Air Quality Monitoring at Selected Communities in Southwestern Manitoba Near Petroleum Handling Facilities (Virden, Pierson, Waskada and Deloraine)

Report of Air Quality Monitoring Program
(June 2000 to July 2001)

Report No. 2002-01
March 2002

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Jim Prokopowich
Air Quality Section
Climate Change Branch

Manitoba Conservation

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Appreciation is expressed for the support in the collection of monitoring data provided by the Petroleum Branch of Manitoba Industry, Trade and Mines and the Western Region of Manitoba Conservation. In addition to financial assistance, the Petroleum Branch assisted with: selection of monitoring sites, provision of information regarding oil well and battery activity in the areas of interest, relocation of the monitoring stations and associated equipment set-up, biweekly on-site checks of instrument operation, monthly data collection and some on-site troubleshooting. Staff in the Western Region of Manitoba Conservation assisted with the relocation of stations and the corresponding equipment set-up.

Prokopowich, J.E., 2002. Air Quality Monitoring at Selected Communities in Southwestern Manitoba Near Petroleum Handling Facilities (Virden, Pierson, Waskada and Deloraine), Report of Air Quality Monitoring Program (June 2000 to July 2001), Manitoba Conservation, Air Quality Section Report No. 2002-01, pp. 33.

ABSTRACT

Manitoba Conservation along with the Petroleum Branch of Manitoba Industry, Trade and Mines monitored the ambient air for sulphur dioxide and hydrogen sulphide in selected areas of the oilfields of southwestern Manitoba. The monitoring was conducted during various time periods between June 2000 and July 2001 in Virden, Pierson, Waskada and Deloraine. The sulphur dioxide levels measured were largely undetectable and below Manitoba air quality objectives. Hydrogen sulphide was detected, on occasion, at all sites and most frequently at the Virden location. Virden was also the site with the only two exceedences of the Manitoba ambient air quality guideline of 11 parts per billion averaged over one hour.

Prokopowich, J.E., 2002. *Air Quality Monitoring at Selected Communities in Southwestern Manitoba Near Petroleum Handling Facilities* (Virden, Pierson, Waskada et Deloraine), Rapport du programme de surveillance de la qualité de l'air (de juin 2000 à juillet 2001), Conservation Manitoba, Rapport de la section sur la qualité de l'air, n^{o} 2002-01, p. 33.

RÉSUMÉ

Conservation Manitoba et la Direction des ressources pétrolières d'Industrie, Commerce et Mines Manitoba ont analysé la qualité de l'air ambiant sur des emplacements situés à proximité des champs pétrolifères du sud-ouest du Manitoba dans le but d'y détecter la présence d'anhydride sulfureux et d'hydrogène sulfuré. Les analyses ont été effectuées à divers moments entre juin 2000 et juillet 2001 à Virden, Pierson, Waskada et Deloraine. Les taux d'anhydride sulfureux relevés étaient quasi indétectables et étaient largement conformes aux objectifs afférents à la qualité de l'air du Manitoba. Par contre, on a, à certains moments, détecté la présence d'hydrogène sulfuré sur chacun des emplacements analysés, en particulier à Virden. C'est aussi à Virden qu'on a observé, à deux reprises, un dépassement de l'indice de qualité de l'air ambiant au Manitoba qui est de onze parties par milliard échelonnées sur une heure.

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INTRODUCTION

In response to health concerns raised by local residents about potential impacts of oilfield emissions on air quality, Manitoba Conservation conducted an air quality monitoring program in the area of Tilston, MB from July 1998 to June 2000. In this study sulphur dioxide was detected on only a few occasions at the two sites that were monitored. The levels detected were very low and well below the Manitoba Air Quality Objectives for this pollutant. Hydrogen sulphide was also detected at both sites, usually in the early hours of the day during calm conditions. On occasion the levels recorded did exceed the provincial guideline. The results of this study can be found in the TILSTON AIR QUALITY, FINAL REPORT ON THE AIR QUALITY MONITORING PROGRAM (July 1998 to June 20z00), VOLUME I. SUMMARY OF AMBIENT AIR QUALITY MONITORING PROGRAM and VOLUME II. AMBIENT AIR QUALITY DATA, AUGUST 10, 2000, Manitoba Conservation.

As a result of continuing interest in oilfield emissions, Manitoba Conservation along with the Petroleum Branch of Manitoba Industry, Trade and Mines decided to continue background air quality monitoring in the oilfield area of south-west Manitoba. In the first phase of this initiative, the two air monitoring stations previously located near Tilston, MB were relocated in June 2000 to Virden and Pierson. For the next phase the Pierson station was moved to Waskada in February 2001. In May 2001 the Waskada station was subsequently moved to Deloraine. Between these two moves, the Virden site was shut-down in early April 2001.

BACKGROUND

A.) Manitoba Air Quality Objectives and Guidelines

The Province of Manitoba has adopted National Ambient Air Quality Objectives for pollutants for which such objectives have been promulgated (includes sulphur dioxide). For other pollutants Air Quality Guidelines have been developed and adopted for provincial use (includes hydrogen sulphide).

The above criteria have been designed about three levels: the maximum tolerable level (MTL), the maximum acceptable level (MAL) and the maximum desirable level (MDL). The MAXIMUM TOLERABLE LEVEL is the time-based concentration of air contaminant beyond which, due to a diminishing margin of safety, appropriate action is required to protect the health of the general population. The MAXIMUM ACCEPTABLE LEVEL is the time-based concentration of air contaminant which is deemed essential to provide adequate protection for soils, water, vegetation, materials, animals, visibility, and personal comfort and well-being. The MAXIMUM DESIRABLE LEVEL is the long-term goal for air quality and provides a basis for an anti-degradation policy for the unpolluted parts of Manitoba and for the continuing development of control technology.

As in the Tilston study, only the MAXIMUM ACCEPTABLE LEVELS at the 1-hour and 24-hour average periods were of interest. For sulphur dioxide the relevant air quality objectives are 0.34 and 0.11 parts per million (ppm) respectively for the 1-hour and 24-hour average periods. For hydrogen sulphide there is only an air quality guideline for the 1-hour average of 11.0 parts per billion (ppb).

B.) Pollutants

Sulphur Dioxide

Sulphur dioxide (SO_2) is a colourless gas with a pungent irritating odour. It is emitted primarily from the combustion of fossil fuels containing sulphur and from primary non-ferrous smelting. It is usually recognized as one of the major atmospheric pollutants. Sulphur dioxide causes an increased frequency of respiratory disease symptoms and lung disease. It also causes marked effects on vegetation, corrodes materials, and may oxidize in the atmosphere to form sulphuric acid and sulphates. Sulphur dioxide is the major contributor to the formation of acid rain. Sulphur dioxide was continuously measured by the technique of pulsed fluorescence with unit data reported as hourly averages.

Hydrogen Sulphide

Hydrogen sulphide (H_2S) is a toxic foul smelling gas well-known for its rotten egg odour at very low concentrations. Hydrogen sulphide as an occasional air pollutant is almost always associated with some specific incident or industrial process. The concentration of hydrogen sulphide in the ambient air is rarely high enough to harm either vegetation or man. However, at high concentrations, it will produce loss of sense of smell, severe respiratory tract irritation and material damage such as the staining of lead based paints. For hydrogen sulphide the measurement technique was the same as for sulphur dioxide with the addition of a hydrogen sulphide converter containing a sulphur dioxide scrubber. Unit data was also reported as hourly averages.

C.) Monitoring Sites

Figures 1 through 4 show the location of four sites in the towns of Virden, Pierson, Waskada and Deloraine. The Virden site was on the east side of town (a little north-east of Queen St. and Second Ave.). The Pierson site was on the south side of town. The Waskada station was located in the centre of town just across the back lane behind the Department of Industry, Trade and Mines Petroleum Branch office, close to the corner of Railway Avenue and Provincial Highway 251. The Deloraine station was located in the northwest side of town at the end of Finlay Ave.

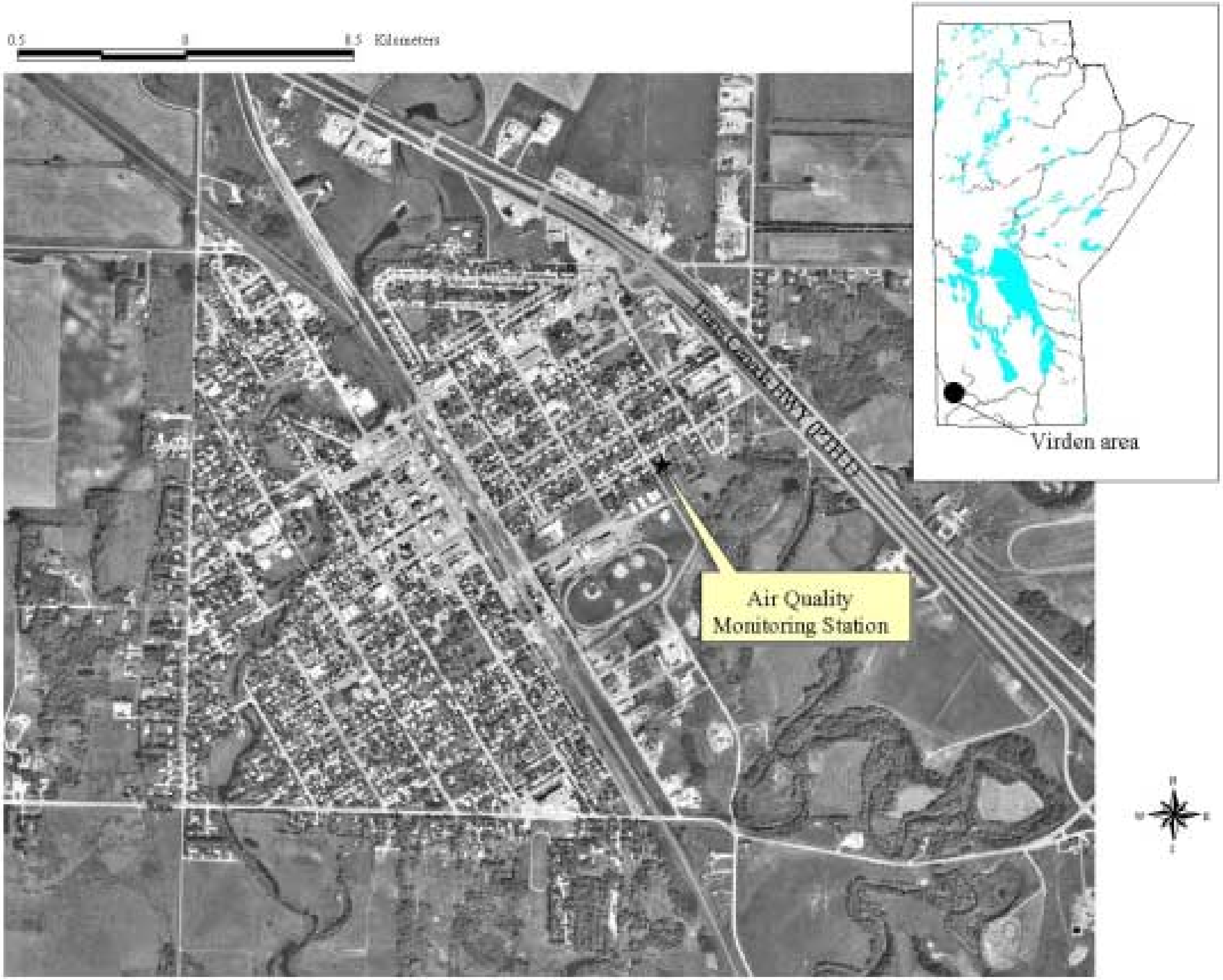

Figure 1. Virden Monitoring Station

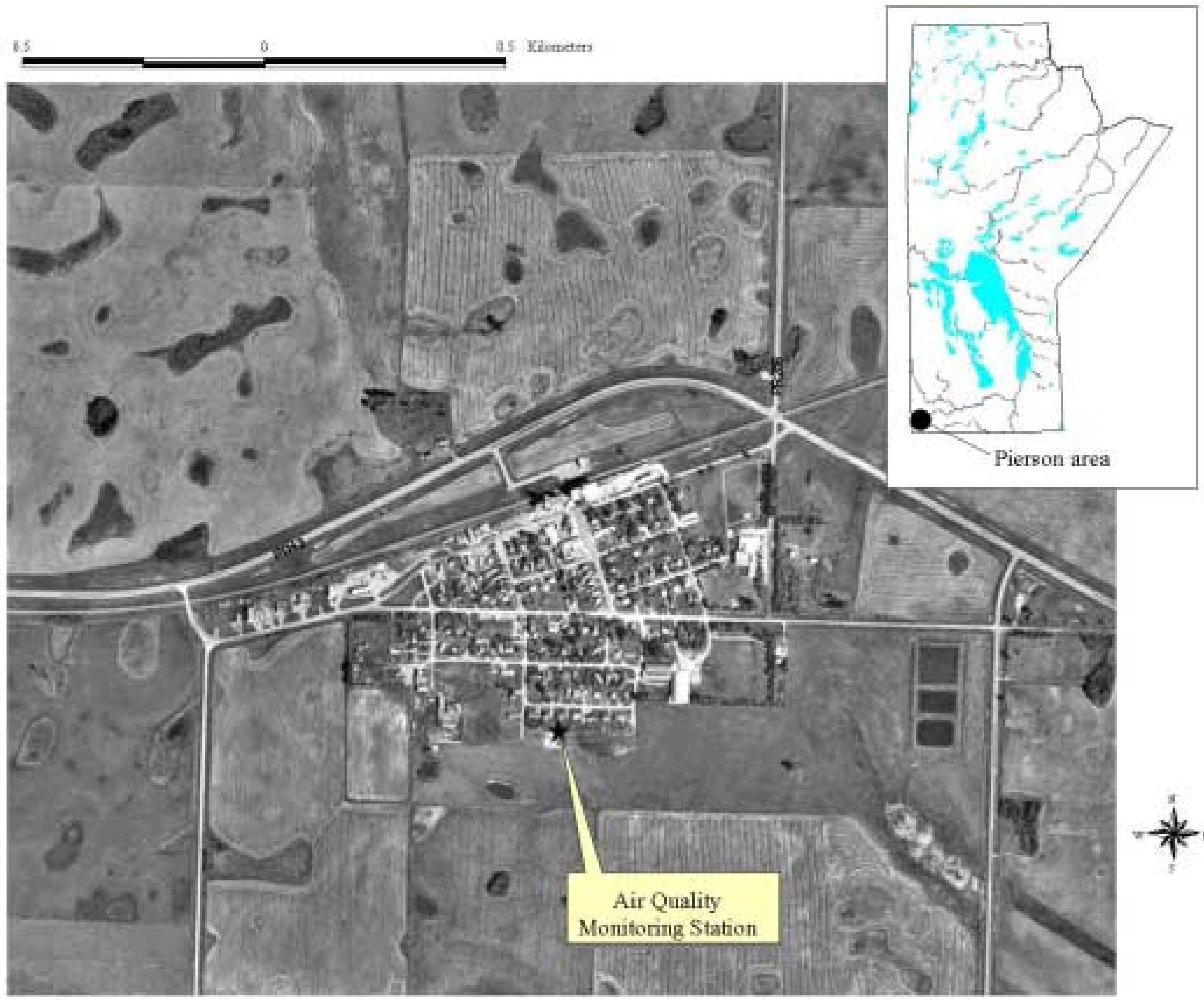

Figure 2. Pierson Monitoring Station

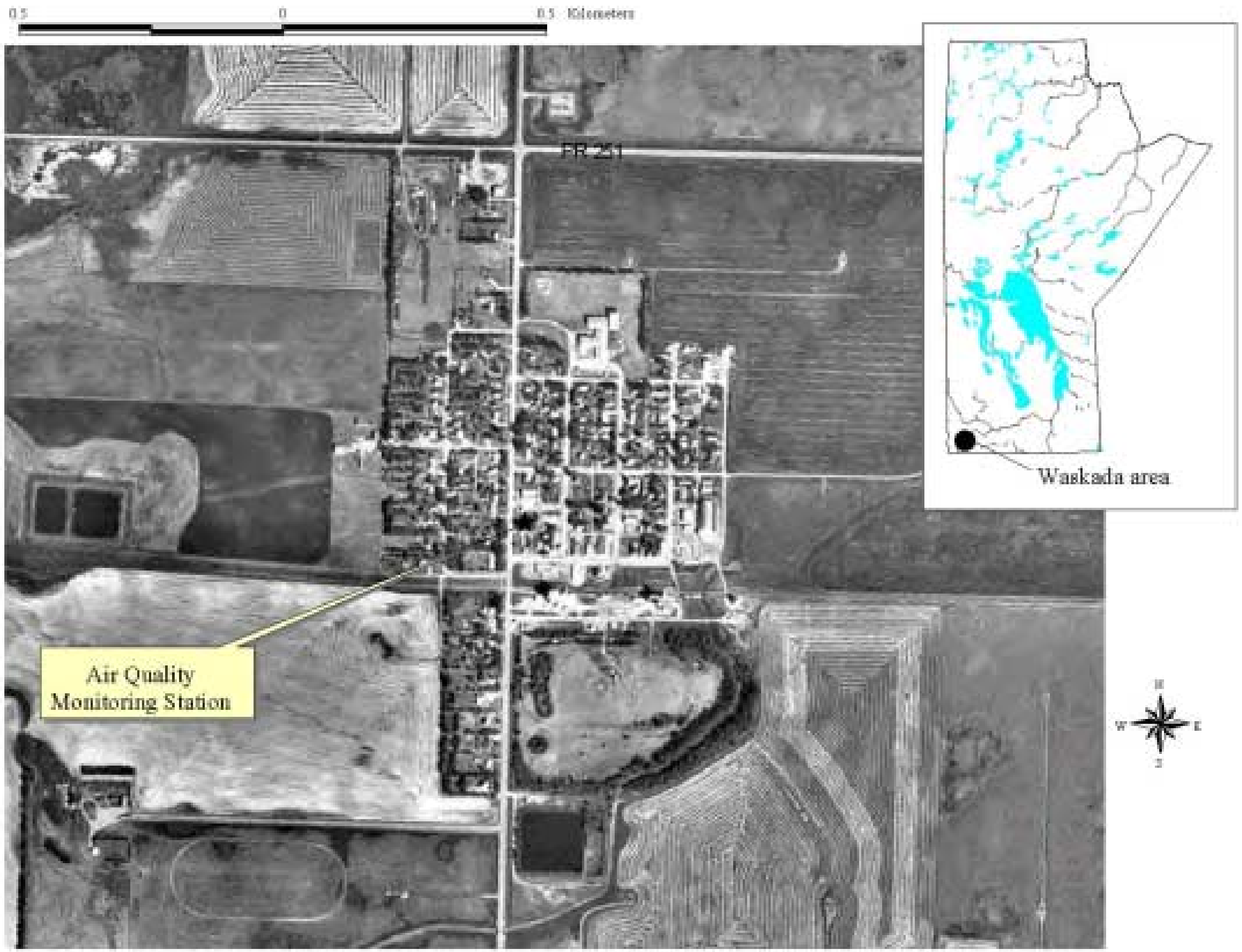

Figure 3. Waskada Monitoring Station

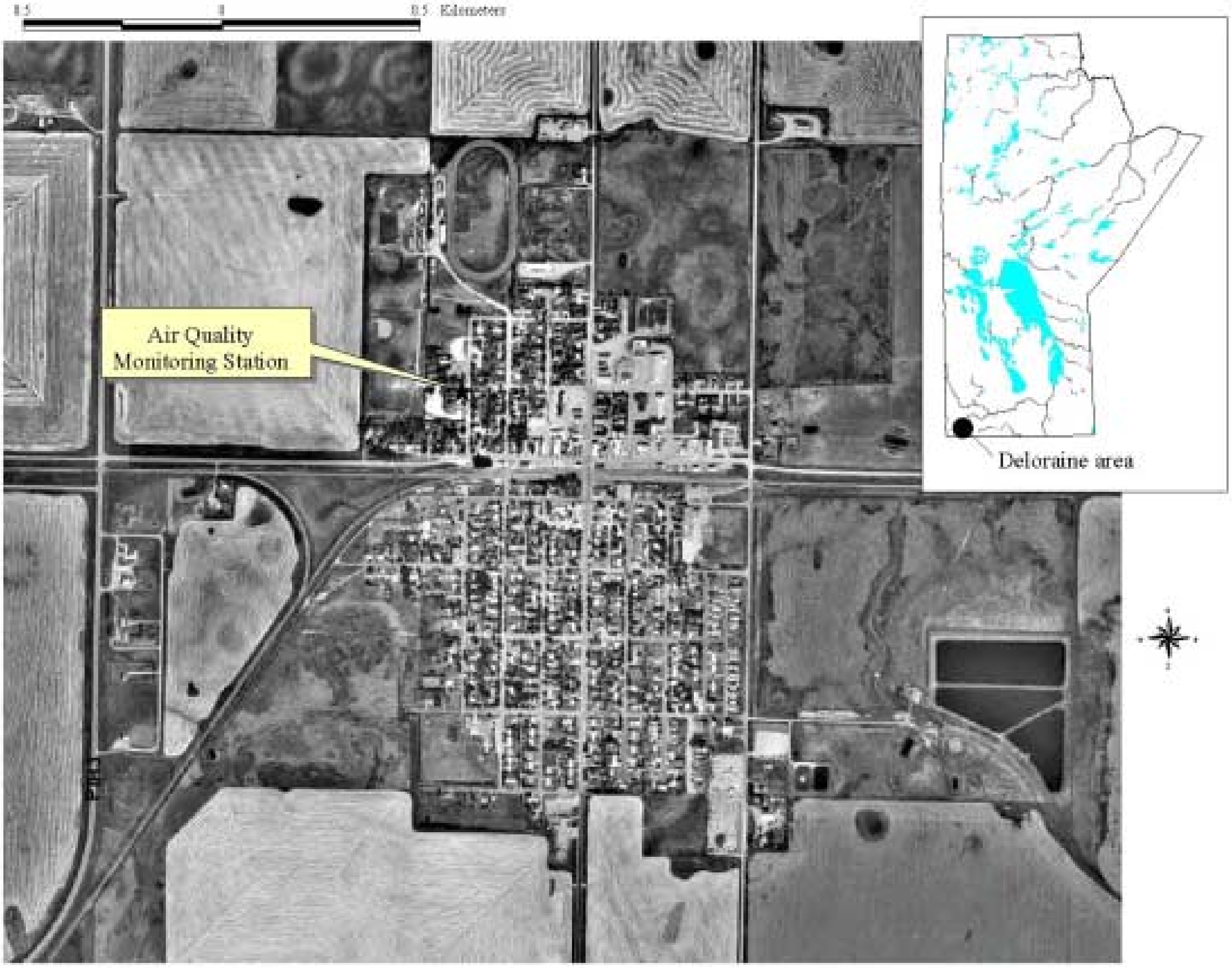

Figure 4. Deloraine Monitoring Station

D.) Sources

The only potential source of sulphur dioxide near the monitoring sites was determined to be oil batteries. For hydrogen sulphide the potential sources of hydrogen sulphide were oil batteries, sewage lagoons and possibly sloughs. Only oil batteries within approximately 5 km of a monitoring station were considered as potential sources for sulphur dioxide and hydrogen sulphide. At all four monitoring sites the closest potential source of hydrogen sulphide was always the town sewage lagoon. They were all within one km of the monitoring station. However, sewage lagoons typically release reduced sulphur compounds such as hydrogen sulphide mostly just after the spring ice break-up.

Virden

The sewage lagoon was located approximately 0.8 km south of the station. There were eleven oil batteries within 5 km of the monitoring station in operation at the time of the study. Six batteries were within approximately 2.0 km of the station. The closest of these was approximately 1.3 km NW of the station, two others were approximately 1.6 km NE and NW of the station, and the other three were approximately 2.0 km NW, SE and SW of the station. Two other batteries were approximately 2.5 km NNW and 3.1 km W of the station. The last three batteries were approximately 3.8 km SSE, 3.9 km SSW and 4.5 km SSW of the station.

Pierson

The sewage lagoon was located approximately 0.5 km E of the monitoring station. There were also two oil batteries within 5 km of the station. One was approximately 3.2 km SE and the other approximately 4.0 km NNE of the station.

Waskada

At this monitoring site the sewage lagoon was 0.5 km W of the station. There were also three oil batteries within approximately 5 km of the station. The closest of these were approximately 3.2 km NE and 3.2 km S of the station. The third oil battery was approximately 4.8 km S of the station.

Deloraine

The sewage lagoon was approximately 0.5 km E of the station. The one oil battery within 5 km of the station was approximately 3.5 km SW of the station.

E.) Equipment

Thermo Environmental Instruments sulphur dioxide analyzers were used for measuring sulphur dioxide and hydrogen sulphide. To measure sulphur dioxide, Teco models 43 and 43C were used. For daily zero/span calibrations the Teco 43 was used with an external Teco 145 permeator. The Teco 43C was equipped with its own internal calibration gas permeator.

Hydrogen sulphide was measured with Teco models 43C and 45C sulphur dioxide analyzers each equipped with an external Teco model 340 hydrogen sulphide converter with internal SO_X scrubber. The SO_X scrubber removes sulphur dioxide from the air prior to passing through the converter. In the converter, hydrogen sulphide is converted to sulphur dioxide for measurement by the instrument. Both the Teco 43C and 45C analyzers were equipped with an internal gas permeator for daily zero/span calibrations.

In addition to the daily zero/span calibrations there were also periodic multipoint calibrations of the sulphur dioxide and hydrogen sulphide analyzers. These primary calibrations were carried out using Bendix models 8861D (Dilution) and 8861P (Permeation) field transportable systems.

Two models of RM Young Wind Monitors were used for measuring wind direction and speed. The primary monitors were two high sensitivity Model 05305VK units. The lower sensitivity Model 05103-10A was a backup unit. It was only used when one of the primary wind monitors was down for repairs.

SumX Model SX-405 telemetry systems were used for remote data acquisition. The on-site units were also used to initiate a daily zero/span of the analyzers. Voltage recorders were a backup for the telemetry system. The recorder used was either a Rikadenki Model B-107 or the Yokogawa Model 4081.

F.) Procedures

The monitoring equipment at a station was put online as soon as it was set up, checked and calibrated. Multipoint calibration of gas analyzers occurred at initial installation, after any major repairs and whenever a potential problem was indicated by zero/span data collected by the telemetry system or during a site visit. Analyzers were usually routinely recalibrated every 3-4 months. Multipoint calibration of an analyzer would include a calibration check of its recorder. As a check of instrument operation a daily zero/span of the analyzers was initiated through the telemetry system.

Telemetry data collected from a site was examined daily. If a problem was indicated or if there were questions as to instrument operation, a field operator would be asked to visit the site. Aside from these special visits, the field operators would visit a site bi-weekly as a matter of routine operation. At month end, they would send in the recorder strip charts.

On a monthly basis the recorder data sent in to Winnipeg would be audited along with the corresponding telemetry data. The data would then be edited and analyzed and the results summarized in tables.

G.) Monitoring Activities

The air quality-monitoring program was started: June 7, 2000 in Virden, MB; June 21, 2000 in Pierson, MB; February 8, 2001 in Waskada, MB; May 2, 2001 in Deloraine, MB.

Hydrogen sulphide and sulphur dioxide along with wind direction and speed were monitored at all four sites. The monitoring of wind direction and speed did not start immediately at Virden and Pierson but were added June 30, 2000 and July 7, 2000 respectively. The sulphur dioxide monitor at the Virden station was removed for repairs from September 16, 2000 to October 19, 2000. Monitoring at the Waskada site started February 8, 2001. At the Deloraine site, monitoring of sulphur dioxide and wind direction and speed started May 2, 2001; however, due to an analyzer problem, the monitoring of hydrogen sulphide was delayed until May 9, 2001.

RESULTS

The study results are summarized below. The complete hourly data from all the stations are available upon request from:

Air Quality Section
Climate Change Branch
Manitoba Conservation
160 – 123 Main Street
Winnipeg, Manitoba
R3C 1A5

Sulphur Dioxide

Sulphur dioxide was only ever detected at the Pierson location. The levels were marginally elevated above the detection limit (0.02 ppm) of the instrument. During November 2000, there were 5 hours of readings slightly above the detection level. This is well below the respective 1-hour and 24-hour air quality objectives of 0.34 ppm and 0.11 ppm. The sulphur dioxide monitoring data from the study are summarized in Tables 1a to 1d.

Hydrogen Sulphide

Detectable levels of hydrogen sulphide were recorded on occasion at all four sites. Most frequently, however, the levels at the sites were below the detection limit of the instrument (*i.e.*, 0.6 ppb). Readings seldom exceeded 5.5 ppb or one-half the ambient air guideline of 11.0 ppb. Virden and Pierson were the only sites with readings greater than 5.5 ppb. The hydrogen sulphide monitoring data for the four sites are summarized in Tables 2a to 2d.

Hydrogen sulphide was most frequently recorded at the Virden site; this was also the only site where the air quality guideline of 11.0 ppb was exceeded. The hourly guideline was exceeded for 2 consecutive hours (0500 CST and 0600 CST) on August 13, 2000 with readings of 16.3 and 11.3 ppb respectively. The next highest reading recorded at this site was 9.6 ppb on September 27, 2000. At the Pierson site the highest recorded hourly average was 8.3 ppb on August 17, 2000. In Waskada there were only 2 readings recorded, both on the same date (April 29, 2001) with the highest being 1.6 ppb. At the Deloraine station, the highest recorded hourly average for hydrogen sulphide was 5.0 ppb, on July 12, 2001.

The provincial air quality guideline is based on managing annoyance from odour and is about 100 times lower than levels reported in the literature to cause direct health effects such as irritation. Hydrogen sulphide levels were therefore substantially less than levels at which health effects (ppm range) have been reported.

Most of the hydrogen sulphide detected occurred during calm meteorological conditions (i.e., when wind speeds were low). Since wind direction measurements are unreliable at low wind speeds, this makes it difficult to establish a direction for the possible sources.

Table 1a. Virden (# 6114) - Sulphur Dioxide (SO_2) in Parts Per Million (PPM)

Date	Percentage of Data that is Valid	Average	Maximum Data Values		Number of Samples Above Air Quality Objective	
			1-HR	24-HR	1-HR	24-HR
June 7, 2000 – April 2, 2001	85	<DL	<DL	<DL	0	0
June, 2000	94	<DL	<DL	<DL	0	0
July, 2000	94	<DL	<DL	<DL	0	0
August, 2000	96	<DL	<DL	<DL	0	0
September, 2000	50	<DL	<DL	<DL	0	0
October, 2000	38	<DL	<DL	<DL	0	0
November, 2000	96	<DL	<DL	<DL	0	0
December, 2000	96	<DL	<DL	<DL	0	0
January, 2001	96	<DL	<DL	<DL	0	0
February, 2001	95	<DL	<DL	<DL	0	0
March, 2001	96	<DL	<DL	<DL	0	0
April, 2001	63	<DL	<DL	<DL	0	0

DL: detection limit (0.02 ppm)
Manitoba Air Quality Objectives for SO_2: 1-hour average: 0.34 ppm 24-hour average: 0.11 ppm

Note: Terminated April 2, 2001

Table 1b. Pierson (# 6115) – Sulphur Dioxide (SO_2) in Parts Per Million (PPM)

Date	Percentage of Data that is Valid	Average	Maximum Data Values		Number of Samples Above Air Quality Objective	
			1-HR	24-HR	1-HR	24-HR
June 21 – February 5, 2001	95	<DL	0.02	<DL	0	0
June, 2000	91	<DL	<DL	<DL	0	0
July, 2000	96	<DL	<DL	<DL	0	0
August, 2000	95	<DL	<DL	<DL	0	0
September, 2000	96	<DL	<DL	<DL	0	0
October, 2000	96	<DL	<DL	<DL	0	0
November, 2000	95	<DL	0.02	<DL	0	0
December, 2000	96	<DL	<DL	<DL	0	0
January, 2001	96	<DL	<DL	<DL	0	0
February, 2001	86	<DL	<DL	<DL	0	0

DL: detection limit (0.02 ppm)
Manitoba Air Quality Objectives for SO_2: 1-hour average: 0.34 ppm 24-hour average: 0.11 ppm

Note: Terminated February 5, 2001

Table 1c. Waskada (# 6116) – Sulphur Dioxide (SO_2) in Parts Per Million (PPM)

Date	**Percentage of Data that is Valid**	**Average**	**Maximum Data Values**		**Number of Samples Above Air Quality Objective**	
			1-HR	**24-HR**	**1-HR**	**24-HR**
February 8 – April 30, 2001	94	<DL	<DL	<DL	0	0
February, 2001	93	<DL	<DL	<DL	0	0
March, 2001	96	<DL	<DL	<DL	0	0
April, 2001	94	<DL	<DL	<DL	0	0

DL: detection limit (0.02 ppm)
Manitoba Air Quality Objectives for SO_2: 1-hour average: 0.34 ppm 24-hour average: 0.11 ppm

Note: Terminated April 30, 2001

Table 1d. Deloraine (# 6117) – Sulphur Dioxide (SO_2) in Parts Per Million (PPM)

Date	**Percentage of Data that is Valid**	**Average**	**Maximum Data Values**		**Number of Samples Above Air Quality Objective**	
			1-HR	**24-HR**	**1-HR**	**24-HR**
May 2 – July 30, 2001	95	<DL	<DL	<DL	0	0
May, 2001	94	<DL	<DL	<DL	0	0
June, 2001	96	<DL	<DL	<DL	0	0
July, 2001	94	<DL	<DL	<DL	0	0

DL: detection limit (0.02 ppm)
Manitoba Air Quality Objectives for SO_2: 1-hour average: 0.34 ppm 24-hour average: 0.11 ppm

Note: Terminated July 30, 2001

Table 2a. Virden (# 6114) - Hydrogen Sulphide (H_2S) in Parts Per Billion (PPB)

Date	Percentage of Data that is Valid	Average	Maximum Data Values		Number of Samples Above Air Quality Guideline
			1-HR	24-HR	1-HR
June 7, 2000 – April 2, 2001	95	<DL	16.3	2.5	2
June, 2000	94	<DL	1.8	<DL	0
July, 2000	95	<DL	6.5	1.4	0
August, 2000	96	<DL	16.3	1.8	2
September, 2000	95	<DL	9.6	2.5	0
October, 2000	96	<DL	4.4	1.3	0
November, 2000	96	<DL	3.5	1.2	0
December, 2000	96	<DL	4.5	1.8	0
January, 2001	96	<DL	6.5	1.9	0
February, 2001	95	<DL	3.5	0.9	0
March, 2001	96	<DL	5.7	1.8	0
April, 2001	63	<DL	2.7	<DL	0

DL: detection limit (0.6 ppb)
Manitoba Ambient Air Quality Guideline for H_2S: 1-hour average: 11.0 ppb

Note: Terminated April 2, 2001

Table 2b. Pierson (# 6115) - Hydrogen Sulphide (H_2S) in Parts Per Billion (PPB)

Date	**Percentage of Data that is Valid**	**Average**	**Maximum Data Values**		**Number of Samples Above Air Quality Guideline**
			1-HR	**24-HR**	**1-HR**
June 21, 2000 – February 5, 2001	95	<DL	8.3	0.9	0
June, 2000	91	<DL	1.1	<DL	0
July, 2000	96	<DL	1.8	<DL	0
August, 2000	96	<DL	8.3	0.8	0
September, 2000	96	<DL	0.9	<DL	0
October, 2000	95	<DL	1.7	<DL	0
November, 2000	95	<DL	0.7	<DL	0
December, 2000	96	<DL	2.4	<DL	0
January, 2001	96	<DL	3.6	0.9	0
February, 2001	86	<DL	<DL	<DL	0

DL: detection limit (0.6 ppb)
Manitoba Ambient Air Quality Guideline for H_2S: 1-hour average: 11.0 ppb

Note: Terminated February 5, 2001

Table 2c. Waskada (# 6116) - Hydrogen Sulphide (H_2S) in Parts Per Billion (PPB)

Date	Percentage of Data that is Valid	Average	Maximum Data Values		Number of Samples Above Air Quality Guideline
			1-HR	24-HR	1-HR
February 8, 2001 – April 30, 2001	94	<DL	1.6	<DL	0
February, 2001	93	<DL	<DL	<DL	0
March, 2001	96	<DL	<DL	<DL	0
April, 2001	94	<DL	1.6	<DL	0

DL: detection limit (0.6 ppb)
Manitoba Ambient Air Quality Guideline for H_2S: 1-hour average: 11.0 ppb

Note: Terminated April 30, 2001

Table 2d. Deloraine (# 6117) - Hydrogen Sulphide (H_2S) in Parts Per Billion (PPB)

Date	Percentage of Data that is Valid	Average	Maximum Data Values		Number of Samples Above Air Quality Guideline
			1-HR	24-HR	1-HR
May 9, 2001 – July 30, 2001	95	<DL	5.0	0.7	0
May, 2001	94	<DL	0.6	<DL	0
June, 2001	96	<DL	2.7	0.7	0
July, 2001	94	<DL	5.0	0.6	0

DL: detection limit (0.6 ppb)
Manitoba Ambient Air Quality Guideline for H_2S: 1-hour average: 11.0 ppb

Note: Terminated July 30, 2001

Wind Speed and Direction

The original wind monitor installed at the Virden site on June 30, 2000 had a threshold sensitivity for wind direction of 2.5 mph (miles per hour) or 4.0 kph (kilometers per hour) at 10° displacement. On July 6, 2000 it was replaced with one having the lower threshold sensitivity of 1.2 mph or 1.9 kph at 10° displacement. The wind monitor installed at the Pierson site on July 7, 2000 also had this lower threshold sensitivity. In Waskada the original wind monitor had the higher threshold sensitivity. It was replaced on March 5, 2001 with one having the lower threshold sensitivity. The only wind monitor in use at Deloraine was the lower threshold sensitivity unit.

Wind data from this study are summarized in two sets of wind roses. A wind rose typically depicts the relative frequency and concentration of some parameter versus wind direction in compass degrees. The length of the bar depicts the frequency of occurrence and the width/shading depicts the concentration range. Figures 5 to 8 show the frequency and levels of hydrogen sulphide versus wind direction at the four sites. Figures 9 to 12 show the relative frequency of wind speed versus direction during the same time periods.

Figures 5 to 8 show the detection of hydrogen sulphide as a function of wind direction for the four stations over the monitoring period. All hydrogen sulphide measurements above the detection limit of 0.6 ppb were matched with the prevailing wind direction. Most of the hydrogen sulphide detected, however, occurred during calm meteorological conditions (*i.e.,* when wind speeds were low). Since wind direction measurements are unreliable at low wind speeds, it is difficult to reliably establish a direction for the possible sources.

At the Virden station, hydrogen sulphide was below the instrument detection limit 90.2% of the time during the monitoring period. While no specific direction was related to 3% or more of the hydrogen sulphide detection, the most frequent wind directions related to hydrogen sulphide detection appeared to be from the S[1], NW and NNW. Hydrogen sulphide was detected during winds from all directions over the monitoring period.

At the Pierson station, hydrogen sulphide was below the instrument detection limit 96.0% of the time. No specific direction was related to 3% or more of the hydrogen sulphide detected, but the most frequent wind directions appeared to be from the W and WNW. Hydrogen sulphide was detected during winds from all directions over the monitoring period.

At the Waskada station, hydrogen sulphide was below the instrument detection limit 99.9% of the time. Hydrogen sulphide was detected on only one day of the monitoring period. On April 29, 2001 there were readings for two consecutive hours, the highest being 1.6 ppb. The wind direction related to the readings appeared to be from the west.

At the Deloraine station, hydrogen sulphide was below the instrument detection limit 91.9% of the time. No specific direction was related to 3% or more of the hydrogen sulphide detected, but the most frequent wind directions appeared to be from the NE, ENE and ESE. Hydrogen sulphide was detected during winds from all directions over the monitoring period.

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[1] N: north NNE: north-north-east NE: north-east ENE: east-north-east
E: east ESE: east-south-east SE: south-east SSE: south-south-east
S: south SSW: south-south-west SW: south-west WSW: west-south-west
W: west WNW: west-north-west NW: north-west NNW: north-north-west

Figures 9 to 12, show the frequency of occurrence and speed of the wind versus its direction. The percent of time that calm conditions (i.e., less than 2.0 kph) occurred at the four stations ranged from 1.9% to 22.5%. Detection of hydrogen sulphide was typically associated with low wind speeds.

At Virden, the predominant wind directions were from the SE and NW quadrants. Winds from the E, SSE, S, WNW, NW and NNW occurred more than 5% of the time; only winds from the S, NW and NNW occurred more than 10% of the time. Calm conditions occurred 9.3% of the time.

Similarly at Pierson, the predominant wind directions were from the SE and NW quadrants. Winds from the SE, SSE, S, W, WNW, NW, NNW and N occurred more than 5% of the time; only winds from the W and WNW occurred more than 10% of the time. Calm conditions occurred 1.9% of the time.

As at Virden and Pierson, the predominant wind directions at Waskada were also from the SE and NW quadrants. Winds from the SSE, S, WNW, NW, NNW, N and NE occurred more than 5% of the time; only winds from the SSE and S occurred more than 10% of the time. Calm conditions occurred 3.9% of the time.

At the Deloraine site the predominant wind directions again were from the SE and NW quadrants. Winds from the SE, SSE, S, WSW, W, WNW, NW and NNW occurred more than 5% of the time; no winds occurred more than 10% of the time. At this site, calm conditions were more prevalent (21.9% of the time) than the other three sites (9.3%, 1.9%, 3.9%.). This might have been because it was the most sheltered site with a large building within 10 metres of the eastern side of the station.

Figure 5. Virden wind rose showing hydrogen sulphide frequency of occurrence (%) and concentration range (ppb) versus wind direction from 30 Jun 00 – 2 Apr 01

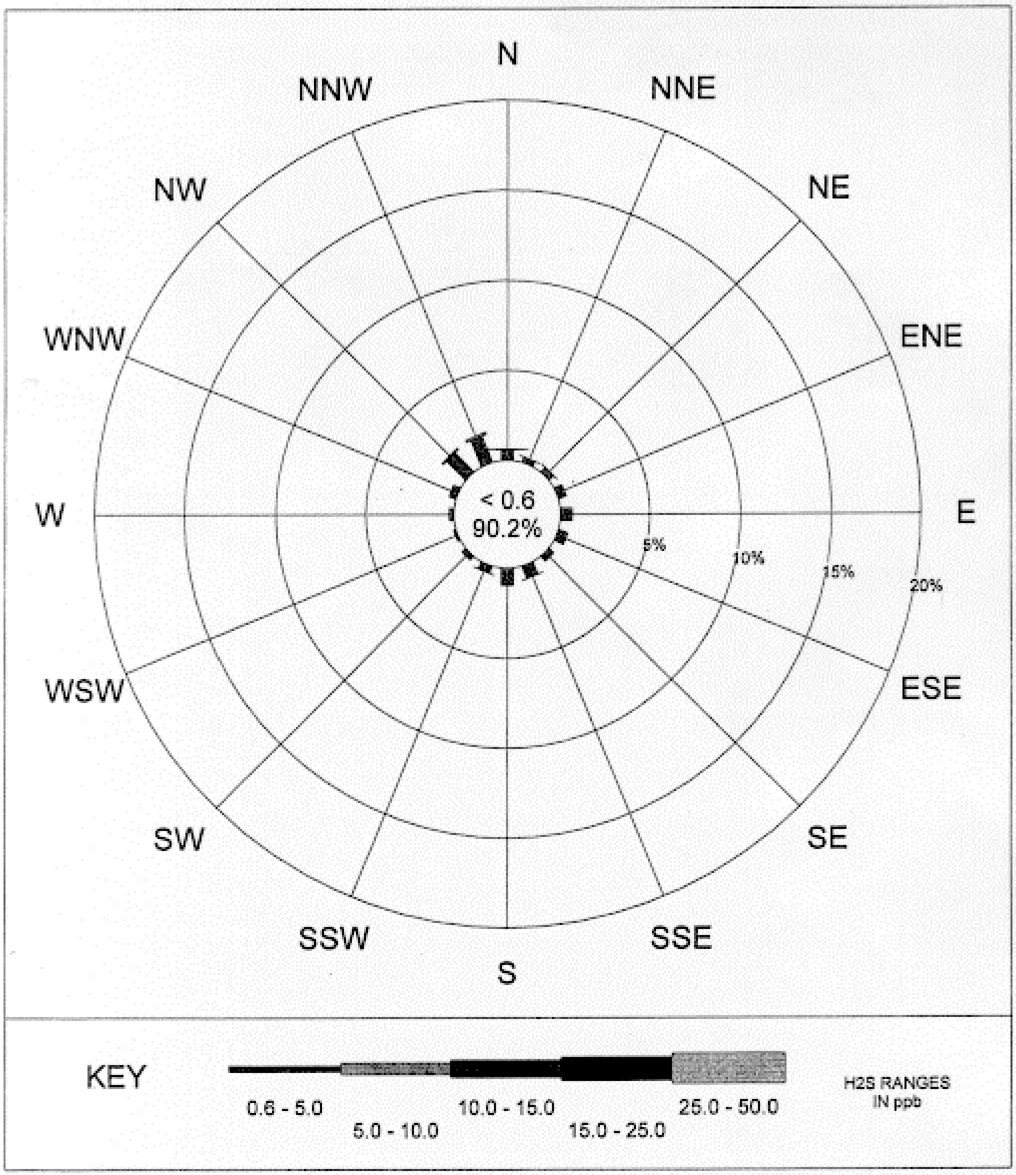


Figure 6. Pierson wind rose showing hydrogen sulphide frequency of occurrence (%) and concentration range (ppb) versus wind direction from 7 Jul 00 – 5 Feb 01

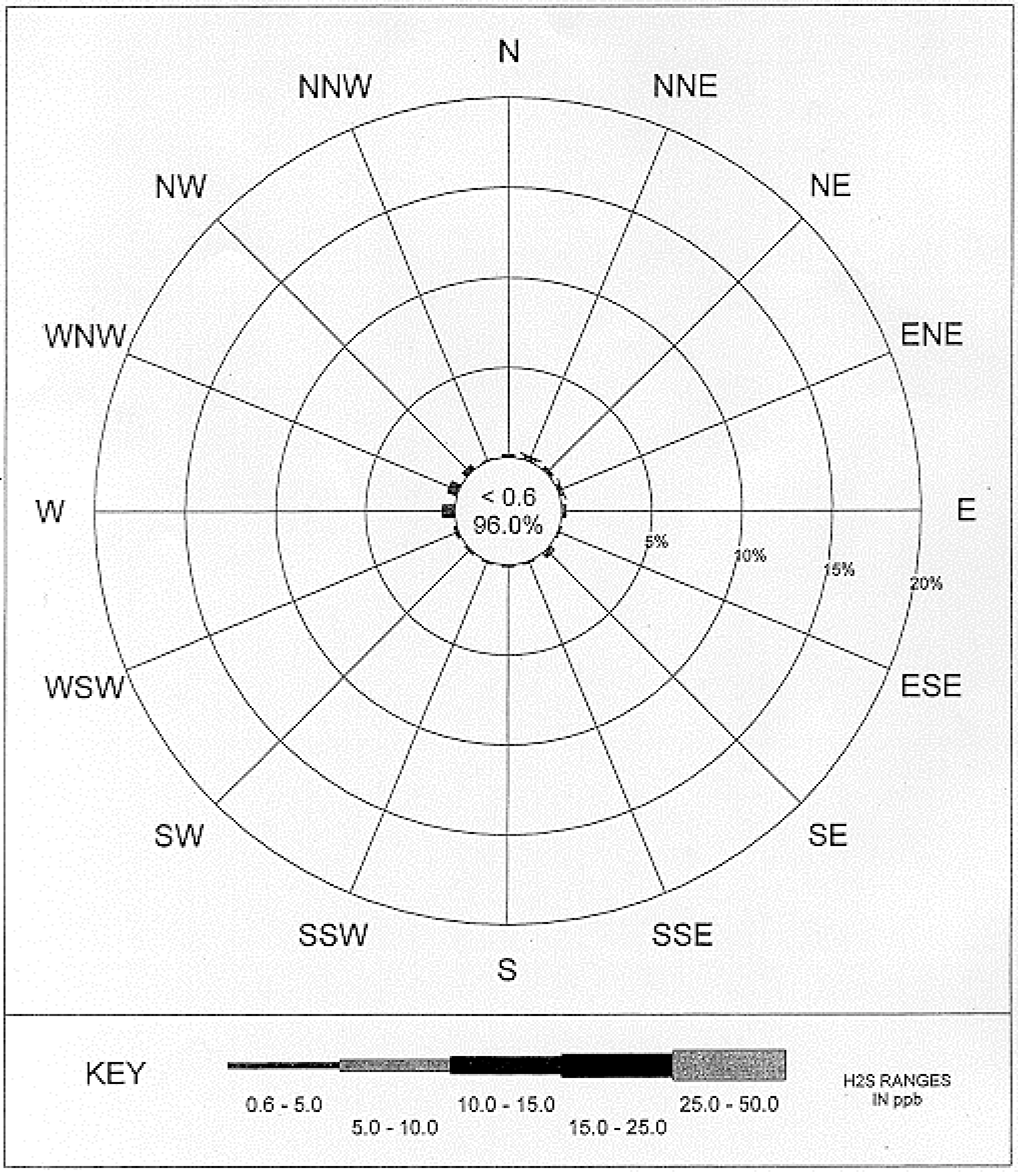


Figure 7. Waskada wind rose showing hydrogen sulphide frequency of occurrence (%) and concentration range (ppb) versus wind direction from 8 Feb 01 – 30 Apr 01

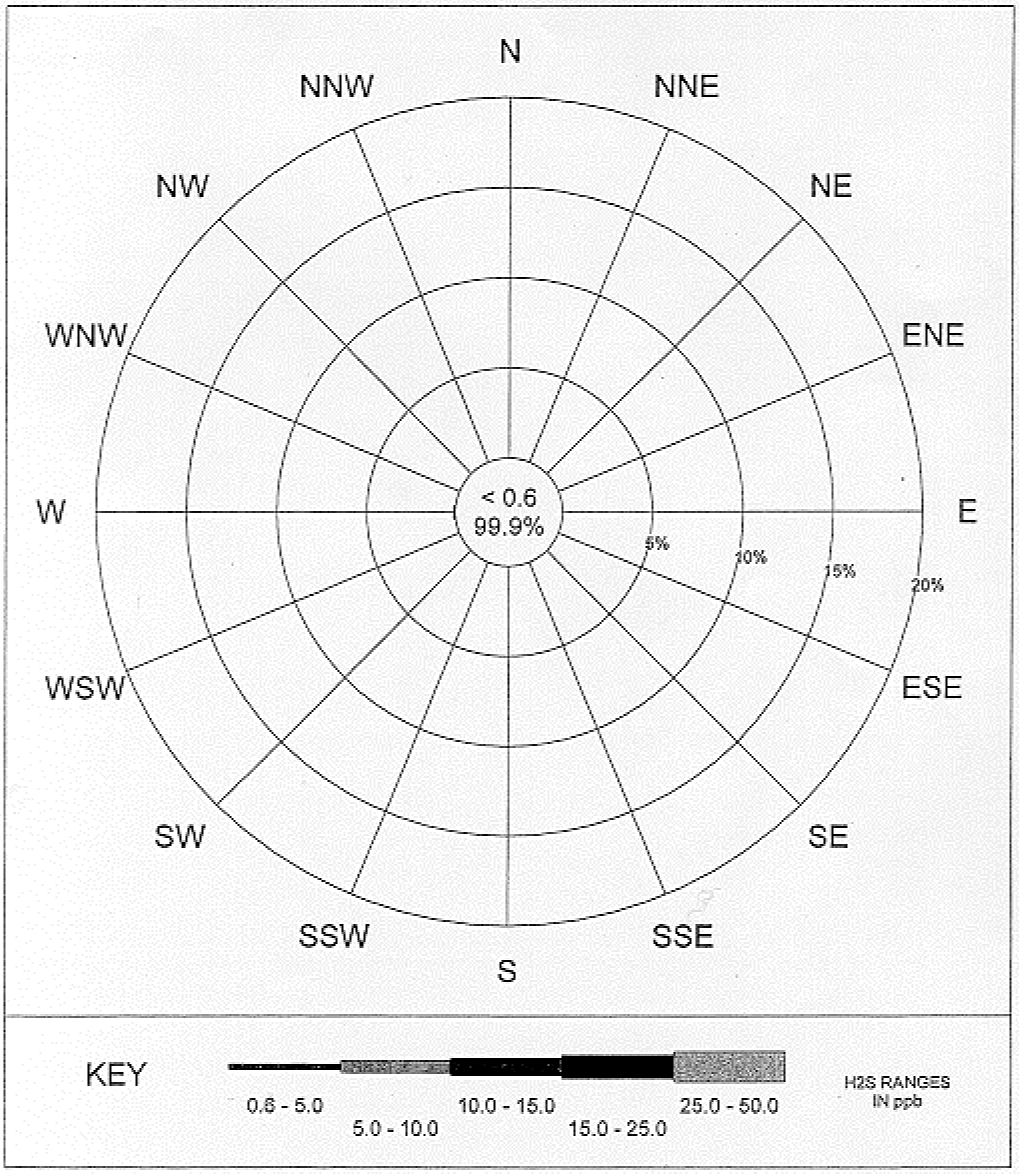


Figure 8. Deloraine wind rose showing hydrogen sulphide frequency of occurrence (%) and concentration range (ppb) versus wind direction from 9 May 01 – 30 Jul 01

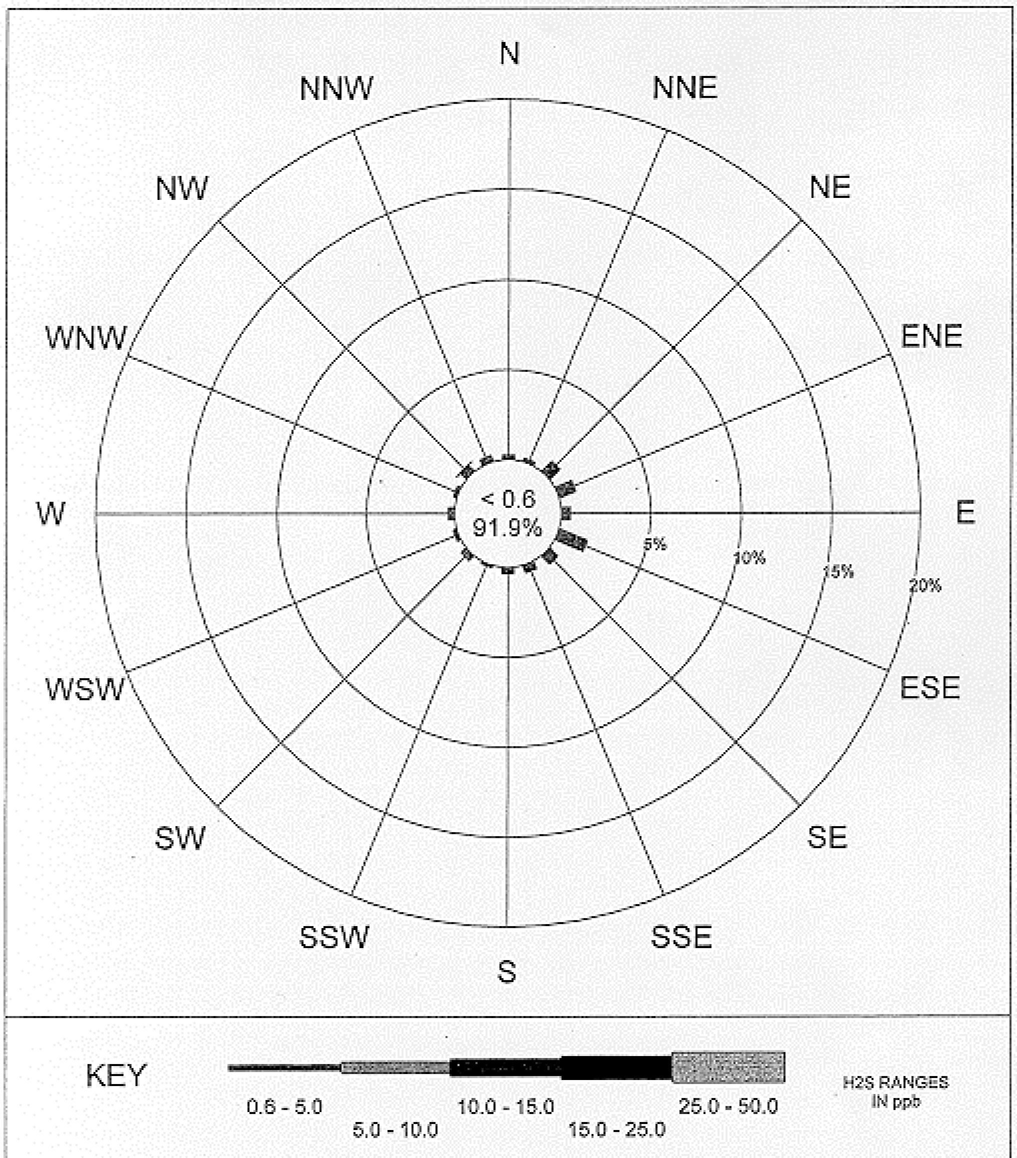


Figure 9. Virden wind rose showing wind speed frequency of occurrence (%) and speed range (kph) versus wind direction from 30 Jun 00 – 2 Apr 01

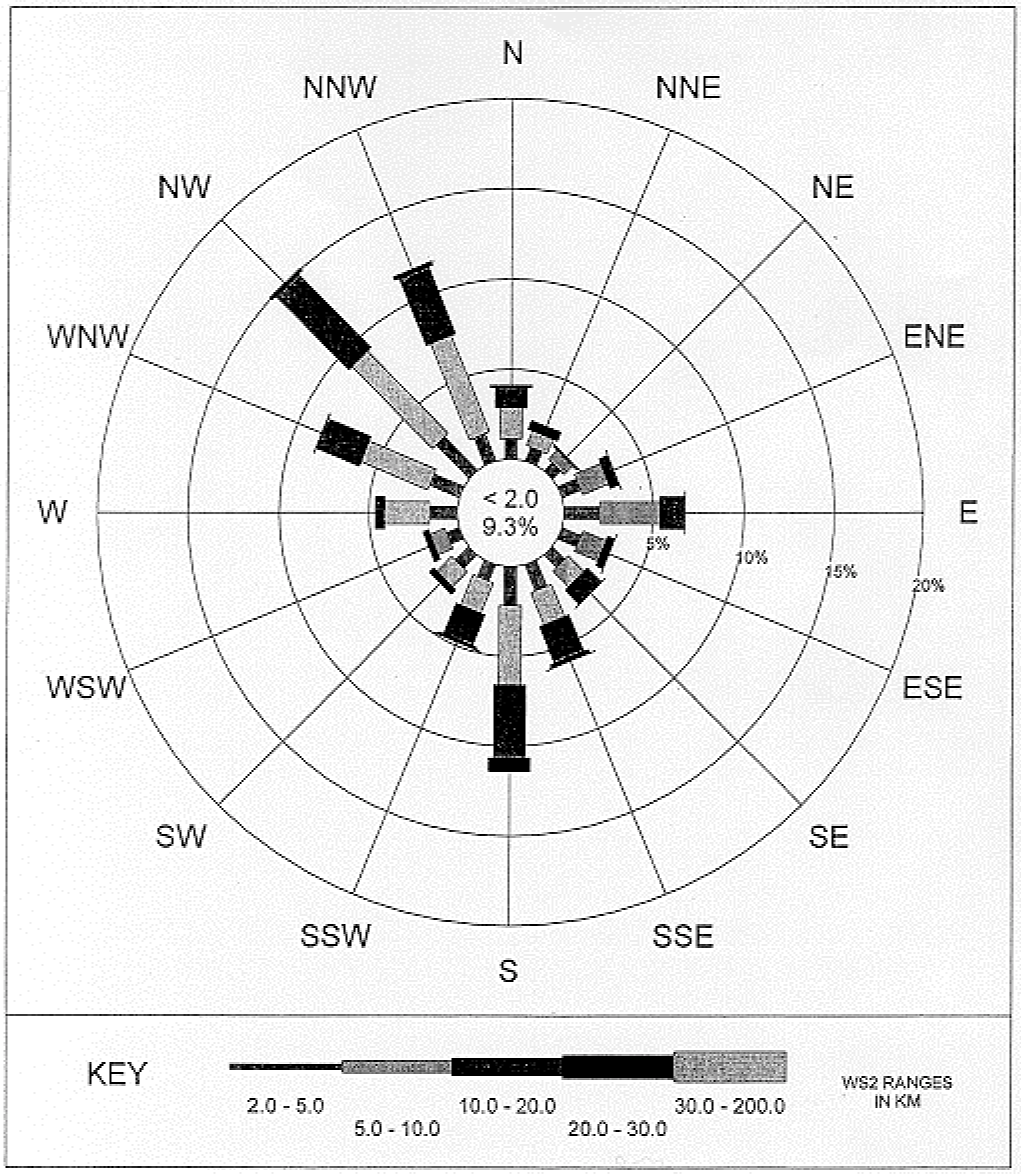


Figure 10. Pierson wind rose showing wind speed frequency of occurrence (%) and speed range (kph) versus wind direction from 7 Jul 00 – 5 Feb 01

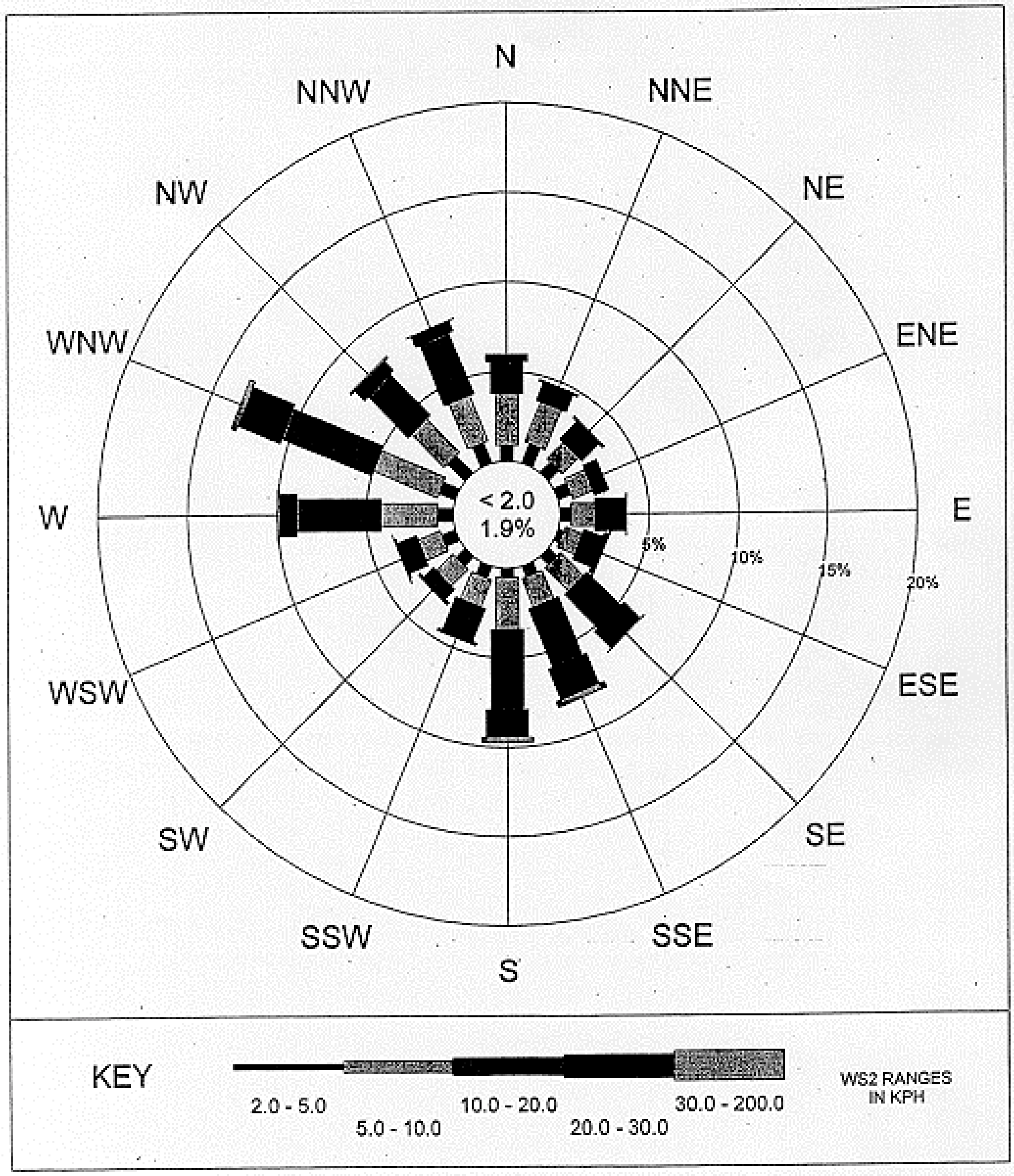


Figure 11. Waskada wind rose showing wind speed frequency of occurrence (%) and speed range (kph) versus wind direction from 8 Feb 01 – 30 Apr 01

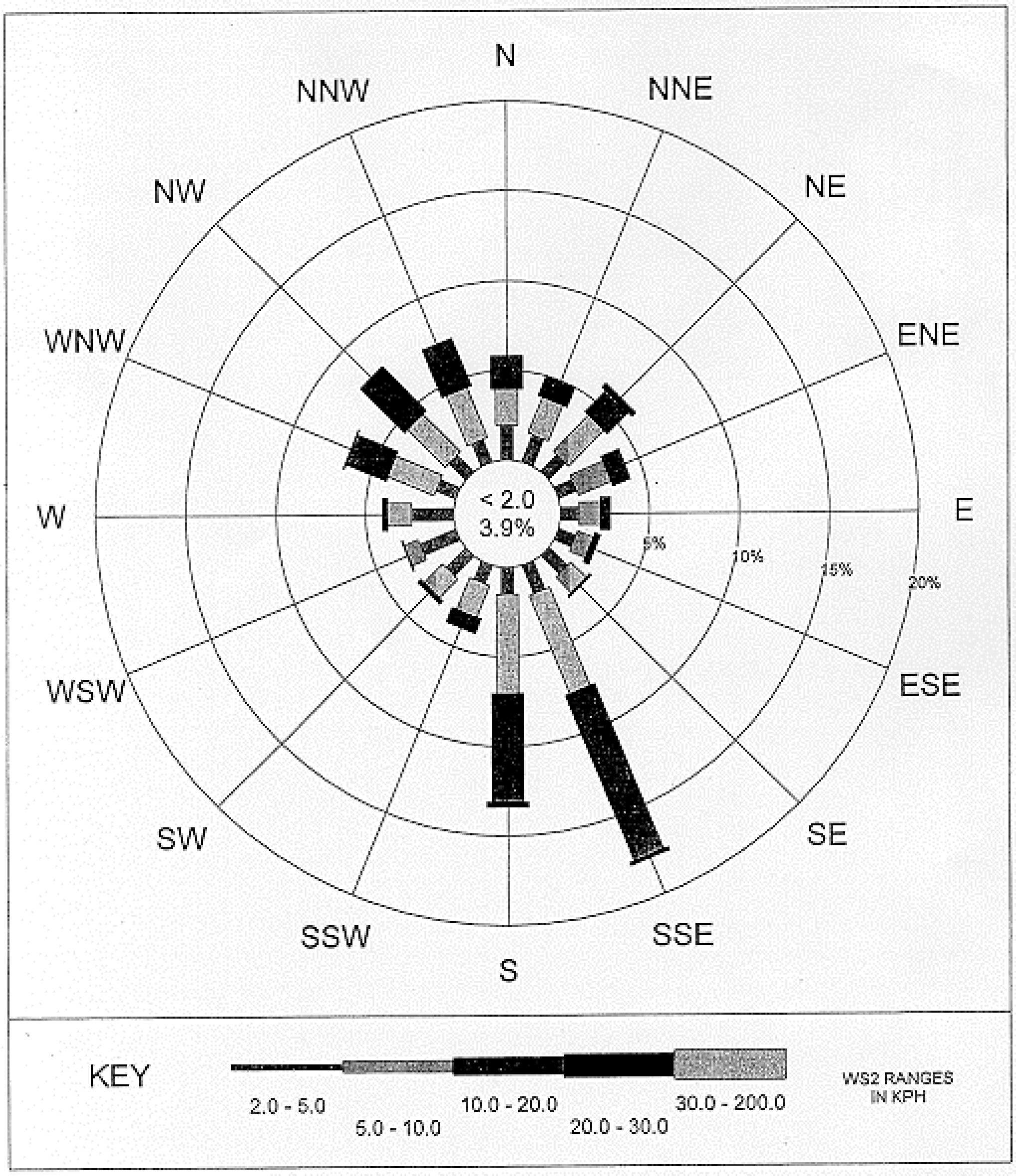
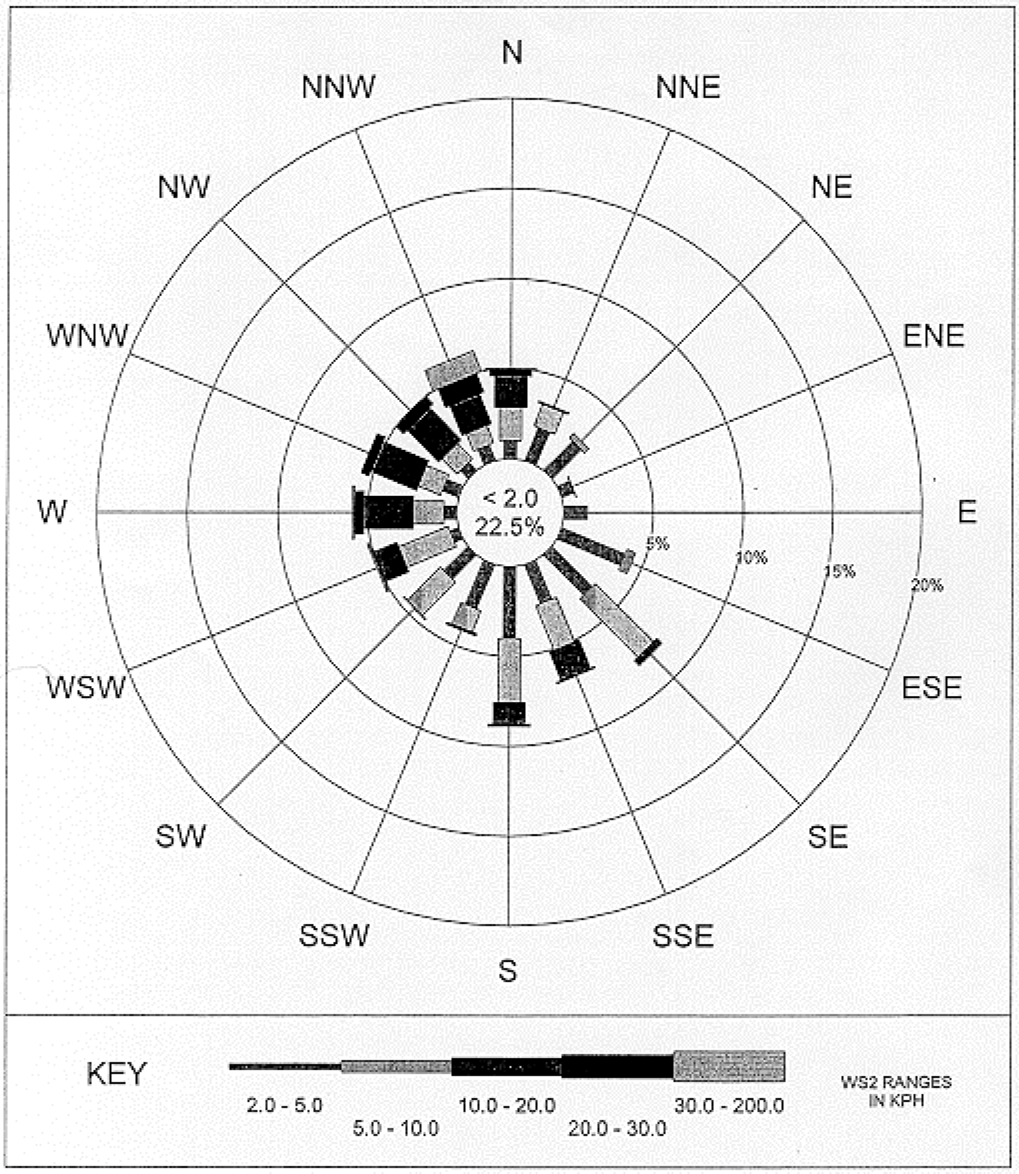


Figure 12. Deloraine wind rose showing wind speed frequency of occurrence (%) and speed range (kph) versus wind direction from 9 May 01 – 30 Jul 01



DISCUSSION

Based on the monitoring data that were collected during this project, some observations can be made:

i) Very low levels of sulphur dioxide were detected only at the Pierson site. Most of the time levels of sulphur dioxide were undetectable at all sites.

ii) Hydrogen sulphide was occasionally measured at all sites, but most frequently at the Virden site and least frequently at the Waskada site. The Virden site was the only site at which the air quality guideline was exceeded (16.3 ppb and 11.3 ppb on August 13, 2000).

iii) Although most of the hydrogen sulphide levels detected were below the air quality guideline, people sensitive to such odours may still have detected odours in the community at these times.