Air quality in Newcastle: Autumn 2018

Air quality in Newcastle from 1 March to 31 May 2018 was generally good.

- Levels of nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and ammonia (NH_3) were all well below benchmark concentrations and assessment goals.
- Daily average levels of fine particulate matter $PM_{2.5}$ (particles less than or equal to 2.5 microns in diameter) were below the 25 micrograms per cubic metre (µg/m^3) benchmark.
- Daily average levels of particulate matter PM_{10} (particles less than or equal to 10 microns in diameter) were above the 50 µg/m^3 benchmark on 16 days during autumn 2018 (3, 10, 14–15, 17, 19–20 March, 2, 9, 11, 13, 15, 18–19 April and 26–27 May). Regional maximum daily PM_{10} levels on these days ranged from 50.2 to 88.6 µg/m^3.
  - Beresfield, Mayfield, Newcastle and Wallsend each recorded two days over the benchmark, Carrington recorded three days and Stockton 15 days.
  - The most extensive events occurred on 19 March and 15 April, being exceptional events due to long-range dust transport. April and May had amongst the highest dust activity in New South Wales since DustWatch commenced in 2005[1].
    - On 19 March, 35 air quality monitoring stations in the NSW network recorded PM_{10} levels over the benchmark. A dust storm was reported on 18 March[1] through Canberra, travelling out to the east coast and impacting the Newcastle region from later that night under southerly winds.
    - On 15 April, PM_{10} levels over the benchmark were recorded at all Hunter air quality monitoring stations along with Tamworth, Gunnedah and Narrabri. The region was impacted by long-range dust from the State's west on this day. More details on this event are found in a section below.
  - At Stockton, the remaining elevated levels mainly occurred, about 69% of the time in total over the season, under onshore easterly winds. Stockton particle levels are influenced by sea salt spray transported by onshore winds[2], which are dominant during the warmer months.
- The Newcastle region had below average rainfall (drier than two of the three previous autumns), with very dry conditions in May. Temperatures were very much above average during the season.

Annual air quality trends in the Newcastle region

A comparison of annual average PM_{10} and $PM_{2.5}$ levels shows the long-term trends. The national annual average benchmarks are 25 µg/m^3 for PM_{10} and 8 µg/m^3 for $PM_{2.5}$, based on a calendar year.

Figure 1 shows the PM_{10} and $PM_{2.5}$ *rolling* annual averages, based on the 12-month periods, to the end of autumn for 2015 to 2018.

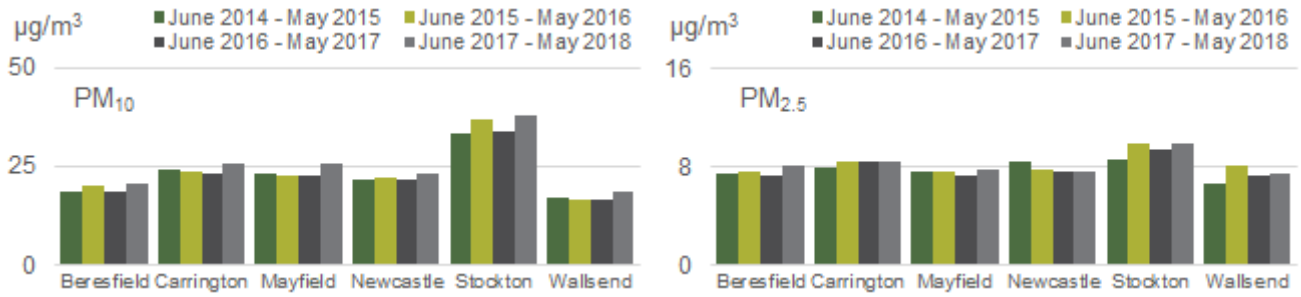

Figure 1 PM_{10} and $PM_{2.5}$ rolling annual averages to the end of autumn 2018

Note: Carrington and Mayfield data from August 2014. Stockton data prior to 14 October 2014 from Orica

[1] DustWatch report March 2018, DustWatch report April 2018 and DustWatch report May 2018
[2] Lower Hunter Particle Characterisation Study

The comparison in Figure 1 shows that the rolling annual average PM_{10} particle levels to the end of autumn 2018 are similar or higher compared to the three earlier years. Many NSW regions, including Newcastle, experienced low rainfall over the past 12 months and are drought affected (Figure 2). Long-range dust from drought-affected areas in New South Wales would have contributed to the increase in the particle rolling annual averages observed in the region.

For $PM_{2.5}$, rolling annual average particle levels have generally remained similar to earlier years. The higher $PM_{2.5}$ annual averages at Stockton is consistent with the Lower Hunter Particle Characterisation Study, which found 40% more $PM_{2.5}$ at Stockton compared to Mayfield, Beresfield and Newcastle. This was found to be due to more sea salt and primary ammonium nitrate at the site, which is very likely due to Orica's ammonium nitrate manufacturing facility on Kooragang Island.

Rolling annual averages are not intended to be compared to the annual benchmarks. The rolling annual averages provide a guide to long-term trends, using the most up to date monitoring data.

The annual averages for the 2015 to 2017 calendar years can be found in the Newcastle summer 2017–18 seasonal newsletter.

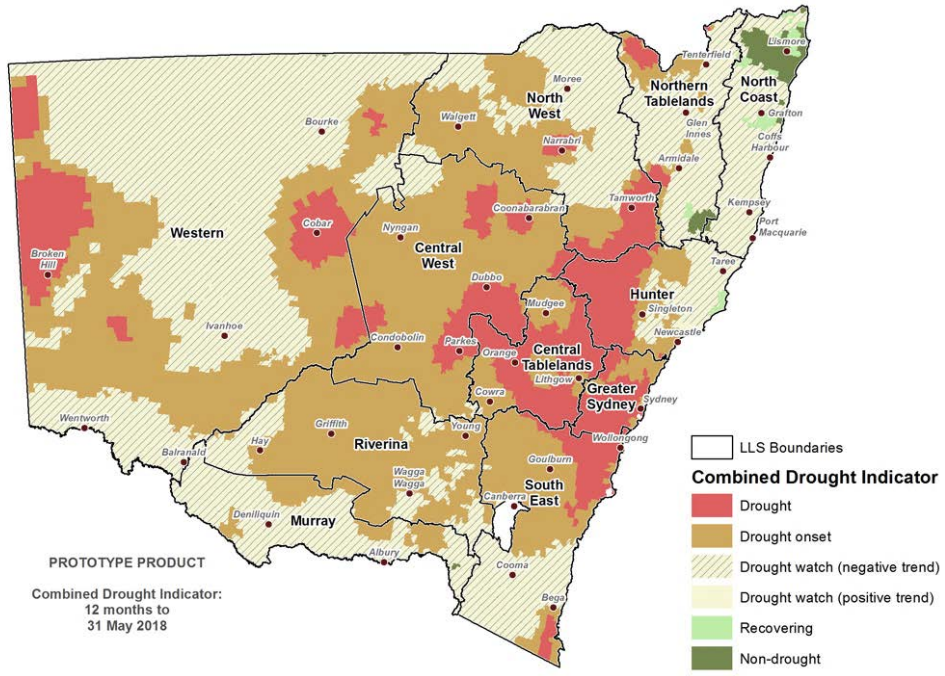

Figure 2 **Department of Primary Industries NSW Combined Drought Indicator to 31 May 2018**[3]

Days above benchmark concentrations

There were 16 days over the PM_{10} benchmark during autumn 2018, predominantly at Stockton which is influenced by sea salt spray under onshore winds. More information on the elevated particle levels at Stockton is included in a section below.

Table 1 **Number of days above the relevant benchmarks – autumn 2018**

Station	PM_{10} daily [50 µg/m^3 benchmark]	$PM_{2.5}$ daily [25 µg/m^3 benchmark]	SO_2 hourly [20 pphm benchmark]	SO_2 daily [8 pphm benchmark]	NO_2 hourly [12 pphm benchmark]	NH_3 hourly [46 pphm benchmark]
Beresfield	2	0	0	0	0	-
Carrington	3	0	0	0	0	-
Mayfield	2	0	0	0	0	-
Newcastle	2	0	0	0	0	-
Stockton	15	0	0	0	0	0
Wallsend	2	0	0	0	0	-

µg/m^3 = microgram per cubic metre
pphm = parts per hundred million by volume (i.e. parts of pollutant per hundred million parts of air)
- = not monitored

[3] Sourced from Department of Primary Industries NSW State seasonal update - May 2018 (accessed July 2018).

Daily time series plots

Daily average time series plots for PM_{10} and $PM_{2.5}$ and daily one–hour maximum plots for NO_2, SO_2 and NH_3 show the daily concentrations throughout the autumn season.

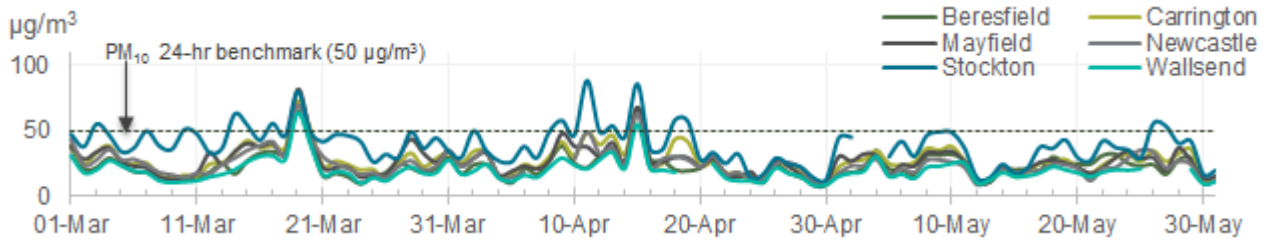

Figure 3 **Daily average PM_{10} during autumn 2018**

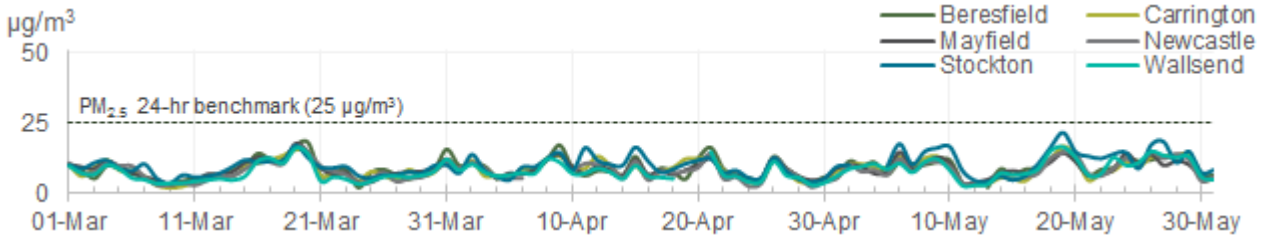

Figure 4 **Daily average $PM_{2.5}$ during autumn 2018**

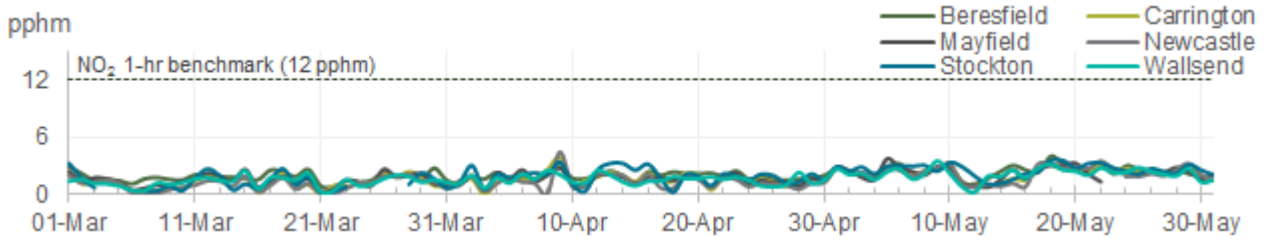

Figure 5 **Daily maximum 1-hr NO_2 during autumn 2018**

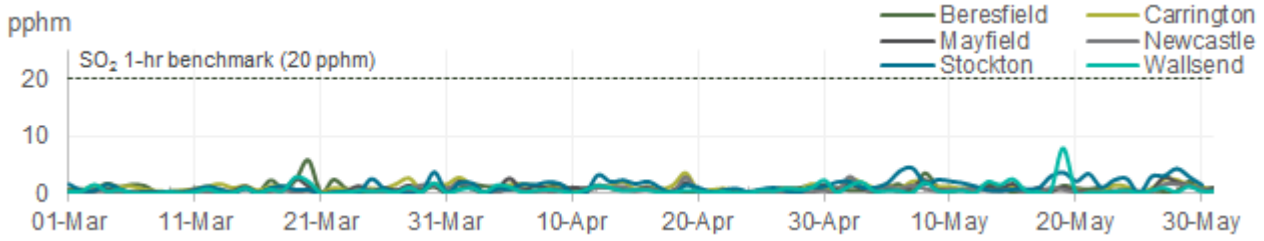

Figure 6 **Daily maximum 1-hr SO_2 during autumn 2018**

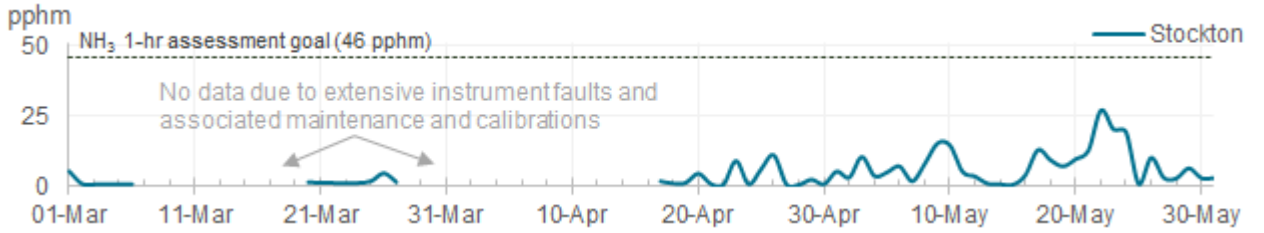

Figure 7 **Daily maximum 1-hr NH_3 during autumn 2018**

Pollution roses

The seasonal pollution rose maps[4] show that PM_{10} and $PM_{2.5}$ levels generally remained low during autumn. A small portion of elevated hourly[5] PM_{10} levels occurred at Stockton under north east winds (see Stockton section below for more detail). The highest PM_{10} levels at all sites were experienced under north west winds, predominantly during long-range dust storm events.

Figure 8 **Hourly PM_{10} pollution roses for the Newcastle region for autumn 2018**

Figure 9 **Hourly $PM_{2.5}$ pollution roses for the Newcastle region for autumn 2018**

[4] Pollution roses show the wind direction and particle levels at a location. The length of each bar around the circle shows the percentage of time that the wind blows from a particular direction. The colours along the bars indicate categories of particle levels.

[5] Note: There are no standards for hourly PM_{10}/$PM_{2.5}$ in the National Environment Protection (Ambient Air Quality) Measure (Air NEPM)

Seasonal comparisons

This section compares air quality levels in autumn 2018 with previous autumn seasons, where data were available. Monitoring at Stockton commenced in October 2012[6] and at Mayfield and Carrington in August 2014. Monitoring of $PM_{2.5}$ at Newcastle commenced in December 2013.

All days were below benchmark concentrations for NO_2 and SO_2 in autumn during the past five years at Beresfield, Newcastle, Stockton and Wallsend and since monitoring began at Carrington and Mayfield. There were no days above the NH_3 assessment criterion at Stockton for the past five autumn seasons.

There were no days above the $PM_{2.5}$ benchmark in the region during autumn 2018. In earlier years, Wallsend recorded one day above the $PM_{2.5}$ benchmark during autumn 2013.

Beresfield, Mayfield, Newcastle and Wallsend each recorded one day over the PM_{10} benchmark in autumn 2018, Carrington three days and Stockton 15 days. At Stockton, this was lower than autumn 2016 when 21 days were recorded over the benchmark, although slightly more than autumns 2015 and 2017 when 10 and 11 days were recorded, respectively. At the other sites, one day was recorded over the PM_{10} benchmark at all sites in May 2015 during a statewide dust storm.

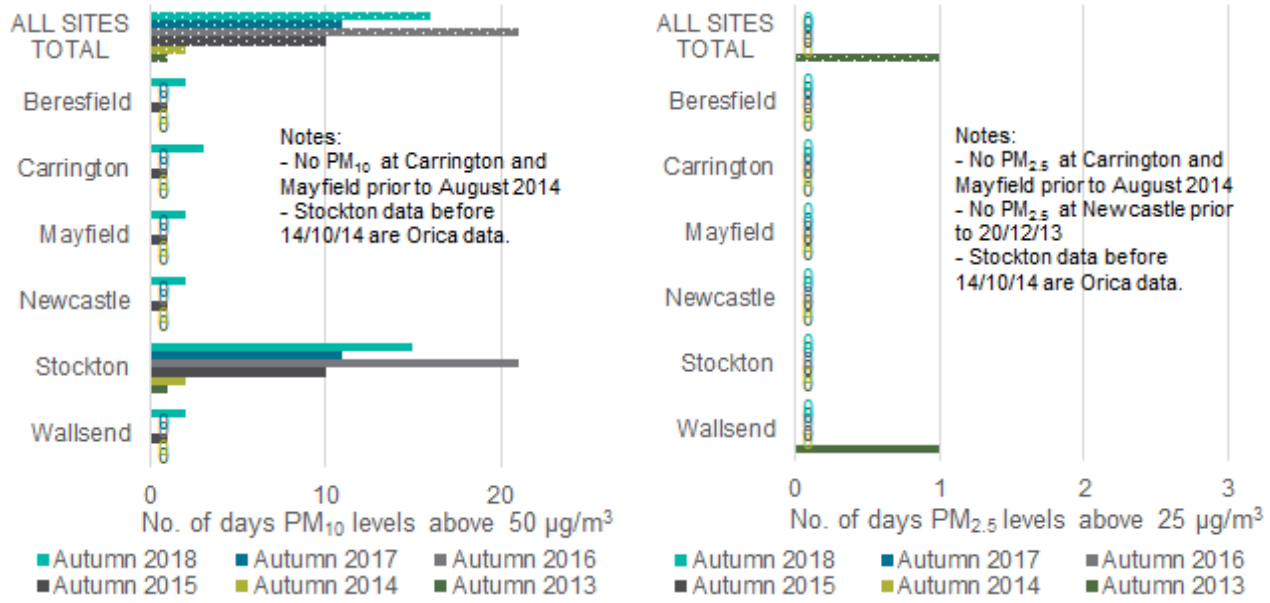

Figure 10 Number of days above the PM_{10} and $PM_{2.5}$ benchmarks: autumns 2013 to 2018

[6] Stockton air quality monitoring was undertaken by Orica from October 2012 to October 2014. From October 2014 it was undertaken by the Office of Environment and Heritage as part of the Newcastle Local Air Quality Monitoring Network.

Particle air quality trends in the Newcastle region

Figure 11 and Figure 12 show daily average PM_{10} during autumn 2018, compared to the daily maximum and minimum (i.e. shaded range) of PM_{10} levels for the autumn periods from 2013 to 2017, at Stockton and Newcastle. These show that daily PM_{10} levels were generally within the range of earlier years, with peaks seen during the dust storm events on 19 March and 15 April. At Stockton, the peak on 11 April occurred under onshore flows. Variability during the season may be partly due to the low number of years of historical data available for comparison. There was very little rainfall in May (Figure 13).

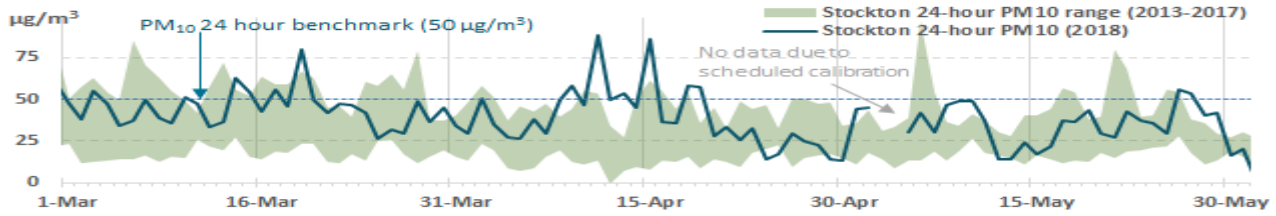

Figure 11 **Stockton daily average PM_{10} during autumn 2018 plotted against the daily maximum and minimum PM_{10} levels recorded from autumn 2013 to 2017**

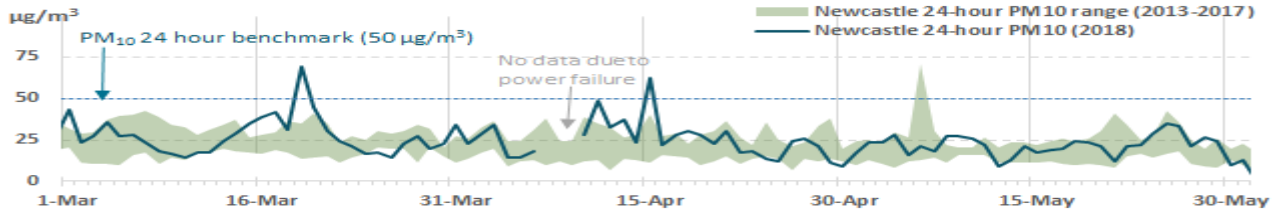

Figure 12 **Newcastle daily average PM_{10} during autumn 2018 plotted against the daily maximum and minimum PM_{10} levels recorded from autumn 2013 to 2017**

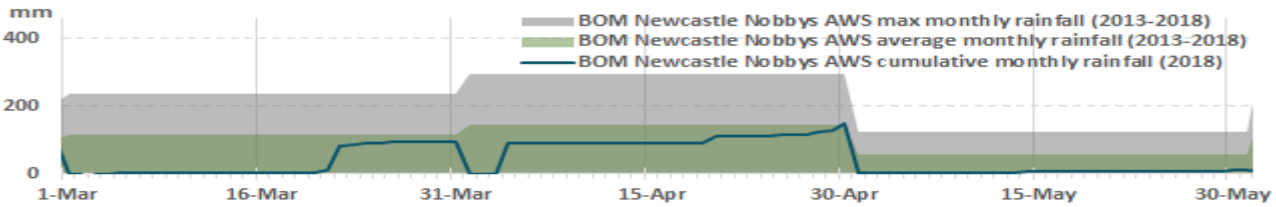

Figure 13 **Bureau of Meteorology Newcastle Nobbys Signal Station AWS[7] cumulative rainfall during autumn 2018 plotted against the monthly maximum and average rainfall from 2013 to 2018**

Figure 14 and Figure 15 show daily average $PM_{2.5}$ during autumn 2018, compared to the daily maximum and minimum levels (shaded range) from autumn 2014 to 2017, at Stockton and Newcastle. These show that daily $PM_{2.5}$ levels were variable compared to the same days in earlier years, with levels on some days higher while others lower. This variability may be partly due to the low number of years of historical data available for comparison.

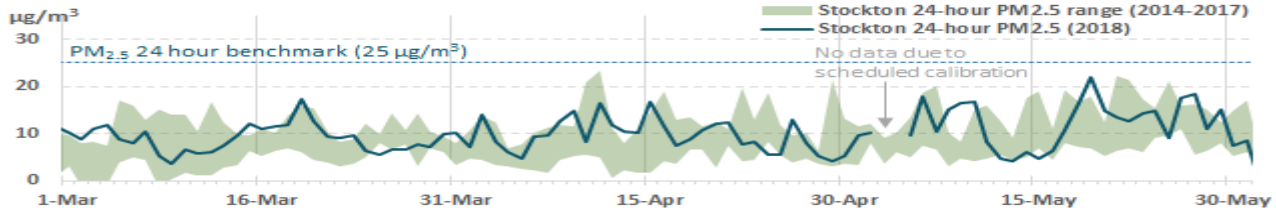

Figure 14 **Stockton daily average $PM_{2.5}$ during autumn 2018 plotted against the daily maximum and minimum $PM_{2.5}$ levels recorded from autumn 2014 to 2017**

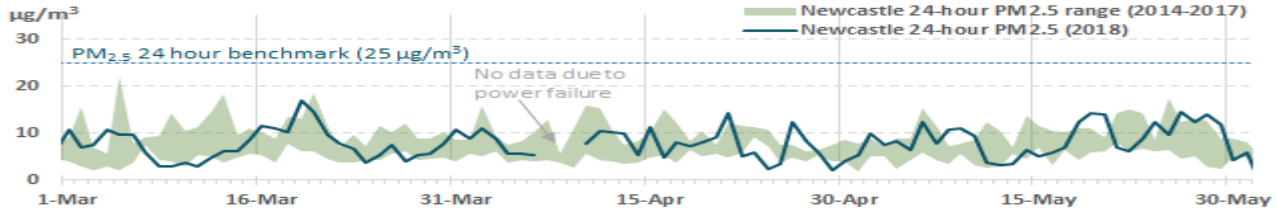

Figure 15 **Newcastle daily average $PM_{2.5}$ during autumn 2018 plotted against the daily maximum and minimum $PM_{2.5}$ levels recorded from autumn 2014 to 2017**

[7] Data from the Bureau of Meteorology Newcastle Nobbys Signal Station AWS monthly rainfall data web page (accessed August 2018)

Meteorological summary

Rainfall and temperature[8]

The Newcastle region experienced predominantly below average rainfall during autumn 2018 compared to long-term records. However, there was variability through the season with generally average rainfall in March and April, while very much below average in May. Autumn 2018 was drier than autumn 2017 (with 100 to 200 millimetres less rain) and autumn 2015 (with 400 to 600 millimetres less rain). However, it was wetter than autumn 2016 with 50 to 100 millimetres more rain.

Maximum and minimum temperatures in Newcastle were very much above average during the season.

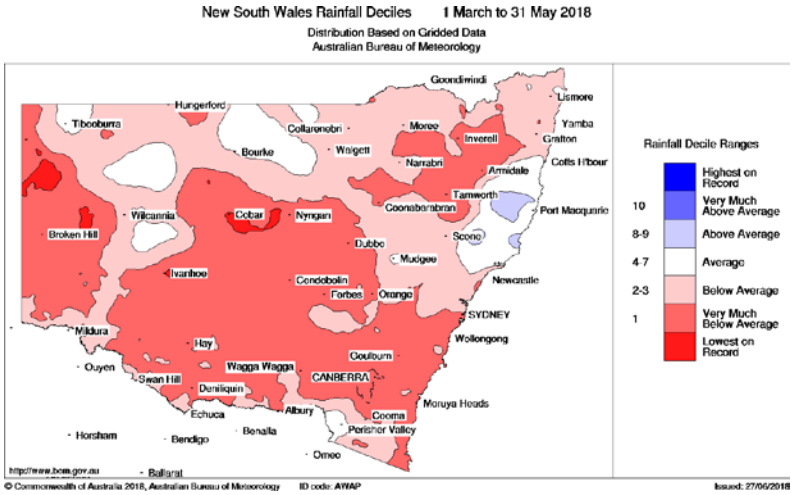

Figure 16 NSW rainfall deciles – autumn 2018

Wind

The winds were variable in the region during autumn 2018. Winds typically change from onshore easterly flows during the warmer months to offshore westerly flows as conditions cool. As an example, Figure 17 shows that at Stockton, easterly component winds prevailed 34% of the time and these were moderate (above five metres per second) 5% of the time.

Typically for autumn, Wallsend experienced frequent south-easterly airflows due to the local topography.

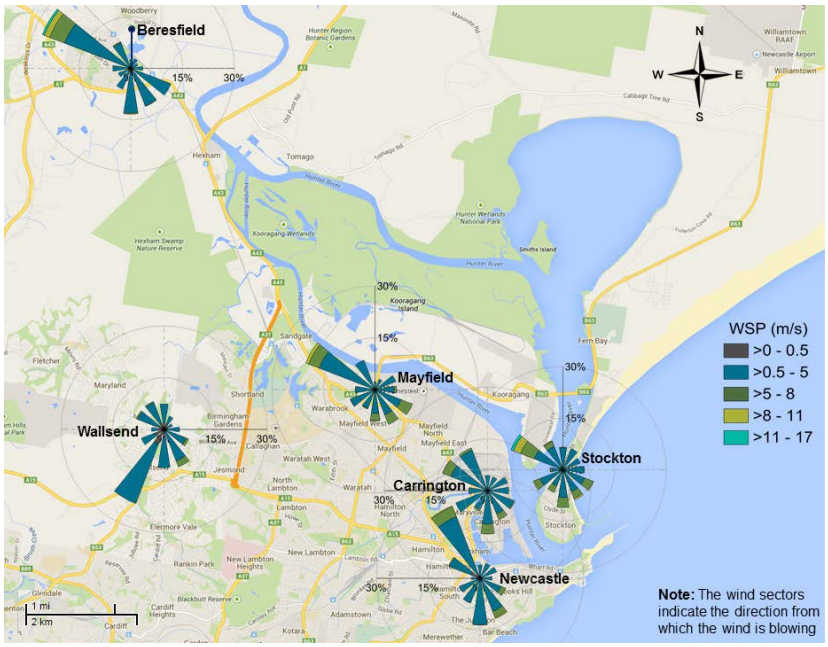

Figure 17 Wind rose map[9] for the Newcastle region for autumn 2018

[8] Rainfall and temperature information are from the Bureau of Meteorology New South Wales autumn 2018 climate statement and climate maps (accessed July 2018).

[9] Wind roses show the wind direction and speed at a location. The length of each bar around the circle in these wind roses show the percentage of time that the wind blows from a particular direction. The colours along the bars indicate the wind speed categories.

Particle event: 15 April 2018

Air pollution levels can be affected by extreme events, such as dust storms, bushfires and hazard reduction burns.

Air quality across NSW on 15 April 2018

An extensive particle event occurred on 15 April 2018. On this day all the Upper Hunter, Lower Hunter and Newcastle Local network sites recorded PM_{10} levels over the benchmark, in addition to Tamworth, Gunnedah and Narrabri (North-west Slopes) (Figure 18). These elevated levels followed the passage of a frontal system through New South Wales (Figure 19).

Figure 18 **Maximum daily regional PM_{10} levels on 15 April 2018, by region**

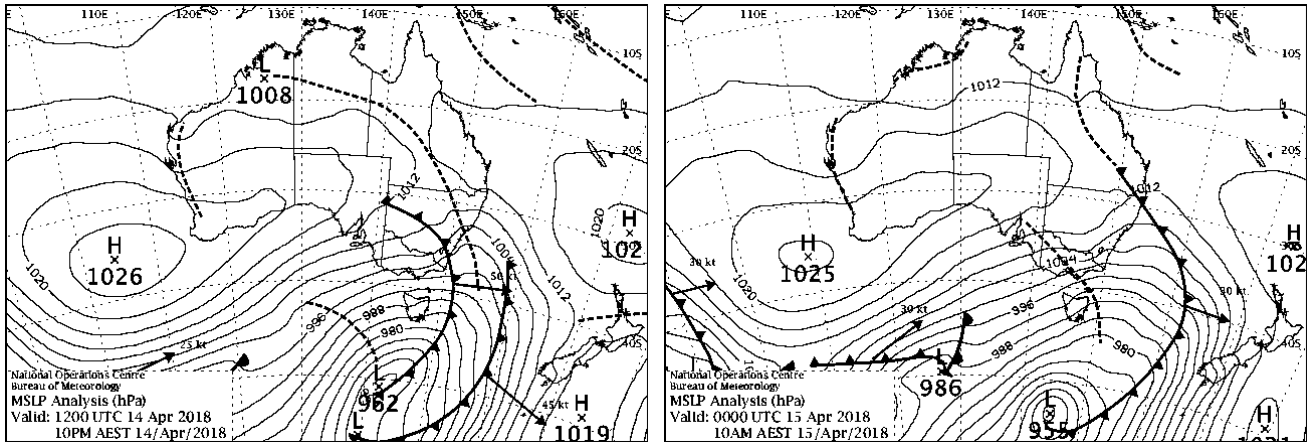

Figure 19 **Synoptic charts[10] showing the passage of a front on 14 and 15 April 2018**

Air quality in the Newcastle region on 15 April 2018

In the Newcastle region, particle levels exceeded the PM_{10} daily benchmark of 50 µg/m^3 on this day at all monitoring sites (Figure 20). Daily PM_{10} levels ranged from 55.4 to 85.9 µg/m^3 on this day.

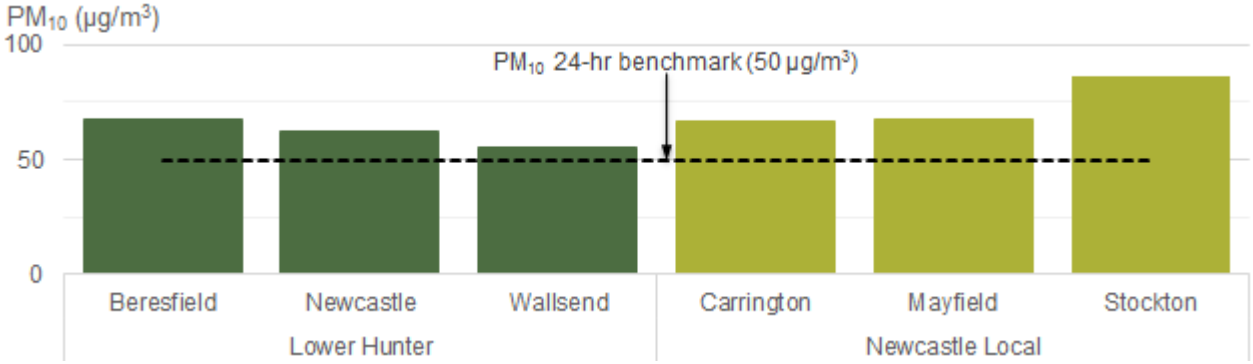

Figure 20 **Daily PM_{10} levels in the Newcastle region, by station type, 15 April 2018**

[10] Sourced from the Bureau of Meteorology Analysis Chart Archive website (accessed in July 2018)

Pollution roses in Figure 21, show elevated hourly PM_{10} levels associated with winds from the north west at all sites in the Newcastle region on 15 April 2018.

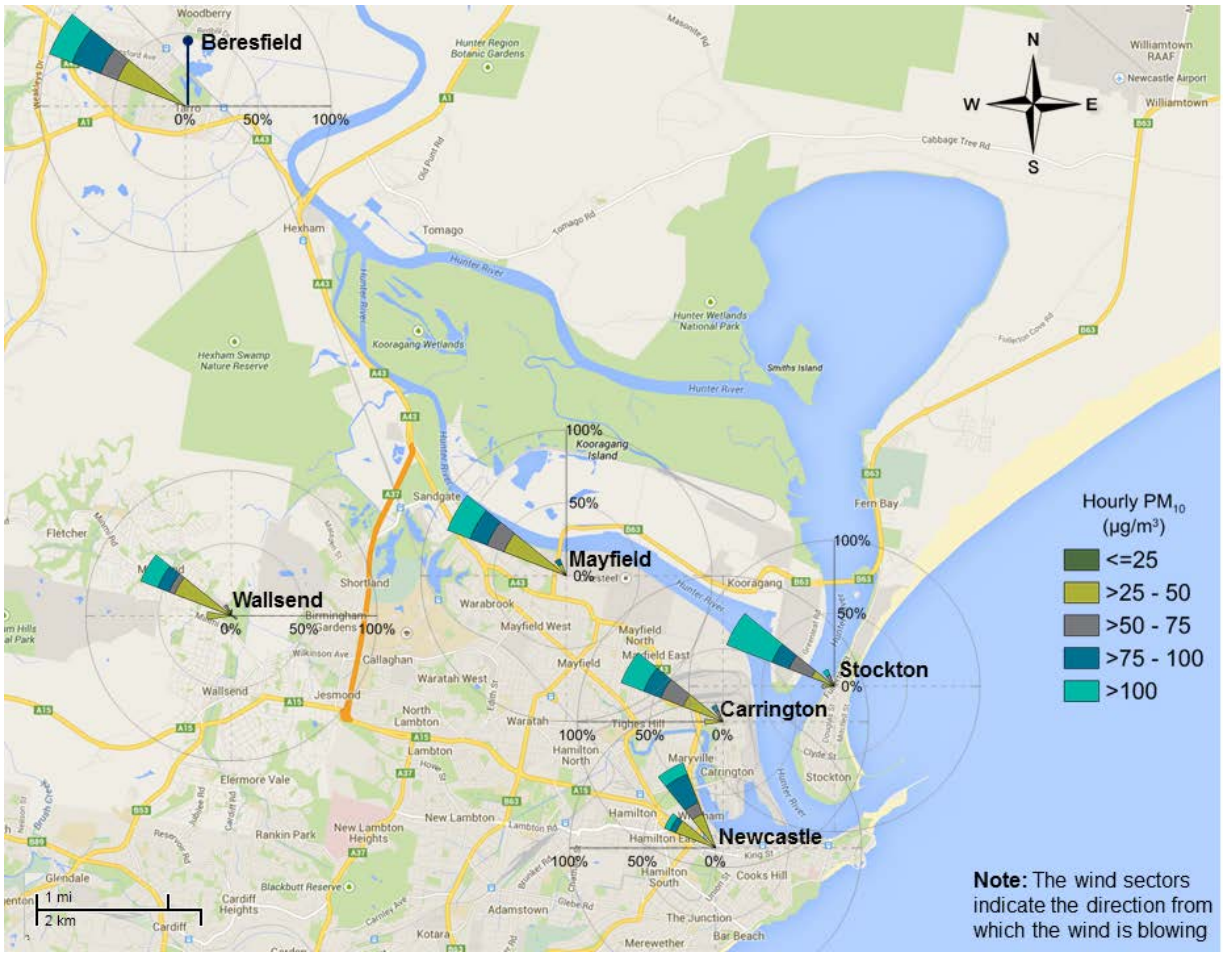

Figure 21 Hourly PM_{10} pollution rose map for the Newcastle region for 15 April 2018

Seasonal weather conditions

Dust activity in New South Wales was high during autumn[11] with most of the State recording below to very much below average rainfall (Figure 16) and much of the State experiencing drought conditions (Figure 2). The Newcastle region was drier than two of the previous three autumn periods, as noted above.

DustWatch reported in May 2018[11] that widespread dust storms are very unusual in winter but are a possibility this year considering the low groundcover and ongoing dry conditions.

HYSPLIT in NSW back-trajectory modelling

The Office of Environment and Heritage (OEH) undertook back-trajectory modelling using HYSPLIT in NSW to determine the source of the elevated particles on 15 April 2018.

Figure 22 shows the modelled trajectory, or passage of air parcels, in the 24 hours before arriving at a location. The trajectories are shown for air parcels modelled at various heights, in metres above ground level (m AGL) arriving at Muswellbrook, Singleton and Newcastle.

Figure 22 shows air travelling to the Hunter from the west and north west on 14 and 15 April 2018. These areas (Central West and Western NSW) are experiencing persistent dry conditions and are currently in drought (Figure 2).

[11] DustWatch report March 2018, DustWatch report April 2018 and DustWatch report May 2018

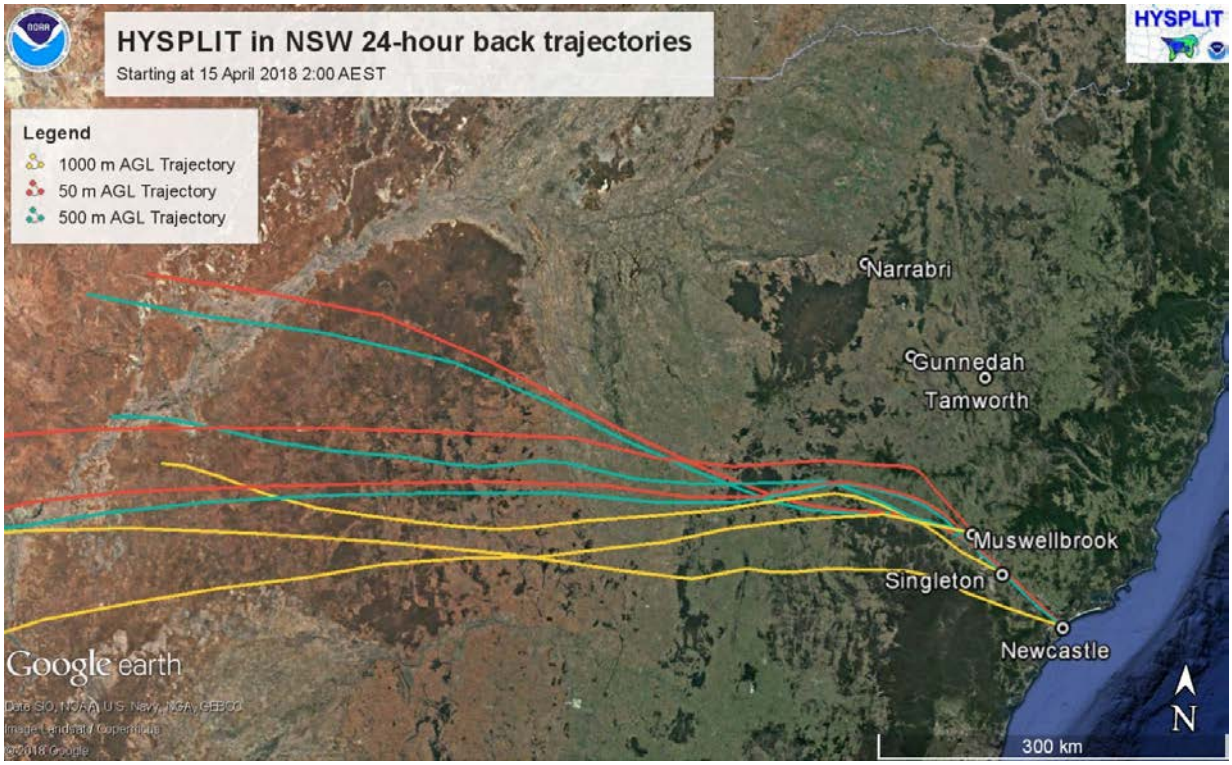

Figure 22 **OEH HYSPLIT in NSW modelling output, shows the passage of air on 14 and 15 April 2018**

Conclusion

The event analysis shows that Hunter air quality was affected by the long-range transport of dust particles on 15 April 2018 from the drought-affected Central West and Western NSW regions. This resulted in PM_{10} exceedances across the Hunter and northern air quality monitoring stations on this day.

Stockton

The Stockton monitoring site continued to record a higher number of days over the PM_{10} benchmark compared to other sites in the region.

In autumn 2018, elevated hourly PM_{10} levels (>75 µg/m^3) occurred 6.5% of the time. The majority of these, approximately 69% of the time, occurred under onshore easterly winds (Figure 23). This indicates the potential contribution of sea salt, with the Lower Hunter Particle Characterisation Study finding sea salt to be a major contributor of particles at the site.

Elevated hourly PM_{10} levels (>75 µg/m^3) were from the north west sector 1.3% of the time (28 hours) during autumn, with 43% (12 hours) of these on 15 April, during the dust storm. The remainder of elevated hourly PM_{10} levels were one to three hours on varying days, potentially due to local industrial sources.

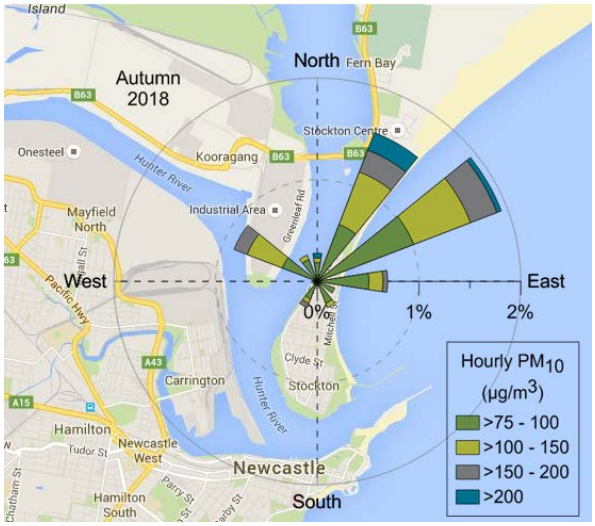

Figure 23 **Stockton autumn 2018 pollution rose - proportion of hourly averaged PM_{10} levels >75 µg/m^3 by wind direction**

Elevated hourly $PM_{2.5}$ levels (>40 µg/m^3) occurred 0.1% of the time (3 hours) during autumn, from the northwest.

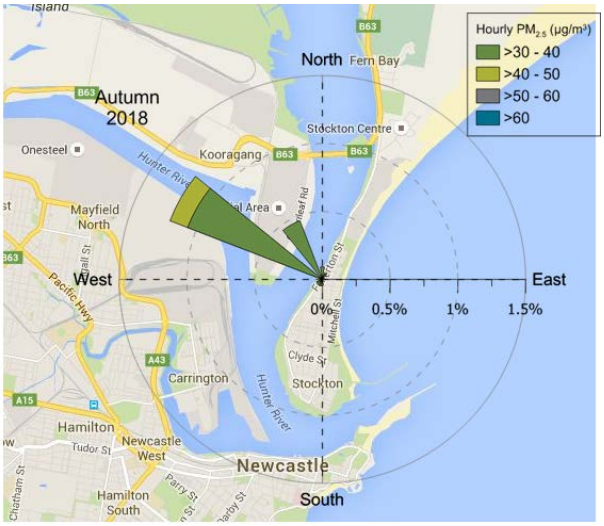

Figure 24 Stockton autumn 2018 pollution rose – proportion of hourly averages $PM_{2.5}$ levels >30 µg/m^3 by wind direction

Network performance

The target network performance is at least 95% available data for all parameters. For NO_2, SO_2 and NH_3, due to daily calibrations, the maximum online time that can be attained is 96%.

Table 2 Online performance (%) during autumn 2018

Station	Particles PM_{10} daily	Particles $PM_{2.5}$ daily	Gases SO_2 hourly	Gases NO_2 hourly	Gases NH_3 hourly	Meteorology Wind hourly
Beresfield	100	98	95	93	-	100
Carrington	100	100	94	92	-	100
Mayfield	100	100	94	93	-	100
Newcastle	97	97	92	93	-	98
Stockton	98	98	92	88	58	100
Wallsend	95	98	95	95	-	99

- = not monitored

The reduced online times were mainly due to:

- Wallsend PM_{10} – power failure following storm (two days) and instrument fault (three days)
- Stockton NO_2 – instrument faults (four days) and calibrations (two days)
- Stockton NH_3 – extensive instrument faults and associated maintenance and calibrations (33 days from 7 to 19 March and 28 March to 16 April). During this period of faults, winds were from the northwest sector (from north to west) 25% of the time.

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