



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

Port Hedland air quality 2023 annual monitoring report



Department of Water and Environmental Regulation
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Summary

- In 2022, the Department of Water and Environmental Regulation (the department) assumed management of the Port Hedland ambient air quality monitoring network, which had previously been operated by the Port Hedland Industries Council.
- The department completed a program of ambient air monitoring network upgrades during 2022 and 2023.
- Key results of particle monitoring (PM₁₀ and PM_{2.5}) for 2023 are summarised below:
 - Overall dust concentrations (PM₁₀) in Port Hedland and surrounds were relatively high when compared with the preceding four years.
 - The Port Hedland Air Guideline Value (AGV) was exceeded 29 times at the Taplin monitoring station, with 13 of these considered to be due to exceptional events, 13 attributed to industry and three to other sources.
 - Fine particles (PM_{2.5}) in smoke from bushfires had a greater influence on air quality in 2023 compared with previous years and contributed to high particle concentrations, especially in October and November.
 - Generally, dust events at sites near the port were dominated by the coarse dust fraction of PM₁₀.
 - Dust events at the regional background station Yule comprised both dust fractions, with some events dominated by coarse dust and others by fine particles in smoke.
 - The *National Environment Protection (Ambient Air Quality) Measure* (AAQ NEPM) daily and annual guidelines for PM_{2.5} were not met at the Taplin monitoring station.
- The results of gas monitoring (nitrogen dioxide – NO₂ and sulfur dioxide – SO₂) at the Taplin and Richardson monitoring stations showed that the AAQ NEPM hourly and annual guidelines were met.

Acknowledgement of Country

The Department of Water and Environmental Regulation acknowledges the Traditional Owners of the lands on which we live and work throughout Western Australia and we pay our respects to Elders past and present. The Department recognises the practice of intergenerational care for Country and its relevance to our work and working with the community. The Department continues to move forward with a shared commitment to protect and conserve Country for our future generations.

1 Background

Dust emissions from port facilities and their influence on air quality have long been recognised as a significant issue in Port Hedland.

To address this, the State Government established the Port Hedland Dust Management Taskforce in 2009 to plan for and coordinate dust management in the town. The Taskforce released their *Port Hedland air quality and noise management plan* in 2010. The Plan proposed, among other recommendations, a Health Risk Assessment (HRA) of the impact of dust on the Port Hedland population. An ambient air quality monitoring network was established to inform the HRA. The network was operated by the Port Hedland Industries Council (PHIC).

The HRA was finalised by the Department of Health in 2016. This work focused on the potential impacts on human health from PM₁₀ (dust) inhalation by residents. A key outcome was the establishment of an interim air guideline value (AGV) for PM₁₀ of 70 µg/m³ averaged over a day as documented in the 2016 *Port Hedland Dust Management Taskforce Report* (Taskforce Report).

In October 2018, the Government released the *Port Hedland Dust Management Taskforce Report – Government Response*. It endorsed the key recommendations that the AGV continues to apply in residential areas of Port Hedland and that the operation of the ambient air quality monitoring network be transferred to the department. It also endorsed the implementation of planning controls to prohibit sensitive land uses and restrict population growth in the West End. The [Port Hedland Dust Taskforce documents](#) can be accessed at the WA government website.

This report summarises data from the monitoring network for the 2023 annual period.

2 Monitoring network

The department assumed management of the monitoring network on 1 January 2022. This document is the second annual monitoring report prepared by the department, with all reports available on the department's website. Previous reports were prepared by PHIC and these can be accessed through their website at [PHIC monitoring reports](#).

Port Hedland's current air quality, can be viewed at the [Port Hedland air quality monitoring network website](#) where historical data can also be downloaded.

2.1 Monitoring sites

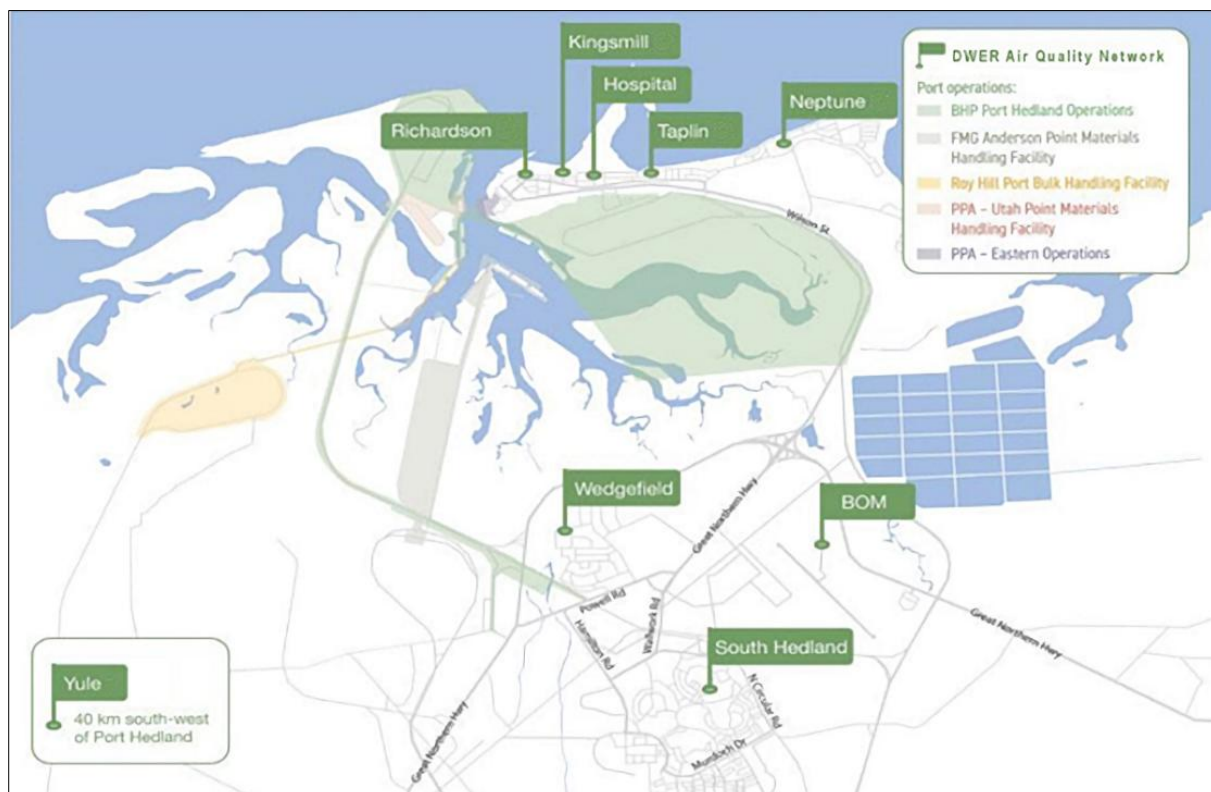


Figure 1 Monitoring station locations

The Port Hedland ambient air quality monitoring network (network) consists of nine monitoring stations as shown in Figure 1. The network's spatial configuration is designed to record data at locations representing residential, light industrial and background areas.

Residential stations are located where people live and include Richardson, Kingsmill, Hospital, Taplin, Neptune and South Hedland. The area west of Taplin Street has been defined as a commercial precinct objective for land use (*Port Hedland West End Improvement Scheme No. 1*).

This planning policy restricts further residential development, and together with the implementation of a buyback scheme aims to reduce residential use in the future. The Taplin Street monitoring station is located on the boundary of the West End, proposed to transition to a commercial precinct, and the East End with its continuing residential use. Monitoring data from Taplin Street is therefore considered representative of dust concentrations experienced in the East End and comparison of

Taplin Street concentrations against the AGV is used as a regulatory tool to protect residential receptors.

Whilst the Taplin Street monitor data are the basis of Government regulatory activities, the remaining monitors in the network ensure the adequacy of this regulatory approach.

Wedgefield is a light industrial area. Yule represents a regional background site while the Bureau of Meteorology (BOM) site near the airport is intended to represent a local background site.

Background sites are those considered not to be influenced by port emissions, whereas the other sites may be influenced by industrial emissions to varying degrees. Site location information is summarised in Table 1.

Table 1 Monitoring site location information

Monitoring station	Short code	Description	Latitude	Longitude	Location category
BOM	BOM	Bureau of Meteorology site, Airport	-20.371508°	118.631353°	local background
Hospital	HO	Old Hospital site, West End	-20.310125°	118.589019	Improvement Scheme No 1 – West End
Kingsmill	KI	Kingsmill Street, West End	-20.309717°	118.585187°	Improvement Scheme No 1 – West End
Neptune	NE	Neptune Place, East End	-20.303910°	118.622836°	Residential – East End
Richardson	RI	Richardson Street, West End	-20.310221°	118.578037°	Improvement Scheme No 1 – West End
South Hedland	SH	Acacia Way, South Hedland	-20.407376°	118.607549°	residential
Taplin	TA	Taplin Street, Boundary West End/East End	-20.309746°	118.599700°	Residential – West/East End border
Wedgefield	WE	Leehey Street, Wedgefield	-20.370454°	118.584820°	light industrial
Yule	YU	Yule River	-20.595167°	118.296311°	regional background

2.2 Monitoring methods and instruments

Particle monitoring is undertaken using Beta Attenuation Monitor (BAM) equipment applying Australia/New Zealand Standards (AS/NZS). Only validated data measured by these instruments are used for data analysis in this report.

In parallel with the BAMs, near real-time monitoring instruments are deployed to record particle concentrations over shorter intervals (10-minute averages). These 10-minute concentration data provide more immediate feedback than the BAMs which record clock-hour averages. Data from real-time monitors are used for displaying current (10-minute) particle concentrations on the website and to generate concentration trigger alerts for real-time dust management actions by port operators.

Monitoring instruments measuring gaseous pollutants (sulfur dioxide and nitrogen dioxide) are also deployed in the network.

A summary of monitoring equipment and the associated AS/NZS is listed in Table 2.

Table 2 Monitoring methods and instruments

Parameter	Equipment	Monitoring method / AS/NZ Standard	Monitoring locations								
			BOM	Hospital	Kingsmill	Neptune	Richardson	South Hedland	Taplin	Wedgefield	Yule
PM₁₀	BAM 1020	Beta attenuation AS/NZS 3580.9.12:2013	x	x	x	x	x	x	x	x	x
	BAM 1020 ¹								x ¹		
	ES-642 / BX-895	Laser nephelometry	x	x	x	x ²	x	x	x	x ²	x
PM_{2.5}	BAM 1020	Beta attenuation AS/NZS 3580.9.12:2013	x	x	x		x	x	x		x
	ES-642	Laser nephelometry	x	x	x		x	x	x		x
NO_x	Serinius 40 NO _x analyser	Chemi-luminescence AS 3580.5.1-2011					x		x		
SO₂	Serinius 50 SO ₂ analyser	Ultraviolet fluorescence AS 3580.4.1-2008 REC:2018					x		x		

¹ Duplicated monitor, ² BX-895

2.3 Network management

Supply, operation and maintenance of monitoring infrastructure

The department has engaged a third-party specialist contractor to operate and maintain the network. As part of their contract with the department, the contractor also supplies all monitoring instrumentation.

In 2023, new loggers were installed at Richardson, Hospital, Taplin, Neptune, South Hedland, BOM and Yule. A data logging issue had occurred affecting the real time data channel at Taplin (although there was no data loss or impact on data quality) and the new loggers were installed to prevent this issue from re-occurring. Taplin, BOM and Yule also received new wind sensors.

Data management

The contractor undertakes data management, which includes the recording of monitoring data and instrument status data on a dedicated database, daily data checks, fault identification and data validation.

Validated data are provided by the contractor to the department, industry stakeholders, and to the public via the website. Data is validated in monthly data packages with the previous month's raw data being made available as validated package by the 15th of the current month.

An automated exceedance alert notification is sent to the department and industry stakeholders when AGV exceedances occur at Taplin Street.

Compliance with AAQ NEPM protocols and Technical Papers is required, as specified in the contract between the department and the contractor. As a provider accredited by the National Association of Testing Authorities, the contractor has comprehensive quality control protocols and procedures in place.

An important aspect of data quality is that adequate data availability is achieved at each monitor. The AAQ NEPM *Technical Paper No. 5 – Data Collection and Handling* stipulates that for assessing annual compliance with NEPM guidelines, in addition to the 75 per cent annual data availability requirement, at least 75 per cent data availability per calendar quarter is required to account for seasonal effects on pollutant variability. Data availability for all averaging periods is calculated based on valid hours. Each hour also requires at least 75% valid data for that hour to be considered valid.

Pollutant analysis in this report therefore includes a table specifying the data availability rates achieved for that pollutant to document performance against this data quality criterion.

The department provides oversight by undertaking regular data reviews and by conducting targeted audits for compliance with quality control protocols. In addition, if network issues are identified, the department implements improvements to reduce the risk of recurrence.

2.4 Air quality guidelines

The National Environment Protection Council has established air quality guidelines under the AAQ NEPM for criteria pollutants including PM₁₀, PM_{2.5}, NO₂ and SO₂ as shown in Table 3. These guidelines are used in the analysis of the 2023 monitoring data.

In Port Hedland the AGV of 70 µg/m³ for PM₁₀ 24-hour (daily) average is applied as endorsed by the State Government in 2018 through the *Port Hedland Dust Management Taskforce Report – Government Response*.

As described in the [Port Hedland Regulatory Strategy](#), the AGV is not an enforceable limit. Rather, it is applied in the same manner as the AAQ NEPM, which provides guidance on population exposure to air pollution through the application of nationally consistent guidelines and monitoring methods. The Port Hedland AGV aligns with the AAQ NEPM guidelines for particles by excluding exceedances caused by natural events, which are defined as bushfires, jurisdiction authorised hazard reduction burning, or continental-scale windblown dust.

The AGV is applied to residential areas, wherever people live on a permanent basis in Port Hedland. It is also used as a regulatory tool against which compliance is assessed. This report states the total number of exceedances of the AGV and differentiates exceptional or natural events, exceedances where industry has likely contributed substantially and exceedances where other sources, such as local background dust made a substantial contribution.

Table 3 Air quality guidelines

Pollutant	Averaging period	Maximum concentration value	Reference
Particles as PM₁₀	1 day	50 µg/m ³	AAQ NEPM
	1 day	70 µg/m ³	AGV
	1 year	25 µg/m ³	AAQ NEPM
Particles as PM_{2.5}	1 day	25 µg/m ³	AAQ NEPM
	1 year	8 µg/m ³	AAQ NEPM
Nitrogen dioxide	1 hour	80 ppb	AAQ NEPM
	1 year	15 ppb	AAQ NEPM
Sulfur dioxide	1 hour	100 ppb	AAQ NEPM
	1 day	20 ppb	AAQ NEPM

3 Monitoring summary

3.1 Summary of Port Hedland meteorology

Port Hedland is situated in the Pilbara region, which is classified as arid tropical with hot summers and mild winters. Major rainfall events are associated with cyclonic systems. Cyclone season is between November and April. Temperature, rainfall and wind conditions affect air pollutant generation and dispersion and are therefore important meteorological factors to consider.

Rainfall

Rainfall data obtained from the BOM station at the Port Hedland Airport are presented in Figure 2, which shows monthly mean rainfall for 2023 compared with monthly mean rainfall for the years 1942–2023. Long-term annual mean rainfall was 313 mm and the annual rainfall for 2023 was 183 mm. The highest rainfall during 2023 occurred in January. 2023 was notably drier than historically experienced and also significantly drier than 2022, which had an annual mean rainfall of 385 mm. Cyclone Isla was active in the Pilbara region making landfall near the Pardoo Roadhouse on 15 April 2023 however it did not result in high rainfall in Port Hedland.

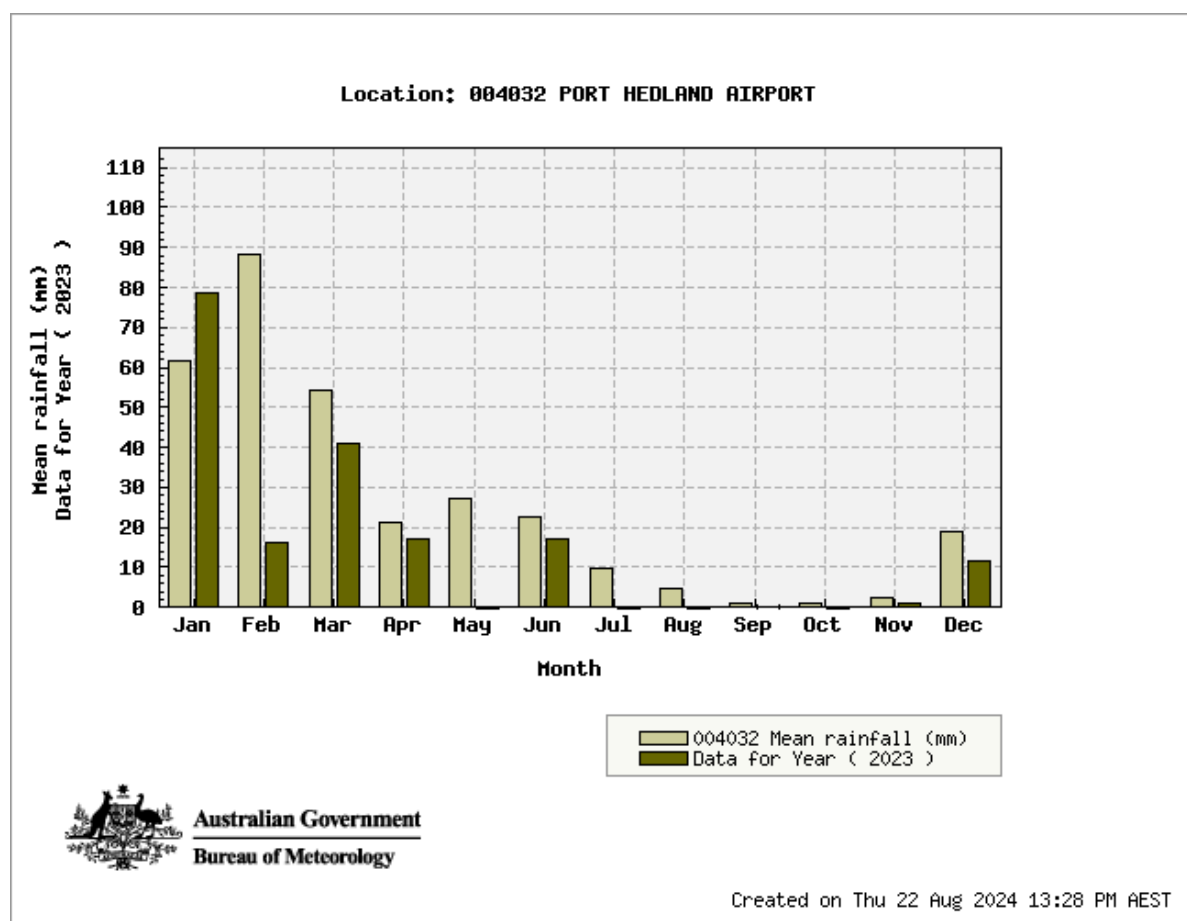


Figure 2 Mean monthly rainfall at Port Hedland Airport

Temperature

Temperature data from the BOM station are presented in Figure 3 and show monthly maximum temperatures for 2023 compared with average monthly maximum temperatures for the years 1942–2023. Compared to long-term data, 2023 recorded higher temperatures from August to October.

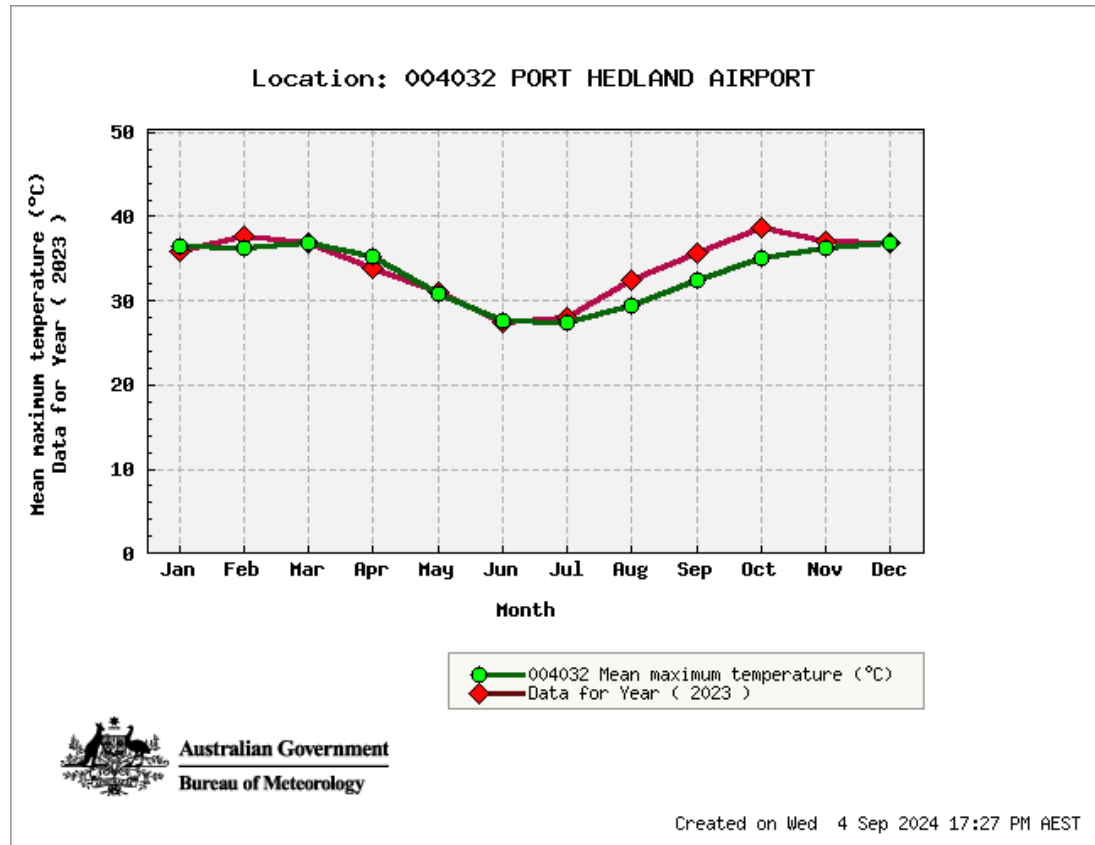


Figure 3 Mean monthly maximum temperature at Port Hedland Airport

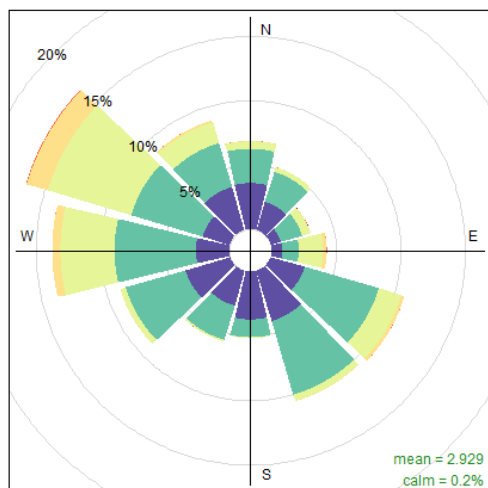
Wind

Figure 4 to Figure 6 provide an overview of wind direction and wind speed data averaged over 10-minute intervals from Taplin, BOM and Yule during 2023. The selected locations represent a residential site in the West End (Taplin), which is influenced by port emissions, and two background sites that reflect a local background (BOM) and a regional background (Yule). All sites can also be influenced by localised emission sources near the monitors.

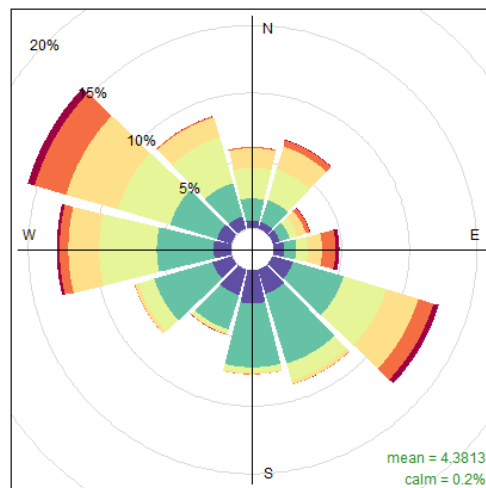
The data are presented as wind rose plots, showing the frequency of wind directions distributed over 12 direction segments. The colour coding reflects wind speed increments distributed over intervals derived from the data range. For each site, an annual plot and a set of four seasonal plots are presented. A summary of wind observations shows:

- Overall similar wind patterns are observed across the three sites with some site-specific differences in the distribution and frequency of wind directions.
- In the annual plots, the predominant wind directions of north-westerly and westerly are consistent across the sites.

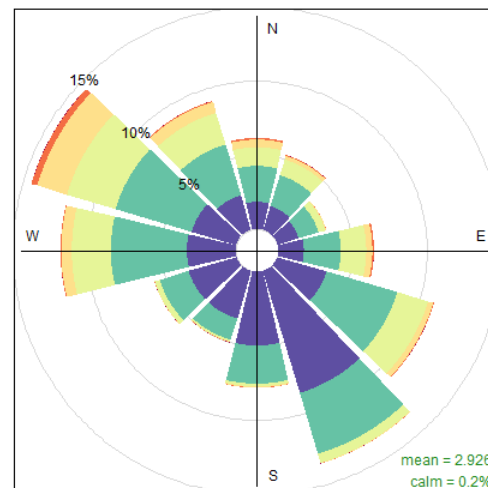
- All sites have similar seasonal patterns with predominantly north-westerly and westerly winds in spring and summer and predominantly south-easterly winds in autumn and winter.
- A comparison of the annual data shows the highest mean wind speed of 4.4 m/s (4.6 m/s in 2022) at BOM, with lower annual mean wind speeds of 2.9 m/s (2.7 m/s in 2022) at Yule and 2.9 m/s (2.9 m/s in 2022) at Taplin.
- There is a higher frequency of high wind speeds (between 8 - 20 m/s) in summer and spring coming from the predominant north-westerly and westerly directions than in autumn and winter.



Taplin

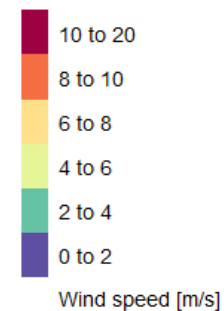


BOM



Yule

Annual



Seasonal

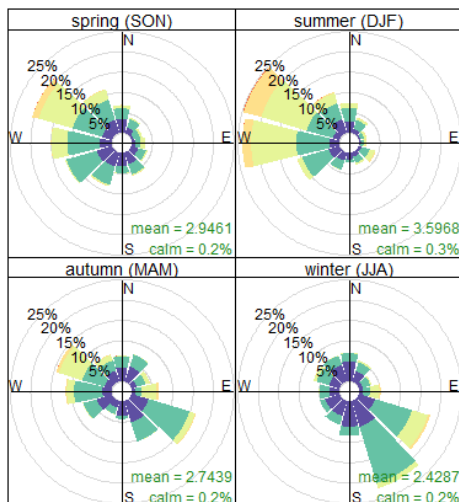


Figure 4 Taplin wind roses

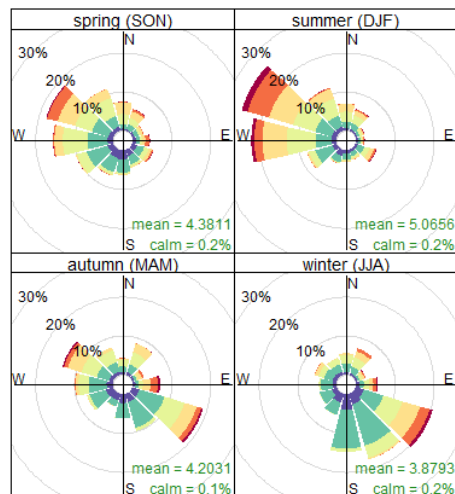


Figure 5 BOM wind roses

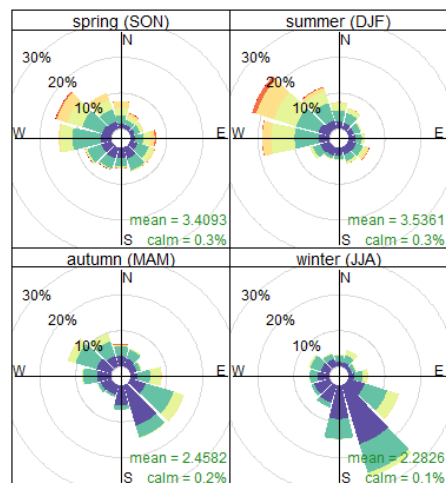


Figure 6 Yule wind roses

3.2 Particles as PM₁₀

Particles are classified into different sized fractions based on their aerodynamic equivalent diameter (AED) measured in micrometres or microns (µm). PM₁₀ particles have an AED of up to 10 µm. They can be derived from many different sources that include industrial emissions and natural sources. Particles of this sized fraction are small enough to be inhaled and can cause health impacts.

Data availability

Adequate data availability rates are a prerequisite for valid data analysis.

Data availability rates for PM₁₀ monitoring during 2023 met the quarterly and annual thresholds with all rates above the minimum of 75 per cent and all annual rates achieving at least 90 per cent (Table 4). A cyclone shut down of monitors occurred in April 2023 during cyclone Isla, which affected the availability rates in quarter 2 of 2023.

Table 4 Data availability for PM₁₀

Monitoring station	Data availability rates (%)				
	Q1	Q2	Q3	Q4	Annual
Kingsmill	100	88.0	96.7	100	96.2
Richardson	100	94.5	96.7	100	97.8
Hospital	97.8	86.8	96.7	98.9	95.1
Neptune	100	86.8	98.9	100	96.4
Taplin	100	92.3	96.7	100	97.3
Wedgefield	100	92.3	90.2	97.8	95.1
BOM	100	89.0	95.7	100	96.2
South Hedland	100	78.0	92.4	98.9	92.3
Yule River	100	83.5	92.4	100	94.0

Daily averages

PM₁₀ monitoring data collected during 2023 are summarised as a simple statistic of daily guideline exceedance counts as presented in Table 5.

Table 5 Comparison against air quality guidelines

Monitoring station	AAQ NEPM Daily average 50 µg/m ³ Number of days > 50 µg/m ³	Port Hedland AGV Daily average 70 µg/m ³ Number of days > 70 µg/m ³	AAQ NEPM Annual average 25 µg/m ³ Annual concentration µg/m ³
Richardson	189	72	54
Kingsmill	151	69	52
Hospital	149	65	51.3
Taplin	107	29	42.8
Neptune	24	10	26.6
South Hedland	25	11	27.5
Wedgefield	203	112	64.0
BOM	46	16	34.9
Yule	20	13	21.3

Compliance with the AAQ NEPM guidelines for PM₁₀ has not been assessed as these guidelines are not applied in Port Hedland. Comparison against these guideline values serves as a statistical tool only. This comparison shows:

- The number of exceedances of the AAQ NEPM daily average PM₁₀ guideline (50 µg/m³) decreases on the Port Hedland peninsula from west to east with Richardson at the western end recording 189 exceedances and Neptune at the eastern end recording 24. The decreasing exceedance gradient aligns with increasing distance from the port operations.
- The lowest number of exceedances in a residential area occurred at Neptune (24).
- Of the non-residential locations, Wedgefield shows the highest number of AAQ NEPM exceedances (203), higher than any of the peninsular locations. Yule (20) had the lowest number of exceedances of all sites while BOM (46) had more than double the number of exceedances than Yule.
- Field information and data analysis indicate that Wedgefield is significantly influenced by local dust sources, especially trucks operating on unsealed roads near the monitor.

- Field information and aerial imagery indicate that BOM may have been significantly influenced by localised dust sources from clearing and earthwork activities nearby.

Regulatory application of the Port Hedland AGV has only been assessed at Taplin (see next section). For the other monitoring locations, the number of days above the AGV serves as a statistical tool to compare dust concentrations at different sites. This comparison shows:

- The exceedances of the AGV show a similar trend to the AAQ NEPM guideline exceedances on the Port Hedland peninsula, with higher exceedance numbers in the west and lower exceedance numbers in the east.
- Consistent with the AAQ NEPM guideline exceedances, Neptune had the lowest number of AGV exceedances in monitored residential areas.
- Wedgefield had the highest number of AGV exceedances (112). The lowest number of AGV exceedances were at Neptune (10) and South Hedland (11).
- In October and November, relatively high daily concentrations were recorded across the network. On those days the contribution of PM_{2.5} to the overall dust concentrations (PM₁₀) was also high, indicating that smoke from fires may have contributed to these AGV exceedances.

Regulatory application of the AGV at Taplin

Exceedance counts of the AGV at Taplin are an important regulatory indicator and are referenced in premises' licences as dust management and reporting conditions. Exceedance information is used to inform regulatory decision-making by assessing the contribution of regulated emission sources. For AGV exceedances to meaningfully inform the regulation of premises, a clear relationship must be established between monitored exceedances and dust emissions from those premises.

Using data from the ambient monitoring network alone for this purpose has inherent limitations, as the network was designed to measure dust concentrations and potential impacts in the community rather than to accurately attribute dust contributions from individual premises or industry as a whole to the concentrations recorded at Taplin. In addition, distinguishing and quantifying contributions from multiple fugitive dust sources located in close proximity to one another, and in the presence of local and background dust, is inherently complex and would require a more intensive and multi-pronged monitoring approach than is currently in place.

Given these limitations, the method used to assess and attribute exceedances is undertaken at a high level.. Broad source categories— namely exceptional (E), Regulatory (R) and other exceedance events (O)—are used, with attribution based on whether a source is considered to have made a *substantial contribution* to the exceedance. Attribution statements therefore reflect likelihood rather than absolute accuracy. A key focus of the method is to ensure that it is clearly defined and replicable. Details of the method are described in the Appendix.

Exceedance attribution

Exceptional is used when exceptional or natural events such as bushfires or regional dust storms have adversely affected regional air quality and caused an exceedance at Taplin Street. A regulatory event means that the exceedance has likely been substantially contributed to by industry emissions and an attribution to other exceedances accounts for substantial contributions from non-industry local and background sources. As summarised in Table 6, in 2023 there were a total of 29 AGV exceedances, with 13 of these considered to be due to exceptional events, 13 attributed to industry and three to local non-industrial sources.

Table 6 AGV exceedance summary at Taplin

Date of exceedance	Daily average PM ₁₀ µg/m ³	Assessment result*
5/01/2023	84	R
16/09/2023	73	R
21/09/2023	82	R
26/09/2023	87	R
28/09/2023	85	R
8/10/2023	78	R
10/10/2023	73	R
13/10/2023	72	R
18/10/2023	80	R
21/10/2023	74	O
22/10/2023	95	R
26/10/2023	95	E
27/10/2023	133	E
5/11/2023	131	E
6/11/2023	124	E
7/11/2023	169	E

Date of exceedance	Daily average PM ₁₀ µg/m ³	Assessment result*
8/11/2023	102	E
9/11/2023	123	E
10/11/2023	149	E
11/11/2023	261	E
12/11/2023	72	E
25/11/2023	76	E
26/11/2023	72	R
29/11/2023	124	E
9/12/2023	71	R
10/12/2023	74	O
21/12/2023	71	O
29/12/2023	76	R
31/12/2023	98	E

*Exceptional event (E)

Regulatory event (R)

Other exceedance event (O)

Annual averages

Table 5 includes the annual average concentrations for each station to allow comparison with the AAQ NEPM guideline of $25 \mu\text{g}/\text{m}^3$. Comparison against this guideline shows that only Yule remained below the guideline value, while it was exceeded at all other locations. The general trend for the annual averages is consistent with the trends for the daily averages, showing higher concentrations in the west of the Port Hedland peninsula compared to the east.

PM₁₀ trend analysis

The objective of the PM₁₀ trend analysis is to describe features of dust concentrations recorded in 2023 and compare these with earlier years. The use of multiple statistics and more complex data analysis in addition to calculating guideline exceedance counts supports a sound approach to assessing particle levels.

Reliance on the number of AGV exceedances as the sole statistic to describe PM₁₀ dust concentrations in Port Hedland can limit the ability to draw meaningful conclusions from the data.

Taplin monthly trend

Figure 7 presents monthly summary statistics for PM₁₀ hourly concentrations at Taplin in the form of a “box and whisker” plot for 2023 and for 2020–22. The plot includes minimum and maximum concentrations, median concentrations, and selected percentiles. The height of the coloured boxes shows the data spread between the 25th and 75th percentiles. The extent of the whiskers indicates the minimum and maximum concentrations, with outliers removed for readability. The median hourly concentration is indicated by the horizontal bar located in each box.

A clear seasonal trend at Taplin is evident, with lower concentrations in winter and higher concentrations in summer in both datasets. Higher ambient temperatures in summer (Figure 3) are likely to contribute to these increased dust concentrations.

Figure 4 shows that the predominant wind direction in summer was from a west/north-westerly direction, which also increases the likelihood of dust contributions at Taplin from port sources, while the predominant south-easterly wind directions in winter decreases the likelihood of dust contributions from port sources.

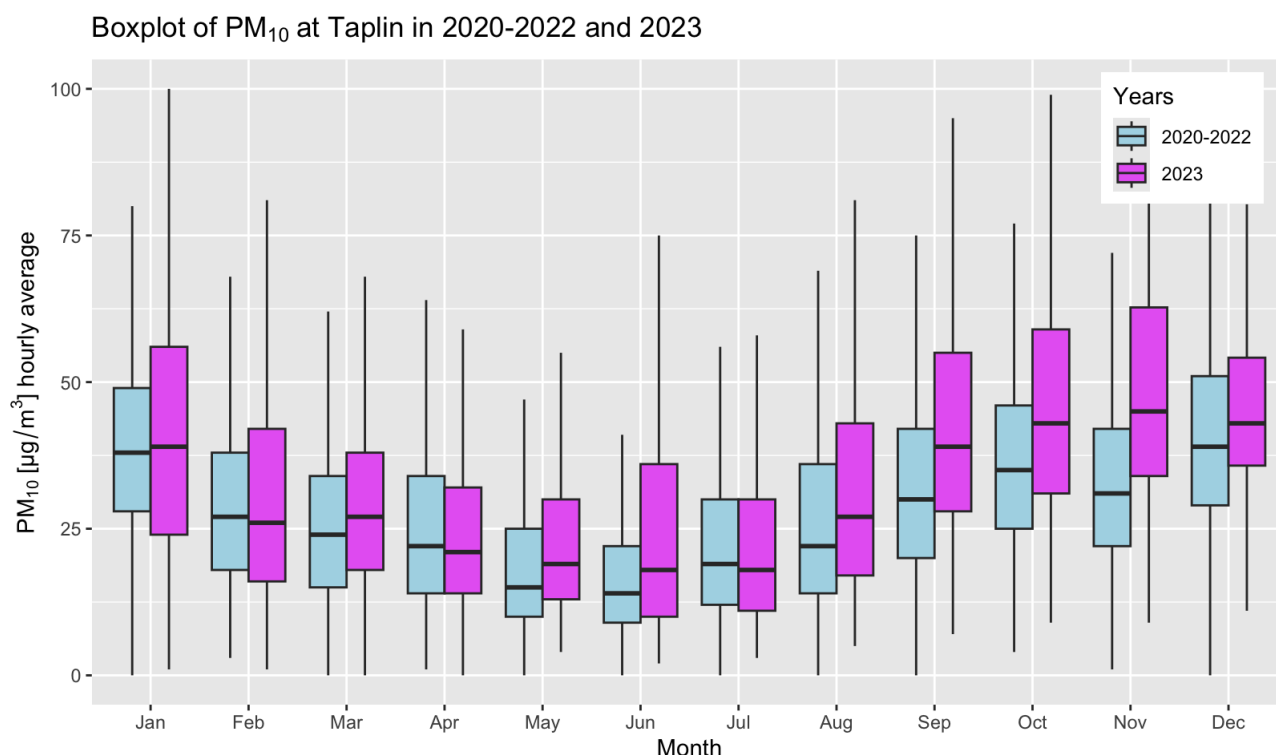


Figure 7 Monthly variability of Taplin PM₁₀ hourly averages for 2023 and 2020–22

Data for each month of 2023 at Taplin can be compared with the previous four years of data for that month. This comparison indicates that dust concentrations in 2023 were higher from August to November (box position higher) which appears to correlate with higher temperatures and low rainfall for this period as noted in Section 3.1

Comparison of sites

While summary statistics like exceedance counts and “box and whisker” plots give some insight into the data trends, a more complex statistical approach has been used to investigate whether there was overall more or less dust in 2023 compared to other years.

This approach calculates the frequency distribution of daily concentration data points and generates a curve showing the accumulated frequency of daily concentrations over a year. In the discussion below, we refer to the curves as accumulated frequency curves.

Examples of accumulated frequency curves are illustrated in Figure 8 which shows site-specific curves for 2023 comparing all peninsular sites.

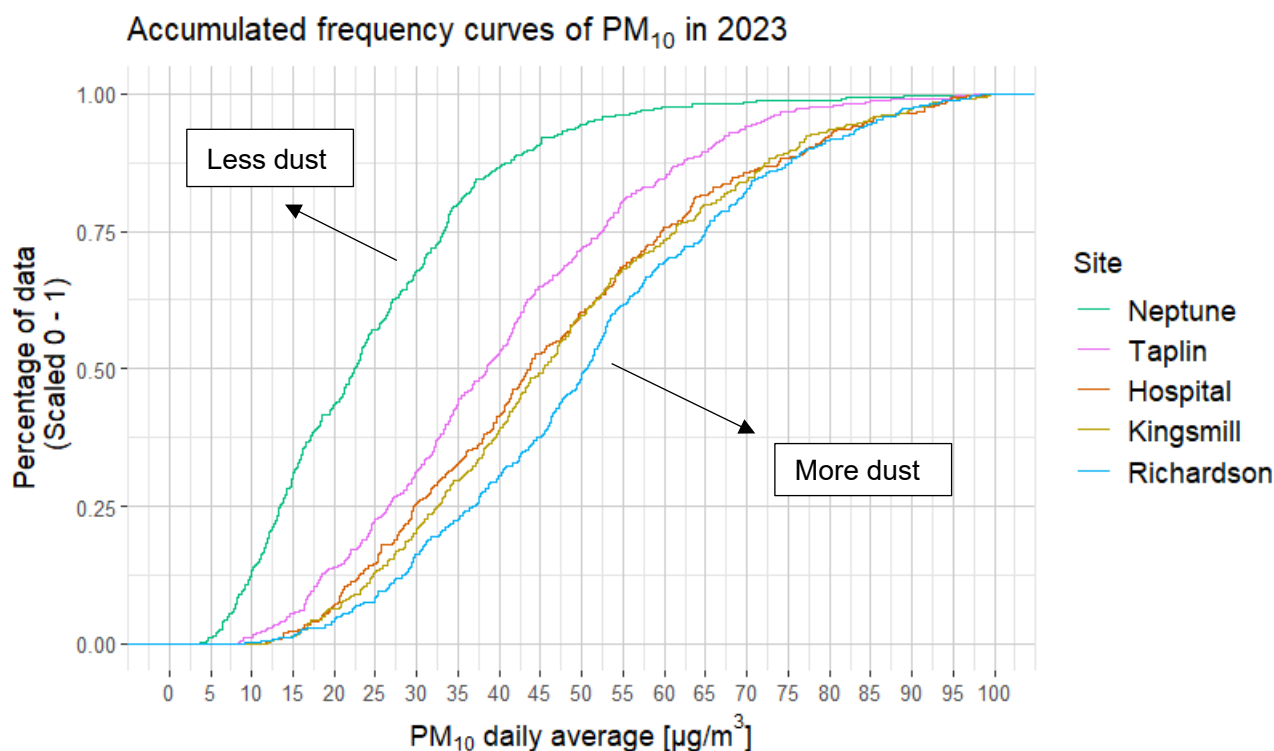


Figure 8 Comparison of dust concentrations at Port Hedland peninsular locations for 2023

In Figure 8 the x-axis represents daily average PM₁₀ concentrations and for each concentration point on the curve the corresponding y-axis value shows the proportion of points in the dataset which are of less or equal value. The y-axis starts at 0 and goes to 1, which is comparable to a 0 to 100 per cent scale. Each dataset to which the statistical treatment is applied generates a unique curve showing the frequency distribution.

Important features to compare are the shape of the curve, its position along the x-axis and how it is different from other curves in the same plot. For example, a dataset with overall lower PM₁₀ concentrations will produce a curve that is positioned more to the left of the graph than a curve representing overall higher PM₁₀ concentrations, which will be positioned further to the right. A steeper (more vertical) slope indicates that concentrations are clustered together while a flatter (more horizontal) curve indicates that concentrations are more spread out.

Comparing each site's curve in Figure 8, there is a clear differentiation with curves moving from left (less dust) to right (more dust) consistent with the site's distance from the port. Neptune is farthest away from the port with generally lower PM₁₀ concentrations (green curve) and Richardson is the closest to the port with generally higher PM₁₀ concentration (blue curve). The positions and shapes of the curves indicate lower to higher PM₁₀ dust concentrations from east to west.

This finding supports previous observations and the general conclusion that PM₁₀ levels on the peninsula are influenced by dust emissions from sources in the direction of the port, and the closer the monitoring site is to these sources, the stronger that influence.

For 2023, the frequency distribution analysis indicates that Richardson was the dustiest site and Neptune the least dusty site on the peninsula, with the other three sites reflecting intermediate levels of dustiness.

Figure 9 shows frequency curves for the years 2019–23 grouped by site. Richardson, Hospital, Taplin and Neptune have been chosen to represent peninsular sites for this data visualisation. Each site's graph contains five curves, one for each calendar year, except for Taplin where only four complete years of valid data are available within the range.

When comparing key features of the graphs in Figure 9, 2019 was consistently one of the dustiest years (excluding Taplin because of invalid data). At Taplin, the accumulated frequency curves indicate that 2023 was the dustiest of the last four years.

Neptune shows a slightly different pattern compared with the other peninsular sites, with 2023 being an intermediate year that was less dusty than 2020.

Accumulated frequency curves for non-peninsular sites are presented in Figure 10. Yule stands out as the least dusty location of all sites analysed, which is expected given it represents regional background and is not influenced by dust from port operations or town activities. Despite experiencing less dust overall, a clear differentiation between dusty and less dusty years is evident. Consistent with all other sites, 2019 was the dustiest year at Yule. This is followed by 2023 and 2020 as less dusty. The least dusty years were 2021 and 2022 at Yule.

BOM recorded significantly more dust than Yule but showed a similar pattern with 2019 and 2023 as the dustiest of the last five years. 2022 was an intermediate year, and 2020 and 2021 were the least dusty years at BOM.

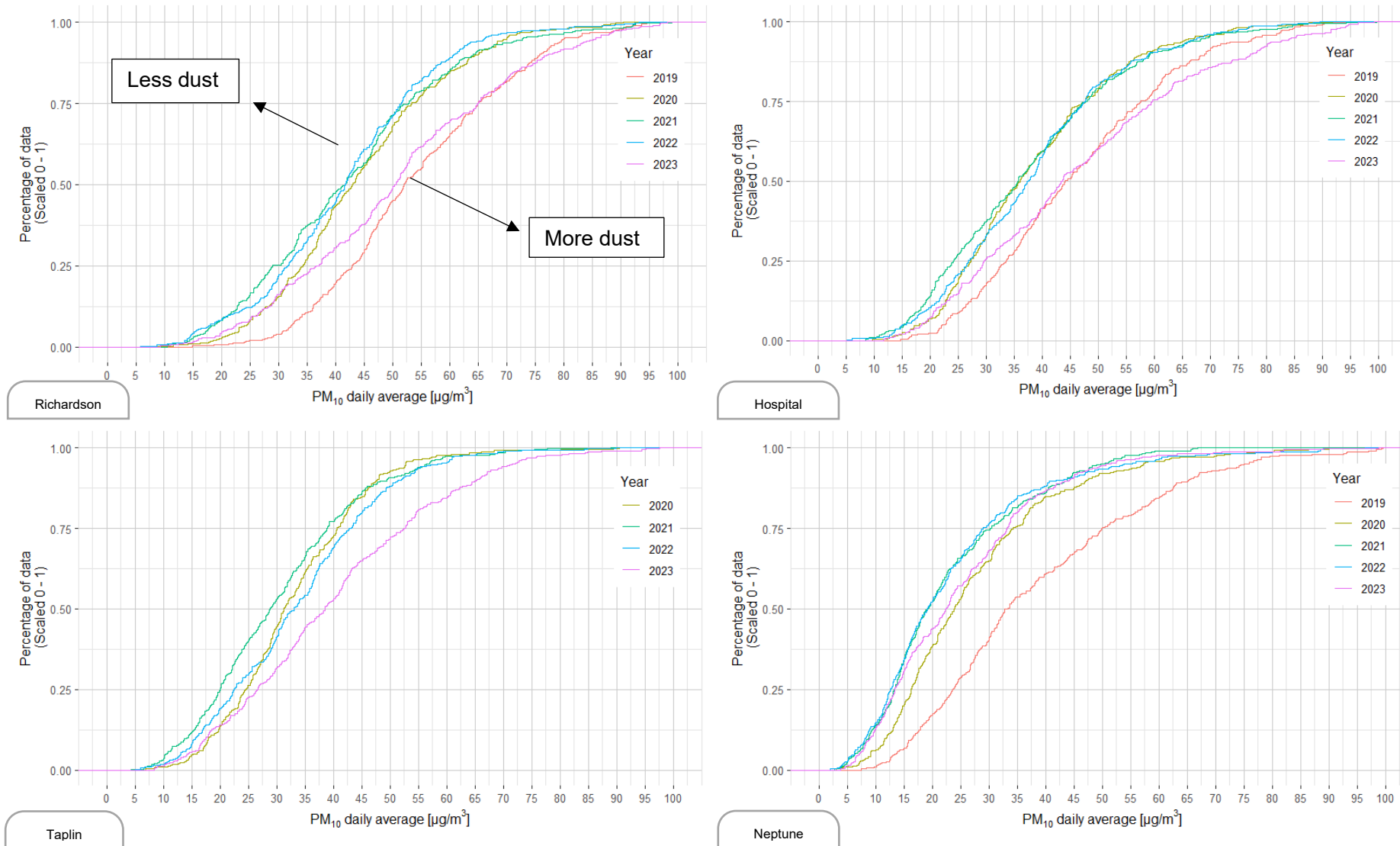


Figure 9 Accumulated frequency curves of PM₁₀ for peninsular locations for 2019–23

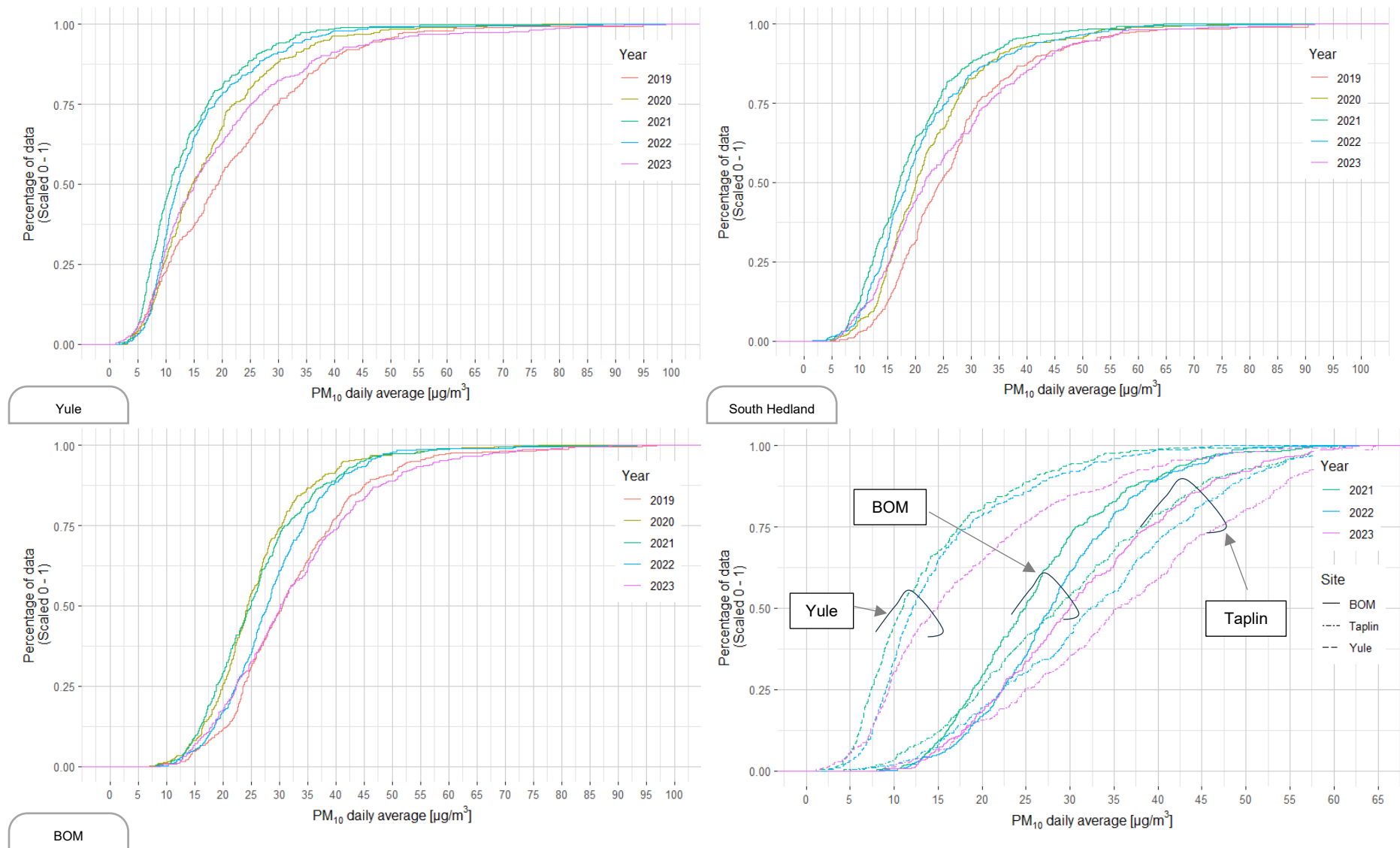


Figure 10 Accumulated frequency curves of PM₁₀ for selected non-peninsular locations for 2019–23 and comparison of Taplin with Yule and BOM for 2020–23

3.3 Particles as PM_{2.5}

PM_{2.5} is defined as particles with an AED of up to 2.5 µm. PM_{2.5} is a subfraction of PM₁₀ and therefore the PM₁₀ fraction consists of both coarse particles (PM₁₀ minus the PM_{2.5} fraction) and a fine particle fraction (PM_{2.5} only). Exposure to elevated levels of PM_{2.5} has been associated with adverse health effects.

PM_{2.5} can be generated from various sources. In urban environments, PM_{2.5} is mostly emitted from anthropogenic combustion sources such as motor vehicles and wood heaters. In non-urban areas, bushfires can be a significant source of PM_{2.5}. The proportion of PM_{2.5} in PM₁₀ in urban areas is often higher than the proportion found in regional areas because there are many more combustion sources that emit PM_{2.5} continuously in urban areas. While bushfires can significantly contribute to higher proportions of PM_{2.5} in regional PM₁₀, their occurrences are episodic and associated with major smoke events with high particle concentrations. In mining industry settings, PM_{2.5} emissions can be generated from processing of materials and from bulk handling of fine materials. Unlike PM_{2.5} emissions from bushfires, emissions from industrial activities are usually more constant and at lower concentrations.

The HRA recognised that in Port Hedland the proportion of PM_{2.5} in PM₁₀ is similar to other regional areas, which reflects the lower contribution from combustion sources (mainly motor vehicles) that is typical of large cities.

Data availability

Adequate data return rates are a prerequisite for valid data analysis.

Data availability rates for PM_{2.5} monitoring met the quarterly and annual thresholds with all rates above the minimum of 75 per cent for quarterly data and all annual rates above 90 per cent (Table 7). A cyclone shut down of monitors occurred in April 2023 during cyclone Isla, which affected the availability rates in quarter 2 of 2023.

Table 7 Data availability for PM_{2.5}

Monitoring station	Data availability rates (%)				
	Q1	Q2	Q3	Q4	Annual
Richardson	100	96.7	96.7	100	98.4
Kingsmill	NA				
Hospital	97.8	88.0	96.7	100	95.6
Taplin	100	91.2	96.7	100	97.0
Neptune	NA				
South Hedland	100	89.0	92.4	98.9	95.1
Wedgefield	NA				
BoM	100	92.3	95.7	100	97.9
Yule	100	81.3	92.4	100	93.4

NA = Not applicable (no monitor at this location)

Daily averages

PM_{2.5} monitoring data collected during 2023 are summarised as a simple statistic of AAQ NEPM daily guideline exceedance counts as presented in Table 8. There were exceedances of this guideline at all of the PM_{2.5} monitoring locations. This is in contrast to the results from 2022, when no exceedances were recorded. Similar to the PM₁₀ daily averaged guideline exceedances, the number of PM_{2.5} guideline exceedances was greatest at Richardson, closest to the port and lowest at Taplin, following a west-east gradient on the peninsula. Yule measured the lowest number of exceedances, followed by BOM and South Hedland.

Annual averages

Table 8 shows the annual average concentrations for each station to allow comparison with the AAQ NEPM annual guideline. Comparison against this guideline shows that all locations except South Hedland and Yule were above the guideline value. The general trend for the annual average shows a higher concentration in the west of the Port Hedland peninsula (Richardson) compared to farther east (Taplin). The lowest value occurred at Yule.

Compliance with the AAQ NEPM guidelines for PM_{2.5} has been assessed in Table 8. There was a substantial increase in PM_{2.5} in 2023 compared to 2022. In 2022 the only non-compliance with the AAQ NEPM guidelines for PM_{2.5} was for the annual average at Richardson.

Table 8 Comparison against PM_{2.5} guidelines

Monitoring station	Number of days > 25µg/m ³	Performance against AAQ NEPM Daily average 25 µg/m ³	Annual average (µg/m ³)	Performance against AAQ NEPM Annual average 8 µg/m ³
Richardson	17	not met	11.86	not met
Kingsmill	NA	NA	NA	NA
Hospital	15	not met	10.73	not met
Taplin	12	not met	8.25	not met
Neptune	NA	NA	NA	NA
South Hedland	11	not met	6.61	met
Wedgefield	NA	NA	NA	NA
BOM	11	not met	9.10	not met
Yule	8	not met	4.90	met

NA = Not applicable (no monitor at this station)

PM_{2.5} analysis

Figure 11 presents monthly summary statistics for PM_{2.5} hourly concentrations at Taplin in the form of a “box and whisker” plot for 2023 and for 2019–22. The plot includes minimum and maximum concentrations, median concentrations and selected percentiles. The height of the coloured boxes shows the data spread between the 25th and 75th percentiles. The extent of the whiskers indicates the minimum and maximum concentrations, with outliers removed for readability. The median hourly concentration is indicated by the horizontal bar located in each box.

A clear seasonal trend, with lower concentrations in winter and higher concentrations in summer is evident in both datasets. Higher ambient temperatures in summer (Figure 3) are likely to contribute to these increased concentrations.

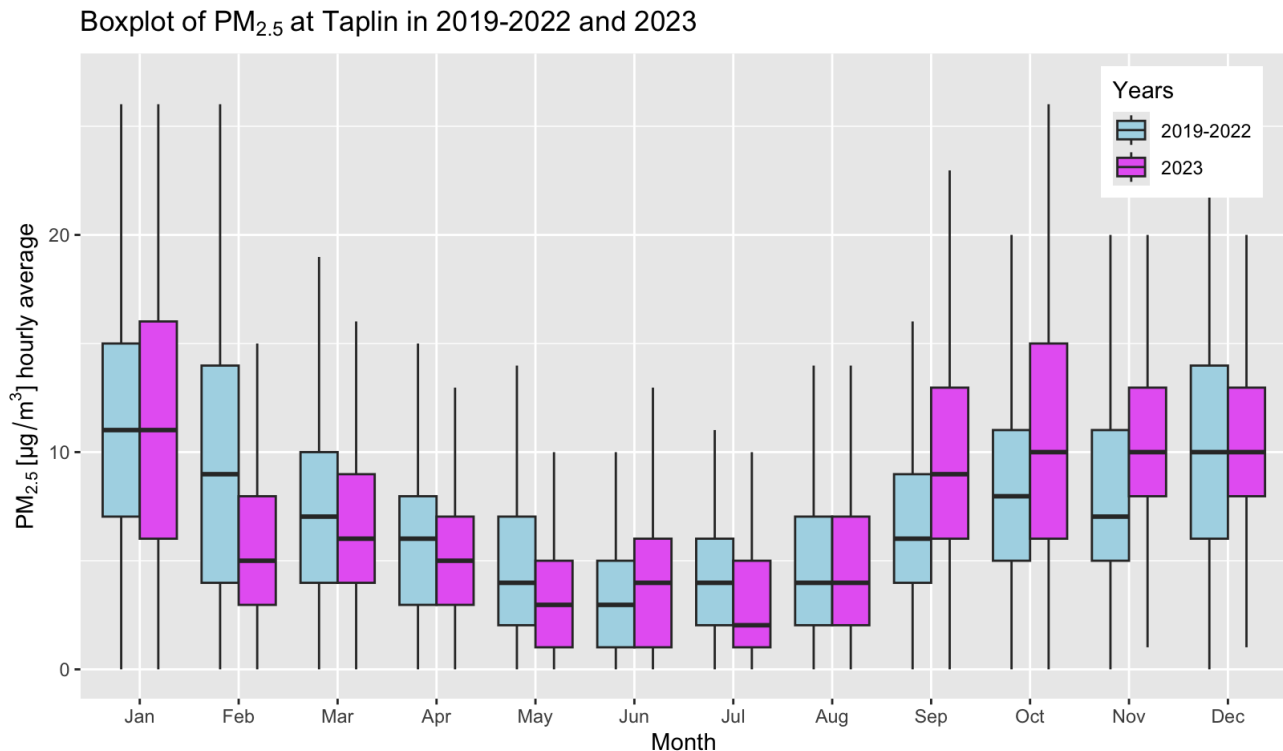


Figure 11 Comparison of monthly variability of PM_{2.5} hourly concentrations

Data for each month of 2023 can be compared with the previous four years of data for that month. This comparison indicates that dust concentrations were lower in February, May and July 2023 compared with corresponding data from the previous four years, but higher in June, September, October and November. The elevated concentrations in the second half of the year correspond with higher temperatures in these months compared to historical data (Figure 3). Dry and hot conditions are typically associated with higher airborne particle concentrations. Bushfires and prescribed burns are common events in the Pilbara that can create elevated concentrations of PM_{2.5} in smoke.

A possible reason for variation in PM_{2.5} concentrations is an increase in bushfire activity due to the hot and dry conditions. For example, a bushfire was reported at Strelley, south-east of the town of Port Hedland on 26 and 27 October 2023. This event is likely reflected in the monitored PM_{2.5} concentrations. All network locations exceeded the AAQ NEPM daily guideline of 25µg/m³ on those days. On 26 and 27 October Taplin recorded PM_{2.5} averages of 35 and 70µg/m³ while Yule recorded 49 and 69µg/m³ respectively. These high PM_{2.5} concentrations coincided with AGV exceedances at Taplin on both days.

Airborne particles created by combustion sources such as fires generally have a high proportion of PM_{2.5}. This means that the PM_{2.5}/PM₁₀ ratio can be used as an indicator of the contribution from combustion sources when analysing PM_{2.5} and PM₁₀ monitoring data. That is, a higher ratio value indicates a higher proportion of PM_{2.5} and therefore combustion sources may be an important cause of elevated particle concentrations. A lower ratio value indicates a lower proportion of PM_{2.5} and therefore combustion sources are not likely to be a major contributor to elevated particle concentrations.

To investigate whether fine particles ($PM_{2.5}$) played a significant role in PM_{10} events that exceed guidelines, a targeted statistical approach examining $PM_{2.5}/PM_{10}$ ratios is applied. The approach is illustrated and explained in Figure 12 Figure 12.

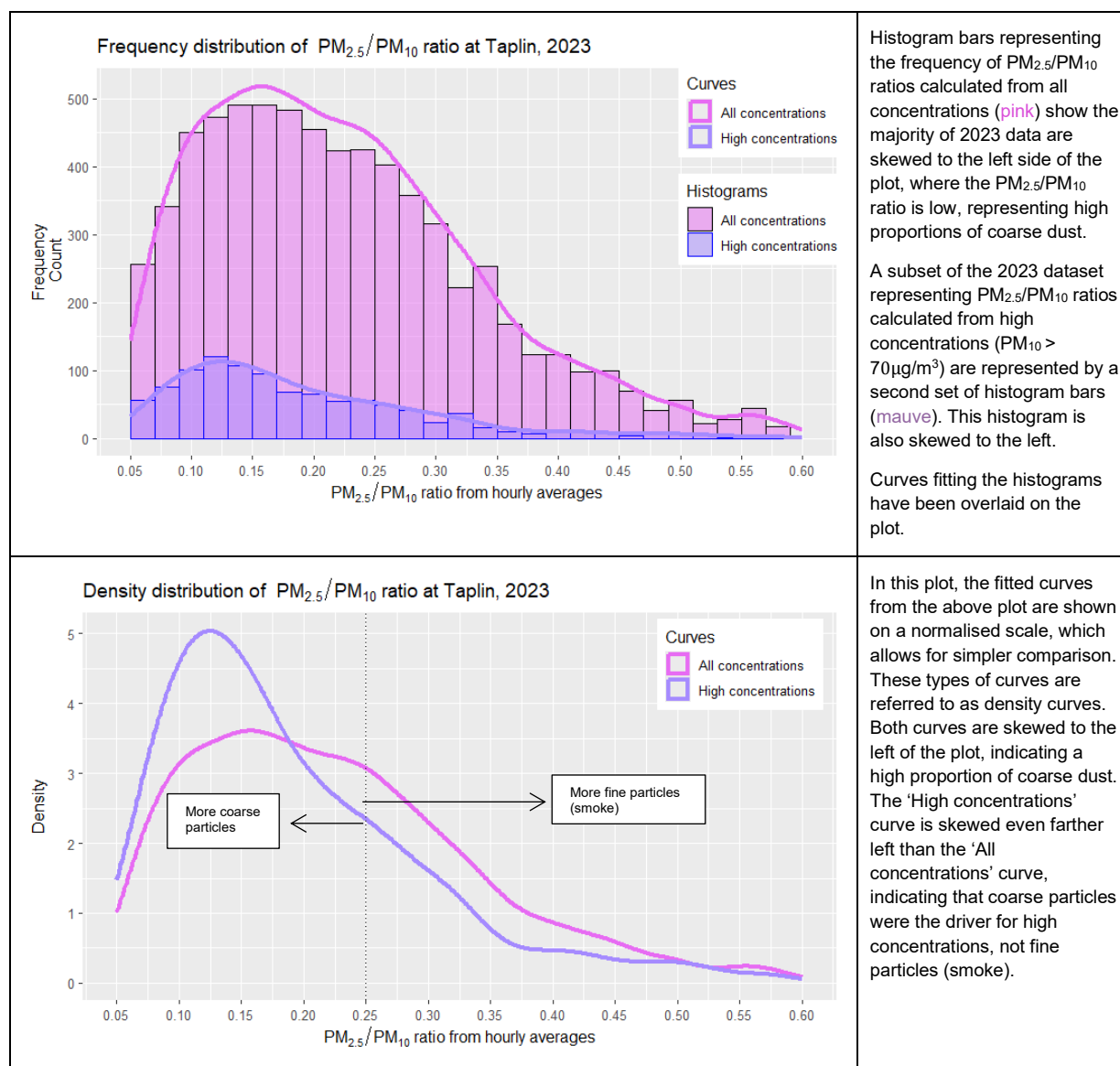


Figure 12 Analytical approach to investigate the contribution of $PM_{2.5}$ to elevated particle concentrations

In Figure 13, the ratio data are presented as density curves, which show the frequency distribution of the ratio values. The $PM_{2.5}/PM_{10}$ ratio is displayed on the x-axis while the frequency is displayed on the y-axis.

Two graphs are provided for each monitoring site, with graph (a) (left side) using all available data and graph (b) (right side) only using data where PM_{10} hourly averages were greater than $70\mu g/m^3$. The (b) graphs therefore only include $PM_{2.5}/PM_{10}$ ratio values for this subset of data, so that we can specifically examine ratios at higher PM_{10} concentrations. For each site there are five annual curves reflecting 2019–23, except for Taplin where only 2020–23 data were available.

Each curve is generated using available hourly average concentration data for a selected calendar year. The “N” values shown in the graph legends are the number of data points used to generate the curves. To achieve optimal graphing the x-axes have been truncated so that the key features of the curves are appropriately scaled for visual examination.

Interpretation of key features of density curves

An important feature of the curve is its peak, which shows where the most common ratio occurs. If the peak of the curve is to the left side of the graph, it means that lower $PM_{2.5}/PM_{10}$ ratio values are more common in the sample. A low $PM_{2.5}/PM_{10}$ ratio means that there is a small proportion of $PM_{2.5}$ in the PM_{10} fraction of particle mass. If the peak of the curve is at the right side of the graph, it indicates that there are more of the higher $PM_{2.5}/PM_{10}$ ratio values, meaning higher proportions of $PM_{2.5}$ in the PM_{10} fraction.

For example, Figure 13 graphs (a) and (b) for Richardson show that there were higher proportions of $PM_{2.5}$ in the PM_{10} fraction in 2023 (pink curve) than for all other years. Graph (a) for Yule shows that the peak in 2023 (pink curve) is to the right of all other curves, indicating that there were overall higher proportions of $PM_{2.5}$ in PM_{10} for that year compared to earlier years.

A curve with a narrow tall peak indicates a higher frequency of closely clustered values, whereas a flatter plateau-like peak describes a broader spread of values from lower to higher. Examples of curves with tall narrow peaks are illustrated in the (b) graphs for Richardson and BOM. Examples of flatter curves are shown in the (a) graph for Richardson for 2023, Hospital for 2019 and Yule for 2019, 2021, 2022 and 2023.

Variability in ratios

Reviewing the (a) graphs in Figure 13 allows comparison of annual and spatial variability. Generally, the lowest $PM_{2.5}/PM_{10}$ ratios occurred in 2020 and 2021 at most sites, indicating a lower contribution of $PM_{2.5}$ to overall PM_{10} in those years. The identification of years with highest $PM_{2.5}$ contributions is not consistent across all sites. For example, $PM_{2.5}$ contributions were highest in 2019 for Yule, BOM and Hospital, but not for Richardson where 2023 was higher. For the background sites BOM and Yule, 2019 and 2023 were high $PM_{2.5}$ years.

As evident in Figure 13 (a) graphs for BOM and especially for Yule, the background sites show a greater influence from $PM_{2.5}$ concentrations than the other sites. Given that the likely source of regional $PM_{2.5}$ is from smoke, the curves indicate that smoke from bushfires was a discernible contributor to overall dust (PM_{10}) in 2023, with this influence most prominent at the background sites.

Likely reasons for this pattern are that bushfires may have occurred closer to the background sites than the peninsular sites and that the peninsular sites, which are in close proximity to port operations may receive a larger proportion of coarse particles than background sites, making the influence of fine particles from smoke less prominent.

Ratios at higher PM_{10} concentrations

To further understand the influence of fine particles on overall particle levels during periods of elevated concentrations, a subset of data where PM_{10} hourly averages were high ($>70 \mu\text{g}/\text{m}^3$) are

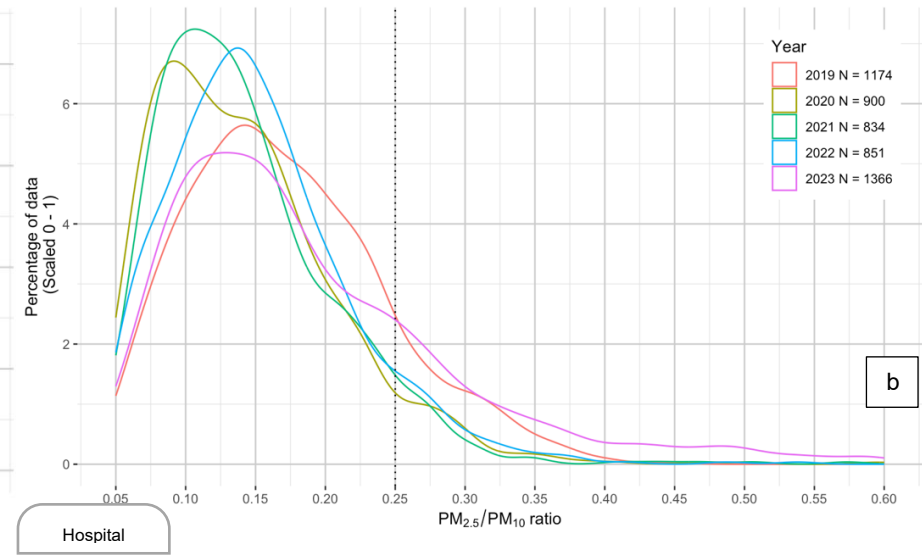
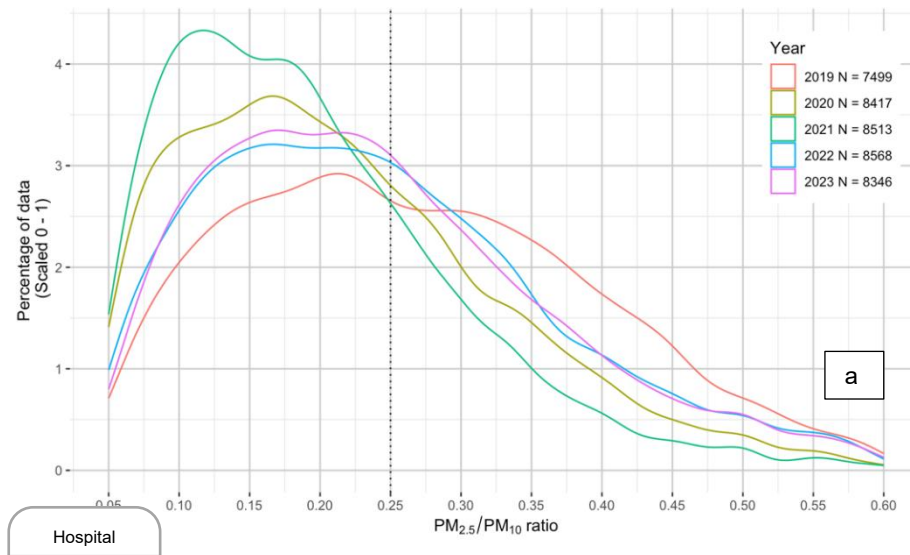
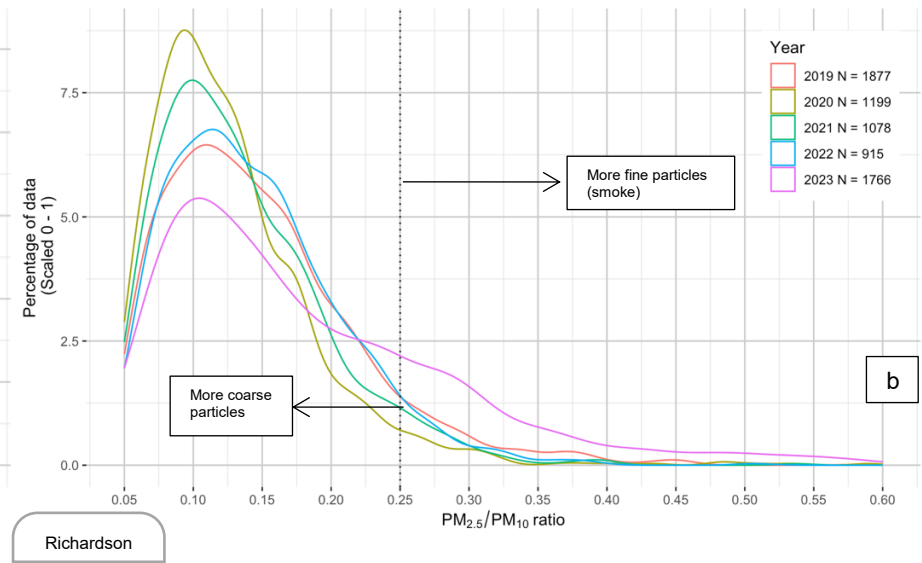
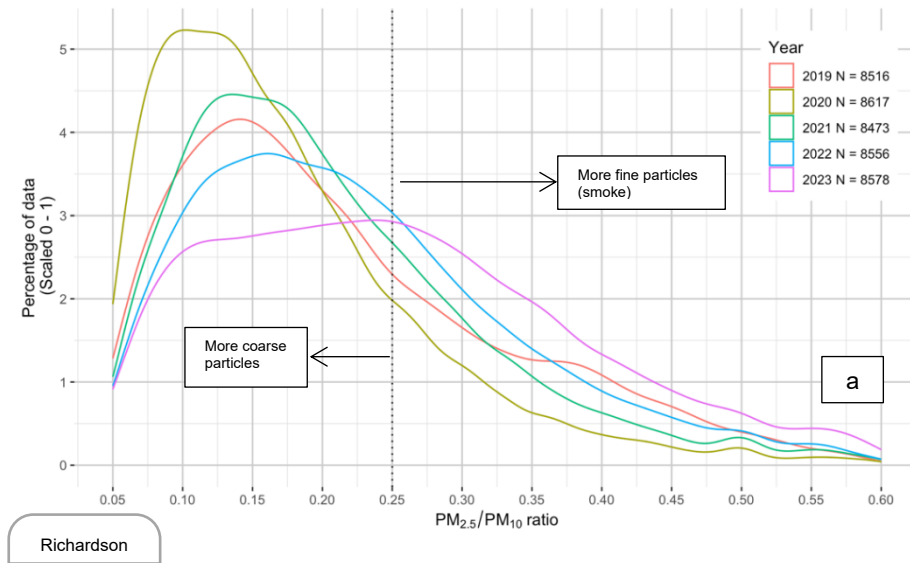
presented in the Figure 13 (b) graphs. The objective of this analysis is to assess whether the $PM_{2.5}/PM_{10}$ ratio changes when dust concentrations are higher.

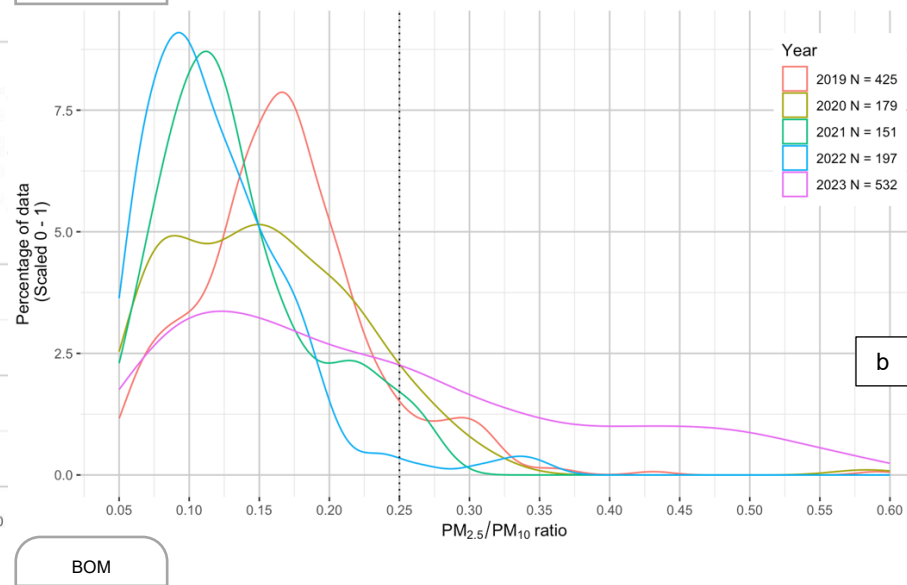
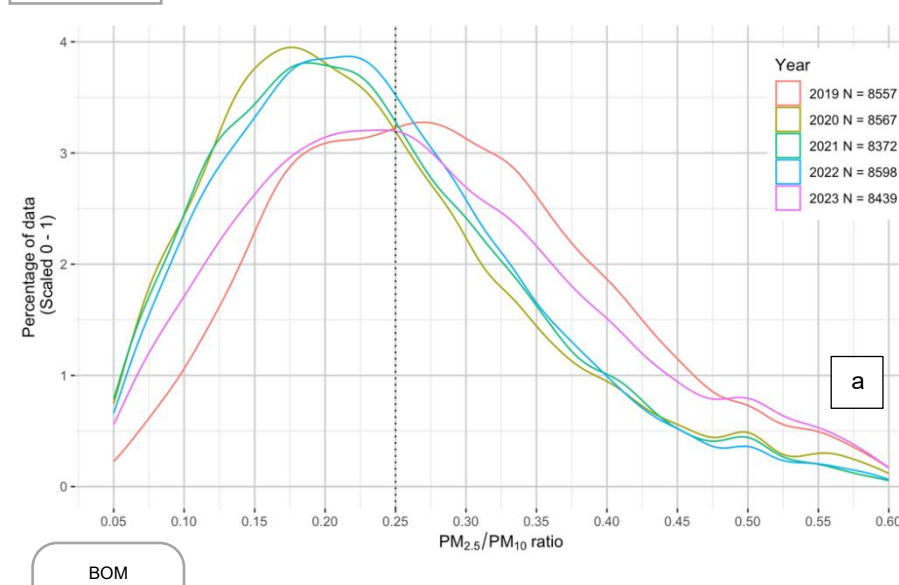
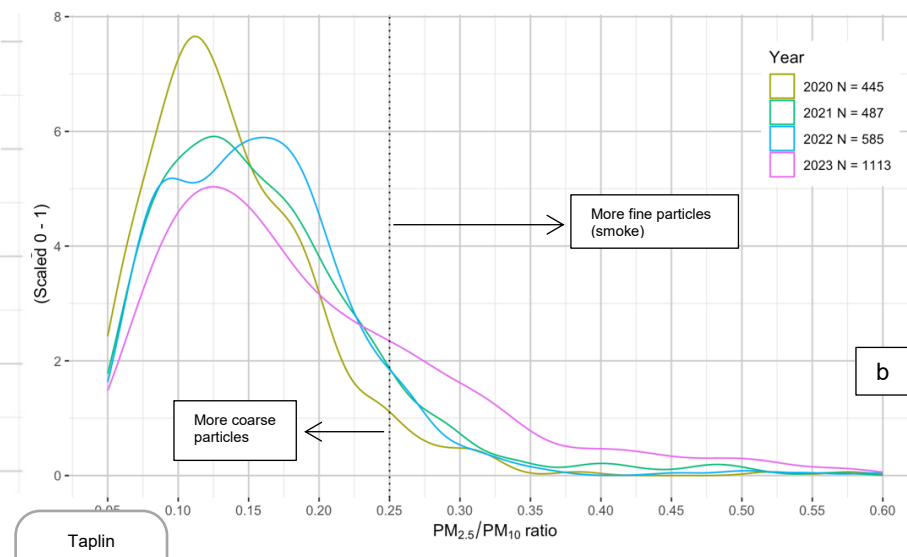
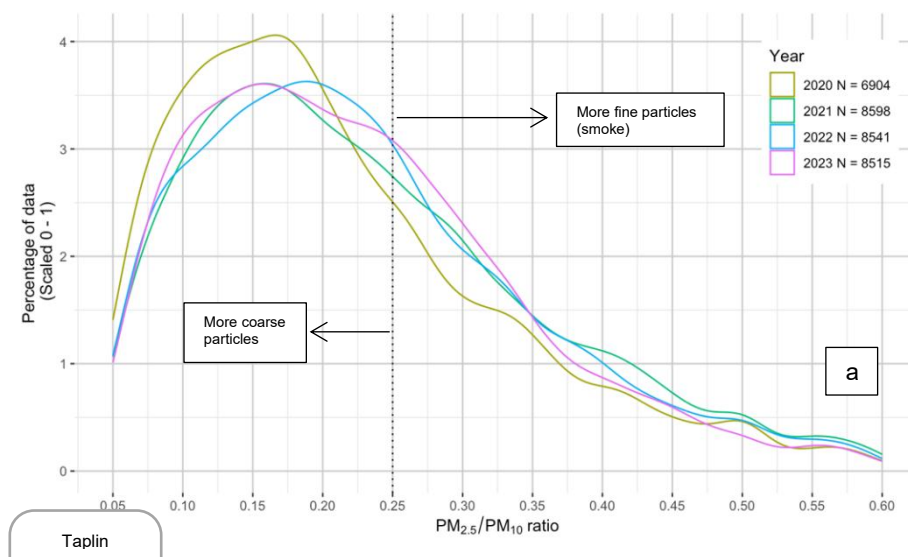
If $PM_{2.5}/PM_{10}$ ratios are higher when PM_{10} concentrations are high, then this would result in differences between the (a) and (b) curves, with (b) curves having peaks shifted to the right. If the curves for the (a) and (b) graphs are similar, or if (b) curves have peaks more to the left side of the graphs, this would mean that $PM_{2.5}$ is not a more significant contributor to high PM_{10} concentrations.

When comparing the (a) and (b) graphs for the peninsular locations, it is evident that they are similar, and that the curve peaks for the (b) graphs are on the left side. This indicates that higher PM_{10} concentrations at these locations are driven by the coarse particle fraction of PM_{10} , not the $PM_{2.5}$ fraction. When comparing the 2023 curves of (b) graphs with the curves from previous years, skewing of 2023 curves to the right is noticeable. This indicates a greater influence of $PM_{2.5}$ on high PM_{10} concentrations. For example, at Taplin, the curves in the (b) graphs all have their peaks at the left side of the graphs but the 2023 curve's peak is lower and the curve is skewed to the right.

While the skewing of 2023 curves in (b) graphs is moderate for the peninsular sites, it is strong for the background sites BOM and Yule, indicating a stronger influence of $PM_{2.5}$ on high PM_{10} concentrations. For Yule the 2023 curve is bimodal (showing two distinct peaks), with one to the left and one to the right of the graph. This indicates that two types of dust events occurred in 2023, those caused by coarse and those caused by fine particles.

Dust events at the regional background station Yule could be attributed to both dust fractions, with some events dominated by coarse dust and others by fine particles in smoke.





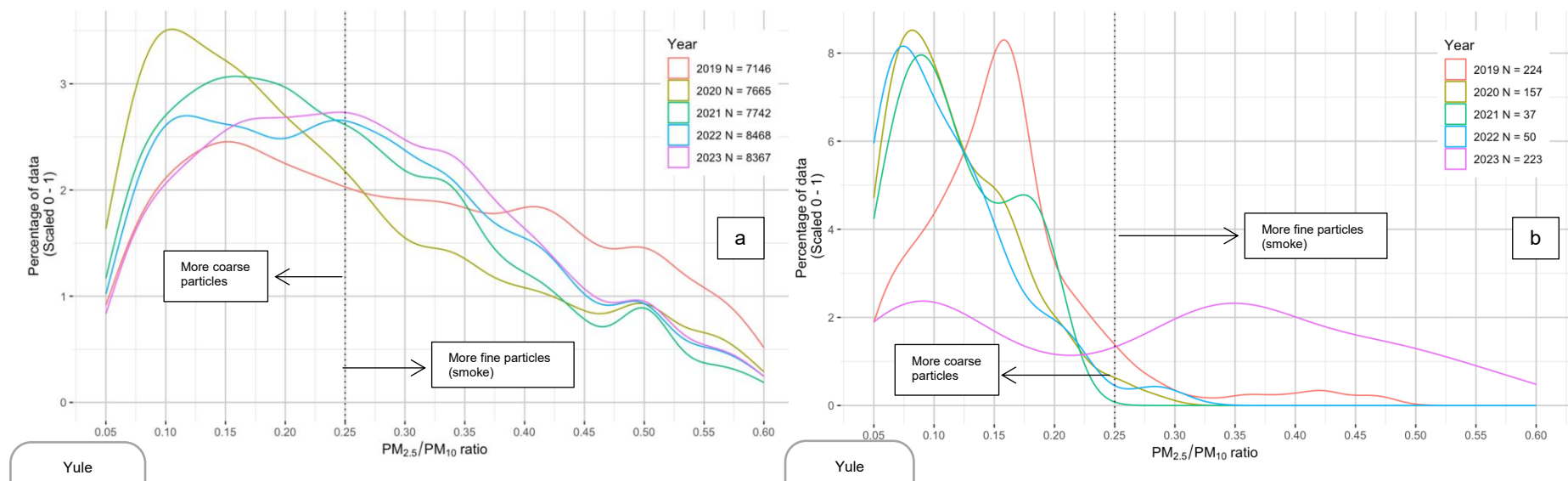


Figure 13 Comparison of PM_{2.5}/PM₁₀ ratio as density curves

3.4 Nitrogen dioxide

Nitrogen oxides, comprising nitric oxide (NO) and nitrogen dioxide (NO₂) 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 NO₂ is an air pollutant. NO₂ is monitored at Taplin and at Richardson in Port Hedland.

Data availability

Adequate data availability rates are a prerequisite for valid data analysis.

Data availability rates for NO₂ monitoring met the thresholds with rates above 80 per cent for all annual and quarterly data (Table 9).

Table 9 Data availability for NO₂

Monitoring station	Data availability rates				
	Q1	Q2	Q3	Q4	Annual
Richardson	88.9	94.5	97.8	100	95.3
Taplin Street	85.6	87.9	95.7	100	92.3

Concentrations compared against guidelines

A summary of NO₂ concentrations and comparison with the AAQ NEPM guidelines at Taplin and Richardson is presented in Table 10. The maximum 1-hour average and the annual average concentrations were lower than the guidelines, with the maximum hourly concentration at Richardson reaching about 84% of the hourly guideline.

Table 10 NO₂ concentrations compared with guidelines at Taplin

Monitoring station	Max 1 hr average NO ₂ ppb	Comparison with AAQ NEPM 1 hr average 80 ppb	Annual average NO ₂ ppb	Comparison with AAQ NEPM annual NO ₂ 15 ppb
Richardson	67.0	met	9.0	met
Taplin	50.9	met	8.2	met

NO₂ trend analysis

Figure 14 presents monthly summary statistics for NO₂ hourly concentrations at Taplin in the form of a “box and whisker” plot for 2023 and for 2019–22. The plot includes minimum and maximum concentrations, median concentrations, and selected percentiles. The height of the coloured boxes shows the data spread between the 25th and 75th percentiles and the extent of the whiskers indicate the minimum and maximum concentrations, with outliers removed. The median hourly concentration is indicated by the horizontal bar located in each box.

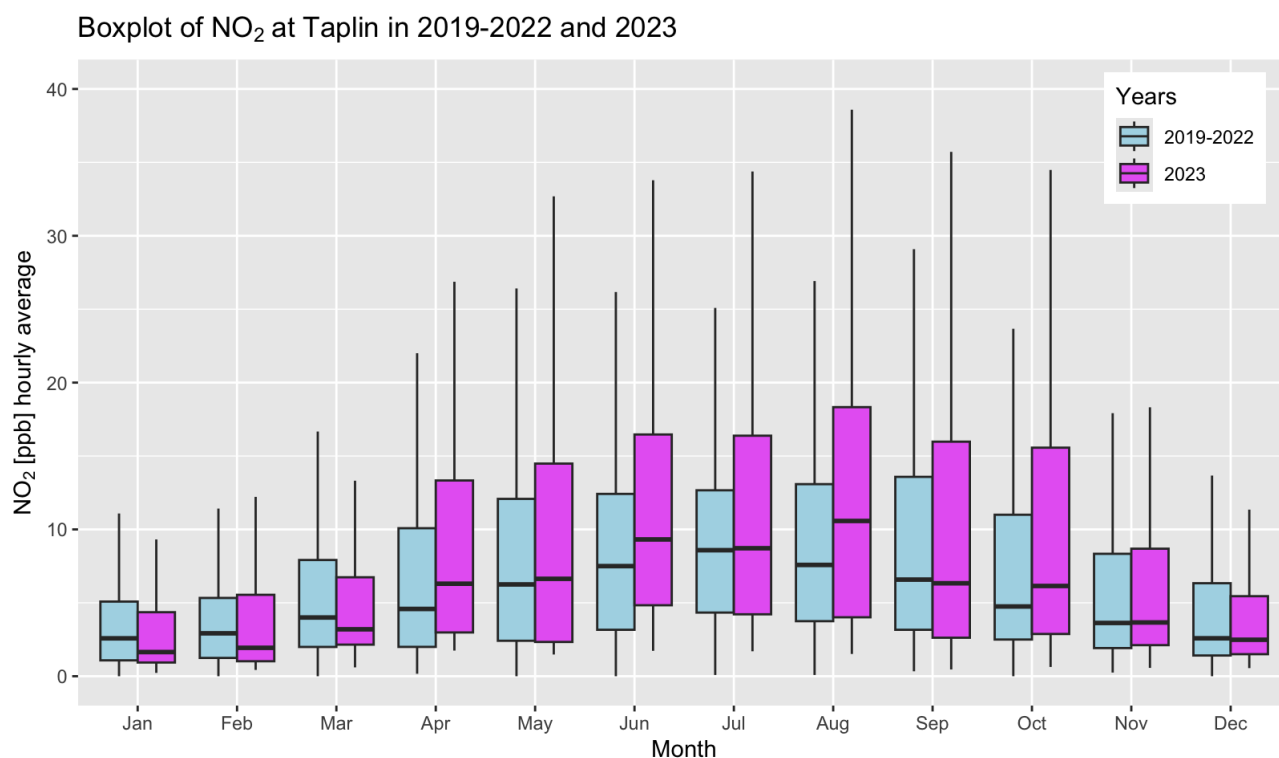


Figure 14 Variability of NO₂ hourly average by month at Taplin

The 2023 and 2019–22 datasets are broadly similar with generally higher NO₂ concentrations in winter than in summer. June, August and October 2023 had higher concentrations compared with the corresponding data from 2019–22.

Reduced concentrations of NO₂ in summer occur because of photochemical reactions under the influence of high solar radiation that produce ozone, which is formed from NO₂. Seasonal changes in the predominant wind direction can also influence NO₂ concentration, where the change in wind direction places the monitor downwind from emission sources.

3.5 Sulfur dioxide

The largest anthropogenic source of SO₂ 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 SO₂ emissions.

Data availability

Adequate data availability rates are a prerequisite for valid data analysis.

Data availability rates for SO₂ monitoring met the thresholds with rates above 85 per cent for all annual and quarterly data (Table 11).

Table 11 Data availability for SO₂

Monitoring station	Data availability rates (%)				
	Q1	Q2	Q3	Q4	Annual
Richardson	97.8	94.5	94.6	96.7	95.9
Taplin	92.2	85.7	95.7	100	93.4

Concentrations compared against guidelines

A summary of SO₂ concentrations and compliance with the AAQ NEPM guidelines at Taplin and Richardson is presented in Table 12. Both the maximum 1-hour average and the daily average concentrations were well below the guidelines.

Table 12 Maximum 1 hr average and maximum daily average for SO₂ at Richardson and Taplin

Monitoring Station	Max 1 hr average SO ₂ [ppb] AAQ NEPM 100 ppb	Max daily average SO ₂ [ppb] AAQ NEPM 20 ppb
Richardson	12.2	4.1
Taplin	10.4	2.0

SO₂ trend analysis

Figure 15 presents monthly summary statistics for SO₂ hourly concentrations at Taplin and Richardson in the form of a “box and whisker” plot for 2023. The plot includes minimum and maximum concentrations, median concentrations, and selected percentiles. The height of the coloured boxes shows the data spread between the 25th and 75th percentiles and the extent of the whiskers indicate the minimum and maximum concentrations, with outliers removed. The median hourly concentration is indicated by the horizontal bar located in each box.

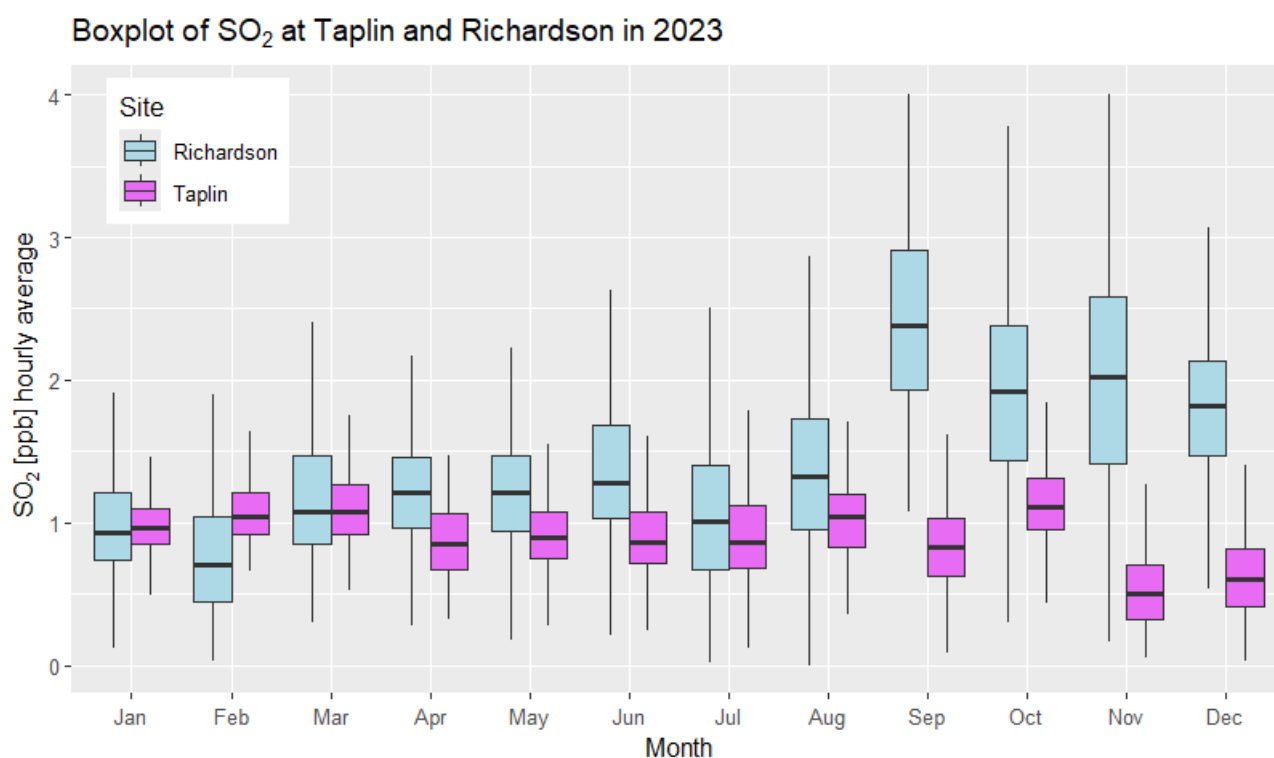


Figure 15 Variability of SO₂ hourly average by month at Taplin and Richardson

Noting the overall low levels of SO₂, the monthly data show a low level of variability at Taplin with higher concentrations in January, February, March and October, and lower concentrations in November and December. Richardson recorded higher concentrations than Taplin for most months which is particularly evident for the months September to December. Differences in site specific concentrations can be related to proximity to emission sources, noting that Richardson is closer to the port and shipping activities. The monthly pattern for SO₂ does not align with any of the other monthly pollutant trends. The analysis of future years' data may assist in discovering meaningful patterns.

Glossary

Term	Description
Air Quality Guideline (AGV)	Daily average of 70 $\mu\text{g}/\text{m}^3$ PM₁₀ applied to residential areas, wherever people live on a permanent basis, excluding natural events. In departmental documents, also referred to as Port Hedland AGV. Defined and endorsed for continuing implementation in: <u>Port Hedland Dust Management Taskforce Report</u>
Daily average	The daily averaged concentrations of pollutants are calculated based on hourly data over a 24-hour period, from midnight to midnight. Concentrations are referenced by the time at the end of the averaging period. The end time of the averaging period determines the calendar day to which the averaging periods are assigned
Dust	A generic term used in this report synonymously with PM₁₀ describing particles that have an aerodynamic equivalent diameter of up to 10 μm.
Micrograms per cubic metre ($\mu\text{g}/\text{m}^3$)	Measurement unit used to quantify concentrations as mass per unit volume. In this report, applied to concentrations of dust and particles. A concentration of 1 $\mu\text{g}/\text{m}^3$ means that one cubic metre of air contains one microgram of dust/particles.
Natural or exceptional event	Defined in the Regulatory Strategy as: <i>Consistent with the National Environment Protection (Ambient Air Quality) Measure, natural events are defined as bushfires, jurisdiction authorised hazard reduction burning, or continental-scale windblown dust.</i> Natural event has the same meaning as exceptional event.

Parts per billion (ppb)	Measurement unit describing concentrations. In this report, applied to gas concentrations of NO ₂ and SO ₂ . A concentration of 1 ppb means 1 part of gas per billion parts of air.
Particles	In air quality, the word “particle” commonly refers to very small solid particles of earth, organic matter, manufactured products, waste matter or combustion derived particles that may become airborne by natural forces (such as wind) and/or by mechanical processes (such as crushing, grinding, milling, conveying, stockpiling or haulage). The general term for these types of particles is “dust”. Particles are also known as particulate matter (PM).
PM ₁₀	Describes a size fraction of particles, specifically particles with an aerodynamically equivalent diameter up to 10 µm.
PM _{2.5}	Describes a size fraction of particles, specifically particles with an aerodynamically equivalent diameter up to 2.5 µm. Smoke from bushfires can contain large amounts of these fine particles.
Peninsula	Describes the geographical location of Port Hedland including the West End and East End. The monitoring stations at Richardson, Kingsmill, Hospital, Taplin and Neptune are referred to as peninsular stations in this report.
Port emissions	General term used for emissions from the port, also referred to as industry emissions.
Regulatory Strategy	A document published by the department. It outlines the application of the AGV Guideline. The assessment of exceedences of the AGV are based on the Regulatory Strategy

Appendix

Exceedance analysis

The method used by the department to attribute exceedances to different source categories is described below. Selected data examples are used to illustrate the approach.

Exceptional event attribution

The term exceptional event is defined in the *National Environment (Ambient Air Quality) Protection Measure* (AAQ NEPM) as “a fire or dust occurrence that adversely affects air quality at a particular location, and causes an exceedance of 1 day average standards in excess of normal historical fluctuations and background levels, and is directly related to: bushfire; jurisdiction authorised hazard reduction burning; or continental scale windblown dust.”

The AAQ NEPM is available at <https://www.legislation.gov.au/F2007B01142/2016-02-03/text>

The department’s use of the term exceptional event in Port Hedland is derived from the above definition and is adapted to the Port Hedland context, where the one-day average standard relates to the AGV, not the PM₁₀ average (AAQ NEPM guideline) and where the ambient monitoring network is designed to detect influences on air quality from port emissions.

This is a point of difference between the Port Hedland network and a typical NEPM network, which has its performance monitors not generally placed in close proximity to industry emissions.

An assessment of an exceptional event is informed by simultaneous exceedance of the AGV at Taplin Street (TA) and at Yule (YU) monitors. Examples of how the department assesses exceptional events based on data from the ambient monitoring network is provided in Table 13 and Table 14

Table 13 Example 1: Exceptional event – Dust Storm

Comparison of daily averages [ug/m ³] across sites			Assessment
Site	Pollutant		The comparison of sites shows that exceedances occurred at Taplin and at Yule River (a background station not influenced by port emissions.) It is therefore likely that there was a dust storm, comparable to what the AAQ NEPM describes as continental scale windblown dust, which affected the Pilbara region on the day. PM_{2.5} concentrations were relatively low indicating that the main contribution to the exceedance was from the coarse fraction of PM₁₀. <u>Conclusion:</u> Exceptional event (dust storm)
	PM ₁₀	PM _{2.5}	
RI	79	15	
KI	71	NA	
HO	81	13	
TA	124*	19	
NE	57	NA	
SH	65	13	
BOM	72	15	
YU	115	22	
* Red indicates exceedance of AGV			

Table 14 Example 2: Exceptional event - Bushfire

Comparison of daily averages [ug/m ³] across sites			Assessment
Site	Pollutant		The comparison of sites shows that exceedances occurred at Taplin and were widespread across the network sites, including Yule River. PM_{2.5} concentrations were elevated across the network sites, including Taplin and Yule River. The PM_{2.5}/PM₁₀ ratio at Taplin was 0.5. High PM_{2.5} concentrations and high PM₁₀/PM_{2.5} ratios indicate a substantial contribution of fine particles to the exceedance. Fine particles are present in smoke from fires. It is therefore likely that there was a bushfire, which substantially contributed to the exceedance at Taplin.
	PM ₁₀	PM _{2.5}	
RI	157	76	
KI	187	NA	
HO	188	80	
TA	133*	75	
NE	110	NA	
SH	132	75	

BOM	140	72	Conclusion: Exceptional event (bushfire)
YU	115	69	
* Red indicates exceedance of AGV			

Identification of regulatory events

The remaining exceedances, which are not classified as exceptional events, are further analysed to assess whether industry emissions or non-industry dust was a more substantial contributor to the exceedance.

The following key data and assessment concepts are considered in the assessment of exceedance attribution to background or industry.

1) Review of time series data

In addition to the daily averages recorded at network locations as shown in the examples for exceptional event assessment, 10-minute average data for PM₁₀, wind speed and wind direction are visualised. Figure 16 illustrates these time series data for an exceedance day.

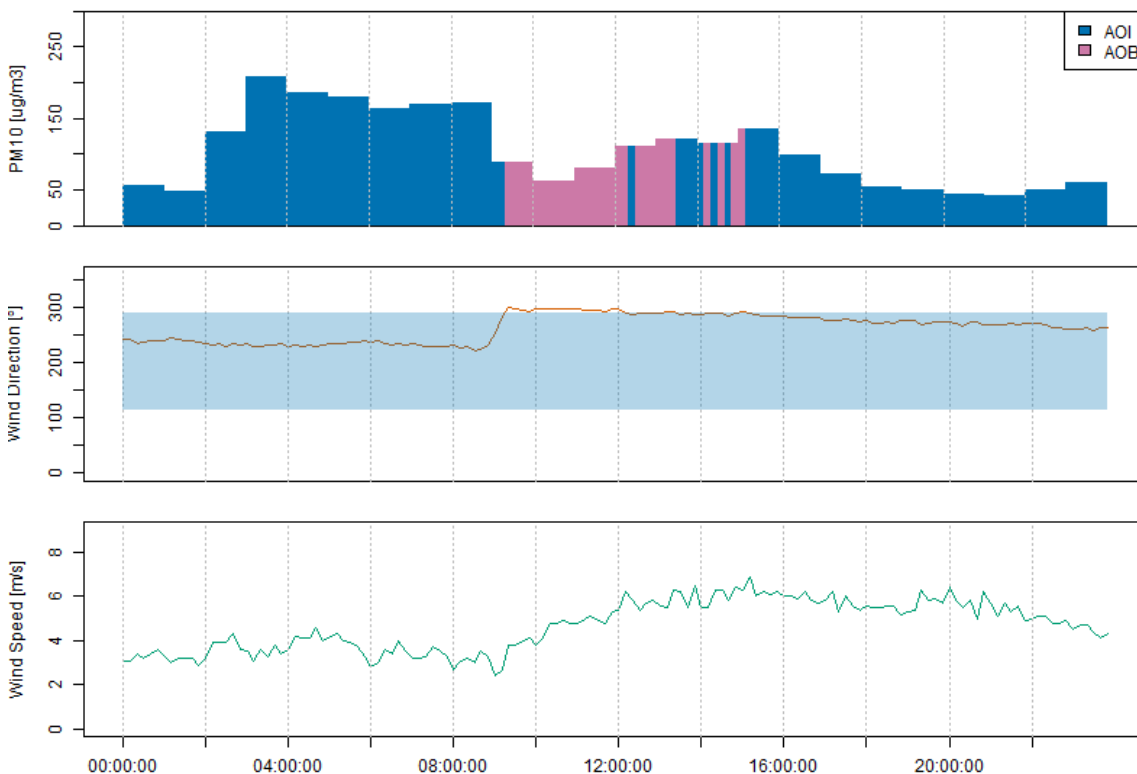


Figure 16 Summary graph for PM₁₀, wind direction and wind speed as 10-min average data

Note: AOI = Arc of industry influence (115° - 290°), AOB = Arc of background

Time series data for PM₁₀, wind direction and windspeed allow interpretation of dust concentrations in relation to changing meteorological conditions throughout the exceedance day. The association of a wind direction with each PM₁₀ data point helps interpret the locations of contributing dust

sources. In particular, this aids the assessment of whether substantial contributions to the overall dust concentration for that day have likely come from the port prescribed premises.

2) Attribution according to wind arcs

The arc of influence (AOI) refers to a defined sector within which windblown dust from a specific location is likely to travel towards and potentially impact a defined receptor. For the purpose of this guideline, the Taplin Street monitor is used as the primary indicator of potential dust impacts on receptors.

A combined arc of industry influence, ranging from 115° to 290° has been defined. It encompasses all individual premises.

Figure 17 illustrates the method of dust attribution whereby dust concentrations generated while the wind is blowing from the arc of industry influence, are attributed to industry. Figure 17 shows industry attribution in blue.

In Figure 17 these attributions are summed for the exceedance day, attributing dust load percentages to industry and background.

A contribution from industry is considered substantial when it is >50% of the total contribution. This result is shown in Figure 17 for the example exceedance day.

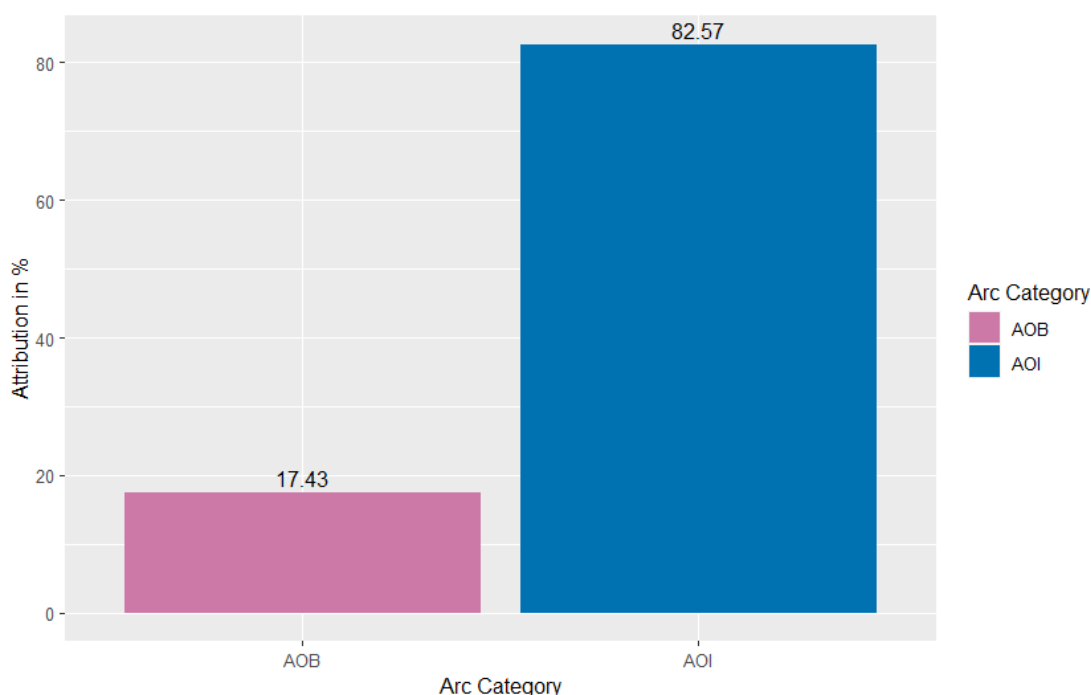


Figure 17 Dust load attribution according to arc of influence

3) Background exceedances and local sources

Exceedances at the background monitor Yule River are often indicative of regional dust events but all network monitors can experience exceedances from local sources near the monitor. Whether such local sources have substantially contributed to an exceedance at Taplin Street requires a review of time series data from other monitors located in the pathway of the presumed local source and Taplin Street.

Alternatively, an exceedance at Taplin Street with no corresponding elevated dust concentrations at nearby monitors could be caused by a nearby source.

The department undertakes further data analyses as required to assess each exceedance.

Example: Exceedance day November 2023

An example of where further analysis involving time series data from several network locations was used when assessing an exceedance at Taplin is the exceedance day during November 2023. A comparison of concentrations at Taplin and Yule indicated that it was not an exceptional event, owing to the PM₁₀ concentration at Yule being below the AGV threshold and due to identifying that a substantial dust contribution was from the arc of industry influence.

Site	PM ₁₀ 24hr average [µg/m ³]
Taplin	76
Yule	63
BOM	67

However, a comparison of time series data from Taplin, Yule and BOM (Figure 18) shows that there was a short-term background dust event that is reflected in both Yule and BOM time series data. This short-term event has likely substantially contributed to the exceedance at Taplin.

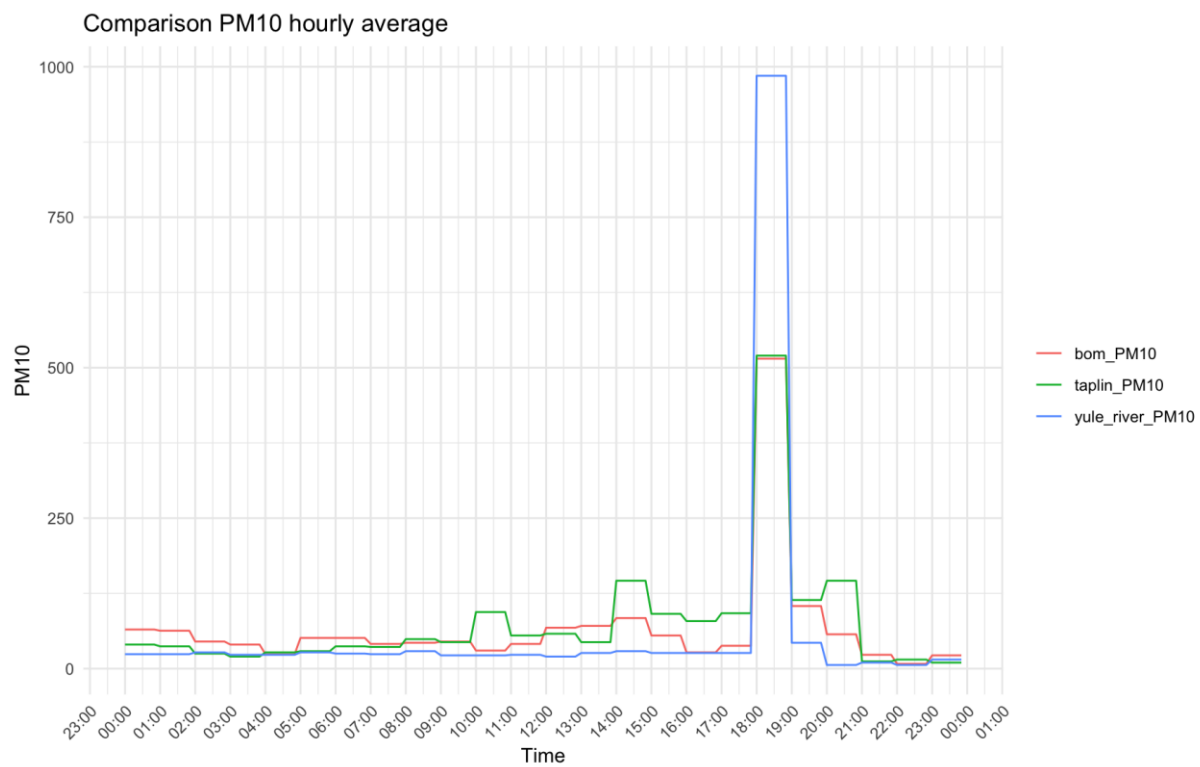


Figure 18 Hourly averages for Taplin Street, BOM and Yule River

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