



# Lower Hunter Particle Characterisation Study

3<sup>rd</sup> Progress Report (Spring)

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January 2015

Prepared for  
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## Citation

Hibberd MF, Keywood MD, Cohen DD, Stelcer E, Scorgie Y and Thompson S (2015). Lower Hunter Particle Characterisation Study, 3<sup>rd</sup> Progress Report (Spring). CSIRO, Australia.

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# Acknowledgments

This project is funded by

- NSW Environment Protection Authority (EPA)
- NSW Office of Environment & Heritage
- NSW Department of Health
- CSIRO Climate & Atmosphere Theme
- ANSTO

The project is supported by the Project Management Team of Matt Riley, Yvonne Scorgie, Judy Greenwood, Ann Louise Crotty, Leanne Graham, Wayne Smith, John Kirkwood, Keith Craig, Mark Hibberd, Melita Keywood, David Cohen, and Ed Stelcer.

We acknowledge the contributions of the CSIRO project support team of Kate Boast and Paul Selleck, the ANSTO project support team of David Garton and Armand Atanacio, and OEH project field staff Peter Crabbe, Scott Thompson, Gareth James and Stuart Masson.

Support provided by Orica Limited for the study by facilitating sampling at Stockton Air Quality Monitoring Site and making available monitoring records from this site is gratefully acknowledged.

Support extended by CSIRO Energy Centre for the establishment of study samplers on the grounds of the centre in Mayfield is acknowledged.

# 1 Introduction

The Lower Hunter Particle Characterisation Study (LHPCS) was initiated in 2013 and is being undertaken to provide the EPA and communities in the Lower Hunter with scientific information about the composition and likely sources of fine airborne particles in their local environment. The study represents a collaboration between the NSW Environment Protection Authority (EPA), the NSW Office of Environment and Heritage (OEH), NSW Health, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Australian Nuclear Science and Technology Organisation (ANSTO). Following the establishment of governance arrangements and an independently peer reviewed study design, the one year airborne particle study program commenced on 1 March 2014 with the first samples collected on 2 March.

This 3<sup>rd</sup> Progress Report documents the samples collected during the second quarter from September to November 2014 (Spring period) of the one year sampling program. It also includes presentation of wind and pollution roses for the sampling period.

## 1.1 Study Objectives

The Lower Hunter Particle Characterisation Study aims to determine the composition of PM<sub>2.5</sub> and PM<sub>10</sub> air particles, and to identify major sources contributing to PM<sub>2.5</sub> and PM<sub>10</sub> concentrations in the region to inform EPA's control programs<sup>1</sup>.

Specific sub-objectives are as follows:

- Determine the composition and major sources contributing to PM<sub>2.5</sub> concentrations at sites representative of regional population exposures.
- Establish airborne particle composition and major sources contributing to PM<sub>2.5</sub> and PM<sub>10</sub> concentrations at sites indicative of population exposures in areas near to the Newcastle Port.

## 1.2 Study Scope and Overview

The study comprises PM<sub>2.5</sub> sampling at four sites in the Lower Hunter region over a one year period, including two sites representative of wider community exposures in the region (Newcastle and Beresfield) and two sites indicative of public exposures in areas neighbouring the Newcastle Port (Stockton and Mayfield). PM<sub>10</sub> sampling and analysis is also being undertaken for the Stockton and Mayfield sites in response to community requests that PM<sub>10</sub> be addressed. The sampling site locations are shown in Figure 1.

Existing or planned ambient air quality monitoring sites were preferred locations since they allow timely establishment of study sampling sites. These sites also have continuous particulate matter and gaseous monitoring records and meteorological data that can be used during the source apportionment analysis. Selected study sites coincided with the existing OEH Beresfield Air Quality Monitoring (AQM) Station, the OEH Newcastle AQM Station, the Orica Fullerton Street Stockton AQM Station, and CSIRO Energy Centre in Mayfield West. Sampling is being conducted over the period 1 March 2014 to 28 February 2015. Since sampling commenced, OEH-operated AQM Stations have been commissioned at CSIRO Energy Centre in July 2014 and at the Orica Fullerton Street Stockton site in October 2014, as part of the Newcastle Local Air Quality Monitoring Network.

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<sup>1</sup> PM<sub>2.5</sub> and PM<sub>10</sub> refer to airborne particulate matter with an equivalent aerodynamic diameter of 2.5 micrometres and 10 micrometres respectively.



**Figure 1 Overview of locations of sampling sites for Lower Hunter Particle Characterisation Study**

A summary of the monitoring sites, equipment and filter types and sampling schedules for the study is given in Table 1.

Sample analysis for the PM<sub>2.5</sub> component will include Ion Beam Analysis (IBA) techniques and Ion Chromatography (IC) on the Teflon filters and organic and elemental carbon (OC/EC) analysis using a DRI Model 2001A Thermal-Optical Carbon Analyzer for the quartz filters.

The use of ANSTO ASP PM<sub>2.5</sub> cyclone samplers at each of the four sites provides the basis for gravimetric analysis to determine PM<sub>2.5</sub> concentrations. Combining results from the gravimetric analysis of the coarse (PM<sub>2.5-10</sub>) and fine (PM<sub>2.5</sub>) fractions from the GENT SFU sampling will allow PM<sub>10</sub> concentrations to be determined.

**Table 1 LHPCS monitoring sites, equipment, filter types and sampling schedule**

MONITORING SITE:	EQUIPMENT, SIZE FRACTION AND FILTER TYPE	SAMPLING SCHEDULE
OEH Newcastle AQM Station	Two ANSTO Aerosol Sampling Program (ASP) PM <sub>2.5</sub> cyclone samplers – one collecting on Teflon filter and one on a quartz filter.	1-in-3 days
OEH Beresfield AQM Station	Two ANSTO ASP PM <sub>2.5</sub> samplers – one collecting on Teflon filter and one on a quartz filter.	1-in-3 days
OEH Mayfield AQM Station (at CSIRO Energy Centre)	One GENT Stacked Filter Unit (SFU) sampling ‘coarse’ (PM <sub>2.5-10</sub> ) particles on a Nuclepore filter and ‘fine’ (PM <sub>2.5</sub> ) particles on a quartz filter. One ANSTO ASP PM <sub>2.5</sub> sampler collecting fine particles on a Teflon filter has been relocated to this site from the nearby former Steel River AQM station. (Separately funded program, with sampling done by OEH, analysis by ANSTO, and funded by the EPA.)	1-in-3 days
OEH Stockton AQM Station (formerly Orica Fullerton Street Stockton AQM Station)	One GENT SFU sampling ‘coarse’ (PM <sub>2.5-10</sub> ) particles on a Nuclepore filter and ‘fine’ (PM <sub>2.5</sub> ) particles on a quartz filter. One ANSTO ASP PM <sub>2.5</sub> cyclone sampler collecting fine particles on a Teflon filter already in operation at this site. (Separately funded program with sampling and analysis undertaken by ANSTO, funded by Orica).	1-in-3 days

Chemical analysis of the PM<sub>2.5-10</sub> component will include IBA and IC on the Nuclepore filters in addition to black carbon (BC) being determined through the use of the Laser Integrated Plate Method (LIPM), which is a light absorption technique. Given that organic carbon is primarily in the fine fraction, the use of quartz filters to support OC/EC analysis of the coarse fraction is not required.

The chemical composition of all the samples will subsequently be input into receptor modelling using a mathematical technique called Positive Matrix Factorisation (PMF) to identify factors and the contribution of each factor to the total PM<sub>2.5</sub> and PM<sub>10</sub> concentration. The key source of emissions in each factor will be identified using a range of information including source characteristics, wind data and the pattern of seasonal variation in the factor.

The [First Progress Report \(PDF, 1.4MB - July 2014\)](#) provides more information on the study method and the sampling program commissioning phase, as well as details about the samples collected during the first quarter (autumn) sampling period. The [Second Progress Report \(PDF, 1.3 MB – October 2014\)](#) summarises data collected during the second quarter (Winter) sampling period and presents photographs of the sampling sites.

## 2 Report on September-November 2014 Sampling

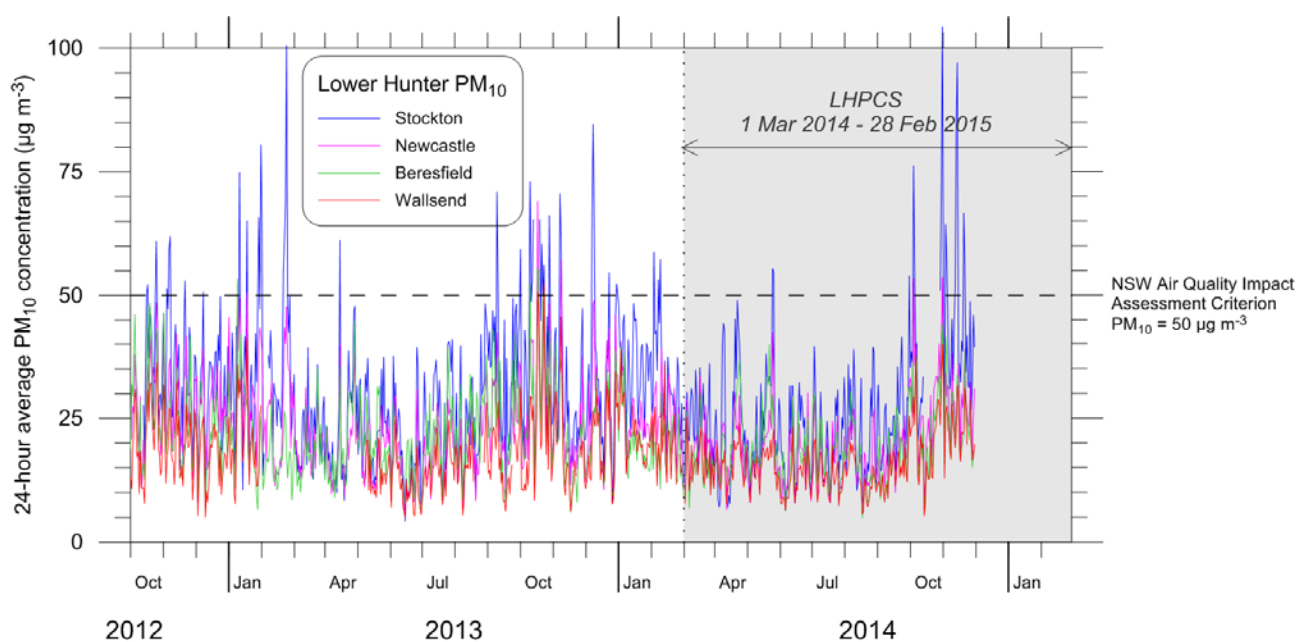
### 2.1 Long-term Regional Air Quality Monitoring

The OEH-operated air quality monitoring stations at Beresfield, Newcastle and Wallsend characterise regional air quality and provide a framework for the detailed particle characterisation study. PM<sub>10</sub>, PM<sub>2.5</sub>, ozone (O<sub>3</sub>), oxides of nitrogen (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>), carbon monoxide (CO) and meteorology (wind speed, wind direction, air temperature and relative humidity) are continuously measured at these stations.

Long-term time series of PM<sub>10</sub> and PM<sub>2.5</sub> for the period October 2012 – November 2014 are shown in Figure 2 and Figure 3. Data are included from the OEH monitoring stations and the site at Stockton, which was run by Orica until 14 October 2014. Table 2 lists some key statistics of the 2013 and 2014 PM<sub>10</sub> and PM<sub>2.5</sub> results – average, median, maximum, and number of days exceeding the criteria.

The figures show stronger regional variations in PM<sub>10</sub> than PM<sub>2.5</sub> concentrations. The PM<sub>10</sub> levels recorded at Stockton are generally higher and characterised by some localised peaks not evident at the regional air quality monitoring stations. PM<sub>2.5</sub> levels measured at the Stockton monitoring station are comparable to levels measured at the OEH Beresfield and Wallsend stations for much of the year, with average and median levels only marginally higher.

Figure 2 shows that the PM<sub>10</sub> values are lowest during both March – August periods, whereas PM<sub>2.5</sub> are lowest in January – April (Figure 3). A clearer picture of the relative importance of the fine and coarse fractions of PM<sub>10</sub> is provided by Figure 4, which shows the smoothed 31-day running average of the PM<sub>2.5</sub>/PM<sub>10</sub> ratio at the four sites and for the last few months for the new Mayfield Site. The almost two years of data shows an annual trend of the PM<sub>2.5</sub>/PM<sub>10</sub> ratio being highest in winter and lowest in summer. Reasons for this will be more fully explored during the final stages of the study when source apportionment modelling is undertaken.



**Figure 2** Long-term (Oct 2012 – Nov 2014) time series of 24-hour average PM<sub>10</sub> concentrations recorded at the OEH Lower Hunter monitoring stations including the Stockton station (run by Orica until 14 October 2014)



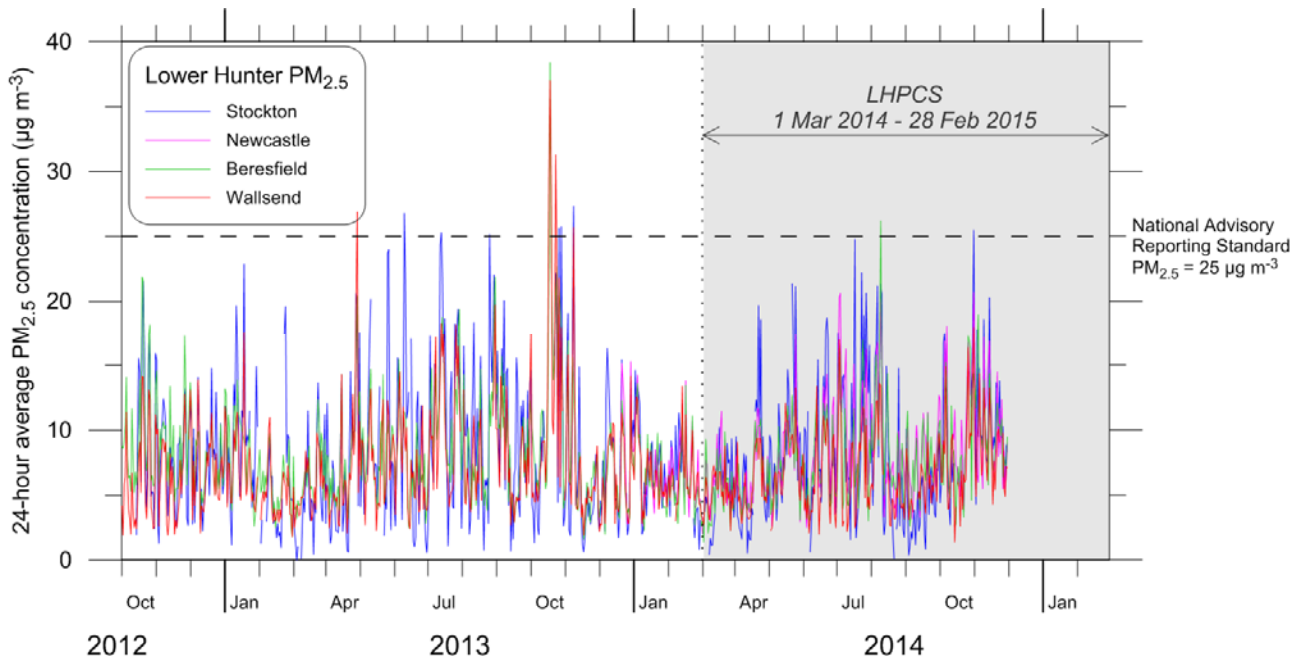


Figure 3 Long-term (Oct 2012 – Nov 2014) time series of 24-hour average PM<sub>2.5</sub> concentrations recorded at the OEH Lower Hunter monitoring stations including the Stockton station (run by Orica until 14 October 2014)

Table 2 Key statistics of the 2013 and 2014 PM<sub>10</sub> and PM<sub>2.5</sub> monitoring results; note that the statistics for 2014 include December 2014 results (not shown in the above figures)

MONITORING SITE	BERESFIELD		NEWCASTLE		STOCKTON		WALLSEND	
	2013	2014	2013	2014	2013	2014	2013	2014
PM <sub>10</sub> (µg m <sup>-3</sup> )								
Average	21.4	19.4	22.7	21.4	29.6	29.1	17.4	16.9
Median	19.1	18.3	20.5	20.5	26.6	27.0	15.5	16.1
Maximum	55.3	45.4	69.0	53.7	100.5	104.3	52.5	43.4
Days>50 µg m <sup>-3</sup>	5	0	4	2	28	26	2	0
PM <sub>2.5</sub> (µg m <sup>-3</sup> )								
Average	8.2	7.5		8.1	8.6	8.0	7.7	6.7
Median	7.2	6.9		7.3	7.3	7.3	6.2	6.3
Maximum	38.4	26.2		20.7	32.6	25.5	37.0	18.0
Days>25 µg m <sup>-3</sup>	1	1		0	7	1	6	0

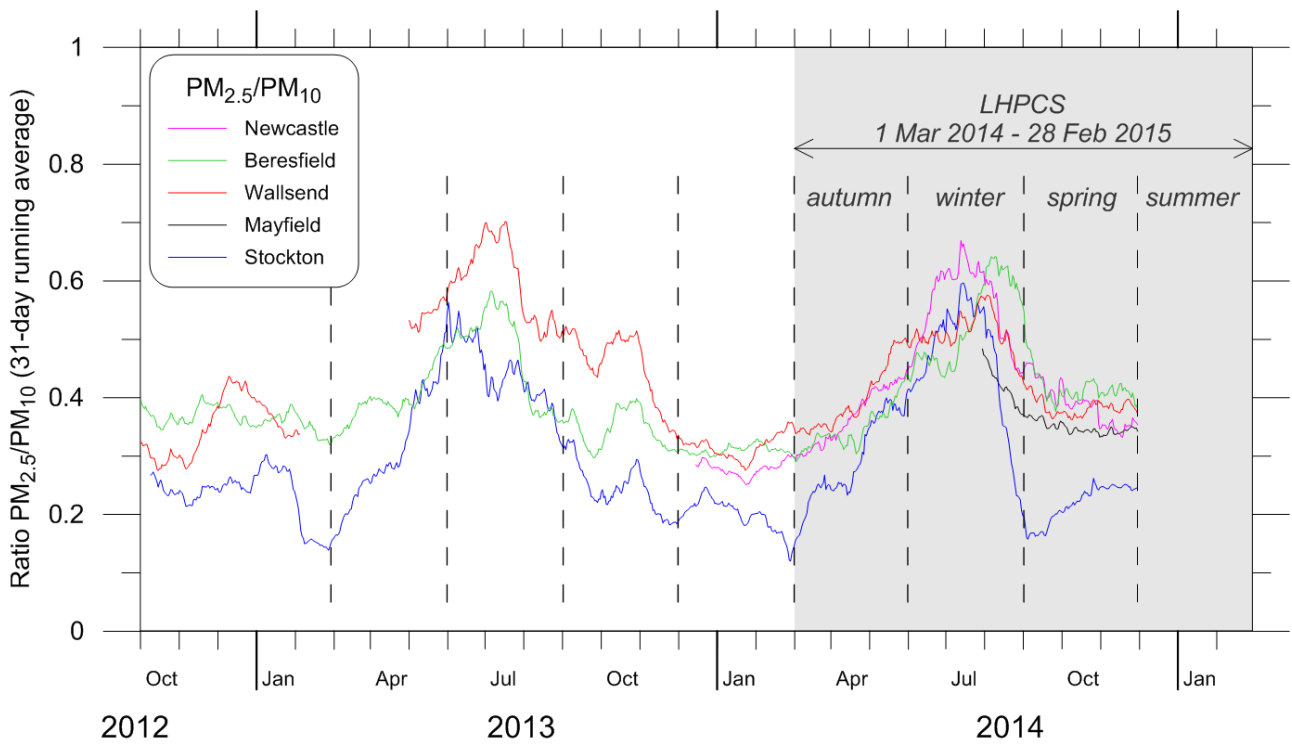


Figure 4 Long-term time series of  $PM_{2.5}/PM_{10}$  ratio (31-day running average) recorded at OEH and Newcastle Local air quality monitoring stations (Oct 2012 – Nov 2014). The Stockton station was run by Orica until 14 October 2014.

## 2.2 Sampling Report

Table 3 lists the status of the sample collection for the third 3 months of the study, with sample collection rates of 100% achieved for seven of the sampler-filter trains and 99% for the Mayfield site, which suffered a power outage at 18:54 on 15/11/2014. This exceeds the LHPCS aim of a 95% valid sample collection rate.

In October 2014, the Orica Fullerton Street Stockton monitoring station was replaced by a comprehensive OEH-operated AQM station on the same site. This site is now part of the new Newcastle Local Air Quality Monitoring Network. The change-over took place on a LHPCS non-sampling day, 14 October, with the LHPCS sampling equipment installed on the roof and fully functional before the next sampling day on 16 October. The change-over is not expected to have any impact on the sampling results, but there was loss of about 3 days of wind direction data.

**Table 3 Status of sample collection for Spring sampling period (September-November 2014)**

SITE	BERESFIELD PM <sub>2.5</sub>		NEWCASTLE PM <sub>2.5</sub>		MAYFIELD PM <sub>COARSE</sub> & PM <sub>2.5</sub>			STOCKTON PM <sub>COARSE</sub> & PM <sub>2.5</sub>		
	ASP14 TEFLON	ASP15 QUARTZ	ASP12 TEFLON	ASP13 QUARTZ	ASP10 TEFLON PM <sub>2.5</sub>	GAS44C NUCLEPORE PM <sub>COARSE</sub>	GAS44Q QUARTZ PM <sub>2.5</sub>	ASP89 TEFLON PM <sub>2.5</sub>	GAS43C NUCLEPORE PM <sub>COARSE</sub>	GAS43Q QUARTZ PM <sub>2.5</sub>
01/09/2014	✓	✓ C	✓	✓ C	✓	✓	✓ C	✓	✓	✓
04/09/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
07/09/2014	✓	✓ C	✓	✓ C	✓	✓	✓ C	✓	✓	✓
10/09/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
13/09/2014	✓	✓ C	✓	✓ C	✓	✓	✓ C	✓	✓	✓ C
16/09/2014	✓ C	✓	✓	✓	✓ C	✓	✓	✓	✓	✓
19/09/2014	✓	✓ C	✓ C	✓ C	✓	✓ C	✓	✓ C	✓ C	✓
22/09/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
25/09/2014	✓	✓ C	✓	✓ C	✓	✓	✓	✓	✓	✓
28/09/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
01/10/2014	✓	✓ C	✓	✓ C	✓	✓	✓	✓	✓	✓
04/10/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
07/10/2014	✓	✓ C	✓	✓ C	✓	✓	✓	✓	✓	✓
10/10/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
13/10/2014	✓ C	✓ C	✓ C	✓ C	✓ C	✓ C	✓ C	✓ C	✓ C	✓ C
16/10/2014	✓	✓	✓	✓	✓	✓	✓	✓ OEH	✓ OEH	✓ OEH
19/10/2014	✓	✓ C	✓	✓ C	✓	✓	✓	✓	✓	✓
22/10/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
25/10/2014	✓	✓ C	✓	✓ C	✓	✓	✓ C	✓	✓	✓
28/10/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
31/10/2014	✓	✓ C	✓*	✓* C	✓*	✓*	✓* C	✓*	✓*	✓*
03/11/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
06/11/2014	✓	✓ C	✓	✓ C	✓	✓	✓	✓	✓	✓
09/11/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
12/11/2014	✓ C	✓ C	✓	✓ C	✓ C	✓ C	✓ C	✓ C	✓ C	✓ C
15/11/2014	✓	✓	✓	✓	✓ <sup>19/24</sup>	✓ <sup>19/24</sup>	✓ <sup>19/24</sup>	✓	✓	✓
18/11/2014	✓ C	✓ C	✓ C	✓ C	✓ C	✓	✓	✓ C	✓ C	✓ C
21/11/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
24/11/2014	✓	✓ C	✓	✓ C	✓	✓	✓	✓	✓	✓
27/11/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
30/11/2014	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Sample collection rate	100%	100%	100%	100%	99%	99%	99%	100%	100%	100%

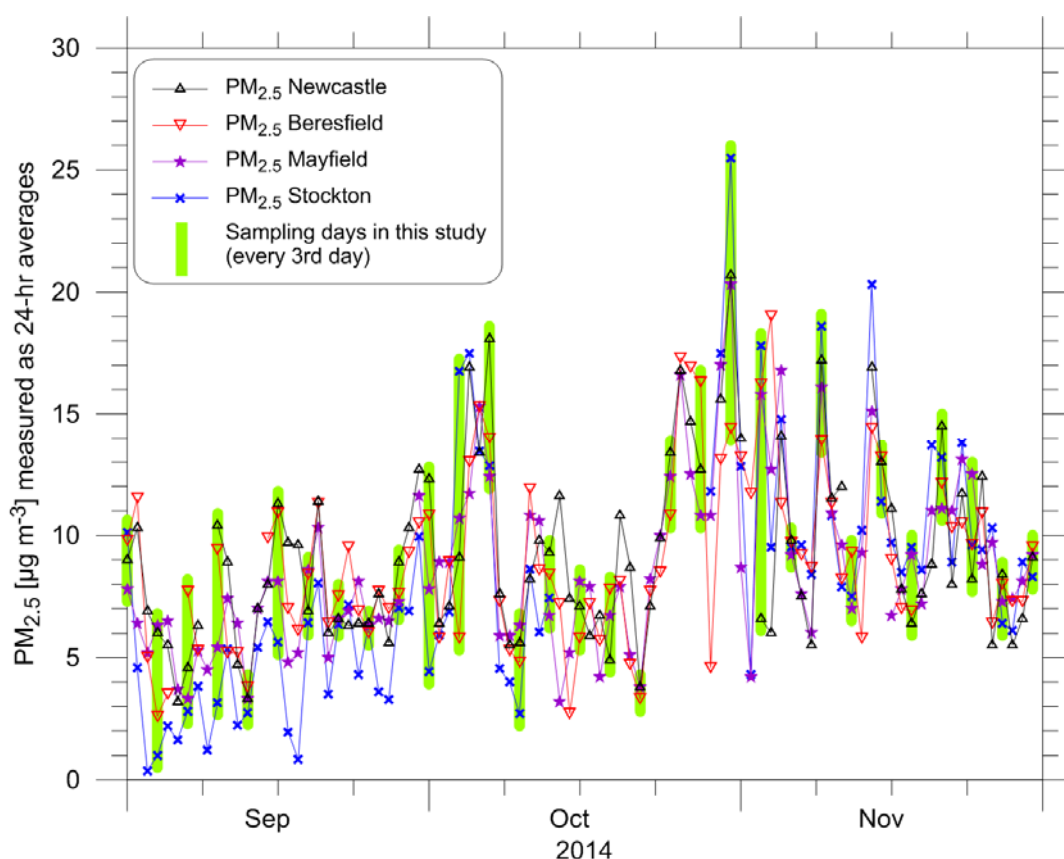
Notes:

- ✓ - Filter sample collected;
- C – control (unexposed) filter included;
- OEH – sampling instruments moved to roof of new OEH station on 14/10/2014 replacing previous Orica station on the same site;
- \* - high filter loadings on 31/10/2014 at Stockton, Newcastle, and Mayfield probably due to bushfires in the area;
- <sup>19/24</sup> – only sampled for 19 hours because of power outage at Mayfield

## 2.3 Daily PM Results from the Monitoring Sites

Figure 5 shows the time series of 24-hour average  $PM_{2.5}$  concentrations measured at the Newcastle, Beresfield, Stockton and newly installed Mayfield monitoring sites using the standard TEOM and BAM equipment for the Spring period (September – November) of the study. The green bars highlight the days when 1-in-3-day sampling was carried out for the current study. It shows that these are representative of the full period, including days with both low and high concentrations, including the day with the highest concentrations at most sites, 31 October.

The average  $PM_{2.5}$  concentrations for the September – November period were  $9.2 \mu g m^{-3}$  at Newcastle,  $9.0 \mu g m^{-3}$  at Beresfield,  $8.7 \mu g m^{-3}$  at Mayfield, and  $8.1 \mu g m^{-3}$  at Stockton. These averages are very similar to the Winter averages, except at Stockton where the Spring average is 15% lower.



**Figure 5** Spring time series of 24-hour average  $PM_{2.5}$  concentrations measured at the Newcastle, Beresfield, Mayfield and Stockton sites using the standard BAM (Beta Attenuation Monitor) equipment. The green bars show the days when sampling for the current study was carried out.

Figure 6 shows the equivalent results for  $PM_{10}$  concentrations. As above, the green bars highlight the days when 1-in-3-day sampling was carried out for the current study, and show that these are generally representative of the full period, including days with both high and low concentrations, including the day with the highest  $PM_{10}$  concentration at Stockton.

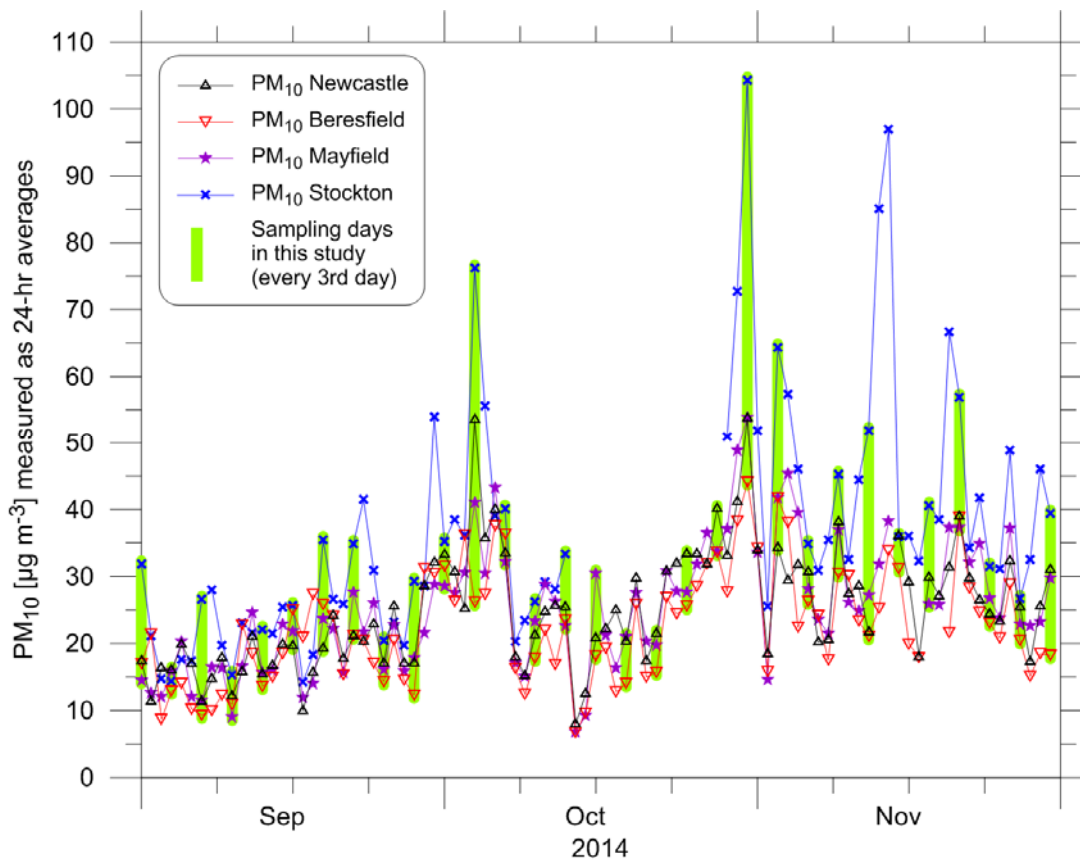


Figure 6 Spring time series of 24-hour average  $PM_{10}$  concentrations measured at the Newcastle, Beresfield, Mayfield, and Stockton sites using the standard TEOM (Tapered Element Oscillating Microbalance) equipment. The green bars show the days when sampling for the current study was carried out.

The average  $PM_{10}$  concentrations for September – November were  $25.0 \mu\text{g m}^{-3}$  at Newcastle,  $22.4 \mu\text{g m}^{-3}$  at Beresfield,  $25.3 \mu\text{g m}^{-3}$  at Mayfield, and  $36.9 \mu\text{g m}^{-3}$  at Stockton. These Spring averages are about 50% higher than those recorded during the Winter sampling period, in contrast to the  $PM_{2.5}$  averages, which were approximately the same in Spring as in Winter. This chemical analysis of the samples collected during this study should provide an explanation for these differences.

## 2.4 Wind and pollution roses

Figure 7 presents the wind roses at the sampling sites for the Spring sampling period. Compared to the Winter period they show significantly more variation between the sites and with more easterly winds. Stockton has the greatest variation in wind directions with significant fractions of ENE, SE and WNW winds. Stockton also has the fewest periods of light winds ( $\leq 2 \text{ m s}^{-1}$ ) due to its coastal location. The data record shows that when the Stockton station was being run by Orica (until 14 October), there were no winds recorded within  $\pm 8^\circ$  of north, which probably indicates an issue with the anemometer.

At the three other sites, north-westerlies were still prominent. At Beresfield the main wind directions are aligned along the NW-SE axis of the valley, whereas the spread of winds with an easterly component increases as one moves closer to the coast: Mayfield  $\rightarrow$  Newcastle  $\rightarrow$  Stockton. At Newcastle, the frequency of winds is approximately the same across the whole of the NE-SE-SW sector.

There are only small differences between the wind roses computed for the 1-day-in-3 sampling days (right-hand side of each pair) and those for the full 91 days of Spring (left-hand side), which confirms the representativeness of the sampling days.

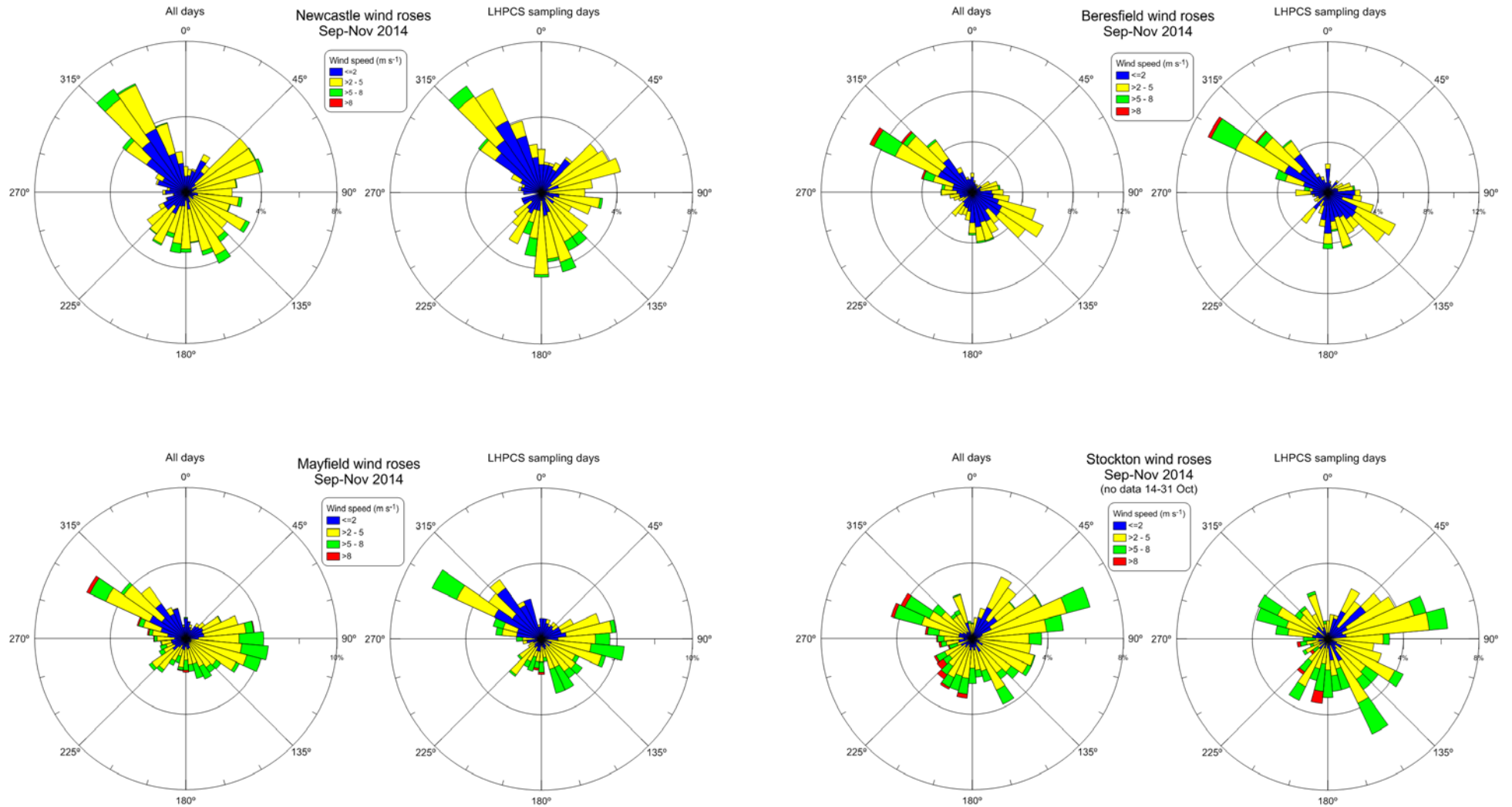


Figure 7 Wind roses for the Spring period at Newcastle, Beresfield, Mayfield, and Stockton showing close agreement between all days (left-hand side) and the 1-day-in-3 sampling days (right-hand side). [Note: a wind rose shows the frequency of winds plotted by wind direction, with colour bands showing wind ranges. The length of each band is proportional to the frequency of wind from that direction.]

In the same way that a wind rose depicts the distribution of wind speeds at each wind direction, a pollution rose depicts the distribution of pollution concentrations at each wind direction. It is an easily understood means of showing which wind directions are associated with the various pollution concentrations.

Figure 8 and Figure 9 show the PM<sub>10</sub> and PM<sub>2.5</sub> pollution roses computed using the hourly-averaged continuous monitoring data from the sampling sites but restricted to above average concentrations, namely PM<sub>10</sub> > 20 µg m<sup>-3</sup> and PM<sub>2.5</sub> > 10 µg m<sup>-3</sup>. This shows the high concentration results more clearly.

For PM<sub>10</sub>, the Newcastle site shows some elevated levels for almost all wind directions. In contrast, at the Beresfield site almost all of the elevated concentrations occur with north-westerly winds, whereas at Mayfield this is the case for easterlies. At Stockton the highest proportion of elevated concentrations coincide with easterly to north-easterly winds (i.e. on-shore), with some occurring with north-westerly winds.

At most sites, the PM<sub>2.5</sub> pollution roses show similar patterns with just Newcastle being noticeably different with the highest concentrations in north-westerly wind conditions. In all case, there is suitably close agreement between the results for the 1-day-in-3 sampling days (right-hand side of each pair) and those for the full 91 days of spring (left-hand side), which confirms the representativeness of the sampling days.

## 2.5 Summary

The sampling conducted during the September to November 2014 period was undertaken successfully and will support chemical analysis and source apportionment for the Spring season. This is concluded based on the overall sample collection rate of 99%-100% achieved, and sampling days generally coinciding with low, high and average ambient particle concentration measurements across all sampling sites. There have been no significant issues with filter shipping and analysis of filter samples is ongoing. Study results will be presented in the Final Study Report due for publication early in 2016.

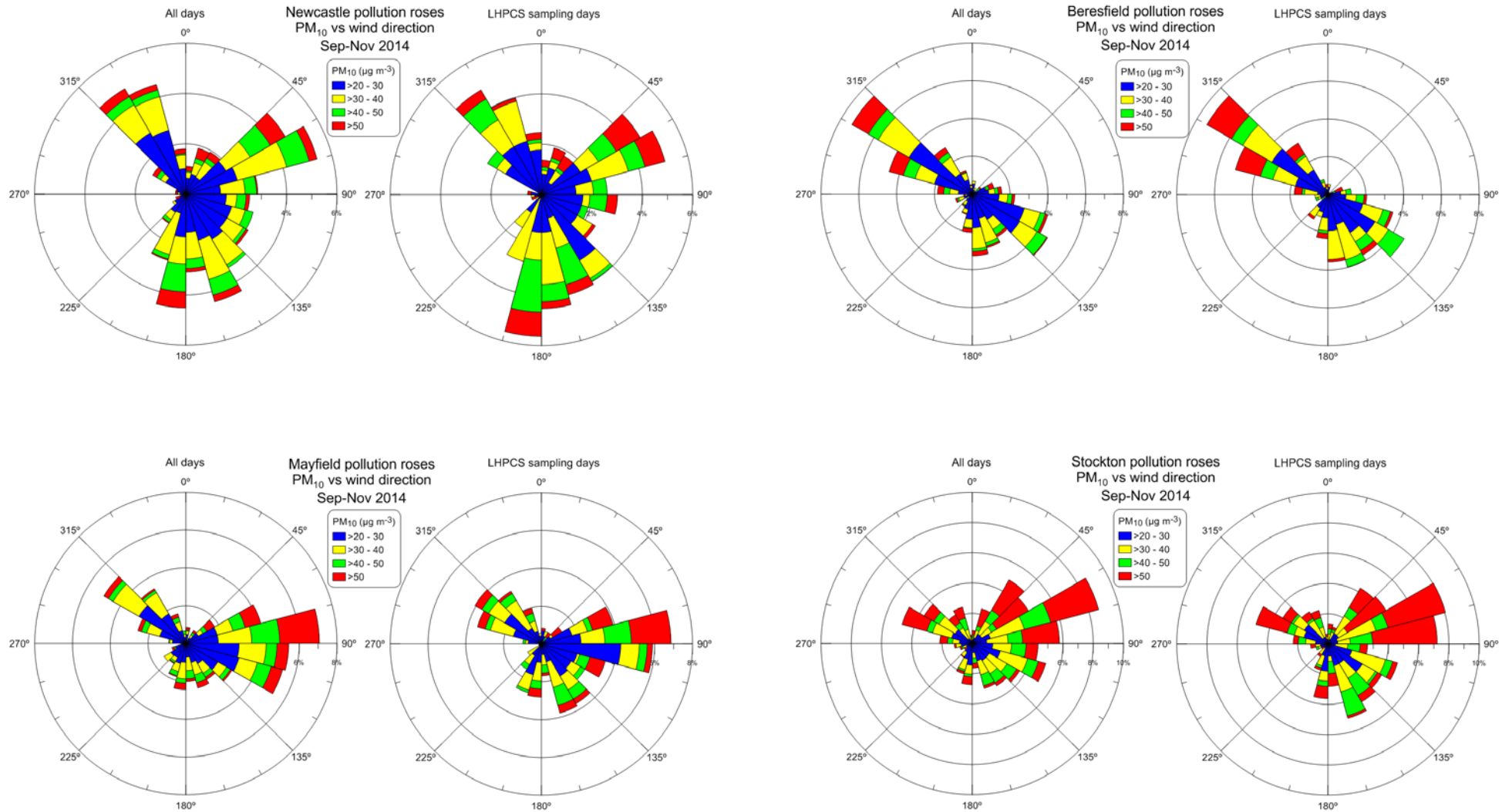


Figure 8 PM<sub>10</sub> pollution roses for PM<sub>10</sub> > 20 µg m<sup>-3</sup> for the Spring period at Newcastle, Beresfield and Stockton showing close agreement between all days (left-hand side) and the 1-day-in-3 sampling days (right-hand side). [Note: these pollution roses depict the distribution of PM<sub>10</sub> concentrations at each wind direction.]



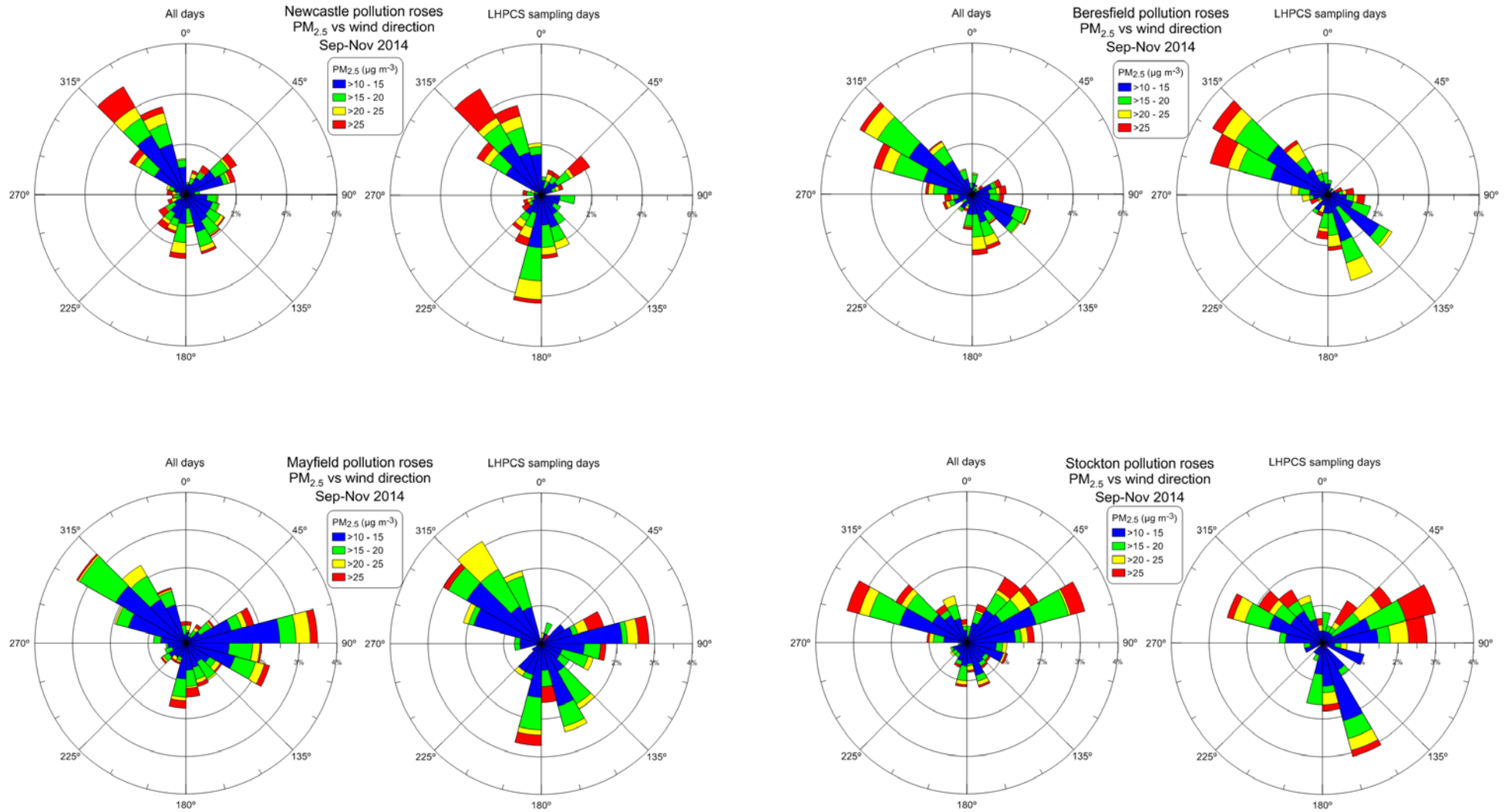


Figure 9 PM<sub>2.5</sub> pollution roses for PM<sub>2.5</sub> > 10 µg m<sup>-3</sup> for the Spring period at Newcastle, Beresfield and Stockton showing close agreement between all days (left-hand side) and the 1-day-in-3 sampling days (right-hand side). [Note: these pollution roses depict the distribution of PM<sub>2.5</sub> concentrations at each wind direction.]

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