00	Bad odour	0.1	0.4	0.00	7.1						6.1	2
4/30/14	10:30	Horse Manure	31.9	2.6	0.00	35.4	51.2	4.0	0.00	0.18		24.2	15
8/4/14	09:00	Wood Burning	1.0	0.7	0.01	19.8	2.0	2.9	0.15	0.13	3.5	1.5	0
22/9/14*	11:00	Very strong sulphur-rotten egg	2.4	9.4	0.00	7.5	12.9	5.5			2.3	1.3	0

* Not in hard-copy complaint log but 8 separate complaints were received

Table 40: FMAQI, AQHI and meteorological data for Alberta Hotline Complaint hours in Fort McKay.

Incident Date	Incident Time	Bertha Ganter			Lower Camp Tower (100 m)		FMAQI		AQHI
		Wind Direction	Wind Speed (km/h)	Temperature (°C)	Wind Direction	Delta (°C)	Value	Highest Sub-Index	
1/7/14	10:00	WNW	1.7	-29.0	NNW	3.1	3.4	THC	2.5
2/8/14	08:15	WNW	2.3	-29.5	N	1.8	1.9	THC	1.8
3/2/14	10:59	SSW	3.2	-20.7	SSE	6.2	9.1	TRS	4.2
3/2/14	11:15	SSW	3.9	-17.2	SSE	5.4	9.2	TRS	5.1
3/2/14	11:23	SSW	3.9	-17.2	SSE	5.4	9.2	TRS	5.1
3/2/14	11:30	S	4.2	-12.3	SSE	4.5	7.5	TRS	5.0
3/2/14	00:00	NNW	2.4	-25.7	NNE	3.2	3.3	AQHI	3.3
4/30/14	10:30	S	6.1	21.6	SSE	2.1	8.8	TRS	3.4
8/4/14	09:00	SSW	2.8	23.0	SSE		3.8	TRS	2.2
22/9/14*	11:00	S	9.5	23.1	SSE		>10	TRS	2.1

Figure 48: Hourly Variation in SO_2, TRS, NO, $PM_{2.5}$, total sulphur and PAH Concentrations at Bertha Ganter-Fort McKay for March 2, 2014.

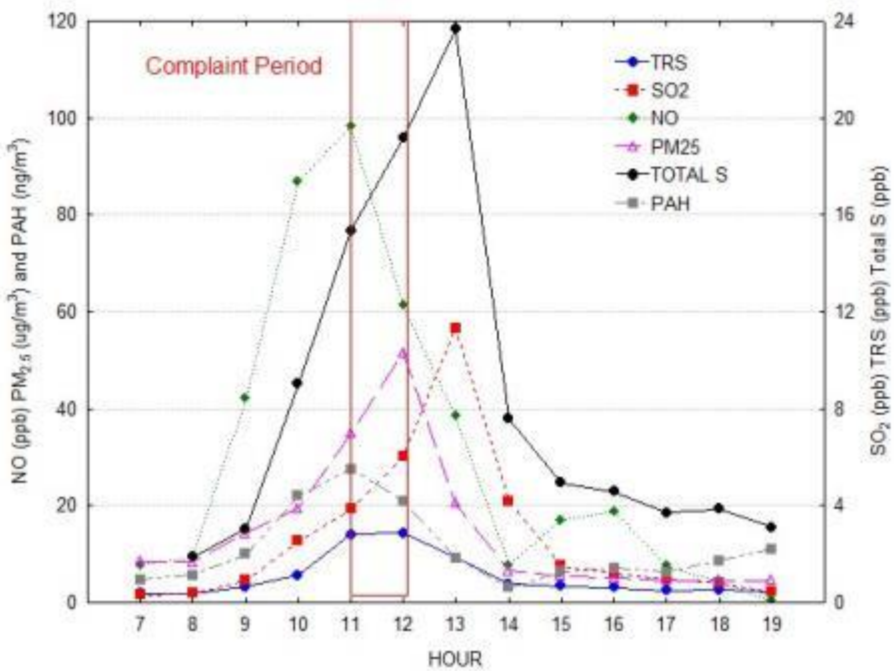


Table 41: Hourly Variation in SO_2, TRS, total sulphur, $PM_{2.5}$ concentrations and eNose readings at Bertha Ganter-Fort McKay for April 30, 2014.

Date	Hour	SO_2		TRS		TOTAL S	FMAQI	$PM_{2.5}$	WIND DIR	eNOSE		
		Hour Avg.	5 min max	Hour Avg.	5 min max					MAX CONC	DELTA	ZSCORE
4/30/14	7	1.3	1.7	0.8	0.9	3.0	4.2	8.7	SSE	4.7	1.0	0.3
4/30/14	8	1.7	1.9	0.9	1.0	4.0	4.7	9.5	SSE	11.5	5.0	0.3
4/30/14	9	4.5	5.8	2.0	2.2	9.7	7.8	8.4	SSE	18.9	8.0	0.4
4/30/14	10	25.7	54.7	2.9	4.3	38.1	9.3	15.9	S	21.8	8.0	0.3
4/30/14	11	31.9	46.4	2.6	3.6	51.2	8.8	35.4	SSE	24.2	15.0	0.7
4/30/14	12	12.8	39.0	0.7	1.5		3.6	10.9	S	19.0	9.0	0.5
4/30/14	13	6.1	12.1	0.3	0.5	9.7	2.0	6.8	SSE	7.7	4.0	0.5
4/30/14	14	4.1	12.3	0.3	0.3	6.7	2.0	5.4	S	4.1	2.0	0.7

Fort McMurray: There were only three complaints to the Alberta Hotline from the Fort McMurray area as shown in Table 42. The table includes the concentration of the parameters measured at both the Athabasca Valley (AMS#7) and Patricia McInnes (AMS#6) monitoring sites. All these dates were included in COMP complaint days as shown in Table 37.

Table 42: Concentrations of air quality parameters for Alberta Hotline Complaint Hours in Fort McMurray. (measurements greater than 95th percentile are highlighted).

Incident Date	Incident Time	Reported Odour by Complainant	SO_2		TRS		NMHC		Wind Direction	
			AMS6	AMS7	AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
1/10/14	15:05	Odour	0.3	2.0	0.3	0.8	0.00	0.21	NW	N
3/19/14	16:45	Very strong cat pee, ammonia	4.5	1.4	0.4	0.4	0.14	0.01	NE	NNE
9/22/14	00:00	Hydrocarbon	0.2	0.5	0.5	0.5	0.00	0.09	W	SSE

Anzac: A listing of the five hours with complaints to the Alberta Hotline from the Anzac area is shown in Table 43. The table includes the concentration of SO_2 and TRS measured at the Anzac monitoring site (NMHC data were not available on these dates) and wind direction at the site and wind direction and inversion strength at Lower Camp tower. Four of the five hours were associated with TRS greater than 1 ppb with one greater than 1.5 ppb. This site did record a total of 90 hours with TRS greater than 1.5 ppb. The highest TRS concentration of 9.3 ppb was not associated with a recorded complaint.

Table 43: Concentrations of air quality parameters for Alberta Hotline Complaint hours in Anzac (measurements greater than 95th percentile are highlighted).

Incident Date	Incident Time	Reported Odour by Complainant	SO_2	TRS	WIND DIR	WIND SPEED	Lower Camp Tower	
							WIND DIR	DELTA
1/9/14	07:20	Very Strong Rotten Eggs	0.1	1.1	SE	5.1	S	0.7
1/9/14	08:00	Very Strong Burning Oil	0.1	1.1	SE	5.1	S	0.7
1/9/14	09:35	Strong Gassy Smells		2.1	SE	4.6	SSW	0.0
1/11/14	00:40	Petroleum	0.0	1.2	W	6.1	SW	
3/3/14	09:00	Very strong ammonia, cat pee	0.9	0.7	SSW	1.9	SSE	9.4

Other: A listing of all hours with complaints to the Alberta Hotline from sites other than the communities of Anzac, Fort McMurray and Fort McKay is provided in Table 44. The table includes the concentration of the parameters H_2S and SO_2 measured at the Mildred Lake (AMS#2) and Mannix (AMS#5) monitoring sites since these were usually the closest locations to the reported complaints which were mostly from Highway #63. There was no consistent association between SO_2 and/or H_2S and reported odours and H_2S values were below the 95th percentile for all hours. Wind direction data for Mildred Lake and wind direction and inversion strength data for Lower Camp tower are also included in the table. Winds were either southerly or northerly for the odour complaints with wind speeds generally less than 10 km/hour. Six of fourteen hours recorded a temperature inversion of 1 °C or greater at the Lower Camp tower.

Table 44: Concentrations of air quality parameters at Mildred Lake (AMS#2) and Mannix (AMS#5) for Alberta Hotline complaint hours (measurements greater than 95th percentile are highlighted).

Incident Date	Incident Time	Reported Odour by Complainant	General Location of Complaint	SO_2		H_2S		WIND DIR	WIND SPEED	Lower Camp Tower	
				AMS5	AMS2	AMS5	AMS2			WIND DIR	DELTA
1/7/14	15:45	Strong acidic, rotten oil	Driving Hwy 63 S and passed oil sands facilities	0.3	1.7	0.7	1.4	S	3.8	SSE	2.7
1/7/14	18:06	Very Strong Sulphur	Driving Hwy 63 S from Fort McKay to Fort McMurray	0.1	1.8	0.6	2.0	SSE	4.0	SSE	1.6
1/8/14	17:02	Hydrocarbon	Driving Hwy 63 S from Fort McKay to Fort McMurray	1.0	2.4	0.6	1.3	SSE	7.8	S	0.9
1/13/14	08:18	Strong Hydrocarbons	Driving Hwy 63N and passed oil Sands facilities	1.2	0.5	1.2	0.5	SSW	5.7	SSW	0.2
1/13/14	17:59	Strong Hydrocarbons	Driving Hwy 63S and passed oil Sands facilities	0.3	0.1	0.6	0.2	NE	8.5	NNE	-1.2
1/14/14	08:20	Very Heavy Hydrocarbons	Driving Hwy 63N and passed oil Sands facilities	0.6	7.1	0.5	1.4	S	6.6	SSE	4.0
1/14/14	17:01	Strong Hydrocarbons	Driving Hwy 63S from Fort McKay to Fort McMurray	1.0	0.9	0.5	0.7	S	8.8	SSE	3.8
1/16/14	13:00	Very Strong Petroleum/Oily smells	Driving Hwy 63S from Fort McKay to Fort McMurray and between oil sands facilities	0.5	2.4	0.4	1.8	SW	6.9	SSW	5.9
2/1/14	14:18	Very strong SO_2 and H_2S	Driving Hwy63N near oil sands operation	0.5	4.0	0.5	1.7	SSW	8.2	SSW	2.6
3/13/14	16:50	Oil and gas and sulphur	Hwy 63 near Fort McMurray city area	1.3	0.0	0.2	0.2	NNE	10.8	NNE	-1.3
3/17/14	16:50	Very strong sulphur	Hwy 63N near oil sands operation area	1.4	0.3	0.4	0.2	N	10.9	N	-1.7
3/19/14	17:03	Very strong sulphur	Driving Hwy 63 passing overpass at oil sands area	44.0	0.2	0.7	0.3	N	9.8	N	-1.2
9/8/14	00:00	Strong Cat pee	5 km north of Fort McMurray on Hwy 63N	0.1	0.2	1.1	0.3	NNE	5.8	NNE	
5/11/14	20:00	Sewerage	Various							NNW	-1.5

5.3 Correlation Analysis

5.3.1 Correlations between Sites for Selected Parameters

Correlations between the individual monitoring sites for TRS/H_2S, SO_2, $PM_{2.5}$, NO and NO_2 are provided in Table 45 for all hours. Only the instances with correlation coefficients (r) greater than 0.4 (for NO_2 a cutoff of 0.5 was used and for $PM_{2.5}$ a cutoff of 0.75 was used) are shown in the table. The distance between site pairs is also provided. A similar analysis for NMHC, THC and methane is provided in Table 46 with a cutoff of 0.4 (except the collocated Anzac and AMS 104A correlation is included).

The highest correlations for TRS were between Bertha Ganter and Barge Landing and Fort McKay South. The TRS from AMS#104 was very highly correlated with the H_2S from Mildred Lake and interestingly the next best correlations for TRS for Bertha Ganter were with these two sites. The Bertha Ganter and Fort McKay South sites also are well correlated for SO_2, NO, NO_2 and $PM_{2.5}$. The two Fort McMurray sites are well correlated for SO_2, NO_2 and $PM_{2.5}$ but not for TRS, NO or NMHC. The parameters $PM_{2.5}$ and then NO_2 showed the highest correlation over distances greater than 50 km. It is not clear why Anzac NMHC was well correlated with Athabasca Valley but not with the collocated AMS104A site. All other site to site NMHC correlations were less than 0.2.

5.3.2 Correlations between Parameters at Selected Sites

In Table 47 the correlations between parameter pairs for TRS/H_2S, SO_2, THC, methane, NMHC, $PM_{2.5}$, NO, NO_2, and the AQHI (FMAQI and AQHI at Bertha Ganter) for community sites are shown for all hours (only correlations > 0.5 are shown). The highest correlations were between THC and methane/NMHC and between TRS and the FMAQI at Bertha Ganter.

In Table 48 correlations between selected parameters for other measured parameters are shown for the Bertha Ganter-Fort McKay site including the eNose, the PFGC results and the EC measurements from the Fort McKay Oski ôtin site. Many of the EC measured BTEX species were highly correlated with one another but not with the NMHC or the PFGC results. The eNose calculated parameters were poorly correlated with other measurements (see Table 49). Table 50 shows the parameters with the highest correlations with the PFGC naphtha results.

Table 51 shows correlation between parameters measured at the Patricia McInnes and Athabasca Valley sites for all COMP complaint hours. Since many of the hours were associated with smoke it is not surprising that $PM_{2.5}$ and the AQHI were highly correlated at Athabasca Valley. There was a lack of correlation between TRs and SO_2 and TRS and wind speed at both sites.

Table 45: Correlation between monitoring sites for TRS/H_2S, SO_2, $PM_{2.5}$, NO and NO_2 for all hours (only correlations > 0.4 are shown for TRS/H_2S, SO_2 and NO; > 0.5 for NO_2 and > 0.75 for $PM_{2.5}$).

SITE 1	SITE 2	DISTANCE BETWEEN SITES (km)	CORRELATION COEFFICIENT
TRS/H_2S			
MILDRED LAKE	AMS104	0.0	0.976
ANZAC	AMS104A	0.0	0.844
BERTHA GANTER	BARGE LANDING	2.7	0.683
BERTHA GANTER	FORT MCKAY SOUTH	4.4	0.621
BARGE LANDING	FORT MCKAY SOUTH	6.0	0.474
BERTHA GANTER	AMS104	16.2	0.439
FORT MCKAY SOUTH	AMS104	12.0	0.427
SO_2			
BERTHA GANTER	FORT MCKAY SOUTH	4.4	0.824
PATRICIA MCINNES	ATHABASCA VALLEY	5.7	0.629
BERTHA GANTER	SHELL MUSKEG	10.2	0.434
BERTHA GANTER	CNRL HORIZON	14.0	0.412
NITRIC OXIDE			
BERTHA GANTER	FORT MCKAY SOUTH	4.4	0.816
BERTHA GANTER	SHELL MUSKEG	10.2	0.398
NITROGEN DIOXIDE			
BERTHA GANTER	FORT MCKAY SOUTH	4.4	0.856
BERTHA GANTER	MILLENNIUM	36.8	0.665
ATHABASCA VALLEY	MILLENNIUM	17.4	0.587
BERTHA GANTER	ATHABASCA VALLEY	52.9	0.569
PATRICIA MCINNES	ATHABASCA VALLEY	5.7	0.565
MILLENNIUM	FORT MCKAY SOUTH	32.9	0.553
BERTHA GANTER	PATRICIA MCINNES	49.7	0.552
PATRICIA MCINNES	MILLENNIUM	16.3	0.550
MILLENNIUM	CNRL HORIZON	50.8	0.543
ATHABASCA VALLEY	FORT MCKAY SOUTH	48.7	0.538
PATRICIA MCINNES	FORT MCKAY SOUTH	45.3	0.527
BERTHA GANTER	CNRL HORIZON	14.0	0.521
$PM_{2.5}$			
BERTHA GANTER	FORT MCKAY SOUTH	4.4	0.948
BERTHA GANTER	SHELL MUSKEG	10.2	0.908
FORT MCKAY SOUTH	SHELL MUSKEG	13.6	0.894
PATRICIA MCINNES	ATHABASCA VALLEY	5.7	0.842
BERTHA GANTER	CNRL HORIZON	14.0	0.829
CNRL HORIZON	SHELL MUSKEG	14.8	0.828
FORT MCKAY SOUTH	CNRL HORIZON	18.1	0.778
SHELL MUSKEG	WAPASU	36.8	0.753
PATRICIA MCINNES	MILLENNIUM	16.3	0.747
BERTHA GANTER	WAPASU	44.7	0.745
PATRICIA MCINNES	ANZAC	43.0	0.745

Table 46: Correlation between monitoring sites for NMHC, methane and THC for all hours (only correlations > 0.4 are shown).

SITE 1	SITE 2	DISTANCE BETWEEN SITES (km)	CORRELATION COEFFICIENT
NMHC			
ATHABASCA VALLEY	ANZAC	38.2	0.482
ANZAC	AMS104A	0.0	0.204
Methane			
PATRICIA MCINNES	ATHABASCA VALLEY	5.7	0.648
BERTHA GANTER	ATHABASCA VALLEY	52.9	0.518
ANZAC	AMS104A	0.0	0.464
BERTHA GANTER	PATRICIA MCINNES	49.7	0.442
BERTHA GANTER	AMS104	16.2	0.420
THC			
MILDRED LAKE	AMS104	0.0	0.929
BERTHA GANTER	FORT MCKAY SOUTH	4.4	0.803
PATRICIA MCINNES	ATHABASCA VALLEY	5.7	0.638
BERTHA GANTER	BARGE LANDING	2.7	0.622
BUFFALO VIEWPOINT	MANNIX	7.4	0.597
BARGE LANDING	FORT MCKAY SOUTH	6.0	0.532
MILDRED LAKE	LOWER CAMP	4.6	0.528
LOWER CAMP	AMS104	4.6	0.491
ANZAC	AMS104A	0.0	0.479
LOWER CAMP	MILLENNIUM	16.9	0.474
BERTHA GANTER	ATHABASCA VALLEY	52.9	0.464
BUFFALO VIEWPOINT	ATHABASCA VALLEY	31.8	0.455
BUFFALO VIEWPOINT	PATRICIA MCINNES	28.2	0.413
BUFFALO VIEWPOINT	LOWER CAMP	6.5	0.408
ATHABASCA VALLEY	LOWER CAMP	33.4	0.404
MANNIX	PATRICIA MCINNES	24.2	0.403

Table 47: Correlation between selected parameter pairs at community sites for all hours (only correlations > 0.5 are shown).

Compound 1	Compound 2	CORR. (r)
	Bertha Ganter	
THC	METHANE	0.965
TRS	FMAQI	0.891
$PM_{2.5}$	AQHI	0.752
THC	FMAQI	0.729
METHANE	FMAQI	0.729
NO_2	METHANE	0.711
NO_2	THC	0.695
NITRIC OXIDE	METHANE	0.658
NITRIC OXIDE	THC	0.636
NITRIC OXIDE	NO_2	0.579
NO_2	FMAQI	0.555
NMHC	FMAQI	0.546
TRS	METHANE	0.533
THC	NMHC	0.531
TRS	THC	0.530
	Patricia McInnes	
THC	METHANE	0.949
NITRIC OXIDE	NO_2	0.683
TRS	METHANE	0.593
$PM_{2.5}$	AQHI	0.586
TRS	THC	0.560
THC	NMHC	0.559
NO_2	THC	0.546
NITRIC OXIDE	THC	0.508
	Athabasca Valley	
THC	METHANE	0.961
NITRIC OXIDE	NO_2	0.788
THC	NMHC	0.647
NO_2	AQHI	0.599
$PM_{2.5}$	AQHI	0.517
NITRIC OXIDE	AQHI	0.507
	Anzac	
THC	METHANE	0.987
$PM_{2.5}$	NMHC	0.529
	AMS104A	
THC	METHANE	0.960
THC	NMHC	0.648

Table 48: Correlation between selected parameters measured at Fort McKay Bertha Ganter and EC Fort McKay for all hours (only correlations greater than 0.5 shown).

Compound 1	Compound 2	CORR. (r)
eNose MAX CONC	eNose DELTA	0.937
EC Octane	EC m and p-Xylene	0.913
EC Ethylbenzene	EC o-Xylene	0.901
EC Toluene	EC m and p-Xylene	0.893
SO_2 5min Max	EC TOTAL S	0.887
EC Heptane	EC Octane	0.878
EC Toluene	EC Octane	0.833
EC Ethylbenzene	EC m and p-Xylene	0.833
eNose MEAN	eNose MAX CONC	0.827
PFGC NAPTHA	PFGC SUM_ID	0.825
EC Toluene	EC Ethylbenzene	0.808
EC Octane	EC Ethylbenzene	0.798
EC Heptane	EC m and p-Xylene	0.796
$PM_{2.5}$	EC Black Carbon	0.795
EC Heptane	EC Toluene	0.792
AQHI	EC Black Carbon	0.695
NO_X	EC PAH	0.678
EC Heptane	EC Ethylbenzene	0.674
EC m and p-Xylene	EC o-Xylene	0.670
NO_2	EC PAH	0.580
eNose MEAN	eNose DELTA	0.580
AQHI	EC Benzene	0.579
THC	EC PAH	0.571
EC Black Carbon	EC PAH	0.509

Table 49: Highest correlations between eNose Delta and other parameters measured at Fort McKay Bertha Ganter for all hours.

Compound 1	Compound 2	CORR. (r)
eNose DELTA	PFGC AROMATIC	0.186
eNose DELTA	PFGC HEAVY	0.111
eNose DELTA	NMHC	0.106
eNose DELTA	TEMPERATURE	0.085

Table 50: Highest correlations between PFGC Naphtha and other parameters measured at Fort McKay Bertha Ganter for all hours.

Compound 1	Compound 2	CORR. (r)
PFGC Naphtha	NMHC	0.204
PFGC Naphtha	EC Hexane	0.178
PFGC Naphtha	THC	0.177

PFGC Naphtha	NO_2	0.150

Table 51: Correlation between selected parameters Measured at Patricia McInnes and Athabasca Valley for COMP complaint hours (correlations greater than 0.5 and other interesting correlations are shown).

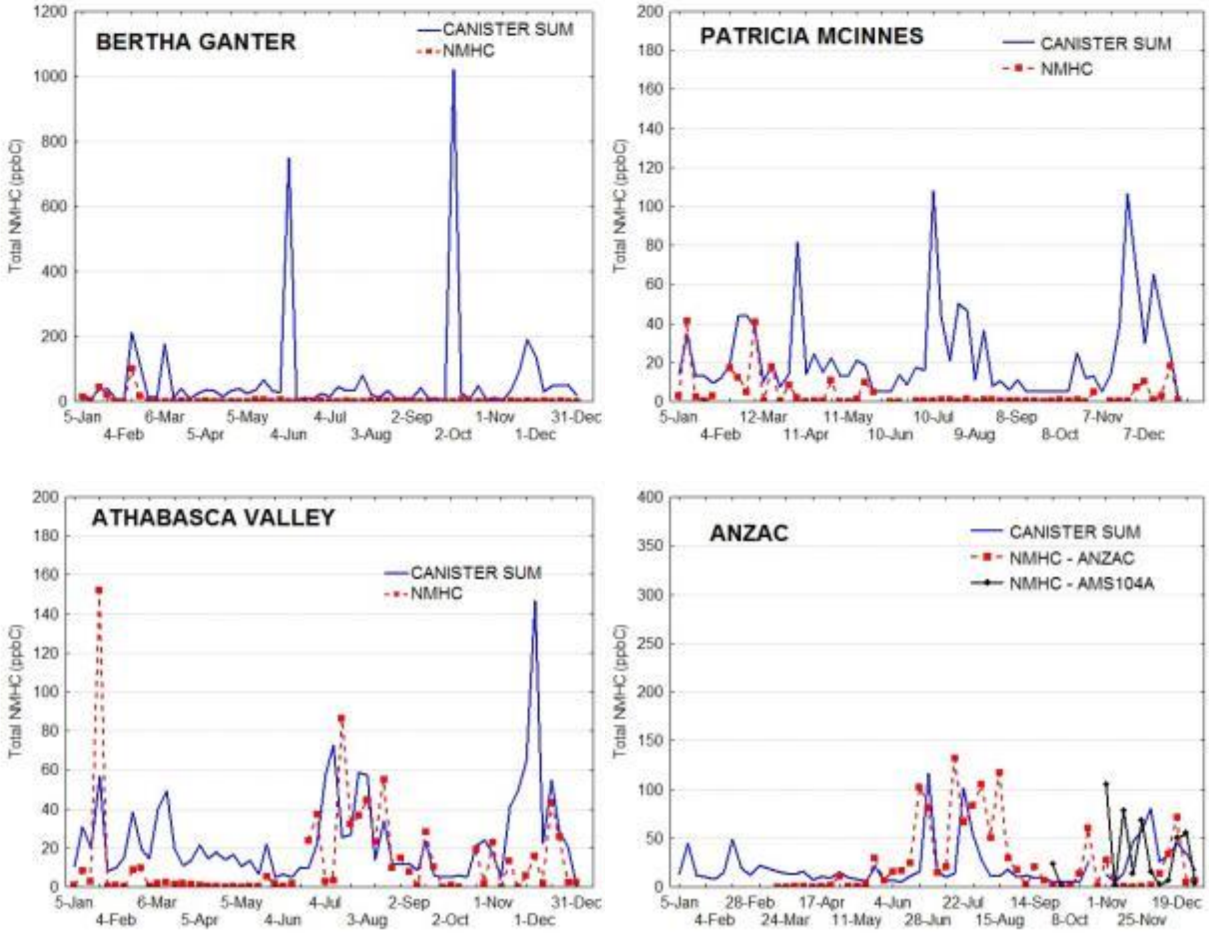
Compound 1	Compound 2	CORR. (r)
Patricia McInnes		
THC	METHANE	0.933
$PM_{2.5}$	AQHI	0.849
NITRIC OXIDE	NO_2	0.739
NO_2	THC	0.658
NO_2	NMHC	0.572
NITRIC OXIDE	THC	0.560
TRS	METHANE	0.548
NO_2	METHANE	0.503
SO_2	TRS	0.353
TRS	WIND SPEED	0.024
NO_2	AQHI	0.007
TRS	NMHC	0.005
Athabasca Valley		
THC	METHANE	0.964
$PM_{2.5}$	AQHI	0.839
THC	NMHC	0.796
NITRIC OXIDE	NO_2	0.723
$PM_{2.5}$	NMHC	0.603
NO_2	METHANE	0.602
NMHC	METHANE	0.542
NO_2	THC	0.538
NMHC	AQHI	0.537
NO_X	METHANE	0.529
TRS	NMHC	0.423
TRS	METHANE	0.466
TRS	NO_2	0.297
SO_2	TRS	0.214
NO_2	AQHI	0.066
TRS	WIND SPEED	0.060

6 Discussion of Results

6.1 Issues Affecting Data Analysis and Integration

1. The baseline output from the eNose was more stable than in previous years. The greatest discontinuity in output occurred between May 19 and May 25 (high readings) and between November 6 and November 30 (low readings).
2. The response of both PFGC's to some compound categories such as aromatics, heavy molecular weight species and sulphur containing species was variable through time. There were a variety of operational problems with both PFGC instruments with substantial data loss for the SCD measurements. The SCD at AMS104 was typically not responding to COS or CS_2 during the year and at Bertha Ganter-Fort McKay the SCD only detected COS or CS_2 intermittently.
3. Benzene was not detected by either PFGC instrument over the course of the year and propane was only detected at AMS104-Anzac. Toluene was most frequently detected at AMS104-Mildred Lake. After relocation to Anzac the PFGC instrument only appeared to respond to propane.
4. Except for one observation at AMS104-Mildred Lake, the other target species: thiophene, 2-methyl thiophene, 3-methyl thiophene, 2-ethyl thiophene, 2, 5-dimethyl thiophene and 2,4-dimethyl thiophene were never found above detection during the year for the SCD. Detection percentages for both COS and CS_2 were very low compared to previous years.
5. Carbonyl sulphide was the most frequently detected RSC in canister samples but since it has a background concentration of 0.5 ppb but was only detected in 20% of samples the effective detection level for RSCs in canister samples is probably in the range of 0.5 to 1 ppb.
6. There are uncertainties in emission estimates from stack and fugitive sources and a lack of correspondence of ambient to source SO_2/TRS ratios.
7. No data were available on process upsets or emission control equipment abnormalities at industrial sources.
8. There were no data on the most odorous VOC/RSC species emissions from sources in the airshed.
9. There are no methods currently implemented that are capable of routinely quantifying the most odorous VOC/RSC species such as substituted thiophenes, mercaptans or cresols (see Table 1) in ambient air. As part of the PFGC program, multiple GC-MS cartridge samples were taken at three sites during 2014 and qualitative analysis of these samples consistently showed the presence of up to 13 (all possible C_7) substituted thiophenes.
10. There may have been issues with the continuous NMHC instruments during the year as summary statistics at some sites were quite different (lower) than previous years. Figure49 provides a comparison of sum of VOC (ppbC) in canisters versus 24-hour average NMHC concentrations (ppbC) by day for the community sites. Since C_2 and C_3 hydrocarbons are not measured in the canister samples, it would be expected that NMHC values would normally be higher than canister totals. As shown in the figure this was not the case at Bertha Ganter or Patricia McInnes with better correspondence at Athabasca Valley and Anzac. The collocated NMHC instrument at AMS104-Anzac showed variable correspondence with the Anzac NMHC and with the canister results.

Figure 49: Comparison of sum of VOC (ppbC) in canisters versus 24-hour average NMHC concentrations (ppbC) for canister sampling days at the community sites.



6.2 Main Observations

6.2.1 Air Quality Measurements

1. For the community sites there were no hours with TRS greater than 10 ppb (Alberta AAQO). For the industrial sites there were a total of 34 hours with TRS or H_2S greater than 10 ppb with 14 hours recorded at Mannix and 7 hours at Mildred Lake. The highest maximum and mean SO_2 concentrations were measured at Mannix. Of the community sites, Bertha Ganter recorded the highest annual mean SO_2 concentration of 1.4 ppb and Athabasca Valley recorded the highest one-hour value of 88 ppb. No sites in the network (industrial or community) exceeded the Alberta 1h AAQO for SO_2 of 172 ppb or the annual average AAQO of 8 ppb.
2. Five-minute data for the community sites TRS, SO_2 and NMHC were also examined. In 2013 Alberta Environment and Parks began a trial odour index program for the WBEA Region which is based on 5-minute values of TRS and SO_2. The current trial system indicates a potential for odour when 5-minute TRS exceeds 2.55 ppb for 2 out of 3 five-minute adjacent measurements or when SO_2 exceeds 40.5 ppb for 2 out of 3 five-minute adjacent measurements. The 5-minute TRS threshold was exceeded from 52 times at Patricia McInnes to 381 and 432 times at Bertha

Ganter and Anzac respectively. The 5-minute SO_2 threshold was exceeded from 5 times at Athabasca Valley to 110 times at Bertha Ganter.

3. There was a large reduction in maximum TRS concentration from 2012 to 2013 with a slight increase at Bertha Ganter-Fort McKay from 2013 to 2014 and a decrease at Anzac. Hours with TRS greater than 3 ppb decreased by more than 90% at Bertha Ganter-Fort McKay, Patricia McInnes and Athabasca Valley from 2012 to 2014 and by 50% at the Anzac site.
4. When the fifteen year data record (2000 to 2014) for TRS and H_2S data was examined, the year 2009 was a peak year in almost all the site records whereas the years 2013 and 2014 are two of the lowest years in the records. The Anzac site was an exception with the highest values recorded in 2007 with little change through 2013. In 2013 and 2014 Anzac recorded the highest 99th percentile TRS concentration and the most hours greater than 3 ppb of the community sites.
5. Since NO is rapidly converted to NO_2 in the atmosphere, high NO concentrations can be a useful indicator of fresh and nearby emissions. Of the community sites, the highest mean and 90th percentile NO concentrations were measured at the Athabasca Valley site. Of the industrial sites, the highest mean and 90th percentile concentrations were measured at the Millennium and Shell Muskeg River sites.
6. The highest mean NMHC concentrations were measured at Anzac but mean NMHC levels were very low at all sites as measured by the continuous method. Of the community sites, Bertha Ganter had the highest maximum NMHC concentration of 1.4 ppm but also recorded the lowest 95th percentile. The AMS104 site at Mildred Lake recorded a maximum NMHC value of 7 ppm.
7. Comparison of wind direction and wind speed in 2013 and 2014 for the Bertha Ganter and Athabasca Valley sites indicates there were no major differences in predominant wind direction between the two years for these sites. Temperature data from the Lower Camp and Mannix towers showed that temperature inversions can occur at night during all seasons.
8. Carbonyl sulphide was the most frequently reported RSC in the canister results. For all samples at community sites the overall detection frequency for carbonyl sulphide was 20%, for carbon disulphide 11%, for hydrogen sulphide 3%, thiophene 3%, dimethyl sulphide 2%, 2 and 3-methyl thiophene 1%, 2-ethyl thiophene 1%, 2, 5-dimethyl thiophene 1% and all other RSC were detected less than 1% of the time. Detection frequencies were similar at the industrial sites.
9. Mean concentrations of benzene ranged from 0.2 to 0.9 ppb across the sites with the highest mean recorded at Anzac. Mean toluene concentrations showed more variability ranging from 0.2 ppb at CNRL Horizon to 0.9 ppb at Bertha Ganter. Mean hexane concentrations ranged from 0.3 ppb at Anzac to 2.4 ppb at Millennium.
10. The highest correlations for TRS were between Bertha Ganter and Barge Landing and Fort McKay South. The TRS from AMS104 was very highly correlated with the H_2S from Mildred Lake and interestingly the next best correlations for TRS for Bertha Ganter were with these two sites. The Bertha Ganter and Fort McKay South sites also are well correlated for SO_2, NO, NO_2 and $PM_{2.5}$. The two Fort McMurray sites are well correlated for SO_2, NO_2 and $PM_{2.5}$ but not for TRS, NO or NMHC. The parameters $PM_{2.5}$ and then NO_2 showed the highest correlation over distances greater than 50 km. When correlations between parameter pairs for TRS/H_2S, SO_2, THC,

methane, NMHC, $PM_{2.5}$, NO, NO_2 were examined, the highest correlations were between THC and methane/NMHC.

11. Environment Canada has operated a monitoring site in Fort McKay since 2013 as part of the Joint Oil Sands Monitoring Program. The site is known as Fort McKay Oski ôtin and is located approximately 0.6 km south of Bertha Ganter-Fort McKay. Measurements from this site were also available for total sulphur, benzene, toluene, ethylbenzene, xylenes (BTEX), black carbon and particulate PAH for a portion of 2014.
12. Many of the Environment Canada measured BTEX species were highly correlated with one another but not with the NMHC or the PFGC results. The eNose mean, maximum and calculated parameters were poorly correlated with other measurements.

6.2.2 Odour Complaints

13. For the COMP project there were a total of 138 unique complaints recorded in 2014. Some of these observations spanned multiple hours and the total hours with potential odour complaints amounted to 312 over the year. There were 36 participants registered as volunteers at the end of the fourth quarter of the first year of the project and there were 27 participants in the program as of December 2014. Approximately half (43%) of the observations identified the odour as asphalt/tar or hydrocarbon/solvent which is a similar percentage to the odour types reported in 2013. Eighty-two percent of odour reports were recorded during the months of May to September and eighty-six percent between the hours of 7:00 AM to 9:00 PM. Of the approximately 37 participants in the program, eighteen reported odours on one or more occasion. Most complaints were associated with NNE or NE wind directions and with wind speeds greater than 7 km/h and no precipitation.
14. Twelve of the COMP complaint hours were associated with TRS values greater than or equal to 1.5 ppb at Patricia McInnes and five hours at Athabasca Valley. Very high $PM_{2.5}$ values were measured on a number of days with odour complaints with the majority of odours described as "burnt/smoke". The proposed Alberta odour indicator threshold for 5-minute TRS of 2.55 was reached for only 3 percent of complaint hours and the SO_2 and the suggested NMHC thresholds were never reached.
15. For the Alberta Hotline there were a total of 32 unique complaints recorded on 20 separate dates with 9 from Fort McKay (5 on same date), 3 from Fort McMurray, 5 from Anzac (3 on same date) and 14 from outside the communities. The three Alberta hotline complaint days in Fort McMurray coincided with COMP complaint days. Twenty-seven of the complaints were recorded between January-March with only six complaints in the later months. Forty-two percent of the complaints described the odour as "hydrocarbon/ petroleum/bitumen". In 2013 there were 93 complaints and it appears that the Alberta hotline may have stopped being used by residents during 2014 as the COMP complaints did not show a similar drop-off in frequency. There may be some instances of reported odour complaints not appearing on the hard copy records also.
16. At the Bertha Ganter site five of the nine complaints to the Alberta Hotline were associated with TRS concentrations greater than 1.5 ppb and these complaint hours also showed high SO_2 and high total sulphur (from the EC site). Four of the complaints were recorded with no parameters

greater than their 95th percentile values. A high eNose reading was associated with one of the complaints. Complaint hours had winds either from the south/southwest (south southeast at Lower Camp tower) or northwest. Temperature inversions of 1 °C or greater at the Lower Camp Tower were recorded for all hours.

17. For Anzac four of the five hours with complaints to the Alberta Hotline were associated with TRS greater than 1 ppb with one hour greater than 1.5 ppb. This site did record a total of 90 hours with TRS greater than 1.5 ppb. The highest TRS concentration of 9.3 ppb was not associated with a recorded complaint.
18. The majority of odour complaints were associated with only a few wind directions at the community sites and are undoubtedly associated with specific sources.

6.2.3 Emissions

19. In general, estimated emissions increased from most facilities in 2012 as compared to 2011 and then decreased in 2013. Emissions from Suncor, in particular, showed a large decrease between 2012 and 2013 (final NPRI emission data for 2014 are not yet available).
20. For both Syncrude and Suncor, emissions of H_2S accounted for 36% of total reported TRS emissions. There were no reported emissions of carbon disulphide from the Suncor plant in 2013.
21. SO_2 emissions were essentially all from stacks whereas 77% of VOC emissions were from fugitive sources. The split between stack and fugitive emissions for VOC species was quite variable depending on the facility and the compound.

6.2.3 Other

22. Fort McKay's air and health scientists recently developed a "community-specific" Fort McKay Air Quality Index (FMAQI) which attempts to provide a general indication and measure of the air quality in the community based on the continuous measurements of a variety of parameters from the Bertha Ganter-Fort McKay measurement site. The FMAQI index should have a better relationship to odours than the AQHI and has been endorsed by Alberta Environment and Parks and WBEA as a useful communication tool with results routinely posted on the WBEA website for Fort McKay. Using the FMAQI, air quality was characterized as poor or very poor in Fort McKay for approximately 3% of hours in 2014. THC and AQHI both accounted for the highest sub index 39% of the time with TRS accounting for the highest sub index 22% of the time and SO_2 only 0.3% of the time. Five of the nine hours with a complaint to Alberta Hotline had a calculated FMAQI greater than six.

7 Recommendations

The following preliminary recommendations are provided:

1. The Community Odour Monitoring Program provides more consistent observations of odours and is providing a valuable data set. Because of the reduction in reports to the Alberta Hotline obtaining a similar record of community complaints from Fort McKay and Anzac would be highly beneficial.
2. The usefulness of the eNose system as an indicator of odours is not apparent regardless of which data processing technique is employed. The lack of directionality in results and the poor correlation with all other measured parameters resulted in the data being of very limited value. There are two other eNose systems operated in Fort McKay by the community and it would be very useful to compare the results from the three different units.
3. Results from the two PFGC systems were again very variable with many step changes in response to VOC species and to groups of species through the course of the year. Detection percentages for both COS and CS_2 were very low compared to previous years. The PFGC program was terminated in April 2015 so no further recommendations are warranted.
4. Detection levels for the canister sampling are too high to identify any of the most odorous target species and either the measurements should be terminated or improvements in detection levels should be sought. The cartridge sampling program which commenced in 2015 by HEMP may produce much more useful results for RSC species.
5. The NMHC measurements appeared variable and the lack of correlation amongst the various NMHC/VOC measurement methods is cause for concern. Since many of the complaints refer to hydrocarbon odours, additional effort is required to identify and routinely measure odorous and/or indicator VOC species. The EC BTEX instrument did appear to operate consistently through the year with low detection levels for a number of species.
6. The special measurements made by Environment Canada at the Fort McKay Oski ôtin site may be useful as indicators of specific sources of odours but there were too few hours with recorded odour complaints to do a complete analysis. Further analysis of the data is recommended if additional records of odour complaints in Fort McKay can be obtained.
7. The response of TRS instrumentation to other RSC such as carbonyl sulphide and carbon disulphide should be investigated.
8. Data on source and control equipment operations during complaint periods should be obtained to see if there are any linkages to odour complaints. This is a vital piece of information to improve our understanding of why odours occur and thus potentially reduce the number of odour complaints in the future.
9. There is often a disconnect between odour complaints and elevated levels of currently measured ambient species suggesting that the specific compounds responsible for complaints are not being measured and/or detected. It may be more beneficial to carry out source emission characterization for a list of candidate odorous compounds than to implement more ambient measurement programs. The strong directionality of odour complaints at all community sites suggests that there are specific sources responsible for the odour complaints.

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Appendix A:

Table A1: Meteorological Parameters for Patricia McInnes and Athabasca Valley on COMP Complaint Days.

Date	Hour	#	Observed Weather	Observed Wind	Wind Direction		Wind Speed		Temperature	Delta	Wind Dir 100m	Wind Speed 100m
					AMS6	AMS7	AMS6	AMS7	AMS6	LC	LC	LC
1/9/14	6	1	Cloudy	Calm Winds	157	149	4.8	5.7	-11.1	1.4	156	10.6
1/9/14	18	2	Cloudy	Calm Winds	139	251	5.0	3.7	-9.3		24	6.0
1/10/14	7	3	Snow	Calm Winds	333	329	9.6	8.3	-13.4			
1/10/14	15	4	Snow	Calm Winds	325	357	5.2	6.0	-11.8			
1/17/14	16	5	Cloudy	Calm Winds	290	288	25.0	20.7	6.2	-0.2	299	31.7
1/18/14	15	6	Sunny/Clear Blue Sky	Calm Winds	222	165	10.4	2.4	5.9	5.1	162	7.1
1/18/14	16	6	Sunny/Clear Blue Sky	Calm Winds	220	161	9.5	2.0	0.8	3.9	143	8.9
1/18/14	17	7	Sunny/Clear Blue Sky	Calm Winds	240	135	10.0	2.7	-2.3	2.4	65	11.0
1/18/14	18	7	Sunny/Clear Blue Sky	Calm Winds	286	56	9.8	4.4	-5.1	1.4	41	13.3
1/18/14	19	8	Cloudy	Calm Winds	329	6	9.6	5.9	-7.4	0.6	17	14.8
1/19/14	11	9	Cloudy	Calm Winds	331	312	5.3	2.8	-11.1	0.1	359	10.0
1/25/14	15	10	Cloudy	Calm Winds	334	9	18.6	12.3	-4.6	0.1	358	17.2
2/14/14	12	11	Sunny/Clear Blue Sky	Calm Winds	353	342	4.9	3.4	-17.2	1.6	343	6.7
3/13/14	18	12	Snow	Calm Winds	353		13.6		-2.7	-1.3	10	14.1
3/17/14	9	13	Periods of Cloud	Windy	333	274	8.7	2.8	0.2	0.8	351	9.4
3/17/14	10	13	Periods of Cloud	Windy	338	283	9.0	3.1	-0.5	0.5	355	9.5
3/17/14	11	13	Periods of Cloud	Windy	342	300	10.5	4.8	0.3	0.1	1	10.9
3/17/14	12	13	Periods of Cloud	Windy	346	313	12.0	7.0	1.8	-0.3	3	11.4
3/17/14	13	13	Periods of Cloud	Windy	351	327	13.7	8.9	2.9	-0.8	6	12.1
3/17/14	14	13	Periods of Cloud	Windy	353	338	14.8	10.5	4.0	-1.2	8	12.9
3/17/14	16	14	Sunny/Clear Blue Sky	Calm Winds	355	348	16.5	13.2	4.6	-1.6	4	14.0
3/18/14	18	15	Cloudy	Calm Winds	300	309	17.5	14.6	3.1	-1.2	319	17.8
3/19/14	7	16	Cloudy	Calm Winds	131	128	4.5	6.3	-5.4	2.5	146	6.9
4/3/14	8	17	Cloudy	Calm Winds	345	349	12.0	10.7	-17.0	-0.2	353	11.8
5/1/14	2	18	Rain	Calm Winds	229	196	8.9	4.1	14.9	1.3	243	24.5
5/1/14	7	19	Rain	Very Windy	296	292	13.6	9.3	8.9	0.7	333	18.3
5/1/14	9	20	Sunny/Clear Blue Sky	Windy	315	326	13.8	7.9	10.0	0.2	339	16.5
5/3/14	2	21	Cloudy	Windy	353	355	18.5	16.8	-3.5	-1.5	3	27.6

Date	Hour	#	Observed Weather	Observed Wind	Wind Direction		Wind Speed		Temperature	Delta	Wind Dir 100m	Wind Speed 100m
					AMS6	AMS7	AMS6	AMS7	AMS6	LC	LC	LC
5/7/14	9	22	Cloudy	Calm Winds	323	328	11.2	9.1	0.4	0.5	349	13.0
5/7/14	9	23	Cloudy	Windy	323	328	11.2	9.1	0.4	0.5	349	13.0
5/9/14	9	24	Cloudy	Calm Winds	333	328	6.6	6.6	2.5	-1.0	342	7.6
5/9/14	10	25	Sunny/Clear Blue Sky	Calm Winds	332	318	6.3	6.3	2.2	-1.2	341	8.3
5/10/14	19	26	Cloudy	Calm Winds	326	333	19.3	19.0	1.6	-1.4	335	16.4
5/14/14	9	27	Sunny/Clear Blue Sky	Windy	110	129	6.0	5.4	10.4	0.8	144	12.4
5/15/14	9	28	Rain	Calm Winds	101	131	6.4	7.5	8.5	-0.2	100	12.5
5/17/14	10	29	Cloudy	Windy	162	105	3.6	4.3	12.1	0.7	110	4.1
5/17/14	22	30	Cloudy	Calm Winds	42	46	8.3	7.0	14.3	-1.2	47	10.1
5/18/14	14	31	Cloudy	Calm Winds	83	294	5.7	4.0	17.8	-1.5	327	8.9
5/21/14	11	32	Sunny/Clear Blue Sky	Very Windy	200	146	9.9	8.2	20.9	-0.2	152	13.1
5/26/14	9	33	Rain	Windy	71	95	6.4	3.3	12.0	-0.6	107	11.8
5/26/14	9	34	Cloudy	Calm Winds	71	95	6.4	3.3	12.0	-0.6	107	11.8
5/26/14	10	33	Rain	Windy	75	100	8.2	4.7	11.8	-0.7	103	10.0
5/28/14	19	35	Cloudy	Calm Winds	75	100	10.0	7.4	10.6	-1.5	131	11.8
5/29/14	9	36	Rain	Windy	60	75	6.0	3.8	6.9	-0.5	101	5.7
5/29/14	14	37	Rain	Windy	359	345	9.7	8.0	8.1	-0.8	5	11.6
5/29/14	15	37	Rain	Windy	353	341	10.6	9.2	8.3	-0.8	3	13.7
5/29/14	16	38	Rain	Windy	349	338	11.3	11.0	8.2	-0.8	2	15.6
5/29/14	17	39	Rain	Calm Winds	348	339	13.3	13.4	7.9	-0.8	0	17.0
5/29/14	18	40	Sunny/Clear Blue Sky	Calm Winds	343	336	14.5	14.2	7.5	-0.8	358	19.2
5/31/14	9	41	Sunny/Clear Blue Sky	Calm Winds	231	139	6.8	2.8	14.9	0.9	18	3.8
5/31/14	10	42	Sunny/Clear Blue Sky	Windy	253	117	5.7	3.2	16.1	0.5	4	4.3
5/31/14	12	43	Sunny/Clear Blue Sky	Calm Winds	19	0	6.3	5.1	17.5	-0.8	353	6.8
6/1/14	13	44	Sunny/Clear Blue Sky	Calm Winds	121	126	12.6	9.1	17.3	-0.9	143	28.1
6/2/14	7	45	Sunny/Clear Blue Sky	Calm Winds	190	138	4.9	6.3	11.8	1.2	167	11.1
6/2/14	19	46	Sunny/Clear Blue Sky	Calm Winds	322	30	11.4	7.5	22.9	-1.2	295	17.2
6/2/14	22	47	Sunny/Clear Blue Sky	Calm Winds	358	13	12.5	9.0	15.7	-0.5	3	17.5
6/2/14	22	48	Sunny/Clear Blue Sky	Calm Winds	358	13	12.5	9.0	15.7	-0.5	3	17.5
6/3/14	6	49	Sunny/Clear Blue Sky	Calm Winds	307	256	5.0	2.3	10.6	3.7	3	11.1

Date	Hour	#	Observed Weather	Observed Wind	Wind Direction		Wind Speed		Temperature	Delta	Wind Dir 100m	Wind Speed 100m
					AMS6	AMS7	AMS6	AMS7	AMS6	LC	LC	LC
6/3/14	7	49	Sunny/Clear Blue Sky	Calm Winds	322	300	5.4	2.4	14.5	3.0	1	11.5
6/3/14	8	49	Sunny/Clear Blue Sky	Calm Winds	341	5	5.3	2.3	15.8	2.1	2	11.0
6/3/14	8	50	Sunny/Clear Blue Sky	Calm Winds	341	5	5.3	2.3	15.8	2.1	2	11.0
6/3/14	8	51	Sunny/Clear Blue Sky	Calm Winds	341	5	5.3	2.3	15.8	2.1	2	11.0
6/3/14	8	52	Sunny/Clear Blue Sky	Calm Winds	341	5	5.3	2.3	15.8	2.1	2	11.0
6/3/14	20	53	Rain	Calm Winds	12	29	17.0	11.4	11.5	-1.3	358	28.8
6/3/14	24	54	Cloudy	Calm Winds	336	334	19.3	17.4	9.5	-1.0	1	24.8
6/4/14	8	55	Rain	Calm Winds	313	313	8.8	10.4	8.0	-1.1	358	11.5
6/4/14	13	56	Cloudy	Windy	310	320	13.3	14.3	9.4	-1.3	352	13.1
6/5/14	9	57	Rain	Windy	350	358	18.5	17.5	6.0	-1.4	2	23.9
6/6/14	10	58	Cloudy	Calm Winds	322	299	6.5	4.5	10.1	-1.1	343	5.4
6/6/14	19	59	Sunny/Clear Blue Sky	Calm Winds	23	338	7.5	6.5	14.0	-1.8	2	8.4
6/7/14	13	60	Cloudy	Calm Winds	75	98	8.0	5.9	13.9	-1.3	350	9.1
6/8/14	10	61	Periods of Cloud	Calm Winds	159	120	4.6	5.4	15.1	0.3	170	6.3
6/10/14	7	62	Cloudy	Calm Winds	357	19	10.3	8.2	9.2	-0.1	34	17.5
6/12/14	11	63	Sunny/Clear Blue Sky	Calm Winds	231	91	4.8	3.4	20.5	0.2	194	3.8
6/14/14	10	64	Sunny/Clear Blue Sky	Windy	122	142	9.1	8.6	20.4	-0.9	148	25.7
6/16/14	7	65	Cloudy	Calm Winds	292	164	2.2	2.0	11.0	4.0	119	7.0
6/16/14	15	66	Cloudy	Calm Winds	109	143	9.5	6.5	21.1	-1.5	148	10.8
6/16/14	16	67	Cloudy	Calm Winds	112	155	8.8	6.9	21.6	-1.6	157	10.6
6/16/14	20	68	Cloudy	Calm Winds	169	168	4.6	5.8	19.8	-1.2	88	12.0
6/17/14	19	69	Rain	Calm Winds	145	134	10.1	8.3	16.6	-1.6	154	13.7
6/19/14	8	70	Sunny/Clear Blue Sky	Calm Winds	153	137	3.8	3.9	15.2	-0.2	149	17.2
6/20/14	9	71	Cloudy	Calm Winds	214	180	2.2	2.3	16.7	-0.2	3	6.7
6/20/14	9	72	Cloudy	Calm Winds	214	180	2.2	2.3	16.7	-0.2	3	6.7
6/20/14	9	73	Cloudy	Calm Winds	214	180	2.2	2.3	16.7	-0.2	3	6.7
6/21/14	7	74	Rain	Windy	343	329	6.5	6.4	14.3	-0.5	9	7.0
6/21/14	8	74	Rain	Windy	349	333	6.9	6.4	14.3	-0.6	9	8.0
6/21/14	9	74	Rain	Windy	352	334	7.9	6.7	14.3	-0.6	11	9.0
6/21/14	8	75	Rain	Calm Winds	349	333	6.9	6.4	14.3	-0.6	9	8.0
6/21/14	9	76	Rain	Calm Winds	352	334	7.9	6.7	14.3	-0.6	11	9.0
6/21/14	9	77	Rain	Calm Winds	352	334	7.9	6.7	14.3	-0.6	11	9.0
6/21/14	9	78	Rain	Calm Winds	352	334	7.9	6.7	14.3	-0.6	11	9.0

Date	Hour	#	Observed Weather	Observed Wind	Wind Direction		Wind Speed		Temperature	Delta	Wind Dir 100m	Wind Speed 100m
					AMS6	AMS7	AMS6	AMS7	AMS6	LC	LC	LC
6/21/14	10	78	Rain	Calm Winds	347	334	8.5	7.3	14.4	-0.6	7	10.3
6/21/14	11	79	Rain	Calm Winds	345	334	9.3	8.2	14.7	-0.7	359	11.2
6/21/14	12	80	Rain	Calm Winds	344	334	9.6	8.6	14.9	-0.7	349	12.0
6/22/14	14	81	Rain	Calm Winds	323	343	9.2	7.2	19.4	-1.6	334	9.1
6/23/14	6	82	Cloudy	Calm Winds	298	162	3.4	1.9	14.7	1.1	351	5.3
6/23/14	7	82	Cloudy	Calm Winds	293	155	2.9	1.9	16.1	1.3	337	5.2
6/23/14	8	83	Cloudy	Calm Winds	301	134	2.7	2.0	17.2	1.3	325	4.6
6/23/14	9	84	Cloudy	Calm Winds	319	125	2.8	2.6	18.0	1.1	318	4.0
6/26/14	21	85	Periods of Cloud	Calm Winds	266	238	7.5	7.3	19.0	-0.7	319	9.5
6/26/14	21	86	Periods of Cloud	Calm Winds	266	238	7.5	7.3	19.0	-0.7	319	9.5
6/26/14	22	87	Periods of Cloud	Calm Winds	289	256	7.2	6.7	18.3	-0.7	336	9.3
6/26/14	22	88	Sunny/Clear Blue Sky	Calm Winds	289	256	7.2	6.7	18.3	-0.7	336	9.3
6/26/14	22	89	Periods of Cloud	Calm Winds	289	256	7.2	6.7	18.3	-0.7	336	9.3
6/26/14	23	90	Sunny/Clear Blue Sky	Calm Winds	317	298	7.1	5.3	16.5	-0.6	335	10.7
6/27/14	8	91	Cloudy	Calm Winds	345	137	3.5	2.4	17.4	0.4	17	4.8
6/27/14	9	91	Cloudy	Calm Winds	2	123	3.3	2.8	19.3	0.1	48	5.3
6/27/14	10	92	Periods of Cloud	Calm Winds	38	117	3.5	2.5	20.7	-0.2	97	5.5
6/27/14	12	93	Cloudy	Calm Winds	77	90	4.5	2.6	22.9	-0.7	113	4.1
6/27/14	13	93	Cloudy	Calm Winds	87	23	4.5	2.4	22.2	-1.0	138	4.2
6/27/14	13	94	Sunny/Clear Blue Sky	Calm Winds	87	23	4.5	2.4	22.2	-1.0	138	4.2
6/27/14	14	93	Cloudy	Calm Winds	85	24	5.6	3.3	21.7	-1.2	167	3.9
6/27/14	15	93	Cloudy	Calm Winds	80	5	5.3	3.1	21.4	-1.0	146	5.5
6/27/14	16	93	Cloudy	Calm Winds	65	282	5.5	3.7	20.4	-0.5	81	5.6
6/27/14	17	93	Cloudy	Calm Winds	8	247	5.7	4.1	22.1	-0.2	2	5.9
6/27/14	18	95	Sunny/Clear Blue Sky	Calm Winds	337	247	5.9	4.4	22.0	-0.1	351	8.1
6/28/14	8	96	Sunny/Clear Blue Sky	Calm Winds	282	108	2.3	2.8	18.6	1.4	5	2.9
6/29/14	8	97	Cloudy	Windy	324	280	9.4	5.7	18.8	2.2	337	11.9
6/29/14	10	98	Cloudy	Windy	329	293	11.1	6.2	21.8	0.7	338	11.2
6/29/14	11	99	Sunny/Clear Blue Sky	Calm Winds	333	309	12.8	7.5	23.1	-0.1	340	11.3
6/29/14	12	99	Sunny/Clear Blue Sky	Calm Winds	340	323	14.4	9.2	24.0	-0.7	341	12.8
6/29/14	13	100	Cloudy	Windy	342	335	16.0	11.5	24.8	-1.1	347	16.9
6/29/14	14	101	Sunny/Clear Blue Sky	Calm Winds	348	346	18.6	14.2	25.6	-1.4	355	20.6
6/29/14	15	102	Cloudy	Windy	351	346	20.3	16.5	26.1	-1.5	359	24.8

Date	Hour	#	Observed Weather	Observed Wind	Wind Direction		Wind Speed		Temperature	Delta	Wind Dir 100m	Wind Speed 100m
					AMS6	AMS7	AMS6	AMS7	AMS6	LC	LC	LC
6/29/14	16	102	Cloudy	Windy	354	346	21.7	18.1	26.2	-1.5	359	28.5
6/29/14	17	102	Cloudy	Windy	354	346	22.8	19.5	25.6	-1.5	0	31.3
6/29/14	18	103	Cloudy	Very Windy	351	347	23.6	20.3	25.3	-1.4	0	33.7
6/29/14	19	104	Sunny/Clear Blue Sky	Windy	351	348	24.7	20.1	25.1	-1.3	0	34.6
6/29/14	20	104	Sunny/Clear Blue Sky	Windy	348	348	24.5	19.6	24.7	-1.2	359	34.8
6/29/14	21	104	Sunny/Clear Blue Sky	Windy	345	347	23.6	18.4	23.4	-1.0	357	34.0
6/29/14	22	105	Cloudy	Calm Winds	341	344	22.1	16.8	21.8	-0.7	354	32.2
6/29/14	23	106	Cloudy	Windy	337	340	20.5	14.2	20.9	-0.4	350	31.1
6/30/14	8	107	Cloudy	Calm Winds	312	331	13.8	9.6	18.6	0.4	334	14.5
6/30/14	9	108	Sunny/Clear Blue Sky	Calm Winds	317	334	14.1	10.4	19.7	0.0	337	14.6
6/30/14	10	109	Cloudy	Windy	322	337	14.5	11.3	20.9	-0.4	342	14.8
6/30/14	11	109	Cloudy	Windy	328	342	15.0	11.0	21.5	-0.9	343	15.3
6/30/14	12	109	Cloudy	Windy	334	345	16.0	11.7	22.0	-1.3	345	16.5
6/30/14	13	110	Cloudy	Windy	337	346	16.8	13.1	22.7	-1.6	346	17.6
7/1/14	8	111	Cloudy	Calm Winds	253	142	3.0	3.1	16.0	2.1	139	2.8
7/1/14	9	111	Cloudy	Calm Winds	234	122	2.7	3.5	17.8	1.5	176	3.1
7/1/14	10	111	Cloudy	Calm Winds	209	119	2.9	3.6	20.1	0.9	168	3.5
7/1/14	11	111	Cloudy	Calm Winds	190	116	3.3	4.2	22.2	0.3	169	4.1
7/1/14	12	112	Cloudy	Calm Winds	170	100	3.9	4.2	23.8	-0.3	170	3.8
7/3/14	24	113	Cloudy	Calm Winds	339	327	5.7	4.1	19.6	-0.9	24	11.9
7/7/14	7	114	Cloudy	Calm Winds	274	234	5.9	7.3	15.7	1.0	313	10.7
7/7/14	7	115	Cloudy	Calm Winds	274	234	5.9	7.3	15.7	1.0	313	10.7
7/7/14	8	116	Cloudy	Calm Winds	275	228	5.8	7.7	17.4	0.9	314	11.0
7/7/14	9	116	Cloudy	Calm Winds	280	223	6.3	7.3	19.0	0.5	313	11.0
7/7/14	10	116	Cloudy	Calm Winds	286	210	6.3	6.1	19.8	0.1	317	10.7
7/7/14	10	117	Sunny/Clear Blue Sky	Calm Winds	286	210	6.3	6.1	19.8	0.1	317	10.7
7/7/14	10	118	Sunny/Clear Blue Sky	Calm Winds	286	210	6.3	6.1	19.8	0.1	317	10.7
7/7/14	10	119	Cloudy	Calm Winds	286	210	6.3	6.1	19.8	0.1	317	10.7
7/7/14	11	116	Cloudy	Calm Winds	294	213	7.6	6.0	20.4	-0.2	322	10.3
7/7/14	12	116	Cloudy	Calm Winds	307	231	9.3	6.1	21.2	-0.7	322	9.6
7/7/14	13	120	Periods of Cloud	Calm Winds	307	314	10.5	6.0	21.9	-1.2	326	10.1
7/7/14	14	120	Periods of Cloud	Calm Winds	314	351	12.2	6.8	22.9	-1.6	331	10.5
7/7/14	15	120	Periods of Cloud	Calm Winds	316	356	13.1	8.2	23.3	-1.8	336	11.2
7/7/14	16	120	Periods of Cloud	Calm Winds	314	341	14.3	10.9	23.1	-1.7	345	12.4

Date	Hour	#	Observed Weather	Observed Wind	Wind Direction		Wind Speed		Temperature	Delta	Wind Dir 100m	Wind Speed 100m
					AMS6	AMS7	AMS6	AMS7	AMS6	LC	LC	LC
7/7/14	17	121	Periods of Cloud	Calm Winds	319	344	14.0	11.4	21.7	-1.5	352	13.1
7/8/14	15	122	Sunny/Clear Blue Sky	Calm Winds	163	152	9.7	4.7	27.2	-1.2	154	18.1
7/8/14	21	123	Sunny/Clear Blue Sky	Calm Winds	181	184	12.3	7.7	23.9	-1.1	170	14.1
7/8/14	21	124	Sunny/Clear Blue Sky	Calm Winds	181	184	12.3	7.7	23.9	-1.1	170	14.1
7/11/14	13	125	Periods of Cloud	Calm Winds	271	250	9.5	9.2	16.6	-1.5	288	15.6
7/12/14	9	127	Cloudy	Calm Winds	314	295	6.9	3.4	13.3	0.2	347	11.1
7/12/14	10	126	Sunny/Clear Blue Sky	Calm Winds	315	290	6.6	3.1	14.6	-0.2	344	10.0
7/12/14	11	126	Sunny/Clear Blue Sky	Calm Winds	316	282	6.9	2.9	15.7	-0.7	339	8.7
7/12/14	12	128	Cloudy	Calm Winds	316	272	7.2	3.3	16.7	-1.2	333	8.6
7/12/14	22	129	Cloudy	Calm Winds	8	311	5.9	4.7	12.9	-0.8	0	7.3
7/16/14	9	130	Cloudy	Calm Winds	241	160	7.7	3.6	20.1	0.3	272	8.0
7/16/14	10	130	Cloudy	Calm Winds	241	160	6.1	3.6	20.7	0.4	290	8.4
7/16/14	11	130	Cloudy	Calm Winds	249	155	4.7	3.5	22.8	0.2	306	8.6
7/16/14	12	131	Cloudy	Calm Winds	261	176	4.8	3.4	23.6	0.0	325	8.7
7/16/14	13	131	Cloudy	Calm Winds	280	140	5.7	3.5	23.4	-0.5	340	9.1
7/16/14	14	132	Sunny/Clear Blue Sky	Calm Winds	302	35	7.2	4.6	21.7	-0.8	353	10.5
7/17/14	9	133	Sunny/Clear Blue Sky	Calm Winds	278	114	4.5	3.5	18.7	1.3	344	5.4
7/17/14	15	134	Sunny/Clear Blue Sky	Calm Winds	117	270	3.7	5.1	23.2	-1.7	272	3.6
7/18/14	8	135	Sunny/Clear Blue Sky	Calm Winds	249	217	3.7	3.6	17.7	1.2	346	8.3
7/18/14	8	136	Periods of Cloud	Calm Winds	249	217	3.7	3.6	17.7	1.2	346	8.3
7/19/14	18	137	Periods of Cloud	Calm Winds	277	288	16.8	17.3	17.5	-1.5	283	27.2
7/19/14	19	137	Periods of Cloud	Calm Winds	279	286	18.1	18.4	15.6	-1.4	294	25.7
7/19/14	20	137	Periods of Cloud	Calm Winds	285	293	17.9	18.3	14.7	-1.3	308	26.2
7/19/14	21	138	Cloudy	Windy	295	302	17.8	19.0	14.2	-1.2	323	25.8
7/19/14	22	137	Periods of Cloud	Calm Winds	304	309	17.0	17.9	14.0	-1.1	329	24.3
7/20/14	10	139	Sunny/Clear Blue Sky	Calm Winds	266	217	6.7	5.6	16.9	-0.6	300	10.1
7/20/14	11	139	Sunny/Clear Blue Sky	Calm Winds	278	203	6.7	4.5	18.0	-0.9	313	9.2
7/20/14	12	140	Sunny/Clear Blue Sky	Calm Winds	294	223	6.8	4.5	19.0	-1.3	323	9.2
7/25/14	7	141	Periods of Cloud	Calm Winds	30	45	9.6	6.2	18.3	0.2	34	12.2
7/25/14	8	142	Cloudy	Windy	19	33	9.7	6.3	18.5	0.2	22	12.7
7/30/14	11	143	Rain	Very Windy	135	136	6.4	8.1	27.7	-0.6	145	11.8

Date	Hour	#	Observed Weather	Observed Wind	Wind Direction		Wind Speed		Temperature	Delta	Wind Dir 100m	Wind Speed 100m
					AMS6	AMS7	AMS6	AMS7	AMS6	LC	LC	LC
7/30/14	23	144	Rain	Very Windy	100	95	12.8	9.7	17.7		148	21.0
7/31/14	21	145	Cloudy	Windy	359	353	18.1	15.3	16.8		5	21.7
7/31/14	17	146	Cloudy	Windy	14	343	14.8	11.7	20.9		16	20.8
7/31/14	18	146	Cloudy	Windy	8	343	17.3	14.4	18.3		14	21.4
7/31/14	18	147	Cloudy	Windy	8	343	17.3	14.4	18.3		14	21.4
7/31/14	18	148	Cloudy	Calm Winds	8	343	17.3	14.4	18.3		14	21.4
7/31/14	19	146	Cloudy	Windy	3	343	18.3	15.7	17.7		9	22.6
7/31/14	20	146	Cloudy	Windy	358	343	19.5	17.4	17.7		8	20.9
7/31/14	20	149	Cloudy	Very Windy	358	343	19.5	17.4	17.7		8	20.9
7/31/14	21	149	Cloudy	Very Windy	359	353	18.1	15.3	16.8		5	21.7
7/31/14	22	149	Cloudy	Very Windy	351	350	17.7	16.0	15.8		359	21.2
7/31/14	23	149	Cloudy	Very Windy	348	348	16.4	16.4	15.2		359	18.8
7/31/14	24	150	Cloudy	Windy	349	347	15.0	14.7	14.8		357	19.0
8/1/14	9	151	Sunny/Clear Blue Sky	Calm Winds	350	349	12.6	13.9	13.6		0	14.6
8/2/14	17	152	Periods of Cloud	Calm Winds	175	233	14.1	11.1	25.2		174	17.3
8/4/14	18	153	Sunny/Clear Blue Sky	Calm Winds	8	341	8.7	9.2	30.0		352	10.1
8/4/14	18	154	Sunny/Clear Blue Sky	Calm Winds	8	341	8.7	9.2	30.0		352	10.1
8/4/14	19	154	Sunny/Clear Blue Sky	Calm Winds	9	342	9.2	8.8	27.8		7	10.8
8/4/14	20	155	Cloudy	Very Windy	9	338	9.2	7.9	23.8		18	11.0
8/4/14	21	156	Cloudy	Calm Winds	359	327	9.0	7.2	20.9		32	12.3
8/5/14	8	157	Sunny/Clear Blue Sky	Calm Winds	249	132	2.6	3.7	16.4		162	8.1
8/5/14	9	158	Sunny/Clear Blue Sky	Calm Winds	172	134	3.2	4.6	18.7		151	8.8
8/5/14	10	159			148	135	3.8	5.0	21.1		142	8.4
8/5/14	11	159			153	130	4.9	5.7	23.4		140	8.9
8/5/14	12	159			133	118	5.9	5.3	26.4		142	9.5
8/5/14	13	160	Sunny/Clear Blue Sky	Calm Winds	121	127	7.0	4.4	28.8		140	8.1
8/5/14	14	160	Sunny/Clear Blue Sky	Calm Winds	119	128	7.9	4.7	29.9		139	7.5
8/5/14	15	161	Sunny/Clear Blue Sky	Calm Winds	113	119	9.0	4.9	30.7		138	9.3
8/7/14	7	162	Sunny/Clear Blue Sky	Calm Winds	232	232	10.8	10.8	15.8		263	27.2
8/7/14	11	163	Periods of Cloud	Calm Winds	255	255	15.8	16.5	21.0		265	29.0
8/8/14	11	164	Sunny/Clear Blue Sky	Windy	318	71	4.6	4.0	19.4		2	6.3

Date	Hour	#	Observed Weather	Observed Wind	Wind Direction		Wind Speed		Temperature	Delta	Wind Dir 100m	Wind Speed 100m
					AMS6	AMS7	AMS6	AMS7	AMS6	LC	LC	LC
8/12/14	17	165	Sunny/Clear Blue Sky	Calm Winds	103	119	13.0	10.3	28.7		141	13.9
8/14/14	12	166	Sunny/Clear Blue Sky	Calm Winds	313	308	6.1	4.3	26.5		328	5.3
8/14/14	13	166	Sunny/Clear Blue Sky	Calm Winds	305	331	5.7	4.2	27.9		336	4.4
8/14/14	13	167	Cloudy	Calm Winds	305	331	5.7	4.2	27.9		336	4.4
8/14/14	14	166	Sunny/Clear Blue Sky	Calm Winds	312	345	5.9	4.1	28.4		322	4.2
8/16/14	10	168	Cloudy	Calm Winds	15	117	5.0	3.4	21.3		355	5.7
8/17/14	10	169	Sunny/Clear Blue Sky	Calm Winds	300	243	9.6	7.9	23.7		315	11.0
8/17/14	11	169	Sunny/Clear Blue Sky	Calm Winds	307	260	9.8	7.5	24.7		325	10.1
8/18/14	16	170	Cloudy	Calm Winds	230	218	9.4	6.5	25.3		252	7.9
8/18/14	17	170	Cloudy	Calm Winds	238	241	10.3	7.1	22.7		272	9.5
8/18/14	18	171	Cloudy	Calm Winds	254	265	10.0	8.2	21.7		314	8.7
8/18/14	19	172	Rain	Calm Winds	274	284	9.5	8.6	19.8		332	8.3
8/19/14	7	173	Rain	Calm Winds	254	267	3.7	3.1	15.1		274	4.5
8/20/14	13	174	Cloudy	Calm Winds	354	348	15.4	14.3	12.8		13	19.3
8/20/14	14	174	Cloudy	Calm Winds	352	346	15.5	14.8	13.0		12	19.2
8/21/14	19	175	Sunny/Clear Blue Sky	Calm Winds	356	352	11.8	10.9	14.9		357	14.5
8/21/14	20	175	Sunny/Clear Blue Sky	Calm Winds	3	358	12.0	10.2	13.7		4	14.8
8/23/14	21	176	Sunny/Clear Blue Sky	Windy	108	114	8.7	7.0	14.1		152	7.0
8/24/14	8	177	Cloudy	Calm Winds	316	105	4.0	3.0	10.0		3	6.5
8/24/14	9	178	Cloudy	Calm Winds	319	100	4.1	2.7	12.3		1	7.0
8/24/14	10	179	Periods of Cloud	Windy	325	43	4.1	3.1	15.6		358	7.1
8/24/14	11	179	Periods of Cloud	Windy	340	341	4.0	3.2	17.0		354	6.9
8/26/14	14	180	Cloudy	Calm Winds	196	104	8.3	6.3	25.6		147	11.2
8/26/14	21	181	Cloudy	Calm Winds	232	243	13.3	9.9	19.1		194	16.6
8/26/14	21	182	Cloudy	Calm Winds	232	243	13.3	9.9	19.1		194	16.6
8/30/14	10	183	Sunny/Clear Blue Sky	Calm Winds	156	142	6.2	6.2	11.8		180	14.4
9/2/14	21	184	Cloudy	Calm Winds	316	310	8.3	5.8	10.3		336	10.6
9/4/14	19	185	Rain	Calm Winds		275		6.4	10.8		217	9.2
9/8/14	9	186	Sunny/Clear Blue Sky	Calm Winds	335	331	10.3	12.8	2.6		356	10.9
9/8/14	9	187	Sunny/Clear Blue Sky	Calm Winds	335	331	10.3	12.8	2.6		356	10.9
9/8/14	16	188	Cloudy	Calm Winds	345	338	12.1	11.8	5.7		357	12.3

Date	Hour	#	Observed Weather	Observed Wind	Wind Direction		Wind Speed		Temperature	Delta	Wind Dir 100m	Wind Speed 100m
					AMS6	AMS7	AMS6	AMS7	AMS6	LC	LC	LC
9/8/14	17	188	Cloudy	Calm Winds	341	339	11.5	11.5	5.7		358	13.2
9/8/14	18	190	Cloudy	Calm Winds	340	343	11.1	10.5	5.3		0	13.7
9/8/14	19	189	Sunny/Clear Blue Sky	Calm Winds	342	350	10.8	9.8	4.6		359	14.1
9/8/14	19	192	Cloudy	Windy	342	350	10.8	9.8	4.6		359	14.1
9/9/14	19	193	Cloudy	Calm Winds	323	296	5.9	5.2	4.3		113	3.0
9/8/14	20	191	Cloudy	Calm Winds	346	1	10.3	8.4	3.3		6	12.6
9/12/14	6	194	Periods of Cloud	Calm Winds	220	131	8.9	4.2	3.5		252	13.1
9/12/14	7	194	Periods of Cloud	Calm Winds	216	132	7.8	3.9	3.9		251	10.2
9/12/14	8	194	Periods of Cloud	Calm Winds	215	126	7.2	3.7	4.7		257	9.8
9/12/14	9	194	Periods of Cloud	Calm Winds	218	123	6.9	3.2	8.4		271	9.8
9/12/14	10	194	Periods of Cloud	Calm Winds	237	117	6.7	3.3	10.5		291	10.1
9/13/14	23	195	Cloudy	Calm Winds	162	115	5.3	3.0	2.8		159	11.4
9/14/14	20	196	Sunny/Clear Blue Sky	Calm Winds	253	222	7.9	6.9	10.7		230	10.1
9/15/14	13	197	Sunny/Clear Blue Sky	Calm Winds	174	105	5.8	5.2	18.9		169	3.8
9/15/14	13	198	Sunny/Clear Blue Sky	Calm Winds	174	105	5.8	5.2	18.9		169	3.8
9/16/14	5	199	Sunny/Clear Blue Sky	Calm Winds	17	20	6.7	3.7	5.9		3	11.8
9/16/14	5	200	Sunny/Clear Blue Sky	Calm Winds	17	20	6.7	3.7	5.9		3	11.8
9/16/14	6	199	Sunny/Clear Blue Sky	Calm Winds	350	7	7.4	4.3	6.2		3	12.2
9/16/14	7	199	Sunny/Clear Blue Sky	Calm Winds	350	2	7.1	4.5	6.7		359	11.9
9/18/14	11	201	Sunny/Clear Blue Sky	Calm Winds	301	81	4.3	3.2	14.6		351	5.3
9/21/14	11	202	Sunny/Clear Blue Sky	Windy	223	133	12.7	9.0	20.0		164	13.0
9/22/14	10	203	Sunny/Clear Blue Sky	Calm Winds	189	141	4.8	3.3	16.1		159	11.9
9/23/14	11	204	Cloudy	Calm Winds	285	281	6.6	2.8	18.2			
9/23/14	12	205	Sunny/Clear Blue Sky	Calm Winds	313	317	7.1	3.8	19.6			
9/23/14	19	206	Sunny/Clear Blue Sky	Calm Winds	4	337	6.3	6.6	16.1			
9/24/14	20	207	Cloudy	Calm Winds	105	116	15.7	10.9	18.7	-0.2	129	24.3
9/25/14	17	208	Cloudy	Calm Winds	304	315	14.8	15.9	11.3	-1.5	314	20.2
9/25/14	18	208	Cloudy	Calm Winds	316	324	13.5	13.8	10.9	-1.4	327	18.5
9/25/14	19	209	Cloudy	Calm Winds	328	335	12.5	12.7	10.7	-1.4	339	16.5
9/28/14	15	210	Sunny/Clear	Windy	158	148	18.8	16.1	13.9	-1.5	163	30.1

Date	Hour	#	Observed Weather	Observed Wind	Wind Direction		Wind Speed		Temperature	Delta	Wind Dir 100m	Wind Speed 100m
					AMS6	AMS7	AMS6	AMS7	AMS6	LC	LC	LC
9/30/14	15	211	Cloudy	Calm Winds	313	342	8.5	3.2	12.5	-0.7	303	7.7
9/30/14	16	212	Rain	Calm Winds	326	349	9.0	4.1	13.4	-0.9	322	8.1
10/5/14	14	213	Sunny/Clear Blue Sky	Calm Winds	236	227	11.5	9.4	15.8	-1.3	178	8.1
10/6/14	18	214	Periods of Cloud	Windy	315	323	9.6	8.8	7.3	-1.5	336	11.8
10/7/14	10	215	Cloudy	Calm Winds	284	221	15.4	7.9	6.7	0.1	307	22.5
10/7/14	11	215	Cloudy	Calm Winds	289	226	16.2	6.7	7.9	-0.4	312	18.9
10/7/14	12	215	Cloudy	Calm Winds	294	239	16.9	6.2	9.5	-0.9	319	14.6
10/18/14	14	216	Sunny/Clear Blue Sky	Calm Winds	180	121	5.3	5.7	13.1	-0.8	164	7.9
10/22/14	11	217	Cloudy	Calm Winds	154	139	6.2	6.1	7.5	3.1	151	11.0
10/23/14	9	218	Cloudy	Calm Winds	95	62	5.5	1.7	6.0	2.8	109	11.5
10/27/14	21	219	Cloudy	Calm Winds	318	322	7.8	7.3	-0.7	-1.0	355	9.4
10/29/14	9	220	Cloudy	Calm Winds	38	2	7.1	2.8	-0.6	-1.0	21	6.0
10/31/14	17	221	Cloudy	Calm Winds	133	134	8.4	11.7	3.3	-0.9	160	19.4
11/3/14	9	222	Snow	Calm Winds	163	172	6.3	6.6	-2.8	-0.8	160	9.1
11/3/14	15	223	Snow	Calm Winds		226		5.2	0.0	-1.0	2	7.7
11/5/14	9	224	Cloudy	Calm Winds	271	271	16.0	13.1	-1.4	-1.0	286	24.6
11/7/14	21	225	Periods of Cloud	Calm Winds	328	334	14.2	18.4	-10.5	-1.3	339	21.7
11/12/14	24	226	Cloudy	Calm Winds	194	123	3.3	5.4	-18.5		172	10.3
11/14/14	17	227	Cloudy	Windy	344	343	12.1	10.6	-11.5		354	13.0
11/19/14	14	228	Sunny/Clear Blue Sky	Windy	234	251	7.7	7.4	-8.7	-1.1	241	10.0
11/21/14	17	229	Cloudy	Calm Winds	340	344	9.7	6.9	-6.6	-1.4	357	12.4
11/23/14	17	230	Sunny/Clear Blue Sky	Calm Winds	181	163	7.2	3.6	-12.3		162	10.1
11/26/14	10	231	Cloudy	Calm Winds	180	177	4.1	5.4	-27.6		160	10.5
12/4/14	13	232	Periods of Cloud	Calm Winds	343	356	5.9	6.3	-14.4		16	5.6
12/10/14	19	233	Periods of Cloud	Calm Winds	233	142	5.9	3.6	-3.9	2.8	98	12.6
12/13/14	9	234	Cloudy	Calm Winds	131	161	3.2	3.8	-7.7	-0.8	120	4.8
12/13/14	17	235	Cloudy	Calm Winds	174	198	2.4	2.1	-5.3	-0.5		
12/14/14	13	236	Cloudy	Calm Winds	308	314	7.2	5.9	-6.5	-0.4		
12/15/14	9	237	Snow	Calm Winds	169	171	7.2	8.3	-10.7	-0.7		
12/26/14	18	238	Cloudy	Calm Winds	8	355	4.3	5.5	-26.6	24.7	316	3.1

Table A2: Five-minute maximum readings of TRS, NMHC and SO_2 for COMP complaint hours at Patricia McInnes and Athabasca Valley.

DATE	HOUR	RECORD	TRS		NMHC		SO2	
			AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
95th Percentile			1.0	1.1	0.13	0.13	8.4	5.8
1/9/14	6	1	0.4	0.6	0.05	0.03	0.6	0.8
1/9/14	18	2	0.9	1.5	0.42	0.07	0.8	1.1
1/10/14	7	3	0.6	0.9	0.24	0.10	7.6	4.0
1/10/14	15	4	0.5	0.9	0.13	0.20	0.9	3.0
1/17/14	16	5	0.4	0.4	0.00	0.08	0.3	1.1
1/18/14	15	6	0.4	0.7	0.54	0.19	0.6	1.0
1/18/14	16	6	0.7	2.0	0.44	0.13	4.9	1.1
1/18/14	17	7	1.0	1.3	0.28	0.15	7.8	4.2
1/18/14	18	7	1.0	1.0	0.41	0.03	9.1	4.9
1/18/14	19	8	1.1	1.1	0.45	0.02	9.0	4.4
1/19/14	11	9	0.7	2.2	0.25	0.11	2.7	1.1
1/25/14	15	10	0.5	0.8	0.17	0.00	8.4	4.4
2/14/14	12	11		1.2		0.14	13.4	11.2
3/13/14	18	12	0.6	0.4	0.14	0.00	16.1	4.2
3/17/14	9	13	0.5	1.1	0.22	0.14	0.5	1.1
3/17/14	10	13	0.4	1.0	0.24	0.10	9.0	4.2
3/17/14	11	13	0.4	0.4	0.00	0.00	4.8	4.0
3/17/14	12	13	0.4	0.6	0.00	0.00	4.8	8.8
3/17/14	13	13	0.4	0.6	0.00	0.00	17.7	12.5
3/17/14	14	13	0.3	0.6	0.02	0.00	5.4	12.1
3/17/14	16	14	0.4	0.5	0.02	0.00	5.1	8.8
3/18/14	18	15	0.4	0.4	0.03	0.00	4.4	4.4
3/19/14	7	16	0.4	0.6	0.27	0.00	0.6	0.8
4/3/14	8	17	0.6	0.8	0.03	0.00	4.9	1.3
5/1/14	2	18	0.2	0.3		0.00		0.4
5/1/14	7	19	0.2	3.5	0.00	0.00	0.3	1.1
5/1/14	9	20	0.2	1.0	0.00	0.00	1.6	2.0
5/3/14	2	21	0.3	1.2		0.00		3.4
5/7/14	9	22	0.5	0.8	0.00	0.00	3.7	7.3
5/7/14	9	23	0.5	0.8	0.00	0.00	3.7	7.3
5/9/14	9	24	0.4	0.5	0.02	0.00	4.6	5.8
5/9/14	10	25	0.2	0.4	0.00	0.00	2.7	3.9
5/10/14	19	26	0.3	0.7	0.00	0.00	0.4	7.6
5/14/14	9	27	0.3	0.5	0.00	0.01	1.0	0.9
5/15/14	9	28	0.4	3.7	0.12	0.00	0.6	0.5
5/17/14	10	29	0.2	0.4	0.00	0.00	0.4	0.7
5/17/14	22	30	2.2	0.2	0.00	0.00	0.3	0.5
5/18/14	14	31	0.5	0.4	0.00	0.00	7.0	9.2
5/21/14	11	32	0.3	0.6	0.00	0.00	0.2	0.6
5/26/14	9	33	0.3	0.4	0.00	0.00	0.2	0.4
5/26/14	9	34	0.3	0.4	0.00	0.00	0.2	0.4
5/26/14	10	33	0.2	0.4	0.00	0.00	0.3	0.6
5/28/14	19	35	0.1	0.3	0.00	0.00	0.2	0.5
5/29/14	9	36	0.2	0.9	0.00	0.00	0.2	0.5
5/29/14	14	37	0.8	1.9	0.05	0.04	0.8	0.5
5/29/14	15	37	0.7	1.5	0.04	0.03	0.7	0.6
5/29/14	16	38	0.9	1.1	0.05	0.00	1.3	0.9
5/29/14	17	39	0.6	1.5	0.08	0.00	3.5	2.3
5/29/14	18	40	0.3	0.2	0.12	0.00	4.0	2.1

DATE	HOUR	RECORD	TRS		NMHC		SO2	
			AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
5/31/14	9	41	0.9	1.9	0.04	0.00	9.5	17.0
5/31/14	10	42	0.8	0.9	0.00	0.00	11.6	7.6
5/31/14	12	43	0.7	0.6	0.08	0.00	15.0	8.3
6/1/14	13	44	0.3	0.3	0.00	0.00	0.2	0.7
6/2/14	7	45	0.2	0.4	0.00	0.01	0.2	0.6
6/2/14	19	46	0.4	0.5	0.00	0.01	3.6	2.1
6/2/14	22	47	0.5	0.6	0.14	0.00	0.2	0.5
6/2/14	22	48	0.5	0.6	0.14	0.00	0.2	0.5
6/3/14	6	49	1.1	1.1	0.28	0.05	0.5	0.6
6/3/14	7	49	0.9	2.1	0.20	0.00	0.4	0.8
6/3/14	8	49	0.6	1.9	0.01	0.01	0.4	1.1
6/3/14	8	50	0.6	1.9	0.01	0.01	0.4	1.1
6/3/14	8	51	0.6	1.9	0.01	0.01	0.4	1.1
6/3/14	8	52	0.6	1.9	0.01	0.01	0.4	1.1
6/3/14	20	53	0.5	0.8	0.00	0.00	4.6	3.7
6/3/14	24	54						
6/4/14	8	55	0.4	1.6	0.00	0.00	3.4	5.5
6/4/14	13	56	0.4	0.8		0.01		2.8
6/5/14	9	57	0.3	0.6	0.00	0.00	3.4	2.7
6/6/14	10	58		0.5	0.00	0.00	9.3	4.2
6/6/14	19	59	0.5	0.5	0.00	0.00	5.0	5.3
6/7/14	13	60	0.7	0.4	0.00	0.00	13.3	2.6
6/8/14	10	61	0.3	0.3	0.00	0.00	1.2	1.2
6/10/14	7	62	0.3	1.2	0.00	0.00	0.2	0.5
6/12/14	11	63	0.6	1.2	0.00	0.00	2.7	4.0
6/14/14	10	64	0.4	0.6	0.00	0.02	0.4	1.0
6/16/14	7	65	0.4	0.5	0.00	0.01	0.2	0.6
6/16/14	15	66	0.3	0.2	0.00		0.2	
6/16/14	16	67	0.3	0.3	0.00	0.00	0.3	0.5
6/16/14	20	68	0.3	0.4	0.00	0.02	0.4	0.8
6/17/14	19	69	0.3	0.4	0.00	0.00	0.2	0.6
6/19/14	8	70	0.2	0.4	0.00	0.05	0.4	0.6
6/20/14	9	71	0.6	0.3	0.00	0.10	0.9	0.7
6/20/14	9	72	0.6	0.3	0.00	0.10	0.9	0.7
6/20/14	9	73	0.6	0.3	0.00	0.10	0.9	0.7
6/21/14	7	74	0.6	0.7		0.05	1.1	1.0
6/21/14	8	74	1.0	0.9		0.04	2.6	1.0
6/21/14	9	74	0.7	0.7		0.04	0.6	0.7
6/21/14	8	75	1.0	0.9		0.04	2.6	1.0
6/21/14	9	76	0.7	0.7		0.04	0.6	0.7
6/21/14	9	77	0.7	0.7		0.04	0.6	0.7
6/21/14	9	78	0.7	0.7		0.04	0.6	0.7
6/21/14	10	78	0.6	0.9		0.04	0.7	0.7
6/21/14	11	79	0.6	0.8		0.04	1.8	1.0
6/21/14	12	80	0.6	0.7		0.03	1.7	0.8
6/22/14	14	81	0.6	0.7		0.07	10.3	4.0
6/23/14	6	82	0.8	0.3		0.06	0.5	0.5
6/23/14	7	82	0.8	0.4		0.04	0.6	0.6
6/23/14	8	83	0.7	0.3		0.05	0.8	0.5
6/23/14	9	84	1.4	0.4		0.32	2.5	0.9
6/26/14	21	85	0.4	0.7	0.00	0.04	0.9	0.5
6/26/14	21	86	0.4	0.7	0.00	0.04	0.9	0.5
6/26/14	22	87	0.8	0.6	0.00	0.10	1.2	0.7
6/26/14	22	88	0.8	0.6	0.00	0.10	1.2	0.7
6/26/14	22	89	0.8	0.6	0.00	0.10	1.2	0.7

DATE	HOUR	RECORD	TRS		NMHC		SO2	
			AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
6/26/14	23	90	0.9	0.9	0.00	0.06	1.1	0.6
6/27/14	8	91	0.4	0.7	0.00	0.04	0.7	0.6
6/27/14	9	91	0.3	0.7	0.00	0.11	0.7	0.6
6/27/14	10	92	0.3	0.9	0.10	0.15	0.7	0.6
6/27/14	12	93	0.3	0.7	0.02	0.02	0.6	0.7
6/27/14	13	93	0.2	0.6	0.00	0.02	0.6	0.7
6/27/14	13	94	0.2	0.6	0.00	0.02	0.6	0.7
6/27/14	14	93	0.3	0.7	0.00	0.02	0.6	0.7
6/27/14	15	93	0.3	0.7	0.00	0.03	0.7	0.5
6/27/14	16	93	0.2	0.6	0.00	0.03	0.6	0.5
6/27/14	17	93	0.3	0.6	0.00	0.02	0.7	0.4
6/27/14	18	95	0.3	0.7	0.00	0.02	0.8	0.7
6/28/14	8	96	0.8	0.9	0.00	0.06	0.7	0.7
6/29/14	8	97	1.4	2.2	0.00	0.14	9.1	1.0
6/29/14	10	98	1.2	0.8	0.00	0.03	13.6	6.0
6/29/14	11	99	0.6	0.7	0.00	0.03	5.3	1.0
6/29/14	12	99	0.6	0.6	0.00	0.01	5.2	1.0
6/29/14	13	100	0.5	0.5	0.00	0.01	4.5	2.1
6/29/14	14	101	0.7	0.4	0.00	0.01	3.1	1.0
6/29/14	15	102	0.5	0.6	0.00	0.00	2.3	0.7
6/29/14	16	102	0.5	0.5	0.00	0.01	2.6	1.8
6/29/14	17	102	0.5	0.6	0.02	0.02	4.6	2.1
6/29/14	18	103		0.6		0.02		2.9
6/29/14	19	104		0.8		0.03		4.0
6/29/14	20	104		0.7		0.02		5.0
6/29/14	21	104	0.5	2.2		0.02	1.4	2.8
6/29/14	22	105	2.2	1.9	0.00	0.02	7.2	0.9
6/29/14	23	106	1.1	2.0	0.00	0.04	6.6	2.3
6/30/14	8	107	0.9	1.4	0.01	0.08	6.7	5.7
6/30/14	9	108	0.9	1.2	0.00	0.05	12.2	5.8
6/30/14	10	109	0.7	1.1	0.00	0.04	5.4	7.4
6/30/14	11	109	0.5	1.2	0.00	0.04	6.0	8.1
6/30/14	12	109	0.5	0.9	0.00	0.03	3.6	5.0
6/30/14	13	110	0.5	0.7	0.00	0.03	3.2	2.3
7/1/14	8	111	0.7	0.8	0.00	0.29	0.8	0.9
7/1/14	9	111	0.6	0.8	0.00	0.05	0.9	0.8
7/1/14	10	111	0.5	0.7	0.00	0.04	1.0	0.9
7/1/14	11	111	0.4	0.8	0.00	0.05	1.5	1.0
7/1/14	12	112	0.3	0.7	0.00	0.03	1.6	1.1
7/3/14	24	113						
7/7/14	7	114	0.4	0.7	0.00	0.02	0.4	0.9
7/7/14	7	115	0.4	0.7	0.00	0.02	0.4	0.9
7/7/14	8	116	0.4	0.6	0.00	0.03	0.5	0.6
7/7/14	9	116	0.5	0.6	0.00	0.04	1.2	0.7
7/7/14	10	116	0.6	0.7	0.00	0.06	1.1	1.3
7/7/14	10	117	0.6	0.7	0.00	0.06	1.1	1.3
7/7/14	10	118	0.6	0.7	0.00	0.06	1.1	1.3
7/7/14	10	119	0.6	0.7	0.00	0.06	1.1	1.3
7/7/14	11	116	0.6	0.9	0.05	0.06	2.6	2.3
7/7/14	12	116	0.7	0.9	0.00	0.06	3.1	2.9
7/7/14	13	120	0.4	0.5	0.00	0.05	0.5	2.0
7/7/14	14	120	0.4	0.6	0.00	0.04	0.4	1.0
7/7/14	15	120	0.4	0.5	0.00	0.03	0.4	0.8
7/7/14	16	120	0.5	0.6	0.00	0.05	0.6	0.9
7/7/14	17	121	0.4	0.6	0.00	0.05	0.9	0.8

DATE	HOUR	RECORD	TRS		NMHC		SO2	
			AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
7/8/14	15	122	0.3	0.6	0.00	0.02	0.2	0.5
7/8/14	21	123	0.4	0.5	0.05	0.15	0.2	0.6
7/8/14	21	124	0.4	0.5	0.05	0.15	0.2	0.6
7/11/14	13	125	0.2	1.8	0.00	0.02	0.7	1.4
7/12/14	9	127	2.3	1.5	0.00	0.05	11.1	2.3
7/12/14	10	126	1.9	1.3	0.00	0.05	8.4	5.8
7/12/14	11	126	0.6	1.3	0.00	0.05	4.4	5.7
7/12/14	12	128	0.5	0.9	0.00	0.04	8.7	7.9
7/12/14	22	129	0.5	0.8	0.00	0.07	2.3	2.0
7/16/14	9	130	0.3	0.8	0.00	0.15	0.6	1.0
7/16/14	10	130	0.3	0.7	0.02	0.17	0.4	0.9
7/16/14	11	130	1.3	1.0	0.00	0.16	2.3	0.8
7/16/14	12	131	1.5	1.0	0.00	0.16	3.1	1.1
7/16/14	13	131	0.9	1.2	0.07	0.16	3.1	1.2
7/16/14	14	132	1.1	2.4	0.00	0.12	15.8	3.0
7/17/14	9	133	0.7	1.2	0.00	0.08	0.6	1.1
7/17/14	15	134	0.4	0.5	0.00	0.03	0.3	0.8
7/18/14	8	135	1.2	1.1	0.00	0.07	1.1	0.9
7/18/14	8	136	1.2	1.1	0.00	0.07	1.1	0.9
7/19/14	18	137	0.4	0.8	0.00	0.04	0.3	0.5
7/19/14	19	137	0.3	0.8	0.02	0.04	0.3	0.6
7/19/14	20	137	0.6	1.2	0.00	0.04	5.5	2.0
7/19/14	21	138	0.7	0.8	0.00	0.03	4.2	0.9
7/19/14	22	137	0.5	0.8	0.00	0.03	2.8	0.6
7/20/14	10	139	0.3	0.6	0.00	0.04	12.2	1.0
7/20/14	11	139	0.4	0.9	0.02	0.04	11.1	5.1
7/20/14	12	140	0.5	0.9	0.00	0.05	7.5	13.6
7/25/14	7	141	1.6	0.5	0.00	0.02	1.0	0.8
7/25/14	8	142	0.5	0.4	0.00	0.01	0.5	0.6
7/30/14	11	143	0.5	0.6	0.00	0.06	1.1	1.0
7/30/14	23	144	0.9	0.6	0.00	0.02	12.0	2.4
7/31/14	21	145	3.2	2.2	0.00	0.11	6.1	2.0
7/31/14	17	146	3.5	2.7	0.00	0.18	8.1	4.4
7/31/14	18	146	3.1	1.3	0.00	0.15	5.3	1.3
7/31/14	18	147	3.1	1.3	0.00	0.15	5.3	1.3
7/31/14	18	148	3.1	1.3	0.00	0.15	5.3	1.3
7/31/14	19	146	1.9	2.8	0.00	0.18	5.3	2.7
7/31/14	20	146	1.9	1.5	0.00	0.14	7.2	2.4
7/31/14	20	149	1.9	1.5	0.00	0.14	7.2	2.4
7/31/14	21	149	3.2	2.2	0.00	0.11	6.1	2.0
7/31/14	22	149	2.5	1.7	0.00	0.07	5.0	3.0
7/31/14	23	149	1.7	1.6	0.05	0.09	5.1	3.1
7/31/14	24	150						
8/1/14	9	151	0.7	0.6	0.00	0.05	0.5	1.2
8/2/14	17	152	0.5	0.4	0.00	0.03	0.3	0.8
8/4/14	18	153	1.0	0.9	0.00	0.14	1.9	1.9
8/4/14	18	154	1.0	0.9	0.00	0.14	1.9	1.9
8/4/14	19	154	0.7	0.9	0.07	0.17	0.7	1.1
8/4/14	20	155	0.7	0.7	0.00	0.20	0.5	1.1
8/4/14	21	156	0.7	0.7	0.00	0.20	0.4	0.9
8/5/14	8	157	0.7	0.7	0.00	0.07	0.4	0.8
8/5/14	9	158	0.8	0.8	0.00	0.08	0.6	0.9
8/5/14	10	159	0.9	0.8	0.00	0.23	1.0	1.0
8/5/14	11	159	0.9	0.8	0.00	0.14	1.2	1.1
8/5/14	12	159	0.8	0.6	0.04	0.14	1.3	1.1

DATE	HOUR	RECORD	TRS		NMHC		SO2	
			AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
8/5/14	13	160	0.6	0.5	0.00	0.12	0.7	1.1
8/5/14	14	160	0.5	0.5	0.04	0.16	0.6	1.1
8/5/14	15	161	0.5	0.4	0.00	0.06	1.0	1.3
8/7/14	7	162	0.5	0.7	0.00	0.04	0.2	0.4
8/7/14	11	163	0.3	0.5	0.00	0.00	0.1	0.6
8/8/14	11	164	0.6	0.6	0.00	0.04	6.7	19.2
8/12/14	17	165	0.6	0.5	0.00	0.04	0.8	1.0
8/14/14	12	166	1.0		0.00	0.12	14.2	5.4
8/14/14	13	166	0.8		0.00	0.09	5.2	8.6
8/14/14	13	167	0.8		0.00	0.09	5.2	8.6
8/14/14	14	166	0.7		0.00	0.05	6.2	4.8
8/16/14	10	168	0.7	0.4	0.00	0.07	0.5	0.5
8/17/14	10	169	0.6	0.5	0.00	0.04	8.6	12.5
8/17/14	11	169	0.6	0.5	0.00	0.03	7.1	14.3
8/18/14	16	170	0.7	0.5	0.00	0.07	0.4	0.9
8/18/14	17	170	1.2	1.6	0.00	0.12	0.5	0.9
8/18/14	18	171	1.2	1.8	0.00	0.13	2.1	3.0
8/18/14	19	172	0.7	1.3	0.00	0.15	1.3	3.4
8/19/14	7	173	1.0	0.7	0.00	0.08	2.5	2.0
8/20/14	13	174	2.4	1.1	0.02	0.00	6.2	13.0
8/20/14	14	174	2.4	1.3	0.00	0.29	6.9	18.8
8/21/14	19	175	0.8	0.5	0.00	0.06	6.7	3.0
8/21/14	20	175	0.4	0.6	0.02	0.10	0.5	0.7
8/23/14	21	176	0.5	0.6	0.00	0.02	0.5	0.7
8/24/14	8	177	1.6	1.7	0.03	0.08	0.5	0.8
8/24/14	9	178	1.7	1.2	0.00	0.17	0.6	0.9
8/24/14	10	179	1.3	0.9	0.00	0.30	0.6	0.9
8/24/14	11	179	0.8	1.3	0.00	0.09	0.5	0.9
8/26/14	14	180	0.5	0.4	0.04	0.06	0.4	0.8
8/26/14	21	181	0.5	1.2	0.00	0.15	0.9	1.0
8/26/14	21	182	0.5	1.2	0.00	0.15	0.9	1.0
8/30/14	10	183	0.6	0.3	0.01	0.02	0.2	0.8
9/2/14	21	184	0.5	1.3	0.00	0.07	2.3	4.0
9/4/14	19	185	1.9	0.5	0.00	0.01	0.9	0.4
9/8/14	9	186	1.4	0.4	0.00	0.00	4.1	0.7
9/8/14	9	187	1.4	0.4	0.00	0.00	4.1	0.7
9/8/14	16	188	0.6	0.7	0.04	0.00	6.5	6.1
9/8/14	17	188	1.6	0.5	0.00	0.00	11.6	4.2
9/8/14	18	190	0.9	0.3	0.00	0.00	2.2	1.8
9/8/14	19	189	0.6	0.3	0.00	0.00	0.5	0.5
9/8/14	19	192	0.6	0.3	0.00	0.00	0.5	0.5
9/9/14	19	193	0.7	0.5	0.00	0.00	6.6	4.9
9/8/14	20	191	0.5	0.2	0.00	0.01	0.4	0.4
9/12/14	6	194		0.2	0.00	0.01	0.1	0.7
9/12/14	7	194	0.4	0.3	0.00	0.02	0.1	0.9
9/12/14	8	194	0.5	0.4	0.00	0.04	0.1	0.9
9/12/14	9	194	0.6	0.4	0.00	0.05	7.5	1.0
9/12/14	10	194	0.6	0.4	0.00	0.03	16.4	1.5
9/13/14	23	195	0.6	0.6	0.00	0.04	0.2	0.4
9/14/14	20	196	0.4	0.5	0.00	0.12	0.3	0.6
9/15/14	13	197	0.7	0.5	0.00	0.01	1.9	8.1
9/15/14	13	198	0.7	0.5	0.00	0.01	1.9	8.1
9/16/14	5	199	1.5		0.01	0.01	0.7	0.7
9/16/14	5	200	1.5		0.01	0.01	0.7	0.7
9/16/14	6	199	1.0	0.7	0.00	0.08	0.5	0.8

DATE	HOUR	RECORD	TRS		NMHC		SO2	
			AMS6	AMS7	AMS6	AMS7	AMS6	AMS7
9/16/14	7	199	0.6	0.3	0.00	0.10	0.2	0.5
9/18/14	11	201	0.8	1.2	0.00	0.05	0.8	1.1
9/21/14	11	202	0.6	0.5	0.00		0.4	0.7
9/22/14	10	203	0.7	0.5	0.00	0.03	0.8	0.7
9/23/14	11	204	0.9	2.4	0.00	0.18	6.4	17.0
9/23/14	12	205	1.1	1.7	0.00	0.13	6.4	9.3
9/23/14	19	206	0.6	0.7	0.09	0.01	1.8	1.1
9/24/14	20	207	0.6	0.5	0.00	0.05	0.4	0.8
9/25/14	17	208	1.3	0.6	0.00	0.00	5.9	8.1
9/25/14	18	208	1.2	0.6	0.00	0.00	0.7	2.3
9/25/14	19	209	1.1	0.6	0.00	0.00	0.6	1.2
9/28/14	15	210	0.6	0.2	0.04	0.01	0.3	0.9
9/30/14	15	211	1.1	0.9	0.00	0.05	12.5	3.2
9/30/14	16	212	0.7	0.8	0.00	0.04	4.0	11.2
10/5/14	14	213	0.5	0.3	0.00	0.00	0.4	0.7
10/6/14	18	214	0.6	0.9	0.00	0.13	1.4	3.2
10/7/14	10	215	0.5	0.3		0.00		0.9
10/7/14	11	215	0.5	0.4		0.00		0.5
10/7/14	12	215		0.3		0.00		0.7
10/18/14	14	216	0.7	0.2	0.00	0.01	0.5	0.9
10/22/14	11	217	0.8	0.5	0.00	0.06	0.3	0.9
10/23/14	9	218	1.2	7.2	0.00	0.06	0.6	1.7
10/27/14	21	219	0.6	0.7	0.00	0.00	0.2	0.9
10/29/14	9	220	0.7	0.3	0.00	0.00	0.3	0.7
10/31/14	17	221	0.6	0.4	0.00	0.05	0.3	1.0
11/3/14	9	222	0.6	0.5	0.00	0.00	0.1	0.5
11/3/14	15	223	1.2	0.6	0.00	0.04	0.7	0.9
11/5/14	9	224	0.5	0.4	0.00	0.01	0.3	0.6
11/7/14	21	225		0.4		0.00		6.4
11/12/14	24	226						
11/14/14	17	227	0.8	0.5	0.00	0.00	11.1	6.1
11/19/14	14	228	0.6	0.4	0.00	0.00	0.4	0.6
11/21/14	17	229	0.7	0.5	0.00	0.00	6.6	3.9
11/23/14	17	230	0.7	0.4	0.20	0.00	0.5	0.8
11/26/14	10	231	1.1	0.7	0.00		0.8	
12/4/14	13	232	1.0	0.9	0.00	0.00	1.0	1.0
12/10/14	19	233	1.2	2.2	0.05	0.23	6.3	6.9
12/13/14	9	234	1.0	0.6	0.00	0.03	1.3	1.0
12/13/14	17	235	0.9	0.6	0.00	0.11	0.6	1.0
12/14/14	13	236	1.5	0.7	0.00	0.02	9.4	2.5
12/15/14	9	237	0.6	0.3	0.00	0.35	0.5	0.7
12/26/14	18	238	1.5	1.3	0.04	0.20	3.0	5.0