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

Prepared For

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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. Recommendations made by the author in the Report, have neither been considered, nor accepted by WBEA.

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Executive Summary

The need to effectively communicate the meaning behind the data collected under the odour projects of the Wood Buffalo Environmental Association (WBEA) Human Exposure Monitoring Project (HEMP) has become the focus and reason for the HEMP committee's request to have an integration data review. As new data sets are collected annually from HEMP projects and other odour monitoring methods, the HEMP committee also requested that subsequent integration data reviews should be conducted on an annual basis to build on the previous years' data sets, recommendations, and correlations; to provide more insight and to maintain a unified complete monitoring dataset of the monitored odour parameters in the Wood Buffalo region. This is the initial integrated review and includes all odour related data and supplementary meteorological data collected during 2012. The objective of this data integration is to provide HEMP further information on what the combined data amongst the collection methods look like and to provide a means of sharing information on the state of odours in the region with public individuals and stakeholders.

The ability of humans to distinguish different odour intensities is highly subjective with changes in concentration of the order of 25 to 33% needed for an individual to recognize different odour intensities. There is 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.

The Alberta 1-hour air quality objective of 10 ppb was only exceeded four times at community monitoring sites in the WBEA yet there were a total of 76 unique odour related complaints recorded on 53 separate dates by the Alberta Environment hotline. Using a 3 ppb TRS level as an indicator of potential odour, a higher frequency of impact is noted with Fort McKay experiencing the highest frequency and longest persistence of occurrences. The majority of odour complaints in both Fort McKay and Fort McMurray occurred when TRS concentrations were less than 3 ppb and NMHC and THC levels at the sites were also low. The two specialized odour detection, evaluation and quantification instruments (Odotech electronic nose and pneumatic focusing dual detector gas chromatograph (PFGC) with a high sensitivity detector for reduced sulphur compounds) operating at Fort McKay produce hourly outputs which ultimately should prove very useful in characterizing short term odour episode. Although both units show promise, some inconsistencies in output and some periods of missing data prevented any overall insight into the nature of the species or sources responsible for complaints on days with low TRS.

It is recommended that a more consistent program of logging odour complaints in the region be implemented (the recently implemented Community Odour Monitoring Panel should serve this purpose well). Since many of the complaints refer to hydrocarbon odours, additional effort is required to identify and routinely measure odorous hydrocarbon species at additional sites. A database for all observations should be developed and maintained to allow easy integration of data. Annual updates in data analysis should be carried out to allow an assessment of changes in odour incidents in the region.

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, 2013).

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, recently re-named Bertha Ganter-Fort McKay, 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 often associated with odour episodes. Many VOCs and RSCs are well known to cause odours, either individually or in combination (WBEA, 2013).

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 integrated data review. The vision is that as new data sets are collected annually from HEMP projects and other odour monitoring efforts, subsequent 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.

This is the initial integrated data review and is based on data collected in 2012.

2 Odour and Odour Characterization

2.1 Perception of Odours

Human response to odorant 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 neighbours 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 Odour Thresholds for Selected Species

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 people. 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).

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).

Estimated odour thresholds and their reported range are provided in Table 1 for those species currently measured at one or more WBEA sites (continuous or integrated measurement). It should be noted that there is a wide variation in reported odour thresholds depending on the reference used. Hydrogen sulphide is a good example with reported odour thresholds 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.

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

Compound	Descriptor where available	Reported threshold Range (ppb)	Odour threshold (ppb)
Acetaldehyde	apple, stimulant	1 – 2,275	
Acetone	chemical/sweet/solvent	450 – 13,000	4,580
Allyl sulphide			15
Ammonia	sharp, pungent	144 – 16,700	
Benzene	solvent	400 – 29,000	8,650
Benzyl mercaptan	garlic, leeks		2.6
1,3-Butadiene	mild, petrol	190 – 450	455
Butyl mercaptan	stinks	0.5 – 1.0	
Carbon Disulphide	disagreeable, sweet	11 – 700	
Carbonyl sulphide			10
Dimethyl sulphide	decayed cabbage	0.8 – 15	
Dimethyl disulphide		0.3 – 90	
2,5-dimethyl thiophene		None Found	
Ethyl mercaptan		0.1 – 36	
Ethyl sulphide		0.3 – 28	
2-ethyl Thiophene		None Found	
Hydrogen sulphide	rotten eggs	0.5 - 12	0.5
Isobutyl mercaptan			0.8
Isopropyl mercaptan	skunk like		0.3
Methyl mercaptan	sulphur	0.02 – 42	
2-methyl Thiophene		None Found	
3-methyl Thiophene		None Found	
Naphthalene	mothballs		38
Nitrogen dioxide	acrid, pungent	10 – 1,000	
Pentyl mercaptan			0.8
Propyl mercaptan		0.06 – 24	
sec-Butyl mercaptan		None Found	
Sulphur dioxide	suffocating	340 – 8000	
Styrene	penetrating, rubbery, plastic		38
tert-Butyl mercaptan			0.3
tert-Pentyl mercaptan		None Found	
Thiophene	Aromatic, gasoline	0.4 - 4	0.8
Toluene	floral, pungent, moth balls	125 – 210	160
Xylene (mixed)	aromatic, sweet	13 – 20	16

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 odors 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 2013. Other relevant air quality criteria from the province of Ontario are found in Table A-1 of Appendix A.

For some species health effects do potentially occur at levels below their odour threshold whereas for other 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
Acetaldehyde	90	50	1 Hour	Adopted from Texas	1999	Health
Acetone	5,900	2,400	1 Hour	Adopted from Texas	2005	Health
Ammonia	1,400	2,000	1 Hour			Odour
Benzene	3	0.9	Annual		2012	Carcinogenic effects
	30	9	1 Hour			Haematological effects
Carbon disulphide	30	10	1 Hour		2005	Odour
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
Hydrogen sulphide	4	3	24 Hour		1975	Odour
	14	10	1 Hour			Odour
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

National Pollutant Release Inventory (NPRI) estimated emissions of TRS, SO_2 and total VOC (tonnes) for 2011 for sources in the WBEA region are shown in Tables 3, 4 and 5. SO_2 is primarily emitted from stacks whereas VOC is primarily fugitive and TRS comes from both stack and fugitive emissions. It should be noted that estimated fugitive releases of TRS were much higher (~800 additional tonnes) in the 2010 NPRI inventory. Major source locations are provided in Figure 1 and Figure 2.

Table 3: Major TRS Emission Sources (> 10 tonnes) in the WBEA Airshed – 2011 (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	105	12		117
Suncor Energy Oil Sands Limited Partnership	Suncor Energy Inc. Oil Sands	57.00	-111.47	82	3	2	87
Canadian Natural Resources Limited	Horizon Oil Sands Processing Plant and Mine	57.34	-111.76	10	12		22
Syncrude Canada Ltd.	Aurora North Mine Site	57.30	-111.50		11		11
TOTAL				197	38	2	237

Table 4: Major SO_2 Emission Sources (> 200 tonnes) in the WBEA Airshed – 2011 (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	64,727			64,727
Suncor Energy Oil Sands Limited Partnership	Suncor Energy Inc. Oil Sands	57.00	-111.47	20,258			20,258
Canadian Natural Resources Limited	Horizon Oil Sands Processing Plant and Mine	57.34	-111.76	1,981	7		1,988
Nexen Inc.	Long Lake Project	56.41	-110.94	1,744			1,744
Devon Canada Corporation	Jackfish 1 SAGD Plant	55.53	-110.87	466			466
Suncor Energy Oil Sands Limited Partnership	Firebag	57.22	-110.90	369			369
ConocoPhillips Canada Resources Corp.	Surmont SAGD Commercial Battery	56.19	-110.95	294			294
Cenovus FCCL Ltd.	Christina Lake SAGD Bitumen Battery	55.58	-110.89	278			278
TOTAL				90,117	7		90,124

Table 5: Major VOC Emission Sources (> 500 tonnes) in the WBEA Airshed – 2011 (NPRI Estimates).

Company Name	Facility Name	Lat.	Long.	Stack Emissions	Fugitive Emissions	Storage / Handling	Spills	Other	Total
Suncor Energy Oil Sands Limited Partnership	Suncor Energy Inc. Oil Sands	57.00	-111.47	2,841	8,177	1,631			12,649
Syncrude Canada Ltd.	Mildred Lake Plant Site	57.04	-111.62	586	6,857	14		247	7,704
Syncrude Canada Ltd.	Aurora North Mine Site	57.30	-111.50	22	4,680				4,702
Canadian Natural Resources Limited	Horizon Oil Sands Processing Plant and Mine	57.34	-111.76	72	3,302	58			3,432
Shell Canada Energy	Shell Albian Sands Muskeg River Mine and Jackpine Mine	57.35	-111.52	72	1,968		10		2,050
TOTAL				3,593	24,984	1,703	10	247	30,537

Figure 1: Location of Major TRS, SO_2 and VOC Emission Sources in the WBEA Airshed.

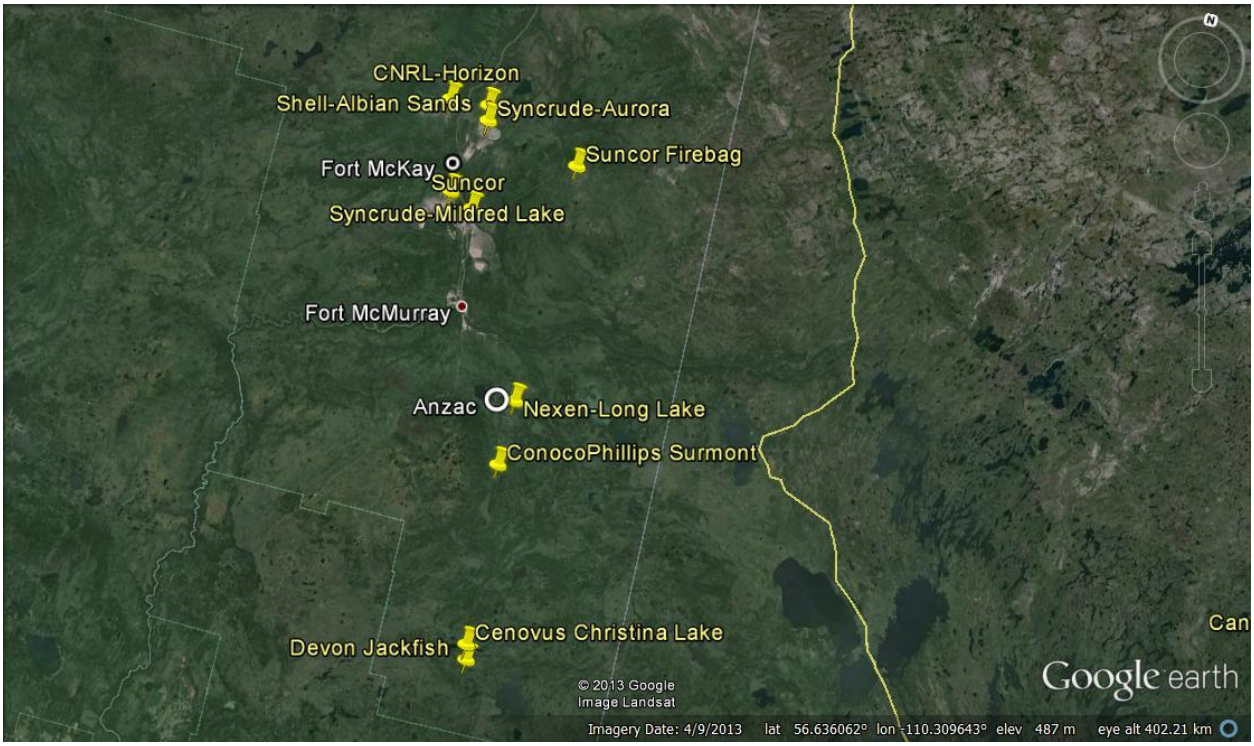
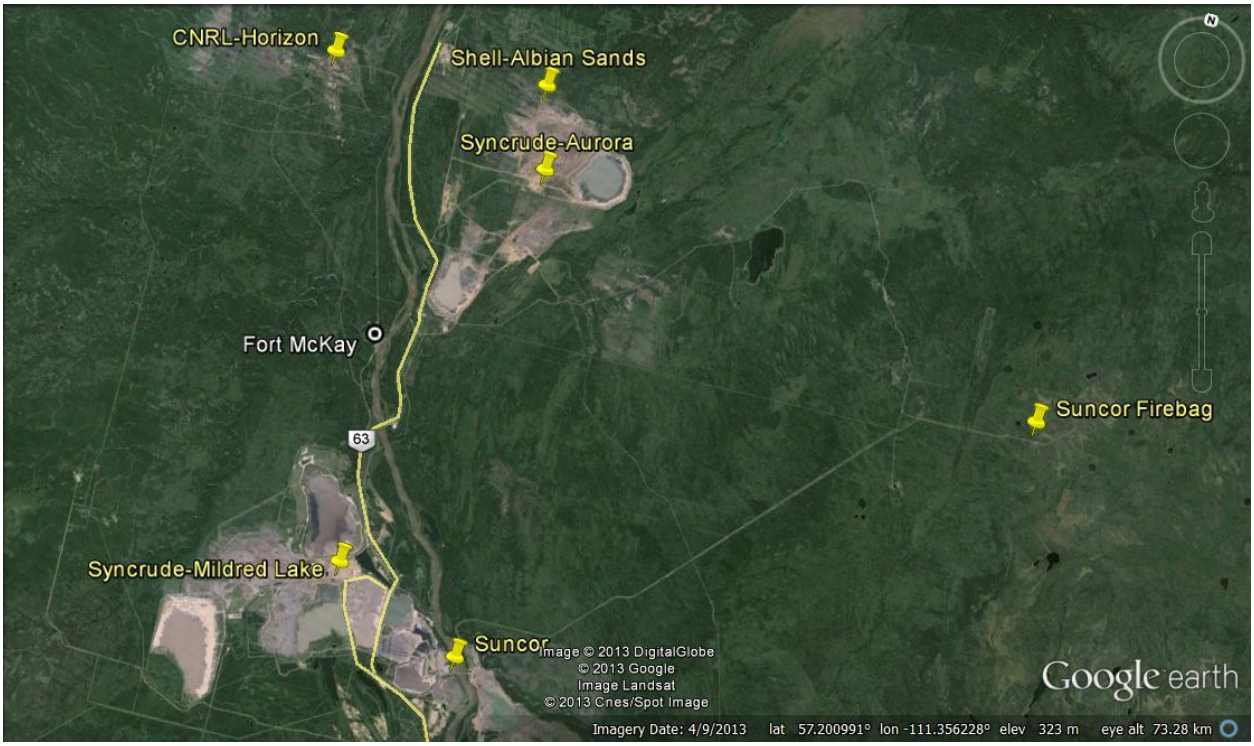


Figure 2: Location of Major TRS, SO_2 and VOC Emission Sources near Fort McKay.



4 Discussion of Available Data for 2012

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 6 and site locations are shown in Figure 3. Parameters routinely measured in the WBEA network on a continuous basis include sulphur dioxide (SO_2), hydrogen sulphide (H_2S) or total reduced sulphur (TRS), total hydrocarbons (THC) and meteorological parameters (relative humidity, temperature, wind speed and direction). A number of other specialized measurements are made at AMS#1 including pneumatic focusing dual detector GC (PFGC) for volatile organic compounds (VOC) and volatile reduced sulphur compounds (RSC), methane (CH_4) and total non-methane hydrocarbons (NMHC) and an Odotech electronic nose (OdoCheck system). Table 6 also shows the sites where integrated 24h samples are collected for VOC and RSC by canister. Environment Canada (EC) also measures VOC in canisters at AMS#13.

Data for these parameters for 2012 were obtained either from the CASA data website or direct from WBEA staff. All data have been processed as described below and stored in a unified data system.

Table 6: WBEA Monitoring Sites and Continuous Parameters Measured in 2012 (only those sites and parameters used in this report).

WBEA ID	PURPOSE	STATION NAME	TRS	H_2S	SO_2	THC	Other[1]	Canister VOC	167 m Tower[2]	75 m Tower[3]	Meteorology[4]
1	HEALTH/COMMUNITY	FORT MCKAY BERTHA GANTER	X		X	X	X	X			X
2	COMPLIANCE	MILDRED LAKE		X	X	X					X
3	METEOROLOGY	LOWER CAMP MET TOWER							X		X
4	COMPLIANCE	BUFFALO VIEWPOINT		X	X	X					X
5	COMPLIANCE	MANNIX		X	X	X				X	X
6	HEALTH/COMMUNITY	FORT MCMURRAY PATRICIA MCINNES	X		X	X	X	X			X
7	HEALTH/COMMUNITY	FORT MCMURRAY ATHABASCA VALLEY	X		X	X	X	X			X
9	ATTRIBUTION	BARGE LANDING	X			X		X			X
11	COMPLIANCE	LOWER CAMP		X	X	X					X
12	COMPLIANCE	MILLENNIUM	X		X	X		X			X
13	ATTRIBUTION	FORT MCKAY SOUTH	X		X	X		X, EC			X
14	HEALTH/COMMUNITY	ANZAC	X		X	X	X	X			X
15	COMPLIANCE	CNRL HORIZON	X		X	X		X			X
16	COMPLIANCE	SHELL MUSKEG RIVER			X	X					X

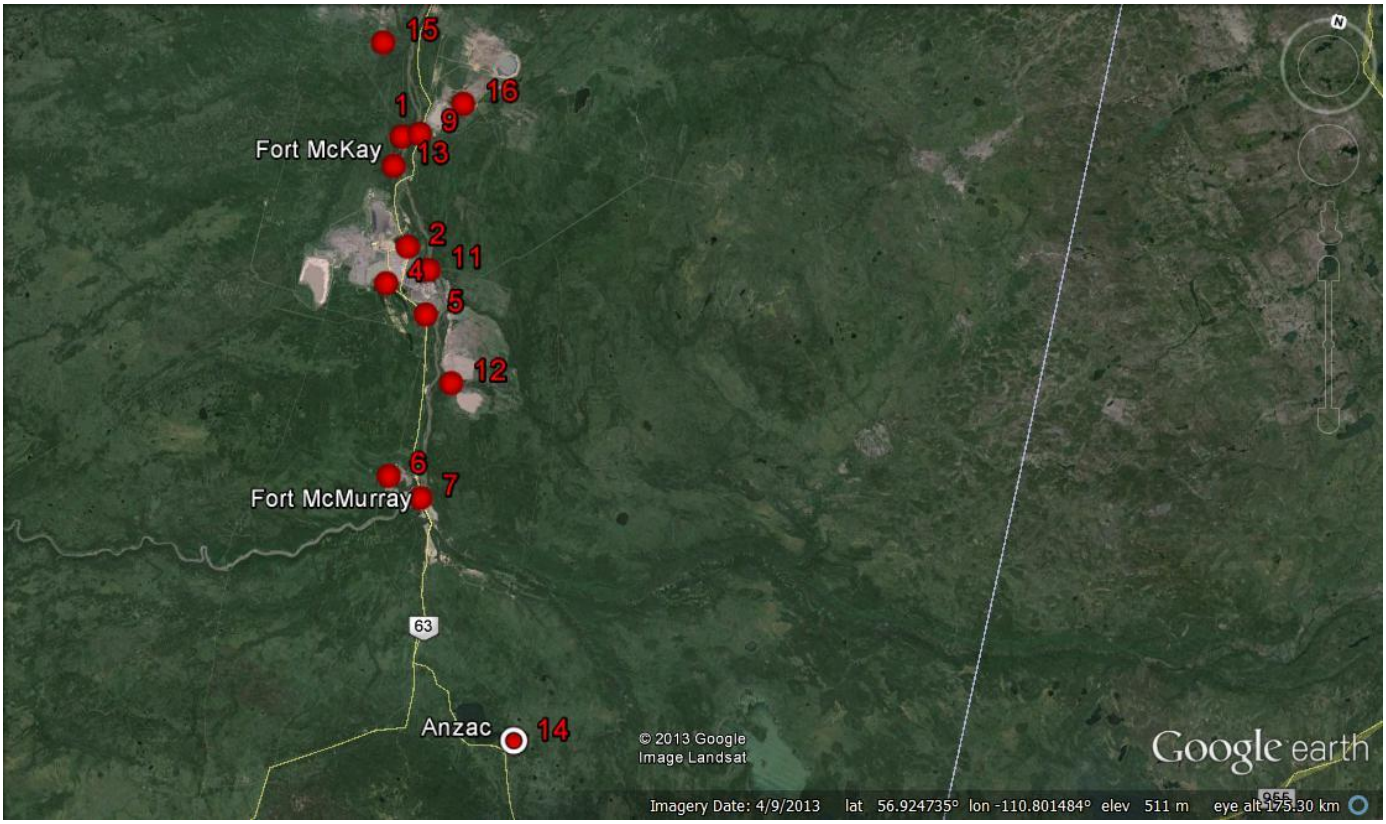
[1] other measurements at Fort McKay include OdoCheck, methane, non-methane hydrocarbons, PFGC and SCD (see below). Methane and non-methane hydrocarbons are also measured at AMS6, AMS7 and AMS14.

[2] temperature, horizontal wind speed and direction, and vertical wind speed are measured at 20 m, 45 m, 100m and 167 m but only 100 m measurements were used.

[3] temperature, horizontal wind speed and direction, and vertical wind speed are measured at 20 m, 45 m and 75 m but only 45 m measurements were used.

[4] wind speed, wind direction, temperature and humidity were used.

Figure 3: WBEA Continuous Monitoring Network (excluding Fort Chipewyan).



4.2 Routine Continuous Measurements: TRS, H_2S, SO_2, THC, NMHC, Methane

As shown in Table 6 the air pollutants continuously measured by the WBEA in the air network and used in this report include SO_2, H_2S, TRS, total hydrocarbons (THC) and methane/non-methane hydrocarbons (CH_4/NMHC). Sulphur dioxide is measured continuously using pulsed fluorescence gas analyzers, operated on 0 to 1000 ppb range. The detection limits observed under field conditions vary from 0.5 to 1 ppb. Total hydrocarbons are measured using 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 50 ppb for CH_4, and 50 ppb for NMHC as propane. Hydrogen sulphide and TRS are measured with pulsed fluorescence gas technology that detects SO_2 formed by the catalytic conversion of hydrogen sulphide or 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).

All 2012 data were downloaded from the CASA website for TRS, H_2S, SO_2 and THC. The NMHC and methane data for Fort McKay Bertha Ganter (AMS#1) were obtained directly from WBEA. The methane data from AMS#1 was used to adjust THC data from other sites to estimate hourly NMHC values at each site. This was only done because there were no alternatives available and it was felt THC data alone would not be a useful metric. It should be noted that the NMHC values from AMS#1 are lower than all the other sites which may be due to the difference in instruments or to the method of estimation for the other sites. NOTE: after completion of the report it was discovered that methane and NMHC are also available from AMS#6, AMS#7 and AMS#14.

Summary statistics for TRS/H_2S, SO_2 and estimated total NMHC are provided in Tables 7, 8 and 9.

Table 7: Summary Statistics for 1-h TRS/H_2S (ppb) – 2012.

Location	N	Percentiles 90th	95th	99th	Max.	Mean	Std. Dev.
TRS							
BERTHA GANTER	8176	1	2	3	87	0.5	1.2
PATRICIA MCINNES	8341	1	1	2	9	0.1	0.5
ATHABASCA VALLEY	8257	1	1	2	9	0.5	0.6
BARGE LANDING	8339	1	1	2	53	0.3	0.9
MILLENNIUM	8315	1	1	3	20	0.3	0.7
FORT MCKAY SOUTH	8231	1	1	2	70	0.2	1.2
ANZAC	8060	1	1	1	14	0.2	0.5
CNRL HORIZON	8318	1	1	2	6	0.3	0.5
H_2S							
MILDRED LAKE	8355	1	2	8	33	0.5	1.6
BUFFALO VIEWPOINT	8307	0	1	2	20	0.1	0.6
MANNIX	8311	1	3	10	46	0.7	2.2
LOWER CAMP	8334	1	2	4	23	0.4	1.0

Table 8: Summary Statistics for 1-h SO_2 (ppb) – 2012.

Location	N	Percentiles 90th	95th	99th	Max.	Mean	Std. Dev.
BERTHA GANTER	8165	2	4	17	83	1.3	3.9
MILDRED LAKE	8349	5	11	32	90	2.2	6.1
BUFFALO VIEWPOINT	8312	1	2	13	100	0.6	3.1
MANNIX	8337	4	8	28	143	1.8	5.6
PATRICIA MCINNES	8337	2	4	11	61	0.7	2.2
ATHABASCA VALLEY	8264	1	2	8	45	0.3	1.7
LOWER CAMP	8340	3	6	20	114	1.3	4.5
MILLENNIUM	8315	1	3	15	74	0.8	3.5
FORT MCKAY SOUTH	8287	2	4	18	149	1.2	4.2
ANZAC	8344	2	3	9	106	0.6	2.3
CNRL HORIZON	8290	2	4	16	129	0.8	4.0
SHELL MUSKEG RIVER	8338	2	5	19	118	1.1	4.1

Table 9: Summary Statistics for 1-h Estimated Total NMHC (ppm) – 2012.

Location	N	Percentiles 90th	95th	99th	Max.	Mean	Std. Dev.
BERTHA GANTER*	6783	0.2	0.3	0.5	1.2	0.1	0.1
MILDRED LAKE	6667	0.8	1.1	2.3	7.0	0.4	0.4
BUFFALO VIEWPOINT	6512	0.6	0.8	1.5	12.6	0.3	0.3
MANNIX	6491	0.7	0.9	1.6	4.7	0.4	0.3
PATRICIA MCINNES	6707	0.3	0.4	0.6	1.2	0.2	0.1
ATHABASCA VALLEY	6258	0.3	0.3	0.5	1.2	0.1	0.1
BARGE LANDING	6678	0.6	0.8	1.1	2.1	0.4	0.2
LOWER CAMP	6675	0.7	0.9	1.4	3.4	0.3	0.3
MILLENNIUM	6687	0.9	1.2	2.2	4.2	0.5	0.4
FORT MCKAY SOUTH	6635	0.5	0.7	1.2	3.6	0.3	0.2
ANZAC	6575	0.3	0.4	0.7	1.7	0.1	0.2
CNRL HORIZON	6647	0.5	0.7	1.5	6.1	0.3	0.3
SHELL MUSKEG RIVER	6245	0.8	1.0	1.8	3.8	0.4	0.4

* NMHC measured directly at this site.

4.3 Meteorological Measurements

The meteorological parameters barometric pressure, relative humidity, temperature and wind speed/direction were also used in the project and 2012 data for all sites were downloaded from CASA. Tower data for Lower Camp (AMS#3) and Mannix (AMS#5) were obtained from WBEA. For episode analysis the following were used: wind speed and direction at 100 m from AMS#3 and wind speed and direction at 45 m from AMS#5. For days experiencing TRS/H_2S equal to or greater than 3 ppb, a

calculation of the average wind direction, standard deviation of wind direction and wind speed for the previous 6 hours was made for all sites using the Yamartino method.

Wind roses for the community sites are shown in Figure 4 and wind roses from 100 m and 45 m at the Lower Camp met tower and at 45 m at the Mannix met tower are shown in Figure 5. Wind roses for all other sites are found in Figure 6.

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 tower measurements are less affected by local flows.

Figure 4: Wind Roses for Fort McKay Bertha Ganter, Fort McMurray Patricia McInnes, Fort McMurray Athabasca Valley and Anzac – 2012.

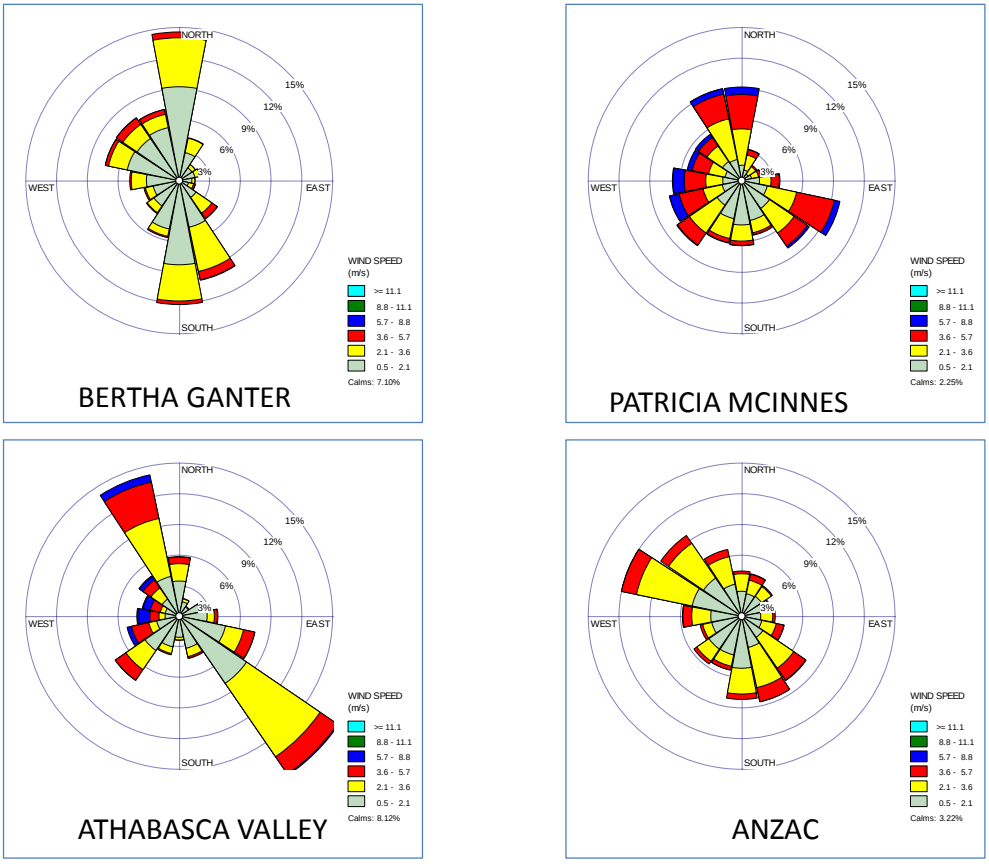


Figure 5: Wind Roses for Lower Camp Tower (100 m), Lower Camp Tower (45 m) and Mannix Tower (45 m) – 2012.

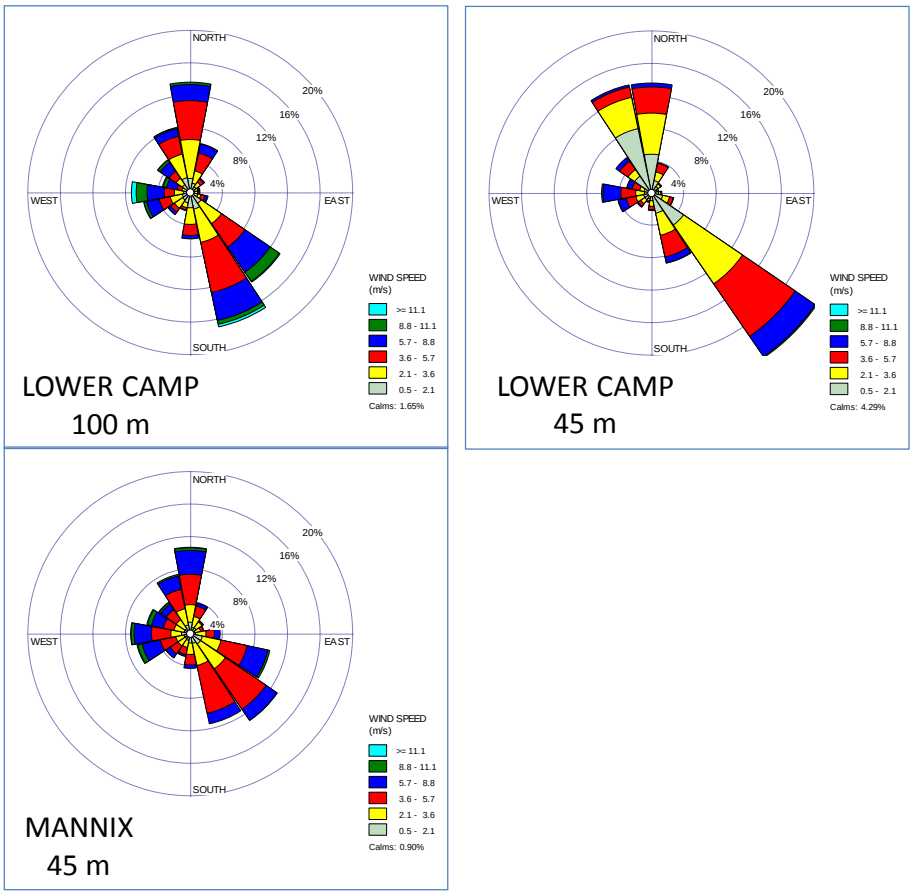
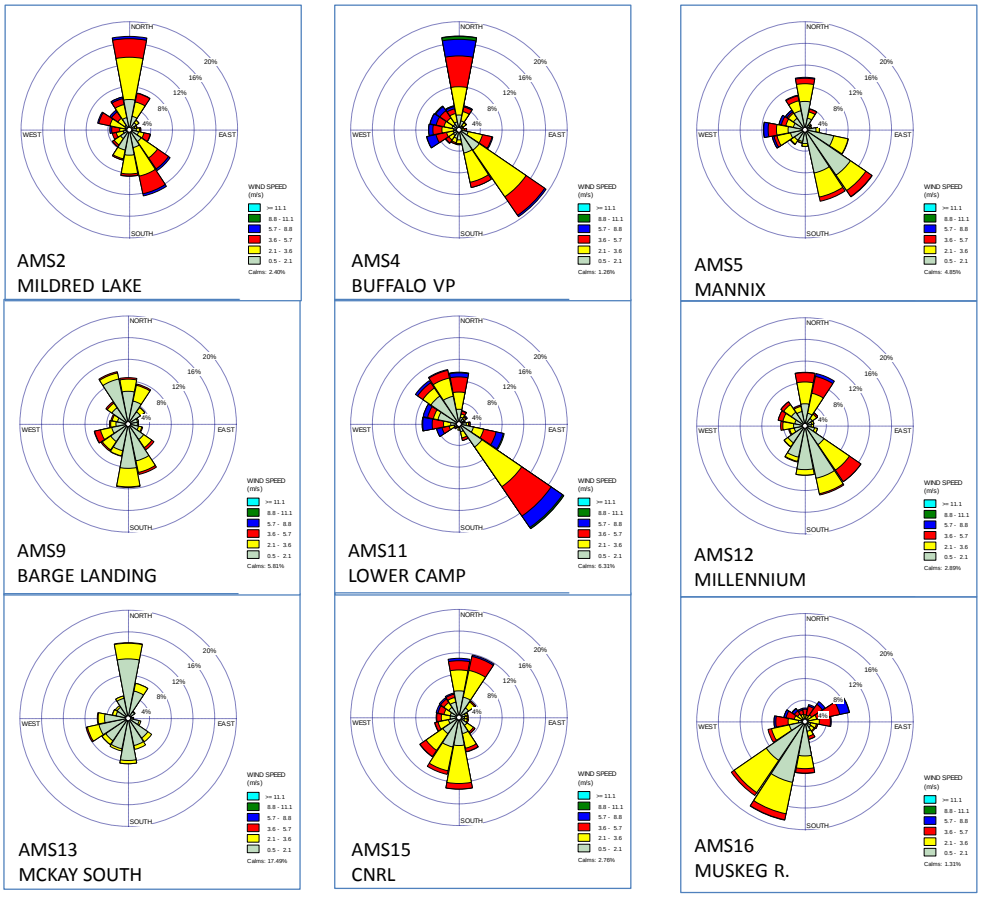


Figure 6: Wind Roses for Other WBEA Sites (AMS2, AMS4, AMS5, AMS9, AMS11, AMS12, AMS13, AMS15 and AMS16.



4.4 OdoCheck System

The OdoCheck system from Odotech is composed of an electronic nose 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. OdoCheck 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 but as stated by the manufacturer: "*because of the location of the electronic nose 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, 2013).*

Monthly data files were received from WBEA and processed into one annual data file including hourly averages and the maximum of the 4 minute readings used to calculate an hourly average. There were some data base issues at Odotech and the data prior to May 18, 2012 is not comparable to later 2012 data. As stated by Odotech "*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 was reprocessed to calculate the integer value of the difference between the maximum and mean for each hour (DELTA) – this provided a usable measure of variability (but may not be a useful signal) and was also used in subsequent episode analysis along with the original OdoCheck average absolute readings. An example of the data before and after processing is shown in Figure 7 and for a shortened period of time in Figure 8 (separate scales).

The output from the instrument appears to stabilize (more consistent baseline) after July 21, 2012 and before Nov. 19, 2012 and for this period Z-scores were calculated for each hour to provide another measure of variability. The Z-score values were calculated by first determining the mean and standard deviation of all hours for this period and then normalizing each hourly average by subtracting the mean and then dividing by the standard deviation. The Z-score will be negative or positive depending if the hour is greater than or less than the mean and results are shown in Figure 9.

Figure 7: OdoCheck Data – Raw and Processed – 2012.

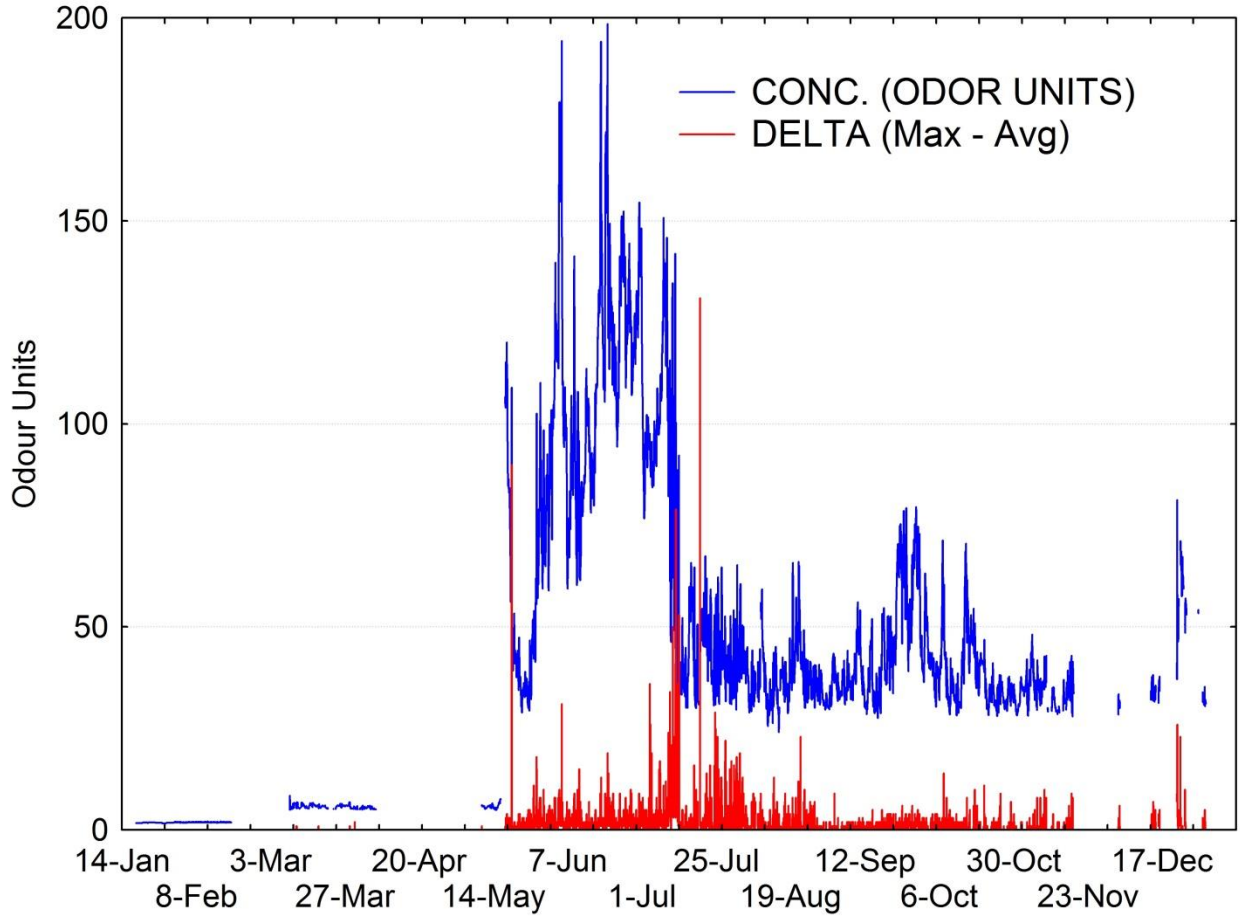


Figure 8: OdoCheck Data – Raw and Processed – July 27 – Aug. 4, 2012.

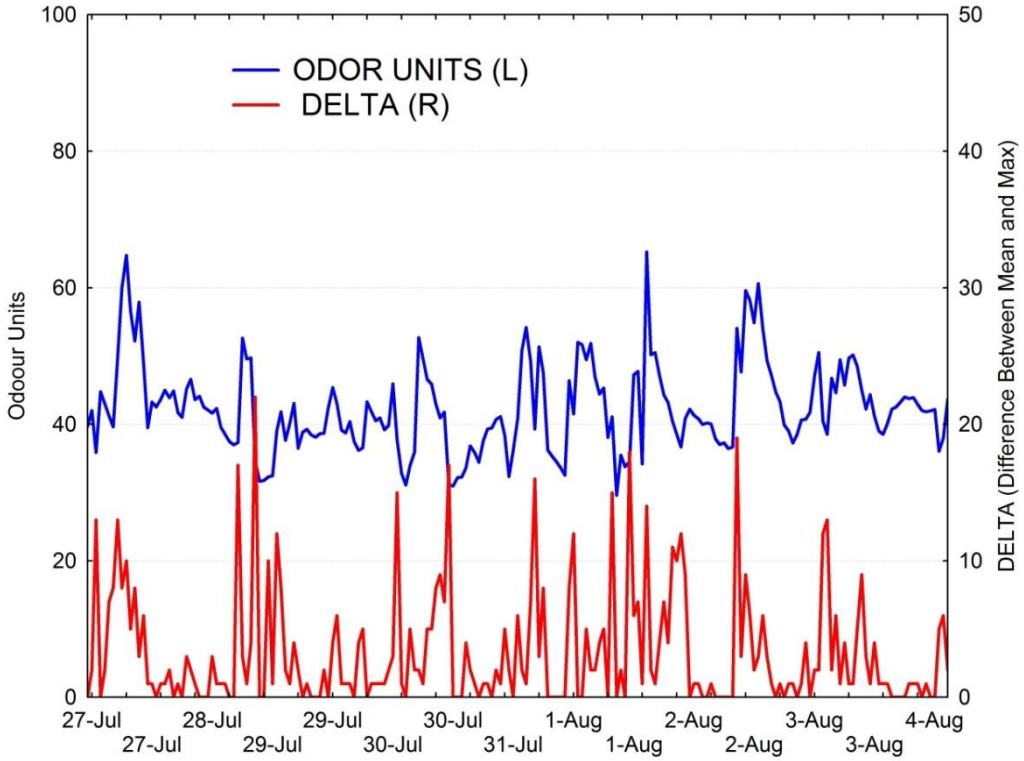
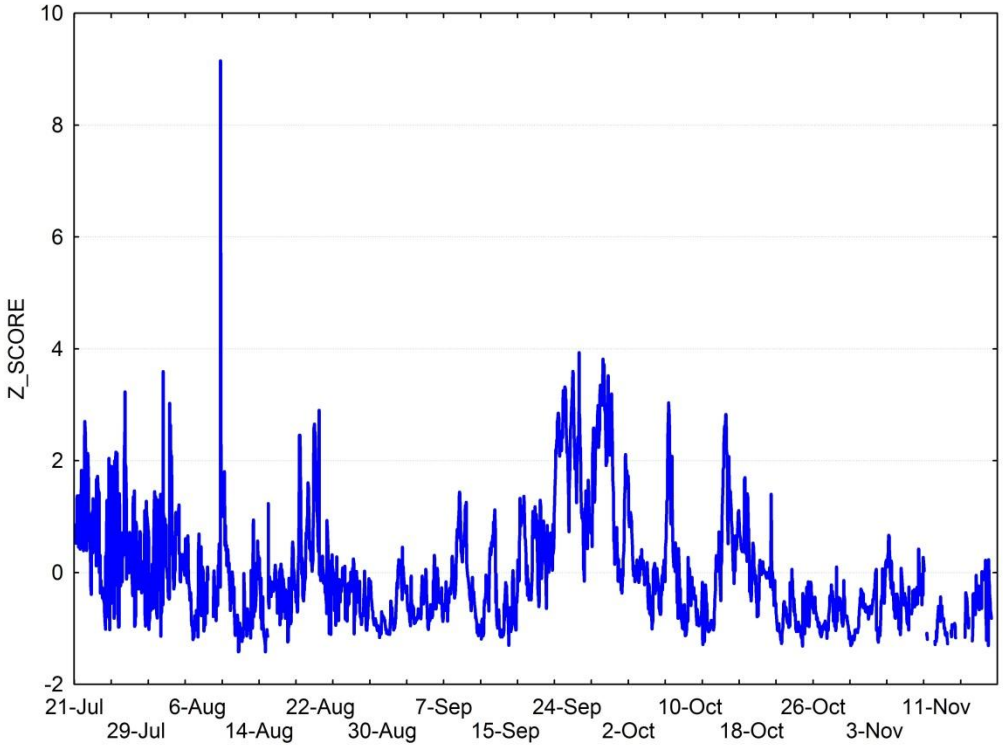


Figure 9: Computed Z-Scores from OdoCheck Hourly Data July 21 – Nov. 19, 2012.



4.5 Pneumatic Focusing Gas Chromatograph (PFGC)

VOC Technologies operates a Pneumatic Focusing Gas Chromatograph (PFGC) at the Fort McKay Bertha Ganter 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. The SCD was added in 2012 and should have the capacity to measure the concentrations of reduced sulphur compounds (RSCs) at levels below 50 parts-per-trillion (ppt). VOC detection levels are estimated to be 100 ppt. Monthly data files were received from WBEA and processed into one annual data file with hourly averages retained for VOC and RSC. Summary statistics for all identified VOC and RSC species are provided in Tables 10 and 11 (values below detection were set to zero). The instrument was operational for 254 days in 2012 and produced 3,586 hours of data for RSC and 3,954 hours of data for VOC. There were no reported results for the period between June 30, 2012 and August 24, 2012 due to the replacement of the PFGC at AMS#1 in August by a second dual detector PFGC with FID and SCD. The initial PFGC system was returned to the VOC Technologies Laboratory for service and refurbishment for easier field operation and maintenance (O'Brien, 2013a). There may have been a change in response of the instrument as a result of this change. As shown in Figures 10 and 11, the response to naphtha (2-methylbutane, 3-methylbutane, pentane, 2-methylpentane, 3-methylpentane and hexane) and aromatic species (benzene, toluene, ethyl benzene, o-xylene and p-xylene) appears to increase greatly after the August restart and conversely the response to RSCs appears to decrease. No such step change was seen in the canister VOC data sets.

Figure 10: Hourly Variation in sum of Naphtha and Aromatic Species (ppbC) from PFGC – 2012.

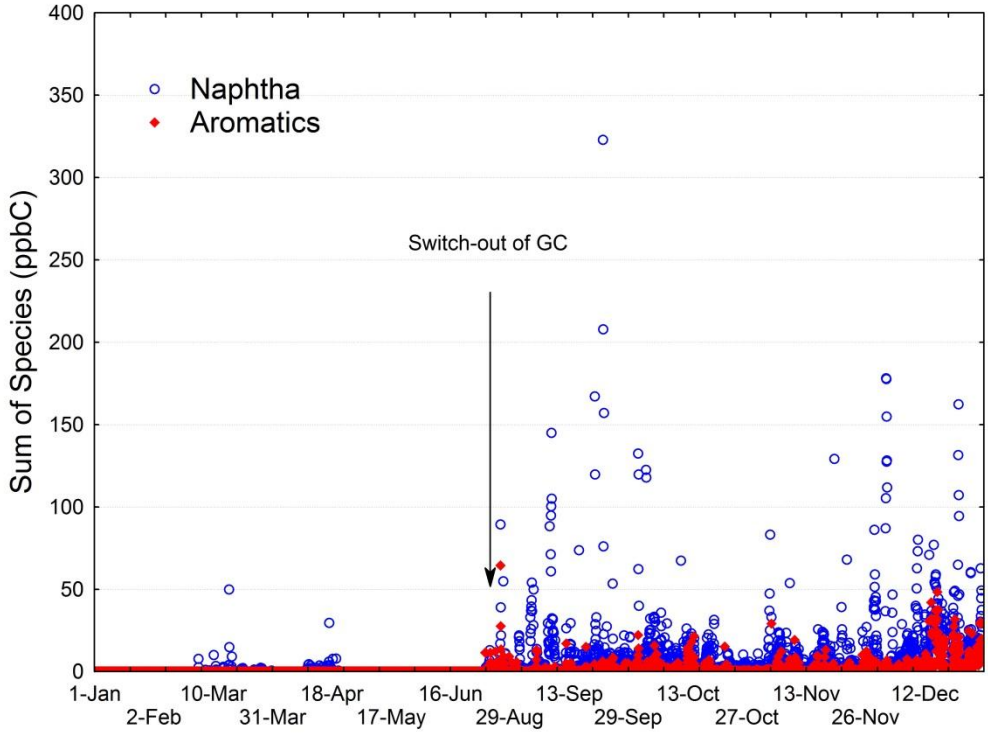


Figure 11: Hourly Variation in some RSC Species (ppb) from PFGC – 2012.

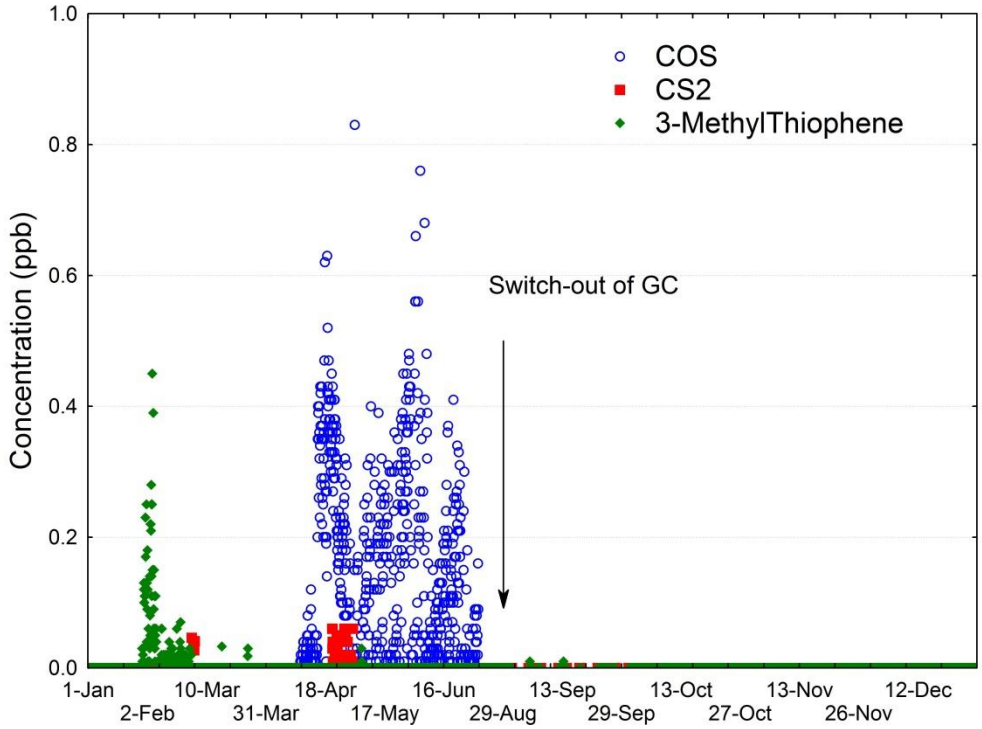


Table 10: Identified RSC Compounds, Frequency of Detection and Summary Statistics (ppb) – 1 h Measurements at AMS#1 (total of 3,586 reported measurements).

Compound	Frequency of Detection	Max.	Mean	Std. Dev.	Median
Carbonyl sulphide	17%	0.83	0.03	0.09	0.00
Carbon disulphide	2%	0.06	0.00	0.00	0.00
2-methyl Thiophene	3%	0.14	0.00	0.01	0.00
3-methyl Thiophene	3%	0.45	0.00	0.02	0.00
2-ethyl Thiophene	0%	0.09	0.00	0.00	0.00
2,5-dimethyl Thiophene	0%	0.08	0.00	0.00	0.00
2,4-dimethyl Thiophene	0%	0.20	0.00	0.00	0.00

Table 11: Identified VOC Compounds, Frequency of Detection and Summary Statistics (ppbC) for 1-h measurements at AMS#1 (total reported hours were 3,954).

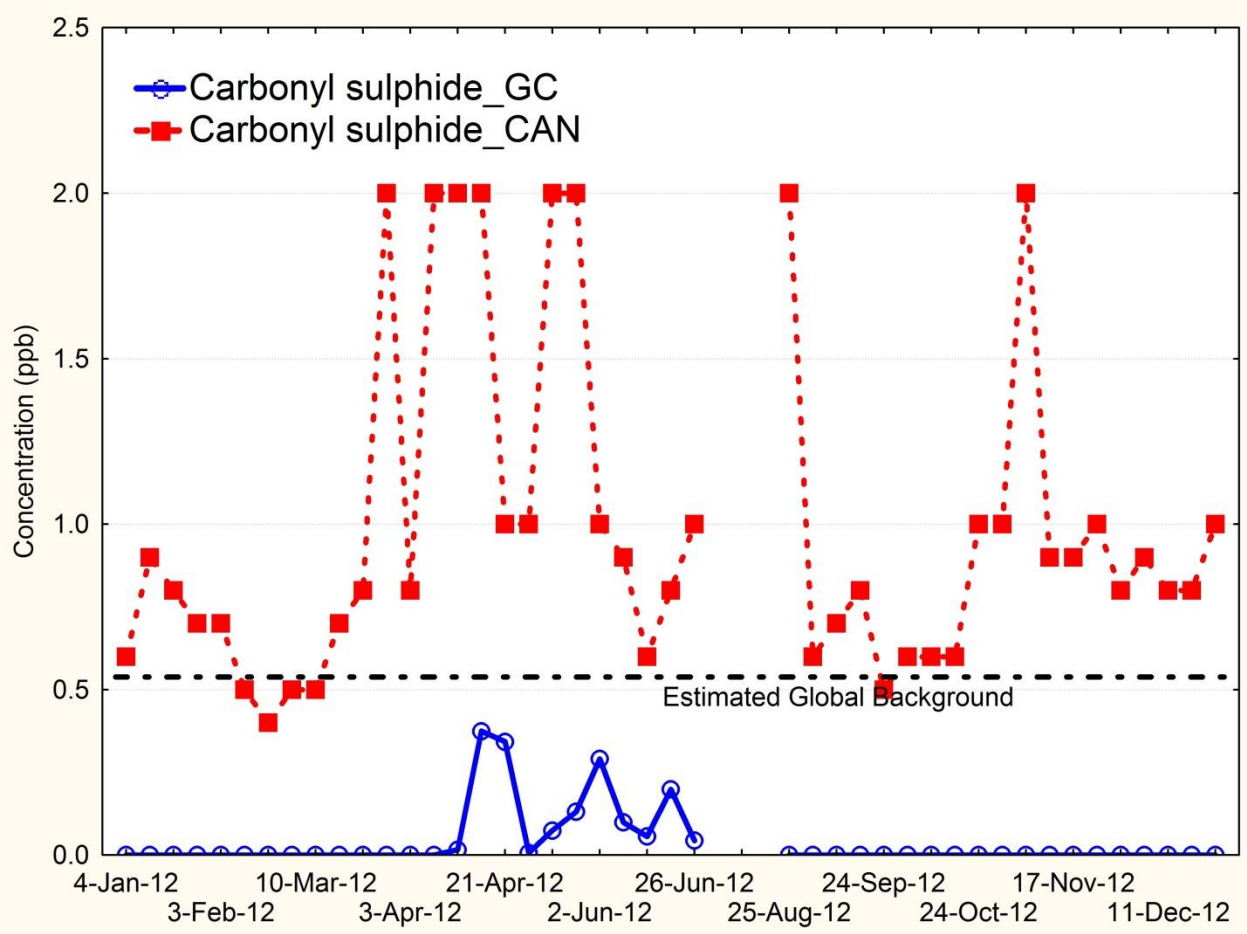
Compound	Frequency of Detection	Max.	Mean	Std. Dev.	Median
Isoprene	45%	28.7	0.3	1.3	0.0
2-Methylbutane	55%	135.2	1.3	4.2	0.1
3-Methylbutane	50%	21.1	0.2	0.8	0.0
Pentane	55%	227.5	1.2	5.5	0.1
Benzene	51%	12.3	0.4	0.9	0.0
Thiophene	32%	11.7	0.1	0.4	0.0
2-Methylpentane	52%	191.3	1.4	5.0	0.0
3-Methylpentane	48%	77.1	0.5	2.0	0.0
Hexane	52%	59.2	0.9	2.5	0.0
Toluene	50%	56.9	0.6	1.8	0.0
2,4-Dimethylpentane	50%	68.9	0.5	1.8	0.0
Heptane	49%	85.7	0.7	2.3	0.0
2,2,4-Dimethylpentane	5%	5.6	0.1	0.4	0.0
Ethyl Benzene	4%	5.3	0.0	0.3	0.0
p-Xylene	5%	11.8	0.1	0.7	0.0
o-Xylene	5%	16.8	0.1	0.9	0.0
m-Xylene & Methylheptane	5%	29.9	0.2	1.5	0.0
Octane	5%	28.7	0.2	1.3	0.0

4.6 Canister VOC and RSC data

Twenty-four hour canister samples were also collected at a number of the sites (see Table 6) and analyzed for VOC and RSC by gas chromatography/mass spectrometry. Measured species and summary statistics for 2012 are provided in Tables 12 and 13 for the AMS#1 site. Because DLs were provided with each sample, the averages have been calculated by substituting 0.5 * DL when the value was below DL. Detection levels were typically 0.03 ppb for VOC and 1 ppb for RSC's. Summary statistics for the most abundant RSC and for naphthalene at the other sites are found in Table A-2 of Appendix A.

Carbonyl sulphide was the most frequently reported RSC in both the canister and PFGC results although the mean concentration from canister results (1.1 ppb) was significantly higher than from the continuous results (0.17 ppb). 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). Calculated 24-h averages of carbonyl sulphide are compared with canister 24 h measurements in Figure 12. While the canister results are never below background the PFGC results are usually well below the expected background.

Figure 12: Comparison of 24h Carbonyl Sulphide Results (ppb) from PFGC and Canister.



Environment Canada also collects VOC canister samples at AMS#13 and measures some VOC species not measured in the WBEA program that are of potential interest. Summary statistics for these species for 2012 are provided in Table 14.

Table 12: RSC species and Reported 24 h Concentrations (ppb) in Canister Samples at AMS#1 for 2012 (A total of 63 samples. Detection limit was 1 ppb).

Compound	Frequency of Detection	Max.	Mean	Std. Dev.	Median
Hydrogen sulphide	17%	2.0	0.5	0.2	0.5
Carbonyl sulphide	100%	5.0	1.1	0.8	0.9
Carbon disulphide	56%	6.0	1.0	1.1	0.5
Methyl mercaptan	2%	0.5	0.5	0.0	0.5
Dimethyl disulphide	2%	0.5	0.5	0.0	0.5
Ethyl mercaptan	0%	-	-	-	-
Dimethyl sulphide	0%	-	-	-	-
Isopropyl mercaptan	0%	-	-	-	-
tert-Butyl mercaptan	0%	-	-	-	-
Propyl mercaptan	0%	-	-	-	-
Thiophene	0%	-	-	-	-
Isobutyl mercaptan	0%	-	-	-	-
sec-Butyl mercaptan	0%	-	-	-	-
Ethyl sulphide	0%	-	-	-	-
Butyl mercaptan	0%	-	-	-	-
tert-Pentyl mercaptan	0%	-	-	-	-
2-methyl Thiophene	0%	-	-	-	-
3-methyl Thiophene	0%	-	-	-	-
Pentyl mercaptan	0%	-	-	-	-
2-ethyl Thiophene	0%	-	-	-	-
Allyl sulphide	0%	-	-	-	-
2,5-dimethyl Thiophene	0%	-	-	-	-

Table 13: VOC species and Reported 24 h Concentrations (ppb) in Canister Samples at AMS#1 for 2012 (A total of 63 samples. Detection limit was 0.03 ppb).

Compound	Frequency of Detection	Max.	Mean	Std. Dev.	Median
Formaldehyde	0%				
Isobutane	83%	3.40	0.41	0.56	0.23
1-Butene	16%	9.67	0.25	1.23	0.02
Acetaldehyde	33%	14.60	1.65	3.40	0.10
Butane	84%	12.50	1.21	1.69	0.82
Methanol	54%	95.70	6.87	15.20	1.85
trans-2-Butene	2%	0.26	0.02	0.03	0.02
cis-2-Butene	2%	0.20	0.02	0.02	0.02
3-Methyl-1-butene	0%				
Isopentane	87%	3.72	0.43	0.53	0.30
1-Pentene	2%	0.26	0.02	0.03	0.02
Acetone	81%	12.50	2.34	2.67	1.36
Pentane	51%	5.25	0.31	0.72	0.08
Isoprene	32%	2.86	0.35	0.67	0.02
trans-2-Pentene	0%				
cis-2-Pentene	2%	0.15	0.02	0.02	0.02
2-Methyl-2-butene	0%				
2,2-Dimethylbutane	35%	0.21	0.05	0.05	0.02
Cyclopentene	0%				
4-Methyl-1-pentene	0%				
2,3-Dimethylbutane	46%	0.45	0.08	0.09	0.02
Cyclopentane	27%	2.08	0.09	0.28	0.02
2-Methylpentane	67%	1.87	0.21	0.31	0.12
3-Methylpentane	60%	0.74	0.11	0.14	0.05
2-Methyl-1-pentene	0%				
Hexane	65%	1.47	0.16	0.22	0.10
Methyl ethyl ketone	3%	3.85	0.20	0.56	0.10
cis-2-Hexene	0%				
trans-2-Hexene	0%				
2,4-Dimethylpentane	2%	0.04	0.02	0.00	0.02
Methylcyclopentane	48%	0.44	0.06	0.08	0.02
Cyclohexane	38%	29.10	1.33	5.66	0.02
Benzene	92%	0.87	0.22	0.17	0.16
2-Methylhexane	44%	2.18	0.11	0.28	0.02
3-Methylhexane	56%	3.75	0.18	0.48	0.09
2,2,4-Trimethylpentane	3%	0.16	0.02	0.02	0.02
Heptane	67%	10.90	0.46	1.40	0.18
Methylcyclohexane	59%	1.71	0.14	0.24	0.08
Methyl isobutyl ketone	0%				
2,3,4-Trimethylpentane	10%	0.11	0.02	0.01	0.02
2-Methylheptane	30%	0.29	0.05	0.06	0.02
Toluene	92%	10.10	0.63	1.39	0.27
3-Methylheptane	21%	0.13	0.03	0.03	0.02
Octane	38%	0.73	0.12	0.18	0.02

Compound	Frequency of Detection	Max.	Mean	Std. Dev.	Median
Ethyl benzene	38%	0.56	0.05	0.08	0.02
m, p-Xylene	63%	1.83	0.15	0.26	0.08
Styrene	6%	0.12	0.02	0.02	0.02
Nonane	30%	0.23	0.04	0.04	0.02
o-Xylene	40%	0.61	0.05	0.08	0.02
Isopropylbenzene	2%	0.14	0.02	0.02	0.02
alpha Pinene	51%	0.76	0.10	0.17	0.04
n-Propylbenzene	3%	0.08	0.02	0.01	0.02
1,3,5-Trimethylbenzene	3%	0.11	0.02	0.01	0.02
beta Pinene	5%	5.70	0.15	0.76	0.02
Decane	32%	0.27	0.04	0.05	0.02
1,2,4-Trimethylbenzene	22%	0.32	0.03	0.05	0.02
Undecane	19%	0.54	0.03	0.07	0.02
Dodecane	8%	0.23	0.02	0.03	0.02
Naphthalene	27%	3.05	0.21	0.47	0.02

Table 14: Selected VOC Species and reported 24 h Concentrations (ppb) in Canister Samples at AMS#13 for 2012 from Environment Canada sampling (A total of 61 samples).

Compound	Frequency of Detection	Max.	Mean	Std. Dev.	Median
Ethylene	100%	2.16	0.53	0.50	0.39
1,3-Butadiene	8%	0.08	0.01	0.01	0.01
Benzene	90%	1.20	0.24	0.22	0.17
Chloromethane	100%	0.72	0.53	0.06	0.52
Dichloromethane	75%	0.13	0.06	0.02	0.06
1,2-Dichloroethane	2%	0.07	0.02	0.01	0.02
Carbon tetrachloride	100%	0.12	0.08	0.01	0.08
Trichloroethylene	0%				
Tetrachloroethylene	0%				
1,4-Dichlorobenzene	0%				

4.7 Odour Complaint Logs

The Alberta Ministry of Environment and Sustainable Resource Development operates a 24-hour hotline where residents can call and report any odour complaints. Logs of complaints dealing with odours in the Fort McMurray 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 76 unique complaints recorded on 53 separate dates in 2012.

5 Data Analysis

5.1 TRS/H_2S by Concentration Value and Wind Direction

All sites were characterized in terms of occurrences of TRS/H_2S concentrations greater than 3, 5, 10 and 20 ppb in 2012 and the results are shown in Table 15. 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 as low as 3 ppb. The results are further subdivided into occurrences by average wind direction (previous 6 hours) in Table 16.

A visual representation of occurrences of TRS/H_2S values greater than 3, 5, 10 and 20 ppb are shown in Figures 13 to 16 for the community sites Fort McKay Bertha Ganter, Fort McMurray Patricia McInnes, Fort McMurray Athabasca Valley and Anzac and in Figure 17 for the Mildred Lake and Mannix sites which had the highest frequency of elevated H_2S (figures for the other monitoring sites are found in Appendix B). The figures are not necessarily at the same scale and the total number of occurrences should be obtained from Table 15. Figure 18 shows TRS/H_2S dose (the product of concentration times the frequency of wind direction) for all hours in 2012. A similar analysis of SO_2 and NMHC dose is found in Figure 19 and 20. The ratio of mean SO_2 to TRS/H_2S Concentration by wind direction for each site is shown in Figure 21. Despite an 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.

For the OdoCheck system a graphical comparison of mean odour units by wind direction for July 21 to November 19 is provided in Figure 22. There is little variation in mean odour units by wind direction and there is some variation by mean DELTA but a plot of Z-score by wind direction (Figure 23) does show that east and south wind directions are associated with the highest odour values. For the PFGC, the concentration of the sum of naphtha species (2-methylbutane, 3-methylbutane, pentane, 2-methylpentane, 3-methylpentane and hexane) by wind direction and the sum of aromatic species (benzene, toluene, ethyl benzene, o-xylene and p-xylene) by wind direction are provided in Figure 24. Results are also shown for pentane and toluene.

Table 15: Number of Hours with TRS/H_2S Concentration Values greater than 3, 5, 10 and 20 ppb by Site.

ID	SITE NAME	3 to 5 (ppb)	5 to 10 (ppb)	10 to 20 (ppb)	> 20 (ppb)	Sum
1	FORT MCKAY BERTHA GANTER	111	12	1	1	125
2	MILDRED LAKE	215	91	53	4	363
4	BUFFALO VIEWPOINT	50	5	4	0	59
5	MANNIX	243	156	66	15	480
6	PATRICIA MCINNES	21	6	0	0	27
7	ATHABASCA VALLEY	22	6	0	0	28
9	BARGE LANDING	59	8	2	1	70
11	LOWER CAMP	171	30	10	1	212
12	MILLENNIUM	101	13	4	0	118
13	FORT MCKAY SOUTH	45	7	0	3	55
14	ANZAC	26	4	2	0	32
15	CNRL HORIZON	18	1	0	0	19

Table 16: Count of Occurrences of TRS/H_2S Concentrations by Average Wind Direction and Location.

SITE	TRS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
BERTHA GANTER	3-5	0	0	0	0	1	1	1	2	78	19	2	4	2	0	0	1
	5-10	0	0	0	0	0	0	0	0	4	4	2	0	0	0	0	2
	10-20	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	>20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
MILDRED LAKE	3-5	5	2	5	9	17	27	107	17	0	3	1	3	4	5	4	6
	5-10	1	1	0	3	6	22	41	7	1	0	0	2	4	0	1	2
	10-20	1	0	0	0	1	16	13	8	1	0	2	1	9	0	1	0
	>20	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	1
BUFFALO VIEWPOINT	3-5	10	5	3	3	1	4	5	3	1	0	1	1	2	4	5	2
	5-10	2	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0
	10-20	0	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0
	>20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MANNIX	3-5	10	24	26	23	8	8	2	5	22	28	29	15	8	11	12	12
	5-10	12	12	27	33	13	3	4	1	3	5	9	8	3	2	8	13
	10-20	5	2	10	15	4	2	0	3	5	2	1	1	2	4	6	4
	>20	0	2	1	4	3	0	2	1	1	0	0	0	1	0	0	0
PATRICIA MCINNES	3-5	2	1	0	0	0	0	0	0	0	0	0	0	1	2	1	14
	5-10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	5
	10-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ATHABASCA VALLEY	3-5	6	1	2	0	0	0	0	1	0	0	0	6	1	0	3	2
	5-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
	10-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BARGE LANDING	3-5	0	1	0	1	1	1	1	21	27	2	4	0	0	0	0	0
	5-10	0	0	0	0	0	0	0	3	2	0	1	0	0	0	2	0
	10-20	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
	>20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

SITE	TRS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
LOWER CAMP	3-5	2	2	0	2	0	8	31	41	22	15	23	10	6	2	3	4
	5-10	0	0	0	0	0	1	6	7	7	2	5	2	0	0	0	0
	10-20	0	0	0	0	0	0	1	1	2	2	3	0	1	0	0	0
	>20	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MILLENNIUM	3-5	13	7	1	0	3	0	1	6	7	1	5	1	10	24	13	9
	5-10	1	0	0	0	0	0	0	0	0	0	1	0	2	4	5	0
	10-20	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0
	>20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORT MCKAY SOUTH	3-5	0	0	0	0	0	0	1	18	11	12	3	0	0	0	0	0
	5-10	0	0	0	0	0	0	0	2	3	2	0	0	0	0	0	0
	10-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
ANZAC	3-5	0	9	4	3	0	0	4	2	2	2	0	0	0	0	0	0
	5-10	0	1	0	0	0	0	2	1	0	0	0	0	0	0	0	0
	10-20	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
	>20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CNRL HORIZON	3-5	2	1	0	0	1	1	1	3	0	1	1	0	0	3	2	2
	5-10	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	10-20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	>20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 13: Counts of TRS Values greater than 3, 5, 10 and 15 ppb by Wind Direction at Fort McKay Bertha Ganter.

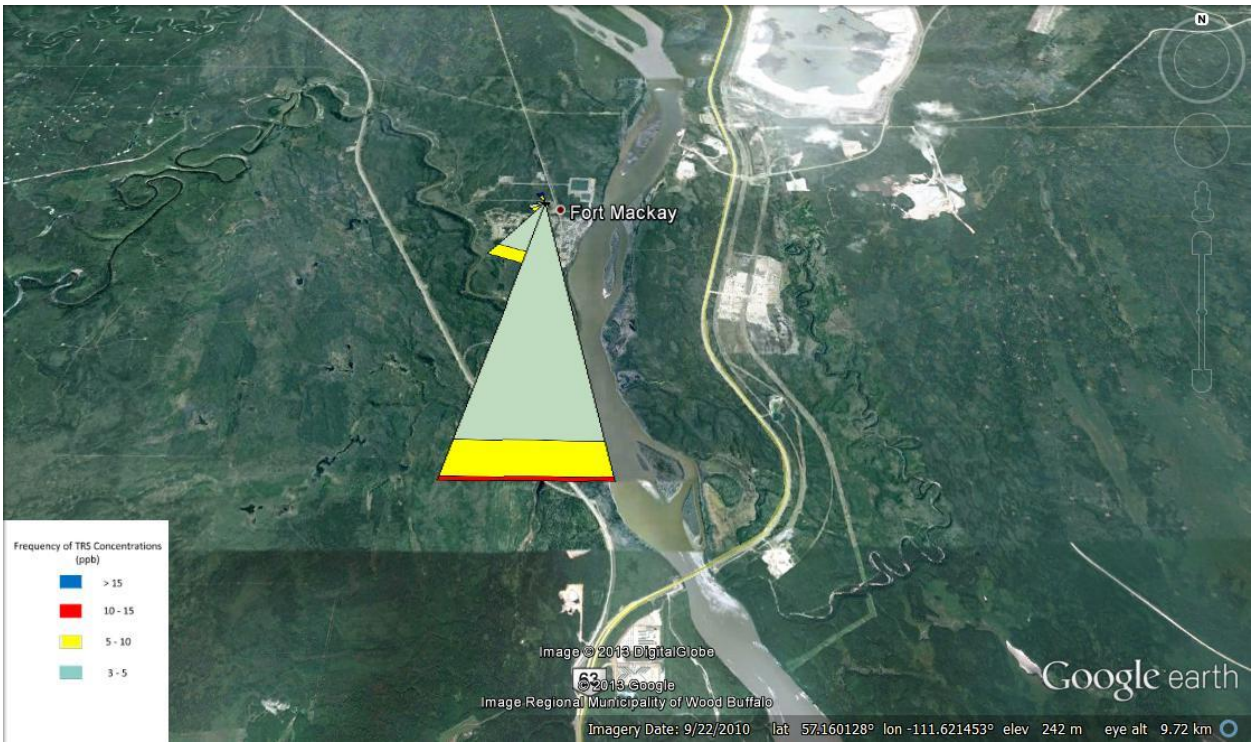


Figure 14: Counts of TRS Values greater than 3, 5, 10 and 15 ppb by Wind Direction at Fort McMurray Patricia McInnes.

Figure 15: Counts of TRS Values greater than 3, 5, 10 and 15 ppb by Wind Direction at Fort McMurray Athabasca Valley.

Figure 16: Frequency of TRS Values greater than 3, 5, 10 and 15 ppb at Anzac.

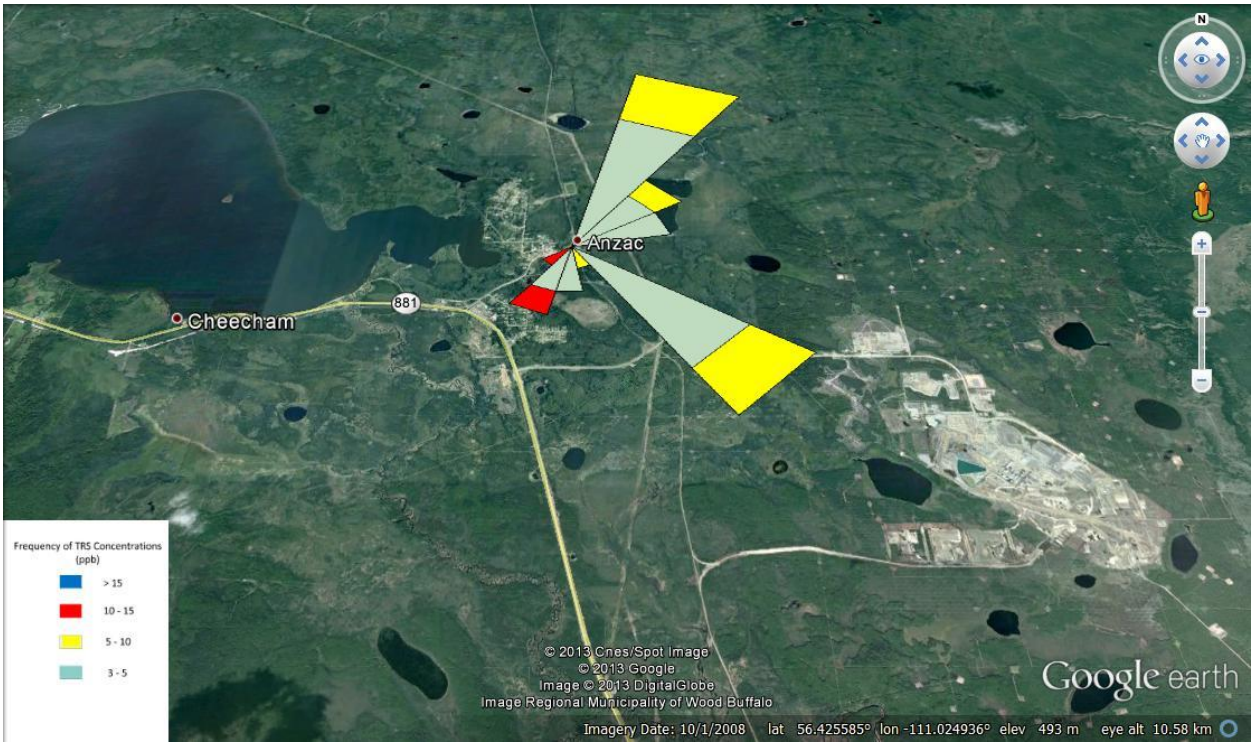


Figure 17: Frequency of H_2S Values greater than 3, 5, 10 and 15 ppb at Mildred Lake and Mannix.

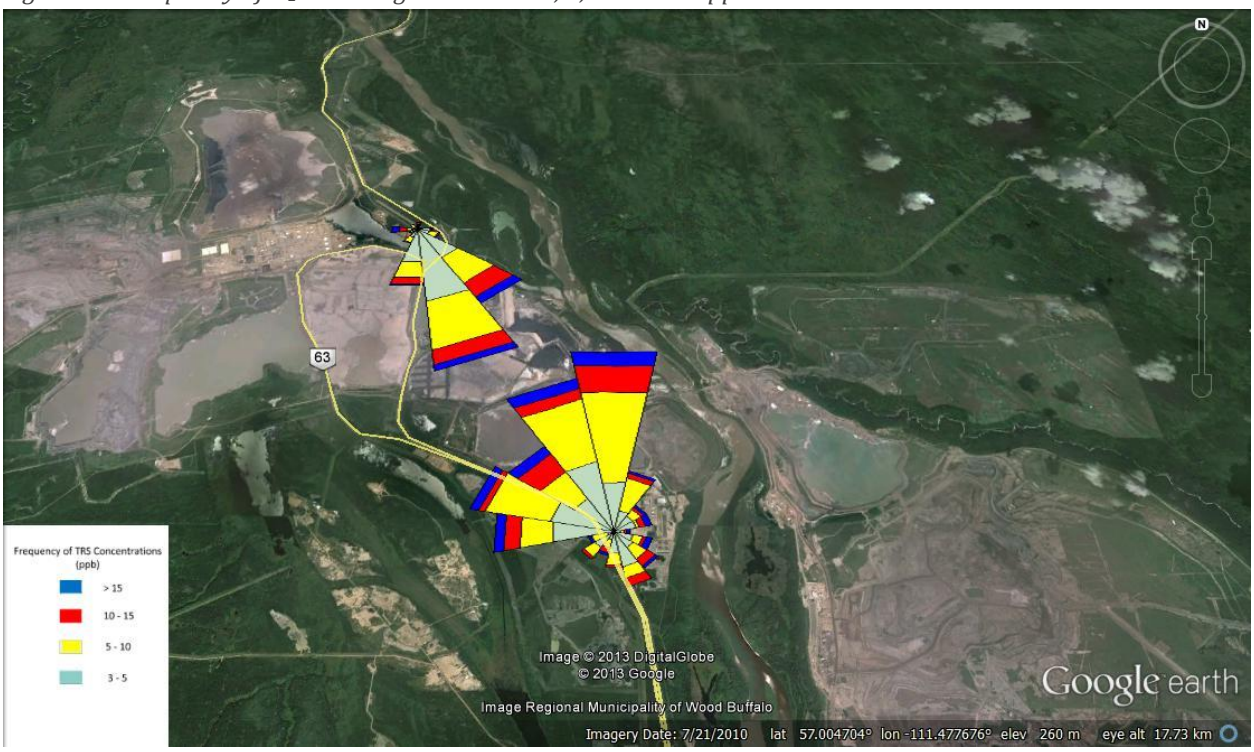


Figure 18: TRS Dose (ppb) at WBEA Monitoring Sites for 2012 (All Hours).

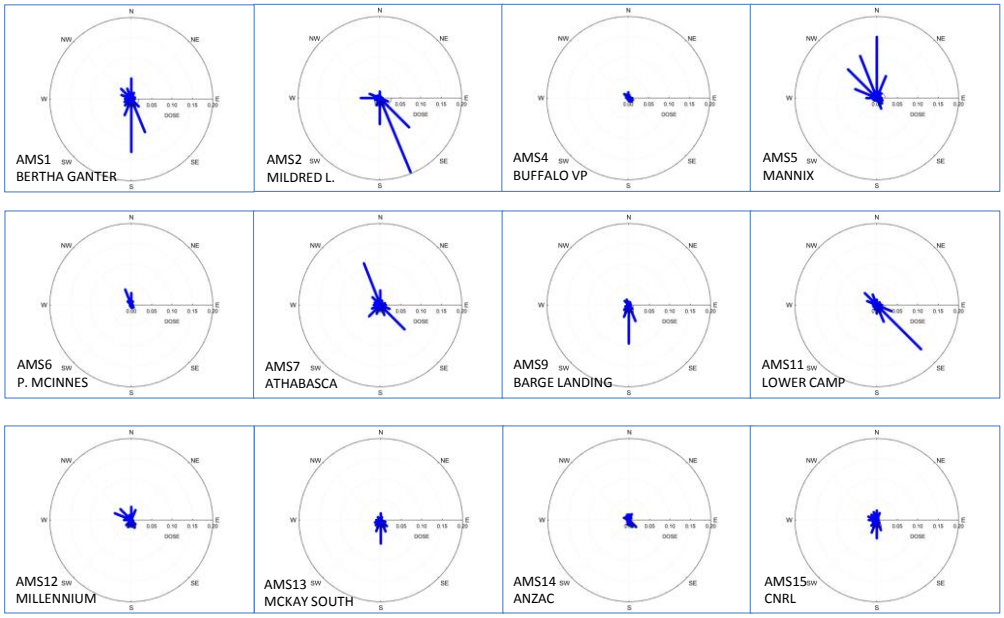


Figure 19: SO_2 Dose (ppb) at WBEA Monitoring Sites for 2012 (All Hours).

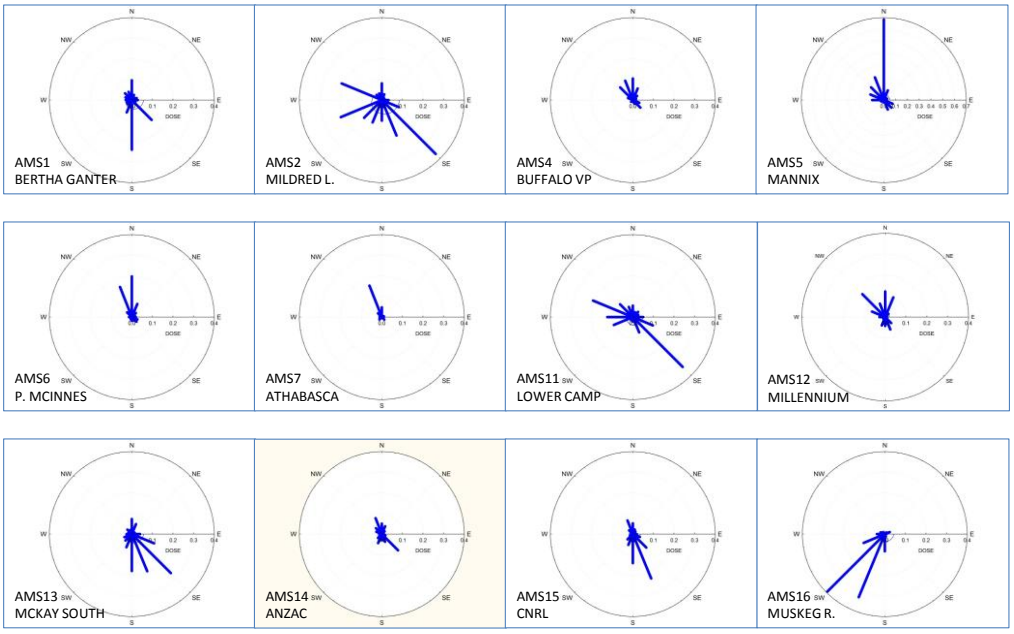


Figure 20: NMHC Dose (ppm) at WBEA Monitoring Sites for 2012 (All Hours).

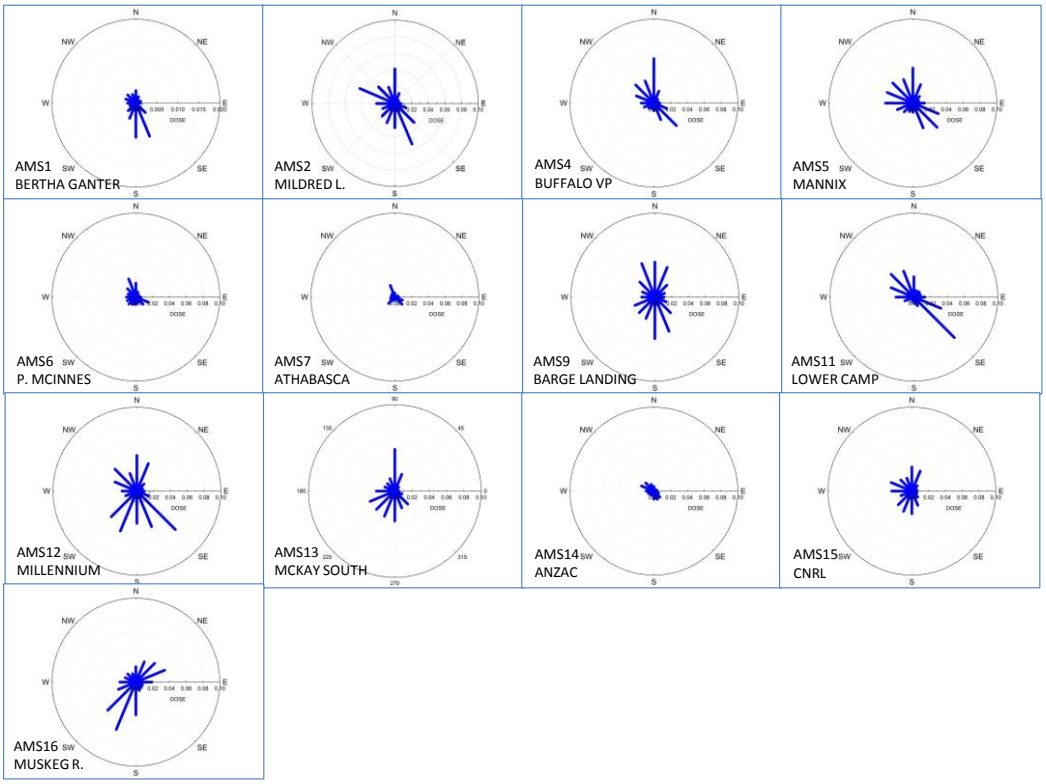


Figure 21: Ratio of Mean SO_2 to Mean TRS/H_2S by Wind Direction at WBEA Monitoring Sites for 2012 (All Hours).

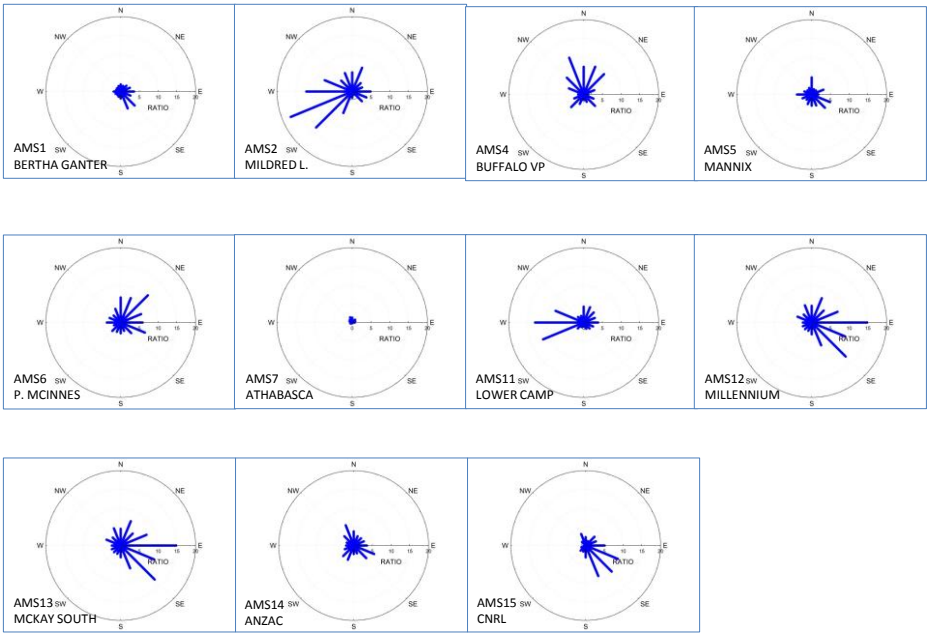


Figure 22: Mean OdoCheck Reading (odour units), mean DELTA and mean Z-SCORE at Bertha Ganter by wind direction for July 21 to Nov. 19, 2012.

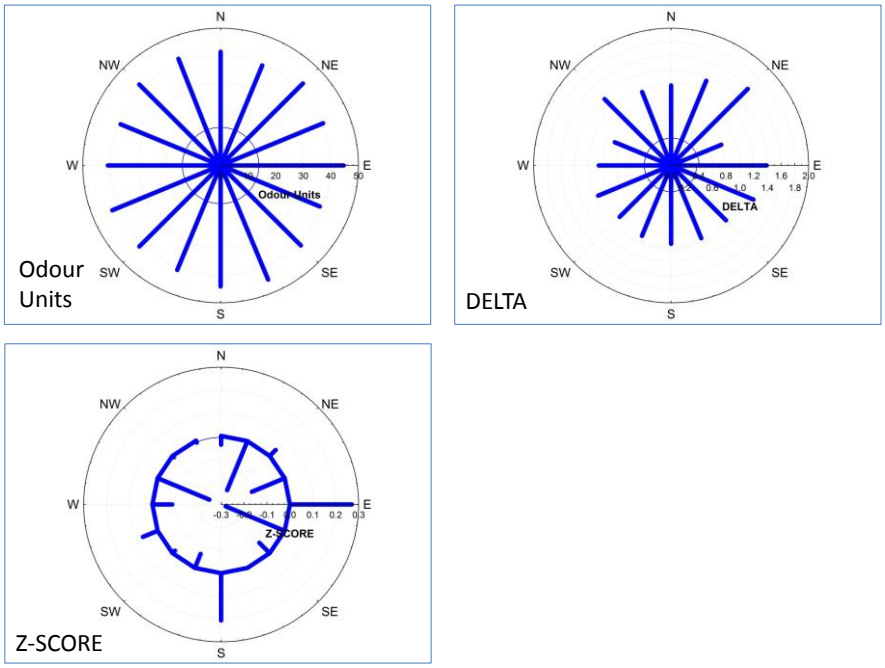
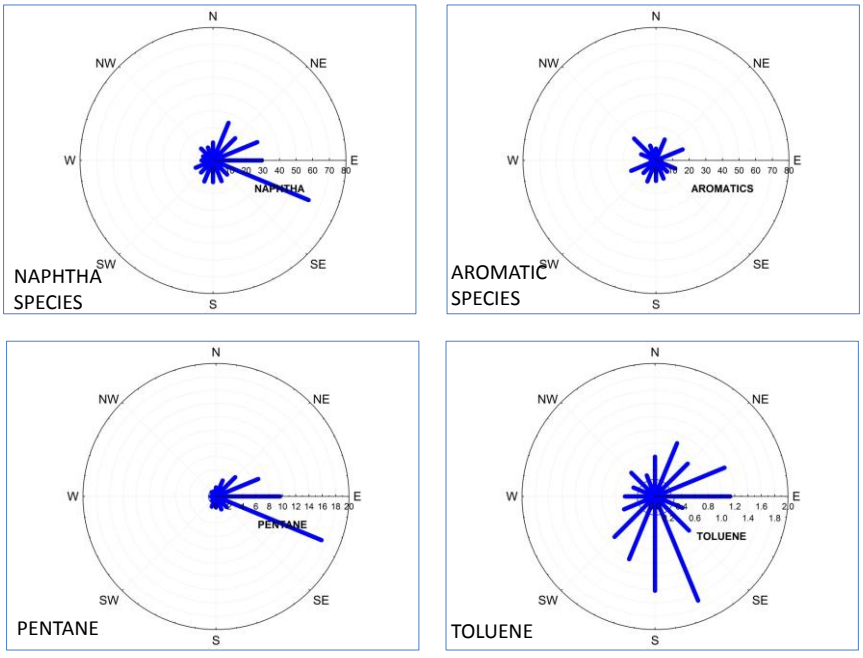


Figure 23: Mean Naphtha and Aromatics (ppbC) by wind direction at Bertha Ganter for August 24 to Dec. 31, 2012.



5.2 Integration of Data to Aid in Episode Characterization

All hours where one or more sites experienced TRS/H_2S values greater than or equal to 3 ppb were identified (a total of 1,330 hours) and all available results were then integrated for each of the hours to include: date, hour, no. of sites with TRS/H_2S equal to or greater than 3 ppb, maximum TRS/H_2S concentration, name of site with maximum concentration, average wind direction (previous 6 hours), standard deviation of wind direction (previous 6 hours), average wind speed (previous 6 hours), average wind direction (previous 6 hours) at 100 m (Lower Camp), temperature and any recorded odour complaint. For Fort McKay Bertha Ganter the OdoCheck values (raw and processed), benzene, pentane, COS and 3-methylThiophene values were also included. A complete table with all hours with H_2S/TRS greater than or equal to 3 ppb at one or more sites is found in Table B-1 of Appendix B for Fort McKay and in Tables B-2 to B-4 for the other community sites. Some of the more important episodes (max TRS greater than or equal to 5 ppb) that occurred at the community sites (Fort McKay, Fort McMurray or Anzac) are shown in Tables 17 to 20.

Since only 12 of the 77 odour complaints occurred on hours with TRS greater than or equal to 5 ppb at a community site (and hence appear in Tables 17 to 20), a separate analysis was carried out for all hours with an odour complaint and the results are provided in Table 21. These are arranged by location of complaint. Since many of the odour complaints were identified as hydrocarbon in nature the table also includes NMHC levels. It is clear from Table 21 that there were many odour complaints recorded on days when no site in the network exceeded 3 ppb TRS/H_2S and when no sites recorded notably high levels of NMHC. As shown in Table 22 odour complaints were most frequent between 8:00 and 17:00 and occurred in all months except November (Table 22). There was no obvious relationship between wind speed and odour complaints with complaints occurring for light, moderate and strong wind speeds.

Of the 14 dates in Fort McKay with complaints and low TRS the PFGC detected COS on 4 of the days and pentane on 4 days. There was no consistent indicator species which may reflect the fact that different sources are contributing to odours on different days. The apparent change in response of the instrument after August 24 confounds any analysis of data. There was no consistency between OdoCheck values on low TRS days at Fort McKay and odour complaints.

Table 17: Data Integration for Dates with TRS Concentrations equal to or greater than 5 ppb at Fort McKay Bertha Ganter.

DATE	HOUR	TRS (ppb)	NMHC (ppm)	ODOCHECK (o.u.)	ODOCHECK DELTA	Max. TRS (All Sites) (ppb)	Location of Maximum TRS value for that hour	Odour Complaint	AVG WD (o)	WIND SDEV (o)	AVG WSPD (km/hr)	AVG WD AT 100 m (Lower Camp)
7/9/12	4	5	0.3	130.3	2	5	FORT MCKAY		S	68.8	5.1	SE
7/9/12	7	3	0.4	130.9	1	17	MILDRED LAKE		SSW	64.2	4.4	SE
7/9/12	8	6	0.6	131.8	3	14	MILDRED LAKE		SSW	64.3	5.1	SE
7/9/12	9	3	0.6	140.6	2	14	MILDRED LAKE		S	41.0	6.2	SE
7/10/12	6	3	0.6	105.7	4	6	MILDRED LAKE		W	58.2	3.0	SE
7/10/12	7	8	1.1	104.2	3	8	FORT MCKAY		SW	58.3	2.9	SE
7/10/12	8	4	0.8	108.0	1	9	BARGE LANDING	Hydrocarbon	SSW	41.8	3.1	SE
7/10/12	11	3		132.8	18	4	MILDRED LAKE		S	23.4	4.7	SSE
7/14/12	9	6	0.4	36.2	0	22	MILDRED LAKE		SW	54.7	3.8	SSE
7/14/12	10	6	0.3	40.1	2	10	MILDRED LAKE		SSW	50.6	4.8	SSE
7/14/12	11	4	0.4	41.8	1	8	MILDRED LAKE		S	44.1	5.6	SSE
7/17/12	4	8	0.4	57.3	3	10	MILDRED LAKE		S	7.9	4.0	SSE
7/17/12	5	7	0.4	61.5	1	12	MILDRED LAKE		S	8.4	4.0	SSE
7/17/12	6	5	0.3	61.8	2	9	MCKAY SOUTH		S	8.3	4.1	SSE
7/17/12	7	5	0.3	59.6	0	5	FORT MCKAY		S	9.2	5.3	SSE
7/17/12	8	3	0.2	59.7	0	3	BARGE LANDING		S	9.5	6.4	SSE
7/22/12	7	4	0.5	53.0	4	7	MILDRED LAKE		SSW	38.4	3.2	S
7/22/12	8	6	0.6	59.3	2	13	MILDRED LAKE		SSW	37.0	3.9	S
7/22/12	9	6	0.5	67.5	3	10	MILDRED LAKE		SSW	40.0	4.6	SSE
7/22/12	10	7	0.5	70.0	2	8	BARGE LANDING		S	43.0	5.3	SSE
8/2/12	14	9	0	37.0	0	9	FORT MCKAY	Sour smells	NNW	17.3	4.3	NNW
8/2/12	15	87	0.1	73.4	19	87	FORT MCKAY	Strong HC and Sulphur, Ammonia, Burnt Hair (5 Complaints)	NNW	22.4	4.6	NNW
8/2/12	16	6	0	51.1	3	70	MCKAY SOUTH		NNW	23.4	5.0	NW
8/2/12	17	3	0	69.4	9	22	MCKAY SOUTH		NNW	49.3	4.7	NW
12/31/12	17	4	0.3	34.1	1	6	BARGE LANDING		S	6.4	7.1	SSE
12/31/12	18	6	0.3	33.8	2	16	BARGE LANDING		S	6.3	7.2	SSE
12/31/12	19	12	0.4	32.2	1	15	BARGE LANDING		S	6.4	7.2	SSE
12/31/12	20	5	0.2	32.6	0	8	ANZAC		S	6.5	7.2	SSE
12/31/12	21	3	0.2	31.7	0	4	ANZAC		S	7.0	7.4	SSE

Table 18: Data Integration for Dates with TRS Concentrations equal to or greater than 5 ppb at Fort McMurray Patricia McInnes.

DATE	HOUR	TRS (ppb)	NMHC (ppm)	Max. TRS (All Sites) (ppb)	Location of Maximum TRS value for that hour	Odour Complaint	AVG WD (o)	WIND STDEV (o)	AVG WSPD (km/h)	AVG WD AT 100 m (Lower Camp)	TEMP (oC)
7/15/12	4	5	1	19	MANNIX		NNE	75.6	5.3	NNE	16.2
7/15/12	5	5	0.8	16	MANNIX		N	59.2	4.9	NNE	15.5
7/15/12	6	7	0.8	11	MANNIX		NNW	28.9	5.3	NNE	15.9
7/15/12	7	7	0.7	15	MANNIX		NNW	9.5	6.5	NNE	16.2
7/15/12	8	5	0.6	15	MANNIX		NNW	9.6	7.0	NNE	17.3
7/15/12	9	5	0.7	7	MANNIX		NNW	5.8	8.1	NNE	18.1
7/15/12	13	4	0.6	9	MANNIX		NNW	2.7	12.4	N	18.9
7/15/12	14	4	0.5	6	MANNIX		NNW	2.0	13.8	N	19.1
7/15/12	15	3	0.4	3	PATRICIA MCINNES		NNW	2.0	15.3	N	20.4
7/28/12	8	4	0.8	4	PATRICIA MCINNES		W	51.1	2.2	N	17.5
7/28/12	9	6	0.9	9	MANNIX		W	51.8	3.2	N	20.2
12/24/12	10	6	0.2	6	PATRICIA MCINNES		NNW	19.2	5.0		-28.3
12/24/12	11	9	0.4	9	PATRICIA MCINNES		NNW	19.0	4.6		-27.6
12/24/12	12	9	0.6	11	MANNIX		NNW	24.7	4.1		-26.9
12/24/12	13	4	0.1	5	ATHABASCA VALLEY		NNW	29.4	3.5		-26

Table 19: Data Integration for Dates with TRS Concentrations equal to or greater than 5 ppb at Fort McMurray Athabasca Valley.

DATE	HOUR	TRS (ppb)	NMHC (ppm)	Max. TRS (All Sites) (ppb)	Location of Maximum TRS value for that hour	Odour Complaint	AVG WD (o)	WIND STDEV (o)	AVG WSPD (km/h)	AVG WD AT 100 m (Lower Camp)	TEMP (oC)
6/18/12	21	6	0.2	6	ATHABASCA VALLEY	Hydrocarbon (4 complaints)	NW	63.9	4.7	NNE	15
6/18/12	22	3	0.2	4	MANNIX		NW	31.1	5.4	NNE	14.7
7/15/12	6	4	0.5	11	MANNIX		NE	27.2	2.7	NNE	16.4
7/15/12	7	4	0.5	15	MANNIX		NNE	32.3	3.6	NNE	16.7
7/15/12	10	6	0.4	7	MANNIX		NNW	23.0	8.2	NNE	18.7
7/15/12	11	6	0.4	9	MANNIX		NNW	5.0	9.7	N	19.1
7/15/12	12	4	0.3	8	MANNIX		NNW	6.8	10.5	N	19.3
7/24/12	4	3		15	MANNIX		N	88.8	4.2	NNE	18.7
7/24/12	6	9		9	ATHABASCA VALLEY	Very strong hydrocarbon	NW	68.0	4.2	N	18.3
7/24/12	7	8		8	ATHABASCA VALLEY		NW	45.6	5.2	N	17.9
7/24/12	8	6		6	ATHABASCA VALLEY		NNW	57.7	5.1	N	16.8
7/24/12	9	3		16	MANNIX		NNW	54.3	6.6	N	17.4

Table 20: Data Integration for Dates with TRS Concentrations equal to or greater than 5 ppb at Anzac.

DATE	HOUR	TRS (ppb)	NMHC (ppm)	Max. TRS (All Sites) (ppb)	Location of Maximum TRS value for that hour	Odour Complaint	AVG WD (o)	WIND STDEV (o)	AVG WSPD (km/h)	AVG WD AT 100 m (Lower Camp)	TEMP (o)
2/4/12	6	11		11	ANZAC		SW	26.1	5.9	SSE	-2.6
2/4/12	7	14		14	ANZAC		SSW	27.7	5.6	SSE	-2.4
2/4/12	8	3		3	ANZAC		SSW	22.2	5.9	SSE	-2.3
5/2/12	7	6	0.7	6	ANZAC		SSE	8.1	6.8	SE	5.2
5/2/12	8	3	0.2	3	ANZAC		SSE	8.6	6.3	SE	7.3
10/28/12	10	3	0.1	3	ANZAC		SE	10.6	10.6	SE	-7.4
10/28/12	11	3	0.1	3	ANZAC		SE	11.9	12.4	SE	-6.4
10/28/12	17	3	0	18	LOWER CAMP		SE	3.8	19.3	SE	-6.4
10/28/12	19	4	0	4	ANZAC		SE	8.8	18.1	SE	-6.3
10/28/12	20	7	0.1	7	ANZAC		SE	8.9	17.0	SE	-6.4
10/28/12	21	7	0.1	7	ANZAC		SE	8.2	15.5	SSE	-6.4
12/28/12	15	5		5	ANZAC		NE	16.1	2.8	S	-17.9
12/28/12	16	4		4	ANZAC		NNE	20.6	2.6	S	-19.7
12/28/12	17	5	0.2	5	ANZAC		NNE	19.7	2.8	SSE	-19.2
12/28/12	18	5	0.2	5	ANZAC		NNE	14.1	2.7	SSE	-17.9
12/28/12	19	3	0	3	ANZAC		NNE	15.0	2.6	SSE	-17
12/28/12	21	3	0.1	3	ANZAC		NNE	13.5	2.4	SSE	-17.3
12/28/12	22	4	0.2	4	ANZAC		NNE	7.8	2.3	SSE	-18.9
12/31/12	4	4		4	ANZAC		ENE	11.3	5.1	S	-15.2
12/31/12	5	3		3	ANZAC		ENE	10.9	4.6	S	-15.5
12/31/12	17	3		6	BARGE LANDING					SSE	-10.4
12/31/12	18	4		16	BARGE LANDING					SSE	-10.9
12/31/12	19	6		15	BARGE LANDING					SSE	-11
12/31/12	20	8		8	ANZAC		NNE	29.1	2.3	SSE	-11
12/31/12	21	4		4	ANZAC		NNE	55.2	2.7	SSE	-7.4

Table 21: Data Integration for Dates with Odour Complaints.

DATE	HR	ODOUR TYPE	ODOUR LOCATION	# of SITES with TRS equal to or greater than 3 ppb	TRS (ppb)	TRS SITE LOCATION	NMHC (ppm)	NMHC SITE LOCATION	ODO-CHECK	ODOCHECK DELTA	PENT-ANE (ppbC)	COS (ppb)	3-methyl Thio (ppb)	WD at 100 m
FORT MCKAY COMPLAINTS						**TRS and NMHC from BERTHA GANTER Site**								
2/2/12	10	Hydrocarbon	Fort McKay First Nation's Reserve	1	3	FORT MCKAY			1.9	0	0.0	0.0	0.25	SSE
2/28/12	13	Hydrocarbon	Fort McKay First Nation's Reserve	0	1	FORT MCKAY								SSE
4/3/12	14	Strong Hydrocarbon	Fort McKay Outside Band Office	0	1	FORT MCKAY	0.0	FORT MCKAY	5.6	0	0.0	0.0	0.0	SE
4/18/12	8	Hydrocarbon	Fort McKay	0	1	FORT MCKAY	0.2	FORT MCKAY			0.67	0.32	0.0	SSE
4/19/12	9	Hydrocarbon and Sulphur	Fort McKay	0			0.0	FORT MCKAY			0.01	0.27	0.0	SSE
5/2/2012	9	Strong Hydrocarbon	Fort McKay	0	1	FORT MCKAY	0.1	FORT MCKAY			0.0	0.0	0.0	SE
5/8/12	14	Very sour smell	Fort McKay	0	0	FORT MCKAY	0.0	FORT MCKAY						SSE
5/8/12	15	Hydrogen Sulphide and Hydrocarbon	Fort McKay	0	0	FORT MCKAY	0.0	FORT MCKAY						SSE
6/27/12	17	Hydrocarbon and Cat pee	Fort McKay	1	0	FORT MCKAY	0.0	FORT MCKAY	142.9	3	0.0	0.02	0.0	NNW
7/10/12	8	Hydrocarbon	Fort McKay	2	4	FORT MCKAY	0.8	FORT MCKAY	108	1				SE
8/2/12	8	Sulphur	Fort McKay	1	0	FORT MCKAY	0.1	FORT MCKAY	41.2	0				N
8/2/12	12	Ammonia	Fort McKay	2	0	FORT MCKAY	0.0	FORT MCKAY	37.6	0				N
8/2/12	15	Strong HC and Sulphur, Ammonia, Burnt Hair	Fort McKay (5 complaints)	4	87	FORT MCKAY	0.1	FORT MCKAY	73.4	19				NNW
8/28/12	13	Hydrocarbon	Fort McKay	0	0	FORT MCKAY	0.0	FORT MCKAY	31.8	0	0.0	0.0	0.0	SSW
9/28/12	11	Oily smell	Fort McKay	0	1	FORT MCKAY	0.3	FORT MCKAY	76.8	1	0.0			SSE
10/11/12	21	Smell like skunk	Fort McKay	0	0	FORT MCKAY	0.0	FORT MCKAY	36.7	0	0.67	0.0	0.0	S
10/13/12	16	Cat pee or rotten eggs	Fort McKay (2)	0	1	FORT MCKAY	0.3	FORT MCKAY	41.9	1	2.15	0.0	0.0	SSE
12/17/12	15	Can't breathe or talk and can't see due to pollution coming from source	Fort McKay	0	1	FORT MCKAY	0.0	FORT MCKAY			3.86	0.0	0.0	N
FORT MCMURRAY COMPLAINTS						**TRS and NMHC from Highest of ATHABASCA or PATRICIA MCINNES Sites**								
1/9/12	16	Burning transmission oil	Fort McMurray Municipality(location not specified)	0	1	ATHABASCA VALLEY								SSE
3/13/12	5	Gas/oil	Downtown Fort McMurray	0	1	PATRICIA MCINNES	0.8	PATRICIA MCINNES						N
3/13/12	10	Strong Hydrocarbon	Downtown Fort McMurray	0	1	PATRICIA MCINNES	0.3	PATRICIA MCINNES						N
5/24/12	9	Odour from oil and gas	Timberlea area, Fort McMurray	1	1	ATHABASCA VALLEY	0.4	ATHABASCA VALLEY						NNW

DATE	HR	ODOUR TYPE	ODOUR LOCATION	# of SITES with TRS equal to or greater than 3 ppb	TRS (ppb)	TRS SITE LOCATION	NMHC (ppm)	NMHC SITE LOCATION	ODO-CHECK	ODOCHECK DELTA	PENT-ANE (ppbC)	COS (ppb)	3-methyl Thio (ppb)	WD at 100 m
6/18/12	20	Sweet Crude	Timberlea	1	2	PATRICIA MCINNES	0.3	PATRICIA MCINNES						NNE
6/18/12	21	Hydrocarbon	Timberlea (4 complaints)	2	6	ATHABASCA VALLEY	0.2	ATHABASCA VALLEY						NNE
7/4/12	18	Very strong HC odour	Fort McMurray Hospital	1	1	ATHABASCA VALLEY	0.4	ATHABASCA VALLEY						NNW
7/15/12	3	Like a dump diluent into the tailing pond	Timberlea	1			0.9	PATRICIA MCINNES						NE
7/23/12	8	Hydrocarbon	Fort McMurray	1	3	PATRICIA MCINNES	0.7	PATRICIA MCINNES						NNW
7/24/12	21	Bad smell from Plant	Timberlea, Fort McMurray	1	2	PATRICIA MCINNES	0.3	PATRICIA MCINNES						NNE
7/28/12	7	Very strong rotten Egg/Sulphur smell	Timberlea, Fort McMurray	0	1	ATHABASCA VALLEY	0.4	ATHABASCA VALLEY						N
8/8/12	10	Hydrocarbon	Fort McMurray	0	0	ATHABASCA VALLEY	0.2	ATHABASCA VALLEY						SE
8/22/12	7	Sulphur and Hydrocarbon	Fort McMurray	1	1	PATRICIA MCINNES								N
10/11/12	21	Smell like skunk	Fort McMurray	0	0	PATRICIA MCINNES	0.2	PATRICIA MCINNES						S
10/16/12	7	Hydrocarbon	Fort McMurray downtown	0	1	PATRICIA MCINNES	1.2	PATRICIA MCINNES						NNE
10/23/12	6	Ammonia, sour gas	Wood Buffalo Municipality, Fort McMurray	0	0	PATRICIA MCINNES	0.3	PATRICIA MCINNES						SSW
12/2/12	3	Very Strong gasoline smells	Downtown, Fort McMurray	0	1	ATHABASCA VALLEY	0.2	ATHABASCA VALLEY						N
12/7/12	10	Smell of dead animal	Thickwood, Fort McMurray	0	1	ATHABASCA VALLEY								SE
ANZAC/JANVIER AREA COMPLAINTS						**TRS and NMHC from ANZAC**								
1/31/12	19	H_2S or Sulphur smell	Nexen /Long Lake project	3	1	ANZAC								NNW
9/16/12	12	Very bad odour	Driving thru the Hwy 881 and go thru Janvier landfill	0	0	ANZAC	0	ANZAC						S
OTHER AREA COMPLAINTS						**TRS and NMHC from Highest Site**								
1/9/12	14	Hydrocarbon	Fort McMurray oil sands mine near Suncor	0	2	FORT MCKAY								S
1/12/12	8	Strong Hydrocarbon	Hwy 63 while driving north between the two tailing ponds	1	3	MILDRED LAKE								S
1/30/12	8	Rotten odour as H_2S	Hwy 63 N while just pass Suncor	0	0	ANZAC			1.8	0				NNE
2/1/12	8	Hydrocarbon	Heading North on Hwy 63, near Syncrude	1	3	FORT MCKAY			1.8	0	0.0	0.0	0.02	SSE
2/13/12	17	Cat's pee	Driving Southbound on Hwy 63 and passing Syncrude	0	1	MILLENNIUM			2	0	0.0	0.0	0.0	W
2/14/12	9	Strong cat's pee	Heading North on Hwy 63 and passing Syncrude towards Fort McKay	0	1	BARGE LANDING			2.5	0	0.0	0.0	0.01	WSW
3/13/12	16	Strong oily smell	Driving Southbound on Hwy 63 and passing Suncor tailings pond	1	3	MILLENNIUM			6.7	0	0.6	0.0	0.0	NNE
3/23/12	15	Strong Hydrocarbon	At Fort McKay before Syncrude site	0	1	PATRICIA MCINNES	1.2	MUSKEG RIVER	5.6	0	0.0	0.0	0.0	NNW

DATE	HR	ODOUR TYPE	ODOUR LOCATION	# of SITES with TRS equal to or greater than 3 ppb	TRS (ppb)	TRS SITE LOCATION	NMHC (ppm)	NMHC SITE LOCATION	ODO-CHECK	ODOCHECK DELTA	PENT-ANE (ppbC)	COS (ppb)	3-methyl Thio (ppb)	WD at 100 m
3/29/12	8	As Tailing ponds are being stirred up	At Syncrude site while driving towards Fort McKay	0	1	FORT MCKAY	0.4	CNRL HORIZON	5.4	0	0.0	0.0	0.0	SE
4/2/12	8	Hydrocarbon	Hwy 63 North Bound	0	1	FORT MCKAY	0.7	MUSKEG RIVER	5.9	0	0.0	0.0	0.0	NW
4/12/12	8	Air Quality Concerns	Between Fort McMurray and Fort McKay	0	1	FORT MCKAY SOUTH	0.8	BARGE LANDING			0.07	0.01	0.0	NNE
4/23/12	8	Strong Hydrocarbon and Sulphur	While approaching Suncor towards Fort McKay	0	1	ATHABASCA VALLEY	2	MUSKEG RIVER			0.0	0.35	0.0	NNW
4/23/12	9	Strong Hydrocarbon and Sulphur	While approaching Suncor overpass at Hwy 63 towards Fort McKay (2)	0	2	MANNIX	1.8	MUSKEG RIVER			0.0	0.22	0.0	NNW
5/22/12	18	Strong Hydrocarbon	Mildred Lake oil sands mine	0	1	LOWER CAMP	0.3	BARGE LANDING	35.6	1				SE
5/24/12	8	Foul oil smell	10 km south from Mildred Lake	2	9	MILLENNIUM	2.8	BUFFALO VIEWPOINT	37.8	2				N
5/28/12	8	Strong Hydrocarbon	Passing Mildred Lake camp on Hwy 63 towards North	0	2	FORT MCKAY	0.6	BARGE LANDING	59.3	3				SSE
5/28/12	17	Sulphur and Hydrocarbons	Hwy 63 towards South just passing Suncor	0	1	FORT MCKAY	0.3	BARGE LANDING	59.5	2	0.0	0.02	0.0	SSE
6/1/12	15	Strong H_2S	Heading South on Hwy 63, near Syncrude	0	1	ATHABASCA VALLEY	0.3	BARGE LANDING	71.7	5	0.0	0.24	0.0	WSW
6/20/12	17	Strong Sulfur and Hydrocarbon	Suncor	0	1	ATHABASCA VALLEY			165.7	4	0.0	0.2	0.0	N
7/3/12	9	HC odour with sulfur	Passing Syncrude and Suncor towards Fort McKay	1	13	MILDRED LAKE	1.3	MILDRED LAKE	99.8	1				SSE
7/4/12	8	Very strong HC odour	Between Suncor and Syncrude on Hwy 63	1	4	MANNIX	0.9	MUSKEG RIVER	94.5	0				NNE
7/4/12	17	Very strong HC and Sulphur	South on Hwy 63 b/w Suncor and Syncrude	1	9	MANNIX	0.4	BARGE LANDING	92.4	2				NNW
7/10/12	17	Very strong odour	Driving Hwy 63S towards Fort McMurray	1	6	MANNIX	0.4	BARGE LANDING	112.5	11				S

Table 22: Odour Complaints by Time of Day and by Month for 2012.

Incident Hour	Count	Incident Month	Count
0	0	**1**	6
1	0	**2**	5
2	0	**3**	6
3	2	**4**	7
4	0	**5**	8
5	1	**6**	9
6	2	**7**	11
7	3	**8**	12
8	14	**9**	3
9	6	**10**	6
10	4	**11**	0
11	1	**12**	3
12	2		
13	2	**Total**	76
14	6		
15	10		
16	6		
17	6		
18	2		
19	1		
20	1		
21	7		
22	0		
23	0		
Total	76		

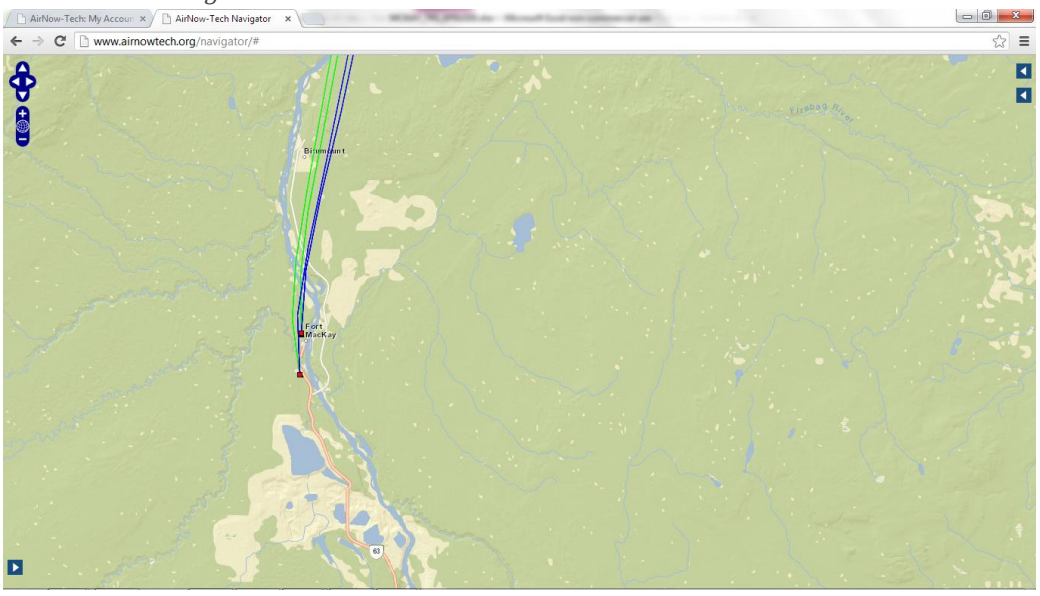
5.3 Features of Episodes at the Community Monitoring Sites

FORT MCKAY BERTHA GANTER: There were a total of 125 hours with TRS concentrations equal to or greater than 3 ppb and two hours greater than 10 ppb at the site with a maximum concentration of 87 ppb measured on August 2, 2012. There were six periods where TRS concentrations equal to or greater than 3 ppb persisted for five hours or more with the longest period spanning thirty-two hours in February, 2012. The majority of occurrences of TRS > 3 ppb occurred with south or south southwest wind directions. Seventeen of the total twenty-three odour complaints from the community occurred on dates with TRS concentrations less than 3 ppb and eleven of these referred to hydrocarbon odour. These incidents were usually associated with winds from the south southeast or southeast although there were three cases with north or north northwest winds. During the incidents SO_2 and NMHC levels were low as were OdoCheck deltas.

Some dates of note with high TRS are discussed below:

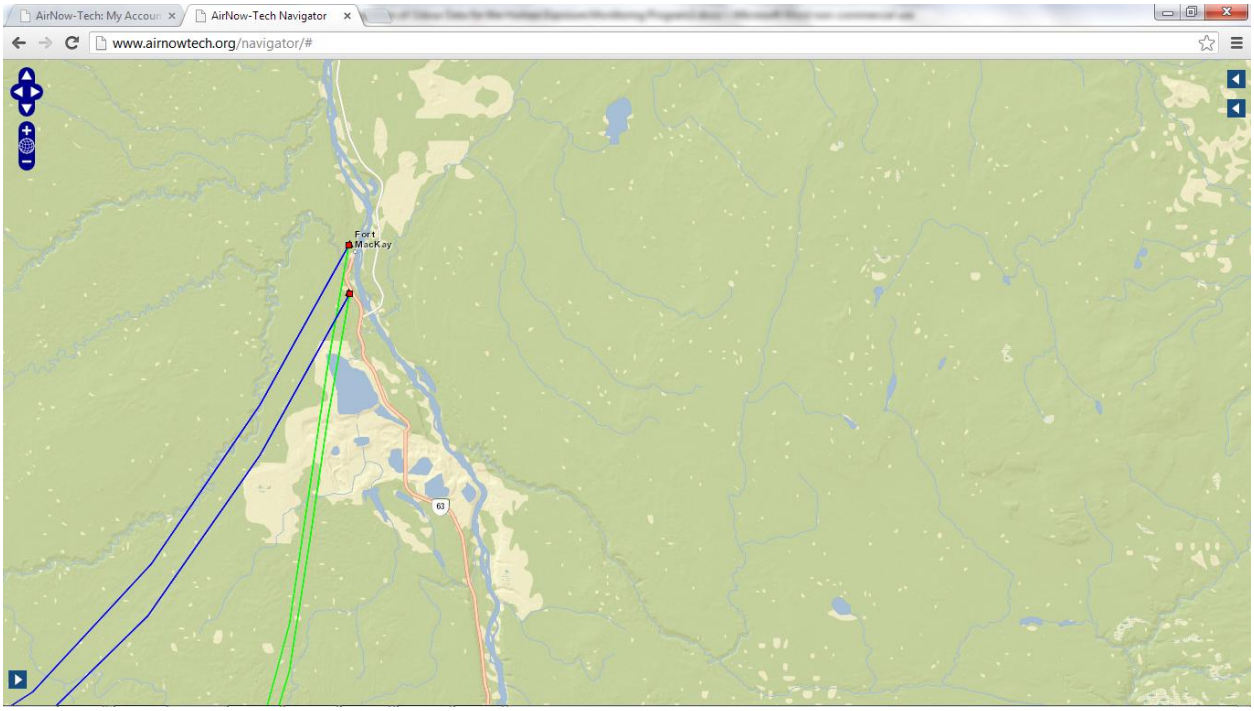
August 2, 2012: The highest TRS concentration of 87 ppb also coincided with the highest SO_2 concentration of 70 ppb and one of the highest OdoCheck delta values of 19. There were no VOC or RSC data available during this period. Seven odour complaints from Fort McKay were registered on this date with the first two complaints recorded before the station TRS values exceeded zero. The Fort McKay South site measured a TRS maximum of 70 ppb during the same event. The event was very unusual for this site in terms of wind direction, with winds persisting from the north northwest and may have been due to an unusual emission release at CNRL Horizon or Shell Albian Sands. A back trajectory calculation from the AirNow-Tech website (AIRNOW, 2013) shows the air mass originating north northeast of the site but surface winds may be a more accurate predictor of source location (see Figure 24).

Figure 24: Six-hour back trajectories at surface (green) and at 50 m (blue) for August 2, 2012 at 17:00 from AirNow-Tech Navigator.



December 31, 2012. This is the only other date where TRS exceeded 10 ppb with a value of 12 ppb recorded at 19:00. TRS concentrations equal to or greater than 3 ppb persisted for five hours but no odour complaints were recorded. A TRS concentration of 16 ppb was measured at Barge Landing. Winds were from the south (SSE at 100m) with a very small standard deviation of wind direction. The PFGC instrument was seeing relatively high levels of VOC species during the period. A six-hour back trajectory is shown in Figure 25.

Figure 25: Six-hour back trajectories at surface (green) and at 50 m (blue) for December 31, 2012 at 19:00 from AirNow-Tech Navigator.



February 1, 2012 to February 4, 2012. TRS concentrations equal to or greater than 3 ppb persisted for thirty-two hours with a maximum of 4 ppb recorded. Wind direction was consistently from the south (SSE at 100 m) with a very small standard deviation of wind direction. One odour complaint was received during the period but the odour was characterized as hydrocarbon in nature. The OdoCheck system showed no response. The PFGC was measuring 3-methyl thiophene during this period with maximum concentrations of 0.45 ppb.

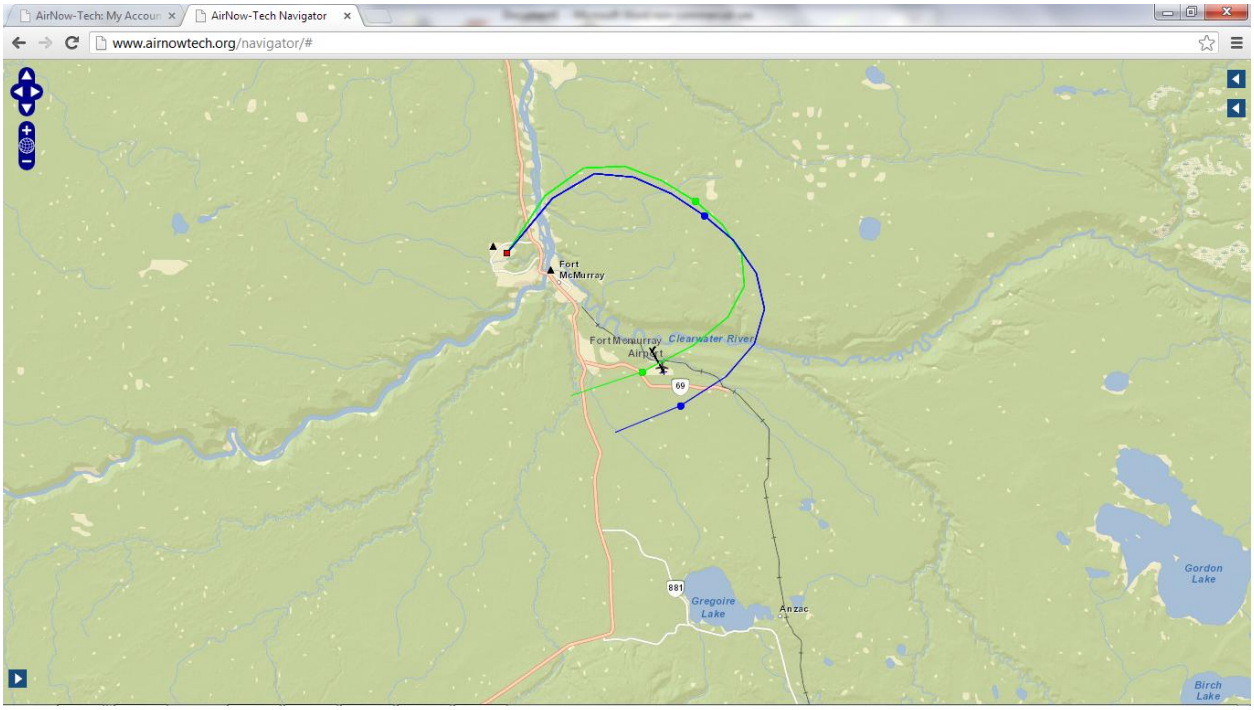
FORT MCMURRAY PATRICIA MCINNES: There were a total of 27 hours with TRS concentrations equal to or greater than 3 ppb at the site with a maximum concentration of 9 ppb measured on two separate hours on December 24, 2012. There was one period where TRS concentrations equal to or greater than 3 ppb persisted for nine hours on July 15, 2012. The majority of occurrences of TRS greater than or equal to 3 ppb occurred with a north northwest wind direction. Fifteen of the total of twenty odour complaints from the Fort McMurray area occurred on dates with TRS concentrations less than 3 ppb at the site and eleven of these referred to hydrocarbon or sulphur and hydrocarbon odour. Nine of these incidents were associated with northerly winds and six with southerly winds. During the incidents SO_2

and NMHC levels were generally low except for October 16, 2012 when the highest NMHC concentration of the year (1.2 ppm) was recorded.

Some dates of note are discussed below:

June 18, 2012: Five separate complaints were received from the Timberlea area describing a sweet crude or hydrocarbon smell. TRS concentrations were below 3 and NMHC below 0.3 ppb. Winds were from the north at the time of the complaints but a back trajectory calculation from the AirNow-Tech website (AIRNOW, 2013) shows a circular pattern with the air mass originating south of Fort McMurray (see Figure 26).

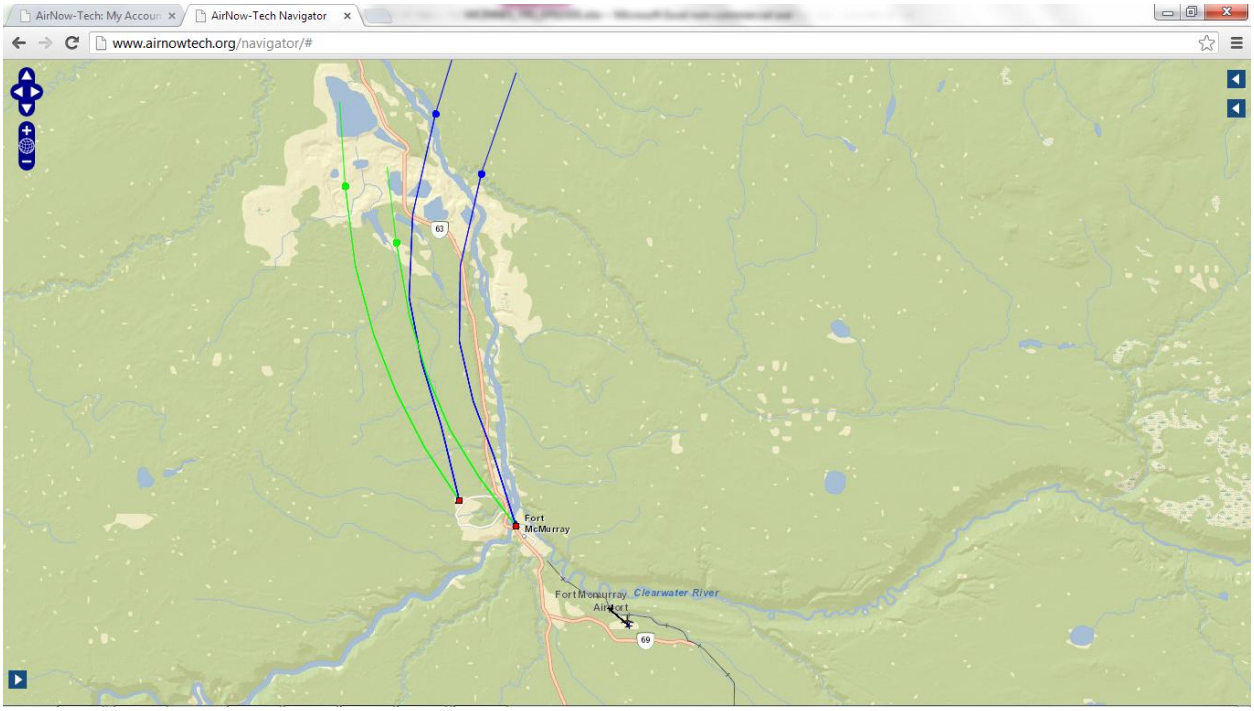
Figure 26: Twelve-hour back trajectories at surface (green) and at 50 m (blue) for June 18, 2012 at 21:00 from AirNow-Tech Navigator.



July 15, 2012: TRS concentrations equal to or greater than 3 ppb persisted for nine hours with a maximum of 7 ppb recorded. Wind direction was consistently from the north northwest (NNE at 100 m) with a small standard deviation of wind direction. One odour complaint was received at the start of the period described as "*a dump diluent into the tailing pond*".

December 24, 2012: TRS concentrations equal to or greater than 3 ppb persisted for four hours with a maximum of 9 ppb recorded on two separate hours. Wind direction was from the north northwest. No odour complaints were received during the period. Back trajectories are shown in Figure 27.

Figure 27: Six-hour back trajectories at surface (green) and at 50 m(blue) for December 24, 2012 at 11:00 from AirNow-Tech Navigator.



FORT MCMURRAY ATHABASCA VALLEY: There were a total of 28 hours with TRS concentrations equal to or greater than 3 ppb at the site with a maximum concentration of 9 ppb measured on July 24, 2012. There were three periods where TRS concentrations equal to or greater than 3 ppb persisted for five hours or more with the longest period spanning seven hours on December 24, 2012. The majority of occurrences of TRS greater than or equal to 3 ppb occurred with north to northwest wind directions. Thirteen of the total of twenty odour complaints from the Fort McMurray area occurred with TRS concentrations less than 3 ppb at the site and nine of these referred to hydrocarbon or sulphur and hydrocarbon odour. Eight of these incidents were associated with northerly winds and five with southerly winds. During the incidents SO_2 and NMHC levels were generally low except for March 3, 2012 when a total NMHC concentration of 0.7 ppm was measured on the same hour of the complaint (wind direction was due north).

Some dates of note are discussed below:

July 24, 2012: TRS concentrations equal to or greater than 3 ppb persisted for seven hours with a maximum of 9 ppb recorded. Wind direction was consistently from the north and north northwest (N at 100 m) with a very small standard deviation of wind direction. Two odour complaints were received during the period but the odour was characterized as hydrocarbon in nature.

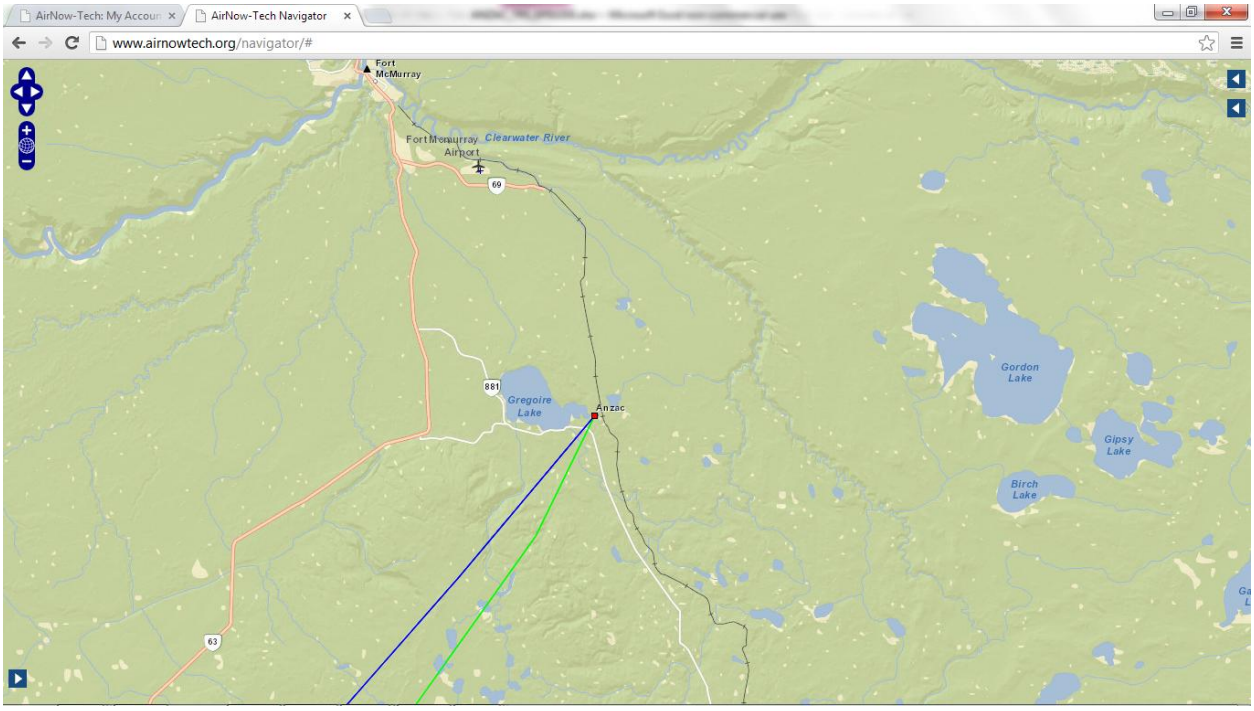
December 24, 2012: TRS concentrations equal to or greater than 3 ppb persisted for seven hours with a maximum of 5 ppb recorded. Wind direction was unusually from the south southwest at the site but at 100 m at the Lower Camp tower the wind was from the north northwest. No odour complaints were received during the period.

ANZAC: There were a total of thirty-two hours with TRS concentrations equal to or greater than 3 ppb at the site with two hours greater than 10 ppb and a maximum of 14 ppb measured on February 4, 2012. There were three periods where TRS concentrations over 3 ppb persisted for five hours or more with the longest period spanning ten hours on December 30/31, 2012. Occurrences of TRS greater than or equal to 3 ppb occurred with a number of wind directions. One odour complaint was received from the area and it occurred with TRS concentrations less than 3 ppb at the Anzac site.

Some dates of note are discussed below:

February 4, 2012: TRS concentrations exceeded 10 ppb at the site for two hours with a maximum TRS concentration of 14 ppb recorded. Winds were from the south southwest (SSE at 100 m) and SO_2 and NMHC concentrations were very low. A six-hour back trajectory is shown in Figure 28.

Figure 28: Six-hour back trajectories at surface and at 50 m for February 4, 2012 at 9:00 from AirNow-Tech Navigator.



October 28, 2012: TRS concentrations equal to or greater than 3 ppb persisted for six hours with a maximum of 7 ppb recorded on two consecutive hours. Wind direction was consistently from the southeast (SE at 100 m). No odour complaints were received during the period. A maximum SO_2 concentration of 15 ppb was recorded with very low NMHC concentrations.

Dec. 30/31, 2012: TRS concentrations equal to or greater than 3 ppb persisted for ten hours with a maximum of 8 ppb recorded. Wind direction was from the northeast or north northeast at the site but the Lower Camp tower recorded a consistent south southeast wind direction at 100 m. No odour complaints were received during the period. SO_2 and NMHC concentrations were very low.

5.4 Correlations between Sites for Selected Parameters

Correlations between the individual monitoring sites for TRS/H_2S, SO_2 and NMHC are provided in Table 23 for the hours where TRS/H_2S was greater than or equal to 3 ppb at one site or more and/or days with an odour complaint. Only the instances that had correlation coefficients (r) greater than 0.3 are shown in the table. The distance between site pairs is also provided.

Not surprisingly the highest correlations for TRS were between Fort McKay and Barge Landing and Fort McKay South. The two sites also showed a good correlation for SO_2 and NMHC. The two Fort McMurray sites showed a good correlation for TRS, SO_2 and NMHC.

Table 23: Correlation between Monitoring Sites for TRS/H_2S, SO_2 and NMHC for All Hours with TRS/H_2S Concentrations equal to or greater than 3 ppb (only correlations > 0.3 are shown).

SITE 1	SITE 2	DISTANCE BETWEEN SITES (km)	CORRELATION COEFFICIENT
TRS/H_2S			
FORT MCKAY	BARGE LANDING	2.7	0.881
FORT MCKAY	FORT MCKAY SOUTH	4.4	0.652
FORT MCKAY SOUTH	BARGE LANDING	6.0	0.552
ATHABASCA VALLEY	PATRICIA MCINNES	5.7	0.416
FORT MCKAY SOUTH	MILDRED LAKE	12.0	0.328
PATRICIA MCINNES	MANNIX	24.2	0.324
SO_2			
FORT MCKAY	FORT MCKAY SOUTH	4.4	0.815
ATHABASCA VALLEY	PATRICIA MCINNES	5.7	0.603
MILLENNIUM	BUFFALO VIEWPOINT	17.4	0.596
MILLENNIUM	LOWER CAMP	16.9	0.476
ATHABASCA VALLEY	BUFFALO VIEWPOINT	31.8	0.437
ATHABASCA VALLEY	MILLENNIUM	17.4	0.432
FORT MCKAY	SHELL MUSKEG RIVER	10.2	0.428
MILLENNIUM	MANNIX	10.7	0.374
BUFFALO VIEWPOINT	LOWER CAMP	6.5	0.367
BUFFALO VIEWPOINT	MANNIX	7.4	0.366
CNRL HORIZON	FORT MCKAY	14.0	0.322
MILLENNIUM	MILDRED LAKE	20.9	0.315
NMHC			
ATHABASCA VALLEY	PATRICIA MCINNES	5.7	0.591
BUFFALO VIEWPOINT	MANNIX	7.4	0.587
ANZAC	PATRICIA MCINNES	43.0	0.523
FORT MCKAY	FORT MCKAY SOUTH	4.4	0.514
ANZAC	ATHABASCA VALLEY	38.2	0.510
MILLENNIUM	LOWER CAMP	16.9	0.435
FORT MCKAY	BARGE LANDING	2.7	0.415
MANNIX	SHELL MUSKEG RIVER	31.3	0.356
LOWER CAMP	MILDRED LAKE	4.6	0.355
ATHABASCA VALLEY	SHELL MUSKEG RIVER	58.0	0.330
FORT MCKAY SOUTH	BARGE LANDING	6.0	0.323
PATRICIA MCINNES	SHELL MUSKEG RIVER	55.5	0.319
MILLENNIUM	MANNIX	10.7	0.316

5.5 Correlations between Parameters at Selected Sites

In Table 24 the correlation between parameter pairs for TRS/H_2S, SO_2, NMHC, temperature and wind speed by site for all days with TRS/H_2S Concentrations equal to or greater than 3 ppb and/or with an odour complaint (only correlations > 0.3 are shown). There were no site correlations greater than 0.3 for SO_2 and NMHC and there were no site correlations greater than 0.3 for wind speed and TRS/H_2S, SO_2 or NMHC and only NMHC at Athabasca Valley had a correlation greater than 0.3 with temperature. The

highest correlations were between TRS and SO_2 at Fort McKay South and Fort McKay and between NMHC and TRS at Patricia McInnes.

In Table 25 correlations between selected parameters for all days with TRS/H_2S concentrations equal to or greater than 3 ppb and/or with an odour complaint are shown for the Fort McKay Bertha Ganter site including the OdoCheck (only data after May 18 included) and the PFGC/RSC results. Correlations for all parameters and all hours are provided in Table C-1 of Appendix C. Many of the VOC species were highly correlated with one another and with NMHC. The correlations for the days equal to or greater than 3 ppb tend to be higher than for all days because many of the correlations are driven by the one extreme event where most parameters peaked at the same time. The OdoCheck instrument has a moderate correlation with temperature for all sampling days which could influence the reliability of its output. The Z-Score correlations are not shown as they would be the same as the OdoCheck raw output for the period that they were calculated.

Table 24: Correlation between Selected Parameter Pairs at All Sites for All Hours with TRS/H_2S Concentrations equal to or greater than 3 ppb (only correlations > 0.3 are shown).

SITE	CORR. COEFF.	N
TRS-SO_2		
FORT MCKAY SOUTH	0.741	1178
FORT MCKAY	0.615	1198
MILDRED LAKE	0.315	1252
TRS-NMHC		
PATRICIA MCINNES	0.529	1023
CNRL HORIZON	0.498	1016
LOWER CAMP	0.491	1009
MILDRED LAKE	0.444	1013
MANNIX	0.440	1005
BUFFALO VIEWPOINT	0.306	986
NMHC-TEMPERATURE		
ATHABASCA VALLEY	0.374	962

Table 25: Correlation between Selected Parameters Measured at Fort McKay Bertha Ganter for Hours with TRS equal to or greater than 3 ppb at the Site and for All Hours.

Parameter 1	Parameter 2	Hours >= 3 ppb		All Hours	
		CORR. COEFF.	N	CORR. COEFF.	N
TRS	SO_2	0.868	119	0.260	7724
TRS	THC	-0.175	112	0.313	7632
TRS	CH_4	-0.225	64	0.188	6393
TRS	NMHC	-0.116	64	0.285	6393
TRS	ODOCHECK DELTA	0.618	64	0.086	4104
TRS	ODOCHECK	0.067	64	0.063	4124
TRS	Peak0805.6	0.831	13	0.336	1941
TRS	Peak0875-L	0.702	13	0.381	1878
TRS	Peak0930-L	0.533	13	0.409	1899
TRS	2MeButane	0.489	13	0.284	2102
TRS	Pentane	0.679	13	0.210	2095
TRS	Hexane	0.374	13	0.418	1970
SO_2	ODOCHECK DELTA	0.619	59	0.036	3874
SO_2	ODOCHECK	-0.003	59	0.115	3890
SO_2	3MeButane	0.866	11	0.025	1987
NMHC	ODOCHECK DELTA	-0.114	62	0.058	3844
NMHC	ODOCHECK	0.393	62	0.085	3859
NMHC	Peak0930-L	0.430	13	0.370	1942
NMHC	Peak1104.1	0.684	13	0.474	1818
NMHC	Benzene	0.677	12	0.210	2008
NMHC	Toluene	0.560	13	0.390	2008
NMHC	Heptane	0.580	13	0.315	1959
ODOCHECK DELTA	ODOCHECK	0.360	64	0.294	4104
ODOCHECK DELTA	TEMPERATURE	0.245	64	0.138	4104
ODOCHECK DELTA	HUMIDITY	-0.091	64	-0.108	4104
ODOCHECK	Pentane	-0.691	13	0.119	1309
ODOCHECK	Benzene	-0.727	12	0.003	1341
ODOCHECK	TEMPERATURE	0.448	64	0.353	4124

6 Discussion of Results

6.1 Issues Affecting Data Analysis and Integration

1. There was a limited set of above detection observations from the PFGC instrument and there was unexplained variability in the number of detected species through time. None of the most odorous species were detected with any consistency.
2. There was large variability in the absolute response of the OdoCheck system and a step change in results after May 2012. The most consistent output period was from July 21 to November 19.
3. There was a lack of detail in the odour complaint logs as to location and timing of complaint (also lots of variability in description of odours).
4. There was a lack of a good measure of VOC/NMHC concentrations at most sites (NMHC was inferred except at AMS#1). The NMHC and methane data from AMS#6, AMS#7 and AMS#14 were inadvertently overlooked but this should not affect any conclusions.
5. Except for carbonyl sulphide and carbon disulphide, integrated canister RSC species concentrations were generally below detection at all sites.
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. There were no data on odorous VOC/RSC species emissions from sources in the airshed.

6.2 Important Observations

1. There were many odour complaints recorded on days when no site in the network equaled or exceeded 3 ppb TRS/H_2S and/or when no sites recorded notably high levels of THC or NMHC.
2. Of all the measured species only TRS/H_2S and SO_2 exceeded Alberta air quality objectives or exceeded estimated odour threshold levels. In many cases, however, the species detection level was above the odour threshold level.
3. The majority of TRS values equal to or greater than 3 ppb were associated with only a few wind directions at the community sites and are undoubtedly associated with specific sources. Days with complaints but low TRS values had a more variable association with wind direction.
4. The correspondence of the OdoCheck system with complaints from Fort MacKay was quite variable and this may be related to an inconsistent baseline output that complicated data analysis over the entire year.
5. The response of the PFGC instrument did appear to change after the original instrument was replaced in August. There were some instances of values above detection for RSC on complaint days at Fort McKay and a relationship between VOC species and wind direction after August but it was difficult to make any quantitative conclusions related to the identification of compounds contributing to odours on low TRS complaint days for the entire year.
6. Of the community sites, Fort McKay records the highest TRS levels and records the highest number of complaints. At the Fort McKay Bertha Ganter site there were a total of 125 hours with TRS concentrations equal to or greater than 3 ppb and two hours greater than 10 ppb with a maximum concentration of 87 ppb measured on August 2, 2012. There were six periods where TRS concentrations equal to or greater than 3 ppb persisted for five hours or more with the

longest period spanning thirty-two hours in February, 2012. The majority of occurrences of TRS equal to or greater than 3 ppb occurred with south or south southwest wind directions.

7. At the Fort McMurray Patricia McInnes site there were a total of 27 hours with TRS concentrations equal to or greater than 3 ppb with a maximum concentration of 9 ppb measured on two separate hours on December 24, 2012. There was one period where TRS concentrations equal to or greater than 3 ppb persisted for nine hours on July 15, 2012. The majority of occurrences of TRS equal to or greater than 3 ppb occurred with a north northwest wind direction.
8. No historical perspective can be applied to the results as to whether conditions are improving or getting worse as only one year of data was examined. It would also be interesting to compare levels of complaints in the WBEA airshed to other Alberta airsheds.
9. The lack of correspondence of emission TRS-H_2S/SO_2 ratios to ambient ratios is puzzling and may reflect an underestimation of fugitive TRS sources.

7 Summary and Recommendations

It is worth restating that the ability of humans to distinguish different odour intensities is highly subjective with changes in concentration of the order of 25 to 33% needed for an individual to recognize different odour intensities. As noted previously there is 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. Perceived odour quality varies with the individual and also with the strength of an odour. The odour thresholds for many odorous species are well below the detection level of monitoring instrumentation especially for sensitive individuals.

The Alberta 1-hour air quality objective of 10 ppb was only exceeded four times at community monitoring sites in the WBEA yet there were a total of 76 unique odour related complaints recorded on 53 separate dates by the Alberta Environment hotline. Using a 3 ppb TRS level as an indicator of potential odour, a higher frequency of impact is noted with Fort McKay experiencing the highest frequency and longest persistence of occurrences. However, the majority of odour complaints in both Fort McKay and Fort McMurray occurred when TRS concentrations were less than 3 ppb and NMHC and THC levels at the sites were also low. The following preliminary recommendations are provided:

1. To supplement the Alberta Environment hotline, implement a more consistent program of logging odour complaints that includes more details on odour description, location, timing and persistence (the recently implemented Community Odour Monitoring Panel should serve this purpose well). Obtaining more detailed records of community complaints from Fort McKay would also be useful.

2. Further evaluation of the performance of the OdoCheck system is warranted in order to stabilize its output. A more frequent review of data from the unit is required and further investigation of data processing methods such as the DELTA and Z-score should be carried out. Access to the real time outputs would be useful.
3. Further evaluation of the performance of the PFGC system is warranted based on the apparent change in output after August and its lack of sensitivity for carbonyl sulphide. It is the only instrument deployed that is capable of producing hourly estimates of VOC and RSC of interest so it is of great value to any odour characterization efforts. A more frequent review of data from the unit is required and access to the real time outputs would be beneficial. Ongoing comparison with 24h canister data (VOC, COS and CS_2) should be carried out.
4. Detection levels for the canister sampling are too high to identify any of the most odorous target species and improvements should be sought.
5. The THC measurements are serving no useful purpose for odour identification and it's not clear that the data serve any other purpose. The resources used for operating these instruments could be best applied to other more specific VOC species monitoring at the community sites. Since many of the complaints refer to hydrocarbon odours, additional effort is required to identify and routinely measure odorous VOC species. Cresols are one potential candidate species (cresols have an odor characteristic to that of other simple phenols, reminiscent to some of a "coal tar" smell).
6. A database for all observations should be developed and maintained to allow easy integration of data. Annual updates in data analysis should be carried out to allow an assessment of changes in odour incidents in the region.
7. Consideration should be given by Alberta Environment to upload meteorological and TRS data into the AIRNOW system. There are a large variety of real time data analysis tools available in AIRNOW Tech that would allow a near real time investigation of odour complaints.

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Appendix A

Table A-1: Relevant Ambient Air Quality Criteria (AAQC) from the Province of Ontario.

CAS #	Contaminant	AAQC (ppb)	Averaging Time	Limiting Effect
50-00-0	Formaldehyde	53	24 Hour	Health
56-23-5	Carbon tetrachloride	0.38	24 Hour	Health
67-64-1	Acetone	5000	24 Hour	Health
71-43-2	Benzene	0.14	Annual	Health
74-85-1	Ethylene	35	24 Hour	Vegetation
74-86-2	Acetylene	52,000	24 Hour	Odour
75-07-0	Acetaldehyde	278	24 Hour	Health
75-15-0	Carbon disulphide	105	24 Hour	Odour
75-18-3	Dimethyl sulphide	12	10 Minute	Odour
79-01-6	Trichloroethylene	0.43	Annual	Health
		2.2	24 Hour	Health
91-20-3	Naphthalene	4.3	24 Hour	Health
		9.5	10 Minute	Odour
95-63-6	Trimethylbenzene, 1,2,4	45	24 Hour	Health
100-41-4	Ethyl benzene	230	24 Hour	Health
		435	10 Minute	Odour
100-42-5	Styrene	94	24 Hour	Health
106-46-7	Dichlorobenzene, 1,4-	16	24 Hour	Health
106-99-0	Butadiene, 1,3-	0.9	Annual	Health
		4.5	24 Hour	Health
107-06-2	Ethylene dichloride	0.1	Annual	Health
		0.5	24 Hour	Health
108-67-8	Trimethylbenzene, 1,3,5	45	24 Hour	Health
108-88-3	Toluene	530	24 Hour	Odour
108-90-7	Chlorobenzene	770	1 Hour	Health
		990	10 Minute	Odour
110-54-3	Hexane, n- (part of a mixture)	700	24 Hour	Health
110-82-7	Cyclohexane	1,780	24 Hour	Health
111-65-9	Octane	13,200	10 Minute	Odour
115-07-1	Propylene	2,300	24 Hour	Health
120-82-1	Trichlorobenzene, 1,2,4-	54	24 Hour	Health
124-18-5	Decane, n-	10,000	1 Hour	Health & Odour
127-18-4	Tetrachloroethylene	53	24 Hour	Health
142-82-5	Heptane, n-	2,700	24 Hour	Health
156-59-2	Dichloroethylene, cis-1,2-	25	24 Hour	Health
156-60-5	Dichloroethylene, trans-1,2-	25	24 Hour	Health
526-73-8	Trimethylbenzene, 1,2,3	45	24 Hour	Health
540-59-0	Dichloroethylene, -1,2-	25	24 Hour	Health
624-92-0	Dimethyl disulphide	15	10 Minute	Odour
1330-20-7	Xylenes	165	24 Hour	Health
		700	10 Minute	Odour
7783-06-5	Hydrogen sulphide	5	24 Hour	Health
		9	10 Minute	Odour
N/A	Total Reduced Sulphur (TRS) Compounds (Pulp, Paper and Paperboard Mills)	10	24 Hour	Health
		9	10 Minute	Odour
	Total Reduced Sulphur (TRS) Compounds (other facilities)	5	24 Hour	Health
		9	10 Minute	Odour

Table A-2: RSC and Naphthalene Concentrations (ppb) at WBEA Sites (2012).

Compound	N	Frequency of Detection	Max.	Mean	Std. Dev.
AMS6					
Naphthalene	60	7%	4.5	0.12	0.60
Hydrogen sulphide	60	10%	1.0	0.50	0.11
Carbonyl sulphide	60	90%	2.0	0.72	0.41
Methyl mercaptan	60	2%	0.6	0.50	0.01
Carbon disulphide	60	18%	2.0	0.47	0.24
AMS7					
Naphthalene	61	3%	0.3	0.02	0.04
Hydrogen sulphide	61	11%	0.6	0.48	0.08
Carbonyl sulphide	61	80%	2.0	0.72	0.39
Methyl mercaptan	61	0%			
Carbon disulphide	61	11%	0.5	0.48	0.08
AMS9					
Naphthalene	59	5%	0.6	0.03	0.09
Hydrogen sulphide	59	14%	1.0	0.48	0.13
Carbonyl sulphide	59	81%	2.0	0.67	0.41
Methyl mercaptan	59	0%			
Carbon disulphide	59	8%	0.5	0.47	0.10
AMS12					
Naphthalene	56	5%	1.5	0.06	0.23
Hydrogen sulphide	56	11%	1.0	0.50	0.09
Carbonyl sulphide	56	89%	2.0	0.66	0.34
Methyl mercaptan	56	0%			
Carbon disulphide	56	11%	0.5	0.46	0.11
AMS13					
Naphthalene	61	5%	0.7	0.04	0.11
Hydrogen sulphide	61	8%	0.5	0.48	0.08
Carbonyl sulphide	61	80%	2.0	0.62	0.28
Methyl mercaptan	61	0%			
Carbon disulphide	61	5%	2.0	0.52	0.20
AMS14					
Naphthalene	60	2%	1.9	0.05	0.24
Hydrogen sulphide	60	3%	0.5	0.50	0.03
Carbonyl sulphide	60	78%	1.0	0.59	0.20
Methyl mercaptan	60	0%			
Carbon disulphide	60	3%	0.5	0.49	0.05
AMS15					
Naphthalene	55	11%	2.0	0.09	0.31
Hydrogen sulphide	55	15%	7.0	0.61	0.88
Carbonyl sulphide	55	93%	8.0	1.02	1.10
Methyl mercaptan	55	0%			
Carbon disulphide	55	25%	3.0	0.48	0.39

Appendix B

Table B-1: Data Integration for Hours with TRS Concentrations equal to or greater than 3 ppb and/or Dates with an Odour Complaint at Fort McKay Bertha Ganter.

DATE	HOUR	Complaint	TRS (ppb)	NMHC (ppb)	SO_2 (ppb)	ODOCHECK	ODOCHECK DELTA	PENTANE (ppbC)	COS (ppb)	3-methylThiophene (ppb)	AVG Wind Direction	Wind STD. DEV.	AVG Wind Speed (km/h)
1/2/12	13		3		6						S	17.0	10.1
1/5/12	2		3								S	9.2	5.6
1/7/12	14		3		2						S	7.9	7.4
1/7/12	15		3		3						S	7.6	7.2
1/7/12	16		4		2						S	6.9	7.3
1/7/12	17		4		1						S	7.9	7.4
1/7/12	18		4		1						S	9.6	6.9
1/7/12	19		3		2						S	15.3	6.4
1/7/12	22		3		4						SSW	10.0	3.7
1/7/12	23		3		10						SSW	9.0	3.7
1/7/12	24		4		5						SSW	11.7	4.8
1/8/12	1		3		3						SSW	10.0	5.2
1/12/12	14		3		1						S	7.4	5.8
1/12/12	15		4		2						S	6.4	5.6
1/12/12	16		4		2						S	7.3	5.8
1/12/12	17		3		1						S	8.8	5.6
1/12/12	22		3		1						S	3.4	5.3
1/12/12	23		3		1						S	5.8	5.6
1/24/12	17		3		0	1.8	0				S	13.6	4.2
1/25/12	18		3		2	1.8	0						
1/31/12	16		3		14	1.8	0				E	50.5	3.0
1/31/12	17		3		4	1.8	0				ESE	32.2	3.1
2/1/12	5		3		1	1.8	0			0.01	SSW	9.9	3.6
2/1/12	6		3		1	1.8	0				SSW	8.7	4.1
2/1/12	8		3		1	1.8	0			0.02	S	8.8	4.8
2/1/12	10		4		3	1.9	0				S	10.8	5.3
2/1/12	11		4		2	1.9	0			0.03	S	11.4	5.6
2/1/12	12		4		2	1.8	0				S	10.5	5.8

DATE	HOUR	Complaint	TRS (ppb)	NMHC (ppb)	SO_2 (ppb)	ODOCHECK	ODOCHECK DELTA	PENTANE (ppbC)	COS (ppb)	3-methylThiophene (ppb)	AVG Wind Direction	Wind STD. DEV.	AVG Wind Speed (km/h)
2/1/12	13		3		3	1.8	0			0.01	S	4.2	6.3
2/1/12	14		3		3	1.8	0				S	4.5	6.8
2/1/12	15		3		2	1.8	0			0.12	S	4.2	7.0
2/1/12	16		3		2	1.8	0			0.13	S	4.6	7.2
2/2/12	9		3		1	1.9	0			0.13	S	7.9	5.1
2/2/12	10	X	3		1	1.9	0				S	7.8	5.4
2/2/12	11		3		1	1.9	0			0.25	S	8.2	5.6
2/2/12	15		3		5	1.8	0				S	4.2	8.3
2/3/12	15		4		3	1.8	0			0.05	S	6.0	7.6
2/3/12	16		3		2	1.8	0				S	5.9	8.4
2/3/12	18		3		1	1.8	0				S	4.2	8.7
2/3/12	19		4		0	1.8	0			0.22	S	3.9	8.7
2/3/12	20		3		0	2.5	0			0.21	S	4.1	8.3
2/3/12	21		3		1	2.2	0				S	4.1	7.7
2/3/12	22		3		1	1.9	0			0.28	S	4.8	7.6
2/3/12	23		3		1	1.8	0				S	4.7	7.1
2/3/12	24		3		1	1.8	0			0.14	S	5.0	6.9
2/4/12	1		3		1	1.8	0			0.25	S	5.0	6.5
2/4/12	2		3			1.8	0				S	2.9	6.9
2/4/12	4		4		1	1.8	0				S	3.9	6.4
2/4/12	5		3		1	2.5	0			0.25	S	3.9	6.8
2/4/12	6		4		1	2.1	0			0.45	S	4.4	6.3
2/4/12	7		3		1	1.9	0				S	4.9	5.8
2/4/12	12		4		3	1.8	0				S	7.2	6.2
2/4/12	13		4		4	1.8	0			0.39	S	7.4	7.2
2/4/12	14		3		4	1.8	0				S	7.3	7.8
2/14/12	9	X	1		0	2.5	0				SW	47.0	2.2
2/17/12	21		5		2	1.8	0				S	9.5	6.6
2/17/12	22		3		1	1.8	0				S	7.8	6.2
2/17/12	23		3		1	1.8	0				S	6.3	5.3
2/28/12	13	X	1		8						S	15.1	6.1
2/28/12	22		3		1						S	3.0	8.2
2/28/12	23		3		1						S	4.6	7.7
2/28/12	24		3		0						S	9.0	6.8
3/23/12	15	X	0	0	1	5.6	0				NNE	6.5	7.5

DATE	HOUR	Complaint	TRS (ppb)	NMHC (ppb)	SO_2 (ppb)	ODOCHECK	ODOCHECK DELTA	PENTANE (ppbC)	COS (ppb)	3-methylThiophene (ppb)	AVG Wind Direction	Wind STD. DEV.	AVG Wind Speed (km/h)
3/29/12	8	X	1	0	1	5.4	0				SSE	3.8	11.5
4/3/12	14	X	1	0	2	5.6	0				SSE	11.5	8.5
4/18/12	8	X	1	0.2	1			0.67	0.32		W	95.3	2.4
4/19/12	9	X		0				0.01	0.27		SW	65.4	2.7
5/2/12	9	X	1	0.1	4						WSW	67.7	3.4
5/8/12	14	X	0	0	1						SSE	4.3	8.9
5/8/12	15	X	0	0	4						SSE	17.1	9.7
6/17/12	9		3	0.2	1	116.1	1				SSE	3.6	8.9
6/27/12	17	X	0	0	0	142.9	3		0.02		NNW	35.4	7.7
7/3/12	9	X	2	0.5	4	99.8	1				S	25.9	5.1
7/9/12	4		5	0.3	0	130.3	2				S	68.8	5.1
7/9/12	7		3	0.4	0	130.9	1				SSW	64.2	4.4
7/9/12	8		6	0.6	1	131.8	3				SSW	64.3	5.1
7/9/12	9		3	0.6	2	140.6	2				S	41.0	6.2
7/10/12	6		3	0.6	1	105.7	4				W	58.2	3.0
7/10/12	7		8	1.1	2	104.2	3				SW	58.3	2.9
7/10/12	8	X	4	0.8	2	108.0	1				SSW	41.8	3.1
7/10/12	11		3		4	132.8	18				S	23.4	4.7
7/14/12	9		6	0.4	4	36.2	0				SW	54.7	3.8
7/14/12	10		6	0.3	8	40.1	2				SSW	50.6	4.8
7/14/12	11		4	0.4	12	41.8	1				S	44.1	5.6
7/16/12	24		3	0.3	0	44.1	1				S	9.2	5.5
7/17/12	4		8	0.4	1	57.3	3				S	7.9	4.0
7/17/12	5		7	0.4	1	61.5	1				S	8.4	4.0
7/17/12	6		5	0.3	1	61.8	2				S	8.3	4.1
7/17/12	7		5	0.3	0	59.6	0				S	9.2	5.3
7/17/12	8		3	0.2	4	59.7	0				S	9.5	6.4
7/18/12	6		3	0.1	1	58.9	0				SE	88.7	2.3
7/18/12	8		4	0.2	0	57.2	3				SSW	71.6	2.5
7/21/12	8		4	0.5	1	50.7	0				WSW	42.8	1.9
7/21/12	9		3	0.2	1	55.8	1				SW	49.7	2.4
7/21/12	10		4	0.2	8	56.2	2				SSW	44.9	3.2
7/21/12	11		3	0.2	7	52.5	0				S	38.0	4.1
7/21/12	15		4	0.3	8	47.2	1				S	10.3	8.1
7/22/12	7		4	0.5	1	53.0	4				SSW	38.4	3.2

DATE	HOUR	Complaint	TRS (ppb)	NMHC (ppb)	SO_2 (ppb)	ODOCHECK	ODOCHECK DELTA	PENTANE (ppbC)	COS (ppb)	3-methylThiophene (ppb)	AVG Wind Direction	Wind STD. DEV.	AVG Wind Speed (km/h)
7/22/12	8		6	0.6	0	59.3	2				SSW	37.0	3.9
7/22/12	9		6	0.5	1	67.5	3				SSW	40.0	4.6
7/22/12	10		7	0.5	2	70.0	2				S	43.0	5.3
7/29/12	16		3	0.2	9	43.3	0				S	19.0	5.6
8/2/12	8	X	0	0.1	0	41.2	0				NW	5.8	3.6
8/2/12	12	X	0	0	0	37.6	0				NNW	17.0	4.3
8/2/12	14		9	0	4	37.0	0				NNW	17.3	4.3
8/2/12	15	X	87	0.1	70	73.4	19				NNW	22.4	4.6
8/2/12	16		6	0	7	51.1	3				NNW	23.4	5.0
8/2/12	17		3	0	4	69.4	9				NNW	49.3	4.7
8/3/12	9		3	0.5	2	49.6	2				W	42.8	3.2
8/3/12	10		3	0.3	4	53.1	2				WSW	48.0	3.5
8/3/12	23		4	0.3	0	45.5	4				S	14.9	5.1
8/4/12	1		3	0.2	0	40.1	1				S	2.9	6.0
8/4/12	2		4			41.8	1				S	4.5	6.5
8/13/12	8		3	0.3		33.1	1				WSW	23.3	2.5
8/13/12	9		3	0.2		42.3	2				WSW	43.0	3.3
8/18/12	9		4	0.3	1	40.9	6				SW	55.9	2.7
8/18/12	10		4	0.3	3	33.6	1				SSW	53.4	3.4
8/19/12	4		3	0.3	1	39.6	0				S	10.5	6.7
8/19/12	5		3	0.3	1	38.5	0				S	17.4	6.3
8/19/12	6		3	0.3	0	37.2	0				S	21.1	6.1
8/19/12	7		3	0.3	1	36.4	0				SSW	17.2	5.6
8/27/12	4		3	0.5	1	37.6	1	0.02			S	29.2	3.7
8/28/12	13	X	0	0	0	31.8	0				S	12.9	7.2
9/6/12	9		3	0.1	1	36.0	1			0.01	SSW	26.6	3.0
9/14/12	5		3	0.3	0	48.1	1	2.21		0.01	S	10.5	5.6
9/14/12	6		3	0.2	0	48.8	1	2.68			S	10.5	4.9
9/14/12	7		3	0.3	0	46.8	1	3.51			SSW	11.9	3.9
9/21/12	11		3	0.2	21	50.7	4				SSW	43.8	4.2
9/27/12	6		3	0.2	2	49.3	0				SSW	22.4	4.5
9/27/12	10		3	0.3	8	52.8	2	0.26			SSW	16.7	4.3
9/27/12	11		3	0.2	12	64.3	5				SSW	19.5	4.9
9/28/12	11	X	1	0.3	4	76.8	1				SSE	11.1	4.7
10/7/12	1		4	0.1	8	43.3	1				SSE	4.2	7.1

DATE	HOUR	Complaint	TRS (ppb)	NMHC (ppb)	SO_2 (ppb)	ODOCHECK	ODOCHECK DELTA	PENTANE (ppbC)	COS (ppb)	3-methylThiophene (ppb)	AVG Wind Direction	Wind STD. DEV.	AVG Wind Speed (km/h)
10/11/12	21	X	0	0	1	36.7	0	0.67					
10/13/12	16	X	1	0.3	1	41.9	1	2.15			SSE	22.1	3.6
11/27/12	14		3	0.3	9						S	4.4	6.1
11/27/12	16		3	0.3	6						S	5.7	6.5
12/15/12	15		3	0.5		37.7	2	6.30			S	16.8	2.2
12/15/12	17		3	0.8		34.4	0	5.56			S	43.8	2.2
12/17/12	15	X	1	0	1			3.86			N	9.5	2.6
12/31/12	17		4	0.3	2	34.1	1				S	6.4	7.1
12/31/12	18		6	0.3	2	33.8	2	8.08			S	6.3	7.2
12/31/12	19		12	0.4	3	32.2	1	10.65			S	6.4	7.2
12/31/12	20		5	0.2	3	32.6	0	9.60			S	6.5	7.2
12/31/12	21		3	0.2	2	31.7	0	6.68			S	7.0	7.4

Table B-2: Data Integration for Hours with TRS Concentrations equal to or greater than 3 ppb and/or Dates with an Odour Complaint at Fort McMurray Patricia McInnes.

DATE	HOUR	Complaint	TRS (ppb)	NMHC (ppm)	SO_2 (ppb)	AVG Wind Direction	Wind STD. DEV.	AVG Wind Speed (km/h)	AVG WD AT 100 m (Lower Camp)	ODOUR TYPE	ODOUR LOCATION
1/9/12	16	X	0			SSW	18.2	5.5	SSE	Burning transmission oil	Fort McMurray Municipality(location not specified)
3/13/12	5	X	1	0.8	0	N	42.0	4.8	N	Gas/oil	Downtown Fort McMurray
3/13/12	10	X	1	0.3	18	NNW	11.7	9.6	N	Strong Hydrocarbon	Downtown Fort McMurray
5/24/12	9	X	1	0.3	10	WNW	43.0	2.9	NNW	Odour from oil and gas	Timberlea area, Fort McMurray
6/18/12	20	X	2	0.3	0	N	49.9	6.0	NNE	Sweet Crude	Timberlea
6/18/12	21	X	1	0.2	0	N	43.9	6.4	NNE	Hydrocarbon	Timberlea (4 complaints)
7/4/12	18	X	1	0.4	2	NNW	12.6	15.4	NNW	Very strong HC odour	Fort McMurray Hospital
7/10/12	17	X	1	0.1	0	SSE	40.7	11.5	S	Very strong odour	Driving Hwy 63S towards Fort McMurray
7/15/12	3	X		0.9	0	ENE	75.5	5.9	NE	Like a dump diluent into the tailing pond	Timberlea
7/15/12	4		5	1	0	NNE	75.6	5.3	NNE		
7/15/12	5		5	0.8	0	N	59.2	4.9	NNE		
7/15/12	6		7	0.8	1	NNW	28.9	5.3	NNE		
7/15/12	7		7	0.7	2	NNW	9.5	6.5	NNE		

DATE	HOUR	Complaint	TRS (ppb)	NMHC (ppm)	SO_2 (ppb)	AVG Wind Direction	Wind STD. DEV.	AVG Wind Speed (km/h)	AVG WD AT 100 m (Lower Camp)	ODOUR TYPE	ODOUR LOCATION
7/15/12	8		5	0.6	2	NNW	9.6	7.0	NNE		
7/15/12	9		5	0.7	3	NNW	5.8	8.1	NNE		
7/15/12	13		4	0.6	3	NNW	2.7	12.4	N		
7/15/12	14		4	0.5	5	NNW	2.0	13.8	N		
7/15/12	15		3	0.4	9	NNW	2.0	15.3	N		
7/16/12	7		4	0.7	1	NNW	2.1	9.1	N		
7/16/12	8		3	0.6	1	NNW	3.1	8.0	N		
7/23/12	8	X	3	0.7	0	WNW	47.6	2.5	NNW	Hydrocarbon	Fort McMurray
7/24/12	6	X	4	0.8	1	N	37.9	8.0	N	Very strong Hydrocarbon	On way from Fort McMurray to Fort McKay
7/24/12	11		4	0.8	1	NNW	75.0	7.7	NNE		
7/24/12	21	X	2	0.3	1	N	11.8	13.2	NNE	Bad smell from Plant	Timberlea, Fort McMurray
7/24/12	23		3	0.3	1	NNW	16.3	11.8	N		
7/25/12	7		3	0.5	0	NNW	13.3	9.8	N		
7/25/12	8		4	0.4	0	NNW	6.8	9.0	N		
7/25/12	9		3	0.3	1	NNW	3.9	8.1	N		
7/26/12	6		3	0.4	0	WNW	38.1	6.0	N		
7/26/12	10		3	0.5	2	NNW	6.1	9.5	N		
7/28/12	7	X	1	0.8	0	WNW	57.9	2.0	N	Very strong Sulphur smell	Timberlea, Fort McMurray
7/28/12	8		4	0.8	0	W	51.1	2.2	N		
7/28/12	9		6	0.9	0	W	51.8	3.2	N		
8/8/12	10	X	0	0.1	1	ESE	12.3	6.6	SE	Hydrocarbon	Fort McMurray
8/20/12	6		3	0.8	0	NW	17.9	5.9	N		
8/22/12	7	X	1		1	NW	8.7	6.2	N	Sulphur and Hydrocarbon	Fort McMurray
10/11/12	21	X	0	0.2	0	SSE	10.3	11.7	S	Smell like skunk	Fort McMurray (1), Fort McKay (1)
10/16/12	7	X	1	1.2	1	SSW	90.0	4.3	NNE	Hydrocarbon	Fort McMurray downtown
10/23/12	6	X	0	0.3	0	SSW	21.0	7.5	SSW	Ammonia, sour gas	Wood Buffalo Municipality, Fort McMurray
12/2/12	3	X		0.1	5	NNW	3.0	10.4	N	Very Strong gasoline smells	Downtown, Fort McMurray
12/7/12	10	X	0	0	0	ESE	15.0	4.0	SE	Smell of dead animal	Thickwood, Fort McMurray
12/24/12	10		6	0.2	5	NNW	19.2	5.0			
12/24/12	11		9	0.4	7	NNW	19.0	4.6			
12/24/12	12		9	0.6	2	NNW	24.7	4.1			

Table B-3: Data Integration for Hours with TRS Concentrations equal to or greater than 3 ppb and/or Dates with an Odour Complaint at Fort McMurray Athabasca Valley.

DATE	HOUR	Complaint	TRS (ppb)	NMHC (ppm)	SO_2 (ppb)	AVG Wind Direction (o)	Wind STD. DEV.	AVG Wind Speed (km/h)	AVG WD AT 100 m (Lower Camp)	ODOUR TYPE	ODOUR LOCATION
1/9/12	16	X	1		0	SE	5.5	6.5	SSE	Burning transmission oil	Fort McMurray Municipality(location not specified)
3/13/12	5	X	1	0.7	0	N	30.1	2.3	N	Gas/oil	Downtown Fort McMurray
3/13/12	10	X	1	0	3	NNW	5.4	7.7	N	Strong Hydrocarbon	Downtown Fort McMurray
5/24/12	9	X	1	0.4	0	ENE	43.5	2.5	NNW	Odour from oil and gas	Timberlea area, Fort McMurray
6/18/12	20	X	0	0.2	0	NNW	81.6	4.3	NNE	Sweet Crude	Timberlea
6/18/12	21	X	6	0.2	0	NW	63.9	4.7	NNE	Hydrocarbon	Timberlea (4 complaints)
6/18/12	22		3	0.2	0	NW	31.1	5.4	NNE		
7/4/12	18	X	1	0.3	1	NW	7.4	17.0	NNW	Very strong HC odour	Fort McMurray Hospital
7/4/12	20		3	0.3	0	NW	9.4	12.2	NNW		
7/15/12	3	X	0	0.3	0	E	35.5	3.5	NE	Like a dump diluent into the tailing pond	Timberlea
7/15/12	6		4	0.5	0	NE	27.2	2.7	NNE		
7/15/12	7		4	0.5	0	NNE	32.3	3.6	NNE		
7/15/12	10		6	0.4	2	NNW	23.0	8.2	NNE		
7/15/12	11		6	0.4	2	NNW	5.0	9.7	N		
7/15/12	12		4	0.3	5	NNW	6.8	10.5	N		
7/17/12	19		3	0.2	4	SSE	12.0	13.8	SSW		
7/23/12	8	X	0	0.2	0	ESE	24.8	2.3	NNW	Hydrocarbon	Fort McMurray
7/24/12	4		3			N	88.8	4.2	NNE		
7/24/12	6	X	9		1	NW	68.0	4.2	N	Very strong Hydrocarbon	On way from Fort McMurray to Fort McKay
7/24/12	7		8		1	NW	45.6	5.2	N		
7/24/12	8		6		0	NNW	57.7	5.1	N		
7/24/12	9		3		0	NNW	54.3	6.6	N		
7/24/12	21	X	1	0.4	0	N	23.1	7.4	NNE	Bad smell from Plant	Timberlea, Fort McMurray
7/25/12	4		3			NW	66.1	5.7	N		
7/28/12	7	X	1	0.4	0	E	33.0	1.9	N	Very strong Egg/Sulphur smell	Timberlea, Fort McMurray
8/8/12	10	X	0	0.2	0	SE	5.3	7.4	SE	Hydrocarbon	Fort McMurray
8/22/12	7	X	1		0	WSW	21.1	2.1	N	Sulphur and Hydrocarbon	Fort McMurray
9/1/12	10		4	0.3	1	NE	40.9	4.1	N		

DATE	HOUR	Complaint	TRS (ppb)	NMHC (ppm)	SO_2 (ppb)	AVG Wind Direction (o)	Wind STD. DEV.	AVG Wind Speed (km/h)	AVG WD AT 100 m (Lower Camp)	ODOUR TYPE	ODOUR LOCATION
9/1/12	13		3	0.3	0	N	16.2	7.1	N		
10/11/12	21	X	0	0	0	SSE	11.1	8.7	S	Smell like skunk	Fort McMurray (1), Fort McKay (1)
10/16/12	7	X	0	0.4	0	SE	59.9	3.1	NNE	Hydrocarbon	Fort McMurray downtown
10/23/12	6	X	0	0.1	0	SSE	23.8	5.4	SSW	Ammonia, sour gas	Wood Buffalo Municipality, Fort McMurray
12/2/12	3	X	1	0.2	1	NNW	1.7	10.0	N	Very Strong gasoline smells	Downtown, Fort McMurray
12/7/12	10	X	1			ENE	72.9	2.0	SE	Smell of dead animal	Thickwood, Fort McMurray
12/18/12	19		3	0.2	0	N	4.6	7.2			
12/18/12	24		3	0.2	0	N	17.9	4.6			
12/19/12	1		3	0.1	0	N	18.1	3.9			
12/19/12	2		3		0	N	21.0	3.0			
12/24/12	12		3	0.2	1	W	44.6	3.2			
12/24/12	13		5	0	1	WSW	34.1	3.2			
12/24/12	14		4	0.1	1	WSW	17.7	3.3			
12/24/12	15		4	0.2	1	WSW	17.2	3.4			
12/24/12	16		4	0.1	2	WSW	15.9	3.3	NNW		
12/24/12	17		3	0.1	2	WSW	16.8	3.6	NNW		
12/24/12	18		3	0.1	2	WSW	13.8	3.4	NNW		

Table B-4: Data Integration for Hours with TRS Concentrations equal to or greater than 3 ppb and/or Dates with an Odour Complaint at Anzac.

DATE	HOUR	Complaint	TRS (ppb)	NMHC (ppm)	SO_2 (ppb)	AVG Wind Direction	Wind STD. DEV.	AVG Wind Speed (km/h)	AVG WD AT 100 m (Lower Camp)	ODOUR TYPE	ODOUR LOCATION
1/21/12	8		4		0				SSE		
1/31/12	19	X	1		0	SW	85	3	NNW	H_2S or Sulphur smell	Nexen /Long Lake project
2/4/12	6		11		0	SW	26	6	SSE		
2/4/12	7		14		1	SSW	28	6	SSE		
2/4/12	8		3		0	SSW	22	6	SSE		
5/2/12	7		6	0.7	0	SSE	8	7	SE		
5/2/12	8		3	0.2	0	SSE	9	6	SE		
9/16/12	12	X	0	0	0	W	12	4	S	Very bad odour	Driving thru the Hwy 881 and go thru Janvier landfill
10/28/12	10		3	0.1	7	SE	11	11	SE		

DATE	HOUR	TRS (ppb)	NMHC (ppm)	SO_2 (ppb)	AVG Wind Direction	Wind STD. DEV.	AVG Wind Speed (km/h)	AVG WD AT 100 m (Lower Camp)	ODOUR TYPE	ODOUR LOCATION
10/28/12	11	3	0.1	15	SE	12	12	SE		
10/28/12	17	3	0	14	SE	4	19	SE		
10/28/12	19	4	0	1	SE	9	18	SE		
10/28/12	20	7	0.1	0	SE	9	17	SE		
10/28/12	21	7	0.1	0	SE	8	15	SSE		
11/1/12	8	3	0.1	3	SSE	3	14	SE		
12/17/12	10	3	0	1	NE	11	5	SSE		
12/17/12	12	3	0	3	NNE	11	6	SSE		
12/24/12	15	3	0.1	11	S	15	3			
12/24/12	16	3	0.1	17	S	14	4	NNW		
12/24/12	17	3	0.1	13	SSW	12	4	NNW		
12/28/12	15	5		1	NE	16	3	S		
12/28/12	16	4		1	NNE	21	3	S		
12/28/12	17	5	0.2	1	NNE	20	3	SSE		
12/28/12	18	5	0.2	1	NNE	14	3	SSE		
12/28/12	19	3	0	1	NNE	15	3	SSE		
12/28/12	21	3	0.1	1	NNE	14	2	SSE		
12/28/12	22	4	0.2	1	NNE	8	2	SSE		
12/29/12	6	4	0.1	0	ENE	10	2	SSE		
12/30/12	16	4	0	1	NE	16	6	SSE		
12/30/12	17	3	0	0	NE	13	6	SSE		
12/30/12	19	3	0	0	NNE	5	7	SSE		
12/31/12	4	4	0	0	ENE	11	5	S		
12/31/12	5	3	0	0	ENE	11	5	S		
12/31/12	17	3	0	0				SSE		
12/31/12	18	4	0	0				SSE		
12/31/12	19	6	0	0				SSE		
12/31/12	20	8	0	0	NNE	29	2	SSE		
12/31/12	21	4	0	1	NNE	55	3	SSE		

Appendix C:

Table C-1: Correlation between TRS, SO_2, NMHC and OdoCheck with All Other Parameters Measured at Fort McKay Bertha Ganter for all Hours – 2012.

Parameter 1	Parameter 2	CORR. COEFF.	N
TRS	SO2	0.260	7724
TRS	THC	0.313	7632
TRS	CH4	0.188	6393
TRS	NMHC	0.285	6393
TRS	ODOCHECK_DELTA	0.086	4104
TRS	ODOCHECK	0.063	4124
TRS	Peak0805.6	0.336	1941
TRS	Peak0875-L	0.381	1878
TRS	Peak0930-L	0.409	1899
TRS	Peak1044.4	-0.003	1783
TRS	Peak1104.1	0.342	1780
TRS	Isoprene	0.080	1707
TRS	Peak1192.5	-0.023	1681
TRS	2MeButane	0.284	2102
TRS	3MeButane	0.154	1945
TRS	nPentane	0.210	2095
TRS	Thio-S	0.013	1671
TRS	Peak1364.1	-0.028	1892
TRS	Benzene	0.231	1967
TRS	Peak1434.6	0.096	1607
TRS	Peak1468.9	0.177	1893
TRS	2MePentane	0.305	1998
TRS	3MePentane	0.197	1872
TRS	nHexane	0.418	1970
TRS	Peak1721.3	0.122	1827
TRS	Toluene	0.397	1964
TRS	24dMPentane	0.314	1947
TRS	2&3MHexane&McHexane	0.384	1966
TRS	Heptane	0.333	1916
TRS	224dMPentane	0.055	177
TRS	EthylBenzene	0.136	161
TRS	Peak2624-5	0.071	165
TRS	pXylene	0.337	176
TRS	oXylene	0.338	180
TRS	mX&MHeptane	0.340	180
TRS	Octane	0.292	179
TRS	Peak3408-S	-0.092	175
TRS	COS	0.161	600
TRS	CS2	0.206	68
TRS	2-MethylThiophene	0.384	87

Parameter 1	Parameter 2	CORR. COEFF.	N
TRS	3-MethylThiophene	0.650	111
TRS	2-EthylThiophene	0.285	11
TRS	2,5-diMethyThiophene	0.628	14
TRS	2,4-diMethylThiophene.	-0.053	11
TRS	WIND_SPEED	-0.041	8127
TRS	TEMPERATURE	0.015	8175
TRS	REL_HUMID	0.050	8175
SO2	THC	0.053	7607
SO2	CH4	0.034	6375
SO2	NMHC	0.088	6375
SO2	ODOCHECK_DELTA	0.036	3874
SO2	ODOCHECK	0.115	3890
SO2	Peak0805.6	0.073	1867
SO2	Peak0875-L	0.059	1807
SO2	Peak0930-L	0.057	1826
SO2	Peak1044.4	-0.006	1713
SO2	Peak1104.1	0.113	1709
SO2	Isoprene	0.085	1639
SO2	Peak1192.5	-0.003	1614
SO2	2MeButane	0.030	2023
SO2	3MeButane	0.025	1868
SO2	nPentane	0.029	2017
SO2	Thio-S	0.034	1605
SO2	Peak1364.1	-0.020	1818
SO2	Benzene	0.075	1891
SO2	Peak1434.6	0.079	1541
SO2	Peak1468.9	0.033	1818
SO2	2MePentane	0.103	1922
SO2	3MePentane	0.065	1801
SO2	nHexane	0.171	1897
SO2	Peak1721.3	0.057	1754
SO2	Toluene	0.165	1890
SO2	24dMPentane	0.130	1872
SO2	2&3MHexane&McHexane	0.157	1891
SO2	Heptane	0.194	1842
SO2	224dMPentane	0.115	169
SO2	EthylBenzene	-0.083	153
SO2	Peak2624-5	-0.038	158
SO2	pXylene	-0.064	168
SO2	oXylene	-0.063	172
SO2	mX&MHeptane	-0.058	172
SO2	Octane	-0.039	171
SO2	Peak3408-S	-0.079	167
SO2	COS	0.075	575
SO2	CS2	0.379	63
SO2	2-MethylThiophene	-0.075	84
SO2	3-MethylThiophene	0.145	106
SO2	2-EthylThiophene	0.327	11

Parameter 1	Parameter 2	CORR. COEFF.	N
SO2	3-MethylThiophene	0.145	106
SO2	2-EthylThiophene	0.327	11
SO2	2,5-diMethyThiophene	-0.271	14
SO2	2,4-diMethylThiophene.	0.426	11
SO2	WIND_SPEED	0.112	7675
SO2	TEMPERATURE	0.114	7723
SO2	REL_HUMID	-0.177	7723
NMHC	ODOCHECK_DELTA	0.058	3844
NMHC	ODOCHECK	0.085	3859
NMHC	Peak0805.6	0.231	1862
NMHC	Peak0875-L	0.306	1803
NMHC	Peak0930-L	0.365	1821
NMHC	Peak1044.4	0.034	1709
NMHC	Peak1104.1	0.471	1703
NMHC	Isoprene	0.183	1634
NMHC	Peak1192.5	0.003	1610
NMHC	2MeButane	0.517	2013
NMHC	3MeButane	0.372	1859
NMHC	nPentane	0.460	2011
NMHC	Thio-S	0.059	1601
NMHC	Peak1364.1	-0.016	1813
NMHC	Benzene	0.228	1885
NMHC	Peak1434.6	0.111	1532
NMHC	Peak1468.9	0.400	1812
NMHC	2MePentane	0.545	1915
NMHC	3MePentane	0.473	1794
NMHC	nHexane	0.526	1892
NMHC	Peak1721.3	0.168	1748
NMHC	Toluene	0.388	1885
NMHC	24dMPentane	0.351	1867
NMHC	2&3MHexane&McHexane	0.377	1885
NMHC	Heptane	0.317	1839
NMHC	224dMPentane	0.321	171
NMHC	EthylBenzene	0.496	155
NMHC	Peak2624-5	0.231	159
NMHC	pXylene	0.626	170
NMHC	oXylene	0.773	174
NMHC	mX&MHeptane	0.759	174
NMHC	Octane	0.715	173
NMHC	Peak3408-S	0.022	169
NMHC	COS	0.018	568
NMHC	CS2	0.159	63
NMHC	2-MethylThiophene	-0.225	32
NMHC	3-MethylThiophene	-0.596	10
NMHC	2-EthylThiophene	-0.265	11
NMHC	2,5-diMethyThiophene	0.316	14
NMHC	2,4-diMethylThiophene.	-0.294	11
NMHC	WIND_SPEED	-0.194	6356

Parameter 1	Parameter 2	CORR. COEFF.	N
NMHC	TEMPERATURE	0.052	6393
NMHC	REL_HUMID	0.104	6393
ODOCHECK_DELTA	ODOCHECK	0.294	4104
ODOCHECK_DELTA	Peak0805.6	0.040	1305
ODOCHECK_DELTA	Peak0875-L	0.057	1278
ODOCHECK_DELTA	Peak0930-L	0.065	1281
ODOCHECK_DELTA	Peak1044.4	-0.008	1235
ODOCHECK_DELTA	Peak1104.1	0.047	1219
ODOCHECK_DELTA	Isoprene	-0.037	1168
ODOCHECK_DELTA	Peak1192.5	-0.020	1122
ODOCHECK_DELTA	2MeButane	0.054	1302
ODOCHECK_DELTA	3MeButane	0.049	1234
ODOCHECK_DELTA	nPentane	0.036	1298
ODOCHECK_DELTA	Thio-S	0.085	1129
ODOCHECK_DELTA	Peak1364.1	0.048	1293
ODOCHECK_DELTA	Benzene	0.124	1330
ODOCHECK_DELTA	Peak1434.6	0.032	1137
ODOCHECK_DELTA	Peak1468.9	0.067	1291
ODOCHECK_DELTA	2MePentane	0.048	1328
ODOCHECK_DELTA	3MePentane	0.047	1255
ODOCHECK_DELTA	nHexane	0.065	1342
ODOCHECK_DELTA	Peak1721.3	0.014	1267
ODOCHECK_DELTA	Toluene	0.057	1335
ODOCHECK_DELTA	24dMPentane	0.036	1338
ODOCHECK_DELTA	2&3MHexane&McHexane	0.040	1346
ODOCHECK_DELTA	Heptane	0.032	1307
ODOCHECK_DELTA	224dMPentane	-0.013	76
ODOCHECK_DELTA	EthylBenzene	0.136	69
ODOCHECK_DELTA	Peak2624-5	0.108	73
ODOCHECK_DELTA	pXylene	0.121	76
ODOCHECK_DELTA	oXylene	0.122	78
ODOCHECK_DELTA	mX&MHeptane	0.151	78
ODOCHECK_DELTA	Octane	0.099	77
ODOCHECK_DELTA	Peak3408-S	-0.084	77
ODOCHECK_DELTA	COS	0.063	302
ODOCHECK_DELTA	2-MethylThiophene	-0.086	28
ODOCHECK_DELTA	2,5-diMethyThiophene	-0.424	13
ODOCHECK_DELTA	WIND_SPEED	-0.005	4092
ODOCHECK_DELTA	TEMPERATURE	0.139	4104
ODOCHECK_DELTA	REL_HUMID	-0.108	4104
ODOCHECK	Peak0805.6	-0.023	1316
ODOCHECK	Peak0875-L	0.052	1285
ODOCHECK	Peak0930-L	-0.064	1292
ODOCHECK	Peak1044.4	0.010	1246
ODOCHECK	Peak1104.1	0.033	1229
ODOCHECK	Isoprene	0.013	1173
ODOCHECK	Peak1192.5	-0.051	1133
ODOCHECK	2MeButane	0.141	1313

Parameter 1	Parameter 2	CORR. COEFF.	N
ODOCHECK	3MeButane	0.172	1242
ODOCHECK	nPentane	0.119	1309
ODOCHECK	Thio-S	0.098	1140
ODOCHECK	Peak1364.1	0.004	1303
ODOCHECK	Benzene	0.003	1341
ODOCHECK	Peak1434.6	0.188	1145
ODOCHECK	Peak1468.9	0.143	1302
ODOCHECK	2MePentane	0.120	1338
ODOCHECK	3MePentane	0.150	1263
ODOCHECK	nHexane	0.164	1352
ODOCHECK	Peak1721.3	0.127	1278
ODOCHECK	Toluene	0.037	1346
ODOCHECK	24dMPentane	0.067	1348
ODOCHECK	2&3MHexane&McHexane	0.003	1356
ODOCHECK	Heptane	0.019	1318
ODOCHECK	224dMPentane	-0.132	78
ODOCHECK	EthylBenzene	-0.162	71
ODOCHECK	Peak2624-5	-0.100	75
ODOCHECK	pXylene	-0.217	78
ODOCHECK	oXylene	-0.158	80
ODOCHECK	mX&MHeptane	-0.228	80
ODOCHECK	Octane	-0.132	79
ODOCHECK	Peak3408-S	0.047	79
ODOCHECK	COS	-0.009	302
ODOCHECK	2-MethylThiophene	-0.053	28
ODOCHECK	2,5-diMethyThiophene	-0.157	13
ODOCHECK	WIND_SPEED	0.014	4110
ODOCHECK	TEMPERATURE	0.353	4124
ODOCHECK	REL_HUMID	-0.201	4124