# Air Quality Monitoring Network



#### Upper Hunter Summer 2023-24

Air quality in the Upper Hunter was generally good during summer 2023–24. At Muswellbrook and Singleton population centres, daily particle levels were below national benchmarks<sup>1</sup> 99% of the time, while hourly particle levels were in the good to fair air quality categories<sup>2</sup> 99.8% of the time.

- Nitrogen dioxide (NO<sub>2</sub>) and sulphur dioxide (SO<sub>2</sub>) levels were good to fair, remaining below hourly and daily national benchmarks 100% of the time at all stations.
- Daily average PM2.5<sup>3</sup> levels were below the benchmark at all stations, except Merriwa and Muswellbrook on 19 December 2023. This was due to a large bushfire at Pilliga Nature Reserve, 200 km north-west of Merriwa, with smoke impacts from the North West Slopes to the Illawarra.
- Daily average PM10<sup>4</sup> levels exceeded the benchmark on 17 days across the Upper Hunter. On these days, the regional maximum daily PM10 ranged from 50.6 to 60.7 μg/m<sup>3</sup>.<sup>5</sup>
  - The highest number of days occurred at Warkworth (14 days), likely due to mining activities.
  - At population centres, PM10 levels exceeded the benchmark at Singleton on 4 February, likely due to regional dust. Muswellbrook and Aberdeen had no days over the benchmark.
  - The rest of the region had from zero days (Jerrys Plains and Merriwa) to 4 days (Maison Dieu).
- The region experienced average rainfall and above-average temperatures during summer.

## Annual air quality trends in the Upper Hunter

Figures 1 and 2 show the PM10 and PM2.5 rolling annual averages<sup>6</sup>, based on the 12-month periods from summer 2012–13 to summer 2023–24.



#### Figure 1 PM10 rolling annual averages from the end of summer 2012–13 to 2023–24

Note: Data in this figure are listed in Table 3, Appendix A: Rolling annual averages.



#### Figure 2 PM2.5 rolling annual averages from the end of summer 2012–13 to 2023–24

Note: The Merriwa background air quality monitoring station was upgraded in July 2020 to also monitor PM2.5. The data in this figure are listed in Table 4, Appendix A: Rolling annual averages.

PM10 rolling annual average levels increased throughout the region, compared to recent record low years (particularly to the end of summers 2021–22 and 2022–23), due to the region experiencing drought conditions. This was most evident at Warkworth, recording the highest 12-month PM10 rolling average for summer 2023–24, and the only station over 25  $\mu$ g/m<sup>3</sup> (Figure 1). The 12-month PM10 rolling average at Warkworth of 32.3  $\mu$ g/m<sup>3</sup> also came close to the 2019–20 level of 34.8  $\mu$ g/m<sup>3</sup> recorded during extreme drought and bushfire conditions. The Warkworth station was likely impacted by emissions from nearby mining operations<sup>7</sup>, exacerbated by drier conditions over the previous 12 months.

PM2.5 rolling annual average levels to the end of summer 2023–24 saw some increases, although levels were similar to those recorded to the end of summer 2020–21 and continued to remain below  $8 \mu g/m^3$  (Figure 2).

At the end of summer 2023–24, 45% of New South Wales was in one of 3 drought categories (Figure 3)<sup>8</sup> compared to zero per cent drought-affected in 2022–23<sup>9</sup>, and 3% that was drought-affected in 2021–22<sup>10</sup>.





#### Days above benchmark concentrations

Daily PM10 levels were above the benchmark in the Upper Hunter on 17 days during summer 2023–24 (6–7, 9–11 and 14–19 December; 22 and 26 January; 3–5 and 23 February). This ranged from zero days at Aberdeen, Jerrys Plains, Merriwa and Muswellbrook to 14 days at Warkworth (Table 1).

The PM2.5 daily benchmark was exceeded at Muswellbrook and Merriwa on one day (19 December), due to the large bushfire in the Pilliga Nature Reserve near Narrabri.

SO<sub>2</sub> and NO<sub>2</sub> levels remained below the national benchmarks at all stations throughout the season.

Table 1Number of days above the relevant national benchmarks: summer 2023–24

Station type <sup>11</sup>	Station	PM10 daily [50 µg/m <sup>3</sup> benchmark]	PM2.5 daily [25 µg/m³ benchmark]	SO₂ hourly [10 pphm benchmark]	SO₂ daily [2 pphm benchmark]	NO₂hourly [8 pphm benchmark]	
Population centre	Aberdeen	0	-	-	-	-	
Population centre	Muswellbrook	0	1	0	0	0	
Population centre	Singleton	1	0	0	0	0	
Smaller community	Bulga	1	-	-	-	-	
Smaller community	Camberwell	1	0	-	-	-	
Smaller community	Jerrys Plains	0	-	-	-	-	
Smaller community	Maison Dieu	4	-	-	-	-	
Smaller community	Warkworth	14	-	-	-	-	
Smaller community	Wybong	2	-	-	-	-	
Diagnostic	Mount Thorley	2	-	-	-	-	
Diagnostic	Muswellbrook NW	2	-	-	-	-	
Diagnostic	Singleton NW	2	-	-	-	-	
Background	Merriwa	0	1	0	0	0	
Background	Singleton South	1	-	-	-	-	

 $\mu$ g/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.

## Seasonal trends

This section compares air quality in summer 2023–24 with previous summer seasons from 2012–13 to 2022–23 (Figures 4 to 12).

- NO<sub>2</sub> gaseous: There were no days over the national benchmark for NO<sub>2</sub> in summer 2023–24 or in previous summers.
- SO<sub>2</sub> gaseous: There were no days over the national benchmarks for SO<sub>2</sub> in summer 2023–24. In previous summers, only Muswellbrook recorded 20 hours above the current SO<sub>2</sub> hourly benchmark of 10 pphm<sup>12</sup>, occurring over 16 days (Figure 4). There were also 4 days above the current SO<sub>2</sub> daily benchmark of 2 pphm at Muswellbrook in previous summers (Figure 5).
- PM10 particles: There were 17 days over the PM10 daily benchmark during summer 2023–24. This is the second-highest number of PM10 exceedance days during summer since the network

began operations 11 years ago (Figure 6). This increase, compared to recent record low years, was largely driven by particle levels at stations closer to mines under drier conditions, especially Warkworth (Figures 7 to 10). In previous summers, the region recorded between zero days (summer 2021–22) and 51 days (summer 2019–20).

• PM2.5 particles: There was one day over the PM2.5 daily benchmark during summer 2023–24 (Figures 11 and Figure 12). This was at Merriwa and Muswellbrook on 19 December 2023, due to the Pilliga Nature Reserve bushfire near Narrabri. Previously, the region recorded only one summer with PM2.5 exceedances (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 4 Number of days above the SO<sub>2</sub> hourly benchmark in the Upper Hunter: summers 2012–13 to 2023–24







### Figure 6 Number of days above the PM10 daily benchmark in the Upper Hunter: summers 2012–13 to 2023–24



Figure 10 Number of days above the PM10 daily benchmark at background stations: summers 2012– 13 to 2023–24



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

## Daily time series plots

Figures 13 to 20 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>.

Higher particle levels were observed during early December and late January/early February, coinciding with drier periods.



Figure 13 Population centre stations: daily average PM10: summer 2023–24











Figure 16 Background stations: daily average PM10: summer 2023–24



Figure 17 Daily average PM2.5: summer 2023–24





## Particle air quality trends in the Upper Hunter

Figures 21 and 22 show daily average PM10 levels at Singleton and Muswellbrook during summer 2023–24 compared to the daily maximum and minimum levels (i.e. shaded range) for summer periods from 2011–12 to 2022–23. Daily PM10 levels were within the historical range for much of the season at both stations.

Regional rainfall levels were average overall for the season; however, monthly rainfall levels were below average during January (Figure 23). Higher particle levels were observed during early December and late January/early February when conditions were drier.



### Figure 23Bureau of Meteorology Singleton Defence AWS13 cumulative monthly rainfall in summer2023-24 against maximum and average monthly rainfall from 2011-12 to 2022-2314

Figures 24 and 25 show daily average PM2.5 levels at Singleton and Muswellbrook during summer 2023–24, compared to the daily maximum and minimum levels (shaded range) for summer periods

from 2011–12 to 2022–23. Daily PM2.5 levels were mostly within the historical range during much of the season.



maximum and minimum PM2.5 levels from 2011–12 to 2022–23

## Pollution roses from hourly particle data

The seasonal pollution rose maps<sup>15</sup> (Figures 26 and 27) show that during the season, hourly PM10 and PM2.5 levels<sup>16</sup> were predominantly in the good to fair air quality categories<sup>2</sup>.



Figure 26 Hourly PM10 pollution rose map for the Upper Hunter region for summer 2023–24



Figure 27 Hourly PM2.5 pollution rose map for the Upper Hunter region for summer 2023–24

## Meteorological summary

#### Rainfall and temperature<sup>17</sup>

The Upper Hunter experienced average rainfall during summer 2023–24 (Figure 28). It was wetter than summer 2022–23 and drier than summers 2021–22 and 2020–21. Maximum temperatures were above average (Figure 29), while minimum temperatures were very much above average.



#### Figure 28 New South Wales rainfall deciles: summer 2023–24

Figure credit: ©Commonwealth of Australia 2024, Bureau of Meteorology. Base period: 1900–Feb 2024. Dataset: AGCD v2. Issued 20/02/2025



#### Figure 29 New South Wales maximum temperature deciles – summer 2023–24

Figure credit: ©Commonwealth of Australia 2024, Bureau of Meteorology. ID code: AWAP. Issued 28/08/2024

#### Wind

The winds were predominantly from the south-east during summer 2023–24 (Figure 30), which is typical during summer in the Upper Hunter valley.



# Network performance

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

Table 2	Online performance (%) during summer 2023–24
---------	--

Station	Particles PM10 daily	Particles PM2.5 daily	Gases SO₂ hourly	Gases NO₂ hourly	Meteorology Wind hourly
Aberdeen	100	_	_	_	100
Bulga	97	-	-	-	98
Camberwell	100	99	-	-	100
Jerrys Plains	91	-	-	-	98
Maison Dieu	98	-	-	-	100
Merriwa	92	92	90	89	94
Mount Thorley	92	-	-	-	94
Muswellbrook	100	100	96	95	100
Muswellbrook NW	100	-	-	-	100
Singleton	100	98	95	81	100
Singleton NW	96	-	-	-	100
Singleton South	100	-	-	-	100
Warkworth	99	-	-	-	99
Wybong	95	-	-	-	100

– = not monitored

The overall reduced online times were mainly due to:

- Jerrys Plains PM10 scheduled calibrations and datalogger faults
- Merriwa datalogger faults and power outage
- Mount Thorley PM10 and wind datalogger faults, power outage and PM10 scheduled calibrations
- Singleton NO<sub>2</sub> intermittent negative data.

© 2025 State of NSW and Department of Climate Change, Energy, the Environment and Water

The State of NSW and the Department of Climate Change, Energy, the Environment and Water are pleased to allow this material to be reproduced in whole or in part for educational and non-commercial use, provided the meaning is unchanged and its source, publisher and authorship are acknowledged.

Department of Climate Change, Energy, the Environment and Water has compiled this report in good faith, exercising all due care and attention. No representation is made about the accuracy, completeness or suitability of the information in this publication for any particular purpose. The department shall not be liable for any damage which may occur to any person or organisation taking action or not on the basis of this publication. Readers should seek appropriate advice when applying the information to their specific needs.

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;

Web: www.environment.nsw.gov.au.

ISSN 2206-0391; EH 2025/00111; April 2025

#### Appendix A: Rolling annual averages

Station type*	Station	2012- 13	2013- 14	2014- 15	2015- 16	2016- 17	2017- 18	2018- 19	2019- 20	2020 -21	2021- 22	2022 -23	2023 -24
Population centre	Aberdeen	17.4	18.6	16.2	15.7	16.4	18.1	22.7	30.4	14.3	13.2	12.3	15.3
Population centre	Muswellbrook	22.2	23.4	20.1	19.6	19.9	22.5	27.4	35.2	19.4	18.3	16.9	21.8
Population centre	Singleton	22.9	23.7	19.9	19.9	20.0	20.8	23.8	31.4	18.3	17.2	14.8	19.4
Smaller community	Bulga	19.3	19.8	16.0	15.4	16.6	17.6	21.5	29.3	15.5	12.9	10.8	18.0
Smaller community	Camberwell	26.7	28.2	23.2	23.0	25.8	26.8	31.5	40.2	22.1	20.3	16.5	21.0
Smaller community	Jerrys Plains	12.6	19.8	16.0	16.3	17.4	18.9	24.5	32.9	17.4	13.4	14.4	19.1
Smaller community	Maison Dieu	26.1	26.2	21.6	21.0	21.3	23.4	27.9	39.0	19.5	17.3	14.5	21.3
Smaller community	Warkworth	21.9	22.4	18.7	18.7	19.5	23.0	25.8	34.8	20.8	20.5	20.9	32.3
Smaller community	Wybong	15.1	17.7	14.9	15.4	15.7	17.6	21.6	30.0	14.3	12.6	12.4	16.5
Diagnostic	Mount Thorley	25.3	24.8	20.9	20.6	23.6	25.0	29.9	36.8	19.9	18.7	14.9	24.3
Diagnostic	Muswellbrook NW	19.6	20.1	17.6	17.3	16.8	19.6	25.6	34.6	17.5	15.6	14.5	18.8
Diagnostic	Singleton NW	26.4	25.9	21.9	21.7	22.5	22.5	27.5	35.3	20.0	18.6	15.5	22.5
Background	Merriwa	14.8	16.0	13.5	13.7	13.7	14.9	19.9	30.8	13.4	11.7	11.5	14.4
Background	Singleton South	19.6	20.4	17.4	17.4	18.8	19.6	23.1	31.6	17.4	16.5	14.3	19.8

Table 3PM10 rolling annual averages (µg/m³) from the end of summer 2012–13 to the end of summer 2023–24

Note: The rolling annual averages are calculated from 1 March to 28/29 February each year

Table 4PM2.5 rolling annual averages (µg/m³) from the end of summer 2012–13 to the end of summer 2023–24

Station type*	Station	2012- 13	2013- 14	2014- 15	2015- 16	2016- 17	2017- 18	2018– 19	2019- 20	2020- 21	2021- 22	2022- 23	2023- 24
Population centre	Muswellbrook	10.2	9.6	9.3	8.8	8.7	9.3	9.6	12.9	8.1	7.4	6.2	7.5
Population centre	Singleton	8.1	8.0	7.4	7.9	8.1	8.1	8.2	11.5	7.2	6.3	5.2	6.8
Smaller community	Camberwell	7.7	8.4	7.3	7.4	7.7	7.4	8.5	11.0	6.4	5.7	4.8	6.2
Background	Merriwa	-	-	-	-	-	-	-	-	-	4.3	3.6	4.6

Note: The rolling annual averages are calculated from 1 March to 28/29 February each year

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

<sup>1</sup> The national benchmarks can be found at National Environment Protection (Ambient Air Quality) Measure.

<sup>2</sup> Information on the air quality categories can be found at <u>About the air quality categories</u>.

<sup>3</sup> PM2.5 refers to airborne particles less than or equal to 2.5 micrometres in diameter.

<sup>4</sup> PM10 refers to airborne particles less than or equal to 10 micrometres in diameter.

<sup>5</sup> Micrograms per cubic metres.

 $^6$  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  $\mu$ g/m<sup>3</sup> for PM10 and 8  $\mu$ g/m<sup>3</sup> for PM2.5.

<sup>7</sup> The <u>United Wambo Joint Venture Open Cut</u> mine starting operations in 2020.

<sup>8</sup> Sourced from Department of Primary Industries <u>NSW State seasonal update – February 2024</u> (accessed May 2024).

<sup>9</sup> Sourced from Department of Primary Industries <u>NSW State seasonal update – February 2023</u> (accessed July 2023).

<sup>10</sup> Sourced from Department of Primary Industries <u>NSW State seasonal update – February 2022</u> (accessed July 2023).

<sup>11</sup> The 14 monitoring stations in the Upper Hunter serve different purposes.

Larger population stations monitor air quality in those centres.

**Smaller community** stations monitor the air quality at those community locations.

**Diagnostic** stations 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** 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).

 $^{\rm 12}$  More stringent standards for  $NO_2$  and  $SO_2$  applied from May 2021 onwards.

<sup>13</sup> Data obtained from the Bureau of Meteorology <u>Singleton Defence AWS monthly rainfall data</u> (accessed June 2024).

<sup>14</sup> The Bureau of Meteorology STP station was decommissioned in January 2019. Therefore, statistics have been calculated from a combination of the <u>Singleton STP monthly rainfall data (accessed March 2020) from</u> January 2011 to March 2017 and Singleton Defence AWS monthly rainfall data from April 2017.

<sup>15</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>16</sup> There are no standards for hourly PM10 or PM2.5 in the <u>National Environment Protection (Ambient Air</u> <u>Quality) Measure</u>.

<sup>17</sup> Rainfall and temperature information is from the Bureau of Meteorology <u>New South Wales summer 2023-</u> <u>24 climate statement</u> (accessed April 2024) and <u>climate maps</u> (accessed April 2024).

<sup>18</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.