Latrobe Valley Air Monitoring Network

REVIEW OF ECOTECH AIR MONITORING 2014

LVAMN Air Monitoring Report 2014

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Overview

Ecotech operated and maintained the Jeeralang Hill and Rosedale South 'rural' air monitoring stations on behalf of the Latrobe Valley Air Monitoring Network Incorporated (LVAMN) during 2014. Ecotech conducted Quality Assurance checks on the monitoring data in accordance with NATA procedures, and provided monthly monitoring data and reports to Jacobs and LVAMN setting out details such as equipment and monitoring specifications, and data capture rates.

The purpose of this report is to provide an independent review of Ecotech's LVAMN 2014 air quality monitoring data acquired from the Jeeralang Hill and Rosedale South stations, with a focus on data interpretation.

In 2014 the Environment Protection Authority (EPA) monitoring program in the Latrobe Valley was expanded after the Hazelwood coal mine fire in February-March, 2014. While analysis of the EPA results was not included in the scope of works for this report, EPA results were used to assist with the interpretation of the LVAMN data.

Sulfur Dioxide

In 2014, the *State Environment Protection Policy (Ambient Air Quality)* objectives and goals for hourly average SO_2 were met for 99.94% of the time at Jeeralang Hill and for all hours at Rosedale South. The 24-hour objectives were met throughout the year at both stations.

There were 5 exceedences of the *SEPP(AAQ)* objective for hourly average SO_2 (200 ppb), and 3 exceedences of the goal allowing 1 day of exceedences per year, at Jeeralang Hill. The five highest hourly average SO_2 concentrations at Jeeralang Hill occurred during the early morning hours on three days: 25/02/14 2:00-3:00 (292 ppb); 22/10/14 2:00-3:00 (237 ppb); 25/02/14 3:00-4:00 (222 ppb); 25/02/14 5:00-6:00 (206 ppb); 31/01/14 1:00-2:00 (204 ppb). These maxima occurred during easterlies with low wind speeds of approximately 2-3 m/s. These and other higher SO_2 concentrations were most likely due to plumes from coal-fired power stations intercepting high ground in the Strzelecki Ranges, including at Jeeralang Hill. Review of EPA reports and data indicated that the three SO_2 exceedences on 25/2/14 were not due to the Hazelwood coal mine fire.

The highest hourly average SO_2 concentration at Rosedale South was 79 ppb (11/1/14, 17:00-18:00). For comparison, at Jeeralang Hill peak hourly average SO_2 concentrations occurred in the first 2 hours of 11/1/14 (approximately 20 ppb), and a peak of 105 ppb was observed at Jeeralang Hill early on the previous day. The higher SO_2 results for 11/1/14 were likely caused by the coal-fuelled power stations. The Hazelwood coal mine fire started on about 9/2/14 and did not cause significant SO_2 emissions (EPA, 2015a; EPA, 2015b; EPA, 2015c; Fisher *et al.*, 2015).

At Jeeralang Hill, the median hourly average SO_2 concentration was 0.9 ppb; data capture was 93.8%.

At Rosedale South, the median hourly average SO_2 concentration was 1.2 ppb; data capture was 93.2%.

Nitrogen Dioxide

In 2014, oxides of nitrogen (NO_x) measurements including nitrogen dioxide (NO_2) were undertaken at Jeeralang Hill and Rosedale South, with NO_x measurements commencing at Jeeralang Hill on 3/2/14. There were no recorded exceedences of the SEPP(AAQ) objective for maximum hourly average nitrogen dioxide (NO_2, 120 ppb), at the two sites.

At Jeeralang Hill, the median hourly average NO_2 concentration was 0.8 ppb. The highest hourly average NO_2 concentration was 49 ppb; data capture was 84.7%.

At Rosedale South, the median hourly average NO_2 concentration was 1.7 ppb, the highest hourly average NO_2 concentration recorded was 24 ppb (22 ppb in 2013); data capture was 93.1%.

Further analysis of the NO_x data was undertaken by investigating the ratios between the NO_2 and NO_x concentrations (NO_2/NO_x). Lower values of NO_2/NO_x can be indicative of local NO_x sources in cases where

some NO has had insufficient time to convert to NO_2. The analysis indicated that as the NO concentrations increased the NO_2/NO_x ratios decreased, which is typical of NO_x emissions from the combustion of fossil fuels; e.g., due to road traffic. The NO_2/NO_x ratios ranged between 17% and 29% for the four NO concentrations greater than approximately 100 ppb (these all from Jeeralang Hill). There was a slight upwards trend in the NO_2/NO_x ratios as the NO concentrations decreased, which was indicative of NO_x that had been in the atmosphere for longer periods allowing more time for NO_2 to form.

Ozone

In 2014, at Jeeralang Hill, the median hourly average O_3 concentration was 17 ppb, and median 4-hour rolling average 18 ppb. The highest hourly average O_3 concentration 68 ppb and data capture was 84.3%.

At Rosedale South, both the median hourly average and rolling 4-hourly average O_3 concentration were 19 ppb. The highest hourly average O_3 concentration 82 ppb and data capture 93.2%.

Further analysis of the NO_2 and O_3 results at Jeeralang Hill and Rosedale South indicated higher NO_x levels at Jeeralang Hill contributed to smaller O_3 concentrations there (NO_2 formation dominating over O_3 formation). Higher O_3 levels were recorded at Rosedale South, which is more distant from the power stations.

Particulate Matter

The good correlation between the PM_{10} measurements at Jeeralang Hill and Rosedale South indicated that for the majority of days the PM_{10} was due to regional influences, rather than local sources. The variations in the time series for both stations (24-hour averages), were very similar to the EPA's PM_{10} data for Traralgon (see EPA, 2015c). Data capture rates for hourly average PM_{10} were high: at Jeeralang Hill (97.2%), and Rosedale South (95.9%).

The NEPM objective for PM_{10} is the 24-hour average, 50 $\mu g/m^3$. The objective was met on 363 days at Jeeralang Hill and 362 days at Rosedale South. At Jeeralang Hill, some slight exceedences occurred on these days: 12/2/2014 (68 $\mu g/m^3$) and 15/2/2014 (54 $\mu g/m^3$); and at Rosedale South: 9/2/14 (54 $\mu g/m^3$); 12/2/14 (55 $\mu g/m^3$); and 15/2/14 (50 $\mu g/m^3$). There were no exceedences of the NEPM goal at both sites; i.e., not more than 5 exceedences per annum.

Local Visual Distance (Rosedale South)

In 2014, in situ nephelometer measurements of the atmospheric scattering coefficient (B_{sca}) were obtained at Rosedale South. Results for B_{sca} were used to calculate Local Visual Distance (LVD) in accordance with a Victorian Government procedure set out in the *State Environment Protection Policy, The Air Environment* (VG, 1982). According to the Rosedale South measurements and calculations, the visibility minimum of 20 km was exceeded for a total of 54 hours in 2014, on 12 days. Therefore there were 9 exceedences of the 3-day goal and visibility was deemed acceptable on 97.5% of days in 2014.

Summary of Results

A summary of results for each of the air pollutants and objectives with respect to the relevant Victorian ambient air quality standards and goals is set out in the table below. In the right-hand columns of the table, results are provided for maximum concentrations (ppb) and exceedences of the goals for exceedences [days per year], for Jeeralang Hill and Rosedale South.

Indicator	Statistic & averaging period	Objective	Goal (Exceedence)	Jeeralang Hill [Exceedences in brackets]	Rosedale South [Exceedences in brackets]
SO_2	Max. 1 hour	200 ppb	1 day/year	292, 237,222, 206, 204 [2 days]	79 [0]
	Max. daily	80 ppb	1 day/year	50 [0]	21 [0]
	Annual	20 ppb	None	2.9 [0]	2.3 [0]
O_3	Max. 1 hour	100 ppb	1 day/year	68 [0]	82 [0]
	Max. 4 hour	80 ppb	1 day/year	57 [0]	73 [0]

Indicator	Statistic & averaging period	Objective	Goal (Exceedence)	Jeeralang Hill [Exceedences in brackets]	Rosedale South [Exceedences in brackets]
NO_2	Max. 1 hour	120 ppb	1 day/year	49 [0]	24 [0]
	Annual	30 ppb	None	2.0 [0]	2.3 [0]
Particles as PM_{10}	Max. 24 hour	50 µg/m^3	5 days/year	68, 54 [0]	55, 54, 50 [0]
Local Visual Distance	Minimum 1 hour	20 km	3 days/year	N/A	2.6 km – 19.7 km [9 days]

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to provide data interpretation for Ecotech's 2014 ambient air quality monitoring data for LVAMN, in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

Some of the data obtained in 2014 from the LVAMN Jeeralang Hill and Rosedale South monitoring stations were unable to be validated due to a variety of technical problems and the causes were detailed in Ecotech's 2014 monthly reports. Any further data removed from the analysis by Jacobs are described in this report. The main assumption of this review was that all the ambient air monitoring data provided by Ecotech, minus the additional data deletions just mentioned, were of sufficient accuracy for data interpretation.

This report has been prepared on behalf of, and for the exclusive use of, Jacobs's Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

1. Introduction

1.1 Background

The Latrobe Valley Air Monitoring Network (LVAMN) has undertaken ambient air quality monitoring in the Latrobe Valley since the 1980s. CSIRO (1989) provides a summary of the air quality monitoring undertaken in the Latrobe Valley in the 1980s, and associated studies. Aurecon (2012) reviews some statistics for monitoring data acquired over 1980–2011. Historically LVAMN summary reports have been published on an annual basis; Jacobs (2014) provides the previous year's annual report.

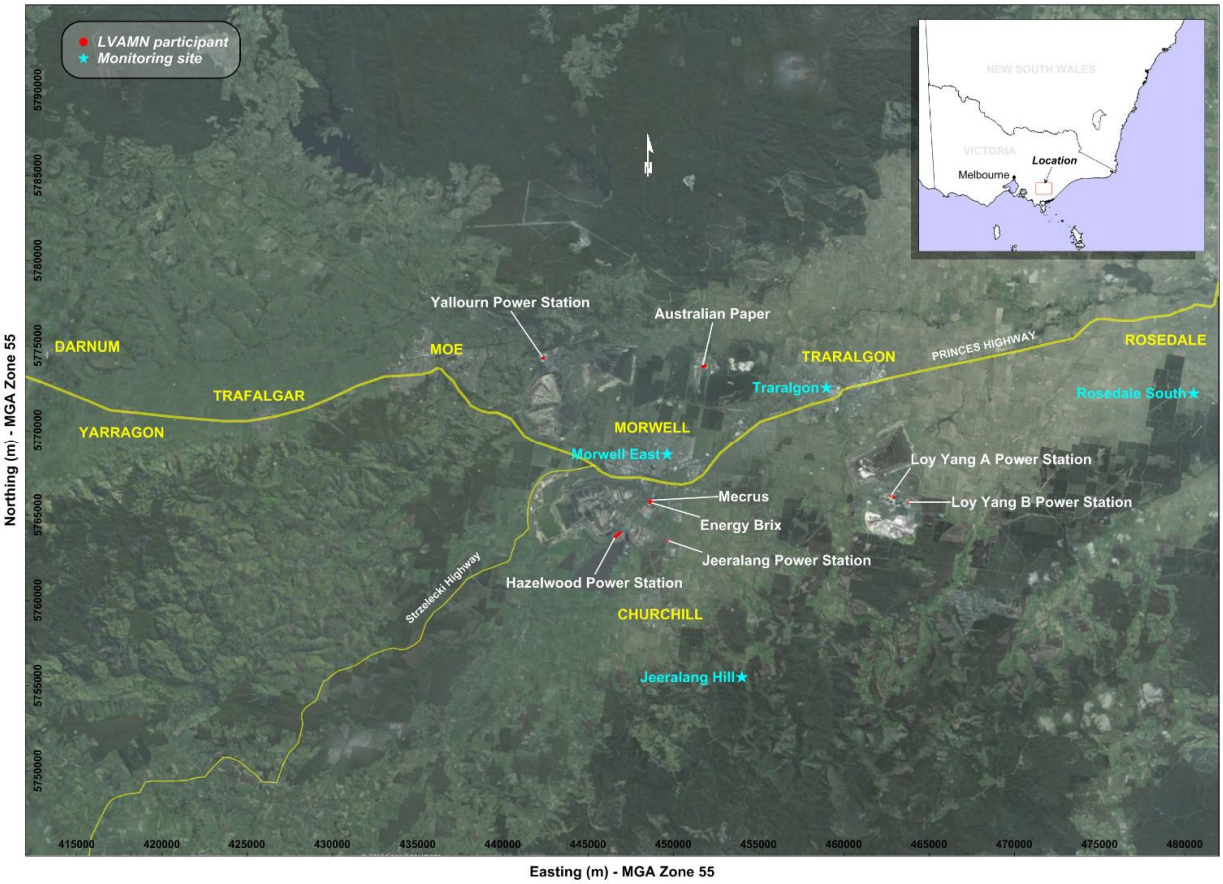
In 2012, Ecotech Pty Ltd was commissioned by LVAMN Incorporated to provide monitoring and data reporting for the LVAMN stations Jeeralang Hill and Rosedale South. The Ecotech monitoring station locations for calendar year 2014 were unchanged from 2013:

(1) Jeeralang Hill, a rural site in the Strzelecki Ranges approximately 11 km southeast of Hazelwood Power Station and 13.5 km southwest of Loy Yang Power Stations.

(2) Rosedale South, a rural site south of the town of Rosedale approximately 5 km south of the Rosedale township and 19 km east-north-east of Loy Yang Power Station.

A map of the Latrobe Valley is provided in Figure 1-1 (see also Appendix A), showing the locations of towns, the larger industrial facilities; i.e. the LVAMN participants, and four monitoring stations used for collecting information on air quality and meteorological conditions. The Traralgon and Morwell East stations, operated by Victoria's Environment Protection Authority (EPA), are shown but data from these stations have not been analysed in the report.

Figure 1-1 Map of Latrobe Valley and Locations of Air Quality Monitoring Stations



1.2 Ecotech Monthly Reports

The monthly air monitoring reports for 2014 are detailed in the series of reports; Ecotech (2014a–2014k) and Ecotech (2015). The reports include details such as:

- Monitoring equipment, methods, and measured parameters
- Data collection methods and compliance with monitoring standards
- Data capture rates and key statistics for the measurement parameters
- Recording of measured exceedences of ambient air quality standards and levels

1.3 Purpose of this Report

The purpose of this report was to review the 2014 ambient air monitoring data from the Ecotech-operated LVAMN sites, Jeeralang Hill and Rosedale South, and interpret the data rather than audit data quality.

The Ecotech measurement parameters reviewed for this report focus on the air pollutants for which objectives and goals are listed in the Victoria Government (VG) *State Environment Protection Policy (Ambient Air Quality)* ('SEPP(AAQ)'; or VG, 1999); i.e., sulfur dioxide (SO_2); nitrogen dioxide (NO_2); ozone (O_3); particulate matter comprising particles with aerodynamic diameters less than 10 microns (µm) in size (PM_{10}); and visibility reducing particles (measured as Local Visual Distance).

It is noted the *State Environment Protection Policy (Air Quality Management)* ('SEPP(AQM)', or VG, 2001), varied the SEPP(AAQ) by removing the 8-hour average standards for O_3.

1.4 Overview of Hazelwood Mine Fire: February-March 2014

The Hazelwood coal mine fire occurred south of Morwell from 9/2/14 to 25/3/14 inclusive; i.e., a total of 45 days; e.g., VG (2014). This period of the fire is illustrated with the LVAMN ozone (O_3) data in Figure 1-2 (the O_3 results are described later in Section 3.3).

As will be shown in this report, the fire did not have a significant effect on the LVAMN air quality monitoring data collected at Jeeralang Hill and Rosedale South. However some details about the fire are set out here due to the significance of the air quality effects experienced in Morwell and surrounding communities, which are in the LVAMN's area of interest. Also, specifying the period of the mine fire was necessary for the data interpretation required for this report.

The Hazelwood Coal Mine, associated with the Hazelwood Power Station, is situated south of Morwell in the Latrobe Valley. On 9th February 2014 a fire commenced in the Hazelwood Coal Mine caused by embers spotting into the mine from nearby bushfires[1]. The Hazelwood Mine Fire burned for 45 days sending smoke and ash over the town of Morwell and surrounding areas (VG, 2014).

The EPA provided summaries of air monitoring results from an extensive monitoring program installed four days after the fire commenced, at Morwell and Traralgon (EPA, 2015a; EPA, 2015b; EPA, 2015c; Fisher *et al.*, 2015). A summary of the main findings relevant to this report, from EPA (2015b), is provided by the following points:

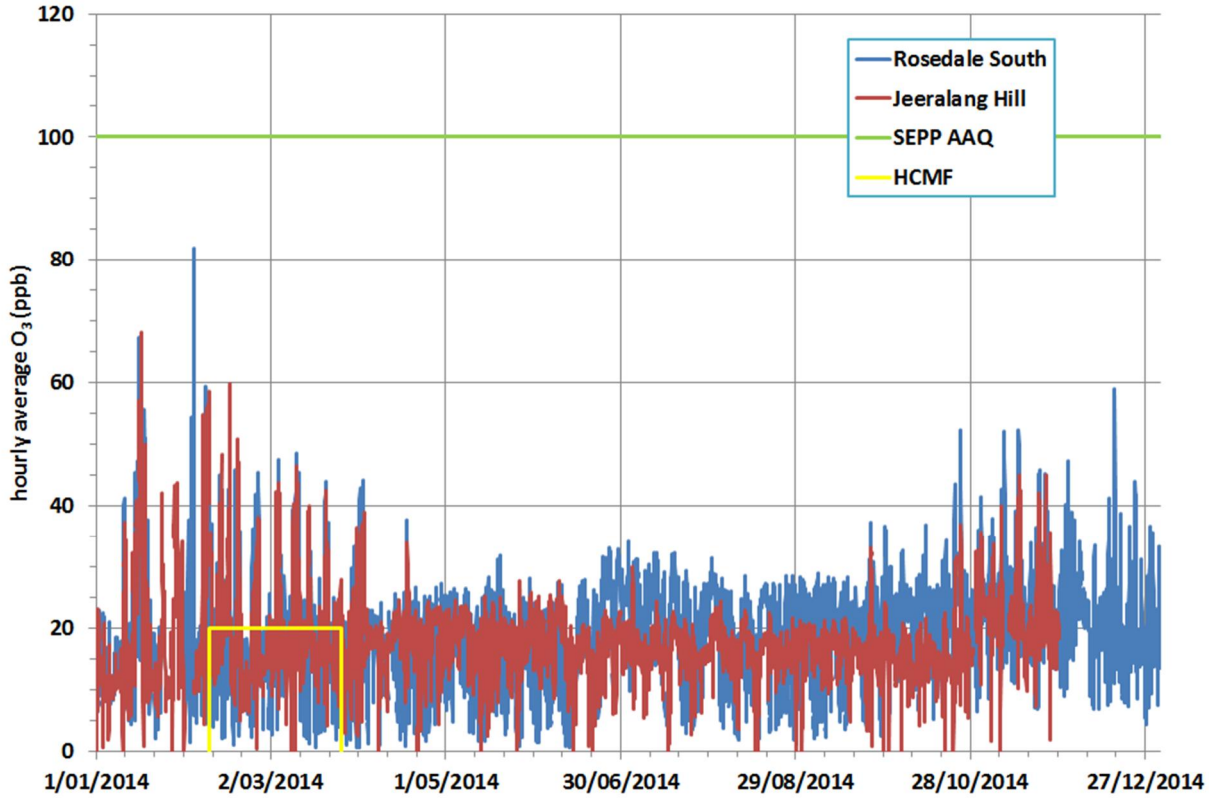
- Particulate Matter 2.5[2] ($PM_{2.5}$) levels were very high on occasions, particularly in the two weeks following the outbreak of the fire.
- The Particulate Matter 10 (PM_{10}) guideline was exceeded on 3 days at Traralgon and 8 days at Morwell South.

[1] On Friday 7th February 2014 the Hernes Oak fire started. On Sunday 9th February the Driffield fire started. Both were regarded by Victoria Police as suspicious and are the subject of ongoing investigation. Spotting from the Hernes Oak fire was the more likely cause of the Hazelwood Mine fire while spotting from the Driffield fire may also have contributed (LVAMN, 17/12/16).

[2] For definitions and acronym expansions, see Glossary of Terms (Section 0).

- Carbon monoxide (CO) levels also were recorded at high levels. There were three occasions when the CO standard was exceeded (21, 22, 26 February). As the fire became more contained, the CO levels dropped significantly. From 27th February onward, the CO levels met the standard.
- The visibility reduction measurements were very high for a significant period of the fire event, being similar to those caused by bushfires and planned burns.
- The sulphur dioxide (SO_2) monitoring showed lower levels than anticipated from a coal fire of this scale. No significant SO_2 levels were detected in Morwell or Traralgon. The peaks that were detected were not considered to be very high and fitted within the range of what would be expected from normal operations by the coal fired power stations. No SO_2 standards were exceeded.
- All other compounds measured have been compared against a range of Australian and international criteria (see EPA, 2015b).

Figure 1-2 Period of the Hazelwood Coal Mine Fire (HCMF) Shown with LVAMN Ozone Data



The LVAMN O_3 results shown in **Figure 1-2** are described later in **Section 3.3**.

1.5 Glossary of Terms

Abbreviation	Expansion / definition
AQI	Air Quality Index
CO	Molecular formula for carbon monoxide
CPF	Conditional Probability Function
EPA	Environment Protection Authority (Victoria)
LVAMN	Latrobe Valley Air Monitoring Network
µm	micron (thousandth of a millimetre)
NEPC	National Environment Protection Council
NEPM	National Environment Protection (Ambient Air Quality) Measure
NO	Molecular formula for nitric oxide
NO_2	Molecular formula for nitrogen dioxide
NO_x	Oxides of nitrogen
O_3	Molecular formula for ozone
$PM_{2.5}$	Particulate Matter 2.5; particulate matter comprising particles with aerodynamic diameters less than 2.5 microns (µm) in size
PM_{10}	Particulate Matter 10; particulate matter comprising particles with aerodynamic diameters less than 10 microns (µm) in size
SEPP(AAQ)	State Environment Protection Policy (Ambient Air Quality) (VG, 1999)
SEPP(AQM)	State Environment Protection Policy (Ambient Air Quality) (VG, 2001)
SO_2	Molecular formula for sulfur dioxide
USEPA	United States Environmental Protection Agency
VG	Victoria Government

2. Objectives and Goals

2.1 SEPP(AAQ) Objectives and Goals

A purpose of the SEPP(AAQ) (VG, 1999), was to adopt National Environment Protection Council (NEPC) objectives and goals set out in the *National Environment Protection (Ambient Air Quality) Measure* (NEPM) (NEPC, 2003).

The SEPP(AAQ) objectives and goals used to review the air quality monitoring data for this report are listed in Table 2-1, but without the 8-hour average O_3 standards in accordance with the variation set out in the SEPP(AQM) (VG, 2001).

Table 2-1 SEPP(AAQ) Objectives and Goals Used in this Report

Environmental Indicator (Air Pollutant)	Averaging Period	Objective	Goal (exceedences)*
NO_2 (maximum conc.)	1 hour	120 ppb	1 day/year
	1 year	30 ppb	None
O_3 (maximum conc.)	1 hour	100 ppb	1 day/year
	4 hours#	80 ppb	1 day/year
SO_2 (maximum conc.)	1 hour	200 ppb	1 day/year
	1 day	80 ppb	1 day/year
	1 year	20 ppb	None
Particles as PM_{10}	1 day	50 µg/m^3	5 days/year
Visibility reducing particles (minimum visual distance)	1 hour	20 km	3 days/year

*Goals are maximum allowable exceedences of objective.

#Rolling 4-hour average based on 1 hour averages.

"Day" and "Year" mean “calendar day” and “calendar year”.

2.2 Review of NEPM 2014-2015

It is noted the NEPM is likely to be modified in the near future, with a current draft NEPM setting out recommendations for stricter air quality standards for particles (NEPC, 2014). Hundreds of submissions for the draft NEPM were received by the NEPC, and non-confidential submissions were available online (Australian Government, 2015).

3. Measured Parameters

3.1 Sulfur Dioxide

The most significant sources of sulfur dioxide (SO_2) emissions in the Latrobe Valley are the brown coal-fuelled power stations, and the Maryvale Paper Mill. As a result the highest SO_2 concentrations detected at the LVAMN monitoring stations usually can be attributed to SO_2 emissions from the larger power stations.

3.2 Oxides of Nitrogen

Oxides of nitrogen (NO_x) emissions produced by the burning of fuels; e.g., by road vehicle fleets associated with cities and larger towns including on the M1 Freeway, bushfires and planned burns, and power stations, comprise mostly nitric oxide (NO), and smaller amounts of NO_2. In the atmosphere, NO may be oxidised to NO_2; e.g., through the following reaction with ozone (O_3): $O_3 + NO \rightarrow NO_2 + O_2$.

3.3 Ozone

The significant source of ozone (O_3) in the atmosphere is the photolysis of NO_2 in sunlight involving ultraviolet photons ($h\nu$) with wavelengths less than 424 nanometres; i.e. via the following pair of reactions: $NO_2 + h\nu \rightarrow NO + O$; and $O + O_2 \rightarrow O_3$.

Information about sources and concentrations of NO_x and reactive hydrocarbons are important for understanding the formation of photochemical O_3. In the Latrobe Valley, local sources of NO_x and hydrocarbons would include the power stations, road vehicle traffic including on the M1 Freeway, and 'natural' sources of hydrocarbons such as forested areas. Also, air pollution transported into the Valley from the Melbourne airshed would affect the Valley's O_3 levels.

3.4 Particulate Matter

Potential local sources of Particulate Matter 10 (PM_{10}) in the Latrobe Valley include: open cut coal mining and vehicle wheel generated dust on unpaved roads; road vehicle traffic on the M1 Freeway (locomotives would be a minor source), domestic wood heaters and open fireplaces, planned burns and bushfires; and industry; e.g., power stations and paper mills. Measurements of PM_{10} in the Latrobe Valley would also include components transported from outside the region, such as sea salt aerosols from Bass Strait and beyond.

3.5 Local Visual Distance

Air pollution can affect amenity by forming a visibility-reducing haze, caused by light scattering by small particles in the atmosphere (aerosols). The sources of such aerosols are similar to those for particulate matter e.g. open cut coal mining; domestic wood heaters and open fireplaces; planned burns and bushfires; and photochemical smog. In humid conditions, fog and mist (essentially low cloud), also reduce visibility. The SEPP(AAQ) sets out an objective for minimum visibility of 20 km. In Victoria, compliance with the visibility objective is determined by measuring light scattering properties of ambient air conditioned to a relative humidity of 70%, using a nephelometer. The Victorian Government Gazette No. 120 (VG, 1982), sets out the following equation for determination of the Local Visual Distance (LVD) from a nephelometer-measured light scattering parameter:

$$LVD = 47 \times (10{,}000 \times B_{sca})^{-1},$$

where B_{sca} is the atmospheric light scattering coefficient (units m^{-1}), measured by an integrating nephelometer. For example, using a scattering coefficient of 4.7×10^{-5} m^{-1}, the calculated LVD is 100 km. The Ecotech results for LVD were calculated from measurements of B_{sca} by an Aurora 1000 Nephelometer at the Rosedale South monitoring station; e.g., see Ecotech (2015a). The Aurora unit replaced a MRI 1550B nephelometer on 29/1/15 (Ecotech, 2015b).

4. Ecotech LVAMN Operations 2014

4.1 Overview

Measurements of air pollutants, winds and other meteorological parameters were undertaken by Ecotech at Jeeralang Hill and Rosedale South in 2014. This section sets out key results from the measurements by a review of Ecotech's monthly reports. Further details about equipment, specifications and data capture, may be found in the monthly reports Ecotech (2014a) through to Ecotech (2014k), and Ecotech (2015). Some of the data obtained in 2014 from Rosedale South and Jeeralang Hill were invalidated due to a variety of technical non-compliances and the causes detailed in the Ecotech monthly reports.

4.2 Ecotech LVAMN Data Capture for In Situ Measurements

A statistical summary of the hourly average data for the air pollutants and wind parameters measured at Jeeralang Hill for 2014 is provided in Table 4-1, and similarly for Rosedale South in Table 4-2. At Rosedale South the network minimum data capture requirement of 80% was not met for the wind data. In September 2014 an anemometer was calibrated and installed at Rosedale; subsequently some incorrect data were recorded. The wind speed and wind direction data were recovered for this period, but the associated sigma theta data were invalidated.

Table 4-1 Summary of Jeeralang Hill Monitoring Data for 2014 (Hourly Averages)

Parameter (units of measure)	No. of hourly average records	Data Capture 2014
SO_2 (ppb)	8213	93.8%
NO (ppb)	7416	84.7%
NO_2 (ppb)	7416	84.7%
NO_x (ppb)	7416	84.7%
O_3 (ppb)	7382	84.3%
PM_{10} ($\mu g/m^3$)	8513	97.2%
WS[a] (m/s)	8617	98.4%
WD[b] (deg)	8617	98.4%
σ_θ[c] (deg)	8617	98.4%

a. Wind Speed; b. Wind Direction; c. Sigma-theta, or standard deviation of the horizontal wind direction.

Table 4-2 Summary of Rosedale South Monitoring Data for 2014 (Hourly Averages)

Parameter (units of measure)	No. of hourly average records	Data Capture 2014
SO_2 (ppb)	8161	93.2%
NO (ppb)	8158	93.1%
NO_2 (ppb)	8158	93.1%
NO_x (ppb)	8158	93.1%
O_3 (ppb)	8163	93.2%
PM_{10} ($\mu g/m^3$)	8403	95.9%
LVD[d] (km)	8246	94.1%
WS[a] (m/s)	6697	76.4%
WD[b] (deg)	6697	76.4%
σ_θ[c] (deg)	4043	46.2%

a. Wind Speed; b. Wind Direction; c. Sigma-theta, or standard deviation of the horizontal wind direction; d. Local Visual Distance.

Wind roses were created from the wind speed and direction data for 2014; see Appendix C.1 (Jeeralang Hill); and Appendix C.2 (Rosedale South).

5. LVAMN Results 2014

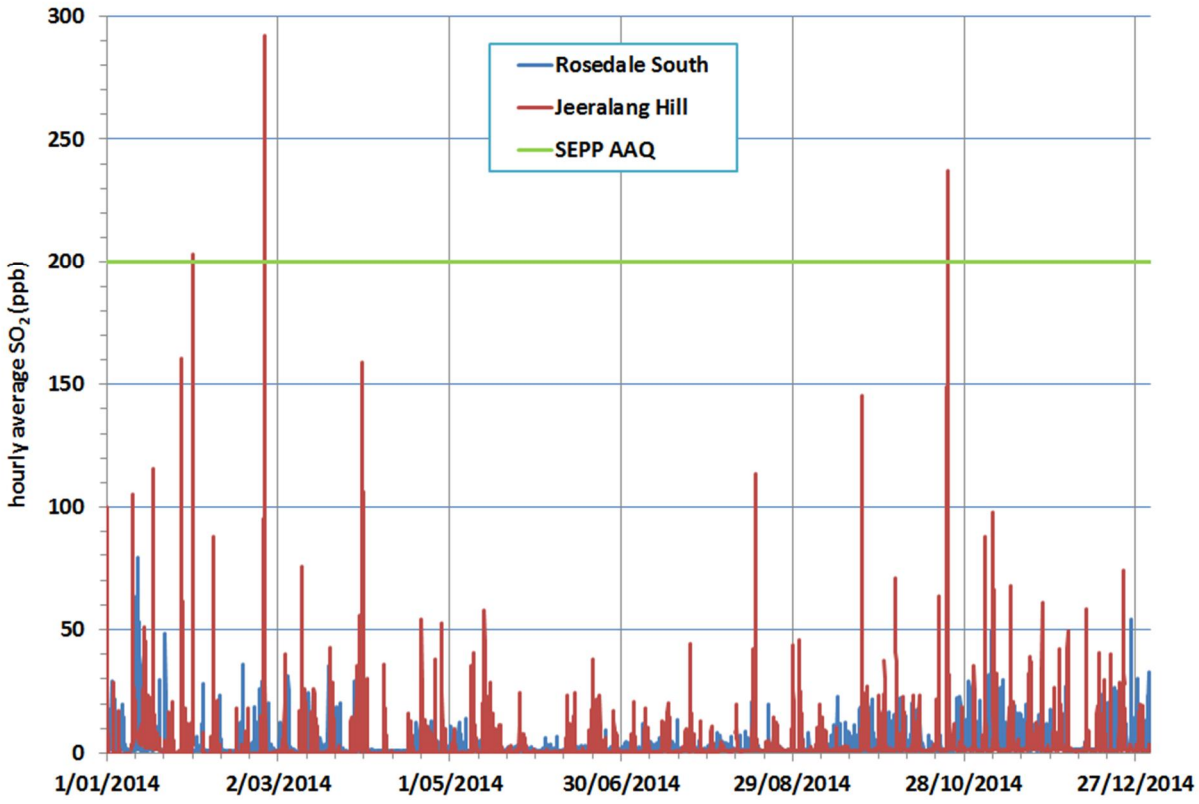
5.1 Overview

This section provides results of a review of the LVAMN air monitoring data acquired in 2014 at the air monitoring stations Jeeralang Hill and Rosedale South. Ecotech's reported 1-hour and 24-hour averages were based on a minimum of 80% valid readings within the averaging period. The same fraction was adopted for the calculations undertaken for this report. It is noted Jacobs (2014) adopted a stricter standard of 95.8% for the 2013 data; i.e., at least 23 hours out of 24 required to record a 24 hour average.

5.2 Sulfur dioxide – Jeeralang Hill and Rosedale South

The LVAMN 2014 results for hourly average SO_2 concentrations (ppb) measured at Jeeralang Hill and Rosedale South are provided in Figure 5-1. Comparisons of the results shown in Figure 5-1 with EPA data (2015c) indicates hourly average SO_2 concentrations were lower at Morwell East, Morwell South and Traralgon, even during the period of the Hazelwood coal mine fire (9/2/14–25/3/14); see also EPA (2015b); and Fisher et al., 2015).

Figure 5-1 LVAMN Results for Hourly Average SO_2 Concentration (ppb)



A summary of results of the analysis of the hourly average SO_2 concentrations acquired from Jeeralang Hill in 2014 is set out in Table 5-1. Daily averages were calculated for days where 80% of hourly average data were available for that day.

Table 5-1 Summary of Results: Jeeralang Hill SO_2 Concentrations

Parameter (Jeeralang Hill)	Hourly Averages	Daily Averages	Annual Average
Number of records	8213	352	1
Total records possible	8760	365	1
Data capture	93.8%	96.4%	100%
Median	0.9 ppb	1.3 ppb	–
Annual average	2.9 ppb	See col. 2	2.9 ppb
70th percentile	1.3 ppb	2.8 ppb	–
Maximum	292 ppb	50 ppb	–
SEPP(AAQ) Objective	200 ppb	80 ppb	20 ppb
Percentage of time Objective met	99.94%	100%	100%
Exceedences of Objective	5 hours over 3 days	0	0
SEPP(AAQ) Goal	Exc. 1 day/year	Exc. 1 day/year	No exceedences
Exceedences of Goal	2 (days)	0	0

The five highest hourly average SO_2 concentrations at Jeeralang Hill occurred during the early morning hours on three days: 25/02/14 2:00-3:00 (292 ppb); 22/10/14 2:00-3:00 (237 ppb); 25/02/14 3:00-4:00 (222 ppb); 25/02/14 5:00-6:00 (206 ppb); 31/01/14 1:00-2:00 (204 ppb). These maxima occurred during easterlies with low wind speeds of approximately 2-3 m/s; i.e., a similar result to 2013; see Jacobs (2014). The higher SO_2 concentrations observed at Jeeralang Hill are indicative of plume strikes on higher ground in the Strzelecki Ranges due to emissions from coal-fired power stations.

Analysis of the concurrent SO_2 and wind data at Jeeralang Hill showed that the higher SO_2 concentrations can occur with wind direction almost anywhere in the northern sector, highlighting the complexity of air pollutant dispersion in this region; see **Appendix A**.

A summary of results of the analysis of the hourly average SO_2 concentrations acquired at Rosedale South in 2014 is set out in Table 5-2.

Table 5-2 Summary of Results: Rosedale South SO_2 Concentrations

Parameter (Rosedale South)	Hourly Averages	Daily Averages	Annual Average
Number of records	8161	347	1
Total records possible	8760	365	1
Data capture	93.2%	95.1%	100%
Median	1.2 ppb	1.4 ppb	–
Annual average	2.3 ppb	See col. 2.	2.3 ppb
70th percentile	1.5 ppb	1.0 ppb	–
Maximum	79 ppb $^{\#}$	21 ppb	–
SEPP(AAQ) Objective	200 ppb	80 ppb	20 ppb
Percentage of time Objective met	100%	100%	100%
Exceedences of Objective	0	0	0
SEPP(AAQ) Goal	Exc. 1 day/year	Exc. 1 day/year	No exceedences
Exceedences of Goal	0	0	0

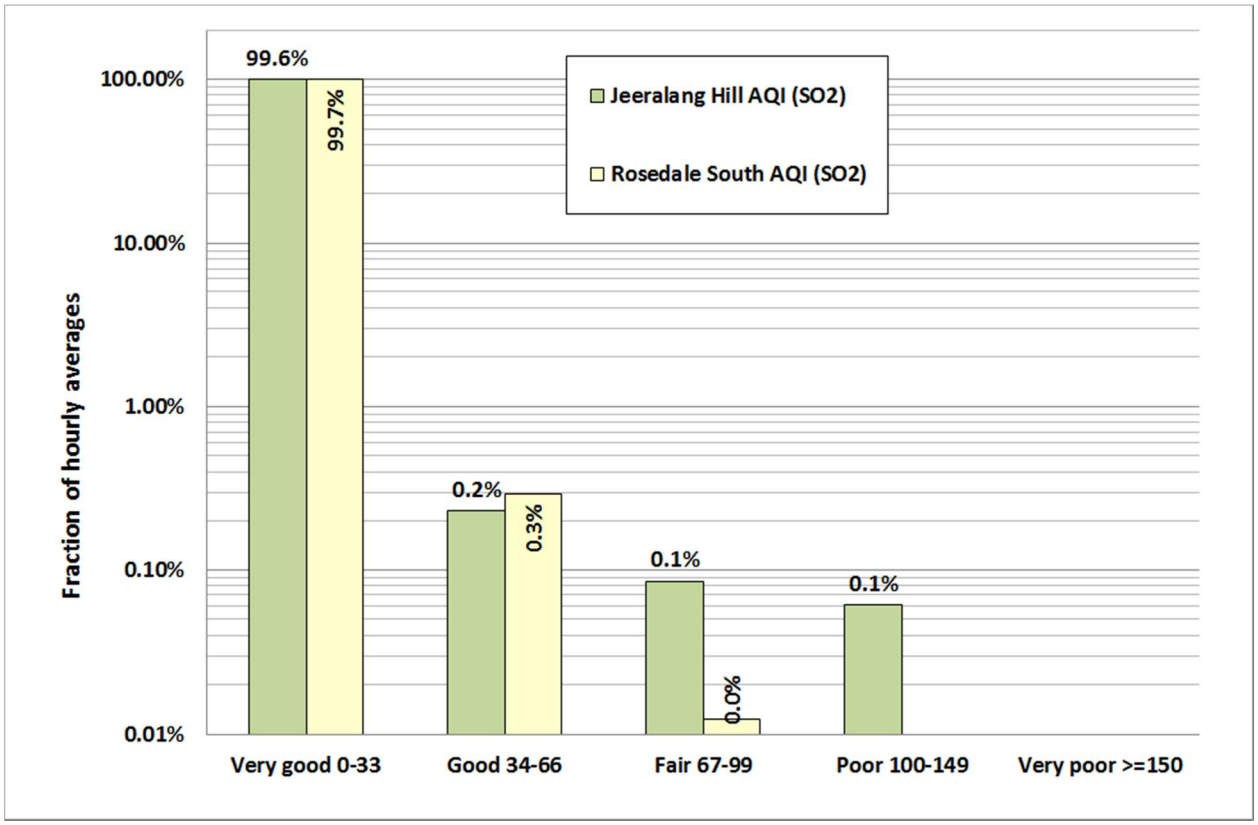
The three highest hourly average SO_2 concentrations at Rosedale South occurred on 11th January, 2014: 17:00-18:00 (79 ppb); 12:00-13:00 (64 ppb); and 16:00-17:00 (59 ppb). For comparison, at Jeeralang Hill peak hourly average SO_2 concentrations occurred in the first 2 hours of 11/1/14 (approximately 20 ppb), and a peak of 105 ppb was observed at Jeeralang Hill early on the previous day. The higher SO_2 results for 11/1/14 were likely caused by the coal-fuelled power stations. (The Hazelwood coal mine fire started on about 9/2/14 and did not cause significant SO_2 emissions).

5.3 Air Quality Indices from SO_2 Concentrations

Air Quality Indices (AQI) based on EPA Victoria procedures were calculated using the Jeeralang Hill and Rosedale South SO_2 data. Simply, the AQI is a concentration expressed as a percentage of the relevant air quality standard; in this case, maximum hourly average 200 ppb. The Jeeralang Hill and Rosedale South SO_2 results are provided as frequency distributions in Figure 5-2 (logarithmic plots). Inspection of Figure 5-2 clearly demonstrates that air quality due to SO_2 at Jeeralang Hill and Rosedale South was very good for the majority of the time; i.e., more than 99% of the time for both locations.

As expected, air quality due to SO_2 was slightly worse at Jeeralang Hill due to the closer proximity of the coal fuelled power stations, and the higher elevation of Jeeralang Hill, 510 metres above sea level, being more conducive to plume strikes (whereas Rosedale South is 52 metres above sea level).

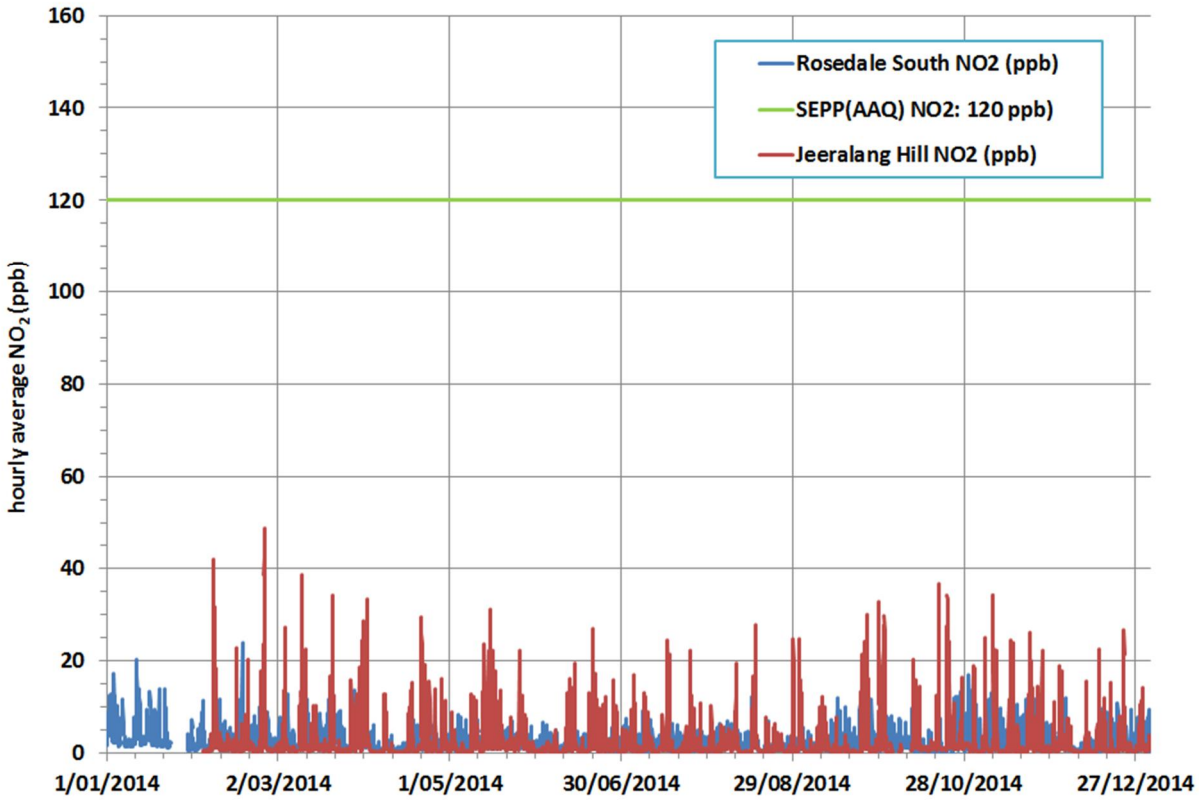
Figure 5-2 Frequency Distributions of Air Quality Indices – Hourly Average SO_2



5.4 Oxides of Nitrogen – Jeeralang Hill and Rosedale South

In 2014 oxides of nitrogen (NO_x) measurements were undertaken at Rosedale South, and NO_x measurements commenced at Jeeralang Hill on 3/2/14. The results for hourly average NO_2 concentrations (ppb) are provided in Figure 5-3. There were no exceedences of the SEPP(AAQ) objective of 120 ppb for maximum hourly NO_2 concentration at either location.

Figure 5-3 LVAMN Results for Hourly Average NO_2 Concentration (ppb)



A summary of results of the analysis of the Jeeralang Hill hourly average NO_2 concentrations is set out in Table 5-3. There were no exceedences of the SEPP(AAQ) objectives and goals for NO_2.

Table 5-3 Summary of Results: Jeeralang Hill NO_2 Concentrations

Parameter	Hourly Averages	Annual Average
No. records	7416	1
Total possible	8760	1
Data capture	84.7%	100%
Median	0.8 ppb	–
Annual average	2.0 ppb	2.0 ppb
70th percentile	1.3 ppb	–
Maximum	49 ppb	–
SEPP(AAQ) Objective	120 ppb	30 ppb
Percentage of time Objective met	100%	100%
Exceedences of Objective	0	0
SEPP(AAQ) Goal	Exc. 1 day/year	No exceedences
Exceedences of Goal	0	0

A statistical summary for all the NO_x components measured at Jeeralang Hill is provided in Table 5-4.

Table 5-4 Statistical Summary for All NO_x Components – Jeeralang Hill

Air Pollutant	Median Conc. (ppb)	Average Conc. (ppb)	70th Percentile Conc. (ppb)	Maximum Conc. (ppb)
NO	0.1	0.8	0.2	167
NO_2	0.8	2.0	1.3	49
NO_x	0.8	2.8	1.5	201

A summary of results of the analysis of the Rosedale South hourly average NO_2 concentrations is set out in Table 5-5. There were no exceedences of the SEPP(AAQ) objectives and goals for NO_2.

Table 5-5 Summary of Results: Rosedale South NO_2 Concentrations

Parameter	Hourly Averages	Annual Average
No. records	8158	1
Total possible	8760	1
Data capture	93.1%	100%
Median	1.7 ppb	–
Annual average	2.3 ppb	2.3 ppb
70th percentile	2.6 ppb	–
Maximum	24 ppb	–
SEPP(AAQ) Objective	120 ppb	30 ppb
Percentage of time Objective met	100%	100%
Exceedences of Objective	0	0
SEPP(AAQ) Goal	Exc. 1 day/year	No exceedences
Exceedences of Goal	0	0

A statistical summary for all the NO_x components measured at Rosedale South is provided in Table 5-6.

Table 5-6 Statistical Summary for All NO_x Components – Rosedale South

Air Pollutant	Median Conc. (ppb)	Average Conc. (ppb)	70th Percentile Conc. (ppb)	Maximum Conc. (ppb)
NO	0.3	0.7	0.5	22
NO_2	1.7	2.3	2.6	24
NO_x	2.1	3.0	3.2	39

5.5 Analysis of NO_2/NO_x Ratios

Further analysis of the NO_x data was undertaken by investigations of the ratios between the NO_2 and NO_x concentrations (NO_2/NO_x). Lower values of the NO_2/NO_x ratio can be indicative of local NO_x sources, in cases where some NO has had insufficient time to convert to NO_2. A select few of the NO_x data were used in this analysis. Data was selected by the following steps: (1) Negative and zero results for NO_x concentrations were removed; (2) NO_2/NO_x ratios greater than unity and less than or equal to zero were removed; and (3) Negative values for the NO concentrations were removed. The resulting NO_2/NO_x ratios are listed in Table 5-7.

Table 5-7 Summary of Calculated NO_2/NO_x Ratios for 2013 (Limited Dataset)

NO Range (ppb)	Median NO_2/NO_x Ratio	No. Hourly Records	Percentage of Hourly Data Used for Ratio
Jeeralang Hill			
1 ≤ [NO] < 5	72%	404	60%

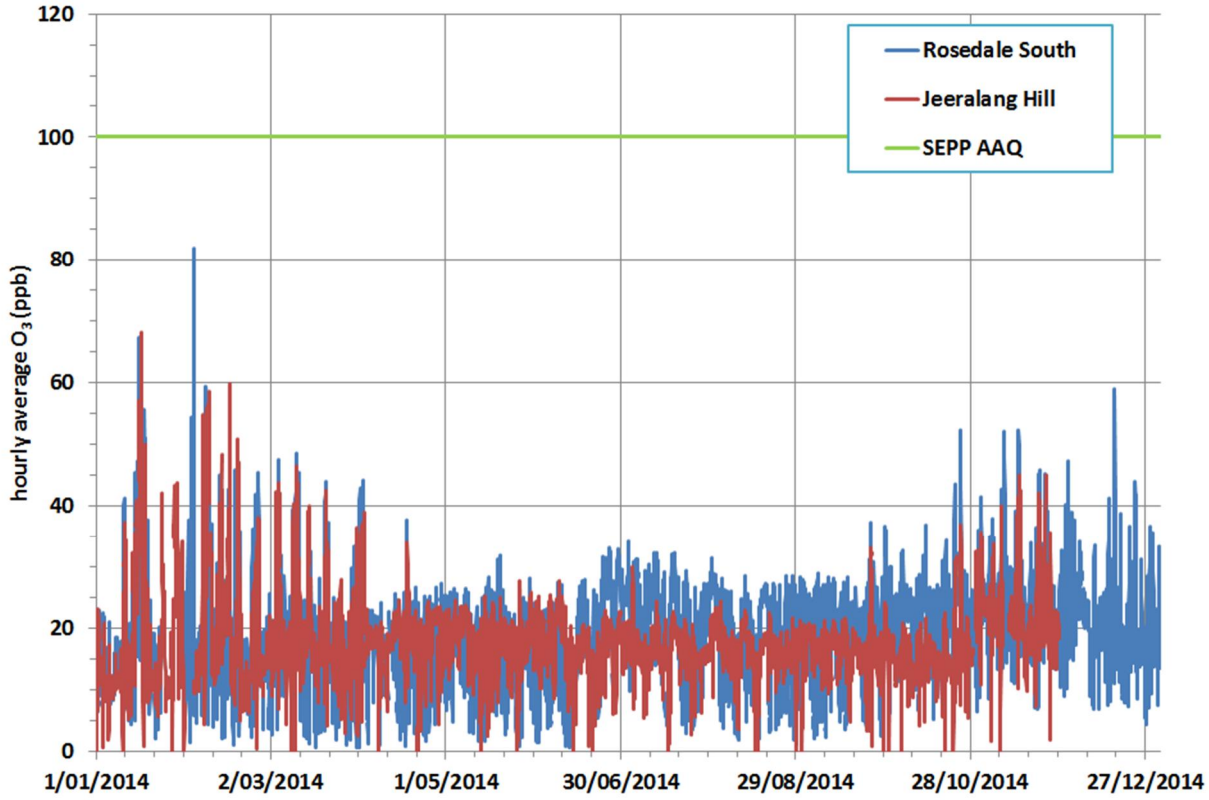
NO Range (ppb)	Median NO_2/NO_x Ratio	No. Hourly Records	Percentage of Hourly Data Used for Ratio
Jeeralang Hill			
5 ≤ [NO] < 10	62%	122	18%
10 ≤ [NO] < 20	53%	85	13%
[NO] ≥ 20	41%	57	9%
Rosedale South			
1 ≤ [NO] < 5	64%	1199	86%
5 ≤ [NO] < 10	53%	151	11%
10 ≤ [NO] < 20	47%	41	3%
[NO] ≥ 20	40%	3	<1%

Inspection of the results listed in Table 5-7 indicates that as the NO concentrations increase the NO_2/NO_x ratios decreases, which is typical of NO_x emissions from the combustion of fossil fuels; e.g., due to road vehicle traffic. The NO_2/NO_x ratios ranged between 17% and 29% for the four NO concentrations greater than approximately 100 ppb (all from Jeeralang Hill). There is a slight upwards trend in the NO_2/NO_x ratios as the NO concentrations decrease, which is indicative of NO_x that has been in the atmosphere for longer periods, allowing more time for NO_2 to form.

5.6 Ozone – Jeeralang Hill and Rosedale South

The Jeeralang Hill and Rosedale South results for hourly average O_3 concentrations (ppb) are provided in Figure 5-4. The results are shown with the SEPP(AAQ) hourly average objective (100 ppb); all the hourly O_3 data were less than the objective.

Figure 5-4 Ecotech LVAMN Results for Hourly Average O_3 Concentration (ppb)



Summaries of results of the analysis of the hourly average O_3 concentrations are set out in Table 5-8 (Jeeralang Hill); and Rosedale South (Table 5-9).

The O_3 concentrations were less at Jeeralang Hill; this is investigated in some further detail in the next section.

Table 5-8 Summary of Results: Jeeralang Hill O_3 Concentrations

Parameter (Jeeralang Hill)	1h average	4h rolling average
No. records	7382	8500
Total possible	8760	8757
Data capture	84.3%	97.1%
Median (ppb)	17	18
Annual average (ppb)	18	19
70th percentile (ppb)	20	20
Maximum (ppb)	68	57
SEPP(AAQ) Objective (ppb)	100	80
Percentage of time Objective met	100%	100%
Exceedences of Objective	0	0
SEPP(AAQ) Goal	Exc. 1 day/year	Exc. 1 day/year
Exceedences of Goal	0	0

Note: VG (2001) varied VG (1999) by removing the 8-hour average objectives for O_3.

Table 5-9 Summary of Results: Rosedale South O_3 Concentrations

Parameter (Rosedale South)	1h average	4h rolling average
No. records	8163	8499
Total possible	8760	8757
Data Capture	93.2%	97.1%
Median (ppb)	19	19
Annual average (ppb)	19	19
70th percentile (ppb)	23	23
Maximum (ppb)	82	73
SEPP(AAQ) Objective (ppb)	100	80
Percentage of time Objective met	100%	100%
Exceedences of Objective	0	0
SEPP(AAQ) Goal	Exc. 1 day/year	Exc. 1 day/year
Exceedences of Goal	0	0

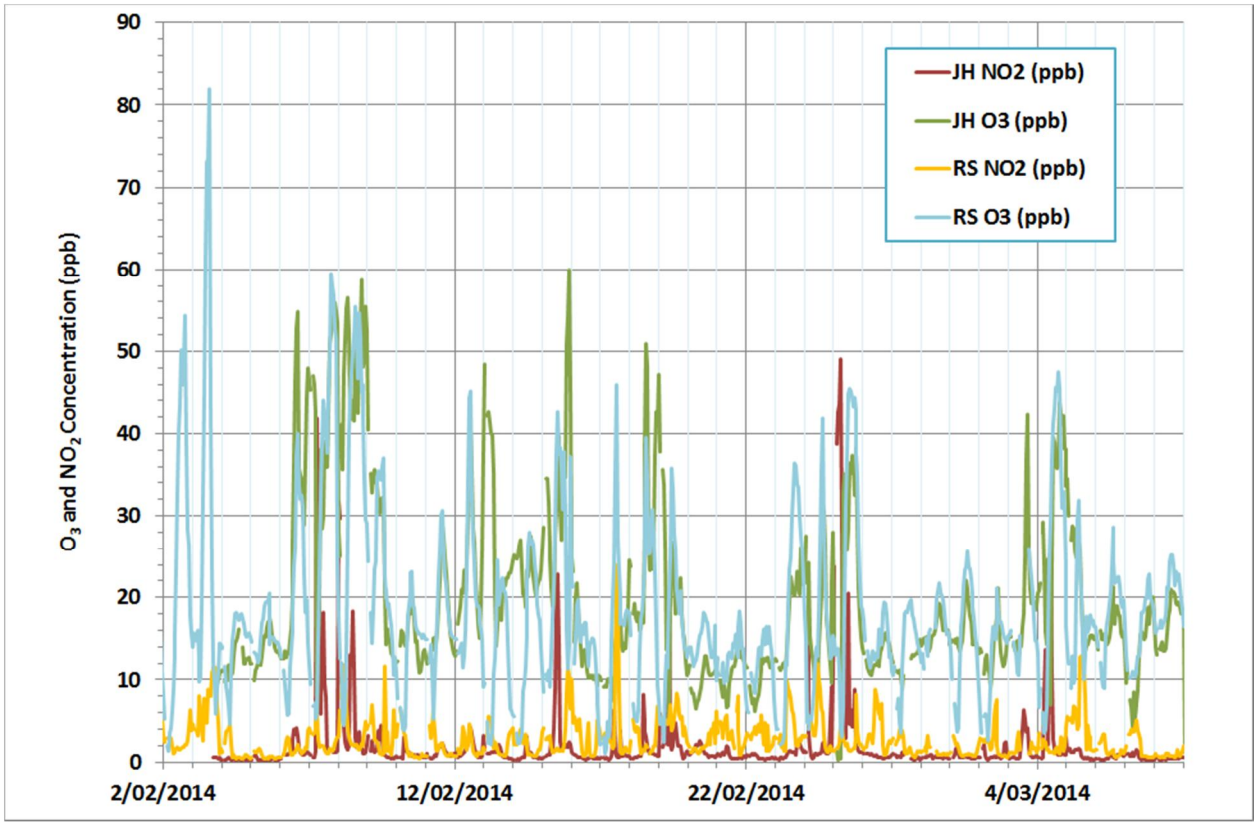
5.7 Products of Photolysis – O_3 and NO_2

This section provides a sample of results for concurrent hourly average O_3 and NO_2 concentrations; making use of the new NO_2 data acquired at Jeeralang Hill in 2014. In general the NO_2 concentrations at Jeeralang Hill and Rosedale South were low and variable, and there was clear evidence of photolysis occurring at both sites, with several well defined O_3 peaks occurring around midday during the summer; e.g., the hourly average data for the period 2/2/14–9/3/14 (covering approximately the period of the Hazelwood coal fire), are shown in Figure 5-5. The NO_2 present earlier in the mornings would have provided the oxygen for formation of O_3, in sunlight (see Sections 3.2 and 3.3).

Most of the hourly average O_3 and NO_2 data are shown in Figure 5-6 as scatter plots for Jeeralang Hill (left), and Rosedale South (right). The plots show quite different relationships between the data for the two sites, because Jeeralang Hill is affected by plume strikes from the power stations' emissions to a greater extent than the more distant Rosedale South. The atmospheric chemistry of photochemical smog is a complex subject; e.g., in addition to the reactions listed in Sections 3.2 and 3.3; other species are important such as CO and hydrocarbons. Releases of volatile organic compounds from the large forests in and near the Latrobe Valley, would contribute to the photochemistry. In any case in 2014, larger amounts of fresher NO_x emissions at

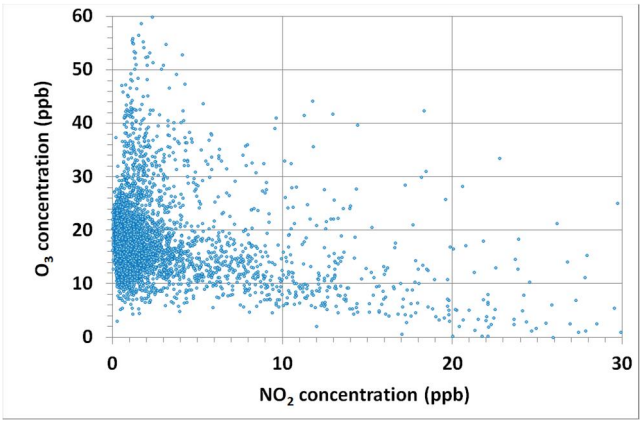
Jeeralang Hill contributed to O_3 formation (with NO_2 formation dominating over O_3). Whereas at Rosedale South, where there were smaller amounts of NO_x present, the formation of O_3 (in sunlight) tended to dominate.

Figure 5-5 Example of O_3 and NO_2 Measurements at Jeeralang Hill and Rosedale South: 2/2/14–9/3/15

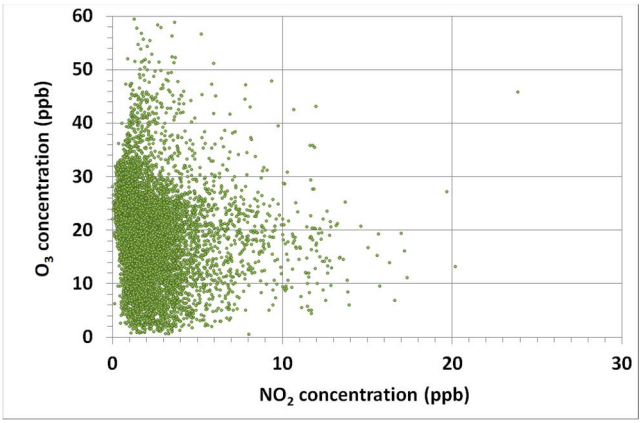


Note: Relevant SEPP (AAQ) Objectives are 100 ppb (O_3) AND 120 ppb (NO_2).

Figure 5-6 Hourly Average O_3 and NO_2: Jeeralang Hill (left) and Rosedale South (right)



Jeeralang Hill; NO_x (NO_2) more dominant

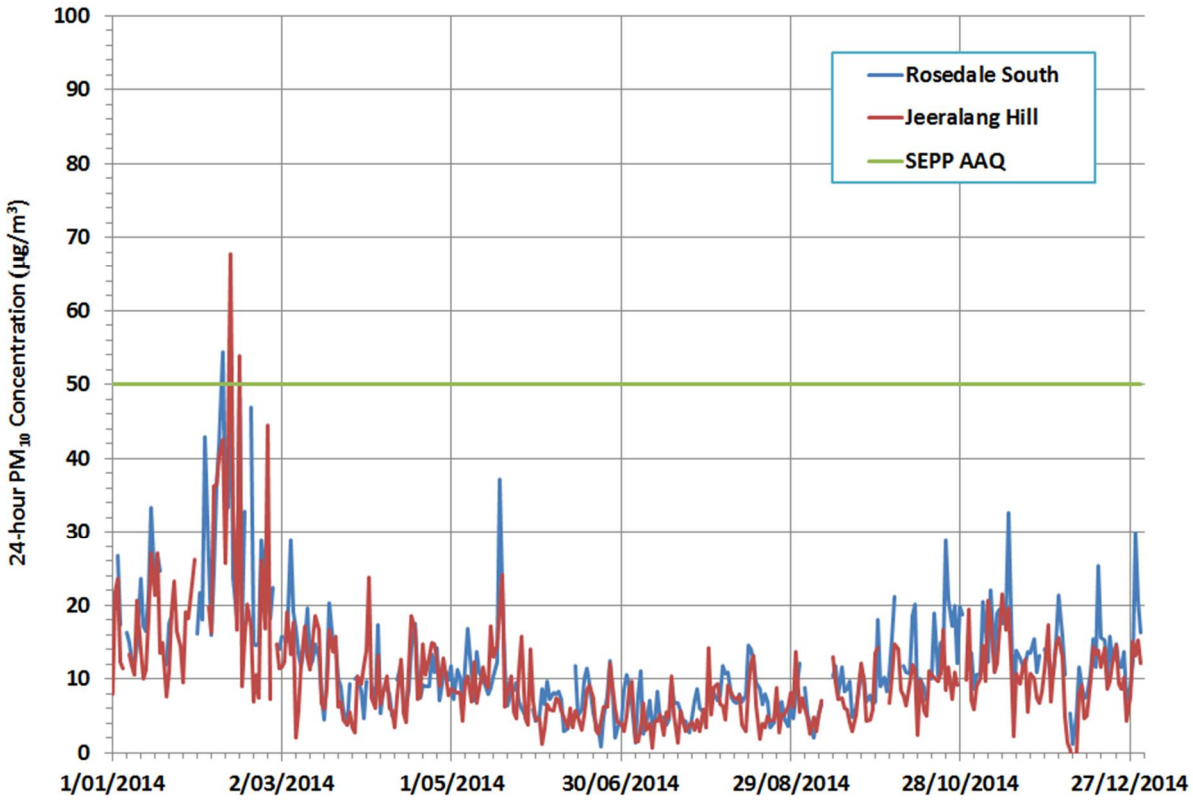


Rosedale South; O_3 more dominant

5.8 Particulate Matter as PM_{10} – Jeeralang Hill and Rosedale South

The Jeeralang Hill and Rosedale South results for daily average PM_{10} concentrations (µg/m^3) are provided in Figure 5-7; the relevant SEPP(AAQ) objective is also shown (50 µg/m^3). The good correlation between the PM_{10} measurements at Jeeralang Hill and Rosedale South indicates that for the majority of days the PM_{10} concentrations were due to regional influences, rather than local sources. The pattern is very similar to the EPA's PM_{10} data for Traralgon (see EPA, 2015c).

Figure 5-7 LVAMN Results for 24-Hour Average PM_{10} Concentration (µg/m^3)



A summary of results for PM_{10} data acquired at Jeeralang Hill and Rosedale South is set out in

Table 5-10. In summary, the NEPM objective was met on 363 days at Jeeralang Hill and 362 days at Rosedale South. At Jeeralang Hill, exceedences occurred on these days: 12/2/2014 (68 µg/m^3) and 15/2/2014 (54 µg/m^3); and at Rosedale South: 12/2/14 (55 µg/m^3); 9/2/14 (54 µg/m^3) and 15/2/14 (50 µg/m^3). The SEPP(AAQ) goal of not more than 5 exceedences (5 days) of this objective, was achieved at both sites.

Inspection of Figure 5-7 indicates there is an excellent correlation between the PM_{10} traces (linear correlation coefficient, 0.82). This is indicative of sampling of homogenous air masses significantly larger than the distance between the two stations. This means that most of the variations in PM_{10} concentrations shown would be characteristic of the atmosphere in the whole Latrobe Valley region, and not local sources such as stacks.

Table 5-10 Summary of Results for PM_{10} Concentrations (µg/m^3) – Jeeralang Hill and Rosedale South

Parameter	Jeeralang Hill	Rosedale South
No. of hourly averages	8513	8403
Data capture (hourly data)	97.2%	95.9%
Median of hourly averages	8.0 µg/m^3	10 µg/m^3
Annual average of hourly averages	11 µg/m^3	12 µg/m^3
70th percentile of hourly averages	12 µg/m^3	14 µg/m^3

Parameter	Jeeralang Hill	Rosedale South
Maximum hourly average	237 µg/m^3	294 µg/m^3
No. of daily averages	351	343
Maximum daily average	68 µg/m^3	55 µg/m^3
SEPP(AAQ) Objective	50 µg/m^3	50 µg/m^3
Percentage of time Objective met	99.4%	99.1%
Exceedences of Objective	2	3
Days of exceedences and values (µg/m^3)	12/2/2014 (68); 15/2/2014 (54)	9/2/14 (54); 12/2/14 (55); 15/2/14 (50)
SEPP(AAQ) Goal	Exceedences 5 days per year	Exceedences 5 days per year
Exceedences of Goal	0	0

5.9 Local Visual Distance

In this section Standard International (SI) units are used for the scattering coefficient (B_{sca}) in an attempt to provide some clarity around the procedure first set out in VG (1982); see Section 3.5 for details.

A summary of the nephelometer results for the hourly average scattering coefficient (B_{sca}) is provided in Table 5-11. Values for LVD calculated from the B_{sca} statistics using the VG (1982) procedure are shown alongside.

Table 5-11 Summary of results for nephelometer measured B_{sca}; Rosedale South 2014

Statistic	B_{sca} (m^{-1})	Calculated LVD (km)
Number of hourly averages	8246 (94.1% of year)	N/A
Maximum hourly average B_{sca}	1.8×10^{-3} m^{-1}	2.6 km
70th percentile hourly average B_{sca}	4.5×10^{-5} m^{-1}	103 km
Median hourly average B_{sca}	3.9×10^{-5} m^{-1}	121 km
Minimum hourly average B_{sca}	1.5×10^{-5} m^{-1}	313 km

A summary of results for the 8246 hourly average *LVD* calculations is provided in Table 5-12. Values for B_{sca} calculated from the *LVD* statistics using the VG (1982) procedure, are shown alongside.

Table 5-12 Summary of results for calculated LVD; Rosedale South 2014

Statistic	*LVD (km)*	Calculated B_{sca} (m^{-1})
Number of hourly averages	8246 (94.1% of year)	N/A
Maximum hourly average *LVD*	313 km	1.5×10^{-5} m^{-1}
70th percentile hourly average *LVD*	140 km	3.4×10^{-5} m^{-1}
Median hourly average *LVD*	121 km	3.9×10^{-5} m^{-1}
Minimum hourly average *LVD*	2.6 km	1.8×10^{-3} m^{-1}
Number of exceedences of the minimum hourly average LVD; 20 km	54 (0.7% of annual hours), occurring on 12 days	N/A
Exceedences of goal (not >3 days)	9 (2.5% of annual days)	N/A

Analysis of the results for LVD showed that there were high uncertainties associated with calculated LVD values. This is indicative of a weakness of the VG (1982) method.

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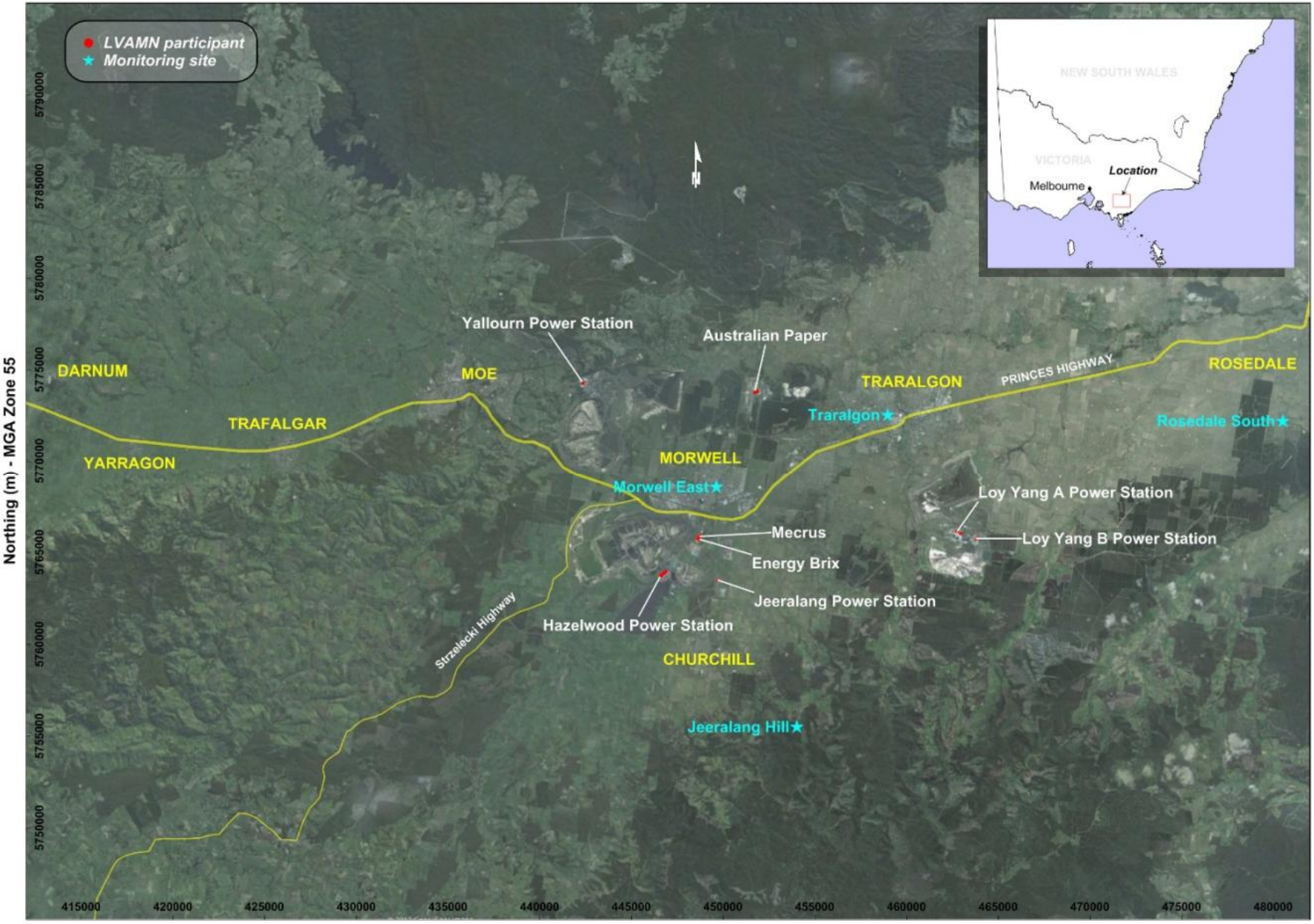
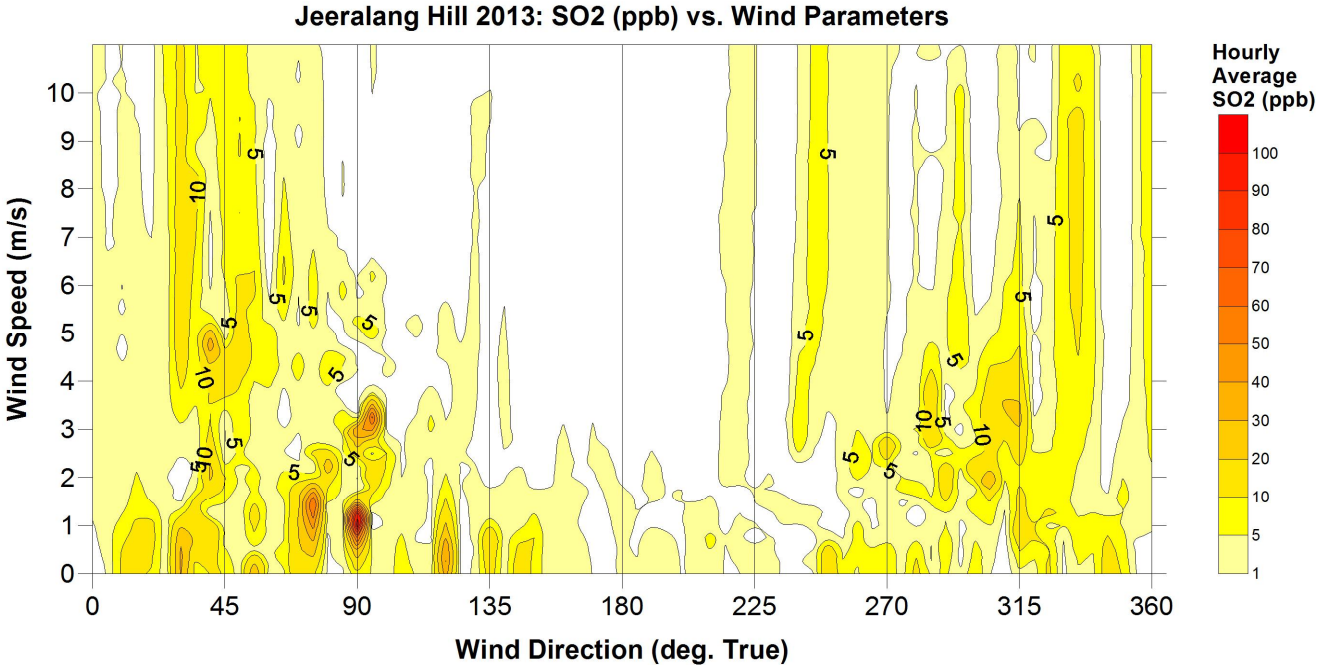
Appendix A. Map of Latrobe Valley

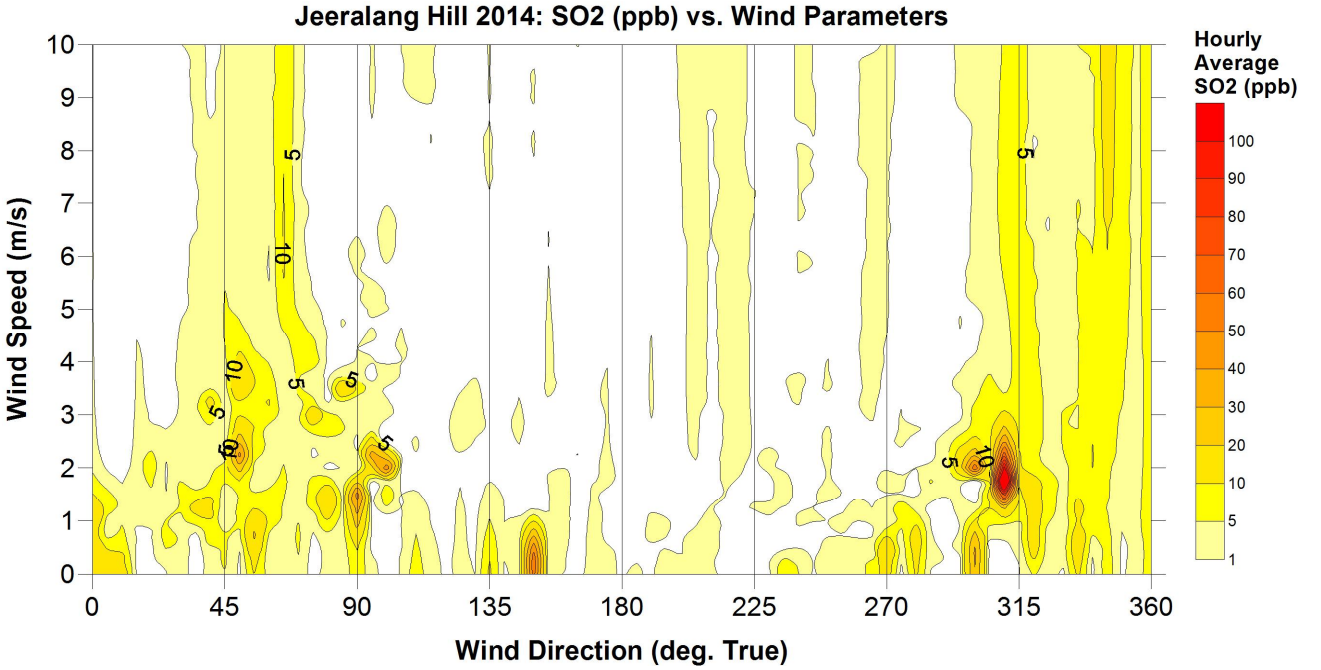

LVAMN participant
Monitoring site
NEW SOUTH WALES
VICTORIA
Location
Melbourne
Yallourn Power Station
Australian Paper
DARNUM
MOE
TRARALGON
PRINCES HIGHWAY
ROSEDALE
Traralgon★
Rosedale South★
TRAFALGAR
YARRAGON
MORWELL
Morwell East★
Loy Yang A Power Station
Loy Yang B Power Station
Mecrus
Energy Brix
Jeeralang Power Station
Hazelwood Power Station
Strzelecki Highway
CHURCHILL
Jeeralang Hill★
Northing (m) - MGA Zone 55
Easting (m) - MGA Zone 55
5790000
5785000
5780000
5775000
5770000
5765000
5760000
5755000
5750000
415000
420000
425000
430000
435000
440000
445000
450000
455000
460000
465000
470000
475000
480000

Appendix B. Jeeralang Hill 2013-2014: SO_2 and Winds

The SO_2-winds map shows hourly average SO_2 concentrations (ppb) measured at Jeeralang Hill in 2014, versus concurrent hourly average wind direction (degrees True), and wind speed (m/s).

The results illustrated highlight the complexity of air pollutant dispersion in the Strzelecki Ranges of the Latrobe Valley; e.g., while there were no significant sources of SO_2 directly to the east of Jeeralang Hill, there is a tendency for higher SO_2 concentrations to be observed during easterly winds. The most likely sources of the highest SO_2 concentrations observed in the sector ENE-to-E would have been the nearby Loy Yang power stations. Energy Brix Australia Corporation, Energy Australia Yallourn and Hazelwood Power Station are potential contributors to the band of SO_2 results in the NW sector (refer to map in Figure 1-1).

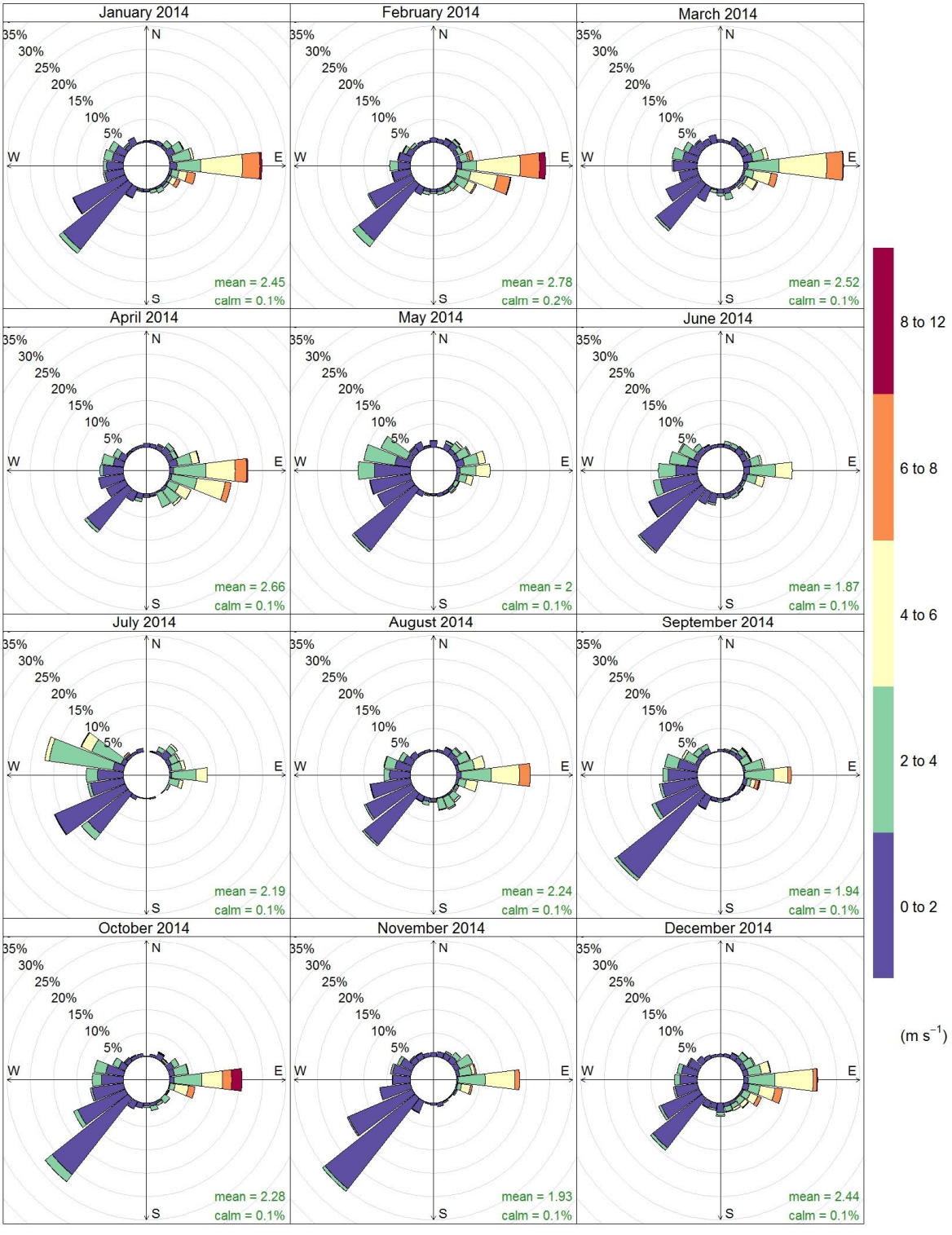




Appendix C. Wind Roses

C.1 Jeeralang Hill 2014 Wind Roses

The Jeeralang Hill 2014 monthly wind rose plots were created using 8617 records of hourly average wind speed and wind direction data (for data capture see **Section 4.2**).



C.2 Rosedale South 2014 Wind Roses

The Rosedale South 2014 monthly wind rose plots were created using 6697 records of hourly average wind speed and wind direction data (for data capture see **Section 4.2**).