



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

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Western Australia.*

2018 Western Australian air monitoring report  
Annual report under the National Environment Protection  
(Ambient Air Quality) Measure

October 2019

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(Ambient Air Quality) Measure

Department of Water and Environmental Regulation  
October 2019

Department of Water and Environmental Regulation  
Prime House, 8 Davidson Terrace  
Joondalup Western Australia 6027  
Locked Bag 10 Joondalup DC WA 6919

Phone: 08 6364 7000

Fax: 08 6364 7001

National Relay Service 13 36 77

[dwer.wa.gov.au](http://dwer.wa.gov.au)

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## Summary

As a signatory to the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM), Western Australia must report annually on the results of air monitoring.

The Department of Water and Environmental Regulation operates and maintains 14 air quality monitoring sites in Western Australia with a total capital cost of more than \$1.5 million. Eight of these sites – Caversham (Ca), Duncraig (Du), Quinns Rocks (QR), Rolling Green (RG), Rockingham (Ro), South Lake (SL), Swanbourne (Sw) and Wattleup (Wt) – are within the Perth metropolitan region. The remaining six are located in Albany (Al), Bunbury (Bn), Busselton (Bs), Collie (Co), Geraldton (Ge) and Kalgoorlie (Kg).

The QR site was decommissioned in early 2017 due to redevelopment of the site. The department will recommission the site at another suitable location in 2019.

In December 2017 we commissioned a site in Kalgoorlie. The site contains instruments to monitor PM<sub>10</sub> and PM<sub>2.5</sub> particles, carbon monoxide and sulfur dioxide.

During the calendar year 2018, the AAQ NEPM goal was not met for PM<sub>10</sub> particles at Albany, Caversham and Geraldton. PM<sub>2.5</sub> particles did not meet the AAQ NEPM goal at Bunbury, Busselton and Kalgoorlie.

Across all monitoring sites there were 42 exceedences in 2018, comprising 21 exceedences of PM<sub>10</sub> particles (including 18 exceptional events) and 21 of PM<sub>2.5</sub> particles (including 18 exceptional events).

Of the 36 particle exceedences that were classed as exceptional events, prescribed burning activities accounted for 27, bushfires for three, windborne dust for one and a combination of bushfires and prescribed burning activities for five. These 'exceptional event' exceedences are not included in the NEPM goal assessment.

The carbon monoxide, ozone, nitrogen dioxide and sulfur dioxide goals of no more than one exceedence per site per calendar year were met for all averaging periods less than 24 hours.

Annual averages were met for all pollutants other than PM<sub>2.5</sub> particles at South Lake and Bunbury.



## A. Monitoring summary

### A.1 Current monitoring stations

The Department of Water and Environmental Regulation monitoring network shown in Figure A1 was carefully designed to support the Perth Photochemical Smog Study, the Perth Haze Study and the management of sulfur dioxide in the Kwinana area.

The network's design was based on knowledge of emissions sources, pollutant chemistry and important features of the meteorology.

Commonwealth Scientific and Industrial Research Organisation (CSIRO) Atmospheric Research provided advice on monitoring site locations for the Perth Photochemical Smog Study and Perth Haze Study.

The Bunbury station shown in Figure A2 was established in the state's South West to monitor fuel reduction burns, with stations in Busselton, Collie and Albany also serving that purpose.

The Geraldton station shown in Figure A2 was established in the state's Mid West to monitor windblown crustal material and smoke from bushfires, hazard reduction or stubble burning, and possibly from wood-fired home heaters.

A monitoring station was also established in Kalgoorlie (Figure A2) to primarily monitor particles and sulfur dioxide. Table A1 indicates the pollutants monitored at each site.



Figure A1: The department's air quality monitoring stations in the Perth metropolitan region

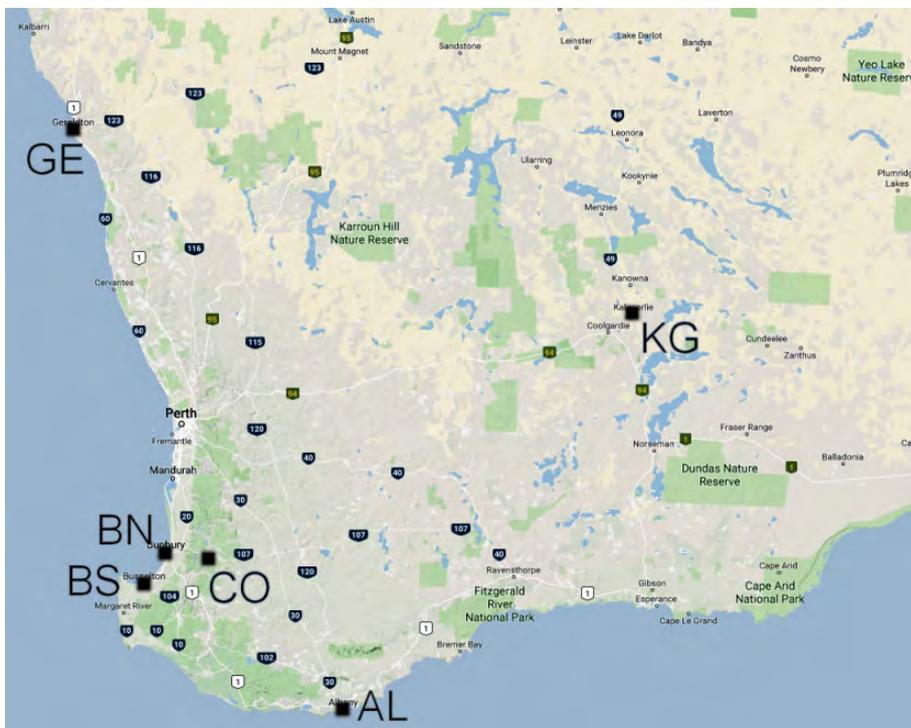


Figure A2: The department's regional air quality monitoring stations

**Table A1: Air quality parameters measured at the monitoring stations**

Monitoring site	CO	O <sub>3</sub>	NO <sub>2</sub>	SO <sub>2</sub>	PM <sub>10</sub> TEOM	PM <sub>2.5</sub> TEOM
<b>Al</b> Albany					07/06 to present	
<b>Bn</b> Bunbury					06/99 to present	04/97 to present
<b>Bs</b> Busselton						11/06 to present
<b>Ca</b> Caversham	08/93 to present	11/89 to present	09/90 to present		01/04 to present	03/94 to present
<b>Co</b> Collie					02/08 to present	
<b>Du</b> Duncraig	08/95 to present		08/95 to present		06/96 to present	01/95 to present
<b>Ge</b> Geraldton					09/05 to present	01/19 to present
<b>Kg</b> Kalgoorlie	12/17 to present			12/17 to present	12/17 to present <sup>#</sup>	12/17 to present
<b>QR*</b> Quinns Rocks		11/92 to 03/17	11/92 to 03/17			07/06 to 03/17
<b>Ro</b> Rockingham		12/95 to present	12/95 to present	07/88 to present		
<b>RG</b> Rolling Green		01/93 to present	01/93 to present			
<b>SL</b> South Lake	03/00 to present	04/06 to present				
<b>Sw</b> Swanbourne		01/93 to present	03/93 to present			
<b>Wt</b> Wattleup				01/88 to present		

\* Quinns Rocks was decommissioned in March 2017 but will be re-established at a new location in 2019

# Kalgoorlie TEOM is fitted with filter dynamic measurement systems (FDMS)

We have, from time to time, done campaign monitoring for various projects. While some of these short-term projects are not reported within this document, detailed reports and/or data can be obtained from [www.dwer.wa.gov.au](http://www.dwer.wa.gov.au), by emailing [airquality@dwer.wa.gov.au](mailto:airquality@dwer.wa.gov.au) or by telephoning (08) 6364 7000.

**Table A2: Methods used to monitor air quality at our monitoring stations**

Pollutant	Standard	Method
Carbon monoxide	AS/NZS 3580.7.1 2011 – Methods for sampling and analysis of ambient air – Determination of carbon monoxide – Direct-reading instrumental method	Gas filter correlation spectrophotometry
Ozone	AS 3580.6.1 2011 – Methods for sampling and analysis of ambient air – Determination of ozone – Direct-reading instrumental method	Ultraviolet absorption
Nitrogen dioxide	AS 3580.5.1 2011 – Methods for sampling and analysis of ambient air – Determination of oxides of nitrogen – Chemiluminescence method	Chemiluminescence
Sulfur dioxide	AS 3580.4.1 2008 – Methods for sampling and analysis of ambient air – Determination of sulfur dioxide – Direct-reading instrumental method	Ultraviolet fluorescence
Particles as PM <sub>10</sub>	AS 3580.9.8 2008 – Methods for sampling and analysis of ambient air – Determination of suspended particulate matter – PM <sub>10</sub> continuous direct mass method using a tapered element oscillating microbalance (TEOM) analyser	Tapered element oscillating microbalance*
Particles as PM <sub>2.5</sub>	AS/NZS 3580.9.13 2013 – Methods for sampling and analysis of ambient air – Determination of suspended particulate matter – PM <sub>2.5</sub> continuous direct mass method using a tapered element oscillating microbalance analyser	Tapered element oscillating microbalance*

\* The TEOM at Kalgoorlie is fitted with a filter dynamic measurement system (FDMS) while TEOMs in the remainder of the network are not. A replacement program is underway to include FDMSs on all existing TEOMs.

**Table A3: Monitoring in Western Australia**

Site	CO	O <sub>3</sub>	NO <sub>2</sub>	SO <sub>2</sub>	PM <sub>10</sub>	PM <sub>2.5</sub>
Al – Albany					P/T	
Bn – Bunbury					P/T	P/T
Bs – Busselton						DWER
Ca – Caversham	DWER	P/T	P/T		P/T	P/T
Co – Collie					DWER	
Du – Duncraig	P/T		DWER		P/T	P/T
Ge – Geraldton					P/T	P/T
Kg – Kalgoorlie	C				P/T	P/T
QR – Quinns Rocks		DWER	DWER			DWER
RG – Rolling Green		DWER	DWER			
Ro – Rockingham		DWER	DWER	DWER		
SL – South Lake	P/T	P/T	P/T	P	P/T	P/T
Sw – Swanbourne		P/T	P/T			
Wt – Wattleup				DWER		

**Key to symbols:**

<b>P</b>	Performance monitoring station
<b>T</b>	Trend performance monitoring station
<b>C</b>	Campaign monitoring
<b>DWER</b>	The department will maintain the instrument for the foreseeable future

**Table A4: Standards for pollutants**

Pollutant	Averaging period	Maximum concentration standard	Maximum allowable exceedences (goals)
Carbon monoxide	8 hours	9.0 ppm	1 day a year
Nitrogen dioxide	1 hour	0.12 ppm	1 day a year
	1 year	0.03 ppm	None
Photochemical oxidants (as ozone)	1 hour	0.10 ppm	1 day a year
	4 hours	0.08 ppm	1 day a year
Sulfur dioxide	1 hour	0.20 ppm	1 day a year
	1 day	0.08 ppm	1 day a year
	1 year	0.02 ppm	None
Lead	1 year	0.05 µg/m <sup>3</sup>	None
Particles as PM <sub>10</sub>	1 day	50 µg/m <sup>3</sup>	None
	1 year	25 µg/m <sup>3</sup>	None
Particles as PM <sub>2.5</sub>	1 day	25 µg/m <sup>3</sup>	None
	1 year	8 µg/m <sup>3</sup>	None

**Table A5: Monitoring site description**

Site	Description
Al – Albany	Large rural town located 380 kilometres south south-west of Perth with moderate-density housing and typical local traffic flows.
Bn – Bunbury	Large rural town located 145 kilometres south of Perth with moderate-density housing and typical local traffic flows.
Bs – Busselton	Small rural town located 185 kilometres south of Perth with moderate-density housing and typical local traffic flows.
Ca – Caversham	Semi-rural north-east metropolitan suburb located in the Swan Valley – a grape growing region next to the Perth foothills – 14 kilometres north-east of the Perth CBD. The region mainly comprises low-density housing and paddocks. Some brick manufacturing occurs in the region.
Co – Collie	Small rural town located within a forested area 152 kilometres south of Perth with moderate-density housing and typical traffic flows. Coal mining and power generation industries are located within the region.
Du – Duncraig	North metropolitan suburb located 16 kilometres north north-west of the Perth CBD with moderate- to high-density housing and moderate to high traffic flow. The site is located 200 metres west of the Mitchell Freeway, a main north–south arterial road carrying about 98 000 vehicles daily.
Ge – Geraldton	Large rural town located 377 kilometres north of Perth in the Mid West with moderate-density housing and typical traffic flows.
Kg – Kalgoorlie	Large rural town located 500 kilometres east north-east of Perth in the Goldfields with a dry climate, moderate-density housing and typical traffic flows.
QR – Quinns Rocks	Outer north coastal suburb located 35 kilometres north of Perth with moderate-density housing and typical local traffic flows.
RG – Rolling Green	Outer east rural suburb located 56 kilometres north-east of Perth with low-density rural housing and low traffic flows. The closest road is 80 metres east of the site, supporting a traffic flow of 3200 vehicles per day.
Ro – Rockingham	A south coastal site located 35 kilometres south of Perth with moderate-density housing and typical traffic flows, and adjacent to the southern border of the Kwinana Industrial Area. A major arterial road carrying 34 700 vehicles per day runs 1 kilometre east of the site.
SL – South Lake	South-east metropolitan site located 17 kilometres south of Perth with moderate- to high-density housing and moderate to high traffic flow. The site is located 1.6 kilometres west of the Kwinana Freeway, a main north–south arterial road carrying about 87 000 vehicles daily, and is 4 kilometres north-east of the northern border of the Kwinana Industrial Area.
Sw – Swanbourne	An inner coastal site located on coastal sand dunes 9 kilometres west of the Perth CBD, and 150 metres west of a major north–south arterial road carrying about 27 200 vehicles per day.
Wt – Wattleup	A south metropolitan site located 25 kilometres south of Perth within a defined buffer area for the Kwinana Industrial Area. Surrounding land uses are retail outlets and market gardens.

**Table A6: Screening procedures used to demonstrate whether pollutants are consistently below standards**

Screening procedures
A. Campaign monitoring at a Generally Representative Upper Bound (GRUB) monitoring location (with no significant deterioration expected over five to 10 years).
B. Use of historical data within a region which will contain one or more GRUB monitoring stations to demonstrate that the full number of stations is not required, either to detect exceedences or gain a more representative depiction of pollutant distribution.
C. Use of modelling within a region which will contain one or more GRUB monitoring stations to demonstrate that the full number of stations is not required, either to detect exceedences or gain a more representative depiction of pollutant distribution.
D. In a region with no performance monitoring, use of validated modelling with detailed and reliable estimates of emissions and meteorological data.
E. In a region with no performance monitoring, and in the absence of emissions and detailed meteorological data, use of generic model results based on gross emissions estimates, 'worst case' meteorology estimates, and other conservative assumptions.
F. In a region with no performance monitoring, comparison with a NEPM-compliant region with greater population, emissions and pollution potential.
P. Performance monitoring.
T. Trend monitoring.
M. Campaign monitoring.

**Table A7: Screening procedures satisfied at each station**

Site	Pop'n <sup>a</sup>	CO	O <sub>3</sub>	NO <sub>2</sub>	SO <sub>2</sub>	Pb	PM <sub>10</sub>
Perth and Rockingham	1 944 000				B&C	A	
Mandurah <sup>b</sup>	80 800	P	P	P	F	F	P
Albany	29 400	F	F	F	F	F	
Bunbury	71 000	A&F	E&F	E&F	D&F	F	
Kalgoorlie-Boulder <sup>c</sup>	29 900	M	E&F	E&F	T	F	P
Geraldton	32 000	F	E&F	E&F	D&F	F	

Grey shaded cells represent performance, trend or campaign sites where monitoring is underway.

- 2016 data (<http://www.censusdata.abs.gov.au>)
- Mandurah station has yet to be established
- Kalgoorlie station was commissioned in December 2017

For details of the screening procedures, go to:

<http://www.nepc.gov.au/resource/ephc-archive-ambient-air-quality-nepm>

**Table A8: Stations' site compliance with AS/NZ 3580.1.1 – 2007**

	Height above ground	Minimum distance to support structures	Clear sky angle of 120°	Unrestricted airflow of 270°/360°	20 metres from trees	No extraneous sources nearby	Minimum distance from road or traffic	Sample line material	Sample line length	Comments
<b>Perth region</b>										
Caversham	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Duncraig	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Six metres to medium-sized trees and presence of power pole.
Rockingham	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Twelve metres to trees. Northern vector dominated by grain storage facility.
Rolling Green	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
South Lake	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Swanbourne	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Wattleup	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>South West region</b>										
Albany	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Bunbury	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Fifteen metres to small- to medium-sized eucalyptus trees.
Busselton	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Five metres to small- to medium-sized eucalyptus trees.
Collie	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Some trees and shipping containers nearby
<b>Mid West region</b>										
Geraldton	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>Goldfields region</b>										
Kalgoorlie	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	

## A.2 Carbon monoxide (CO)

Duncraig monitoring station is an upper bound site for monitoring the combined effects of emissions from vehicles on the nearby Mitchell Freeway, and from domestic wood fires.

The site is located about 200 metres west of the Mitchell Freeway, so it is well beyond the distance of roadside measurement. By Perth's standards the site is densely populated, and lies in a depression through which the freeway passes, hence the effect of stable air pooling in the depression is likely to lead to elevated concentrations. This feature is found in many other places across the coastal plain.

South Lake monitoring station lies in a growing urban area and is likely to detect moderate levels of CO from wood fires in particular. It is not as close to major roads as the Duncraig site, and is therefore more typical of a population-average site.

Caversham monitoring station is located in a region of low population density and is therefore not considered a performance monitoring station.

In summary, Western Australia maintained performance monitoring of CO at the nominated trend stations of Duncraig and South Lake.

Trend analysis for each of these sites shows that, overall, the maximums of the eight-hourly averages at each site have consistently declined between 0.1 and 0.03 ppm per year, as shown in Figure A3. Distinct seasonal influences can be seen in Figure A3 with CO concentrations peaking during winter months and falling during summer.

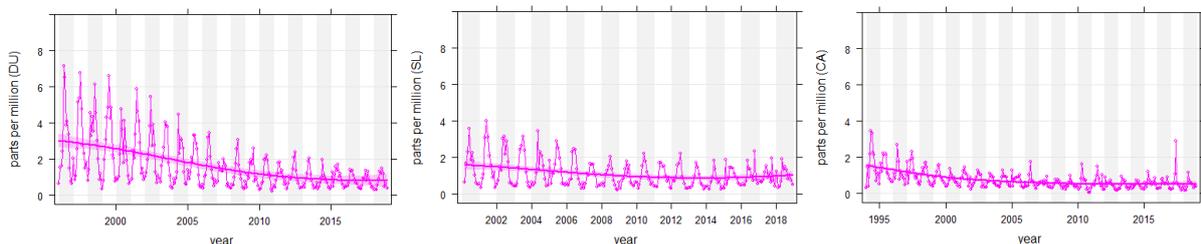


Figure A3: Smoothed trend (dark lines) for CO at Duncraig (left), South Lake (centre) and Caversham (right).

During the 2017–18 National Pollutant Inventory reporting year, CO emissions in urban areas were mainly distributed between motor vehicles (0.25 million tonnes [MT]) and combustion products from fuel reduction burns and wildfires (1.7 MT)<sup>1</sup>. These two sources account for more than 90 per cent of the CO emissions in urban areas, with the next-highest emission from domestic solid fuel burning at 4.4 per cent or 0.23 MT per year.

<sup>1</sup> <http://www.npi.gov.au/npidata/action/load/emission-by-source-result/criteria/substance/20/destination/AIR/source-type/ALL/subthreshold-data/Yes/substance-name/Carbon+monoxide/state/WA/year/2018>

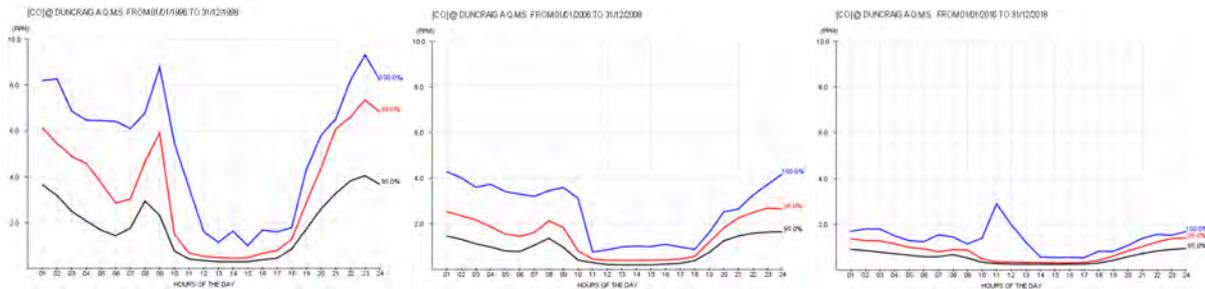


Figure A4: CO maximum (blue), 99th (red) and 95th (black) percentiles for each hour of the day at Duncraig for the three-year periods 1996–98 (left), 2006–08 (centre) and 2016–18 (right)

Percentile concentrations for CO for each hour of the day during three separate three-year periods at Duncraig are shown in Figure A4. The CO profile shows a marked decrease in overnight concentrations over a 20-year timespan. One possible reason for this is the introduction of the Environmental Protection (Domestic Solid Fuel Burning Appliances and Firewood Supply) Regulations 1998. Under these regulations, manufacturers of heating appliances (wood heaters) must meet emission standards set out in the relevant Australian and New Zealand Standard (AS/NZS4013:1999). The moisture content of wood sold as firewood is also prescribed.

In the same period motor vehicle engine technologies have also improved, reducing the emissions of harmful exhaust products and contributing to the overall reduction of CO concentrations.

### A.3 Photochemical oxidants as ozone (O<sub>3</sub>)

Statistics for the coastal sites of Quinns Rocks, Swanbourne and Rockingham indicate little difference between each station over the long-term. Swanbourne was selected as a performance monitoring station. The monitoring stations at Quinns Rocks and those at or near Rockingham were maintained to provide additional information on ozone events.

Given its location, we can be confident that Caversham monitoring station represents an upper bound, middle-distance inland site. It was therefore selected as a performance monitoring station.

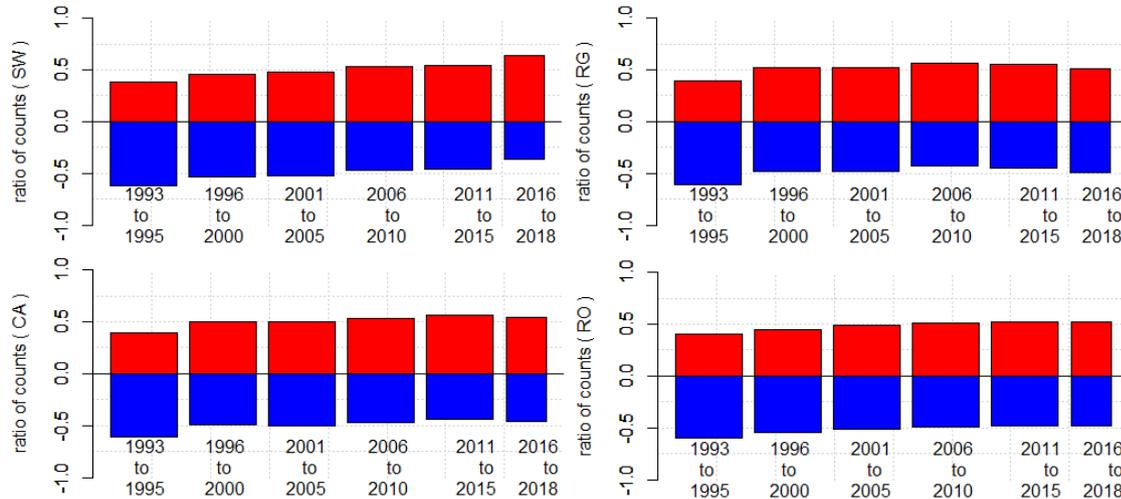
A third performance monitoring station was located at South Lake. It has the following desirable attributes:

- it provides spatial spread of stations (it will measure ozone returning onshore in the southern part of the metropolitan area)
- it is a moderate distance inland in a growing urban area, hence it is well-classed as a population average station
- it may occasionally detect the interactions of ozone (O<sub>3</sub>) with plumes rich in nitrogen oxides (NO<sub>x</sub>) from Kwinana industry – potentially giving elevated nitrogen dioxide (NO<sub>2</sub>) concentrations.

Caversham, Swanbourne and South Lake sites are all nominated as trend stations.

The stations at Rockingham, Quinns Rocks and Rolling Green will continue to be part of our wider ozone network to enable a better understanding of ozone events.

Long-term analysis is presented in Figure A5. The number of periods when the one-hour ozone concentration exceeded the long-term site average at Swanbourne has increased for every five-year period, with the ratio climbing from 0.46 in 1996–2000 to 0.54 in 2011–15. For the three-year period 2016 to 2018, the ratio at Swanbourne increased to 0.63.



**Figure A5:** Ratio of the number of hourly averaged ozone concentrations at Swanbourne and Rolling Green (top panel) and Caversham and Rockingham (lower panel) that was higher (red) or equal to or lower (blue) than the 25-year average concentration for that site.

A similar increasing pattern is evident at the other coastal site of Rockingham. The inland sites of Caversham and Rolling Green have a less distinct pattern.

## A.4 Nitrogen dioxide (NO<sub>2</sub>)

Owing to the close chemical reactivity relationship, NO<sub>2</sub> is being monitored at all stations where O<sub>3</sub> is monitored. We chose the Caversham, Swanbourne and South Lake sites as performance monitoring stations for NO<sub>2</sub> because they provided a good spatial distribution. These sites are also trend stations.

We will continue to measure NO<sub>2</sub> at Quinns Rocks, Rolling Green and Duncraig as part of our wider network to enable a better understanding of photochemical smog formation.

Figure A6 shows how the monthly means of nitrogen oxides (NO<sub>x</sub>) (NO + NO<sub>2</sub>) have decreased at all sites. The median of the daily one-hour NO maximum has also generally decreased over time, with an average decrease of 0.5 ppb per year at Duncraig since 1996.

A possible unintended result of these decreasing concentrations of oxides of nitrogen is the inability to fully suppress ozone formation by (typically) producing NO<sub>2</sub> (NO + O<sub>3</sub> → NO<sub>2</sub> + O<sub>2</sub>). The general build-up in O<sub>3</sub> therefore begins earlier (and consequently closer to populated areas) than it otherwise would<sup>2</sup>.

<sup>2</sup> D.H. Stedman, *Environ. Chem.* 2004, 1, 65–66.

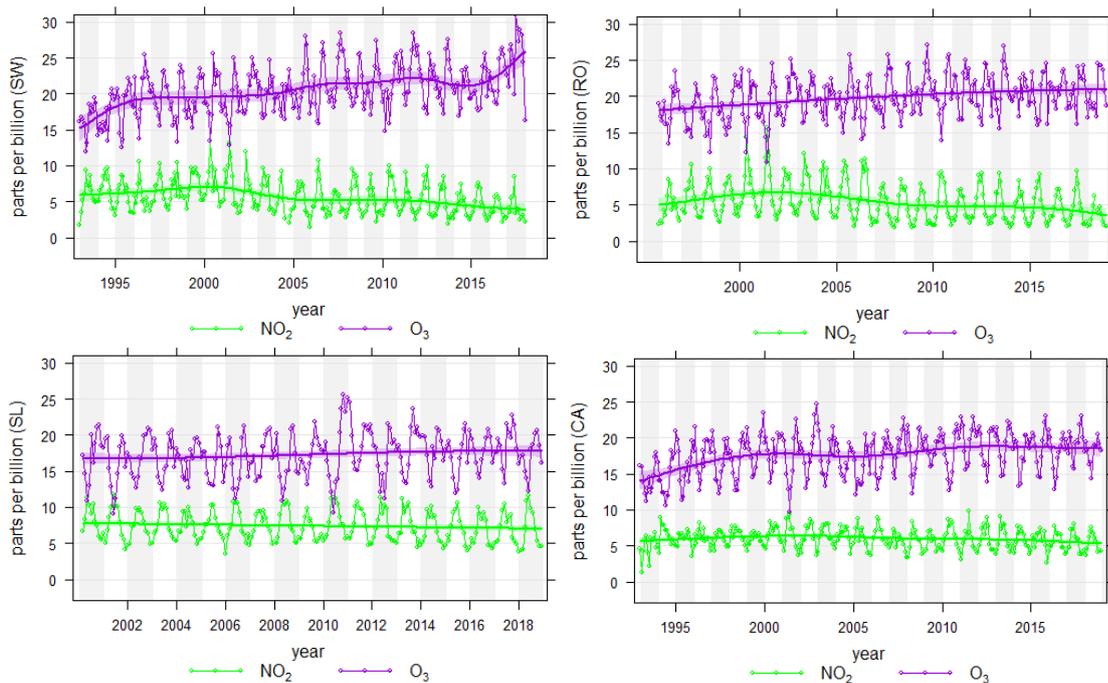


Figure A6: Smoothed trend (dark lines) at Swanbourne and Rockingham (top panel) and South Lake and Caversham (lower panel) using the monthly mean concentration of  $\text{NO}_2$  (green) and  $\text{O}_3$  (violet).

## A.5 Sulfur dioxide

We operate one performance monitoring station at South Lake for sulfur dioxide, while maintaining a source management network that includes Wattleup and Rockingham monitoring stations.

The South Lake site is an upper bound performance monitoring station for sulfur dioxide, and a trend station. It is near the southern extent of the main urban population and downwind of Kwinana in sea-breeze conditions.

Heavy industries in Kwinana are the only significant sources of sulfur dioxide in the Perth/Kwinana/Rockingham region. Concentrations of sulfur dioxide have reduced markedly since the late 1970s because of the conversion from high- to low-sulfur fuels and the installation of sulfur dioxide control technologies.

To control emissions, we put conditions in the licences we issue under Part V of the *Environmental Protection Act 1986*, in concert with the Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1999 (EPP). This helps to ensure ambient concentrations do not exceed ambient standards set in the EPP.

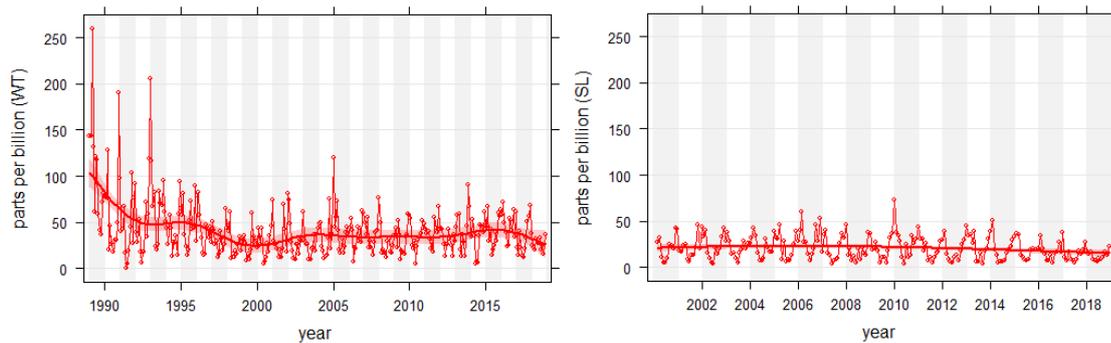


Figure A7: Trend line for maximum hourly averaged sulfur dioxide concentration at Wattleup, located within the Kwinana Industrial Buffer (left) and South Lake (right).

## A.6 Lead

Since 1995, lead levels within the Perth CBD have been below 60 per cent of the  $0.5 \mu\text{g}/\text{m}^3$  annual NEPM standard. In 2001, the average lead level in Perth was  $0.022 \mu\text{g}/\text{m}^3$ , less than 5 per cent of the NEPM standard.

In accordance with *AAQ NEPM technical paper no. 4, screening procedures*, and the Western Australian monitoring plan, a performance monitoring station for lead has not been maintained since 2001.

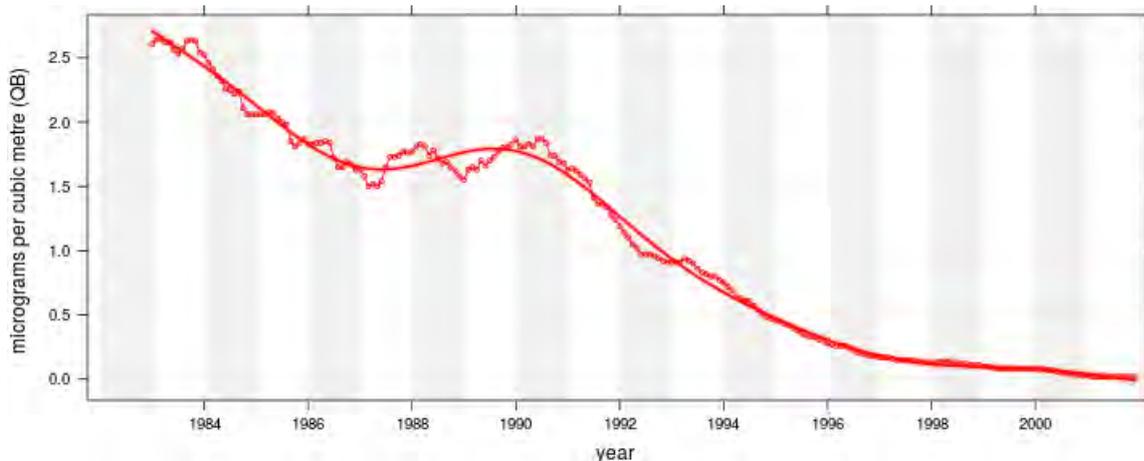


Figure A8: Trend line for annual moving averaged lead concentration within the Perth CBD.

## A.7 Particles as PM<sub>10</sub>

The Duncraig site is an upper bound performance monitoring station site for PM<sub>10</sub>. High levels of PM<sub>10</sub> at this site are caused by a combination of vehicle and domestic wood heater emissions during strongly stable meteorological conditions.

Likewise, the site at South Lake measures significant PM<sub>10</sub> concentrations arising from wood fires and some industrial emissions.

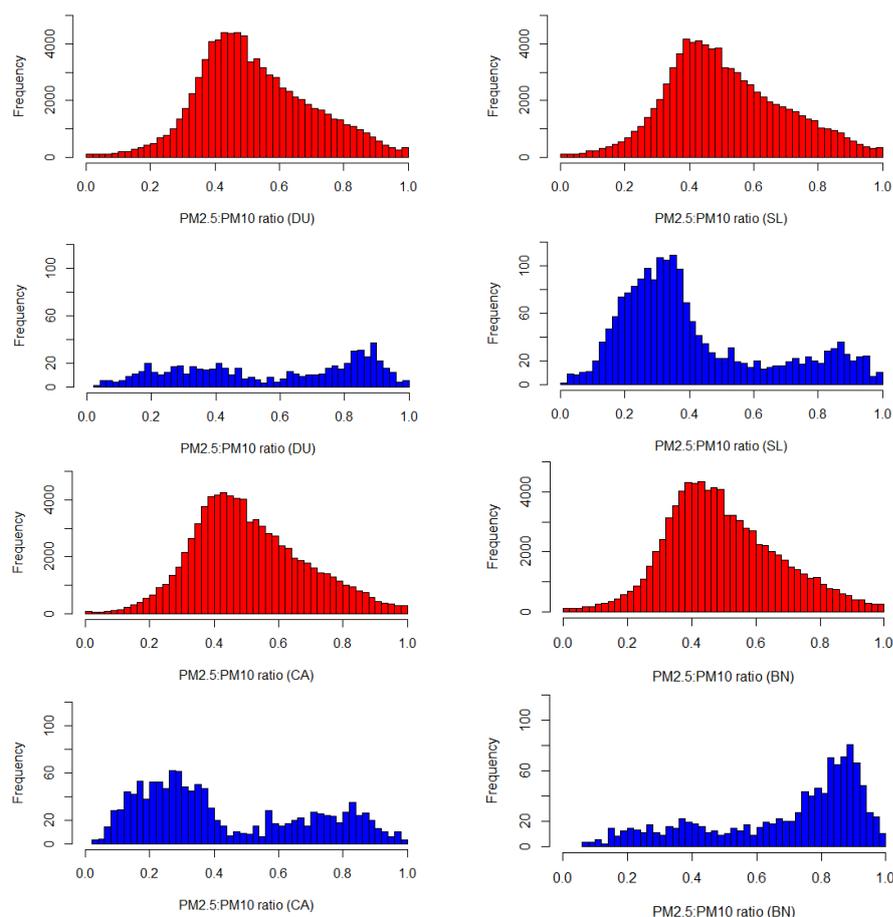
The Duncraig and South Lake sites are both nominated as trend stations.

Monitoring stations were established at Geraldton in September 2005, Albany in July 2006 and Collie in February 2008.

All our tapered element oscillating microbalances (TEOMs) operate continuously and unadjusted for temperature. All TEOM Model 1400AB data presented in this report have the manufacturer's recommended equivalency factor of  $1.03x + 3.00$  applied. We operate a TEOM Model 1405DF at Kalgoorlie and, as per the manufacturer's instructions, no equivalency factors are applied.

A frequency distribution of hourly particle concentrations – such as that shown in Figure A9 for three metropolitan sites and one regional site for the 10-year period 2009–18 – can indicate differences in the ratio of  $PM_{2.5}:PM_{10}$ , and provide some insight into the source of the pollutant. A high ratio of  $PM_{2.5}:PM_{10}$  indicates a high proportion of smaller particles, which is generally caused by particles originating from smoke or fumes. A lower ratio of  $PM_{2.5}:PM_{10}$  may indicate anthropogenic dust or crustal materials.

The lower (blue) plots in Figure A9 show periods where the one-hour averaged  $PM_{10}$  exceeded an arbitrary concentration of  $50 \mu g/m^3$ . This cut-off was chosen to limit the analysis to those concentrations at the higher end of the spectrum. While Duncraig exhibits a lower overall number, both Duncraig and Bunbury exhibit a slightly higher proportion of high-ratio events. Caversham and South Lake display a larger number of low-ratio events.



**Figure A9:** Frequency distribution of  $PM_{2.5}:PM_{10}$  ratios of hourly averages at Duncraig (top left), South Lake (top right) and Caversham (lower left) and Bunbury (lower right) for the 10-year period 2009–18 using all data (red) and data where hourly averaged  $PM_{10}$  was greater than, or equal to  $50 \mu g/m^3$  (blue)

These differences can be explained based on the site locations. Duncraig is located 3.5 km from the coast in a moderate- to high-density housing area with no industry nearby. Thus it is predominantly influenced by vehicles, sea salt and smoke from the occasional bushfire or prescribed burn. We therefore expect to see a larger proportion of high  $PM_{2.5}:PM_{10}$  ratios, which is characteristic of combustion products. Bunbury is similar, being a large coastal town in the state's South West with surrounding bushlands that are subject to controlled burns and occasional bushfires. Caversham is in a semi-rural setting north east of Perth's CBD and has several vineyards and some brick manufacturing nearby. The combination of these two industries likely produces coarse fraction particles and hence a lower  $PM_{2.5}:PM_{10}$  ratio. South Lake is within a moderate- to high-density housing area and close to the Kwinana Industrial Area, market gardens, new housing developments and a cement manufacturing plant. It is therefore associated with lower  $PM_{2.5}:PM_{10}$  ratios.

## A.8 Particles as $PM_{2.5}$

To make assessments against the NEPM standard, we installed four  $PM_{2.5}$  TEOMs in the greater Perth metropolitan region at Quinns Rocks, Caversham, Duncraig and South Lake, and one each in Bunbury and Busselton. All of these will remain in use indefinitely so that we can develop trend data.

We operate all our TEOMs continuously (unadjusted for temperature).

All TEOM Model 1400AB data in this report uses the manufacturer's recommended equivalency factor of  $1.03x + 3.00$ . The TEOM Model 1405DF operating at Kalgoorlie has no equivalency factors applied, as per manufacturer's instructions.

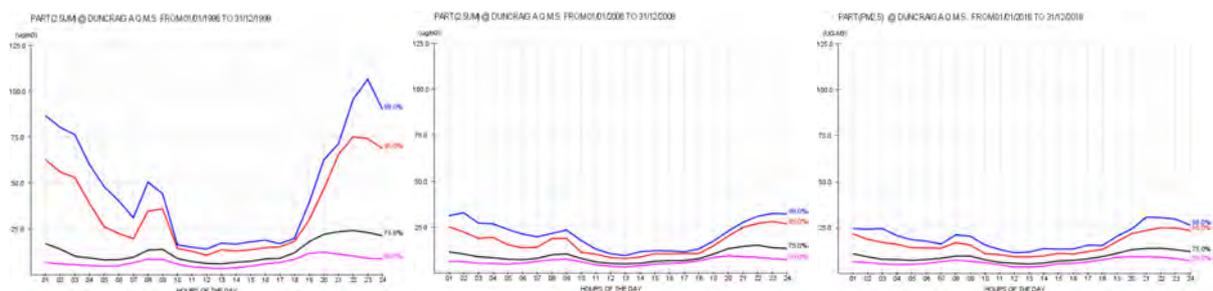


Figure A10: The  $PM_{2.5}$  98th (blue), 95th (red), 75th (black) and 50th (mauve) percentiles for each hour of the day at Duncraig in winter months spanning three-year periods 1996–98 (left), 2006–08 (centre) and 2016–18 (right).

See Figure A10 for percentile concentrations of  $PM_{2.5}$  for each hour of the day in winter months during three different three-year periods at Duncraig. The  $PM_{2.5}$  profile shows a marked decrease in overnight concentrations in the initial 10-year timespan, with a much smaller improvement in the second decade. Similar to carbon monoxide (Section A2), one possible reason for this initial and dramatic decrease in fine particle concentrations during winter is the introduction of the Environmental Protection (Domestic Solid Fuel Burning Appliances and Firewood Supply) Regulations 1998. These regulations require manufacturers of heating appliances (wood heaters) to meet emission standards set out in Standard AS/NZS4013:1999. The moisture content of wood sold as firewood is also prescribed.

In addition, in 2006 and 2007 the department conducted a wood heater replacement program. We offered up to \$600 to people using wood heaters or fireplaces as the main source of home heating to convert to an alternative source.

## A.9 Population exposure

The AAQ NEPM variation<sup>3</sup> made on 26 February 2016 requires a yearly assessment of population exposure to particles as PM<sub>2.5</sub>.

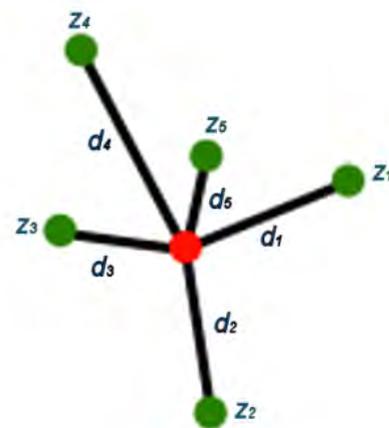
Pending a nationally consistent method to assess population exposures for PM<sub>2.5</sub>, we have used a simple inverse distance weighing (IDW) method.

$$Z(x) = \frac{\sum w_i z_i}{\sum w_i}$$

where

$$w_i = \frac{1}{d(x, x_i)^2}$$

In this simple IDW function,  $Z(x)$  represents a known location for which a PM<sub>2.5</sub> concentration needs to be estimated,  $z_i$  represents known locations for which PM<sub>2.5</sub> concentrations are available, while  $d(x, x_i)$  is the distance from a point  $x_i$  for which we have a known concentration to a point  $x$  where the concentration estimate is needed.



$$\text{Population Exposure} = \sum \frac{Z(x) P_x}{P_{total}}$$

where

$$P_x = \text{population at each suburb}$$

This method uses a simple interpolation and does not take into account land use or terrain effects. It simply causes concentrations of nearer sites to have a significantly greater effect on the estimated concentration than more distant sites.

In 2018, PM<sub>2.5</sub> particle data was collected from three metropolitan sites (Caversham, Duncraig and South Lake) and three regional sites (Bunbury, Busselton and Kalgoorlie). We used the centroid of each suburb in metropolitan Perth and their associated population data to calculate the population weighted average PM<sub>2.5</sub> particle concentration for the Perth region.

It is important to note that all data used to calculate population exposure concentration comes from TEOM Model 1400AB particle monitors. The data has been adjusted according to the manufacturer's most recent instructions<sup>4</sup>:

<sup>3</sup> <https://www.legislation.gov.au/Details/F2016C00215>

<sup>4</sup> See Operating Manual TEOM® SERIES 1400a Ambient Particulate (PM<sub>10</sub>) Monitor (AB serial numbers) June 2004, Revision B, R&P Part Number 42-003347

This is done using the formula  $Y=A+Bx$ , where  $Y$  is the adjusted mass concentration,  $x$  is the unadjusted mass concentration,  $A$  (Const A) is the intercept factor and  $B$  (Const B) is the slope factor. The values of  $A$  and  $B$  must be set to their default values of 3.000 and 1.030, respectively, for the Series 1400a Monitor to be used as a US EPA equivalent method for  $PM_{10}$  measurements. These adjustment factors were determined at sites where non-volatile particulate matter dominated and, therefore, the adjustment factors reflect the filter character more than they reflect the particulate matter.

For  $PM_{2.5}$  measurements, it is justifiable to use the original constants (3.000 and 1.030), because the technical rationale may still apply. The other option is to use no adjustment for  $PM_{2.5}$  by setting the constants to values of 0.000 (Const A) and 1.000 (Const B). In either case, the adjustment factors used may be revisited later as more information becomes available on the best approach. Because the adjustment is attained by a simple linear transformation, it is possible to recalculate the mass concentration values later based upon new information.

A March 2003 NEPM technical paper on *Monitoring for particles as  $PM_{2.5}$* <sup>5</sup> advised the following course for  $PM_{2.5}$  particle concentrations using a TEOM:

*When the monitor is operated as an equivalent  $PM_{10}$  monitor, the values of  $A$  and  $B$  are set to 3.0 and 1.03 respectively. For operation as a  $PM_{2.5}$  monitor for the equivalency program the values for  $A$  and  $B$  must be set to 0 and 1.0 respectively (R&P Operating Manual TEOM Series 1400a Ambient Particulate ( $PM_{10}$ ) Monitor (AB serial Numbers) December 1995 Revision B Section 4.7 Setting Other Hardware Parameters).*

We have applied the manufacturer's recommended adjustment to both  $PM_{10}$  and  $PM_{2.5}$  data collected using the 1400AB TEOM particle monitors. To ensure that population exposure data can be shared with other jurisdictions, the population exposure using both methods of calculating  $PM_{2.5}$  are presented.

**Table A9: Population exposure for particles as  $PM_{2.5}$**

Data adjustment method	Population exposure (Perth metro)
Data with manufacturers recommended adjustment factor ( $Y = 3.0 + 1.03x$ )	8.0 $\mu\text{g}/\text{m}^3$
Unadjusted data ( $Y = 0.0 + 1.00x$ )	4.8 $\mu\text{g}/\text{m}^3$

## A.10 Variation to the NEPM

In February 2016, the AAQ NEPM was varied to, among other things:

- provide for a  $PM_{10}$  annual standard of 25  $\mu\text{g}/\text{m}^3$
- create two standards for  $PM_{2.5}$  of 25  $\mu\text{g}/\text{m}^3$  averaged over 24 hours, and 8  $\mu\text{g}/\text{m}^3$  averaged over one year
- include an aim to move to annual average and 24-hour  $PM_{2.5}$  standards of 7  $\mu\text{g}/\text{m}^3$  and 20  $\mu\text{g}/\text{m}^3$  respectively by 2025
- remove the five allowable exceedences for  $PM_{10}$  one-day average standards when determining compliance with the NEPM goal

<sup>5</sup> <http://www.nepc.gov.au/system/files/resources/9947318f-af8c-0b24-d928-04e4d3a4b25c/files/aaq-pm25-tp-technical-paper-monitoring-particles-final-200303.pdf>

- allow for exceptional events when determining compliance for one-day PM<sub>10</sub> and PM<sub>2.5</sub> with the NEPM goal

An exceptional event means a fire or dust occurrence that adversely affects air quality at a particular location, and causes an exceedence of one-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. For the purpose of reporting compliance against PM<sub>10</sub> and PM<sub>2.5</sub> one-day average standards, jurisdictions are required to exclude monitoring data that has been determined as being directly associated with an exceptional event. For the purpose of reporting compliance against PM<sub>10</sub> and PM<sub>2.5</sub>, one-year average standards, jurisdictions are required to include all measured data, including monitoring data that is directly associated with an exceptional event.

- require that each jurisdiction must evaluate and report population exposures for particles as PM<sub>2.5</sub> yearly from June 2018.

This report has been prepared to comply with these NEPM reporting requirements.

## A.11 Exceedence summary

A number of exceedences of PM<sub>2.5</sub> and PM<sub>10</sub> occurred in 2018. The NEPM goal for particles was not met at Albany, Bunbury, Busselton, Caversham, Geraldton and Kalgoorlie. Detailed summaries of all exceedences are provided in Section F.

**Table A10: Air NEPM standard exceedences recorded during 2018**

Site	Pollutant	Concentration <sup>1,2</sup>	Date	Event cause
Albany	PM <sub>10</sub>	74.3 µg/m <sup>3</sup>	24/05/2018	PB
Albany	PM <sub>10</sub>	89.6 µg/m <sup>3</sup>	09/11/2018	AS
Bunbury	PM <sub>2.5</sub>	27.4 µg/m <sup>3</sup>	12/05/2018	PB
Bunbury	PM <sub>2.5</sub>	25.2 µg/m <sup>3</sup>	20/05/2018	PB
Bunbury	PM <sub>2.5</sub>	33.0 µg/m <sup>3</sup>	22/05/2018	BF/PB
Bunbury	PM <sub>10</sub>	51.9 µg/m <sup>3</sup>	23/05/2018	BF/PB
Bunbury	PM <sub>2.5</sub>	38.4 µg/m <sup>3</sup>	23/05/2018	BF/PB
Bunbury	PM <sub>2.5</sub>	36.9 µg/m <sup>3</sup>	14/11/2018	AS
Busselton	PM <sub>2.5</sub>	32.2 µg/m <sup>3</sup>	16/05/2018	PB
Busselton	PM <sub>2.5</sub>	29.8 µg/m <sup>3</sup>	17/05/2018	PB
Busselton	PM <sub>2.5</sub>	56.5 µg/m <sup>3</sup>	18/05/2018	PB
Busselton	PM <sub>2.5</sub>	28.0 µg/m <sup>3</sup>	20/05/2018	PB
Busselton	PM <sub>2.5</sub>	52.5 µg/m <sup>3</sup>	26/10/2018	PB
Busselton	PM <sub>2.5</sub>	26.3 µg/m <sup>3</sup>	10/11/2018	PB
Busselton	PM <sub>2.5</sub>	28.2 µg/m <sup>3</sup>	14/11/2018	AS
Caversham	PM <sub>2.5</sub>	32.5 µg/m <sup>3</sup>	04/05/2018	PB
Caversham	PM <sub>10</sub>	77.9 µg/m <sup>3</sup>	24/05/2018	AS
Caversham	PM <sub>10</sub>	58.5 µg/m <sup>3</sup>	17/11/2018	PB
Caversham	PM <sub>2.5</sub>	36.7 µg/m <sup>3</sup>	17/11/2018	PB
Collie	PM <sub>10</sub>	84.6 µg/m <sup>3</sup>	29/04/2018	PB
Collie	PM <sub>10</sub>	73.4 µg/m <sup>3</sup>	30/04/2018	PB
Collie	PM <sub>10</sub>	51.8 µg/m <sup>3</sup>	04/05/2018	PB
Collie	PM <sub>10</sub>	69.9 µg/m <sup>3</sup>	05/05/2018	PB
Collie	PM <sub>10</sub>	52.6 µg/m <sup>3</sup>	12/05/2018	PB
Collie	PM <sub>10</sub>	57.1 µg/m <sup>3</sup>	17/05/2018	PB
Collie	PM <sub>10</sub>	50.4 µg/m <sup>3</sup>	22/05/2018	BF/PB
Collie	PM <sub>10</sub>	56.7 µg/m <sup>3</sup>	23/05/2018	BF/PB
Collie	PM <sub>10</sub>	55.0 µg/m <sup>3</sup>	07/11/2018	PB
Collie	PM <sub>10</sub>	57.8 µg/m <sup>3</sup>	15/11/2018	PB
Duncraig	PM <sub>10</sub>	61.3 µg/m <sup>3</sup>	17/11/2018	PB
Duncraig	PM <sub>2.5</sub>	48.6 µg/m <sup>3</sup>	17/11/2018	PB
Geraldton	PM <sub>10</sub>	54.2 µg/m <sup>3</sup>	08/01/2018	AS
Geraldton	PM <sub>10</sub>	68.4 µg/m <sup>3</sup>	10/03/2018	BF
Geraldton	PM <sub>10</sub>	70.0 µg/m <sup>3</sup>	11/03/2018	BF
Kalgoorlie	PM <sub>10</sub>	60.5 µg/m <sup>3</sup>	25/05/2018	WD
Kalgoorlie	PM <sub>2.5</sub>	36.2 µg/m <sup>3</sup>	22/06/2018	AS
South Lake	PM <sub>2.5</sub>	26.8 µg/m <sup>3</sup>	14/01/2018	BF
South Lake	PM <sub>2.5</sub>	37.4 µg/m <sup>3</sup>	04/05/2018	PB
South Lake	PM <sub>2.5</sub>	29.1 µg/m <sup>3</sup>	05/05/2018	PB
South Lake	PM <sub>2.5</sub>	31.2 µg/m <sup>3</sup>	11/05/2018	PB
South Lake	PM <sub>10</sub>	57.1 µg/m <sup>3</sup>	17/11/2018	PB
South Lake	PM <sub>2.5</sub>	43.3 µg/m <sup>3</sup>	17/11/2018	PB

1. All concentrations are 24-hour averages (midnight to midnight) unless otherwise stated.

2. All Model 1400AB TEOMs used by the department are operated continuously (unadjusted for temperature) and have the manufacturer's recommended equivalency factor of 1.03x + 3.00 applied. All particle concentrations are displayed as a daily average.

AS Assessable event

BF Bushfire (exceptional event)

PB Prescribed burning activities (exceptional event)

WD Windborne dust (exceptional event)

3. Kalgoorlie has a Model 1405DF TEOM which does not require an equivalency factor to be applied

## B. Assessment of compliance with standards and goals

**Table B1: 2018 compliance summary for carbon monoxide**

AAQ NEPM standard  
9.0 ppm (eight-hour average)

Regional performance monitoring station	Data availability rates (% of hours)					Number of exceedences (days)	Performance against the standards and goal
	Q1	Q2	Q3	Q4	Annual		
<b>Perth region</b>							
Caversham (north-east metro)	97.6	97.8	97.8	96.4	97.4	0	Met
Duncraig (north metro)	99.4	100	98.1	97.4	98.7	0	Met
South Lake (south-east metro)	99.8	99.5	100	99.7	99.7	0	Met
<b>Goldfields region</b>							
Kalgoorlie	97.7	71.2	81.2	97.6	86.9	0	Not demonstrated

Performance against the standards and goal: 'met', 'not met', 'not demonstrated'.

**Table B2: 2018 compliance summary for nitrogen dioxide**

AAQ NEPM standard  
0.12 ppm (one-hour average)  
0.03 ppm (one-year average)

Regional performance monitoring station	Data availability rates (% of hours)					Annual mean (ppm)	Number of exceedences (days)	Performance against the standards and goal	
	Q1	Q2	Q3	Q4	Annual			1-hour	1-year
<b>Perth region</b>									
Caversham (north-east metro)	98.9	99.7	96.1	99.6	98.6	0.005	0	Met	Met
Duncraig (north metro)	99.4	99.8	98.2	91.0	97.1	0.005	0	Met	Met
Quinns Rocks (outer north coast)	–	–	–	–	–	–	0	ND	ND
Rockingham (south coast)	99.1	44.6	86.1	99.1	82.2	0.003	0	ND	ND
Rolling Green (outer east rural)	99.7	100.0	99.9	99.8	99.8	0.002	0	Met	Met
South Lake (south-east metro)	99.5	98.8	99.2	98.4	98.9	0.007	0	Met	Met
Swanbourne (inner west coast)	97.8	99.8	99.7	99.9	99.3	0.004	0	Met	Met

Performance against the standards and goal: 'met', 'not met', 'not demonstrated' (ND).

**Table B3: 2018 compliance summary for ozone**

AAQ NEPM standard  
 0.10 ppm (one-hour average)  
 0.08 ppm (four-hour average)

Regional performance monitoring station	Data availability rates (% of hours)					Number of exceedences (days)		Performance against the standards and goal	
	Q1	Q2	Q3	Q4	Annual	1-hour	4-hour	1-hour	4-hour
<b>Perth region</b>									
Caversham (north-east metro)	99.5	100.0	99.9	99.7	99.8	0	0	Met	Met
Quinns Rocks (outer north coast)	–	–	–	–	–	0	0	ND	ND
Rockingham (south coast)	100.0	99.7	100.0	99.6	99.8	0	0	Met	Met
Rolling Green (outer east rural)	96.3	97.2	98.8	99.7	98.0	0	0	Met	Met
South Lake (south-east metro)	99.7	100	99.5	99.9	99.6	0	0	Met	Met
Swanbourne (inner west coast)	100	100	99.7	99.9	99.8	0	0	Met	Met

Performance against the standards and goal: 'met', 'not met', 'not demonstrated' (ND).

**Table B4: 2018 compliance summary for sulfur dioxide**

AAQ NEPM standard  
 0.20 ppm (one-hour average)  
 0.08 ppm (24-hour average)  
 0.02 ppm (one-year average)

Regional performance monitoring station	Data availability rates (% of hours)					Annual mean (ppm)	Number of exceedences (days)		Performance against the standards and goal		
	Q1	Q2	Q3	Q4	Annual		1-hour	24-hour	1-hour	24-hour	1-year
<b>Perth region</b>											
Rockingham (south coast)	97.2	96.4	90.9	97.2	95.4	0.001	0	0	Met	Met	Met
South Lake (south-east metro)	97.6	97.5	97.7	96.8	97.4	0.002	0	0	Met	Met	Met
Wattleup (south metro)	96.4	97.2	97.4	96.9	97	0.002	0	0	Met	Met	Met
<b>Goldfields region</b>											
Kalgoorlie	97.5	93.1	81	97.4	92.2	0.001	0	0	Met	Met	Met

Performance against the standards and goal: 'met', 'not met', 'not demonstrated'.

**Table B5: 2018 compliance summary for particles as PM<sub>10</sub>**

AAQ NEPM standard  
 50 µg/m<sup>3</sup> (24-hour average)  
 25 µg/m<sup>3</sup> (annual average)

Regional performance monitoring station	Data availability rates (% of days)					Number of exceedences (days)	Performance against the standards and goal	
	Q1	Q2	Q3	Q4	Annual		24-hour	Annual
<b>Perth region</b>								
Caversham (north-east metro)	99.6	99.4	97.4	99.2	98.9	2	Not met	Met
Duncraig (north metro)	99.5	99.7	98.1	99.7	99.3	1	Met	Met
South Lake (south-east metro)	99.7	99.4	99.6	99.9	99.6	1	Met	Met
<b>South West region</b>								
Albany	99.9	99.4	98.7	76.3	93.5	2	Not met	Met
Bunbury	99.5	99.8	99.3	99.8	99.6	1	Met	Met
Collie	99.9	99.5	97.2	99.2	98.9	10	Met	Met
<b>Mid West region</b>								
Geraldton	86.6	99	98.3	99.7	96	3	Not met	Met
<b>Goldfields region</b>								
Kalgoorlie	95.6	96.3	83.8	98.6	93.6	1	Met	Met

Performance against the standards and goal: 'met', 'not met', 'not demonstrated'.

**Table B6: 2018 compliance summary for particles as PM<sub>2.5</sub>**

AAQ NEPM standard  
 25 µg/m<sup>3</sup> (24-hour average)  
 8 µg/m<sup>3</sup> (annual average)

Regional performance monitoring station	Data availability rates (% of days)					Number of exceedences (Days)	Performance against the standards and goal	
	Q1	Q2	Q3	Q4	Annual		24-hour	annual
<b>Perth region</b>								
Caversham (north-east metro)	99.6	99.7	99.5	99.2	99.5	2	Met	Met
Duncraig (north metro)	99.9	100	98.1	99.8	99.4	1	Met	Met
Quinns Rocks (outer north coast)	–	–	–	–	–	0	ND	ND
South Lake (south-east metro)	99.7	99.5	99.8	99.7	99.7	5	Met	Met
<b>South West region</b>								
Bunbury	99.8	99.9	99.3	99.8	99.7	5	Not met	Met
Busselton	95.7	99.4	96.5	96.5	97	7	Not met	Met
<b>Goldfields region</b>								
Kalgoorlie	95.6	96.3	83.8	98.6	93.6	1	Not met	Met

Performance against the standards and goal: 'met', 'not met', 'not demonstrated' (ND).

## C. Analysis of air quality monitoring

### C.1 Carbon monoxide

The NEPM standard for carbon monoxide of 9.0 ppm averaged over eight hours was not exceeded at any site during 2018. The NEPM goal of no more than one exceedance at each site was met. Table C1 contains the summary statistics for daily peak eight-hour carbon monoxide in Western Australia.

**Table C1: 2018 summary statistics for daily peak eight-hour carbon monoxide**

AAQ NEPM standard  
9.0 ppm (eight-hour average)

Regional performance monitoring station	Data availability rates (%)	Highest (ppm)	Highest		2nd highest (ppm)	2nd highest	
			(date)	(time)		(date)	(time)
<b>Perth region</b>							
Caversham (north-east metro)	97.4	1.1	07/05/2018	1000	0.9	04/05/2018	1000
Duncraig (north metro)	98.7	1.5	11/08/2018	0500	1.3	04/06/2018	0500
South Lake (south-east metro)	99.7	1.9	04/05/2018	1100	1.5	11/07/2018	0400
<b>Goldfields region</b>							
Kalgoorlie	86.9	1.9	22/06/2018	0500	1.1	01/08/2018	0200

## C.2 Nitrogen dioxide

The NEPM standard for nitrogen dioxide of 0.12 ppm averaged over one hour and the 0.03 ppm annual average were not exceeded at any site during 2018. The NEPM goal of no more than one exceedence at each site was met. Table C2 contains the summary statistics for daily peak one-hour nitrogen dioxide in Western Australia.

**Table C2: 2018 summary statistics for daily peak one-hour nitrogen dioxide**

AAQ NEPM standard  
0.12 ppm (one-hour average)

Regional performance monitoring station	Data availability rates (%)	Highest (ppm)	Highest		2nd highest (ppm)	2nd highest	
			(date)	(time)		(date)	(time)
<b>Perth region</b>							
Caversham (north-east metro)	98.6	0.034	09/07/2018	1900	0.032	11/07/2018	2000
Duncraig (north metro)	97.1	0.036	11/05/2018	1900	0.035	22/05/2018	2000
Rockingham (south coast)	82.2	0.029	04/05/2018	1900	0.029	13/08/2018	0800
Rolling Green (outer east rural)	99.8	0.023	27/04/2018	2000	0.022	25/02/2018	2000
South Lake (south-east metro)	98.9	0.047	15/05/2018	1900	0.042	11/05/2018	1900
Swanbourne (inner west coast)	99.3	0.039	11/05/2018	2100	0.038	15/05/2018	2100

The NEPM standard for nitrogen dioxide of 0.03 ppm averaged over one year was not exceeded at any site during 2018. Table C2a contains the summary statistics for annual nitrogen dioxide in Western Australia.

**Table C2a: 2018 summary statistics for annual nitrogen dioxide**

AAQ NEPM standard  
0.03 ppm (annual average)

Regional performance monitoring station	Data availability rates (%)	Annual average (ppm)
<b>Perth region</b>		
Caversham (north-east metro)	98.6	0.005
Duncraig (north metro)	97.1	0.005
Rockingham (south coast)	82.2	0.003
Rolling Green (outer east rural)	99.8	0.002
South Lake (south-east metro)	98.9	0.007
Swanbourne (inner west coast)	99.3	0.004

### C.3 Photochemical smog as ozone

The NEPM standard for ozone of 0.10 ppm averaged over one hour was not exceeded at any site during 2018. The NEPM goal of no more than one exceedence at each site was met. Table C3 contains the summary statistics for daily peak one-hour ozone in Western Australia.

**Table C3: 2018 summary statistics for daily peak one-hour ozone**

AAQ NEPM standard  
0.10 ppm (one-hour average)

Regional performance monitoring station	Data availability rates (%)	Highest (ppm)	Highest		2nd highest (ppm)	2nd highest	
			(date)	(time)		(date)	(time)
<b>Perth region</b>							
Caversham (north-east metro)	99.8	0.067	02/01/2018	1500	0.066	13/03/2018	1800
Quinns Rocks (outer north coast)	–	–	–	–	–	–	–
Rockingham (south coast)	99.8	0.061	14/12/2018	1300	0.059	22/12/2018	1300
Rolling Green (outer east rural)	98.0	0.075	04/04/2018	1600	0.074	10/12/2018	1500
South Lake (south-east metro)	99.6	0.061	23/12/2018	1100	0.060	14/12/2018	1300
Swanbourne (inner west coast)	99.8	0.075	13/03/2018	1600	0.058	06/04/2018	1800

The NEPM standard for ozone of 0.08 ppm averaged over four hours was not exceeded at any site during 2018. The NEPM goal of no more than one exceedence at each site was met. Table C4 contains the summary statistics for daily peak four-hour ozone in Western Australia.

**Table C4: 2018 summary statistics for daily peak four-hour ozone**

AAQ NEPM standard  
0.08 ppm (four-hour average)

Regional performance monitoring station	Data availability rates (%)	Highest (ppm)	Highest		2nd highest (ppm)	2nd highest	
			(date)	(time)		(date)	(time)
<b>Perth region</b>							
Caversham (north-east metro)	99.8	0.056	02/01/2018	1800	0.055	20/01/2018	1700
Quinns Rocks (outer north coast)	–	–	–	–	–	–	–
Rockingham (south coast)	99.8	0.057	14/12/2018	1500	0.047	22/12/2018	1600
Rolling Green (outer east rural)	98.0	0.067	04/04/2018	1700	0.062	21/01/2018	1800
South Lake (south-east metro)	99.6	0.053	14/12/2018	1500	0.051	13/03/2018	1700
Swanbourne (inner west coast)	99.8	0.063	13/03/2018	1700	0.055	06/04/2018	1900

## C.4 Sulfur dioxide

The NEPM standard for sulfur dioxide of 0.20 ppm averaged over one hour was not exceeded at any site during 2018. The NEPM goal of no more than one exceedence at each site was met. Table C5 contains the summary statistics for daily peak one-hour sulfur dioxide in Western Australia.

**Table C5: 2018 summary statistics for daily peak one-hour sulfur dioxide**

AAQ NEPM standard  
0.20 ppm (one-hour average)

Regional performance monitoring station	Data availability rates (%)	Highest (ppm)	Highest		2nd highest (ppm)	2nd highest	
			(date)	(time)		(date)	(time)
<b>Perth region</b>							
Rockingham (south coast)	95.4	0.031	01/07/2018	0900	0.023	26/06/2018	1000
South Lake (south-east metro)	97.4	0.022	21/12/2018	1800	0.018	21/01/2018	1600
Wattleup (south metro)	97	0.038	04/01/2018	1600	0.036	26/12/2018	1500
<b>Goldfields region</b>							
Kalgoorlie	92.2	0.106	22/06/2018	1600	0.090	12/12/2018	0100

The NEPM standard for sulfur dioxide of 0.08 ppm averaged over 24 hours was not exceeded at any site during 2018. The NEPM goal of no more than one exceedence at each site was met. Table C6 contains the summary statistics for daily peak 24-hour sulfur dioxide in Western Australia.

**Table C6: 2018 summary statistics for 24-hour sulfur dioxide**

AAQ NEPM standard  
0.08 ppm (24-hour average)

Regional performance monitoring station	Data availability rates (%)	Highest (ppm)	Highest		2nd highest (ppm)	2nd highest	
			(date)	(time)		(date)	(time)
<b>Perth region</b>							
Rockingham (south coast)	95.4	0.007	01/07/2018	2400	0.007	26/06/2018	2400
South Lake (south-east metro)	97.4	0.005	11/07/2018	2400	0.004	20/01/2018	2400
Wattleup (south metro)	97	0.007	04/01/2018	2400	0.006	26/12/2018	2400
<b>Goldfields region</b>							
Kalgoorlie	92.2	0.008	22/06/2018	2400	0.006	01/05/2018	2400

The NEPM standard for sulfur dioxide of 0.02 ppm averaged over one year was not exceeded at any site during 2018. Table C7 contains the summary statistics for annual sulfur dioxide in Western Australia.

**Table C7: 2018 summary statistics for annual sulfur dioxide**

*AAQ NEPM standard  
0.02 ppm (annual average)*

Regional performance monitoring station	Data availability rates (%)	Annual average (ppm)
<b>Perth region</b>		
Rockingham (south coast)	95.4	0.001
South Lake (south-east metro)	97.4	0.002
Wattleup (south metro)	97.0	0.002
<b>Goldfields region</b>		
Kalgoorlie	92.2	0.001

## C.5 Particles as PM<sub>10</sub>

The NEPM standard for particles as PM<sub>10</sub> of 50 µg/m<sup>3</sup> averaged over 24 hours was exceeded a number of times during 2018, as detailed in Table A10. The NEPM goal was not met at Albany, Caversham and Geraldton. Table C8 contains the summary statistics for daily peak 24-hour PM<sub>10</sub> in Western Australia.

**Table C8: 2018 summary statistics for 24-hour particles as PM<sub>10</sub>**

Regional performance monitoring station	Data availability rates (%)	Highest (µg/m <sup>3</sup> )	Highest		6th highest (µg/m <sup>3</sup> )	6th highest	
			(date)	(time)		(date)	(time)
<b>Perth region</b>							
Caversham <sup>1</sup> (north-east metro)	98.9	<b>77.9</b>	24/05/2018	2400	35.4	14/05/2018	2400
Duncraig <sup>1</sup> (north metro)	99.3	<b>61.3</b>	17/11/2018	2400	31.6	10/11/2018	2400
South Lake <sup>1</sup> (south-east metro)	99.6	<b>57.1</b>	17/11/2018	2400	38.6	15/11/2018	2400
<b>South West region</b>							
Albany <sup>1</sup>	93.5	<b>89.6</b>	09/11/2018	2400	37.2	13/05/2018	2400
Bunbury <sup>1</sup>	99.6	<b>51.9</b>	23/05/2018	2400	36.3	18/05/2018	2400
Collie <sup>1</sup>	98.9	<b>84.6</b>	29/04/2018	2400	<b>56.7</b>	23/05/2018	2400
<b>Mid West region</b>							
Geraldton <sup>1</sup>	96	<b>70.0</b>	11/03/2018	2400	41.5	09/01/2018	2400
<b>Goldfields region</b>							
Kalgoorlie <sup>2</sup>	93.6	<b>60.5</b>	25/05/2018	2400	29.7	13/05/2018	2400

1. Model 1400AB Tapered Element Oscillating Microbalance (TEOM) operating continuously (unadjusted for temperature) and includes the manufacturer's recommended equivalency factor of 1.03x + 3.00.

2. Model 1405DF TEOM operating continuously (unadjusted for temperature) with no equivalency factor.

Bold numerals indicate where a relevant standard has been exceeded.

The NEPM standard for particles as PM<sub>10</sub> of 25 micrograms per cubic metre averaged over one year was met at all sites during 2018. Table C9 contains the summary statistics for annual PM<sub>10</sub> in Western Australia.

**Table C9: 2018 summary statistics for annual particles as PM<sub>10</sub>**

AAQ NEPM standard  
25 µg/m<sup>3</sup> (annual average)

Regional performance monitoring station	Data availability rates (%)	Annual average (µg/m <sup>3</sup> )
<b>Perth region</b>		
Caversham <sup>1</sup> (north-east metro)	98.9	16.3
Duncraig <sup>1</sup> (north metro)	99.3	15.1
South Lake <sup>1</sup> (south-east metro)	99.6	16.3
<b>South West region</b>		
Albany <sup>1</sup>	93.5	14.6
Bunbury <sup>1</sup>	99.6	16.1
Collie <sup>1</sup>	98.9	19.3
<b>Mid West region</b>		
Geraldton <sup>1</sup>	96	20.1
<b>Goldfields region</b>		
Kalgoorlie <sup>2</sup>	93.6	12.8

1. TEOM operating continuously (unadjusted for temperature) and includes the manufacturer's recommended equivalency factor of  $1.03x + 3.00$ .

2. Model 1405DF TEOM operating continuously (unadjusted for temperature) with no equivalency factor.

## C.6 Particles as PM<sub>2.5</sub>

The NEPM standard for particles as PM<sub>2.5</sub> of 25 micrograms per cubic metre averaged over 24 hours was exceeded a number of times as detailed in Table A10 during 2018. The NEPM goal was not met at Bunbury, Busselton and Kalgoorlie. Table C10 contains the summary statistics for daily peak 24-hour PM<sub>2.5</sub> in Western Australia.

**Table C10: 2018 summary statistics for 24-hour particles as PM<sub>2.5</sub>**

AAQ NEPM standard  
25 µg/m<sup>3</sup> (24-hour average)

Regional performance monitoring station	Data availability rates (%)	Highest (µg/m <sup>3</sup> )	Highest (date) (time)		6th highest (µg/m <sup>3</sup> )	6th highest (date) (time)	
<b>Perth region</b>							
Caversham <sup>1</sup> (north-east metro)	99.5	<b>36.7</b>	17/11/2018	2400	19.4	11/12/2018	2400
Duncraig <sup>1</sup> (north metro)	99.4	<b>48.6</b>	17/11/2018	2400	18.1	10/11/2018	2400
Quinns Rocks <sup>1</sup> (outer north coast)	–	–	–	–	–	–	–
South Lake <sup>1</sup> (south-east metro)	99.7	<b>43.3</b>	17/11/2018	2400	22.3	26/12/2018	2400
<b>South West region</b>							
Bunbury <sup>1</sup>	99.7	<b>38.4</b>	23/05/2018	2400	24.2	26/12/2018	2400
Busselton <sup>1</sup>	97	<b>56.5</b>	18/05/2018	2400	<b>28.0</b>	20/05/2018	2400
<b>Goldfields region</b>							
Kalgoorlie <sup>2</sup>	93.6	<b>36.2</b>	22/06/2018	2400	15.9	20/06/2018	2400

1. TEOM operating continuously (unadjusted for temperature) and includes the manufacturer's recommended equivalency factor of 1.03x + 3.00.

2. Model 1405DF TEOM operating continuously (unadjusted for temperature) with no equivalency factor.

Bold numerals indicate where a relevant standard has been exceeded.

The NEPM standard for particles as PM<sub>2.5</sub> of 8 micrograms per cubic metre averaged over one year was not met at some sites during 2018. Table C11 contains the summary statistics for annual PM<sub>2.5</sub> in Western Australia.

**Table C11: 2018 summary statistics for annual particles as PM<sub>2.5</sub>**

AAQ NEPM standard  
8 µg/m<sup>3</sup> (annual average)

Regional performance monitoring station	Data availability rates (%)	Annual average (µg/m <sup>3</sup> )
<b>Perth region</b>		
Caversham <sup>1</sup> (north-east metro)	99.5	8.0
Duncraig <sup>1</sup> (north metro)	99.4	7.7
Quinns Rocks <sup>1</sup> (outer north coast)	–	–
South Lake <sup>1</sup> (south-east metro)	99.7	<b>8.4</b>
<b>South West region</b>		
Bunbury <sup>1</sup>	99.7	<b>8.4</b>
Busselton <sup>1</sup>	97	7.9
<b>Goldfields region</b>		
Kalgoorlie <sup>2</sup>	93.6	5.1

1. TEOM operating continuously (unadjusted for temperature) and includes the manufacturer's recommended equivalency factor of 1.03x + 3.00.

2. Model 1405DF TEOM operating continuously (unadjusted for temperature) with no equivalency factor.

Bold numerals indicate where a relevant standard has been exceeded.

## D. Data analysis

### D.1 Maxima and percentiles by pollutant in 2018

**Table D1: 2018 percentiles of daily peak eight-hour carbon monoxide concentrations**

AAQ NEPM standard  
9.0 ppm (eight-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)	75th percentile (ppm)	50th percentile (ppm)
<b>Perth region</b>								
Caversham (north-east metro)	97.4	1.1	0.7	0.6	0.5	0.4	0.3	0.2
Duncraig (north metro)	98.7	1.5	1.2	1.0	0.8	0.7	0.4	0.2
South Lake (south-east metro)	99.7	1.9	1.3	1.3	1.0	0.9	0.4	0.3
<b>Goldfields region</b>								
Kalgoorlie	86.9	1.9	0.9	0.8	0.5	0.4	0.2	0.2

**Table D2: 2018 percentiles of daily peak one-hour nitrogen dioxide concentrations**

AAQ NEPM standard  
0.12 ppm (one-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)	75th percentile (ppm)	50th percentile (ppm)
<b>Perth region</b>								
Caversham (north-east metro)	98.6	0.034	0.029	0.028	0.026	0.024	0.019	0.014
Duncraig (north metro)	97.1	0.036	0.031	0.030	0.027	0.025	0.021	0.013
Quinns Rocks (outer north coast)	–	–	–	–	–	–	–	–
Rockingham (south coast)	82.2	0.029	0.026	0.025	0.023	0.020	0.014	0.008
Rolling Green (outer east rural)	99.8	0.023	0.018	0.016	0.014	0.012	0.008	0.005
South Lake (south-east metro)	98.9	0.047	0.035	0.033	0.029	0.027	0.022	0.015
Swanbourne (inner west coast)	99.3	0.039	0.031	0.029	0.026	0.021	0.016	0.010

**Table D3: 2018 percentiles of daily peak one-hour ozone concentrations**AAQ NEPM standard  
0.10 ppm (one-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)	75th percentile (ppm)	50th percentile (ppm)
<b>Perth region</b>								
Caversham (north-east metro)	99.8	0.067	0.059	0.056	0.049	0.045	0.034	0.030
Quinns Rocks (outer north coast)	–	–	–	–	–	–	–	–
Rockingham (south coast)	99.8	0.061	0.049	0.045	0.042	0.038	0.035	0.032
Rolling Green (outer east rural)	98	0.075	0.063	0.062	0.055	0.049	0.038	0.034
South Lake (south-east metro)	99.6	0.061	0.048	0.044	0.039	0.035	0.032	0.029
Swanbourne (inner west coast)	99.8	0.075	0.054	0.050	0.046	0.044	0.040	0.036

**Table D4: 2018 percentiles of daily peak four-hour ozone concentrations**AAQ NEPM standard  
0.08 ppm (four-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)	75th percentile (ppm)	50th percentile (ppm)
<b>Perth region</b>								
Caversham (north-east metro)	99.8	0.056	0.052	0.050	0.044	0.040	0.032	0.029
Quinns Rocks (outer north coast)	–	–	–	–	–	–	–	–
Rockingham (south coast)	99.8	0.057	0.045	0.043	0.038	0.036	0.034	0.030
Rolling Green (outer east rural)	98	0.067	0.057	0.053	0.048	0.043	0.036	0.033
South Lake (south-east metro)	99.6	0.053	0.043	0.040	0.035	0.032	0.030	0.027
Swanbourne (inner west coast)	99.8	0.063	0.051	0.047	0.043	0.041	0.039	0.035

**Table D5: 2018 percentiles of daily peak one-hour sulfur dioxide concentrations**AAQ NEPM standard  
0.20 ppm (one-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)	75th percentile (ppm)	50th percentile (ppm)
<b>Perth region</b>								
Rockingham (south coast)	95.4	0.031	0.021	0.019	0.013	0.008	0.004	0.002
South Lake (south-east metro)	97.4	0.022	0.016	0.015	0.012	0.010	0.006	0.003
Wattleup (south metro)	97	0.038	0.033	0.029	0.023	0.017	0.011	0.005
.								
<b>Goldfields region</b>								
Kalgoorlie	92.2	0.106	0.060	0.038	0.019	0.014	0.005	0.001

**Table D6: 2018 percentiles of daily peak 24-hour sulfur dioxide concentrations**AAQ NEPM standard  
0.08 ppm (24-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)	75th percentile (ppm)	50th percentile (ppm)
<b>Perth region</b>								
Rockingham (south coast)	95.4	0.007	0.004	0.004	0.003	0.002	0.001	0.001
South Lake (south-east metro)	97.4	0.005	0.004	0.004	0.004	0.003	0.003	0.002
Wattleup (south metro)	97	0.007	0.006	0.005	0.004	0.003	0.002	0.001
<b>Goldfields region</b>								
Kalgoorlie	92.2	0.008	0.006	0.004	0.003	0.002	0.001	0.001

**Table D7: 2018 percentiles of daily peak 24-hour particles as PM<sub>10</sub> concentrations**AAQ NEPM standard  
50 µg/m<sup>3</sup> (24-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (µg/m <sup>3</sup> )	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )	75th percentile (µg/m <sup>3</sup> )	50th percentile (µg/m <sup>3</sup> )
<b>Perth region</b>								
Caversham (north-east metro)	98.9	<b>77.9</b>	36.1	33.2	27.8	25.0	20.0	15.1
Duncraig (north metro)	99.3	<b>61.3</b>	33.1	28.0	24.1	21.4	17.9	14.6
South Lake (south-east metro)	99.6	<b>57.1</b>	40.7	34.3	26.7	23.7	20.0	15.4
<b>South West region</b>								
Albany	93.5	<b>89.6</b>	43.9	30.1	26.3	21.8	17.3	13.0
Bunbury	99.6	<b>51.9</b>	37.8	35.2	27.8	24.4	18.7	15.0
Collie	98.9	<b>84.6</b>	<b>57.4</b>	<b>52.4</b>	39.6	30.8	22.6	16.7
<b>Mid West region</b>								
Geraldton	96	<b>70.0</b>	42.2	41.0	36.7	31.8	26.0	18.1
<b>Goldfields region</b>								
Kalgoorlie	93.6	<b>60.5</b>	31.8	29.3	22.8	20.6	15.3	12.0

Bold numerals indicate where a relevant standard has been exceeded.

**Table D8: 2018 percentiles of daily peak 24-hour particles as PM<sub>2.5</sub> concentrations**AAQ NEPM standard  
25 µg/m<sup>3</sup> (24-hour average)

Regional performance monitoring station	Data availability rates (%)	Max conc. (µg/m <sup>3</sup> )	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )	75th percentile (µg/m <sup>3</sup> )	50th percentile (µg/m <sup>3</sup> )
<b>Perth region</b>								
Caversham (north-east metro)	99.5	<b>36.7</b>	20.6	17.3	14.8	11.6	8.9	7.2
Duncraig (north metro)	99.4	<b>48.6</b>	19.3	15.6	12.9	11.1	8.9	7.0
Quinns Rocks (outer north coast)	–	–	–	–	–	–	–	–
South Lake (south-east metro)	99.7	<b>43.3</b>	<b>27.6</b>	20.2	15.0	12.3	9.4	7.5
<b>South West region</b>								
Bunbury	99.7	<b>38.4</b>	<b>26.0</b>	22.2	17.2	12.5	9.7	7.2
Busselton	97	<b>56.5</b>	<b>28.9</b>	22.2	16.4	11.3	8.5	6.7
<b>Goldfields region</b>								
Kalgoorlie	93.6	<b>36.2</b>	16.4	14.0	10.2	8.2	5.8	4.4

Bold numerals indicate where a relevant standard has been exceeded.

## D.2 Maxima and percentiles by site 2009–18

**Table D9: Daily peak eight-hour carbon monoxide at Caversham (2009–18)**

**Trend station/region: Caversham**

AAQ NEPM standard  
9.0 ppm (eight-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.2	0	1.0	0.6	0.5	0.4	0.4
2010	85.0	0	1.6	0.8	0.7	0.6	0.5
2011	98.2	0	1.5	1.2	1.0	0.6	0.5
2012	98.0	0	0.9	0.7	0.6	0.5	0.4
2013	97.5	0	0.9	0.7	0.6	0.5	0.4
2014	96.1	0	0.7	0.7	0.6	0.5	0.4
2015	94.1	0	1.2	0.8	0.7	0.6	0.5
2016	99.2	0	0.9	0.6	0.6	0.5	0.4
2017	97.5	0	2.9	1.1	0.8	0.5	0.4
2018	97.4	0	1.1	0.7	0.6	0.5	0.4

**Table D10: Daily peak eight-hour carbon monoxide at Duncraig (2009–18)**

**Trend station/region: Duncraig**

AAQ NEPM standard  
9.0 ppm (eight-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	98.2	0	2.6	1.7	1.4	1.0	0.7
2010	87.5	0	2.3	2.0	1.8	1.5	1.1
2011	99.3	0	1.9	1.3	1.2	1.0	0.7
2012	99.5	0	2.4	1.9	1.5	1.1	0.9
2013	99.5	0	2.1	1.8	1.6	1.2	0.8
2014	99.7	0	1.9	1.4	1.0	0.8	0.7
2015	99.5	0	1.7	1.4	1.3	1.0	0.7
2016	99.8	0	1.4	1.2	1.1	0.8	0.7
2017	96.9	0	1.4	1.1	0.9	0.8	0.6
2018	98.7	0	1.5	1.2	1.0	0.8	0.7

**Table D11: Daily peak eight-hour carbon monoxide at South Lake (2009–18)**

**Trend station/region: South Lake**

AAQ NEPM standard  
9.0 ppm (eight-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.3	0	1.8	1.4	1.1	0.9	0.7
2010	87.8	0	2.2	1.6	1.5	1.2	0.9
2011	98.3	0	1.7	1.5	1.3	1.0	0.8
2012	98.9	0	2.2	1.6	1.4	1.0	0.8
2013	98.5	0	1.7	1.3	1.2	1.0	0.6
2014	99.5	0	1.8	1.4	1.0	0.8	0.7
2015	98.5	0	1.9	1.3	1.2	0.9	0.8
2016	99.8	0	2.3	1.3	1.1	0.9	0.7
2017	98.6	0	1.9	1.4	1.3	1.0	0.7
2018	99.7	0	1.9	1.3	1.3	1.0	0.9

**Table D12: Daily peak eight-hour carbon monoxide at Kalgoorlie (2009–18)****Campaign station/region: Kalgoorlie**AAQ NEPM standard  
9.0 ppm (eight-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	–	–	–	–	–	–	–
2010	–	–	–	–	–	–	–
2011	–	–	–	–	–	–	–
2012	–	–	–	–	–	–	–
2013	–	–	–	–	–	–	–
2014	–	–	–	–	–	–	–
2015	–	–	–	–	–	–	–
2016	–	–	–	–	–	–	–
2017	–	–	–	–	–	–	–
2018	86.9	0	1.9	0.9	0.8	0.5	0.4

**Table D13: Daily peak one-hour nitrogen dioxide at Caversham (2009–18)****Trend station/region: Caversham**AAQ NEPM standard  
0.12 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.3	0	0.044	0.034	0.033	0.028	0.026
2010	84.9	0	0.054	0.040	0.037	0.032	0.029
2011	99.5	0	0.035	0.031	0.029	0.027	0.025
2012	97.0	0	0.037	0.033	0.032	0.029	0.025
2013	97.5	0	0.043	0.034	0.032	0.029	0.025
2014	94.2	0	0.033	0.031	0.030	0.026	0.024
2015	94.6	0	0.041	0.035	0.032	0.027	0.025
2016	99.5	0	0.036	0.032	0.030	0.026	0.024
2017	95.3	0	0.042	0.032	0.031	0.028	0.025
2018	98.6	0	0.034	0.029	0.028	0.026	0.024

**Table D14: Daily peak one-hour nitrogen dioxide at Duncraig (2009–18)****Trend station/region: Duncraig**AAQ NEPM standard  
0.12 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	98.5	0	0.042	0.037	0.034	0.030	0.027
2010	87.5	0	0.038	0.035	0.033	0.030	0.028
2011	99.3	0	0.035	0.032	0.030	0.028	0.027
2012	96.8	0	0.047	0.037	0.033	0.030	0.027
2013	97.9	0	0.040	0.031	0.030	0.028	0.026
2014	99.3	0	0.048	0.029	0.028	0.026	0.024
2015	98.2	0	0.036	0.034	0.032	0.028	0.026
2016	99.8	0	0.033	0.029	0.028	0.026	0.024
2017	98.2	0	0.032	0.031	0.030	0.027	0.026
2018	97.1	0	0.036	0.031	0.030	0.027	0.025

**Table D15: Daily peak one-hour nitrogen dioxide at Quinns Rocks (2009–18)****Trend station/region: Quinns Rocks**AAQ NEPM standard  
0.12 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.0	0	0.034	0.032	0.031	0.027	0.024
2010	88.8	0	0.040	0.032	0.032	0.030	0.027
2011	99.0	0	0.031	0.028	0.027	0.025	0.022
2012	97.3	0	0.041	0.032	0.031	0.027	0.024
2013	97.9	0	0.032	0.026	0.026	0.023	0.020
2014	99.6	0	0.031	0.026	0.024	0.020	0.017
2015	98.8	0	0.030	0.028	0.026	0.024	0.020
2016	97.8	0	0.029	0.026	0.024	0.022	0.020
2017	21.5	0	0.019	0.017	0.016	0.015	0.014
2018	–	–	–	–	–	–	–

**Table D16: Daily peak one-hour nitrogen dioxide at Rockingham (2009–18)****Trend station/region: Rockingham**AAQ NEPM standard  
0.12 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	98.6	0	0.031	0.029	0.028	0.026	0.024
2010	88.7	0	0.036	0.032	0.030	0.028	0.026
2011	96.6	0	0.034	0.028	0.027	0.025	0.022
2012	96.4	0	0.053	0.030	0.030	0.027	0.024
2013	97.8	0	0.035	0.031	0.029	0.027	0.025
2014	98.7	0	0.034	0.027	0.026	0.024	0.021
2015	98.8	0	0.062	0.032	0.029	0.026	0.023
2016	99.3	0	0.029	0.027	0.026	0.024	0.022
2017	93.4	0	0.074	0.047	0.034	0.026	0.023
2018	82.2	0	0.029	0.026	0.025	0.023	0.020

**Table D17: Daily peak one-hour nitrogen dioxide at Rolling Green (2009–18)****Trend station/region: Rolling Green**AAQ NEPM standard  
0.12 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.5	0	0.035	0.023	0.019	0.017	0.015
2010	87.5	0	0.030	0.022	0.019	0.017	0.016
2011	97.1	0	0.023	0.019	0.018	0.015	0.013
2012	91.9	0	0.029	0.019	0.017	0.016	0.014
2013	96.5	0	0.030	0.018	0.017	0.015	0.013
2014	97.2	0	0.021	0.017	0.015	0.013	0.013
2015	98.0	0	0.023	0.018	0.017	0.016	0.013
2016	97.5	0	0.023	0.016	0.016	0.013	0.012
2017	99.1	0	0.018	0.017	0.016	0.014	0.013
2018	99.8	0	0.023	0.018	0.016	0.014	0.012

**Table D18: Daily peak one-hour nitrogen dioxide at South Lake (2009–18)**

Trend station/region: South Lake

AAQ NEPM standard  
0.12 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.3	0	0.048	0.039	0.036	0.033	0.029
2010	87.8	0	0.058	0.045	0.040	0.036	0.030
2011	96.1	0	0.041	0.033	0.032	0.030	0.028
2012	98.7	0	0.046	0.038	0.035	0.031	0.028
2013	97.1	0	0.043	0.037	0.033	0.031	0.027
2014	99.5	0	0.034	0.032	0.029	0.028	0.026
2015	98.7	0	0.043	0.034	0.031	0.028	0.026
2016	95.0	0	0.038	0.030	0.029	0.027	0.025
2017	97.3	0	0.045	0.034	0.030	0.028	0.026
2018	98.9	0	0.047	0.035	0.033	0.029	0.027

**Table D19: Daily peak one-hour nitrogen dioxide at Swanbourne (2009–18)**

Trend station/region: Swanbourne

AAQ NEPM standard  
0.12 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.2	0	0.037	0.034	0.032	0.028	0.026
2010	86.6	0	0.038	0.033	0.032	0.031	0.029
2011	99.4	0	0.032	0.029	0.028	0.026	0.024
2012	98.4	0	0.045	0.033	0.032	0.030	0.027
2013	99.6	0	0.037	0.033	0.031	0.027	0.025
2014	99.8	0	0.036	0.029	0.028	0.024	0.022
2015	99.5	0	0.036	0.034	0.030	0.027	0.023
2016	96.1	0	0.030	0.028	0.026	0.024	0.020
2017	99.8	0	0.033	0.032	0.030	0.026	0.022
2018	99.3	0	0.039	0.031	0.029	0.026	0.021

**Table D20: Daily peak one-hour ozone at Caversham (2009–18)**

Trend station/region: Caversham

AAQ NEPM standard  
0.10 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.3	1	<b>0.104</b>	0.072	0.067	0.056	0.050
2010	84.5	0	0.082	0.069	0.059	0.055	0.046
2011	99.2	0	0.077	0.070	0.067	0.054	0.045
2012	97.5	0	0.098	0.078	0.064	0.052	0.047
2013	95.7	1	<b>0.101</b>	0.074	0.070	0.056	0.051
2014	96.3	0	0.091	0.065	0.058	0.052	0.047
2015	95.4	1	<b>0.103</b>	0.080	0.077	0.062	0.052
2016	99.6	0	0.096	0.066	0.062	0.053	0.046
2017	98.7	0	0.099	0.077	0.069	0.059	0.049
2018	99.8	0	0.067	0.059	0.056	0.049	0.045

Bold numerals indicate where a relevant standard has been exceeded.

**Table D21: Daily peak one-hour ozone at Quinns Rocks (2009–18)****Trend station/region: Quinns Rocks**AAQ NEPM standard  
0.10 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	94.3	0	0.070	0.063	0.061	0.053	0.045
2010	88.7	0	0.091	0.061	0.058	0.054	0.048
2011	99.1	0	0.083	0.068	0.057	0.051	0.045
2012	95.7	1	<b>0.130</b>	0.073	0.069	0.058	0.048
2013	99.2	0	0.087	0.077	0.066	0.058	0.050
2014	99.3	0	0.073	0.065	0.062	0.052	0.045
2015	98.9	0	0.083	0.070	0.064	0.057	0.049
2016	98.7	0	0.089	0.066	0.061	0.056	0.048
2017	21.5	0	0.066	0.064	0.061	0.056	0.051
2018	–	–	–	–	–	–	–

**Table D22: Daily peak one-hour ozone at Rockingham (2009–18)****Trend station/region: Rockingham**AAQ NEPM standard  
0.10 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.0	0	0.078	0.064	0.054	0.048	0.041
2010	88.2	0	0.067	0.060	0.057	0.052	0.044
2011	94.9	0	0.065	0.062	0.057	0.048	0.043
2012	99.0	0	0.095	0.073	0.064	0.053	0.044
2013	98.8	0	0.084	0.068	0.065	0.052	0.044
2014	99.0	0	0.076	0.060	0.053	0.047	0.039
2015	98.9	0	0.069	0.062	0.061	0.052	0.045
2016	98.8	0	0.087	0.064	0.060	0.051	0.044
2017	99.1	0	0.069	0.060	0.058	0.051	0.042
2018	99.8	0	0.061	0.049	0.045	0.042	0.038

**Table D23: Daily peak one-hour ozone at Rolling Green (2009–18)****Trend station/region: Rolling Green**AAQ NEPM standard  
0.10 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.5	1	<b>0.103</b>	0.081	0.069	0.059	0.052
2010	85.6	0	0.088	0.077	0.070	0.056	0.046
2011	95.9	0	0.073	0.068	0.060	0.052	0.043
2012	91.8	1	<b>0.103</b>	0.074	0.066	0.055	0.045
2013	96.8	0	0.099	0.078	0.071	0.061	0.049
2014	98.1	0	0.080	0.069	0.063	0.056	0.047
2015	99.2	1	<b>0.105</b>	0.078	0.073	0.062	0.055
2016	97.5	0	0.075	0.070	0.063	0.053	0.047
2017	98.6	0	0.069	0.064	0.058	0.052	0.043
2018	98.0	0	0.075	0.063	0.062	0.055	0.049

Bold numerals indicate where a relevant standard has been exceeded.

**Table D24: Daily peak one-hour ozone at South Lake (2009–18)****Trend station/region: South Lake**AAQ NEPM standard  
0.10 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.4	0	0.065	0.057	0.053	0.045	0.039
2010	88.0	0	0.070	0.067	0.062	0.052	0.045
2011	99.4	0	0.076	0.064	0.057	0.050	0.044
2012	98.2	0	0.085	0.065	0.062	0.051	0.041
2013	98.6	0	0.087	0.074	0.062	0.054	0.043
2014	99.4	0	0.065	0.059	0.056	0.046	0.041
2015	98.8	0	0.067	0.063	0.060	0.051	0.042
2016	99.6	0	0.091	0.065	0.056	0.050	0.043
2017	98.5	0	0.074	0.061	0.058	0.050	0.043
2018	99.6	0	0.061	0.048	0.044	0.039	0.035

**Table D25: Daily peak one-hour ozone at Swanbourne (2009–18)****Trend station/region: Swanbourne**AAQ NEPM standard  
0.10 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.6	0	0.068	0.063	0.059	0.053	0.044
2010	86.6	0	0.066	0.059	0.056	0.050	0.044
2011	99.6	0	0.085	0.069	0.061	0.051	0.046
2012	98.2	1	<b>0.128</b>	0.074	0.067	0.056	0.047
2013	99.8	0	0.083	0.069	0.064	0.052	0.045
2014	97.8	0	0.066	0.056	0.053	0.048	0.042
2015	99.9	0	0.074	0.066	0.061	0.056	0.044
2016	98.7	1	<b>0.103</b>	0.067	0.064	0.054	0.046
2017	99.5	0	0.079	0.074	0.064	0.056	0.049
2018	99.8	0	0.075	0.054	0.050	0.046	0.044

Bold numerals indicate where a relevant standard has been exceeded.

**Table D26: Daily peak four-hour ozone at Caversham (2009–18)****Trend station/region: Caversham**AAQ NEPM standard  
0.08 ppm (four-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.3	1	<b>0.092</b>	0.067	0.057	0.051	0.043
2010	84.5	0	0.072	0.056	0.052	0.047	0.041
2011	99.2	0	0.063	0.061	0.056	0.049	0.041
2012	97.5	2	<b>0.086</b>	0.070	0.056	0.047	0.041
2013	95.7	0	0.075	0.065	0.060	0.049	0.044
2014	96.3	0	0.073	0.055	0.050	0.046	0.041
2015	95.4	1	<b>0.084</b>	0.070	0.067	0.054	0.046
2016	99.6	1	<b>0.085</b>	0.062	0.053	0.046	0.042
2017	98.7	0	0.077	0.068	0.060	0.050	0.044
2018	99.8	0	0.056	0.052	0.050	0.044	0.040

Bold numerals indicate where a relevant standard has been exceeded.

**Table D27: Daily peak four-hour ozone at Quinns Rocks (2009–18)****Trend station/region: Quinns Rocks**AAQ NEPM standard  
0.08 ppm (four-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	94.3	0	0.062	0.056	0.054	0.048	0.040
2010	88.7	0	0.065	0.056	0.052	0.048	0.042
2011	99.1	0	0.075	0.060	0.052	0.047	0.041
2012	95.7	2	<b>0.108</b>	0.065	0.061	0.051	0.043
2013	99.2	0	0.079	0.068	0.061	0.051	0.045
2014	99.3	0	0.062	0.057	0.051	0.046	0.042
2015	98.9	0	0.071	0.063	0.059	0.053	0.042
2016	98.7	0	0.079	0.060	0.058	0.050	0.044
2017	21.5	0	0.062	0.058	0.054	0.049	0.047
2018	—	—	—	—	—	—	—

Bold numerals indicate where a relevant standard has been exceeded.

**Table D28: Daily peak four-hour ozone at Rockingham (2009–18)****Trend station/region: Rockingham**AAQ NEPM standard  
0.08 ppm (four-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.0	0	0.066	0.058	0.051	0.045	0.039
2010	88.2	0	0.064	0.054	0.053	0.046	0.041
2011	94.9	0	0.061	0.058	0.053	0.045	0.040
2012	99.0	0	0.079	0.065	0.060	0.048	0.040
2013	98.8	0	0.075	0.064	0.057	0.047	0.042
2014	99.0	0	0.067	0.051	0.048	0.043	0.037
2015	98.9	0	0.064	0.056	0.055	0.047	0.041
2016	98.8	0	0.079	0.060	0.057	0.048	0.041
2017	99.1	0	0.062	0.057	0.053	0.046	0.039
2018	99.8	0	0.057	0.045	0.043	0.038	0.036

**Table D29: Daily peak four-hour ozone at Rolling Green (2009–18)****Trend station/region: Rolling Green**AAQ NEPM standard  
0.08 ppm (four-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.5	2	<b>0.083</b>	0.064	0.057	0.051	0.043
2010	85.6	0	0.080	0.065	0.056	0.049	0.042
2011	95.9	0	0.061	0.055	0.051	0.045	0.040
2012	91.8	1	<b>0.081</b>	0.064	0.058	0.049	0.042
2013	96.8	1	<b>0.083</b>	0.065	0.059	0.051	0.045
2014	98.1	0	0.070	0.058	0.054	0.048	0.042
2015	99.2	1	<b>0.093</b>	0.068	0.063	0.054	0.049
2016	97.5	0	0.066	0.059	0.056	0.047	0.042
2017	98.6	0	0.064	0.057	0.051	0.045	0.039
2018	98.0	0	0.067	0.057	0.053	0.048	0.043

Bold numerals indicate where a relevant standard has been exceeded.

**Table D30: Daily peak four-hour ozone at South Lake (2009–18)****Trend station/region: South Lake**AAQ NEPM standard  
0.08 ppm (four-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.4	0	0.057	0.053	0.048	0.040	0.036
2010	88.0	0	0.061	0.055	0.053	0.046	0.042
2011	99.4	0	0.064	0.056	0.051	0.046	0.039
2012	98.2	0	0.080	0.060	0.054	0.046	0.037
2013	98.6	0	0.074	0.063	0.057	0.048	0.039
2014	99.4	0	0.058	0.053	0.049	0.042	0.037
2015	98.8	0	0.060	0.055	0.053	0.045	0.037
2016	99.6	0	0.080	0.054	0.051	0.044	0.038
2017	98.5	0	0.067	0.055	0.052	0.045	0.038
2018	99.6	0	0.053	0.043	0.040	0.035	0.032

**Table D31: Daily peak four-hour ozone at Swanbourne (2009–18)****Trend station/region: Swanbourne**AAQ NEPM standard  
0.08 ppm (four-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	99.6	0	0.063	0.058	0.054	0.046	0.039
2010	86.6	0	0.055	0.053	0.050	0.044	0.040
2011	99.6	0	0.073	0.059	0.056	0.047	0.043
2012	98.2	1	<b>0.108</b>	0.064	0.061	0.051	0.042
2013	99.8	0	0.068	0.063	0.056	0.048	0.042
2014	97.8	0	0.057	0.050	0.049	0.043	0.038
2015	99.9	0	0.067	0.058	0.056	0.049	0.039
2016	98.7	1	<b>0.081</b>	0.062	0.057	0.050	0.042
2017	99.5	0	0.070	0.060	0.057	0.051	0.046
2018	99.8	0	0.063	0.051	0.047	0.043	0.041

Bold numerals indicate where a relevant standard has been exceeded.

**Table D32: Daily peak one-hour sulfur dioxide at Rockingham (2009–18)****Trend station/region: Rockingham**AAQ NEPM standard  
0.20 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	98.7	0	0.032	0.022	0.017	0.010	0.007
2010	89.9	0	0.037	0.022	0.019	0.013	0.009
2011	93.7	0	0.040	0.029	0.024	0.017	0.010
2012	94.4	0	0.040	0.020	0.018	0.011	0.008
2013	94.5	0	0.037	0.028	0.022	0.016	0.011
2014	93.9	0	0.036	0.024	0.021	0.013	0.008
2015	94.6	0	0.051	0.033	0.023	0.018	0.012
2016	96.1	0	0.064	0.041	0.035	0.020	0.013
2017	95.8	0	0.030	0.024	0.017	0.012	0.008
2018	95.4	0	0.031	0.021	0.019	0.013	0.008

**Table D33: Daily peak one-hour sulfur dioxide at South Lake (2009–18)****Trend station/region: South Lake**AAQ NEPM standard  
0.20 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	98.4	0	0.036	0.033	0.029	0.018	0.015
2010	87.8	0	0.073	0.036	0.033	0.025	0.017
2011	95.7	0	0.044	0.029	0.026	0.017	0.012
2012	94.0	0	0.039	0.027	0.019	0.014	0.010
2013	93.3	0	0.044	0.034	0.031	0.020	0.015
2014	94.5	0	0.051	0.028	0.024	0.016	0.012
2015	95.5	0	0.037	0.031	0.029	0.020	0.016
2016	97.4	0	0.034	0.020	0.017	0.014	0.011
2017	95.2	0	0.037	0.023	0.019	0.017	0.013
2018	97.4	0	0.022	0.016	0.015	0.012	0.010

**Table D34: Daily peak one-hour sulfur dioxide at Wattleup (2009–18)****Trend station/region: Wattleup**AAQ NEPM standard  
0.20 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	95.6	0	0.059	0.039	0.036	0.029	0.022
2010	86.8	0	0.057	0.049	0.043	0.036	0.023
2011	94.3	0	0.067	0.049	0.042	0.032	0.026
2012	94.7	0	0.043	0.039	0.034	0.025	0.017
2013	92.5	0	0.090	0.059	0.047	0.037	0.027
2014	95.1	0	0.061	0.046	0.037	0.031	0.024
2015	95.6	0	0.067	0.046	0.045	0.039	0.031
2016	94.5	0	0.072	0.055	0.048	0.033	0.025
2017	96.3	0	0.068	0.051	0.036	0.026	0.021
2018	97.0	0	0.038	0.033	0.029	0.023	0.017

**Table D35: Daily peak one-hour sulfur dioxide at Kalgoorlie (2009–18)****Trend station/region: Goldfields**AAQ NEPM standard  
0.20 ppm (one-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	—	—	—	—	—	—	—
2010	—	—	—	—	—	—	—
2011	—	—	—	—	—	—	—
2012	—	—	—	—	—	—	—
2013	—	—	—	—	—	—	—
2014	—	—	—	—	—	—	—
2015	—	—	—	—	—	—	—
2016	—	—	—	—	—	—	—
2017	—	—	—	—	—	—	—
2018	92.2	0	0.106	0.060	0.038	0.019	0.014

**Table D36: Daily peak 24-hour sulfur dioxide at Rockingham (2009–18)****Trend station/region: Rockingham**AAQ NEPM standard  
0.08 ppm (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	98.7	0	0.008	0.003	0.002	0.001	0.001
2010	89.9	0	0.007	0.004	0.003	0.002	0.002
2011	93.7	0	0.008	0.006	0.006	0.003	0.002
2012	94.4	0	0.006	0.005	0.003	0.002	0.002
2013	94.5	0	0.007	0.005	0.004	0.003	0.002
2014	93.9	0	0.007	0.005	0.004	0.003	0.002
2015	94.6	0	0.013	0.007	0.006	0.004	0.003
2016	96.1	0	0.014	0.010	0.007	0.004	0.002
2017	95.8	0	0.009	0.004	0.003	0.003	0.002
2018	95.4	0	0.007	0.004	0.004	0.003	0.002

**Table D37: Daily peak 24-hour sulfur dioxide at South Lake (2009–18)****Trend station/region: South Lake**AAQ NEPM standard  
0.08 ppm (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	98.4	0	0.006	0.005	0.003	0.003	0.002
2010	87.8	0	0.009	0.005	0.004	0.003	0.002
2011	95.7	0	0.006	0.004	0.003	0.002	0.002
2012	94.0	0	0.006	0.004	0.003	0.003	0.002
2013	93.3	0	0.014	0.005	0.004	0.003	0.002
2014	94.5	0	0.010	0.005	0.004	0.003	0.003
2015	95.5	0	0.007	0.006	0.005	0.005	0.004
2016	97.4	0	0.010	0.007	0.007	0.006	0.005
2017	95.2	0	0.009	0.008	0.008	0.006	0.005
2018	97.4	0	0.005	0.004	0.004	0.004	0.003

**Table D38: Daily peak 24-hour sulfur dioxide at Wattleup (2009–18)****Trend station/region: Wattleup**AAQ NEPM standard  
0.08 ppm (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	95.6	0	0.008	0.005	0.005	0.004	0.003
2010	86.8	0	0.010	0.008	0.006	0.005	0.003
2011	94.3	0	0.008	0.006	0.005	0.004	0.003
2012	94.7	0	0.008	0.005	0.004	0.003	0.002
2013	92.5	0	0.010	0.008	0.006	0.005	0.004
2014	95.1	0	0.008	0.007	0.006	0.005	0.004
2015	95.6	0	0.009	0.007	0.006	0.006	0.005
2016	94.5	0	0.011	0.006	0.005	0.004	0.003
2017	96.3	0	0.007	0.005	0.005	0.004	0.003
2018	97.0	0	0.007	0.006	0.005	0.004	0.003

**Table D39: Daily peak 24-hour sulfur dioxide at Kalgoorlie (2009–18)****Trend station/region: Goldfields**AAQ NEPM standard  
0.08 ppm (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (ppm)	98th percentile (ppm)	95th percentile (ppm)	90th percentile (ppm)
2009	–	–	–	–	–	–	–
2010	–	–	–	–	–	–	–
2011	–	–	–	–	–	–	–
2012	–	–	–	–	–	–	–
2013	–	–	–	–	–	–	–
2014	–	–	–	–	–	–	–
2015	–	–	–	–	–	–	–
2016	–	–	–	–	–	–	–
2017	–	–	–	–	–	–	–
2018	92.2	0	0.008	0.006	0.004	0.003	0.002

**Table D40: Daily peak 24-hour particles as PM<sub>10</sub> at Caversham (2009–18)****Trend station/region: Caversham**AAQ NEPM standard  
50 µg/m<sup>3</sup> (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (µg/m <sup>3</sup> )	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )
2009	99.4	0	45.7	37.2	32.4	29.0	25.8
2010	99.5	1	<b>63.4</b>	40.7	36.1	30.5	26.3
2011	99.1	1	<b>76.1</b>	33.2	30.2	27.3	23.8
2012	97.8	4	<b>68.7</b>	49.2	36.7	27.2	24.4
2013	97.4	1	<b>62.4</b>	34.4	30.7	26.2	23.6
2014	97.2	1	<b>52.6</b>	37.3	34.5	27.2	24.8
2015	95.7	0	46.8	40.7	37.4	30.4	26.3
2016	99.1	0	38.1	33.7	31.5	26.4	22.8
2017	98.6	3	<b>79.2</b>	43.3	32.6	27.8	25.0
2018	98.9	2	<b>77.9</b>	36.1	33.2	27.8	25.0

Bold numerals indicate where a relevant standard has been exceeded.

**Table D41: Daily peak 24-hour particles as PM<sub>10</sub> at Duncraig (2009–18)****Trend station/region: Duncraig**AAQ NEPM standard  
50 µg/m<sup>3</sup> (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (µg/m <sup>3</sup> )	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )
2009	99.2	0	45.5	36.2	30.4	24.5	22.6
2010	99.4	0	47.9	33.1	30.8	25.1	22.7
2011	99.3	1	<b>65.9</b>	30.1	29.5	25.7	23.2
2012	99.4	2	<b>89.5</b>	35.5	28.3	26.1	23.0
2013	99.3	0	37.6	32.1	28.1	25.6	22.8
2014	99.4	1	<b>53.0</b>	31.2	28.1	25.1	22.4
2015	99.4	1	<b>82.7</b>	40.1	36.7	28.0	25.2
2016	99.6	0	40.0	34.2	29.7	25.8	21.8
2017	98.4	1	<b>51.4</b>	33.4	30.1	26.4	22.5
2018	99.3	1	<b>61.3</b>	33.1	28.0	24.1	21.4

Bold numerals indicate where a relevant standard has been exceeded.

**Table D42: Daily peak 24-hour particles as PM<sub>10</sub> at South Lake (2009–18)****Trend station/region: South Lake**AAQ NEPM standard  
50 µg/m<sup>3</sup> (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (µg/m <sup>3</sup> )	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )
2009	99.5	0	49.0	38.7	34.3	30.8	27.5
2010	99.7	4	<b>61.0</b>	46.7	39.8	33.9	28.5
2011	99.2	1	<b>66.2</b>	35.8	31.5	28.1	24.8
2012	99.1	2	<b>81.5</b>	36.6	30.3	28.5	24.1
2013	98.6	0	38.8	34.4	32.3	28.9	25.9
2014	99.4	0	44.5	38.2	34.0	29.4	26.3
2015	97.4	2	<b>53.3</b>	45.7	41.7	34.4	28.5
2016	99.5	0	47.0	38.7	33.4	28.9	24.3
2017	98.2	0	49.6	37.7	31.3	28.6	26.2
2018	99.6	1	<b>57.1</b>	40.7	34.3	26.7	23.7

Bold numerals indicate where a relevant standard has been exceeded.

**Table D43: Daily peak 24-hour particles as PM<sub>10</sub> at Albany (2009–18)****Trend station/region: Albany**AAQ NEPM standard  
50 µg/m<sup>3</sup> (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (µg/m <sup>3</sup> )	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )
2009	97.7	0	36.7	32.3	28.7	24.5	21.4
2010	99.8	1	<b>52.5</b>	36.1	33.2	27.3	25.3
2011	99.3	0	37.3	33.6	30.6	26.3	22.0
2012	99.5	0	37.0	34.6	31.1	27.4	23.6
2013	98.1	3	<b>110.8</b>	43.3	36.0	29.1	23.8
2014	98.6	0	43.5	35.5	31.4	28.1	24.4
2015	99.1	2	<b>76.7</b>	37.3	34.7	28.4	24.5
2016	95.5	6	<b>94.9</b>	<b>56.5</b>	45.2	35.1	28.7
2017	99.5	2	<b>61.8</b>	46.7	41.4	30.7	25.8
2018	93.5	2	<b>89.6</b>	43.9	30.1	26.3	21.8

Bold numerals indicate where a relevant standard has been exceeded.

**Table D44: Daily peak 24-hour particles as PM<sub>10</sub> at Bunbury (2009–18)****Trend station/region: Bunbury**AAQ NEPM standard  
50 µg/m<sup>3</sup> (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (µg/m <sup>3</sup> )	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )
2009	99.5	1	<b>53.8</b>	40.3	36.0	29.5	25.4
2010	99.1	2	<b>134.0</b>	37.6	36.0	29.3	25.3
2011	99.6	2	<b>68.4</b>	39.3	33.8	28.0	23.8
2012	99.5	2	<b>53.5</b>	40.0	32.9	26.5	24.1
2013	98.9	0	46.8	38.1	33.5	26.8	22.6
2014	98.1	0	44.5	31.7	26.2	24.6	22.8
2015	99.7	3	<b>62.9</b>	48.6	40.6	35.6	27.2
2016	97.5	2	<b>74.6</b>	44.4	33.0	28.6	24.9
2017	99.6	0	45.5	36.1	32.9	27.8	24.5
2018	99.6	1	<b>51.9</b>	37.8	35.2	27.8	24.4

Bold numerals indicate where a relevant standard has been exceeded.

**Table D45: Daily peak 24-hour particles as PM<sub>10</sub> at Collie (2009–18)****Trend station/region: Collie**AAQ NEPM standard  
50 µg/m<sup>3</sup> (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (µg/m <sup>3</sup> )	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )
2009	99.5	3	<b>80.4</b>	47.3	46.2	38.0	31.3
2010	99.7	16	<b>163.0</b>	<b>86.7</b>	<b>67.3</b>	46.1	34.9
2011	97.6	4	<b>61.5</b>	<b>52.1</b>	40.4	32.0	29.2
2012	99.4	6	<b>91.7</b>	<b>54.9</b>	46.9	35.1	30.1
2013	99.0	3	<b>61.6</b>	46.0	41.3	36.0	32.0
2014	99.3	2	<b>73.3</b>	42.2	38.8	34.0	29.8
2015	99.0	10	<b>111.9</b>	<b>67.4</b>	<b>53.9</b>	41.9	37.8
2016	99.5	5	<b>89.9</b>	<b>51.0</b>	46.9	38.6	30.4
2017	96.8	11	<b>81.5</b>	<b>56.3</b>	<b>53.7</b>	42.5	33.7
2018	98.9	10	<b>84.6</b>	<b>57.4</b>	<b>52.4</b>	39.6	30.8

Bold numerals indicate where a relevant standard has been exceeded.

**Table D46: Daily peak 24-hour particles as PM<sub>10</sub> at Geraldton (2009–18)****Trend station/region: Geraldton**AAQ NEPM standard  
50 µg/m<sup>3</sup> (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (µg/m <sup>3</sup> )	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )
2009	99.6	14	<b>128.9</b>	<b>69.2</b>	<b>58.6</b>	48.5	40.3
2010	97.7	4	<b>55.6</b>	49.3	47.8	41.6	37.9
2011	98.6	3	<b>63.0</b>	45.4	40.2	35.8	32.2
2012	99.6	3	<b>61.5</b>	47.0	45.3	40.2	33.8
2013	99.3	2	<b>63.1</b>	45.9	42.1	38.9	34.6
2014	98.8	4	<b>55.7</b>	49.7	47.1	41.4	37.5
2015	98.9	5	<b>68.1</b>	<b>54.5</b>	44.4	39.8	35.2
2016	96.7	3	<b>66.0</b>	49.3	42.1	37.3	32.1
2017	99.8	3	<b>73.5</b>	44.3	40.0	36.9	33.7
2018	96.0	3	<b>70.0</b>	42.2	41.0	36.7	31.8

Bold numerals indicate where a relevant standard has been exceeded.

**Table D47: Daily peak 24-hour particles as PM<sub>10</sub> at Kalgoorlie (2009–18)****Trend station/region: Goldfields**AAQ NEPM standard  
50 µg/m<sup>3</sup> (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (µg/m <sup>3</sup> )	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )
2009	—	—	—	—	—	—	—
2010	—	—	—	—	—	—	—
2011	—	—	—	—	—	—	—
2012	—	—	—	—	—	—	—
2013	—	—	—	—	—	—	—
2014	—	—	—	—	—	—	—
2015	—	—	—	—	—	—	—
2016	—	—	—	—	—	—	—
2017	—	—	—	—	—	—	—
2018	93.6	1	<b>60.5</b>	31.8	29.3	22.8	20.6

Bold numerals indicate where a relevant standard has been exceeded.

**Table D48: Daily peak 24-hour particles as PM<sub>2.5</sub> at Caversham (2009–18)****Trend station/region: Caversham**AAQ NEPM standard  
25 µg/m<sup>3</sup> (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (µg/m <sup>3</sup> )	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )
2009	99.5	2	25.5	19.4	17.3	12.9	11.0
2010	99.1	3	<b>45.2</b>	21.9	16.2	13.7	12.1
2011	99.4	1	<b>41.5</b>	12.4	11.7	10.8	9.8
2012	96.9	3	<b>45.9</b>	19.2	15.9	12.3	10.6
2013	97.4	0	22.6	17.2	16.4	13.6	11.6
2014	97.0	1	<b>39.3</b>	16.2	15.2	14.1	11.9
2015	95.8	5	<b>30.0</b>	<b>27.2</b>	22.4	16.1	12.8
2016	99.5	0	24.1	17.0	14.2	12.6	10.9
2017	98.7	5	<b>65.9</b>	<b>31.3</b>	21.8	15.7	11.8
2018	99.5	2	<b>36.7</b>	20.6	17.3	14.8	11.6

Bold numerals indicate where a relevant standard has been exceeded.

**Table D49: Daily peak 24-hour particles as PM<sub>2.5</sub> at Duncraig (2009–18)****Trend station/region: Duncraig**AAQ NEPM standard  
25 µg/m<sup>3</sup> (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (µg/m <sup>3</sup> )	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )
2009	99.4	3	<b>32.7</b>	22.1	17.5	13.2	11.5
2010	99.3	3	<b>36.4</b>	20.1	15.9	13.7	12.0
2011	99.4	1	<b>52.1</b>	14.7	13.4	11.5	10.4
2012	97.5	3	<b>77.3</b>	22.0	14.4	12.7	11.0
2013	98.5	0	18.7	15.6	14.4	12.7	11.4
2014	99.7	1	<b>47.6</b>	16.8	15.3	13.0	11.0
2015	99.6	3	<b>35.8</b>	22.9	18.3	15.2	12.9
2016	99.4	1	<b>27.0</b>	15.9	15.4	12.0	10.9
2017	98.5	3	<b>40.5</b>	22.9	19.0	14.2	11.5
2018	99.4	1	<b>48.6</b>	19.3	15.6	12.9	11.1

Bold numerals indicate where a relevant standard has been exceeded.

**Table D50: Daily peak 24-hour particles as PM<sub>2.5</sub> at Quinns Rocks (2009–18)****Trend station/region: Quinns Rocks**AAQ NEPM standard  
25 µg/m<sup>3</sup> (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (µg/m <sup>3</sup> )	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )
2009	99.8	2	<b>31.3</b>	20.7	15.2	12.7	11.3
2010	99.6	3	<b>33.7</b>	17.6	14.5	12.0	10.9
2011	99.0	2	<b>43.2</b>	17.3	14.6	11.6	10.1
2012	96.5	4	<b>74.5</b>	22.7	14.3	11.9	10.6
2013	98.5	0	19.3	16.6	15.0	13.1	10.9
2014	98.8	2	<b>39.5</b>	15.8	14.5	13.4	11.7
2015	98.9	2	<b>37.9</b>	22.2	20.9	14.8	12.4
2016	98.7	2	<b>28.8</b>	18.4	14.8	12.7	10.8
2017	20.7	0	12.2	12.2	11.8	11.1	10.8
2018	–	–	–	–	–	–	–

Bold numerals indicate where a relevant standard has been exceeded.

**Table D51: Daily peak 24-hour particles as PM<sub>2.5</sub> at South Lake (2009–18)****Trend station/region: South Lake**AAQ NEPM standard  
25 µg/m<sup>3</sup> (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (µg/m <sup>3</sup> )	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )
2009	99.3	3	<b>32.0</b>	22.8	19.1	14.1	11.7
2010	99.5	2	<b>40.0</b>	22.0	19.2	15.9	13.2
2011	99.2	1	<b>48.2</b>	16.2	15.3	13.1	11.5
2012	99.0	4	<b>71.6</b>	25.0	19.3	14.6	13.2
2013	98.6	0	17.1	15.2	14.9	14.0	11.7
2014	98.7	2	<b>29.8</b>	17.7	15.0	13.4	11.5
2015	97.0	5	<b>34.5</b>	<b>29.8</b>	22.8	17.0	13.4
2016	99.6	3	<b>30.4</b>	17.2	15.3	13.1	11.6
2017	98.4	3	<b>46.6</b>	24.2	19.8	14.5	12.8
2018	99.7	5	<b>43.3</b>	<b>27.6</b>	20.2	15.0	12.3

Bold numerals indicate where a relevant standard has been exceeded.

**Table D52: Daily peak 24-hour particles as PM<sub>2.5</sub> at Bunbury (2009–18)****Trend station/region: Bunbury**AAQ NEPM standard  
25 µg/m<sup>3</sup> (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (µg/m <sup>3</sup> )	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )
2009	99.5	7	<b>40.0</b>	<b>26.6</b>	22.3	16.9	12.6
2010	98.6	7	<b>115.3</b>	<b>28.4</b>	24.2	14.8	12.2
2011	98.9	5	<b>45.5</b>	<b>26.6</b>	18.7	13.2	11.2
2012	99.6	7	<b>43.0</b>	<b>26.3</b>	21.0	14.9	12.8
2013	99.3	1	<b>38.3</b>	16.6	15.7	14.0	11.5
2014	98.4	1	<b>34.6</b>	16.1	15.0	13.3	11.7
2015	97.6	9	<b>52.1</b>	<b>35.0</b>	<b>30.2</b>	20.2	14.4
2016	99.7	6	<b>61.5</b>	<b>33.6</b>	22.4	14.9	12.2
2017	99.5	6	<b>33.9</b>	<b>27.2</b>	21.5	14.3	12.7
2018	99.7	5	<b>38.4</b>	<b>26.0</b>	22.2	17.2	12.5

Bold numerals indicate where a relevant standard has been exceeded.

**Table D53: Daily peak 24-hour particles as PM<sub>2.5</sub> at Busselton (2009–18)****Trend station/region: Busselton**AAQ NEPM standard  
25 µg/m<sup>3</sup> (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )
2009	99.8	12	<b>69.0</b>	<b>45.0</b>	<b>31.6</b>	17.7	14.0
2010	99.4	7	<b>62.5</b>	<b>31.6</b>	22.9	15.7	11.6
2011	99.8	6	<b>85.2</b>	<b>36.7</b>	20.5	13.9	11.4
2012	99.6	5	<b>78.0</b>	<b>27.1</b>	21.4	13.4	11.8
2013	98.6	0	17.9	16.6	15.5	12.9	10.9
2014	99.6	1	25.1	13.2	12.4	11.1	10.2
2015	99.1	4	<b>37.8</b>	24.4	21.3	18.6	13.9
2016	99.5	4	<b>61.1</b>	22.8	17.5	13.7	11.3
2017	97.8	1	<b>28.8</b>	22.8	18.0	14.9	12.2
2018	97.0	7	<b>56.5</b>	<b>28.9</b>	22.2	16.4	11.3

Bold numerals indicate where a relevant standard has been exceeded.

**Table D54: Daily peak 24-hour particles as PM<sub>2.5</sub> at Kalgoorlie (2009–18)****Trend station/region: Goldfields**AAQ NEPM standard  
25 µg/m<sup>3</sup> (24-hour average)

Year	Data recovery (%)	No. of exceedences (days)	Max conc. (ppm)	99th percentile (µg/m <sup>3</sup> )	98th percentile (µg/m <sup>3</sup> )	95th percentile (µg/m <sup>3</sup> )	90th percentile (µg/m <sup>3</sup> )
2009	—	—	—	—	—	—	—
2010	—	—	—	—	—	—	—
2011	—	—	—	—	—	—	—
2012	—	—	—	—	—	—	—
2013	—	—	—	—	—	—	—
2014	—	—	—	—	—	—	—
2015	—	—	—	—	—	—	—
2016	—	—	—	—	—	—	—
2017	—	—	—	—	—	—	—
2018	93.6	1	<b>36.2</b>	16.4	14.0	10.2	8.2

Bold numerals indicate where a relevant standard has been exceeded.

### D.3 Maxima by pollutant 2009–18

**Table D55: Annual daily peak eight-hour carbon monoxide concentrations (ppm) for 2009–18**

*AAQ NEPM standard  
9.0 ppm (eight-hour average)*

Regional performance monitoring station	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>Perth region</b>										
Caversham (north-east metro)	1.0	1.6	1.5	0.9	0.9	0.7	1.2	0.9	2.9	1.1
Duncraig (north metro)	2.6	2.3	1.9	2.4	2.1	1.9	1.7	1.4	1.4	1.5
South Lake (south-east metro)	1.8	2.2	1.7	2.2	1.7	1.8	1.9	2.3	1.9	1.9
<b>Goldfields region</b>										
Kalgoorlie	–	–	–	–	–	–	–	–	–	1.9

**Table D56: Annual daily peak one-hour nitrogen dioxide concentrations (ppm) for 2009–18**

*AAQ NEPM standard  
0.12 ppm (one-hour average)*

Regional performance monitoring station	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>Perth region</b>										
Caversham (north-east metro)	0.044	0.054	0.035	0.037	0.043	0.033	0.041	0.036	0.042	0.034
Duncraig (north metro)	0.042	0.038	0.035	0.047	0.040	0.048	0.036	0.033	0.032	0.036
Quinns Rocks (outer north coast)	0.034	0.040	0.031	0.041	0.032	0.031	0.030	0.029	0.019	–
Rockingham (south coast)	0.031	0.036	0.034	0.053	0.035	0.034	0.062	0.029	0.074	0.029
Rolling Green (outer east rural)	0.035	0.030	0.023	0.029	0.030	0.021	0.023	0.023	0.018	0.023
South Lake (south east metro)	0.048	0.058	0.041	0.046	0.043	0.034	0.043	0.038	0.045	0.047
Swanbourne (inner west coast)	0.037	0.038	0.032	0.045	0.037	0.036	0.036	0.030	0.033	0.039

**Table D57: Annual daily peak one-hour ozone concentrations (ppm) for 2009–18**

*AAQ NEPM standard  
0.10 ppm (one-hour average)*

Regional performance monitoring station	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>Perth region</b>										
Caversham (north-east metro)	<b>0.104</b>	0.082	0.077	0.098	<b>0.101</b>	0.091	<b>0.103</b>	0.096	0.099	0.067
Quinns Rocks (outer north coast)	0.070	0.091	0.083	<b>0.130</b>	0.087	0.073	0.083	0.089	0.066	–
Rockingham (south coast)	0.078	0.067	0.065	0.095	0.084	0.076	0.069	0.087	0.069	0.061
Rolling Green (outer east rural)	<b>0.103</b>	0.088	0.073	<b>0.103</b>	0.099	0.080	<b>0.105</b>	0.075	0.069	0.075
South Lake (south east metro)	0.065	0.070	0.076	0.085	0.087	0.065	0.067	0.091	0.074	0.061
Swanbourne (inner west coast)	0.068	0.066	0.085	<b>0.128</b>	0.083	0.066	0.074	<b>0.103</b>	0.079	0.075

Bold numerals indicate where a relevant standard has been exceeded.

**Table D58: Annual daily peak four-hour ozone concentrations (ppm) for 2009–18**

*AAQ NEPM standard  
0.08 ppm (one-hour average)*

Regional performance monitoring station	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>Perth region</b>										
Caversham (north-east metro)	<b>0.092</b>	0.072	0.063	<b>0.086</b>	0.075	0.073	<b>0.084</b>	<b>0.085</b>	0.077	0.056
Quinns Rocks (outer north coast)	0.062	0.065	0.075	<b>0.108</b>	0.079	0.062	0.071	0.079	0.062	–
Rockingham (south coast)	0.066	0.064	0.061	0.079	0.075	0.067	0.064	0.079	0.062	0.057
Rolling Green (outer east rural)	<b>0.083</b>	0.080	0.061	<b>0.081</b>	<b>0.083</b>	0.070	<b>0.093</b>	0.066	0.064	0.067
South Lake (south east metro)	0.057	0.061	0.064	0.080	0.074	0.058	0.060	0.080	0.067	0.053
Swanbourne (inner west coast)	0.063	0.055	0.073	<b>0.108</b>	0.068	0.057	0.067	<b>0.081</b>	0.070	0.063

Bold numerals indicate where a relevant standard has been exceeded.

**Table D59: Annual daily peak one-hour sulfur dioxide concentrations (ppm) for 2009–18**AAQ NEPM standard  
0.20 ppm (one-hour average)

Regional performance monitoring station	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>Perth region</b>										
Rockingham (south coast)	0.032	0.037	0.040	0.040	0.037	0.036	0.051	0.064	0.030	0.031
South Lake (south-east metro)	0.036	0.073	0.044	0.039	0.044	0.051	0.037	0.034	0.037	0.022
Wattleup (south metro)	0.059	0.057	0.067	0.043	0.090	0.061	0.067	0.072	0.068	0.038
<b>Goldfields region</b>										
Kalgoorlie	–	–	–	–	–	–	–	–	–	0.106

**Table D60: Annual daily peak 24-hour sulfur dioxide concentrations (ppm) for 2009–18**AAQ NEPM standard  
0.08 ppm (24-hour average)

Regional performance monitoring station	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>Perth region</b>										
Rockingham (south coast)	0.008	0.007	0.008	0.006	0.007	0.007	0.013	0.014	0.009	0.007
South Lake (south-east metro)	0.006	0.009	0.006	0.006	0.014	0.010	0.007	0.010	0.009	0.005
Wattleup (south metro)	0.008	0.010	0.008	0.008	0.010	0.008	0.009	0.011	0.007	0.007
<b>Goldfields region</b>										
Kalgoorlie	–	–	–	–	–	–	–	–	–	0.008

**Table D60a: Annual averaged sulfur dioxide concentrations (ppm) for 2009–18**AAQ NEPM standard  
0.02 ppm (annual average)

Regional performance monitoring station	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>Perth region</b>										
Rockingham (south coast)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
South Lake (south east metro)	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.003	0.003	0.002
Wattleup (south metro)	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.001	0.002
<b>Goldfields region</b>										
Kalgoorlie	–	–	–	–	–	–	–	–	–	0.001

**Table D61: Annual daily peak 24-hour particles as PM<sub>10</sub> concentrations (µg/m<sup>3</sup>) for 2009–18**AAQ NEPM standard  
50 µg/m<sup>3</sup> (24-hour average)

Regional performance monitoring station	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>Perth region</b>										
Caversham (north-east metro)	45.7	<b>63.4</b>	<b>76.1</b>	<b>68.7</b>	<b>62.4</b>	<b>52.6</b>	46.8	38.1	<b>79.2</b>	<b>77.9</b>
Duncraig (north metro)	45.5	47.9	<b>65.9</b>	<b>89.5</b>	37.6	<b>53.0</b>	<b>82.7</b>	40.0	<b>51.4</b>	<b>61.3</b>
South Lake (south-east metro)	49.0	<b>61.0</b>	<b>66.2</b>	<b>81.5</b>	38.8	44.5	<b>53.3</b>	47.0	49.6	<b>57.1</b>
<b>South West region</b>										
Bunbury	<b>53.8</b>	<b>134.0</b>	<b>68.4</b>	<b>53.5</b>	46.8	44.5	<b>62.9</b>	<b>74.6</b>	45.5	<b>51.9</b>
Collie	<b>80.4</b>	<b>163.0</b>	<b>61.5</b>	<b>91.7</b>	<b>61.6</b>	<b>73.3</b>	<b>111.9</b>	<b>89.9</b>	<b>81.5</b>	<b>84.6</b>
Albany	36.7	<b>52.5</b>	37.3	37.0	<b>110.8</b>	43.5	<b>76.7</b>	<b>94.9</b>	<b>61.8</b>	<b>89.6</b>
<b>Mid West region</b>										
Geraldton	<b>128.9</b>	<b>55.6</b>	<b>63.0</b>	<b>61.5</b>	<b>63.1</b>	<b>55.7</b>	<b>68.1</b>	<b>66.0</b>	<b>73.5</b>	<b>70.0</b>
<b>Goldfields region</b>										
Kalgoorlie	–	–	–	–	–	–	–	–	–	<b>60.5</b>

Bold numerals indicate where a relevant standard has been exceeded.

For explanation of this year's exceedences, please see Table A10 of this report.

For explanation of exceedences in previous years, please refer to the relevant year report.

**Table D62: Annual daily peak 24-hour particles as PM<sub>2.5</sub> concentrations (µg/m<sup>3</sup>) for 2009–18**AAQ NEPM standard  
25 µg/m<sup>3</sup> (24-hour average)

Regional performance monitoring station	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>Perth region</b>										
Caversham (north-east metro)	<b>25.5</b>	<b>45.2</b>	<b>41.5</b>	<b>45.9</b>	22.6	<b>39.3</b>	<b>30.0</b>	24.1	<b>65.9</b>	<b>36.7</b>
Duncraig (north metro)	<b>32.7</b>	<b>36.4</b>	<b>52.1</b>	<b>77.3</b>	18.7	<b>47.6</b>	<b>35.8</b>	<b>27.0</b>	<b>40.5</b>	<b>48.6</b>
Quinns Rocks (outer north coast)	<b>31.3</b>	<b>33.7</b>	<b>43.2</b>	<b>74.5</b>	19.3	<b>39.5</b>	<b>37.9</b>	<b>28.8</b>	12.2	–
South Lake (south-east metro)	<b>32.0</b>	<b>40.0</b>	<b>48.2</b>	<b>71.6</b>	17.1	<b>29.8</b>	<b>34.5</b>	<b>30.4</b>	<b>46.6</b>	<b>43.3</b>
<b>South West region</b>										
Bunbury	<b>40.0</b>	<b>115.3</b>	<b>45.5</b>	<b>43.0</b>	<b>38.3</b>	<b>34.6</b>	<b>52.1</b>	<b>61.5</b>	<b>33.9</b>	<b>38.4</b>
Busselton	<b>69.0</b>	<b>62.5</b>	<b>85.2</b>	<b>78.0</b>	17.9	<b>25.1</b>	<b>37.8</b>	<b>61.1</b>	<b>28.8</b>	<b>56.5</b>
<b>Goldfields region</b>										
Kalgoorlie	–	–	–	–	–	–	–	–	–	<b>36.2</b>

Bold numerals indicate where a relevant standard has been exceeded.

For explanation of this year's exceedences, please see Table A10 of this report.

For explanation of exceedences in previous years, please refer to the relevant year report.

**Table D63: Annual averaged particles as PM<sub>10</sub> concentrations (µg/m<sup>3</sup>) for 2009–18**

*AAQ NEPM standard  
25 µg/m<sup>3</sup> (annual average)*

Regional performance monitoring station	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>Perth region</b>										
Caversham (north-east metro)	17.1	17.0	16.2	16.8	15.4	17.4	16.7	15.0	16.1	16.3
Duncraig (north metro)	15.9	15.8	15.3	16.2	15.5	15.5	16.5	14.4	15.7	15.1
South Lake (south-east metro)	17.7	19.0	16.3	16.9	16.6	17.4	17.9	15.8	16.7	16.3
<b>South West region</b>										
Bunbury	17.6	17.6	17.0	17.5	16.8	16.1	17.5	16.5	16.5	16.1
Collie	20.0	22.8	19.6	20.0	20.1	19.2	22.4	19.3	21.7	19.3
Albany	14.3	15.9	14.5	15.0	15.4	16.0	15.9	17.5	16.6	14.6
<b>Mid West region</b>										
Geraldton	23.9	21.7	19.6	21.3	20.9	22.3	20.2	18.8	21.3	20.1
<b>Goldfields region</b>										
Kalgoorlie	–	–	–	–	–	–	–	–	–	12.8

**Table D64: Annual averaged particles as PM<sub>2.5</sub> concentrations (µg/m<sup>3</sup>) for 2009–18**

*AAQ NEPM standard  
8 µg/m<sup>3</sup> (annual average)*

Regional performance monitoring station	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
<b>Perth region</b>										
Caversham (north-east metro)	7.8	<b>8.2</b>	7.0	7.8	7.9	<b>8.1</b>	<b>8.5</b>	7.7	<b>8.5</b>	8.0
Duncraig (north metro)	<b>8.2</b>	<b>8.2</b>	7.8	<b>8.2</b>	7.6	7.6	<b>8.4</b>	7.5	<b>8.2</b>	7.7
Quinns Rocks (outer north coast)	7.8	7.8	7.2	7.9	7.8	8.0	<b>8.3</b>	7.5	7.8	–
South Lake (south-east metro)	<b>8.2</b>	<b>8.7</b>	7.8	<b>8.9</b>	8.0	<b>8.1</b>	<b>8.8</b>	8.0	<b>8.7</b>	<b>8.4</b>
<b>South West region</b>										
Bunbury	<b>8.3</b>	<b>9.2</b>	8.0	<b>8.6</b>	7.8	7.8	<b>9.3</b>	<b>8.4</b>	<b>8.7</b>	<b>8.4</b>
Busselton	<b>9.0</b>	<b>8.5</b>	<b>8.5</b>	<b>8.6</b>	7.7	7.2	<b>8.6</b>	<b>8.1</b>	<b>8.2</b>	7.9
<b>Goldfields region</b>										
Kalgoorlie	–	–	–	–	–	–	–	–	–	5.1

Bold numerals indicate where a relevant standard has been exceeded.

## E. Graphical trends

This section provides graphical representations of tables D9 to D54 of Section D.

Each graph shows the maximum, 99th percentile, 98th percentile, 95th percentile and 90th percentile of daily maximum concentration for all pollutants monitored by the department in Western Australia. The nominated percentiles can also be expressed as an Nth highest concentration.

Based on 100 per cent data recovery and a normal year (365 days), the following table gives each percentile an equivalent Nth highest ordinal value. The bracketed numbers represent the exact (as calculated) value of the ordinal number.

Percentile	Nth highest
100	1 (maximum)
99	5 (4.65)
98	8 (8.3)
95	19 (19.25)
90	38 (37.5)

## E.1 Carbon monoxide

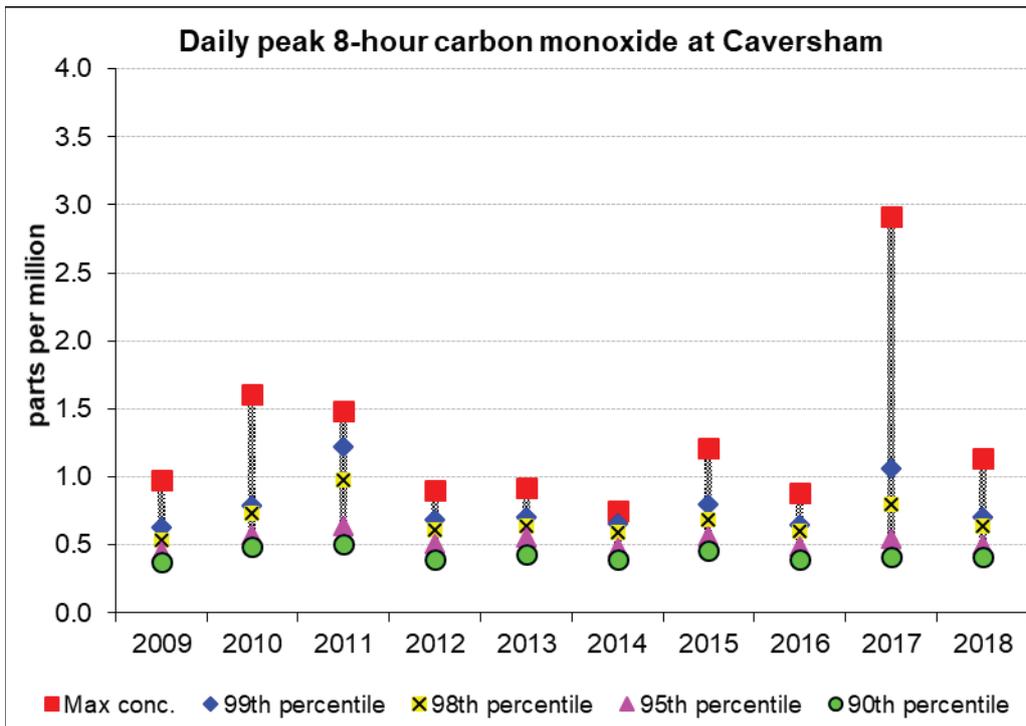


Figure E1-1 – eight-hour carbon monoxide at Caversham

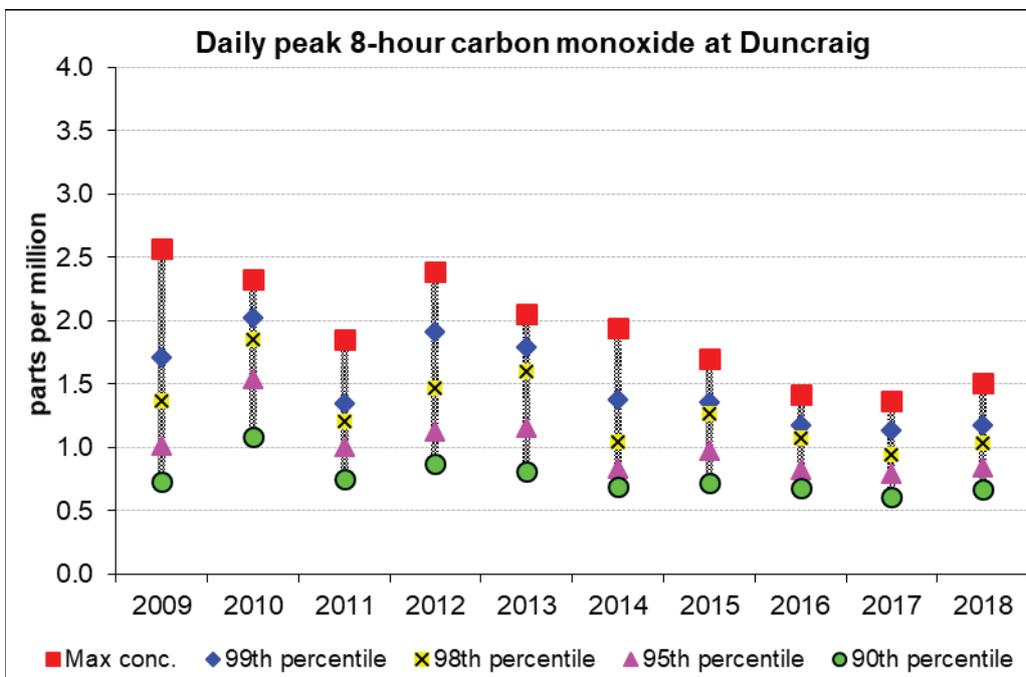


Figure E1-2 – eight-hour carbon monoxide at Duncraig

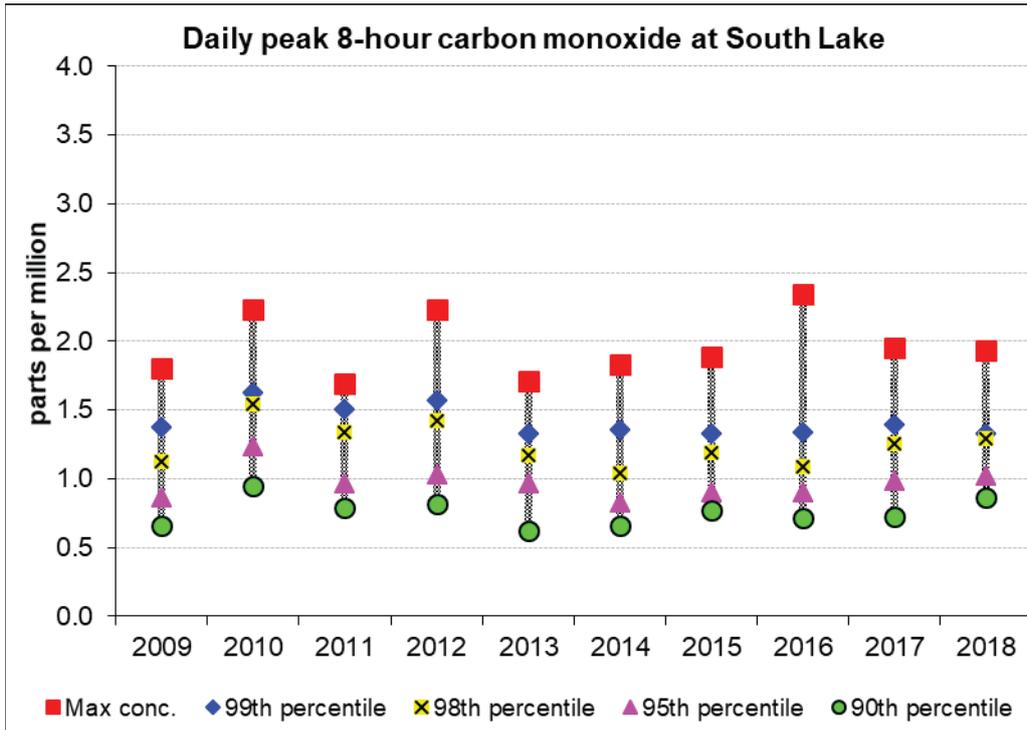


Figure E1-3 – eight-hour carbon monoxide at South Lake

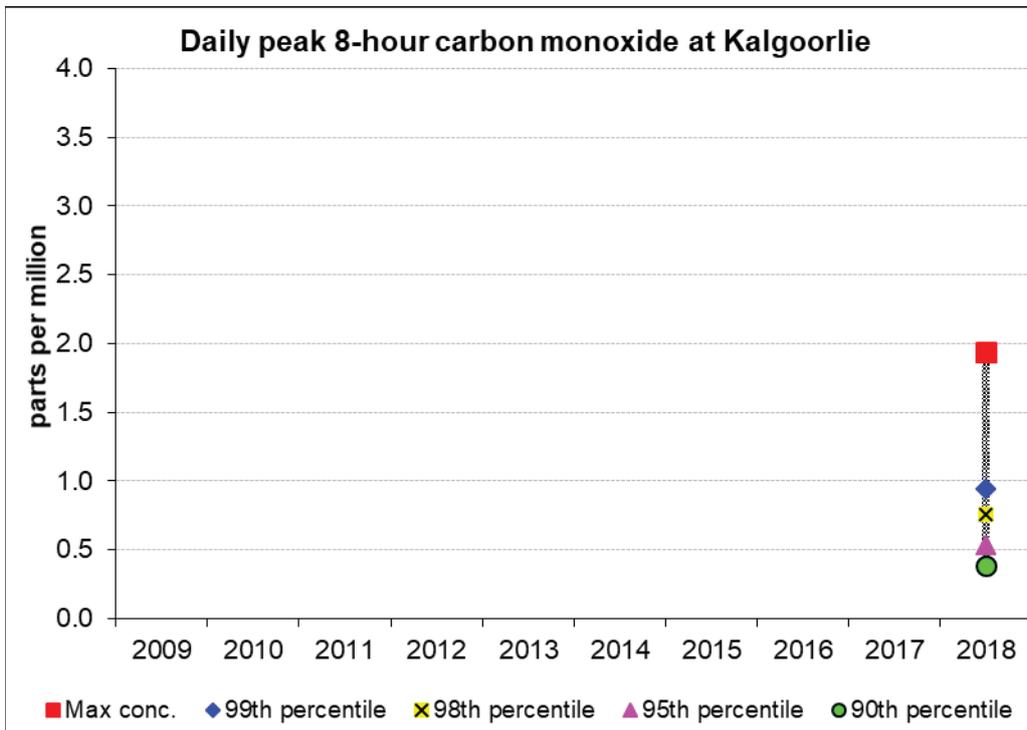


Figure E1-4 – eight-hour carbon monoxide at Kalgoorlie

## E.2 Nitrogen dioxide

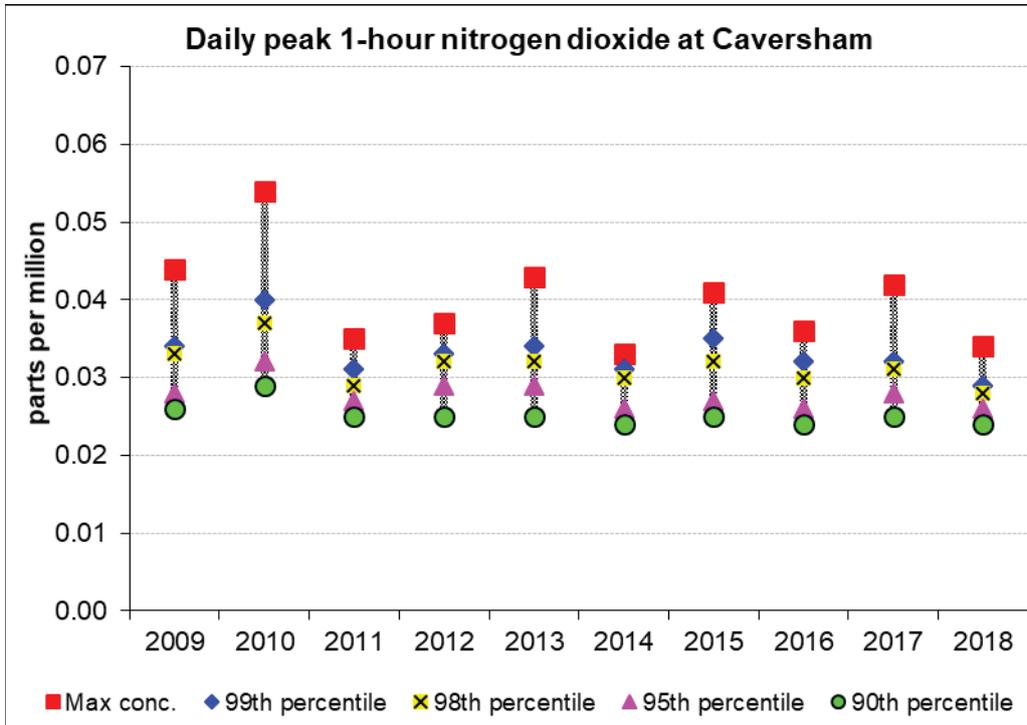


Figure E2-1 – one-hour nitrogen dioxide at Caversham

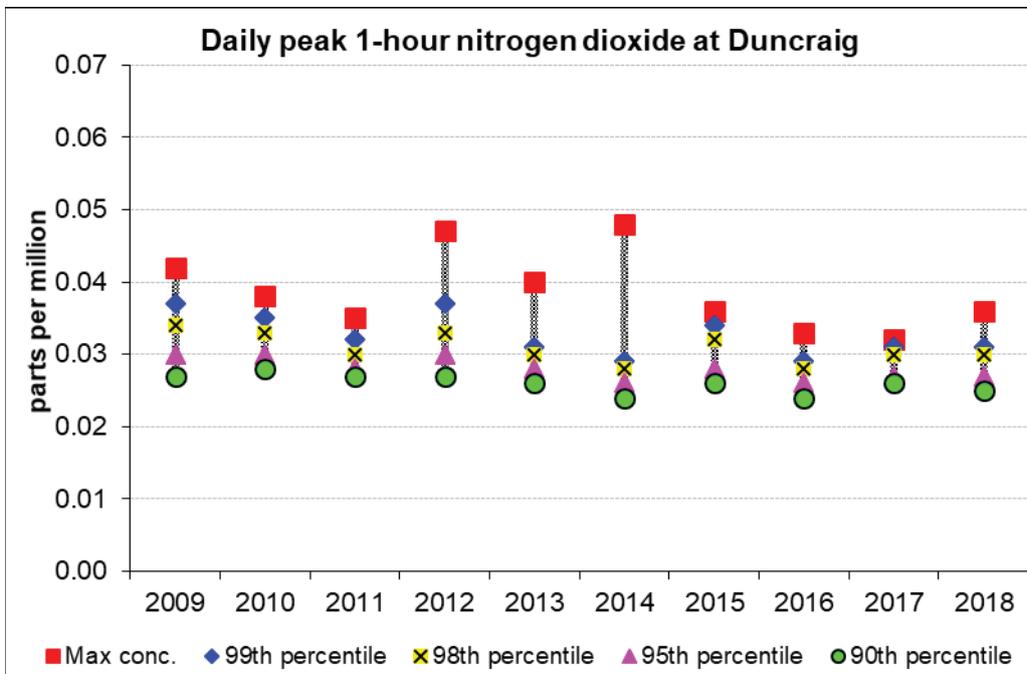


Figure E2-2 – one-hour nitrogen dioxide at Duncraig

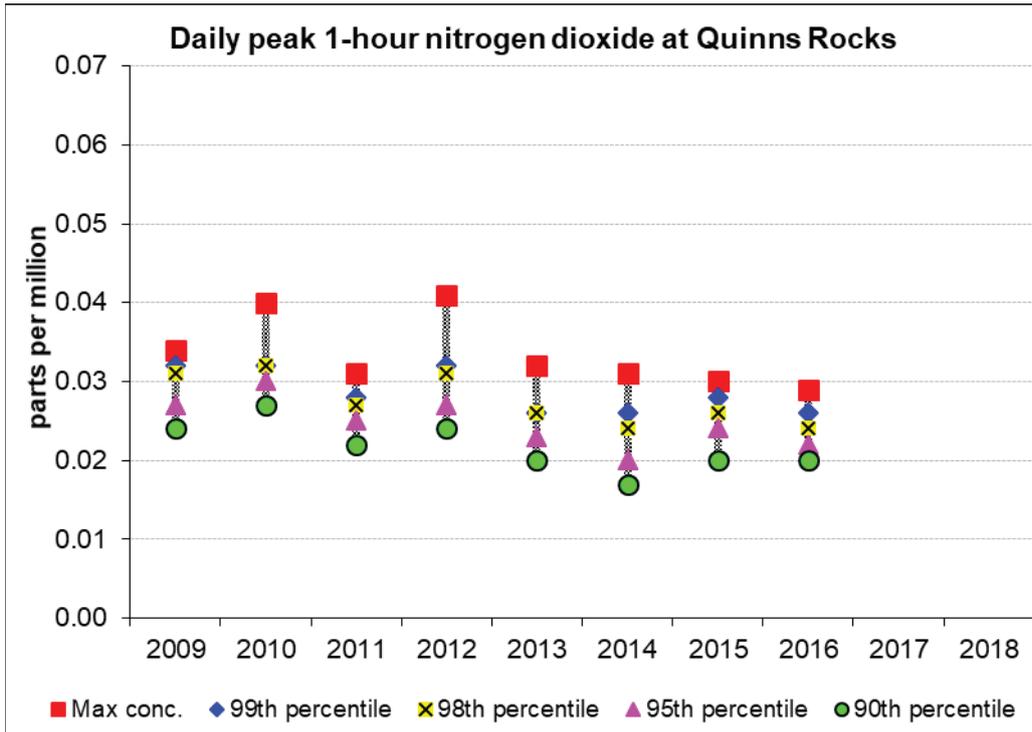


Figure E2-3 – one-hour nitrogen dioxide at Quinns Rocks (2017 and 2018 not included)

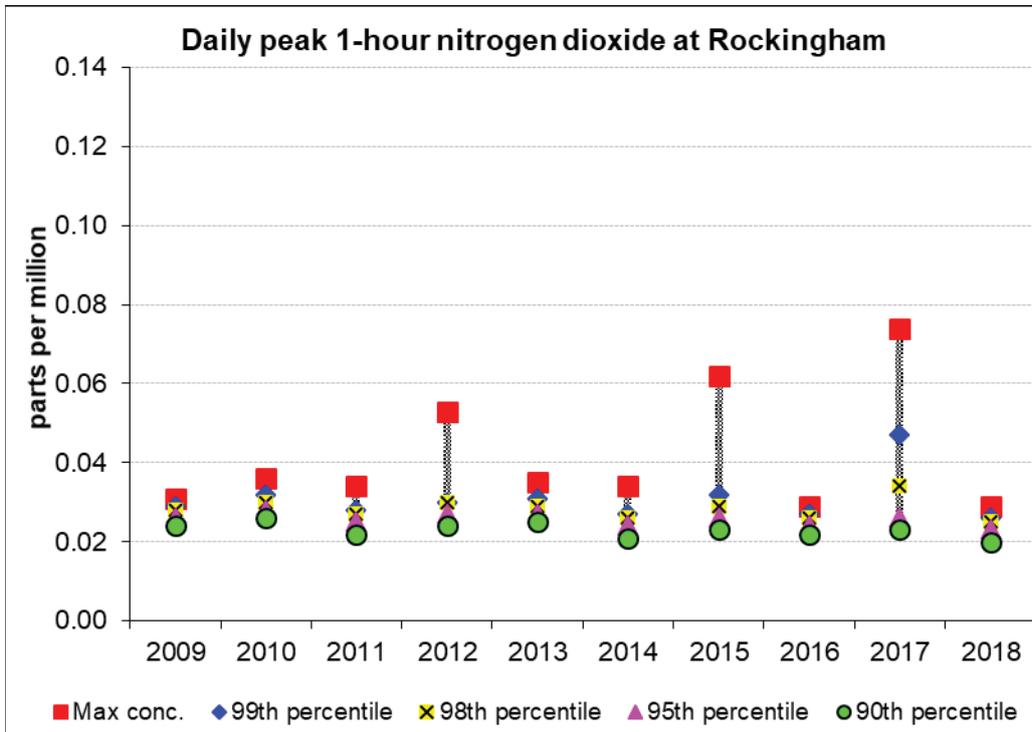


Figure E2-4 – one-hour nitrogen dioxide at Rockingham

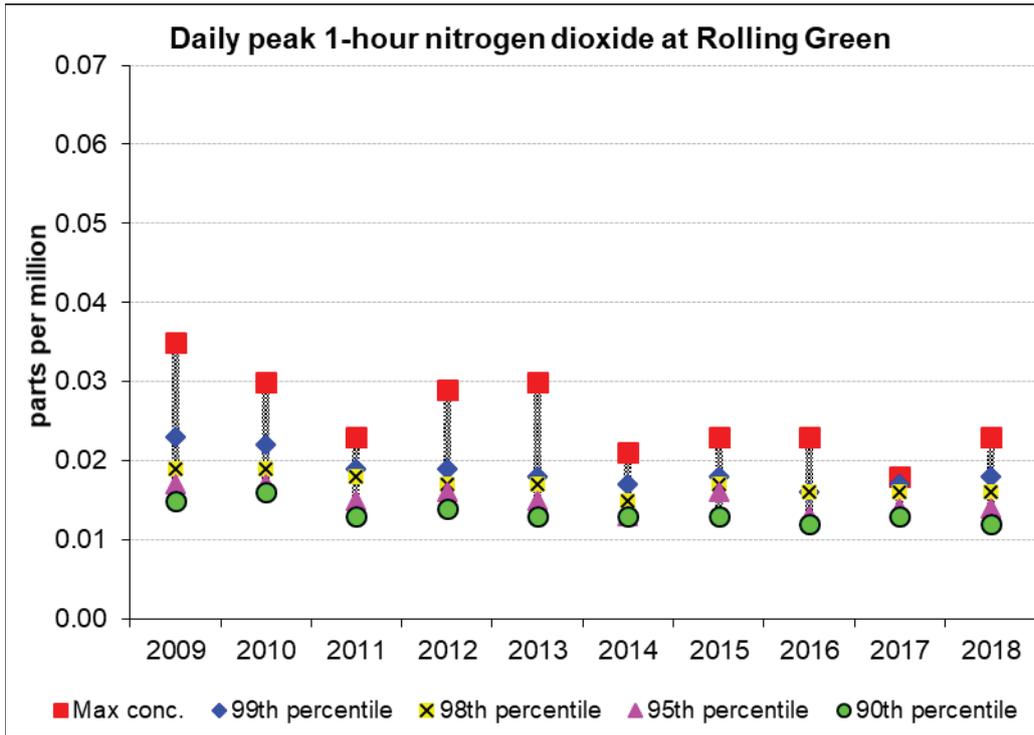


Figure E2-5 – one-hour nitrogen dioxide at Rolling Green

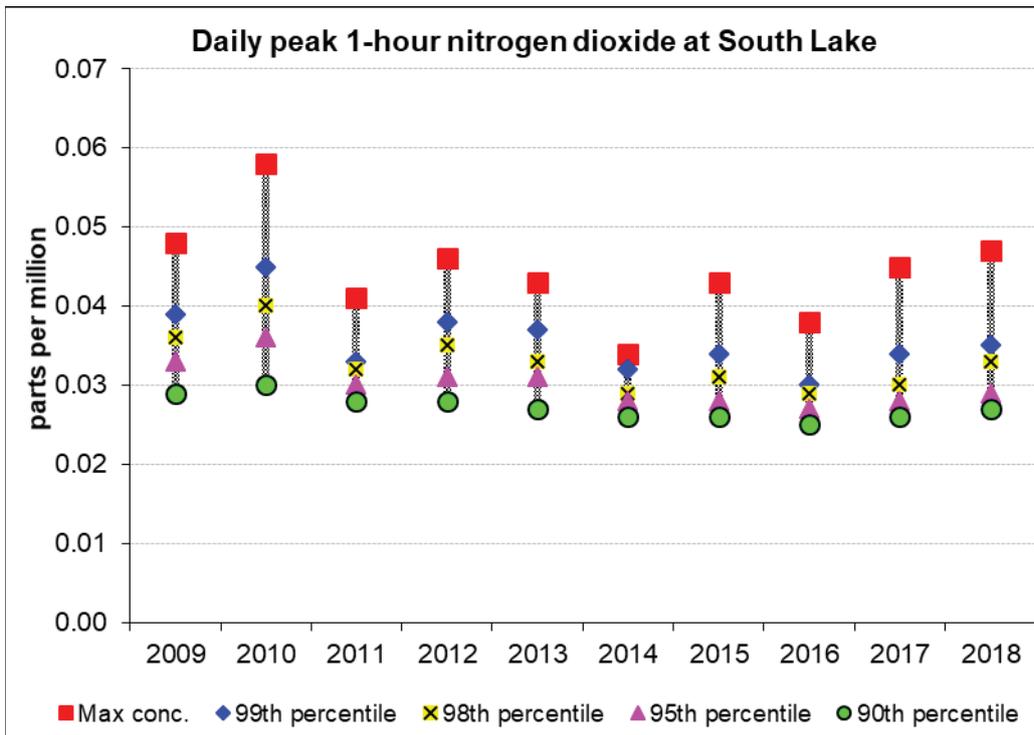


Figure E2-6 – one-hour nitrogen dioxide at South Lake

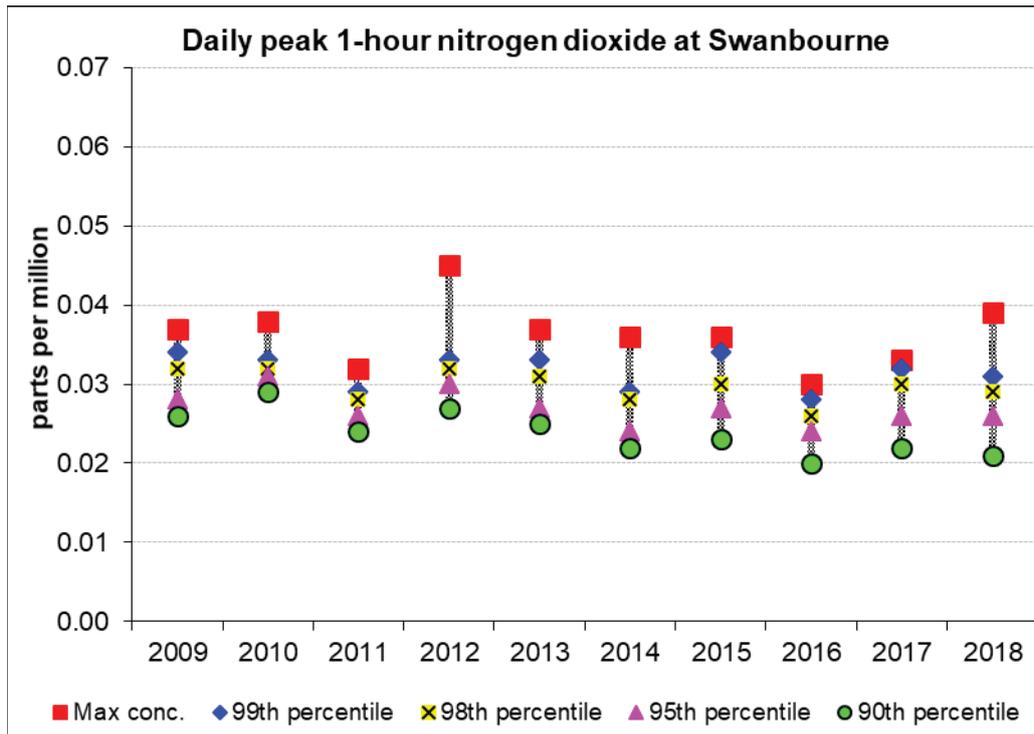


Figure E2-7 – one-hour nitrogen dioxide at Swanbourne

### E.3 Ozone

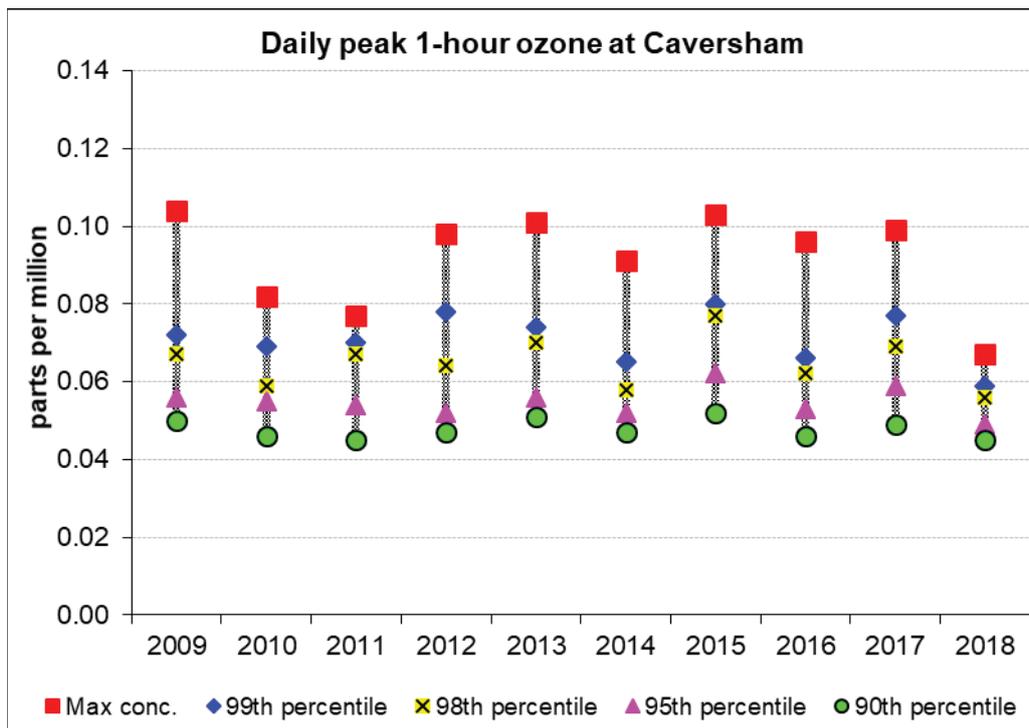


Figure E3-1 – one-hour ozone at Caversham

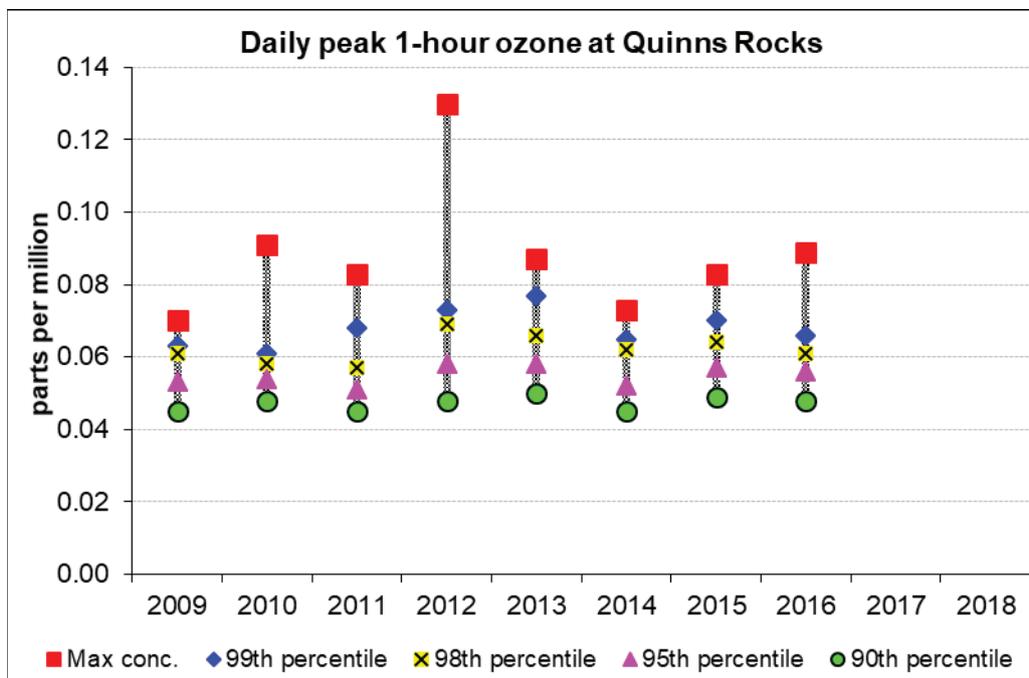


Figure E3-2 – one-hour ozone at Quinns Rocks (2017 and 2018 not included)

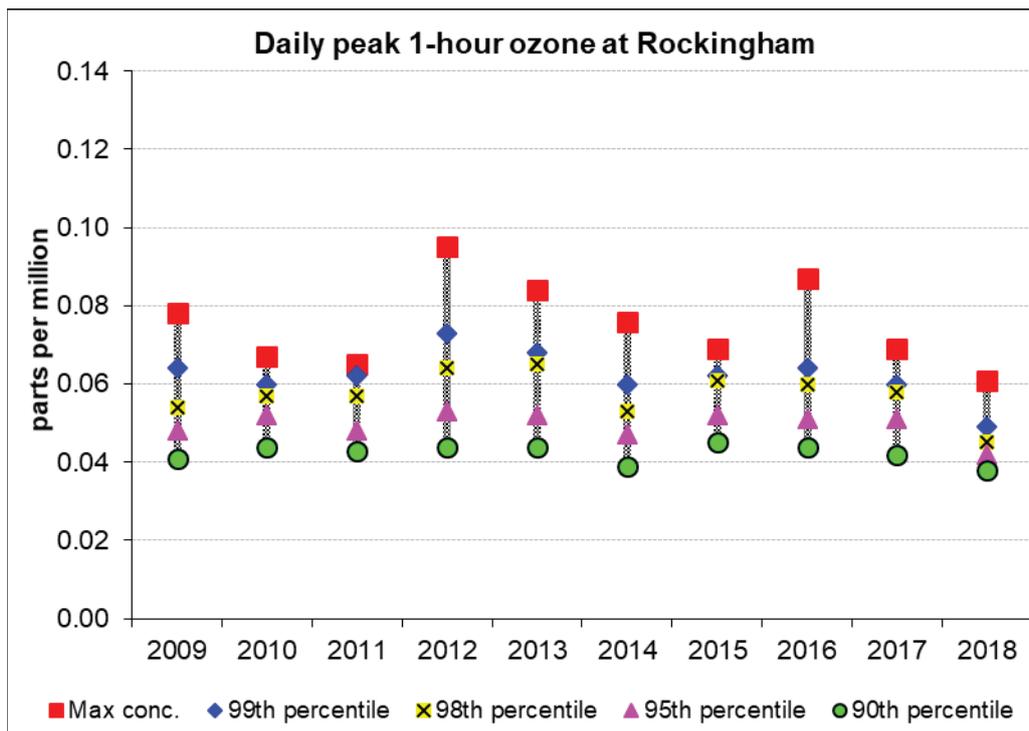


Figure E3-3 – one-hour ozone at Rockingham

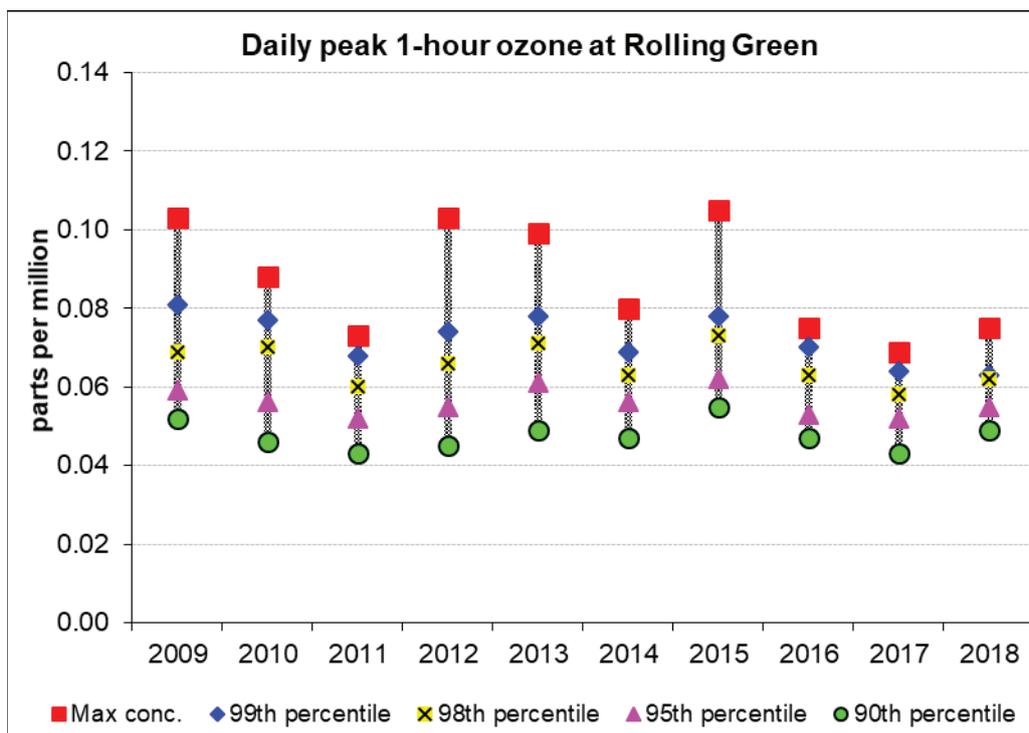


Figure E3-4 – one-hour ozone at Rolling Green

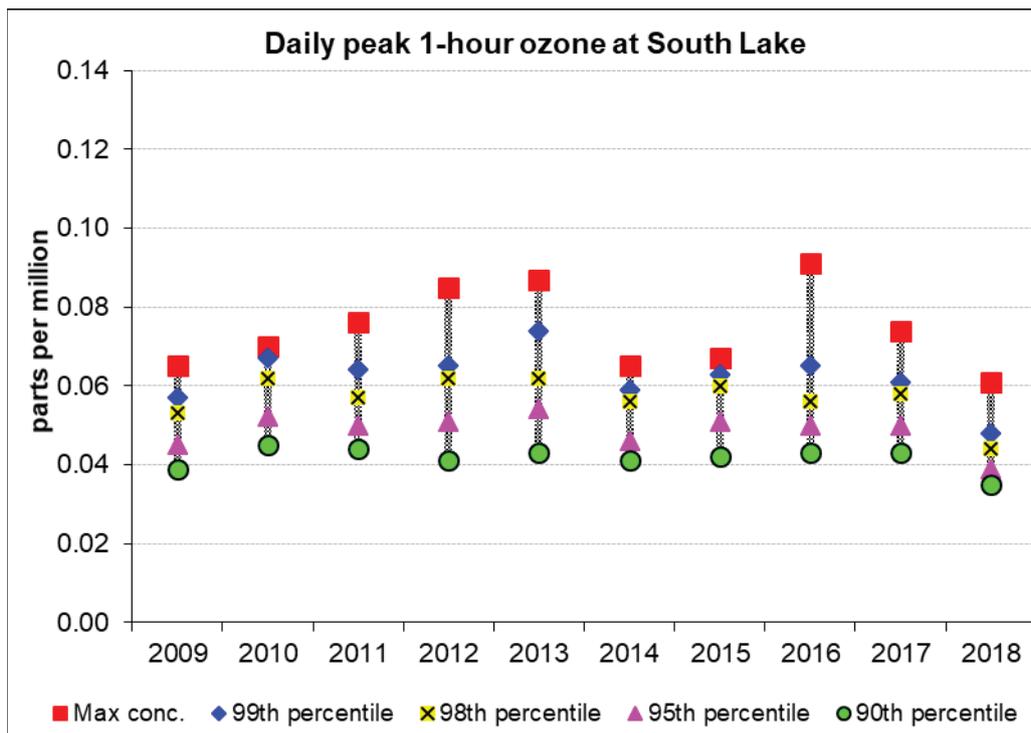


Figure E3-5 – one-hour ozone at South Lake

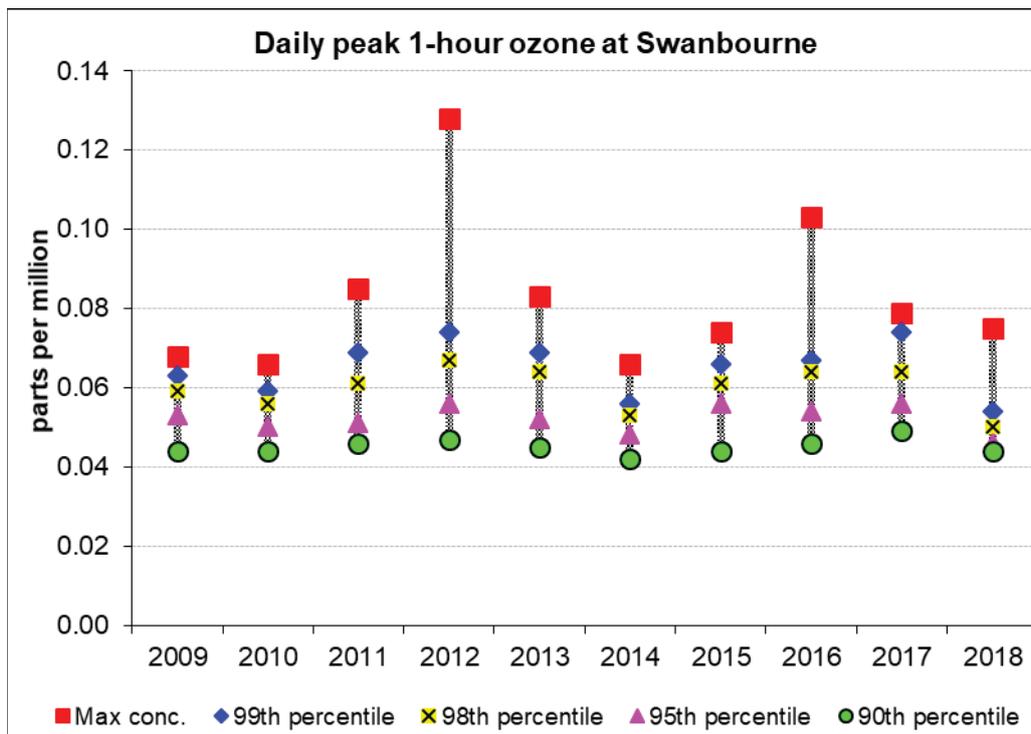


Figure E3-6 – one-hour ozone at Swanbourne

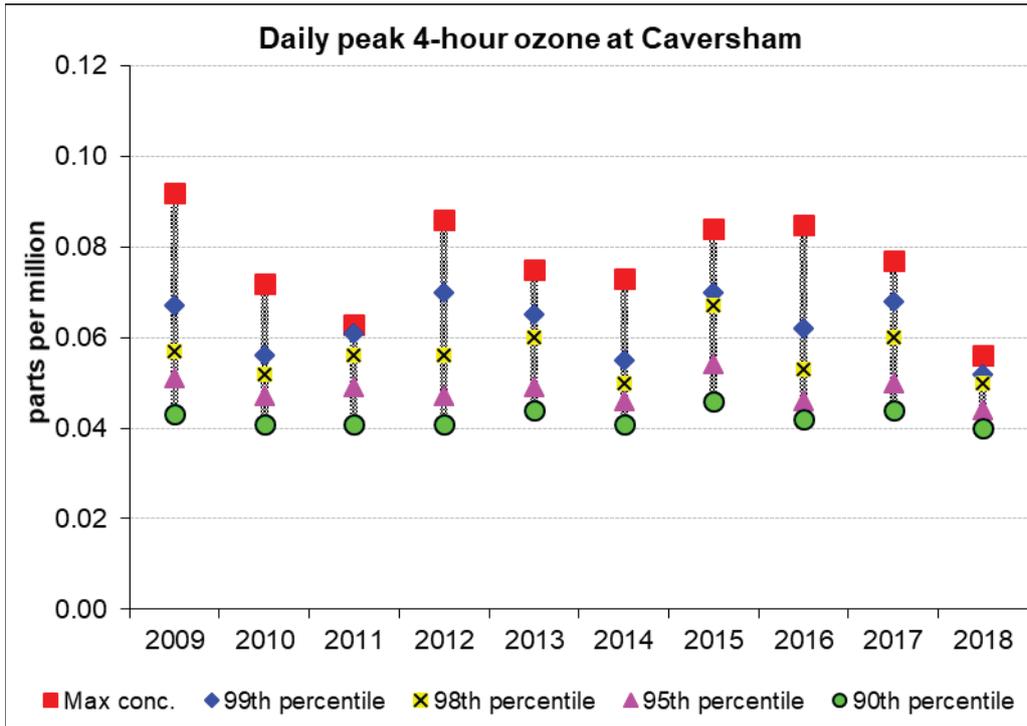


Figure E3-7 – four-hour ozone at Caversham

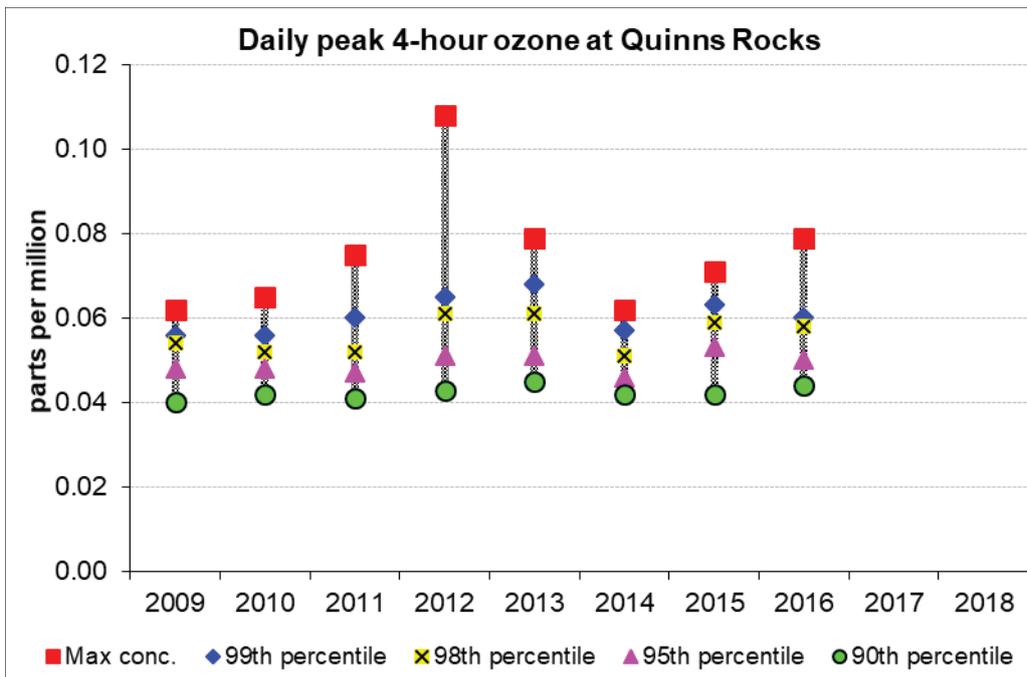


Figure E3-8 – four-hour ozone at Quinns Rocks (2017 and 2018 not included)

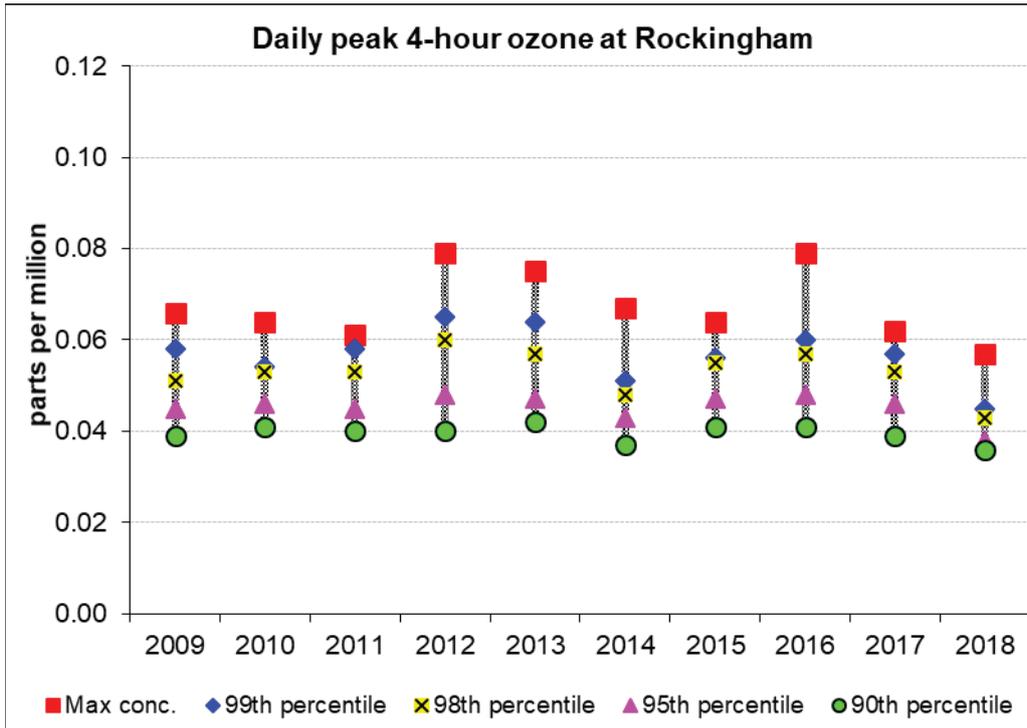


Figure E3-9 – four-hour ozone at Rockingham

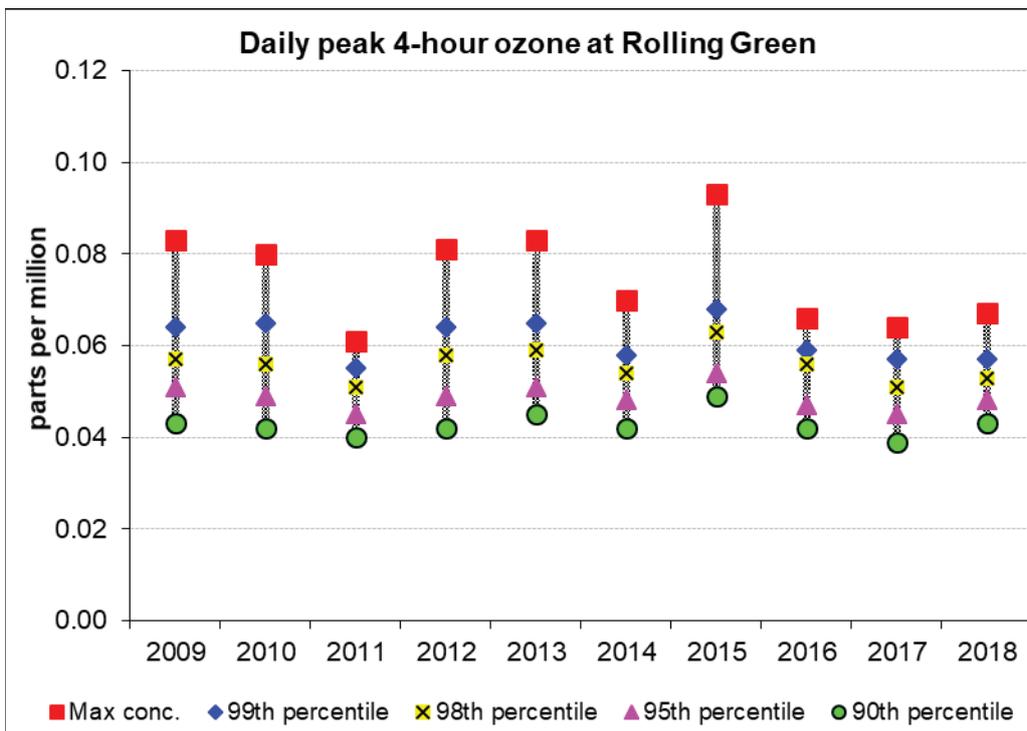


Figure E3-10 – four-hour ozone at Rolling Green

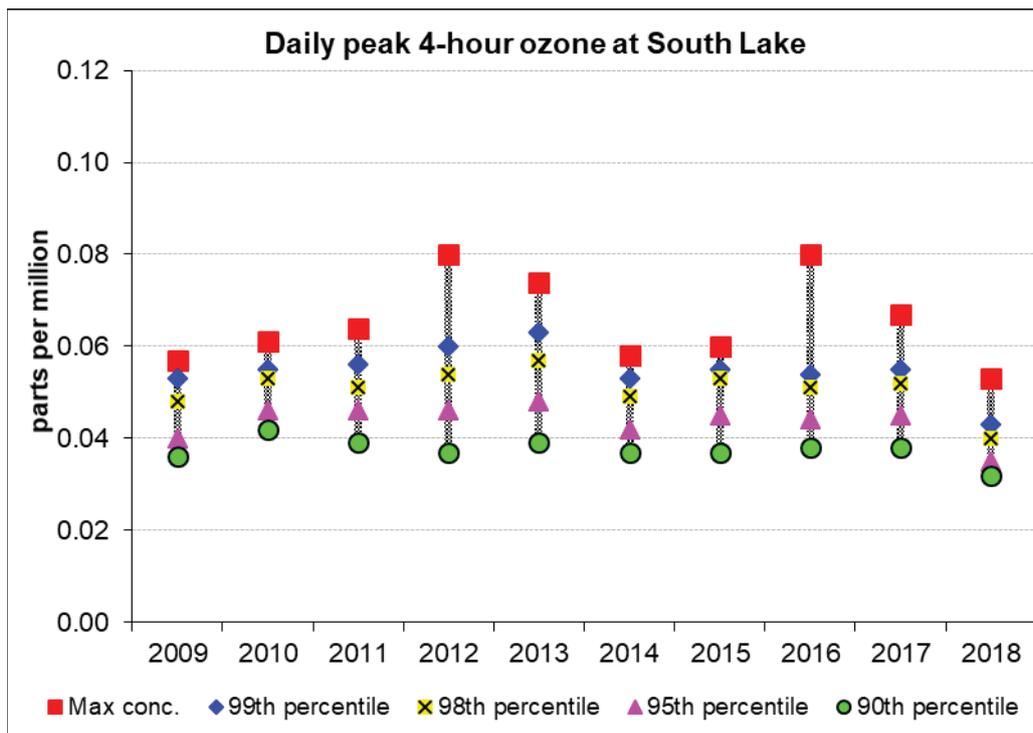


Figure E3-11 – four-hour ozone at South Lake

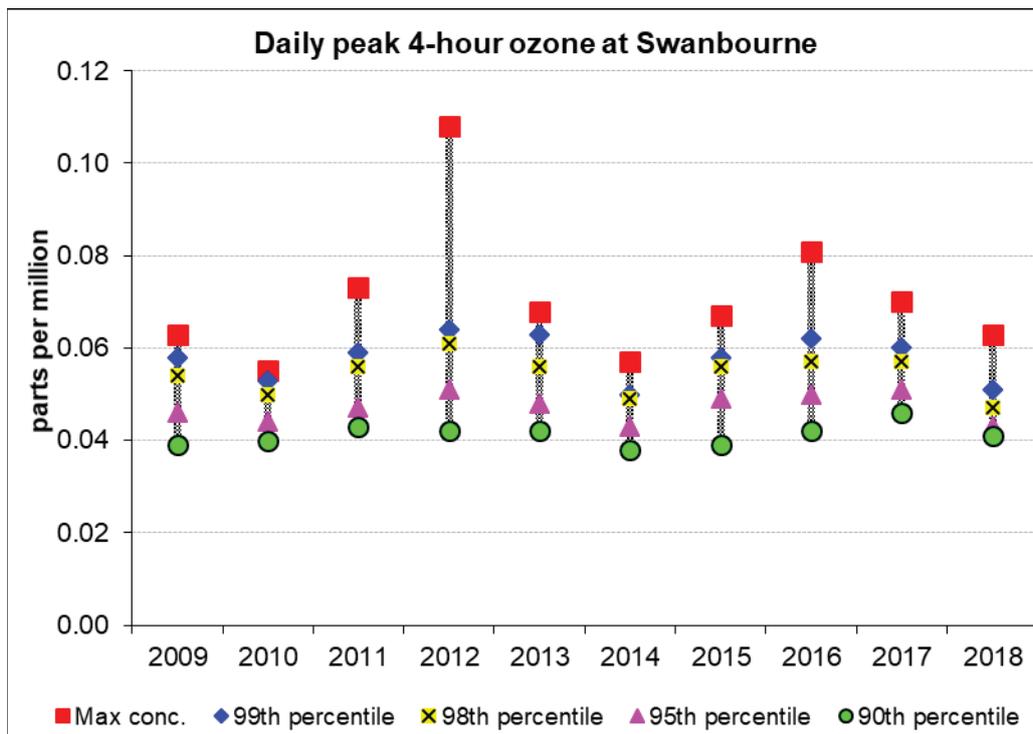


Figure E3-12 – four-hour ozone at Swanbourne

## E.4 Sulfur dioxide

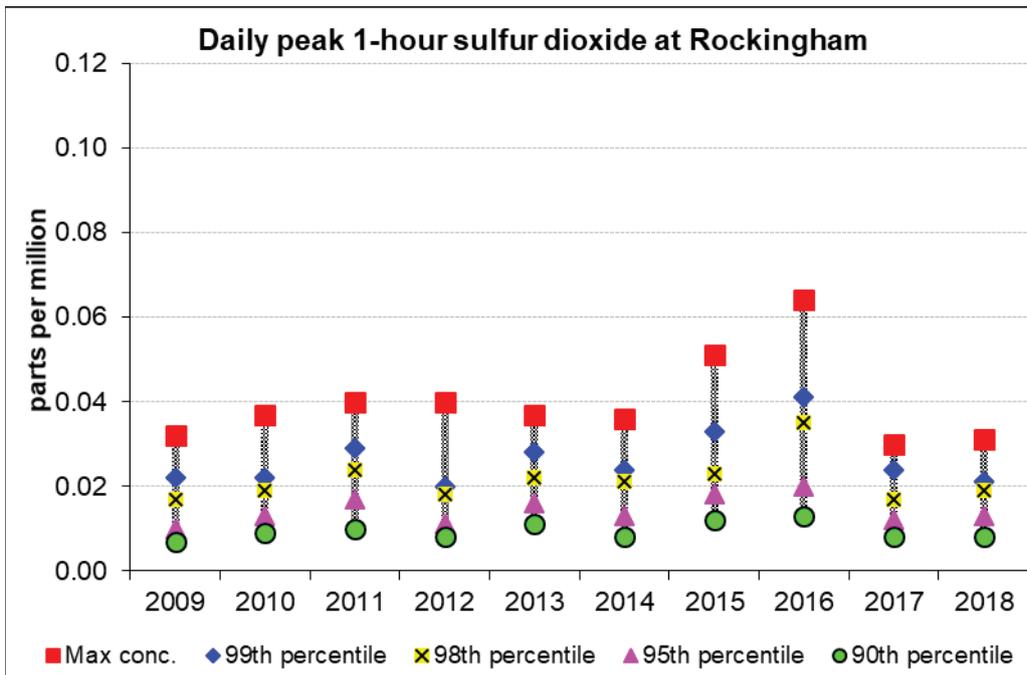


Figure E4-1 – one-hour sulfur dioxide at Rockingham

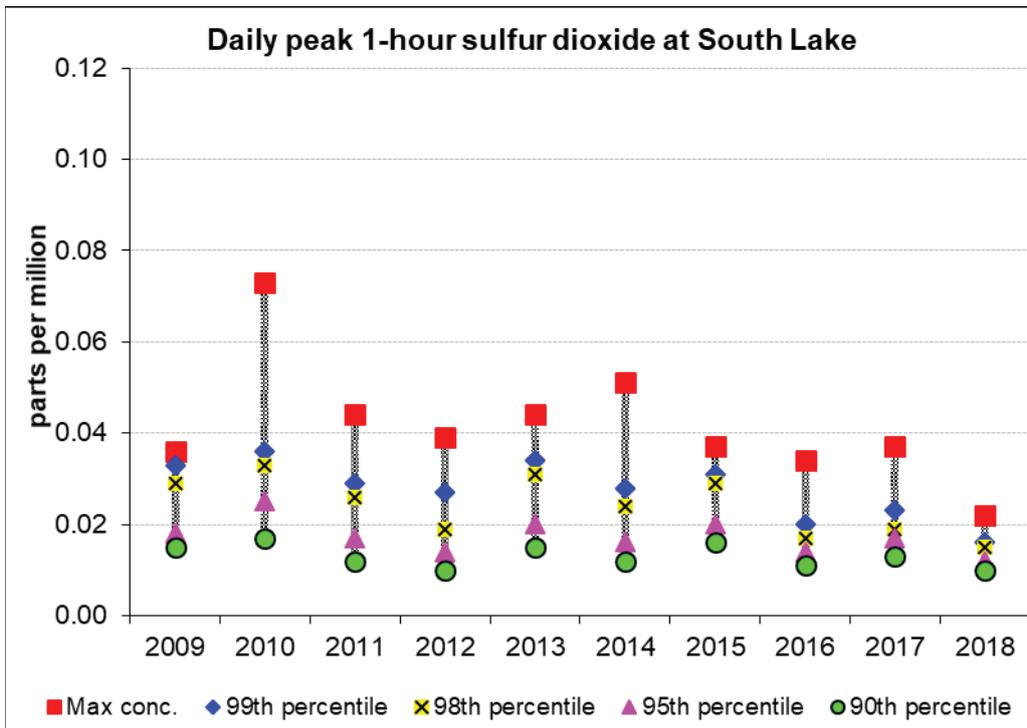


Figure E4-2 – one-hour sulfur dioxide at South Lake

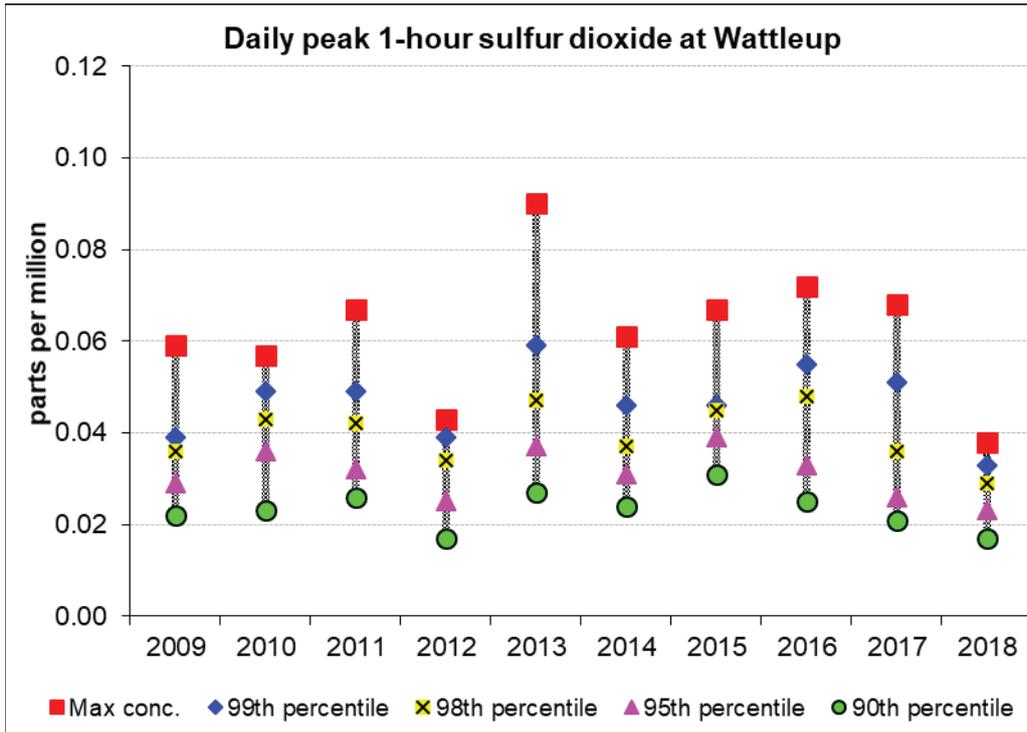


Figure E4-3 – one-hour sulfur dioxide at Wattleup

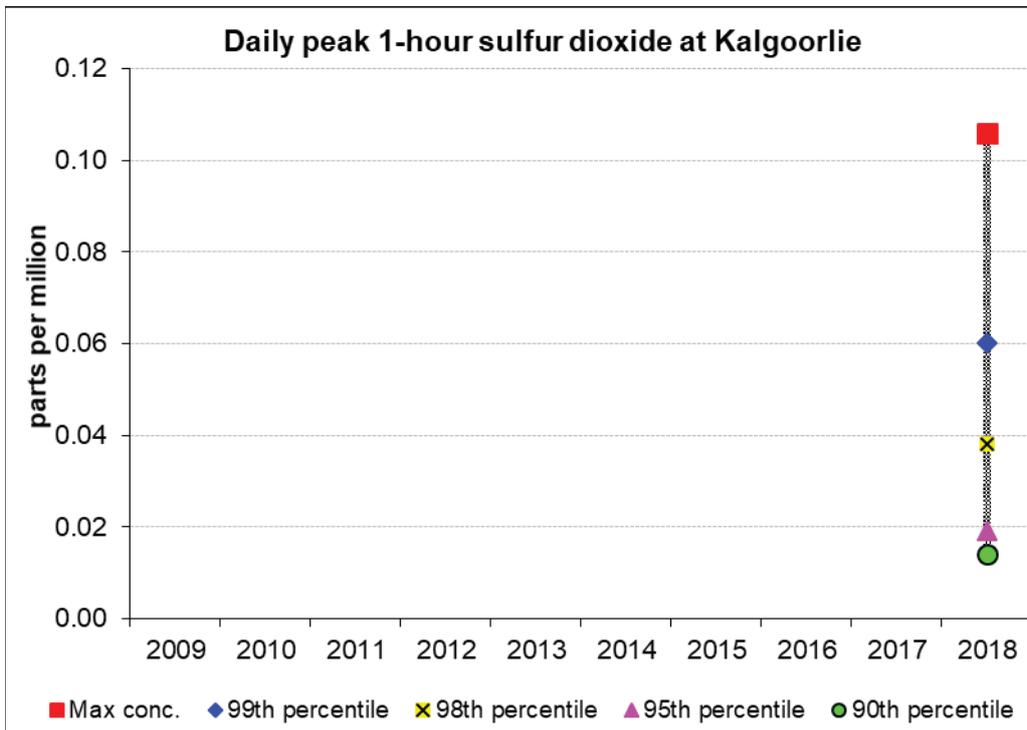


Figure E4-4 – one-hour sulfur dioxide at Kalgoorlie

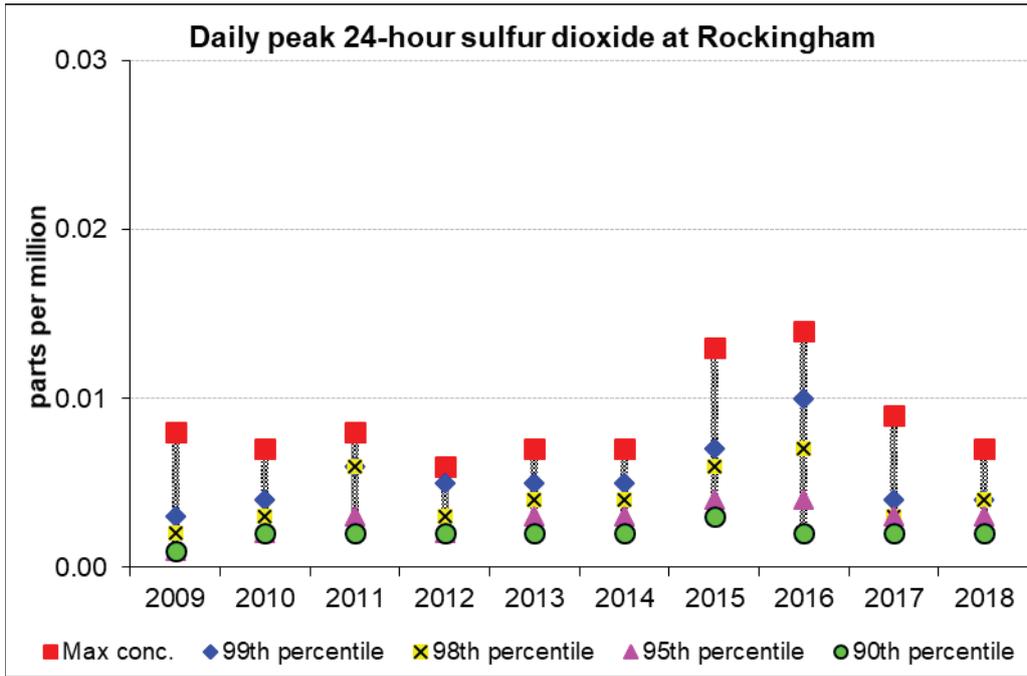


Figure E4-5 – 24-hour sulfur dioxide at Rockingham

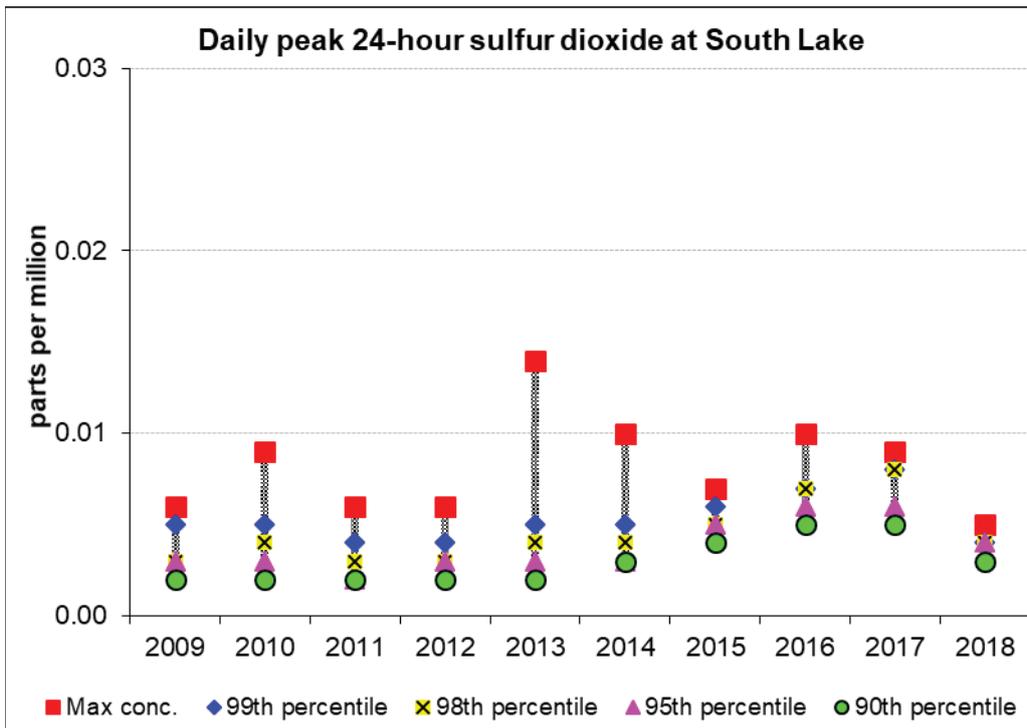


Figure E4-6 – 24-hour sulfur dioxide at South Lake

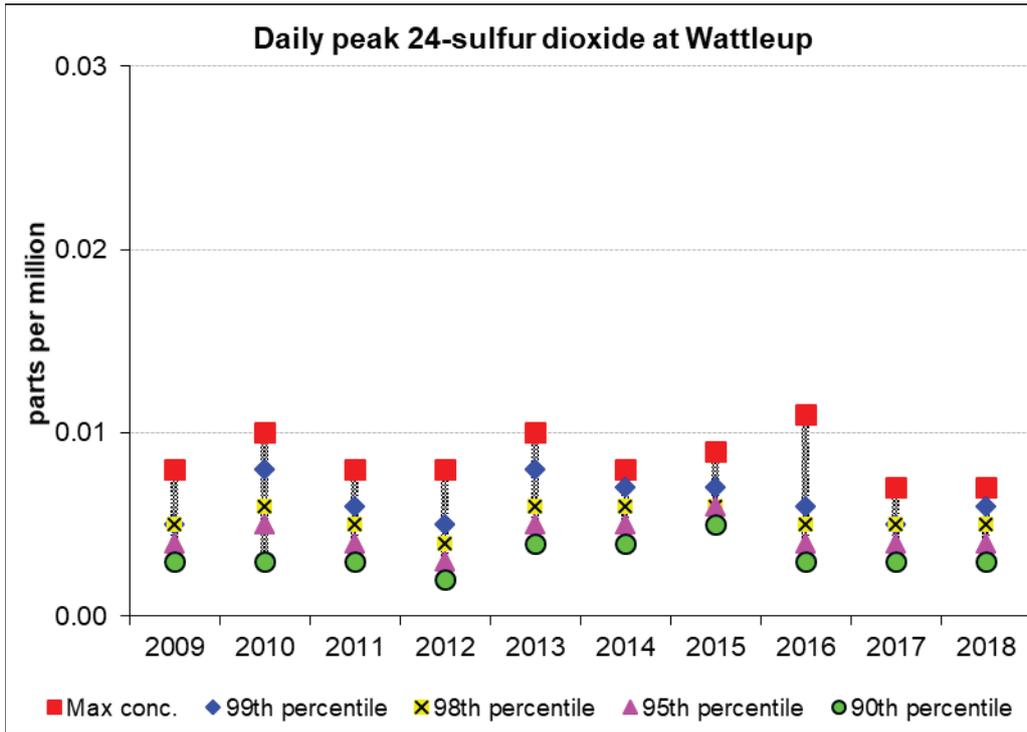


Figure E4-7 – 24-hour sulfur dioxide at Wattleup

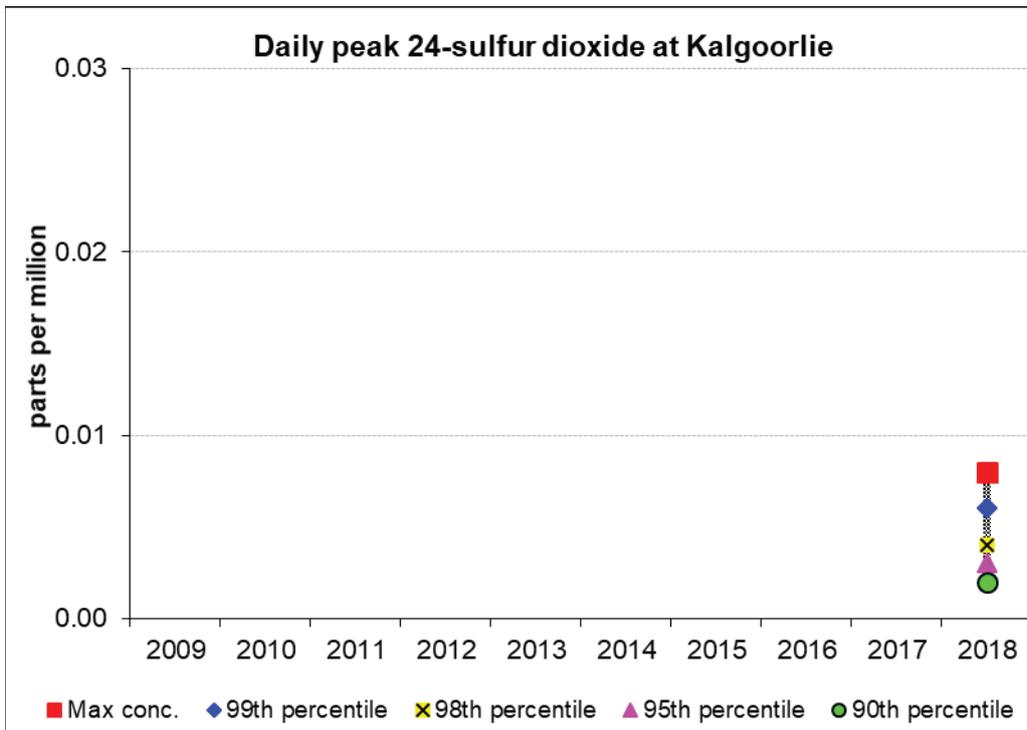


Figure E4-8 – 24-hour sulfur dioxide at Kalgoorlie

## E.5 Particles as PM<sub>10</sub>

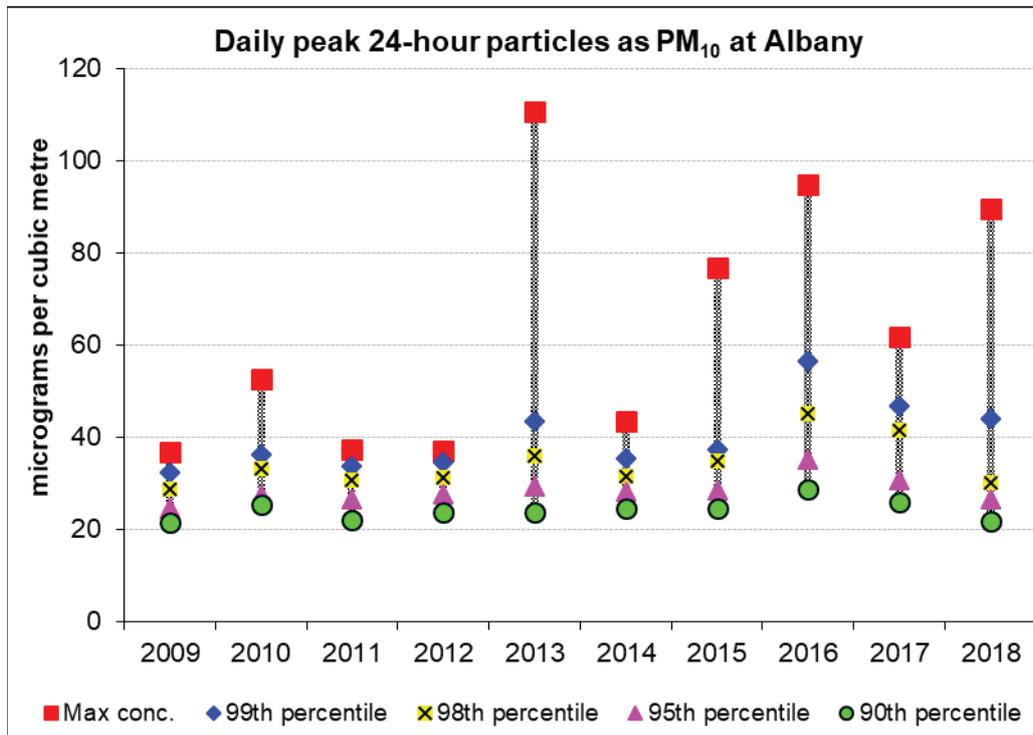


Figure E5-1 – 24-hour PM<sub>10</sub> at Albany

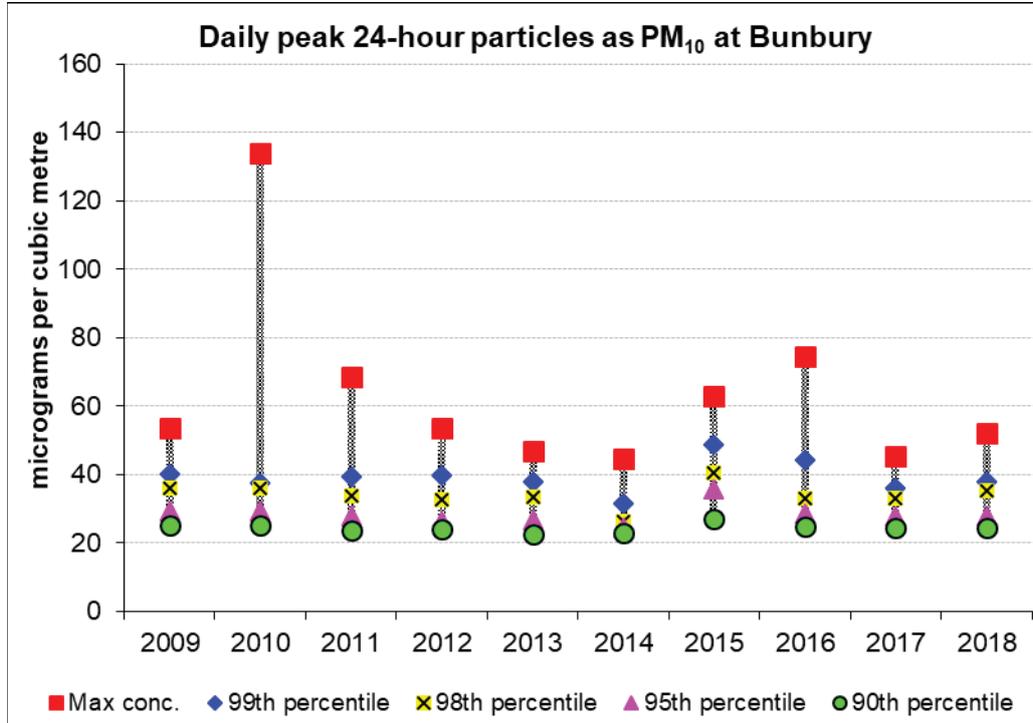


Figure E5-2 – 24-hour PM<sub>10</sub> at Bunbury

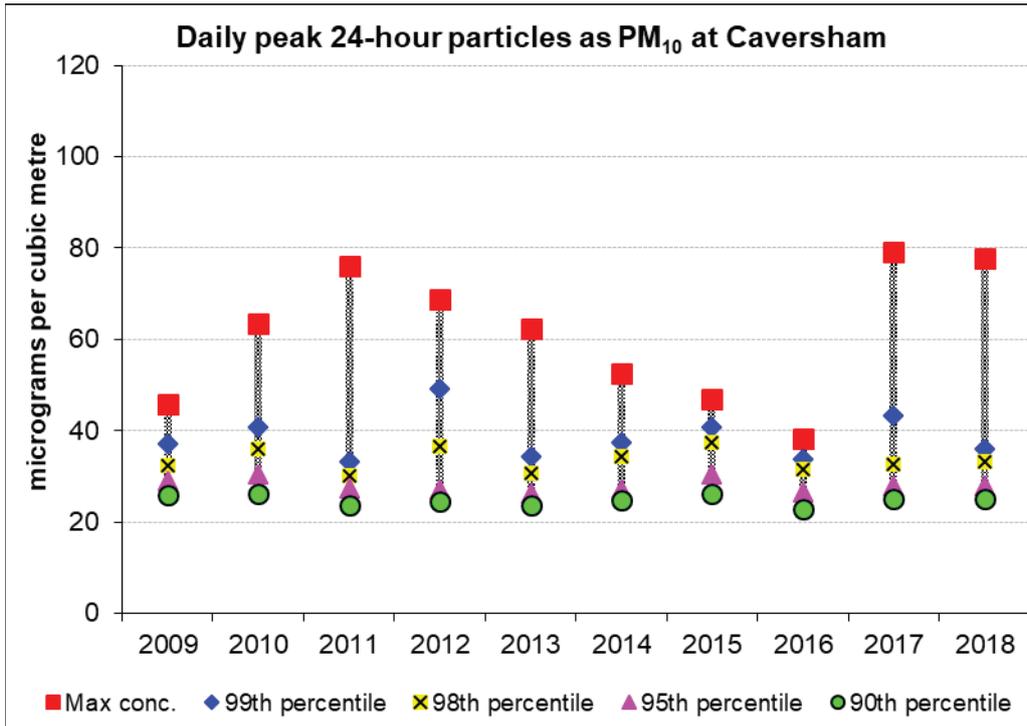


Figure E5-3 – 24-hour PM<sub>10</sub> at Caversham

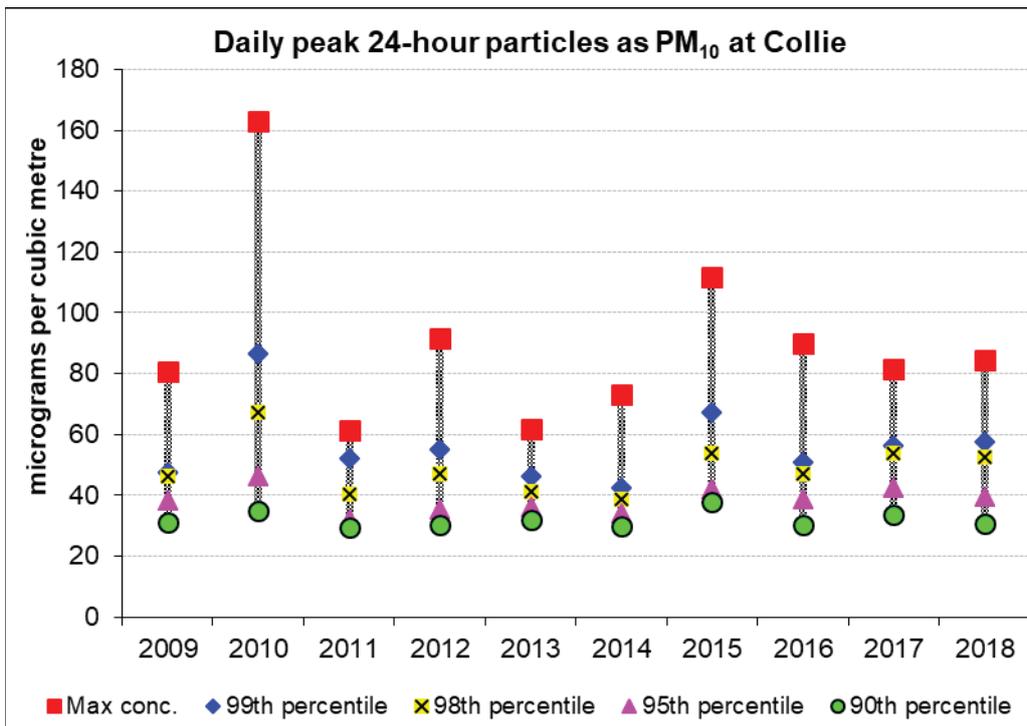


Figure E5-4 – 24-hour PM<sub>10</sub> at Collie

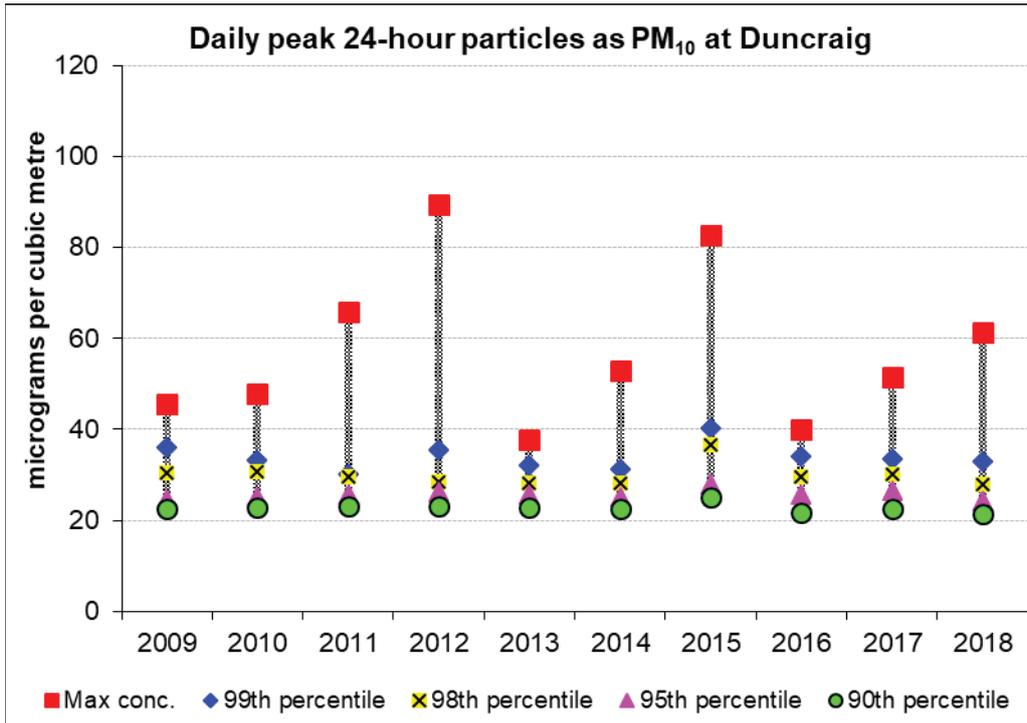


Figure E5-5 – 24-hour PM<sub>10</sub> at Duncraig

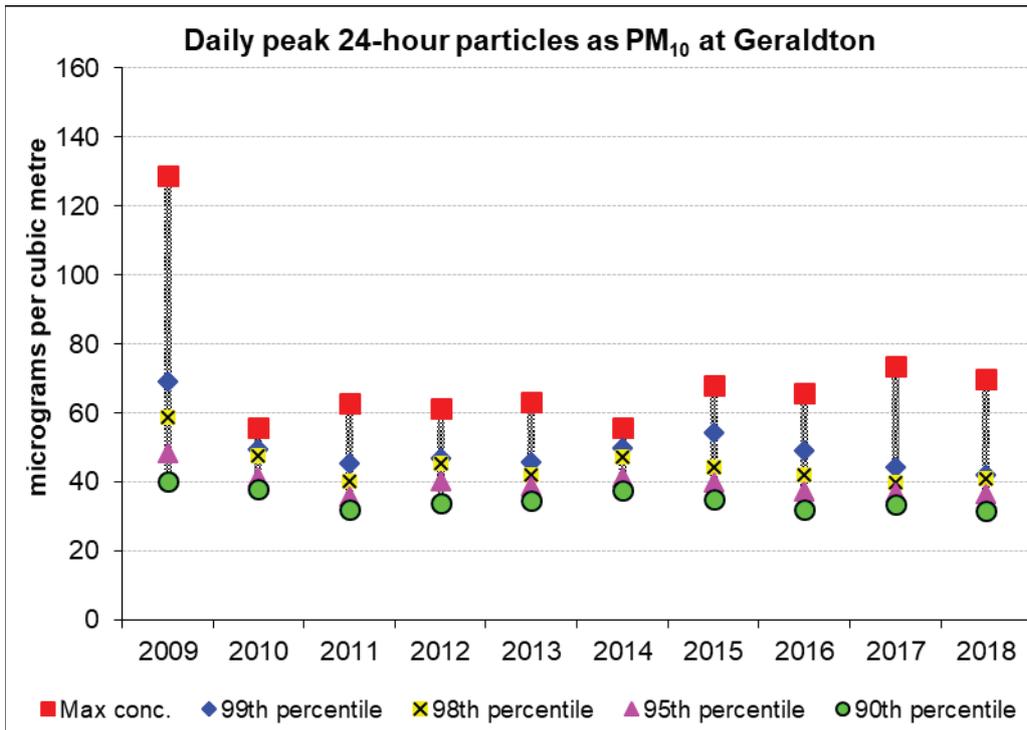


Figure E5-6 – 24-hour PM<sub>10</sub> at Geraldton

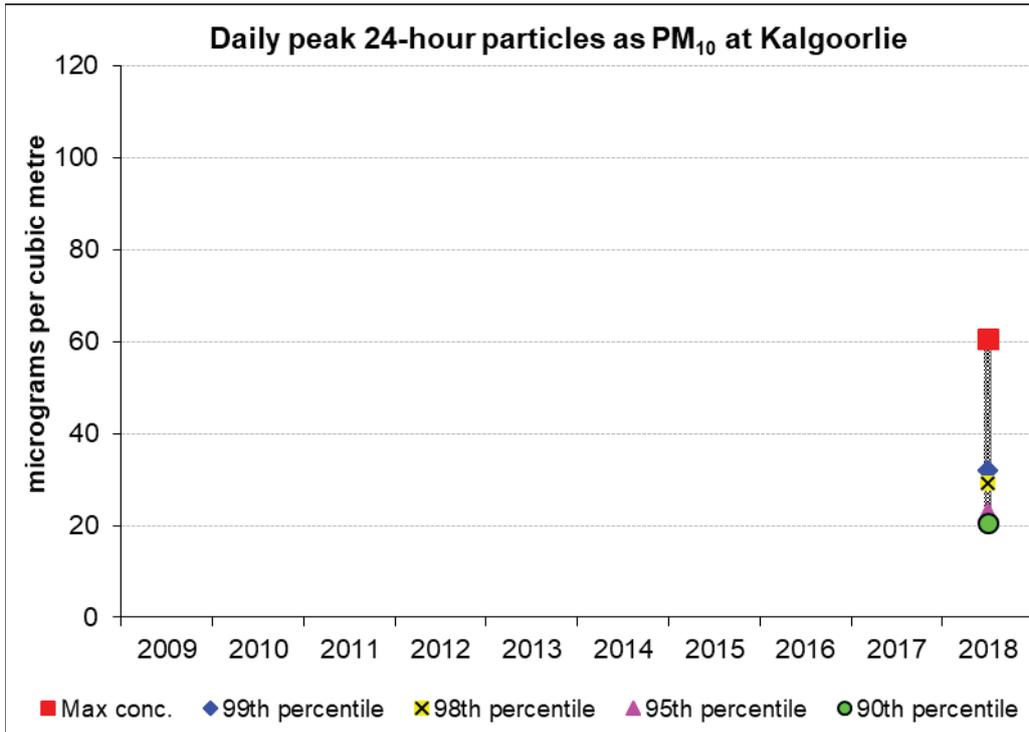


Figure E5-7 – 24-hour PM<sub>10</sub> at Kalgoorlie

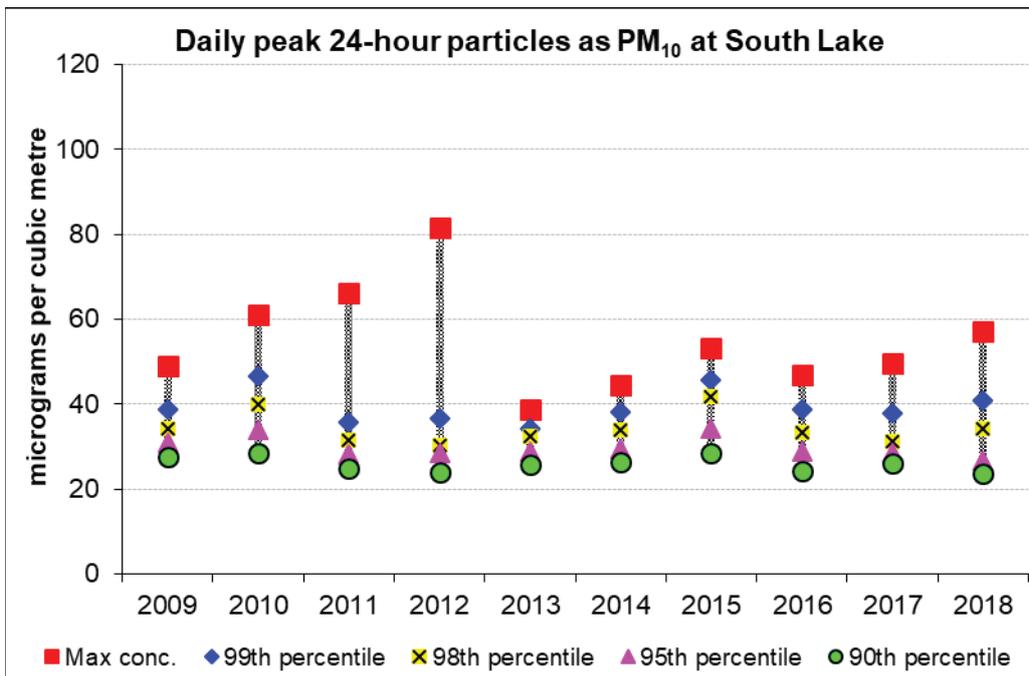


Figure E5-8 – 24-hour PM<sub>10</sub> at South Lake

## E.6 Particles as PM<sub>2.5</sub>

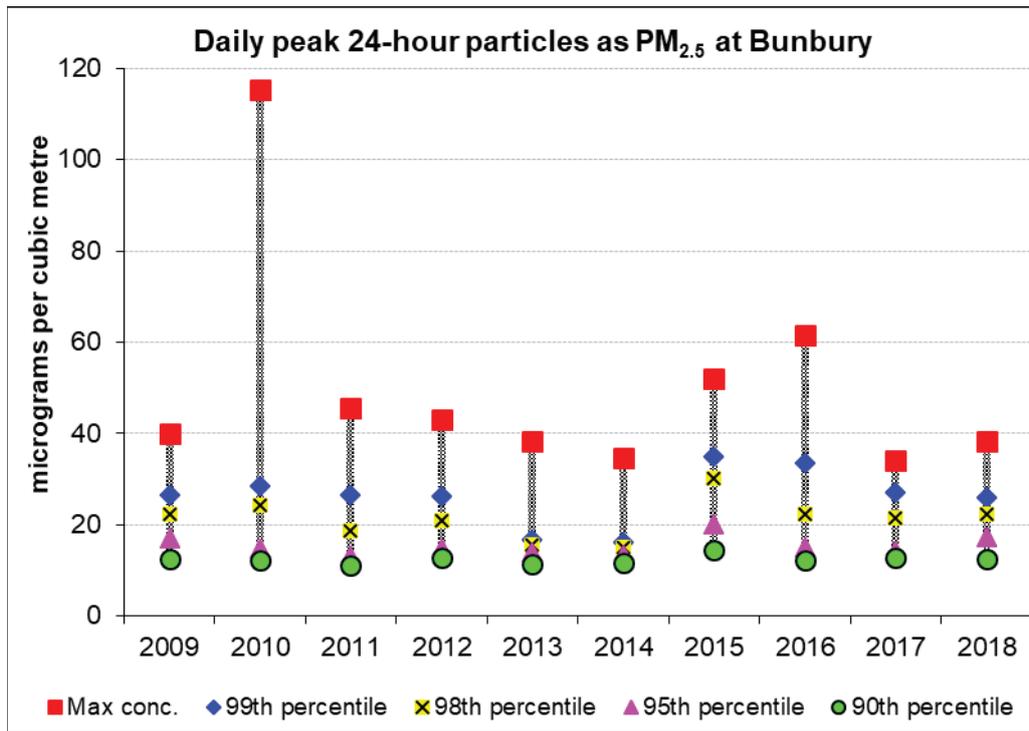


Figure E6-1 – 24-hour PM<sub>2.5</sub> at Bunbury

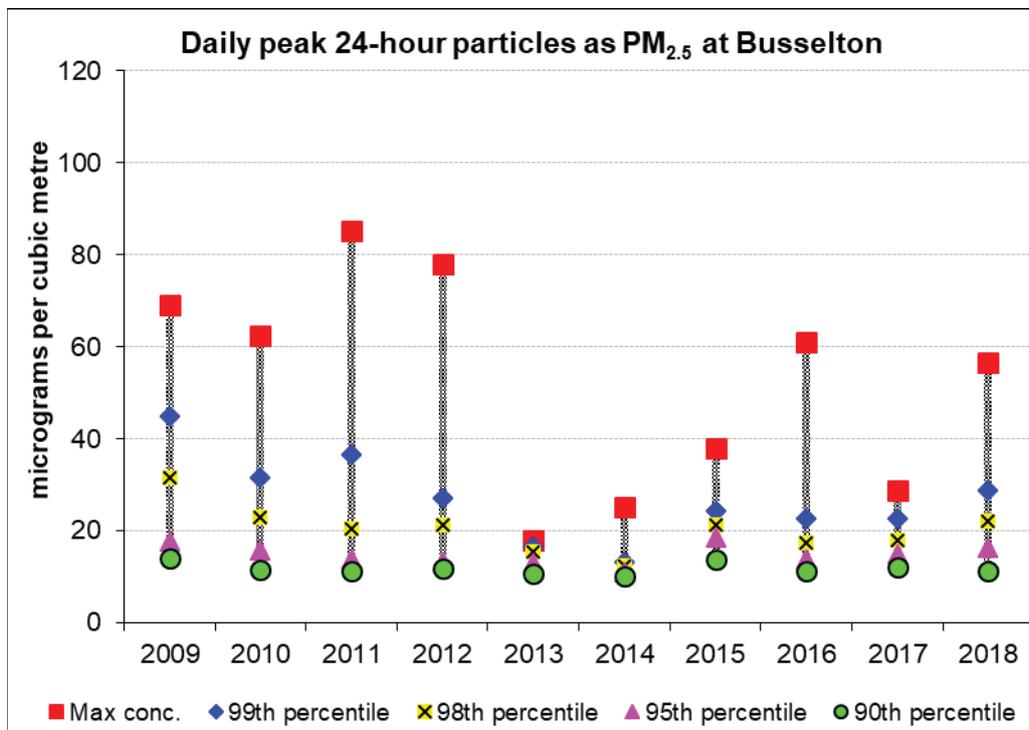


Figure E6-2 – 24-hour PM<sub>2.5</sub> at Busselton

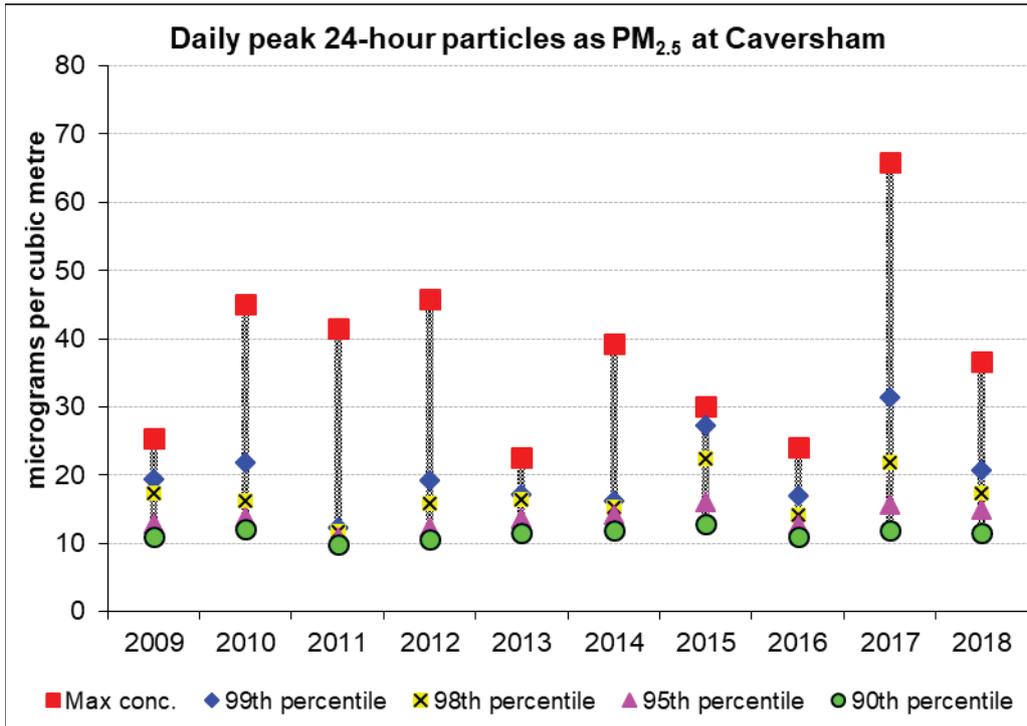


Figure E6-3 – 24-hour PM<sub>2.5</sub> at Caversham

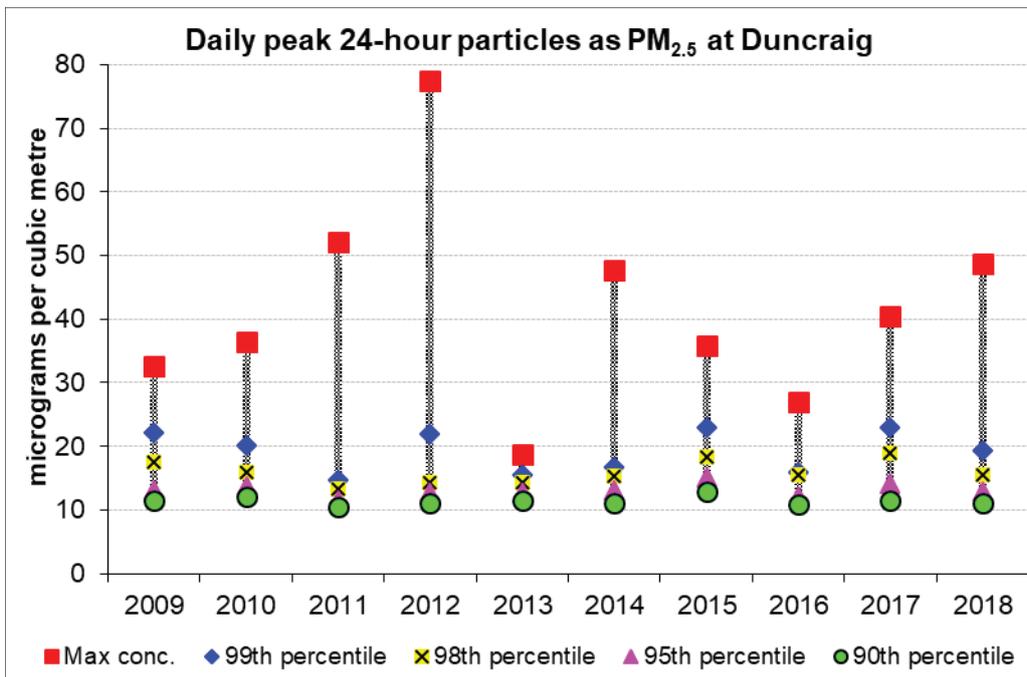


Figure E6-4 – 24-hour PM<sub>2.5</sub> at Duncraig

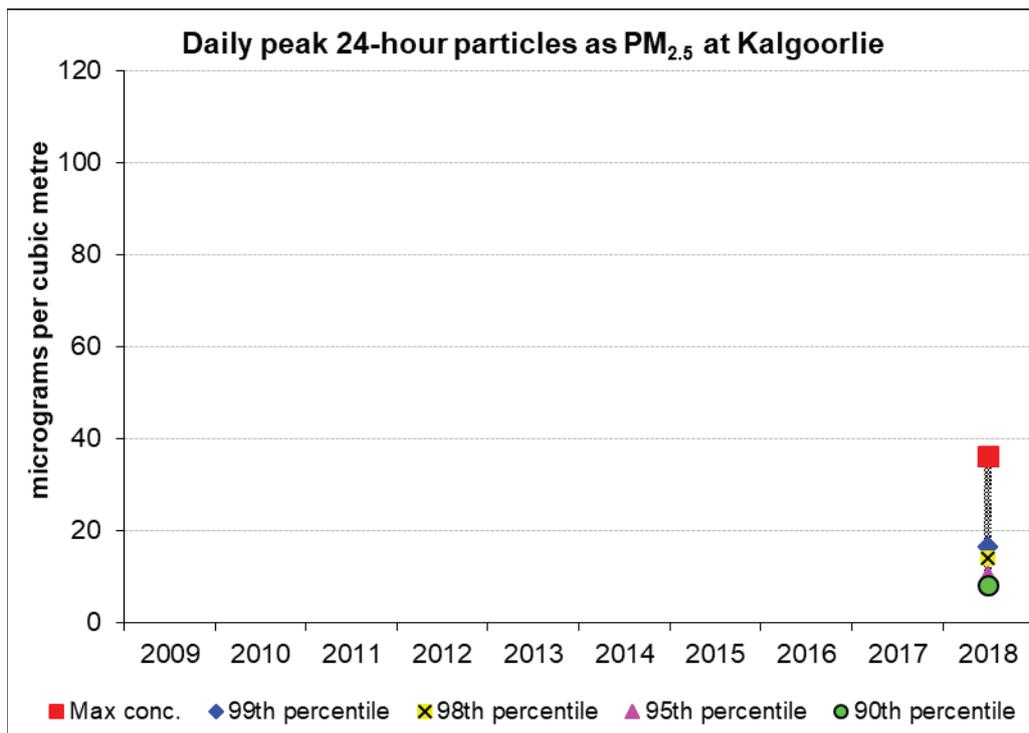


Figure E6-5 – 24-hour PM<sub>2.5</sub> at Kalgoorlie

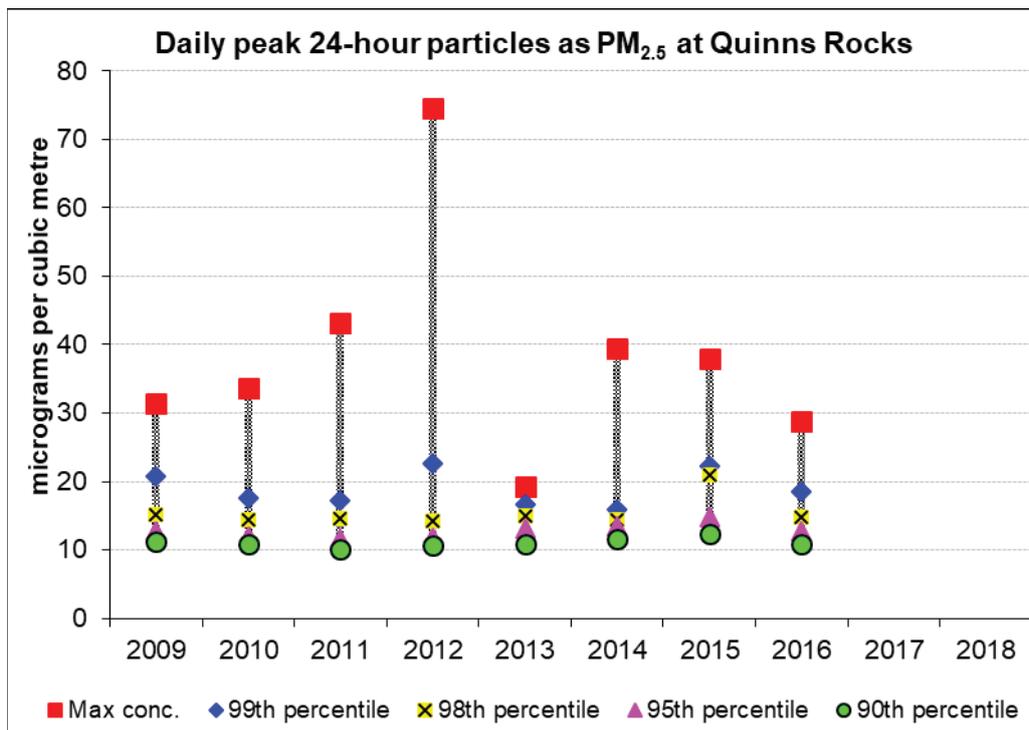


Figure E6-6 – 24-hour PM<sub>2.5</sub> at Quinns Rocks (2017 and 2018 not included)

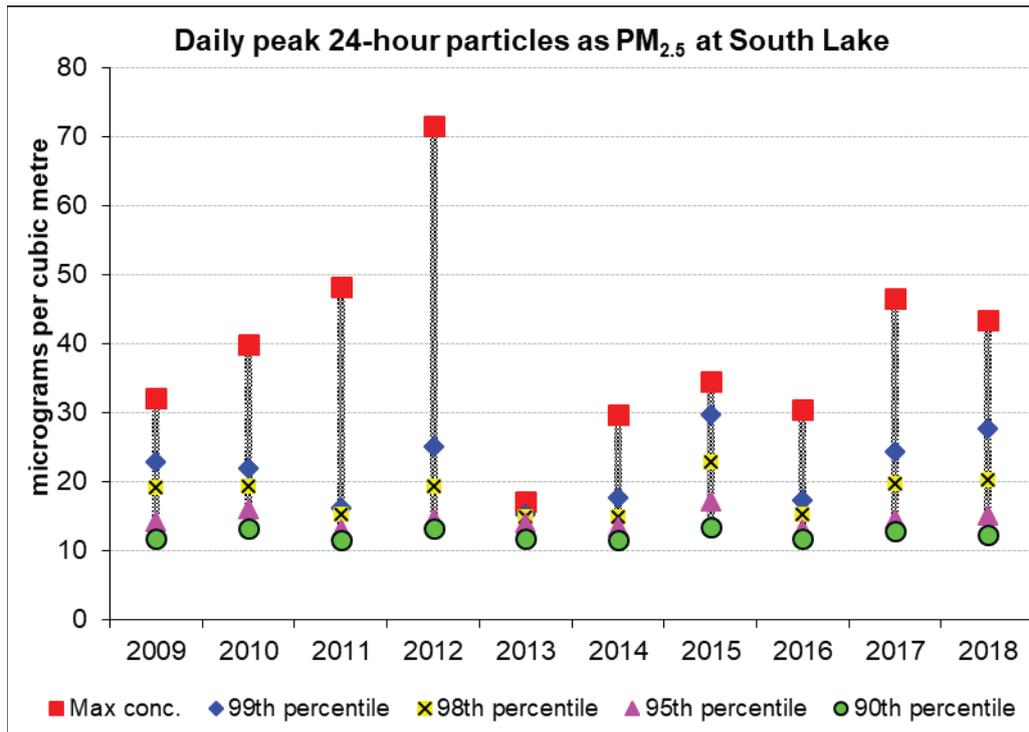


Figure E6-7 – 24-hour PM<sub>2.5</sub> at South Lake

## F. Exceedence analysis

The following pages contain information specific to each parameter exceeding the relevant NEPM standard during 2018. Each analysis is provided in date order and may include one or two satellite images of the region, a back trajectory, concentration and/or wind plots, together with information on the specific concentrations reached and possible sources.

Each back trajectory (where provided) is specific to one event and shows a possible path that a parcel of air may have taken through space to have arrived at a particular location at a certain time. A back trajectory does no more than use the wind speed and direction information recorded at various monitoring sites to track a simple path backwards to a possible origin site. Some major assumptions made in the calculation of these back trajectories, such as no air dispersion throughout the path, create large uncertainties in the indicated path and must be acknowledged. Notwithstanding, the back trajectories as calculated provide a reasonable first approximation for the possible path taken by an air parcel in arriving at its destination.

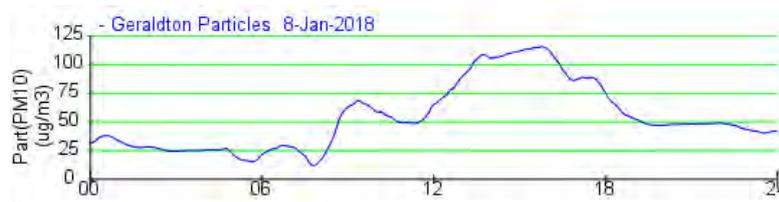
We have used satellite images from <https://worldview.earthdata.nasa.gov>, where available and when cloud cover does not obscure the plume.

Abbreviations are occasionally used to represent air monitoring sites. The more common of these are:

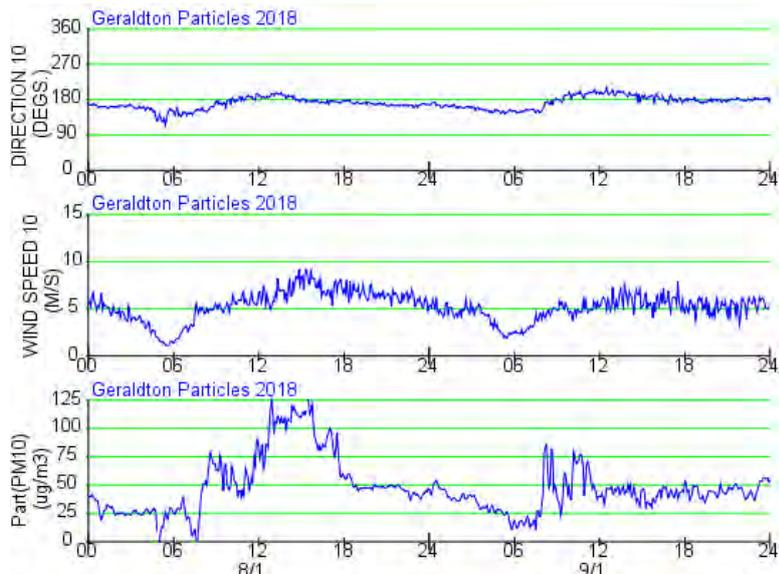
Metropolitan sites	
Ca	Caversham
Du	Duncraig
QR	Quinns Rocks
Ro	Rockingham
RG	Rolling Green
SL	South Lake
Sw	Swanbourne
Wt	Wattleup

Regional sites	
Al	Albany
Bn	Bunbury
Bs	Busselton
Co	Collie
Ge	Geraldton
Kg	Kalgoorlie

08 January 2018



Sixty-minute averaged PM<sub>10</sub> for Geraldton.



Five-minute averaged PM<sub>10</sub>, wind speed and direction for Geraldton.

Pollutant

PM<sub>10</sub>

Monitoring site

Geraldton

NEPM standard

50 µg/m<sup>3</sup>

Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

54.2 µg/m<sup>3</sup>

Description of event

No regional fire events were detected by MODIS hotspot around Geraldton.

No Department of Conservation, Biodiversity and Attractions (DBCAs) prescribed burns or bushfires were conducted in the region. Temperatures in the early afternoon were in the mid 20s.

It was likely due to a local event a few degrees west of south of the monitor. The five-minute profile seems to indicate the concentration peaked just after noon on the 8th and again in the mid-morning of the 9th. These were times when the wind directions were similar.

Assessable event

14 January 2018



Terra/MODIS satellite image showing Mundaring fire plume.

Pollutant

PM<sub>2.5</sub>

Monitoring site

South Lake

NEPM standard

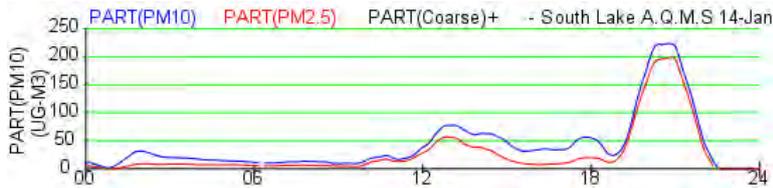
25 µg/m<sup>3</sup>

Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

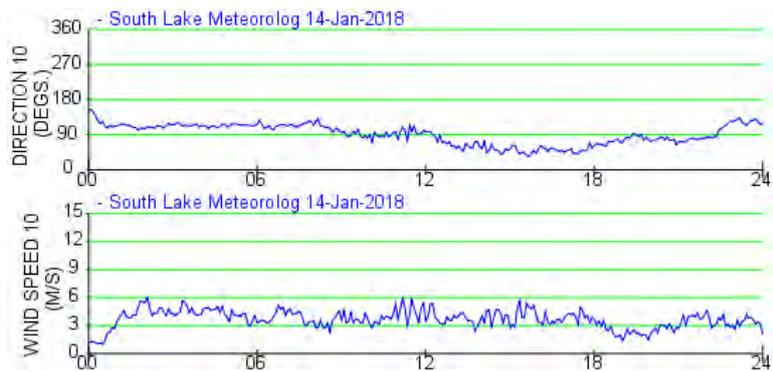
Location	PM <sub>10</sub>	PM <sub>2.5</sub>
Caversham	18.6	6.2
Duncraig	15.0	6.0
South Lake	40.6	26.8
Bunbury	20.5	9.7



Sixty-minute averaged particles and carbon monoxide for South Lake.

Description of event

Smoke from fires in Mundaring caused elevated particle levels in South Lake.

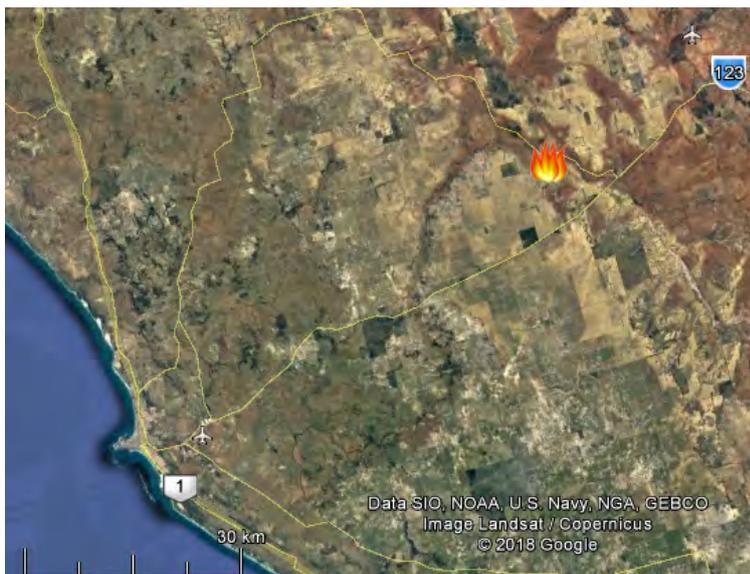


Five-minute averaged wind speed and direction for South Lake.

The satellite image shows smoke generally impacting on metropolitan areas south of the Perth CBD.

Exceptional event

10-11 March 2018



Pollutant

PM<sub>10</sub>

Monitoring site

Geraldton

NEPM standard

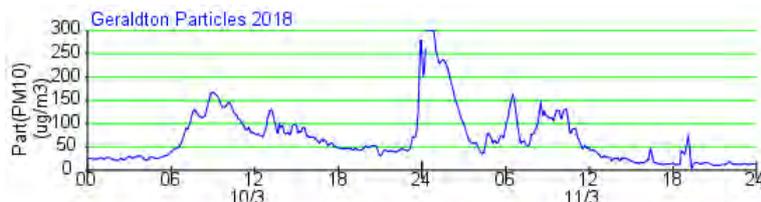
50 µg/m<sup>3</sup>

Averaging period

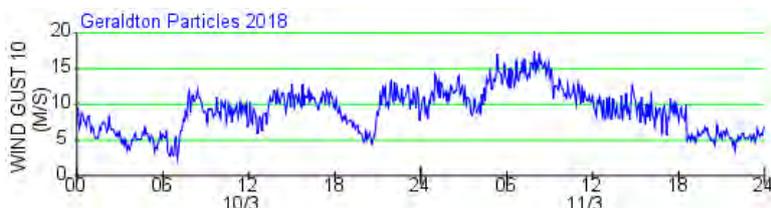
24 hours

Concentration (µg/m<sup>3</sup>)

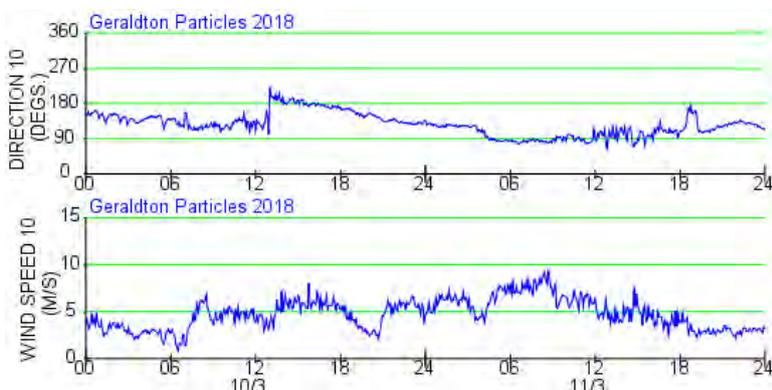
Date	PM <sub>10</sub>
10/03/2018	68.4
11/03/2018	70.0



Hourly averaged PM<sub>10</sub> at Geraldton.



Wind speed gusts at Geraldton.



Five-minute averaged wind speed and direction at Geraldton.

Description of event

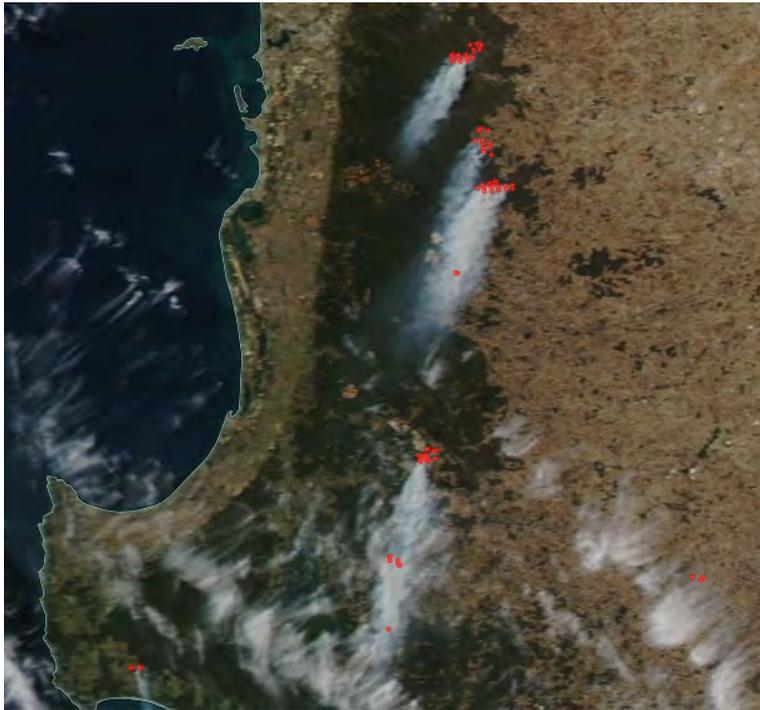
The period was dominated by high easterly to south-easterly winds resulting in lift-off from the surrounding farming areas.

Cause of the unusually high event at midnight is unknown.

A fire was known to be approximately 70 km north-east of Geraldton.

Exceptional event

29-30 April 2018



Aqua/MODIS satellite image of the South West showing smoke plumes from prescribed burns.

Pollutant

PM<sub>10</sub>

Monitoring site

Collie

NEPM standard

50 µg/m<sup>3</sup>

Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

Date	PM <sub>10</sub>
29/04/2018	84.6
30/04/2018	73.4

Description of event

Prescribed burns conducted in the region caused elevated particle levels in Collie.

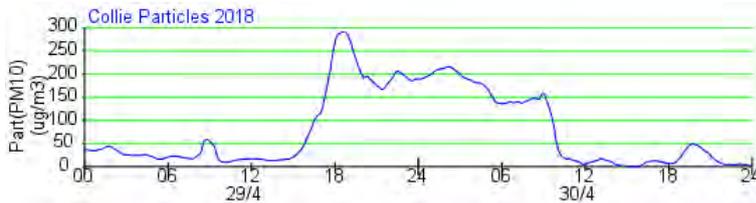
Burns within the region at the time included:

PHS\_143 Gibbs 35 km east south-east of Jarrahdale

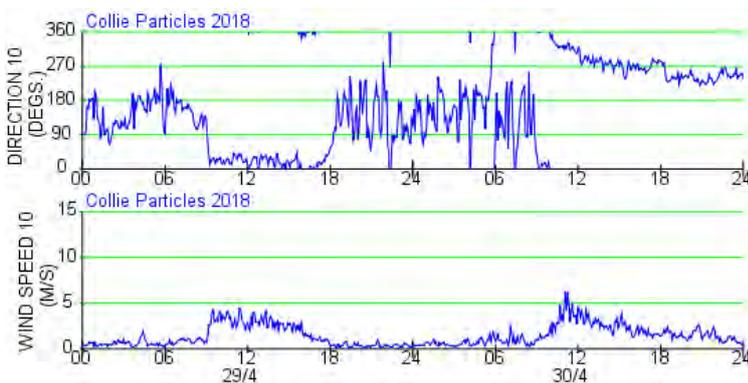
PHS\_126 Flynn 25 km south-east of Mundaring

WTN\_040 Shotts 17 km south-east of Collie

Exceptional event

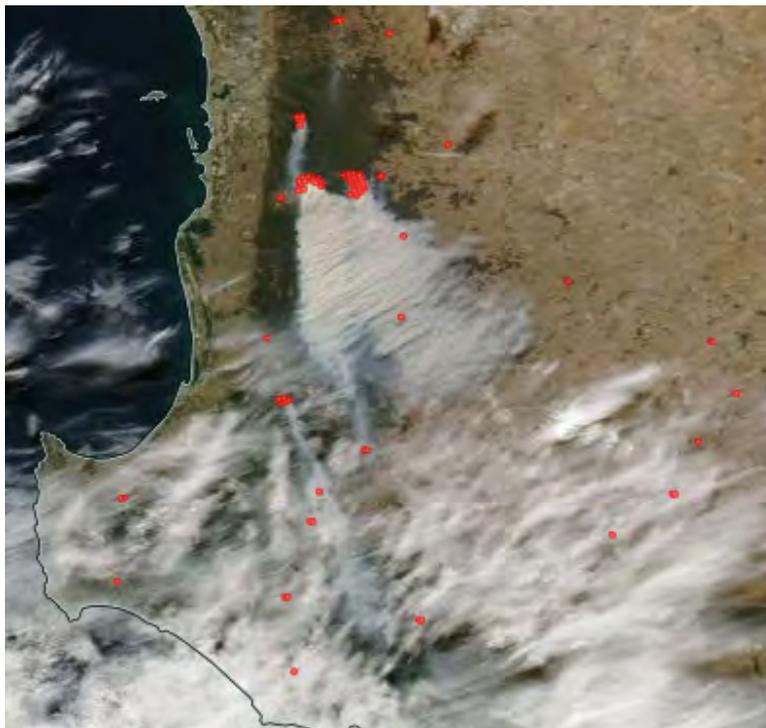


Sixty-minute running averaged time series plot

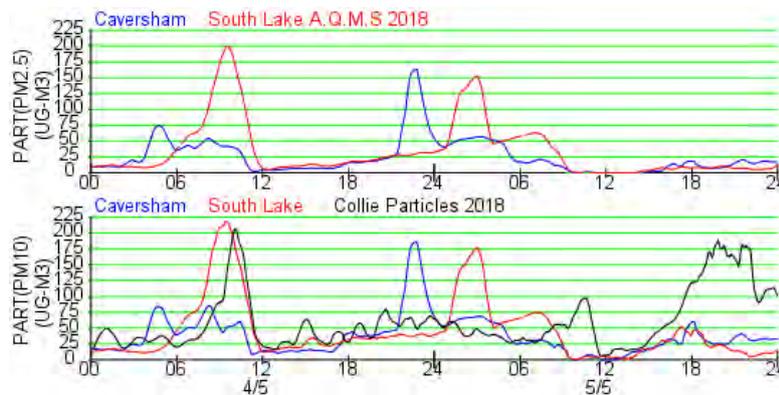


Five-minute averaged time series plot of wind speed and direction at Collie.

4-5 May 2018



Aqua/MODIS satellite image of the South West showing smoke plumes from prescribed burns.



Sixty-minute running averaged time series plot Caversham (blue), South Lake (red) and Collie (black).

Prescribed burn activities in the South West

5 May 2018	6 May 2018
PHS_114 Cobiac 10 km east of Jarrahdale	PHS_142 Taree_Hakea 25 km south-east of Dwellingup
PHS_143 Gibbs 35 km east south-east of Jarrahdale	PHS_114 Cobiac 10 km east of Jarrahdale
PHS_120 Victoria Carinyah 12 km of Kalamunda	PHS_143 Gibbs 35 km east south-east of Jarrahdale
WTN_052 Palmer 15km north-east of Collie	WTN_066 Mungalup 5 km south-west of Collie
PHS_050 Huntly Heaps Prescription 15 km south of Jarrahdale	

Pollutant

PM<sub>10</sub> and PM<sub>2.5</sub>

Monitoring site

Caversham (Ca)

Collie (Co)

South Lake (SL)

NEPM standard

PM<sub>10</sub> 50 µg/m<sup>3</sup>

PM<sub>2.5</sub> 25 µg/m<sup>3</sup>

Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

4 May 2018

Site	PM <sub>10</sub>	PM <sub>2.5</sub>
Ca	45.1	32.5
Co	51.8	N/A
SL	48.6	37.4

5 May 2018

Site	PM <sub>10</sub>	PM <sub>2.5</sub>
Ca	30.0	17.4
Co	69.9	N/A
SL	40.9	29.1

Description of event

A number of prescribed burns were underway during this period which caused smoke impacts at various population centres.

Exceptional event

11 May 2018



Aqua/MODIS satellite image of the South West showing smoke plumes from prescribed burns.

Pollutant

PM<sub>2.5</sub>

Monitoring site

South Lake

NEPM standard

25 µg/m<sup>3</sup>

Averaging period

24 hours

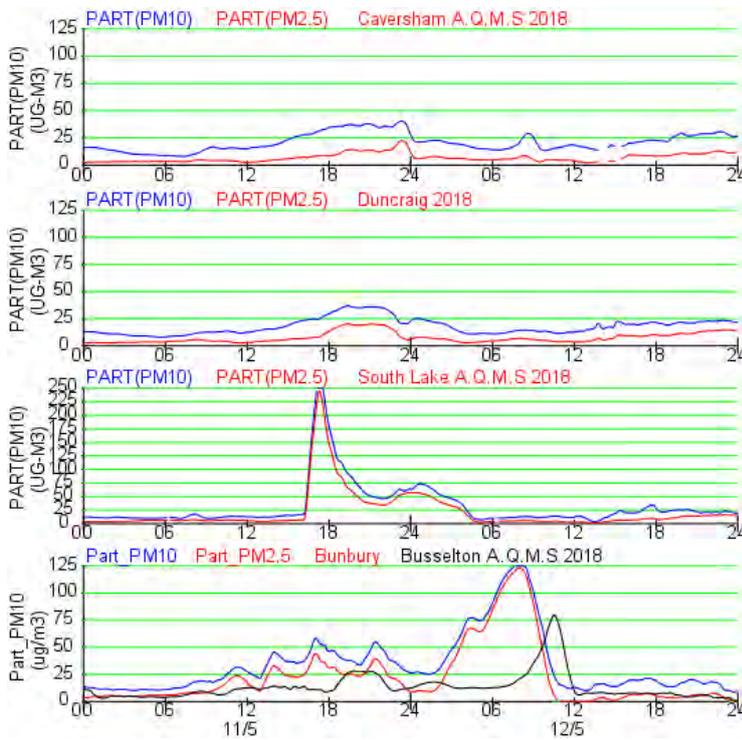
Concentration (µg/m<sup>3</sup>)

Site	PM <sub>10</sub>	PM <sub>2.5</sub>
Ca	21.3	6.8
Co	18.5	7.6
SL	41.9	31.2
Bn	27.2	17.3

Description of event

Prescribed burns conducted south and east of Perth caused smoke to affect the southern and eastern parts of the metropolitan region.

Exceptional event



Sixty-minute running averaged time series plot.

12 May 2018



Terra/MODIS satellite image of the South West showing smoke plumes from prescribed burns.

Pollutant

PM<sub>10</sub> and PM<sub>2.5</sub>

Monitoring site

Collie (Co)

Bunbury (Bn)

NEPM standard

PM<sub>10</sub> 50 µg/m<sup>3</sup>

PM<sub>2.5</sub> 25 µg/m<sup>3</sup>

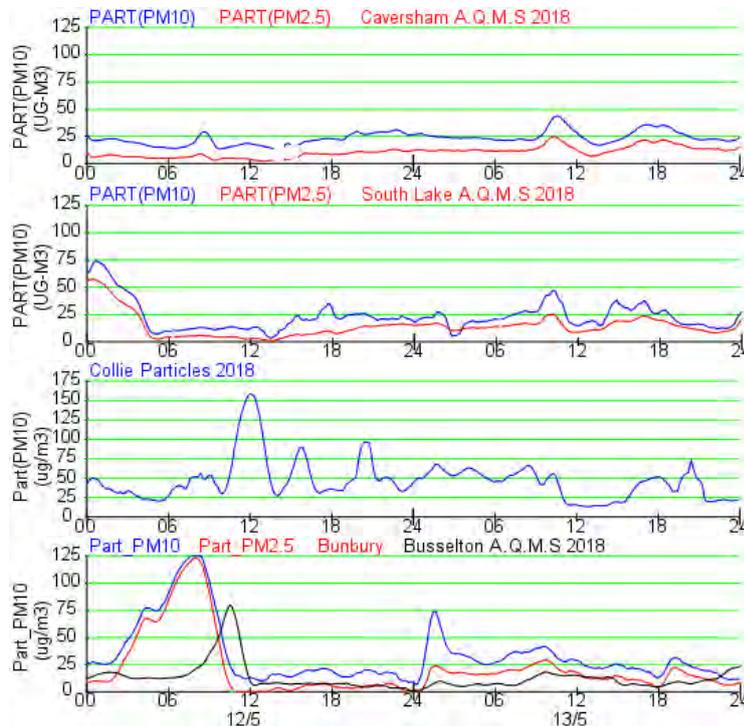
Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

Site	PM <sub>10</sub>	PM <sub>2.5</sub>
Ca	20.9	7.1
SL	22.3	12.5
Co	52.6	NA
Bn	39.5	27.4

Back trajectory over



Sixty-minute running averaged time series plot.

Description of event

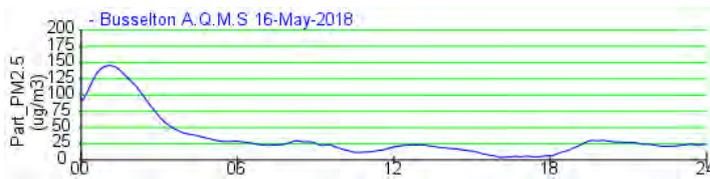
Prescribed burns conducted south and east of Perth caused smoke to affect the southern and eastern parts of the metropolitan region.

Exceptional event

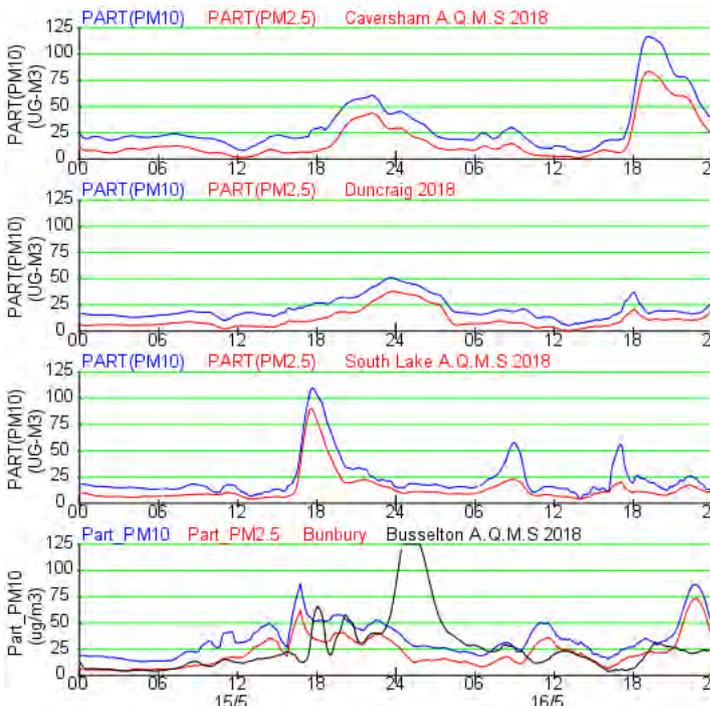
16 May 2018



Aqua/MODIS satellite image of the South West showing smoke plumes from prescribed burns.



Sixty-minute running averaged time series plot.



Sixty-minute running averaged time series plot of various sites.

Pollutant

PM<sub>2.5</sub>

Monitoring site

Busselton

NEPM standard

25 µg/m<sup>3</sup>

Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

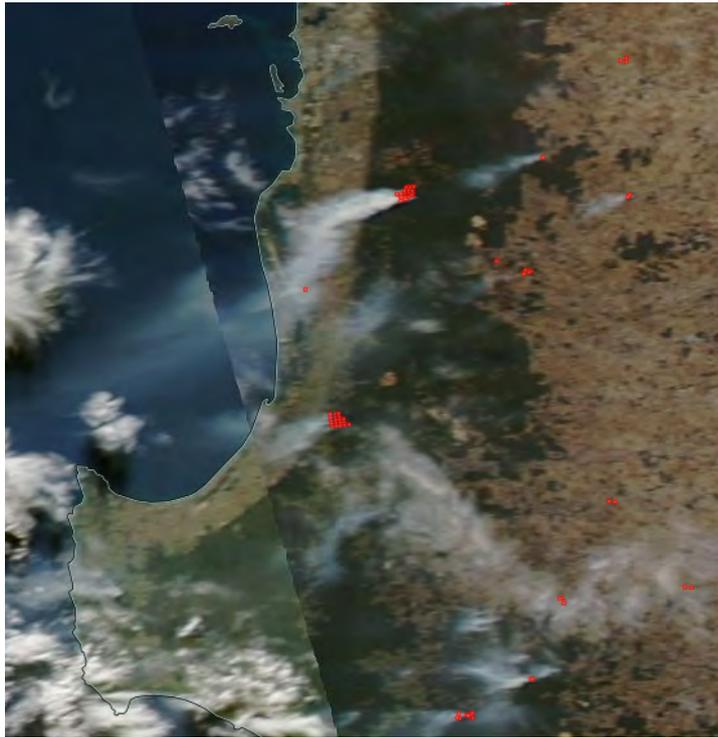
32.2 µg/m<sup>3</sup>

Description of event

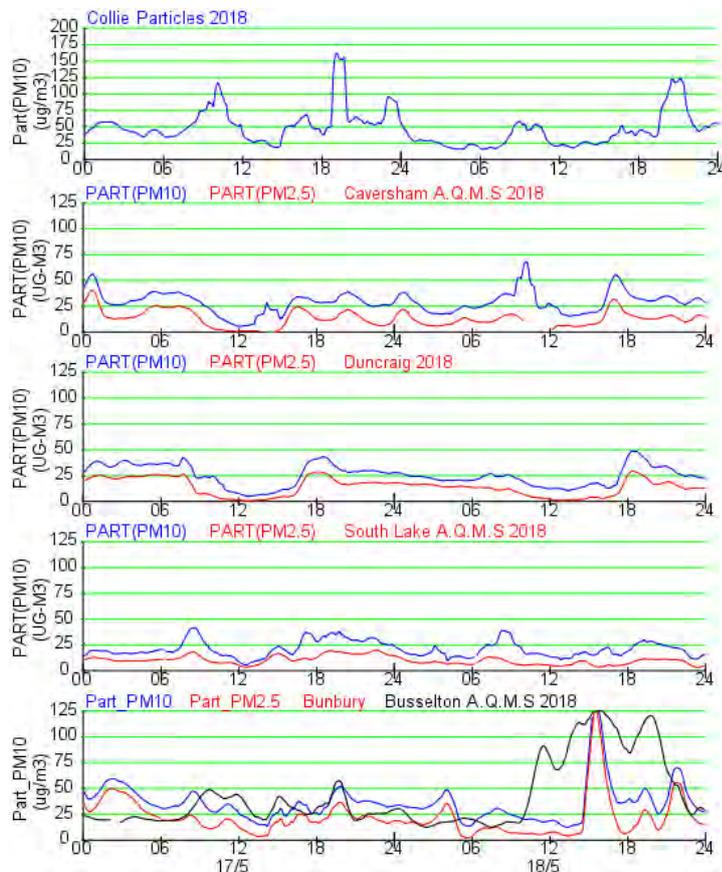
Prescribed burns conducted south and east of Perth caused smoke to affect the southern and eastern parts of the metropolitan region and resulted in a NEPM exceedence at Busselton.

Exceptional event

17 May 2018



Aqua/MODIS satellite image of the South West showing smoke plumes from prescribed burns.



Sixty-minute running averaged time series plot.

**Pollutant**

PM<sub>10</sub> and PM<sub>2.5</sub>

**Monitoring site**

Collie (Co)

Busselton (Bs)

**NEPM standard**

PM<sub>10</sub> 50 µg/m<sup>3</sup>

PM<sub>2.5</sub> 25 µg/m<sup>3</sup>

**Averaging period**

24 hours

**Concentration (µg/m<sup>3</sup>)**

Site	PM <sub>10</sub>	PM <sub>2.5</sub>
Ca	28.1	14.6
SL	22.8	12.3
Co	57.1	NA
Bn	35.7	22.7
Bs	N/A	29.8

**Description of event**

Prescribed burns conducted south and east of Perth caused smoke to affect the southern part of the state and resulted in a NEPM exceedence at Collie and Busselton.

**Exceptional event**

18 May 2018



Terra/MODIS satellite image of the South West showing smoke plumes from prescribed burns.

Pollutant

PM<sub>2.5</sub>

Monitoring site

Busselton

NEPM standard

25 µg/m<sup>3</sup>

Averaging period

24 hours

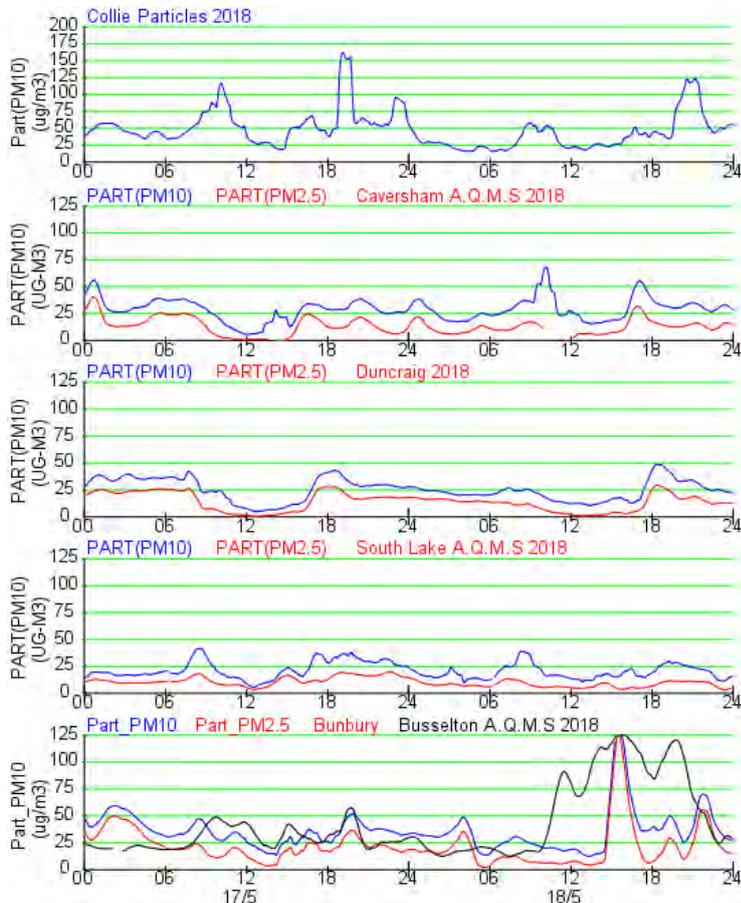
Concentration (µg/m<sup>3</sup>)

56.5 µg/m<sup>3</sup>

Description of event

Prescribed burns conducted south and east of Perth caused smoke to affect the southern part of the state and resulted in a NEPM exceedence at Busselton.

Exceptional event

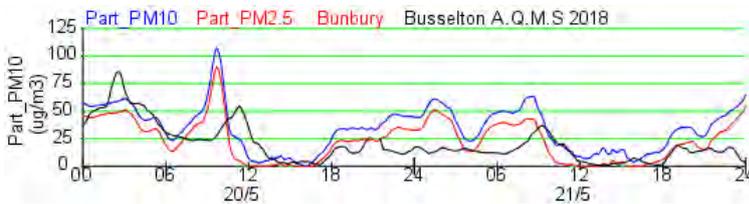


Sixty-minute running averaged time series plot.

20 May 2018



Terra/MODIS satellite image of the South West showing smoke plumes from prescribed burns.



Sixty-minute running averaged time series plot.

Pollutant

PM<sub>2.5</sub>

Monitoring site

Busselton and Bunbury

NEPM standard

25  $\mu\text{g}/\text{m}^3$

Averaging period

24 hours

Concentration ( $\mu\text{g}/\text{m}^3$ )

Busselton: 28.0  $\mu\text{g}/\text{m}^3$

Bunbury: 25.2  $\mu\text{g}/\text{m}^3$

Description of event

Residual smoke from prescribed burns conducted south and east of Perth affected the southern part of the state and resulted in a NEPM exceedance at Bunbury and Busselton.

Exceptional event

22 May 2018



Aqua/MODIS satellite image of the South West showing smoke plumes from prescribed burns.

Pollutant

PM<sub>10</sub> and PM<sub>2.5</sub>

Monitoring site

Collie (Co)

Bunbury (Bn)

NEPM standard

PM<sub>10</sub> 50 µg/m<sup>3</sup>

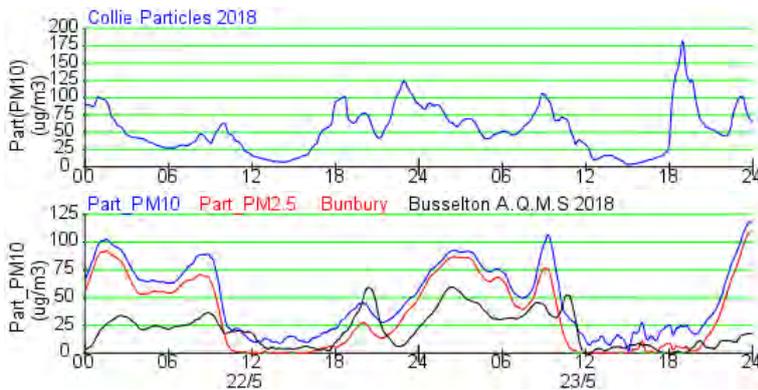
PM<sub>2.5</sub> 25 µg/m<sup>3</sup>

Averaging period

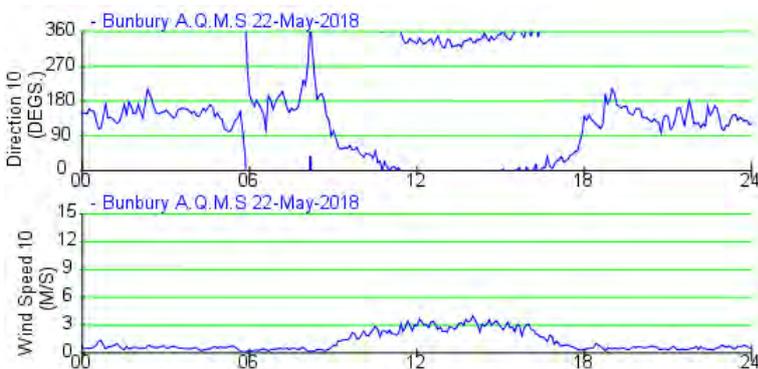
24 hours

Concentration (µg/m<sup>3</sup>)

Site	PM <sub>10</sub>	PM <sub>2.5</sub>
Co	50.4	NA
Bn	46.5	33.0
Bs	N/A	20.1



Sixty-minute running averaged time series plot.



Five-minute averaged time series plot of wind speed and direction at Bunbury.

Description of event

Bushfires and prescribed burns conducted in the South West caused smoke to affect the southern part of the state and resulted in NEPM exceedences at Collie and Bunbury.

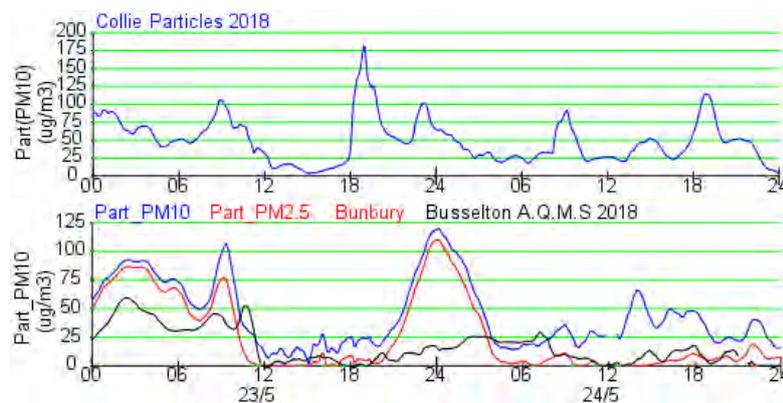
While the satellite image was taken when winds were from the north north-west, Bunbury winds were from the south south-east for much of the day.

Exceptional event

23 May 2018



Aqua/MODIS satellite image of the South West showing smoke plumes from prescribed burns.



Sixty-minute running averaged time series plot.

Pollutant

PM<sub>10</sub> and PM<sub>2.5</sub>

Monitoring site

Collie (Co)

Bunbury (Bn)

NEPM standard

PM<sub>10</sub> 50 µg/m<sup>3</sup>

PM<sub>2.5</sub> 25 µg/m<sup>3</sup>

Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

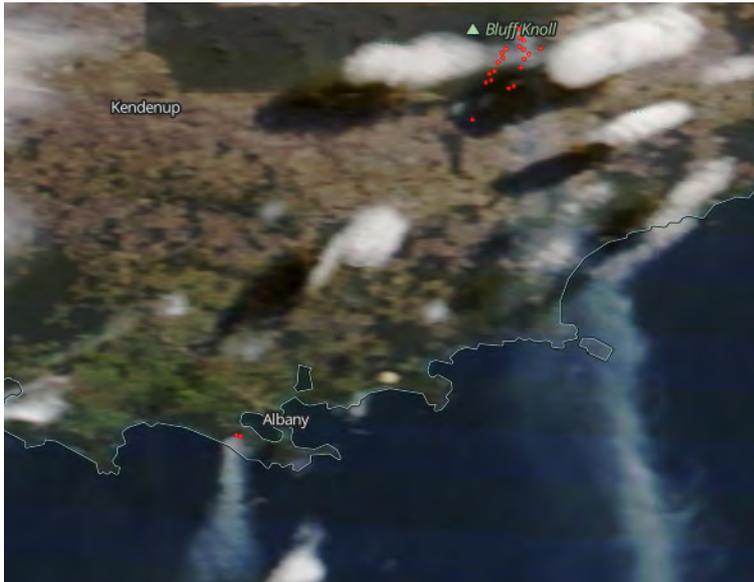
Site	PM <sub>10</sub>	PM <sub>2.5</sub>
Co	56.7	NA
Bn	51.9	38.4
Bs	N/A	22.0

Description of event

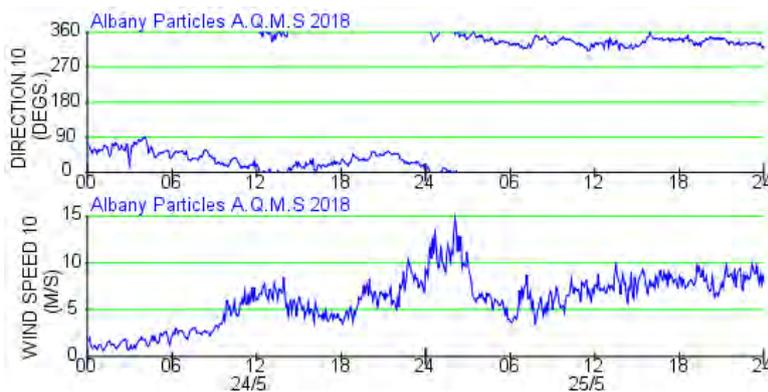
Bushfires and prescribed burns conducted in the South West caused smoke to affect the southern part of the state and resulted in NEPM exceedences at Collie and Bunbury.

Exceptional event

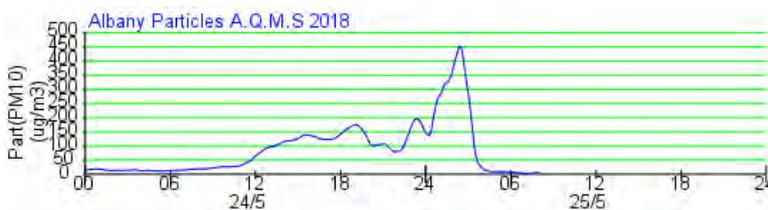
24 May 2018



Terra/MODIS satellite image showing smoke plumes from fires in and around Albany.



Five-minute averaged time series plot of wind speed and direction at Albany.



Sixty-minute running averaged time series particle plot at Albany.

Pollutant

PM<sub>10</sub> and PM<sub>2.5</sub>

Monitoring site

Albany (Al)

Caversham (Ca)

NEPM standard

PM<sub>10</sub> 50 µg/m<sup>3</sup>

PM<sub>2.5</sub> 25 µg/m<sup>3</sup>

Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

Site	PM <sub>10</sub>	PM <sub>2.5</sub>
Al	74.3	NA
Ca	77.9	10.3
Co	39.5	NA

Description of event

A smoke alert was issued for people in or near Willyung and surrounding areas in the City of Albany on 24 May 2018. Smoke from prescribed burning activities had been carried by prevailing winds. The smoke was expected to clear during the days following.

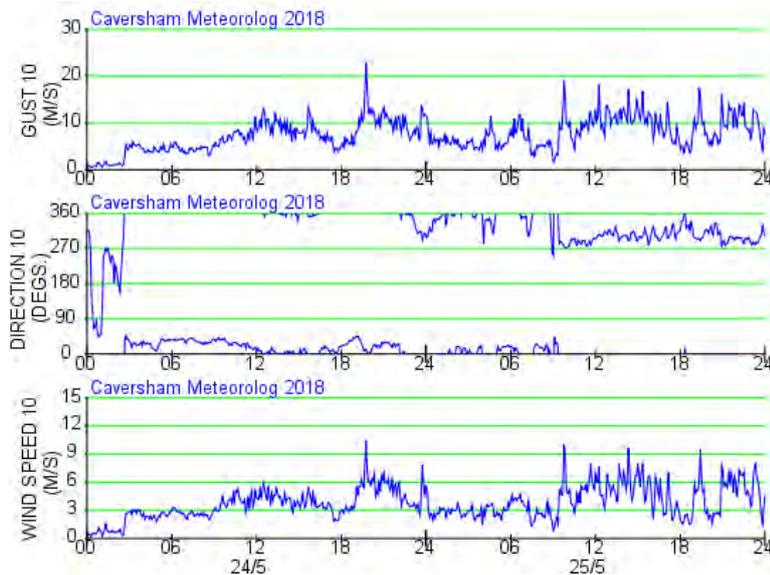
Additionally, there were a number of bushfires in the northern part of Albany region.

Exceptional event

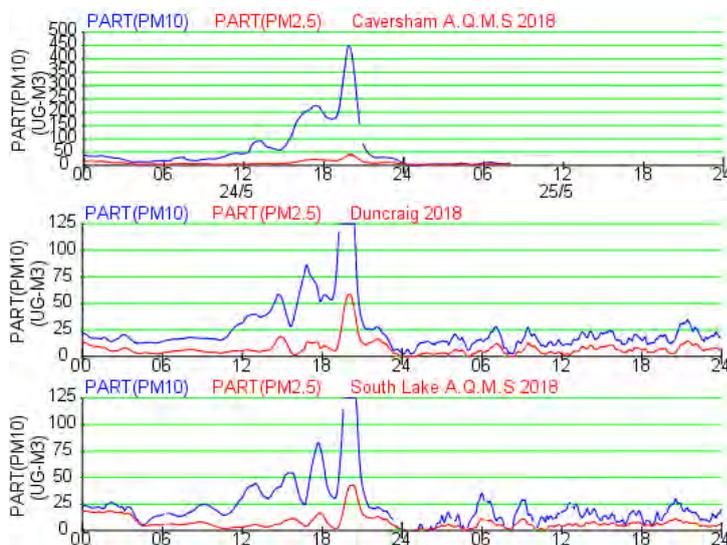
24 May 2018 (cont.)



Terra/MODIS satellite image from the previous day showing a fire and plume north-east of the Caversham site.



Five-minute averaged time series plot of wind speed and direction at Caversham.



Sixty-minute running averaged time series particle plot at Caversham, Duncraig and South Lake with PM<sub>10</sub> in Blue and PM<sub>2.5</sub> in red.

Pollutant

PM<sub>10</sub> and PM<sub>2.5</sub>

Monitoring site

Albany (Al)

Caversham (Ca)

NEPM standard

PM<sub>10</sub> 50 µg/m<sup>3</sup>

PM<sub>2.5</sub> 25 µg/m<sup>3</sup>

Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

Site	PM <sub>10</sub>	PM <sub>2.5</sub>
Al	74.3	NA
Ca	77.9	10.3
Co	39.5	NA

Description of event

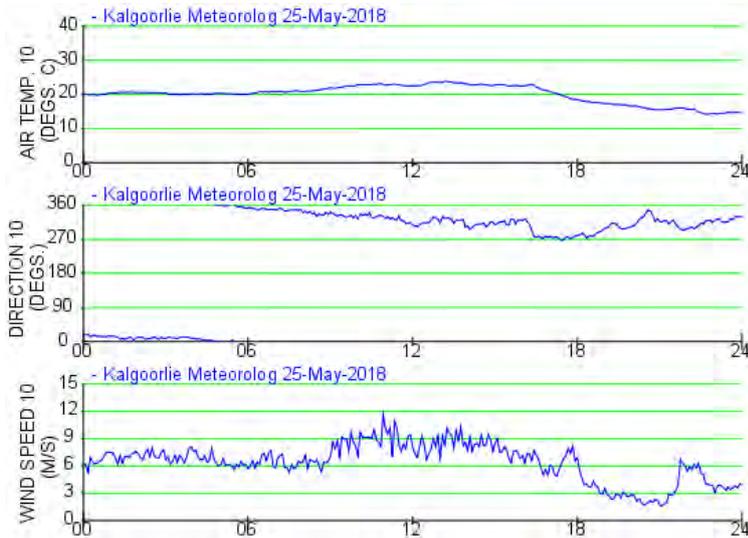
While a satellite image taken on the previous day has a fire near the Caversham site, the low levels of PM<sub>2.5</sub> coupled with high winds most likely points to dust lift-off from the surrounding agricultural areas.

Satellite images for the metro area on the 24th were obscured by heavy cloud.

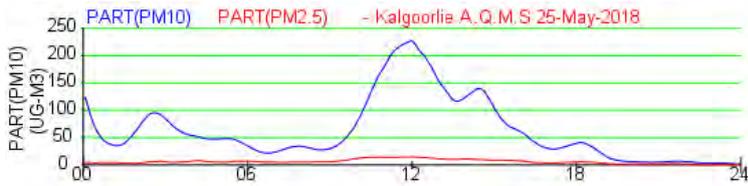
All other metropolitan particle sites (Duncraig and South Lake) recorded elevated particle levels between 18:00 and 20:00 with hourly averages greater than 130 µg/m<sup>3</sup>.

Assessable event

25 May 2018



Five-minute averaged time series plot of wind speed and direction at Albany.



Sixty-minute running averaged time series particle plot at Kalgoorlie.

Pollutant

PM<sub>10</sub>

Monitoring site

Kalgoorlie

NEPM standard

50 µg/m<sup>3</sup>

Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

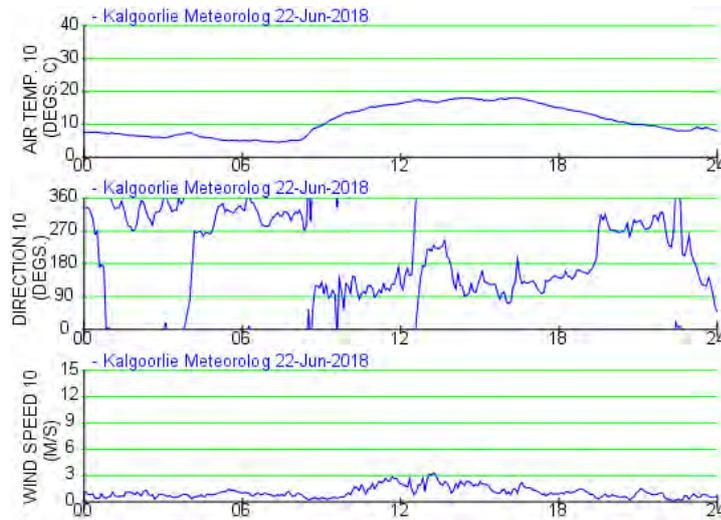
60.5 µg/m<sup>3</sup>

Description of event

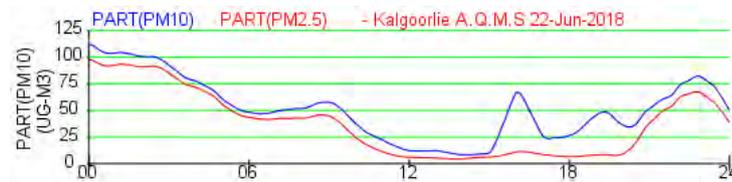
High winds caused dust lift-off with very low PM<sub>2.5</sub> concentrations.

Exceptional event

22 June 2018



Five-minute averaged time series plot of wind speed and direction at Albany.



Sixty-minute running averaged time series particle plot at Kalgoorlie.

Pollutant

PM<sub>2.5</sub>

Monitoring site

Kalgoorlie

NEPM standard

PM<sub>2.5</sub> 25 µg/m<sup>3</sup>

Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

36.2 µg/m<sup>3</sup>

Description of event

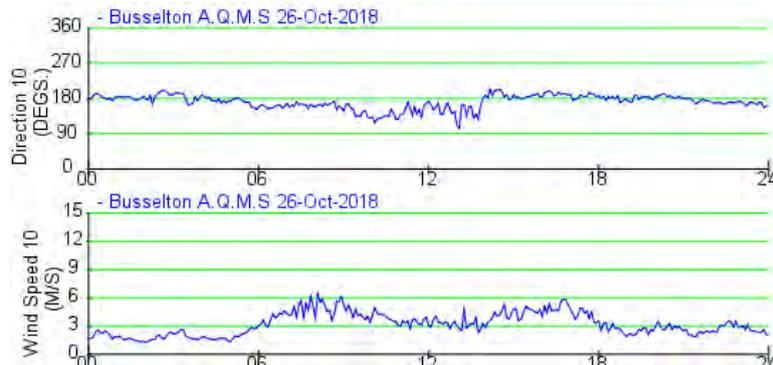
Low wind speed and low temperatures with overnight elevated PM points to wood heater smoke.

Assessable event

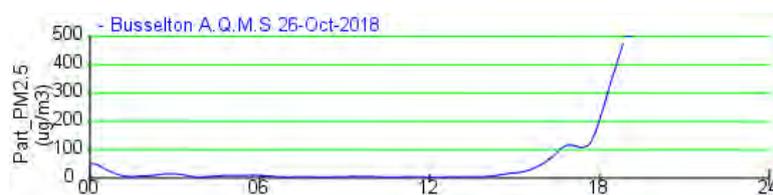
26 October 2018



Terra/MODIS satellite image showing a fire and plume south of the Busselton site



Five-minute averaged time series plot of wind speed and direction at Busselton.



Sixty-minute running averaged time series plot.

Pollutant

PM<sub>2.5</sub>

Monitoring site

Busselton

NEPM standard

25 µg/m<sup>3</sup>

Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

52.5 µg/m<sup>3</sup>

Description of event

A number of prescribed burns south of Busselton.

PM<sub>2.5</sub> instrument stopped collecting data due to blocked filter.

Data ceased at 19:10 when the five-minute average was 700 µg/m<sup>3</sup>. Data recovery for the day was 80 per cent.



Time series plot showing Busselton PM<sub>2.5</sub> (blue) and filter loading (mauve) for the past week.

**Exceptional event**

Burn ID	Name	Location	Burn Purpose	Area	Est Start WST
BWD.037	MOLLOY_547	17km S of Busselton	Bushfire Risk Management, Biodiversity Management	3400.0 ha	11:00

26/10/2018 burn notice for 17 km south of Busselton.

7 November 2018



Aqua/MODIS satellite image showing a fire and plume near Collie.

Pollutant

PM<sub>10</sub>

Monitoring site

Collie

NEPM standard

50 µg/m<sup>3</sup>

Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

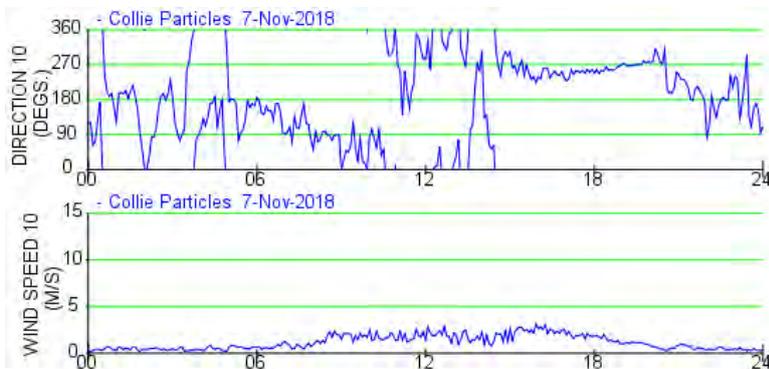
55.0 µg/m<sup>3</sup>

Description of event

A number of prescribed burns in the South West were active during this period.



Sixty-minute running averaged time series plot.



Five-minute averaged time series plot of wind speed and direction at Collie.

Exceptional event

DBCA prescribed burns approved for ignition on 6/11/2018

Burn ID	Name	Location	Burn Purpose	Area	Est Start WST
WTN_006	GERVASSE 040	18km W of Collie	Bushfire Risk Management, Biodiversity Management	80.0 ha	09:30
WTN_089	Ernest	14km NW of Collie	Bushfire Risk Management, Silviculture	1650.0 ha	13:00

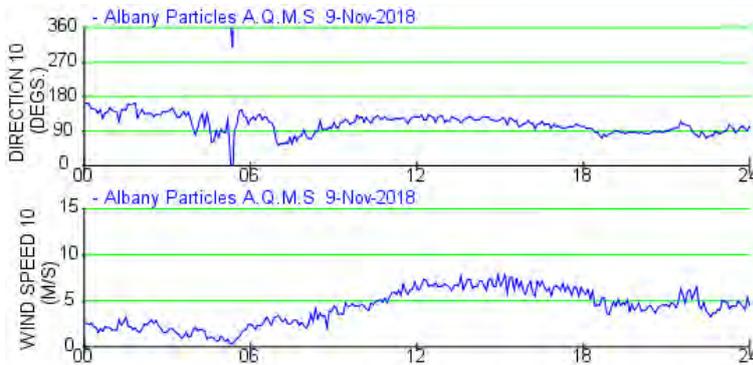
9 November 2018



Google Earth image of ongoing redevelopment of the parklands in Albany.



Sixty-minute running averaged time series plot.



Five-minute averaged time series plot of wind speed and direction at Albany.

Pollutant

PM<sub>10</sub>

Monitoring site

Albany

NEPM standard

50 µg/m<sup>3</sup>

Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

89.6 µg/m<sup>3</sup>

Description of event

The council was undertaking earthworks near the site as part of a redevelopment of the park grounds.

The reduction in particle concentration during the lunch break is noticeable.

Assessable event

10 November 2018



Aqua/MODIS satellite image showing a fire and plume near Busselton.

Pollutant

PM<sub>2.5</sub>

Monitoring site

Busselton

NEPM standard

25 µg/m<sup>3</sup>

Averaging period

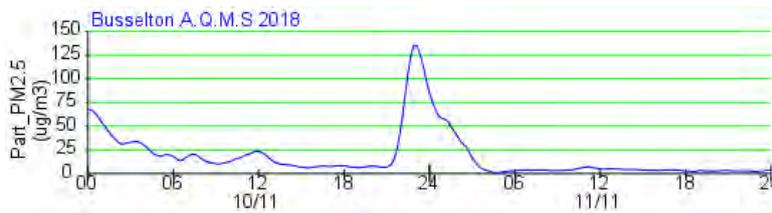
24 hours

Concentration (µg/m<sup>3</sup>)

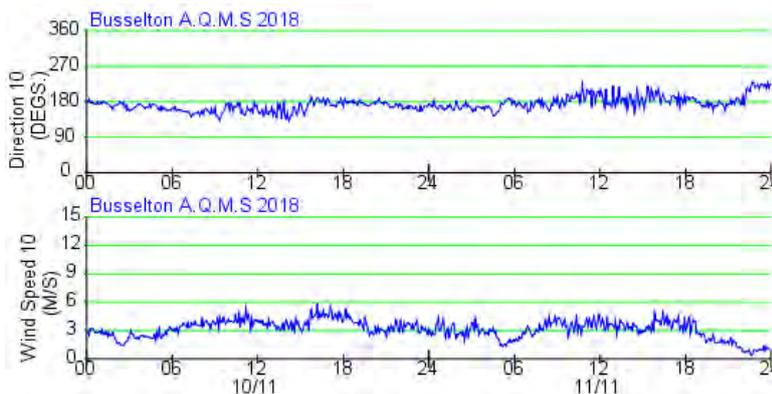
26.3 µg/m<sup>3</sup>

Description of event

A number of prescribed burns in the South West were active during this period.



Sixty-minute running averaged time series plot.



Five-minute averaged time series plot of wind speed and direction at Busselton.

Exceptional event

14 November 2018



Aqua/MODIS satellite image showing a fire and plume near Collie impacting on Bunbury.

Pollutant

PM<sub>2.5</sub>

Monitoring site

Bunbury and Busselton

NEPM standard

25 µg/m<sup>3</sup>

Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

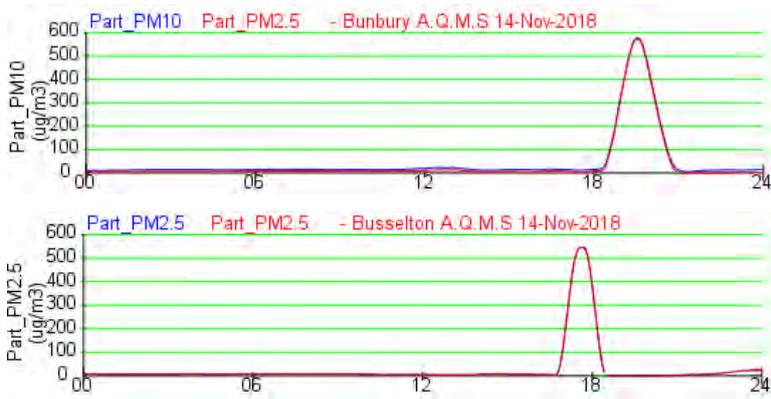
BN: 36.9 µg/m<sup>3</sup>

BS: 28.2 µg/m<sup>3</sup>

Description of event

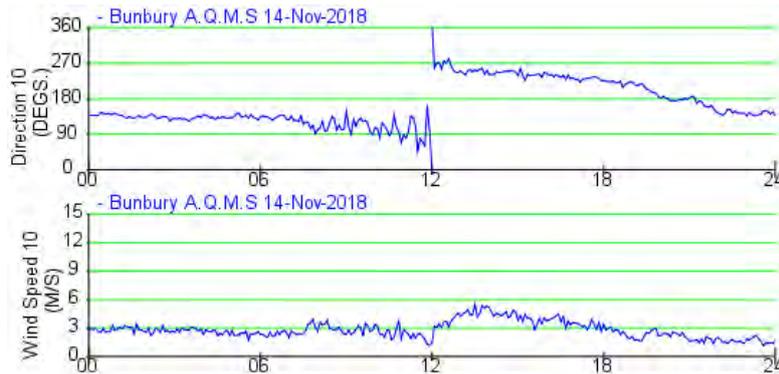
Due to its short-lived nature and timing, this event may have been a local bushfire or burn-off.

PM<sub>10</sub> concentration at Bunbury during the day was 44.8 µg/m<sup>3</sup>.



Sixty-minute running averaged time series plot for Bunbury (top) PM10 (blue) and PM2.5 (red) and Busselton (bottom) PM2.5 (red).

Assessable event



Five-minute averaged time series plot of wind speed and direction at Bunbury.

15 November 2018



Aqua/MODIS satellite image showing a fire and plume near Collie.

Pollutant

PM<sub>10</sub>

Monitoring site

Collie

NEPM standard

50 µg/m<sup>3</sup>

Averaging period

24 hours

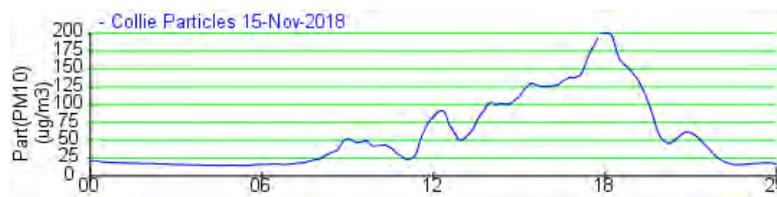
Concentration (µg/m<sup>3</sup>)

57.8 µg/m<sup>3</sup>

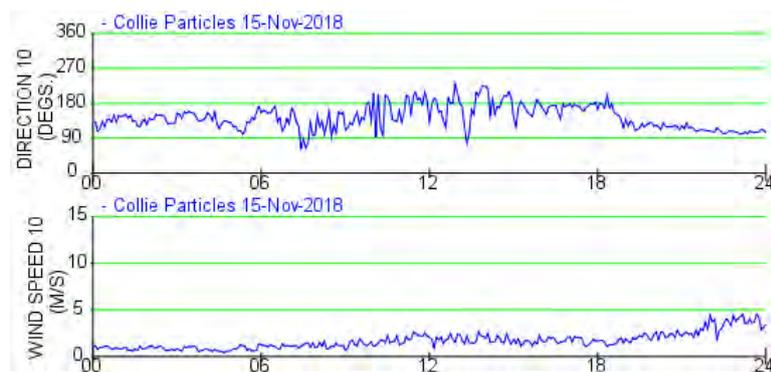
Description of event

DBCA prescribed burn 9 km south of Collie.

Exceptional event

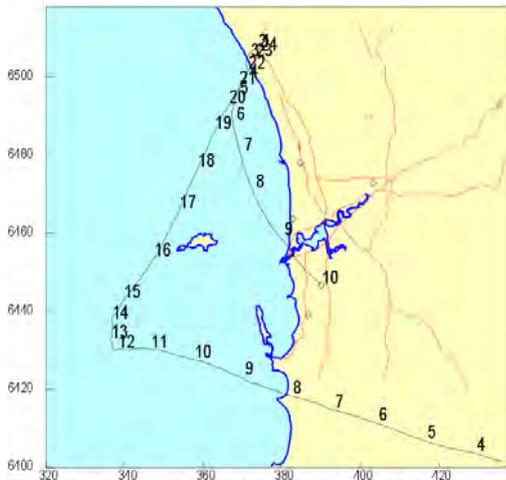


Sixty-minute running averaged time series plot.



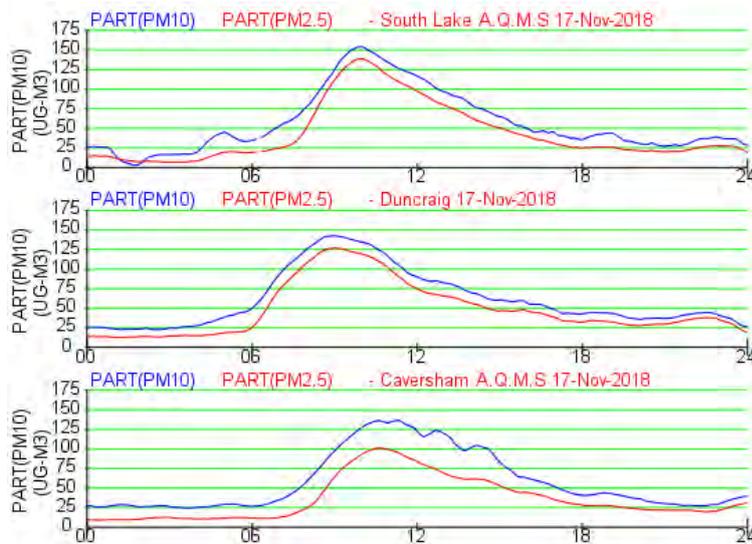
Five-minute averaged time series plot of wind speed and direction at Collie.

17 November 2018

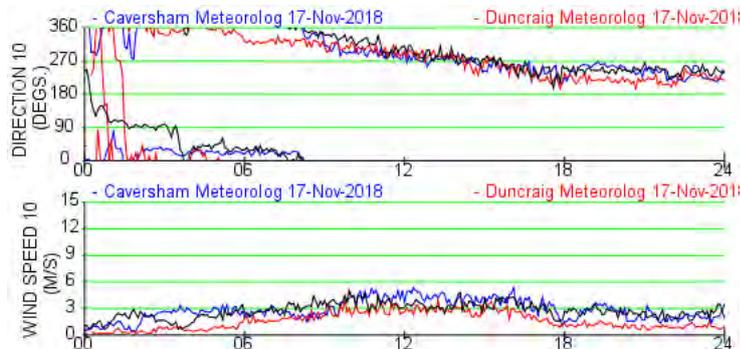


Back trajectory to (390.1,6446.7) over a period of 2160 minutes, ending at 1000 on 17/11/2018

Back trajectory over 36 hours ending at South Lake.



Sixty-minute running averaged time series plot.



Five-minute averaged time series plot of wind speed and direction at Caversham (blue), Duncraig (red) and South Lake (black).

Pollutant

PM<sub>10</sub> and PM<sub>2.5</sub>

Monitoring site

Caversham

Duncraig

South Lake

NEPM standard

PM<sub>10</sub> – 50 µg/m<sup>3</sup>

PM<sub>2.5</sub> – 25 µg/m<sup>3</sup>

Averaging period

24 hours

Concentration (µg/m<sup>3</sup>)

Site	PM <sub>10</sub>	PM <sub>2.5</sub>
Ca	58.5	36.7
Du	61.3	48.6
SL	57.1	43.3

Description of event

Several prescribed burns active in the South West on the previous day (16/11/2018) may have recirculated and caused the elevated smoke levels recorded in the metropolitan region.

Daily averaged PM<sub>10</sub> levels at all three sites listed above were less than 25 µg/m<sup>3</sup> on 16/11/2018 while the PM<sub>10</sub> level recorded at Collie was 27.4 µg/m<sup>3</sup>.

Exceptional event

Department of Water and Environmental Regulation  
Prime House  
8 Davidson Terrace,  
Joondalup WA 6027  
Locked Bag 10,  
Joondalup DC WA 6919  
Phone: 08 6364 7600  
Fax: 08 6364 7601  
National Relay Service 13 36 77  
[dwer.wa.gov.au](http://dwer.wa.gov.au)