Air quality in Newcastle: Spring 2021

Air quality in the Newcastle region was predominantly good during spring 2021. Daily particle levels were within national benchmarks for 93% of the time at Stockton and between 99% to 100% of the time at all other stations. Stockton particle levels typically are affected by sea salt due to the station's proximity to the coast[1]. Hourly particle levels were in the good to fair air quality categories for 97.7% to 100% of the time throughout the region.

- Levels of nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and ammonia (NH_3) were good, all remaining below national benchmark concentrations and assessment goals.
- Daily average levels of fine particulate matter PM2.5 (particles less than or equal to 2.5 microns in diameter) remained below the national benchmark of 25 micrograms per cubic metre (µg/m^3).
- Daily average levels of particulate matter PM10 (particles less than or equal to 10 microns in diameter) were above the 50 µg/m^3 national benchmark on 6 days (8, 12 September and 8, 17, 28 and 29 October 2021) at Stockton and one day at Carrington (29 October 2021). Regional maximum daily PM10 levels on these days ranged from 50.1 to 64.2 µg/m^3.
- At Stockton, elevated hourly PM10 levels (> 75 µg/m^3) predominantly occurred under onshore north-easterly to south-easterly winds (71% of the time that levels were elevated). The events on 8 September and 8, 17 October 2021 were likely due to sea salt[1] with light winds coming onshore from the north-east. See Stockton section for further details.
- Stockton recorded the region's maximum daily PM10 concentration on 93% of days in spring 2021.

Annual air quality trends

The national annual average benchmarks are 25 µg/m^3 for PM10 and 8 µg/m^3 for PM2.5, based on a calendar year. Long-term trends in annual average PM10 and PM2.5 levels are compared in Figure 1, showing the PM10 and PM2.5 **rolling** annual averages[2]. The rolling annual averages are based on the 12-month periods to the end of spring, from 2015 to 2021.

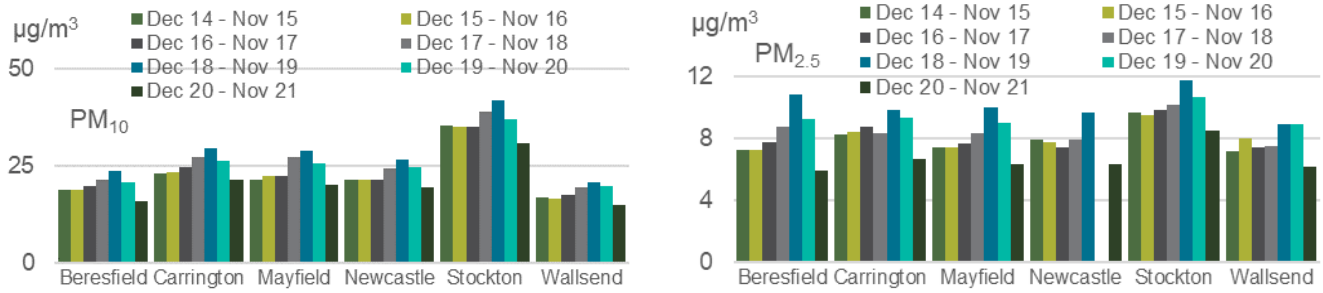

Figure 1 PM10 and PM2.5 rolling annual averages – 2015 to 2021

Figure 1 shows a large decrease in particle levels throughout the region during the 12-month to the end of spring 2021, compared to the same 12-month period in previous years (especially compared to the end of spring 2019 and spring 2020). Rolling annual average PM10 and PM2.5 during the 12-months to the end of spring 2021 were the lowest at each station in the region since the network began operation. In contrast, particle levels across the region during the 12-months to the end of spring 2020 were the second-highest and to the end of spring 2019 were the highest since the network began. This was due to the extended and intense bushfire period in spring–summer 2019–20 and subsequent drought recovery.

[1] Lower Hunter Particle Characterisation Study.

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

The lowest particle levels on record resulted from cooler, wetter conditions in 2021, which reduced impact from dust storms and the likelihood of bushfires. At the end of spring 2021, 5% of New South Wales was drought-affected (Figure 2), compared to 10% of the State drought declared by the end of spring 2020[3].

The higher PM10 and PM2.5 annual averages at Stockton were consistent with findings of the Lower Hunter Particle Characterisation Study. This study found that PM10 at Stockton was 2 and a half times higher than Mayfield, mainly due to fresh sea salt. It also found 40% more PM2.5 at Stockton than Mayfield, Beresfield and Newcastle. This was due to more sea salt in onshore winds and primary ammonium nitrate in north-west winds, particularly in spring (and very likely due to Orica's ammonium nitrate manufacturing facility on Kooragang Island).

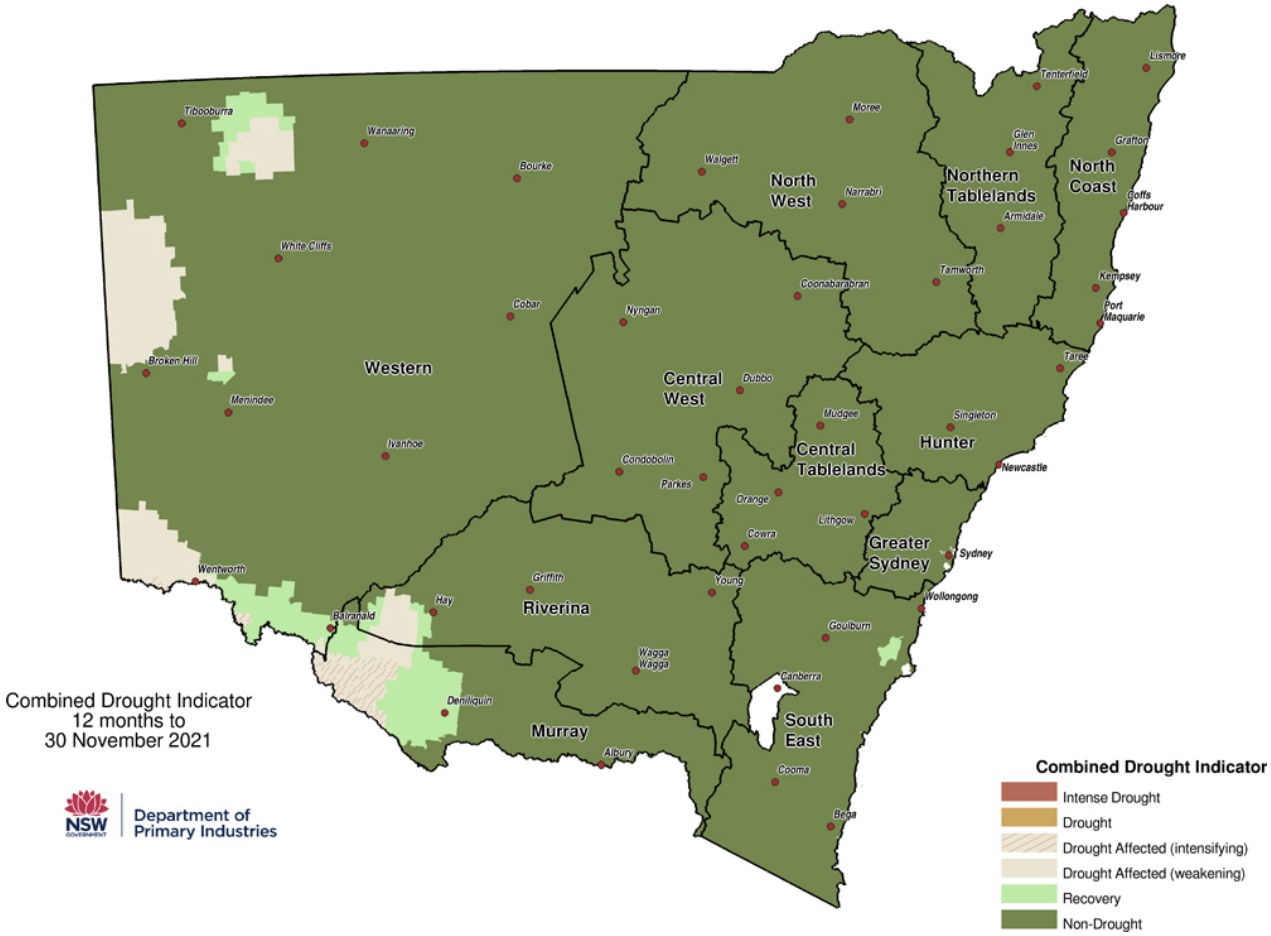

Figure 2 Department of Primary Industries NSW Combined Drought Indicator to 30 November 2021[4]

Days above benchmark concentrations

There were 6 days over the PM10 daily benchmark in spring 2021, being 8 and 12 September and 8, 17, 28 and 29 October. These occurred at Stockton, with one day at Carrington on 29 October 2021.

Concentrations of PM2.5, SO_2, NO_2 and NH_3 remained below relevant benchmarks in spring 2021.

Daily time series plots

Daily average time series plots (Figure 3 to Figure 7) show the concentrations for PM10 and PM2.5 and daily 1-hour maximum for NO_2, SO_2 and NH_3 throughout the spring season. Levels of PM2.5, NO_2, SO_2 and NH_3 remained below the benchmarks[5] and assessment criteria throughout the season.

PM10 levels remained below the benchmark at most stations, except for 6 days at Stockton and one day at Carrington. Stockton PM10 levels were most likely affected by sea salt on 8 and 12 September 2021 and 8 and 17 October 2021, due to its proximity to the coast. See Stockton section for further details.

[3] Sourced from Department of Primary Industries NSW State seasonal update – November 2020 (accessed January 2022).

[4] Sourced from Department of Primary Industries Monthly State Seasonal Update Figures (accessed January 2022).

Table 1 **Number of days above the relevant benchmarks – spring 2021**

Station	PM10 daily [50 µg/m³]	PM2.5 daily [25 µg/m³]	SO_2 hourly[5] [10 pphm]	SO_2 daily[5] [2 pphm]	NO_2 hourly[5] [8 pphm]	NH_3 hourly [46 pphm]
Beresfield	0	0	0	0	0	-
Carrington	1	0	0	0	0	-
Mayfield	0	0	0	0	0	-
Newcastle	0	0	0	0	0	-
Stockton	6	0	0	0	0	0
Wallsend	0	0	0	0	0	-

µg/m³ = micrograms per cubic metre
pphm = parts per hundred million by volume (i.e. parts of pollutant per hundred million parts of air)
- = not monitored

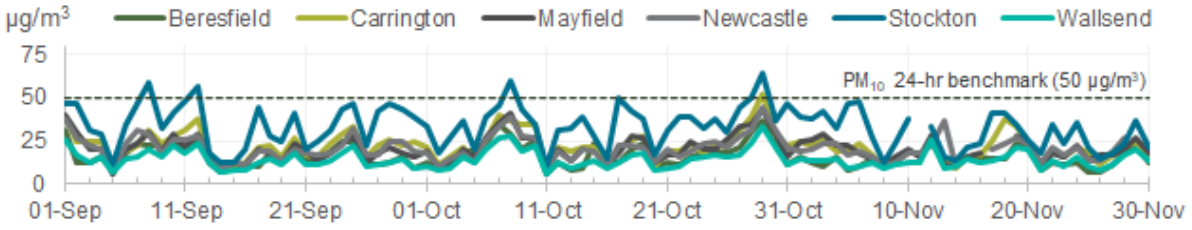

Figure 3 **Daily average PM10 during spring 2021**

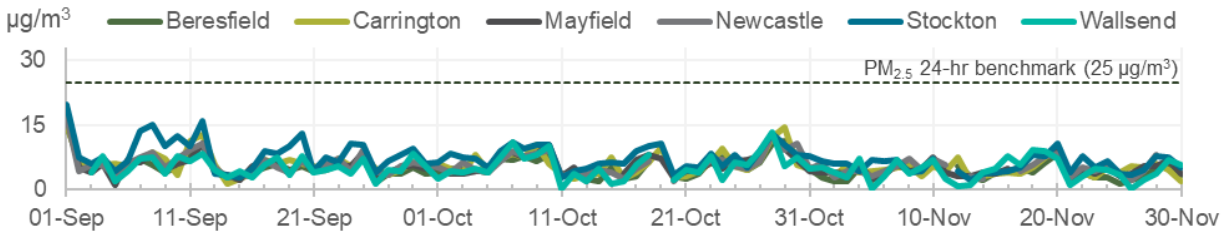

Figure 4 **Daily average PM2.5 during spring 2021**

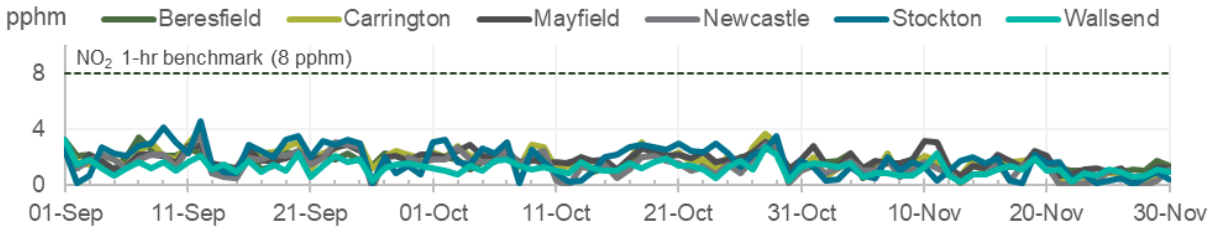

Figure 5 **Daily maximum 1-hr NO_2 during spring 2021**

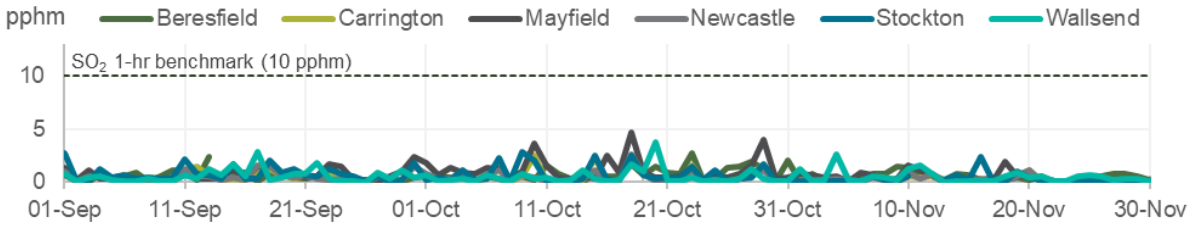

Figure 6 **Daily maximum 1-hr SO_2 during spring 2021**

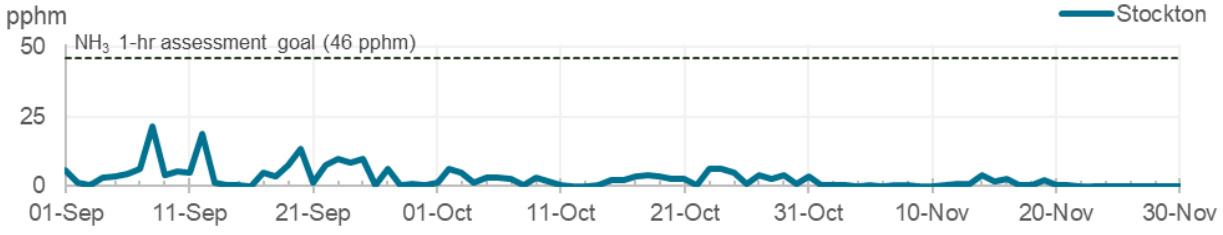

Figure 7 **Daily maximum 1-hr NH_3 during spring 2021**

[5] Note: The National Environment Protection (Ambient Air Quality) Measure (Air NEPM) was updated on 18 May 2021. New national benchmarks were introduced for hourly SO_2 (now 10 pphm), daily SO_2 (now 2 pphm) and hourly NO_2 (now 8 pphm).

Pollution roses from hourly particle data

The seasonal pollution rose maps[6] (Figure 8 and Figure 9) show that hourly[7] PM10 and PM2.5 levels generally remained low (< 75 ug/m^3) during the season.

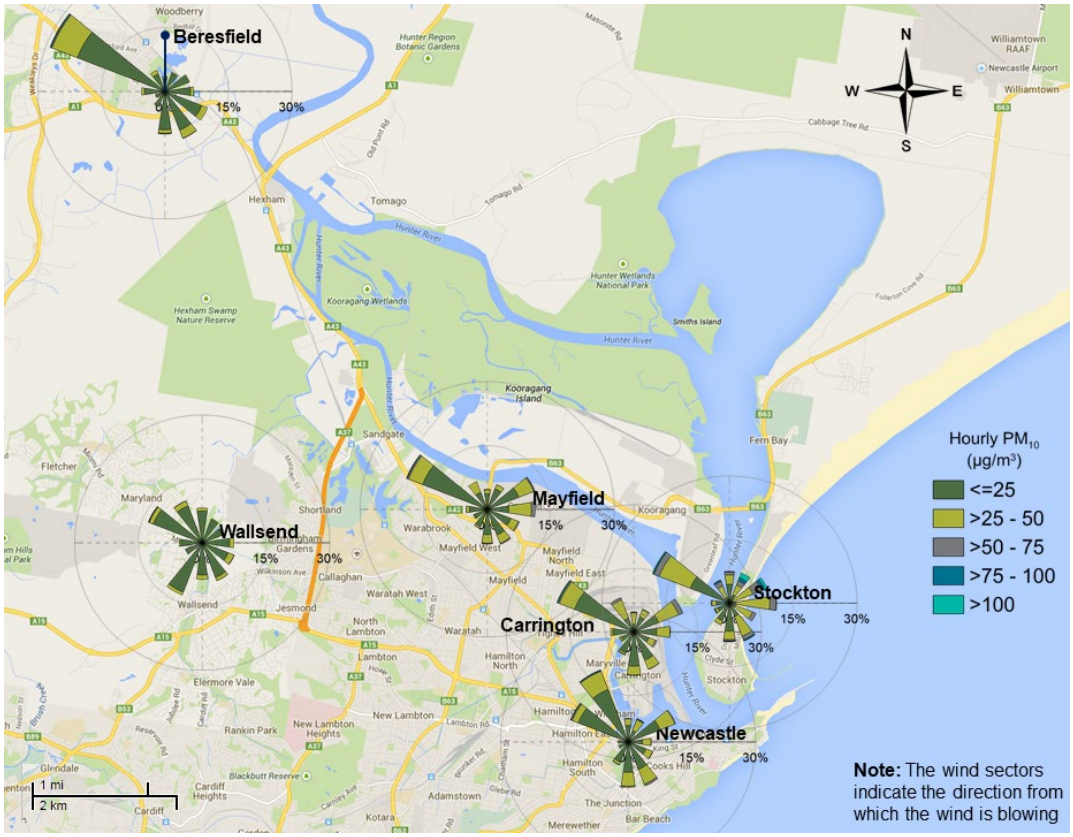

Figure 8 **Hourly PM10 pollution roses for the Newcastle region for spring 2021**

Figure 9 **Hourly PM2.5 pollution roses for the Newcastle region for spring 2021**

[6] 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 the wind blows from a particular direction. The colours along the bars indicate categories of particle levels.

[7] There are no standards for hourly PM10 or PM2.5 in the Air NEPM.

Seasonal trends

This section compares air quality levels in spring 2021 with the previous 9 spring seasons, where data were available[8].

- All days were below benchmark concentrations for NO_2 and SO_2 in spring during the past 9 years at Beresfield, Newcastle, Stockton and Wallsend and since monitoring began at Carrington and Mayfield.
- For NH_3 at Stockton, there were no days during spring that were over the assessment criterion during the past 9 years.
- There were no days above the PM2.5 benchmark during spring 2021, as in spring 2020 and 2015. Twenty days exceeded the PM2.5 benchmark in spring 2019 due to bushfire and drought conditions. Eight exceedance days occurred in the spring of 2013, with the remaining 4 spring seasons experiencing one day above the PM2.5 benchmark, at Stockton only on 3 occasions.
- There were 6 days over the PM10 benchmark during spring 2021, as was for spring 2020. This was the equal fewest number of exceedance days in a spring season across the Newcastle region since the network began. Due to bushfire and drought conditions, there were 42 exceedance days over the PM10 benchmark in spring 2019. For the remaining years, days over the PM10 benchmark in spring ranged from 11 to 22.

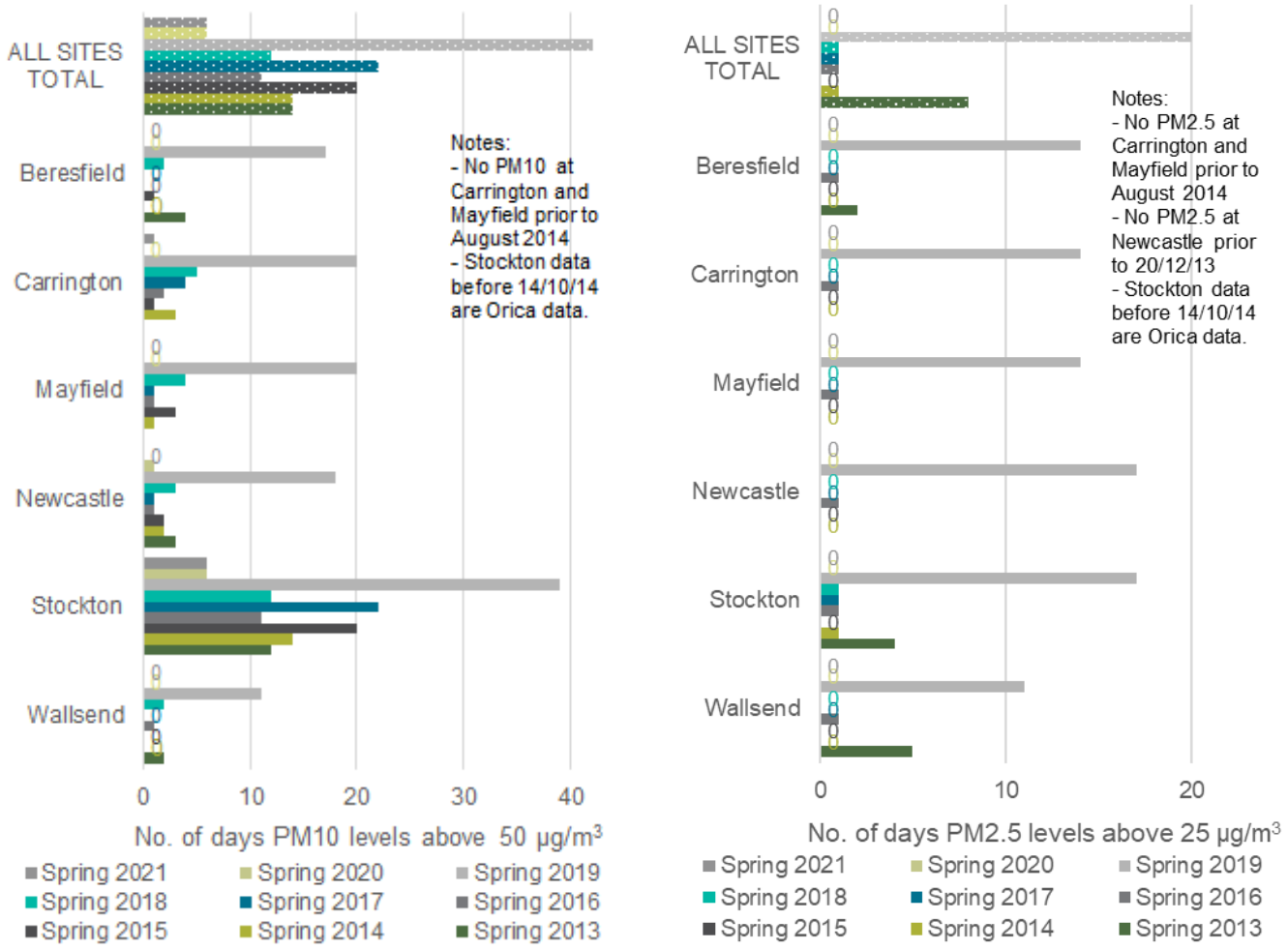

Figure 10 Number of days above the PM10 and PM2.5 daily benchmarks: spring 2013 to 2021

[8] Monitoring at Stockton commenced in October 2012 and at Mayfield and Carrington in August 2014. Monitoring of PM2.5 at Newcastle commenced in December 2013. Stockton air quality monitoring was undertaken by Orica from October 2012 to October 2014. From October 2014 it was undertaken by the NSW government as part of the Newcastle Local Air Quality Monitoring Network.

Particle air quality trends

Figure 11 and Figure 12 show daily average PM10 during spring 2021, compared to the daily maximum and minimum PM10 levels (i.e. shaded range) from spring 2013 to 2020, at Stockton and Newcastle. Daily PM10 levels were generally within the historical range throughout the season, and often towards the lower end of the range, especially throughout November. Rainfall at Newcastle was near average in September and October, but above average in November.

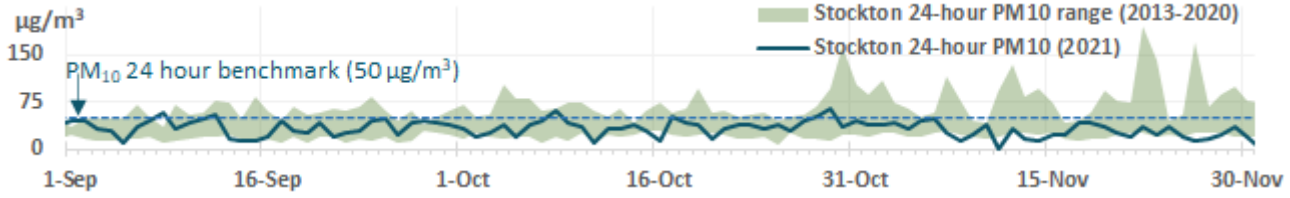

Figure 11 **Stockton daily average PM10 during spring 2021 plotted against the daily maximum and minimum PM10 levels from 2013 to 2020**

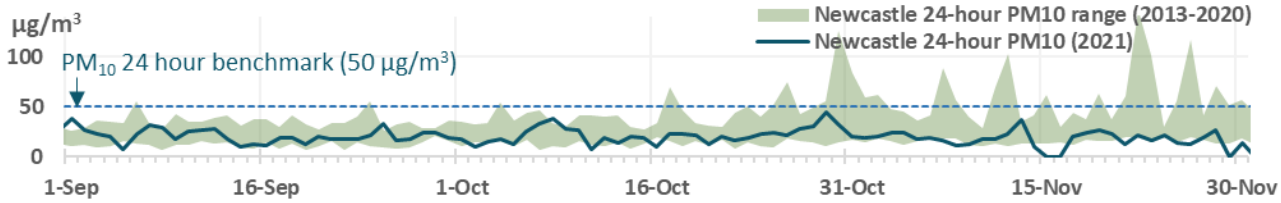

Figure 12 **Newcastle daily average PM10 during spring 2021 plotted against the daily maximum and minimum PM10 levels from 2013 to 2020**

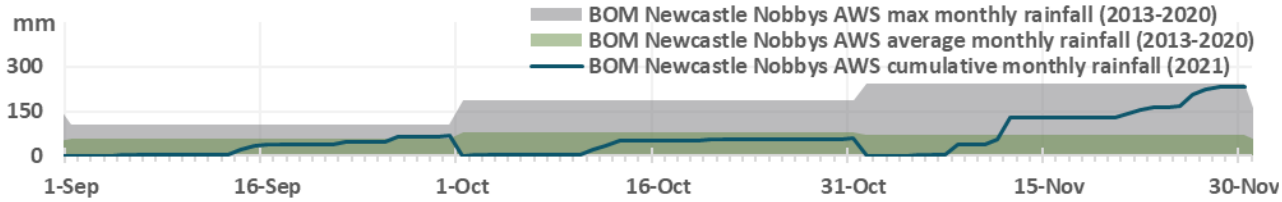

Figure 13 **Bureau of Meteorology Newcastle Nobbys Signal Station AWS[9] cumulative rainfall during spring 2021 plotted against maximum and average rainfall from 2013 to 2020**

Figure 14 and Figure 15 show daily average PM2.5 during spring 2021, compared to the daily maximum and minimum PM2.5 levels (shaded range) from 2014 to 2020, at Stockton and Newcastle. Daily PM2.5 levels were generally within the historical range throughout the season, and often at the lower levels, particularly in November. Daily PM2.5 levels at Newcastle in November were generally below the historical range.

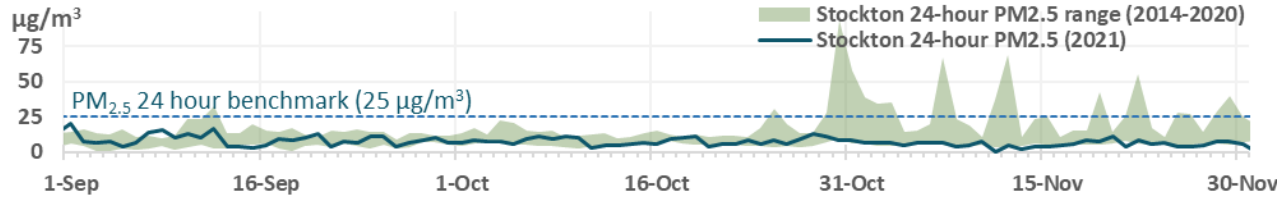

Figure 14 **Newcastle daily average PM2.5 during spring 2021 plotted against the daily maximum and minimum PM2.5 levels from 2014 to 2020**

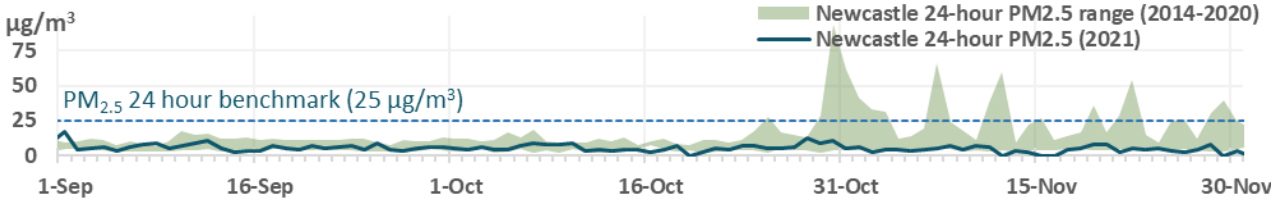

Figure 15 **Stockton daily average PM2.5 during spring 2021 plotted against the daily maximum and minimum PM2.5 levels from 2014 to 2020**

[9] Data from Bureau of Meteorology Newcastle Nobbys Signal Station AWS monthly rainfall page (accessed January 2022)

Meteorological summary

Rainfall[10]

The Newcastle region experienced above average to very much above average rainfall during spring 2021 compared to long-term records (Figure 16). The region saw average rainfall totals during September and October, but above average rainfall during November due to the presence of low pressure troughs. Spring 2021 rainfall was up to 200 millimetres wetter compared to spring 2020 and spring 2019, and up to 100 millimetres wetter compared to spring 2018.

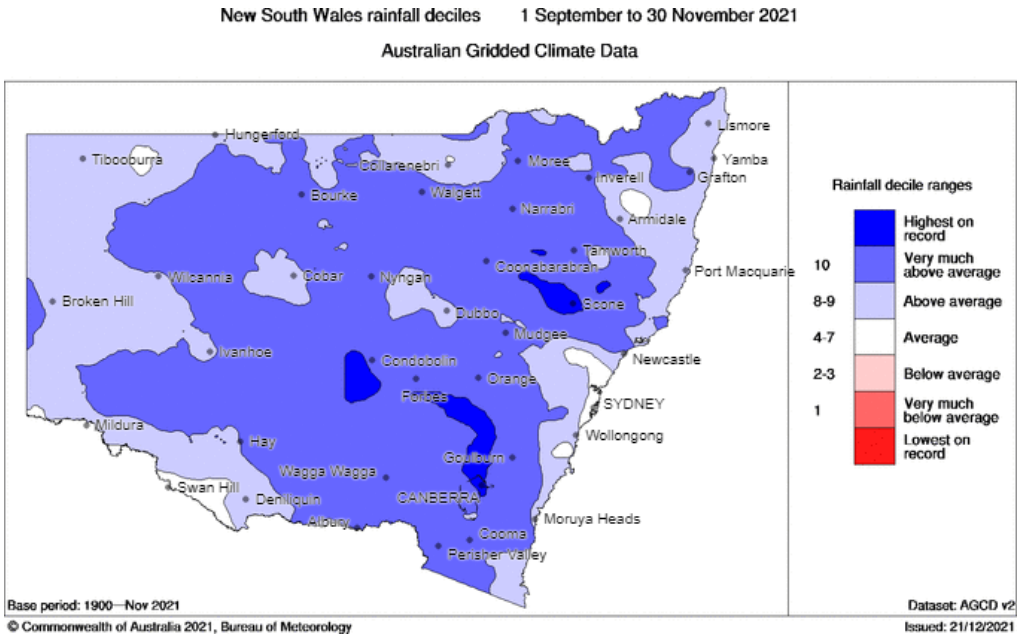

Figure 16 NSW rainfall deciles – spring 2021

Temperatures

Maximum temperatures were average in the Newcastle region during spring 2021 (Figure 17). Minimum temperatures were also average during the season. For the state as a whole, both the mean maximum temperature and the mean minimum temperature were the coolest since 2016[11].

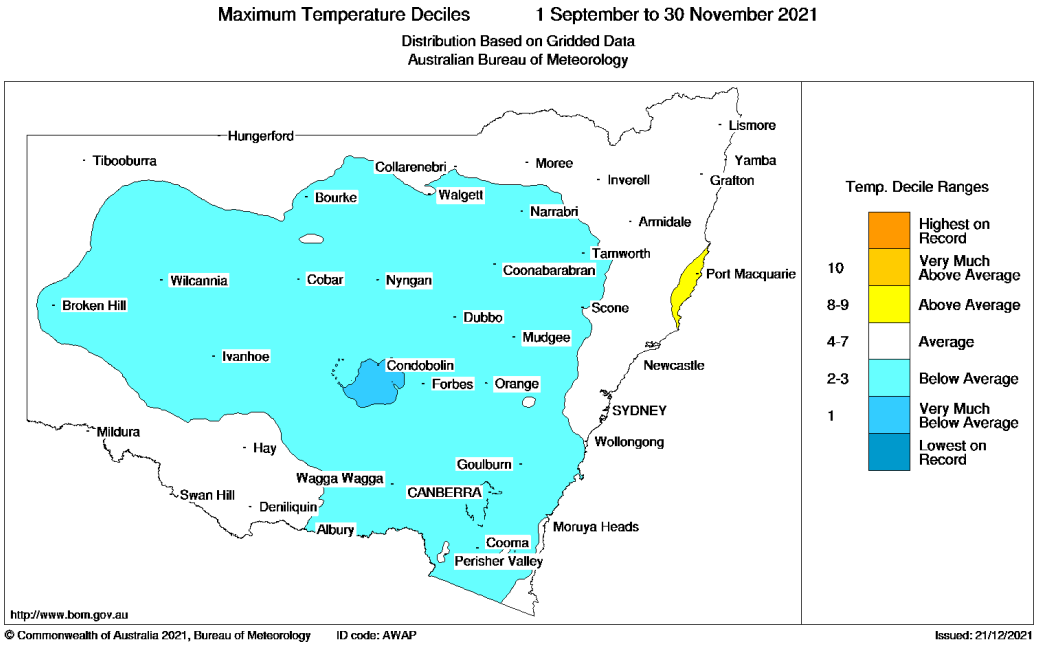

Figure 17 NSW maximum temperature deciles – spring 2021

[10] Rainfall and temperature information is from the Bureau of Meteorology New South Wales spring 2021 climate statement (accessed January 2022) and climate maps (accessed January 2022).

[11] Seasonal Climate Summary for New South Wales in Spring 2021 from the Bureau of Meteorology (accessed March 2022).

Winds

Winds were variable in the region during spring 2021, typical for this transitional season where prevailing winds change from north-westerly in winter to south-easterly during summer.

Figure 18 shows that north-west winds prevailed 20% of the time at Stockton, dominated by moderate or stronger winds (above 5 metres per second). The duration of prevailing north-west winds in spring 2021 was similar to previous springs, with more frequent moderate winds and less frequent light winds.

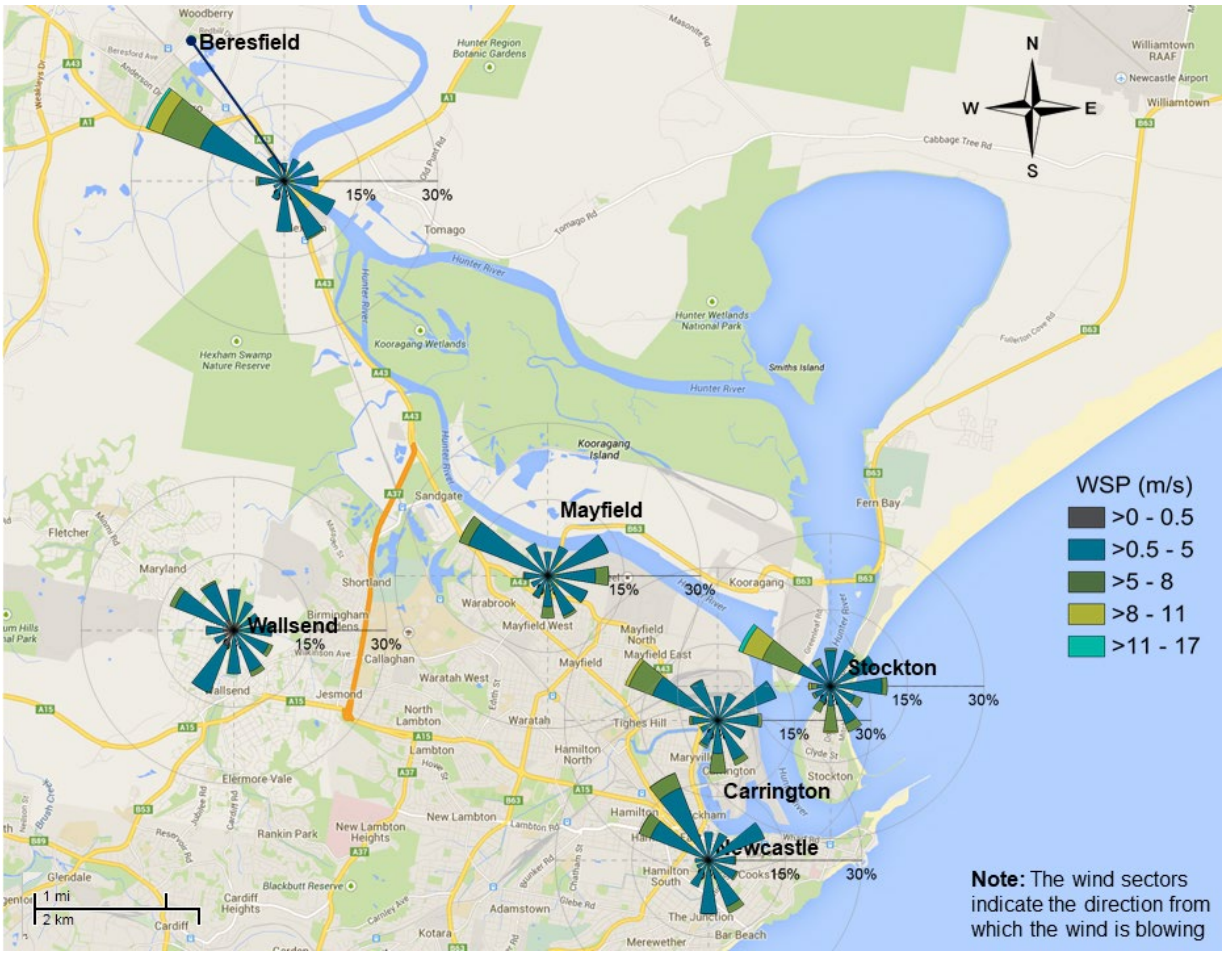

Figure 18 **Wind rose map[12] for the Newcastle region for spring 2021**

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

Stockton

Particles at Stockton in spring 2021

Stockton recorded 6 days over the PM10 daily benchmark during spring 2021 (8, 12 September and 8, 17, 28 and 29 October 2021). This was the same number of days over the PM10 benchmark as in spring 2020, but better than 2019, where 39 spring days were over the PM10 benchmark. Previously, the days above the PM10 benchmark ranged from 11 days in spring 2016 to 22 days in spring 2017 (Figure 10).

In spring 2021, elevated hourly PM10 levels (>75 µg/m^3)[13] were recorded at Stockton 4.9% of the time (Figure 19). These occurred under:

- onshore north-easterly to south-easterly winds 71% of the time (75 hours, 3.5% total for spring)
- north-westerly winds 10% of the time (11 hours, 0.5% total for spring).

Elevated hourly PM10 levels under predominant onshore winds at Stockton indicate the potential contribution of sea salt, as was observed during the 8 September, 8 and 17 October events. The Lower Hunter Particle Characterisation Study found sea salt was a major contributor of particles at the station under onshore winds.

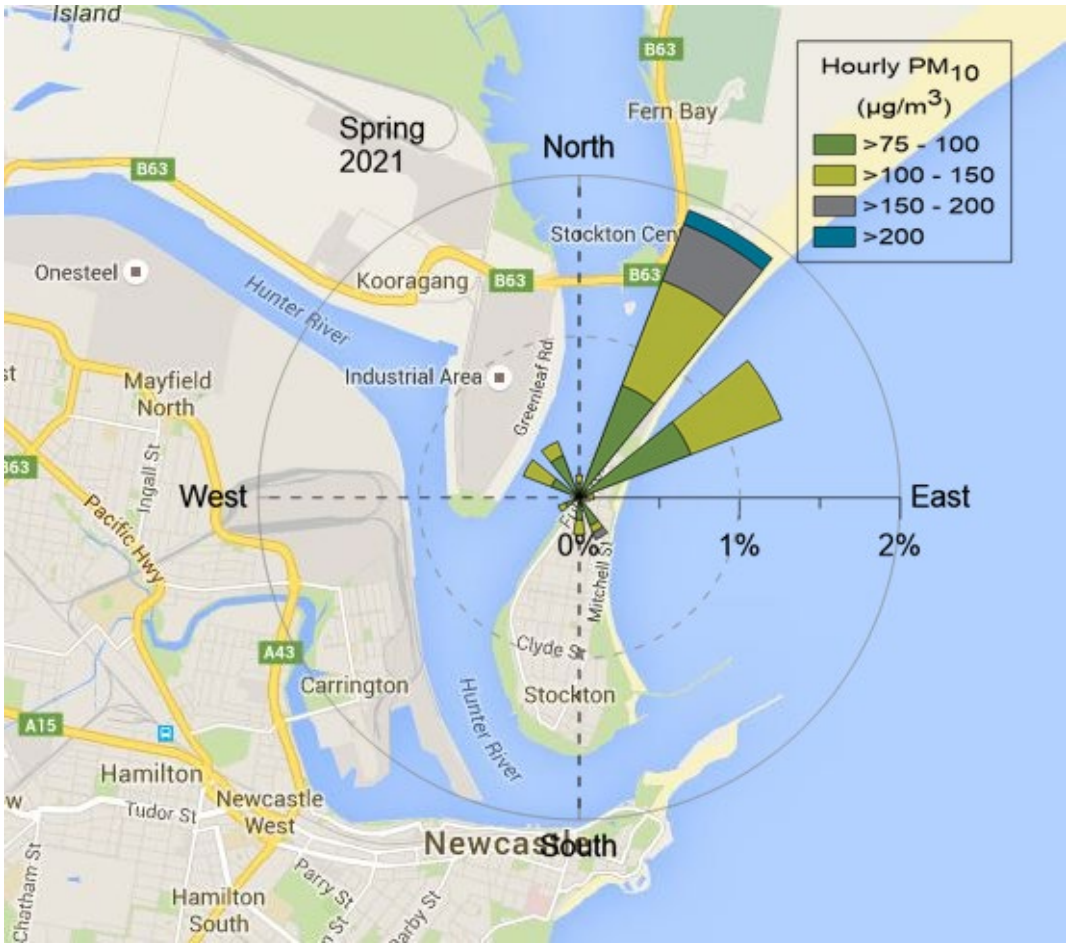

Figure 19 Stockton spring 2021 PM10 pollution rose – proportion of hourly averaged PM10 levels >75 µg/m^3 by wind direction

The Stockton monitoring station did not record any days over the PM2.5 daily benchmark during spring 2021, as was the case in spring 2020 and 2015. Stockton has not recorded a PM2.5 exceedance since January 2020. Stockton recorded 17 days over the PM2.5 daily benchmark in spring 2019 and 4 in 2013. In the remaining years, Stockton recorded one exceedance of the PM2.5 daily benchmark during spring (Figure 10). Elevated levels of hourly PM2.5 (>40 µg/m^3)[13] during spring 2021 occurred 0.2% of the time (5 hours) from the west to north-west (3 hours) and from the north-east (2 hours) (Figure 20).

[13] There are no standards for hourly PM10 or PM2.5 in the Air NEPM.

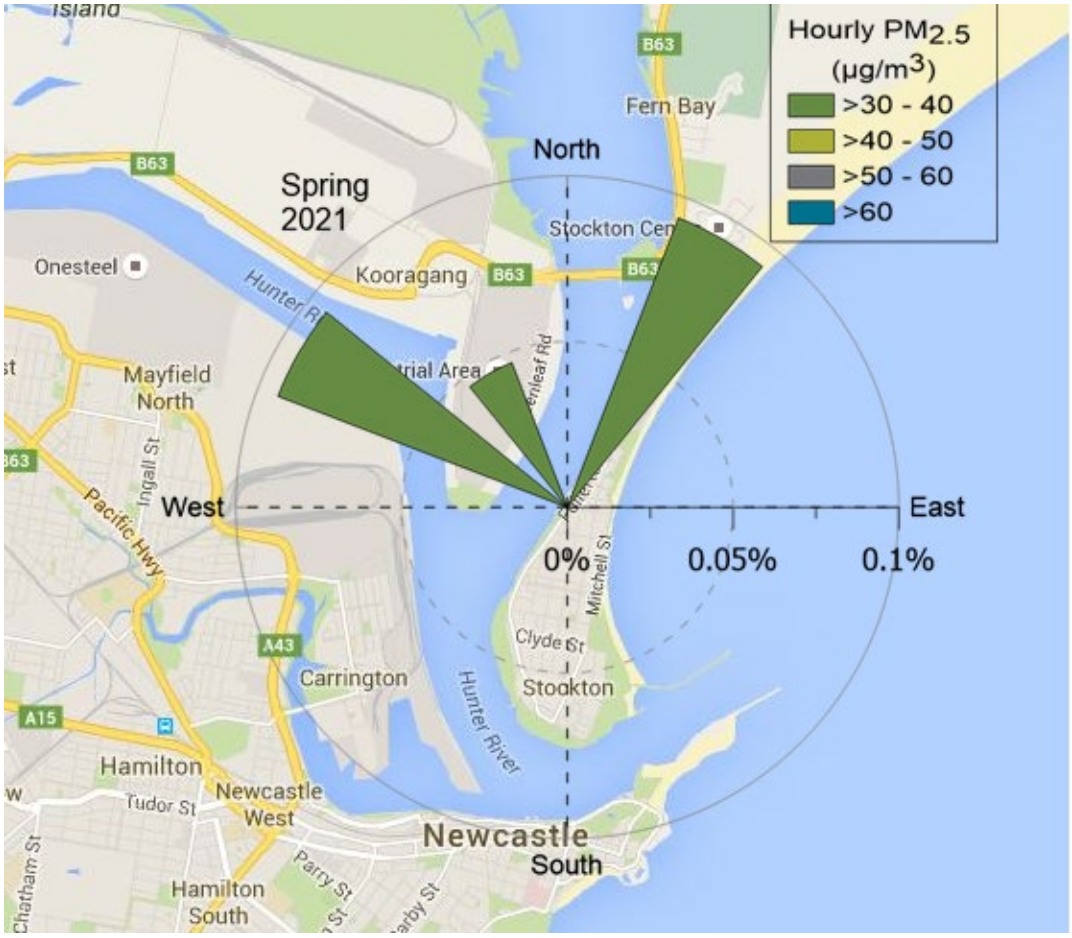

Figure 20 **Stockton spring 2021 PM2.5 pollution rose – proportion of hourly averaged PM2.5 levels >30 µg/m³ by wind direction**

Network performance

All parameters met their online performance goals during spring 2021. The target network performance is at least 95% available data for all parameters. For NO_2, SO_2 and NH_3, the maximum online time that can be attained is 96% due to daily calibrations.

Table 2 **Online performance (%) during spring 2021**

Station	Particles PM10 daily	Particles PM2.5 daily	Gases SO_2 hourly	Gases NO_2 hourly	Gases NH_3 hourly	Meteorology Wind hourly
Beresfield	98	97	94	92		100
Carrington	100	100	95	93		99
Mayfield	97	96	90	90		98
Newcastle	97	95	94	92		100
Stockton	99	99	93	94	94	99
Wallsend	100	98	95	95		100

- = not monitored

This document was prepared by Sean Watt and reviewed by Dr Upma Dutt, David Salter and Dr Leanne Graham.

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