Government of **Western Australia**
Department of **Water and Environmental Regulation**

Ambient air quality monitoring campaign, Pinjarra

Department of Water and Environmental Regulation

November 2025

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Disclaimer

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Summary

This report presents a summary of the data collected by the Department of Water and Environmental Regulation (the Department) during a short-term air quality monitoring campaign in Pinjarra, Western Australia. The campaign was initiated in response to community concerns about potential dust emissions from the nearby Alcoa Pinjarra Refinery.

An air quality monitoring station (AQMS) was installed at a central location in Pinjarra to assess potential community exposure and operated for six months from November 2024 to April 2025. The campaign objective was to assess levels of ambient dust and gaseous pollutants, with a focus on likely worst-case conditions during summer when higher temperatures and frequent easterly winds prevail.

The monitoring station was equipped with:

- A tapered element oscillating microbalance (TEOM) to measure concentrations of particles in ambient air as particulate matter (PM) with a:
  - diameter of 10 micrometres (µm) or less (PM_{10})
  - diameter of 2.5 µm or less ($PM_{2.5}$)

  for public health assessment.
- A high-volume air sampler (HVAS) to measure the metals and respirable crystalline silica (RCS) content of PM_{10} for public health assessment.
- Four gas analysers measuring carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and ozone (O_3) for public health assessment.
- A dust deposition gauge (DDG) for the assessment of amenity impacts, such as soiling of surfaces.
- A meteorological sensor to measure wind speed and wind direction to assist with data analysis and interpretation.

The Department commissioned and operated the monitoring station, as well as a background site for measuring dust deposition.

Based on the Department's analysis, the campaign's findings for particle concentrations in relation to *National Environment Protection (Ambient Air Quality) Measure* (NEPM) health guidance were:

- There were no exceedances of the NEPM PM_{10} daily guideline of 50 µg/m^3, based on the TEOM and HVAS data.
- There was one exceedance of the NEPM $PM_{2.5}$ daily guideline of 25 µg/m^3 on 18 December 2024, most likely due to smoke from prescribed burns in the South West.
- Based on data collected across the six months of monitoring, there was no indication of exceedances of the NEPM PM_{10} or $PM_{2.5}$ annual guidelines.

The campaign's findings for metals and RCS concentrations in PM_{10} samples were that there were no exceedances of the available daily guidelines and no indication of exceedances of the available annual health guidelines, based on data collected across the six months of monitoring.

The campaign’s findings for gaseous pollutants were:

- There were no exceedances of the NEPM one-hour, eight-hour or daily guidelines.
- There was no indication of an exceedance of the NEPM NO_2 annual guideline.

The campaign’s findings for deposited dust were:

- There were no exceedances of the deposited dust amenity guideline for the five valid monthly samples collected during the campaign.

The Department’s analysis also looked at when PM_{10} and $PM_{2.5}$ hourly concentrations were elevated, and the average wind directions for these hours:

- Overall, there were a small number of hours with elevated concentrations.
- For PM_{10}, the majority of these elevated hourly concentrations occurred when winds were from the general direction of the Alcoa operations. Most of these do not appear to be related to smoke.
- For $PM_{2.5}$, wind directions associated with elevated hourly concentrations were mostly not from the general direction of the Alcoa operations. These hourly concentrations appear to be related to regional smoke impacts.

The Department of Health (DoH) has reviewed the results and advised that the measured concentrations of dust, metals, RCS and gases do not represent a public health risk at the location where the monitoring was conducted.

1 Background

The Department has received community complaints expressing concern about potential impacts of dust emissions in the Pinjarra area for several years. Complaints suggest Alcoa Pinjarra operations, east of town, as a source of dust. Although primarily concerned about health impacts, some families attending community meetings also described impacts on their amenity due to dust in the air and being deposited on their properties.

In 2023 and 2024, an air quality monitoring station operated across three periods for a total of about five months at the north-eastern edge of town. The objective was to assess ambient dust levels for different times of the year at a site chosen for its relevance as a community receptor location.

The monitoring campaign found the levels of dust in the air were below national guidelines. However, smoke from nearby fires caused a higher level of fine particles on two occasions. The concentration of metals in airborne dust was also measured and found to be lower than health guidelines.

The Department of Health reviewed the results of the previous campaign and advised that the measured concentrations of dust and metals did not represent a public health risk at the monitoring location.

In response to continued community concerns about dust, the Department designed a short-term air quality monitoring campaign to assess the concentration and composition of airborne particles, concentration of gaseous pollutants and levels of deposited dust. The monitoring station was positioned in central Pinjarra, to represent potential community exposure in the town, and deposited dust was also measured at a background location.

Department field staff conducted the monitoring from 1 November 2024 to 30 April 2025, focusing on likely worst-case conditions during summer with higher temperatures and frequent easterly winds.

This report presents a summary of the data collected during the campaign.

1.1 Campaign objectives

The objectives of the monitoring campaign were to:

- measure the levels of airborne particles (PM_{10} and $PM_{2.5}$) and the metals and respirable crystalline silica (RCS) content of PM_{10} at a location in the central Pinjarra area that was relatively close to potential sources and compare these levels with air quality guidelines
- measure the levels of deposited dust in the central Pinjarra area and at a background site and compare these levels with amenity guidelines
- assess short-term elevated airborne particle levels along with wind data to see if there was evidence of higher levels of particles coming from specific wind directions that may indicate a potential source

- measure the levels of gaseous air pollutants carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and ozone (O_3) at a location in central Pinjarra and compare these levels with air quality guidelines.

1.2 Campaign area

Pinjarra is located 83 km south of Perth in the Peel region of Western Australia (WA). It has a population of approximately 4,000 people.

Pinjarra's climate is characterised by hot, dry summers and cool, wet winters. Figure 1 provides a climate summary, based on the Bureau of Meteorology (BoM) monitoring sites at Karnet and Dwellingup.

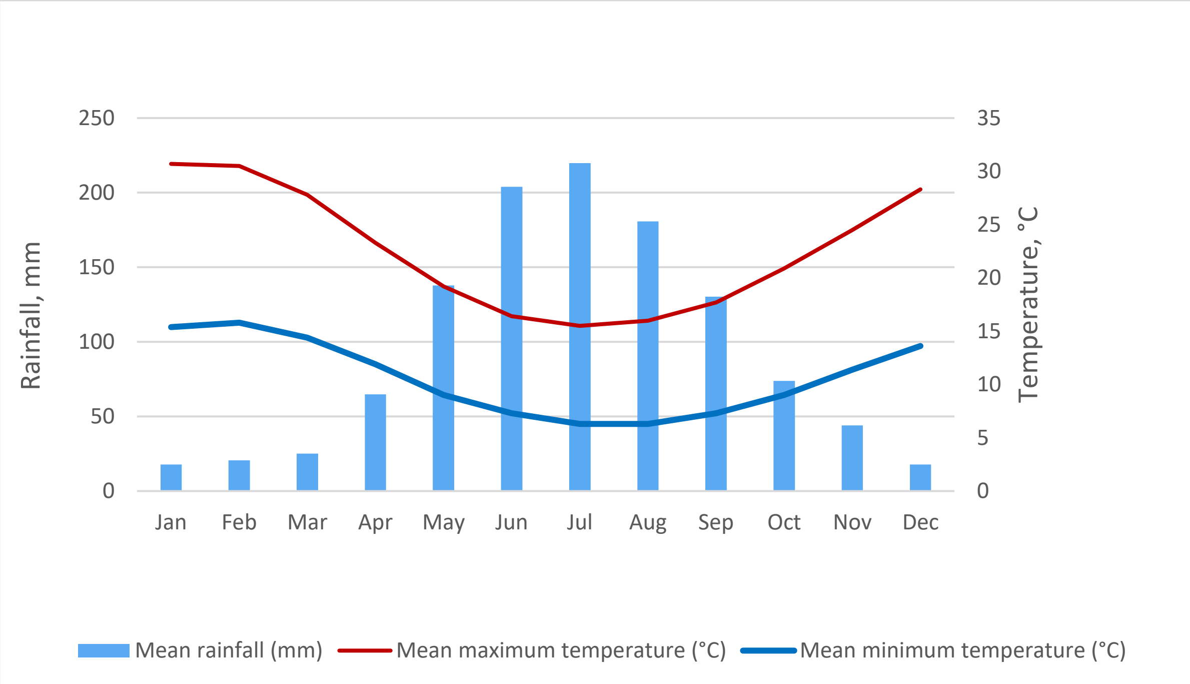


Figure 1 Pinjarra climatology based on BoM data at Karnet and Dwellingup

The region has various dust sources including industry operations, natural events and local activities, each of which may contribute to dust levels in the town.

Local sources of dust in Pinjarra include:

- the Alcoa Pinjarra refinery, which is located about 3.5 km east of the town centre
- the racecourse located about 1 km to the east of town
- the train line running through the town, which transports a variety of industrial products
- unsealed roads
- adjacent agricultural land.

Alcoa Pinjarra operates several air quality monitoring stations in the vicinity of their operations. This campaign was independent of Alcoa's monitoring program.

1.3 Dust

In air quality terminology, 'dust' and 'particles' refer to particulate matter (PM) comprising very small solid particles of earth, organic matter, manufactured products or waste matter. These may become airborne by natural forces (such as wind) and/or by mechanical processes (such as crushing, grinding, milling, conveying, stockpiling or haulage). PM can also include combustion particles, organic compounds, metals, pollen and mould.

PM is classified into different size fractions based on the particle diameter (known as equivalent aerodynamic diameter) measured in micrometres (µm). The common size fractions are:

- $PM_{2.5}$ – particulate matter of diameter approximately 2.5 µm or less.
- PM_{10} – particulate matter of diameter approximately 10 µm or less.

These particle sizes are important for public health assessment because they are small enough to breathe in and reach the respiratory tract and lungs, potentially causing health issues.

Figure 2 shows the $PM_{2.5}$ and PM_{10} size fractions compared with other common materials.

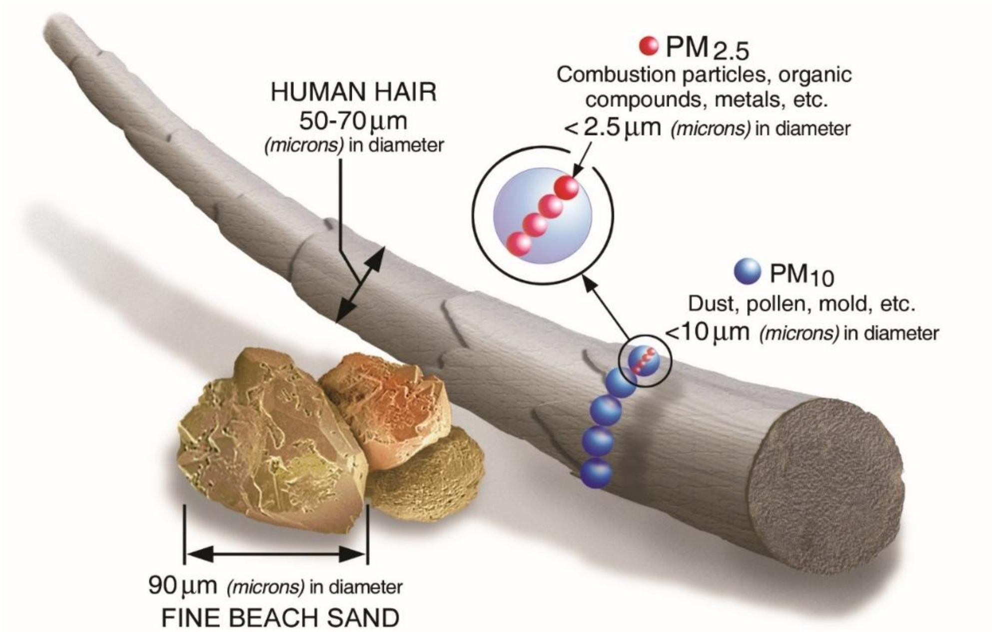


Figure 2 Size comparisons for PM (USEPA 2018)

Deposited dust is defined as particles which, because of their size, rapidly settle from the air. These can cause impacts to amenity, such as soiling vehicles, property and other surfaces.

1.4 Metals and RCS

Metals occur naturally in the earth's crust, mainly in the form of solid metal particles or metals attached to the surface of other particles. Metals are elements and thus cannot be broken down, nor can their properties be altered easily.

Metals enter our bodies through food, drinking water and air. Small amounts of some metals, like iron and magnesium, are needed for good health but too much can be harmful.

Silica is a name which collectively describes various forms of silicon dioxide, including both the crystalline and non-crystalline (amorphous) forms. Very small particles of the crystalline form of silica are referred to as respirable crystalline silica (RCS). RCS can cause serious illness at elevated concentrations, but those concentrations generally only occur in workplace settings. Silica is found in nature as quartz that is a constituent of many igneous and sedimentary rocks. The most common type of quartz is called alpha-quartz, which is one of the main forms of RCS.

PM_{10} samples for this campaign were analysed for the presence of metals and RCS (as alpha-quartz) and the results compared with health guidelines.

1.5 Gaseous pollutants

The gaseous pollutants listed in the *National Environmental Protection (Ambient Air Quality) Measure* (NEPM) are CO, NO_2, O_3 and SO_2.

CO is produced by the incomplete combustion of fuels. Common sources of CO include motor vehicles, industrial combustion processes, prescribed burns and bushfires.

Nitrogen oxides (NO_X), comprising nitric oxide (NO) and NO_2 are primarily generated through burning fuel and are emitted from cars, trucks, locomotives, heavy machinery and ships, as well as power plants and industrial processes. NO in ambient air is harmless whereas NO_2 is a precursor to O_3 formation (smog) as well as being a toxic air pollutant.

O_3 is a 'secondary' pollutant meaning it is not directly emitted from sources but forms in the atmosphere from reactions between nitrogen oxides and organic compounds, which are 'primary' pollutants or 'precursors' that are directly emitted.

The largest anthropogenic source of SO_2 in the atmosphere is the burning of fossil fuels. Locomotives, ships and other vehicles running on diesel fuel or similar distillates as well as industrial processes that burn coal contribute to SO_2 emissions.

2 Monitoring campaign scope

The campaign scope was to monitor the following pollutants in the Pinjarra town centre from November 2024 to April 2025 for a total of six months:

- levels of ambient dust as PM_{10} and $PM_{2.5}$ using a tapered element oscillating microbalance (TEOM)
- the levels of metals and RCS contained in dust collected using a high-volume air sampler (HVAS)
- ambient concentrations of gaseous pollutants ($CO/NO_2/SO_2/O_3$) using reference standard instruments
- deposited dust using a dust deposition gauge (DDG)
- wind speed, wind direction, humidity and temperature using a meteorological sensor.

The Department's Pinjarra air quality monitoring station (AQMS) is shown in Figure 3. The AQMS was at a central Pinjarra location as shown in Figure 4, which was representative of potential community exposure in the town. The AQMS was about 70 m from the South Western Highway and 3.7 km west of the Alcoa residue disposal area.

Deposited dust was also monitored at a background location in West Coolup.

The monitoring locations were selected from several potential sites identified through desktop studies, liaison with the Shire of Murray and site inspections. The AQMS and background locations were selected based on:

- sites that are representative of potential community exposure in Pinjarra and representative of regional background air quality
- land tenure arrangements and availability for the duration of the campaign
- best possible compliance with Australian Standards for ambient air quality monitoring (AS3580.1.1) and meteorology (AS3580.14)
- availability of power supply where necessary
- security.

Figure 3 Pinjarra AQMS

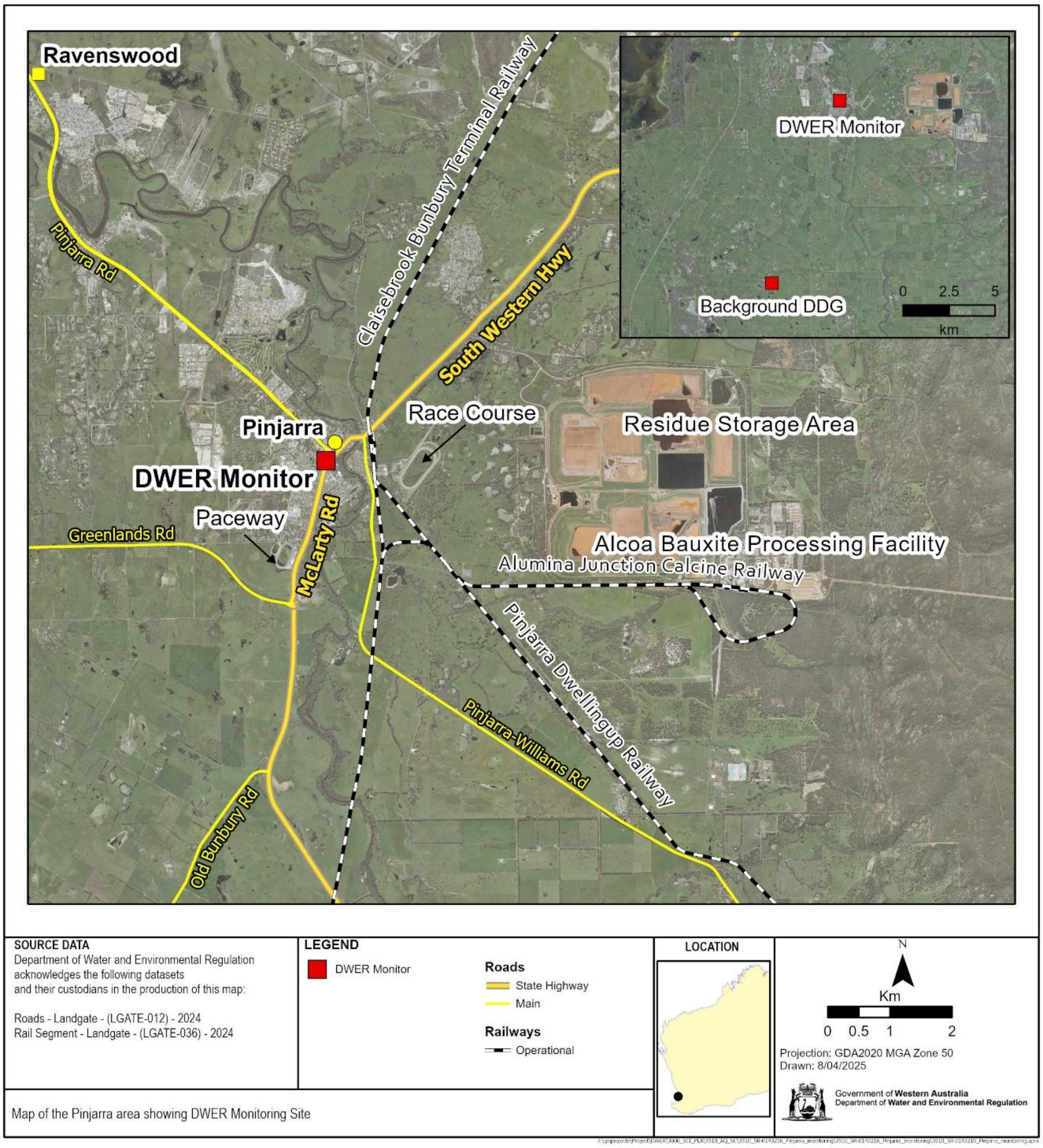


Figure 4 Department ambient air quality monitoring locations

3 Monitoring methods

3.1 PM_{10}

PM_{10} monitoring was undertaken using a Thermo 1405 DF TEOM in accordance with the Australian Standard methods:

- *AS/NZS 3580.9.16:2022 Methods for sampling and analysis of ambient air, Method 9.16: Determination of suspended particulate matter – PM_{10} continuous direct mass method using a tapered element oscillating microbalance monitor incorporating a filter dynamic measurement system (FDMS) unit*
- *AS/NZS 3580.9.7:2009 Methods for sampling and analysis of ambient air, Method 9.7: Determination of suspended particulate matter – Dichotomous sampler (PM_{10}, coarse PM and $PM_{2.5}$) – Gravimetric method*.

This monitor is designed to operate continuously and provides PM_{10} concentrations that are logged every five minutes.

3.2 $PM_{2.5}$

$PM_{2.5}$ monitoring was undertaken using a Thermo 1405 DF TEOM in accordance with the Australian Standard methods:

- *AS/NZS 3580.9.13:2022 Methods for sampling and analysis of ambient air, Method 9.13: Determination of suspended particulate matter – $PM_{2.5}$ continuous direct mass method using a tapered element oscillating microbalance monitor*
- *AS/NZS 3580.9.7:2009 Methods for sampling and analysis of ambient air, Method 9.7: Determination of suspended particulate matter – Dichotomous sampler (PM_{10}, coarse PM and $PM_{2.5}$) – Gravimetric method*.

This monitor is designed to operate continuously and provides $PM_{2.5}$ concentrations that are logged every five minutes.

3.3 Metals and RCS in PM_{10}

Sampling of PM_{10} for analysis of metals and RCS content was undertaken using a HVAS in accordance with the Australian Standard method *AS/NZS 3580.9.6:2015 Methods for sampling and analysis of ambient air, Method 9.6: Determination of suspended particulate matter – PM_{10} high volume sampler with size selective inlet – Gravimetric method*. The sampling was conducted on a one-in-six-day regime.

The HVAS draws ambient air through a filter that collects particles over a 24-hour sample period. The filter is then sent for laboratory analysis.

During the campaign, the Department collected 30 PM_{10} samples and four field blanks. A laboratory accredited by the National Association of Testing Authorities (NATA) Australia determined the mass of total dust, metals and RCS on the filters.

The HVAS also provides PM_{10} concentration data when operated in accordance with the above Australian Standard.

3.4 Carbon monoxide

CO monitoring was undertaken using a TAPI T300 analyser in accordance with the Australian Standard method *AS 3580.7.1:2023 Methods for sampling and analysis of ambient air, Method 7.1: Determination of carbon monoxide – Direct reading instrumental method*.

This monitor is designed to operate continuously and provide five-minute CO concentrations.

3.5 Nitrogen dioxide

Monitoring of NO_2 was undertaken using a TAPI T200 analyser in accordance with the Australian Standard method *AS 3580.5.1:2023 Methods for sampling and analysis of ambient air, Method 5.1: Determination of oxides of nitrogen – Direct reading instrumental method*.

This monitor is designed to operate continuously and provide five-minute NO, NO_2 and total NO_x concentrations.

3.6 Sulfur dioxide

SO_2 monitoring was undertaken using a TAPI T100 analyser in accordance with the Australian Standard method *AS 3580.4.1:2023 Methods of sampling and analysis of ambient air, Method 4.1: Determination of sulfur dioxide – Direct reading instrumental method*.

This monitor is designed to operate continuously and provide five-minute SO_2 concentrations.

3.7 Ozone

O_3 monitoring was undertaken using a TAPI T400 analyser in accordance with the Australian Standard method *AS 3580.6.1:2023 Methods for sampling and analysis of ambient air, Method 6.1: Determination of Ozone – Direct reading instrumental method*.

This monitor is designed to operate continuously and provide five-minute O_3 concentrations.

3.8 Deposited dust

Deposited dust was measured using a DDG in accordance with the Australian Standard method *AS/NZS 3580.10.1:2016 Methods for sampling and analysis of ambient air, Method 10.1: Determination of particulate matter – Deposited matter – Gravimetric method*.

This is a passive monitoring method, with airborne dust settling out of the air into a glass vessel over a monthly sampling period.

3.9 Meteorological monitoring

Meteorological monitoring was conducted to measure wind speed and direction to facilitate data analysis and interpretation. The monitoring was undertaken with a 10-metre measurement mast in accordance with *AS/NZS 3580.14:2014 Methods for sampling and analysis of ambient air, Part 14: Meteorological monitoring for ambient air quality monitoring applications.*

3.10 Siting of ambient air monitoring equipment

The ambient air monitors were sited in accordance with the Australian Standard method *AS/NZS 3580.1.1:2016 Methods for sampling and analysis of ambient air, Part 1.1: Guide to siting air monitoring equipment.*

The monitoring sampling inlets met the requirements of the standard in terms of spacing from walls, horizontal spacing between sample inlets, clear sky angle and vertical sample inlet heights. All sample inlets were located away from nearby trees.

The monitoring sites both met the distance requirements of being sufficiently away from nearby roads.

4 Data quality

4.1 Data validation

The Department's technical specialists have undertaken a data quality assessment in accordance with standard procedures and with Australian Standard method *AS 3580.19:2020 Methods for sampling and analysis of ambient air, Method 19: Ambient air quality data validation and reporting*. The assessment comprises the following:

- Data checking for spikes, flat-lines, negative or spurious data.
- Checking of equipment operational modes or status conditions that indicate invalid data and instrument stability after power outages or maintenance.
- Validation that the instrument enclosure temperatures were between 20 and 30 degrees Celsius during operation.
- Examination of data trends and other indicators of instrument stability.
- Examination of logbooks, maintenance records, field sheets and chain of custody records.

As per *AS 3580.19*, the initial presumption is that all data are valid. Following detailed checking of the dataset, the following issues were identified:

- The PM_{10} and $PM_{2.5}$ TEOM 1405DF instrument was replaced on 4 December 2024 as a precaution to ensure continued performance. During routine site checks on 3 December 2024, the TEOM failed a leak check. Onsite diagnostic tests confirmed the leak was only present during high vacuum conditions and not under normal operating conditions with low filter loadings. Consequently, the November particle data were considered valid.
- The SO_2 analyser was replaced as a precaution on 4 December 2024 as its performance was not as expected, although still within specification. Outgoing and replacement analysers passed linearity performance checks.
- The laboratory analytical reports for the Pinjarra AQMS and background DDG samples collected between 31 October and 3 December 2024 indicated anomalous sample values, the reason(s) for which are unknown. Consequently, these samples were not included in the analysis in this report.
- Delays in conducting laboratory analysis of HVAS filters, as well as low filter sample mass for duplicates led to several particle and metals results being flagged by the laboratory as quality outliers. These results were considered to be valid and included in the analysis, noting that these are unlikely to have a significant effect on averages due to the low mass of metals detected.

Noting these issues and standard procedures, data considered invalid were removed and the dataset was processed by the Department following standard procedures to calculate exceedances and averages and to produce time series plots. A record of invalidated data is maintained for audit purposes.

4.2 Data recovery

Following data processing, data recovery was calculated using the *National Environmental Protection (Ambient Air Quality) Measure (NEPM) Technical Paper No.5 – data collection and handling* with the results shown in Table 1.

Data recovery greater than 75% meets NEPM reporting requirements, while the Department aims for data recoveries greater than 90%. Data recovery was above 95% for the NEPM pollutants monitored.

Parameter	Valid hours %	Valid days %
PM_{10}	99.2	98.9
$PM_{2.5}$	99.2	98.9
CO	97.9	100.0
NO_2	99.8	100.0
O_3	100.0	100.0
SO_2	97.2	98.9

Table 1 Data recovery

5 Results and analysis

5.1 PM_{10} and $PM_{2.5}$

Daily averages

PM_{10} concentrations were compared with the NEPM daily guideline of 50 µg/m^3 and $PM_{2.5}$ concentrations were compared with the NEPM daily guideline of 25 µg/m^3. We have also included comparisons with data from other AQMS operated by the Department during the campaign.

The TEOM $PM_{2.5}$ and TEOM/HVAS PM_{10} concentrations are included as time series plots in Appendix 1 and a summary of the data is presented below. The TEOM data are also available in comma-separated values (CSV) tabulated format on the Department's website (Appendix 5).

During the campaign, there were no exceedances of the PM_{10} daily guideline. The highest daily concentration of PM_{10} was 46 µg/m^3, recorded by the TEOM on 18 December 2024.

The $PM_{2.5}$ daily guideline was exceeded once during the campaign, on 18 December 2024. This result is shown in *Table 2*.

Date of exceedance	Daily $PM_{2.5}$ (µg/m^3) NEPM daily guideline 25 µg/m^3
18 December 2024	30.2

Table 2 $PM_{2.5}$ daily guideline exceedance

The $PM_{2.5}$ daily guideline exceedance on 18 December 2024 was likely due to smoke from prescribed burns in the South West based on information from the Department of Biodiversity, Conservation and Attractions and satellite imagery (Appendix 2). As discussed further in Section 5.5, it appears smoke carried by winds from the south-westerly direction resulted in the exceedance. The South Lake AQMS also recorded an exceedance of the daily guideline on this day.

Table 3 shows the number of exceedances of the NEPM daily guidelines recorded at other Department AQMS during the campaign.

AQMS	PM_{10} daily guideline 50 µg/m^3 Number of days > 50 µg/m^3	$PM_{2.5}$ daily guideline 25 µg/m^3 Number of days > 25 µg/m^3
Armadale	0	1
Busselton	2	3
Caversham	0	0
South Lake	0	2

Table 3 PM_{10} and $PM_{2.5}$ NEPM daily guideline exceedances at other Department AQMS during the campaign

Annual averages

The TEOM average results were compared with the PM_{10} and $PM_{2.5}$ annual guidelines. While it is noted the campaign collected data for a part of the year, these data have been extrapolated to estimate annual average concentrations. The estimated annual averages for PM_{10} and $PM_{2.5}$ were below the guidelines as shown in Table 4. Table 5 shows the estimated annual averages recorded at other Department AQMS during the campaign.

Period	Average PM_{10} (µg/m^3) NEPM annual guideline 25 µg/m^3	Average $PM_{2.5}$ (µg/m^3) NEPM annual guideline 8 µg/m^3
Annual	17.2	6.0

Table 4 PM_{10} and $PM_{2.5}$ estimated annual average concentrations

AQMS	Average PM_{10} (µg/m^3) NEPM annual guideline 25 µg/m^3	Average $PM_{2.5}$ (µg/m^3) NEPM annual guideline 8 µg/m^3
Armadale	14.7	5.4
Busselton	13.3	5.8
Caversham	16.1	6.4
South Lake	16.4	6.5

Table 5 PM_{10} and $PM_{2.5}$ estimated annual average concentrations at other Department AQMS during the campaign

5.2 Metals and RCS in PM_{10}

The HVAS PM_{10} samples and field blanks were analysed in a NATA accredited laboratory for a suite of 35 substances including metals and RCS as detailed in Appendix 3.

For 17 of the substances analysed, daily and/or annual ambient air guidelines from the Department's draft *Guideline – Air emissions* or guidelines derived in consultation with DoH were used. For the other substances, the Department has not adopted guidelines.

As was done for the PM_{10} and $PM_{2.5}$ data, annual averages for the substances analysed were also estimated. The campaign collected data for a part of the year and these data have been extrapolated to estimate annual average concentrations. Where a daily concentration was below the laboratory's limit of detection (referred to as the Practical Quantitation Limit, or PQL), half of the PQL was assumed for the calculation of the annual average.

Table 6 presents the maximum daily concentrations and estimated annual averages for those substances for which guidelines are available. There were no guideline exceedances. It was assumed that all the aluminium (Al) was present in the form of aluminium oxide (Al_2O_3), and all the iron (Fe) was present in the form of iron oxide (Fe_2O_3). RCS is reported as quartz (alpha-quartz) as this is the main form of RCS likely to be present in the samples.

The DoH has reviewed the results for the 35 substances analysed and advises that the measured concentrations do not represent a public health risk.

Substance	Highest daily concentration (µg/m^3)	Daily guideline (µg/m^3)	Estimated annual average concentration (µg/m^3)	Annual guideline (µg/m^3)
Alumina (Al_2O_3)	2.05	10.00	0.59	NA[1]
Antimony	ND[1]	NA	0.003	0.03
Arsenic	ND	0.03	0.0007	0.003
Beryllium	ND	NA	0.00007	0.0002
Chromium[2]	0.005	0.50	0.002	NA
Cobalt	ND	0.10	0.0007	0.10
Copper	0.002	1.00	0.001	NA
Iron (Fe_2O_3)	3.20	120	0.65	NA
Lead	ND	NA	0.002	0.50
Manganese	0.004	0.15	0.001	0.15
Mercury	ND	NA	0.00007	0.20
Molybdenum	ND	12.00	0.002	NA
Nickel	0.0018	0.14	0.0007	0.02
RCS (alpha-quartz)	0.65	10.00	0.32	NA
Uranium	ND	NA	0.001	0.04
Vanadium	0.006	1.00	0.001	1.00
Zinc	0.006	50.00	0.003	NA

1. Not detected (ND) means the result is below the laboratory PQL. Not applicable (NA) means the Department has not adopted a guideline.
2. Chromium was assumed to be present as the trivalent form Cr III, which is more common in the environment.

Table 6 Daily and annual metals and RCS concentrations compared to the guidelines

5.3 Gaseous pollutants

This section describes the results of the NEPM gases monitored during the campaign. Each gas has different guidelines, which are presented in Table 7.

Pollutant	Averaging period	NEPM guideline (ppm)	Campaign maximum (ppm)
CO	8 hours	9.0	0.54
NO_2	1 hour	0.08	0.026
O_3	8 hours	0.065	0.059
SO_2	1 hour	0.075	0.007
	1 day	0.02	0.006

Table 7 NEPM short-term guidelines and campaign maxima for gaseous pollutants

Using the gas analyser data, gas concentrations were compared with the NEPM hourly, eight-hour and daily guidelines shown in Table 7. These guidelines were not exceeded during the campaign.

NO_2 concentrations were also compared with the NO_2 annual guideline, assuming the limited period of data collection is representative of the entire year and can be reliably extrapolated to estimate annual average concentrations. The estimated annual average concentration for NO_2 was 0.003 ppm which was below the guideline of 0.015 ppm.

The gas concentrations are included as time series plots in Appendix 6 and these data are also available in CSV tabulated format on the Department's website (Appendix 5).

5.4 Deposited dust

Five valid deposited dust samples were collected during the campaign from both the AQMS in central Pinjarra and the background site in West Coolup. There were no exceedances of the adopted amenity criterion for total solids of 4 g/m^2/month as shown in Table 8.

Sample dates	Dust as total solids (g/m^2/month)	
	Central Pinjarra	Background
3 December 2024 to 2 January 2025	2.4	0.7
2 January to 3 February 2025	<0.10	0.15
3 February to 4 March 2025	2.3	1.9
4 March to 2 April 2025	1.6	3.3
2 April to 1 May 2025	1.7	2.4

Table 8 Deposited dust results

5.5 Hourly particle concentrations

Combining short-term (hourly averaged) data on particle concentrations and wind directions can indicate whether certain wind directions were associated with higher particle concentrations. Note that this type of analysis does not identify specific particle sources.

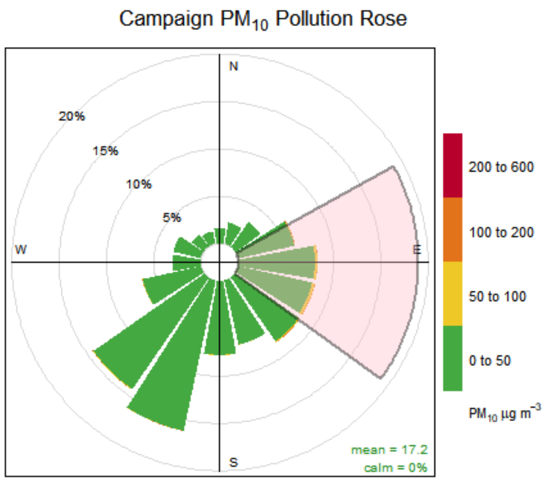
The analysis comprises:

- "Wind rose" plots, which show the frequencies of wind speed and direction. Wind directions are distributed over 16 segments that align with compass points such as north, north-east and south-south-west. The colour coding of the segments reflects wind speed ranges. Further information on how to read a wind rose can be found on the U.S. Environmental Protection Agency website (How to read a wind rose).
- Combined PM_{10}, $PM_{2.5}$ and wind data as "pollution rose" plots, which show the frequency of particle concentration ranges distributed over the same 16 wind direction segments. The segment colour coding for the particle concentrations is the same as that used for the Air Quality Index (AQI) on the Department's website (Air quality index - Department of Water and Environmental Regulation).
- The plots include a pink shaded sector that represents winds from the general direction of the Alcoa operations. The sector assigned is between 61 degrees to 126 degrees.

These data have been examined:

- Pollution roses and wind roses for the entire period of monitoring, where the plots are shown side by side to compare general patterns.
- Pollution roses for all the hours when the hourly concentrations exceeded the daily particle guidelines. The daily guidelines are compared to hourly data to highlight periods of high short-term levels, even though the overall daily averages may not have exceeded the NEPM guidelines.

- Pollution roses for days when daily particle guidelines were exceeded. These figures also include a time series plot which shows how particle concentrations varied over the day.



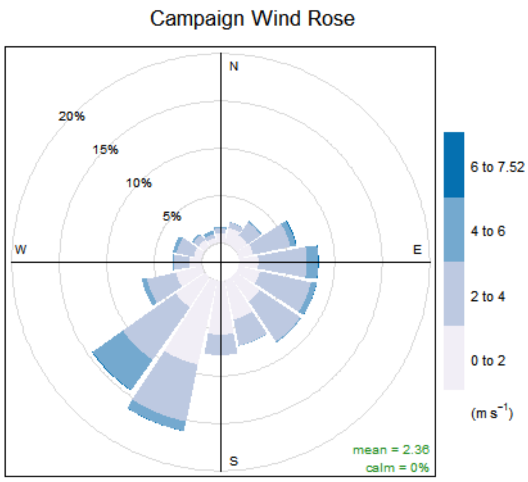


Figure 5 Campaign PM_{10} pollution rose and wind rose

Figure 5 contains all the hourly PM_{10} concentration data and the corresponding hourly wind data. The wind rose (plot on right side) shows higher frequencies of south-westerly and south-south-westerly wind directions during the campaign. Higher wind speeds were most commonly from the south-westerly direction. The pollution rose (plot on left side) shows that hourly concentrations were generally low (green) in all directions.

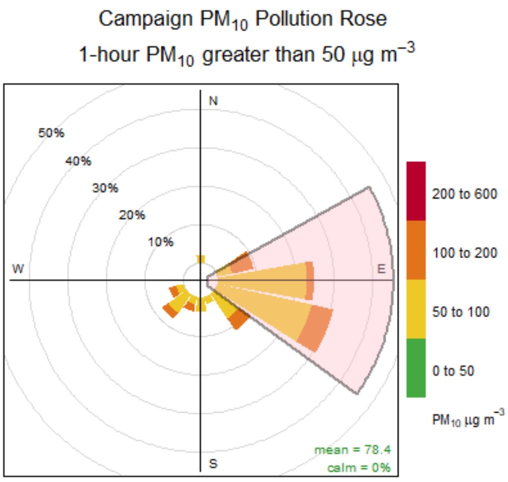


Figure 6 Campaign PM_{10} pollution rose for concentrations above 50 µg/m^3

Figure 6 shows all the PM_{10} hourly concentrations above the daily particle guideline, which is an indicator of the direction of only the elevated hourly concentrations of PM_{10}. There was a total of 52 hours during the campaign where the PM_{10} concentration was above the daily guideline.

The wind directions with the highest frequencies of these concentrations were easterly and east-south-easterly. There were 35 hours where the wind direction was from the general direction of Alcoa operations and consequently Alcoa dust sources potentially contributed to these results. The particle concentrations during these hours do not appear to be related to smoke.

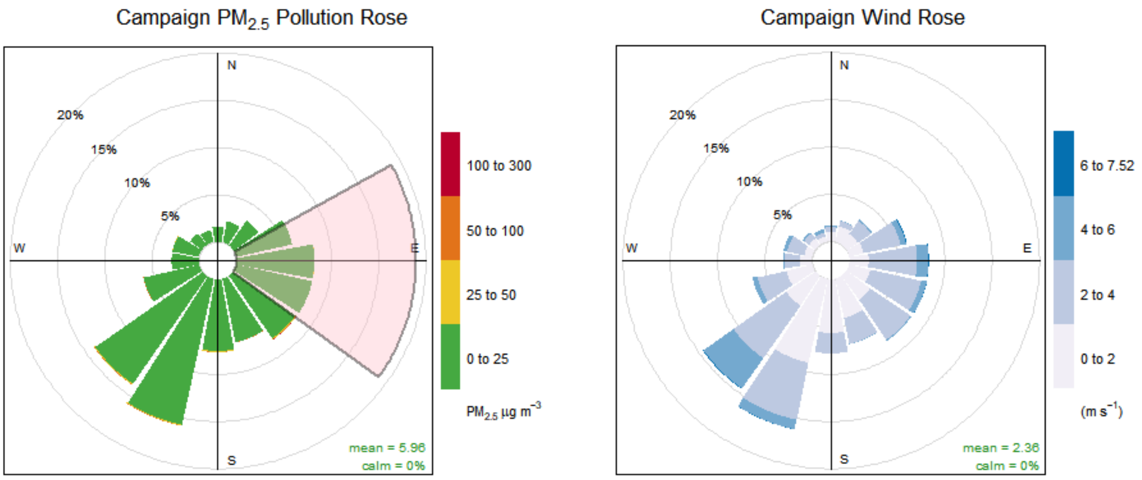


Figure 7 Campaign $PM_{2.5}$ pollution rose and wind rose

Figure 7 contains all the hourly $PM_{2.5}$ concentration data and the corresponding hourly wind data. The wind rose (plot on right side) shows higher frequencies of south-westerly and south-south-westerly wind directions during the campaign. Higher wind speeds were most commonly from the south-westerly direction. The pollution rose (plot on left side) shows that hourly concentrations were generally low (green) in all directions.

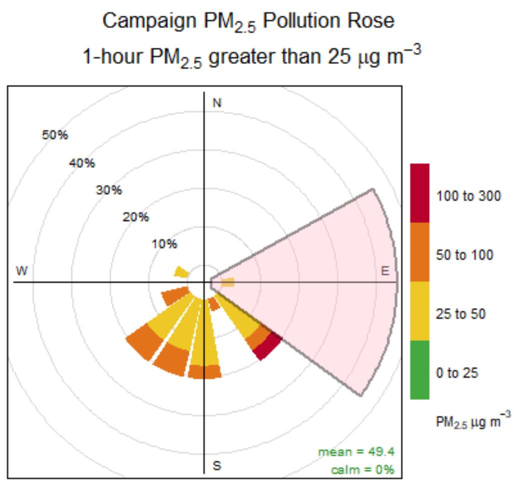


Figure 8 Campaign $PM_{2.5}$ pollution rose for concentrations above 25 µg/m³

Figure 8 shows all the $PM_{2.5}$ hourly concentrations above the daily particle guideline, which is an indicator of the direction of only the elevated hourly concentrations of

$PM_{2.5}$. There was a total of 29 hours during the campaign where the $PM_{2.5}$ concentration was above the daily guideline.

The wind directions with the highest frequencies of these concentrations were south-westerly to south-easterly. The particle concentrations during these hours appear to be related to smoke. Three of the one-hourly measurements were in the general direction of the Alcoa operations. The elevated hourly concentrations in the west-south-westerly to south-south-westerly directions also reflect the $PM_{2.5}$ exceedance day on 18 December 2024 (Figure 9).

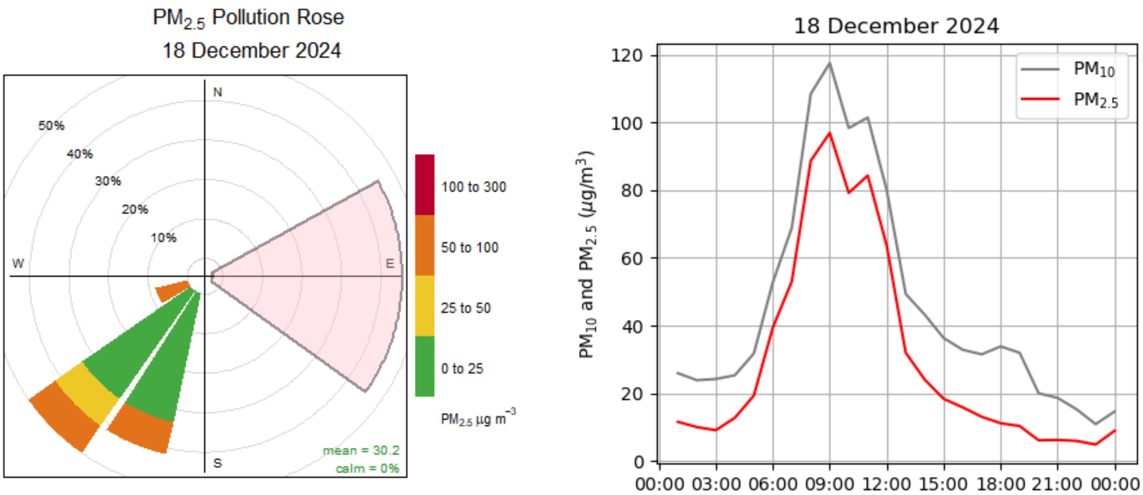


Figure 9 $PM_{2.5}$ pollution rose and concentration time series for exceedance day 18 December 2024

Figure 9 shows that hourly $PM_{2.5}$ concentrations between about 40 and 100 µg/m^3 were measured between 5am and noon from a south-westerly direction. The most likely source was smoke from prescribed burns in the South West, based on information from the Department of Biodiversity, Conservation and Attractions (Appendix 2). The time series plot (right side of Figure 9) also indicates that $PM_{2.5}$ comprised a large proportion of PM_{10} over this period, which is characteristic of smoke pollution.

A summary of the analysis in this section is:

- Of key interest are the PM_{10} and $PM_{2.5}$ hourly concentrations that were elevated and the average wind directions for these hours. Overall, there were a small number of hours with elevated concentrations.
- For PM_{10}, the majority of these elevated hourly concentrations occurred when winds were from the general direction of the Alcoa operations. Most of these do not appear to be related to smoke.
- For $PM_{2.5}$, wind directions associated with elevated hourly concentrations were mostly not from the general direction of the Alcoa operations. These hourly concentrations appear to be related to regional smoke impacts.

6 References

National Environment Protection Council 2021, *National Environment Protection (Ambient Air Quality) Measure*.

National Environment Protection Council 2001, *National Environmental Protection (Ambient Air Quality) Measure (NEPM) Technical Paper No.5 – data collection and handling.*

Standards Australia 2009, *AS/NZS 3580.9.7:2009 Methods for sampling and analysis of ambient air, Method 9.7: Determination of suspended particulate matter – Dichotomous sampler (PM_{10}, coarse PM and $PM_{2.5}$) – Gravimetric method*

Standards Australia 2014, *AS/NZS 3580.14:2014 Methods for sampling and analysis of ambient air, Part 14: Meteorological monitoring for ambient air quality monitoring applications*

Standards Australia 2015, *AS/NZS 3580.9.6:2015 Methods for sampling and analysis of ambient air, Method 9.6: Determination of suspended particulate matter – PM_{10} high volume sampler with size selective inlet – Gravimetric method*

Standards Australia 2016, *AS/NZS 3580.10.1:2016 Methods for sampling and analysis of ambient air, Method 10.1: Determination of particulate matter – Deposited matter – Gravimetric method*

Standards Australia 2016, *AS/NZS 3580.1.1:2016 Methods for sampling and analysis of ambient air, Part 1.1: Guide to siting air monitoring equipment*

Standards Australia 2020, *AS 3580.19:2020 Methods for sampling and analysis of ambient air, Method 19: Ambient air quality data validation and reporting*

Standards Australia 2022, *AS/NZS 3580.9.16:2022 Methods for sampling and analysis of ambient air, Method 9.16: Determination of suspended particulate matter – PM_{10} continuous direct mass method using a tapered element oscillating microbalance monitor incorporating a filter dynamic measurement system (FDMS) unit*

Standards Australia 2022, *AS/NZS 3580.9.13:2022 Methods for sampling and analysis of ambient air, Method 9.13: Determination of suspended particulate matter – $PM_{2.5}$ continuous direct mass method using a tapered element oscillating microbalance monitor*

Standards Australia 2023, *AS 3580.7.1:2023 Methods for sampling and analysis of ambient air, Method 7.1: Determination of carbon monoxide – Direct reading instrumental method*

Standards Australia 2023, *AS 3580.5.1:2023 Methods for sampling and analysis of ambient air, Method 5.1: Determination of oxides of nitrogen – Direct reading instrumental method*

Standards Australia 2023, *AS 3580.4.1:2023 Methods of sampling and analysis of ambient air, Method 4.1: Determination of sulfur dioxide – Direct reading instrumental method*

Standards Australia 2023, *AS 3580.6.1:2023 Methods for sampling and analysis of ambient air, Method 6.1: Determination of Ozone – Direct reading instrumental method*

United States Environmental Protection Agency 2018, *Particulate matter (PM) pollution,* Research Triangle Park, NC. www.epa.gov/pm-pollution/particulate-matter-pm-basics#PM.

7 Shortened forms and glossary

Equivalent aerodynamic diameter	Diameter of a spherical particle of density 1 g/cm^3 which exhibits the same aerodynamic behaviour as the particle in question
AQMS	Air quality monitoring station
BoM	Bureau of Meteorology
DDG	Dust deposition gauge
DoH	Western Australian Department of Health
The Department	The Department represents the Department of Water and Environmental Regulation and its predecessors such as the former Department of Environment Regulation and former Department of Environment and Conservation
HVAS	High-volume air sampler
NA	Not applicable. This is in relation to whether the Department has adopted a guideline for pollutant concentration
ND	Not detected. The result is below the laboratory PQL
NEPM	*National Environmental Protection (Ambient Air Quality) Measure*. NEPMs are a special set of national objectives designed to help protect or manage particular aspects of the environment. www.nepc.gov.au/nepms
PM	Particulate matter
$PM_{2.5}$	Particulate matter with a diameter up to 2.5 μm (micrometres)
PM_{10}	Particulate matter with a diameter up to 10 μm (micrometres)
PQL	Practical Quantitation Limit: the minimum concentration of a compound that can be measured within specified limits of precision and accuracy for a particular laboratory and analytical method
RCS	Respirable crystalline silica
TEOM	Tapered element oscillating microbalance
USEPA	United States Environmental Protection Agency

Appendices

The appendices listed below are available on the Department website at Pinjarra air quality

Appendix 1 TEOM and HVAS time series particle concentration data

Appendix 2 Planned burn and bushfire information

Appendix 3 HVAS filter analysis results

Appendix 4 Laboratory analysis reports

Appendix 5 Monitoring data in tabulated format

Appendix 6 Time series gas concentration data