TODOROSKI AIR SCIENCES

LOWER HUNTER AIR QUALITY REVIEW OF AMBIENT AIR QUALITY DATA

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Lower Hunter Air Quality Review of Ambient Air Quality Data

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EXECUTIVE SUMMARY

This report has been prepared by Todoroski Air Sciences for the NSW Environment Protection Authority (NSW EPA) and presents ambient air quality monitoring data recorded in the Lower Hunter region for the month of September 2013. The results indicate that the air quality was generally very good to fair in the Lower Hunter Region in September 2013.

The data summary (shown below) indicates that in September 2013, the Fullerton St Stockton monitor recorded two 24-hour average PM_{10} levels above the criterion of 50µg/m^3. All other data recorded in September were below the applicable criteria. Further details are provided in the report. The full data are provided in the Appendices.

Lower Hunter Air Quality Pictorial Summary - September 2013

Lower Hunter Air Quality Tabular Summary - September 2013

Site	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	SO_2 (µg/m^3)	NO_2 (µg/m^3)	SO_2 (µg/m^3)	NH_3 (ppm)
	24-hour average	24-hour average	24-hour average	1-hour average	1-hour average	1-hour average
	Air Quality Impact Criteria					
	50	25*	228	246	570	0.46
Wallsend	✓	✓	✓	✓	✓	-
Newcastle	✓	-	✓	✓	✓	-
Beresfield	✓	✓	✓	✓	✓	-
Fullerton St Stockton	×	✓	-	✓	-	✓
Roxburgh St Stockton	-	-	-	✓	-	-
Fullerton St Stockton HVAS	✓	-	-	-	-	-
Steel River HVAS	✓	-	-	-	-	-
Mayfield HVAS	✓	-	-	-	-	-

✓ - All data below applicable criteria
× - At least one elevated level above applicable criteria
- - Not applicable
HVAS - High Volume Air Sampler
* - Advisory reporting standard for $PM_{2.5}$ concentrations (refer to Section 5.1)

1 INTRODUCTION

This report has been prepared by Todoroski Air Sciences on behalf of the NSW EPA. It provides a summary and analysis of the available ambient air quality and meteorological data collected in the Lower Hunter region during September 2013.

2 PROJECT SCOPE

The following outlines the scope of work for this project.

- Provide a monthly report written in plain English to the NSW EPA summarising and analysing available air quality data and meteorological information.
- The report will be published on the EPA's website and will assess the available data recorded at: Beresfield, Wallsend, Newcastle, Mayfield, Steel River and Stockton.
- The aim is to provide a simplified report that is accessible and contains results that would be clearly understood by the general public.

The work is for the period of ten months from September 2013 to June 2014.

3 THE PURPOSE OF AMBIENT MONITORING

It is important to note that the data presented in this report are from both EPA and industry monitoring sites. The EPA and the industry sites collect data for different purposes and this needs to be understood when comparing the data to the criteria.

The EPA monitoring sites are specifically designed to measure the likely levels of pollutants that the general population in the area would experience, whereas industry monitoring sites are specifically designed to measure the maximum pollutant levels that may occur due to a particular industry.

Data from the EPA sites can be compared with national air quality standards. Where the levels measured at the EPA monitoring sites are above the national standards on a prolonged and consistent basis, this indicates that some investigation of the potential cause of the issue may be warranted to determine whether any action on a regional level would reduce or better manage the pollutant levels. In the case of PM_{10}, it is noted that the national standards permit five days annually above the criteria to allow for events such as bushfires and dust storms.

Data from industry monitoring sites can be compared with EPA impact assessment criteria. Where the levels measured at industry monitoring sites are above the impact assessment criteria on a prolonged and consistent basis, this indicates that further investigation is warranted to determine whether industry is responsible and, if so, whether action to reduce or better manage the pollutant can be taken.

Whether there is any harmful effect on an individual will depend on many additional factors, and not just on the measured level of a pollutant. These factors include the total exposure to the pollutant, individual circumstances (age, health, body mass, levels of pollutants at work), levels of other pollutants in the area, and many other factors.

Where pollutant levels are below the criteria generally, harm would not be expected to occur, but it does not follow that harm automatically occurs when pollutant levels are above the criteria.

The criteria serve to highlight potential issues with the levels of pollutants that may warrant more detailed examination. The criteria may also serve to prioritise action in various areas, for example areas with the highest pollutant levels and highest populations or highest exposure would be expected to receive priority action.

4 AIR QUALITY MONITORING SITES

Figure 4-1 and **Table 4-1** summarise the locations and recorded parameters of the air quality monitoring sites in the Lower Hunter in September 2013.

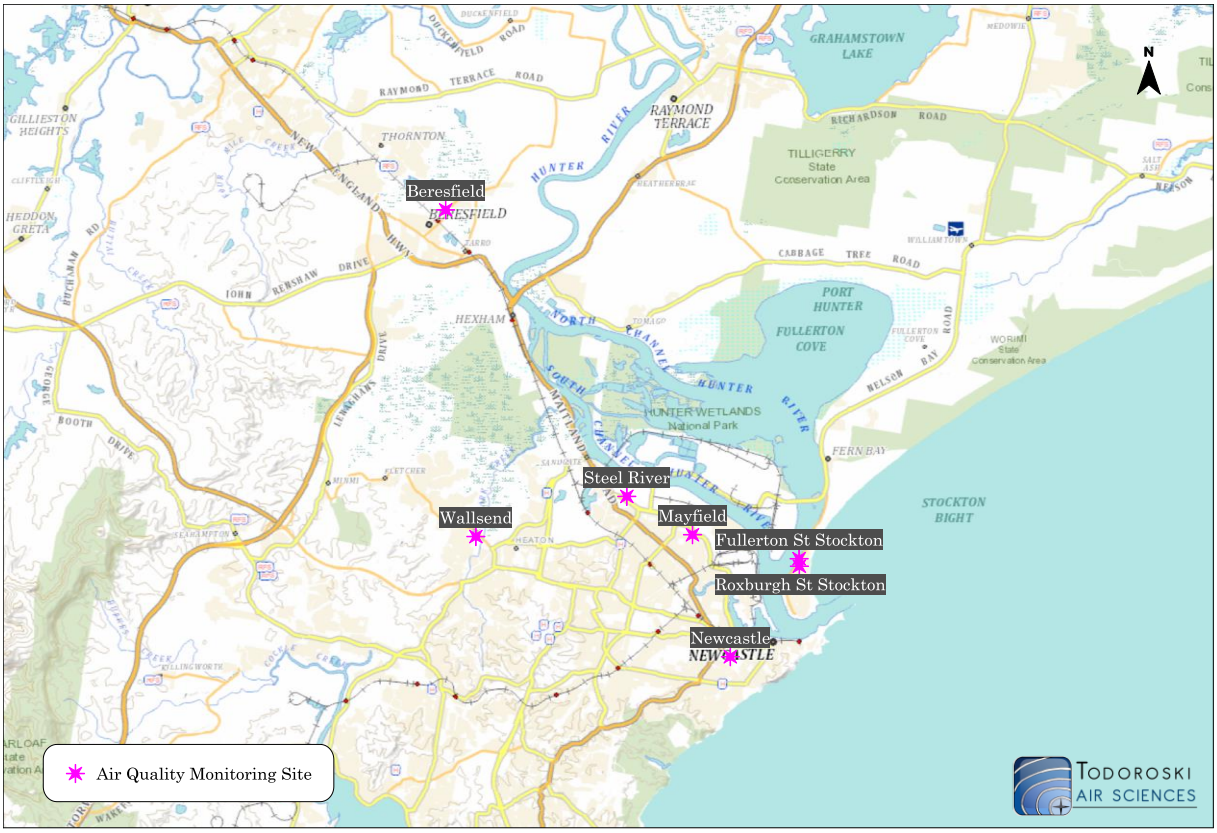

Figure 4-1: Monitoring site locations

Table 4-1: Monitoring sites

Monitoring Station	Type	Recorded Parameters	Recording Periods
Beresfield	NSW EPA site	PM_{10} (TEOM), $PM_{2.5}$, NO_2, SO_2, WS, WD	Hourly/Daily
Wallsend	NSW EPA site	PM_{10} (TEOM), $PM_{2.5}$, NO_2, SO_2, WS, WD	Hourly/Daily
Newcastle	NSW EPA site	PM_{10} (TEOM), NO_2, SO_2, WS, WD	Hourly/Daily
Fullerton St, Stockton	Industry site	PM_{10} (TEOM), $PM_{2.5}$, NO_2, NH_3, WS, WD	Hourly/Daily
Roxburgh St, Stockton	Industry site	NO_2	Hourly
Fullerton St, Stockton (HVAS)	Industry site	PM_{10} (HVAS)	Every 6th Day
Steel River	Industry site	PM_{10} (HVAS)	Every 6th Day
Mayfield	Industry site	PM_{10} (HVAS)	Every 6th Day

PM_{10} - Particulate matter < 10µm
$PM_{2.5}$ - Particulate matter < 2.5µm
TEOM - Tapered Element Oscillating Microbalance (which samples air continuously)
NO_2 - Nitrogen dioxide
SO_2 - Sulfur dioxide
NH_3 - Ammonia
WS - Wind speed
WD - Wind direction
HVAS - High volume air sampler (which samples for a 24-hour period every 6 days)

5 AIR QUALITY CRITERIA

The sections below identify the key pollutants currently being monitored at the Lower Hunter air quality monitoring sites and the applicable air quality criteria.

5.1 Particulate matter

Particulate matter consists of particles of varying size and composition. The total mass of all particles suspended in air is defined as the Total Suspended Particulate matter (TSP). The upper size range for TSP is nominally taken to be 30 micrometres (µm) as in practice particles larger than 30 to 50µm will settle out of the atmosphere too quickly to be regarded as air pollutants.

The TSP is defined further into two sub-components. They are PM_{10} particles, particulate matter with aerodynamic diameters of 10µm or less, and $PM_{2.5}$, particulate matter with aerodynamic diameters of 2.5µm or less.

Table 5-1 summarises the air quality goals that are relevant to particulate pollutants as outlined in the NSW Environment Protection Agency (EPA) document "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" (**NSW DEC, 2005**).

Table 5-1: EPA air quality impact assessment criteria

Pollutant	Averaging Period	Criterion
Total suspended particulates (TSP)	Annual	90µg/m^3
Particulate Matter < 10µm (PM_{10})	Annual	30µg/m^3
	24-hour	50µg/m^3

Source: **NSW DEC, 2005**

5.1.1 $PM_{2.5}$ concentrations

The NSW EPA currently do not have impact assessment criteria for $PM_{2.5}$ concentrations, however the National Environment Protection Council (NEPC) has released a variation to the National Environment Protection Measure (NEPM) (**NEPC, 2003**) to include advisory reporting standards for $PM_{2.5}$ (see **Table 5-2**). As with the NEPM goals, the advisory reporting standards apply to the average, or general exposure of a population, rather than to "hot spot" locations such as industry monitoring sites.

Table 5-2: Advisory standard for $PM_{2.5}$ concentrations

Pollutant	Averaging Period	Concentration
Particulate Matter < 2.5µm ($PM_{2.5}$)	24-hour	25µg/m^3
	Annual	8µg/m^3

Source: **NEPC, 2003**

5.2 Other air pollutants

Nitrogen dioxide (NO_2) is reddish-brown in colour (at high concentrations) with a characteristic odour and can irritate the lungs and lower resistance to respiratory infections such as influenza. NO_2 belongs to a family of reactive gases called nitrogen oxides (NO_x). These gases form when fuel is burned at high temperatures, and mainly originates from motor vehicles, power generators and industrial boilers (**USEPA, 2013**). NO_x may also be generated by blasting activities. It is important to note that when formed, NO_2 is generally a small fraction of the total NO_x generated.

Sulfur dioxide (SO_2) is a colourless, toxic gas with a pungent and irritating smell. It commonly arises in industrial emissions due to the sulfur content of the fuel. SO_2 can have impacts upon human health and the habitability of the environment for flora and fauna. SO_2 emissions are a precursor to acid rain, which can be an issue in the northern hemisphere; however it is not known to be an issue in NSW.

Ammonia (NH_3) is a colourless gas with a pungent smell familiar to most people because ammonia is used in smelling salts and household cleaners such as bleach and window cleaning products. It also occurs naturally in air, soil and water and is found in fertilisers. Ammonia is a corrosive substance and the main toxic effects are restricted to the sites of direct contact with ammonia (i.e., skin, eyes, respiratory tract). For example, if you spilled a bottle of concentrated ammonia on the floor, you would smell a strong ammonia odour; you might cough, and your eyes might water because of irritation. If you were exposed to very high levels of ammonia, you would experience more harmful effects. For example, if you walked into a dense cloud of ammonia or if your skin comes in contact with concentrated ammonia, your skin, eyes, throat, or lungs may be severely burned (**ATSDR, 2004**).

Table 5-3 summarises the air quality goals for NO_2, SO_2 and NH_3.

Table 5-3: Air quality impact assessment criteria for air toxics

Pollutant	Averaging period	Criterion
NO_2	1-hour	246µg/m^3
	Annual	62µg/m^3
SO_2	10-minute	712µg/m^3
	1-hour	570µg/m^3
	24-hour	228µg/m^3
	Annual	60µg/m^3
NH_3	1-hour	0.46ppm

Source: **NSW DEC, 2005**

5.3 Summary of applicable criteria for this assessment

The particulate and gaseous pollutants monitored in the Lower Hunter have air quality criteria which are averaged over short and long time periods. Annually averaged criteria require a full year of data.

As this report only looks at one month of ambient air quality data, the annually average criteria are not applicable. The SO_2 10-minute average criterion was not included as 10-minute monitoring data are not available. Therefore the criteria relevant to this assessment are those averaged over the shorter time periods (1-hour and 24-hours).

Table 5-4 summarises the applicable air quality criteria for this assessment.

Table 5-4: Air quality impact assessment criteria used in this assessment

Pollutant	Averaging Period	Type	Concentration
Particulate Matter < 10µm (PM_{10})	24-hour	Criterion	50µg/m^3
Particulate Matter < 2.5µm ($PM_{2.5}$)	24-hour	Advisory Reporting Standard	25µg/m^3
Nitrogen Dioxide (NO_2)	1-hour	Criterion	246µg/m^3
Sulfur Dioxide (SO_2)	1-hour	Criterion	570µg/m^3
	24-hour	Criterion	228µg/m^3
Ammonia (NH_3)	1-hour	Criterion	0.46ppm

6 METEOROLOGICAL MONITORING DATA

Representative wind speed and direction data have been obtained from the Beresfield, Wallsend, Newcastle and Stockton air quality monitoring stations. The data are presented as a series of windroses. For an example of how to read a windrose, refer to **Figure A-1** in **Appendix A**.

Figure 6-1 presents the September 2013 windroses for Beresfield, Wallsend, Newcastle and Stockton.

The Beresfield weather station recorded a high proportion of west-northwest and northwest wind directions during September. The station recorded few periods of wind from other directions. This is to be expected as the prevailing winds during cooler months generally originate from the upper Hunter Valley and flow along a northwest to southeast axis.

The predominant wind directions recorded at the Wallsend weather station were from the northwest and south-southwest. Wind speeds recorded at this location were generally lower than those recorded at the other locations. This is an indicator of potential valley drainage flows influenced by the local terrain features. The terrain features to the west and northwest act to shield Wallsend from some of the north-westerly Hunter Valley wind flows, however these flows were still evident in the wind directions recorded by the Wallsend weather station, but occur with lower wind speeds than the other more exposed locations.

The Newcastle weather station recorded predominant wind directions from the northwest and north-northwest. The station recorded few periods of wind from other directions.

The Stockton weather station recorded wind speeds which were generally higher than the other stations, with the predominant wind direction from the west-northwest. The higher wind speeds at the Stockton weather station are to be expected as it is located in a relatively unsheltered coastal location.

Figure 6-1 shows some differences between the distributions of wind at the four meteorological stations. The variation in localised winds is clear to see, however the four locations also display a similar underlying trend in the wind distribution patterns, with the common winds tending to originate from the Hunter Valley.

The prevailing wind patterns indicate that emissions from industry and urban sources are likely to be recorded more frequently at the Stockton and Newcastle stations in September. However as wind speeds are also generally high at Stockton, there is also likely to be some increased level of dilution or dispersion of air emissions in the ambient air.

The Bureau of Meteorology (BOM) reported in the September 2013 Monthly Weather Review (**BOM, 2013**) that this month was Australia's warmest September on record for maximum, minimum and mean temperatures. In the Lower Hunter region the Newcastle Nobbys Signal, Williamtown RAAF and Paterson (Tocal) weather stations (located approximately 2km, 15.5km and 37.5km from Newcastle CBD respectively) all measured their highest September mean temperatures on record. The warm temperatures, below average rainfall and strong winds during this period contributed to an early start to the bushfire season.

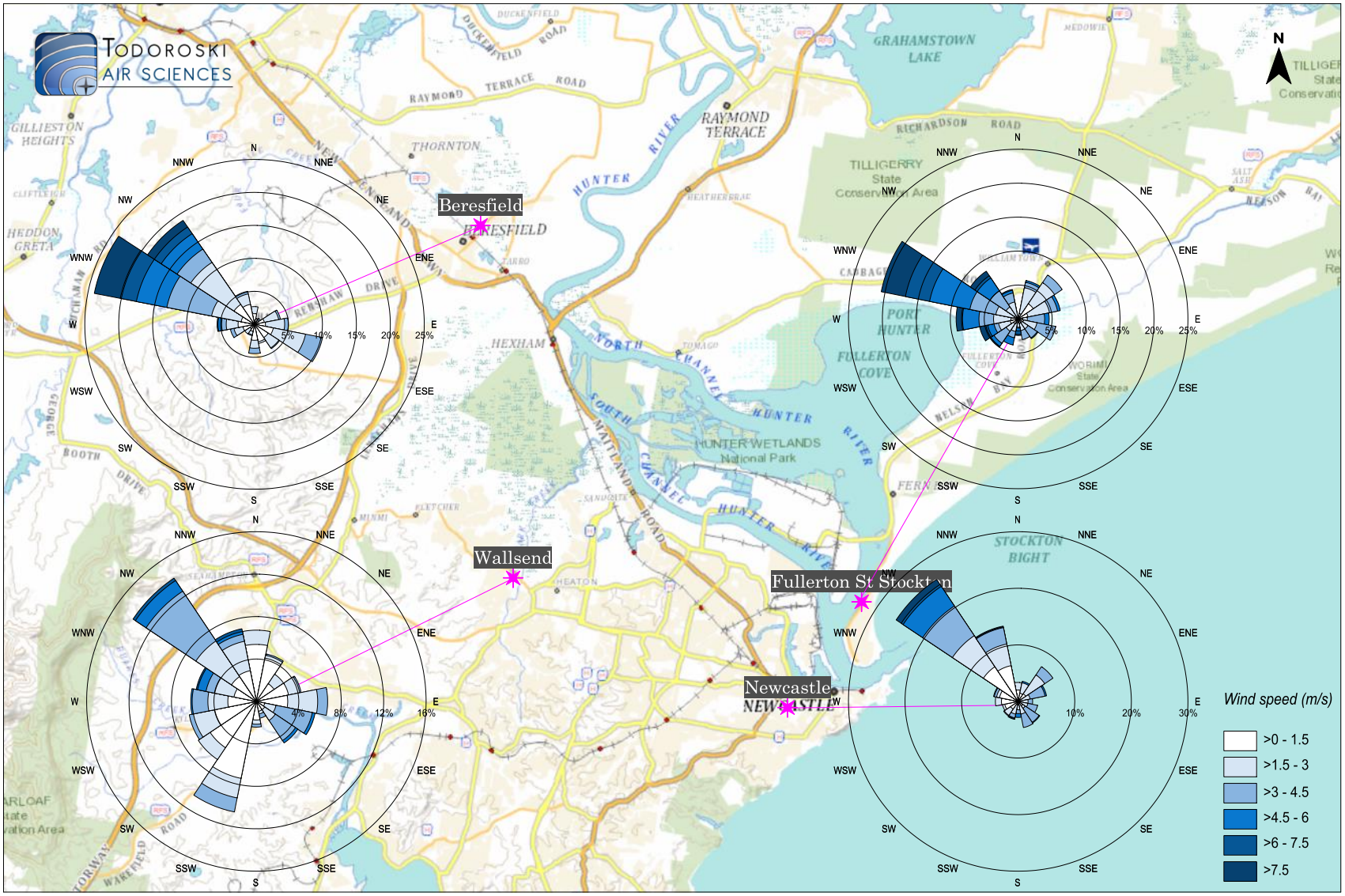

Figure 6-1: September Windroses - Beresfield, Wallsend, Newcastle and Stockton

7 AMBIENT AIR QUALITY MONITORING DATA

7.1 Preamble

The monitoring data in this report are presented in raw form as provided to Todoroski Air Sciences by the NSW EPA.

The Fullerton St Stockton monitoring site data included a note stating that:

- The data has undergone validation to remove erroneous data due to maintenance, instrument failures and nightly auto calibrations. Data gaps can be explained by this validation.
- The averaged data is based on a minimum of 75% data availability (i.e. a minimum of 75% of data is required to calculate an average for the time period, if below this, the cell will be blank).
- Data displayed on the www.stocktonairqualitymonitoring.com website has not undergone any validation, therefore there will be differences between the data in this report and the website at the time.
- Small negative concentration readings are due to the instrument noise at low/zero concentration levels and are a normal part of the operation of gas and particulate analysers.
- NO_2 and NH_3 data are unavailable from 2am on 5 September to 8pm on 24 September because the instrument was removed to be repaired.

The 24-hour average data presented in this report have been averaged using the 1-hour average readings. Days which contain less than 75% data (less than 18 hours of 1-hour average data) have not been included in this report.

All of the monitoring data provided to Todoroski Air Sciences are presented in a graphical format in **Appendix B** and tabulated format in **Appendix C**.

7.2 Analysis of Monitoring Data

Table 7-1 presents a summary of the maximum pollutant levels occurring during September 2013. The results indicate that Fullerton St Stockton recorded two 24-hour average PM_{10} levels above the criterion of 50µg/m^3. The ambient air concentrations recorded by all other monitors were below the relevant criteria during September 2013.

Table 7-1: Maximum pollutant levels - September 2013

Site	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	SO_2 (µg/m^3)	NO_2 (µg/m^3)	SO_2 (µg/m^3)	NH_3 (ppm)
	24-hour average	24-hour average	24-hour average	1-hour average	1-hour average	1-hour average
	Air Quality Impact Criteria					
	50	25*	228	246	570	0.46
Wallsend	28.5	14.2	13.1	80.8	52.4	-
Newcastle	42.4	-	12.6	77.1	44.5	-
Beresfield	43.1	15.7	12.8	67.7	68.1	-
Fullerton St Stockton	**70.9**	20.1	-	60.3	-	0.25
Roxburgh St Stockton	-	-	-	84.6	-	-
Fullerton St Stockton HVAS	48.5	-	-	-	-	-
Steel River HVAS	39.0	-	-	-	-	-
Mayfield HVAS	47.0	-	-	-	-	-

* Advisory reporting standard for $PM_{2.5}$ concentrations (refer to Section 5.1)

- Not applicable

7.3 PM_{10}

Figure 7-1 presents all of the 24-hour average PM_{10} monitoring results recorded in the Lower Hunter region in September 2013.

Relative to the Air Quality Index, as shown by the coloured bands in the figure, PM_{10} levels were generally very good or good at all locations with the exception of Fullerton St Stockton which experienced fair levels 50% of the time, and poor levels on two days. Beresfield recorded fair levels on eight days and Newcastle recorded fair levels on two days.

The data indicate that the Fullerton St Stockton TEOM monitor recorded levels above the 24-hour average PM_{10} criterion level of 50µg/m^3 on 9 and 10 September 2013. This monitor recorded a 24-hour average level equal to the criterion of 50µg/m^3 on 24 September. All other data recorded at the Lower Hunter monitoring sites were below the 24-hour average PM_{10} criterion level.

Figure B-1 to **Figure B-4** in **Appendix B** present the 1-hour average PM_{10} data in graphical form for each individual site. There is no criterion that applies to 1-hour average PM_{10} levels and these 1-hour results are not intended to be compared with the PM_{10} criterion. It is a normal occurrence and it is expected, that in the normal environment 1-hour average PM_{10} levels will fluctuate more significantly than 24-hour average PM_{10} levels.

7.4 $PM_{2.5}$

Figure 7-2 presents all of the 24-hour average $PM_{2.5}$ monitoring data[1] recorded in the Lower Hunter region in September 2013.

Relative to the Air Quality Index, as shown by the coloured bands in the figure, the data indicate that $PM_{2.5}$ levels were very good to good at all locations except Fullerton St Stockton which recorded one day of fair levels.

All data were below the advisory reporting standard on all days.

Figure B-5 to **Figure B-7** in **Appendix B** present the 1-hour average $PM_{2.5}$ data in graphical form for each individual site. There is no criterion that applies to 1-hour average $PM_{2.5}$ levels and these 1-hour results are not intended to be compared with the $PM_{2.5}$ advisory reporting standard. It is a normal occurrence, and it is expected, that in the normal environment 1-hour average $PM_{2.5}$ levels will fluctuate more significantly than 24-hour average $PM_{2.5}$ levels.

7.5 Nitrogen dioxide NO_2

Figure 7-3 presents the 1-hour average NO_2 monitoring data recorded in the Lower Hunter region in September 2013.

Relative to the Air Quality Index, as shown by the coloured bands in the figure, the data indicate the NO_2 levels were very good to good all of the time at all of the monitors.

All data were below the applicable criterion on all days.

7.6 Sulfur dioxide SO_2

Figure 7-4 presents the 1-hour average SO_2 monitoring data recorded in the Lower Hunter region in September 2013.

Relative to the Air Quality Index, as shown by the coloured bands in the figure, the data indicate the SO_2 levels were very good all of the time at all of the monitors.

All data were below the applicable criterion on all days.

Figure B-8 to **Figure B-10** in **Appendix B** present the 24-hour average SO_2 data in graphical form for each individual station.

7.7 Ammonia NH_3

Figure 7-5 presents the 1-hour average NH_3 monitoring data recorded at the Fullerton St Stockton monitor in September 2013.

[1] We note the Wallsend, Beresfield and Fullerton St, Stockton sites recorded periods in which 1-hour average $PM_{2.5}$ levels were higher than the 1-hour average PM_{10} levels. This is not an unusual occurrence and may arise due to the presence of volatile matter (which registers as a solid mass at first, but then evaporates, registering negative mass at a later time). This is a relatively common issue when there is wood heater smoke or bushfire smoke present in the air also.

The data indicate that the measured levels of NH_3 were generally low, however technical issues with the monitoring device meant that data were not recorded for a significant proportion of the month.

Figure 7-5 also presents the 1-hour average wind direction data recorded at the Fullerton St Stockton monitor in September 2013. The figure shows that NH_3 levels above 0.1ppm were generally associated with winds from the west and west-northwest.

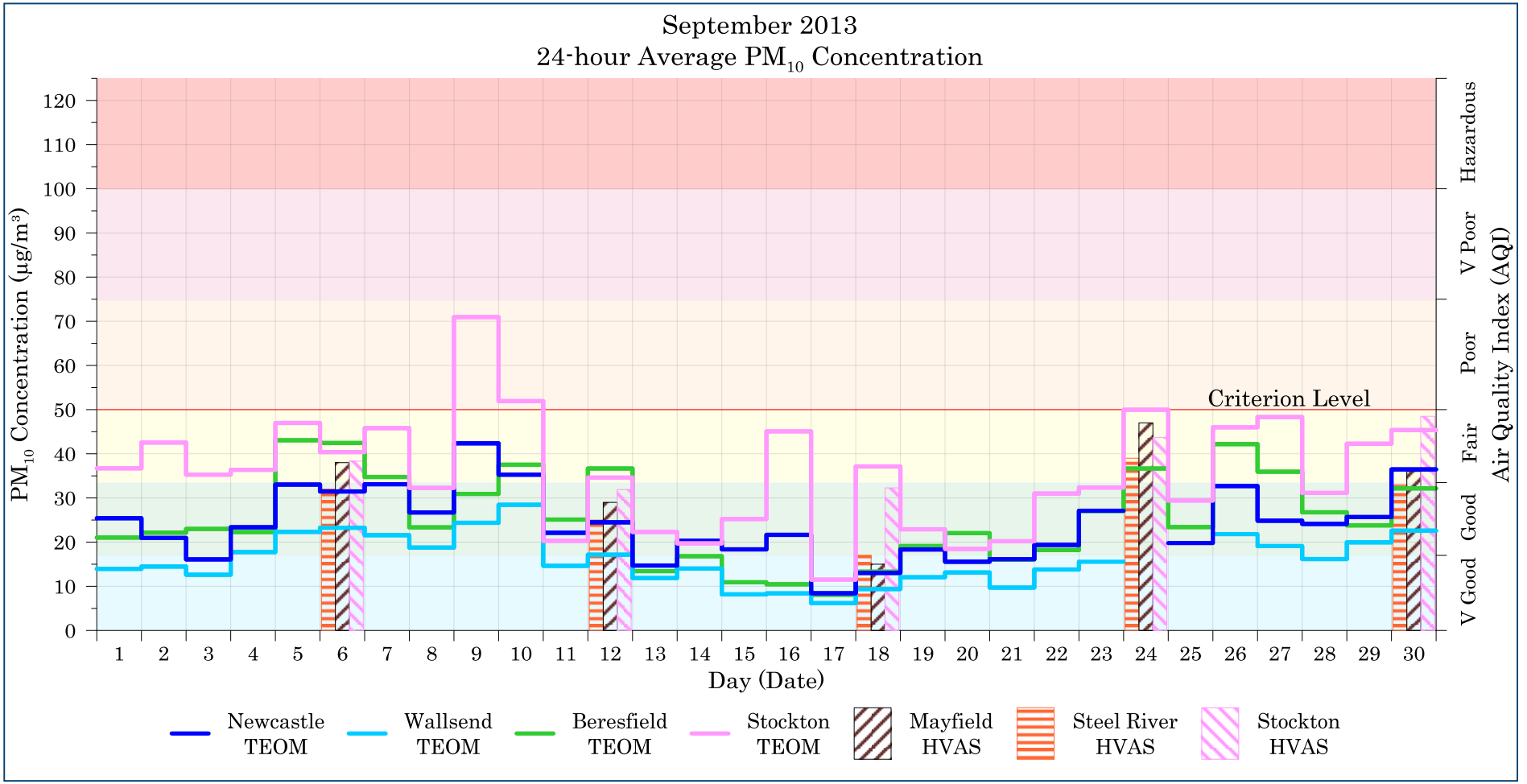

Figure 7-1: Lower Hunter 24-hour average PM_{10} levels – September 2013

The Fullerton St Stockton TEOM monitor recorded two 24-hour average PM_{10} levels above the criterion of 50µg/m^3 in September 2013. PM_{10} levels were generally very good to good at all locations with the exception of Fullerton St Stockton which experienced fair levels 50% of the time, and recorded poor levels on two days. Beresfield recorded fair levels on eight days, while Newcastle recorded fair levels on two days.

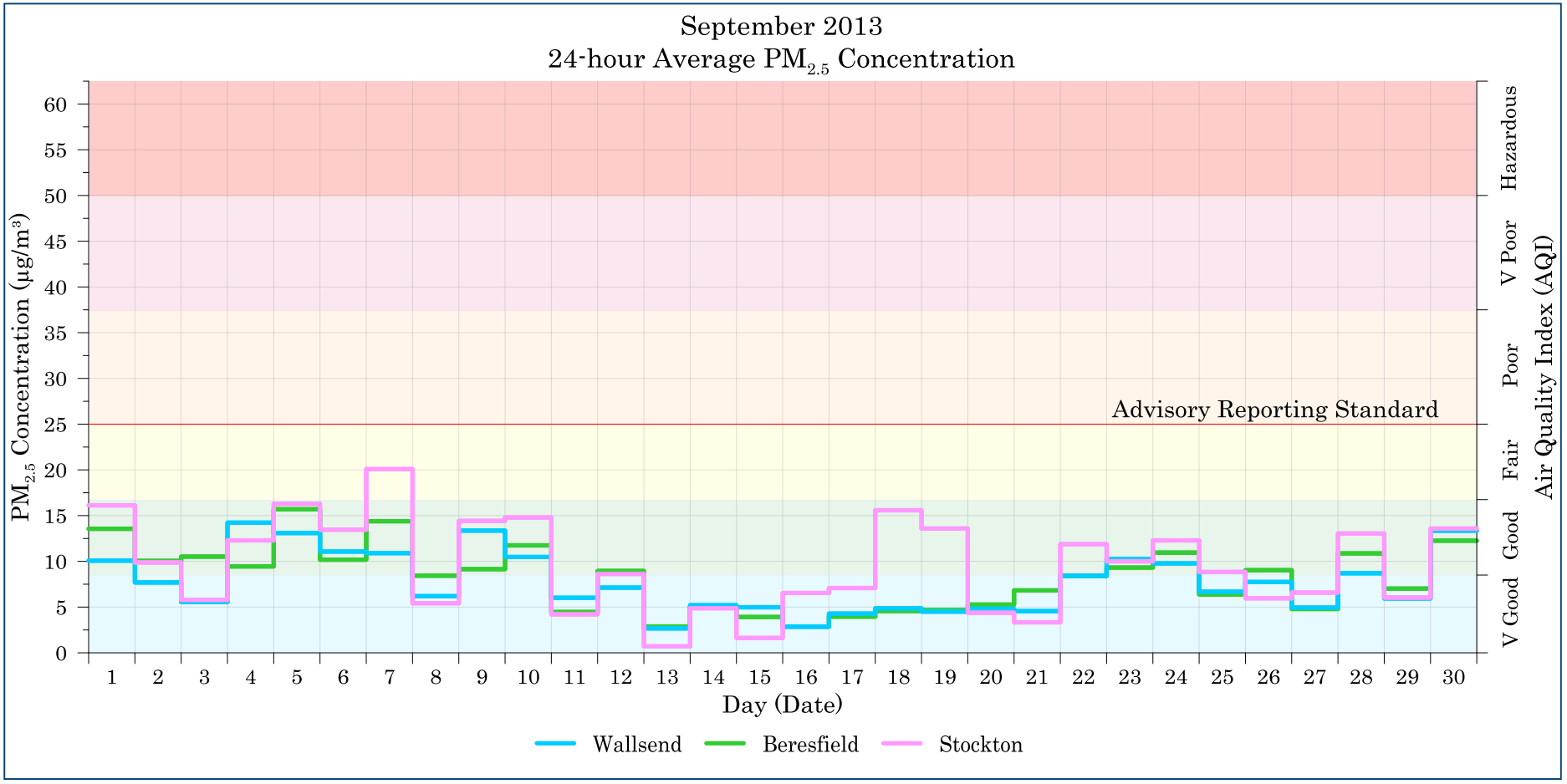

Figure 7-2: Lower Hunter 24-hour average $PM_{2.5}$ levels – September 2013

$PM_{2.5}$ levels were very good to good at all locations except Fullerton St Stockton which recorded one day with fair levels. All data recorded at the Lower Hunter monitoring sites in September 2013 were below the 24-hour average $PM_{2.5}$ advisory reporting standard of 25µg/m^3.

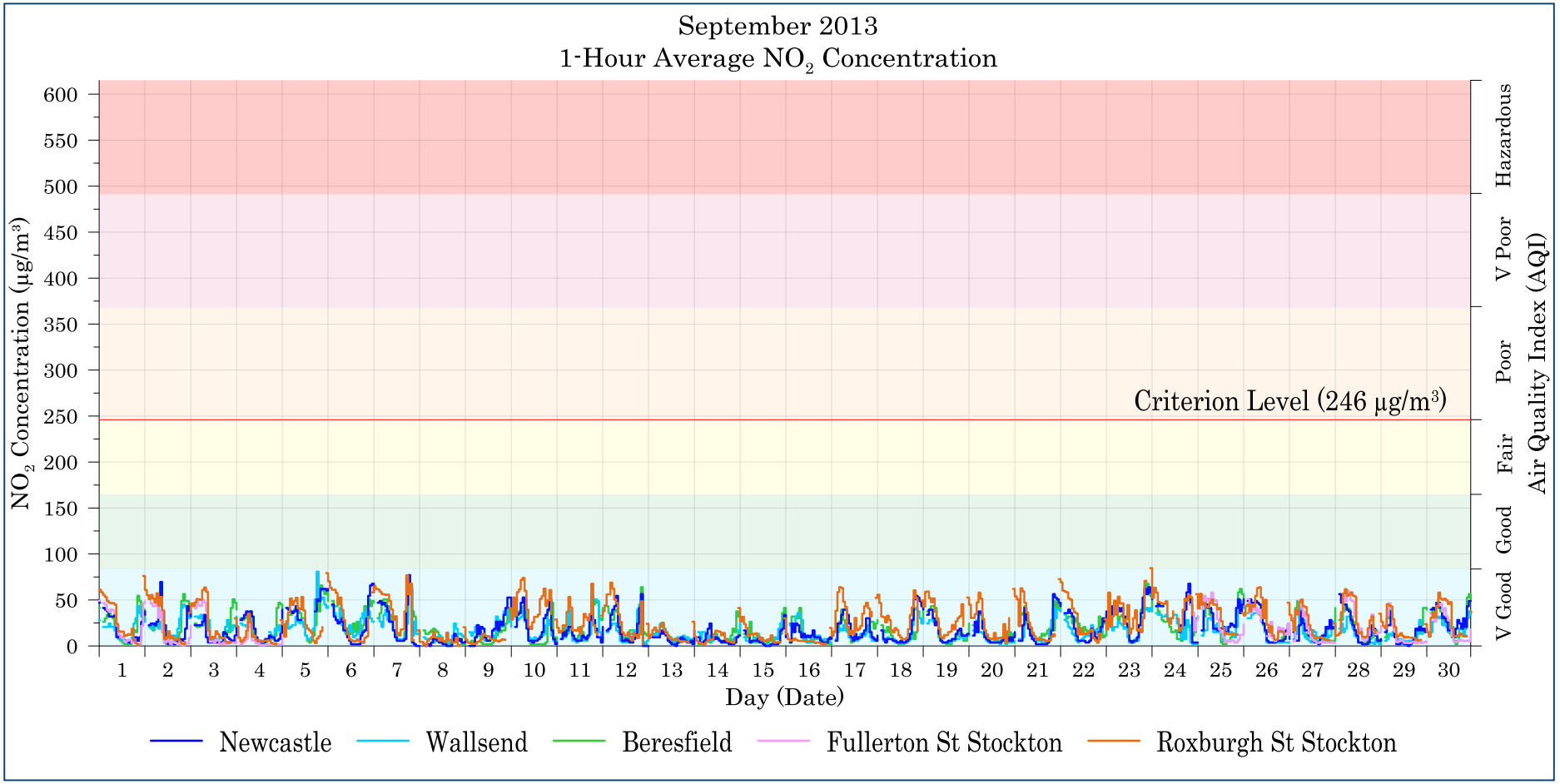

Figure 7-3: Lower Hunter 1-hour average NO_2 levels – September 2013

All data recorded at the Lower Hunter monitoring sites were below the 1-hour average NO_2 criterion level of 246µg/m^3 in September 2013. Measured levels of NO_2 were very good or good at all monitors at all times.

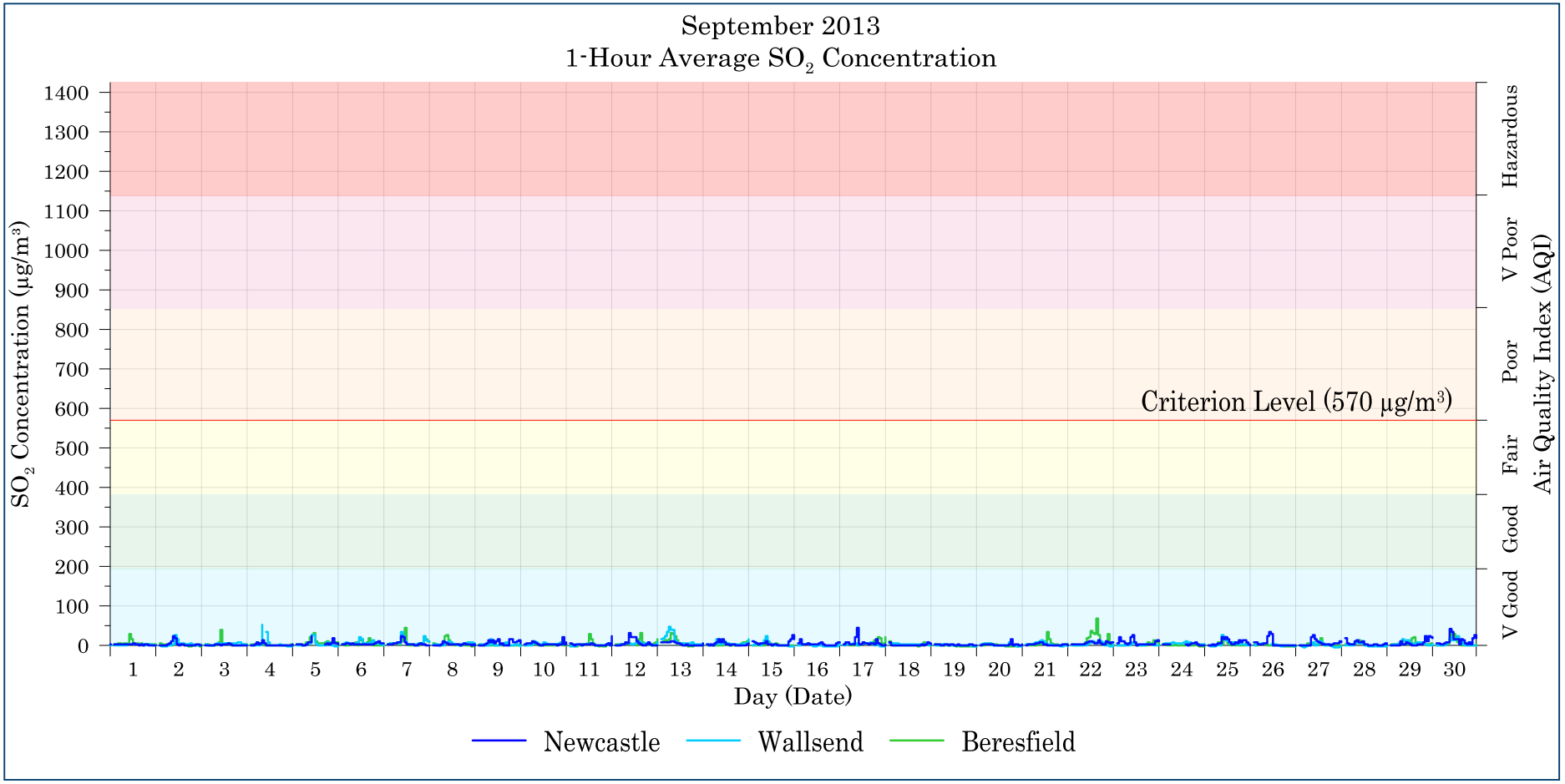

Figure 7-4: Lower Hunter 1-hour average SO_2 levels – September 2013

All data recorded at the Lower Hunter monitoring sites were below the 1-hour average SO_2 criterion level of 570µg/m^3 in September 2013. Measured levels of SO_2 were very good at all monitors at all times.

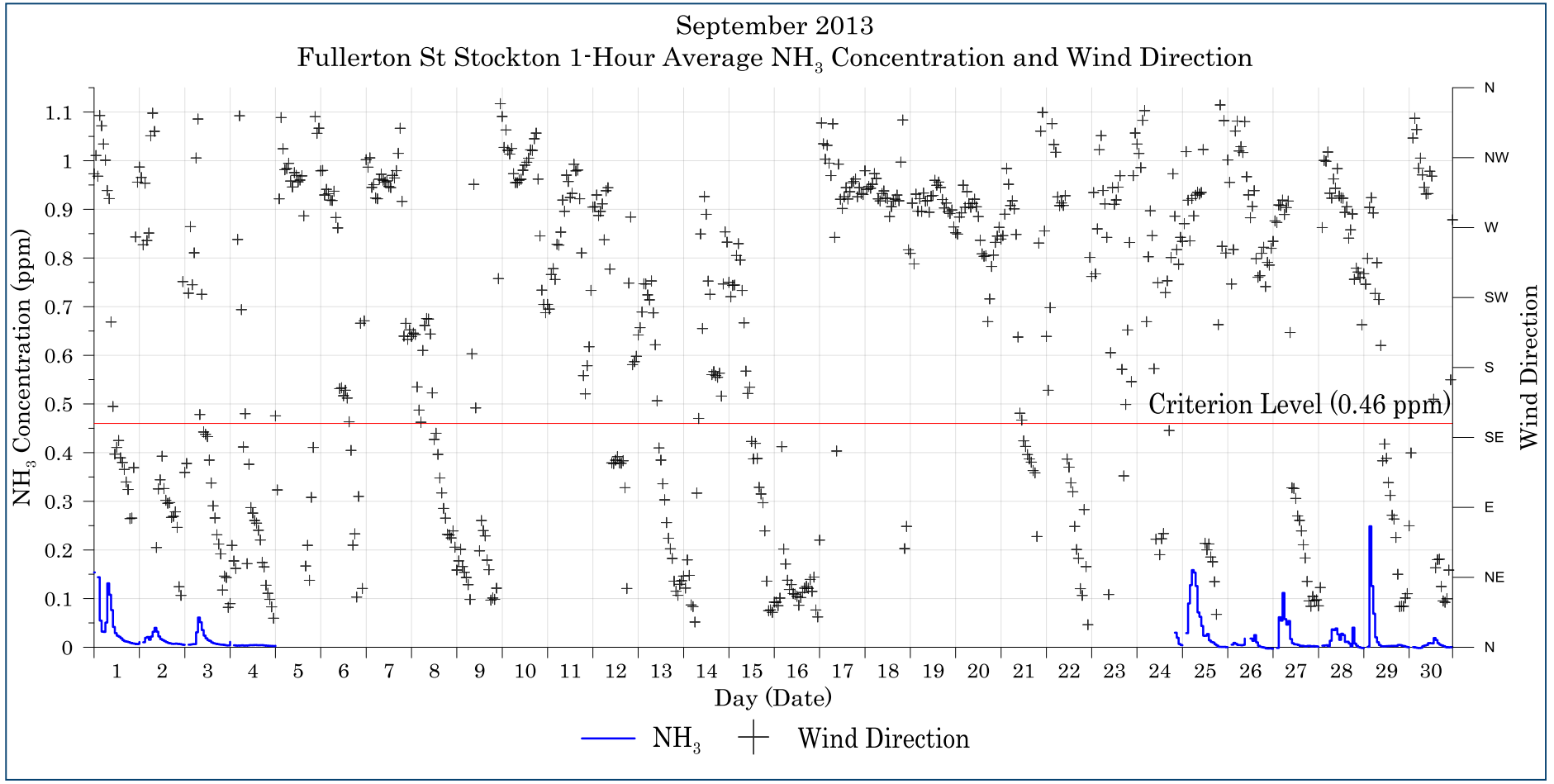

Figure 7-5: Lower Hunter 1-hour average NH_3 levels – September 2013

The figure shows that the Fullerton St Stockton NH_3 monitor was offline for a period of approximately 20 days in September 2013. All NH_3 data recorded at this monitor were below the 1-hour average criterion of 0.46ppm.

8 ANALYSIS OF ELEVATED POLLUTANT LEVELS

8.1 Fullerton St Stockton – 9 September 2013

- 24-hour average PM_{10} level of 70.9µg/m^3

Figure 8-1 presents an hourly plot of the 1-hour average PM_{10}, wind speed and wind direction data recorded at Fullerton St Stockton during this day. The 1-hour average PM_{10} levels recorded at Newcastle, Beresfield and Wallsend have also been included.

The data presented in **Figure 8-1** show that the Fullerton St Stockton monitor recorded levels significantly higher than those recorded at Newcastle, Beresfield and Wallsend monitors. The Fullerton St Stockton monitor recorded elevated levels when the wind was from the east to north-northeast and recorded a peak PM_{10} level of 242µg/m^3 at 7pm. The Newcastle monitor also recorded elevated PM_{10} levels during periods of winds from the north-northeast. The Wallsend and Beresfield monitors did not record such large increases in PM_{10} levels during this time.

Considering the wind direction and location of the monitors near the peak in PM_{10} levels at 7pm, it is possible that the cause of the high spike in PM_{10} levels at Fullerton St Stockton was due to heavily salt laden air blowing from the northeast along the surf break on Stockton Beach.

8.2 Fullerton St Stockton – 10 September 2013

- 24-hour average PM_{10} level of 51.9µg/m^3

Figure 8-2 presents an hourly plot of the 1-hour average PM_{10}, wind speed and wind direction data recorded at Fullerton St Stockton during this day. The 1-hour average PM_{10} levels recorded at Beresfield, Wallsend and Newcastle have also been included.

The data presented in **Figure 8-2** show that the Fullerton St Stockton monitor generally recorded PM_{10} levels greater than those recorded at the Wallsend and Beresfield monitors. The Beresfield monitor recorded a spike in PM_{10} levels of 150µg/m^3 at 8am. The Fullerton St Stockton monitor recorded a prolonged period of elevated PM_{10} levels during the day, with a peak PM_{10} level of 93µg/m^3 at 11am.

The higher PM_{10} levels recorded at Fullerton St Stockton occurred when the wind was from the northwest while the wind speed was high, reaching up to 11m/s. Beresfield, which lies to the northwest of Fullerton St Stockton, recorded a spike in PM_{10} levels before the increase in wind speed and then recorded lower PM_{10} levels during the periods of high wind speeds. This indicates that the source of PM_{10} may have been generated from a point between the two locations. Two possibilities for the source of the PM_{10} spike during this time include:

- Due to the strong winds, it is likely that pollen and dust blown from dry ground was carried towards Fullerton St Stockton;
- It is possible that particulates were carried to Fullerton St Stockton by industrial activities.

It is likely that the elevated levels on this day may be due to a combination of both sources.

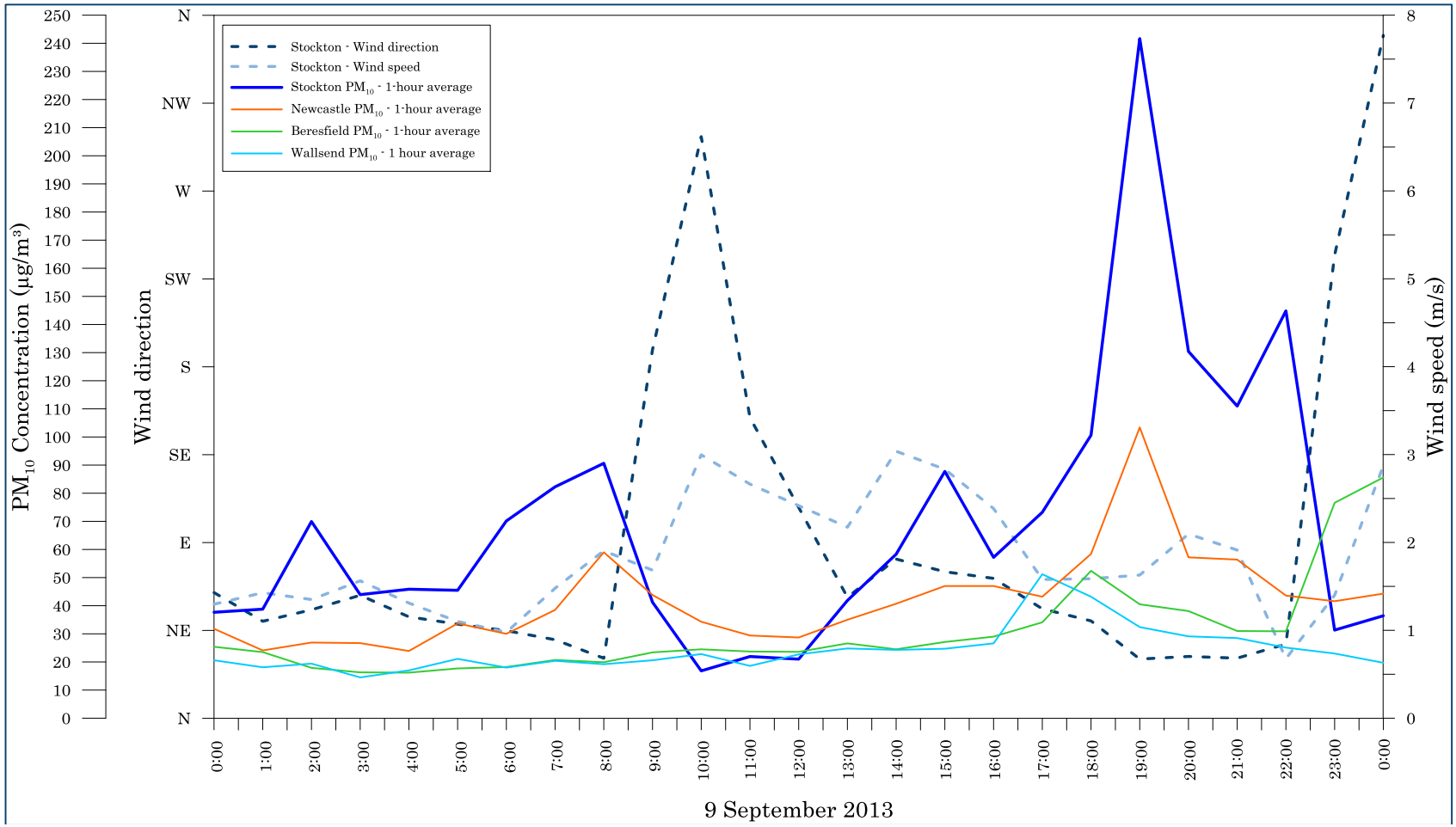

Figure 8-1: Analysis of elevated PM_{10} levels on 9 September 2013 – Fullerton St Stockton

The Fullerton St Stockton monitor showed spikes in PM_{10} associated with northeast to north northeast winds.

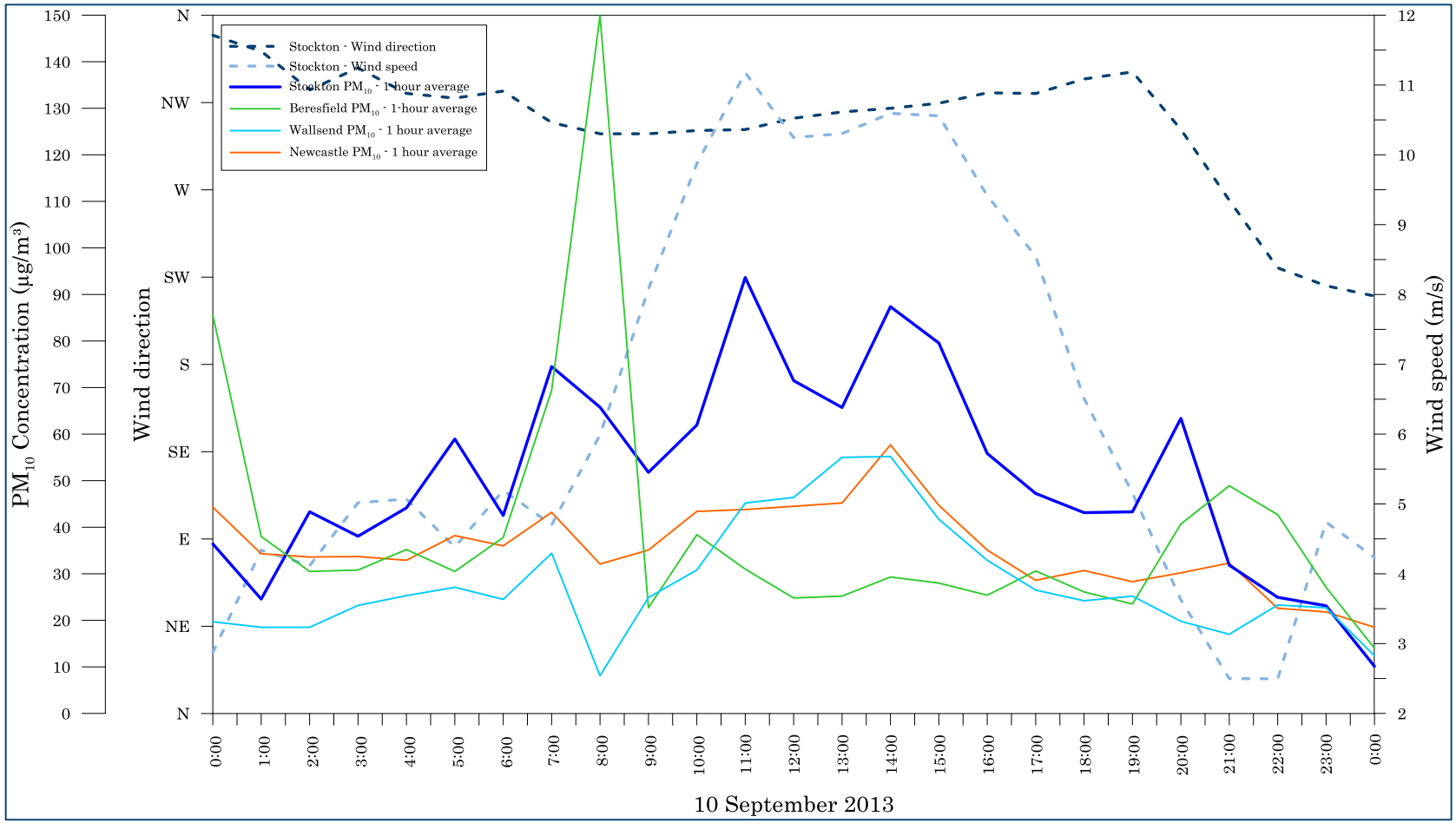

Figure 8-2: Analysis of an elevated PM_{10} levels on 10 September 2013 – Fullerton St Stockton

The Fullerton St Stockton monitor showed elevated PM_{10} levels associated with stronger winds from the northwest.

9 CONCLUSIONS

The results indicate that the monitoring stations recorded very good to good air quality for the majority of the time.

The Fullerton St Stockton monitor recorded 24-hour average PM_{10} levels above the criterion of 50µg/m^3 on 9 and 10 September 2013. The wind directional data suggest that the PM_{10} level of 70.9µg/m^3 recorded on 9 September may have been caused by heavily salt laden air blowing from the northeast along the surf break of Stockton Beach. The level of 51.9µg/m^3 recorded on 10 September may have been caused by windblown dust or pollen from strong winds and/or a localised source to the northwest of the monitor.

All other data indicate pollutant levels were below the applicable criteria for the remaining periods.

Relative to the Air Quality Index:

- The measured levels of NO_2 were very good or good at all monitors at all times;
- The measured levels of SO_2 were very good at all monitors at all times;
- The measured levels of $PM_{2.5}$ were very good to good at all times for all locations, with the exception of Fullerton St Stockton which recorded one day of fair levels during September.
- The measured PM_{10} levels were very good or good at all locations most of the time with the exception of Fullerton St Stockton which recorded fair levels approximately 50% of the time and recorded two days above the 24-hour average applicable criterion of 50µg/m^3. Beresfield recorded fair levels on eight days, while Newcastle recorded fair levels on two days.

On this basis it can be concluded that the air quality in the Lower Hunter was generally good in September 2013.

10 REFERENCES

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"Public Health Statement for Ammonia", Agency for Toxic Substances and Disease Registry September 2004.

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"Monthly Weather Review Australia September 2013", Bureau of Meteorology, 23 October 2013.

NEPC (2003)

"Variation to the National Environment Protection (Ambient Air Quality) Measure for Particles as $PM_{2.5}$", National Environment Protection Council, May 2003.

NSW DEC (2005)

"Approved Methods for the Modelling and Assessment of Air Pollutants in NSW", Department of Environment and Conservation (NSW), August 2005.

USEPA (2013)

Health Effects of Pollution, United States Environmental Protection Agency website, <http://www.epa.gov/region07/air/quality/health.htm>, accessed May 2013.

Appendix A

How to read a windrose

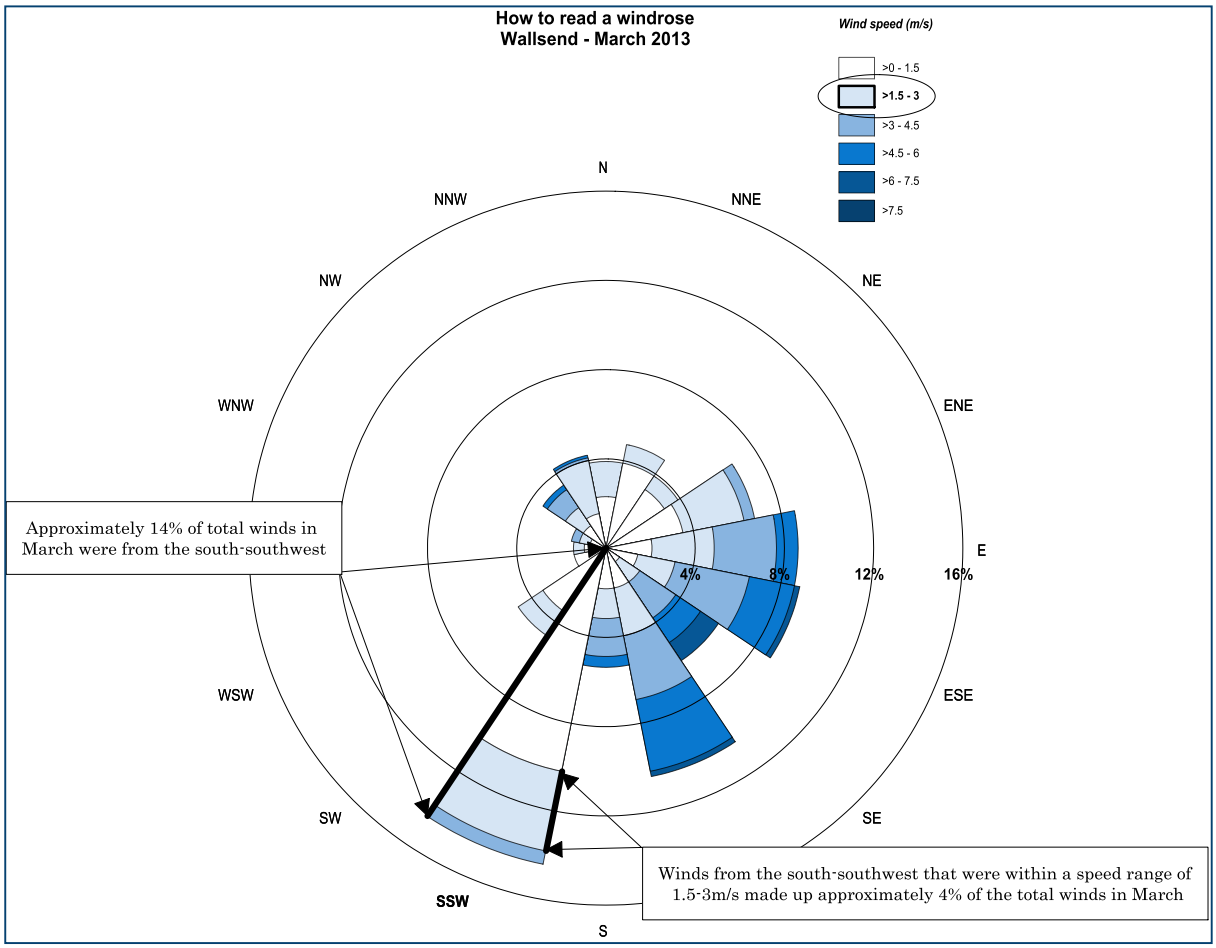

Figure A-1: How to read a windrose

Appendix B

Monitoring Data (Graphical)

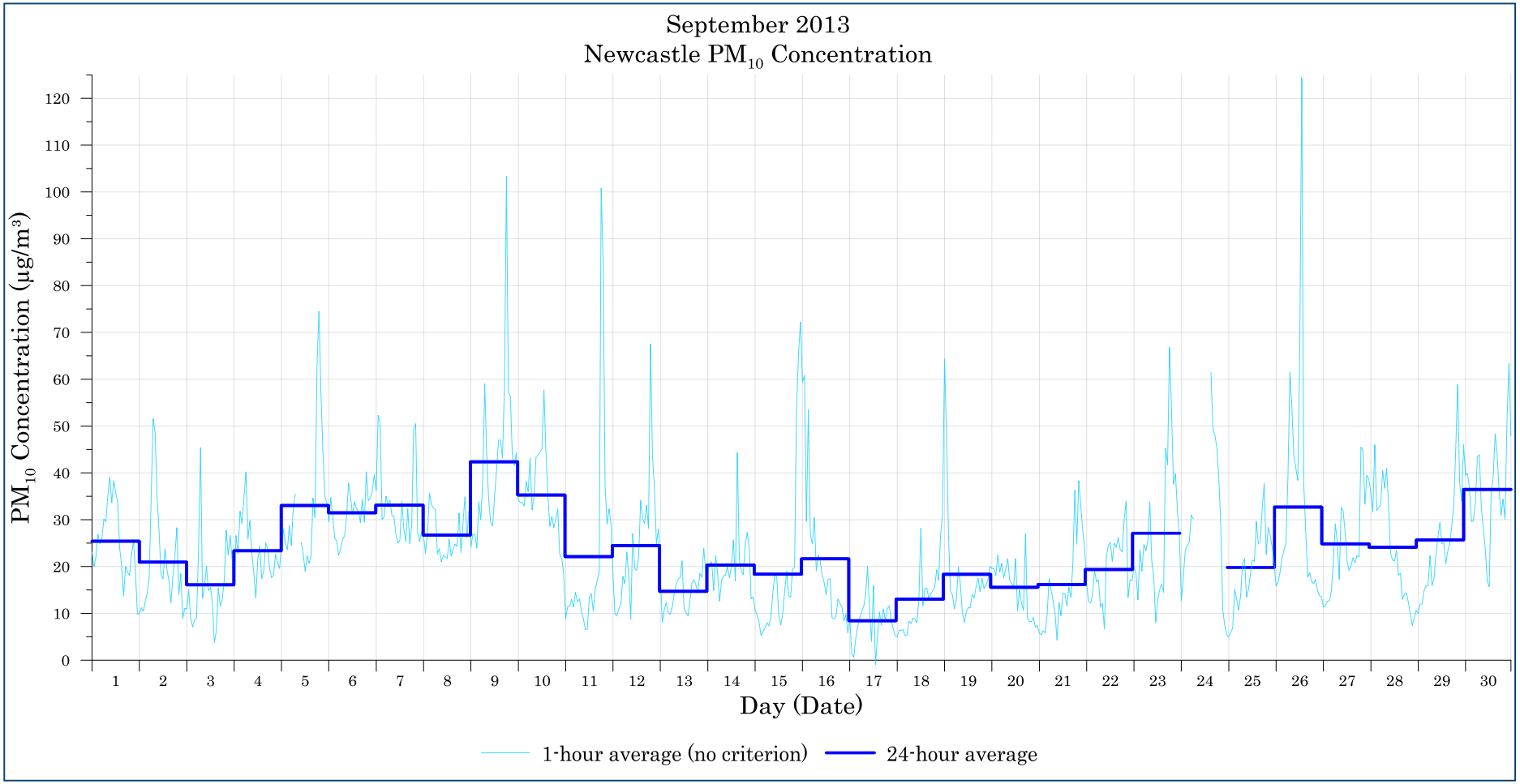

Figure B-1: Newcastle PM_{10} concentration - September

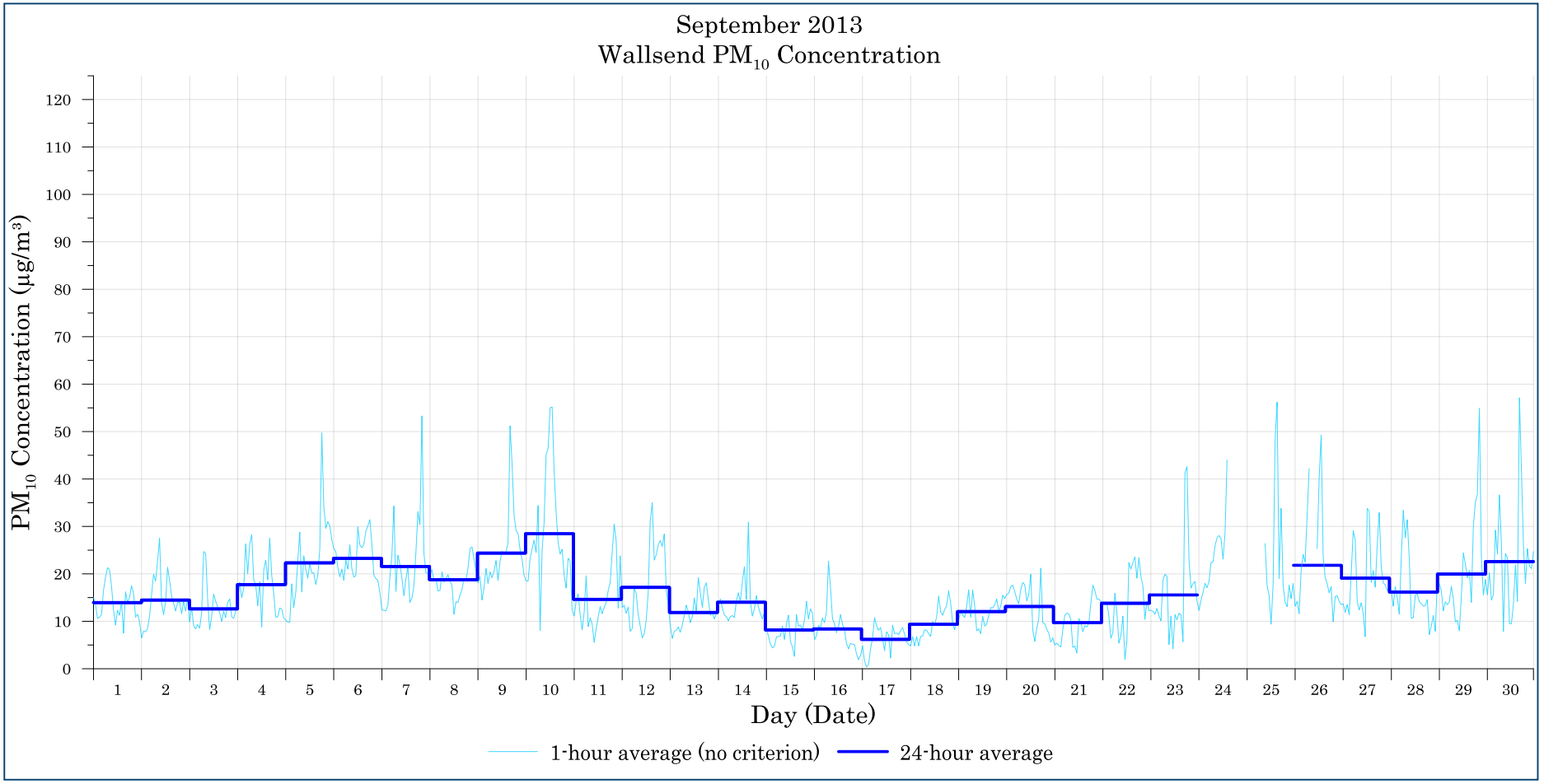

Figure B-2: Wallsend PM_{10} concentration - September

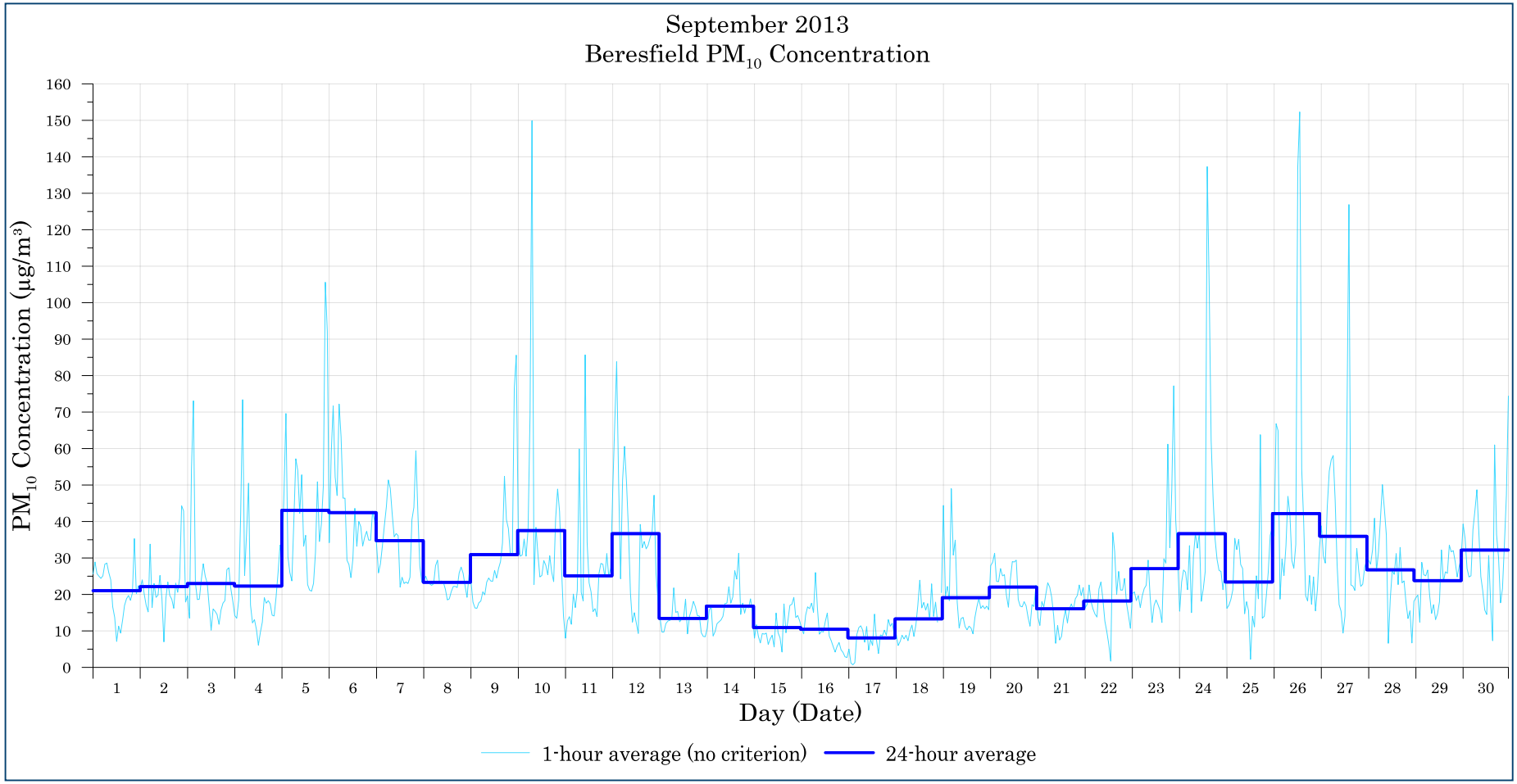

Figure B-3: Beresfield PM_{10} concentration - September

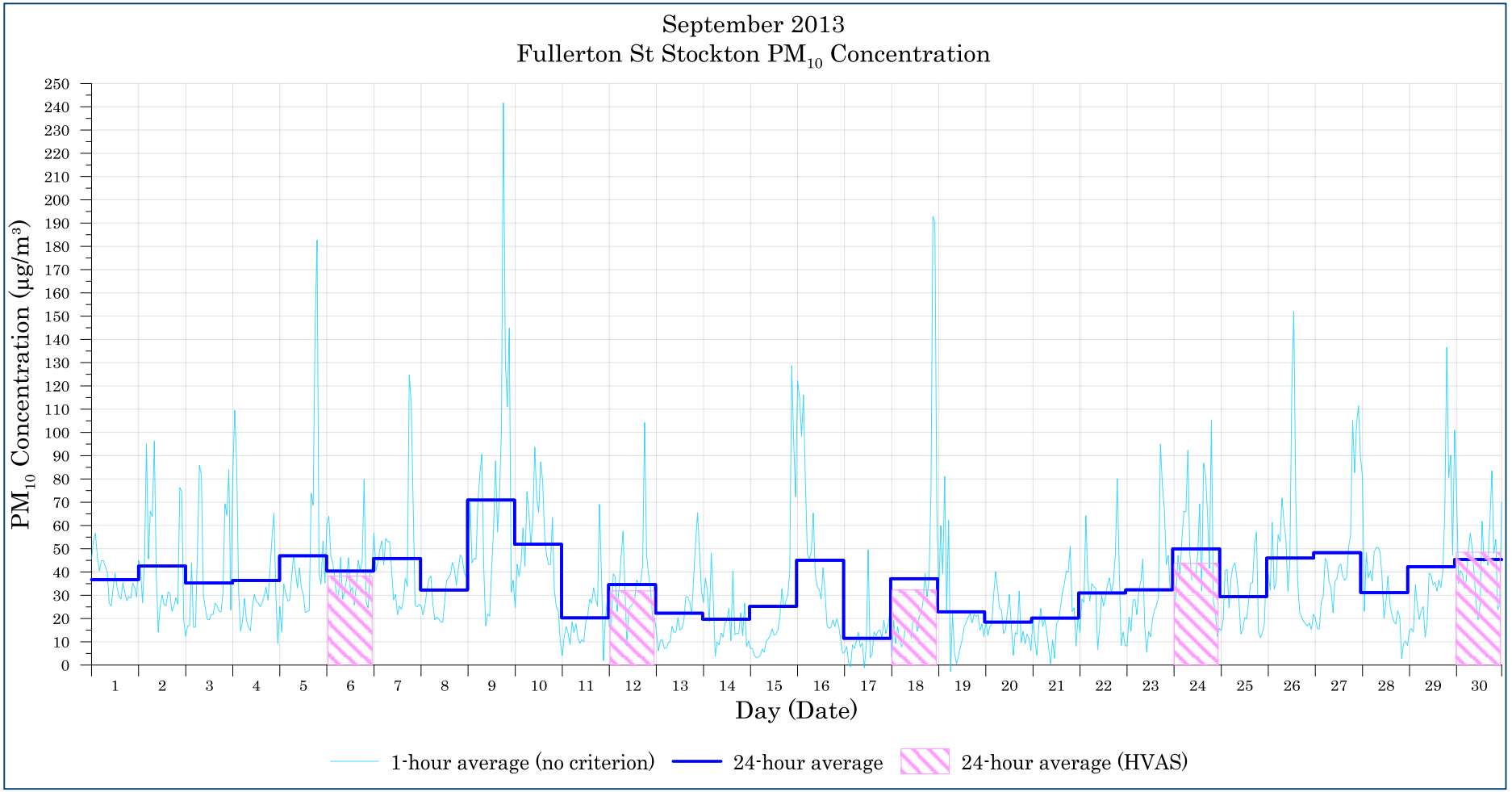

Figure B-4: Stockton PM_{10} concentration - September

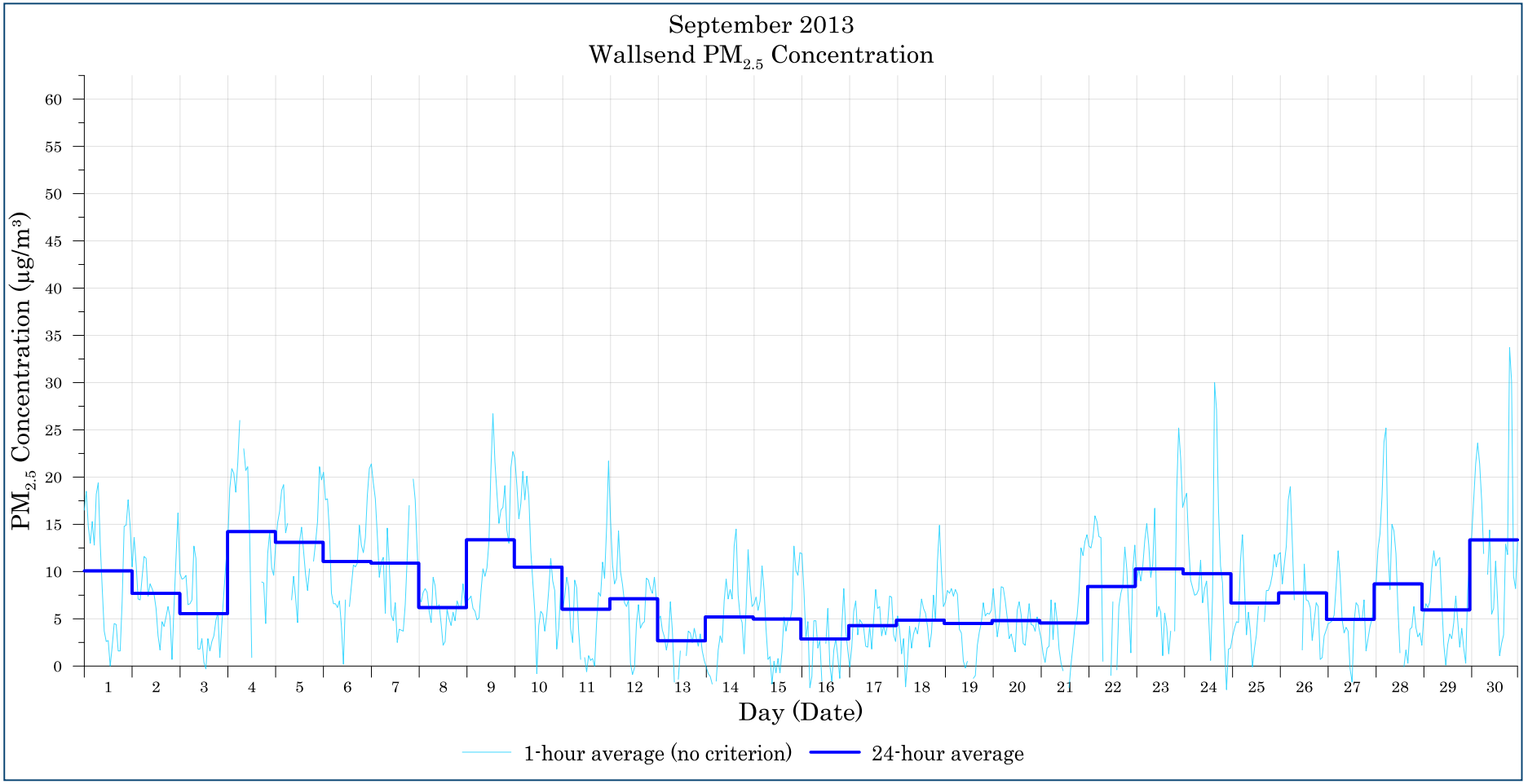

Figure B-5: Wallsend $PM_{2.5}$ concentration - September

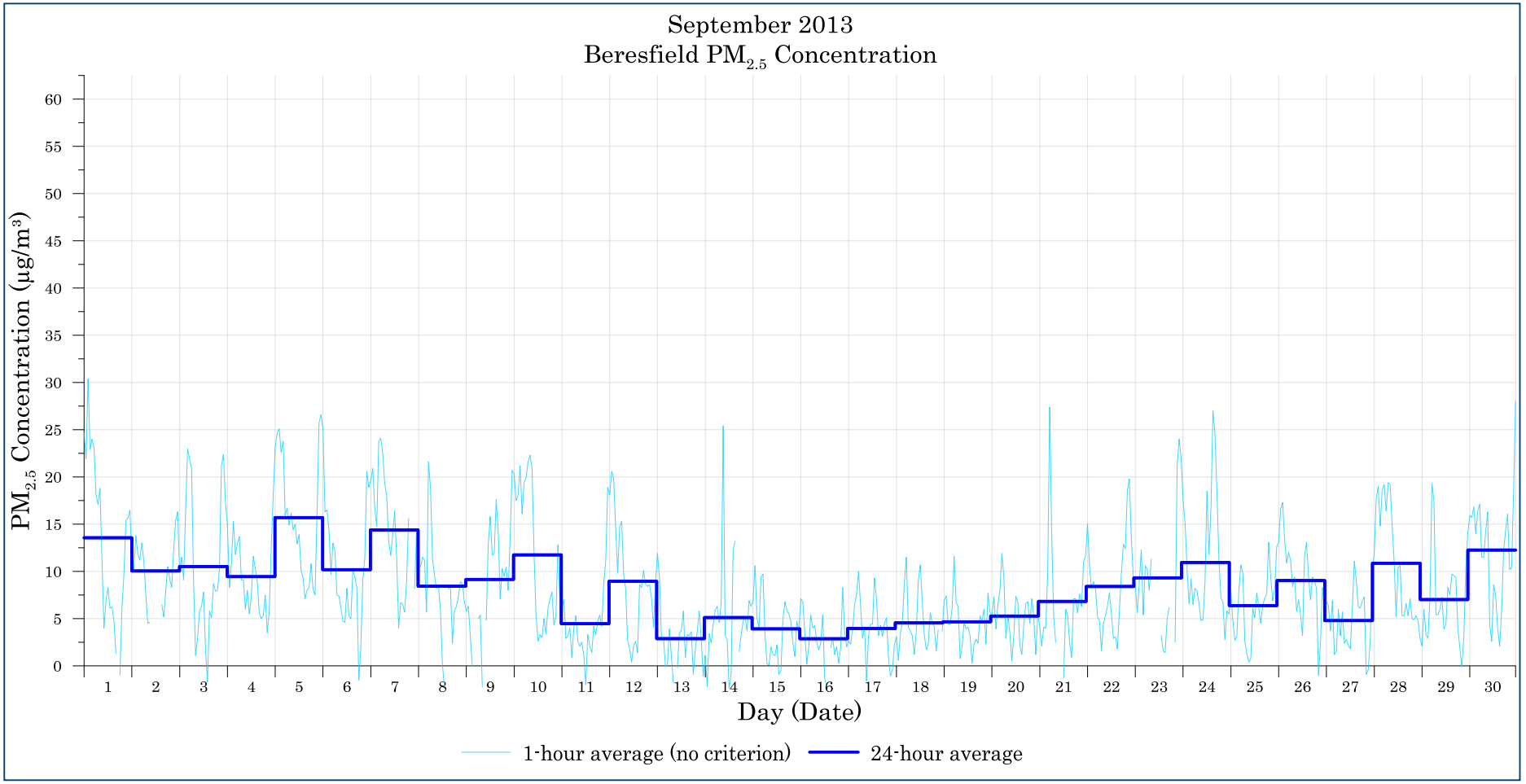

Figure B-6: Beresfield $PM_{2.5}$ concentration - September

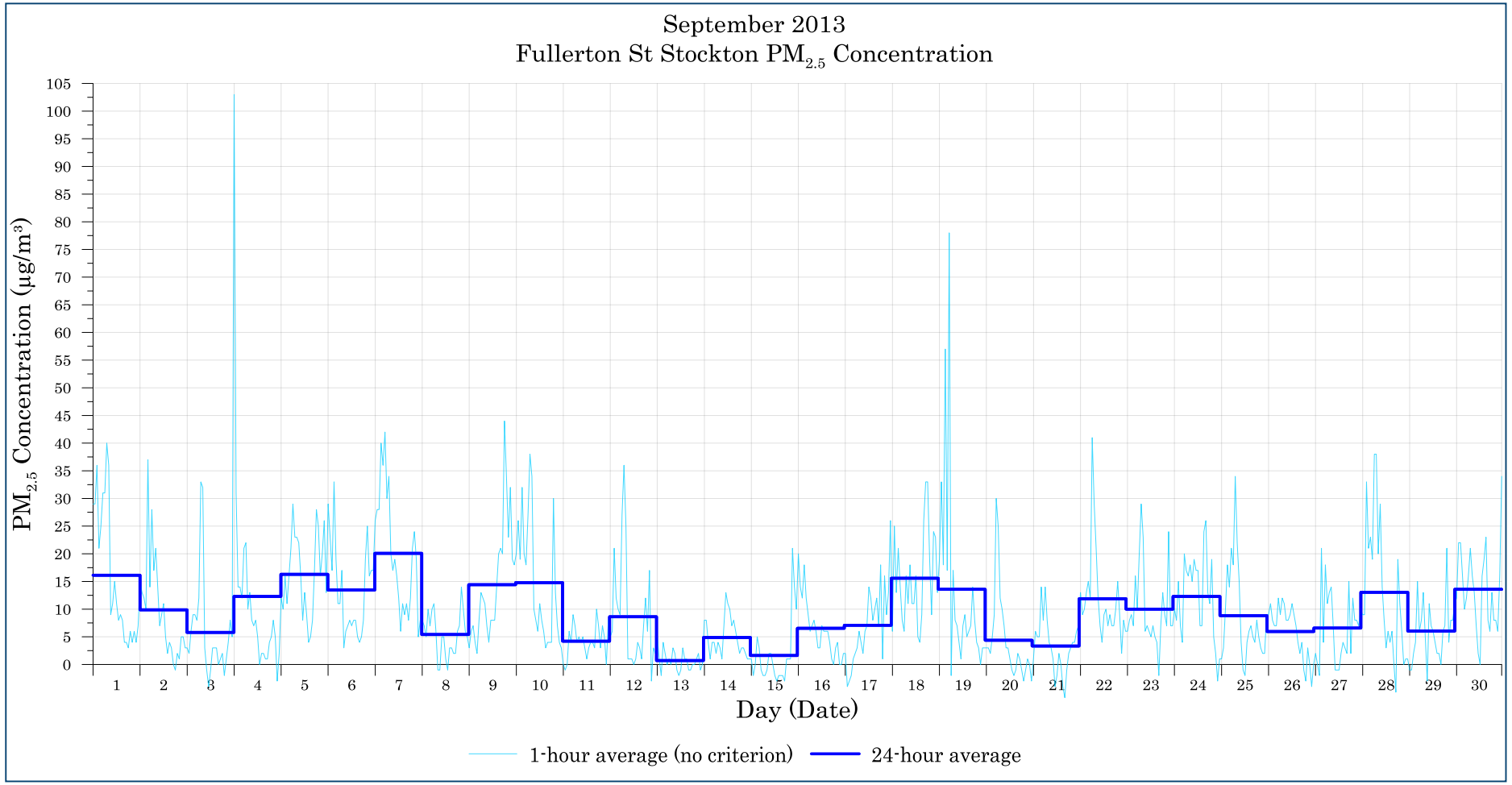

Figure B-7: Stockton $PM_{2.5}$ concentration - September

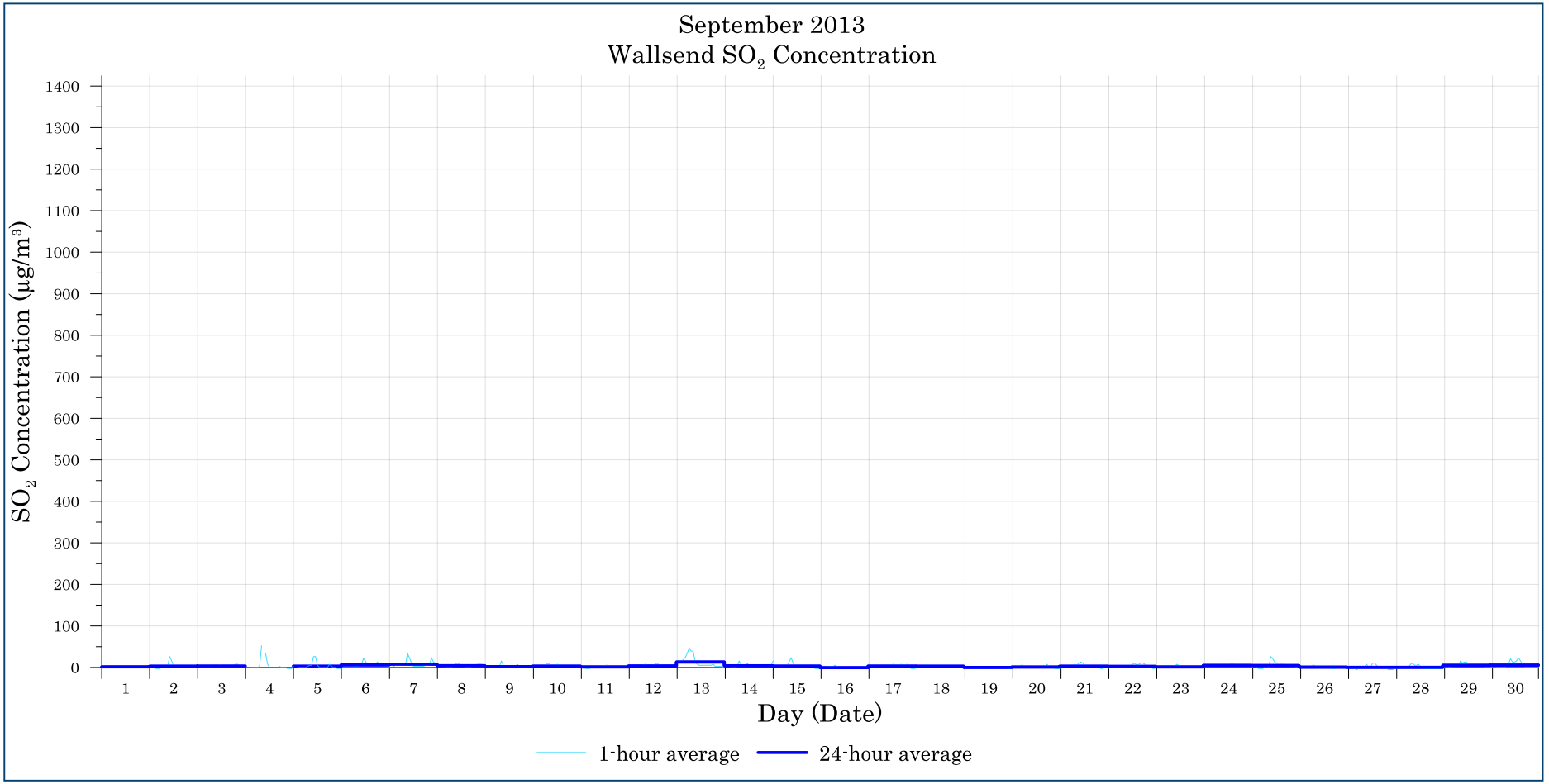

Figure B-8: Wallsend SO_2 concentration - September

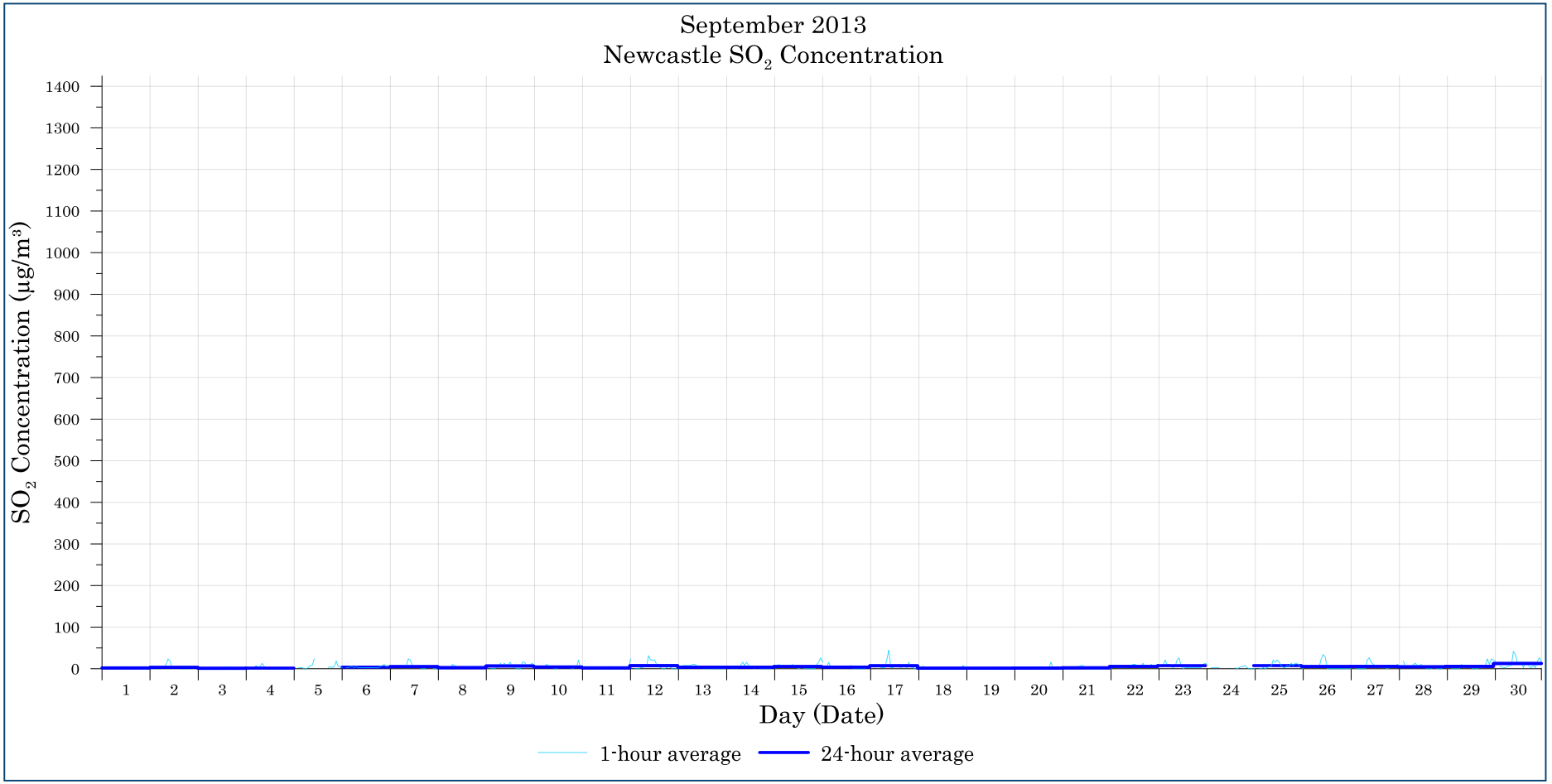

Figure B-9: Newcastle SO_2 concentration - September

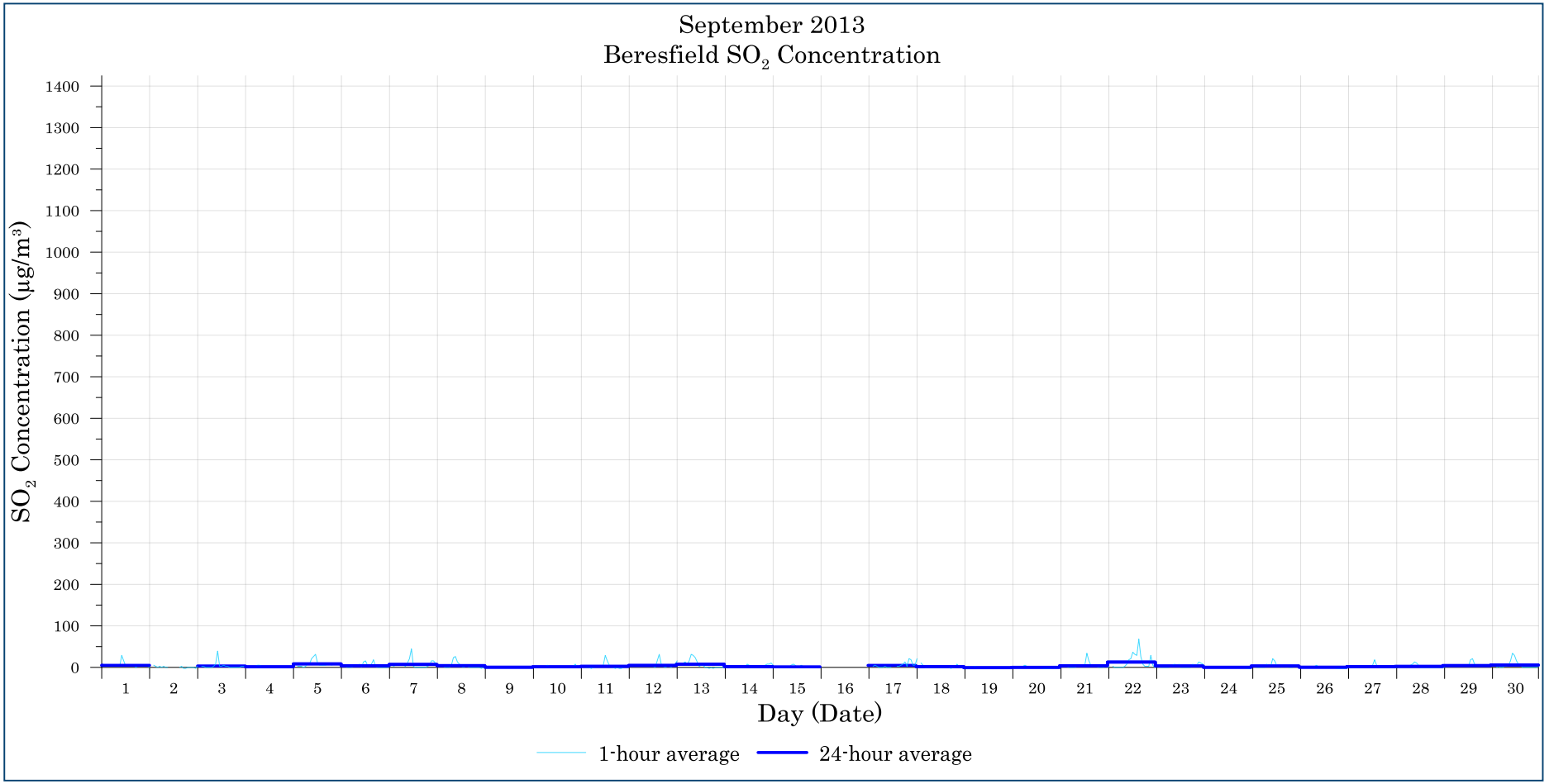

Figure B-10: Beresfield SO_2 concentration - September

Appendix C

Monitoring Data (Tabulated)

Table C-1: September 24-hour average monitoring data

Date	PM_{10} (µg/m³)				$PM_{2.5}$ (µg/m³)			SO_2 (µg/m³)		
	Wallsend	Newcastle	Beresfield	Fullerton St Stockton	Wallsend	Beresfield	Fullerton St Stockton	Wallsend	Newcastle	Beresfield
01/09/2013	13.9	25.4	21.0	36.7	10.1	13.6	16.1	1.4	2.1	4.9
02/09/2013	14.5	20.9	22.1	42.5	7.7	10.0	9.9	3.0	3.2	0.4
03/09/2013	12.6	16.1	23.0	35.3	5.6	10.5	5.8	3.6	1.0	3.4
04/09/2013	17.7	23.4	22.3	36.4	14.2	9.4	12.3	5.1	1.6	1.4
05/09/2013	22.3	33.0	43.1	47.0	13.1	15.7	16.3	3.4	-	8.4
06/09/2013	23.3	31.5	42.4	40.4	11.1	10.2	13.5	6.2	3.9	3.9
07/09/2013	21.6	33.1	34.8	45.8	10.9	14.4	20.1	8.0	5.0	7.1
08/09/2013	18.8	26.7	23.3	32.3	6.2	8.4	5.4	4.3	2.6	4.2
09/09/2013	24.4	42.4	30.9	70.9	13.4	9.1	14.4	2.2	6.6	0.3
10/09/2013	28.5	35.3	37.5	51.9	10.5	11.7	14.8	3.1	4.2	1.4
11/09/2013	14.6	22.1	25.1	20.3	6.0	4.5	4.2	1.3	2.2	2.5
12/09/2013	17.1	24.5	36.7	34.6	7.1	9.0	8.6	3.5	7.3	4.7
13/09/2013	11.9	14.7	13.4	22.3	2.7	2.9	0.7	13.1	3.6	7.6
14/09/2013	14.0	20.3	16.8	19.7	5.2	5.1	4.9	4.2	3.6	1.9
15/09/2013	8.2	18.4	10.9	25.2	5.0	3.9	1.6	3.2	5.2	1.4
16/09/2013	8.4	21.6	10.5	45.1	2.9	2.9	6.5	-0.6	4.0	-
17/09/2013	6.2	8.4	8.1	11.5	4.3	4.0	7.1	3.2	7.1	4.8
18/09/2013	9.4	13.0	13.3	37.1	4.9	4.6	15.6	3.0	1.3	2.0
19/09/2013	12.1	18.3	19.1	22.9	4.5	4.7	13.6	0.1	1.3	-0.8
20/09/2013	13.1	15.6	22.0	18.5	4.8	5.3	4.4	1.0	1.7	0.1
21/09/2013	9.7	16.2	16.1	20.2	4.6	6.8	3.3	3.0	2.3	3.9
22/09/2013	13.8	19.4	18.2	31.0	8.4	8.4	11.9	2.6	5.5	12.8
23/09/2013	15.6	27.1	27.1	32.4	10.3	9.3	10.0	1.3	7.4	3.3
24/09/2013	-	-	36.7	50.0	9.8	11.0	12.3	4.9	-	0.2
25/09/2013	-	19.8	23.4	29.4	6.7	6.4	8.8	4.7	7.5	3.3
26/09/2013	21.8	32.7	42.2	46.0	7.7	9.0	6.0	0.8	5.2	0.3
27/09/2013	19.1	24.8	35.9	48.3	4.9	4.8	6.6	0.3	5.5	1.9
28/09/2013	16.2	24.1	26.8	31.1	8.7	10.9	13.0	0.3	4.7	2.4
29/09/2013	20.0	25.7	23.8	42.3	5.9	7.0	6.0	5.1	5.6	4.3
30/09/2013	22.6	36.5	32.2	45.4	13.4	12.3	13.6	5.6	12.6	5.6

- Not applicable

Table C-2: September 24-hour average HVAS monitoring data

Date	PM_{10} (HVAS)

	(µg/m³)		
	Steel River	**Mayfield**	**Fullerton St Stockton**
06/09/2013	32.0	38.0	38.3
12/09/2013	25.0	29.0	31.9
18/09/2013	17.0	15.0	32.3
24/09/2013	39.0	47.0	43.7
30/09/2013	33.0	36.0	48.5

- Not applicable

Table C-3: 9 September 1-hour average monitoring data – Fullerton St Stockton

Fullerton St Stockton					Beresfield	Wallsend	Newcastle
Date	Time	WS (m/s)	WD (°)	PM_{10} (µg/m³)			
08/09/2013	24:00	1.3	64.4	38	25.4	20.6	31.8
09/09/2013	01:00	1.4	49.7	39	23.5	18.1	24.1
09/09/2013	02:00	1.4	55.6	70	17.9	19.4	26.9
09/09/2013	03:00	1.6	63.0	44	16.3	14.5	26.7
09/09/2013	04:00	1.3	52.0	46	16.2	17.0	23.9
09/09/2013	05:00	1.1	48.2	45	17.7	21.1	33.7
09/09/2013	06:00	1.0	44.9	70	18.2	18.0	30.0
09/09/2013	07:00	1.5	40.2	82	20.7	20.4	38.5
09/09/2013	08:00	1.9	30.8	91	19.9	19.2	59.0
09/09/2013	09:00	1.7	188.8	41	23.4	20.6	43.8
09/09/2013	10:00	3.0	297.8	17	24.5	22.8	34.3
09/09/2013	11:00	2.7	154.0	22	23.7	18.6	29.4
09/09/2013	12:00	-	-	21	23.6	22.7	28.7
09/09/2013	13:00	2.2	62.0	42	26.6	24.8	35.0
09/09/2013	14:00	3.0	81.5	58	24.5	24.3	40.7
09/09/2013	15:00	2.8	75.1	88	27.1	24.7	47.0
09/09/2013	16:00	2.4	71.6	57	29.0	26.6	47.0
09/09/2013	17:00	1.6	56.1	73	34.1	51.2	43.2
09/09/2013	18:00	1.6	49.9	101	52.4	43.2	58.4
09/09/2013	19:00	1.6	30.3	242	40.5	32.4	103.4
09/09/2013	20:00	2.1	31.7	130	38.1	29.1	57.2
09/09/2013	21:00	1.9	30.8	111	31.0	28.5	56.4
09/09/2013	22:00	0.7	38.0	145	30.9	25.1	43.6
09/09/2013	23:00	1.4	237.2	31	76.6	23.0	41.6
09/09/2013	24:00	2.9	349.7	36	85.6	19.7	44.3
10/09/2013	01:00	4.3	341.5	25	38.0	18.5	34.3

- Not applicable

Table C-4: 10 September 1-hour average monitoring data - Fullerton St Stockton

Fullerton St Stockton					Beresfield	Wallsend	Newcastle
Date	Time	WS (m/s)	WD (°)	PM_{10} (µg/m³)			
09/09/2013	24:00	2.9	349.7	36	85.6	19.7	44.3
10/09/2013	01:00	4.3	341.5	25	38.0	18.5	34.3
10/09/2013	02:00	4.1	321.6	43	30.5	18.5	33.6
10/09/2013	03:00	5.0	332.8	38	30.8	23.2	33.7
10/09/2013	04:00	5.1	319.7	44	35.2	25.3	32.9
10/09/2013	05:00	4.4	317.3	59	30.5	27.1	38.2
10/09/2013	06:00	5.2	320.9	43	37.8	24.5	36.0
10/09/2013	07:00	4.7	304.7	75	69.4	34.4	43.2
10/09/2013	08:00	6.0	298.9	66	149.9	8.1	32.1
10/09/2013	09:00	8.1	298.9	52	22.7	24.9	35.1
10/09/2013	10:00	9.9	300.6	62	38.4	30.8	43.4
10/09/2013	11:00	11.2	301.1	94	31.0	45.2	43.8
10/09/2013	12:00	10.2	306.9	71	24.8	46.4	44.5
10/09/2013	13:00	10.3	310.2	66	25.2	55.0	45.2
10/09/2013	14:00	10.6	312.0	87	29.3	55.2	57.7
10/09/2013	15:00	10.6	314.6	80	28.0	41.7	44.7
10/09/2013	16:00	9.4	320.0	56	25.4	32.9	35.1
10/09/2013	17:00	8.5	319.7	47	30.6	26.5	28.6
10/09/2013	18:00	6.5	327.1	43	26.1	24.2	30.7
10/09/2013	19:00	5.2	330.8	43	23.5	25.2	28.3
10/09/2013	20:00	3.6	301.2	63	40.7	19.8	30.2
10/09/2013	21:00	2.5	264.7	32	48.9	17.0	32.3
10/09/2013	22:00	2.5	229.8	25	42.7	23.3	22.6
10/09/2013	23:00	4.7	220.6	23	27.1	22.7	21.8
10/09/2013	24:00	4.2	215.2	10	14.0	12.4	18.5
11/09/2013	01:00	4.0	220.6	4	8.0	11.1	8.7