

## Air quality in the Upper Hunter: Summer 2022–23

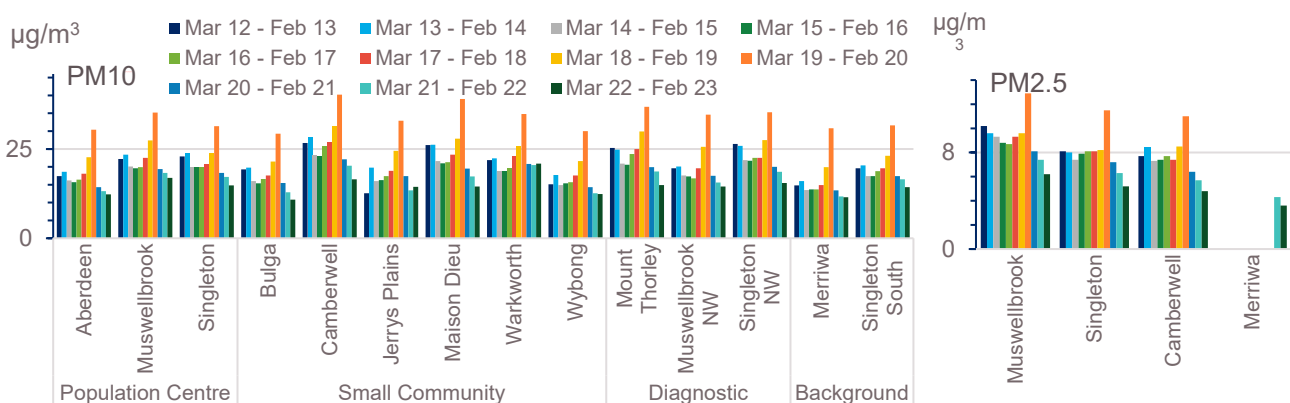
Air quality in the Upper Hunter was generally good during summer 2022–23. Daily particle levels were within national benchmarks 100% of the time at Muswellbrook and Singleton. Hourly particle levels were in the good to fair air quality categories 100% of the time at Singleton and Muswellbrook.

- Nitrogen dioxide (NO<sub>2</sub>) and sulfur dioxide (SO<sub>2</sub>) levels were good to fair, remaining within hourly and daily national benchmarks 100% of the time at Singleton and 99% at Muswellbrook.
- Daily average levels of PM<sub>2.5</sub><sup>1</sup> remained within national benchmarks at all stations.
- Daily average levels of PM<sub>10</sub><sup>1</sup> remained within national benchmarks at all stations, except for 3 days at Warkworth (24 and 27 January, 6 February) and one day at Muswellbrook North West (12 December). The maximum daily PM<sub>10</sub> reached during summer 2022–23 was 55.5 µg/m<sup>3</sup>, reached on 12 December and 6 February, respectively.
- The region experienced below average rainfall and average maximum temperatures during summer.

## Annual air quality trends in the Upper Hunter

A comparison of annual average PM<sub>10</sub> and PM<sub>2.5</sub> levels shows the long-term trends. The national annual average benchmarks are 25 µg/m<sup>3</sup> for PM<sub>10</sub> and 8 µg/m<sup>3</sup> for PM<sub>2.5</sub>, based on a calendar year.

Figure 1 shows the PM<sub>10</sub> and PM<sub>2.5</sub> **rolling** annual averages<sup>2</sup>, based on the 12-month periods from summer 2012-13 to summer 2022–23.



**Figure 1 PM10 and PM2.5 rolling annual averages: to the end of summer 2013–14 to 2022–23**

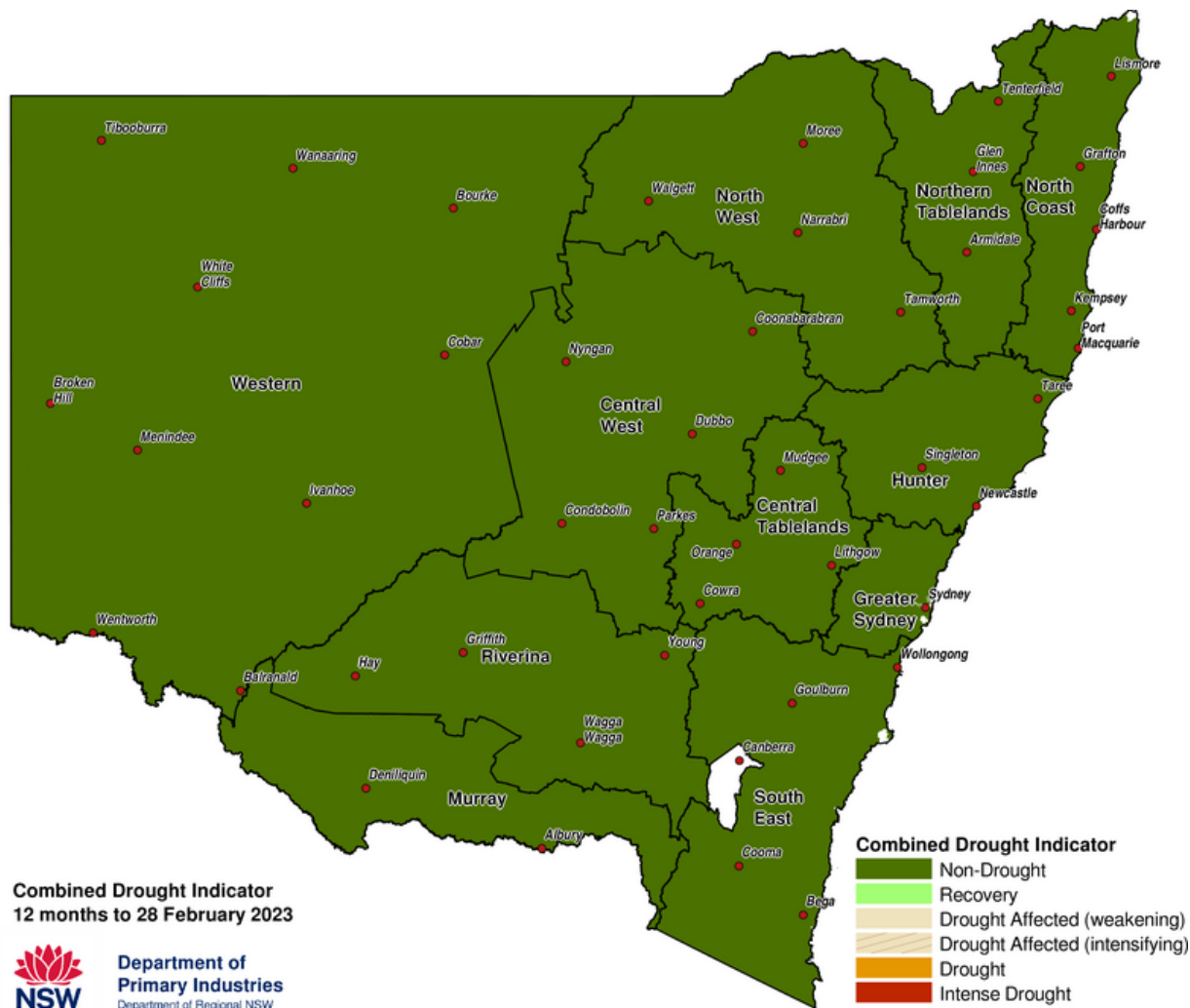
<sup>1</sup> PM<sub>2.5</sub> and PM<sub>10</sub> refer to airborne particles, less than or equal to 2.5 and 10 micrometres in diameter, respectively.

<sup>2</sup> 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 Merriwa background air quality monitoring station was upgraded in July 2020 to also monitor PM2.5. The comparison in Figure 1 shows that particle levels continued to decrease during the 12 months to the end of summer 2022–23 at almost all stations, compared to the same 12-month period in previous years.

All stations recorded rolling annual average PM10 and PM2.5 levels within the annual benchmarks, except Warkworth and Jerrys Plains, recording the lowest since the network began operation. Warkworth PM10 levels have increased year on year since summer 2020-21. This is likely due to nearby mining operations, with the United Wambo Joint Venture Open Cut mine starting operations in 2020.

At the end of summer 2022–23, no areas in New South Wales were affected by drought (Figure 2), compared to 3% at the end of summer 2021–22<sup>3</sup> and 6% at the end of summer 2020-21<sup>4</sup>.



**Figure 2** Department of Primary Industries NSW Combined Drought Indicator to 28 February 2023<sup>5</sup>

<sup>3</sup> Sourced from Department of Primary Industries NSW State seasonal update – February 2022 (accessed July 2023).

<sup>4</sup> Sourced from Department of Primary Industries NSW State seasonal update – February 2021 (accessed July 2023).

<sup>5</sup> Sourced from Department of Primary Industries NSW State seasonal update – February 2023 (accessed July 2023).

# Days above benchmark concentrations

The PM10 daily benchmark (50 µg/m<sup>3</sup>) was exceeded on 3 days at Warkworth and one day at Muswellbrook North West. SO<sub>2</sub> hourly (10 pphm) and daily (2 pphm) benchmarks were exceeded at Muswellbrook over 2 hours on the same day (2 January 2023). PM2.5 and NO<sub>2</sub> remained within the national benchmarks at all sites throughout the season.

**Table 1** Number of days above the relevant national benchmarks – summer 2022–23

Station type*	Station	PM10 daily [50 µg/m <sup>3</sup> benchmark]	PM2.5 daily [25 µg/m <sup>3</sup> benchmark]	SO <sub>2</sub> hourly [10 pphm benchmark]	SO <sub>2</sub> daily [2 pphm benchmark]	NO <sub>2</sub> hourly [8 pphm benchmark]
Population centre	Aberdeen	0	-	-	-	-
Population centre	Muswellbrook	0	0	2	1	0
Population centre	Singleton	0	0	0	0	0
Smaller community	Bulga	0	-	-	-	-
Smaller community	Camberwell	0	0	-	-	-
Smaller community	Jerrys Plains	0	-	-	-	-
Smaller community	Maison Dieu	0	-	-	-	-
Smaller community	Warkworth	3	-	-	-	-
Smaller community	Wybong	0	-	-	-	-
Diagnostic	Mount Thorley	0	-	-	-	-
Diagnostic	Muswellbrook NW	1	-	-	-	-
Diagnostic	Singleton NW	0	-	-	-	-
Background	Merriwa	0	0	0	0	0
Background	Singleton South	0	-	-	-	-

µg/m<sup>3</sup> = micrograms per cubic metre.

pphm = parts per hundred million by volume (i.e. parts of pollutant per hundred million parts of air)

- = not monitored.

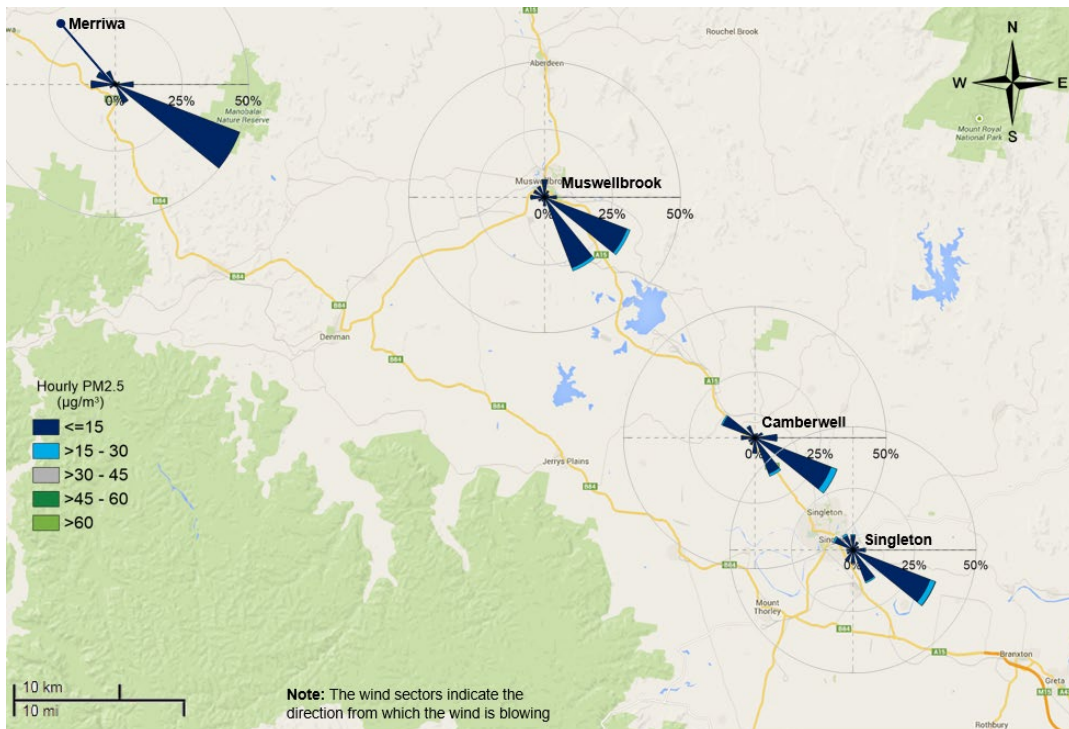
\* For explanation, refer to the end of the report **Definitions: Upper Hunter monitoring station types**.

# Pollution roses from hourly particle data

The seasonal pollution rose maps<sup>6</sup> (Figure 3 and Figure 4) show that hourly PM10 and PM2.5 levels<sup>7</sup> were predominantly in the good to fair air quality category during the season.



**Figure 3** Hourly PM10 pollution rose map for the Upper Hunter region for summer 2022-23



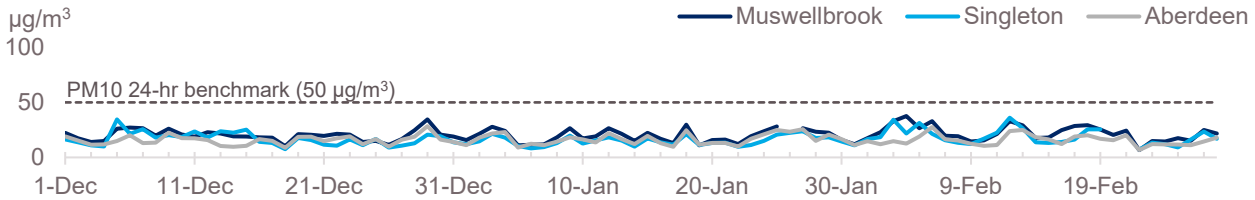
**Figure 4** Hourly PM2.5 pollution rose map for the Upper Hunter region for summer 2022-23

<sup>6</sup> Pollution roses show 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.

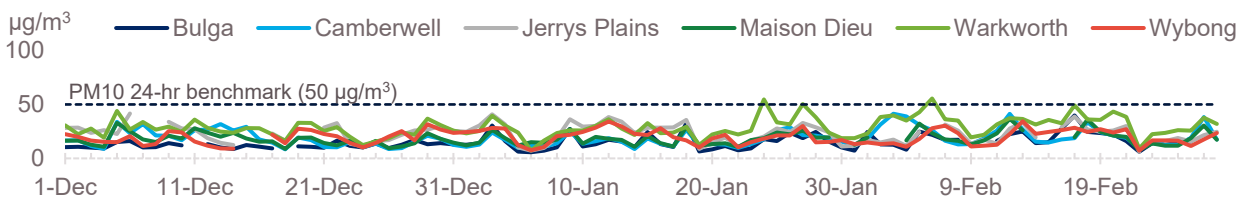
<sup>7</sup> There are no standards for hourly PM10 or PM2.5 in the National Environment Protection (Ambient Air Quality) Measure.

# Daily time series plots

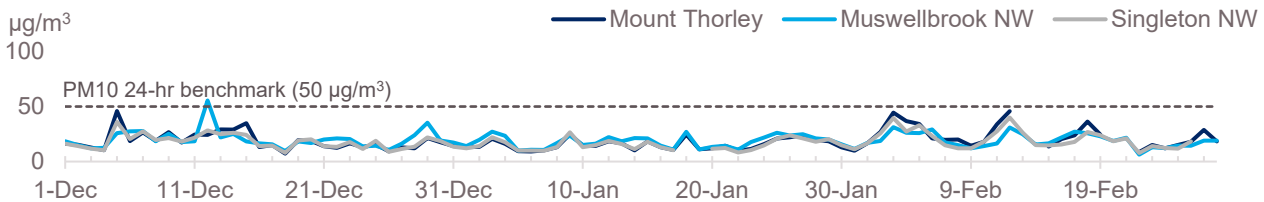
Figure 5 to Figure 12 show daily average time series plots for PM10, PM2.5 and SO<sub>2</sub> and daily 1-hour maximum plots for NO<sub>2</sub> and SO<sub>2</sub>. Daily PM2.5 and NO<sub>2</sub> were within the benchmarks, but daily PM10 was elevated at Warkworth and Muswellbrook North West on several days under light south-south-easterly winds. Daily and hourly SO<sub>2</sub> benchmarks were exceeded at Muswellbrook on 2 January 2023.



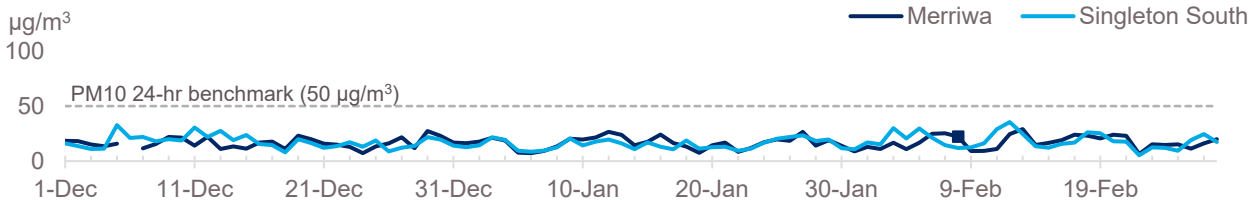
**Figure 5 Population centre stations: daily average PM10 – summer 2022–23**



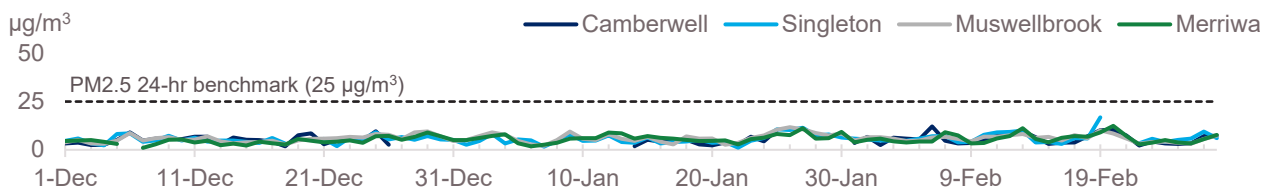
**Figure 6 Smaller community stations: daily average PM10 – summer 2022–23**



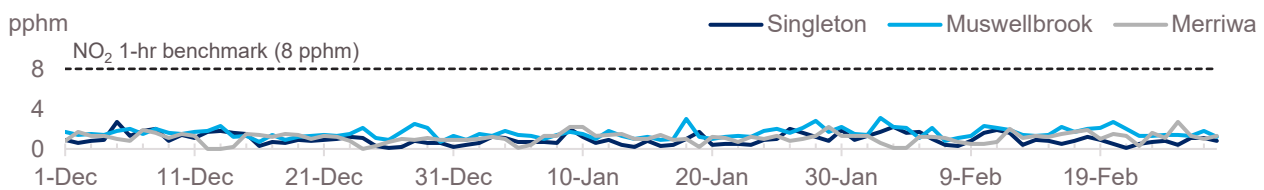
**Figure 7 Diagnostic stations: daily average PM10 – summer 2022–23**



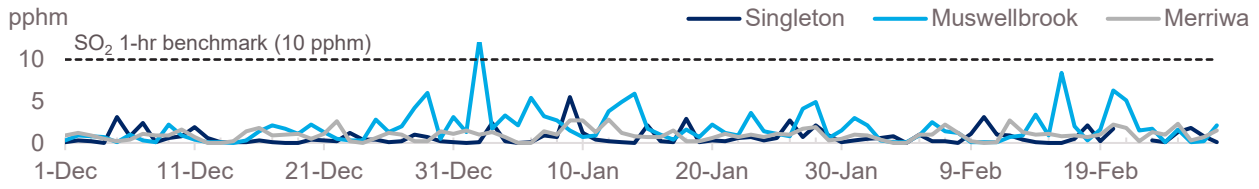
**Figure 8 Background stations: daily average PM10 – summer 2022–23**



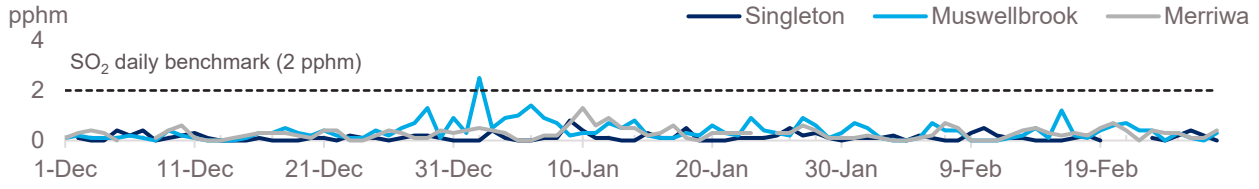
**Figure 9 Daily average PM2.5 – summer 2022–23**



**Figure 10 Daily 1-hr maximum NO<sub>2</sub> – summer 2022–23**



**Figure 11 Daily 1-hr maximum SO<sub>2</sub> – summer 2022–23**



**Figure 12 Daily average SO<sub>2</sub> – summer 2022–23**



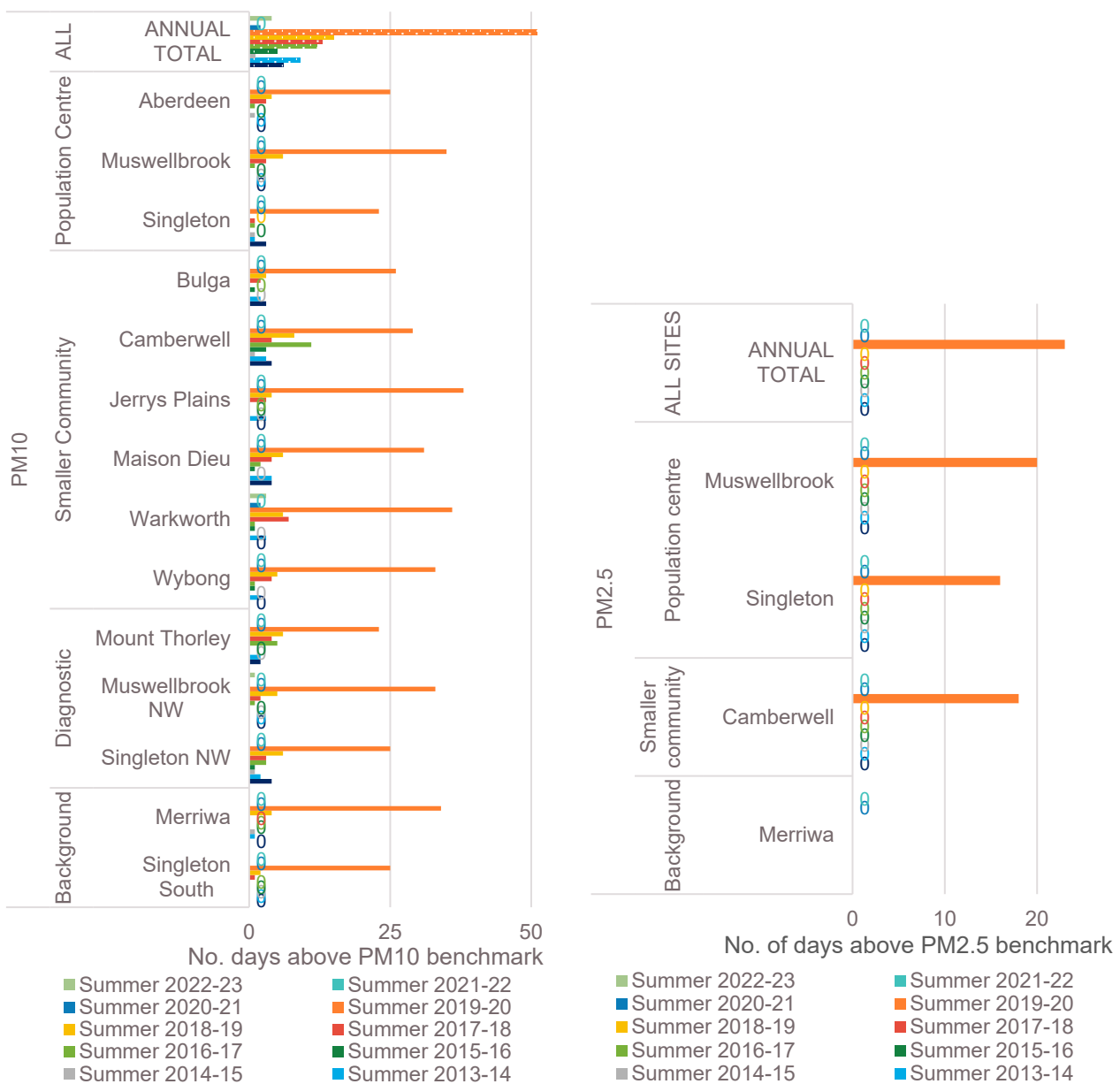
# Seasonal comparisons

This section compares air quality in summer 2022-23 with previous summer seasons (Figure 13).

There were no days over the national benchmarks for NO<sub>2</sub> and one day over the benchmark for SO<sub>2</sub> in summer 2022-23.

There were 4 days over the PM10 daily benchmark during summer 2022-23. This is the fourth lowest number of PM10 exceedance days during summer since the network began operations 10 years ago. From 2012-13 to 2021-22, the region recorded between 0 days (summer 2021-22) and 51 days (summer 2019-20) over the PM10 benchmark.

There were no days over the PM2.5 daily benchmark during summer 2022-23. From 2012-13 to 2021-22, the region has recorded only one season with PM2.5 exceedances, in summer 2019-20 with 23 days above the daily benchmark. Higher particle levels occurred in summer 2019-20 due to severe drought conditions and extreme bushfires.

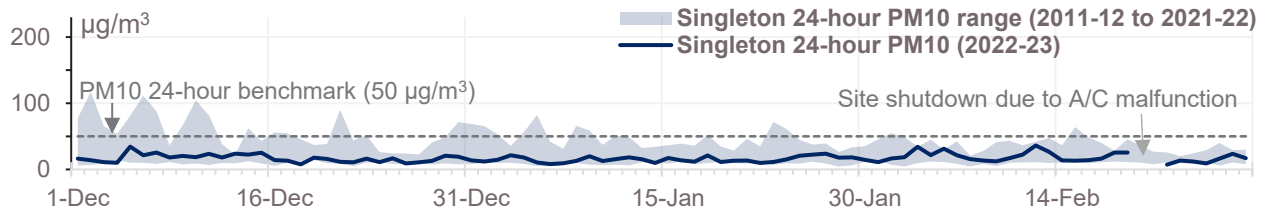


**Figure 13** Number of days above the PM10 and PM2.5 daily benchmarks: summer 2012-13 to 2022-23

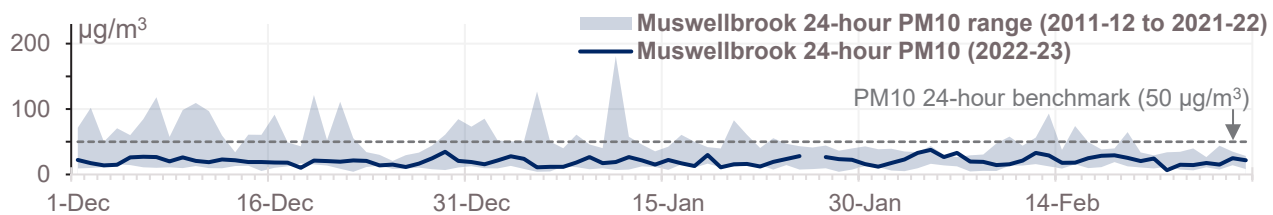
Note: The Merriwa background air quality monitoring station was upgraded in July 2020 to also monitor PM2.5

# Particle air quality trends in the Upper Hunter

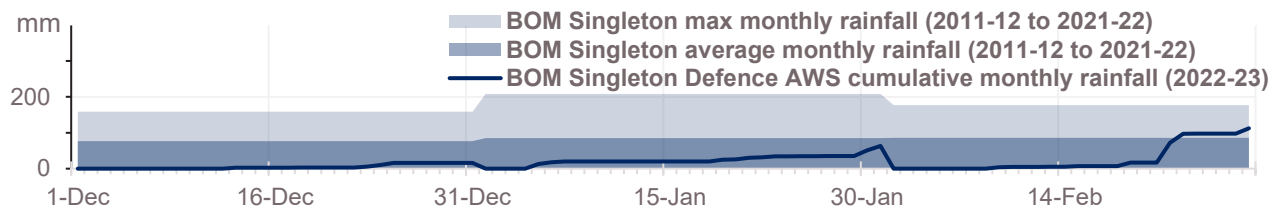
Figure 14 and Figure 15 show daily average PM10 levels during summer 2022–23, compared to the daily maximum and minimum levels (i.e. shaded range) for summer periods from 2011–12 to 2021–22, at Singleton and Muswellbrook. Daily PM10 levels were within or below the historical range throughout the season at both sites. Regional rainfall levels were below average for most of the season (Figure 16).



**Figure 14** Singleton daily average PM10 during summer 2022–23 plotted against the daily maximum and minimum PM10 levels from 2011–12 to 2021–22

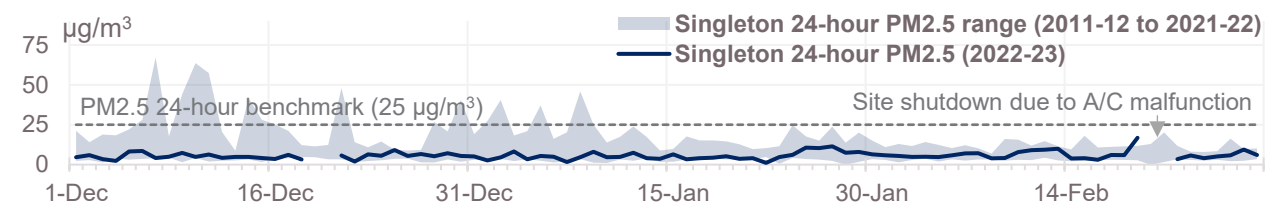


**Figure 15** Muswellbrook daily average PM10 during summer 2022–23 plotted against the daily maximum and minimum PM10 levels from 2011–12 to 2021–22



**Figure 16** Bureau of Meteorology Singleton Defence AWS<sup>8</sup> cumulative monthly rainfall in summer 2022–23 against maximum and average monthly rainfall from 2011–12 to 2021–22<sup>9</sup>

Figure 17 and Figure 18 show daily average PM2.5 levels during summer 2022–23, compared to the daily maximum and minimum levels (shaded range) for summer periods from 2011–12 to 2021–22, at Singleton and Muswellbrook. Daily PM2.5 levels were within or below the historical range in the season.

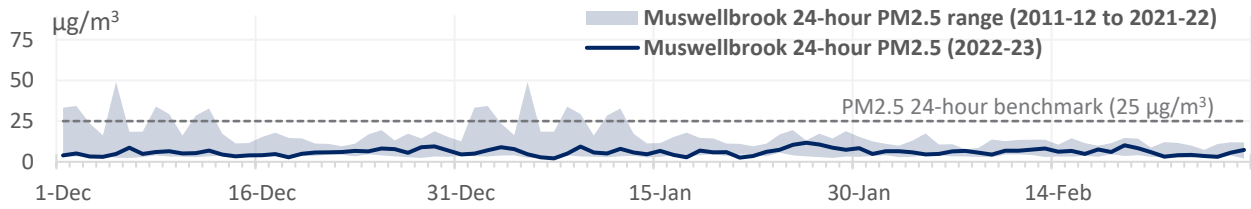


**Figure 17** Singleton daily average PM2.5 during summer 2022–23 plotted against the daily maximum and minimum PM2.5 levels from 2011–12 to 2021–22

<sup>8</sup> Data obtained from the Bureau of Meteorology [Singleton Defence AWS monthly rainfall data](#) (accessed January 2023).

<sup>9</sup> The Bureau of Meteorology STP station was decommissioned in January 2019. Therefore, statistics have been calculated from a combination of the [Singleton STP monthly rainfall data](#) (accessed March 2020) from January 2011 to March 2017 and [Singleton Defence AWS monthly rainfall data](#) from April 2017.





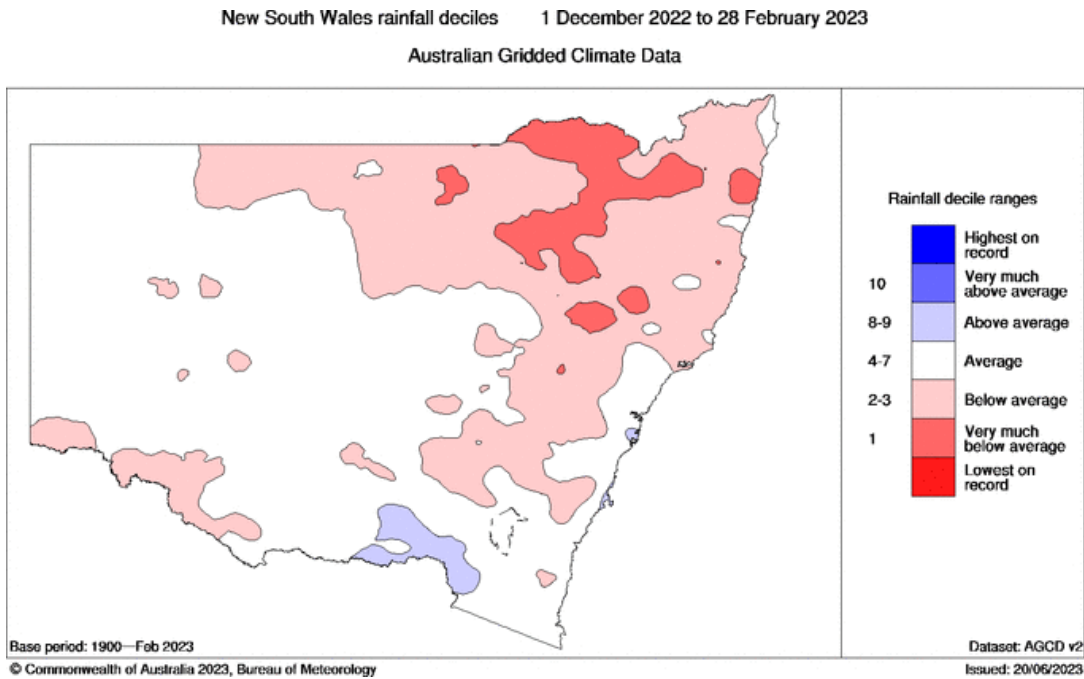
**Figure 18** Muswellbrook daily average PM2.5 during summer 2022–23 plotted against the daily maximum and minimum PM2.5 levels from 2011–12 to 2021–22

# Meteorological summary

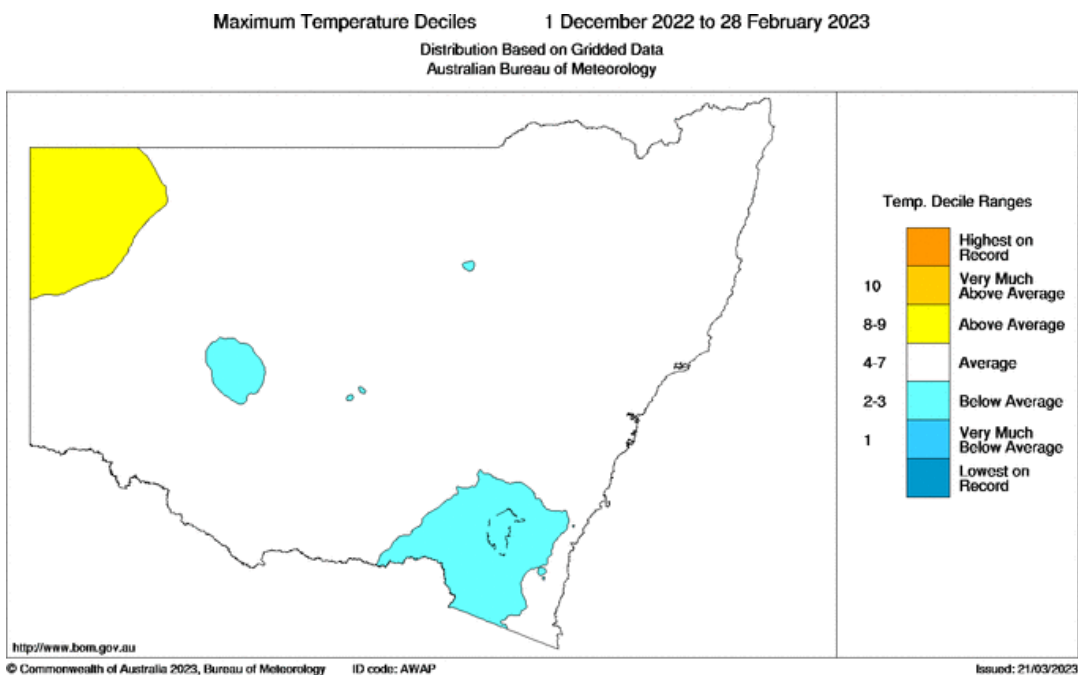
## Rainfall and temperature<sup>10</sup>

The Upper Hunter experienced below average rainfall during summer 2022–23 (Figure 19). Summer 2022–23 was drier than summer 2021–22 (82 millimetres less rain) and summer 2020–21 (144 millimetres less rain).

Maximum temperatures were average (Figure 20), and minimum temperatures were cooler than average during the season.



**Figure 19**    NSW rainfall deciles – summer 2022–23

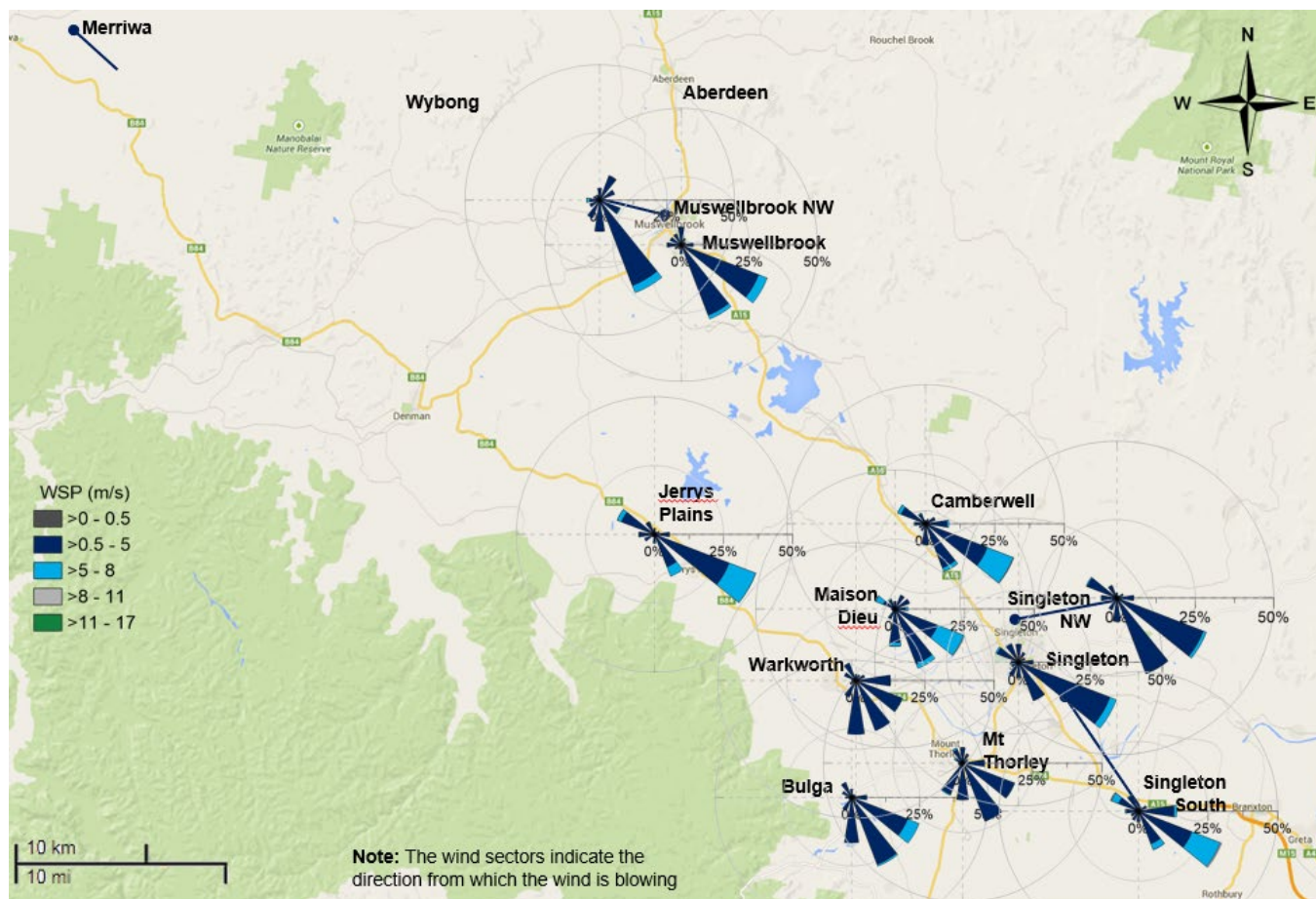


**Figure 20**    NSW maximum temperature deciles – summer 2022–23

<sup>10</sup> Rainfall and temperature information is from the Bureau of Meteorology [New South Wales summer 2022–23 climate statement](#) (accessed July 2023) and [climate maps](#) (accessed July 2023).

## Wind

The winds were predominantly from the south-east during summer 2022–23 (Figure 21), typical during summer in the Upper Hunter Valley.



**Figure 21** Wind rose map<sup>11</sup> for the Upper Hunter region for summer 2022–23

<sup>11</sup> Wind roses show the wind direction and speed 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 the wind speed categories.

# Network performance

The target network performance is at least 95% available data for all parameters. Due to daily calibrations, the maximum online time that can be attained for NO<sub>2</sub> and SO<sub>2</sub> is 96%.

**Table 2 Online performance (%) during summer 2022–23**

Station	Particles PM10 daily	Particles PM2.5 daily	Gases SO <sub>2</sub> hourly	Gases NO <sub>2</sub> hourly	Meteorology Wind hourly
Aberdeen	100	-	-	-	100
Bulga	94	-	-	-	98
Camberwell	100	76	-	-	100
Jerrys Plains	90	-	-	-	99
Maison Dieu	93	-	-	-	97
Merriwa	99	99	94	94	100
Mount Thorley	96	-	-	-	99
Muswellbrook	99	100	96	95	100
Muswellbrook NW	100	-	-	-	100
Singleton	98	96	93	92	99
Singleton NW	97	-	-	-	100
Singleton South	100	-	-	-	100
Warkworth	100	-	-	-	100
Wybong	98	-	-	-	100

- = not monitored

The overall reduced online times were mainly due to Camberwell PM2.5 – instrument malfunction causing data invalidation for 17 days until maintenance could occur.

## Definitions: Upper Hunter monitoring station types

The 14 monitoring stations in the Upper Hunter serve different purposes.

**Larger population:** stations near the larger population centres monitor the air quality in these centres.

**Smaller communities:** stations near smaller communities monitor the air quality at those locations.

**Diagnostic:** provide data that can help diagnose the likely sources and movement of particles across the region; they do not provide information about air quality at population centres.

**Background:** the stations near Merriwa and Singleton South are at both ends of the valley and provide background data, measuring the quality of air entering and leaving the Upper Hunter Valley under predominant winds (south-easterlies and north-westerlies).

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This document was prepared by Emily Goodale and reviewed by Margaret Haak and David Salter.

Published by: Department of Climate Change, Energy, the Environment and Water, Locked Bag 5022, Parramatta NSW 2124. Ph: 131 555 (environment information and publications requests). TTY: (02) 9211 4723. Email: [info@environment.nsw.gov.au](mailto:info@environment.nsw.gov.au);

Web: [www.environment.nsw.gov.au](http://www.environment.nsw.gov.au).

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