Air Quality Monitoring Network

Newcastle Winter 2023

Air quality in the Newcastle region was generally good during winter 2023. Daily particle levels were within national benchmarks 100% of the time at all stations except Stockton where PM10[i] was over the benchmark on 2 days. Hourly particle levels were in the good to fair air quality categories ranging from 98.7% of the time at Stockton to 100% of the time at Beresfield, Mayfield and Wallsend.

- 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 PM2.5[i] particle levels remained below the 25 µg/m^3 benchmark at all sites.
- Daily average PM10 particle levels remained below the 50 µg/m^3 benchmark at all sites, except Stockton on 6 June (51.4 µg/m^3) and 8 August (52.4 µg/m^3).
- The Newcastle region recorded very much below-average rainfall and highest-on-record maximum temperatures during the season.

Annual air quality trends

Figure 1 shows the rolling annual averages[ii] for PM10 and PM2.5 particles, for the 12-month periods from winter 2015 to winter 2023.

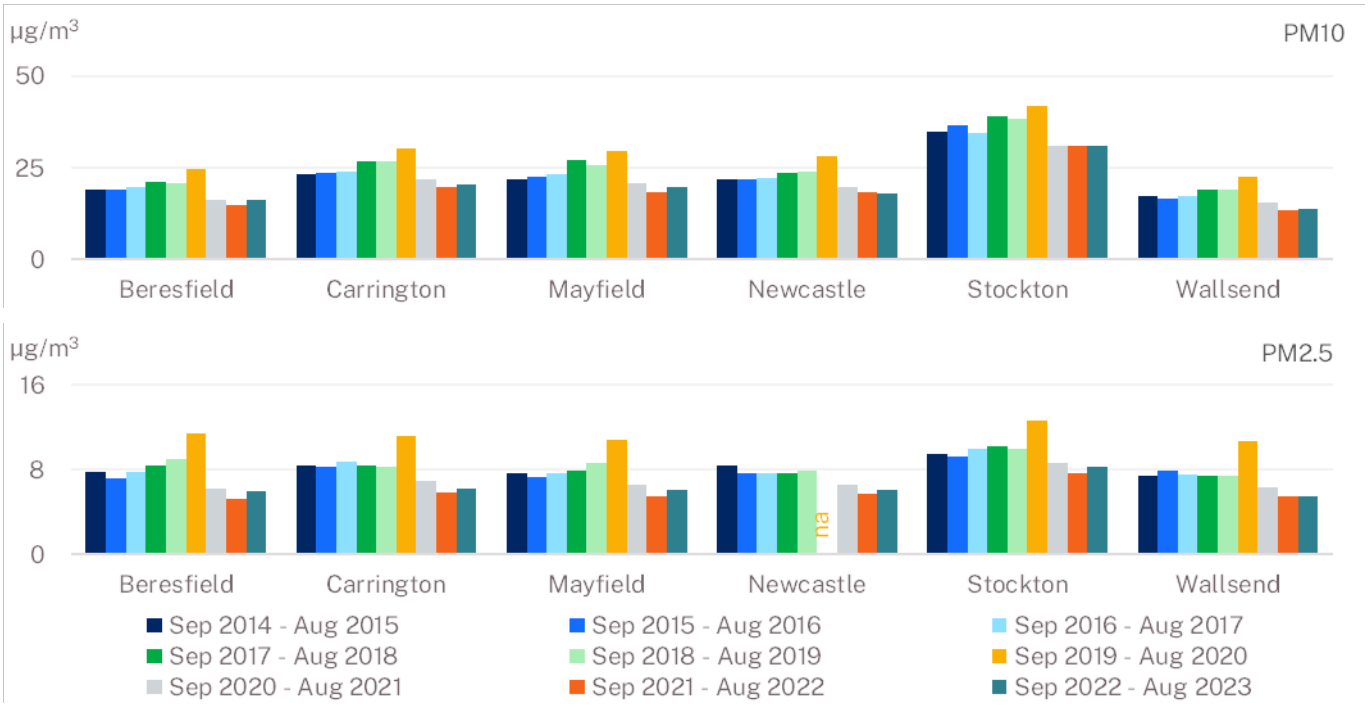

Figure 1 **Rolling annual average to the end of winter 2015 to winter 2023 for PM10 (top) and PM2.5 (bottom)**

na = rolling annual average unavailable due to insufficient data availability

The comparison in Figure 1 shows that particle levels increased at most stations in the region during the 12 months to the end of winter 2023 compared to the previous 12 months to the end of winter 2022. However, a decreasing trend since the end of winter 2020 can still be observed. Rolling annual average PM10 and PM2.5 levels were below the benchmarks at all stations in the 12 months to the end of winter 2023, except Stockton.

At the end of winter 2023, 9% of New South Wales was in drought or drought-affected (Figure 2), compared to 7% at the end of winter 2021[iii] and 0% at the end of winter 2022[iv]. The slightly higher particle levels at most sites in the 12 months to the end of winter 2023 were expected with the drying landscape.

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

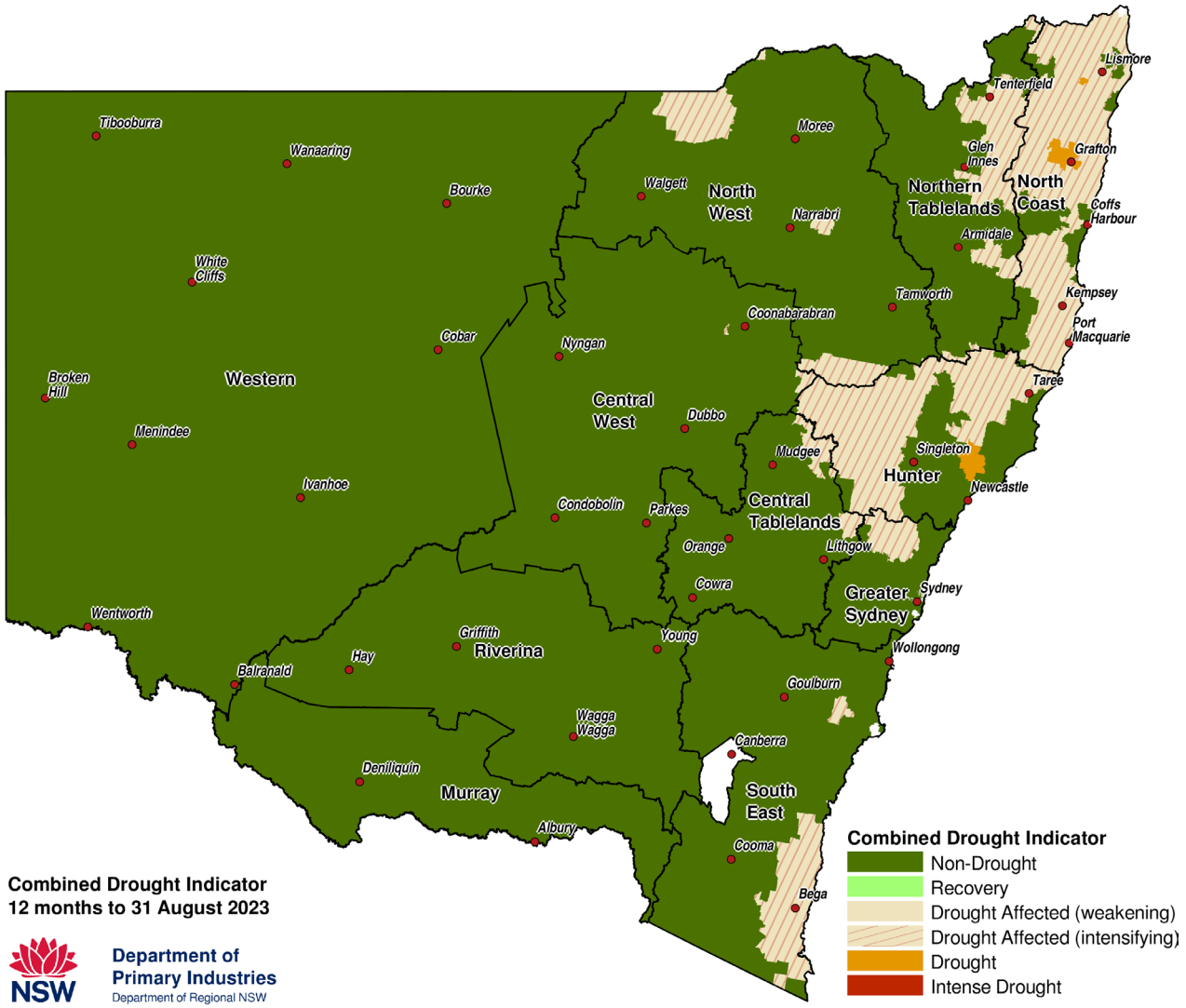

Figure 2 **Department of Primary Industries NSW Combined Drought Indicator to 31 August 2023[v]**

Days above benchmark concentrations

There were 2 days over the PM10 benchmark at Stockton, while all other sites recorded no days above the PM10 or PM2.5 daily benchmark in winter 2023 (Table 1). Concentrations of SO_2, NO_2 and NH_3 also remained below relevant benchmarks during the season.

Table 1 Number of days above the relevant benchmarks – winter 2023

Station	**PM10** daily [50 µg/m^3 benchmark]	**PM2.5** daily [25 µg/m^3 benchmark]	**SO_2** hourly [10 pphm benchmark]	**SO_2** daily [2 pphm benchmark]	**NO_2** hourly [8 pphm benchmark]
Beresfield	0	0	0	0	0
Carrington	0	0	0	0	0
Mayfield	0	0	0	0	0
Newcastle	0	0	0	0	0
Stockton	2	0	0	0	0
Wallsend	0	0	0	0	0

µg/m^3 = micrograms per cubic metre.
pphm = parts per hundred million by volume (i.e. parts of pollutant per hundred million parts of air).

Seasonal comparison

This section compares days above benchmarks in winter 2023 with previous winter seasons (Figure 3).

All days were below benchmark levels for NO_2 and SO_2 in winter during the past 11 years at Beresfield, Newcastle, Stockton and Wallsend and since monitoring began at Carrington and Mayfield[vi].

For NH_3 at Stockton, there were no days over the assessment criterion in winter in the past 11 years.

There were 2 days over the PM10 daily benchmark during winter 2023. This is higher than the previous year (winter 2022) and equal to winter 2021, which had 2 days over the benchmark. From 2013 to 2020, the region recorded between zero days (winters 2013, 2014, 2016 and 2017) and 8 days (winter 2018) over the PM10 daily benchmark.

There were no days over the PM2.5 daily benchmark during winter 2023. This is the same as winter 2022 and 2021. From 2013 to 2020, the region recorded between zero days (winters 2014, 2016, 2017 and 2018) and 5 days (winter 2015) over the PM2.5 daily benchmark.

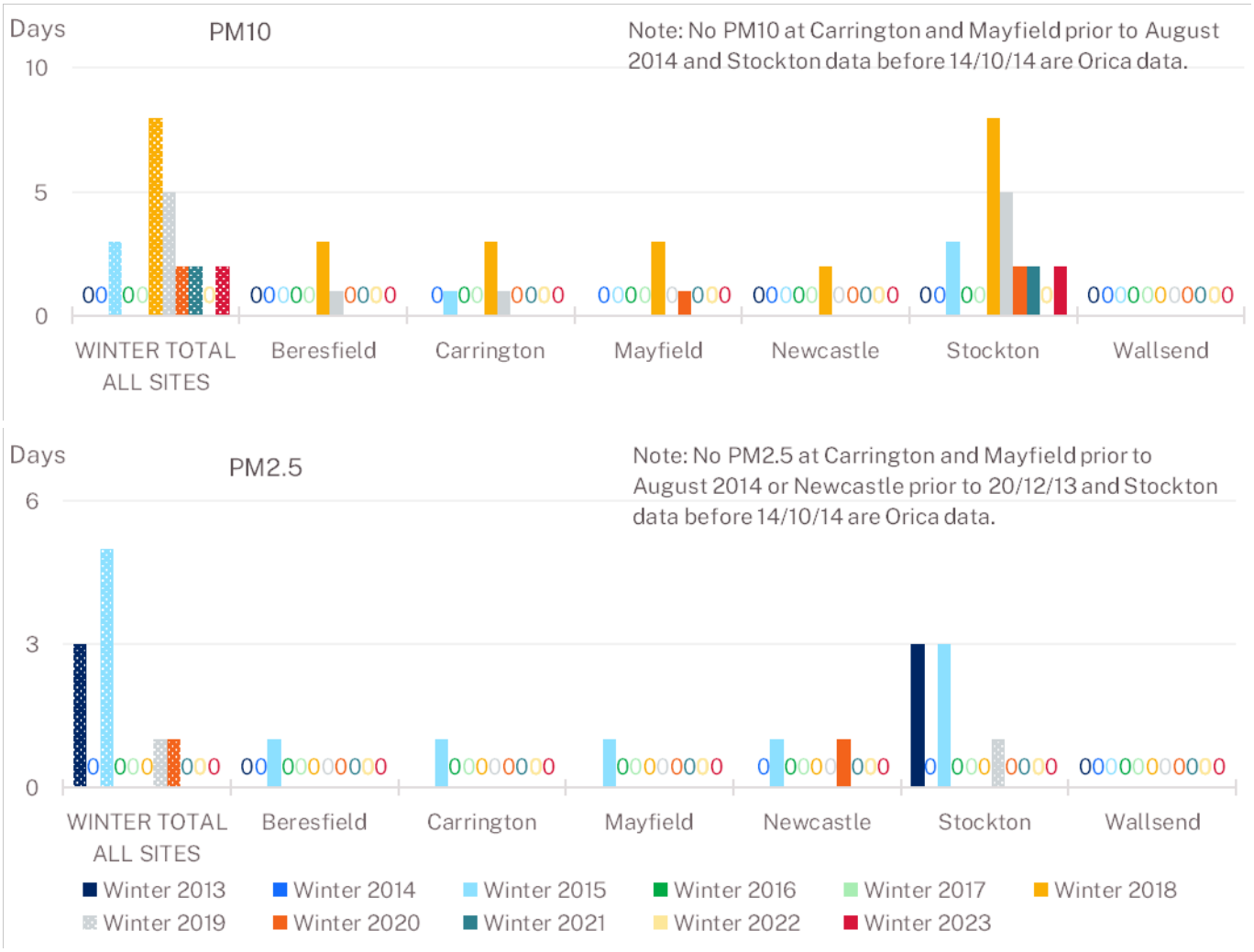

Figure 3 **Number of days above the PM10 (top) and PM2.5 (bottom) daily benchmarks: winter 2013 to 2023**

Daily time series plots

Daily average time series plots for PM10 and PM2.5 and daily 1–hour maximum plots for NO_2, SO_2 and NH_3 show the concentrations throughout the winter (Figure 4 to Figure 8).

All parameters except Stockton PM10 remained below the benchmarks and assessment criteria throughout the season.

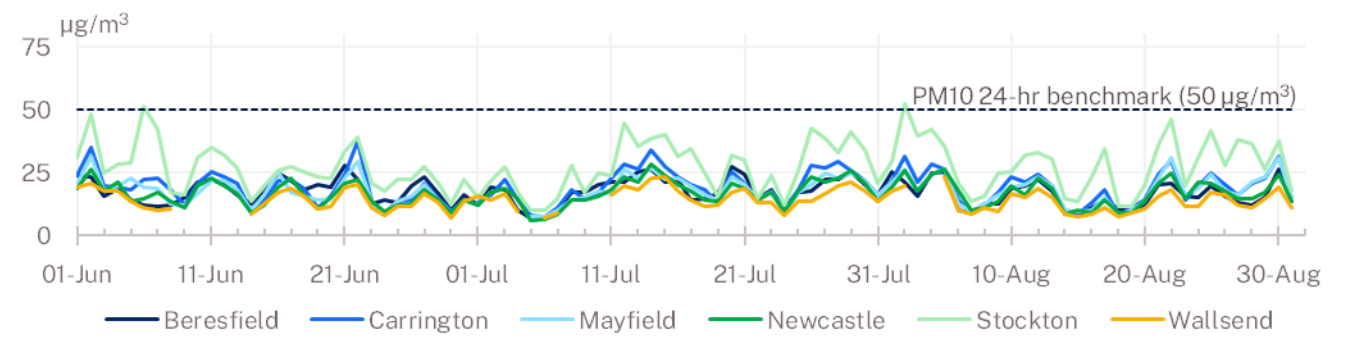

Figure 4 **Daily average PM10 during winter 2023**

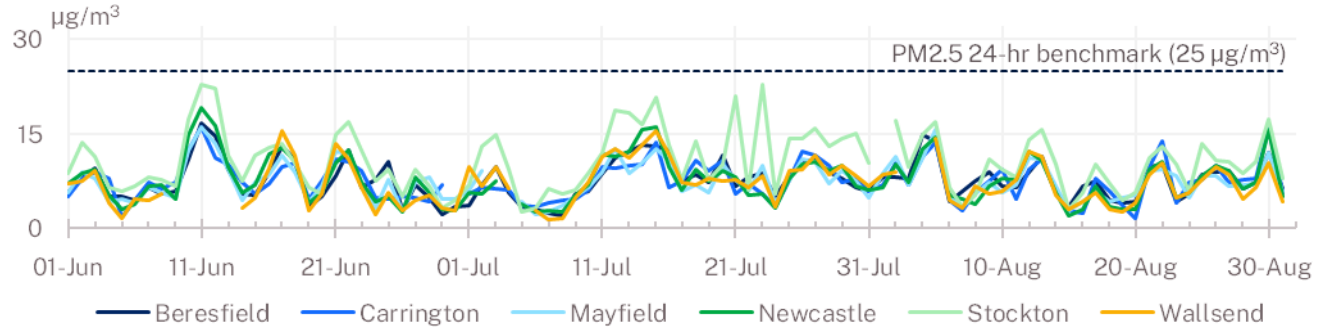

Figure 5 **Daily average PM2.5 during winter 2023**

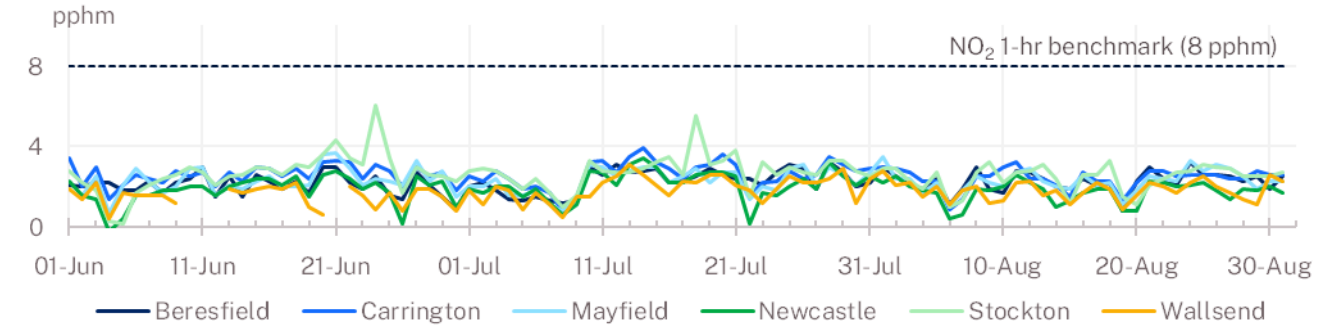

Figure 6 **Daily maximum 1-hr NO_2 during winter 2023**

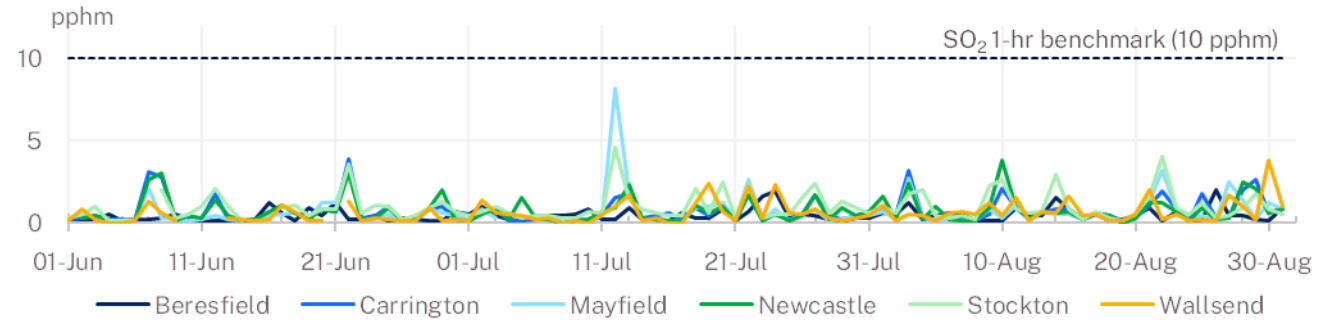

Figure 7 **Daily maximum 1-hr SO_2 during winter 2023**

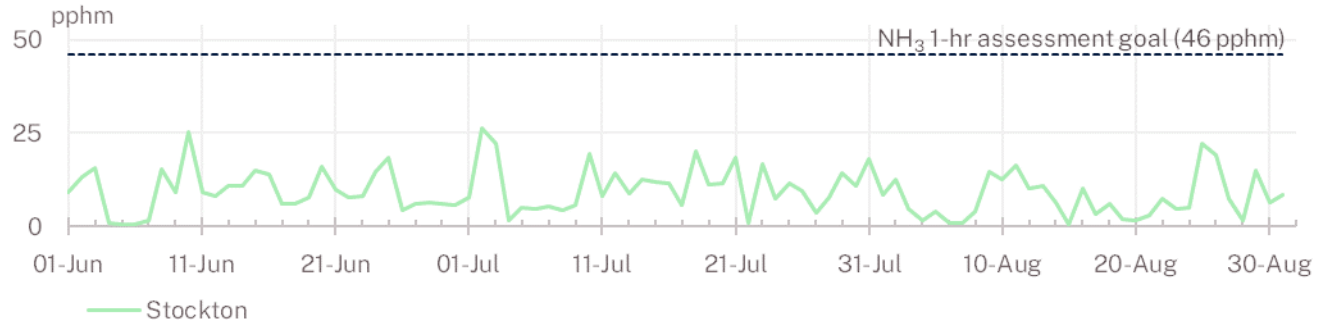

Figure 8 **Daily maximum 1-hr NH_3 during winter 2023**

Pollution roses from hourly particle data

The seasonal pollution rose maps[vii] (Figure 9 and Figure 10) show that across the Newcastle region hourly[viii] PM10 and PM2.5 particle levels remained generally low during the season; however, all sites recorded several hours in the fair air quality category.

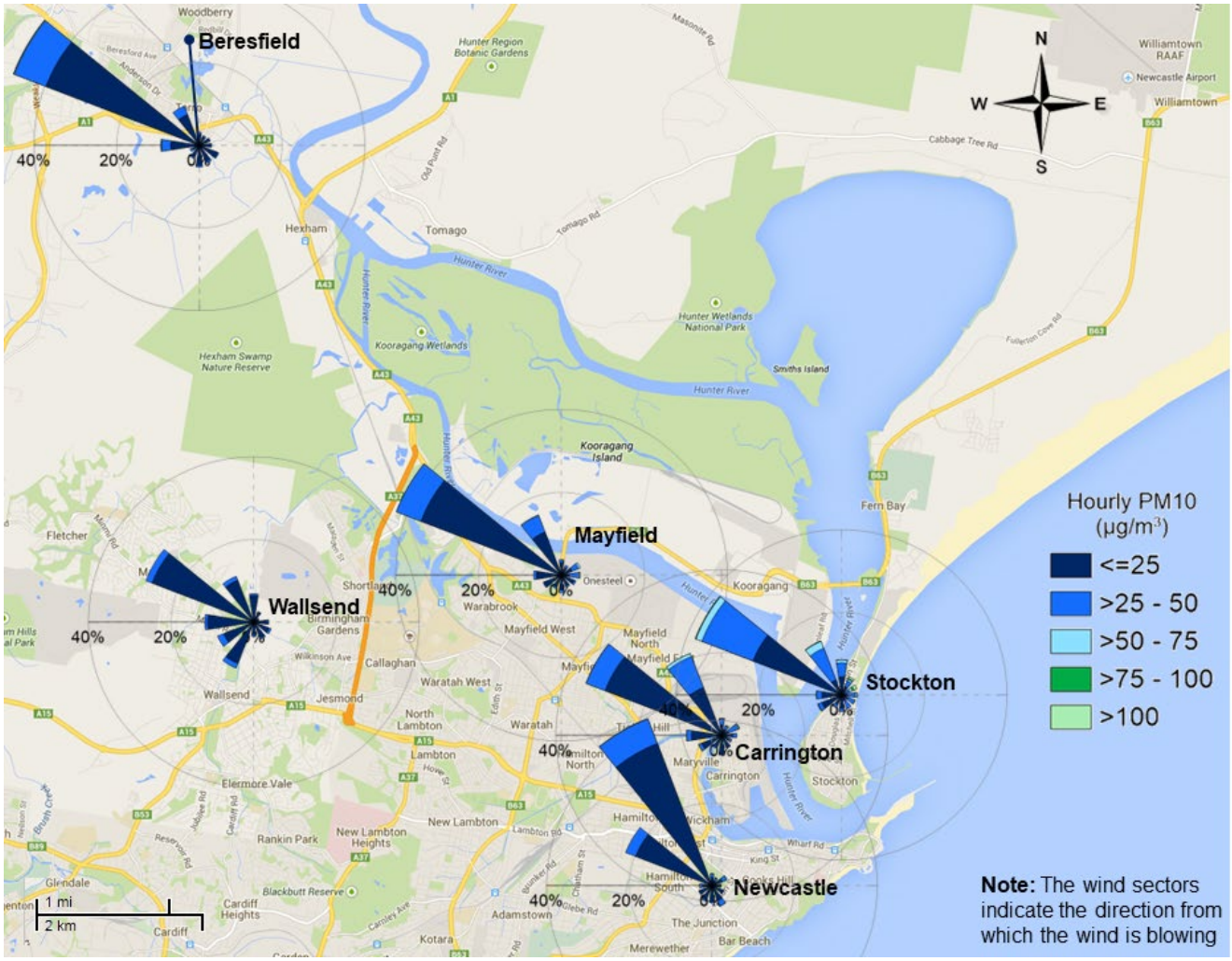

Figure 9 **Hourly PM10 pollution roses for the Newcastle region for winter 2023**

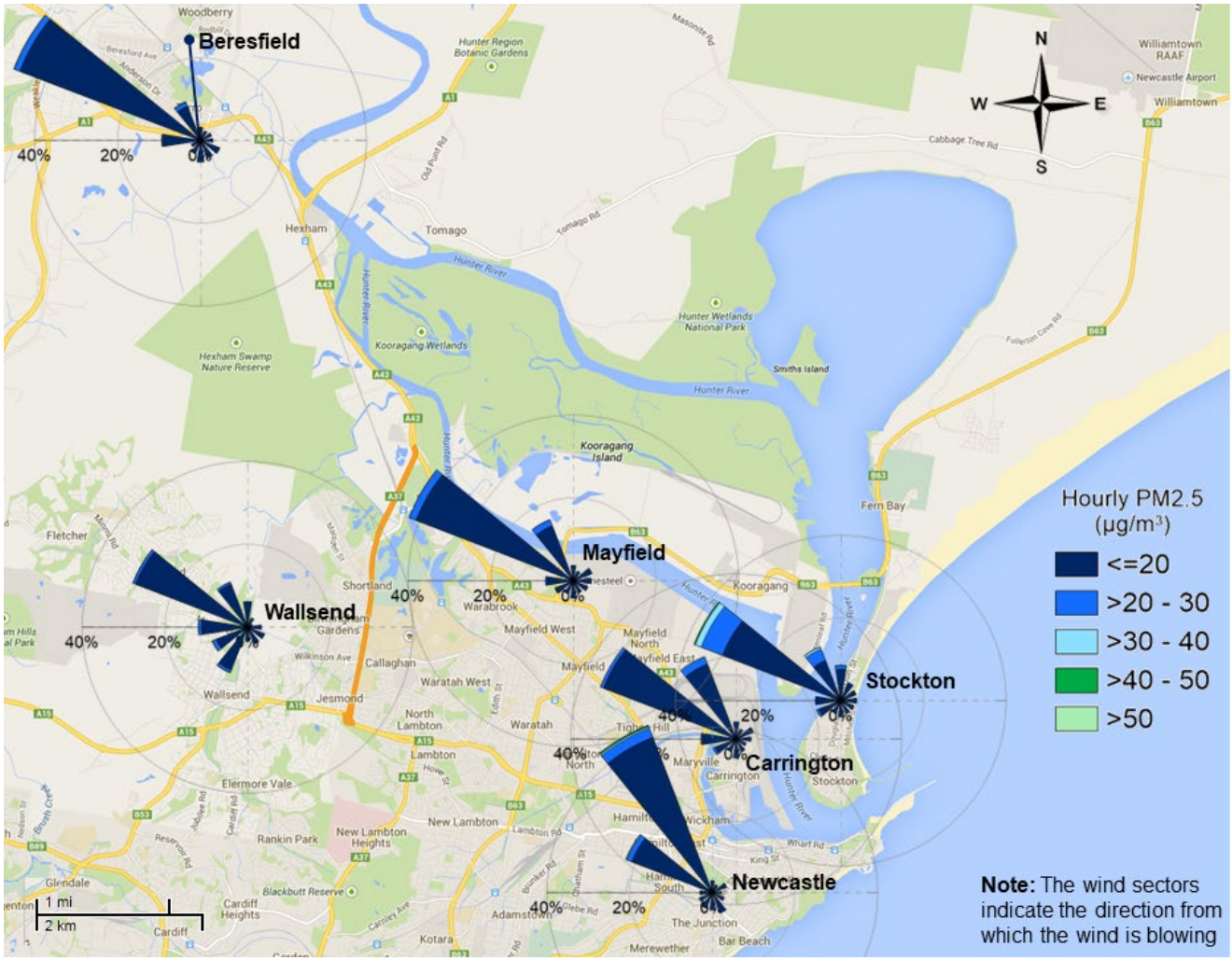

Figure 10 **Hourly PM2.5 pollution roses for the Newcastle region for winter 2023**

Particle air quality trends

Figure 11 and Figure 12 show daily average PM10 during winter 2023, compared to the daily maximum and minimum PM10 levels (shaded range) from 2013 to 2022, at Stockton and Newcastle. Daily PM10 levels were generally within the historical range throughout the season.

Rainfall in Newcastle was very much below average overall during winter (Figure 13), with very dry conditions in June and early July followed by average rainfall in August.

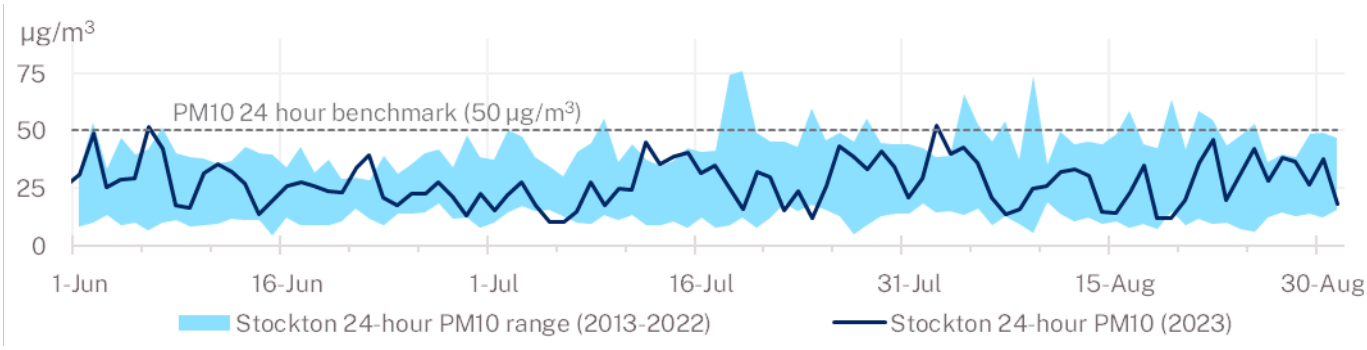

Figure 11 **Stockton daily average PM10 during winter 2023 plotted against the daily maximum and minimum PM10 levels from 2013 to 2022**

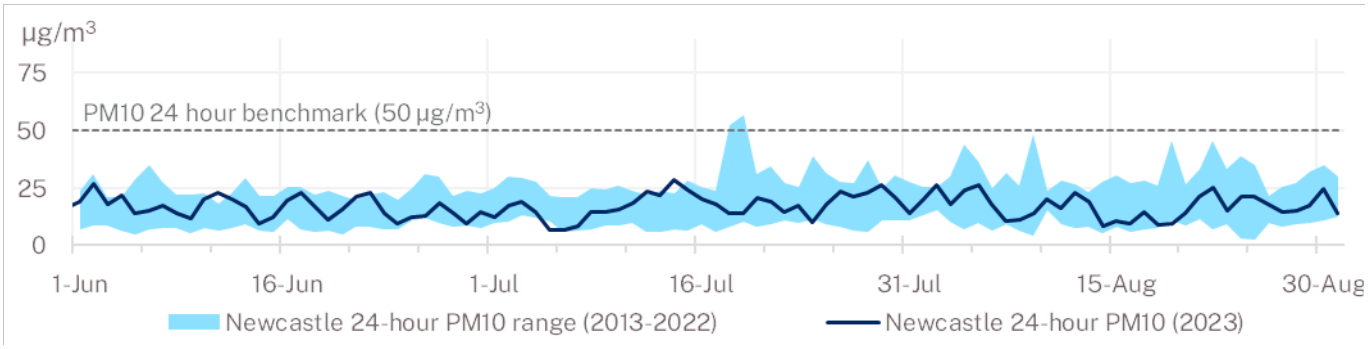

Figure 12 **Newcastle daily average PM10 during winter 2023 plotted against the daily maximum and minimum PM10 levels from 2013 to 2022**

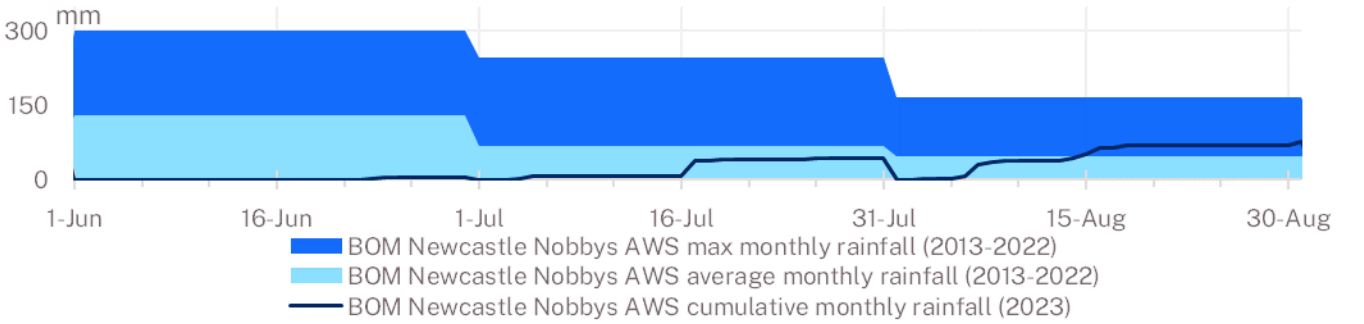

Figure 13 **Bureau of Meteorology Newcastle Nobbys Signal Station AWS[ix] monthly cumulative rainfall during winter 2023 plotted against maximum and average rainfall from 2013 to 2022**

Figure 14 and Figure 15 show daily average PM2.5 during winter 2023, compared to the daily maximum and minimum PM2.5 levels (shaded range) from 2014 to 2022, at Stockton and Newcastle. Daily PM2.5 levels were mostly within the historical range throughout the season.

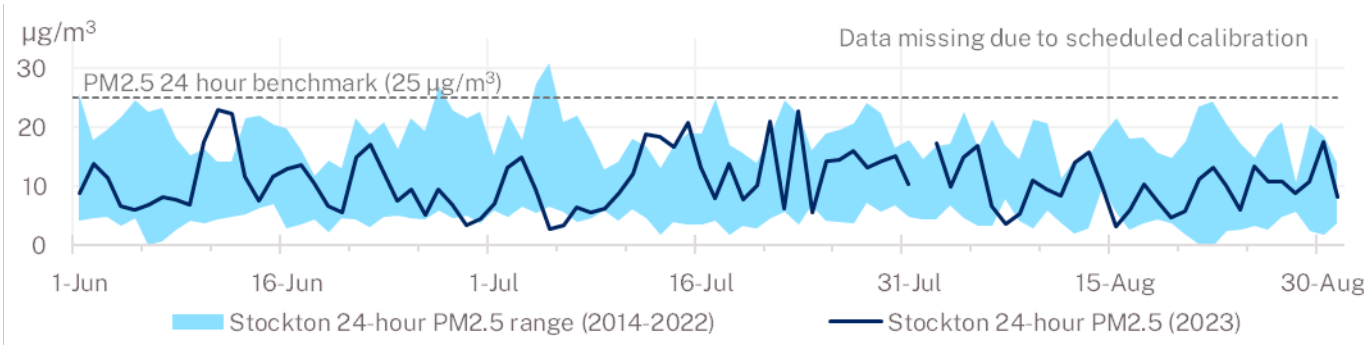

Figure 14 **Stockton daily average PM2.5 during winter 2023 plotted against the daily maximum and minimum PM2.5 levels from 2014 to 2022**

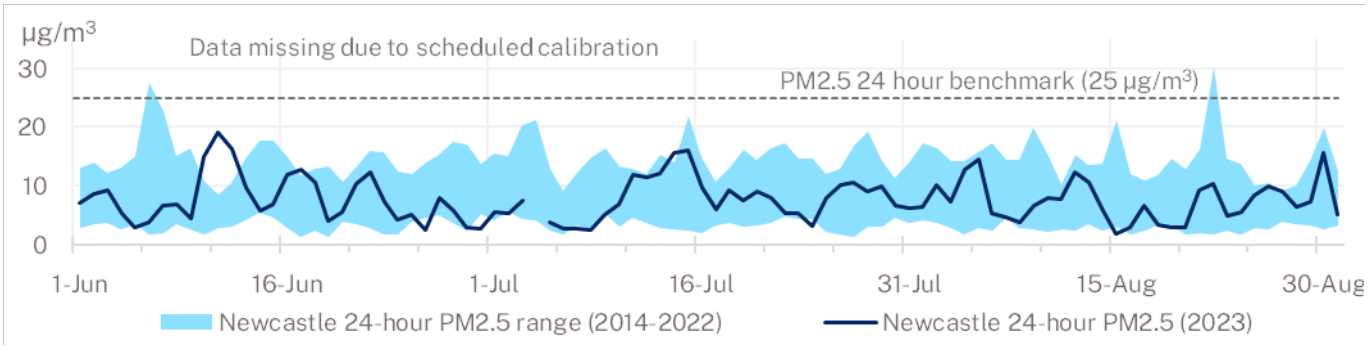

Figure 15 **Newcastle daily average PM2.5 during winter 2023 plotted against the daily maximum and minimum PM2.5 levels from 2014 to 2022**

Meteorological summary

Rainfall[x]

The Newcastle region experienced very much below-average rainfall overall during winter 2023 compared to long-term records (Figure 16). Rainfall in winter 2023 was variable, with very much below average rainfall during June and the first half of July, followed by average rainfall in August. Winter 2023 was drier than winter 2022 and winter 2020 but on par with rainfall received in winter 2021.

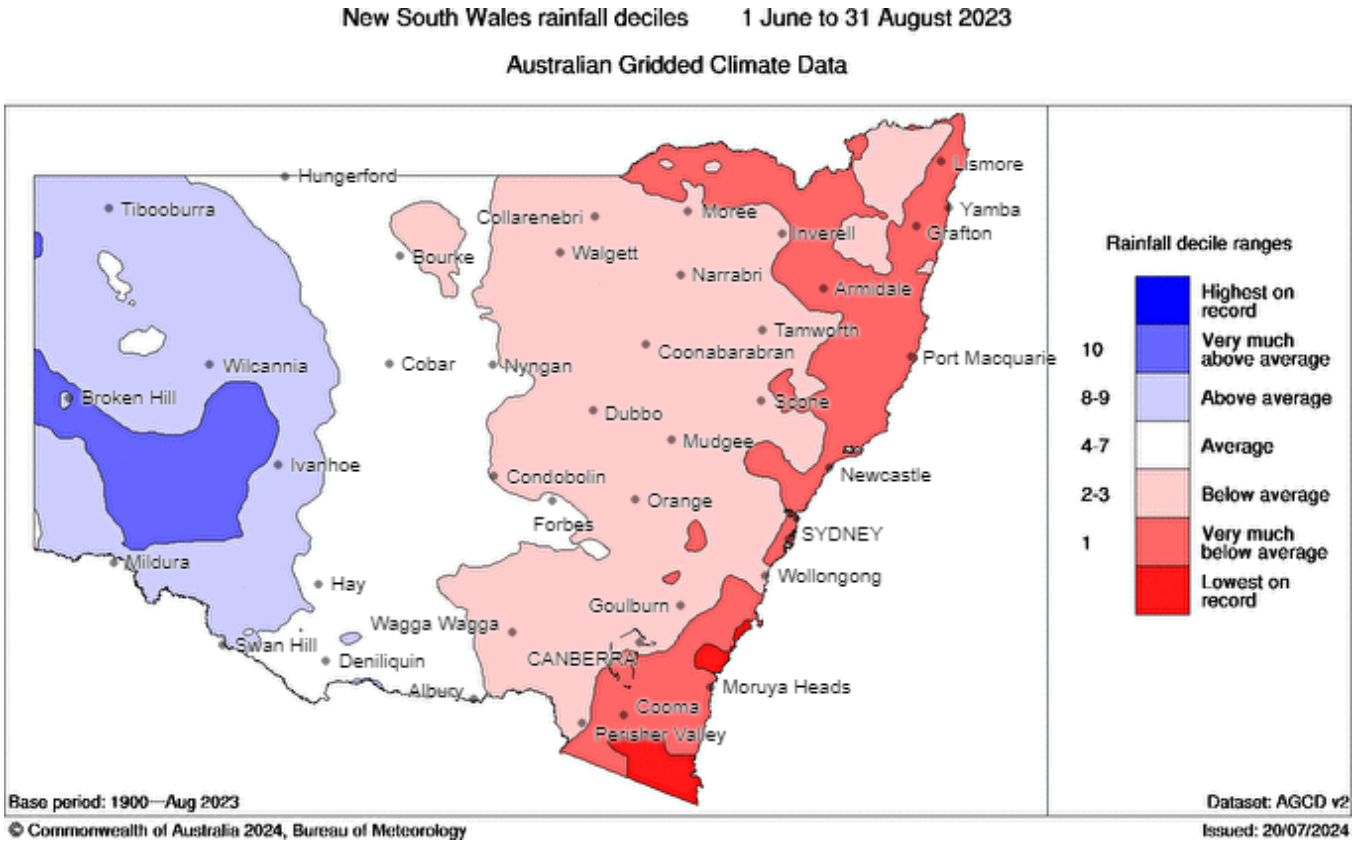

Figure 16 NSW rainfall deciles – winter 2023

Temperatures[x]

Maximum temperatures were among the highest on record during the season (Figure 17), and minimum temperatures were above average.

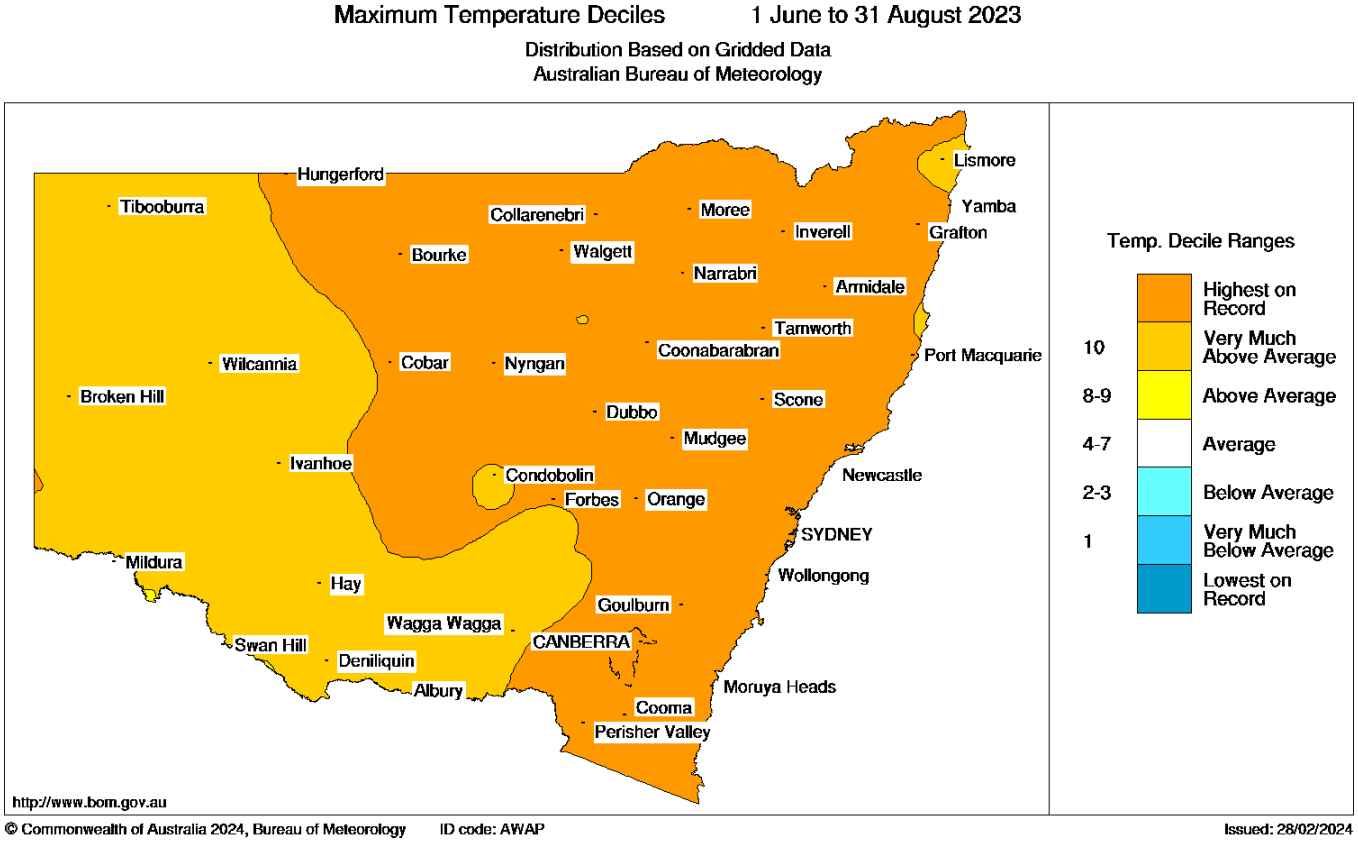

Figure 17 NSW maximum temperature deciles – winter 2023

Wind

Winds were predominantly from the north-west across the region during winter 2023, which was typical for this time of year.

As an example, Figure 18 shows that north-west winds prevailed 43% of the time at Stockton, with these moderate or stronger (above 5 metres per second) 46% of the time, comparable to previous winter seasons.

Figure 18 **Wind rose map[xi] for the Newcastle region for winter 2023**

Stockton

Particles at Stockton in winter 2023

The Stockton monitoring station recorded 2 days over the PM10 daily benchmark during winter 2023. This is 2 days more than winter 2022. From 2013 to 2022, Stockton recorded between zero days (winters 2013, 2014, 2016, 2017, and 2022) and 8 days (winter 2018) over the PM10 daily benchmark (Figure 3).

In winter 2023, elevated hourly PM10 levels (>100 µg/m^3)[xii] were recorded at Stockton 1.2% of the time (27 hours) (Figure 19). The majority of PM10 >100 µg/m^3 hours occurred under onshore north-easterly winds.

Elevated PM10 levels under predominant onshore winds at Stockton indicate the potential contribution of sea salt. The Lower Hunter Particle Characterisation Study found sea salt was a major contributor of particles at the site under onshore winds.

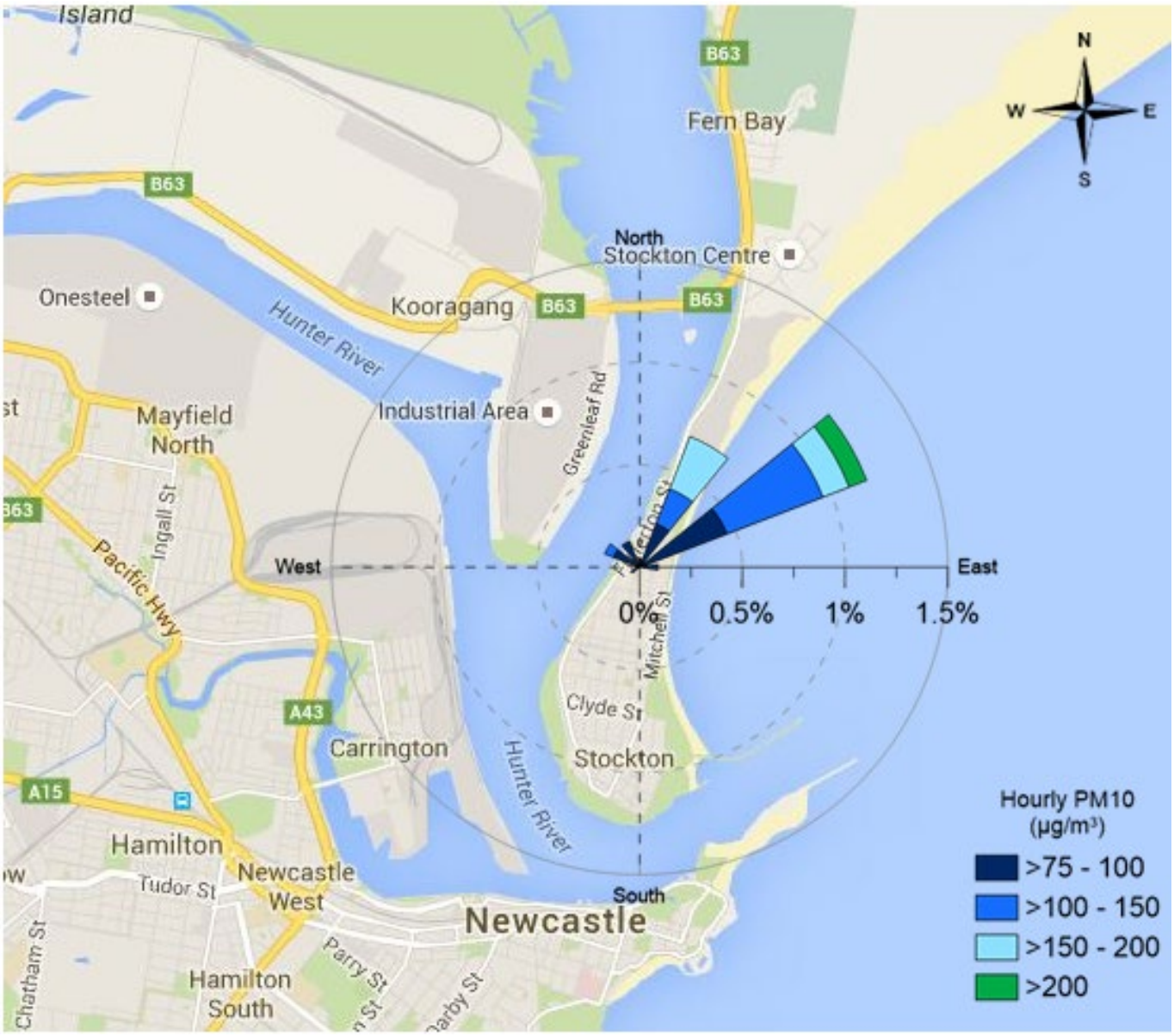

Figure 19 **Stockton winter 2023 PM10 pollution rose – proportion of hourly averaged PM10 levels >75 µg/m³ by wind direction**

The Stockton monitoring site did not record any days over the PM2.5 daily benchmark during winter 2023. From 2013 to 2022, there were 3 days over the PM2.5 daily benchmark in the winters 2013 and 2015 and one day in winter 2019 (Figure 3).

In winter, there was only one elevated hourly PM2.5 level (>50 µg/m^3)[xii] at Stockton (Figure 20).

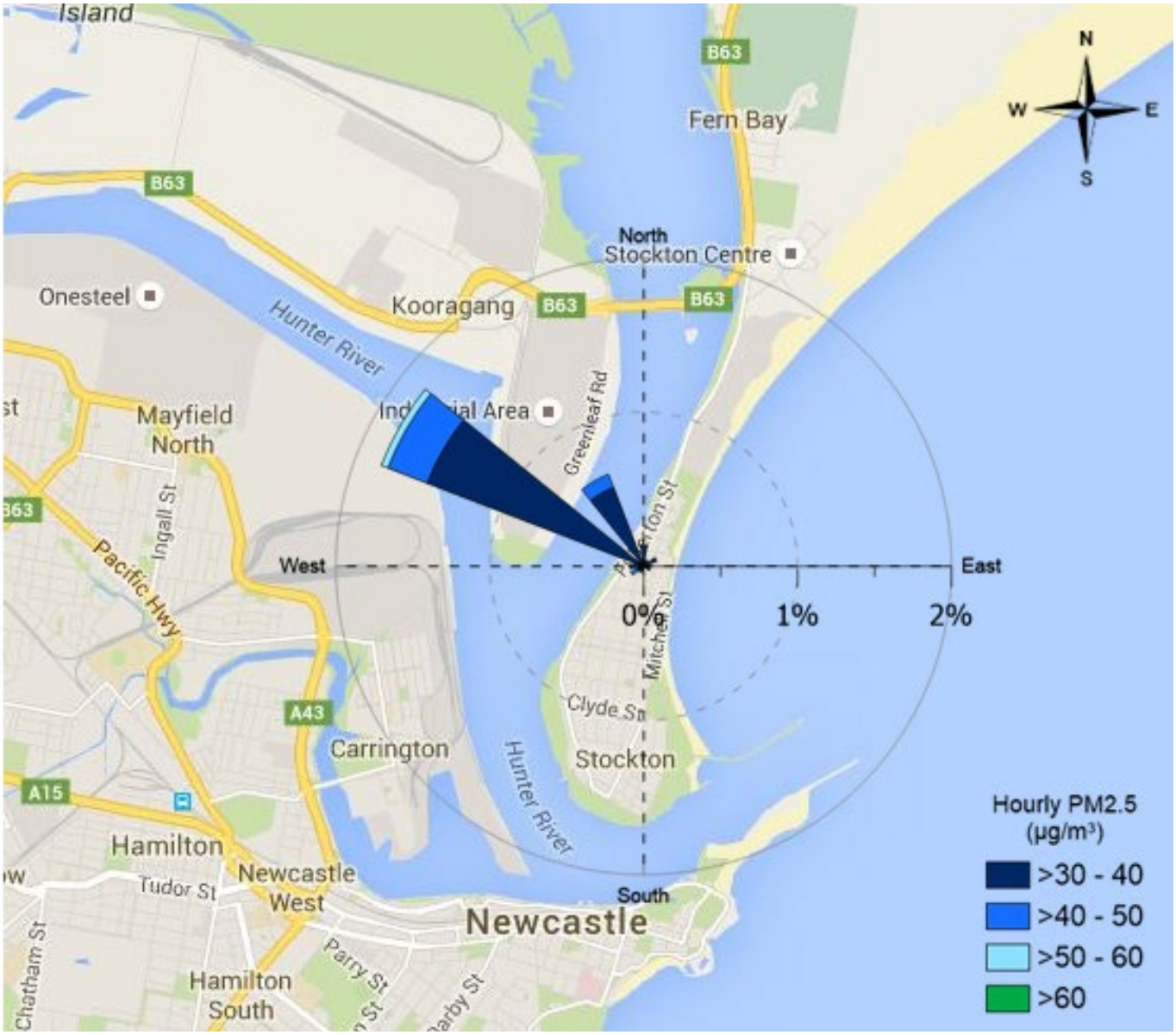

Figure 20 **Stockton winter 2023 PM2.5 pollution rose – proportion of hourly averaged PM2.5 levels >30 µg/m³ by wind direction**

Ammonia at Stockton in autumn and winter 2023

There were no days over the hourly NH_3 assessment goal of 46 pphm at Stockton during autumn and winter 2023 (Figure 21).

Figure 21 shows the daily NH_3 1-hour maximum concentrations in winter 2023, plotted against the daily minimum and maximum levels from 2013 to 2022. This shows that daily 1-hour maximum NH_3 levels in winter 2023 were mostly within the range of the same seasons in earlier years.

NH_3 levels at Stockton follow a seasonal pattern, with levels increasing in cooler months (when winds are predominantly from the north-west) and decreasing in warmer months (when winds are predominantly onshore easterly) (Figure 22). The primary ammonia source at Stockton is Orica's ammonium nitrate manufacturing facility on Kooragang Island, located north-west of the station. Figure 22 shows that the maximum 1-hour average NH_3 concentrations from 2013 to 2023 were highest in 2013 and lowest in 2016 and 2019.

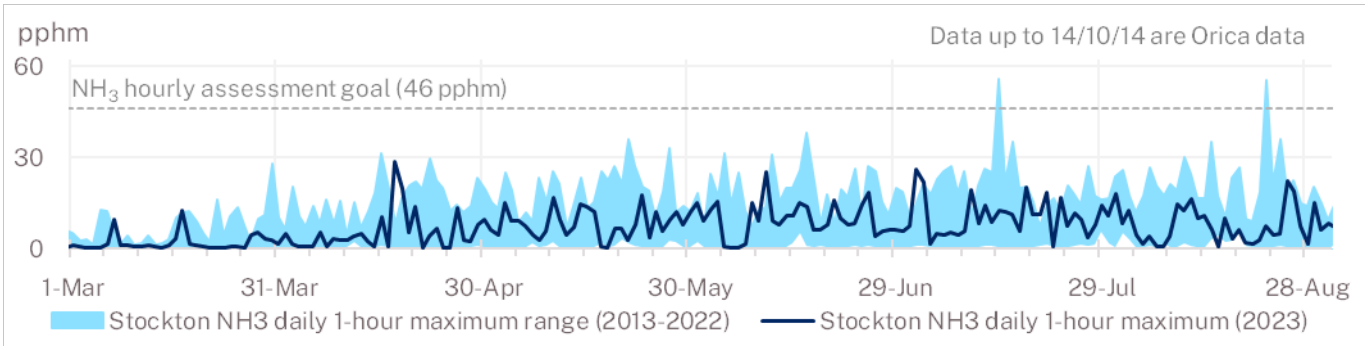

Figure 21 **Stockton daily 1-hour maximum NH_3 for autumn and winter 2023 compared to daily levels from autumn and winter 2013 to 2022**

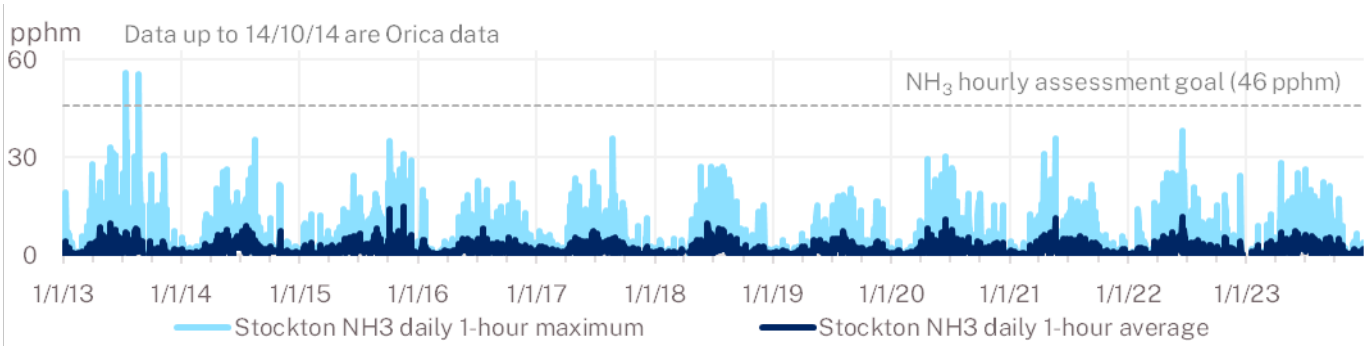

Figure 22 **Stockton daily 1-hour maximum and average NH_3 from 2013 to 2023**

Network performance

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

Reduced online time at Wallsend for gaseous parameters was due to a calibration fault, and particles due to maintenance.

Table 2 **Online performance (%) during winter 2023**

Station	Particles PM10 daily	Particles PM2.5 daily	Gases SO_2 hourly	Gases NO_2 hourly	Gases NH_3 hourly	Meteorology Wind hourly
Beresfield	100	100	95	95	-	100
Carrington	99	98	92	95	-	99
Mayfield	98	97	92	93	-	96
Newcastle	100	99	93	91	-	100
Stockton	100	99	92	95	95	100
Wallsend	88	91	89	89	-	94

- = not monitored

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[i] PM10 and PM2.5 refer to airborne particles, less than or equal to 2.5 and 10 micrometres in diameter, respectively, measured in micrograms per cubic metre (µg/m^3).

[ii] Rolling annual averages use 12-months of data to the end of a season. These are used indicatively to assess long-term trends using the most recent data and are not intended for comparison to the calendar year annual benchmarks of 25 µg/m^3 for PM10 and 8 µg/m^3 for PM2.5.

[iii] Sourced from Department of Primary Industries NSW State seasonal update – August 2021 (accessed October 2022).

[iv] Sourced from Department of Primary Industries NSW State seasonal update – August 2022 (accessed October 2022).

[v] Sourced from Department of Primary Industries NSW State seasonal update – August 2023 (accessed November 2023).

[vi] 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.

[vii] 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.

[viii] There are no standards for hourly PM10 or PM2.5 in the National Environment Protection (Ambient Air Quality) Measure (Air NEPM).

[ix] Data from Bureau of Meteorology Newcastle Nobbys Signal Station AWS monthly rainfall (accessed November 2023)

[x] Rainfall and temperature information is from the Bureau of Meteorology New South Wales winter 2023 climate statement (accessed November 2023) and climate maps (accessed November 2023).

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

[xii] There are no standards for hourly PM10 or PM2.5 in the National Environment Protection (Ambient Air Quality) Measure. The hourly PM10 and PM2.5 thresholds in this section are consistent with the current air quality categories.