Air Quality Monitoring Network

Upper Hunter spring 2023

Air quality in the Upper Hunter was mostly good-to-fair during spring 2023, but PM10 levels increased compared to the previous season. This was driven mainly by drier conditions, with parts of the region experiencing intense drought. Hourly particle levels remained within the good-to-fair air quality categories 100% of the time at Singleton and 99.5% at Muswellbrook during the season.

- Nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) levels were good, remaining below hourly and daily national benchmarks.
- Daily average PM2.5[1] levels remained below national benchmarks at all stations.
- Across the Upper Hunter, daily average PM10[1] levels exceeded the benchmark on 22 days. The regional maximum daily PM10 on these days ranged from 51.9 to 93.6 µg/m^3.
    - The highest number of days occurred at Warkworth, with 21 days over the PM10 daily benchmark. This is likely due to nearby mining activities, exacerbated by dry conditions.
    - At population centres, PM10 levels exceeded the daily benchmark at Muswellbrook on 2 October and 22 October. These were likely due to regional dust. There were no days over the benchmark at Singleton and Aberdeen.
    - The rest of the region saw between 0 days at Merriwa to 11 days at Mount Thorley.
- The region experienced average to below-average rainfall during spring 2023 and maximum temperatures were very much above average.

Annual air quality trends

Figure 1 and Figure 2 show the rolling annual averages[2] for PM10 and PM2.5 particles for the 12-month periods from spring 2013 to spring 2023.

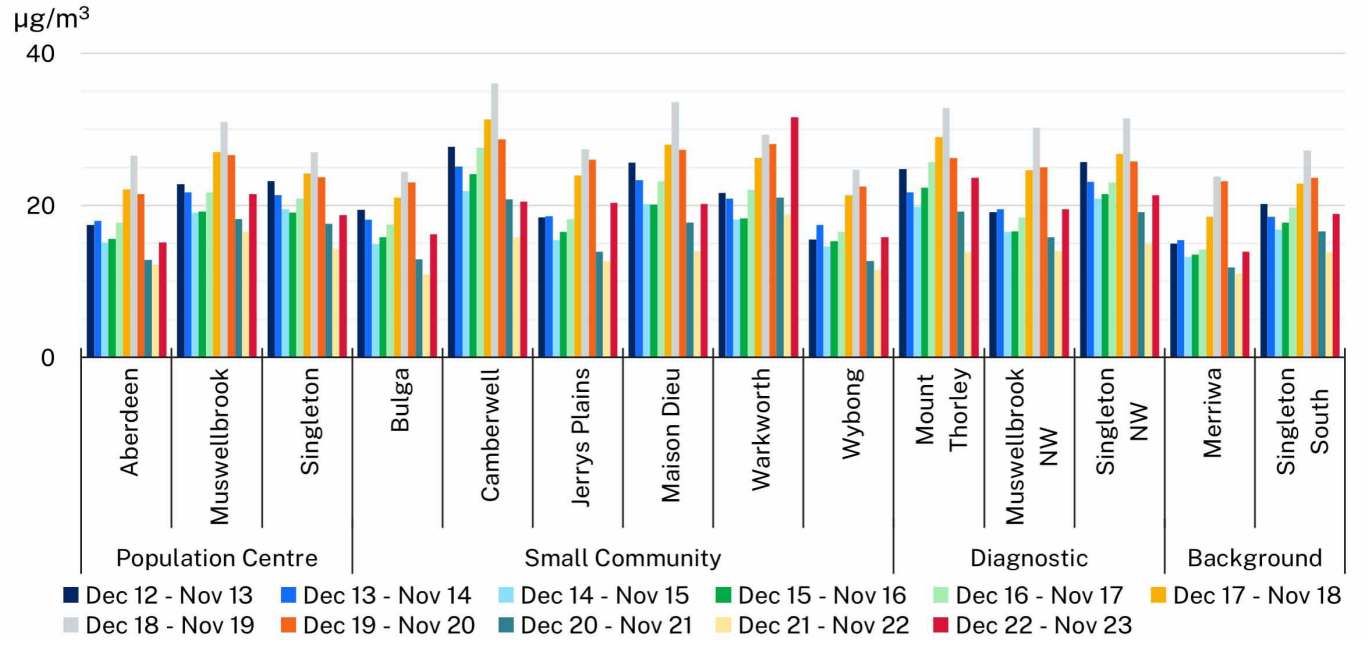

Figure 1 PM10 rolling annual averages based on 12-month periods from spring 2013 to spring 2023

Note: The tabulated PM10 rolling annual average data are found in Table 3 in Appendix A: Rolling annual averages.

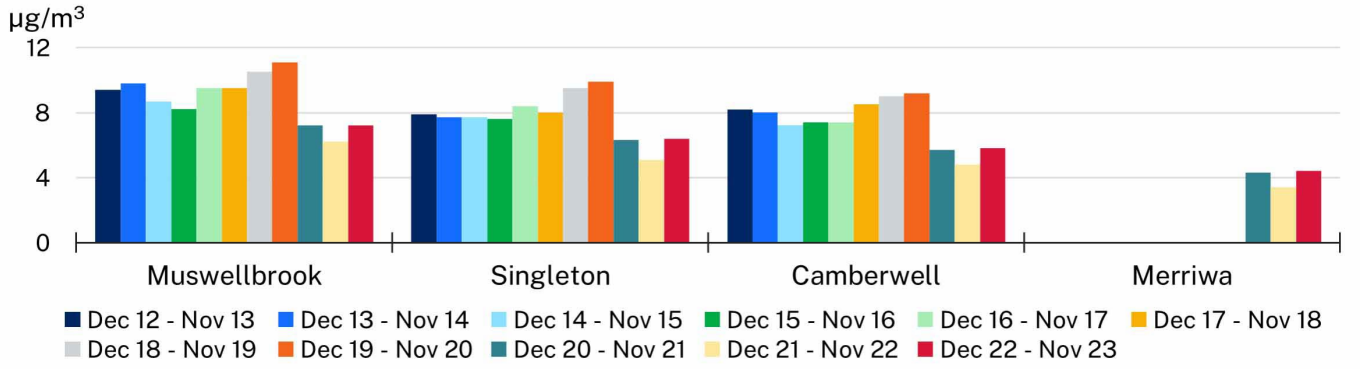

Figure 2 PM2.5 rolling annual averages based on 12-month periods from spring 2013 to spring 2023

Note: The Merriwa background station was upgraded in July 2020 to also monitor PM2.5.
The tabulated PM2.5 rolling annual average data are found in Table 4 in Appendix A: Rolling annual averages.

PM10 levels increased throughout the region, compared to recent record low years (2021 and 2022). This was especially evident at Warkworth, recording the highest 12-month PM10 rolling average for spring 2023 and the only station over 25 µg/m^3 (Figure 1). The 12-month PM10 rolling average at Warkworth also exceeded the 2019 levels recorded during extreme drought and bushfire conditions. The Warkworth station was likely impacted by emissions from nearby mining operations, which the drier conditions exacerbated.

PM2.5 rolling annual averages levels to the end of spring 2023 saw some increases, however, they were similar to those seen during the same period in the past couple of years (Figure 2).

At the end of spring 2023, the NSW Department of Primary Industries reported that 65% of New South Wales had deteriorated to fall within one of the 3 drought categories[3] (Figure 3). Large parts of the Upper Hunter were categorised as being in intense drought, an increase from winter 2023. In comparison, there were no drought-affected areas in the state at the end of the spring 2022[4], while 5% was drought-affected at the end of spring 2021[5].

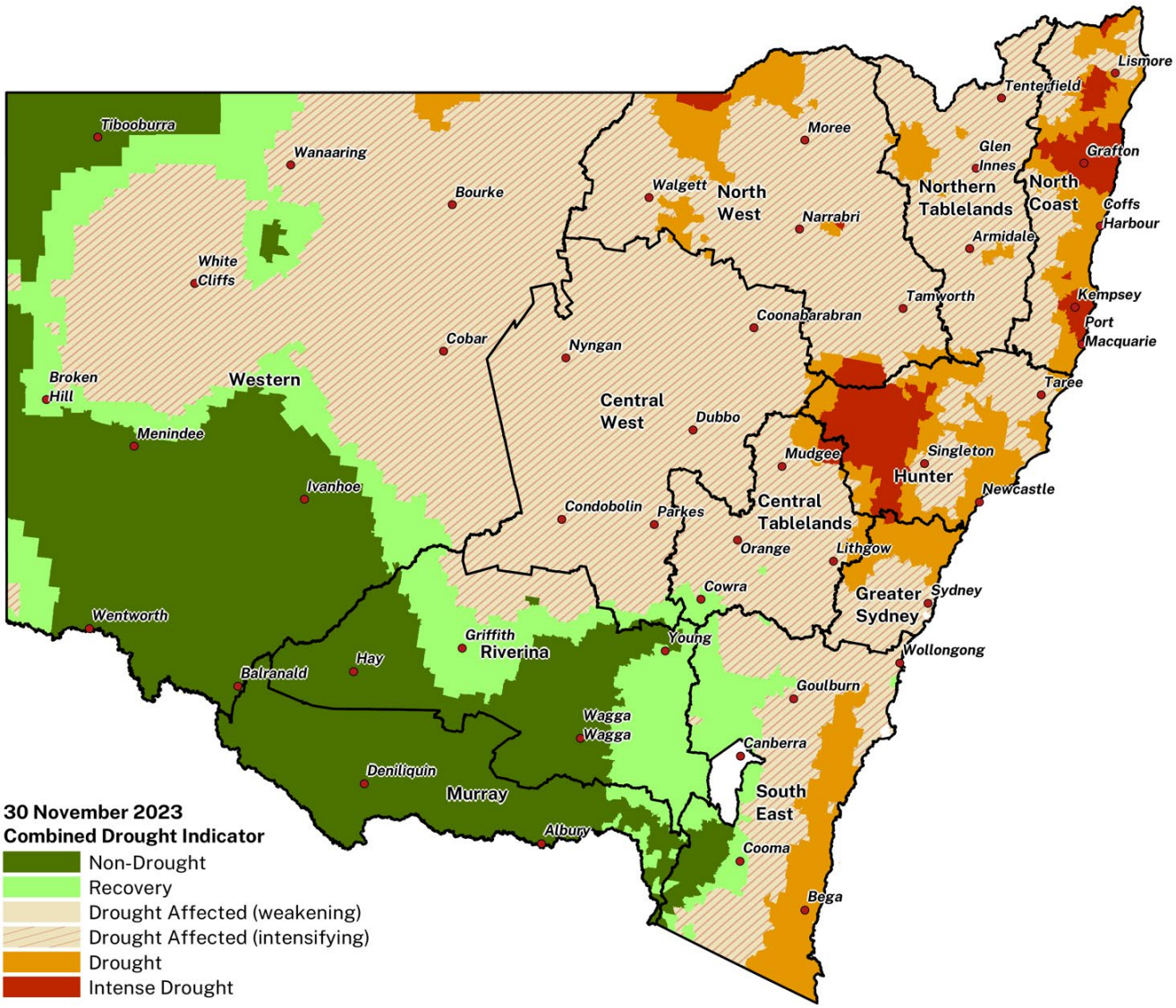

Figure 3 Department of Primary Industries NSW combined drought indicator to 30 November 2023[3]

Figure produced by NSW Department of Primary Industries © State of New South Wales EDIS v2.2.

Days above benchmark concentrations

PM10 levels were above the daily benchmark in the Upper Hunter on 22 days (7 and 16–20 September; 1–4, 15–16, 21–25 and 30–31 October; 12, 14 and 19 November). This ranged from no days at Aberdeen, Merriwa and Singleton to 21 days at Warkworth (Table 1). This is likely due to increased dust levels under drought conditions. There may also be some impact from fires during the season.

PM2.5 levels remained below the daily benchmark at all stations during spring 2023.

SO_2 and NO_2 levels also remained below the national benchmarks throughout the season.

Table 1 Number of days above the relevant national benchmarks – spring 2023

Station type*	Station	PM10 daily [50 µg/m³ benchmark]	PM2.5 daily [25 µg/m³ benchmark]	SO_2 hourly [10 pphm benchmark]	SO_2 daily [2 pphm benchmark]	NO_2 hourly [8 pphm benchmark]
Population centre	**Aberdeen**	0	–	–	–	–
Population centre	**Muswellbrook**	2	0	0	0	0
Population centre	**Singleton**	0	0	0	0	0
Smaller community	**Bulga**	1	–	–	–	–
Smaller community	**Camberwell**	5	0	–	–	–
Smaller community	**Jerrys Plains**	2	–	–	–	–
Smaller community	**Maison Dieu**	2	–	–	–	–
Smaller community	**Warkworth**	21	–	–	–	–
Smaller community	**Wybong**	1	–	–	–	–
Diagnostic	**Mount Thorley**	11	–	–	–	–
Diagnostic	**Muswellbrook NW**	2	–	–	–	–
Diagnostic	**Singleton NW**	5	–	–	–	–
Background	**Merriwa**	0	0	0	0	0
Background	**Singleton South**	1	–	–	–	–

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

* See 'Definitions: Upper Hunter monitoring station types' at the end of this report.

Pollution roses using hourly particle data

The seasonal pollution rose maps[6] for spring 2023 (Figure 4 and Figure 5) show that hourly PM10 and PM2.5 levels[7] remained predominantly low across the Upper Hunter region. Elevated hourly PM10 levels (above 100 µg/m^3) were recorded at stations closer to mines, particularly at Warkworth.

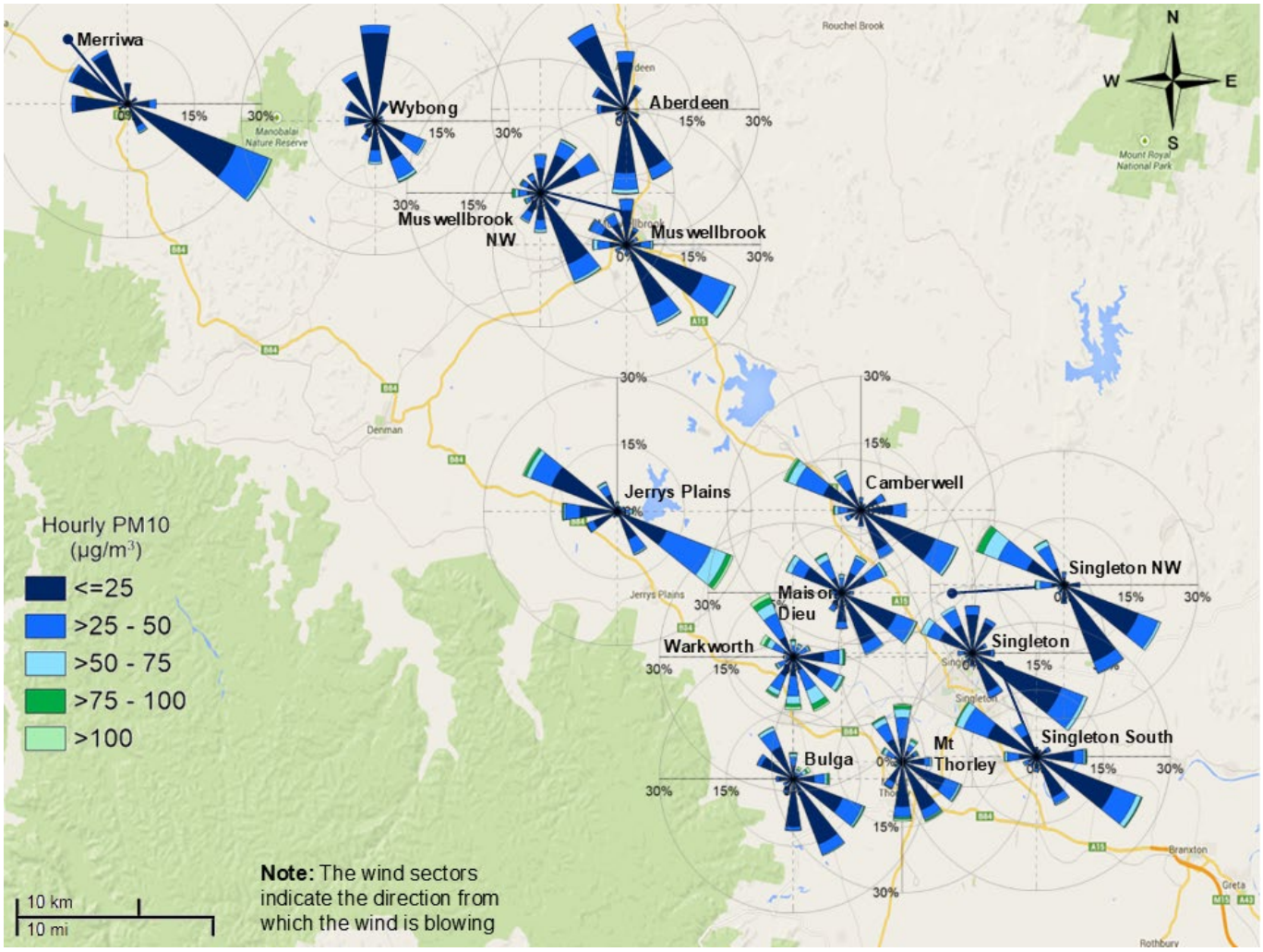

Figure 4 **Hourly PM10 pollution rose map for the Upper Hunter region for spring 2023**

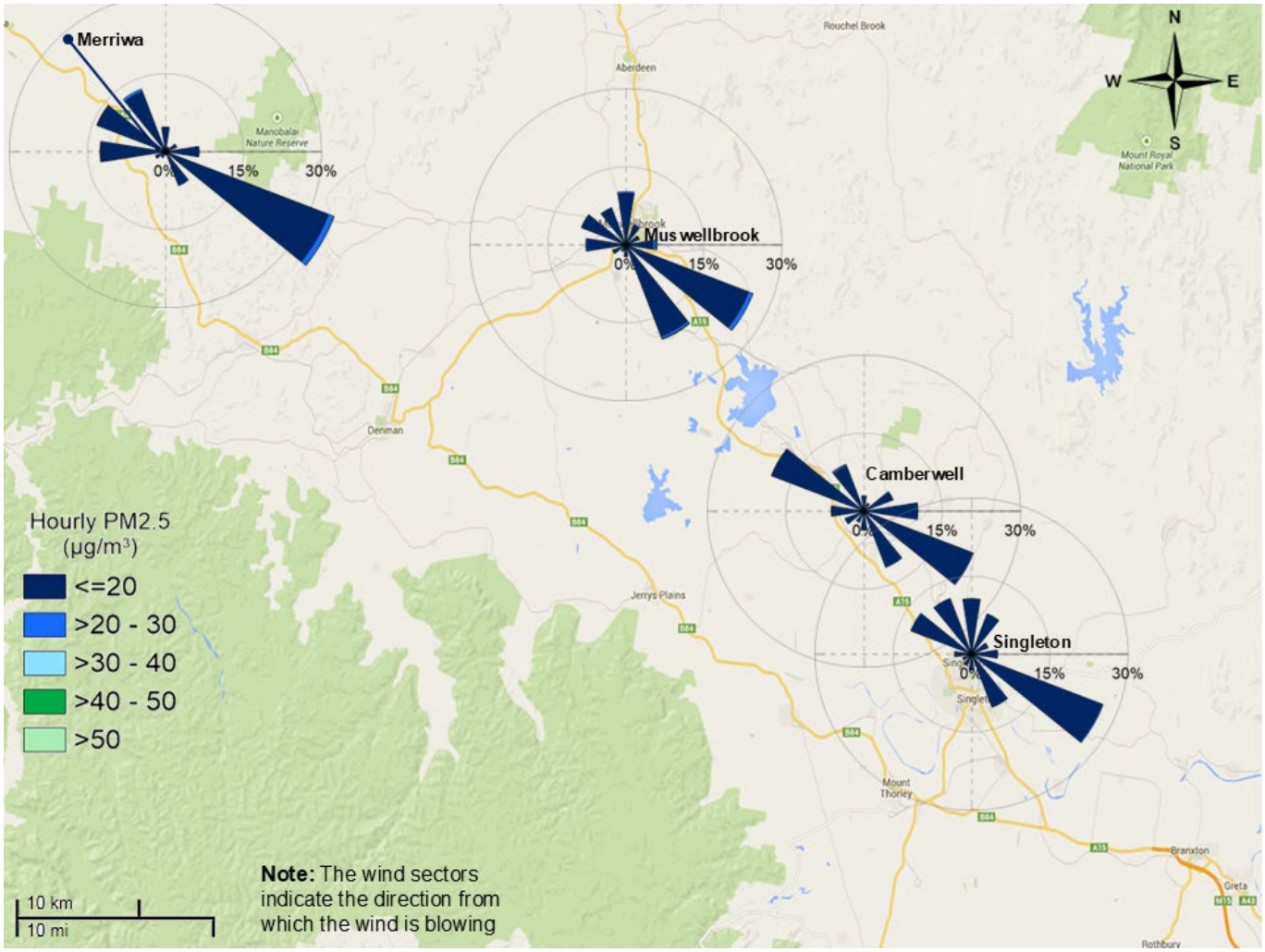

Figure 5 **Hourly PM2.5 pollution rose map for the Upper Hunter region for spring 2023**

Daily time series plots

Figure 6 to Figure 9 show the daily average PM10 concentrations observed during spring 2023. PM10 levels exceeded the daily benchmark on 22 days during the season.

PM2.5, NO_2 and SO_2 levels were below the benchmarks during the season (Figure 10 to Figure 12).

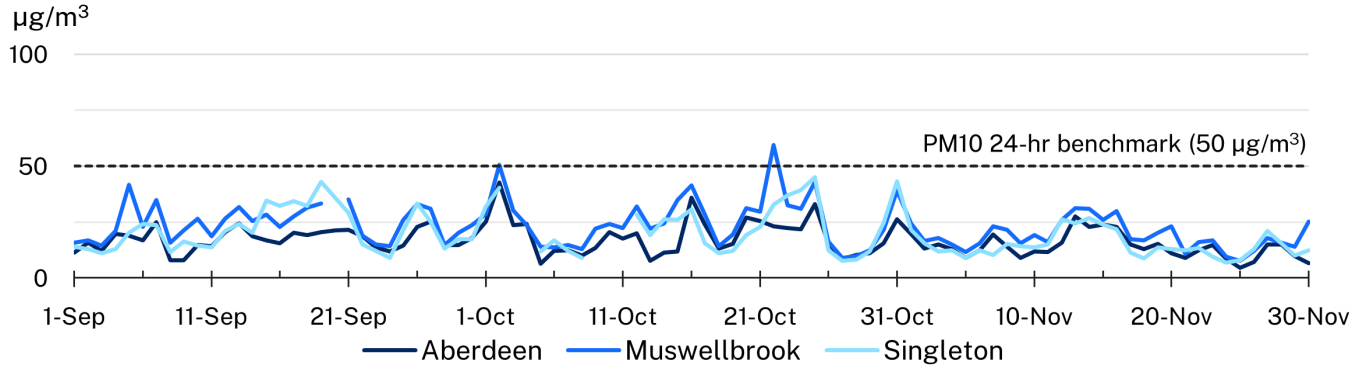

Figure 6 **Population centre stations: daily average PM10 – spring 2023**[8]

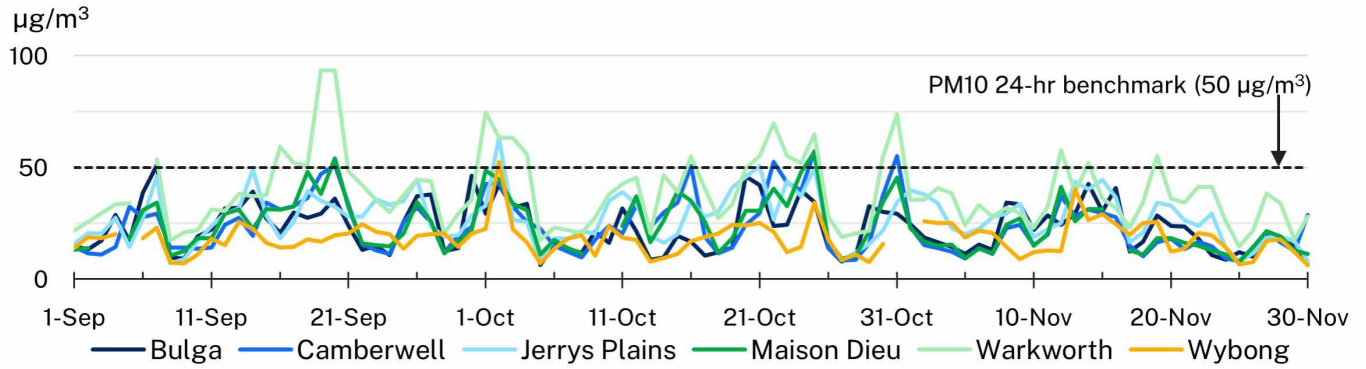

Figure 7 **Smaller community stations: daily average PM10 – spring 2023[8]**

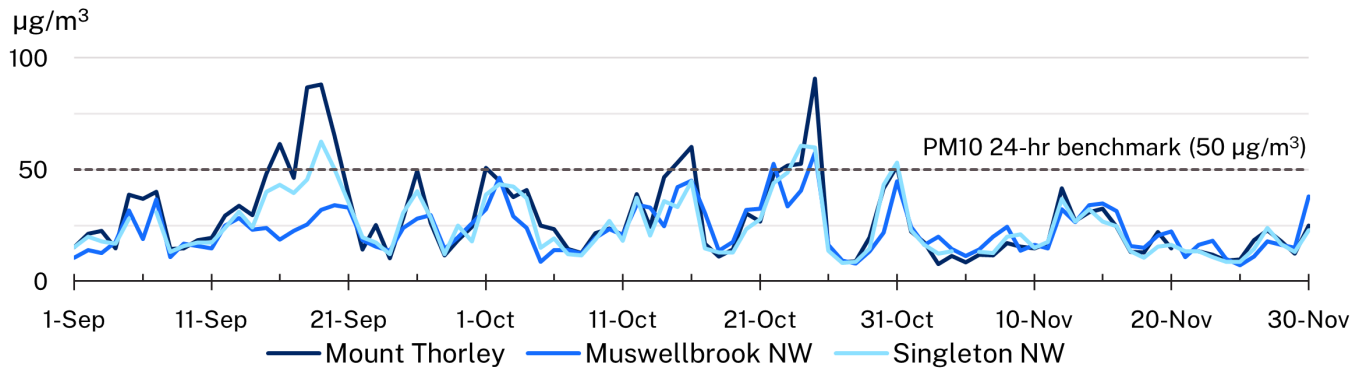

Figure 8 **Diagnostic stations: daily average PM10 – spring 2023[8]**

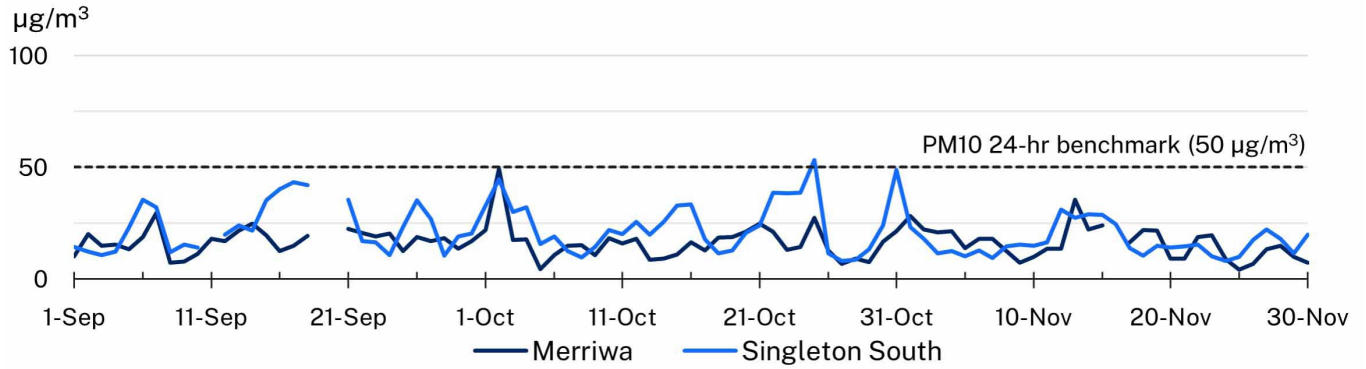

Figure 9 **Background stations: daily average PM10 – spring 2023[8]**

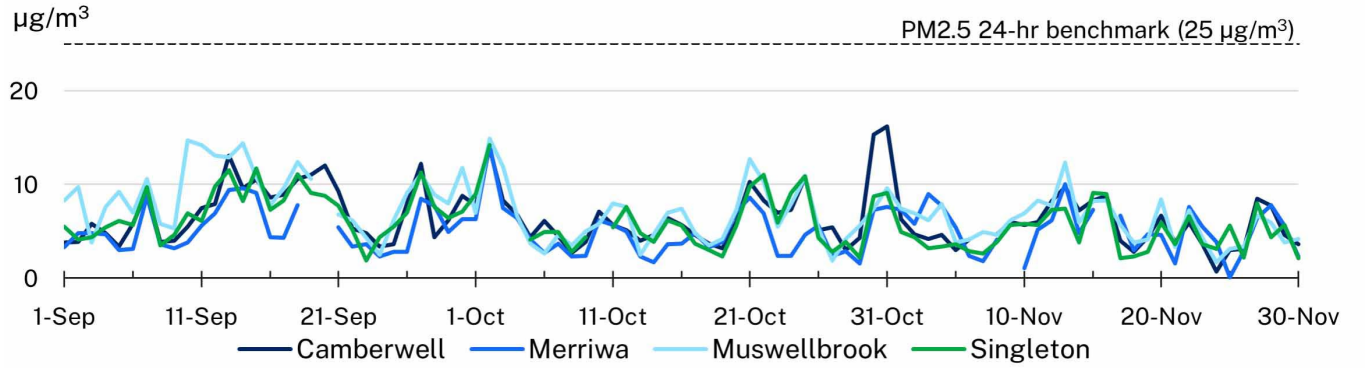

Figure 10 **Daily average PM2.5 – spring 2023[8]**

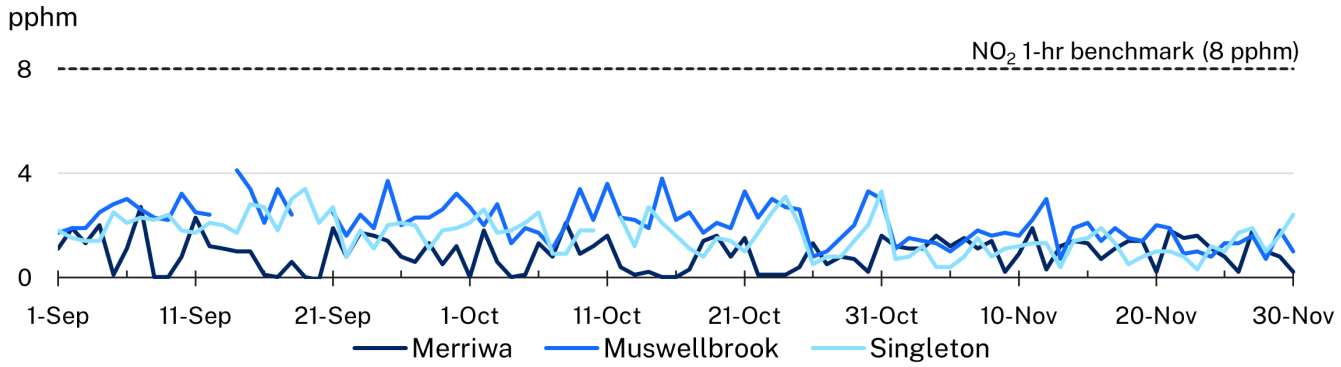

Figure 11 **Daily 1-hr maximum NO_2 – spring 2023**[8]

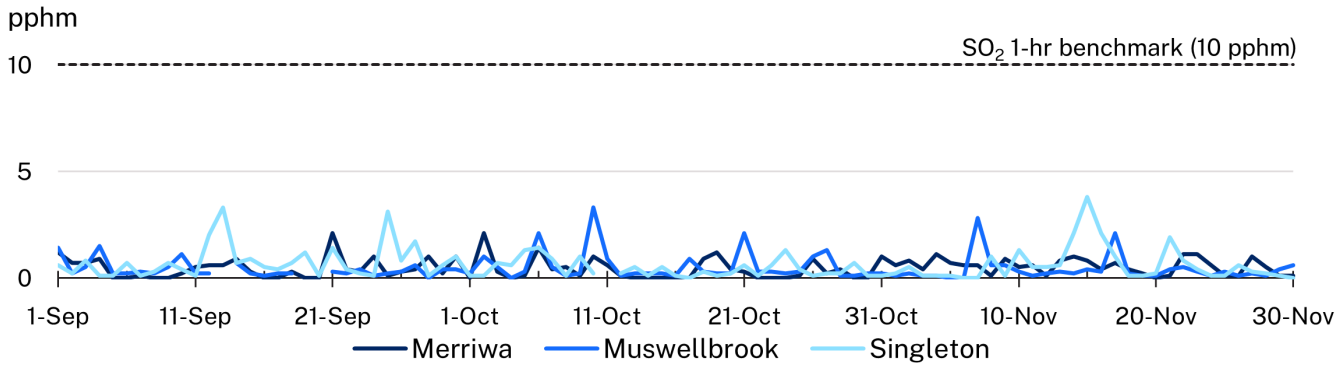

Figure 12 **Daily 1-hr maximum SO_2 – spring 2023**[8]

Seasonal comparison

This section compares days above air quality benchmarks in spring 2023 with previous spring seasons.

- **NO_2 gaseous:** There were no days over the national benchmarks during spring 2023 or in spring of any of the previous years from 2011 to 2022.
- **SO_2 gaseous:** There were no days over the national benchmarks during spring 2023. From 2012 to 2022 in spring, Muswellbrook recorded 5 hours above the current hourly SO_2 benchmark of 10 pphm. This includes one hour in 2011, 2016 and 2018 and 2 hours in 2019, occurring on 2 days. There were also 2 days above the current daily SO_2 benchmark at Muswellbrook, one each in 2013 and 2017.
- **PM10 particles:** The PM10 daily benchmark was exceeded on 22 days during spring 2023, with drier conditions throughout the region (Figure 13). This increase, compared to recent record low years (2021 and 2022), was largely driven by particle levels at stations closer to mines, especially Warkworth (Figure 14 to Figure 17). From 2012 to 2022, the region recorded between one day (spring 2022) and 45 days (spring 2019) over the PM10 benchmark.
- **PM2.5 particles:** There were no days over the PM2.5 daily benchmark during spring 2023 (Figure 18 and Figure 19). From 2012 to 2022, the region recorded between 0 days (springs 2015 to 2018 and 2020 to 2022) and 14 days (spring 2019) over the PM2.5 benchmark.

Higher particle levels occurred in spring 2019 due to severe drought conditions and extreme bushfire events.

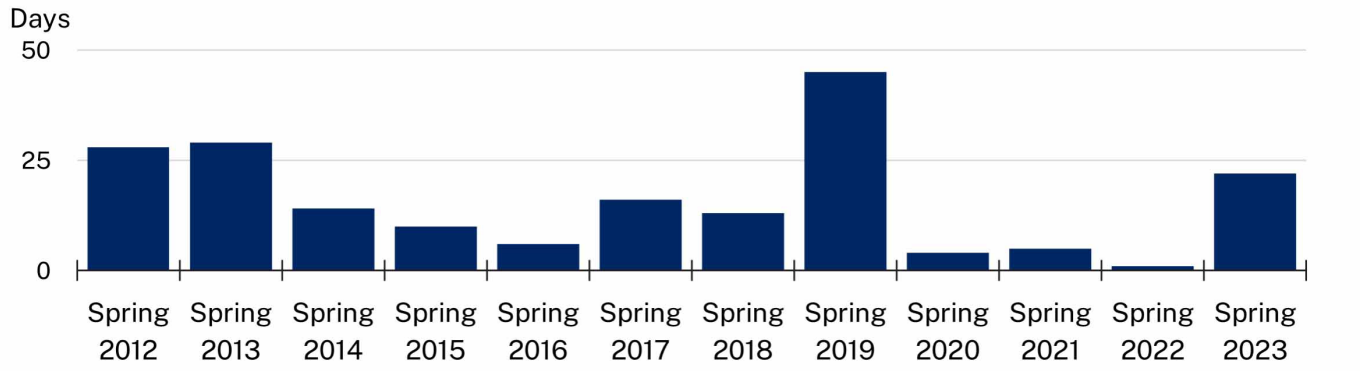

Figure 13 **Number of days above the daily PM10 benchmark in the Upper Hunter: spring 2012 to 2023**

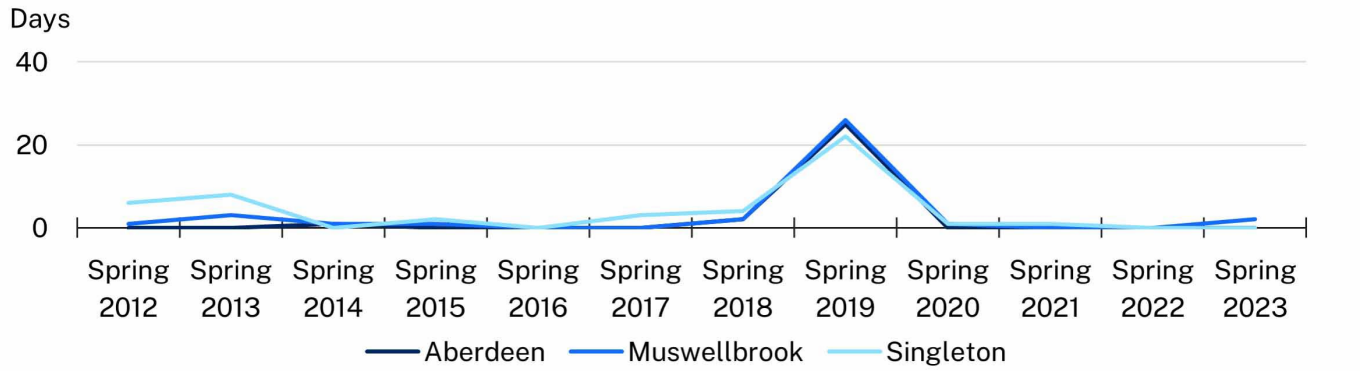

Figure 14 **Number of days above the daily PM10 benchmark at population centres: spring 2013 to 2023**

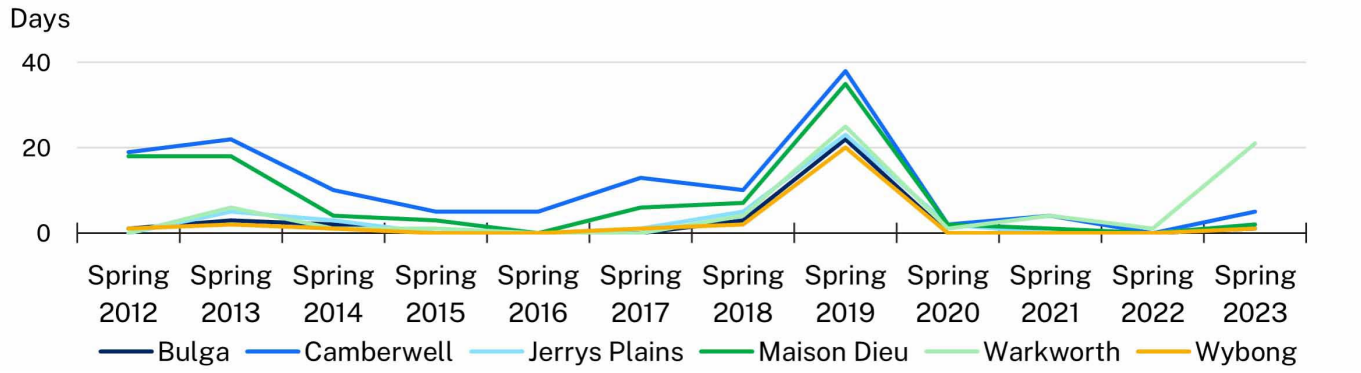

Figure 15 **Number of days above the daily PM10 benchmark at smaller communities: spring 2013 to 2023**

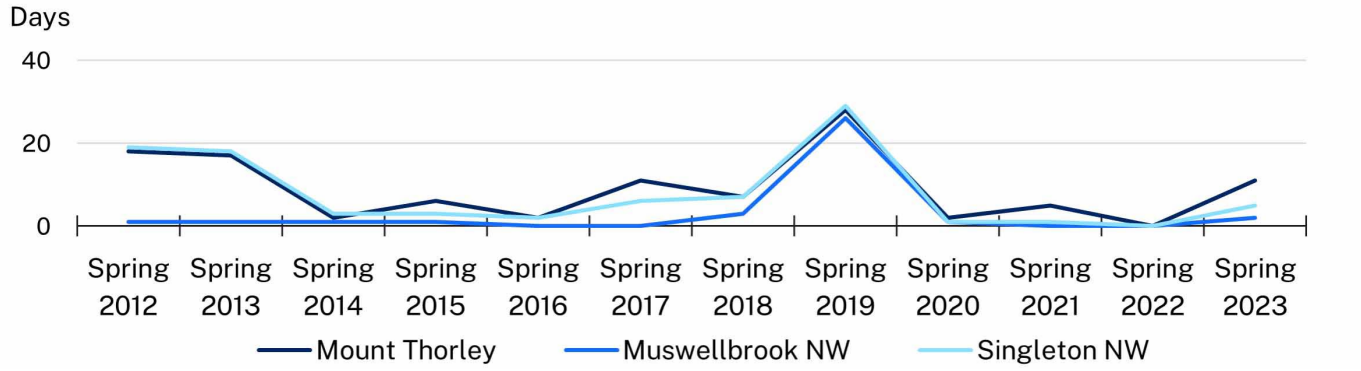

Figure 16 **Number of days above the daily PM10 benchmark at diagnostic stations: spring 2013 to 2023**

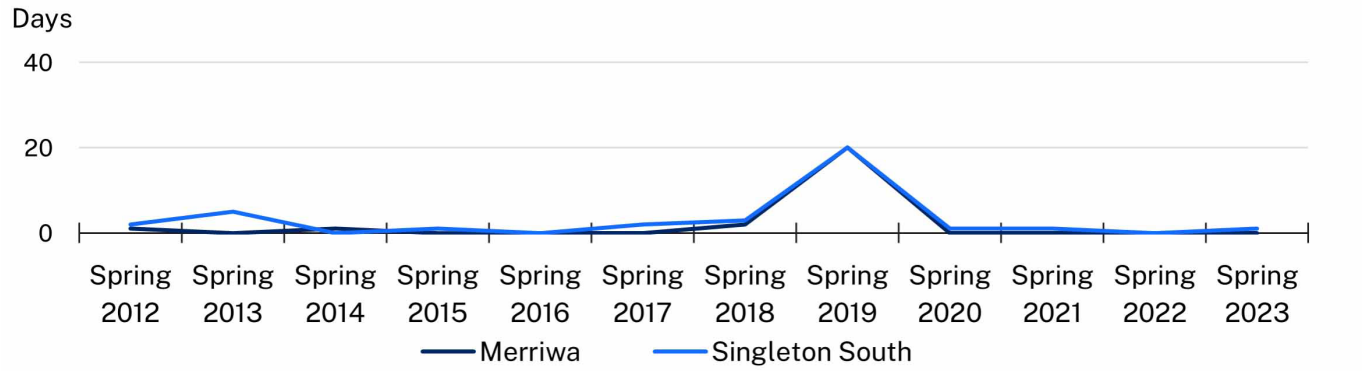

Figure 17 **Number of days above the daily PM10 benchmark at background stations: spring 2013 to 2023**

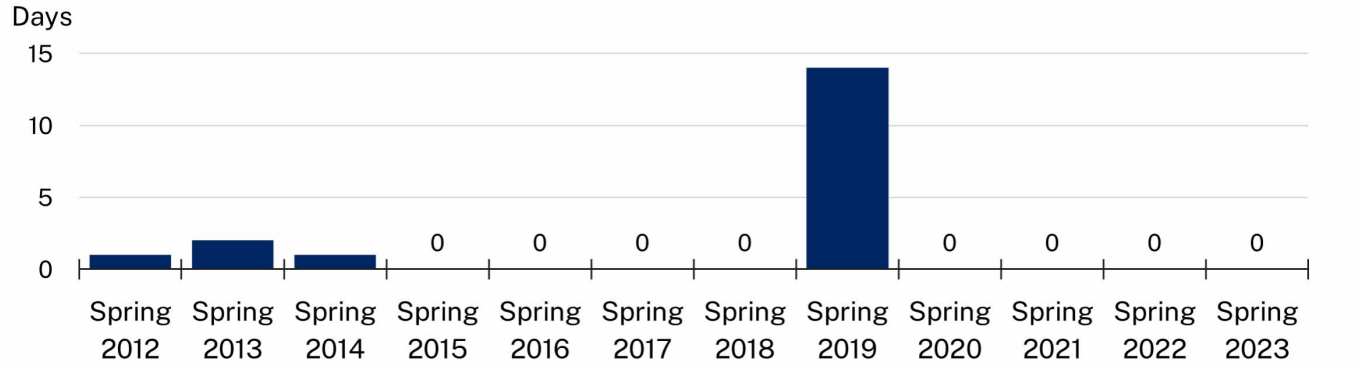

Figure 18 **Number of days above the daily PM2.5 benchmark in the Upper Hunter: spring 2012 to 2023**

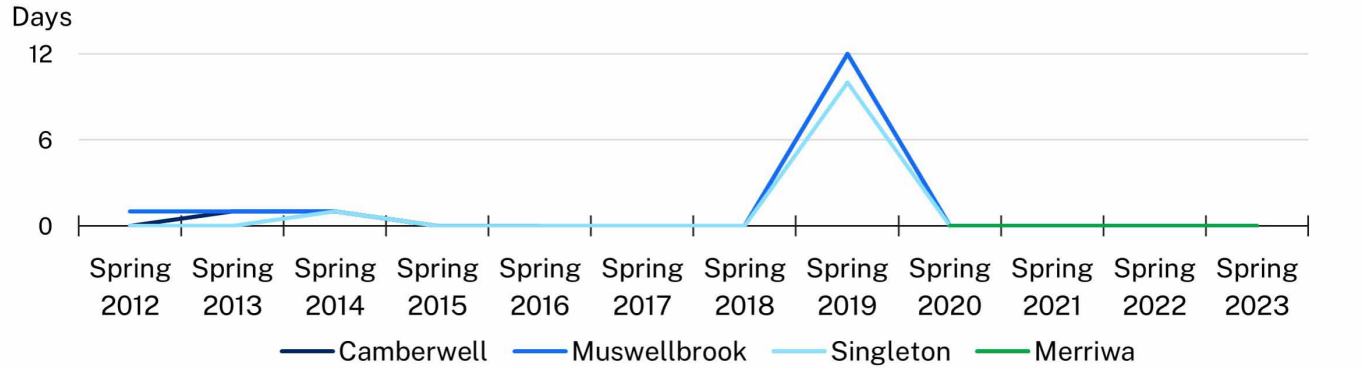

Figure 19 **Number of days above the daily PM2.5 benchmark at each station: spring 2023 to 2023**

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

Particle air quality trends at population centres

Figure 20 and Figure 21 show the daily average PM10 levels during spring 2023, compared to the daily maximum and minimum levels (i.e. shaded range) for spring periods from 2011 to 2022, at Singleton and Muswellbrook. Daily PM10 levels were within the historical range, and below the daily benchmark throughout most of the season. Regional rainfall levels were average to below-average for the season (Figure 22).

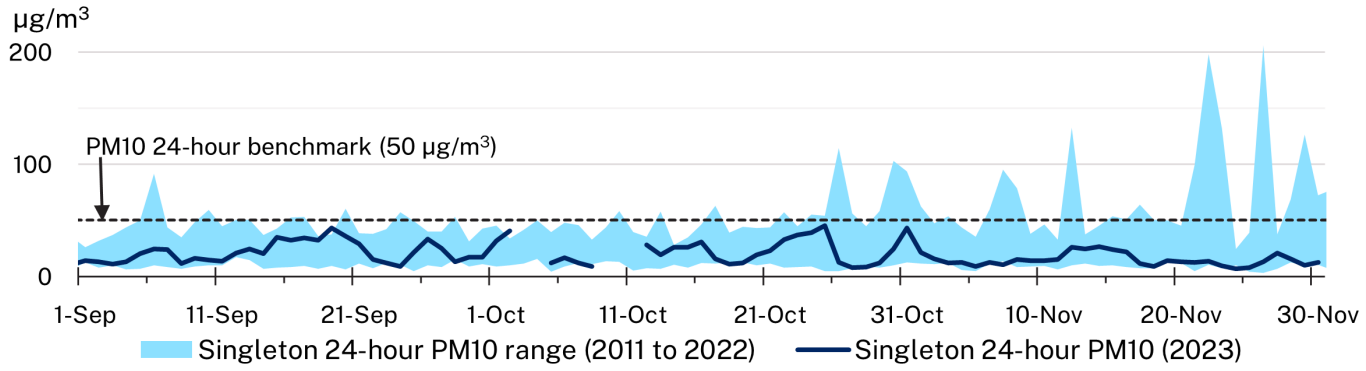

Figure 20 **Singleton daily average PM10 during spring 2023[8] plotted against the daily maximum and minimum PM10 levels from 2011 to 2022**

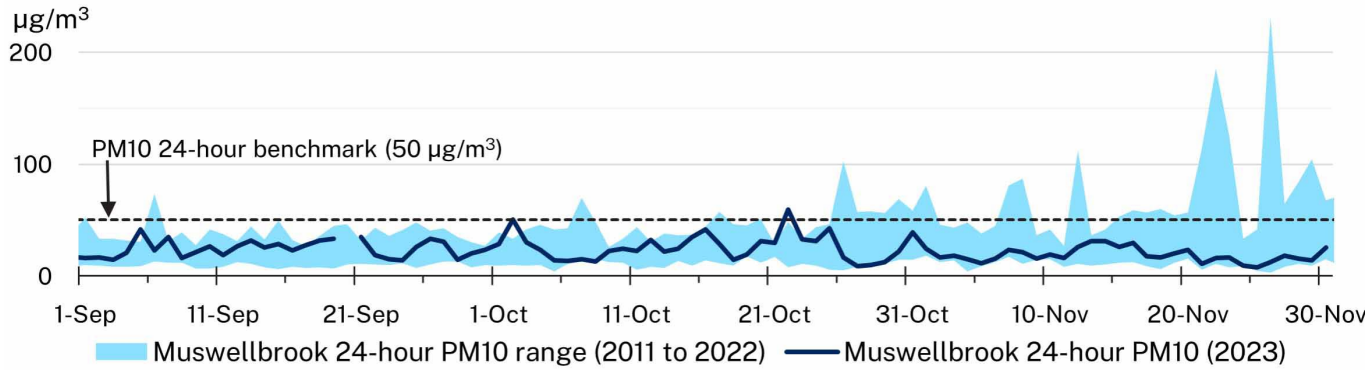

Figure 21 **Muswellbrook daily average PM10 during spring 2023[8] plotted against the daily maximum and minimum PM10 levels from 2011 to 2022**

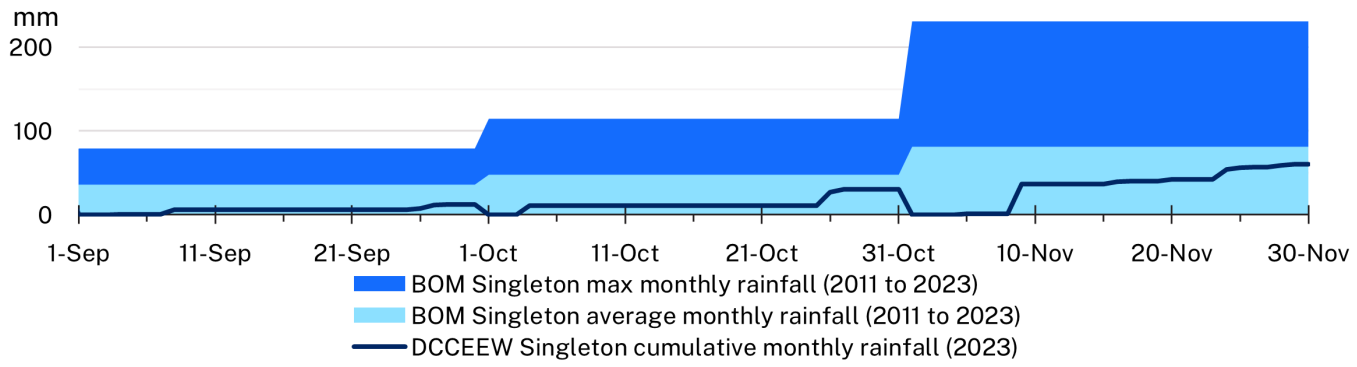

Figure 22 **Department of Climate Change, Energy, the Environment and Water[9] Singleton cumulative monthly rainfall in spring 2023 against Bureau of Meteorology maximum and average monthly rainfall from 2011 to 2022[10]**

Figure 23 and Figure 24 show daily average PM2.5 levels during spring 2023, compared to the daily maximum and minimum levels (shaded range) for spring periods from 2011 to 2022, at Singleton and Muswellbrook. Daily PM2.5 levels were within the historical range in the season, and well below the daily benchmark.

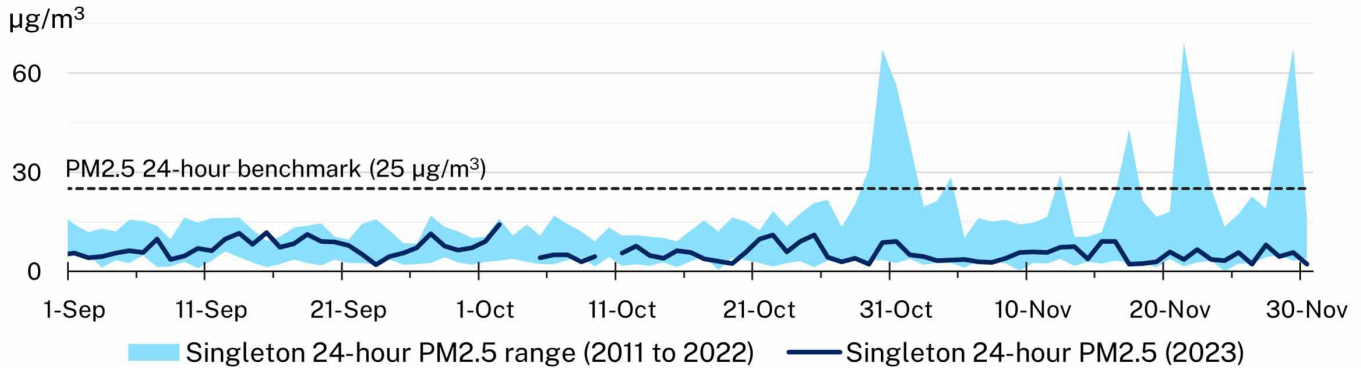

Figure 23 **Singleton daily average PM2.5 during spring 2023[8] plotted against the daily maximum and minimum PM2.5 levels from 2011 to 2022**

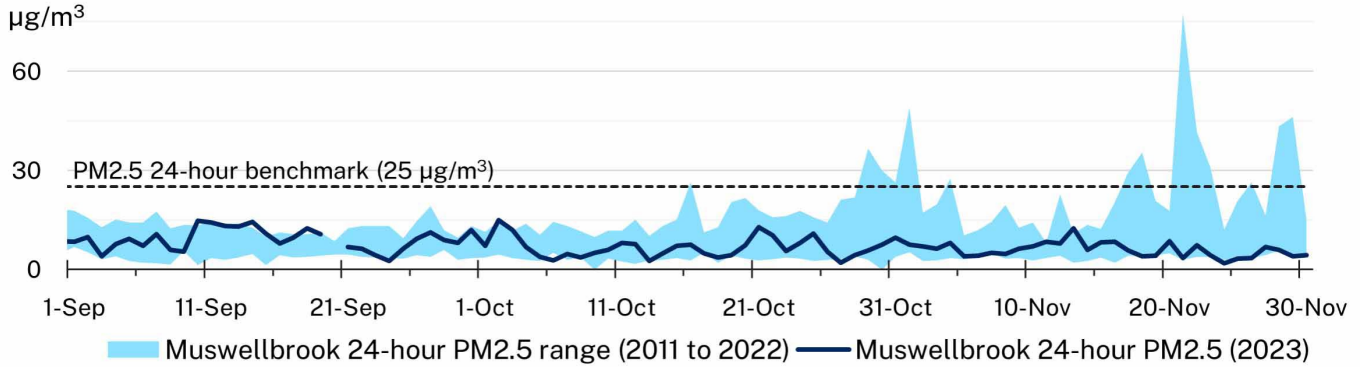

Figure 24 **Muswellbrook daily average PM2.5 during spring 2023[8] plotted against the daily maximum and minimum PM2.5 levels from 2011 to 2022**

Meteorological summary[11]

Rainfall and temperature

The Upper Hunter experienced average to below-average rainfall during spring 2023 compared to long-term records (Figure 25). This contrasts with the previous 2 spring seasons, when rainfall totals were very much above average. There was 100 to 200 millimetres less rain in spring 2023 than spring 2022; 200 to 400 millimetres less rain than spring 2021; and 50 to 100 millimetres less rain than spring 2020.

Maximum temperatures were very much above average during spring 2023 (Figure 26), while minimum temperatures were above average. According to the Bureau of Meteorology annual statement 2023[12], these observations for the Upper Hunter during spring 2023 were consistent with temperature trends across much of Australia.

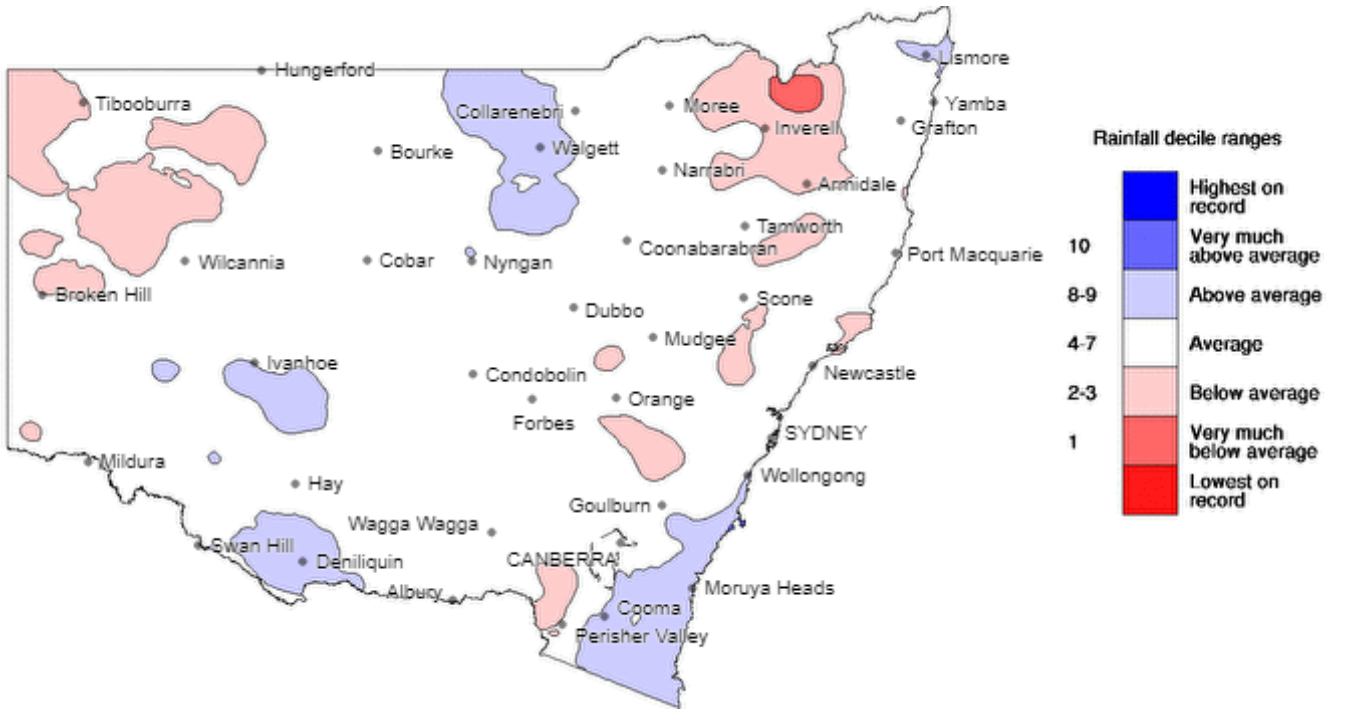

Figure 25 NSW rainfall deciles – spring 2023

Figure credit: ©Commonwealth of Australia 2024, Bureau of Meteorology. Base period: 1900-Nov 2023. Dataset: AGCD v2. Issued 20/09/2024.

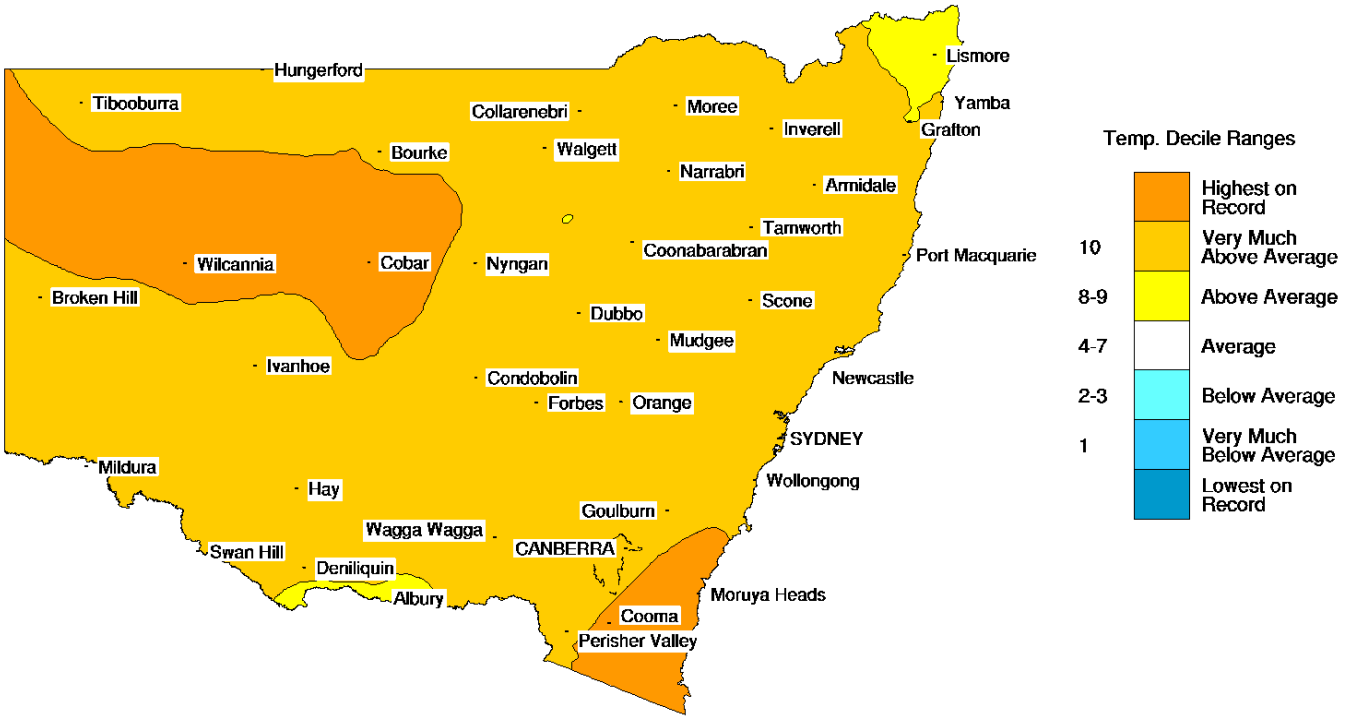

Figure 26 NSW maximum temperature deciles – spring 2023

Figure credit: ©Commonwealth of Australia 2024, Bureau of Meteorology. ID code: AWAP. Issued 29/05/2024.

Wind

Winds throughout the region during spring 2023 were variable (Figure 27), which is typical for this transitional season. Winds typically change from north-westerly in winter to south-easterly in summer. The strongest winds mostly came from the north-west.

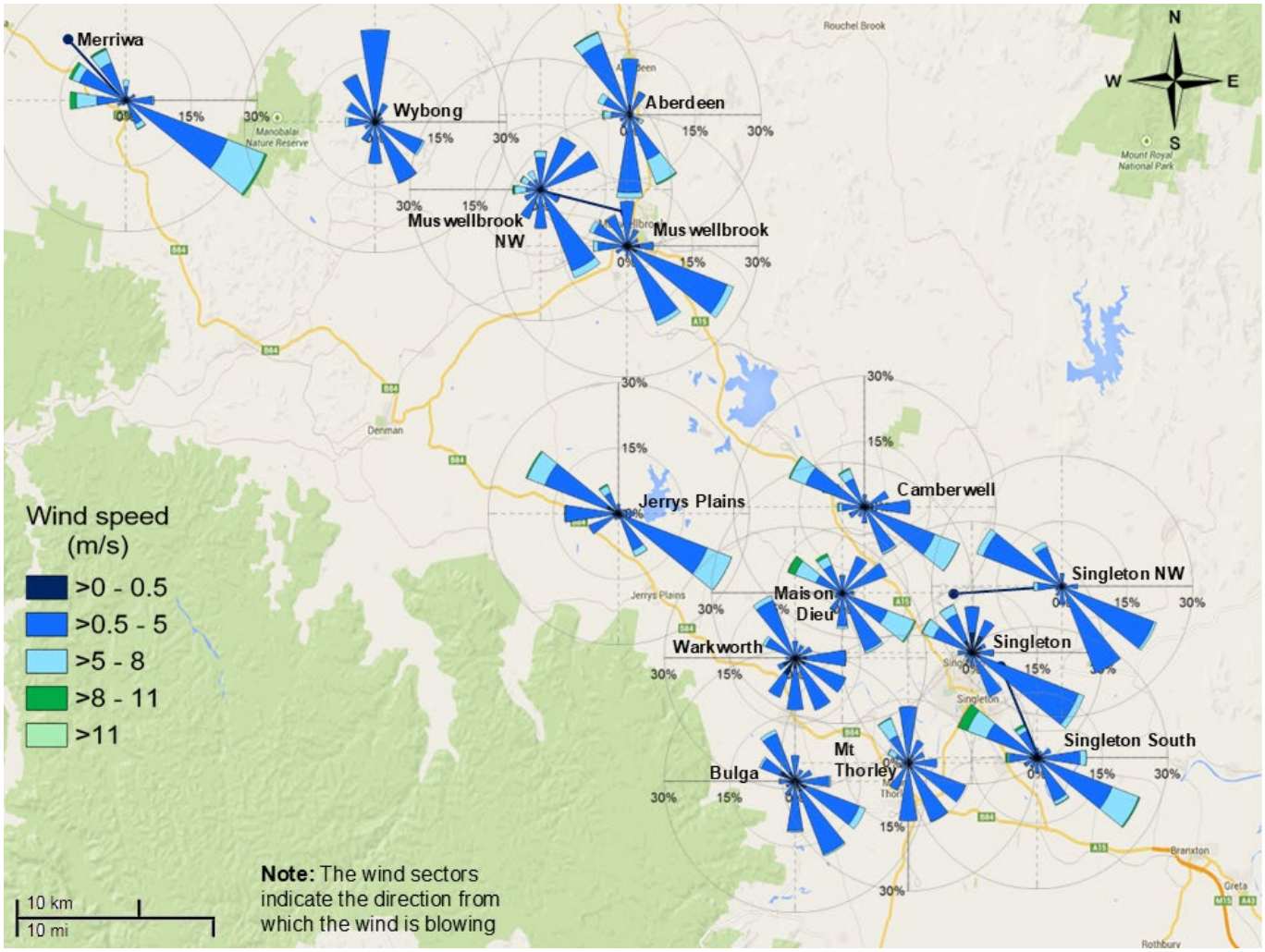

Figure 27 **Wind rose map[13] for the Upper Hunter region for spring 2023**

Network performance

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

In spring 2023, particle and meteorological parameters at all stations met the 95% target (Table 2).

Table 2 Online performance (%) during spring 2023

Station	Particles PM10 daily	Particles PM2.5 daily	Gases SO_2 hourly	Gases NO_2 hourly	Meteorology wind hourly
Aberdeen	100	–	–	–	100
Bulga	100	–	–	–	98
Camberwell	100	99	–	–	100
Jerrys Plains	100	–	–	–	99
Maison Dieu	95	–	–	–	98
Merriwa	97	96	93	93	98
Mount Thorley	99	–	–	–	99
Muswellbrook	99	99	91	91	99
Muswellbrook NW	100	–	–	–	99
Singleton	95	97	92	92	99
Singleton NW	98	–	–	–	99
Singleton South	97	–	–	–	99
Warkworth	99	–	–	–	99
Wybong	97	–	–	–	99

– = not monitored

Definitions: Upper Hunter station types

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

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

Smaller communities: stations near smaller communities monitor 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).

Appendix A: Rolling annual averages

Table 3 **PM10 rolling annual averages (µg/m^3) from spring 2013 to spring 2023**

Station	December 2012 – November 2013	December 2013 – November 2014	December 2014 – November 2015	December 2015 – November 2016	December 2016 – November 2017	December 2017 – November 2018	December 2018 – November 2019	December 2019 – November 2020	December 2020 – November 2021	December 2021 – November 2022	December 2022 – November 2023
Aberdeen	17.4	18	15.1	15.6	17.7	22.1	26.5	21.5	12.8	12.2	15
Bulga	19.4	18.1	14.9	15.8	17.5	21	24.4	23	12.9	10.9	16.2
Camberwell	27.7	25.1	21.9	24.1	27.5	31.3	36	28.7	20.8	15.8	20.5
Jerrys Plains	18.4	18.6	15.4	16.5	18.2	23.9	27.4	26	13.9	12.7	20.3
Maison Dieu	25.6	23.3	20.2	20.1	23.2	28	33.6	27.3	17.7	14	20.2
Merriwa	15	15.4	13.2	13.5	14.2	18.5	23.8	23.2	11.8	11	13.9
Mount Thorley	24.8	21.7	19.8	22.3	25.7	29	32.8	26.2	19.2	13.8	23.6
Muswellbrook	22.8	21.7	19	19.2	21.7	27	31	26.6	18.2	16.5	21.5
Muswellbrook NW	19.1	19.5	16.5	16.6	18.4	24.6	30.2	25	15.8	14	19.5
Singleton	23.2	21.3	19.5	19	20.9	24.2	27	23.7	17.6	14.3	18.7
Singleton NW	25.7	23.1	20.9	21.5	23	26.8	31.4	25.8	19.1	15	21.3
Singleton South	20.2	18.5	16.8	17.7	19.7	22.9	27.2	23.6	16.6	13.8	18.9
Warkworth	21.6	20.9	18.1	18.3	22	26.2	29.3	28.1	21	18.8	31.6
Wybong	15.5	17.4	14.6	15.3	16.5	21.3	24.7	22.5	12.7	11.5	15.8

Table 4 PM2.5 rolling annual averages (µg/m³) from spring 2013 to spring 2023

Station	December 2012 – November 2013	December 2013 – November 2014	December 2014 – November 2015	December 2015 – November 2016	December 2016 – November 2017	December 2017 – November 2018	December 2018 – November 2019	December 2019 – November 2020	December 2020 – November 2021	December 2021 – November 2022	December 2022 – November 2023
Camberwell	8.2	8	7.2	7.4	7.4	8.5	9	9.2	5.7	4.8	5.8
Merriwa	–	–	–	–	–	–	–	–	4.3	3.4	4.4
Muswellbrook	9.4	9.8	8.7	8.2	9.5	9.5	10.5	11.1	7.2	6.2	7.2
Singleton	7.9	7.7	7.7	7.6	8.4	8	9.5	9.9	6.3	5.1	6.4

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

This document was prepared by Jo Heidenreich and reviewed by Loredana Warren, Margaret Haak and David Salter.

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[1] PM2.5 and PM10 refer to airborne particles, less than or equal to 2.5 and 10 micrometres in diameter, respectively.
[2] 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.
[3] Sourced from Department of Primary Industries NSW State seasonal update – November 2023 (accessed February 2024).
[4] Sourced from Department of Primary Industries NSW State seasonal update – November 2022 (accessed October 2024).
[5] Sourced from Department of Primary Industries NSW State seasonal update – November 2021 (accessed October 2024).
[6] Pollution roses show wind direction and particle levels at a location. The length of the bar around the circle shows the percentage of time the wind blows from a particular direction. The colours along the bars indicate hourly particle levels.
[7] There are no standards for hourly PM10 or PM2.5 in the National Environment Protection (Ambient Air Quality) Measure (Air NEPM). The Department of Climate Change, Energy, the Environment and Water air quality categories are defined as poor when hourly PM10 levels are higher than 100 µg/m^3 or hourly PM2.5 levels are higher than 50 µg/m^3.
[8] Data gaps at Upper Hunter stations this season were predominantly due to data logger and communication issues. However, at some stations there were also some small periods of unavailable data due to calibration and maintenance checks or power outages.
[9] Department of Climate Change, Energy, the Environment and Water cumulative monthly rainfall data was used as there were no Bureau of Meteorology Singleton Defence AWS data available from 23 October 2023 to 4 November 2023.
[10] 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.
[11] Rainfall and temperature information is from the Bureau of Meteorology New South Wales spring 2023 climate statement and climate maps (accessed February 2024).
[12] Annual climate statement 2023 – Bureau of Meteorology
[13] 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.